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Study on Strength Property of Concrete using Hypo Sludge and Waste Foundry Sand

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Abstract : The industrial by-products and waste materials need to be re-used in some way to avoid land contamination. One of the way to reuse such materials is to include in concrete materials. This will reduce pollution and encourage sustainable development in environment conservation. This paper deals with inclusion of hypo sludge (HS) and waste foundry sand (WFS) in concrete. M_{20} grade of concrete with 0.4 w/c ratio was used. About 6 mixes with 5% HS was kept constant and WFS varied with 0%, 5%, 10%, 15% and 20% were prepared. Strength properties were determined by compressive strength at 7 days and 28 days. The optimum strength was attained as 28.2 N/mm^2 in H5/F15 mix at 28 days.
Key Words: land contamination, sustainable development, hypo sludge, waste foundry sand, compressive strength.

1.0 Introduction

Infrastructure development is the main criteria for any developing country[2]. The key factor for infrastructure development is waste management in an efficient way. Environment conservation is also taken into consideration for this development. Control in CO_2 emission and recycling waste materials need to be carried out to achieve a healthy environment. Concrete plays a vital role in infrastructure development[1]. Cement and fine aggregate are some of the main ingredients for concrete. Production of cement emits large amount of CO_2 into the atmosphere. Natural river sand which is used as fine aggregate gets depleted due to its immense usage. Hence alternative materials for cement and fine aggregate are to researched and applied in concrete production to protect our environment. Such alternative materials are hypo sludge (HS) and waste foundry sand (WFS)[4]. HS or paper waste is a by-product of paper and pulp industries[5,6]. They are basically secondary wastes obtained from de-inking and re-pulping processes. These are dumped in landfills which leads to land occupation as well as land pollution. Recycling of this by-product is to be analyzed. WFS is a by-product of ferrous and non-ferrous industries. It is unused product obtained during metal casting process. These are dumped on empty land which pollutes the ground water on wet conditions due to its high chemical content. Reuse of this by-product need to be encouraged for better usage.

The main aim of this research was to use HS and WFS in concrete replacing cement and natural sand respectively and study its concrete properties in macro level. It is indeed a rare combination of materials and hence this research work is unique. In this research different proportions of WFS (5, 10, 15 and 20%) with constant proportion of HS (5%) were used as it was concluded from literature that usage of these by-products improves performance of concrete. The fresh concrete properties were determined by slump cone test, hardened concrete properties were determined by compressive strength.

2.0 Experimental Investigation

2.1 Materials

2.1.1 Cement

Ordinary Portland Cement (OPC) of 53-grade of priya cements confining to IS:12269-1987was used for all mixes. Table 1 shows the chemical property of cement. Specific gravity was found to be 3.16, Fineness of cement was observed as 6%, Initial setting time was 32 minutes and consistency of cement 34%.

2.1.2 Hypo Sludge (HS)

HS from TNPL mill was collected. It was initially sun dried for 48 hours and then grinded. It was then sieved in 90micron sieve and then used in concrete. From the SEM analysis in Fig 1, it was found that HS is a fibrous compound which was mentioned earlier by Anil Kumar and Devika Rani [1].The specific gravity was found to be 1.7. Table 1 shows the chemical composition of HS.

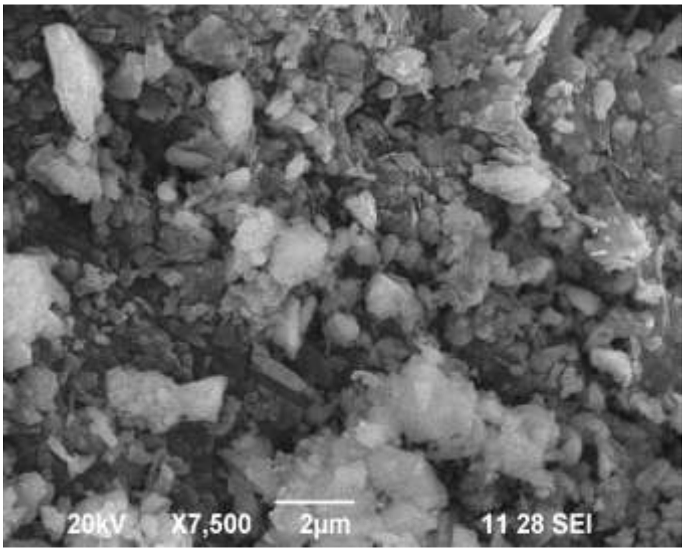

Fig 1 SEM image of Hypo Sludge

Table 1 Physical and chemical composition of OPC and HS

Chemical constituent %	OPC	HS
SiO_2	21.04	23.56
Al_2O_3	5.02	1.87
Fe_2O_3	3.12	0.59
CaO	62.11	16.06
MgO	2.44	2.94
K_2O	0.56	0.56
Na_2O	0.28	0.89
LOI	2.5	47.52

2.1.3 Fine Aggregate

Naturally available river sand was used as fine aggregate (FA). Table 2 represents physical and chemical composition of FA. The specific gravity was found to be 2.59 and fineness modulus to be 3.91 where it lies under Zone II as per IS: 383-1970 [14].

2.1.4 Waste Foundry Sand (WFS)

WFS was collected from Kovai Engineering Corporation and used for this project. Fig 2 represents SEM images of WFS where it was observed that WFS has sub-angular to round in shape as mentioned by RafatSiddhique [7]. The specific gravity was found to be 2.54 and fineness modulus to be 3.8 where it lies under Zone II. Table 2 represents physical and chemical composition of WFS.

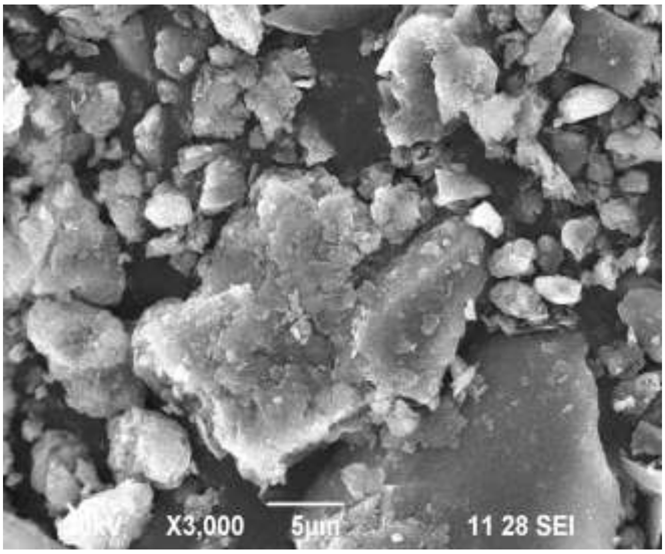

Fig 2 SEM image of Waste Foundry Sand

Table 2 Physical and chemical composition of FA and WFS

Chemical constituent %	FA	WFS
SiO_2	73.6	80.63
Al_2O_3	9.1	7.07
Fe_2O_3	1.35	3.63
CaO	0.25	0.59
MgO	0.05	1.18
K_2O	0.002	0.81
Na_2O	0.004	1.08
LOI	3.7	4.89

2.1.5 Coarse Aggregate

Locally available crushed aggregates of 20mm size were used as coarse aggregate (CA). The specific gravity of CA was found to be 2.85 and impact factor was 38%.

2.1.6 Super Plasticizer

Polycarboxylate ether based super plasticizer of SIKA-Viscocrete 10R brand with a relative density of 1.08kg/l at $30^{o}C$ to obtain desired fresh concrete properties was used. Portable water was used during mixing and curing of concrete.

2.2 Mix Proportion

The mix proportions used in this research are summarized in Table 3. Totally six concrete mixtures of M_{20} grade of concrete, with partial replacement of OPC by HS (5%) and FA by WFS (5%, 10%, 15%, 20%) with W/C ratio of 0.4 constant for all mixesnamelyH0/F0 to H5/F20presented in Table 3

Table 3 Mix proportions

S.No	Mix	OPC kg/m^3	HS %	HS kg/m^3	FA kg/m^3	WFS %	WFS kg/m^3	CA kg/m^3	W/C	water kg/m^3	SP
1	H0/F0	370	0	0	704	0	0	1318	0.4	148	2.96
2	H5/F0	353.5	5	16.5	704	0	0	1318	0.4	148	2.96
3	H5/F5	353.5	5	16.5	668.8	5	35.2	1318	0.4	148	2.96
4	H5/F10	353.5	5	16.5	633.6	10	70.4	1318	0.4	148	2.96
5	H5/F15	353.5	5	16.5	598.4	15	105.6	1318	0.4	148	2.96
6	H5/F20	353.5	5	16.5	563.2	20	140.8	1318	0.4	148	2.96

2.3 Tests on Fresh Concrete

Fresh concrete properties namely workability was defined by slump cone test which was conducted according to IS:1199-1959 [15]

2.4 Tests on Hardened Concrete

Hardened concrete properties such as compressive strength was performed according to IS:516-1959 [16]. Three cubes of sizes 150x150x150mm were casted, cured and tested in 7th day and 28th day. The rate of loading was kept as 140 kg/cm^2/min.

3.0 Results and Discussions

3.1 Fresh Concrete Properties

The slump value of all mixes is shown in Table 4. Due to fibrous component of HS, the water gets absorbed quickly in concrete. Addition of SP improves the workability of concrete. The control mix H0/F0has better slump value of 40mm. On addition of HS and WFS, the slump value decreases gradually which was similar to that of the results observed by Salokhe and Desai [10]

Table 4 Fresh concrete properties

S.No	Mix	Slump value (mm)
1	H0/F0	40
2	H5/F0	30
3	H5/F5	25
4	H5/F10	25
5	H5/F15	20
6	H5/F20	20

3.2 Compressive Strength

Compressive strength of all mixes increased with all ages. At 28 days, the compressive strength was 18.7, 20.5, 22.5, 25.4, 28.2 and 22.6N/mm^{2}for H0/F0 to H5/F20 mixes respectively. There was increase in strength up to H5/F15 mix (5% HS and 15%WFS) which is considered as optimum mix. At 56 days, all mixes showed higher strength compared to 28 days. The percentage increase in strength varied from 9.6% to 50.8% which was at optimum compared to conventional concrete (H0/F0 mix) at 28 days and further showed reduced strength but was higher than conventional concrete. The initial strength of all mixes showed better results except for optimum mix. Similar strength results was observed by Salokhe and Desai [10] where optimum mix was obtained up to 20% replacement of WFS. The strength results at all ages is shown in Table 5 and Fig 3

Table 5 Compressive strength

S.No	Mix	7th day N/mm^2	28th day N/mm^2
1	H0/F0	15.7	18.7
2	H5/F0	18.8	20.5
3	H5/F5	20.5	22.5
4	H5/F10	23.1	25.4
5	H5/F15	17.8	28.2
6	H5/F20	19.2	22.6

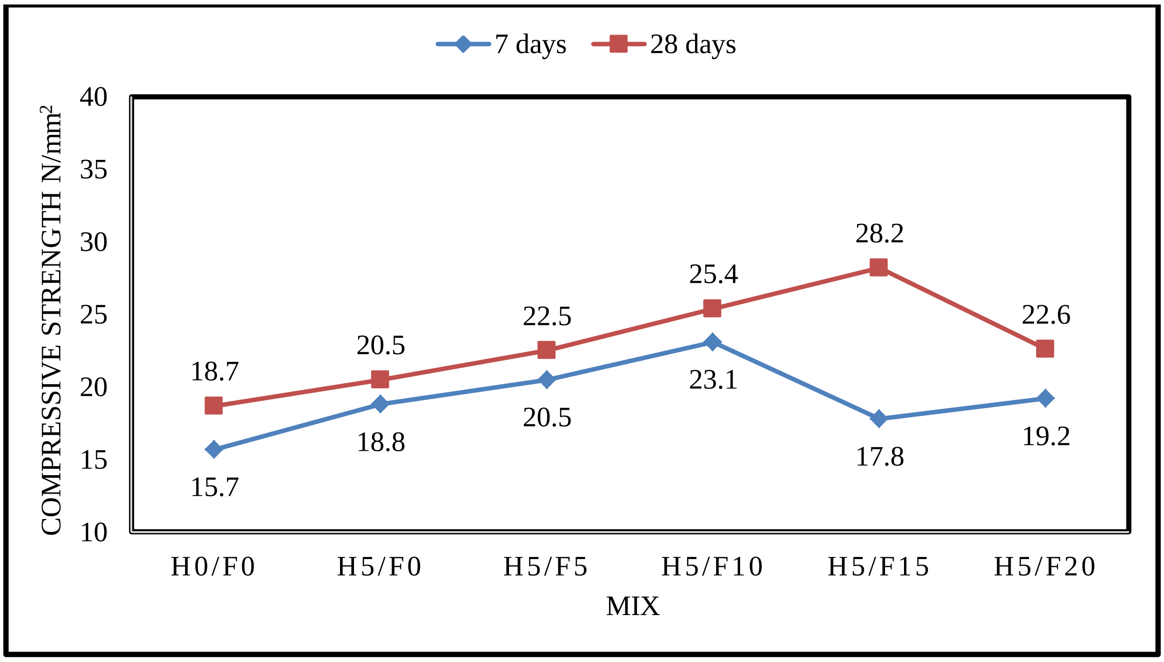

Fig 3 Comparison of compressive strength

4.0 Conclusions

From the above results the following conclusions are obtained,

- HS is a highly fibrous compound and has high water absorption capacity.
- WFShas high silica content which is similar to regular river sand and hence both materials can be replaced in concrete.
- Workability decreased due to the addition of hypo sludge with high water absorption capacity.
- The compressive strength was observed to be increasing till H5/F15 mix (5% HS and 15% WFS) which is considered as the optimum mix.
- The compressive strength was increased up to 50.8% in the optimum mix and decreased further.
- Compressive strength increased with age. The strength obtained in 28 days was higher compared to 7 days strength.

5.0 References

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