Performance of Microsilica in Hyposludge Concrete

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***Abstract* – This project present the results of experimental investigations carried out to evaluate "is replaced with that of hyposludge on various THE PERFORMANCE OF MICROSILICA IN HYPOSLUDGE CONCRETE" where cement proportions in Concrete (0%,5%,10%,15%,20%,25%,30%,35%,40%).The basic objective of this study was to identify alternative source of cement and to produce new type of concrete made of hyposludge as a green concrete and to control pollution to the environment. The pollution occurs due the disposal of hyposludge by burning as well as dumping process. By using these waste materials in concrete we can control cost of materials used in construction. Hyposludge is the waste of industrial product from paper production. It provides great opportunity to utilize it as an alternative to cement due to the silica and magnesium properties. In this study, concrete of M25(1:1:2) grade were considered for a W/C ratio of 0.5 for the replacements of various percentage of cement by hyposludge. Micro silica is added as a mineral admixture in hypo sludge concrete in order to increase its strength (15% of hypo sludge). The investigation revealed improvement in compressive strength, split tensile strength based on the overall observations. This study investigates the performance of concrete mixtures containing hyposluge in terms of Compressive strength at 7, 14 and 28 days. Results show that concrete incorporating hyposludge had higher compressive strength of concretes.**

Keyword: High compressive strength, workability increases, durability.

I. INTRODUCTION

GENERAL

Energy plays a crucial role in growth of developing countries like India. 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 cannot be underestimated. During manufacturing of 1 tones of Ordinary Portland Cement (OPC) we need about 1…1⅓ t of earth resources like limestone, etc. Further during manufacturing of 1 t of Ordinary Portland Cement an equal amount of carbon dioxide are released into the atmosphere. The carbon-di-oxide emissions act as a silent Killer in the environment under various forms. In this Backdrop, the search for cheaper substitute to OPC is a needful one.

SOLID WASTE FROM PAPER INDUSTRY

HYPO SLUDGE PROPERTIES

Where, this hypo sludge contains, low calcium and maximum calcium chloride and minimum amount of silica. Hypo sludge behaves like cement because of silica and magnesium properties. This silica and magnesium improve the setting of the concrete.

SOURCE OF HYPOSLUDGE

The process of formation of paper from pulp includes the following processes during which the Hypo sludge is formed as waste by-product is purely a chemical wastes and do not contain any bio-degradable element**.** Most of the mills are using only woody raw material (bamboo, eucalyptus, casuarinas, poplar and other species), but some other mills are using biogases in substantial quantity as raw material.

NEED FO R HYPO SLUDGE UTILIZATION

While producing paper the various wastes are comes out from the various processes in paper industries. From the preliminary waste named as hypo sludge, due to its low calcium is taken out for our project to replace the cement utilization in concrete. Due to the cement production green house gases are emitted in the atmosphere. For producing 4 million ton of cement, 1 million ton green house gases are emitted. Also, to reduce the environmental degradation, this sludge has been avoided in mass level disposal in land. To eliminate the ozone layer depletion, production of cement becomes reduced. For this, the hypo sludge is used as partial replacement in the concrete as high performance concrete. By utilizing this waste the strength will be increased and also cost reduction in the concrete is achieved.

PAPER WASTE

Over 300 million tonnes of industrial wastes are being produced per annum in India. These materials pose problems of disposal and health hazards. This paper mill sludge consumes a large percentage of local landfill space for each and every year. Worse yet, some of the wastes are land spread on cropland as a disposal technique, raising concerns about trace contaminants building up in soil or running off into area lakes and streams. Some companies burn their

sludge in incinerators, contributing to our serious air pollution problems. To reduce disposal and pollution problems from these industrial wastes, it is most essential to develop profitable building materials from them. For each tone of recycled paper about 300 kg of paper waste sludge is produced which is comparatively a large volume of sludge produced each day. Keeping this in view, investigations were undertaken to produce low cost concrete by blending various ratios of cement with hypo sludge. Hypo sludge behaves like cement because of silica and magnesium properties. This hypo sludge contains, low calcium and maximum calcium chloride and minimum amount of silica. Concrete, is most widely used man made construction material and is the largest production of all the materials used in construction industry. Concrete is basically made of cementations materials which have to properly bind themselves together, as well as with other materials to form a solid mass. Concrete or mortar is made up of cement, water and aggregates (Coarse and Fine Aggregate) and sometimes with necessary admixtures. Concrete has attained the status of a major building material in all the branches of modern construction. It is difficult to point out another material of construction which is as variable as concrete. Concrete is the best material of choice where strength, durability, impermeability, fire resistance and absorption resistance are required. Compressive strength is considered as an index to assess the overall quality of concrete and it is generally assumed that an improvement in the compressive strength results in improvement of all other properties. Hence strength investigations are generally centred on compressive strength. Even though concrete mixes are proportioned on the basis of achieving the desired compressive strength at the specified age, flexural strength often play a vital role in concrete making .Energy plays a crucial role in growth of developing countries like India. 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 cannot be under estimated. During manufacturing of 1 tonnes of Ordinary Portland Cement an equal amount of carbon-di-oxide are released into the atmosphere. The carbon-di-oxide emissions act as a silent Killer in the environment as various forms. In this Backdrop, the search for cheaper substitute to OPC is a needful
one. Paper fibres can be recycled only a limited number of times before they become too short or weak to make high quality paper. It means that the broken, low- quality paper fibres are separated out to become waste sludge. In order to increase the strength of hypo sludge concrete micro silica is added (mineral admixture). Hypo sludge contain low silica content that results to decrease in strength of hypo sludge, Micro silica is preferred as compared to nano silica in order to produce economic cost of construction. 15% of hypo sludge is taken as the composition of mineral admixture in each ratio of hypo sludge. Silica comes from the family of quartz and due to the lack of silica in hypo sludge it is added in order to analyse the performance of micro silica in hypo sludge concrete.

CHAPTER 2 LITERATURE REVIEW

GENERAL

The study about the "PERFORMANCE OF MICROSILICA IN HYPOSLUDGE CONCRETE", behaviour and the characteristics of hyposludge. Some of the literatures related to the research works about hyposludge and microsilica are discussed below.

LITERATURE REVIEW

DURABILITY STUDIES ON CONCRETE WITH HYPO SLUDGE AS PARTIAL REPLACEMENT OF CEMENT

VVS.Sarma et al (2016) Researched on Durability Studies on Concrete with Hypo Sludge as Partial Replacement of Cement. This paper summarizes the research work on the properties of hypo sludge when used as partial replacement for Ordinary Portland Cement (OPC) in concrete as the control. Compacting factor test was carried . OPC was replaced with hypo sludge by weight at 0%, 5%, 10%, 15%, 20% and 25%. 0% replacement served out on fresh concrete while Compressive Strength test was carried out on hardened 150mm concrete cubes after 7, 14 and 28 days curing in water. The results revealed that the Compacting factor decreased as the percentage replacement of OPC with hypo sludge increased.

OBJECTIVES OF THE PROJECT

To investigate the utilization of Hypo Sludge as Supplementary Cementitious Materials (SCM) and influence of these hypo sludge on the Strength on concretes made with different Cement replacement levels.

- To replace the maximum amount of cement in concrete.
- To increase the compressive strength of concrete.
- To study the behavior of hyposludge concrete with microsilica.
- To know the performance of microsilica.
- To study the strength behavior of concrete when it is partially replaced with Hypo Sludge.
- To know at what percentage of Hypo Sludge we will attain maximum strength with microsilica.
- To provide a most economical concrete.

SCOPE OF THE PROJECT

- To provide a most economical concrete.
- Using the wastes in useful manner.
- To reduce the cost of the construction.
- To promote the low cost housing.
- Minimize the maximum demand for cement.
- Minimize the maximum degradation in environment due to cement and safeguard the ozone layer from green house gases.

NEED FOR RESEARCH

- Use of hypo sludge in concrete can save the paper industry disposal costs and produces a 'greener' concrete for construction.
- The cost analysis indicates that it is economic as compared to normal work and it is used for disaster area for low cost construction.
- An innovative supplementary cementitious construction material is found through this research.

METHODOLOGY

FLOW CHART

SEARCHING ALTERNATE RESOURCE OF CEMENT

↓

COLLECTOROF MATERIAL

↓

PRELIMINARY TEST OF MATERIAL

↓

MIX DESIGN

↓

PREPARATION OF CONCRETE MIXES FOR VARIOUS RATIONS

↓

CASTING OF CUBES AND CYLINDERS

↓

CURING OF CASTING SPECIMENS

↓

TESTING FOR CUBES FOR COMPRESSIVE STRENGTH AND CYLINDERS FOR SPLIT TENSILE STRENGTH

↓

FINDING OF BETTER REPLACEMENT RATIO FOR REPLACEMENT OF CEMENT

↓

RESULT ANALYSIS

↓

CONCLUSION

CHAPTER 3 EXPERIMENTAL INVESTIGATION

GENERAL

Concrete mixtures with and without hyposludge for different compressive strength values were prepared in this research work. The materials used to develop the concrete mixes in this study were coarse aggregate, fine aggregate, cement, water and mineral admixture. A total of 8 proportions were prepared consisting of concrete grades M_{25} with partial replacements of the cement by the hyposludge. Moreover, a control mix with no replacement of the cement was produced to make a comparative analysis. In the subsequent parts, the different materials used in this study are discussed.

MATERIAL USED AND PROPERTIES

CEMENT

The Portland Pozzalonic Cement of 53 grades conforming to IS 1489 (PART 1) -1991 is being used. Cement is a generic name that can apply to all binders. The chemical composition of the cements can be quite diverse but by

far the greatest amount of concrete used today is made with Portland cements. Lime and silica make up about 85% of the mass. Common among the materials used in its manufacture are limestone, shells, and chalk or marl combined with shale, clay, slate or blast furnace slag, silica sand, and iron ore. Lime and silica make up about 85% of the mass. Common among the materials used in its manufacture are limestone, shells, and chalk or marl combined with shale, clay, slate or blast furnace slag, silica sand, and iron ore.

CHEMICAL COMPOSITION OF CEMENT:

Chemical constituents	Percentage(%)
CaO	63.81
SiO_2	21.45
Al_2O_3	4.45
Fe_2O_3	3.07
MgO	2.42
P_2O_5	0.11
TiO_2	0.22
Na_2	0.20
K_2O	0.83
SO_3	2.46
Loss on ignition	0.81
Insoluble residue	0.16

FINE AGGREGATE:

Those fractions from 4.75 mm to 150 microns are termed as fine aggregate. The river sand is used as fine aggregate conforming to the requirements of IS: 383 1970. The river sand is washed and screened, to eliminate deleterious materials and oversize particles.

COARSE AGGREGATE:

The fractions from 80 mm to 4.75 mm are termed as coarse aggregate. The Coarse Aggregates from crushed Basalt rock, conforming to IS: 383 is be use. The Flakiness and Elongation Index were maintained well below 15%.

WATER:

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Since it helps to from the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully.

REPLACED MATERIALS:

In this project "The Performance Of Micro silica In Hyposludge Concrete", the cement is partially replaced with hyposludge (paper waste) and the mineral admixture is added in order to increase the strength of the concrete.

HYPOSLUDGE:

It is the byproduct of the paper waste. This hypo sludge contains low calcium and minimum amount of silica. Hypo sludge behaves like cement because of silica and magnesium properties. It is usually used in proportion of percent of cement content of the mix.

CHEMICAL COMPOSITION OF HYPOSLUDGE:

Chemical Constituents	Percentage(%)
CaO	62.81
SiO_2	19.83
Fe_2O_3	5.08
Na_2O	0.19
SO_3	2.82
Loss on ignition	0.86
K_2O	0.90
MgO	2.64
Al_2O_3	3.79

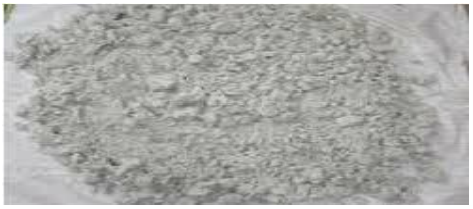

Fig 3.1 HYPOSLUDGE

MINERAL ADMIXTURE:

Microsilica is a mineral admixture composed of very fine solid glassy spheres of silicon dioxide (SiO_2). The particles are less than 1 micron (0.00004 inch) in diameter, generally 50 to 100 times finer than average cement. As an admixture, microsilica can improve the properties of both fresh and hardened concrete. Microsilica effectiveness as a pozzolan and a filler depends largely on its composition and particle size which in turn depend on the design of the furnace and the composition of the raw materials with which the furnace is charged. At present there are no U.S. standard specifications for the material or its applications.

Dosages of microsilica used in concrete have typically been in the range of 5 to 20 percent by weight of cement, but percentages as high as 40 have been reported.

Fig 3.2 MICROSILICA

PRELIMINARY TEST

SPECIFIC GRAVITY TEST:

Weight of empty bottle (W_1) = 0.488kg Weight of bottle + 1/3rd of fine aggregate

(W_2) = 0.854kg

Weight of bottle + 1/3rd of fine aggregate + water (W_3) = 1.372kg

Weight of bottle + water (W_4) = 1.152kg

FORMULA:

$$S.G = (W_2 - W_1)/[(W_4 - W_1)-(W_3 - W_2)]$$

$$= (0.854-0.488)/[(1.152-0.488)-(1.312-0.854)]$$

$$= 2.506$$

WATER ABSORPTION TEST:

Dry weight (W_1) = 1kg

Saturated weight (W_2) = 1.028kg FORMULA:

TABLE 4.2 COMPRESSIVE STRENGTH OF CONCRETE FOR REPLACEMENT OF CEMENT

%of replacement	7 days	14 days	28 days
5%	17.014	25.78	28.68
10%	17.8	26.98	29.97
15%	18.717	28.36	31.47
20%	21.56	32.67	36.26
25%	25.05	37.96	42.13
30%	26.41	40.02	44.42
35%	23.32	35.34	39.22
40%	20.37	30.87	34.26

(N/mm^2)

W.A = (W_3 /W_1)

W_3 = (W_2 –W_1) = (1.028-1)

= 0.028 = 2.8%

SIEVE ANALYSIS :

Total weight of soil = 1000g

Total weight of soil passes through 4.75mm IS sieve = 750g

Hence more than 50 % of soil is passes through 4.75mm IS sieve

SLUMP CONE TEST:

Slump value=100mm

ANALYSIS OF SPECIFIC GRAVIT

Specific gravity of Coarse Aggregate = 2.74 Specific gravity of Fine Aggregate = 2.74 Specific gravity of Hyposludge = 2.6 Specific gravity of Microsilica = 2.3

CHAPTER 4 RESULTS AND DISCUSSIONTEST RESULTS

GRAPHS FOR COMPRESSIVE STRENGTH OF CONCRETE (f_{ck}) IN N/mm^2

DISCUSSION

In this research hyposludge is used as replacement of conventional building materials such as cement in partial in various proportions its quantity. The Replacements are done for a ratio of 5% 10% 15% 20% 25%30% 35% and 40%. The concrete tested for compressive strength. The grade of concrete mixed is M25 grade with a water cement ratio of 0.5 the grade chosen as per IS 456-2000 for an exposure condition of severe for reinforced concrete. The mix was prepared is non pumping mix with ratio of 1: 1.8: 2.829. The optimum strength obtained at a replacement of 30% of hyposludge by cement with the micro silica (mineral admixture). The hyposludge concrete made with the optimum strength gained replacements. The strength of the hyposludge concrete at an age of 7 days 14 days and 28 days are more than the conventional concrete.

COMPRESSIVE STRENGTH OF CONCRETE in N/mm^2

Cube specimen shall be of size not less than four times the maximum size of the course aggregate and not less than 150 mm Compressive strength of concrete made with 15cm X 15cm X 15 cm Cubes are made with M25 grade of concrete, concrete mixed and cured and tested with reference to Indian standard code specification IS 516 – 1959.

CUBES CASTED

Conventional concrete = 6 Replacement of cement = 48 cubes for each composition = 6

Total no: of cubes = 54 cubes

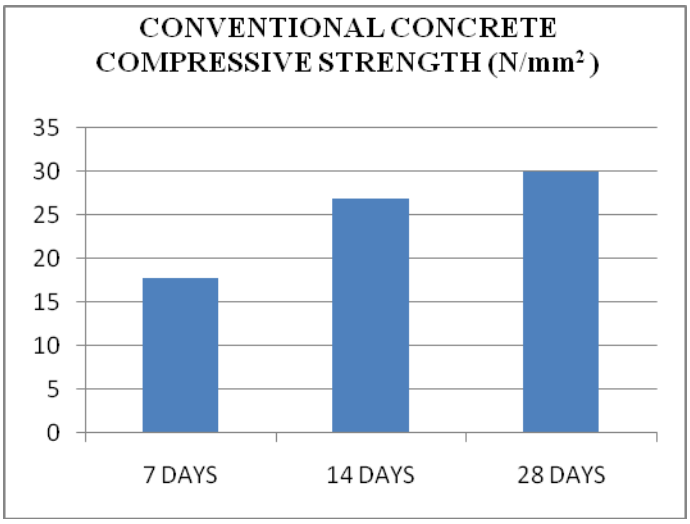

TABLE 4.1 COMPRESSIVE STRENGTH OF CONVENTIONAL CONCRETE (N/mm^2)

DAYS	7 days	14 days	28 days
Characteristic compressive strength of concrete (**fck)**	15.42	24.35	24.89

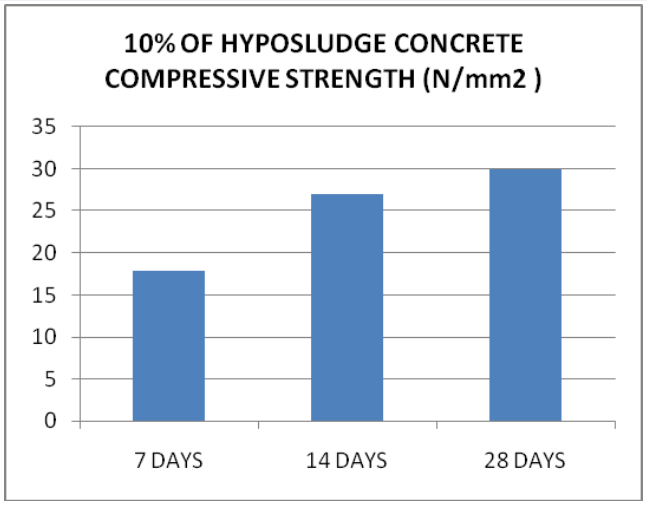

Fig 4.2 COMPRESSIVE STRENGTH OF CONVENTIONAL CONCRETE

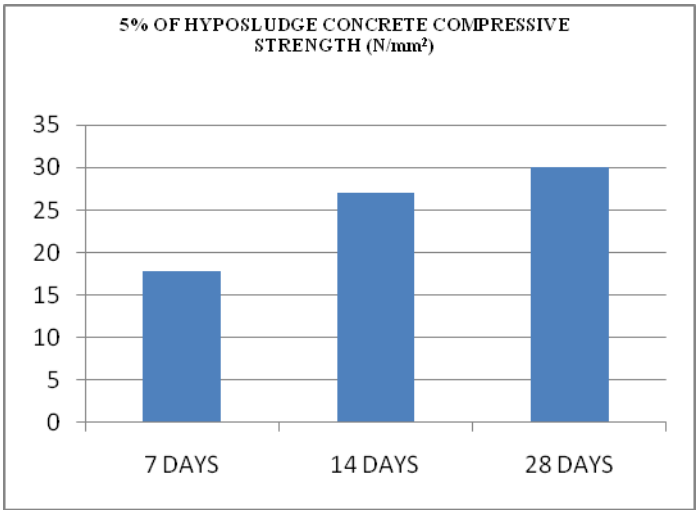

Fig 4.3 COMPRESSIVE STRENGTH FOR HYPOSLUDGE CONCRETE (5% REPLACEMENT)

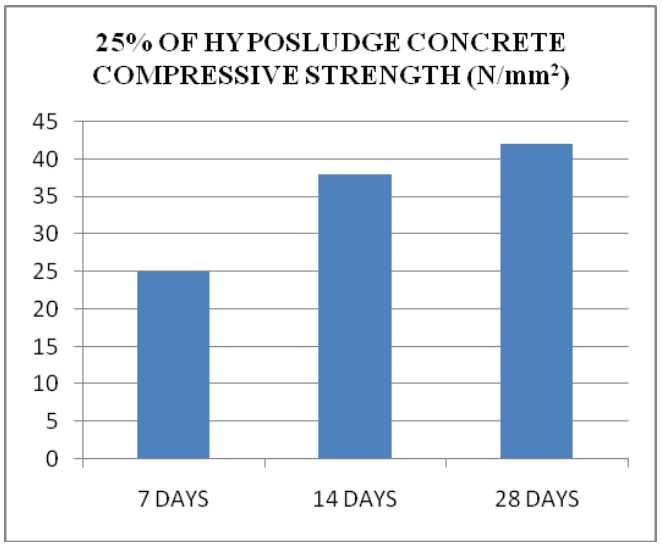

Fig 4.4 COMPRESSIVE STRENGTH FOR HYPOSLUDGE CONCRETE (10% REPLACEMENT)

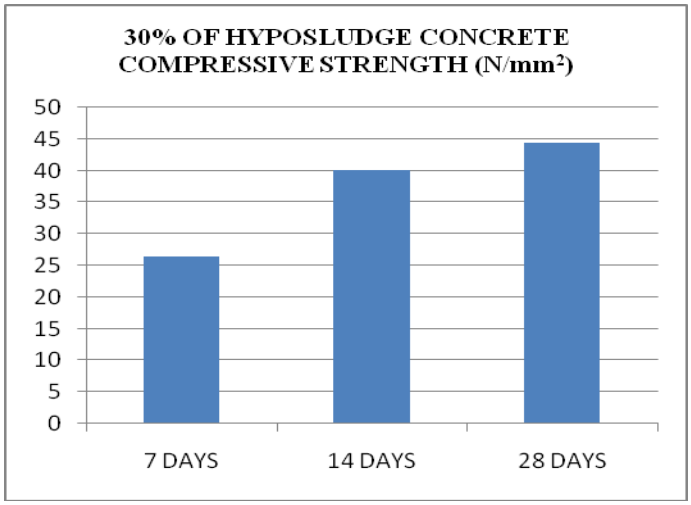

Fig 4.6 COMPRESSIVE STRENGTH FOR HYPOSLUDGE CONCRETE (20% REPLACEMENT)

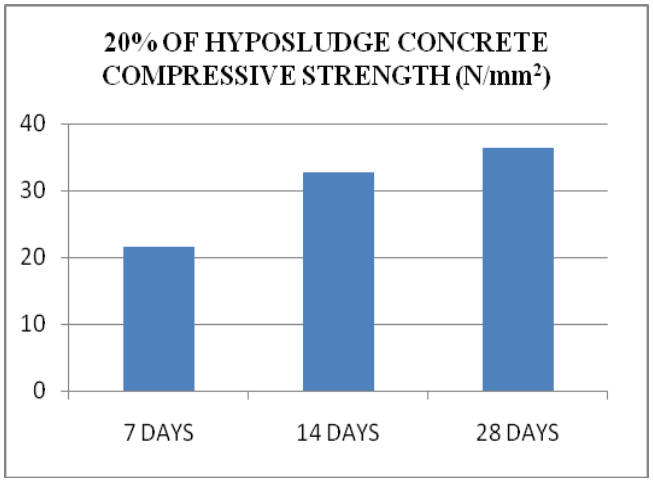

Fig 4.5 COMPRESSIVE STRENGTH FOR HYPOSLUDGE CONCRETE (15% REPLACEMENT)

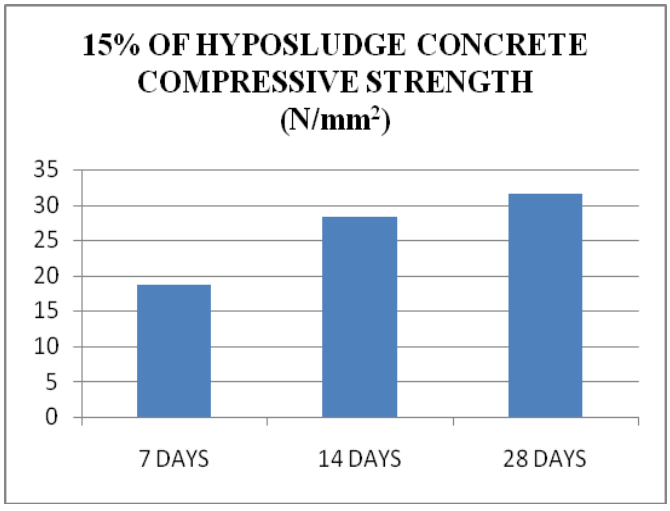

Fig 4.7 COMPRESSIVE STRENGTH FOR HYPOSLUDGE CONCRETE (25% REPLACEMENT)

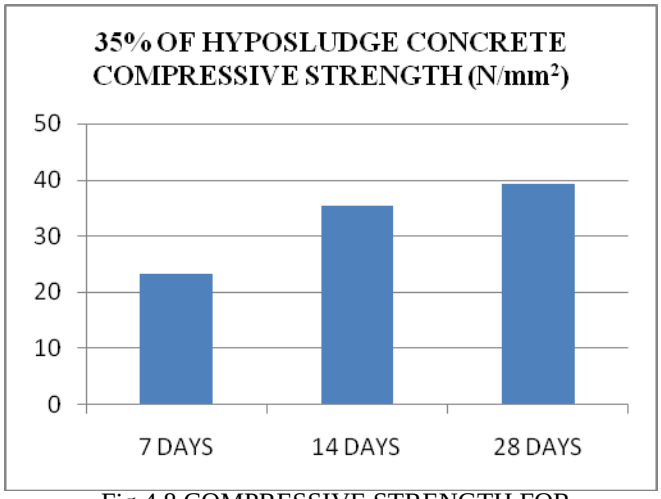

Fig 4.8 COMPRESSIVE STRENGTH FOR HYPOSLUDGE
CONCRETE (30% REPLACEMENT)

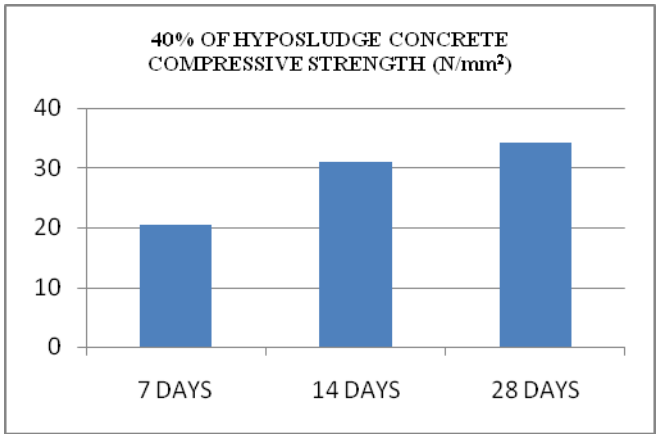

Fig 4.9 COMPRESSIVE STRENGTH FOR HYPOSLUDGE
CONCRETE (35% REPLACEMENT)

Fig 4.10 COMPRESSIVE STRENGTH FOR HYPOSLUDGE
CONCRETE (40% REPLACEMENT)

c) Maximum nominal size of aggregate : 20mm aggregate
d) Minimum cement content : 320 kg/m^3
e) Maximum Water-Cement ratio : 0.5
f) Workability : 100mm (slump)
g) Exposure condition : Severe (For reinforced concrete)
h) Method of concrete placing : Pumping / Non Pumping
i) Degree of supervision : Good
j) Type of aggregate : Crushed angular aggregate
k) Maximum Cement content : 450 kg/m^3

Test data for materials

a) Cement used : PPC 53 grade conforming IS 8112
b) Specific gravity of cement : 3.15
c) Specific gravity of
1) Coarse aggregate : 2.74
2) Fine aggregate : 2.74
d) Water adsorption
1) Coarse aggregate : 0.5 percent
2) Fine aggregate : 1.0 percent
e) Free (surface) moisture
1) Coarse aggregate : Nil
2) Fine aggregate : Nil c)Sieveanalysis

1) Coarse aggregate:			
IS Sieve sizes (mm)	Analysis of coarse aggregate fraction	% of different fractions	
	I II	I II combined 60% 40% 100%	
20	100 100	60 40 100	conforming to table 2 of IS 383
10	0 71.20	0 28.5 28.5	
4.75 2.36	9.400	3.7 3.7	
2) Fine aggregate : conforming grading zone I of table of IS 383			

Target strength for mix proportioning

$f'_{ck} = f_{ck} + 1.65S$

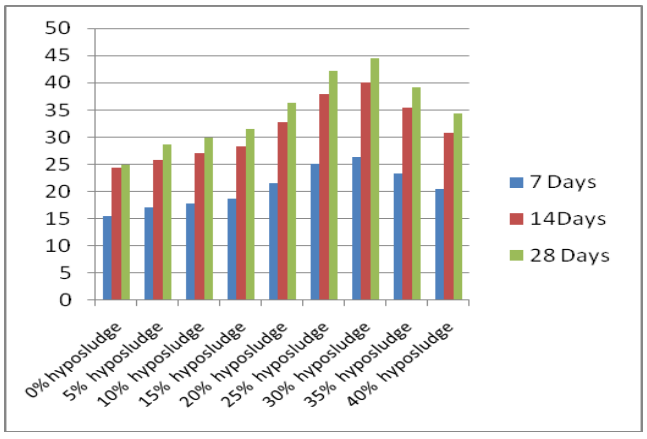

Fig 4.11 COMPRESSIVE STRENGTH OF HYPOSLUDGE CONCRET

CHAPTER 5

Where,

f'ck = Target average compressive strength at 28days. fck = Characteristic compressive strength at 28days. S = Standard deviation

CONCLUSION

The aim of the project is to increase the strength of hyposludge concrete by using micro silica as mineral admixture and also the project is to control the manufacturing and usage of cement in construction work and enlarge the usage of waste materials (by products) which can replace the cement, by having more or less similar physical and chemical properties. By this research we have proved that the use of hyposludge in part of cement by adding Micro silica (mineral admixture) can improve the compressive strength and split tensile strength of concrete. By the use of cement as part of conventional building materials can help in reduction in disposal problem, we can produce a cost effective concrete, and by controlling usage of conventional building materials, the increase in cost can be controlled , Environmental pollution caused by manufacturing of cement can be controlled. By the test results of replacement in cement we have analyzed that the hyposludge with micro silica can be effectively replaced for 30% of cement even after 30% of replacing of hyposludge the strength of the hyposludge concrete is not fall below the conventional concrete strength , hence the optimum percentage of strength achieved for this percentage and finally hyposludge concrete produced by replacing 30% of cement and strength achieved for 7 days, 14 days & 28 days for compressive strength are 26.41, 40.02, 44.42.

rom table -1, Standard deviation,

S = 4N/mm^2 Therefore, Target strength = 30 + (1.65 × 4)

=

31.6 N/mm^2 **A-4 Selection of Water-Cement ratio** From table 5 of IS 456, maximum

Water-Cement ratio = 0.5.

A-5 Selection of Water content

From table2,

Maximum water content for 20mm aggregate

= 186 liter (for 25 to 50mm slump range) Estimate Water content for 100mm Slump

= 186 + (6/100) × 186

=

197 liter **A-6 Calculation of Cement content**

Water-Cement ratio = 0.5

Cement content = 197 / 0.5

= 394 kg/m^3

APPENDIX

MIX DESIGN OF M25CONCRETE ILLUSTRATIVE EXAMPLE ON CONCRETE MIX PROPORTIONING

From table 5 of IS456,

Minimum cement content for 'severe' exposure condition

= 320 kg/m^3

An example illustration the mix proportioning for a concrete of M25 in

A-1 to A-11

A-1

a) Grade designation : M25

rade is given

394 kg/m^3 > 320 kg/m^3 and should be less than 450 kg/m^3 Hence Ok.

Proportion of volume of coarse aggregate and Fine aggregate

From table 3, volume of coarse aggregate corresponding to 20mm size coarse aggregate and fine aggregate (zone I)

b) Type of cement : PPC conforming to IS 8112

Water-Cement ratio of 0.5 = 0.60

In the present case Water-Cement ratio is 0.40. Therefore volume of coarse aggregate is required to be increased to decrease the fine aggregate content. As the Water-Cement ratio is lower by 0.05, the proportion of volume of coarse aggregate is increased is increased by 0.01 (at the rate of ± 0.01 for every ±0.05 change in Water-Cement). Therefore, corrected proportion of volume of coarse aggregate

Water-Cement ratio of 0.5 = 0.60

Note: In case the coarse aggregate is not angular one, then also volume of coarse aggregate may be required to be increased suitably based on experience.

For pumping concrete these values should be reduced by 10% Therefore, Volume of Coarse aggregate for pumping concrete mix

0.60 × 0.9 = 0.54

Volume of coarse aggregate for non pumping concrete

= 0.60

Volume of Fine aggregate content for pumping concrete mix

= 1 – 0.60

= 0.40

Volume of fine aggregate for non pump able concrete mix

= 0.36

REFERENCE

1. IS 10262 (2009): Guidelines for concrete mix design proportioning [CED 2: Cement and Concrete]
2. IS 383 (1970): Specification for Coarse and Fine Aggregates From Natural Sources For Concrete [CED 2: Cement and Concrete]
3. IS 456 (2000): Plain and Reinforced Concrete - Code of Practice [CED 2: Cement and Concrete]
4. IS 2386-4 (1963): Methods of test for aggregates for concrete, Part 4: Mechanical properties [CED 2: Cement and Concrete]
5. IS 2386-3 (1963): Methods of test for aggregates for concrete, Part 3: Specific gravity, density, voids, absorption and bulking [CED 2:

Cement and Concrete]
6. IS 1489-1 (1991): Specification for Portland pozzolana cement, Part 1: Fly ash based [CED 2: Cement and Concrete]
7. IS 516 (1959): Method of Tests for Strength of Concrete [CED 2: Cement and Concrete]

MIX CALCULATIONS

The mix calculations per unit volume of concrete shall be as follows.

a) Volume of concrete = $1m^3$

b) Volume of cement = (Mass of cement / Specific gravity of cement) × (1/1000)
= (394 / 3.15) × (1/1000)
= $0.125/m^3$

Mix proportions for Trial number 1

Cement = $437.78\ kg/m^3$
Water = $197\ kg/m^3$
Fine aggregate (P) = $918.15\ kg/m^3$
Coarse aggregate (P) = $1118\ kg/m^3$
Fine aggregate (NP) = $794\ kg/m^3$
Coarse aggregate (NP) = $1242\ kg/m^3$
Water-Cement ratio = 0.45
Mix ratio (P) = 1: 2.1: 2.554
Mix ratio (NP) = 1: 1.814: 2.84

Note: Aggregate should be used in saturated surface dry condition. If otherwise, when computing the requirement of mixing water, allowance shall be made for the free (surface) Moisture contributed by the fine aggregate and coarse aggregate. On the other hand, if the aggregates are dry, the amount of mixing water should be increased by an amount equal to the moisture likely to be absorbed by the aggregates. Necessary adjustments are also required to be made in mass of aggregate. The surface water and percent water absorption of aggregate shall be determined according to IS2383.

The slump shall be measured and the water content and dosage of admixture shall be adjusted for achieving the required slump based on trial if required. The mix proportions shall be reworked for the actual water content and checked for the durability requirements.

Two more trials having variation of ±10 percent of Water-Cement ratio in A-10 shall be carried out and graph between three Water-Cement ratios and their corresponding strengths shall be plotted to work out the mix proportions for the given target strength for field trials. However, durability requirement shall be met

8. S 9103 (1999): Specification for Concrete Admixtures - [CED 2: Cement and Concrete]