Experimental Investigation of Durability Characteristics of Concrete by Adding Nano Silica, Glass Fibre and Partial Replacement of Cement by Flyash

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Abstract - **Use of concrete in present days is increased, but it does not meet the exact requirement. Therfore the partial replacement of cement by flyash, and adding glass fibre and nano silica in the concrete to meet the exact requirement. Hence the performance concrete characteristics like workability, high strength & durability increased. As these characteristics are not found in conventional concrete. Use of Nano materials is gaining importance due to its vital characteristics, these materials helps in developing concrete performance. The basic concept behind using this material is improve compressive strength at early ages, improved hydration characteristics and reduced porosity, water absorption when compared with conventional cementitious material. Glass fiber is a material consisting of numerous extremely fine fibers of glass. The high dose of glass fibers leads to high tensile strength while the high polymer content makes the concrete flexible and resistant to cracking. The disposal of fly ash has become a considerable environmental problem, because it as a waste material may cause substantial environmental hazards. To increase the usage rate, large quantities of fly ash are proposed to be incorporated in the structural and paving concrete mixes. Nanosilica, as a new material, is also known to promote concrete behavior. Here adding a glass fibre and nano silica of certain amount for increasing the strength in concrete and by improve its crack resistance, ductility, energy absorption characteristics.**

Key words— Nanosilica, fly ash, glass fibre,partial replacement, strength of concrete

I. INTRODUCTION

Concrete is a heterogeneous mix of cement, aggregates and water. But, the cement production consumes large amount of energy and emits carbon dioxide results in environmental pollution. Hence, one of the solutions to these problems is to reduce the consumption of cement and utilise Pozzolana materials for the preparation of concrete . . Fly ash is an inorganic, non-combustible by product of coal–burning power plants. Today, there is a general trend to replace higher levels of Portland cement with flyash in concrete. To improve the performance of concrete further, Nano materials are now being introduced as supplementary materials. . Nano-Silica (NS) is a Nano-sized, highly reactive amorphous silica. Due to the smaller particles size and high surface areas compared to the other pozzolanic materials, the use of nano-silica possibly enhances the performance of concrete more effectively. As the nano-silica particles are very fine and they tend to agglomerate due to high surface interaction, uniform dispersion of nano-silica is an important issue to get its beneficial effects The use of nanosilica in concrete can also protect the structure from sulphate attack and alkali silica reaction. With the use of nanosilica, concrete becomes more compact and its resistance to water permeability increases.Glass fiber is a material consisting of numerous extremely fine fibers of glass. The high dose of glass fibers leads to high tensile strength while the high polymer content makes the concrete flexible and resistant to cracking.

II. OBJECTIVE

The objective of the present research work is to find the influence of the partial replacement of cement by flyash , and adding nano silica and glass fibre on concrete on various strength properties of M20 grade of concrete. 55% of fly ash replaced by weight cement and adding .5%, and 1% of nano-silica and .5%, and 1% of glass fibre are added along the mixtures and adopted as Compressive strength, split tensile strength, flexural strength and modulus of elasticity of concrete and the results are to be compared with the controlled concrete.

III. LITERATURE REVIEW

Alirza Naji Givi s et.al. studied the size effect of nano SiO_2 particles of size 15nm and 80nm by replacement with 0-5, 1, 1.5 & 2% b.w.c. and result shows that at 1.5% gets maximum compressive strength and there after decreases, also final strength of 80nm particles is more than 15nm particles, also there is considerable improvement in flexural and split tensile strength of Nano SiO_2 blended concrete.
A. Sadrmotazi et.al. has studied effect of PP fiber along with nano SiO2 particles up to 7% which improves the compressive strength of cement mortar by 6.49% also PP fiber dosages beyond 0.3% decreases the compressive strength but beyond 0.3% dose of PP fiber increases the flexural strength which shows effectiveness of nano SiO_2 particles. Also up to 0.5% PP fibers in mortar water

absorption decreases which indicates pore refinement of nano SiO_2 particles and better dispersion of fibers. Also mortar with 0.1% PP fiber shows improvement in shrinkage. **Ali Nazari, Shadi Riahi** – studied the effect of Nano SiO_2 particles along with 3% replacement of nano particles and 45% replacement of cement by GGBFS shows improved split tensile strength. The pore structure of SCC containing SiO2 particles is improved and content of all mega pores and macro pores is decreased. They have also studied effect of ZnO2 nano particles on SCC concrete with constant w/c ratio of 0.4 and observed that by increasing the content of super plasticizer flexural strength decreases i.e. plasticizers retards the cement hydration, ZnO_2 content increased up to 4% b.w.c. increases the flexural strength of SCC. In another experimentation the same author studied effect of Al_2O_3 nano particles on properties of concrete.

Surya Abdul Rashid et.al. studied effect of Nano SiO_2 particle on both mechanical properties(Compressive, split tensile and flexural strength) and physical properties (water permeability, workability and setting time) result shows that binary blended concrete with nano SiO_2 particles up to 2% has significantly higher compressive, split tensile and flexural strength compared to normal concrete. Partial replacement of nano SiO_2 particles decreases the workability and setting time of fresh concrete for samples cured in lime solution.**Tanveer Hussain.S[1], Gopala Krishna Sastry.K.V.S[2] (2014)** have studied the strength properties of concrete by using micro and macro silica wih ordinary portland cement. Nano silica possess more pozzolanic nature, it has the capability to react with the free lime during the cement hydration and forms additional C-S-H gel which gives strength, impermeability and durability to concrete They observed that micro silica and nano silica in concrete increases strength and reduces the capillary pores. Strength parameters of concrete made with partial replacement of cement by microsilica (5%, 7.5%, 10%, 15%) and nano silica (1%,1.5%, 2%, 2.5%) in M40 and M50 grade of cement. . Cement replacement up to 7.5% with SF and up to 2% with NS, leads to increasing compressive strength, split tensile strength and flexural strength for both M40 and M50 grade. **Sridhar.C. K[1]., Vanakudre .S.B[2]** have studied the Development of High Performance Concrete Using Nano Silica. It is found that the high performance concrete can be developed by using supplementary cementetious materials & high quality superplasticizers. Use of Nano materials is gaining importance due to its vital characteristics, these materials helps in developing high performance concrete. The study aims at developing high performance concrete using Nanosilica. Initially, M60 grade concrete (high strength concrete) is designed and prepared with and without Nano silica. Then it is proposed to make this concrete as high performance concrete by using high quality superplasticizer and a better packing of coarse aggregate(40% 10mm downsize &60% 20mm down size).The test results shows that slump higher than210mm , strength 68.44 to 75.11MPa and better resistance to water obsorption **Siva Sai.A et al., (2013)** have studied the comparative studies on high strength concrete mixes using micro silica and nanosilica. One of the bye-products is Condensed Silica Fume (CSF) which enhances the durability and strength of the concrete. In the present investigation the strength of M60 and M70 concretes with the use of micro silica and in combination with colloidal nano-silica was used to study the mechanical properties. It is found from the experimental investigation that concrete composites with superior properties can be produced with the combination of micro-silica and nano-silica. It has been observed that with addition of CSF and the compressive strength of concrete at 7 days and 28 days are more than that of controlled specimens . It has been observed that the compressive strength of concrete at 7 days and 28 days are maximum with 10% CSF and 2%Nano silica

IV. MATERIALS AND METHODOLOGY

Materials required for making conventional concrete and flyash, nano silica and glass fibre are collected from the nearby source; the various material required are cement, fine aggregate, coarse aggregate. The various materials collected are prepared and batched for casting.

Materials that are used for making concrete were tested before casting the specimens. The properties obtained from the tests were used in mix design. The preliminary tests were conducted for the following materials.

- Cement
- Fine Aggregate(River sand)
- Coarse aggregate
- Flyash
- Nano silica
- glass fibre

The overall methodology is as shown in fig.1.0

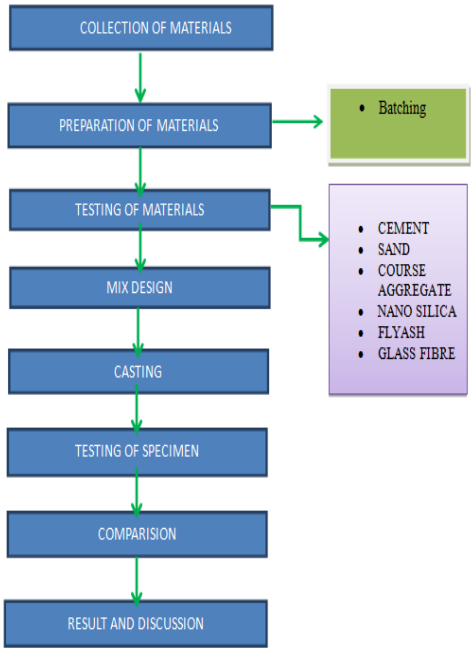

Fig.1.0 Flow chart for methodology

V. PROPERTIES OF MATERIALS

1. Cement

In the present investigation Ordinary Portland cement (OPC) of 43 Grade confirming to IS specifications was used. The properties of cement are shown in Table 1.

Table 1: Properties of Cement

S.No	Property	Value
1	Specific Gravity	3.15
2	Normal Consistency	33 %
3	Setting Time i) Initial Setting time ii) Final setting time	 40 Min 6 hours

2. Fine Aggregate

Locally available river sand confirming to IS specifications was used as the fine aggregate in the concrete preparation. The properties of fine aggregate are shown in Table 2.

Table 2: Properties of Fine Aggregate

S.No	Property	Result
1	Specific Gravity	2.6
2	Fineness Modulus	2.8
3	Bulk Density (Loose)	15.75 kN/m^3
4	Grading of Sand	Zone - II

3. Coarse Aggregate

Coarse aggregate of nominal size 20 mm and 10 mm, obtained from the local quarry confirming to IS specifications was used. The properties of coarse aggregate are shown in Table.3. The coarse aggregate used for the preparation of concrete is a mixture of 20 mm and 10 mm size aggregates in ratio 1.5: 1.0.

Table 3: Properties of Coarse Aggregate

S.No	Property	Result
1	Specific Gravity	2.60
2	Bulk Density (Loose)	14.15 kN/m^3
3	Water Absorption	0.5%
4	Fineness Modulus	7.2

4. Fly Ash

In the present experimental investigation 'Class F' Fly ash obtained from a Thermal Power Plant is used. Cement is replaced by 55% of fly ash by weight of cement. The properties of fly ash are shown in Table 4.

Table 4: Properties of Fly Ash

S.No.	Ingredient	Value
1	Silica (SiO_2)	56.88 %
2	Aluminum trioxide (Al_2O_3)	27.65 %
3	Ferric oxide (Fe_2O + Fe O)	6.28 %
4	Titanium dioxide (TiO_2)	0.31 %
	Calcium oxide (Cao)	3.6 %
	Magnesium oxide (MgO)	0.34 %
7	Sulphate (SO_4)	0.27 %
8	Loss of ignition (LOI)	4.46 %
9	Specific gravity of Fly Ash	2.12

5. Nano-Silica

Nano-silica is a new pozzolanic material commercially available in the form of water emulsion of colloidal silica. It is potentially better than the other pozzolanic materials because of high content of amorphous silica (>99%) and the reduced size of its spherical particles of order 5-10*nm*. In this experimental investigation cement is replaced by 1.5%, 3% and 4.5% of nano-silica by weight. The properties of nano-silica are shown in the Table 5.

Table 5: Properties of Nano-Silica

S.No.	Property	Actual Analysis
1	Active nano Silica Content	35-40%
2	PH	9.3 -9.6
	Specific Gravity	1.08-1.1
	Texture	Milky White Liquid
5	Dispersion	Water

6. Water

Water used for casting and curing of concrete test specimens is free from impurities which when

present can adversely influence the strength of concrete.

7. Glass fibre

Glass fiber is a material consisting of numerous extremely fine fibers of glass. The high dose of glass fibers leads to high tensile strength while the high polymer content makes the concrete flexible and resistant to cracking. The glass fibres used are of Cem-FIL AntiCrack HD with modulus of elasticity 72 GPa, Filament diameter 14 microns, specific gravity 2.68, length 12 mm and having the aspect ratio of 857, the number of fibres per kg is 212 million fibres.

VI. SUMMARY AND FUTURE WORK

The results of the experimental investigation indicate that the fly ash, glass fibre and nano-silica can be adopted as Ordinary Portland cement replacement for concrete preparation. It is very interesting to note that the variation of compressive strength, split tensile strength, flexural strength and modulus of elasticity of M20 grade fly ash concrete with nano-silica and glass fibre indicates the similar trend. The increase in various strength characteristics of concrete containing fly ash with increase in the nano-silica and glass fibre content can be due to the availability of additional binder in the presence of nanosilica. Nano silica has high amorphous silicon dioxide content. The Portland cement in concrete releases calcium hydroxide during the hydration process. The nano silica, glass fibre and fly ash reacts with the calcium hydroxide to form additional binder material. It can be concluded that the cement content can be reduced without compromising the strength of concrete by the use of nano-silica, glass fibre and flyash combination at an appropriate proportion.

In the first phase complete from literature review, material collection and some basic test

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