Experimental Study of Use of Hypo Sludge in Cement Concrete

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Abstract— To mitigate emission of carbon dioxide and other greenhouse gases, it is necessary to develop alternative ways by which sustainable development can be improved. While creating paper different squanders are turns out from the different procedures in paper ventures. The primer waste from paper industry is named as hypo sludge. In this study the material obtained from the paper industry waste (hypo sludge) is partially replaced with Portland cement at different replacement levels. The properties of concrete was investigated which includes workability, setting time, compressive strength and optimum percentage of hypo sludge as supplementary cementations material (SCM) is also determined. This dissertation discusses various combination of cement with hypo sludge in concrete. Earlier study shows that hypo sludge is very rich in lime content and thus it works as a partial replacement material in concrete. Past studies also shows that the presence of silica, magnesium and calcium in hypo sludge makes it similar to that of cement and hence there is a possibility to replace cement with hypo sludge. The Hypo sludge can minimize the demand for cement and reduce the construction cost. This dissertation deals with experimental investigations to evaluate the optimum percentage of hypo sludge to be used for manufacturing concrete. M30 and M40 grade of concrete were used in this study. Different percentage of hypo sludge i.e. 3%, 5%, 7%, 10% and 12% is replaced by OPC cement of 43 grades. The outcome demonstrates that the quality of the solid increments by adding hypo sludge up to 10%. Be that as it may, additionally increment in hypo sludge diminishes the compressive strength.

Key words: Hypo Sludge, Sustainability, Eco-Efficient, Cost-Efficient, Compressive Strength, Slump Test, Concrete Mix, Paper Waste

I. INTRODUCTION

World paper industry assumes nearly 3.5% of the world industrial production and 2% of world's trade. Demand of paper and boards worldwide will reach 470 million tonnes with an average annual increase of paper demand of about 3.7%. Paper and boards demand is estimated to reach 740 million tonnes in 2030. The wood consumption in the world is expected to increase from 861 million tonnes in 1995 to 2050 million tonnes in 2030. With merely 17 units in 1950 with production of 0.11 million tonnes paper, presently we have about 380 mills with a total installed capacity of around 4.2 million tonnes. There are 28 large mills and the remaining are small paper mills. Per capita consumption of paper in India is a meagre 3.2 kg against Asia and world average of 18 kg and 47.7 kg respectively. Per capita consumption of newsprint is 0.6 kg as compared to Asian average of 1.9 kg and world average of 6 kg.

Hypo sludge is a waste or by-product of paper industry, which is generated during calcium hypo chlorite generation. In order to reduce the consumption of natural and conventional resources, which by the way are limited, use of other industrial wastes are inevitable. To replace these wastes with fresh materials, one of the feasible options is to control degradation of environment. Hypo sludge is purely chemical waste and requires large space for disposal. We can use it as a partial replacement material in cement concrete. Use of hypo sludge in cement concrete not only solve the disposal problem but also make concrete has economical by had replacing cemented partially. Hypo sludge will improve construction functionality and ecological sustainability and results in low life-cycle cost. Its response to different loads and durability could be major concern for construction professionals. Therefore, it is necessary to do an experimental study of such concrete.

II. METHODOLOGY

Hypo Sludge is a waste material collected from the Paper Industry. It is used as cement replacement in producing concrete. Hypo sludge behaves like cement because of silica and magnesium properties. This silica and magnesium improve the setting of concrete. Hypo sludge is collected from PAPER MILL AMLAI SHAHDOL DISTT M.P. The hypo sludge have some moisture so it was dried in oven at 107°C for 24 hours then grinded and sieved to make it fine so that it can replace cement. The specific gravity of hypo sludge was calculated using Pycnometer method. The specific gravity of hypo sludge was 2.10 which were quite similar to sand. Cement used in this project is ordinary Portland cement of grade 43. River sand and crushed aggregate used as fine and coarse aggregate respectively. Mix design is done as per IS 10262 and grade of concrete is M30 & M40. Slump cone test and compressive strength is performed in concrete. Mix designation of concrete cubes is given in table 1 and table 2.

S.No.	Cement %	% Replacement (Hypo Sludge)	Mix Designation
			M30 Grade (7 & 28 days)
1.	100%	0%	H0
2.	97%	3%	H1
3.	95%	5%	H2
4.	93%	7%	H3
5.	90%	10%	H4
6.	88%	12%	H5

Table 1: Designation of M30 Grade Cubes

S.No.	Cement %	% Replacement (Hypo Sludge)	Mix Designation
			M40 Grade(7 & 28 days)
1.	100%	0%	S0
2.	97%	3%	S1
3.	95%	5%	S2
4.	93%	7%	S3
5.	90%	10%	S4
6.	88%	12%	S5

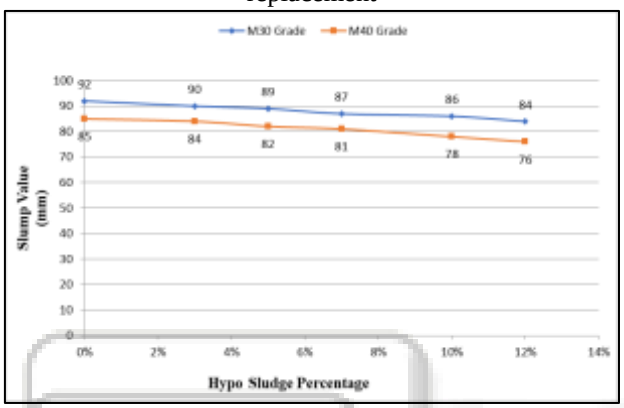
Table 2: Designation of M40 Grade Cubes

III. RESULT & DISCUSSION

To check the workability Slump cone test was performed and its results & percentage variation are shown in Table 3 and Graph 1.

S.No.	Mix Name	Hypo sludge %	Slump Value	
			M30	M40
1.	A	0%	92	85
2.	H.S.1	3%	90	84
3.	H.S.2	5%	89	82
4.	H.S.3	7%	87	81
5.	H.S.4	10%	86	78
6.	H.S.5	12%	84	76

Table 3: Slump value for M30 and M40 grade at different replacement



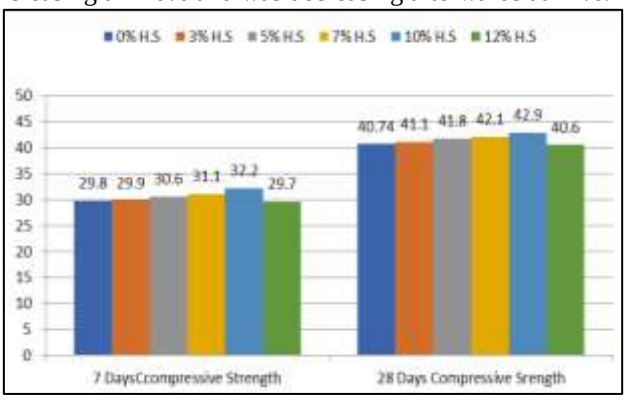
Graph 1: Slump Values of Different Mixes

The Slump value of M30 grade Concrete decreased from 92 mm at 0% to 84 mm at 12 % replacement. The Slump value of M40 grade Concrete decreased from 85 mm at 0% to 76 mm at 12 % replacement. So test results shows that as percentage of hypo sludge increases slump value decreases. Percentage variation of both M30 and M40 mix coincides at 5 % after which M40 mix variation is slightly more as M30 mix variates.Compressive strength of concrete cube test provides an idea about all the characteristics of concrete. Compressive strength of M30 and M40 Concrete for 7days and 28 days with (0, 3, 5, 7, 10,12 %) replacement given in table 4 and graph 2,3,4 & 5.

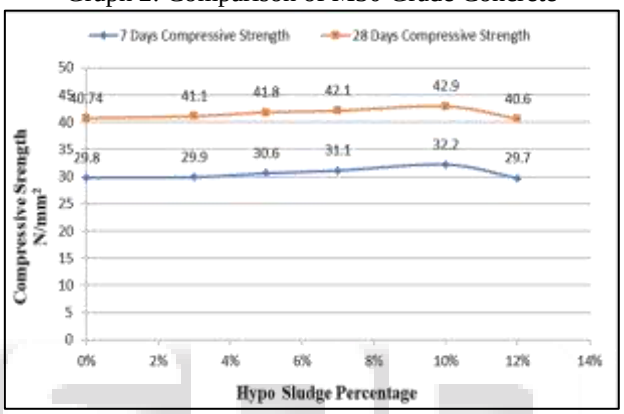
S.No.	Hypo Sludge %	Mix Name	Compressive strength N/mm^2 M40 Grade		Mix Name	Compressive strength N/mm^2 M30 Grade	
			7 Days	28 Days		7 Days	28 Days
1.	0%	S0	36.05	50.89	H0	29.80	40.74
2.	3%	S1	36.09	51.20	H1	29.90	41.10
3.	5%	S2	37.30	51.90	H2	30.60	41.80
4.	7%	S3	37.90	52.70	H3	31.10	42.10
5.	10%	S4	38.60	53.20	H4	32.20	42.90
6.	12%	S5	36.04	50.70	H5	29.70	40.60

Table 4: Compressive Strength of different Concrete Cubes

The Chart shown in Graph 2 and Graph 3 clearly shows that the compressive strength of Concrete was increasing till 10% and was decreasing afterwards at 12%.

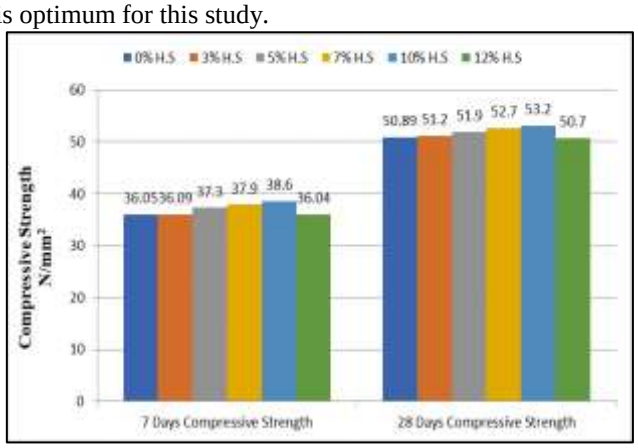


Graph 2: Comparison of M30 Grade Concrete

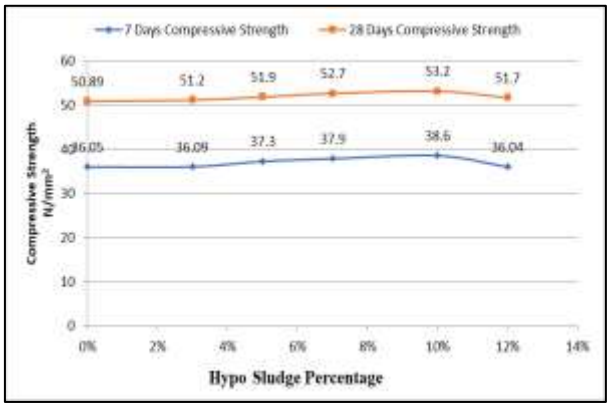


Graph 3: Comparison of M30 Grade Concrete

Result shows that the compressive strength of Concrete was increased till 7% and was decreased afterwards at 12%. Replacing Hypo Sludge with cement the compressive strength of concrete increased till the 10 % replacement and decreased after 12 %. The Compressive Strength of M40 Grade of concrete reached to 54.2 N/mm^2 at 10% cement replacement with Hypo Sludge which was optimum value. At 12 % the compressive strength of concrete is 51.70 N/mm^2 which was slightly less than that of conventional concrete i.e., 51.89 N/mm^2 which shows that strength will further decreased as cement was replaced. So, on comparing results it is clear that 10% replacement of cement with Hypo sludge is optimum for this study.



Graph 4: Comparison of M40 Grade Concrete



Graph 5: Comparison of M40 Grade Concrete

IV. CONCLUSIONS

Based on experimental investigations such as compressive strength of cement mortar at different replacement, slump value at different replacement, compressive strength of concrete at different replacement and their results obtained we concluded that the Compressive Strength of Pervious Concrete is increases when the replacement of Cement with Hypo Sludge up to 10% replaces by weight of Cement. The compressive strength of concrete increased up to 10% replacement of Hypo Sludge and further increase in Hypo Sludge reduces the strength at 12%.

The compressive strength of mortar increased till 10% replacement of Hypo sludge with cement and decreased at 12%. The most suitable mix proportion is the 3%, 5%, 7 % and 10% replacement of Hypo sludge to cement. Since the optimum Compressive Strength for mortar and concrete was achieved at 10 % replacement thus, the optimum replacement for this study is 10%.

The Normal Consistency of Cement is increased when the Hypo Sludge was partially replaced with it. Thus, Initial and Final Setting time also increased. There was an increase in water absorption of the concrete mixes as the content of the Hypo sludge increased. This phenomenon is expected since more amount of Hypo Sludge in term of quantity will involve in the hydration process. Therefore, additional amount of water was required for cement hydration which is the common solution to this kind of problem. However, higher water content decreases the strength of concrete.

Percentage variation at different replacement level with respect to normal consistency of cement (at 0%), optimum variation were obtained at 10% replacement, after which there is decrease in variation at 12% replacement. Percentage variation of initial and final setting time at different replacement level which clearly shows that with increase in percentage replacement initial and final time also increases. However, initial setting time has more variation as compared to final setting time because initially hypo sludge absorbs more water as compared to cement and due to heat of hydration there is more variation in initial setting time.

The slump value decreased as the cement content decreased and Hypo Sludge content increased in concrete. Use of Hypo Sludge in concrete can save the pulp and paper industry disposal costs and produce a 'greener' concrete for construction. Shows percentage variation of cement mortar at different replacement level with respect to conventional mortar at 7 and 28 Days. Graph clearly shows optimum variation was obtained at 10% replacement and then decreases at 12%.

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