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EVALUATION OF HIGH PERFORMANCE CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH SILICA FUME NATURAL SAND AND MANUFACTURED SAND

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Abstract: Portland cement is the most important ingredient of concrete and is a versatile and relatively high cost material. Large scale production of cement is causing environmental problems on one hand and depletion of natural resources on other hand. This threat to ecology has led to researchers to use industrial by products as supplementary cementations material in making concrete. The main parameter investigated in this study is M30 grade concrete has been designed using fine aggregate comprising with manufactured sand and river sand with silica fume in High Performance Concrete (HPC). Concrete mixes were evaluated for compressive strength and flexural strength. The ordinary Portland cement was partially replaced with silica fume for various proportion of 5%, 10%, 15%, 20%.The compressive and tensile strength of conventional concrete as well as concrete made by using silica fume in river sand and m sand are going to arrived by conducted compression test and tensile test as per Indian standards.. From the test results the High Performance of concrete using silica fume is going to be evaluated.

INTRODUCTION

Concrete is produced by mixing of cement, fine aggregate, coarse aggregate and water to produce a material that can be mould into almost any shape. There are many formulation of concrete, which provide varied properties and concrete is the most used man made product in the world. Concrete is widely used for making architectural structures, foundation, brick/block walls, pavement, bridge, motorway/roads, runways, parking structures, dams, reservoirs, pipes. Mineral admixture are widely used in concrete for various reasons especially for reducing the amount of cement required for making concrete which shows to a reduction in construction cost. Moreover, most pozzolanic materials are by-product materials. The use of these materials shows the reduction in waste, freeing up valuable land, save in energy consumption to produce cement and save the environment. Durability of Portland cement concrete is defined as its ability to resist weathering action, chemical attack, abrasion, fire or another process of deterioration. In other words, cement concrete will be termed durable, when it keeps its form and shape within the allowable limits, while exposed to different environmental conditions. Durability of concrete has been a major concern of civil engineering professionals. Also, it has been of considerable scientific and technological interest over the last few decades.
The American concrete institute (ACI) defines silica fume as a ‘‘very fine non crystalline silica produced in electric arc furnaces as a by-product of production of elemental silicon or alloys containing silicon’’. Silica fume is also known as micro silica, condensed silica fume, volatized silica or silica dust. It is usually a grey coloured powder, somewhat similar to Portland cement or some fly ashes. It can exhibit both pozzolanic and cementitious properties. Silica fume has been recognized as a pozzolanic admixture that is effective in enhancing the mechanical properties to a great extent. Addition of silica fume to concrete improves the durability of concrete and also in protecting the embedded steel from corrosion. When fine pozzolana particles are dispersed in the paste, they generate a large number of nucleation sites for the precipitation of the hydration products. Therefore, this mechanism makes the paste more homogeneous and dense as for the distribution of the fine pores. This is due to the reaction between the amorphous silica of the pozzolanic and the calcium hydroxide produced by the cement hydration reactions. Silica fume is a by-product and it is the most beneficial uses in concrete. Because of its chemical and physical properties, it is a very reactive pozzolana. Concrete containing silica fume can have very high strength and can be very durable. In this paper the advantages of using silica fume in concrete in partial replacement of cement are found. The present experimentation has been carried out to determine the mechanical properties of conventional concrete and concrete using silica fume. Suitability of silica fume has been discussed by replacing cement with silica fume at varying percentage and the strength parameters were compared with conventional concrete.

CONCRETE

Concrete is a composite material composed of aggregate bonded together with fluid cement which hardens over time. Most use of the term "concrete" refers to Portland cement concrete or to concretes made with other hydraulic cements, such as cement found. However, road surface are also a type of concrete," asphalticconcrete", where the cement material is bitumen.

Concrete is one of the most widely used constructional material throughout the world. Fresh concrete or plastic concrete is a freshly mixed material which can moulded into any shape. The relative quantities of cement, aggregates and water mixed together, control the properties of concrete in the wet state as well as in hardened state.

Cement

Portland cement is the most common type of cement in general usage. It is a basic ingredients of concrete, mortar and plaster. It consists of moisture of oxides ofcalcium, silicon aluminium. Portland cement and similar material are made by heating limestone (a source of calcium) with clay and grinding this product called clinker with a source of sulphate (most commonly gypsum).in recent years, alternative have beendeveloped to help replace cement. Products such as plc (Portland limestone cement),whichincorporates limestone into the mix, are being tested. This is due to cement productionbeing one of the largest procedures of global greenhouse gas emission.

Properties of cement

- Fineness
- Soundness
- Setting time
- Compressive strength
- Specific gravity

Fine Aggregate

When the size of the aggregate is smaller than 4.75mm, termed as fine aggregate. Natural sand is generally used as fine aggregate. Sand may be obtained from pits, river, and lake or sea shore. When obtained from pits, it should be washed to free it from clean and silt. Hence it should be thoroughly washed before used. Angular grained sand produces good and strong concrete, because it has good interlocking property, while round grained particles of sand do not afford such interlocking.

Properties of fine aggregate

- Density and specific gravity
- Particle shape
- Absorption, porosity, and permeability
- Surface texture
- Hardness

Coarse Aggregate

Construction aggregate, or simply" aggregate" is a broad category of coarse particulate material used in construction, including sand, gravel, crushed stone, slag, recycled concrete and geosynthetic aggregates. Aggregates are the most mined material in the world. Aggregate are a component of composite material such as concrete and asphalt concrete.

The Aggregates serves as reinforcement to add strength to the overall composite material. Due to the relatively high hydraulic conductivity value as compared to most soils, aggregates are widely used in drainage application such as foundation and French drains, septic drain fields, retaining well drains, and road slide edge drains. Aggregate are also used as base material Under foundation, roads, and rail roads, in other words, aggregates are used as a stable foundation or road/rail base with predictable, uniform properties(e.g. to help prevent differential settling under the road or building),or as a low-cost extender that blinds with more expensive cement or asphalt to form concrete.

Properties of coarse aggregate

- Flakiness & Elongation index
- Specific Gravity
- .Bulk Density

Water

When combines water with a cementations material it forms a cement paste by the process of hydration. The cement paste glues the aggregate together, fills voids within it and allows it to flow more freely. Less water in the cement paste will yield a stronger, more durable concrete. More water will give a free flowing concrete with in a higher slump. Impure water used to make concrete can cause problems when setting or in causing premature failure of the structure.

SILICA FUME

Silica fume, also known as micro silica, is an amorphous(non-crystalline) polymorph of silicon dioxide, silica. It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production and consists of spherical with an average particle diameter of 150mm. the main field of application is as pozzolanic material for high performance concrete. Silica fume is an ultrafine material with spherical particles less than 1 □m in diameter, the average being about 0.15 □m. this makes it approximately 100 times smaller than the average cement particle. The bulk density of silica fume depends on the degree of densification in the silo and varies from 130 to 600 kg/m3. The specific gravity of silica fume is generally in the range of 2.2 to 2.3. the specific area of silica fume can be measured with the BET method or nitrogen adsorption method. It typically range from 15,000 to 30,000 m2 /kg

M sand:

Manufactured Sand is a sand produced from crushing of granite stones in required grading to be used for construction purposes as a replacement for river sand.

Manufactured sand is a substitute of river for construction purposes sand produced from hard granite stone by crushing. The crushed sand is of cubical shape with grounded edges, washed and graded to as a construction material. The size of manufactured sand (M-Sand) is less than 4.75mm.

M-sand

Properties of M sand and River sand

Properties	Type of Sand	
	M-sand	River sand
1. Textural composition (% by weight)		
Coarse Sand (4.75 – 2.00 mm)	28.1	6.6
Medium sand (2.00 – 0.425 mm)	44.8	73.6
Fine sand (0.425 – 0.075 mm)	27.1	19.8
2. Specific gravity	2.63	2.67
3. Bulk density (kN/m^3)	15.1	14.5
4. pH	10.11	8.66
5. Chemical composition of M-sand		
M-sand contrains elements like Si, Al, Ca, Mg, Na, K, Fe, etc.		

Advantages of Manufactured Sand

- It is well graded in the required proportion.
- It does not contain organic and soluble compound that affects the setting time and properties of cement, thus the required strength of concrete can be maintained.
- It does not have the presence of impurities such as clay, dust and silt coatings, increase water requirement as in the case of river sand which impair bond between cement paste and aggregate. Thus, increased quality and durability of concrete.
- M-Sand is obtained from specific hard rock (granite) using the state-of-the-art International technology, thus the required property of sand is obtained.
- M-Sand is cubical in shape and is manufactured using technology like High Carbon steel hit rock and then rock on rock process which is synonymous to that of natural process undergoing in river sand information.
- Modern and imported machines are used to produce M-Sand to ensure required grading zone for the sand.

OBJECTIVE

The main objective of this project is to evaluatethe strength of concrete with the replacement of M-sand by river sand, at an addition of silica fume with cement.

FOLLOWING METHODOLOGY PROPOSED BY

- Literature collection
- Materials procurements
- Testing of materials
- Preparation of design mix
- Casting of specimens
- Testing of specimens

REVIEW OF LITERATURE

BEAMS

N. Ganesan, P.V. Indira and Ruby Abraham "***STEEL FIBRE REINFORCED HIGH PERFORMANCE CONCRETE BEAM-COLUMN JOINTS SUBJECTED TO CYCLIC LOADING"***ISET Journal of Earthquake Technology, Technical Note, Vol. 44, No. 3-4, Sept.-Dec. 2007, pp. 445–456 ST N.

This paper describes the experimental results of ten steel fibre reinforced high performance concrete (SFRHPC) exterior beam-column joints under cyclic loading. The M60 grade concrete used was designed by using a modified ACI method suggested them. Volume fraction of the fibres used in this study varied from 0 to 1% with an increment of 0.25%. Joints were tested under positive cyclic loading, and the results were evaluated with respect to strength, ductility and stiffness degradation. Test results indicate that the provision of SFRHPC in beam-column joints enhances the strength, ductility and stiffness, and is one of the possible alternative solutions for reducing the congestion of transverse reinforcement in beam column joints. Also, an attempt has been made to compare the shear strengths of beam-column joints obtained by using the models. As these models are meant for the joints in ordinary concrete, comparison was not found to be satisfactory.. The proposed model was found to compare satisfactorily with the test results.

*S.Shanmugam, et.al," **Effects Of Corrosion On Reinforced Concrete Beams With Silica Fume And Polypropylene Fibre"***

International Journal of Civil, Environmental, Structural, Construction and Architectural Engineering Vol:7, No:2, 2013.

Reinforced concrete has good durability and excellent structural performance. But there are cases of early deterioration due to a number of factors, one prominent factor being corrosion of steel reinforcement. The process of corrosion sets in due to ingress of moisture, oxygen and other ingredients into the body of concrete, which is unsound, permeable and absorbent. Cracks due to structural and other causes such as creep, shrinkage, etc also allow ingress of moisture and other harmful ingredients and thus accelerate the rate of corrosion. There are several interactive factors both external and internal, which lead to corrosion of reinforcement and ultimately failure of structures. Suitable addition of mineral admixture like silica fume (SF) in concrete improves the strength and durability of concrete due to considerable improvement in the microstructure of concrete composites, especially at the transition zone. Secondary reinforcement in the form of fibre is added to concrete, which provides three dimensional random reinforcement in the entire mass of concrete. Reinforced concrete beams of size 0.1 m X 0.15 m and length 1m have been cast using M 35 grade of concrete. The beams after curing process were subjected to corrosion process by impressing an external Direct Current (Galvanostatic Method) for a period of 15 days under stressed and unstressed conditions. The corroded beams were tested by applying two point loads to determine the ultimate load carrying capacity and cracking pattern and the results of specimens were compared with that of the companion specimens. Gravimetric method is used to quantify corrosion that has occurred.

M. Kaarthik, and K.Subrmanian " ***Flexural Behavior of Concrete Beams using Recycled Fine Aggregate and Steel Fibres***" International Conference on Biological, Civil and Environmental Engineering (BCEE-2014) March 17-18, 2014 Dubai (UAE)

The feasibility of making concrete with silica fume with partial replacement for cement and recycled fine aggregate with partial replacement for Fine aggregate has already been established individually. Its mechanical properties and durability have been extensively studied. However, its application as structural concrete has hardly been studied. This research work focuses on both partial replacement of river sand with R.F.A and partial replacement of Silica fume with cement and by addition of fibers, to minimize the waste disposal problem and also to increase strength of concrete. Different replacement levels were tried and optimum replacement percentage of cement and sand is obtained using Silica Fume and R.F.A. In addition steel fibres were added at various percentage levels with the optimum mix. With the objective of establishing the characteristics of silica fume and R.F.A as a structural material, investigations are carried out by casting concrete beams of size 100mm x 150mm x 1200mm in the laboratory using the optimum mix.

Kumaravel, et al,"***Flexural Behaviour Of Geopolymer Concrete Beams"*** International Journal of Advanced Engineering Research and Studies E-ISSN2249–8974

The production of Ordinary Portland Cement (OPC) causes pollution to the environment due to the emission of CO2. As such, an alternative material has been introduced to replace OPC in the concrete. Low calcium Fly ash based is a by-product from the coal industry, which is widely available in the world. Fly ash is rich in silicate and alumina, hence it reacts with alkaline solution to produce alumina silicate gel that binds the aggregate to produce a good concrete. The compressive strength increases with the increase is fly ash fineness and thus the reduction in porosity is obtained. The flexural behaviour of geopolymer concrete (GPC) beams and control cement concrete beams are studied. The beams are cast over an effective span of 3000 mm and tested up to failure under static loads. The load-displacement response of the geopolymer concrete beams and control beams are obtained and compared with the theoretical results. The results show that the geopolymer concrete beams exhibit increased flexural strength. The deflections at different stages including service load and peak load stage are higher for GPC beams.

Arivalagan.S"***Flexural Behaviour Of Reinforced Fly Ash Concrete Beams"***InternationalJournal of Structural and Civil Engineering ISSN : 2277 7032(Volume 1 Issue 1).

This paper deals with an experimental study on the properties of concrete containing fly ash. The flexural behaviour of fly ash concrete beams with and without reinforcement was conducted in this study. The addition of fly ash content used was 10% and 20% of mass basis. All beams had the same dimensions tested under two point load. The experiment results showed that addition of fly ash into Portland cement improves the tensile strength and improves the cracking behaviour in terms of significant increase in first crack load and the formation of large number of finer cracks. However, only marginal improvement was observed in the case of ultimate load.

G. Venkatesanet.al,***"Flexural Behaviour Of Reinforced Concrete Beams Using High Volume Fly Ash Concrete Confinement In Compression Zone"***Journal of Civil Engineering (IEB), 41 (2) (2013) 87-97.

In India, the total production of fly ash is nearly as much as production of cement. But utilization of fly ash is only about 5% of the population in India. In the recent days, the importance and use of fly ash in concrete has grown so much that it has almost become a common ingredient in concrete. This project deals with flexural behaviour of reinforced concrete beam using high volume fly ash concrete confinement in compression zone. To study fly ash mixed concrete, the various mix designs are prepared for various proportions of Fly Ash in proportions of cement such as 0%, 50%, 55%, and 60% for M40 grade of concrete. Based on the results, 50 percent replacement of fly ash with cement and addition of 1.5 percent super plasticizer gave better compressive strength and the result is taken for analysis of Flexural behaviour of R.C.C beams using High Volume Fly Ash concrete confinement in compression zone. The experiments show that strength of R.C.C beam using high volume fly ash concrete is less at earlier stages and it gains more strength at later stage than the conventional concrete.

Y.M.Pudale1 et.al,***"Comparative Study Of Flexural Behaviour Of R.C.C Beam And Fly Ash Reinforced Concrete Beam Wrapped With Gfrp Sheet"***International Journal of Advance Research In Science And Engineering IJARSE.

This paper investigates the Comparative Study of Flexural behavior of R.C.C. beam wrapped with GFRP(Glass Fiber Reinforced Polymer) sheet. A total 8 beams, with (150×150) mm rectangular cross section and of span 700 mm were casted and tested. Three main variables namely, Initial Crack Load, Ultimate Load Carrying capacity,and deflection of Fly Ash reinforced beam and R.C.C. beam were investigated. In first set of four R.C.C beams two were strengthened with GFRP sheet in single layer from tension face which is parallel to beam axis subjected to static loading tested until failure; the remaining two beams were used as a control specimen. In second set of four Fly Ash Reinforced beams two were strengthened with GFRP sheet tested until failure ; the remaining two were used as a control specimen. Comparison has been made between results of two sets.

EXPERIMENTAL WORK

GENERAL

The material used for casting of structural elements should provide the guarantee for the require strength to achieve the desired strength the right proportion of the materials is necessary which depends on the various properties of the constituents. The properties of the different materials used for the present work are thoroughly studied.

MATERIALS USED

CEMENT USED

Ordinary Portland cement of 43grade was used throughout the work.

COARSE AGGREGATE

Crushed granite metal obtained from a local source was as a coarse aggregate that passed through 21mm and retained in 16mm sieve was used.

FINE AGGREGATE

Locally available river sand was used as a fine aggregate which passed through 2.36mm sieve and retained in 1.18mm sieve was used.

M-SAND

Manufactured Sand is a sand produced from crushing of granite stones in required grading to be used for construction purposes as a replacement for river sand. Manufactured sand is a substitute of river for construction purposes sand produced from hard granite stone by crushing. The crushed sand is of cubical shape with grounded edges, washed and graded to as a construction material. The size of manufactured sand (M-Sand) is less than 4.75mm.

WATER

Potable water was used for mixing and curing purposes.

SILICA FUMES

Astrramicrosilica, grade 920-D, non-combustible amorphous Sio2, densified bag of 50 kg was used.Because of its extreme fineness and very high amorphous silicon dioxide content, silica fume is a very reactive pozzolanic material. As the Portland cement in concrete begins to react chemically, it releases calcium hydroxide. Silica fume reacts with this calcium hydroxide to form additional binder material known as "calcium silicate hydrate", which is very similar to the calcium silicate hydrate formed from Portland cement.

DETIALS OF TEST SPECIMEN

- ✓ Size of casted cube: 150mmx150mmx150mm
- ✓ Size of prsim:150mmx150mmx700mm
- ✓ Size of beam : 1000mmx150mmx200mm
- ✓ Grade of concrete: M30
- ✓ Total number of cubes: 30
- ✓ Total number of prism: 10
- ✓ Total number of beam: 10
- ✓ Total number of specimen casted: 50

MATERIAL TESTING

Determination of specific gravity of cement

- ➢ The density bottle was dried carefully and weighed (W1)
- ➢ About 1/3 volume of density bottle is to be filled with cement sample and weighed (W2)
- ➢ Kerosene is added to the cement when stirred with glass tube to allow entrapped air to be released. Finally the jar is filled completely with water weighed (W3)
- ➢ Density bottle is then emptied and filled with kerosene alone and weighed (W4)
- ➢ Specific gravity= 0.85*(W2-W1)/{(W4-W1)-(W3-W2)}

Specific Gravity Test for Cement

Specific Gravity Test for Cement (empty weight)

Specific Gravity Test For Cement

S.no	Weight density of empty bottle W1 (g)	Weight of dry bottle + Cement W2 (g)	Weight of density bottle + Cement + Kerosene W3 (g)	Weight of density bottle + Full Kerosene W4 (g)	Specific gravity
1.	0.26	0.43	0.77	0.67	3.1
2.	0.26	0.43	0.79	0.67	3.1
3.	0.26	0.43	0.85	0.70	3.1

Determination of Fineness of cement

- Fineness defines the surface area of cement particles present in per unit weight, which implies that more fineness means more particles in unit weight.
- Fineness modulus of cement = (100 * w2)/ w1

Fineness of cement

Fineness of cement

s.no	Weight of cement in gms (w1)	Weight of the cement retained (w2)	Fineness modulus of cement in %
1.	100	3	3
2.	100	8	8
3.	100	4	4

Determination of Consistency of Cement

- The standard consistency of a cement paste is defined as that consistency which will permit a Vicat plunger having 10 mm diameter and 50 mm length to penetrate to a depth of 33 -35 mm from the top of the mould.
- To find out the percentage of water required to produce a cement paste of standard consistency.
- Water content= weight of cement X % of water content.

Consistency of Cement

Sl.no	Water cement ratio	Water content		Depth of penetration
		percentage (%)	Ml	
1.	0.25	25	100	14
2.	0.27	27	108	15
3.	0.29	29	116	33
4.	0.31	31	124	36

The standard consistency of cement paste= 31 %

3.4.4 Determination of specific gravity of coarse aggregate

- The pycnometer should be dried carefully and weighed (W1)
- About 1/3 volume of pycnometer was filled with coarse aggregate sample and weighed (W2)
- Water was added to the sample when stirred with glass tube to allow entrapped air to be released. Finally the jar was filled completely with water weighed (W3)
- Pycnometer was emptied and filled with water alone and weighed (W4)

Table 3.4 Specific Gravity for Coarse Aggregate

S.No	Weight of pycnometer (W1)	Weight of pycnometer+sample(W2)	Weight of pycnometer+ sample+water(W3)	Weight of pycnometer + water (W4)	Specific gravity
1	455	825	1435	1195	2.85
2	455	935	1500	1195	2.74
3	455	870	1405	1195	2.02
				Mean	2.54

3.4.5 Determination of specific gravity of fine aggregate

- The pycnometer was dried carefully and weighed (W1)
- About 1/3volume of pycnometer was filled with fine aggregate sample and weighed (W2)
- Water was added to the sand when stirred with glass tube to allow entrapped air to be released. Finally the jar was filled completely with water weighed (W3)
- Pycnometer was then emptied and filled with water alone and weighed (W4)

Table:3.5 Specific Gravity for Fine Aggregate

Si no	Wt of empty pycnometer (W1)	Weight of sample (W2)	Weight of sample+ water (W3)	Weight of water (W4)	Specific gravity value
1.	450	898	1.527	1.243	2.77
2.	450	770	1.405	1.215	2.88
3.	450	765	1.425	1.216	3.01
mean value specific gravity value =					2.74

3.4.6 Determination of grain size distribution using sieve for fine aggregate

- A oven dry soil sample of about 1000g is to be taken.
- The sieves are to be cleaned and the empty weight are to be taken.
- Then arrange the sieves in order and place the soil at top sieve. Shake the sieve set using a mechanical shaker for 5 – 10 minutes.
- The material retained on each sieve is to be weighed. The sum of the retained soil weights is to be checked.

Table 3.6 Sieve Analysis Test For Fine Aggregate

Si no	Sieve opening	Empty wt of sieve	Wt of sand sieve	Wt of soil retained	% of soil retained	Cummulative %of soil retained	% finess passing
1	4.75 mm	425	430	5	1	1	99
2	2.36 mm	340	345	5	1	2	98
3	1.18 mm	360	390	30	6	8	92
4	600 micron	345	660	315	63	71	29
5	300 micron	345	345	0	0	71	29
6	150 micron	320	455	135	27	98	2
7	received	225	235	10	2	100	0

3.4.7 Determination of grain size distribution using sieve for M sand

- A oven dry soil sample of about 1000g is to be taken.
- The sieves are to be cleaned and the empty weight are to be taken.
- Then arrange the sieves in order and place the soil at top sieve. Shake the sieve set using a mechanical shaker for 5 – 10 minutes.
- The material retained on each sieve is to be weighed. The sum of the retained soil weights is to be checked.

3.4.8 Determination of specific gravity of M sand:

- The pycnometer was dried carefully and weighed (W1)
- About 1/3volume of pycnometer was filled with fine aggregate sample and weighed (W2)
- Water was added to the sand when stirred with glass tube to allow entrapped air to be released. Finally the jar was filled completely with water weighed (W3)
- Pycnometer was then emptied and filled with water alone and weighed (W4)

3.5 CONCRETE MIX DESIGN

The design of concrete mix specified grade involves the economical selection of relative proportion of cement, fine aggregate, coarse aggregate and water. Although compliance with respect to characteristics strength is the main criteria for acceptance, it is implicit that concrete must also have desired workability in the fresh state and impermeabilityand hardened state. Mix design on recommended guide lines is really a process of making an initial guess at optimum combination of ingredients and final mix proportion is obtained only on the basis of further rail mixes. As mentioned earlier under the project a comparative study is being carried, as such only type on fine aggregate is varied and all other ingredients are kept constant. To arrive at a concrete mix for this study mix design kept constant. To arrive at a concrete mix design for this study M_{30} concrete was carried as per IS code.

Table 3.9 MixProportion forM30 Grade Concrete(1:1.85:3.2)

Water	Cement (kg)	Fine aggregate (kg)	Coarse aggregate (kg)
175	389	720	1257

Table 3.10 Detail of Mix Proportion (River sand and M sand)

Trail	Cement in %	Fine aggregate in %	Coarse aggregate in %	Silica fume in %
conventional	100	100	100	-
Trail-1	95	100	100	5
Trail-2	90	100	100	10

Trail-3	85	100	100	15
Trail-4	80	100	100	20

3.6PREPARATION OF TEST SPECIMEN:

3.6.1 Preparation of mould

Before assembling the moulds, make sure that there is no hardened mortar or dirt on the faces of the flange that prevent the sections from fitting together closely .These faces must be thinly coated with mould oil to prevent leakage during filling, and a similar oil film should be provided between the contact surfaces of the bottom of the mould and the base. The inside of the mould must also be oiled to prevent the concrete from sticking to it. The two section must be bolted firmly together, and the moulds held down firmly on the base plate.

3.6.2 Mixing of concrete

Thorough mixing of the materials is essential for the production of uniform concrete. The mixing should ensure that the mass becomes homogeneous, uniform in colour and consistency. The concrete shall be mixed by hand or preferably in a laboratory batch mixer, in such a manner as to avoid loss of water or other materials. Each batch of concrete shall be of such a size as to leave about 10 percent excess after moulding the desired number of test specimens.

3.6.3 Filling the cube moulds and compacting the concrete

After the sample has been remixed, immediately fill the cube moulds and compact the concrete, either by hand or vibration. Any air trapped in the concrete will reduce the strength of the cube.

Hence, the specimens must be fully compacted 150 mm moulds filled in three approximately equal layers (50 mm deep). A compacting bar is provided for compact the concrete. It is a 380 mm long steel bar, weighs 1.8 kg and has a 25 mm square end for ramming. During the compaction of each layer with the compacting bar, the strokes should be distributed in a uniform manner over the surface of the concrete and each layer should be compacted to its full depth. The minimum number of strokes per layer required to produce full compaction will depend upon the workability of the concrete, but at least 35 strokes will be necessary except in the case of very high workability concrete. After the top layer has been compacted, a trowel should be used to finish off the surface level with the top of the mould, and the outside of the mould should be wiped clean.

3.6.4 De moulding of test specimens

Test specimens should be de moulded between 16 and 24 hours after they have been made. If after this period of time the concrete has not achieved sufficient strength to enable de moulding without damaging the cube then the de moulding should be delayed for a further 24 hours. When removing the concrete cube from the mould, take the mould apart completely. Take care not to damage the cube because, if any cracking is caused, the compressive strength may be reduced.

Figure 3.9 De Moulding of Specimen

3.6.5 Curing of specimen

Specimen must be cured before they are tested. Unless required for test at 24 hours, the cube should be placed immediately after de moulding in the curing tank.

The curing temperature of the water in the curing tank should be maintained at 27-30°C. curing should be continued as long as possible up to the time of testing.

In order to provide adequate circulation of water, adequate space should be provided between the specimens, and between the specimen and the side of the curing tank. If curing is in a moist room, there should be sufficient space between specimens to ensure that all surface of the specimens are moist at all times.

Figure:3.10Curing of Specimen

Figure :3.11 After finishing

Table 3.11 Details of Cubes Specimen for 28 Days

Specimen tested	Properties test	Type		Size mm	No.of specimens
		Silica fume in river sand	Silica fume in M sand		
Cube	28 days compressive strength	Conventional	conventional	150x150x150	6
	28 days compressive strength	5% replacement	5% replacement	150x150x150	6
	28 days compressive strength	10% replacement	10% replacement	150x150x150	6
	28 days compressive strength	15% replacement	15% replacement	150x150x150	6
	28 days compressive strength	20% replacement	20% replacement	150x150x150	6

Figure: 3.12 Casting of Cubes

Table 3.12 Details of PCC Prism Specimen

Specimen tested	Properties test	Type		Size mm	No.of specimens
		Silica fume in river sand	Silica fume in M sand		
PCC prism	28 days flexural strength	Conventional	conventional	700x150x150	2
	28 days flexural strength	5% replacement	5% replacement	700x150x150	2
	28 days flexural strength	10% replacement	10% replacement	700x150x150	2
	28 days flexural strength	15% replacement	15% replacement	700x150x150	2
	28 days flexural strength	20% replacement	20% replacement	700x150x150	2

Figure :3.13 Prism casting

Table 3.13 Details of Reinforced Beam Specimen

Specimen tested	Properties test	Type		Size mm	No.of specimens
		Silica fume in river sand	Silica fume in M sand		
Beam	28 days flexural strength	Conventional	conventional	1000x150x200	2
	28 days flexural strength	5% replacement	5% replacement	1000x150x200	2
	28 days flexural strength	10% replacement	10% replacement	1000x150x200	2
	28 days flexural strength	15% replacement	15% replacement	1000x150x200	2
	28 days flexural strength	20% replacement	20% replacement	1000x150x200	2

Figure: 3.14 Casting of Beam

RESULTS AND DISCUSSION

4.1 COMPRESSIVE STRENGTH

The compressive strength of a material is that value of uniaxial compressive stress reached when the material fails completely. The compressive strength is usually obtained experimentally by means of a compressive strength. The apparatus used for this experiment is the same as that used in a tensile test. However, rather than applying a uniaxial tensile load, a uniaxial compressive load is applied. As can be imagined, the specimen (usually cylindrical) is shortened as well as spread laterally.

Even in a compressive test, there is a linear region where the material follows hooks law. Hence for this region $\sigma = E\epsilon$ where this time E refers to youngs modules for compression.

There is a difference between the engineering stress and true stress. By its basic definition the uniaxial stress is given by:

$$\sigma = F/A$$

where, F = Load applied(N), A = Area (m^2)

it is one of the most important properties of concrete and influence many other describable properties of the hardened concrete. The mean compressive strength required at a specific age, usually 28 days, determines the nominal water cement ratio of the mix.

Compressive strength of concrete is usually found by testing cubes and prisms. Cube of size 150 mm x 150 mm x 150 mm concrete specimens were casting using M_{30} grade concrete. Specimens with nominal concrete and silica fume, glass powder (glass powder and silica fume is a partially replacement if cement) were casted. During casting the cubes were manually compacted using tamping rods. After 24 hours, the specimen were removed from the mould and subjected to water curing for 28 days. After curing, the specimens were tested for compressive strength using a compressive testing machine.

$$f_c = p/bd$$

Figure :4.1compressive strength testing of Specimen

Table 4.1 Compressive Test On Cubes (River Sand)

S.No	Types of specimen	Compressive	
	Silica fume	Load in KN	Strength in N/mm^2
1	Conventional	695	31.6
2	5% replacement	710	32.5
3	10% replacement	765	34.0
4	15% replacement	810	36.1
5	20% replacement	840	37.5

Table 4.2 Compressive Test On Cubes (M sand)

S.No	Types of specimen	Compressive	
	Silica fume	Load in KN	Strength in N/mm^2
1	Conventional	780	34.61
2	5% replacement	857	38.54

3	10% replacement	895	39.75
4	15% replacement	930	41.33
5	20% replacement	945	42.10

4.2 FLEXURAL STRENGTH OF PRISM

Flexural strength is the one of the measure of tensile strength of concrete. It is the ability of a beam to resist failure in bending. It is measured by loading un-reinforced 150 mm x 150 mm concrete prism with a span of 700 mm. Prism of size 150 mm x 150 mm x700 mm were casting using M_{30} grade concrete. Specimens with nominal concrete and silica fume, glass powder concrete (silica fume and glass powder is partially replaced with cement) were casted. During moulding, the prisms were manually compacted using tamping rods. After 24 hours, the specimen were removed from the mould and subjected to water curing for 28 days. After curing, the specimens were tested for compressive strength on a standard reinforced concrete. The bed of testing machine should be supported, and these rollers should be mounded that the distance from center is 300 mm for 700 mm specimen. The prism is simply supported and subjected to one third points loading flexure failure. The maximum tensile stress reached in the modulus of rupture values for concreteusing silica fume and glass powder.

The flexural strength is expressed as "modulus of rupture" (MR) in N/mm^2

f_b = 3pl/2bd2

where,

p = maximum load in N applied to the specimen.

L = measured length in cm of the specimen.

d = measured depth in cm of the specimen.

b = measured breath in cm of the specimen.

Figure No 4.3 Testing Of PCC Prism

While performing bending test on the silica fume and glass powder shows an increased strength in 10% replacement.

Table 4.3Flexural Strength On PCC Prism (River sand)

S.No	Type of specimen	Flexural	
	Silica fume	Load in KN	strength in N/mm²
1	Conventional	13×10^3	3.90
2	5% replacement	18×10^3	5.60
3	10% replacement	22×10^3	6.84
4	15% replacement	34×10^3	10.57
5	20% replacement	54×10^3	16.80

Table 4.4Flexural Strength On PCC Prism (M sand)

S.No	Type of specimen	Flexural	
	Silica fume	Load in KN	strength in N/mm²
1	Conventional	15×10^3	4.66
2	5% replacement	21×10^3	6.53
3	10% replacement	26×10^3	8.01
4	15% replacement	37×10^3	11.51
5	20% replacement	55×10^3	17.10

4.3 FLEXURAL STRENGTH OF RCC BEAMS

Flexural strength is the one of the measure of tensile strength of concrete. It is the ability of a beam to resist failure in bending. It is measured by loading reinforced 200 mm x 150 mm concrete beam with a span 1000 mm. Beam of size 200 mm x 150 mm x 1000 mm were casting using M_{30} grade concrete. Specimens with nominal concrete and silica fume, glass powder concrete (glass powder and silica fume is partially replaced with cement) were casted. During moulding, the beams were manually compacted using tamping rods. After 24 hours, the specimens were removed from the mould and subjected to water curing for 28 days. After curing, the specimens were tested for compressive strength on a standard reinforced concrete. The bed of testing machine should be supported, the these roller should be mounded that the distance from cener is 300 mm for 1000 mm specimen. The beam is simply supported and subjected to one third points loading flexural failure. The maximum tensile stress reached in the modulus of rupture values for concrete using silica fume, glass powder.

The flexural strength is expressed as "modulus of rupture" (MR) in N/mm^2

$$f_b = 3pl/2bd^2$$

where,

p = maximum load in N applied to the specimen.

L = measured length in cm of the specimen.

d = measured depth in cm of the specimen.

b = measured breath in cm of the specimen.

Table 4.5Load Vs Deflection Curve for River sand and M-sand Beam

Load (Kn)	Deflection (Div) conventional	Deflection (Mm) River Sand	Deflection (Div) conventional	Deflection (Mm) M-Sand
5	0	0	0	0
10	30	0.30	25	0.19
15	82	0.82	55	0.55
20	104.5	1.04	78	0.78
25	152	1.52	110	1.10
30	193.5	1.93	135.5	1.35
35	241	2.41	175.5	1.75
40	302.5	3.02	205.5	2.05
45	382	3.82	238	2.38
50	456	4.56	300.5	3.00
55	509.5	5.09	380	3.80
60	578	5.78	440.5	4.40
65	603	6.03	520	5.20
70	664	6.64	580.5	5.80
75	700	7.00	630	6.30
80	735	7.35	690	6.90

Table 4.6Load Vs Deflection Curve for River sand and M-sand Beam (5% silica fume)

Load (KN)	Deflection (Div) 5% Silica Fume	Deflection (Mm) River Sand	Deflection (Div) 5% Silica Fume	Deflection (Mm) M-Sand
5	0	0	0	0
10	26	0.26	21	0.21
15	56	0.56	51	0.51
20	85	0.85	70	0.70
25	126	1.26	115	1.15
30	144.5	1.44	135	1.35

35	170	1.70	160.5	1.60
40	220.5	2.20	210.5	2.10
45	255	2.55	240	2.40
50	270	2.70	255	2.55
55	295.5	2.95	280.5	2.80
60	340.5	3.40	310.5	3.10
65	380.5	3.80	360.5	3.60
70	420.5	4.20	390.5	3.90
75	445.5	4.45	410.5	4.10
80	460	4.60	430.5	4.30

Table 4.7Load Vs Deflection Curve for River sand and M-sand Beam

Load (Kn)	Deflection (Div) 10% Silica Fume	Deflection (Mm) River Sand	Deflection (Div) 10% Silica Fume	Deflection (Mm) M-Sand
5	0	0	0	0
10	0	0	0	0
15	25	0.25	0	0
20	64	0.64	55	0.55
25	110	1.10	120	1.20
30	144.5	1.44	138.5	1.38
35	168	1.68	160	1.60
40	200	2.00	190	1.90
45	240	2.40	210	2.10
50	265	2.65	245.5	2.45
55	295.5	2.95	270.5	2.70
60	320.5	3.20	300.5	3.00
65	350.5	3.50	340.5	3.40
70	400.5	4.00	390.5	3.90
75	425.5	4.25	410.5	4.10
80	445.5	4.45	435.5	4.35

Table 4.8 Load Vs Deflection Curve for River sand and M-sand Beam

Load (Kn)	Deflection (Div) 15% Silica Fume	Deflection (Mm) River Sand	Deflection (Div) 15% Silica Fume	Deflection (Mm) M-Sand
5	0	0	0	0
10	0	0	0	0
15	0	0	0	0
20	10	0.10	0	0
25	19	0.19	20	0.20
30	40	0.40	33	0.33
35	55	0.55	50	0.50
40	95	0.95	90	0.90
45	120	1.20	110	1.10

50	126	1.26	122	1.22
55	160	1.60	150	1.50
60	250	2.50	240	2.40
65	310	3.10	305	3.05
70	335	3.35	320	3.20
75	360	3.60	345	3.45
80	395	3.95	385	3.85

Table 4.9 Load Vs Deflection Curve for River sand and M-sand Beam

Load (Kn)	Deflection (Div) 20% Silica Fume	Deflection (Mm) River Sand	Deflection (Div) 20% Silica Fume	Deflection (Mm) M-Sand
5	0	0	0	0
10	0	0	0	0
15	0	0	0	0
20	0	0	8	0.08
25	15	0.15	19	0.19
30	45	0.45	35	0.35
35	58	0.58	54	0.54
40	82.5	0.82	79	0.79
45	112.5	1.12	103	1.03
50	135.5	1.35	126	1.26
55	156	1.56	150	1.50
60	182	1.82	177	1.77
65	197	1.97	194	1.94
70	210	2.10	202	2.02
75	242	2.42	234	2.34
80	260	2.60	256	2.56
85	272	2.72	278	2.78
90	310	3.10	292	2.92

SUMMARY AND CONCLUSION

We have tested compressive strength and flexural strength of reference concrete by casting cubes of size (150 x 150 x 150), prism size is (700 x 150 x 150), beam size is (1000 x 150 x 200) and after 28 days curing the result were obtained and tabulated are shown in the previous chapters.

Based on the experimental investigation, the following results have been found.

28 days strength of concrete with M-sand is higher than that of with River sand. Also, due to the superior gradation of M-sand gave good plasticity to mortar providing excellent workability.

Silica fume with Manufactured sand combination has achieved 5%, 10%, 15%,20% higher than the target strength at age of 28 days and other strength parameters such as compressive strength and flexural strength also slightly increased in this combination comparatively.

The usage of M-sand for high strength high performance concrete provides stronger and durable concrete structures which will be economical as well as environment friendly by preserving natural resources such as river sand.