Advancement in Physical Properties of Hypo Sludge Concrete

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Abstract-

Hypo Sludge is an alternate binder which has been used in concrete by partially replacing cement. Hypo sludge utilization minimizes the production of cement which directly reduces emission of carbon dioxideand other toxic gases. The properties of Hypo sludge concrete (HSC) has investigated in detail to check its suitability as a replacement to cement. In this study, mechanical & durability properties of hypo sludge concrete is investigated and compared. The research was mainly focused on compressive strength, split tensile strength, flexural strength, sorptivity and acid effect tests of concrete. The test results total of 12 prisms, 72 cubes, 12 cylinders for M20 grade hypo sludge concrete as well as for conventional concrete (Ordinary Portland Cement) are presented in this paper. The test results indicate that the compressive strength & flexural strength of HSC is about 33.69 & 13.09% are more than conventional concrete and Percentage mass loss is less when immersed in H_2SO_4 & HCL when compared to conventional concrete

KEY WORDS: Acid tests, Compressive strength, Flexural strength, Hypo sludge concrete, Split tensile strength, Sorptivity.

1.1 Introduction–Energy plays a crucial role in the growth of developing countries. In the context of low availability of non-renewable energy resources coupled with the requirements of large quantities of energy for building materials like cement, the importance of using industrial waste is very important. Ordinary Portland cement (OPC) plays a major rolein constructions. To manufacture one ton of Ordinary Portland cement, the same amount of carbon dioxide is released to the atmosphere which leads to greenhouse effect. .Therefore, to save environment from global warming there should be replacement in cement with different binders having cementious properties like hypo sludge, fly ash, silica fume GGBS, Metakoline etc. To reduce disposal and pollution problems emanating from these industrial wastes, it is most essential to develop profitable building materials from them.In this respect Hypo sludge is one of the sustainable technique. The hypo sludge contains, low calcium, maximum calcium chloride and minimum amount of silica which behaves like cement because of calcium and magnesium properties. The raw hypo sludge shown in figure 1.1. In general, the common causes of failures are strength and durability etc. Due to presence of toxic gasses present in atmosphere it reduces the life of concrete. This paper concisely explains the technical and environmental benefits of supplementary cementitious materials use as well as the limitations, applications and specifications.

Jayeshkumar et. al. [2013]developedM-25 and M-40 grade of concrete and found out compressive strength and split strength of concrete increases by optimally by 10 % by replacing hypo sludge in cement. **R. Siddique[2002]**replaced fine aggregate (sand) with Class F fly ash (10%, 20%, 30%, 40%, and 50%) by weight and found out mechanical properties of concrete such as compressive strength, splitting tensile strength, flexural strength, and modulus of elasticityat 7, 14, 28, 56, 91, and 365 days which indicates significant improvement in the strength properties of plain concrete and can be effectively used in structural concrete. A.Oner**et. al. [2007]** investigated tests on concrete by replacing cement with GroundGranulated Blast Furnace Slag (GGBS) at around 55% of the total binder content and found out compressive strength of concrete mixture. Which does not show any significant improvement in the compressive strength of concrete. This can be explained by the presence of unreacted GGBS, acting as a filler material in the paste.**Kamran at. al. [2004]** in his research used GGBS (Ground Granulated Blast furnace Slag) in concrete for different mix and investigated that effect of replacement was reflected on workability, compressive strength, tensile strength, modulus of rupture and concluded that cost of concretewas reduced by 25 to 50 percent and therefore proved to be economical.

From the literature it was noticed that the work on utilization of hypo sludge in concrete is scarce.

2.0 MATERIALS

2.1 Cement

Cementused in this researchwas 53 Grade Ordinary Portland cement confirming to IS: 12269. The specific gravity of cement was 3.14 and specific surface area of 225 m^2/kg having initial setting time of 40 min and final setting is 600 min respectively.

2.2Fine Aggregate

The fine aggregate used in this investigation is conforming to Zone-2 as per BIS: 383-1970. The fine aggregate specific gravity is found to be 2.65, while the bulk density of sand is 1.45 gram/c.c.

2.3 Coarse Aggregate

Crushed granite is used as coarse aggregate. The coarse aggregate is obtained from a local crushing passing from 20mm sieve and retaining on 12.5mm sieve well graded aggregate according to BIS: 383-1970. The specific gravity of coarse aggregate is found to be 2.80, while the bulk density is found to be 1.5 gram/c.c.

2.3 Super plasticizer

To improve the workability of concrete, 0.5% of cement weight of CONPLAST SP430 is used as chemical admixture.

2.4 Hypo sludge

In this research an attempt is made to produce sludge based concrete specimens constituting hypo sludge as alternative material for cement. The Hypo sludge used in the experiment is obtained from paper industry at International tobacco center, Bhadrachalam (ITC),Telangana state, India. The specific gravity of hypo sludge is found to be 2.17. The chemical composition of cement and Hypo sludge is presented in Table.1.

3.0 EXPERIMENTAL PROGRAM

In this research work an attempt is made to produce sludge concrete specimens constituting hypo sludge. The proportion of binder components (i.e.) the percentage of hypo sludge is taken as 10%, 20% &30% replaced with cement and found out strength and durability properties. Water cement ratio is taken as 0.45.In order to reduce the low workability problem of hypo sludge concrete, chemical admixture (CONPLAST SP430) is added to improve the workability of concrete.

EXPERIMENTAL ANALYSIS ON CONSTITUENTS OF CONCRETE

It includes the various tests on constituents of concrete i.e., on

(1)Aggregate
- (i)Sieve analysis
- (ii)Specific gravity of aggregate
- (iii)Mechanical properties of aggregate

(2)Cement
- (i)Specific gravity of cement
- (ii)Fineness of cement
- (iii)Normal consistency of cement
- (iv) Initial final setting time of cement
- (v)Compressive strength of cement

(vi) Slump test

3.2 Mix design

The mix design is prepared for M 20 grade of concrete according to recommendation of IS 456-2000 code book. As in case of ordinary Portland cement concrete, the cement content is taken as 250kg/m3 because to find the properties of sludge, the coarse aggregates and fine aggregates occupy about 75%-80% mass of concrete. The mix proportion for M20 grade of concrete is presented in Table.2

3.3 Mixing and casting of sludge based Concrete-

In the laboratory, Hypo sludge and the aggregates are mixed for3-5minutes in a rotary mixing machine withaddition ofWater and admixture to the dry mix. Total of72 cubes, 12 cylinders and 12 prisms were casted. The concrete is poured into the moulds and compacted with the help of vibrating table machine. The top surface is well finished. The sizes of the cube moulds used are (150mm x 150mm x 150mm), cylindrical moulds(150mm dia and 300 mm height) and prism moulds(500 mm x 100 mm x 100 mm).The cast specimens are demoulded after 24 hours of casting and are kept in different curing regimes. The specimens cured in water for 28 days.

4 TEST RESULTS AND DISCUSSION

4.1Compressive Strength

Concrete specimens with and without sludge are prepared and cured for 28 days in water then tested for compressive strength. The sludge based concrete specimens are prepared for five replacements and tested at the age of 7 and 28 days. The results are shown in graph 4.1.

4.2Split Tensile Strength

The cylindrical Specimens of size 150x300mm are prepared and tested for splitting tensile strength on conventional and sludge based concrete. The sludge based concrete specimens are prepared for three replacements and they also tested for the split tensile strength at an age of 28 days after casting are shown in graph 4.2.

4. 3 Flexural Strength of concrete. The flexural strength of sludge concrete of various replacements are shown in fig 4.3. Flexural strength tests were conducted on 100*100*500 specimens with and without sludge replacements and compared The 28 days flexural strength results are plotted in graph.4.3.

The experimental results obtained are closely observed and studied well, so as to compare the strength parameters of sludge based concrete and conventional concrete. On comparing the strength aspects, the sludge based concrete specimens are better than the ordinary Portland cement concrete.

4.4 Acid attack

To study the resistance of normal and hypo sludge concrete,12 cube specimens of size 150*150*150mm were immersed in a tub and cured for 28 days in water and then again immersed in 5% of H_2SO_4 and HCL respectively. These tubs were kept covered throughout the tests to minimize the loss of evaporation. The various observations made are explained below.

4.4.1 Loss of Weight

The change in the mass of the specimens were observed and plotted against the number of immersion days in 5%H_2SO_4 & 5% Hclacids as shown in the following graph 4.4 and 4.5

4.5 Acid Durability Factor-

The percentage loss of Compressive Strength and Acid Durability Factor (ADF) of the specimens were observed and plotted against the number of immersion days in acids as shown in the following graphs 4.5.1, 4.5.2, 4.5.3& 4.5.

From the figures4.5.1, 4.5.2, 4.5.3 & 4.5.4, the following observations are made:

1. After 28 days curing, Percentage mass lossin 20% cement replacement and percentage loss of compressive strength in 10% cement replacementwith sludge are shown better properties compared to conventional concrete

2. In5% sulphuric acid and hydrochloric acid, the properties of sludge based concrete is good when compare to normal concrete.

4.6 Sorptivity

In the present investigation Sorptivity tests were conducted on cube specimens 150*150*150mm with w/c 0.5. The weight recorded at the end of different intervals is noted down and Sorptivity is calculated. The results are showed in fig 4.6.

4.8 COST ANALYSIS

Cost analysis is carried out for the optimum proportion of percentage of hypo sludge in concrete. The cost of conventional concrete is compared with hypo sludge concrete.

Cost of materials

Cost of cement per ton = Rs.4000.00
Cost of sand per ton = Rs.650.00
Cost of hypo sludge per ton = Rs.500.00
Cost of coarse aggregate per ton = Rs.370.00
Cost of admixture per liter = Rs.100.00
Cost analysis of conventional concrete materials are shown in table 4.8.1

The cost of conventional concrete is Rs**. 2199.500**
The cost of hypo sludge concrete /m^3 @ 10 % replacement of hypo sludge is Rs.**2112.400**
The cost of hypo sludge concrete /m^3 @ 20 % replacement of hypo sludge is Rs.**2024.550**
The cost of hypo sludge concrete /m^3 @ 30 % replacement of hypo sludge is Rs.**1937.050**

The compared values of cost show gradual decrement in total cost of per ***cubic meter*** concrete.

The above table shows cost values up to 30% replacement and the **difference in cost** from conventional concrete to partially replaced concrete was **Rs. 262/-**

5.0 Conclusions

Based on the experimental work the following conclusions are drawn:

1. Sludge based concrete shows better performance in strength properties compared to conventional concrete
2. To determine compressive strength and flexural strength, various replacements of sludge in cement has done. After 28 days curing, the maximum compressive strength and flexural strength with 30% replacement are 33.69% and 13.09% more than conventional concrete
3. It was found that sludge based concrete when immersed in Acid solutions(H_2SO_4& HCL) has better properties with 10% replacement in cement compared to normal concrete
4. The properties for coefficient of sorptivity like water absorption found less in sludge based concrete.
5. It was noticed that sludge based concrete is economical and eco friendly

(Figures. Tables and graphs)

Figure 1.1 Raw hypo sludge

Chemical composition	Hypo Sludge	Cement (in %)
Lime(Ca O)	46.2	62
Silica(SiO_2)	09	22
Alumina	3.6	05
Magnesium	3.33	01
Calcium sulphate	4.05	04

Table: 1 Chemical Composition of hypo sludge and cement

Particulars	Normal concrete	Sludge based concrete (10%)	Sludge based concrete (20%)	Sludge based concrete (30%)
Cement (kg/m^3)	250	225	200	175
Hypo sludge (kg/m^3)	-	25	50	75
Coarse Aggregate (Kg/m^3)	1420	1420	1420	1420
Fine Aggregate (kg/m^3)	711	711	711	711
Water (kg/m^3)	125	125	125	125
SP (kg/m^3)	1.25	1.25	1.25	1.25

Table2: Mix Proportions of Different Mixes

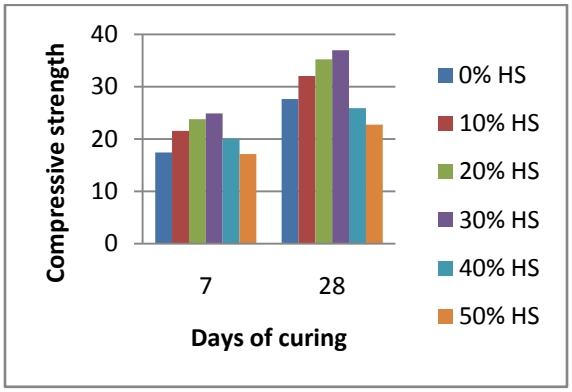
Cost of material of conventional concrete/ m^3			
Description	**Quantity kg/m^3**	**Cost(Rs)**	**Cost of material (Rs.)**
Cement	250	4000/t	1000

Hypo sludge	-	500/t	-
Fine aggregate	711	650/t	462.15
Coarse aggregate	1420	370/t	525.4
Admixture	2.12	100/liter	212
Cost		**Total**	2199.5

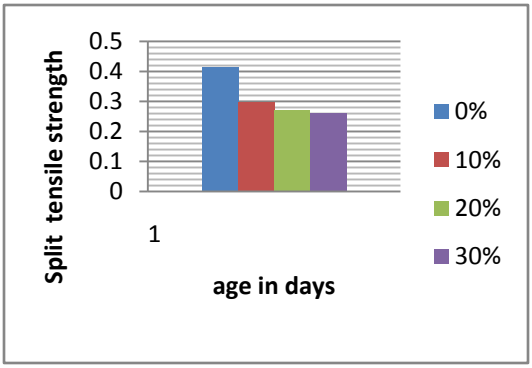
Table – 4.8.1 Cost analyses of conventional concrete materials

Cost of hypo sludge concrete/ m^3 @30% replacement of hypo sludge			
Description	**Quantity kg/m^3**	**Cost (Rs.)**	**Costof material (Rs.)**
Cement	175	4000/t	700
Hypo sludge	75	500/t	37.5
Fine aggregate	636	650/t	462.15
Coarse aggregate	1272	370/t	525.4
Admixture	2.12	100/liter	212
Cost		**Total**	1937.050

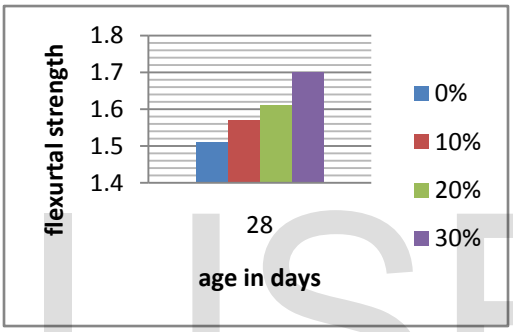
Table – 4.8.2 Cost analysis of partially replaced concrete materials



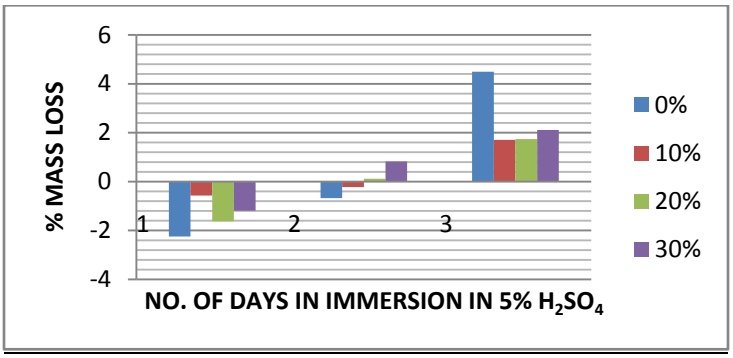
Graph 4.1 Compressive strength Conventional concrete and sludge based concrete.



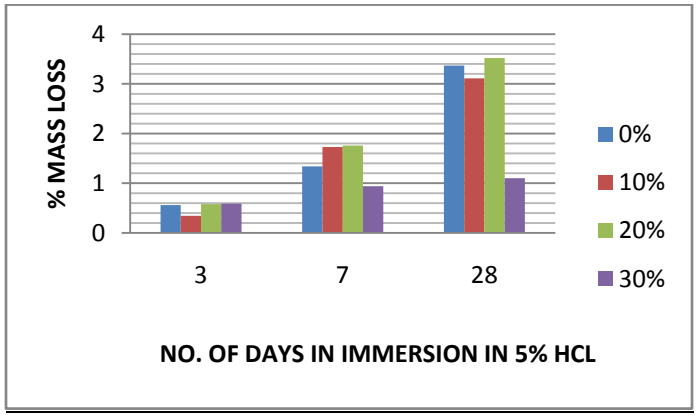
Graph 4.2 Split Tensile strength of conventional and sludge based Concrete.



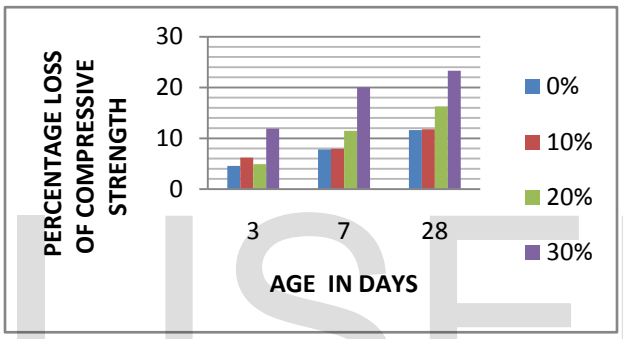
Graph 4.3 comparison of specimens for flexural strength



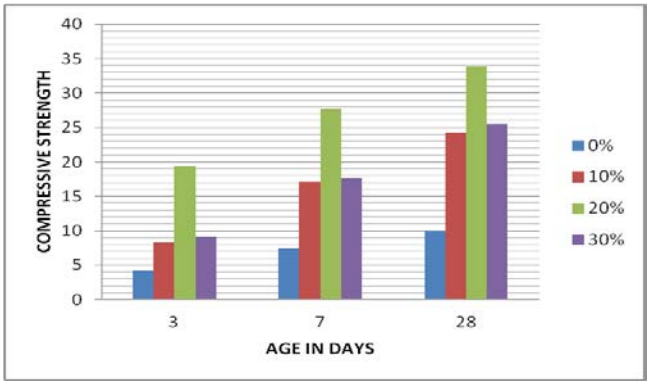
Graph 4.4 Percentage mass loss when immersed in 5%H_2SO_4



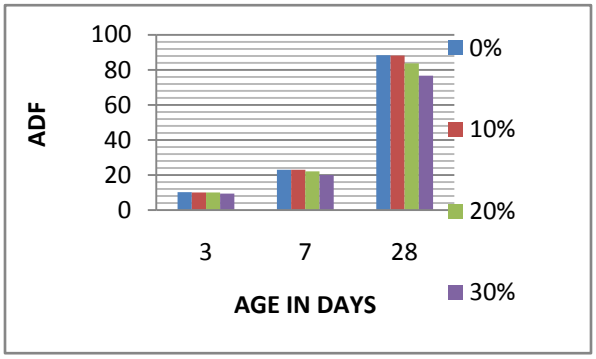
Graph 4.5 Percentage mass loss when immersed in 5% Hcl



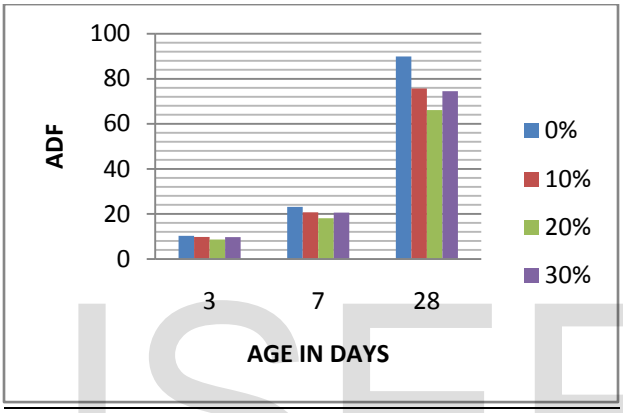
Graph 4.5.1 Percentage loss of Compressive Strength for cubes immersed in 5% H_2SO_4



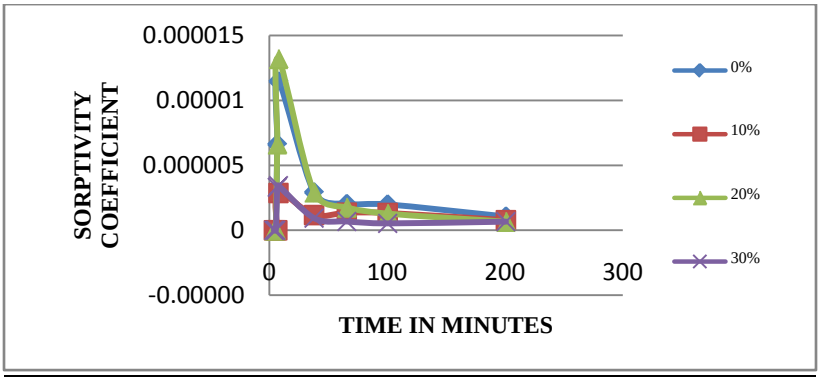
Graph 4.5.2Percentage loss of Compressive Strength for cubes immersed in 5% Hcl



Graph 4.5.3 Acid Durability Factor and No. of days in immersion in 5% H_2SO_4



Graph4.5.4 Acid Durability Factor and No. of days in immersion in 5% Hcl



Graph 4.6 Sorptivity of the cubes immersed up to 10mm in water

REFERENCES

1. Cement and Concrete: Environmental Considerations from *EBN (Environmental Building News)* Volume 2, No. 2 - March/April 1993.

2. Eco Smart concrete Seminar held in two cities in the United Arab Emirates – October 22, 2007 in Abu Dhabi and October 24, 2007 in Dubai.

3. Gambhir.M.L.,"*concrete technology*", 3rd edition ,the Tata McGraw Hill Publishers, 2007.

4. Hemant.S, Mittal L.N, Kulkarni.P.D, "*Laboratory manual on concrete technology*", CBS Publications, 2005.

5. Krishna Raju.N, "Design of concrete mixes" 4th edition, CBS Publishers, 2002.

6. Malhotra, V.M., "Role of Supplementary Cementing Materials in Reducing Greenhouse Gas Emissions", *Concrete Technology for a Sustainable Development in the 21st Century*, London, 2000.

7. Mehta,P.K., "*Greening of the Concrete Industry for Sustainable Development*", Concrete International, July 2002.

8. Mehta,P.K.,"*Reducing the Environmental Impact of Concrete*"Concrete International, October 2001, Vol. 19, No. 7, pp. 61-66.

9. Santhakumar,A.R.,"*Concrete technology*" 3rd edition, oxford university publishers, 2009.

10. Shetty, M.S., "concrete technology", first multi color edition, Schand publications, 2005.

11.Venta, G.J., Bouzoubaa, N. and Fournier, B. "Production and Use of Supplementary Cementing Materials in Canada and the Resulting Impact on Greenhouse Gas Emissions Reductions", *Eighth CANMET/ACI International Conference on Fly Ash, Silica Fume, Slag and Natural Pozzolans in Concrete, Supplementary Papers*, Las Vegas, U.S.A., pp. 73-87, May 23-29, 2004.

CODE BOOKS

1) IS: 456:2000, *Indian Standard Plain and Reinforced Concrete Code of practice*, 4th revision, Bureau of Indian Standards, New Delhi.

2) IS: 10262-1982, *Recommended Guidelines for Concrete Mix Design*, Bureau of Indian Standards, New Delhi.

3) IS: 383-1970, *Specification for Coarse and Fine Aggregate from Natural Source of Concrete*, Bureau of Indian Standards, New Delhi.