Design and Manufacture of High Performance Concrete by using GGBFS & Alccofine

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Abstract - The durability of high performance concrete is the key index of design. With the high durability, the high volume firmness, the high compressive strength and the good workability, high performance concrete extensively used in high-rise buildings, large-span Bridges, offshore in the construction of buildings, roads, etc. This paper prepared with different water & cement ratio of high performance concrete and verified the concrete workability, mechanical properties, and durability. High performance concrete need to prepare with low water & cement ratio, choose high quality raw materials, adding a adequate number of mineral admixtures and high-performance admixture. Using the high strength and high performance concrete can made reduction in the size of cross section, lose weight, and gain superior economic benefits.

Key Words: GGBFS, Alccofine, Concrete, *Poly carbolic ether*

1. INTRODUCTION

By using convectional concrete it can consume more water because of which w/c ratio increases and compressive strength decreases. Hence by using ggbs and Alccofine as an mineral admixture in concrete it will enhance the initial and final setting time of the concrete, the workability and compressive strength of concrete is also increased when ggbs and Alccofine is used as mineral additive in composition of concrete. The binding properties of ggbs and Alccofine will reduce the water content in concrete mix to enhance the properties of concrete. Being cheaper in cost it can be used in low budget construction and it improves high compressive strength, tensile strength, high flexural strength.

1.1 Literature review

[1]Grain size distribution plays a vital role for characterization of soil. Particle size distribution (PSD) in a soil mass is a character which gives a major idea about bearing capacity of soils and bearing capacity of the soil is a key parameter to design foundation of any civil engineering structure. Indian Standards has classified the soils as per particle size gradation. As per I S Code range of the particle size varies from boulder to clay. This paper discusses about the results of particle size distribution of varied soil stratum at a construction location in Jabalpur M.P. Present paper also suggests some recommendations about types of foundation and suitable methods for ground improvement.

[2] In this research study, the effect of magnetized water on workability and compressive strength of concrete was studied, in order to obtain operative concrete with high resistance and at a lower cost. Data were collected from previous studies and researches. The magnetized water was prepared using the magnetic treatment system. Four concrete mixes were prepared, one without magnetized water and three with. Cement reduction of 12.5 % and 25 % was imposed on the last two mixes with magnetized water. Slump and compressive strength tests were carried out on all four mixes and it was found out that concrete produced by the magnetic technology is easy to operate without affecting the compressive resistance of concrete. It was also found that magnetized water increases the compressive resistance of concrete while cement is reduced up to 25 %.

[3] In consideration of higher specifications for concrete, particularly in strength, the proportion of ingredients is usually modified to satisfy the mix design requirements. However, its practicality is not always appropriate in construction because of the expense and availability of the materials. Hence, additives and supplementary materials are adopted in the mix design with present studies directed to the application of nanoclay constituents to concrete technology. Consequently, the study is concerned with the utilization of nano-montmorillonite and halloysite nanoclay as partial substitutes to cement in which the workability and compressive strength of concrete are investigated at combined replacements of these nanoclays. The results show that the workability of fresh concrete generally decreased at the addition of nanoclay in the mix wherein a maximum loss of 50.000 percent in the slump is observed for 5% replacement of the nanoclay combination. In addition, a 28th-day compressive strength of 44.541 MPa is achieved as the highest among the concrete samples at 3% replacement which demonstrates an increase by 27.430 % compared to a control specimen with strength of 34.954 MPa. It is also recognized that there is a parabolic trend of compressive strength with respect to the amount of nanoclay replacement which indicates that the strength of concrete continues to increase until the optimal value of nanoclay replacement is attained.

[4] The World Earth Summits in Rio de Janeiro, Brazil and Kyoto, Japan in 1992 and 1997 respectively, have made it clear that uncontrolled increased emission of greenhouse gases to the atmosphere is no longer environmentally and socially acceptable for sustainable development. The increase of cement production will affect the environmental preservation, natural conservation and increase the CO2 emission, which is one of the primarily gases that contribute to the global warming. The use of ground granulated blast furnace slag (ggbs) to replace a part of Portland cement in concrete can reduce the CO2 emission. It also can provide significant benefits to concrete properties, such as increase the workability and durability of concrete. The early strength of ggbs concretes that had been cured at standard curing temperature (200C) were slower than that of concretes with Portland cement only, cured at the same temperature. However, there are some indications show that curing the ggbs concrete at elevated temperatures will significantly enhanced the early age strength of the concrete. The objectives of this research are to find out the effect of curing temperatures and levels replacement of Portland cement by ggbs on the strength development of concretes. The levels of ggbs to replace Portland cement were 0, 20, 35, 50 and 70%, while the curing temperatures were 200C, 500C and adiabatic curing. The concrete cubes were tested at ages: 6 and 12 hours, 1, 2, 4, 8, 16, 32, 64, 128, 256 and 365 days. The results showed that curing the ggbs concrete at temperatures higher than standard curing temperature, increased the strength development of the concrete at early ages.

[5] In the present investigation Ground Granulated Blast Furnace Slag (GGBS) is used as replacement to cement by weight. The GGBS is used as partial replacement for cement in the concrete mix with particles in the range of 125-250μm, 90- 125μm, 45-90μm, 20-45μm and <20μm. The dosage of GGBS is varied from 10% to 40% at an increment of 10% to evaluate the compressive strength of concrete along with micro structural analysis of concrete. The micro structural study is carried out using scanning electron microscopy (SEM) and energy dispersive spectrometer (EDS).The two main compounds observed in the study are Silica and Calcium, their consumptions before and after the pozzolonic reactions. The optimum compressive strength is observed for <20 μm size particles at 20% replacement level and it are also observed that the consumption of calcium is more for the above said replacement.

[6] GGBS based Geo polymer concrete is innovative composite material for civil engineering industry for which binding material cement and water is replaced by pozzolanic material like fly ash, GGBS and activated by highly alkaline solutions to act as a binder in the concrete. Mix design procedure used is proposed on the basis of quantity, fineness of fly ash, quantity of water, grading of fine aggregate, fine to total aggregate ratio and GGBS is used for M40 grade of GGBS based geo polymer concrete. The samples are cured in oven at 450C temperature for 24 hrs. The results show that the strength of geo polymer concrete increases with increase in percentage of GGBS in the mix. The strength increase up to 40% replacement of fly ash with GGBS after that it starts decreasing. In case of fly ash based geo-polymer concrete as there is no CaO content so curing takes place due to polymerization process, but with the addition of GGBS in fly ash based geo-polymer concrete curing is due to combine effect of polymerization as well as heat of hydration due to presence of alkaline solution and CaO respectively. As morality of NaOH increases from 12M to 16M, compressive strength, flexural strength, split tensile strength also increases.

[7] Geo-polymer concrete was developed from Ground Granulated Blast furnace Slag (GGBS) and dolomite which are obtained from steel and rock industries. Optimum proportions of GGBS and dolomite were found out based on the maximum compressive strength. GGBS Dolomite geo-polymer concrete can reduce construction time and cost due to high early age strength. Experimental investigations were conducted to evaluate the behavior of GGBS dolomite geo-polymer concrete short columns under axial loading. GGBS-dolomite geo-polymer concrete column showed better stress-strain behavior compared to cement concrete specimens. Parameters such as ultimate load, deflection, ductility and crack pattern of axially loaded short columns were evaluated using finite element method. It was observed that geo-polymer concrete has 28% reduction in cost/ultimate load compared to ordinary concrete. GGBS-dolomite geo-polymer concrete short columns without ductile detailing behaves similar to that of cement with ductile detailing (as per IS 13920-2016) with reduced cost/strength ratio.

[8] In this study, ground granulated blast-furnace slag (GGBS) was introduced as an additive to improve the setting and hardened properties of alkali-activated high-calcium FA binders at standard curing condition. FA was partially replaced by GGBS with contents of 0, 10%, 20%, 30%, 40% and 50% by mass to form a binary blend, which was then activated by an alkaline solution consisting of Na2SiO3 and NaOH to produce alkali-activated binders. The performance of alkali-activated high-calcium FA binders modified by GGBS was evaluated by multi-technical characterization. Moreover, the correlations between multiple properties were also analyzed. The results show that adding GGBS as an additive could accelerate the setting times of alkali-activated high-calcium FA binders. The viscosity increases with an increase in GGBS content and is closely related to the flow ability. Increasing GGBS content significantly improves the compressive strength of the paste sample, especially its early compressive strength, but makes the material more brittle. The resulting decrease of threshold and critical diameters may be the main reason for the decrease of sorptivity coefficient.

[9] Geo-polymer concrete (GPC) is a cement less concrete in which polymerization gives strength to concrete. In this present study, geo-polymer concrete was developed from Ground Granulated Blast furnace Slag (GGBS) and dolomite. The behavior of GGBS-dolomite geo-polymer concrete was found to be brittle in nature. Experimental investigations were conducted to evaluate the effect of the addition of steel fibers to GGBS-Dolomite geo-polymer concrete. Improved engineering properties were observed for steel fiber reinforced geo-polymer concrete. The performance of beam-column joints was monitored with the addition of 0.25, 0.5 and 0.75% steel fibers by volume of concrete under monotonic loading. Parameters such as ultimate load, energy absorption capacity, and ductility index and crack behavior of steel fiber reinforced geo-polymer concrete were compared with geo-polymer concrete (without steel fibers). Higher ductile behavior, energy absorption and toughness were observed along with the addition of steel fibers. The Performance of beam-column joints was evaluated by finite element method and compared with experimental results. Parametric studies were done by numerical methods and concluded that the GGBS-dolomite GPC beam-column joint has an improved load carrying capacity when compared to cement concrete beam-column joints with ductile detailing as per IS-13920 2016.

[10]Various combinations of micro silica (MS) and ground granulated blast furnace slag (GGBS) were used to produce optimum ternary concrete mixture. MS and GGBS were added according to the partial replacement method. All the mixtures were tested for workability, compressive strength, split tensile strength and flexural strength. A total of 12 ternary mixtures in three groups (S2, S3 and S4) and one control mix (S1) with 324 kg/m3 of cement content were prepared according to the binder content and all the mixture had the same water-binder ratio of 0.55. The test results proved that the workability of the ternary mixtures are increased as the GGBS content increases to certain level and it decreases as the MS content increases. The results of this study recommend that certain combinations of MS-GGBS can enhance the strength characteristics of concretes when compared MS and GGBS alone.

[11] The precursor materials for geo-polymer. Water glass was used as the alkaline activator for polymer synthesis and standard sand was used as the aggregate in the polymer composites. A series of laboratory tests including unconfined compressive strength (UCS) tests, Brazil tensile strength (BTS) tests, scanning electron microscopy (SEM) tests were carried out for mechanical and micro structural analysis. The coupled influence of the content of refuse mudstone (P) and the content of alkaline activator (Q) was investigated. Results show that it is feasible to synthesize geo-polymer using refuse mudstone, GGBS and red mud. The influence of Q on the UCS and eUCS was not evident and it was affected by P. Similarly, the influence of P and Q on the BTS of geo-polymer composites was also found to be dependent on each other.

1.2 Problem identification

The production cost of concrete we use in construction is very high so we use different methodology to bring down the high prices for example we use different type of admixtures to enhance the properties of concrete the admixture can be retarders as well as enhancer. There are so many admixtures which can be used earlier but in this review paper we can study the use molasses in the concrete mix. The additives are used to bring special properties to the fresh or hardened concrete; these special properties are related to the reduction of water consumption, increased resistance to compression or extension of the setting time, and others, they also can improve the durability, workability and strength of a concrete mixture and also is used to overcome difficult situations construction such as casts in hot or cold weather, pumping requirements, early strength requirements or specifications of a water/cement ratio very low.

2. MATERIALS

Cement: - OPC 53 grade brand – ACC confirming IS 269.
Fine aggregates: - Artificial sand – locally available basalt VSI- Vertical shaft impact.
Course aggregates – crushed stones having sizes 20mm & 10mm as per is sieve size.
Water – portable water available Having pH more than 7.
Alccofine (1203) – it is proprietary low calcium silica based mineral additive.
Ground granulated blast furnace slag (GGBFS) brand JSW GGBFS.
Admixtures – Very high ultra-range water reducer having chemical form of poly carbolic ether. (Hyper-fluid R-100)

Figure 2.1 Material mix

2.1 Ground granulated blast furnace slag (GGBFS)

Ground-granulated blast-furnace slag (GGBS or GGBFS) is obtained by quenching molten iron slag from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder.

Ground-granulated blast furnace slag is highly cementations and high in CSH (calcium silicate hydrates) which is a strength enhancing compound which increases the strength, durability and appearance of the concrete.

Table 2.1: Typical chemical composition

Calcium oxide:	40%
Silica:	35%
Alumina:	13%
Magnesia:	8%
Color:	off-white
Specific gravity:	2.9

2.2 Alccofine: Alccofine is a new generation, ultrafine, low calcium silicate manufactured in India it has distinct characterizes to enhance performance of concrete in a fresh and harden concrete. Alccofine is a specially processed product based on slag of high glass contact with highly reactivity obtained through the process of controlled granulation. Alccofine is micro fine mineral for concrete & mortar. It improves durability parameters of concrete pore structure, educe permeability & also improve pump ability and maintain PH of concrete to protect steel reinforcement. Enhanced rate of strength gain in concrete mixes with high pozzolanic material contents like fly ash, GGBS, etc.

3. TESTING METHODS

3.1 Test on cement: Cement is one of the most important materials used in construction. The strength of a structure depends upon several factors; cement quality is one of them. To achieve the desired strength of concrete and to increase the longevity of structure good quality cement should always be used.

3.2 Standard Consistency Test: In order to find out, the quantity of water required to produce a cement paste of standard consistency, which permits the Vicat's plunger confirming to IS: 5513-l976, to penetrate to a point 5 to 7mm from the bottom of the Vicat's mould standard consistency Test was conducted. The cement sample was taken in accordance with the requirements of IS: 3535-1986. To conduct the test, a paste of 300 gm of cement was prepared by mixing with water. To start with potable water weighing 25% by weight of cement was taken. Care was taken, that the gauging time was not less than 3 minutes, or more than 5 minutes. The Vicat's mould was filled with this paste; the mould was placed upon a non-porous plate. After completely filling the mould, the surface of the paste was made smooth, making it level with the top of the mould. The mould was faintly shaken to expel the air. Test block was placed in the mould, together with the non-porous resting plate, under the rod bearing the Vicat's plunger; the plunger gently lowered to touch the surface of the test block, and quickly released, allowing it to sink into the paste. The test as described above was repeated until the amount of water necessary for making up the standard consistency was found.

3.3 Test on Fine aggregate: Aggregate plays an important role in pavement construction. Aggregates influence, to a great extent, the load transfer capability of pavements. Hence it is essential that they should be thoroughly tested before using for construction. Not only that aggregates should be strong and durable, they should also possess proper shape and size to make the pavement act as rigidly. Aggregates are tested for strength, toughness, hardness, shape, and water absorption.

3.4 Sieve Analysis: It is carried out to determine particle size distribution and fineness modulus of both fine aggregates and coarse aggregates by sieving and screening as per IS: 2386(Part1)-1963 methods of test for aggregates for concrete. And to confirm the zoning of fine aggregates as per table number IV of IS: 383-1970. For sieve analysis sieves of the sizes 4.75 mm, 3.35 mm, 2.36mm, 1.18 mm, 600micron, 300micron, 150 micron and 75 micron given in Table I, conforming specification given by IS:460-1962 for test sieves (revised) were used. 1kg of air dried natural sand was collected by quartering accurately weighted by using weighing scale of capacity 25 kg and accuracy up to 0.005 kg. Weight of sample was chosen according to specifications given in table number II and IV of IS: 2386 (Part 1)-1963 (Reaffirmed 2002). Four of such samples were chosen for testing purpose. Sieves were placed over one another with largest size sieve at the top and lowest at the base followed by a pan. The sieve set was then placed on a mechanical sieve shaker and sieving was done for 10 minutes. After completion of sieving, the material retained on each sieve, accompanied by any material cleaned from the mesh, was carefully weighed and recorded in a table as explained in the chapter analysis of test results.

3.5 Specific gravity test: The test was carried to specific gravity of fine aggregate as per clause 2.4.2.1 of IS: 2386 (Part III) 1963. A sample of about 500gm was placed in a tray and covered with distilled water at room temperature. Soon after immersion, air entrapped in or bubbles on the surface of the aggregates were removed by gentle agitation with a glass rod. The sample was kept immersed for about 24 hours. The water was then carefully drained from the sample by decantation through a filter paper any material retained was returned to the sample. The aggregate including any solid matter retained on the filter paper was exposed to a gentle current of warm air to evaporate surface moisture and stirred at frequent intervals to ensure uniform drying until no free surface moisture can be seen and the material just attains a free-running condition. Care was taken to ensure that this stage is not passed. The saturated and surface-dry sample shall be weighed (weight A). The aggregate was then placed in the pycnometer which was filled with distilled water. Any trapped air was eliminated by rotating the pycnometer on its side, the hole in the apex of the cone being covered with a finger. The pycnometer was topped up with distilled water to remove any froth from the surface and so that the surface of the water in the hole is flat. The pycnometer was dried on the outside and weighed (weight B). The contents of the pycnometer shall be emptied into the tray, care being taken to ensure that all the aggregate is transferred. The pycnometer was refilled with distilled water to the same level as before, dried on the outside and weighed (weight C). Care was taken the difference in the temperature of the water in the pycnometer during the first and second weighing shall not exceed 2°C. The water was then be carefully drained from the sample by decantation through a filter paper and any material retained returned tithe sample. The sample shall be placed in the oven in the tray at a temperature of 100 to 110°C for 24 hrs, during which period it shall be stirred occasionally to facilitate drying. It shall be cooled in the air-tight container and weighed (weight D).

$$\text{Specificgravity} = \frac{(w2 - w1)}{(w4 - w1) - (w3 - w1)}$$

$$\text{Waterabsorption} = \frac{100\ (A - D)}{D}$$

Where,
w1= Weight of surface dried sample in gm

w2= Weight of pycnometer containing sample and distilled

w3= Weight of pycnometer containing distilled water

w4= Weight of oven dried sample in gm.

3.6 Test on Course aggregate (Sieve analysis): It is carried out to determine particle size distribution and fineness modulus of coarse aggregates by sieving and screening as per IS: 2386(Part1)-1963(Reaffirmed 2002) methods of test for Aggregates for concrete. And to confirm the maximum size of aggregates as per table number V of IS: 383-1970. For sieve analysis sieves of the sizes80mm, 63mm, 50mm, 40mm, 31.5mm,25mm, 20mm, 16mm, 12.5mm, 10 mm,6. 3mm, 4.75 mm given in Table I, conforming specification given by IS: 460-1962 for test sieves (revised), were used. 5kg of air dried coarse aggregate was collected by quartering accurately weighted by using weighing scale of capacity 25 kg and accuracy up to 0.005 kg. Weight of sample was chosen according to specifications given in table number II and IV of IS: 2386 (Part1)-1963 (Reaffirmed 2002). Four of such samples were chosen for testing purpose. Sieves were placed over one another with largest size sieve at the top and lowest at the base followed by a pan. The sieve set was then placed on a mechanical sieve shaker and sieving was done for 10 minutes. After completion of sieving, the material retained on each sieve, accompanied by any material cleaned from the mesh, was carefully weighed and recorded in a table as explained in the chapter analysis of test results.

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$$\text{Specific gravity} = \frac{(w2 - w1)}{(w4 - w1) - (w3 - w2)}$$

$$\text{Water absorption} = \frac{100\ (A - D)}{D}$$

Where,
w1= Weight of surface dried sample in gm

w2= Weight of pycnometer containing sample and distilled

w3= Weight of pycnometer containing distilled water

w4= Weight of oven dried sample in gm.

Slump flow test: This standard covers the test method for slump flow of self-compacting concrete with a maximum coarse aggregate size of 40 mm or less.

3.8 Procedure:

1. Wipe the internal and external surfaces of the slump cone and plate with wet cloth Place the slump cone on the plate, which is laid horizontally.
2. Fill the sample in the cone either by Method A or Method B. The case where the actual construction does not involve consolidation is referred to as Method A, and the case with vibratory consolidation is referred to as Method B.
3. In Method A, concrete is filled in one continuous layer without rodding or vibrating. In Method B, concrete is filled in three layers of equal quantities. Level each layer with a tamping rod and then rod five strokes uniformly over the area.
4. In Method A, concrete is filled in one continuous layer without rodding or vibrating. In Method B, concrete is filled in three layers of equal quantities. Level each layer with a tamping rod and then rod five strokes uniformly over the area.
5. The time from the beginning to the end of filling concrete in the slump cone shall be within 2 minutes.
6. Level the top surface of concrete with the top rim of the slump cone, and immediately raise the cone vertically by a steady upward lift without interruption. When the movement of the concrete has stopped, measure the apparently
7. Maximum diameter and the diameter at right angles to it, and take the average of both diameters as the slump flow. The measurement shall be performed once.
8. When measuring the time to 500mm flow, measure the time from the beginning of the raising of the slump cone to the moment when the apparently maximum diameter reaches 500 mm with a stopwatch to the nearest 0.1sec.
9. When measuring the time to the end of the flow, measure the time from the beginning of the raising of the slump cone to the moment when the flow visually stops with a stopwatch to the nearest 0.1 sec.

3.9 V-Funnel Test procedure:

1. About 12 liter of concrete is needed to perform the test, sampled normally. Set the V-funnel on firm ground. Moisten the inside surface of the funnel. Keep the trapdoor to allow any surplus water to drain. Close the trap door and place a bucket underneath. 2. Fill the apparatus completely with the concrete without compacting or tamping; simply strike off the concrete level with the top with the trowel. 3. Open within 10 sec after filling the trap door and allow the concrete to flow out under gravity. Start the stopwatch when the trap door is opened, and record the time for the complete discharge (the flow time). This is taken to be when light is seen from above through the funnel. The whole test has to be performed within 5 minutes.

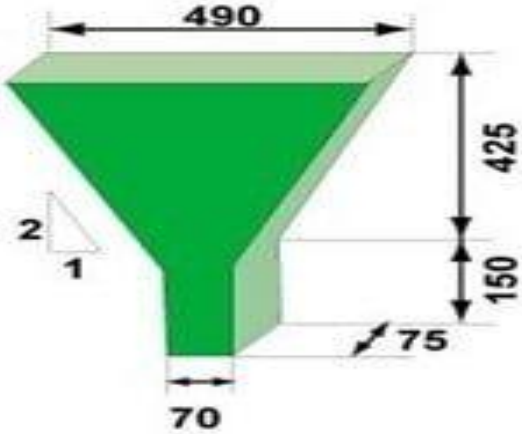

Figure 3.1 V-Funnel Apparatus

3.10 Compressive strength test:

1. The test is conducted on according to the specifications given by IS: 516 – 1959 (Methods of tests for strength of concrete, Eighteenth Reprint June 2006). BIS specified cube moulds of 150 X 150 X 150 mm size were used for the testing.
2. The cubes were filled with concrete in three layers of equal height. Each layer was compacted by a standard steel rod confirming to IS-10086:1982 of diameter 16mm and bulleted end with 35 gentle blows per layer. Care was taken that each concrete layer was compacted uniformly. The mould was filled up to top and extra concrete was scraped off using knife edge and surface was made smooth.
3. The mould ware kept under wet gunny bags for twenty four hours. After twenty four hours the cubes ware marked and removed from the moulds. The cubes are then kept under water until taken out just prior to testing.
4. Cubes were tested for compressive strength on 3th, 7th, 14st and 28th days, at the time of testing, the cubes ware removed from the water. The cubes ware wiped with dry cloth and tested on UTM for compressive strength.

4. RESULT AND DISCUSSION:

4.1 Properties of cement tested in the laboratory

Sr No	Characteristic property	Results Obtained	Standard results
1	Fineness	1.50%	Less than 10%
2	Standard consistency	34%	NA
3	Initial setting time	30 min	NA
4	Final Setting time	578 min	NA

Table No. 4.1 Properties of Cement

Result: i) cement is found 1.50% which is less than 10% from standard results. ii) 34% of water by mass of cement required to preparing a cement of standard consistency. iii)

Initial setting time of cement sample is found to be 30min final setting time of cement is found to be 578 min.

4.2 Sieve analysis on artificial sand:

IS Sieve Size	Mass Retained	Percentage Weight Passing	Cumulative % Passing
4.75 mm	61	6.10%	6.10%
2.36 mm	139	13.90%	20.00%
1.18 mm	295	29.50%	49.50%
600 mic	97	9.70%	59.20%
300 mic	181	18.10%	77.30%
150 mic	127	12.70%	90.00%
75 mic	49	4.90%	94.90%
Residue	51	5.10%	100.00%

Table No. 4.2 Gradation Analysis of Fine Aggregate

Result: i) The cumulative percentage, by weight of the total sample. ii) The percentage by weight of the total sample passing through one sieve and retained on the next smaller sieve, to residue is 5.10%.

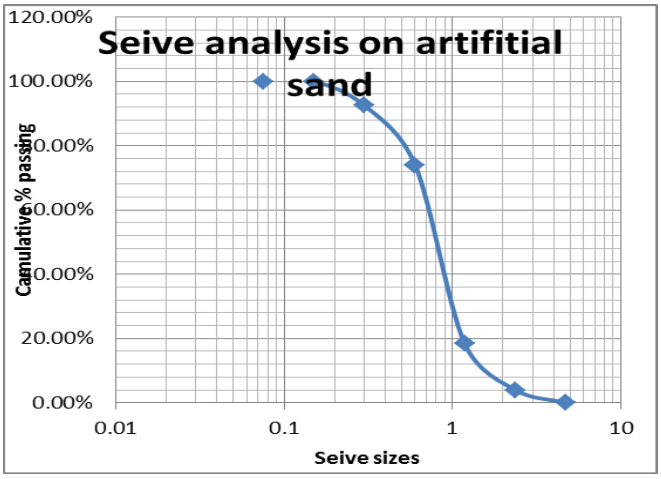

Figure No. 4.1 gradation analysis on artificial sand

Result: sieve analysis is represented by using graphic format in the grading chart of given sample conform to the specification.

4.3 Properties of all aggregates tested in the laboratory

Sr No	Characteristic property	AS	CA 10 mm	CA 20 mm
1	Fineness modulus	3.17	3.005	2.99
2	Silt content	18.65%	NA	NA
3	Specific gravity	2.79	2.88	2.92
4	Surface absorption	3.78%	1.90%	1.40%

4.4 Combined gradation analysis of all in aggregates

Sieve Size	% combined passing	Upper Limit	Lower Limit
20mm	98%	100.00%	95.00%
4.75mm	40%	50.10%	29.80%
0.6mm	18%	20.00%	12.00%
0.15mm	7%	8.00%	3.00%

4.5 Mix Design Matrices

i) Matrix-1

OPC - 53	GGBFS	F.A	C.A	W/C	Admixture	Alccofine
192 kg	448 kg	742.4 kg	1248 kg	0.24	1.92 kg	32 kg
30%	70%	39.39 %	60.61 % 20mm = 60% 10mm = 40%	153.6 lit/m3 free water Corrected water = 166.1 lit/m3	1%	5%

ii) Matrix-2

OPC - 53	GGBFS	F.A	C.A	W/C	Admixture	Alccofine
256 kg	384kg	742.4 kg	1248kg	0.25	2.048 kg	32 kg
40%	60%	39.39 %	60.61% 20mm = 60% 10mm = 40%	160 lit/m3 Free water Corrected water =170.91 lit/m3	0.8 %	5%

iii) Matrix-3

OPC - 53	GGBFS	F.A	C.A	W/C	Admixture	Alccofine
320 kg	320 kg	742.4 kg	1248 kg	0.25	2.56 kg	32 kg
50%	50%	39.39%	60.61% 20mm = 60% 10mm = 40%	160 lit/m3 free water Corrected water = 190.91 lit/m3	0.8%	5%

4.6 Comparison of slump values of matrices

Sr. No	Batch	Sample 1	Sample 2	Sample 3	Average (mm)
		Slump in mm	Slump in mm	Slump in mm	
1	Matrix 1	569.00	554.00	518.00	547.00

2	Matrix 2	614.00	638.00	654.50	635.50
3	Matrix 3	660.60	690.00	696.00	684.2

Result: The flow ability of HPC is measured in terms of spread, when using modified version of slump test. The spread (slump flow) depending of HPC ranges from 455 mm to- 810mm.

4.7 Compressive Strength Analysis

Sr No	Batch	Strength in MPa			
		3 day	7 day	14 day	28 day
1	M-1	38.78	61.18	70.82	78.88
2	M-2	40.55	66.72	74.35	81.18
3	M-3	36.88	57.46	68.44	73.22

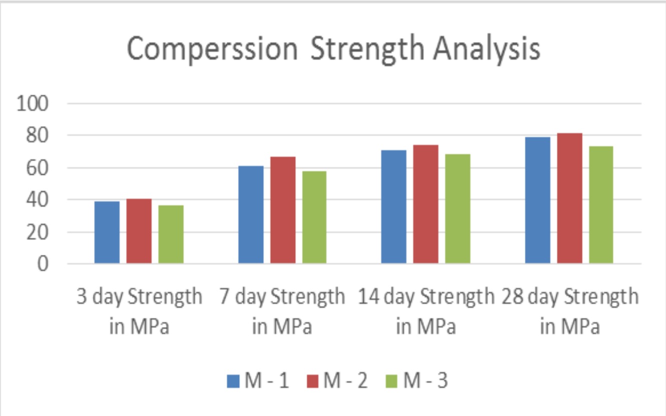

Figure No. 4.2 Compression test analysis

4.8 Results of Concrete Cube Test:

Compressive strength of the Matrix 1 = 78.88 MPa
Compressive strength of the Matrix 2 = 81.18 MPa
Compressive strength of the Matrix 3 = 73.22 MPa

4.9 Temperature test on fresh concrete:

Sr No	Batch	Fresh sample (^oC)	After 30min (^oC)	After 60min (^oC)	After 120min (^oC)
1	M - 1	22.8	22.9	23.1	26.4
2	M - 2	24.5	24.7	25.6	27.1
3	M - 3	23.3	24.1	26.6	27.9

Result: Temperature of matrix 1 after 120 min = 26.4
Temperature of matrix 2 after 120 min = 27.1
Temperature of matrix 3 after 120 min = 27.9

4.10 V-Funnel analysis

BATCH	Initial	½ Hr	1 Hr	2 Hr	3 Hr
M – 1	Bleed	Bleed	8 Sec	11 Sec	12 Sec
M - 2	Bleed	9 Sec	11 Sec	13 Sec	14 Sec
M - 3	Bleed	10 Sec	13 Sec	15 Sec	19 Sec

4.11 pH test analysis

BATCH	Initial	½ Hr	1 Hr	2 Hr	3 Hr
M – 1	12.4	11.9	11.8	11.8	11.8
M – 2	12.3	12.2	12.0	11.9	11.9
M – 3	12.1	11.2	11.0	11.0	11.0

Result: pH of fresh concrete of matrix 1 is 12.1 and matrix 2 is 12.3 and matrix 3 is 12.1

4.12 Economic Analysis

i) Rate analysis for Matrix-1

Material	Weight in kg	Rate (Rs)	Total rate(Rs)
Cement	320	5.0 / kg	1600
GGBFS	320	2.8 / kg	896
F.A (VSI)	742.2	4000 / brass	1514.69
CA 10 mm	499.2	2200 / brass	560.32
CA 20 mm	748.8	2000 / brass	764.08
Admixture	2.56	60 / kg	153.6
Alccofine	32	20 / kg	640
Processing	-------	------	500
Total cost	**6628 Rs /m3**		

ii) Rate analysis for Matrix-2

Material	Weight in kg	Rate (Rs)	Total rate (Rs)
Cement	256	5.0 / kg	1280
GGBFS	384	2.8 / kg	1075
F.A (VSI)	742.2	4000/brass	1514.69
CA 10 mm	499.2	2200/brass	560.32
CA 20 mm	748.8	2000/brass	764.08
Admixture	2.56	60 / kg	153.6
Alccofine	32	20 / kg	640
Processing	-------	------	500
Total cost			**6487.71**

iii) Rate analysis for Matrix-3

Material	Weight in Kg	Rate (Rs)	Total rate(Rs)
Cement	192	5.0 / kg	960
GGBFS	448	2.8 / kg	1254.4
F.A (VSI)	742.2	4000/brass	1514.69
CA 10 mm	499	2200/brass	560.32
CA 20 mm	748	2000/brass	764.08
Admixture	1.92	60 / kg	115.2
Alccofine	32	20 / kg	640
Processing	----	----	500
Total cost			6308.69 Rs/m3

3.13 Rate analysis on Standard Concrete

Material	Weight in Kg	Rate (Rs)	Total rate(Rs)
Cement	640	5.0 / kg	3200
GGBFS	0	2.8 / kg	0
F.A (VSI)	742.2	4000/ brass	1514.69
CA 10 mm	499.2	2200 / brass	560.32
CA 20 mm	748.8	2000 / brass	764.08
Admixture	6.4	60 / kg	384
Alccofine	0	20 / kg	0
Processing	-------	------	500
Total cost			6923.9 Rs/m3

4. CONCLUSION

The unique properties of HPC have more advantages over normal concrete owing to its material ingredients and composition. Following is the final conclusions were drawn from the dissertation study, experimental program, economic study and analysis of the test results. Matrix 3 gave the optimum strength than other percentage mixes. (Matrix-1 & Matrix-2) In rate analysis matrix-3 was reduce to cost than standard concrete up to 16.59%. Workability of concrete of matrix-2 was increases, than the standard concrete up to 13.61% .The temperature of concrete remains constant no any other treatment required to control the temperature of the concrete. No carbonation effect is created because of water cement ratio is less than 0.5 We are also consume the CO_2 emission by concrete up to 48.50%.

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