EXPREMENTAL INVESTIGATION OF CONCRETE WITH PARTIAL REPLACEMENT OF CEMENT BY USING HYPO SLUDGE AND SILICA FUME

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***Abstract*: Hypo sludge is also known as paper industry waste. Paper making generally produces a large amount of solid waste. This paper mill sludge consumes a large percentage of local landfill space for each and every year. To reduce disposal and pollution problems emanating from these industrial wastes, it is most essential to develop profitable building materials from them. The quantity of sludge varies from mill to mill. 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. So Hypo sludge may be used as partially replacement of cement. So we can use Hypo sludge as a partial replacement of cement in concrete. The rapid increase in construction activities leads to active shortage of conventional construction Materials such as cement, fine aggregate and coarse aggregate. Therefore, in this paper, the effect of rice husk ash and Hypo sludge on properties of Ordinary Portland Cement (OPC) Concrete of M20 grade are investigated with silica fume as powder along with cement. This research work is concerned with experimental investigation on strength of concrete and optimum percentage of the partial replacement by replacing cement via 20%, 30%, and 40% of Hypo Sludge and constant 5% of silica fume. Keeping all this view, the aim of investigation is the behavior of concrete while adding of waste with different proportions of Hypo sludge and silica fume in concrete by using tests like compressive strength and split tensile strength test were conducted. The curing period should be 7,14and 28 days.**

***Keywords*: Hypo sludge, silica fume**

1. INTRODUCTION

1.1 GENERAL

Paper making industries generally produces a large amount of solid waste. This paper mill sludge consumes a large percentage of local landfill space for each and every year. Paper making generally produces a large amount of solid waste. Paper fibers 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 fibers are separated out to become waste sludge. All the inks, dyes, coatings, pigments, staples and "stickiest" (tape, plastic films, etc.) are also washed off the recycled fibers to join the waste solids. The shiny finish on glossy magazine-type paper is produced using a fine kaolin clay coating, which also becomes solid waste during recycling. 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 emanating from these industrial wastes, it is most essential to develop profitable building materials from them. Keeping this in view, investigations were undertaken to produce low cast concrete by blending various ratios of cement with hypo sludge. 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 shall help not only to control degradation of environment but also the conserve them for the use of future generation. This can be achieved by the process of recycling and, making use of industrial wastes, disposal of which otherwise is a serious problem. 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. Silica fume consists primarily of amorphous (non-crystalline) silicon dioxide (SiO2).

1.2 OBJECTIVE

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

1.3BENEFITS OF HYPO SLUDGE

- Hypo sludge improves the properties of fresh and hardens concrete.
- Hypo sludge reduces degradation and bleeding.
- Hypo sludge improves the durability of concrete.

- Hypo sludge improves the setting of concrete due to presence of silica and magnesium.
- Environmental friendly.
- Hypo sludge is the cheaper substitute to Ordinary Portland Cement.

1.4 LIMITATIONS OF HYPO SLUDGE

- Availability.
- Handling problem.

1.5 CHEMICAL REACTIONS INVOLVED IN PARTIALLY REPLACED IN CONCRETE

1.4.1. Primary Hydration

Cement + Water → C-S-H (gel) + Ca $(OH)_2$

1.4.2. Secondary Hydration

Here Silica Fume and Hypo Sludge act as a pozzolana.

Ca $(OH)_2$ + Pozzolana → C-S-H (gel)

Increase in amount of C-S-H gel increase the compressive strength but only up to a certain extent.

1.6 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 hardwood species), but some other mills are using bagasse in substantial quantity as raw material. Most of the paper mills in India prepare bleach liquor (calcium hypochlorite) using lime and elemental chlorine. Six mills among eight mills are using ClO_2 as bleaching agent either as partial substitution of elemental chlorine or in final stage of bleaching to attain desired brightness level. These mills are producing ClO_2 with environmental friendly process. Three mills among eight mills are still using calcium hypo chlorite in final stage for bleaching. Solid wastes generated during calcium hypo chlorite generation are called hypo sludge.

2 MATERIAL USED

2.1 GENERAL

Concrete is an artificial material, which is made up of cement, fine aggregate, coarse aggregate and water. In this project an attempt has been made to partial replacement of cement by Hypo sludge and Silica fume. Hence the properties of material have been arrived by conducting laboratory tests and the results are presented in this chapter.

2.2 CEMENT

The most common cement used is an Ordinary Portland Cement (OPC). The Ordinary Portland Cement of 53 grade conforming to IS:8112-1989 is used. Following tests were conducted on cement; some of them are specific gravity and setting time tests.

2.2.1The physical properties of cement

1) Setting time
2) Soundness
3) Fineness
4) Strength

2.2.2 Ordinary portland cement (opc)

Portland cement may be defined as a product obtained by finely pulverizing the clinker produced by calcining to fusion, an intimate & properly proportioned mixture of argillaceous & calcareous materials. The ordinary Portland cement has been classified as.

1) 33Grade (IS 269:1989)
2) 43 Grade (IS 8112:1989)
3) 53 Grade (IS 12669:1987)

We have to use 53 grade ordinary Portland cement (OPC) for this study program.

2.2.3 Chemical composition of (OPC)

Cao = 60-65%, Sio2 = 17-25%, Al2O3 = 3-8%, Fe2o3 = 0.5-6%, Mgo = 0.5-4%

2.3 COARSE AGGREGATE

The fractions from 20 mm to 4.75 mm are used as coarse aggregate. The Coarse Aggregates from crushed Basalt rock, conforming to IS: 383 are used. Crushed granite aggregate with specific gravity of 2.6 and passing through 20 mm sieve and retained on 4.75 mm to be used. Several investigations concluded that maximum size of coarse aggregate should be restricted in strength of the composite.

2.4 FINE AGGREGATE

Those fractions from 4.75 mm passing andretained as0.0075mm are termed as fine aggregate. The river sand is washed and screened, to eliminate deleterious materials and over size particles. The codel provision IS: 383-1970 are used. The most important function of the fine aggregate is to provide workability and uniformity in the mixture. The fine aggregate also helps the cement paste to hold the coarse aggregate particle in suspension. Locally available clean and dry river sand passing through IS 4.75 mm sieve is used for casting the specimens. The sand has the following properties.

2.5 WATER

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. The ph value of water is six. Since it helps to from the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully. Casting and curing of specimens were done with the portable well and bore water in the college.

2.6 HYPO SLUDGE

Hypo Sludge is a waste material collected from the Paper Industry. It is used as cement replacement in producing concrete and was investigated on its chemical and physical properties. Construction material with natural resources now become limited and causes of air pollution and environmental problems. Hypo Sludge becomes a new innovation material that can be used as material to support the green technology. Hypo sludge behaves like cement because of silica and magnesium properties. This silica and magnesium improve the setting of the concrete. Its chemical investigation is done by Geo-test house Baroda.

Table 2.1 Properties of Raw Hypo Sludge

Sr. No.	Hypo Sludge	%HypoSludge
1.	Silicon dioxide (SiO_2)	9.27
2.	Aluminum oxide (Al_2O_3)	1.45
3.	Iron oxide (Fe_2O_3)	1.60
4.	Calcium Oxide (CaO)	29.83
5.	Magnesium Oxide (MgO)	4.28
6.	Loss on Ignition	49.24

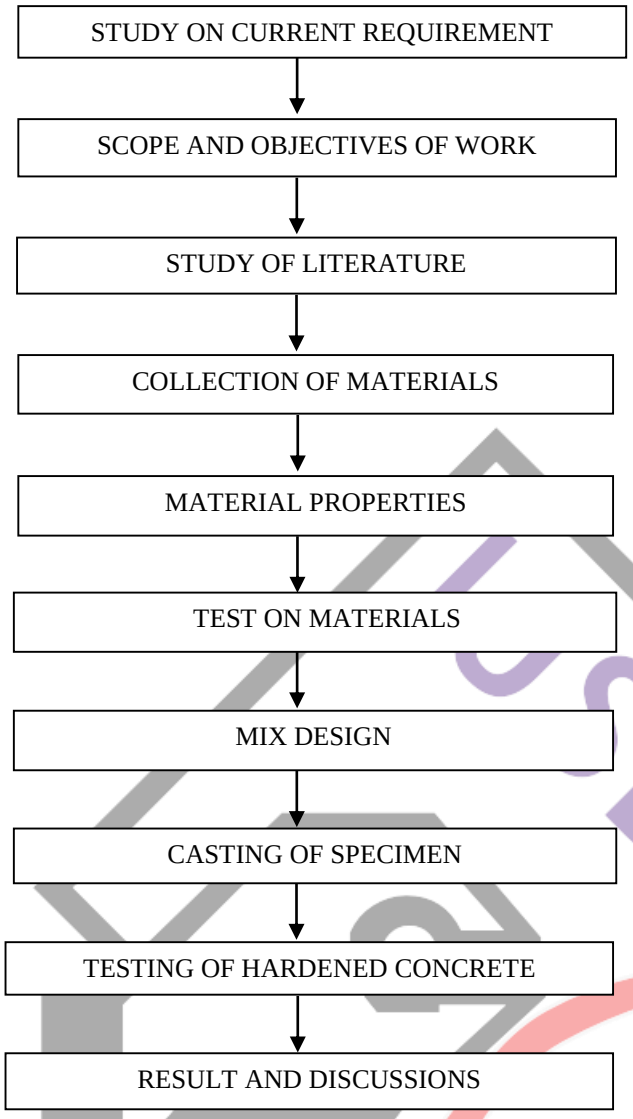
2.7 SILICA FUME

Silica fume particles are extremely small, with more than 95% of the particles being less than 1 µm. Particle size is extremely important for both the physical and chemical properties of silica fume of concrete.

Table 2.2 Chemical properties of Silica fume

Sr. No.	Ingredients	% in Silica Fume
1.	Silicon dioxide (SiO_2)	90
2.	Aluminum oxide (Al_2O_3)	2.18
3.	Iron oxide (Fe_2O_3)	2.2
4.	Calcium Oxide (CaO)	1.52
5.	Magnesium Oxide (MgO)	0.9
6.	SO3	1.2
7.	Alkalies (K2O, Na2O)	2

3. METHODOLOGY



4. TEST OF MATERIALS

4.1 GENERAL

Concrete is an artificial material, which is made up of cement, fine aggregate, coarse aggregate and water. In this project an attempt has been made to partial replacement of cement by Hypo sludge and Silica fume. Hence the properties of material have been arrived by conducting laboratory tests and the results are presented in this chapter. To investigate the properties of the materials that were used for casting the specimens, various laboratory tests were performed; following the IS codes 2386:1963 and IS 383:1970.

4.2 CEMENT

The most common cement used is an Ordinary Portland Cement (OPC). The Ordinary Portland Cement of 53 grade conforming to IS:8112-1989 is used. Following tests were conducted on cement; some of them are specific gravity and setting time tests.

4.2.1Standard consistency test

For finding out initial setting time, final setting time and soundness of cement and strength parameter known as standard consistency has to be used,the standard consistency of a cement paste is defined as that consistency which will permit a vicar plunger having 10mm diameter and 50mm length to penetrate a depth of 33-35mm from the top of the mould

Standard Consistency of cement = 30%

4.2.2 Fineness of Cement Test

100gm of cement taken and sieved in a standard IS no 90µ. The air which get lump is broken down and the material was sieved continuously for 15 minutes using sieve shaker. The weight of residue left on the sieve is noted. The Fineness of Cement is 7.5%.

4.2.3 Initial setting time test

Lower the needle (c) gently and bring it in contact with the surface of the test block quickly release. Allow it to penetrate into the block. But after some times when the paste starts losing its plasticity needle may penetrate only to a depth of 33-35mm from the top.

The period elapsing between the times when water is added when the water is added to the test block to a depth equal to 33-35mm form the top is takenas initial setting time.

Initial setting time of the cement used = 28 Minutes

4.2.4 Final setting time of cement test

Replace the needle (c) of the Vicat apparatus (F). The cement shall be considered as finally set when , upon , lowering the attachment gently cover the surface of the test block, the center needle makes an impression, while the circular cutting edge of the attachment fails to do so . In other words the paste more than 0.5mm. Replace the needle of the vicat apparatus by a circular attachment. The cement shall be considered as finally set when , upon lowering the attachment gently cover the surface of the test block , the center needle makes an impression , while the circular edge of the attachment fails to do so.

Final setting time of cement = 540 min

Table 4.1 PROPERTIES OF CEMENT

S. No.	Property Of Cement	Values
1	Fineness of Cement	7.5%
2	Grade of Cement	53
3	Specific Gravity	3.15
4	Initial Setting time	28 min
5	Final Setting time	540 min

4.3FINE AGGREGATE

Those fractions from 4.75 mm passing and retained as0.0075mm are termed as fine aggregate. The river sand is washed and screened, to eliminate deleterious materials and over size particles. The codel provision IS: 383-1970 are used.The most important function of the fine aggregate is to provide workability and uniformity in the mixture. The fine aggregate also helps the cement paste to hold the coarse aggregate particle in suspension. Locally available clean and dry river sand passing through IS 4.75 mm sieve is used for casting the specimens. The sand has the following properties.

4.3.1Specific gravity test

The specific gravity of aggregate is made use of in design calculation of concrete mixes. Specific gravity of aggregate is also required calculating the compaction factor in connection with the workability measurement. The specific gravity is determined by pycnometer method.

Specific gravity of sand =dry weight of sand / weight of equal volume of water.

The above table represented in specific gravity of fine aggregate results is 2.65. This test are mentioned above table. Average specific gravity of the fine aggregate various from 2.6 to 2.8.

The results of tests done on fine aggregate are presented in table and all the parameters were within the permissible limits.

Table 4.2 Properties of Fine Aggregate

S. No.	Properties	Values
1	Specific Gravity	2.65
2	Fineness Modulus	2.90
3	Water absorption (%)	1.80

4.4 COARSE AGGREGATE

4.4.1Water absorption test

The coarse aggregate for the work should be river gravel or stone. The maximum size of aggregate is generally limited to 20mm. aggregate of 10 to 20mm is desirable for structures having congested reinforcement. Well graded cubical or rounded

aggregates are desirable aggregates should be of uniform in size for this project 20mm size aggregate were used. The Water absorption is 0.50%.

4.4.2Specific gravity test for coarse aggregate

The specific gravity of aggregate is made use in design calculation of concrete mixes. Within the specific gravity of each constituent known, its weight can be converted into solid volume and hence a theoretical yield of concrete per unit volume can be calculated. Similarly specific gravity of aggregate is required to be considered when we deal with light and heavy weight concrete. The specific gravity of aggregate is 2.55.

4.5 HYPO SLUDGE

Hypo Sludge is a waste material collected from the Paper Industry. It is used as cement replacement in producing concrete and was investigated on its chemical and physical properties. Construction material with natural resources now become limited and causes of air pollution and environmental problems. Hypo Sludge becomes a new innovation material that can be used as material to support the green technology. Hypo sludge behaves like cement because of silica and magnesium properties. This silica and magnesium improve the setting of the concrete. Its chemical investigation is done by Geo-test house Baroda.

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6.	SO3	1.2
7.	Alkalies (K2O, Na2O)	2

5. MIX DESIGN

5.1 DESIGN STIPULATION:

1. Characteristic compressive strength Required in field @ 28 day - 20 Mpa
2. Max size of aggregate - 20 mm(Angular)
3. Degree of workability - 0.90 C.F
4. Degree of quality control - Good
5. Type of exposure - Modurate
6. Specific gravity of cement - 3.15
7. Specific gravity of fine aggregate - 2.60
8. Specific gravity of coarse aggregate - 2.55

5.2 TARGET MEAN COMPRESSIVE STRENGTH:

The target mean strength for specified characteristic cube strength

$$= f_{ck} + (t \times s)$$

$$= 20 + (1.65 \times 4)$$

= 26.6 Mpa

Where f_{ck} = Characteristic compressive strength at 28 days

t = risk factor

S = standard deviation

5.3 SELECTION OF W/C RATIO:

The water cement ratio required for target mean strength of 26.6 Mpa is 0.4.This is lower than the maximum value of 0.6 prescribed for modurate exposure. Hence adopt water cement ratio 0.5.

5.4 SELECTION OF WATER AND CEMENT CONTENT:

From table 4 in IS 10262,for 20 mm max size aggregate, sand conforming to grading zone II, water content per cubic meter of concrete = 186 kg and sand content as percentage by absolute volume = 35 %

For change in value in w/c ratio, compacting factor, for sand belonging to Zone II, following adjustment is required.

Table 5.1 Adjustments for water and sand

Change in condition (Table 6 in IS 10262)	Water content	Sand in total aggregate
For decrease in w/c ratio by (0.60 – 0.45= 0.15)	0	-3.0
For increase in compacting factor (0.90.8=0.10)	+3	0
For sand conforming to Zone II of table 4,IS 383 -1970	0	0
Total	+3	-3

Therefore, required sand content as percentage of

Total aggregate by absolute volume = 35 – 3

= 32%

Required water content = 186 + 5.58

= 191.6 kg/m^3

5.5 DETERMINATION OF CEMENT CONTENT:

Water/cement ratio = 0.5
Water = 191.6 lit
Cement = 191.6/0.5
= 383.20 kg/m^3

This cement content is adequate for 'modurate' exposure condition.

5.6 DETERMINATION OF FINE AND COARSE AGGREGATE:

From table 3 in IS 10262, for the specified max size of aggregate of 20 mm, the amount of entrapped air in the wet concrete is 2 %.

Fine aggregate:

$V = [W+(C/S_c) + f_a/P \times Sf_a][1/1000]$

Coarse aggregate:

$C_a = (1-P)/P \times f_a \times (Sc_a/Sf_a)$

Where,

V = absolute volume fresh concrete, which is equal to gross Volume (M^3)minus the volume of entrapped air,

W = Mass of water (kg) per m3 of concrete

C = Mass of cement (kg) per m3 of concrete

Sc = Specific gravity of cement

P = Ratio of FA to total aggregate by absolute volume

f_a, C_a = Total mass of FA and CA (kg) per m^3 of concrete respectively

Sfa, Sca = Specific gravities of FA and CA respectively

Fine aggregate:

V = [W+ (C/Sc) + f_a/P x Sf_a][1/1000]

1- 0.02 = (191.6+ (383.2/3.15) + (f_a/0.32x2.60)x (1/1000)

Hence f_a = 554.73 kg / m^3

Coarse aggregate:

C_a = (1-P)/P x f_a x (S_{ca}/S_{fa})

C_a = (1-0.32)/0.32 x 550.26 x (2.55/2.60)

C_a = 1155.23 kg / m^3

The mix proportion then becomes:

Water	**:**	**Cement**	**:**	**Fine Aggregate**	**:**	**Coarse Aggregate**
191.6	:	383.20kg	:	554.73 kg	:	1155.23kg
0.50	:	1	:	1.45	:	3

6. EXPERIMENTAL INVESTIGATION

6.1 GENERAL

Concrete is an artificial material, which is made up of cement, fine aggregate, coarse aggregate, water. In this project partial replacement of cement by Hypo sludge Silica fume. Hence the properties of material have been arrived by conducting laboratory test and hardened concrete tested by conducting laboratory test.

Table 6.1 Percentage replacement materials

S.no	Type of mix	Silica fume %	Hypo sludge %	Cement %
1	CVC	-	-	100
2	M1	5	20	75
3	M2	5	30	65
4	M3	5	40	55

6.2 MEASUREMENTS OF WORKABILITY

The following test are commonly employed to measure workability

Slump test

The mould for slump test is in the form of cone bottom diameter 20cm, top diameter 10cm, and height 30cm. The is in filled with fresh concrete in four layer, each approximately one quarter of height of the mould is filled with fresh concrete in four layer, each approximately one quarter of height of the mould. Each layer shall be tamped with 25 strokes of the rounded end of the tamping rod. After the top layer has been rodded and top surface leveled, the mould is removed from the concrete by raising it slowly in vertical direction. The concrete subsides and the slump is measured immediately by determining the difference between the height of the mould and of the highest point of the specimen being tested. The test determines the consistency of the fresh concrete and given comparable results in the case of wet mixes.

Table 6.2 slump test values

Grade of concrete	Replacement level of Hypo sludge%	Replacement level of silica fume%	Slump in mm
M20	0	0	133
M20	20	5	128
M20	30	5	125
M20	40	5	110

6.3 CASTING AND CURING OF TEST SPECIMEN

From the mix design, the ratio 1:1.45:3 were used to cast the concrete cubes with moulds. Here hand mixing was done with the coarse aggregate, fine aggregate, cement and hypo sludge. The cubes of dimension 15 x15 x15cm cast for mix design. The water cement ratio was fixed to 0.5. About 30 cubes were cast. The specimen was left in the mould for 24 hours and then it is de- mould. Identification marks were made on the exposed face of specimen and immersed in curing tank. The specimen were taken out from the curing tank after 7th , 14th days and 28th days of curing and tested for compressive strength test.

6.4COMPRESSIVE STRENGTH OF CONCRETE

For compressive strength test, the specimens are cast cubical in shape, of size 15cm*15cm*15cm. Compressive test or made at recognized ages of the test specimens, the most usual being 7,14 and 28 days. Least three specimens, preferably from different batches shall be made for testing at each selected age. Specimens stored in water are tested immediately on removal of water and while they are still in wet condition. The cubes are placed in the compression testing machine in such apple manner that the load is applied apposite sides of the cube as cast. The load is applied at rate approximately 140kg/cm2 /min until failure of the specimen. The compressive strength of concrete gives an idea about the overall quality of concrete.

Table 6.3 Hardened Concrete Test Results

Mix designation	7 days Average Compressive Strength N/mm2	14 days Average Compressive Strength N/mm2	28 days Average Compressive Strength N/mm2
CVC	19.37	19.78	21.95
M1	19.24	19.64	21.21
M2	22.19	21.58	23.71
M3	7.42	10.56	13.54

6.5 SPLIT TENSILE TEST

1. The cylinders are placed in the compression testing machine horizontally
2. Load is applied gradually.
3. The load is increased at a uniform rate until the specimen fails and the maximum load applied to the specimen during the test is recorded.
4. The tensile strength of the specimen is calculated using the below mentioned formula.

Table 6.4 Hardened Concrete Test Results

Mix designation	7 days Average Split tensile Strength N/mm^2	14 days Average Split tensile Strength N/mm^2	28 days Average Split tensile Strength N/mm^2
CVC	1.72	2.13	2.75
M1	2.07	2.91	3.34
M2	1.96	2.50	2.90
M3	1.85	2.38	2.54

8. RESULT AND DISCUSSION

The above chart shows that compressive andtensile strength of concrete at 7, 14 days and 28 days decreases gradually as the percentage of replacementincreases. However, replacement by 20% and 30% and 40% is found to be more than the conventional concrete.

CONCLUSION

The industrial waste material like silica fume and hypo sludge are used in M_{20} grade concrete with the experimental studies conducted on the following conclusion can be drawn.

HYPO SLUDGE

It helps to some extent in preserving the environment as it is application reduces the environment of cement ran material.

Solves it is problem of disposal.

Economises the cost of concrete use of silica fume gives significant result on properties of concrete as compared to conventional concrete.

WORKABILITY

Experimental reveal that at the percentage of hypo sludge in the mix increases the slump decreses.

COMPRESSIVE STRENGTH

30% replacement of cement by hypo sludge and silica fume gives as strength as pure cement.

TENSILE STRENGTH

20% replacement of cement by hypo sludge and silica fume gives as much as strength pure cement concrete.

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