Strength Characteristics of GGBS and Fly Ash Based Geopolymer Concrete using Overburnt Bricks as Coarse aggregate

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Abstract: The construction industry has grown significantly in importance as a result of meeting the needs of the world's growing population. Apart from naturally available resources such as coarse aggregate, fine aggregate, and water, cement is the most essential and artificially man-made substance utilized in the manufacture of concrete. Cement manufacture not only depletes natural resources but also emits toxic chemicals into the atmosphere, such as CO2 and NOx [R]. As a result, alternative cement binder ingredients that lower carbon footprint are required. Aside from reducing cement production by employing alternative materials, it is also necessary to investigate the availability of alternative materials that can be utilized in place of naturally accessible coarse aggregates.

Many research investigations have been launched in quest of alternative binder materials, with Geopolymer concrete (GPC) being one of them. GPC may be made by combining cementitious materials like as fly ash and Ground Granulated Blast Furness Slag (GGBS) with typical concrete production components such as coarse aggregate and fine aggregates. For binding all of the raw ingredients, an alkaline molar activator composed of NaoH and Na2SiO3 is used. The current study aims to investigate the compressive strength characteristics of GPC prepared using various GGBS to fly ash proportions (100:0, 75:25, 50:50, and 25:75), alkaline molar activators (2,4,6, and 8) and coarse aggregate to burnt brick proportions (100:0, 90:10, 80:20, 70:30, 60:40, and 50:50).

Of all 64 mix proportions, the GGBS to fly ash ratio (100:0), substitution of coarse aggregate with overburned brick (90:10) using 8M resulted in the maximum strength. All types of significant concrete works can employ this brick geopolymer concrete. In comparison to all 64 mix proportions, the replacement of coarse aggregate with overburned brick (90:10) using 8M resulted in moderate strength with a GGBS to fly ash ratio of 50:50. With respect to the various material proportions described above, the fluctuation of GPC's compressive strength is shown.

Keywords: *Geopolymer Concrete (GPC), Fly Ash, GGBS, over burnt bricks (OBB), Sodium Hydroxide, Sodium Silicate, Brick Geopolymer Concrete (BGPC).*

1. Introduction

The term GPC is coined by a French scientist Prof. Joseph Davidovitts, in the year 1978. Concrete is a basic man-made building material used in constructions like buildings, bridges, roads and dams etc. Generally, the concrete is widely used in the construction as its possess high strength, hardness, toughness, durability and versatility during construction of a structure. These properties have made concrete a trust-worthy and ever-lasting choice in construction. Despite being used widely in the construction, cement has its drawbacks are as cement is most highly consumed product. But it also releases an extreme amount of carbon dioxide every year which creates pollution causing harm to our environment. It requires more mechanical energy to manufacture the cement. Cement substitutes are materials that may be substituted to some degree in order to overcome the disadvantages of cement during manufacturing. The alternative cementitious Cement substitutes are materials that may be substituted to some degree in order to offset the shortcomings of cement during manufacture. Fly ash and GGBS are two substitutes for cement that are finely divided cementitious materials. We can create GPC, a type of concrete that is an eco-friendly substitute for Portland cement concrete, by employing alternative ingredients materials finely divided materials which replace cement are Fly ash, GGBS. By using alternate materials, we can manufacture GPC, is a type of concrete which is eco-friendly construction material and alternate to Portland cement concrete .He substituted overburned bricks for ordinary ones in this investigation to a maximum of 100%.

For compressive strength, he is getting excellent results. Additionally, he performed the slump cone test for all mix amounts in this investigation. achieving success [1]. This is base paper for my research work from this paper using mix proportions calculations and alkali activators proportions[2]. He experimented with different fly ash to ggbs ratios in this research using alkali activators such sodium hydroxide and sodium silicate. Geopolymer concrete will provide good compressive strengths in this investigation [3]. This study found that there is a significant drop in strength when the strength may be compared to conventional concrete up to a 30-35 percent replacement. Micro-structural investigation of geopolymer fly ashaggregates are also carried out using SEM and X-Ray Diffraction (XRD) analysis [4].

In this work, coarse aggregate is used in place of OBB, and satisfactory compressive strength findings are obtained. However, this is a typical concrete. Additionally, he does not clarify how the proportionality of OBB increases with water absorption [5]. Although alkaline activators' effects are discussed in this study, alkali activators have a high heat of hydration and provide good mixing properties for geopolymer concrete [6]. The geopolymer concrete activators' molarity in this investigation is up to 16m. While molarity is rising, the expense of molarity is also rising thanks to OBB's successful operations [7]. Effect of alkaline activators and sand mechanical characteristics of ggbs-based mortars were studied. However, this only applies to cement strength, not to compressive strengths. it will be used for ggbs outcomes [8]. modified fly ash-based geopolymer-based mortars were studied. It is beneficial for the research investigation [9]. Although this study compares fly ash to ggbs rations, fly ash to ggbs based GPC is showing good outcomes. There is no change in the proportions of the ingredients despite the application of various alkaline activators [10]. In this work, alkaline activators were used to speed up the cement-steel slag composite binder's setting time and hydration performance but not its compressive and tensile strengths [11].

GPC is produced by using industrial byproducts like fly ash, GGBS, alkali activators such sodium silicate and sodium hydroxide, as well as both fine and coarse aggregates. Due to the fact that the construction industry uses a significant amount of natural resources and produces a lot of waste, the idea of sustainable construction has become increasingly important. Due to its widespread use as a building material worldwide, concrete is one of the major consumers of natural resources..

Concrete is viewed as a material with a potential location for wastes because of its composite nature (a binder, aggregates, and water), and because it is utilised all over the world, it suggests that if a waste could be absorbed into concrete, then most certainly massive amount of it may be recycled. Any decrease in the use of natural aggregates will have a significant negative impact on the environment because aggregates make up between 60 and 75 percent of the components of concrete. The rate at which stone pits can be utilised is generally slowed down by the environmental problems they cause, which include vibrations, noise, dust, and a significant influence on the surrounding area.

On the other hand, research into and usage of alternative resources, such as construction and demolition waste (CDW) and other industrial wastes, is growing. These materials can be used in place of natural aggregates to create concrete that is more environmentally friendly .

Burnt brick is a type of brick that has had a kiln treatment at a high temperature to strengthen it mechanically and increase its resistance to moisture. A specific number of bricks are fractured, underburnt, or overburnt depending on the heating (firing) and handling techniques used throughout the manufacturing process. It has chemical components including iron, silica, lime, alumina, and magnesia, among others, making its usage in the creation of concrete quite practical. Concrete built with burnt bricks or clay has the

Research Significance

In order to compare the compressive strength of GPC made with GGBS and Fly ash (100:0, 75:25, 50:50, and 25:75) with different molarities in GPC such as 2, 4, and 6, with alkaline activators of NaOH and Na_2SiO_3, along with overburnt bricks (10%, 20%, 30%, 40%, and 50%) as the coarse aggregates, this research is crucial..

Objective of the current study

The primary goal of the current study is to examine the strength properties of GPC employing GGBS and fly ash at various molarities, along with substituting burnt bricks for coarse aggregate in the M-20 design mix.

2. Materials

The following materials used in the preparation of GPC mix.

i) Fly ash

ii) Ground granulated blast furnace slag
iii) Fine aggregate
iv) Coarse aggregate
v) Alkaline Activators (NaOH, Na2SiO3)
vi) Over burnt bricks

Alkaline activator solution is created by mixing sodium hydroxide and sodium silicate with 1 litre of potable water for each mixture. To manufacture sodium hydroxide solution, flakes are dissolved in potable water to create NaOH solution. At least 24 hours should pass before the solution is ready for usage. Bricks that were overburnt have been pulverised with crushers to the necessary size. Sand from rivers is utilised as the mix's fine aggregate. SP-30 is used into the entire GPC mix to make it more workable [6].

3. Methodology

It depicts the experimental work that will be done to determine how much overburned brick replacement affects the compressive strength of geopolymer concrete manufactured with GGBS and fly ash. The compressive strength of geopolymer concrete made with GGBS and fly ash (100:0, 75:25, 50:50, and 25:75) as well as different molarities of geopolymer concrete, such as 2, 4, and 6, with alkaline activators of NaOH and Na2SiO3 as well as over-burnt bricks as the coarse aggregates, is being compared in this research, which is crucial.

4. Results and Discussions

A. Experimental Programme

The experimental programme involved casting and testing cubes of size 100 mm X 100 mm X 100 mm at their 7 days and 28 days ambient curing in order to determine the compressive strength of GGBS and Fly Ash based GPC reinforced with different Coarse aggregate to Burnt brick in different volume proportions for different GGBS to Fly Ash ratios with different molarities.

B. Mixing, Casting and Curing of BGPC Specimens:

The same standard methods that are used to produce concrete are also employed to produce BGPC. Cube specimens were created by stacking three layers of fresh BGPC, compacting each layer with a tamping rod, and then putting the finished product on a table vibrator for ten seconds. After casting, cubes were demoulded after 24hrs.

The compressive strength data of GPC manufactured utilizing different GGBS to fly ash proportions, four different alkaline molar activators, four different coarse aggregate to burned brick proportions, and six different coarse aggregate to burnt brick proportions, are tabulated in Tables 1 through 4.
With an ALC to Binder ratio of 0.6, a CA: OBB ratio of 90:10, and a GGBS: FA ratio of 100:0, Table.1 presented the compressive strength of GPC for 7 days and 28 days. In comparison to the GPC without any proportion of OBB taken as reference concrete strength of 61.64Mpa for 8M, this ratio yields a compressive strength of 64.90Mpa, as shown in Figures 1 and 2.

With an ALC to Binder ratio of 0.6, a CA:OBB ratio of 90:10, and a GGBS:FA ratio of 75:25, Table.2 presented the compressive strength of GPC for 7 days and 28 days. In comparison to the GPC without any proportion of OBB taken as reference concrete strength of 52.76Mpa for 8M, this ratio yields a compressive strength of 59.29Mpa, as shown in Figures 3 and 4. The Compressive strength of GPC is assessed in Table.3 for 7 days and 28 days with an ALC to Binder ratio of 0.6, a CA:OBB ratio of 90:10, and a GGBS:FA ratio of 50:50. In comparison to the GPC without any proportion of OBB taken as reference strength of 26.05Mpa for 8M, this ratio yields a compressive strength of 37.56Mpa, as shown in Figures 5 and 6.

With an ALC to Binder ratio of 0.6, a CA:OBB ratio of 90:10, and a GGBS:FA ratio of 25:75, Table.4 assesses the compressive strength of GPC for 7 days and 28 days. In comparison to the GPC without any proportion of OBB taken as reference concrete strength of 21.98Mpa for 8 M, this ratio yields a compressive strength of 26.76Mpa, as shown in Figures 7 and 8.
Of all 64 mix proportions, the GGBS to fly ash ratio (100:0), substitution of coarse aggregate with over burned brick (90:10) using 8M resulted in the maximum strength.

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All sorts of significant concrete operations can employ this brick geopolymer concrete. In comparison to all 64 mix proportions, the substitution of coarse aggregate with over burned brick (90:10) using 8M resulted in moderate strength with a GGBS to fly ash ratio of 50:50.

The fluctuation of GPC's compressive strength with the various material ratios indicated above is represented graphically. Out of all 64 mix proportions, the aggregate with overburnt brick (90:10) produced the maximum strength.
All sorts of significant concrete operations can employ this brick geopolymer concrete. In comparison to all 64 mix proportions, the substitution of coarse aggregate with over burned brick (90:10) using 8M resulted in moderate strength with a GGBS to fly ash ratio of 50:50.
Graphical representation of the change in GPC's compressive strength with respect to the various material proportions described above

Table 1: Compressive strength of GPC (7D & 28D) For $(\frac{ALC}{Binder}) = 0.6$, $GGBS\ 100: FA\ 0$

Sl. No	Designation	Molarity (M)	(GGBS : FA) A	C : B		$(\frac{BB}{CA})$ Ratio	Compressive strength (MPa) 7D	Compressive strength (MPa) 28D
1	2MA1	2	100:0	1	C50B50	1	32.93	33.09
2	2MA2			2	C60B40	0.67	35.06	36.12
3	2MA3			3	C70B30	0.43	37.2	39.4
4	2MA4			4	C80B20	0.25	42.27	42.61
5	2MA5			5	C90B10	0.11	43.11	43.33
6	2MA6			6	C100B0	0	45.83	46.54
7	4MA1	4		1	C50B50	1	31.05	31.12
8	4MA2			2	C60B40	0.67	35.69	36.63
9	4MA3			3	C70B30	0.43	38.68	42.05
10	4MA4			4	C80B20	0.25	39.84	43.69
11	4MA5			5	C90B10	0.11	49.48	49.72
12	4MA6			6	C100B0	0	50.94	51.53
13	6MA1	6		1	C50B50	1	31.96	32.21
14	6MA2			2	C60B40	0.67	36.85	38.47
15	6MA3			3	C70B30	0.43	41.10	41.65
16	6MA4			4	C80B20	0.25	46.28	50.77
17	6MA5			5	C90B10	0.11	48.29	52.94
18	6MA6			6	C100B0	0	51.84	54.03
19	8MA1	8		1	C50B50	1	34.18	36.06
20	8MA2			2	C60B40	0.67	37.64	39.90
21	8MA3			3	C70B30	0.43	41.25	42.43
22	8MA4			4	C80B20	0.25	50.26	59.22
23	8MA5			5	C90B10	0.11	61.64	64.90
24	8MA6			6	C100B0	0	62.91	66.20

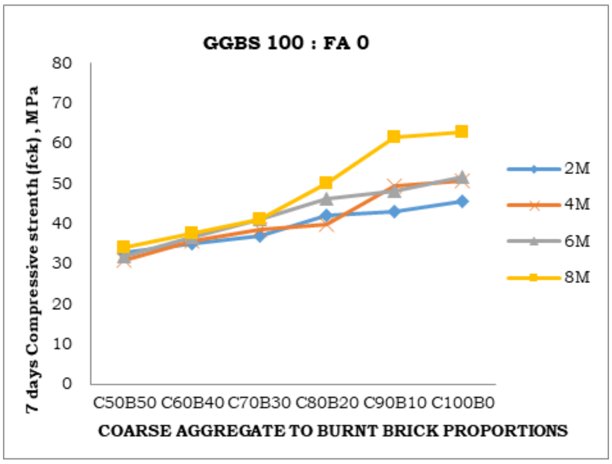

Fig 1. Variation of 7D-f_{ck} for constant GGBS to FA ratio 100:50

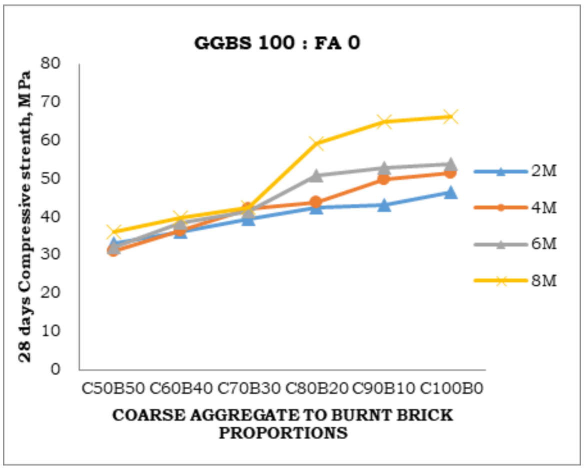

Fig 2. Variation of 28D-f_{ck} for constant GGBS to FA ratio 100:0

Table 2: Compressive strength of GPC (7D & 28D) For $\left(\frac{ALC}{Binder}\right) = 0.6$, $GGBS\ 75: FA\ 25$

Sl.No	Designation	Molarity (M)	(GGBS : FA) B	CA: BB		$\left(\frac{BB}{CA}\right)$ Ratio	Compressive strength (MPa)	
							7D	28D
1	2MB1	2	75:25	1	C50B50	1	30.70	31.01
2	2MB2			2	C60B40	0.67	31.69	32.69
3	2MB3			3	C70B30	0.43	32.76	33.72
4	2MB4			4	C80B20	0.25	33.31	35.93
5	2MB5			5	C90B10	0.11	34.69	37.71
6	2MB6			6	C100B0	0	34.84	38.97
7	4MB1	4		1	C50B50	1	31.02	32.69
8	4MB2			2	C60B40	0.67	36.37	36.72
9	4MB3			3	C70B30	0.43	37.08	38.54

10	4MB4			4	C80B20	0.25	40.08	42.17
11	4MB5			5	C90B10	0.11	42.36	44.16
12	4MB6			6	C100B0	0	41.96	48.01
13	6MB1	6		1	C50B50	1	33.15	34.01
14	6MB2			2	C60B40	0.67	36.06	36.33
15	6MB3			3	C70B30	0.43	38.47	38.97
16	6MB4			4	C80B20	0.25	41.32	44.60
17	6MB5			5	C90B10	0.11	45.11	46.33
18	6MB6			6	C100B0	0	44.97	50.48
19	8MB1	8		1	C50B50	1	36.60	39.11
20	8MB2			2	C60B40	0.67	40.04	42.40
21	8MB3			3	C70B30	0.43	41.51	47.95
22	8MB4			4	C80B20	0.25	44.39	54.02
23	8MB5			5	C90B10	0.11	52.76	59.29
24	8MB6			6	C100B0	0	51.98	61.83

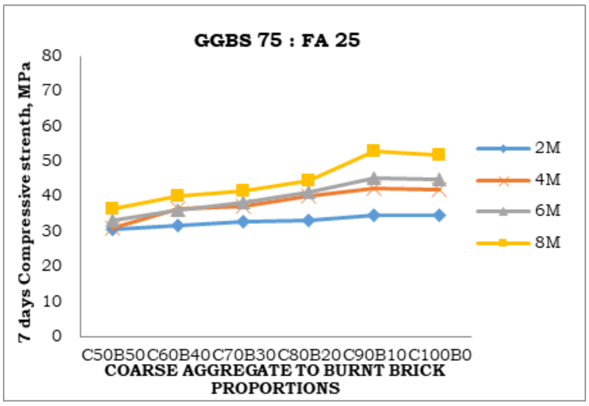

Fig 3. Variation of 7D-f_{ck} for constant GGBS to FA ratio 75:25

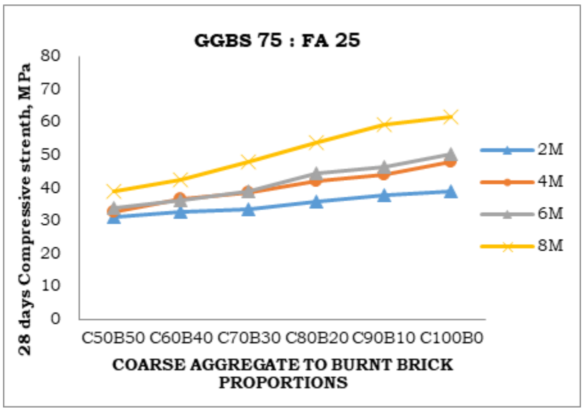

Fig 4. Variation of 28D-f_{ck} for constant GGBS to FA ratio 75:25

Table 3: Compressive strength of GPC (7D & 28D) For $\left(\frac{ALC}{Binder}\right) = 0.6$, $GGBS\ 50 : FA\ 50$

							Compressive strength (MPa)	

Sl.No	Designation	Molarity (M)	(GGBS : FA) C	CA: BB		$\left(\frac{BB}{CA}\right)$ Ratio	7D	28D
1	2MC1	2	50 : 50	1	C50B50	1	21.01	22.82
2	2MC2			2	C60B40	0.67	25.33	26.43
3	2MC3			3	C70B30	0.43	26.73	27.76
4	2MC4			4	C80B20	0.25	27.54	28.13
5	2MC5			5	C90B10	0.11	27.60	28.35
6	2MC6			6	C100B0	0	27.85	29.43
7	4MC1	4		1	C50B50	1	17.81	21.02
8	4MC2			2	C60B40	0.67	21.02	27.06
9	4MC3			3	C70B30	0.43	22.5	28.51
10	4MC4			4	C80B20	0.25	23.9	28.77
11	4MC5			5	C90B10	0.11	25.58	27.88
12	4MC6			6	C100B0	0	25.35	28.16
13	6MC1	6		1	C50B50	1	18.34	24.12
14	6MC2			2	C60B40	0.67	24.05	27.45
15	6MC3			3	C70B30	0.43	29.75	31.79
16	6MC4			4	C80B20	0.25	30.63	32.33
17	6MC5			5	C90B10	0.11	31.86	35.53
18	6MC6			6	C100B0	0	31.06	33.97
19	8MC1	8		1	C50B50	1	25.85	29.62
20	8MC2			2	C60B40	0.67	29.82	33.3
21	8MC3			3	C70B30	0.43	30.94	33.4
22	8MC4			4	C80B20	0.25	31.22	35.89
23	8MC5			5	C90B10	0.11	26.05	37.56
24	8MC6			6	C100B0	0	27.79	38.13

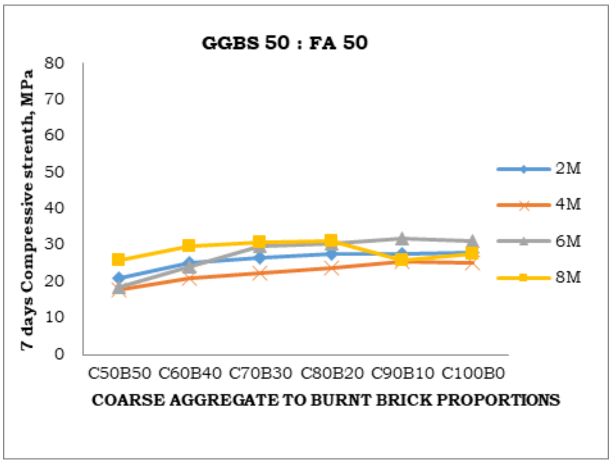

Fig 5. Variation of 7D-f_{ck} for constant GGBS to FA ratio 50:50

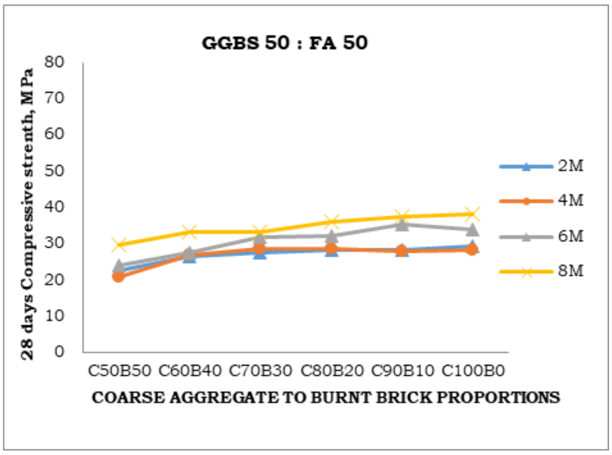

Fig 6. Variation of 28D-f_{ck} for constant GGBS to FA ratio 50:50

Table 4: Compressive strength of GPC (7D & 28D) For $(\frac{ALC}{Binder}) = 0.6$, $GGBS\ 25: FA\ 75$

Sl.No	Designation	Molarity (M)	(GGBS : FA) D	CA: BB		$(\frac{BB}{CA})$ Ratio	Compressive strength (MPa)	
							7D	28D
1	2MD1	2	25 : 75	1	C50B50	1	12.74	14.89
2	2MD2			2	C60B40	0.67	14.50	16.41
3	2MD3			3	C70B30	0.43	15.61	16.21
4	2MD4			4	C80B20	0.25	17.87	18.28
5	2MD5			5	C90B10	0.11	19.89	20.95
6	2MD6			6	C100B0	0	20.84	21.02
7	4MD1	4		1	C50B50	1	14.06	16.50
8	4MD2			2	C60B40	0.67	16.81	17.36
9	4MD3			3	C70B30	0.43	16.50	18.15
10	4MD4			4	C80B20	0.25	18.77	20.54
11	4MD5			5	C90B10	0.11	20.84	21.83
12	4MD6			6	C100B0	0	21.07	24.01
13	6MD1	6		1	C50B50	1	15.43	16.33
14	6MD2			2	C60B40	0.67	17.02	18.40
15	6MD3			3	C70B30	0.43	17.17	19.14
16	6MD4			4	C80B20	0.25	19.51	20.71
17	6MD5			5	C90B10	0.11	21.06	23.82
18	6MD6			6	C100B0	0	21.97	25.94
19	8MD1	8		1	C50B50	1	16.28	20.53
20	8MD2			2	C60B40	0.67	18.03	21.16
21	8MD3			3	C70B30	0.43	18.75	22.14
22	8MD4			4	C80B20	0.25	20.51	23.86
23	8MD5			5	C90B10	0.11	21.98	26.76
24	8MD6			6	C100B0	0	22.01	29.89

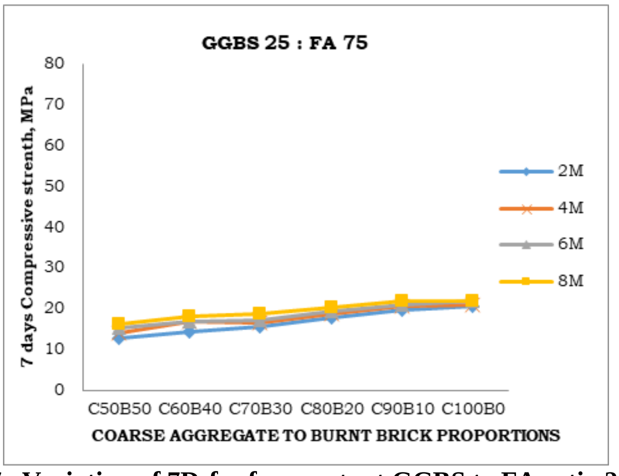

Fig 7. Variation of 7D-f_{ck} for constant GGBS to FA ratio 25:75

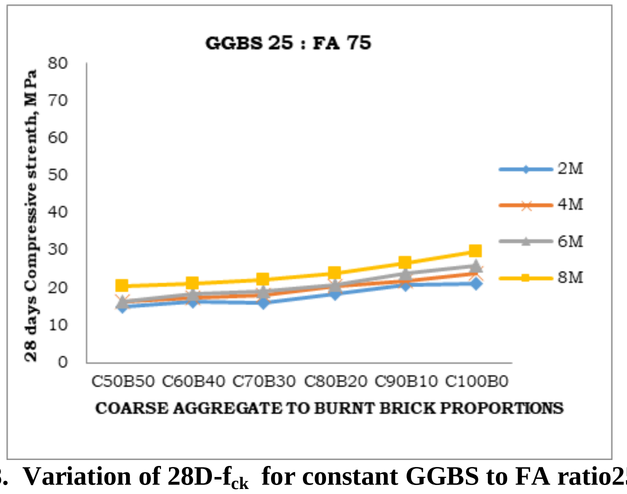

Fig 8. Variation of 28D-f_{ck} for constant GGBS to FA ratio25:75

5. Conclusions

Analyze the graph, which shows a comparison of compressive strength values for FA: GGBS-25:75 with molarity variation but no change in those values.

When utilizing 4M and 2M, the values of the FA: GGBS -25:75 compressive strength graph are dropping. We are unable to do more study on this mix ratio since the compressive strength values are declining.

The molarity does not vary substantially. All OBB replacements are compared with CA in GGBS at 25:75. Graph 1 analysis of 28 days' compressive strength is declining as the OBB rises CA is used in place. the number 2M received at CA: OBB -50:50 for 28 days with compressive strength 31.01.

Compressive strength values for a 50:50 CA: OBB comparison, denoted in percentage, are 18. OBB replacement was increased while the CA compressive strength was marginally declining.

The 7D and 28D were chosen by GGBS to fly ash ratio for any constant alkaline molar activator. Increases in the percentage of burned brick (BB) to coarse aggregate enhance the compressive strength of GPC. This has demonstrated that using BB in the proper ratios (50:50) with coarse aggregate is possible. This may facilitate the usage of waste products like BB and slow the depletion of coarse aggregates found in nature.

The 7D and 28D Compressive Strength of GPC is improved with an increase in the GGBS to Fly ash ratio for any constant alkaline molar activator (100:0, 75:25, 50:50 and 25:75). This shown that the Compressive strength of GPC grew along with the GGBS percentage.

The 7D and 28D Compressive Strength of GPC is improved with an increase in alkaline molar activator for any constant BB to Coarse Aggregate Ratio, GGBS to Fly Ash Ratio.

Of all 64 mix proportions, the GGBS to fly ash ratio (100:0), substitution of coarse aggregate with overburned brick (90:10) using 8M resulted in the maximum strength. All sorts of significant concrete operations can employ this brick geopolymer concrete.

In comparison to all 64 mix proportions, the substitution of coarse aggregate with over burned brick (90:10) using 8M resulted in moderate strength with a GGBS to fly ash ratio of 50:50.
According to the study's findings, replacing coarse aggregate with over burned brick results in the maximum strength while employing the least amount of natural resources.

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