

Effect of hypo sludge as partial replacement of cement in concrete

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Abstract— The hypo sludge is a waste material obtained from paper industry. Since, paper is not recyclable for long time, the disposal of hypo sludge poses potential threat on environment. Hypo sludge contains certain chemicals which are observed to have cementitious properties, hence, hypo sludge is useful for partially replacing cement in concrete. In present study, the hypo sludge is used to replace cement in cement concrete in varying amount. The effect of amount of hypo sludge on cement concrete is studied by testing for slump and compressive strength. The empirical relations are developed for compressive strength based on experimental data.

Key words: Cement Concrete; Hypo Sludge; Partial Replacement; Ecofriendly Materials

I. INTRODUCTION

It is estimated that over three hundred million tons of business wastes area unit being made each year by chemical and agricultural method. These materials cause issues of disposal and subsequent hazard to health and safety. The wastes like phosphogypsum, fluorogypsum and red mud contain objectionable impurities that adversely have an effect on the strength and other properties of building materials prepared from them. Out of other type of wastes, the utilization of phosphogypsum, fluogypsum, lime sludge, hypo sludge, red mud, and mine tailing is ecofriendly [1]–[4].

Paper industries produce large amount of solid waste. Paper fibers are recycled solely in restricted range of times before they become too short or weak to form prime quality paper. It implies that the broken, low- quality paper fibers area unit separated resolute are wasted [1]–[9].

All the inks, dyes, coatings, pigments, staples, tape, plastic films, etc. are washed off the recycled fibers to affix the waste solids. The shiny end on shiny magazine-type paper is made employing a fine china stone clay coating that conjointly becomes solid waste throughout. This sludge consumes an oversized proportion of native lowland space for many years [10]–[12]. A number of the wastes area unit land unfold on cropland as a disposal technique, raising issues regarding trace contaminants build up in soil or running off into space lakes and streams. Some corporations burn their sludge in incinerators, conducive to our serious pollution issues [1], [2], [5], [9].

The various types of waste product that can be utilized in cement concrete were reviewed by [13] and hypo sludge was found to be feasible as replacement of cement.

II. LITERATURE REVIEW

Many researchers have used hypo sludge as replacement of cement in cement concrete and chief finding of which are given in this section. The hypo sludge is mostly used along with fly ash, another waste product, and its effect on properties of concrete is evaluated.

In a study to evaluation modulus of elasticity of concrete replaced with hypo sludge and fly ash [6], it was

found that modulus of elasticity slightly decreased as amount of replacement increased and hence it was concluded that fly ash and hypo sludge can be used as replacement of cement.

The study conducted to find out feasibility of use of hypo sludge in rural roads [14] concluded that cost of pavement construction for different CBR values decrease by 10% to 20% when cement was partially replaced by hypo sludge and hence is an innovative supplementary cementitious material for low cost roads which is also ecofriendly.

In ref. [5], the experimental study on hypo sludge replacement concrete concluded that though compressive strength of concrete reduces but the environmental effects are beneficial. Also the total cost is reduced.

The study to evaluate flexural strength of concrete beams with fly ash and hypo sludge [7] observed that flexural strength of concrete beams is increase by about 11% for 10% replacement and 9% for 20% replacement.

The structural performance of concrete evaluated in [2] concluded that compressive strength of concrete increases up to 10% replacement but starts decreasing with 30% replacement. Similar pattern was found in case of split tensile strength and flexural strength.

The experimental study of concrete with hypo sludge and fly ash [4] found similar pattern that 10% replacement increase compressive strength but further increase in amount of hypo sludge as replacement results in decrease of compressive strength.

In ref. [9], the experimental study to find feasibility of hypo sludge concluded that workability of concrete increase as hypo sludge is used as replacement of concrete. The compressive strength was found to decrease beyond 30% replacement as observed in other studies above. The split tensile strength was also found to decrease with increase in split tensile strength. However the upside of using hypo sludge is its cost reduction and ecofriendly characteristic.

The low cost concrete prepared in experimental study [15] was found to have increase in compressive strength up to 20% replacement however, strength decreased beyond this. The reduction of cement reduced the total cost significantly.

Similarly in another study [3] it was found that at 30% replacement of cement with hypo sludge in cement concrete, the properties of concrete are similar to that of conventional concrete.

The hypo sludge is also used to replace cement in cement mortar [16], though it was found that compressive strength of final product was not adequate and hence it is not suggested in mortar. However, it can be used in places with low stresses.

III. EXPERIMENTAL PROGRAM

A. Materials:

The materials used in for present study are cement, fine aggregate, coarse aggregate, water, and hypo sludge

The cement used is ordinary portland cement of 43 grade obtained from local cement supplier. The specific gravity is 3.15, fineness is 97.11. The initial and final setting time was found to be 37 minutes and 427 minutes respectively.

Locally available sand and stones are used as fine aggregate and coarse aggregate. The sand passing through a IS sieve 4.75 mm and conforming to Zone III of IS 383:1970 [17] is used. The fine aggregates physically fill the cavities between coarse aggregates thus condensing the void size of the final product. The reduction in void size results in increased density and strength with less permeability. Coarse aggregate size used are of nominal size 20 mm and particles smaller than 4.75 mm are sieved out.

Tap water or potable water obtained from public sources are considered acceptable for preparing concrete, hence tap water is used in present study.

Hypo sludge material used (Fig. 1) is obtained from mill industry. It is composed of chemicals like calcium chloride and slight amount of silica. The silica and magnesia are responsible for cementitious property of hypo sludge. The moisture content of hypo sludge at time of mixing was found to be 63.25%.

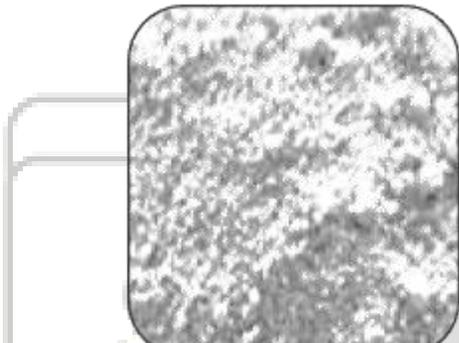


Fig. 1: Hypo sludge material

B. Mix Design:

The study consists of replacing cement in cement concrete with hypo sludge in varying percentage as follows.

- 1) 5% 6. 30%
- 2) 10% 7. 35%
- 3) 15% 8. 40%
- 4) 20% 9. 45%
- 5) 25% 10. 50%

The concrete prepared is of grade M20 prepared according to the provisions of IS 456:2000 [18] and IS 10262:2009 [19].

C. Preparation of Specimen:

The compressive strength is tested by preparing standard concrete cubes in molds of size 150 mm. Three specimen of each sample. The concrete is mixed by hand and each sample containing varying percentage of hypos sludge is mixed individually. After 24 hours of placing concrete, the concreted cubes are removed from mold and cured in cleaned water. The tests are then performed by removing specimens from water and surface drying.

IV. RESULTS AND DISCUSSIONS

The effect of hypo sludge on strength of cement concrete when used as partial replacement of concrete is given in this

section. The workability of samples is first presented followed by compressive strength.

A. Slump Test:

The results obtained from slump test are shown in Table 1 and plotted in Fig. 2. It can be observed that there is significant decrease in workability of concrete when cement is replaced with hypo sludge. The increase in amount of replacement decreases workability further.

Designation	Amount	Slump (mm)
0.	0%	114
1.	5%	94.17
2.	10%	93.98
3.	15%	92.39
4.	20%	87.02
5.	25%	86.49
6.	30%	81.61
7.	35%	81.32
8.	40%	80.7
9.	45%	76.12
10.	50%	73.95

Table 1: Slump test results for hypo sludge concrete

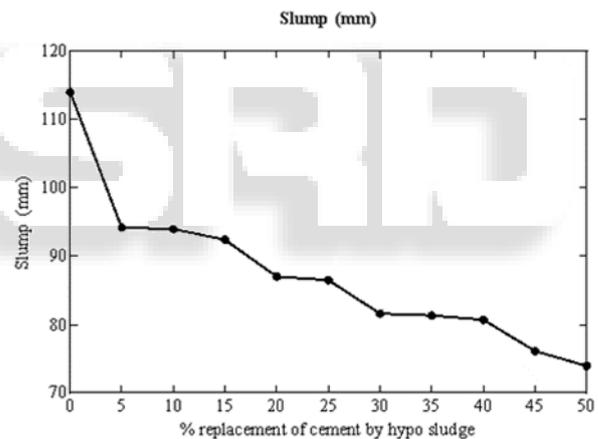


Fig. 2: Slump test result plot

B. Compressive Strength:

The compressive strength test results are shown in Table 1 which shows results for both 7 days and 28 days compressive strength. The compressive strength is found to increase only slightly up to 20% replacement. Beyond 20% replacement, the compressive strength is found to decrease uniformly.

The empirical relation to calculate 7 days and 28 days compressive strength are obtained through non-linear regression. For this purpose, a fifth order polynomial equation is fitted in experimental results obtained in Table 1. The fitted equation are given in subsequent section.

Designation	Amount	7 days Compressive Strength (N/mm ²)	28 days Compressive Strength (N/mm ²)
0.	0%	17.05	28.38
1.	5%	17.22	29.16

2.	10%	17.73	29.69
3.	15%	18.62	29.70
4.	20%	17.02	28.11
5.	25%	15.56	27.96
6.	30%	14.06	25.39
7.	35%	13.21	23.27
8.	40%	12.53	22.14
9.	45%	11.84	21.28
10.	50%	11.53	20.72

Table 2: Compressive strength test results for hypo sludge concrete

C. Relation for 7 Days Compressive Strength:

The empirical expression to calculate 7 days compressive strength of concrete replaced with varying amount of hypo sludge is obtained as follows. Here 'x' is percentage replacement of cement with hypo sludge.

$$C_{7\text{days}} = 17 - 0.09068 \times x + 0.04483 \times x^2 - 0.003353x^3 + 8.117 \times 10^{-5} \times x^4 - 6.441 \times 10^{-7} \times x^5 \quad (1)$$

The fitted curve for this equation is shown in Fig. 3

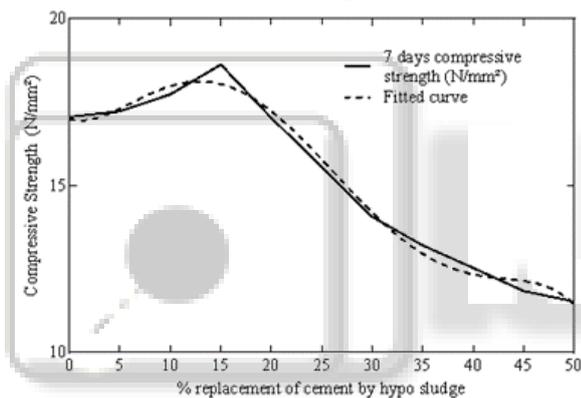


Fig. 3: 7-Days Compressive Strength Result with Curve Fitted

D. Relations for 28 Days Compressive Strength:

The empirical expression to calculate 28 days compressive strength of concrete replaced with varying amount of hypo sludge is obtained as follows.

$$C_{28\text{days}} = 28.4 + 0.1083 \times x + 0.01380 \times x^2 - 0.001522x^3 + 3.500 \times 10^{-5} \times x^4 - 2.436 \times 10^{-7} \times x^5 \quad (2)$$

The fitted curve for this equation is shown in Fig. 4

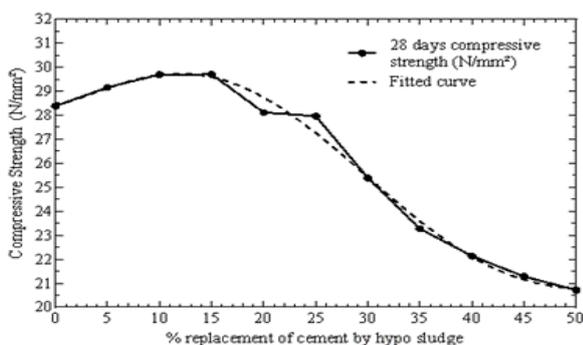


Fig. 4: 28-Days Compressive Strength Result with Curve Fitted

V. CONCLUSION

The hypo sludge is a waste material obtained from paper industry and its apposite disposal is necessary so as not to affect the environment. Hypo sludge contains chemicals which are found to have cementitious properties, hence, hypo sludge is used to partially replace cement in concrete.

In present study, the hypo sludge is used to replace cement in cement concrete in varying amount. The effect of amount of hypo sludge on cement concrete is studied by testing for slump and compressive strength.

From results obtained, it is observed that up to 20% replacement, the strength of concrete remains more or less similar to ordinary concrete, may also increase. But, beyond 20% replacement, strength starts to decrease. Similar pattern is obtained for workability. From experimental data obtained, two empirical relations are developed by non-linear curve fitting of data in a fifth order polynomial. The equation will now readily give prediction of compressive strength for given amount of hypo sludge concrete.

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