Section A-Research paper
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Comparison between Fly ash and Rice husk ash based Geopolymer concrete.

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Abstract

In this study, fly ash (FA) is used to create geopolymer concrete (GPC), and FA is substituted with rice husk ash (RHA) in varying ratios of 20, 40, 60, 80, and 100%. The alkaline activator (AAC) utilised is a 10M solution of sodium hydroxide and sodium silicate (SS/SH). 400 kg/m3 of fly ash is present. The ratio of SS to SH is 2, while the ratio of AAC to binder (BI) is 0.4. The findings showed that the RHA-based GPC achieved less workability than the FA-based GPC, and that the slump value gradually declined as the RHA concentration in the mixes rose. The RHA-based GPC mixes have a marginally higher 7, 28, and 90 days compressive, split tensile, and flexural strength than FA-based GPC mixes, which is less than 10%. The strength of two separate source material-based GPC blends does not significantly differ from one another.

Key words: Fly ash; rice husk ash; Geopolymer concrete.

Introduction

One of the most frequently utilised produced goods worldwide is concrete. As the binding agent for concrete, Portland cement is an essential component. Carbon dioxide emissions rise as a result of cement production's increased usage of energy and raw materials. 5 to 8% of the world's carbon footprint is attributable to the manufacture of cement [1, 2]. In addition, making cement uses a lot of energy and raw materials, and a lot of liquid and solid waste is created [2]. This procedure has negative effects on the environment in addition to raising cement prices. Under these conditions, the carbon footprint and resource costs connected with cement production must be safely and sustainably decreased. There is a serious problem with how these wastes are disposed of because the bulk of them are placed in landfills, which occupy less space and harm the environment. Only a few of the wastes that have been successfully used into cement replacement materials to improve their quality are fly ash, ground-granulated blast furnace slag, and silica fume [3–7]. The ability to produce biomass fuel from agricultural waste has recently been demonstrated. But the resulting bottom ash attracted a lot of attention worldwide. Corn cob ash, rice husk ash (RHA), elephant grass ash, bamboo ash, paper mill ash, wood ash, bovine manure ash and sugarcane bagasse ash are a few examples of biomass ash that can be used as pozzolanic materials [8-19]. Several studies have shown [20–22] that adding biomass ash to cement can increase the strength and longevity of concrete. It can help lower building costs by correctly utilising agricultural wastes and minimising environmental damage.

This study intends to substitute rice husk ash (RHA) for fly ash (FA), two by-products of coal-burning thermal power plants and agriculture. Although much work has been done on both FA-based and RHA-based GPC, it is still unclear how the two differ fundamentally or whether one is superior. The purpose of this study is to clarify this issue and determine the best of two.

2. Materials used

Burning rice husk in a muffle furnace at a rate of 10 degrees per minute produced rice husk ash (RHA), which was created in a laboratory setting. For two hours, RHA was subjected to temperatures in the 900 range. To avoid burning on both sides, a section that was 1-inches thick was kept in the pan. After two hours of control heating, the sample was taken out of the furnace and allowed to cool outside. It is also important to remember that each RHA sample was processed in a ceramic ball mill at 66 rpm for the requisite 35 minutes with a grinding medium to RHA ratio of 5 by weight before being used. The range for cement fineness was reached once the (RHA) sample's fineness was 2750 cm2/gm. Thermal power plants produce fly ash, which was obtained from Rajpura Power Plant in Punjab and employed in this experiment. At Raicon Labs Sonepat, RHA and FA's chemical makeup was examined. Table 1 lists the chemical make-up of RHA and FA.

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The alkaline activator used was a solution of sodium silicate and sodium hydroxide. The sodium hydroxide concentrations of 12 to 16M have been shown to give GPC better strength and workability [23–28], hence 12M NaOH was used in this study. One percent of the original material was employed as a superplasticizer.

The IS 383: 2016 [29] fine aggregates free of dirt, muck, and debris were used. In this investigation, coarse aggregates with a size larger than 12.5 mm and less than 19 mm in accordance with IS 2386 (part I) [30] were used. The physical and chemical characteristics of the materials are displayed in Tables 1 and 2.

Table 1 Physical properties of materials

Material	Colour	Specific Gravity (kg/ cm^3)	Fineness (passing 45 µm)
FA	Grey	2.2	3
RHA	Black	2.13	2.7

Table 2: Chemical composition of materials.

Material	Al_2O_3 (%)	SiO_2 (%)	CaO (%)	Fe_2O_3(%)	Na_2O (%)	MgO (%)	SO_3 (%)	K_2O (%)	SrO (%)	TiO_2 (%)	P_2O_5 (%)	Mn_2O_3 (%)	Total Alkali	Others
FA	32.10	51.20	3.50	9.40	0.30	1.10	0.10	0.50	<0.1	1.80	0.45	0.15	0.60	--
RHA	0.15	91.5	0.48	0.06	0.27	--	1.29	--	--	--	--	--	--	6.25

3. Mix preparation and testing

The mix design and procedure of Mahapara and Gyanendra [31] were used for sample preparation. The cast samples underwent ambient curing. Since each test result is the average of three sample tests, a set of 15 samples was drawn for each test. Because there are no special codes for GPC testing, the testing was conducted in accordance with ASTM. Table 3 provides the mix proportions. Hardened GPC was subjected to compression, split tensile, and flexural strength tests in accordance with ASTM C39 [33], C496 [34], and C293 [35], respectively. The workability test was conducted in accordance with ASTM C143 [32]. As shown in Table 2 the Fa-based GPC mix (control mix) with 0 % RHA is designated as R0F where 'R' stands for RHA and 'F' denotes Fa. Likewise, the no 0, 20, 40, 60, and 80, in blends denote the percentage of RHA in the mixes. In Table 3, AAC denotes alkaline activator and BI denotes binder which is

FA and RHA, SP denotes superplasticizer, SS denotes Na_2SiO_3, SH denotes NaOH, CAG denotes coarse aggregates, FAG denotes fine aggregates.

Table 3: Mix proportions of mixes

Mixes	R0F	20RF80	40RF60	60RF40	80RF20	RF0
SS / SH	2	2	2	2	2	2
SH (kg/m^3)	66.67	66.67	66.67	66.67	66.67	66.67
AAC/BI	0.4	0.4	0.4	0.4	0.4	0.4
SS (kg/m^3)	133.33	133.33	133.33	133.33	133.33	133.33
SP (kg/m^3)	4	4	4	4	4	4
Extra water (kg/m^3)	60	60	60	60	60	60
NaOH (M)	10	10	10	10	10	10
FA (kg/m^3)	400	320	240	160	80	0.00
RHA (kg/m^3)	0.00	80	160	240	320	400
CAG (kg/m^3)	906	906	906	906	906	906
FAG (kg/m^3)	475	475	475	475	475	475

4. Results and discussion

Fly ash based geopolymer concretes are having practical applications and nova days RHA based GPC are gaining importance day by day. This study aims which GPC is best in terms of workability and strength. FA is replaced by RHA in GPC in various percentages of 20, 40, 0, 80, and 100 %. The various test results are discussed in this section along with figures.

4.1. Workability

The workability of various mixes is expressed in terms of slump at different times. The slump values of the blends are given in figure 1. The figure 1 reveals that the workability of the mixes decreases as the RHA content increases. The mix with 0 % RHA and 100 % FA has shown high workability and the workability decreases linearly with the increase in RHA content from 0 to 100 %. This is due to the fineness of RHA as RHA is finer than FA. The fineness of the source material is the prime factor for the workability of GC mixes, the higher the fineness higher the workability [23-25, 31, 36-38].

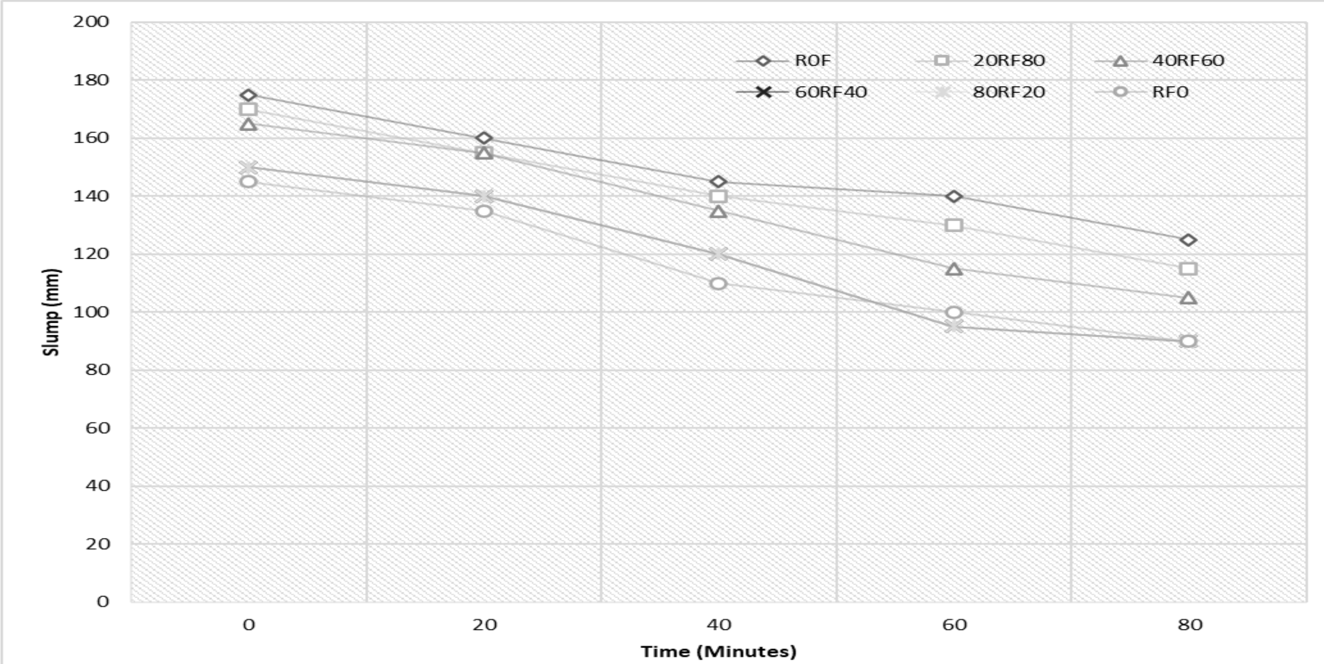

Figure 1. Slump values of GPC blends.

4.2. Compressive strength (CS)

The 7,28-, and 90-days CS of the mixes varied between 20 to 24 MPa, 28 to 31 MPa, and 32 to 38 MPa, respectively. The CS of the blends are given in figure 2. The figure 2 reveals that there is not any higher variation in CS of the mixes as the RHA content increases. The mix with 0 % RHA and 100 % FA has shown good strength but the CS of the mix with 100 % RHA and 0 % FA has been slightly increased. This is due to the fineness and higher silica content of RHA as RHA is finer than FA. The fineness of the source material and higher silica content is the prime factor for the strength of GPC mixes, the higher the fineness and silica content higher the strength [23-25, 31, 36-38].

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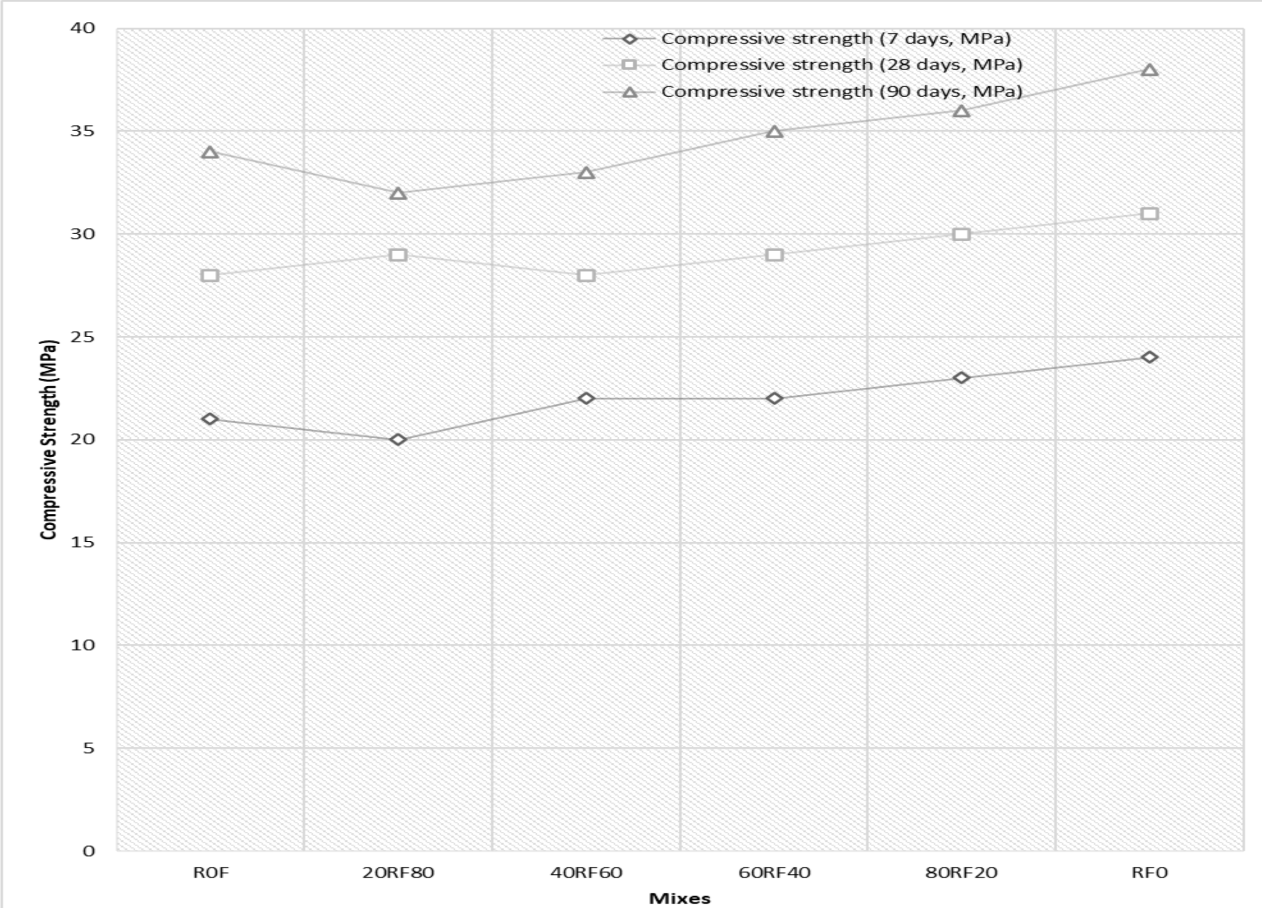

Figure 2. Compressive strength of GPC blends.

4.3.Split tensile strength (STS)

The 7,28-, and 90-days STS of the mixes varied between 2.3 to 2.8 MPa, 3 to 3.3 MPa, and 3.7 to 4.2 MPa, respectively. The STS of the blends are given in figure 3. The figure 3 reveals that there is not any higher variation in STS of the mixes as the RHA content increases. The mix with 0 % RHA and 100 % FA has shown good STS but the STS of the mix with 100 % RHA and 0 % FA has been slightly increased. This is due to the fineness and higher silica content of RHA as RHA is finer than FA. The fineness of the source material and higher silica content is the prime factor for the strength of GPC mixes, the higher the fineness and silica content higher the strength [23-25, 31, 36-38].

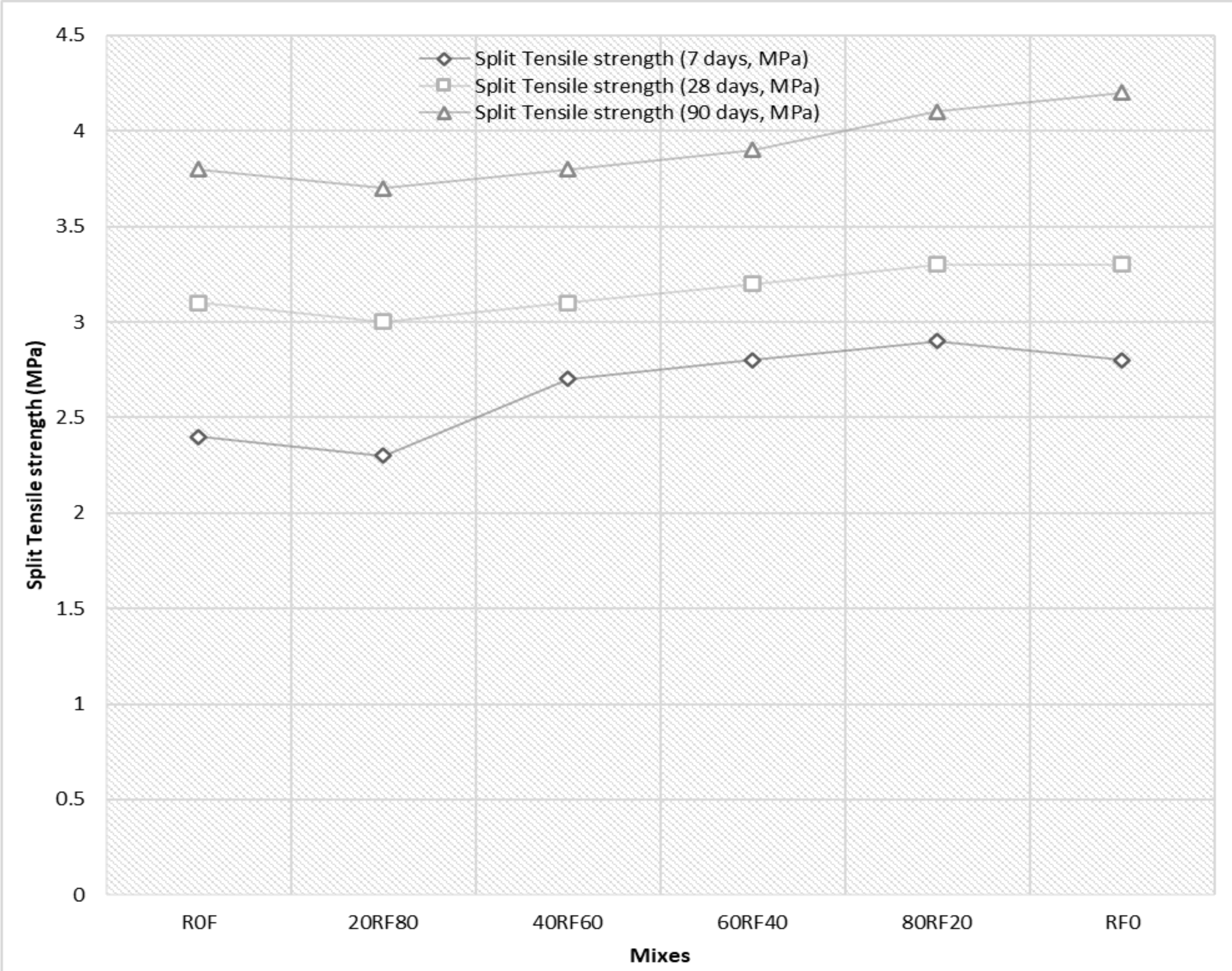

Figure 3. Split tensile strength of GPC blends.

4.4. Flexural strength (FS)

The 7,28-, and 90-days FS of the mixes varied between 2.3 to 2.9 MPa, 3 to 3.3 MPa, and 3.7 to 4.1 MPa, respectively. The FS of the blends are given in figure 3. The figure 3 reveals that there is not any higher variation in FS of the mixes as the RHA content increases. The mix with 0 % RHA and 100 % FA has shown good FS but the STS of the mix with 100 % RHA and 0 % FA has been slightly increased. This is due to the fineness and higher silica content of RHA as RHA is finer than FA. The fineness of the source material and higher silica content is the prime factor for the strength of GPC mixes, the higher the fineness and silica content higher the strength [23-25, 31, 36-38].

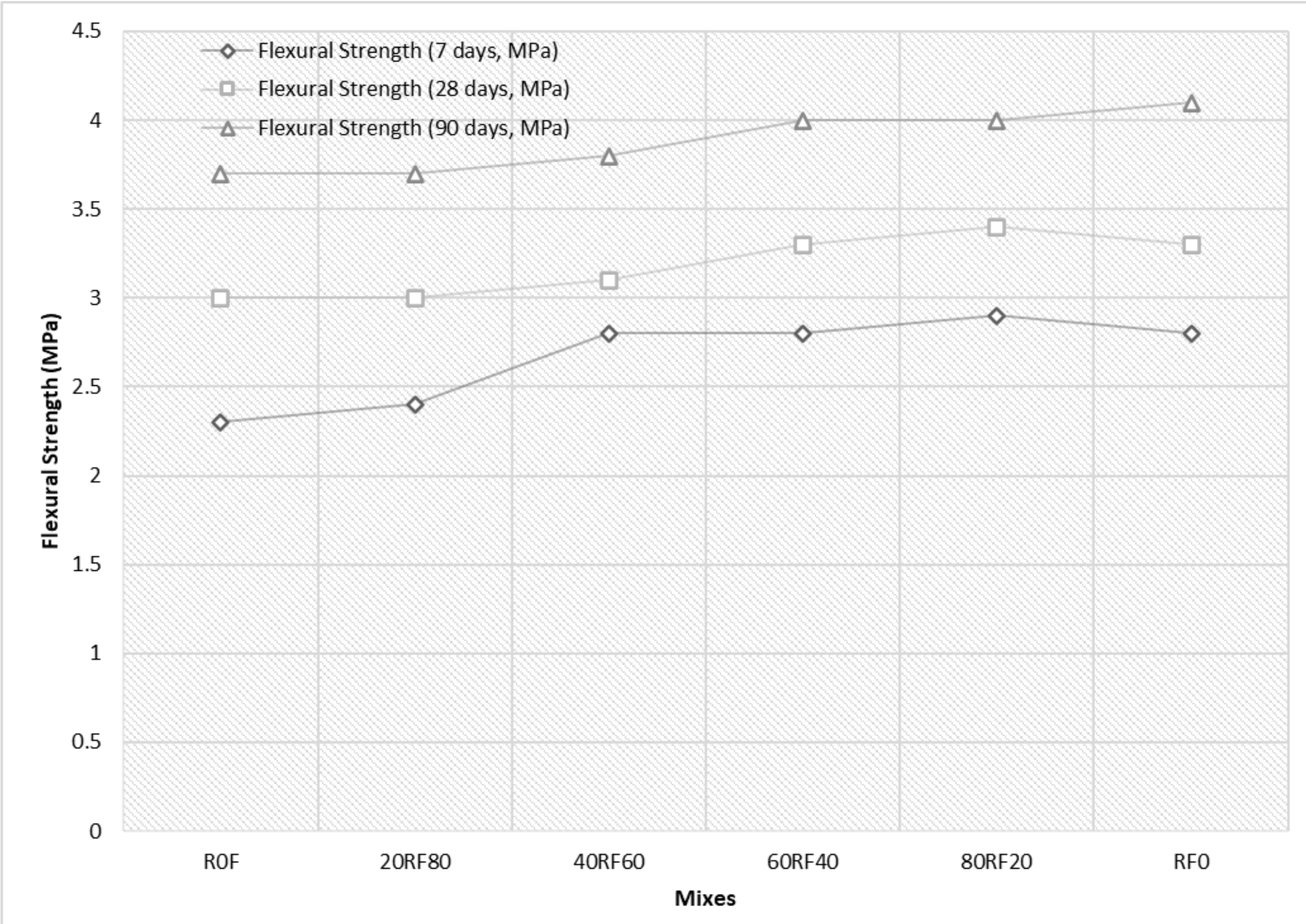

Figure 4. Flexural strength of GPC blends.

5. Conclusion

The following conclusions are made from the study

1. Both GPCs are eco-friendly and made from the utilization of byproducts.
2. The flowability of RHA based GPC is lower than FA based GPC.
3. The compressive strength of RHA based GPC is slightly higher than FA based GPC.
4. The flexural and split tensile strength of RHA based GPC is slightly higher than FA based GPC not more than 10 %
5. By products used resulted in good strength GPC.
6. Cement replacement in GPC reduces carbon dioxide emission.

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