Consequences of Recycled Glass Powder Waste as Assets of Flyash and GGBS based Geopolymer Concrete

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ABSTRACT

The utilization of recycled materials in concrete is attractive for decreasing the consumption &waste of natural resources. The geo-polymer will be inorganic binder materials that as developed as alternate to conventional cement binders for concrete field. The geo-polymer concrete (GPC) will be established with the use of source materials such as sodium silicate, flyash, & alkaline activator sodium hydroxide, &cured at elevated temperature. An attempt was made to create GPC utilizing inappropriate mix of industrial waste materials such as flyash, glass powder and aggregates, & ground granulated blast furnace slag (GGBS). In current work, effort has been made to survey the usage effect of glass powder as incomplete replacement of flyash (FA) and GGBS based GPC. The flyash in GPC was exchanged by glass powder in range of 5 to 20% with an increase of 5%. It is noticed that 10% replacement of FA by GP provided maximum 28 days strength. The simulation outcomes depicted that replacement of GP & FA by numerous GGBS percentages resulted in increment of split tensile, compressive, flexural strength of FA based GPC up to 15% and thereafter there will be a reduction in strength values. Therefore, the outcomes of strength experiments on GPC cubes cured &prepared at 60^{0}C temperature at 48 hours only specify the improve men attained consistent to nominated optimum replacement of FA by GGBS glass powder. Therefore, the main industrial wastes like GP, FA, &GGBS is discover to be possible in production of novel sustainable green construction material of reasonable good strength.

Keywords Geo-polymer; fly-ash (FA); GGBS; Glass powder(GP), compressive strength (CS)

INTRODUCTION

Concrete will be the main utilized & generated construction material in world. It will be strong & low cost; however, it has environmental disadvantages. The cement production industry will be the main CO_2emittingindustrialsector; it will be responsiblefor5%of global CO_2 emissions [1].

Geo-polymers are a relatively novel class of construction materials [2]. Geo-polymers do not need calcium silicate-hydrate gel; however, utilize the poly-condensation of alumina &silica precursors to attain a higher strength level[3].Geo-polymer method might convert industrial solid wastes comprising alumina silicates into valuable products [4]. Any waste material comprising proper amount of alumina &silica might help as precursor for geo-polymerization [5].

In last year's investigators are concentrated on utilizing diverse kinds of glass waste in geo-polymers production, thanks to their pozzolanic properties & amorphous nature [6]. Each year millions loads of glass have produced in municipal waste & because of impurities and mixed colors only a quarter of this glass waste might be reused. Thanks to high portion of alkali and silicate, utilizing recycled glass as raw materials for making geo-polymers. This outcome will be favorable from environmental & economic points of view[7].Glass powder is an amorphous material consists big amount of silica because of its silica content finely ground glass might be deliberated as a pozzolanic material & might be display same assets as other pozzolanic material utilized for concrete production [8].

Fine glass powder provides higher pozzolani creativity; furthermore, an increment in curing temperature accelerates the activation of both FA &recycled glass [9].To enhance GPC workability, a water reducer super plasticizer or extra water might be included to mixture. Glass powder finer than 600micron becomes reactive silica; therefore, it might be utilized as additional source for Si. The chemical examination of accessible FA designated low percentage (less than 9%) of Aluminum oxide. To increment the number of Al in geo-polymer,

MATERIAL USED

Fly Ash

Fly ash is a by-product of combustion of pulverized coal in thermal power plants. In this work class, FA will be attained from Raja rajeshwari ready mix plant at Kurnool, Andhra Pradesh, India. Flyash particles as per IS code 3812:2003 [11] have usually spherical, ranging in diameter from 1umup to 150 um. The chemical composition &physical properties of FA have represented in Table1 and Table2.

GGBS

The GGBS will be by product from blast furnaces utilized to make iron. The GGBS contains important silicates and alumina silicates of calcium. GGBS will be attained from JSW steel Ltd, Gadivemula. The chemical composition &physical properties of GGBS have represented in Table1 and Table3.

Table 1: Physical Properties of GGBS& FA

Property	Values	
	GGBS	FA
Specific Gravity of ash	2.92	2.2
Specific Surface area of particle	350-450	380

Table 2: Chemical Composition of FA

Chemical composition	Percentage in Mass
	FA
Cao	4.00
SO3	0.12
SiO2+Al2O3+Fe2O3	82.00
MgO	0.92
SiO2	59.50
L.O.I	0.95

Table 3: Chemical Composition of GGBS

S. No	Oxide	Percentage by mass (%)
1	Al_2O_3	14.42
2	MgO	8.71
3	Fe_2O_3	1.11
4	CaO	37.34
5	SiO_2	36.71
6	SS	0.39
7	LOI	1.41
8	MnO	0.02

Coarse Aggregate

The coarse aggregate utilized in this work was of 20mm down nominal size. The granite crushed angular shaped coarse aggregate is attained from local crushing plants having specific gravity is 2.76.

Fine Aggregate

In current study, river sand available in local area is utilized as fine aggregate and has a specific gravity is 2.63. As per IS 383: 1970 the fine aggregate falls under category zone -II.

Alkaline Activators

In current survey, sodium based alkaline activators have utilized. The mixture of sodium silicate &sodium hydroxide results have utilized for activation of FA based geopolymer concrete. It will be noticed, which GPC compressive strength (CS) enhances with increment in concentration of sodium hydroxide solution in terms of morality (M) makes concrete much brittle with improved CS. Next, solid sodium hydroxide price will be high & preparation is very acidic. In this survey, the sodium hydroxide concentration is maintained at 10 M, whereas sodium silicate concentration comprising SiO2 of 34.35 %, NaO of 16.45 %, & H2O of 49.20 % will be utilized as alkaline activator solutions.

Glass Powder

The GP is attained by crushing available waste glass pieces utilizing a crusher & power passing through 200M is sieve is utilized in investigation.

Table4: physical properties of GP

Physical state	Fine powder
odour	odourless
appearance	Free flowing(clear particles pure)
color	Natural pure white
Boiling point	>1300 C
Specific gravity	2.6% ,max
moisture	Below 0.5%
Particle size	200M

Table5: chemical properties of GP

SiO_2	99.5%
CaO	0.01%
MgO	0.01%
L.O.I	0.28%
Al_2O_3	0.08%
TiO_2	0.04%
Fe_2O_3	0.04%
Alkalies	0.29%

EXPERIMENTAL PROGRAM

Objectives of Study

The goal of current work include

- To survey the result of waste GP in diverse percentages i.e.; 5%,10%,15%,20% on flyash based GPC.
- To study optimum percentage of GGBS in FA and waste glass powder corresponding to maximum strength properties for a particular morality.

Mix Design of GPC

The mix design of GPC is purely diverse to that of cement concrete. The GPC production is carried out by utilizing error &trial model. In GPC, usually the mass of joined aggregates might vary between70% to80%. With regard to alkaline liquid to FA ratio by mass of FA, values in range of 0.35 to 0.5 have suggested. In initial, the whole number of 4 trial mixes of GPC is generated to evaluate the workability features and survey the impact of numerous factors on CS. Lastly, the ratio of alkaline liquid to FA was kept at 0.45 as constant and sodium silicate solution ratio to sodium hydroxide solution was kept at 2.5 as constant for all mix proportions. The details of mix proportions studied have provided below in the Table6.

Table 6: Mix proportions of diverse mixes

Mix No	Mix designation	FA kg/m³	F.A kg/m³	C.A kg/m³	Liquid /binder	GP in %	Curing temperature
1	FA-GP-0 (control GPC mix)	380.689	554	1293.6	0.45	0	oven curing 60^0 C
2	FA-GP-5	361.659	554	1293.6	0.45	5	oven curing60^0 C
3	FA-GP-10	342.629	554	1293.6	0.45	10	oven curing60^0 C
4	FA-GP-15	323.589	554	1293.6	0.45	15	oven curing60^0 C
5	FA-GP-20	304.55	554	1293.6	0.45	20	oven curing60^0 C

Table 7: Mix proportions of different mixes

` Mix No	Mix designation	FA kg/m³	GGBS	F.A kg/m³	C.A kg/m³	Liquid /binder	Glass powder in %	GGBS in %	Curing temperature
1	FAGP-GGBS-0 (control GPC mix	342.629	_	554	1293.6	0.45	10	0	oven curing 60^0 C
2	FA-GP-GGBS-5	327.401	15.228	554	1293.6	0.45	10	5	oven curing 60^0 C
3	FA-GP-GGBS-10	308.367	34.262	554	1293.6	0.45	10	10	oven curing 60^0 C
4	FA-GP-GGBS-15	291.239	51.39	554	1293.6	0.45	10	15	oven curing 60^0 C
5	FA-GP-GGBS-20	266.499	76.13	554	1293.6	0.45	10	20	oven curing 60^0 C

Mixing, Casting and Curing

The dry material such as flyash, GGBS &aggregates were first mixed together in pan mixer for about 3 minutes. Alkaline activator was prepared utilizing NaoH of 10 molar concentration mixed with Na_2sio_3 solution in ratio of 1:2 (by weight) to make alkali activator fluid. The replacement of flyash by GP in (5%, 10%, 15% and 20%) was added to the dry material. The liquid component of mixer was then included to dry materials & mixing continued further for about 3 minutes to manufacture the fresh concrete.

GPC specimens were cast in fresh state, which include cylinder for split tensile test, cube for compression test, and beams for flexural test. During casting the moulds were cleaned and properly oiled before placing fresh concrete is placed in 3 layers and each layer pass tamped and vibrated on vibration table. Remolding was done after the final setting of GPC.

The flyash and GGBS based GPC samples are cured at 60^0C temperature for 48 hours with in hot air oven. Moreover, the instances are kept at ambient temperature until the test.

RESULTS AND DISCUSSION

Strength properties of FA based GPC by the replacement of glass powder 0- 20% are shown in table 7. It observed that mix with 10% glass powder at 28 days obtained maximum strength. Further in next stage by keeping GP percentage constant at 10%, mix for FA changed with GGBS. The outcomes have represented in table 8. From table 8, it will be noticed that a slow increment in GPC strength when FA is replaced by GGBS up to 15% & then reduces at 20%. From this study it has noticed that, mix with FA replacement by GP provides better strength properties than the control GPC mix. However, the strength properties of GGBS blended flyash GPC exhibits higher strength properties than all the other GPC mixes.

The CS variation of GPC the FA replacement by GP and FA replacement and GP by GGBS are shown infig1&2.

The split tensile strength (STS) variation of GPC the FA replacement by GP and FA replacement and GP by GGBS are shown in fig3&4.

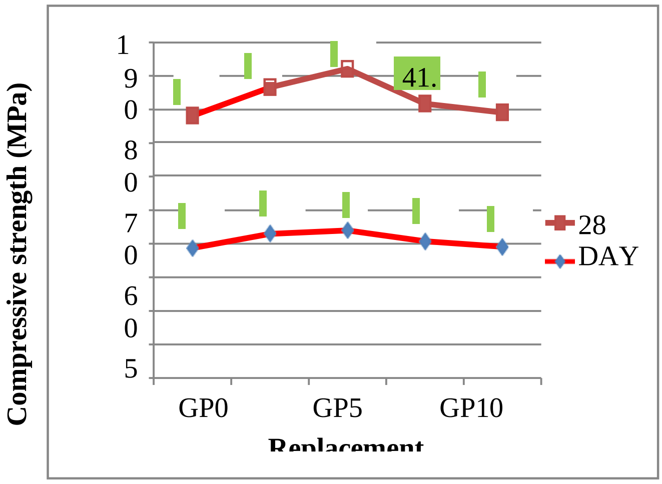

Figure1: CS variation of cubes (FA + GP)

The flexural strength (FS) variation of GPC the FA replacement by GP and FA replacement and GP by GGBS are shown in fig 5&6.

Table8: strength properties of GPC replacement of flyash by glass powder

s. no	Mix designation	CS (MPa)		STS (MPa)	FS (MPa)
		7 days	28 days	28 days	28 days
1	FA-GP-0(control GPC mix)	38.66	39.55	3.67	4.35
2	FA-GP-5	42.96	43.70	4.59	4.53
3	FA-GP-10	44	48.14	4.88	4.84
4	FA-GP-15	40.74	41.03	4.10	4.65
5	FA-GP-20	39.05	40.10	3.75	4.37

Table 9: strength properties of GPC replacement of FA and GP by GGBS

s.no	Mix designation	CS (MPa)		STS (MPa)	FS(MPa)
		7 days	28 days	28 days	28 days
1	FA-10%GP-GGBS(0) (control GPC mix)	44	48.14	4.88	4.84
2	FA-10%GP-GGBS(5)	45.01	49.77	4.95	4.91
3	FA-10%GP-GGBS(10)	46.22	51.11	5.09	4.99
4	FA-10%GP-GGBS(15)	48.88	52	5.23	5.07
5	FA-10%GP-GGBS(20)	44.44	50.66	5.16	4.96

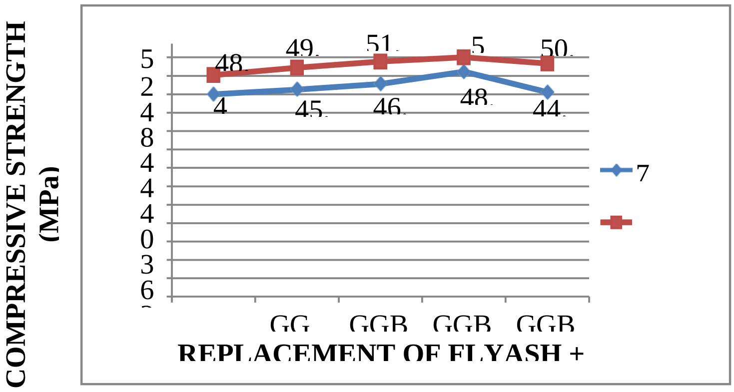

Figure 2: CS variation of cubes (FA+10% GP+GGBS)

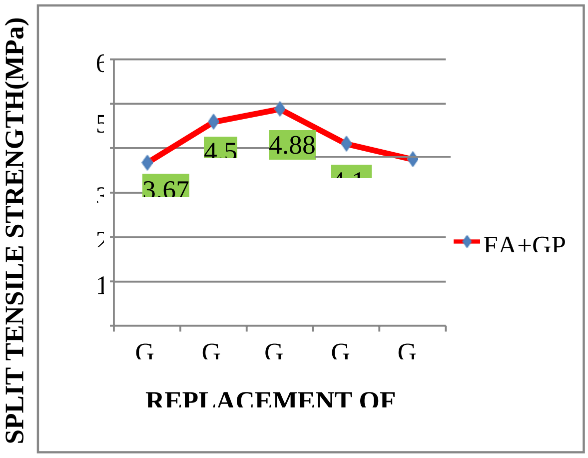

Figure 3: Variation of 28 days STS (FA+GP)

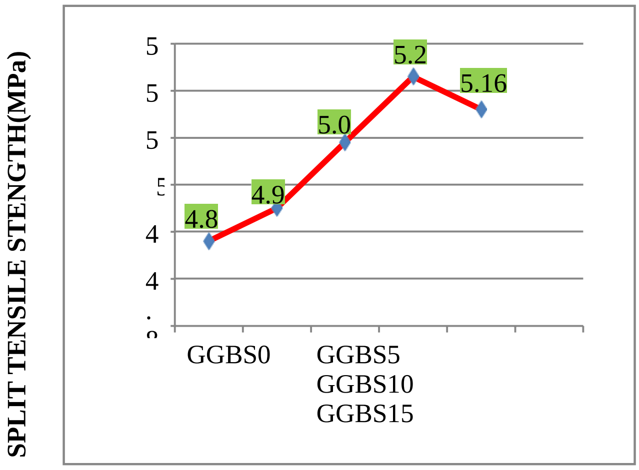

Figure 4: Variation of 28 days STS (FA+10%GP+GGBS)

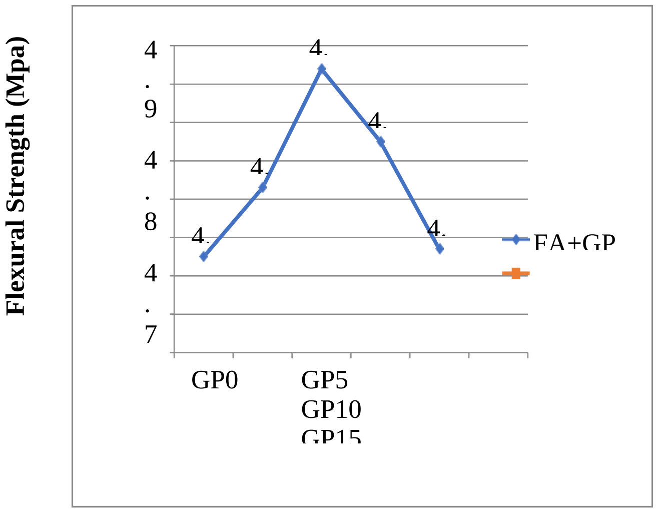

Figure 5: Variation of FS (FA+GP)

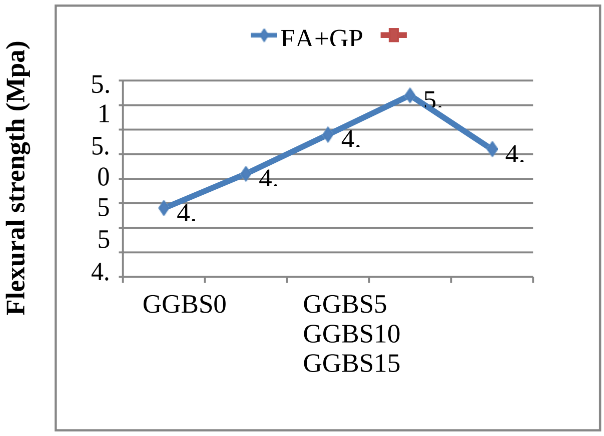

Figure 6: FS variation (FA+10%GP+GGBS)

CONCLUSIONS

Based on the present study the subsequent conclusions might be drawn.

The STS, CS, FS of GPC increments with increment in number of GP up to 10% FA replacement. Beyond 10% replacement. The CS, STS, FS is reduces.

The CS,STS,FS of GPC increments with enhance in the amount of GGBS up to 15% replacement of FA & GP beyond 15% replacement STS, CS, FS are decreases.

In all the mixes used a greyish white powder which was coming out from all the surfaces of the cube sample /beam sample/cylinder sample during the initial periods of curing is found to be a mixture of bicarbonates of sodium, magnesium and sulphates of iron.

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