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EXPERIMENTAL INVESTIGATION OF STRENGTH CHARACTERISTICS OF CONCRETE BY ADDING NANO SILICA, GLASS FIBRE AND FLYASH

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Abstract

Concrete is the most important material in building which is being used in construction as a strong structural substance that is fundamental to modern civilization and culture. Plain cement concrete has a good compressive strength, but it is brittle and has low tensile strength, minimal crack resistance, and poor toughness. So, Fibers are added to concrete to improve its performance and overcome its flaws. The primary goal of incorporating fibres into the concrete matrix is to improve the concrete's post-crack reaction. In the presence of nanotechnology, the development of construction materials technology, notably concrete, is accelerating rapidly. Nano-silica is one substance that researchers should look into. From locally accessible silica sand, amorphous nano-silica with high reactivity can be produced using nanotechnology. With the rise in demand for construction materials, alternative materials are becoming increasingly important for long-term growth. The use of fly-ash as a partial replacement for cement in concrete is gaining a lot of traction these days, owing to the increased long-term durability of concrete as well as the environmental benefits. An experimental investigation is conducted on a concrete containing 20% of fly ash and nano-silica and glass fibre in the range of 0.5%, 1% & 2% of by weight of cement. In terms of workability and strength, the material is created, tested, and compared to standard concrete. The mechanical properties of concrete were determined by conducting experiments for 7, 14, and 28 days.

Keywords: *Nano Silica, Glass Fibre, Flyash, Compressive strength, Split tensile strength, Flexural strength.*

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1. Introduction

Concrete is a mixture of different materials like water, cement and aggregates, but whereas the production of cement uses greater energy and liberates CO_2 gases which causes major pollution to the environment. So as a solution for this problem and as well as to reduce the usage of cement in concrete, pozzolanic materials were introduced for the making of concrete.

Fly Ash being a non-combustble and an inorganic by product of coal burning power plants, used as an alternate material for portland cement concrete and also to improve further performance of concrete. Nano materials were introduced as a supplementary materials in the form of Nano-Silica (NS) being a highly reactive amorphous silica of smaller particles size with higher surface area compared to the other pozzolanic materials used effectively to improve the performance of concrete. The use of nanosilica helps to reduce the problems occurred in concrete like sulphate attack and alkali silica reaction and it makes the concrete to become more compact and also increases the water resistance characteristics. Also some fibrous materials like Glass fibre which consists of large number fine fibres of glass, having higher tensile strength and which makes the concrete flexible and crack resistance which can also be implemented.

As there is a demand in modern engineering practices, there is a need for special types of materials with new properties. Scientists, technologists and engineers are continuously searching for some innovative materials, which can be used as an alternate for conventional materials and would enable new designs and innovations in the structure which can be built economically. Many research attempts have been made to introduce new materials, which is in combination of two or more different materials, technically termed as a composite material added in concrete. To reduce the amount of concrete production, use of pozzolanic materials like blast furnace slag, rice husk ash and fly ash were suggested for the partial replacement of cement; glass, sea shells and ceramic materials are used in place of fine aggregates and when coming to course aggregates the materials like palm kernel shells, coconut shells and sea shells are introduced.

2. Research Elaboration

2.1. Materials Used

- Coarse aggregate
- Fine aggregate
- Cement
- Nano Silica
- FlyAsh
- Glass Fibre

2.2. Material Details

Coarse aggregate – It is a crushed stone material which pass through an IS sieve of 19 mm and retained in the IS sieve of 4.75 mm. It is of well graded and rough surface material for good compaction property. Locally available crushed stone with a grade size of 20 mm is being preferred as coarse aggregate with a specific gravity of 2.74.

Fine aggregate – It is a stone crusher dust material with fractions passing through an IS sieve of 4.75 mm and retained in the IS sieve of 0.075 mm, which consist of 100% fine dust without any impurities. Manufactured Sand as fine aggregate is bought from nearby company. It is found that the sand belongs to Zone II (IS 383-1970) with a specific gravity of fine aggregate 2.63.

Cement – Grade 53 of Ordinary Portland Cement (OPC) confirming to IS 8112-1989 codal provision were being preferred in the present experiment work and it was bought from nearby company with a Specific

gravity of cement as 3.06 and the setting time initial is 30 mins and final is 600 mins.

Nano silica - The NS used in this project is procured from ASSTRA chemicals. The average size of selection of nano silica was found to be 17 nm. It is a new commercial material present in the water emulsion form named as Colloidal Silica. In the present investigation, cement is replaced by 0.5%, 1% and 2% nano silica with a specific gravity of 1.03.

Flyash - "Class F" Flyash obtained from the power plants (thermal) is used in the current experimental work as a replacement material for cement by 20% of flyash. The specific gravity of flyash is 2.2.

Glass fibre – The fibre used in this project is of Cem-FIL AntiCrack HD of 12 mm length and 14 micron filament diameter. Glass fibre consists of large number fine fibres of glass which is having high tensile strength and makes the concrete flexible and crack resistance. The specific gravity of glass fibre is 2.6.

3. Experimental procedure

3.1. Mix proportion

The ingredients for making the concrete were selected properly and the quantity of materials have been arrived according to the strength requirements as economically as possible. The mix proportion for the trail mixes are calculated with a nominal mix design procedure for M25 grade concrete by considering all the supplementary materials.

Mix Ratio = Cement : Fine Aggregate : Coarse Aggregate [C:FA:CA]

= **1 : 1.9 : 3.3** (Water Cement Ratio is **0.45**)

3.2. Steps followed

The following procedure have been adopted for casting the concrete specimens before testing the samples.

- Batching of materials
- Mixing of materials
- Placing of materials
- Finishing
- Curing

3.3. Tests Conducted

The experiments below were carried out to determine the strength qualities of concrete by incorporating various supplementary materials in concrete mix. They are,

- Concrete Cubes - **Compressive Strength Test**
- Concrete Cylinders - **Split Tensile Strength Test**
- Concrete Beams - **Flexural Strength Test**

Fig. 1. Casting, curing and testing of concrete samples

4. Results and discussion

The results of the experiments conducted were tabulated and figured below:

Table 1. Compressive strength test result of concrete cubes on 7th day

Mix (M25)	Compressive strength in N/mm^2 (7th day)			
	Conventional concrete	**Trial mix 1** Flyash-20% Nano silica-0.5% Glass fiber-0.5%	**Trial mix 2** Flyash-20% Nano silica-1% Glass fiber-1%	**Trial mix 3** Flyash-20% Nano silica-2% Glass fiber-2%
Sample 1	25.91	22.70	25.51	27.67
Sample 2	24.69	22.40	24.15	27.80
Sample 3	25.76	22.88	25.62	27.98

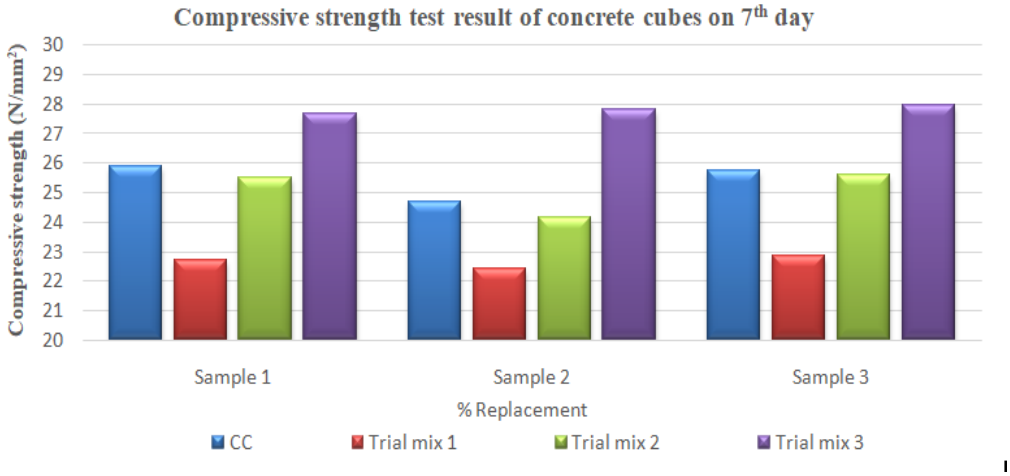

Fig. 2. Compressive strength test result of concrete cubes on 7th day

The above figure 2 and table 1 represents the Compressive strength of the cube in 7 days for the conventional concrete and the different trial mixes used based on their proportions. It is concluded that the strength characteristics increases in the second and third trial mix whereas it is not achieved in first trial mix when compared to the conventional concrete.

Table 2. Compressive strength test result of concrete cubes on 14th day

Mix (M25)	Compressive strength in N/mm^2 (14th day)			
	Conventional concrete	**Trial mix 1** Flyash-20% Nano silica-0.5% Glass fiber-0.5%	**Trial mix 2** Flyash-20% Nano silica-1% Glass fiber-1%	**Trial mix 3** Flyash-20% Nano silica-2% Glass fiber-2%
Sample 1	27.71	26.60	27.86	28.13
Sample 2	27.40	26.87	27.61	27.87
Sample 3	27.50	26.69	27.98	28.73

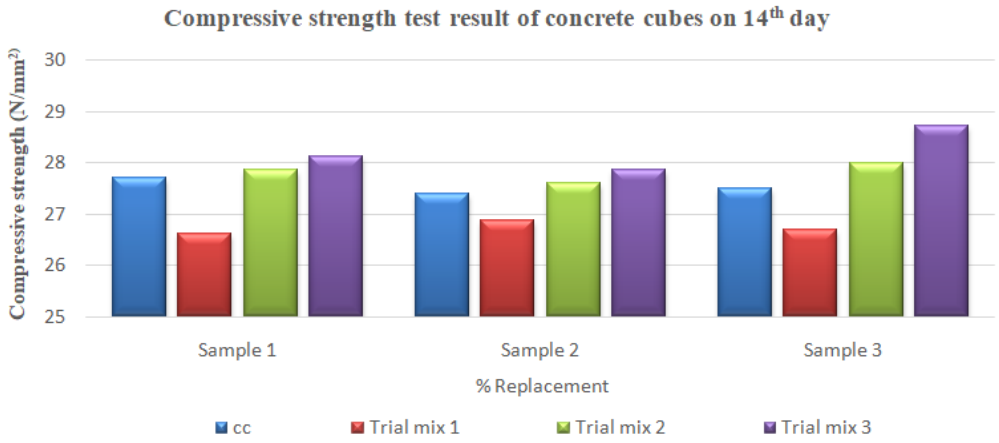

Fig. 3. Compressive strength test result of concrete cubes on 14th day

The above figure 3 and table 2 represents the Compressive strength of the cube in 14 days for the conventional concrete and the different trial mixes used based on their proportions. It is concluded that the strength characteristics increases when the percentage of nano silica and glass fiber is from 1-2% when compared with the 0.5% of nano silica and glass fiber.

Table 3. Compressive strength test result of concrete cubes on 28th day

Mix (M25)	Compressive strength in N/mm^2 (28th day)			
	Conventional concrete	**Trial mix 1** Flyash-20% Nano silica-0.5% Glass fiber-0.5%	**Trial mix 2** Flyash-20% Nano silica-1% Glass fiber-1%	**Trial mix 3** Flyash-20% Nano silica-2% Glass fiber-2%
Sample 1	29.70	27.93	29.87	30.89
Sample 2	29.27	27.67	29.24	30.29
Sample 3	30.51	27.29	29.73	30.96

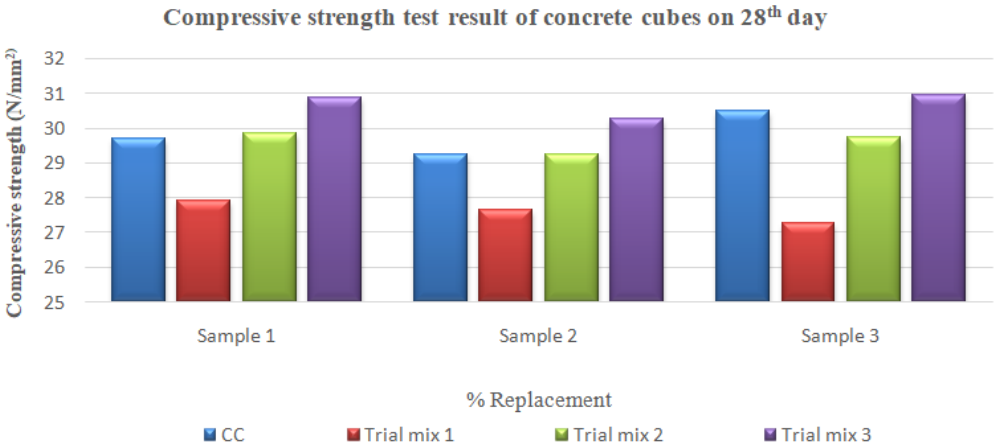

Fig. 4. Compressive strength test result of concrete cubes on 28th day

The above figure 4 and table 3 represents the Compressive strength of the cube in 28 days for the conventional concrete and the different trial mixes used based on their

proportions. This graph clearly shows that there is increase in the second and third trial mixes when compared to the first trail mix.

Table 4. Split tensile strength test result of concrete cylinders on 28th day

Mix (M25)	Split tensile strength in N/mm^2 (28th day)			
	Conventional concrete	**Trial mix 1** Flyash-20% Nano silica-0.5% Glass fiber-0.5%	**Trial mix 2** Flyash-20% Nano silica-1% Glass fiber-1%	**Trial mix 3** Flyash-20% Nano silica-2% Glass fiber-2%
Sample 1	2.93	2.38	3.69	3.85
Sample 2	2.98	2.02	3.82	4.04
Sample 3	2.91	2.50	3.89	4.30

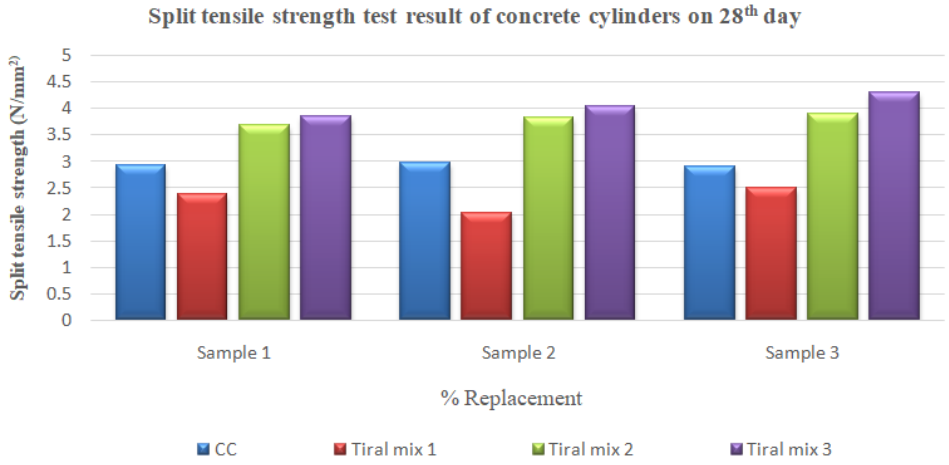

Fig. 5. Split tensile strength test result of concrete cylinders on 28th day

The above figure 5 and table 4 represents the Split tensile strength of the cylinder in 28 days for the conventional concrete and the different trial mixes used based on their proportions. It is concluded that the strength characteristics increases when the percentage of nano silica and glass fiber is from 1-2% when compared with the 0.5% of nano silica and glass fiber.

Table 5. Flexural strength test result of concrete beams on 28th day

Mix (M25)	Flexural strength in N/mm^2 (28th day)			
	Conventional concrete	**Trial mix 1** Flyash-20% Nano silica-0.5% Glass fiber-0.5%	**Trial mix 2** Flyash-20% Nano silica-1% Glass fiber-1%	**Trial mix 3** Flyash-20% Nano silica-2% Glass fiber-2%
Sample 1	3.80	3.69	6.45	7.58
Sample 2	3.61	3.38	6.42	7.50
Sample 3	3.70	3.52	6.30	7.76

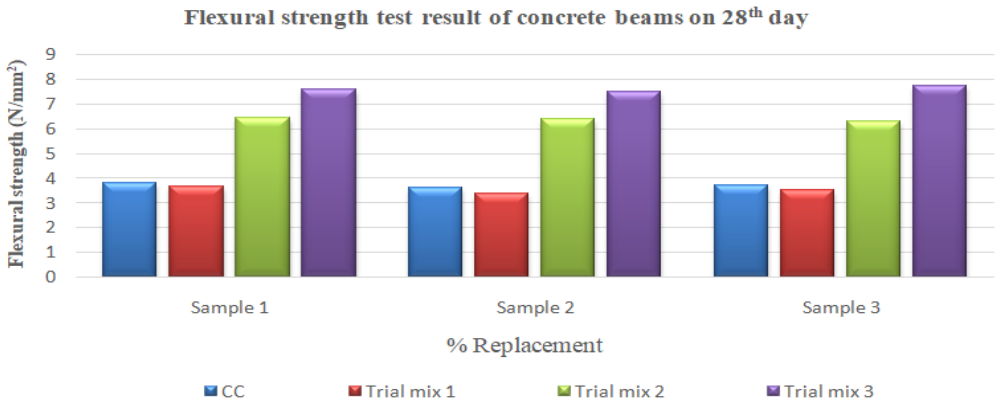

Fig. 6. Flexural strength test result of concrete beams on 28th day

The above figure 6 and table 5 represents the Flexural strength of the beam in 28 days for the conventional concrete and the different trial mixes used based on their proportions. It is concluded that the strength characteristics increases in the second and third trial mix whereas it is not achieved in first trial mix when compared to the conventional concrete.

5. Conclusion

The findings of the experiments show that a mixture of glass fibre, nano-silica, and fly ash can be utilised as a partial replacement for portland cement concrete. According to the results of the tests, increasing the percentages of Nano-silica for a constant percent of fly ash increases the strength qualities of concrete by up to 2%. At first, the compressive strength of concrete initially decreases slightly and then increases gradually. The chart also reflects the same and reaches the optimum value upto 2% cement replacement with Nano silica. It was also concluded that by combining fly ash with nano silica, the cement content of concrete can be lowered without affecting its strength. Finally, variations in compressive, split tensile, and flexural strength for M25 grade concrete with flyash, glass fibre, and nano silica show a similar pattern.

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