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RESEARCH ARTICLE

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EXPERIMENTAL INVESTIGATION ON GEOPOLYMER CONCRETE WITH TERNARY BLENDS OF NATURAL STEATITE POWDER,METAKAOLIN, RICE HUSK ASH AND COCONUT SHELL FOR COARSE AGGREGATE REPLACEMENT

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ABSTRACT
The present study investigates the geopolymer concrete with ternary blends of natural steatite powder,metakaolin, rice husk ash and coconut shell for coarse aggregate replacement. In this paper the natural steatite powder and ricehusk ash are kept constant as 5%, metakolin varied by 5,10%. The coarse aggregate is replaced by coconut shell by 5%,10%, 15%. The compressive strength can be reduced as 5% as addition of coconut shell, split tensile strength reduced as 2.5% and flexural strength to be reduced as 2.5%, the strength to be reduced by adding the coconut shell, the weight of the specimen also reduced by 7.5%..

Keywords—Geopolymer ; Natural fsteatite powder; compressive strength, split tensile strength, coconut shell, ricehuskash

INTRODUCTION

Concrete is one of the most widely used construction materials the Portland cement is used for making the concrete. Nowadays the consumption of cement will be increase day by day.

The cement emits high amount of CO_2 during the manufacturing process, these CO_2 gasses creates the greatest environmental issues such as global warming, These global warming is caused by the emission of greenhouse gases, such as CO2, to the atmosphere by human activities. The use of Portland cement is unavoidable to construction, therefore many efforts are being made in order to reduce the use of Portland cement,

The various raw materials such as fly ash, silica fume, granulated blast furnace slag, rice-husk ash and metakaolin are used partially for replacing the Portland cement, at that time geopolymer technology is introduced by Davidvoits. .In geopolymer technology the Portland cement is fully replaced by flyash. In this technology the emission of CO_2 has to been reduced

In this project, the flyash has to been replaced by the various supplementary materials such as natural steatite powder, metakaolin and ricehuskash as certain percentage, the coarse aggregate has also been replaced by coconut shell as certain percentage

The objective of this study was to evaluate the strength of concrete by using the various supplementary materials, in order to reduce the co_2 emission. The various supplementary materials used in various percentage and to determine the

compressive strength, split tensile strength and flexural strength of geopolymer concrete.

Experimental Program

Materials Used

i)FLYASH

According to American society of Testing and materials ASTM C 618, there are two types of fly ash

1. Class F type of fly ash
   Class F fly ash is designated in ASTM C 618 and originates from anthracite and bituminous coals. It consists mainly of alumina and silica and has a higher LOI than Class C fly ash. Class F fly ash also has a lower calcium content than Class C fly ash.
2. Class C type of fly ash
   Class C fly ash is designated in ASTM C 618 and originates from sub bituminous and lignite coals. Its composition consists mainly of calcium, alumina, and silica with a lower loss on ignition (LOI) than Class F fly ash

TABLE I. CHEMICAL COMPOSITION OF FLYASH

chemical composition of flyash	
Constituents	***Contents (%)***
SiO_2	64.43
Al_2O_3	23.67
Fe_2O_3	23.67
CaO	1.25
Na_2O	0.40
K_2O	0.60
MgO	1.54
SO_3	0.6
S_c	2.30
μ	7.64

ii)FINE AGGREGATE

Locally available sand is used as fine aggregate. The sand confirming to IS: 2386 (part I) 1963 is used as fine aggregate. Physical properties of the sand is given in the below table.

TABLE II PHYSICAL PROPERTIES OF SAND

Physical properties of sand	
Specific gravity	2.65
Colour	Gray
Shape of grains	Sub angular
Fineness modulus	3.57

iii) COARSE AGGREGATE

Coarse aggregate are the crushed stone is used for making concrete. The commercial stone is quarried, crushed, and graded.

The size of coarse aggregate 20 mm is used .Physical properties of the coarse aggregate is given in the below table.

TABLE III PHYSICAL PROPERTIES OF COARSE AGGREGATES

Physical properties of coarse aggregate	
Specific gravity	2.7
Shape of	Angular
Fineness modulus	7.73

iv) NATURAL STEATITE POWDER

Steatite is a type of metamorphic rock, largely composed of talk ore, rich in magnesium. It is the softest known mineral and listed as 1 on the Mohs hardness scale. Physical and chemical properties of steatite is given in the below tables.

TABLE IV chemical composition of natural steatite powder

Chemical composition of natural steatite powder	
constituents	***Contents (%)***
SiO_2	62.67
Al_2O_3	0.24
Fe_2O_3	0.30
CaO	0.2
MgO	33.26

TABLE V PHYSICAL PROPERTIES OF NATURAL STEATITE POWDER

Physical properties of natural steatite powder	
Colour	White
Bulk density	0.6
Specific gravity	2.75
pH	8
Crystal structure	Hexagonal

v)RICE HUSKASH

At burning temperatures of 550 ^{0}C – 800 ^{0}C, amorphous silica is formed, but at higher temperatures crystalline silica is produced. Rice husk is an agricultural residue which accounts for 20% of the 649.7 million tons of rice produced annually worldwide. Burnt husk is used to overcome the

environmental issue by utilizing this material as a supplementary cementing material. The flow of the mix is mush reduced with RHA because of its fine and cellular structures.

TABLE VI PHYSICAL AND chemical composition of RICEHUSK ASH

Constituents	Contents (%)
Silicon dioxide SiO_2	86.75
Aluminium oxide Al_2O_3	1.23
Ferric oxide, Fe_2O_3	2.09
Calcium Oxide, CaO	0.87
Sulphur trioxide, SO_3	0.54
Sodium oxide,Na_2O	1.16
Magnesium oxide, MgO	1.02
Potassium oxide, K_2O	1.05
Loss of ignition	5.03
Specific gravity	2.15
Fineness modulus (passing through 45micron sieve)	26.3

vi) METAKAOLIN

Metakaolin (MK) is a pozzolanic material. It is obtained by the calcinations of kaolinitic clay at a temperature ranging between 500 °C and 800 °C. Although it showed certain amount of pozzolanic property, they are not highly reactive. High reactive metakaolin is made by water processing to remove un reactive impurities to make 100% pozzolan. Such a product, white or cream in colour, purified thermally activated is called high reactive Metakaolin.

The raw material input in the manufacture of metakaolin (Al2Si2O7) is kaolin. High reactive metakaolin by trade name “Metacem”. Chemical composition and Physical properties of coir fiber is given in the below table.

TABLE VII PHYSICAL PROPERTIES OF METAKAOLIN

property	
Specific gravity	2.60
Bulk density	0.3 to 0.4
Physical form	Powder
color	Off-White
GE Brightness	79–82

TABLE VIII CHEMICAL COMPOSITION OF METAKAOLIN

Chemical composition	%
SiO_2	51.52
Al_2O_3	40.18
Fe_2O_3	1.23
CaO	2.0
MgO	0.12
K_2O	0.53
SO_3	0.0
TiO_2	2.27
Na_2O	0.08
LoI	2.01

TABLE II.

VII) SODIUM SILLICATE

Sodium silicate is the common name for a compound Sodium metasilicate, Na_2SiO_3, also known as water glass or liquid glass.

TABLE IX PHYSICAL PROPERTIES OF SODIUM SILLICATE

Chemical formula Na_2O x SiO_2	**Colour less**
Na_2O	15.9%
SiO_2	31.4%
H_2O	52.7%
Appearance	Liquid (Gel)
Colour	Light yellow Liquid (gel)
Boiling Point	102 C for 40% aqueous solution
Molecular Weight	184.04
Specific Gravity	1.6

VIII) SODIUM HYDROXIDE

The sodium hydroxides are available in solistate in the form of Pellets and flakes as shown in Figure 3.2. The cost of the sodium hydroxide is mainlyvaried according to the purity of the substance. Since our geopolymer concrete is homogenous material and its main process to activate the sodium silicate it is recommended to use the lowest cost i.e. up to 94% to 96% purity. In this investigation the sodium hydroxide pellets in 8 molar concentrations are used

TABLE X PHYSICAL PROPERTIES OF SODIUM HYDROXIDE

Colour	**Colour less**
Specific Gravity	1.47
pH	14

TABLE XI CHEMICAL COMPOSITION OF SODIUM HYDROXIDE

Assay	97%
Carbonate (Na_2CO_3	2%
Chloride (Cl)	0.02%
Sulphate (SO_4)	0.01%
Lead (Pb)	0.002%
Iron (Fe)	0.005%
Potassium (K)	0.1%
Zinc (Zn)	0.02%

Mix proportion

A mix proportion of flyash based geopolymer concrete can be derived from the previous journals., the mix proportion were shown in table as below

TABLE XII MIX PROPORTION

Mix	FLYASH	Fine aggregate (Kg/m^3	Coarse aggregate (Kg/m^3)	Sodium silicate (Kg/m^3)	NaOH (Kg/m^3)
CM	350	672	1248	100	40

MIX NAME	Flyash	**MK**	**NSP**	**RHA**	**F.A**	**C.A**	**C.S**
GPC1	100	-	-	-	100	100	-
GPC2	85	5	5	5	100	95	5
GPC3	80	10	5	5	100	95	5
GPC4	85	5	5	5	100	90	10
GPC5	80	10	5	5	100	90	10
GPC6	85	5	5	5	100	85	15
GPC7	80	10	5	5	100	85	15

Preparation of alkaline solutions

The sodium hydroxide is poured into the distilled water and mixed it thoroughly, these solutions are made 24 hours before casting, the sodium silicate solution(gel form) are mixed to the sodium hydroxide solution, these solution is known as alkaline activator

Casting of specimens

Fly ash is mixed with other ingredients and then mixed with fine aggregate, they are mixed thoroughly and then coarse aggregate is added, the alkaline solutions are added to mix the aggregates and ingredients,, the fresh concrete was filled in the mould. All specimens were cast in three layers. Each layer was compacted using a tamping rod. After casing, all specimens were kept at room temperature for one day. Then it was removed from the mould and kept in room for 28 days.

Compressive test

Compressive test is the most common test conducted on hardened concrete, partly because it is an easy test to perform, the partly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength. The cube specimen is of the size 150 X 150 X 150 mm.The fresh concrete were cast and allowed to set at 40^0C temperature for 24h before being removed from the moulds and kept at room temperature (20º C) until tested in compression and flexural strength. Compressive strength for each mortar mixture was obtained from an average of 3 specimens from those broken in flexure. The tests are done on Compression-testing machine and compressive load is applied on opposite faces axially, slowly at the rate of 140 Mpa/minute. The compressive load is noted for the ultimate failure. Record the total maximum load indicated by the testing machine, and calculates the compressive strength as follows:

$$F = P/A$$

Where :F = compressive strength in psi or [MPa],

P = total maximum load in lbf or [N], and

A = area of loaded surface in2 or [mm2].

FIGI 1 specimen before testing

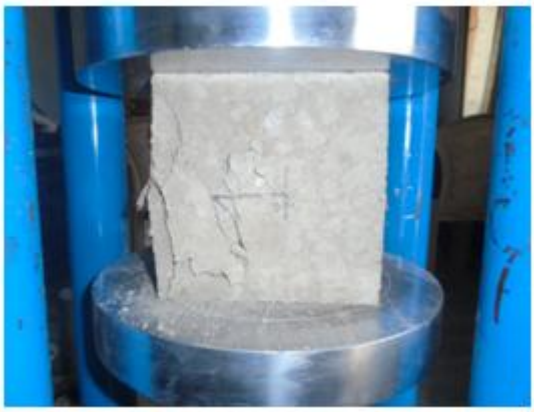


Fig 2: specimen after testing

Figure 3 cylinder specimen setup

Fig 4: cylinder specimen at failure

Split tensile strength

Split tensile strength is conducted for hardened concrete, the specimen of size 150X150X300mm, the cylinder is casted and kept at room temperature at 28 days, the split tensile strength is calculated by the formula given below

$F=2P/\pi A$

Where F = tensile strength in psi or [MPa],
P = total maximum load in lbf or [N], and
A = area of loaded surface in2 or [mm2].

Flexural strength

The three point bending beam testing was performed on a flexural testing machine of 100kN capacity. The beam was placed on two supports at a distance of 240mm. The loading was provided at centre. The strength to be calculated by the following formula

F=Pl/bd2

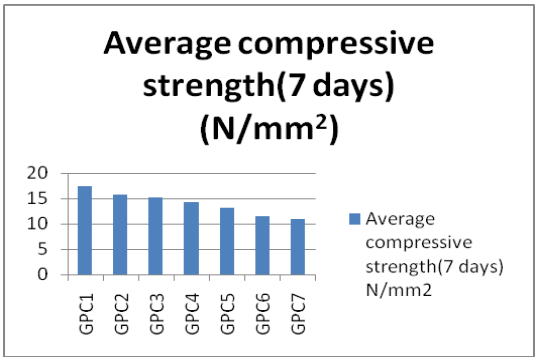
where F= flexural strength
L= length of the beam loaded
b= breadth of the beam
p=load
d=depth of the beam

Figure 5. Failure of the specimen

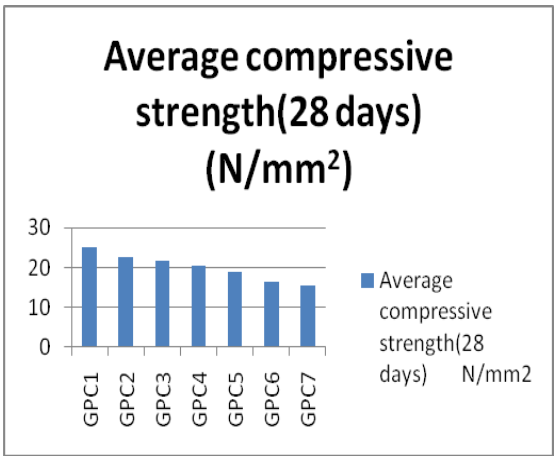
IV) Result and Discussion

The test should be carried out the specimens whereas the addition of the ingredients and replacing coarse aggregate by coconut shell. The compressive strength, split tensile strength and flexural strength to be calculated, the results are carried out by plotting the graph

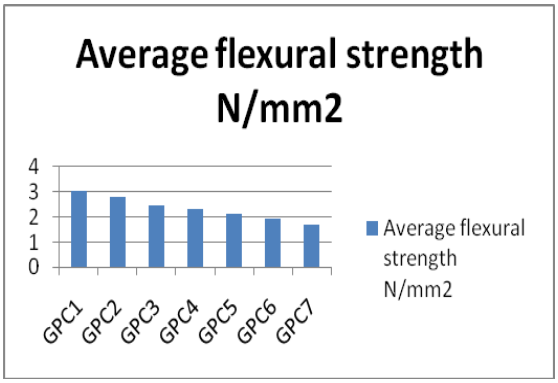
The 7 day compressive strength has been calculated by the above formula and to draw the chart as given below, the strength of the concrete to be reduced by adding the coconut shell by coarse aggregate, and the different ingredients replaced by flyash,



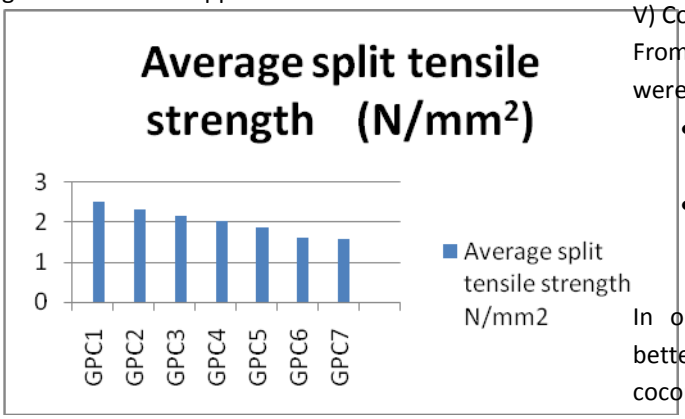
The 28 days compressive strength has been calculated, the chart is to be drawn given below



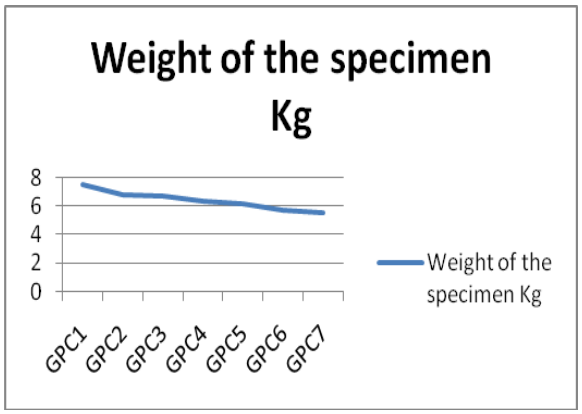
The flexural strength of the concrete to be determined by adding the various supplementary materials and addition of coconut shell at certain percentage,



The split tensile strength can be determined by the various supplementary materials at certain percentage, the strength can be determined by the given formula and pplotted the chart



The weight of the specimen to be determined and plotted the chart for adding the supplementary materials



The compressive strength of the concrete can be determined by the given formula, the strength of the specimen to be reduced, in order to adding the various supplementary materials such as natural steatite powder, ricehuskash, metakaolin and coconut shell by replacing coarse aggregates

The coconut shell is added in the mix and increased the percentage, if coconut shell is increased the weight of the specimen is decreased and also the compressive strength, split tensile strength and flexural strength of the concrete will be decreased.

In ordinary concrete adding coconut shell gives better results but in geopolymer concrete adding coconut shell it gives decrease in strength.

The geopolymer concrete is the better materials to alternate ordinary Portland cement, it reduces the carbon dioxide emission compared to ordinary Portland cement..

V) Conclusions

From the study conducted, the following conclusions were made.

- The $CO_@$ emission is reduced compared to ordinary concrete.
- In geopolymer concrete, the weight of the specimen to be reduced compared to ordinary Portland cement.

In ordinary concrete adding coconut shell gives better results but in geopolymer concrete adding coconut shell it gives decrease in strength.

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