Partial Replacement of Aggregates in Geopolymer Concrete

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Abstract- *Global warming is a major concern in the present day. The main reason for global warming is the emission of CO_2. The sustainable concept of development is unavoidable that has become more relevant because the greater people of this world are breathing the same polluted air as the rest of us. We can reduce the ill effects on environment, by increasing the usage of industrial waste products in the construction industry. Geopolymer concrete is a industrial waste product based material that is used in the present study, to produce the geopolymer concrete with partial aggregate replacement, the ordinary Portland cement is completely replaced with fly ash, the fine aggregate is partially replaced with charcoal powder and coconut shells in crushed form is used as a partial replacement to the coarse aggregates. Different replacement proportions of aggregates (i.e) 0%, 10% and 20% are prepared for determining the strength characteristics of each mix proportion. The Geopolymer concrete specimens are tested for their strength characteristics at 7th day and 28th day.*

Key Words: **Geopolymer concrete, tensile strength, compressive strength, flexural strength, charcoal powder, coconut shells.**

1. INTRODUCTION

For constructing any structure, concrete is the main material. The concrete that is used for construction is the most extensively used material next to water in the world. The quality of urban environment is at stake, energy efficient buildings can reduce the emission of hazardous gases such as CO_2 and SO_2. One of the prominent materials used in concrete is the cement. Production of 1 ton of cement emits 1 ton of carbon dioxide due to combustion processes that requires high temperatures in the order of 1200°C-1500°C, this constitutes about 7% of total man made greenhouse emissions and it is the second most cause for carbon dioxide emissions after pollution caused due to automobiles and 17% of the total discharge of harmful gas related to construction and building field. In the present day where the availability of energy resources is less, it becomes a major concern and hence reduction in the usage of cement will bring reduction in energy utilized and also the emission of highly dangerous greenhouse gases. Other than cement, the production of concrete involves the usage of sand and aggregates. Earlier these aggregates were available at nominal prices with very good qualities due to abundant availability. But due to the continuous excavation of aggregates it has caused depletion at an exponential rate which has increased the cost and demand. The quarrying operations that are done for the extraction of aggregates are highly energy intensive and they release large quantities of wastes. The coarse aggregate used is the crushed granite stones. These are natural resources which are non-renewable and these are excessively mined which will have a greater ecological impact hence some alternate material has to be found that is either a waste material or available at lesser cost. Generally, the density of the aggregates is high which increases the weight of the concrete and also the impact resistance property is also low. Thus, usage of light weight aggregates makes it ideal for prefabricated structural elements. This weightless concrete is also suitable for reinforced concrete construction.

2. MATERIALS AND METHODS

By using alternate binding material in concrete other than cement, environment friendly concrete can be obtained. The usage of industrial by products as binders can reduce the problem. In this aspect a new technology geopolymer concrete is a promising technique, in terms of reducing the CO_2 emissions to the atmosphere due to cement and aggregates. If the industrial wastes are used properly it can reduce the problem in disposal. The industrial coal that is manufactured by the burning of coal in an electrostatic precipitator which has Fly ash as a by-product . The cementitious properties of fly ash were discovered in late 19th century and it has been used widely in cement manufacturing for over 100 years. It generally replaces the Portland cement between 20% and 80%.

Coconut shell is an agricultural waste product that is extensively grown in the tropics. When coconut shells are used as the coarse aggregate in concrete it gives medium strength to the concrete with high impact resistance. It was observed that coconut shell concrete is very suitable for low cost and it can be used as a replacement to the natural coarse aggregate up to certain limits. This serves as a counter measure for the scarcity. It is one of the most common agricultural solid wastes in many tropical countries like India, Malaysia….

Table-1: Material properties of coconut shells

Properties	Coconut shells
Specific Gravity	1.31
Impact Value	20.12%
Crushing Value	24.51%

Charcoal powder is an agricultural by product that is obtained after the combustion of coconut shells. The particle size of the powder is very much similar to the fine aggregate that is used in the concrete. Charcoal powder can be effectively used as an alternate material to fine aggregate due to the excess availability and cheaper cost.

Table-2: Material properties of charcoal powder

Properties	Charcoal Powder
Fineness Modulus	1.93
Specific Gravity	2.18

3. EXPERIMENTAL WORK

The conventional method of making normal concrete is adopted in the preparation geopolymer concrete. First, M-sand, Charcoal powder, Coarse aggregate, Crushed coconut shells and Fly-ash are mixed in dry condition for about 2-3 minutes and then alkaline solutions (Sodium silicate and Sodium hydroxide) is added and mixing is done evenly for effective bonding of all the materials in the mix. After the mixing, the cubes, cylinders and prisms are casted and compacted well. The sizes of the moulds are:

Cubes – 150mmx150mmx150mm
Cylinders – 150mmx300mm
Prisms – 500mmx100mmx100mm

Table-3: Geopolymer concrete mix proportion

Material	Mass(Kg/m^3)
Coarse aggregate	1294
Fine aggregate	554
Fly ash	409
Sodium silicate	102
Sodium hydroxide	41

Fig-1 Casting of Geopolymer concrete

For the curing of geopolymer concrete specimens, the specimens are placed in direct sunlight. In this dry curing, after 24 hours of casting the specimens are demoulded and are subjected to dry curing.

4. OBSERVATIONS AND RESULTS

The test results of the mixes are shown in the Table 4-6.

Table-4: Compressive strengths in N/mm^2

S.No.	% of Aggregate replacement	7 Days	28 Days
1.	0%	11.70	24.9
2.	10%	8.89	25.63
3.	20%	7.41	23.26

Table-5: Tensile strengths in N/mm^2

S.No.	% of Aggregate replacement	7 Days	28 Days
1.	0%	1.46	2.5
2.	10%	1.08	2.26
3.	20%	0.90	1.79

Table-6: Flexural strengths in N/mm^2

S.No.	% of Aggregate replacement	7 Days	28 Days
1.	0%	2.5	5
2.	10%	1.75	3.25
3.	20%	1	2.88

5. CONCLUSIONS

1) The compressive strength of the geopolymer concrete of proportions such as 0%, 10% and 20% are found to be 24.9 N/mm^2, 25.63 N/mm^2 and 23.26 N/mm^2 respectively.

2)From the compressive strength test results it is observed that the 10% replacement mix has high strength than the other mixes in the 28th day test.

3)The tensile strength of the geopolymer concrete of proportions such as 0%, 10% and 20% are observed to be 2.5 N/mm^2, 2.26 N/mm^2 and 1.79 N/mm^2 respectively.

4)From the tensile strength test results it can be observed that the 0% replacement mix has higher strength compared to other mix proportions but the 10% mix proportion almost has similar strength of the former.

5)The flexural strength of the geopolymer concrete of proportions such as 0%, 10% and 20% are found to be 5 N/mm^2, 3.25 N/mm^2 and 2.88 N/mm^2 respectively.

6)From the flexural strength test results it can be stated that the 0% mix proportion has high strength than the other mix proportions. It is clearly observed that increase in replacement proportion greatly affects the flexural strength.

7)The fresh geopolymer concrete is easy to handle for first few minutes without any sign of setting but after few minutes it sets rapidly.

8)We observe that the strength parameters of the concrete are reduced with increase in replacement proportion of the aggregates.

9)With increase in replacement proportion the weight of the geopolymer concrete decreases. Thus it can be used for light weight concreting.

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