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To Analyze the Effect of Fly Ash, GBPS, Rice Husk Ash, RCA and Pet Fibers on Geopolymer Concrete

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***Abstract*: Concrete is a building material which entails mainly cement, fine aggregate, coarse aggregate and water. Apart from these material, different kinds of admixtures and other enhancing materials are also used for achieving high strength concrete. The production of these raw materials is on the higher end as the demand is at its peak. Green concrete is a concrete which is produced by replacing one or more than one raw ingredients with an alternative replacement material. Several research studies have been conducted on green concrete in the past and many are still going on. The present experimental work involves the replacement of cement (100%) with fly ash, ground granulated blast furnace slag (GGBS) and rice husk ash in order to produce geopolymer concrete and replacement of natural aggregates with recycled concrete aggregate with the addition of PET fibers. From the present experimental program, the final outcome can be concluded that the usage replacement materials fly ash, ground granulated blast furnace slag, rice husk and recycled concrete aggregate along with the PET fibers in geopolymer concrete enhances the strength parameters of concrete.**

***Keywords*: Fly Ash, GGBS, Rice Husk Ash, Flyash, Geopolymer Concrete.**

1. Introduction

With the over exploitation of raw ingredients of concrete, the need of replacement material arises. As mentioned earlier, cement produces large amount of carbon dioxide in the environment which is a treat to ecosystem. Therefore, to eliminate the usage of cement, Geopolymer was invented and introduced various replacement material which can easily replace cement in concrete. Geopolymer concrete is a concrete in which cement is replaced 100% with particular replacement material which exhibits bind properties and other similar properties of cement in various forms. The most common replacement material to cement is fly ash. Almost all the geopolymer concretes are fly ash based. First research work on this concrete was also carried out with the usage of fly ash.

2. Material used

A. Fly Ash

Fly ash is a very fine powder which is produced by the gases which is generated by the coal based fuel power generation. Major power plants in whole world generates millions of tons of fly ash yearly and being the waste and end product, it is being dumped in the landfill on regular basis. But with the invention of replacement material technique, this material plays an impeccable role on concrete production.

Table 1
Chemical composition of Fly Ash

Component	Mass (%)
CaO	04.06
SiO_2	57.54
Al_2O_3	19.88
Fe_2O_3	05.98
MgO	06.46
SO_3	00.07
K_2O	00.21
Na_2O	00.45

B. Ground granulated blast-furnace slag (GGBS)

When the iron is melted in the blast-furnace, slag is produced and gathered at the top of molten iron. The quenching of this slag generates the granulated slag of iron which is fine as resembles the cement properties. it entails little amount of crystals and its cementitious nature is very useful in concrete. Blast furnace also cement is also available in the market which is prepared by mixing the blast furnace slag with cement clinkers. This material comes second in the list of replacement material of cement.

Table 2
Chemical composition of GGBS

Component	Mass (%)
CaO	37.41
SiO_2	40.12
Al_2O_3	15.10
Fe_2O_3	01.56
MgO	05.31
SO_3	00.30
K_2O	00.13
Na_2O	0.28

C. Rice husk ash

Rice husk ash is a green and valuable waste by product of rice. RHA is obtained from the burning of rice husk which is a covering of rice. This material has lots of potential and contains

non crystalline silicon dioxide along with higher specific surface area and higher pozzolanic reactivity. Rice husk ash is a natural and waste product which has a high utilization in concrete industries as it resembles the properties of cement as well as fine aggregates in order to produce sustainable and green concrete.

Table 3
Properties of Rice Husk Ash

Test	Value Obtained
Particle size	< 45Micron
Specific gravity	2.23
Appearance	Very Fine
Color	Gray

D. Recycled Concrete aggregate

Recycled concrete aggregate is a replacement material to coarse aggregate and it is collected after recycling the clean concrete waste such as debris etc. RCA is an impeccable material which is produced in stationary recycling plants just like the plants of natural aggregates. The production of RCA generally entails 2 stage crushing process i.e. primary crushing which is done by jaw crushers and then secondary crushing which is done with the help of impact crushers. After the process of crushing, the removal of unwanted waste and screening is carried out. As this aggregates are obtained from the waste of concrete, therefore, removal of steel bars has to be done by huge electromagnets after the screening stage.

Table 4
Physical Properties of RCA

Test	Results
Specific Gravity	2.21
Water Absorption	3.59 %

E. PET fibers

Polyethylene terephthalate PET belongs to the polyester family of polymers and it is most commonly used in the packing (food and liquid containers) and textile industries. PET is processed in various ways so that it can be converted into fibers or fabrics or bottles etc. It is generated when the polymerization of ethylene glycol is occurred with terephthalic acid. Due to quick development in this field, the usage of PET has increased so rapidly that they are commonly used in concrete production as it increases the bonding capacity and various other properties of concrete. PET fibers can be obtained from various sources but most commonly obtained from plastic waste bottles by cutting them into thread like fibers.

3. Concrete mix proportion

Cement was replaced with fly ash by 30% and 40%, GGBS by 30% and 40% and rice husk ash by 20% and 40%. Recycled aggregate was used to replace natural aggregates in geopolymer concrete at varying proportion of 20% and 40%. Along with replacement material PET fibers were added in the concrete at 1% and 2%. The description of various concrete mixes is represented in the table below:

Table 5
Varying Proportions of Replacement Material and PET Fibers.

Design mix	Fly Ash	GGBS	Rice husk ash	RCA	PET Fibers
Control Mix	-	-	-	-	-
Mix1	30	30	40	20	1
Mix 2	30	30	40	20	2
Mix 3	40	40	20	40	1
Mix 4	40	40	20	40	2

4. Results and discussion

A. Compressive strength

Various design mix samples, after oven dry curing and normal temperature curing, were tested under CTM for compressive strength of concrete. The so obtained results have been presented in table and graphs below.

Table 6
Compressive strengths for oven drying curing

Design Mix	7 Day	28 Day
Control mix	23.6	35.9
M1	24.0	36.2
M2	25.2	38.0
M3	24.9	36.5
M4	25.6	37.3

Table 7
Compressive strengths for Normal temperature curing

Design Mix	7 Day	28 Day
Control mix	21.6	33.2
M1	22.7	34.5
M2	24.4	35.8
M3	23.6	34.6
M4	24.0	36.1

After performing compressive strength test, it can be concluded that, design mix M2 reflects better results at 28 days of curing period. Maximum compressive strength for oven dry curing method and normal temperature curing method was 38 MPa and 36.1 MPa at 28 days respectively.

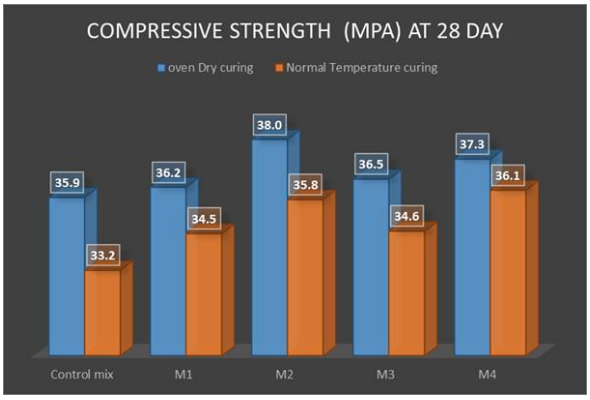

Fig. 1. Compressive strength at 28 days.

B. Flexural strength

Various design mix samples of size 100 x 100 x 500 mm, after oven dry curing and normal temperature curing, were tested for strength of concrete. Therefore, the obtained results of test have been presented in table and graphs below.

Table 8
Flexural strengths for oven drying curing

Design Mix	7 Day	28 Day
Control mix	23.6	35.9
M1	24.0	36.2
M2	25.2	38.0
M3	24.9	36.5
M4	25.6	37.3

Table 9
Flexural strengths for Normal temperature curing

Design Mix	7 Day	28 Day
Control mix	21.6	33.2
M1	22.7	34.5
M2	24.4	35.8
M3	23.6	34.6
M4	24.0	36.1

The results of flexural strength showed that the design mix M2 has maximum strength of 8.2 MPa when the oven dry curing method was adopted. Maximum flexural strength for oven dry curing method and normal temperature curing method was 8.2 MPa and 7.5 MPa at 28 days respectively.

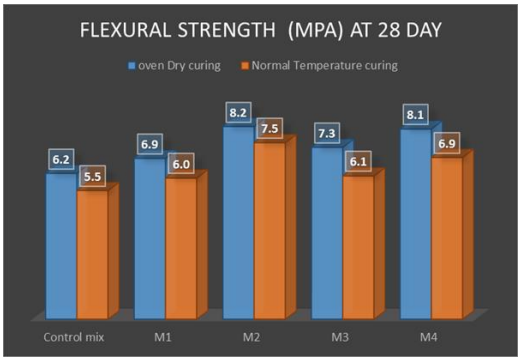

Fig. 2. Flexural strength at 28 days

5. Conclusion

After comparing the obtained results of present experimental program, following inferences were made:

- After performing compressive strength test, it can be concluded that, design mix M2 reflects better results at 28 days of curing period. Maximum compressive strength for oven dry curing method and normal temperature curing method was 38 MPa and 36.1 MPa at 28 days respectively.
- The results of flexural strength showed that the design mix M2 has maximum strength of 8.2 MPa when the oven dry curing method was adopted. Maximum flexural strength for oven dry curing method and normal temperature curing method was 8.2 MPa and 7.5 MPa at 28 days respectively.
- From both the curing method, results of oven dry method was found better than normal temperature curing method. The results of oven dry curing method were approximately 1.2 times the results of normal temperature curing method.

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