

Behavioural Analysis of Concrete Using Micro Silica and Hypo Sludge as Partial Replacement in Cement

Riyaz Khan N.H, Venkatesh S, Padmavathi S, Sony George

Abstract: A conglomerate of Paste and aggregates or rocks is often derives the name Concrete. The slurry comprising of Portland cement and water acts as an effective binder along the surfaces called as the Hydration, this mixture of paste and aggregates hardens and gain strength to form the mass well-known as Concrete. The permutations and combinations tried in the proportions of ingredients of the mixture, comprising of cement, hypo sludge and micro silica, reduces the cost considerably. In this paper the influence of Hypo Sludge and Micro Silica, which play a vital role as a partial and a potential substitute for cement, in the mixture under loading conditions has been studied. The strength of the mixtures in withstanding the constant crushing load up to 28days was studied. As an outcome of the model pertaining to IS standards M20 grade concrete used to design the concrete mix, the compressive strength scaled up to 11% on inclusion of hypo sludge and micro silica, but further increase in hypo sludge gradually reduces the compressive strength.

Index Terms: Compressive Strength, Hypo Sludge, Micro Silica, Split Strength.

I. INTRODUCTION

The whole world is on a construction spree, which increases the demand for cement and on the other hand the disadvantages of using cement is inevitable. Nowadays, cement became popular as Portland cement and extremely popular among the engineers because of its characteristics. Every stage of its production, associated with various pollution problems [7-9]. In developing countries like India, Energy plays a vital role. To get the carbon credits, the effective utility of industrial wastes like Hypo Sludge and Micro Silica are to be maximized, which saves the energy & environment for future. During recycling process, the fine kaolin clay, used as a coating material to give shiny finish on paper, becomes a solid waste in the manufacture of paper.

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* Correspondence Author (s)

Riyaz Khan N.H*, Lecturer, Department of Cadastral Surveying and Geomatics, Ambo University, Ambo, Ethiopia.

Venkatesh S, Assistant Professor, Department of Civil Engineering, St. Joseph's Institute of Technology, Chennai, Tamil Nadu.

Padmavathi. S, Student, Department of Civil Engineering, St. Joseph's Institute of Technology, Chennai, Tamil Nadu.

Sony George, Student, Department of Civil Engineering, St. Joseph's Institute of Technology, Chennai, Tamil Nadu

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This hypo sludge occupies large amount of land space. Every year, in order to decrease the harms arising out of industrial wastes as an alarming pollution content, it is very important to make building materials that are economical and eco-friendly [1]. Hypo sludge is available in plenty throughout the world, but its usage is very limited. It is having a low bulk density of 200 to 350 kg/m³, which makes the powder handling difficult [2]. The correct usage of mineral and chemical admixtures along with quality control makes the High Performance Concrete (HPC) [3].

The efficiency of micro-silica as a pozzolanic material and as a filler is largely dependent on its composition and particle size. With its unique properties, it has become a good construction material and as a replacement for cement to some extent [4]. Both these materials, Hypo sludge and Micro-silica, could be used partially as a potential alternate for cement in concrete. It makes the concrete more eco-friendly and this paper deals with the investigation of effects of the hypo sludge and micro-silica in concrete.

II. MATERIAL PROPERTIES AND METHODOLOGY

A. Cement

The most commonly used is Ordinary Portland Cement. The OPC 53 grade compatible to IS 8112 – 1989 was the standard followed in the mix. The following tests like Specific Gravity, Consistency and Setting time tests were conducted and the results are compared with IS code standards as exemplified in table 1.

Table 1. Properties of cement in comparison with IS code standards

S.no	Physical Properties	Result	Requirement as per IS code
1	Fineness	6.5%	Not greater than 10%
2	Specific Gravity	3.15	3.10-3.15
3	Initial Setting Time	45 min	Should be greater than 30 min

B. Fine Aggregate

As per the international standards of the construction materials, the fine aggregate particles lie in the fractions falling between 4.75mm to 150 microns [6]. IS 383: 1970 (Table 4) justifies the standard adopted for the river sand utilized in these tests.

C. Coarse Aggregate

The coarse aggregates of fractions lie between 20mm and 80mm. These aggregates from basalt rock conforming to IS 2386 (part 3): 1963 was used in this study.

D. Hypo Sludge

Hypo sludge contains maximum calcium chloride and low calcium with minimum amount of silica. It is having the behavior of cement with silica and magnesium properties. This silica and magnesium prolongs the setting time of the concrete.

E. Micro-silica

Silica fume is a non-crystalline polymorph of silicon dioxide. It was collected as a fine powder in the form of by-product from the silicon and ferrosilicon alloy production. It comprised of spherical particles with the size of 150 nm [5].

III. EXPERIMENTAL METHODOLOGY

The mix, comprising of Cement and aggregates along with sludge and slurry formed with water and micro-silica, was formed as per the design.

A. Compression Test

Compressive strength is an effective way of measuring how much load a surface or material can bear. The strength of the concrete upon applying the external compressive force steeply increases initially in the test time duration of 28 days. After this period it gained strength but at a slower rate. Concrete Cubes of 150mm in all the three directions were casted with M20 grade. Specimens with ordinary Portland cement were substituted with hypo sludge and micro-silica at the proportion of 10%, 20% and 30% levels in the cast. Water curing was done on all the specimens, after removing it from the mold, for the periods of 7 days and 28 days.

B. Split Strength Testing

An effective analysis on the tensile strength is inevitable for a structure to endure. Cracking in the structure is a debacle that has to be addressed. More the tensile load, more would be the tensile stress developed on any structure resulting in the initiation of the crack. The developed crack propagates with the increase in the tensile load. Concrete has the tendency to reach the point of failure due to its brittleness. Since brittle failures are sudden and non anticipatory, the study of tensile load attains utmost significance. The researchers widely adopt the splitting tensile strength test on cylinders, of 150 mm diameter and 300 mm length, to find the strength of the concrete.

IV. RESULTS AND DISCUSSIONS

For each combination two specimens were casted. The compressive strength results and split strength results are obtained and explained below.

A. Compressive strength

Concrete specimens with above mentioned combination are prepared and tested at the period of 7 days and 28 days. The results are shown in table 2 and the average results are shown in fig 1. From fig 1, the combination of

10% replacement of hypo sludge and micro silica gives the maximum average compressive strength of 21.96 N/mm² and 28.88 N/mm² is obtained at the age of 7 days and 28 days respectively.

Table 2 7days and 28 days Cubes Strength Results

Type	Days	Conventional	Con + 10%H.S	10%H.S + 10%M.S	20%H.S + 10%M.S	30%H.S + 10%M.S
Cube I	7	16.44	21.11	21	19.11	15.55
	28	19.55	21.55	30.66	21.33	17.33
Cube II	7	15.11	20.33	23.33	18.22	12.44
	28	20	21.22	29.33	20	12.44
Cube III	7	17.33	19.77	21.55	19.11	14.66
	28	20	23.77	26.66	19.11	14.66
Average	7	16.29	20.40	21.96	18.81	14.26
	28	19.85	22.18	28.88	20.14	14.81

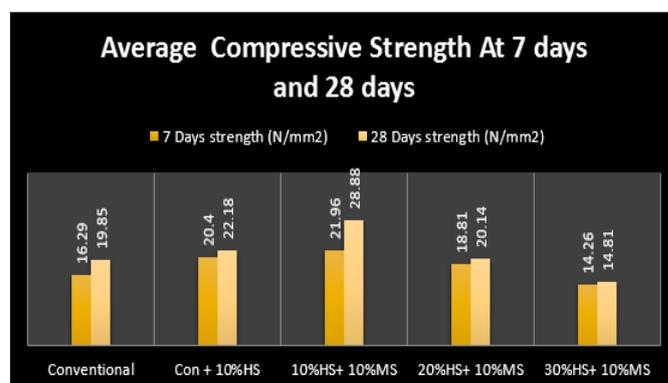


Figure 1 Compressive Strength results

B. Split tensile strength

The cylindrical specimens of size 150x300mm were prepared and tested for splitting tensile strength on conventional and the proposed mix proportion of concrete at a period of 7 and 28 days, the outcomes of the split tensile strength are shown in table 3 and the average results are shown in fig 2.

Table 3 Split Tensile Strength Results

Type	Days	Conventional	Con + 10%H.S	10%H.S + 10%M.S	20%H.S + 10%M.S	30%H.S + 10%M.S
Cylinder I	7	2.41	2.68	2.72	1.69	1.69
	28	2.41	2.41	2.95	1.98	1.70
Cylinder II	7	2.69	2.54	2.98	1.84	1.56
	28	2.83	2.52	2.86	1.98	1.56
Cylinder III	7	2.26	2.36	2.41	1.69	1.84
	28	2.55	2.99	2.95	1.84	1.41
Average	7	2.45	2.52	2.70	1.74	1.70
	28	2.60	2.64	2.92	1.93	1.56



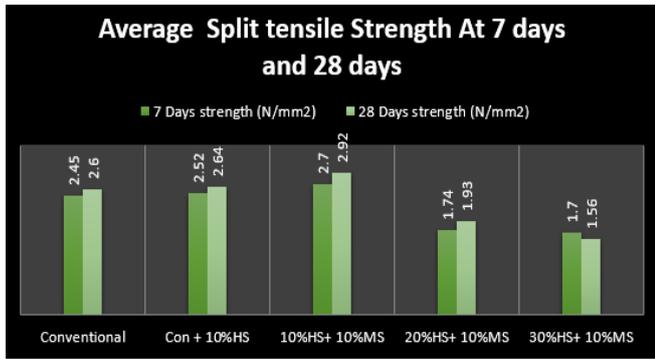


Figure 2 Split Tensile Strength results

From fig 2 as like as compressive strength, at the combination of 10% of replacement of hypo sludge and micro silica will give the maximum average split tensile strength of 2.70 N/mm² and 2.86 N/mm² at the age of 7 and 28 days respectively.

V. CONCLUSION

Based on scanty work relating to the compressive & split tensile strengths of concrete, the following conclusions are drawn using the proposed mixture:

A. Compressive Strength

Cement replacement with Micro Silica and Hypo sludge of 10% each the compressive strength of concrete increases because of its fineness and greater surface area. There is a steady drop off in the compressive strength due to silica content in the hypo sludge as the content is increased beyond 10%.

B. Split Tensile Strength:

Cement replacement with Micro Silica and Hypo sludge of 10% each the split tensile strength of concrete increases, but with further raise in the content of Hypo sludge results in the decrease of the same.

The proposed experiment concludes that Hypo sludge and Micro Silica can be used as the viable replacement for the cement up to the minimum level (10% each) thus reducing the residual amount of cement production. The use of hypo sludge in concrete is not only for decreasing the environmental pollution but also decreases the cost of construction economically. Paper waste sludge could be a valuable resource and will be advantageous from the standpoint of cost economy, durability, energy efficiently and overall ecological profile of concrete.

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AUTHORS PROFILE



Riyaz Khan N.H. acquired his under graduate degree in Civil Engineering from the University Department of Anna University Trichirapalli, BIT Campus in 2012. In 2014 he received his Master's Degree in Geomatics from College of Engineering Guindy Campus, Anna University, Chennai. He joined Sethu Institute of Technology as Assistant Professor in 2014. Now he renders his service as a Lecturer in the Department of Cadastral Surveying and Geomatics, Ambo University, Ambo, Ethiopia. He has published a number of journals in International Conference and Journals.



Venkatesh S got his Bachelor degree in Civil Engineering from Tamilnadu College of Engineering in 2011. In 2014 he acquired his Master's Degree in Geomatics from College of Engineering Guindy Campus, Anna University, Chennai. He had one year of industrial experience and having five years of teaching experience. He has published four international journals.



Padmavathi.S. Student, Department of Civil Engineering, St.Joseph's Institute of Technology, Chennai, Tamil Nadu.



Sony George , Student, Department of Civil Engineering, St.Joseph's Institute of Technology, Chennai , Tamil Nadu.

