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Experimental Investigation of Micro Silica Based on Geopolymer Concrete by Using Coconut Fibres

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***Abstract* - In the current situation, concrete is the most essential factor. This binding substance is used for the whole building process. Because of the tremendous demand for mega structures, cement use has been at an all-time high for the previous few decades. Furthermore, cement is the sole substance whose demand is rising on a daily basis in order to satisfy humanity's requirements. Since a result, the price of cement is rising, as the demand for it is growing rapidly and the supply is restricted. Cement production emits CO2 and other gases, which contribute to global warming and, in turn, climate change, making it one of the most complex materials. Its usage cannot be halted, but it may be curtailed by utilising a variety of materials. This article looks at how Micro silica and Coconut Fibres may be used to replace cement and coarse aggregate, respectively. Experiments were carried out on plain concrete, which was then altered by the addition of other materials. After that, the results of the conventional concrete and geopolymer concrete were compared. Compressive and tensile strength tests were conducted after 7 and 28 days, respectively.**

***Index Terms* - Cement, coconut fibres, compressive strength, geopolymer concrete, micro silica.**

1.INTRODUCTION

Concrete is a used as building material for modern construction. One tonne of Portland cement releases about one tonne of CO2 into the atmosphere during production. CO2 accounts for about 65 percent of global warming among greenhouse gases. The global influence of ordinary Portland cement creation to greenhouse gas emissions is assessed to be around 1.35 billion tonnes per year. Thermal power plants based on coal account for about 65 percent of India's total installed capacity for electricity generation. Fly ash (FA) is generated in thermal power plants, causing disposal issues and causes landfill problems. The by-product of blast furnaces during the manufacture of iron is ground granulated blast furnace slag (GGBS).
Geopolymer concrete (GPC) is an inorganic polymer composite that has the potential to replace or enhance traditional concrete in environmentally sustainable building. GPC has a high tensile strength and is resistant to chloride penetration, acid attack, and other factors.

2. OBJECTIVE OF THE PROJECT

a. To explore the impact of various parameters on the compressive strength of fly ash-based geopolymer concrete at various ages.
b. Fly ash-based geopolymer concrete was made with low-calcium fly ash, aggregates, alkaline liquids, extra water, and a super plasticizer.

3. MATERIAL

Fly ash
Fly ash obtained from Ennore thermal power plant and belongs to the F class. Table 1 shows the properties of fly ash.

Table: 1 Physical properties of fly ash

S.No.	Property	Test result
1	Specific gravity of fly ash	2.13
2	Fineness, Percentage passing on 150 µm sieve	99.6

Coarse aggregate

Coarse aggregate with size of 20mm utilized. Table 2 and 3 represents the properties and sieve analysis of coarse aggregate.

Table: 2 Properties of coarse aggregate

Sl. No	Properties	Test results
1	Specific gravity	2.68
2	Fineness modulus	8.65
3	Bulk density	1540 Kg/m^3
4	Water absorption	0.5%

Table: 3 Sieve analysis of coarse aggregate

IS Sieve	Weight	Cumulative	Cumulative
Size	Retained (%)	Weight retained (%)	Weight Passing (%)
20mm	45.0	45.0	55
16mm	38.0	83.0	17
12.5mm	15.0	98.0	2
10mm	1.35	99.35	0.65
4.7mm	0.05	99.40	0.60

Fine aggregate

Locally available river sand with a grain size of 4.75 mm. The properties and sieve analysis of fine aggregates were determined and are shown in Table 4 and 5.

Table: 4 Properties of fine aggregate

Sl. No	Properties	Test results
1	Specific gravity	2.65
2	Fineness modulus	2.49
3	Bulk density	1260 Kg/m^3
4	Water absorption	1%

Table: 5 Sieve analysis of fine aggregate

	Weight	Cumulative	Cumulative
IS Sieve	retained	Weight	Weight
Size	(%)	retained	Passing
		(%)	(%)
4.75mm	1.15	1.15	98.85
2.36mm	0.6	1.75	98.25
1.18mm	20.85	22.6	77.4
600µm	25.55	48.15	51.85
300µm	29.75	77.9	22.1
150µm	20.5	98.4	1.6

Alkaline solution

A blend of sodium silicate solution and sodium hydroxide solution was utilised as an alkaline solution. With a purity of 97-98 percent, the sodium was employed in flake or pellet form. The solids must be dissolved in water to form a solution with the desired concentration. The concentrations of sodium hydroxide in the solution are 8mol/L.

Super plasticizer

Sulphonated, naphthalene formaldehyde condensate based super plasticizer was used for the concrete mixtures as water reducing agents. The super plasticizer was a dark brown solution with a solids content of 42 percent.

Coconut fibre

The naturally available coconut fibre varying from 1 to 5% of incremental of 1% added to the concrete.

Water content of mixture

The ratio of water to geopolymer solids was set to 0.26 as a constant.

4. MIX PROPORTION

Rangan has provided design recommendations for low calcium fly ash based geopolymer concrete that is heat cured. The parameters in Table 6 for the design of low calcium fly ash based geopolymer concrete were proposed based on the results of several combinations made in the laboratory over a four-year period.

In this project, the above-mentioned approach for determining mixture proportion was used. Table 7 shows the mixture proportions for various alkaline solution to fly ash ratios such as 0.35, 0.40, and 0.45. For an alkaline solution to fly ash ratio of 0.35, the mix design for low–calcium fly ash based geopolymer concrete.

Table: 6 Design data of geopolymer [Rangan]

Water to geopolymer solids ratio, by mass	Workability	Design compressive strength (wet mixing time of 4 minutes, steam curing at 60°C for 24hrs after casting), MPa
0.16	Very stiff	60
0.18	Stiff	50
0.20	Moderate	40
0.22	High	35
0.24	High	30

Table: 7 Design data of geopolymer –ii [Rangan]

Materials	Mass (Kg/m^3)		
Alkaline solution /fly ash (by mass)	0.35	0.4	0.45
Coarse aggregate	1260	1260	1260
Fine aggregate	540	540	540
Fly ash	444	429	414
Sodium hydroxide solution	45	49	53
Sodium silicate solution	111	122	133

5. MANUFACTURE OF GEOPOLYMER CONCRETE

The sodium hydroxide (NaOH) solids were dissolved in water to form the solution. The mass of NaOH solids in a solution varies with the concentration of the solution, which is measured in molar, M.

Manufacture of fresh concrete and casting

In the laboratory, the fly ash and aggregates were combined for around 3 minutes in a pan mixer. A saturated, dry surface was used to prepare the aggregates. After that, the alkaline solution was added to the dry components, and the mixing procedure was continued for another 4 minutes to produce the new concrete. It was possible to handle fresh concrete for up to 120 minutes without it settling or losing its compressive strength. Fresh concrete was poured into the moulds in three layers as soon as it was mixed, yielding cubical specimens measuring 100mm x 100mm x 100mm. Each layer of the specimens was manually compacted with 60 to 80 roding bar strokes. Figure 1 depicted the fresh concrete.

Curing of test specimens

After casting, the geopolymer concrete specimens were immediately cured. In this study, both oven and ambient curing were used. The test specimens were cured in an oven and at room temperature for oven curing and ambient curing, respectively. The specimens were oven-cured for 24 hours at 60°C and 100°C. The test specimens were left in the moulds for at least six hours following the curing time to avoid a fast change in ambient conditions. The specimens were demolded and allowed to air dry in the lab until testing day.

6. EXPERIMENTS CONDUCTED

Workability test

The slump value of concrete was kept in this project work between 30mm and 40mm.

Compressive strength

At 7 and 28 days, the compressive strength of geopolymer concrete specimens varied depending on the alkaline solution to fly ash ratio, concentration of alkaline solution, coconut fibre, micro silica and curing circumstances. Tables 9 to 12 include the test findings.

Table: 9 Compressive strength of coconut fibre – 7 & 28 days

S.No.	Coconut	7 Days	28 Days
1	0%	34.04	49.13
2	1%	34.95	50.58
3	2%	35.05	51.10
4	3%	37.78	53.00
5	4%	36.20	51.79
6	5%	34.95	51.25

Table: 10 Compressive strength of micro silica – 7 & 28 days

Sl.No.	Micro	7 DAYS	28 DAYS
1	0%	34.04	49.13
2	5%	36.35	52.16
3	7.5%	39.01	56.62
4	12.5%	37.55	52.74

Table: 11 Compressive strengths of NAOH -8m at 28 days

Curing	Concentration of	Compressive
Accelerating	8M	23.86

Table: 12 Compressive strengths of combined replacement of materials

Sl.No.	Combined replacements	Compressive strength 28 days (N/mm^2)
1	NC	49.13
2	8MGPC+7.5%MS+3%CF	59.91

Split tensile strength

The cylinder has a diameter of 150 mm and a length of 300 mm were cast and tested at 7 and 28 days. The split tensile strength presented in table 13 and 14.

Table: 13 Split tensile strength of coconut fibre

Sl.No.	Coconut fibre	7 days	28 days
1	0%	3.34	4.81
2	1%	3.35	4.85
3	2%	3.42	4.90
4	3%	3.65	5.14
5	4%	3.39	4.92
6	5%	3.15	4.61

Table: 14 Split tensile strength of micro silica at 7 & 28 days

Sl.NO	MICRO SILICA	7 DAYS	28 DAYS
1	0%	3.34	4.81
2	5%	3.54	5.13
3	7.5%	3.71	5.43
4	12.5%	3.26	4.74

7. CONCLUSIONS

Based on the test results, the following conclusions are drawn:

- Based on the compressive strength results for conventional concrete is as 34.04 and 49.13N/mm2 at 7 and 28 days.
- From the replacements with coconut fibre 3% performed well as 37.78 and 53N/mm2 at 7 and 28 days.
- On other hand Micro silica with 7.5% at 7 and 28 days is 39.01and 56.62N/mm2.
- Split tensile strength results are noted as 3.34 and 4.81N/mm2 at 7 and 28 days.
- From the replacements with coconut fibre 3% performed well as 3.65 and 5.14N/mm2 at 7 and 28 days for split tensile strength.
- On addition of Micro silica with 7.5% at 7 and 28 days is 3.71 and 5.43N/mm2.
- 28 days compressive strength of oven cured specimens at 60 & 100℃ is 1.3 times and 1.1 times more than that of ambient cured specimens, for alkaline ratio of 0.45.
- Geopolymer concrete cured in the laboratory ambient conditions gains compressive strength with age.
- In ambient curing, compressive strength at 28 days is about 3 times and 1.4 times higher than 7 and 14 days respectively.
- Alkaline solution of NaoH-8M with accelerated curing noted compressive strength is 23.86 N/mm2
- The optimum replacement is said as 8M [GPC] With 7.5% of MS and 3% of coconut fibres is 59.91N/mm2.
- Generally concrete is weak in tension zone but here by observation of tensile results the obtained values are very satisfactory shown greater STS as 4.61, 4.74 both CF & MS respectively.

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