

Replacement of Cement by Hypo Sludge and Silica Fume in Concrete – A Review

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Abstract: The global cement industry imparts a lot of greenhouse gas discharge to the earth's atmosphere. In order to decrease cement production and discarding problem of industrial waste, there is a require to develop alternative binders in construction field. Utilization of industrial waste materials as Supplementary Cementitious Material (SCM) in concrete is very important ingredient in view of economic, environmental and technical reasons. The selection of the industrial waste materials was according to their chemical properties are nearest same as cement properties and silica fume is finest particles then the cement particles, it was work as a filler material and increase the setting time of concrete. Hypo sludge and silica fume which are mainly used for the experiments by different researchers for their study. Hypo sludge and silica fume improves the structural properties such as compressive strength, water permeability, split tensile strength and durability of the normal concrete which was found by the performing different type of experiment on too many specimens had varying sizes used by different researchers for their study of hypo sludge concrete and silica fume concrete in comparison with the conventional concrete and from the experiment it was also found that use of hypo sludge and silica fume in concrete up to 10% by weight of cement.

Keywords: compressive strength, fresh concrete, hypo sludge, OPC cement, silica fume, split tensile strength

I. INTRODUCTION

Today construction cost is very high with using routine material like cement, fine aggregate and coarse aggregate. This study includes use of different waste material as a partial replacement of cement. Industries in India produce lots of waste which may be useful in partial replacement of all the raw materials due to their different properties. So hereby we studied as many useful research papers in this field and trying to improve with locally available waste material so it can be proved economical as well. Research in this field and positive results are crucial so as to continue all developments with least damage to surrounding environment and obtaining all infrastructures for services and convenience which are desired to get.

Natural resources are not unlimited therefore, they must be optimally consumed. The manufacturing of Ordinary Portland cement (OPC) which is the main ingredient of concrete but it releases a large amount of greenhouse gases specially CO₂. On the other side dumping of wastes produced from industries causes a major problem to environmental issues. This can be achieved by the process of recycling and, making use of industrial wastes, disposal of which otherwise is a serious problem.

II. MATERIALS & PROPERTIES

2.1 HYPO SLUDGE

Paper waste (hypo sludge) is a waste from paper and board industry. The material is by-product of the de-inking and re-pulping of paper. Paper sludge are varying with strong and weak fibres. Strong fibres of waste are taken for the recycling process to make recycled paper and the weak fibres are taken to the disposal site. Due to this disposal, it causes a severe problem of air pollution, water pollution and soil pollution. To reduce the disposal problem paper sludge is replaced with cement. About 300 kg of sludge is produced for each tone of recycled paper. [4] This is a relatively large volume of sludge produced each day that making landfill uneconomical as paper mill sludge is bulky.[4] The million tons quantity of paper mill sludge produced in the world. Paper sludge behaves like cement because of silica and magnesium properties which improve the setting of the concrete.[3]



Fig. 1 Hypo Sludge

This paper mill sludge consumes a large percentage of local landfill space for each and every year.

Table 1: Chemical Properties of Hypo Sludge

Chemical Components	Values (%)
CaO	46.84
Al ₂ O ₃	0.69
Fe ₂ O ₃	1.12
SiO ₂	9.32
MgO	3.66
Loss ignition	38.37

2.2 SILICA FUME

Silica fume is a by-product of producing silicon metal or ferrosilicon alloys. Silica fume has been recognized as a pozzolanic admixture that is effective in greatly enhancing mechanical properties. One of the most beneficial uses for silica fume is in concrete. Because of its chemical and physical properties, it is a very reactive pozzolan. [8] Silica fume consists primarily of amorphous (non-crystalline) silicon dioxide (SiO₂). [5] The addition of silica fume to concrete improves the latter's durability by reducing permeability and refining pore structure, leading to a reduction in the diffusion of harmful ions and the calcium hydroxide content, resulting in greater resistance to sulphate attack.[10]



Fig. 2 Silica Fume

The first testing of silica fume in Portland-cement-based concretes was carried out in 1952. [5] Silica fume is a very fine pozzolanic material. Concrete containing silica fume has very high strength and is very durable.

Table 2: Chemical Properties of Silica Fume

Chemical Components	Values (%)
CaO	0.72
Al ₂ O ₃	1.19
Fe ₂ O ₃	1.83
SiO ₂	92.21
MgO	0.73

K ₂ O	1.21
SO ₃	1.2
Loss ignition	0.91

III. FRESH & HARDENED PROPERTIES

3.1 WORKABILITY

Following are the test result obtained from slump cone test for various grade and % replacement of hypo sludge,[4]

Table 3: Slump Test Value [4]

GRADE/ %Replacement	M20	M30	M35
0	140	120	105
5	125	95	90
10	95	80	82
15	70	75	75
20	55	50	48
25	40	38	35

Based on above table shows the Workability of concrete by slump cone test. The following observations are to be concluded from above table 3,

From the above table, increase in rate of hypo sludge (5% to 25%) in concrete the slump value also decreases because hypo sludge absorbs the water. As grade of concrete increases the slump value of concrete decreases. [1]

3.2 COMPRESSIVE STRENGTH OF HYPO SLUDGE CONCRETE

The below table shows the result of compressive strength test and split tensile strength test when hypo sludge is used for M35 grade of concrete at 3,7 and 28days. The following observations to be concluded from below figure no. 3 & table 4.

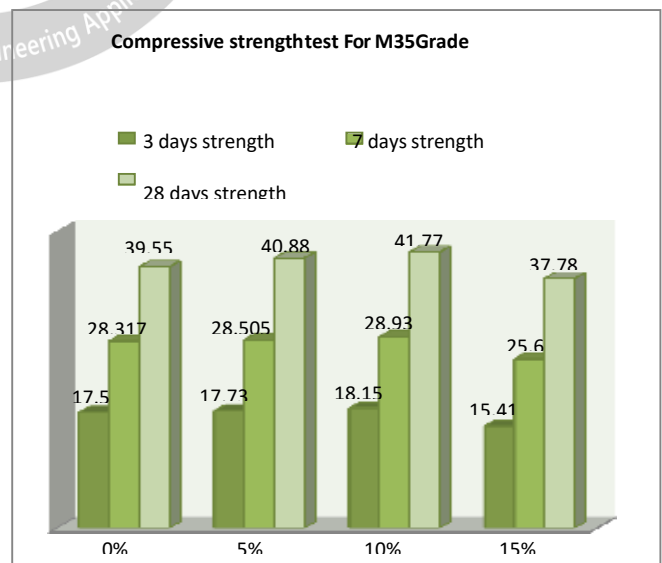


Fig. 3: Comparison of hypo sludge concrete with normal concrete [1]

3.3 SPLIT TENSILE STRENGTH OF HYPO SLUDGE CONCRETE

Table 4: Comparison hypo sludge concrete with normal concrete

Sr no.	No. of Days	Split tensile strength of normal concrete N/mm ²	Split tensile strength of concrete with hypo sludge N/mm ²
1	7	3.25	5.06
2	28	3.76	6.27

As the % of Hypo sludge increased from 5% to 10% the value of compressive strength and split tensile strength are increases than the normal concrete strength for grade of concrete. When the Hypo sludge % increases above 10% the values of compressive strength and split tensile strength goes on reduced. [1,4]

3.4 COMPRESSIVE STRENGTH OF SILICA FUME CONCRETE

The table below gives the result of compressive strength test and split tensile strength test and comparison of normal concrete with silica fume concrete produced with different percentages of silica fume. The variation of compressive strength and split tensile strength as shown in table 5 & 6.

Table 5: Comparison of silica fume concrete with normal concrete

Sr no.	No. of Days	Compressive strength of normal concrete N/mm ²	Compressive strength of concrete with silica fume N/mm ²
1	7	18.11	21.26
2	14	22.87	29.65
3	28	26.20	34.93

3.5 SPLIT TENSILE STRENGTH OF SILICA FUME CONCRETE

Table 6: Comparison of silica fume concrete with normal concrete

Sr no.	No. of Days	Split tensile strength of normal concrete N/mm ²	Split tensile strength of concrete with silica fume N/mm ²
1	7	2.62	3.95
2	14	3.31	4.13
3	28	4.71	4.91

By adding 10% silica fume, there is large amount of increase in strength after 7, 14 and 28 days respectively. The split tensile strength tends to increase with increase percentages of silica fume in the mix and decreases after 10% replacement.

IV. CONCLUSIONS

Based on literature review concerning compressive and split tensile strength of concrete with hypo sludge and silica fume

as a partial replacement of cement, the following conclusion below;

- The compressive strength and split tensile strength of concrete is increased by the use of hypo sludge up to 10% replacement of cement. After 10% there is a decrease in strength. [1,3,4]
- Increase in rate of hypo sludge (5% to 25%) in concrete the slump value also decreases because hypo sludge absorbs the water. [2]
- The strength mainly depends on the percentage of silica fume because of its high pozzolanic nature to form more densely packed C-S-H gel. [10,11]
- The compressive strength and split tensile strength of concrete is increased by the use of silica fume up to 10% replacement of cement. After 10% there is a decrease in strength. [5,7,8,10]

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