An Appropriate Relation between Strength Characteristics & Combined NDT'S of GPC

S. Kalyan Kumar[1] C. Sreenivasulu[2] P. Vijay Kumar[3] A. Lakshmipriya[4] M. Dinesh Kumar[5]
[1,4,5]M.Tech Student [2,3]Assistant Professor
[1,2,3,4,5]Annamacharya Institute of Technology & Sciences, Tirupati, India

Abstract— In present days the demand of cement (OPC) is growing for satisfying the need of improvement of infrastructure facilities. OPC production releases greater amount of carbon dioxide to the environment, it's far harmful to the human health and additionally pollute environment. Consequently, its miles essential to find alternatives to make the concrete surroundings friendly. On this respect, Davidovits (1988) proposed an alternative binder for the concrete era and it indicates a terrific results. Those binders are produced through an alkaline liquid reacts with the silica (Si) and aluminum (Al) present inside the source materials. The technology proposed by way of the Davidovits is usually called as Geo-polymers or Geo-polymer technology. This paper gives the study on Mechanical houses of GPC of class f fly ash (FA-50%) & GGBS (50%) based GPC the use of silica sand, copper slag and granite slurry as sand replacement at unique stages (0%, 10%, 20% & 30%).In the present investigation to study the compressive strength and predict the compressive strength by using Rebound Hammer and Ultrasonic Pulse Velocity at different curing periods after 7, 28 & 90 days curing at ambient room temperature. By using Regression analysis formed the equations Silica Sand from 0% to 30% compressive strength , Rebound number and Ultrasonic Pulse Velocity values increased and form the varies equations and also copper slag and Granite slurry 0% to 30% compressive strength, Rebound number and Ultrasonic Pulse Velocity increased and formed the various equations. By using Regression analysis and available data as compressive strength, Rebound number and Ultrasonic Pulse Velocity formed the various equations at different replacement levels.

Key words: Geo-Polymer Concrete, Silica Sand, Copper Slag & Granite Slurry

I. INTRODUCTION

Geo-polymer binder which was introduced by Davidovits 1978, is an inorganic polymer binder, rich in silica and aluminium. In the process of polymerization of materials, alkaline substances are to be added. The source material for silica and aluminium are Fly ash (FA), which is produced from thermal power plants as a waste and ground granulated blast furnace slag (GGBS), which is produced from AASTRA Chemicals, Chennai. Alkaline substances used for obtaining Polymerization reaction are alkaline grade sodium silicate solution (Na2Sio3) and sodium hydroxide solution (NaOH) as an alkaline activator, were taken as 8M. Geo-polymer concrete made with only fly ash as a source material for silica and aluminium has shown poor results. Geo-polymer concrete require curing under ambient room temperature itself. Results are already concluded that GGBS and FA blended GPC mixes attained enhanced mechanical properties at ambient room temperature itself. The behaviour of geopolymers were studied the many of researches using various types of source materials like fly ash, GGBS, silica sand, copper slag and granite slurry etc. The present study deal with the development and the mechanical properties of geopolymer concrete incorporating silica sand, copper slag and Granite slurry as fine aggregate with different replacement levels from 10% to 30% at ambient room temperature curing. To develop a mixture proportioning process to manufacture fly ash (ASTM Class F) and GGBS based geopolymer concrete incorporating silica sand as fine aggregate. To identify and study the effect of prominent parameters that affects the properties of fly ash and GGBS based geopolymer concrete.

The present investigation is aimed to study the strength properties of hardened low calcium fly ash-based geo-polymer concrete incorporating silica sand, copper slag and granite slurry as fine aggregate with different replacement levels from 10% to 30% at ambient room temperature curing.

II. EXPERIMENTAL STUDY

A. Materials

In this respect, FA, GGBS silica sand, copper slag and Granite slurry were used as binders whose chemical and physical properties are tabulated in Table1. According to ASTM C 618 (2003) [7], class F fly ash produced from Lanco Industry, srikalahasti, A.P and GGBS produced from AASTRA chemicals, Chennai, A.P were used in the manufacturing of GPC.

Particulars	Class F fly ash	GGBS	Silica sand
Chemical composition			
% Silica(Sio2)	65.6	30.61	81.5
% Alumina(Al2O3)	28.0	16.24	0.64
%Iron Oxide(Fe2O3)	3.0	0.584	0.76
% Lime(Cao)	1.0	34.48	0.14
% Magnesium(Mgo)	1.0	6.79	0.99
%Titanium Oxide(TiO)	0.5	-	-
%Sulphur Trioxide(So3)	0.2	1.85	-
Loss on Ignition	0.29	2.1	-
Physical properties			
Specific gravity	2.12	2.94	2.60
Fineness(m2/kg)	360	400	-

Table 1: Chemical & Physical Properties of Class F Fly Ash, GGBS & Silica Sand

The alkaline liquid used was a combination of sodium silicate solution (Na2O = 13.7%, SiO2 = 29.4% and water = 55.9%) and sodium hydroxide (NaOH) in pellets form with 97% - 98% purity was purchased from local suppliers. The sodium hydroxide (NaOH) solution was prepared with a concentration of 8M. The sodium silicate solution and sodium hydroxide solution were mixed together one day before prior to use. Crushed granite stones of size

20mm and 10mm used as coarse aggregate, river sand used as fine aggregate and silica sand used as replacement of natural sand at different levels 100:0, 90:10, 80:20 and 70:30. The bulk specific gravity in oven dry condition and water absorption of the coarse aggregate 20mm and 10mm were 2.66 and 0.3% respectively. The bulk specific gravity in oven dry condition and water absorption of the fine aggregate were 2.62 and 1% respectively. The bulk specific gravity in oven dry condition and water absorption of silica sand were 2.60 and 0.4% respectively.

B. Mix Design

Based on the limited past research on GPC, the mix proportions were selected based on Rangan's method. Geopolymer concrete mix proportions of constituent materials are shown in Table 2.

Materials		Mass(gm/ml)			
		100:0	90:10	80:20	70:30
Coarse aggregate	20mm	774	774	774	774
	10mm	516	516	516	516
Fine aggregate		549	494.1	439.2	384.3
silica sand		0	54.9	109.8	164.7
Copper slag		0	54.9	109.8	164.7
Granite slurry		0	54.9	109.8	164.7
Fly ash(Class F)		204.5	204.5	204.5	204.5
GGBS		204.5	204.5	204.5	204.5
Sodium silicate solution		102	102	102	102
Sodium hydroxide solution		41	41	41	41
Extra water		55	55	55	55
Super plasticizer		2.86	2.86	2.86	2.86

Table 2: GPC Mix Proportions of Constituent Materials

C. Granite Slurry

A granite slurry powder turned into used, which become received as a spinoff of granite sawing and shaping from Egyptian marble manufacturing facility (gang noticed granite type from Shaqu Elteban area). It is able to be located that the granite powder had a high precise surface area; this may imply that its addition should confer greater cohesiveness to concrete. The granite waste is produced as ''slurry", a mud product of powder and water. The moist granite sludge was dried up prior to the instruction of the concrete samples that allows you to have a steady W/C ratio within the designed mix. Slurry granite waste changed into weighed before installing an oven at a temperature of 2 hundred C for 6 hours. The granite powder changed into then weighed returned and the difference of weight (before and after drying) need to be much less than 10% to insure minimum water content.

D. Copper Slag

Copper slag is the material which is taken into consideration as a waste material that could have a bright destiny in production enterprise as partial or complete alternative of both cement and aggregates. It's far via- product received throughout the matte smelting and refining of copper. In production of each ton of copper, about 2.2–3.0 tons' copper slag is generated as a spinoff material. Currently, approximately 2600 tons of Copper slag is produced in step with day and a total accumulation of around 1.5 million tons. [1] If we're able to use the copper slag in place of natural sand then we are able to successively gain a fabric to replace the sand, which is eco-friendly and value powerful.

III. RESULTS & DISCUSSION

This chapter describes the Compressive strength, Rebound Hammer and Ultrasonic pulse velocity method. Also by Rebound Hammer test method and Ultrasonic pulse velocity method values were derived from compressive strength values using the formulae provided in IS codebooks.

A. Compressive Strength

Compressive strength was tested for the mixes with the various SS replacement levels of 100:0, 90:10, 80:20, and 70:30. The samples were tested after curing periods of 7, 14 and 28 days. It was observed that there was a significant increase in compressive strength with the increase in percentage of CS from 0% to 30% in all curing periods. After 7 days of curing, 80:20 sample exhibited a compressive strength of 31.45 MPa, whereas after 28 days of curing it was 46 MPa. For CS the compressive strength values at 28 days of curing 43.95 MPa for 100:0, 43.96 MPa for 90:10, 44.02 MPa for 80:20 and 43.26 MPa for 70:30. For GS the compressive strength values at 28 days of curing 43.95MPa for 100:0, 44.93MPa for 90:10, 47.96 MPa for 80:20 and 47.26MPa for 70:30. It is to be noted that the significant improvement in compressive strength is mainly due to the filling of voids with CS and silica and alumina content present in the copper slag it forms polymeric chain reaction then strength will be enhanced.

Schmidt Rebound Hammer was tested for the mixes with the various CS, SS and GS replacement levels of 100:0, 90:10, 80:20 and 70:30. The samples were tested after curing periods of 7, 14 and 28 days. It was observed that there was a significant increase in Schmidt Rebound Hammer with the increase in percentage of CS from 0% to 30% in all curing periods. After 7 days of curing, replacement of SS, sample exhibited a Schmidt Rebound Hammer of 29.57, whereas after 28 days of curing it was 33.2 and after 90 days of curing it was 47.02.For CS, the samples exhibited Schmidt Rebound Hammer at 28 days of curing, 35.6 for 100:0, 36.3 for 90:10, 37 for 80:20 and 38.3 for 70:30. For GS it varies as 35.6 for 100:0, 36.3 for 90:10, 37 for 80:20 and 38.3 for 70:30. After 7days, it is to be noted that the significant improvement in Schmidt Rebound Hammer is mainly due to the filling of voids with CS and silica and aluminium content present in the copper slag it forms polymeric chain reaction then strength will be enhanced.

Ultrasonic pulse velocity was tested for the mixes with the various CS replacement levels 100:0, 90:10, 80:20 and 70:30. The samples were tested after curing periods of 7, 14 and 28 days. It was observed that there was a significant increase in ultra-pulse velocity with the increase in percentage of CS from 0% to 30% in all curing periods. After 7 days of curing, SS exhibited an ultra-pulse velocity of 3.145 Km/s, whereas after 14 days of curing it was 4.6 km/s and after 28 days of curing it was 4.702 km/s. For CS pulse velocity at 28 days 3.796 Km/s for 100:0, 3.671 Km/s for 90:10, 3.741Km/s of 80:20 and 3.479Km/s of 70:30. For GS pulse velocity varies like 3.796Km/s of 100:0, 3.744 Km/s of 90:10, 3.668Km/s of 80:20 and 3.582Km/s of 70:30.It is to be noted that the significant improvement in ultra-pulse velocity is mainly due to the filling of voids with CS and silica and aluminia content present in the copper slag it forms polymeric chain reaction then strength will be enhanced.

Mix Type	Compressive strength (MPa)		
	7 days	28 days	90 days
100:0	30.98	41.6	51.02
90:10	32.5	42.5	45.38
80:20	31.45	46	43.14
70:30	28.24	41.4	43.84

Table. 3: Compressive Strength of Cubes at 7, 28 and 90days Curing

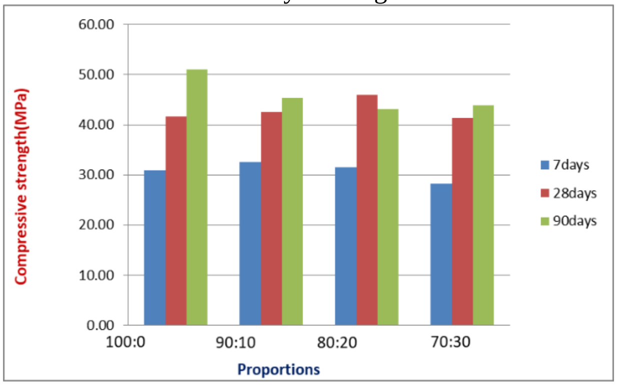

Fig 1: Comparison of Compressive Strength of Cubes at 7, 28 & 90 Days Curing

Fig. 2: Compressive Strength Test

Fig. 3: Rebound Hammer Test

Fig. 4: UPV Test

Mix Type	Rebound hammer Test		
	7 days	28 days	90 days
100:0	25	33.4	37.39
90:10	25	33	37.5
80:20	29.57	35.2	40.81
70:30	24	31.4	33.25

Table 4: Rebound Hammer Test for Silica Sand at 7 Days, 28 Days & 90 Days of Curing

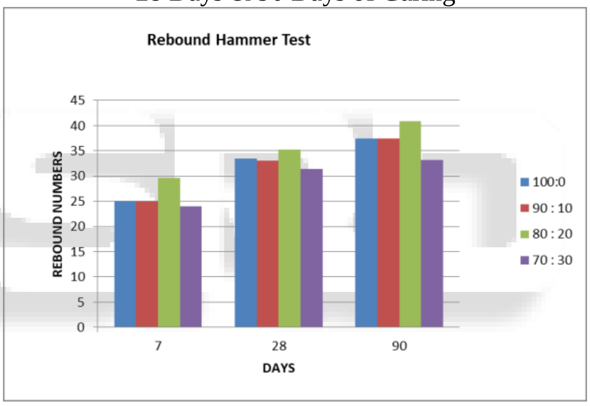

Fig. 5: Comparison of Rebound Hammer Test at 7, 28 & 90 Days Curing

Mix Type	Ultrasonic pulse velocity(m/s)		
	7 days	28 days	90 days
100:0	3876	3629	3102
90:10	3731	3570	2958
80:20	3844	3546	3219
70:30	3601	3423	3211

Table 5: UPV Test for Silica Sand at 7 days, 28 days and 90 days

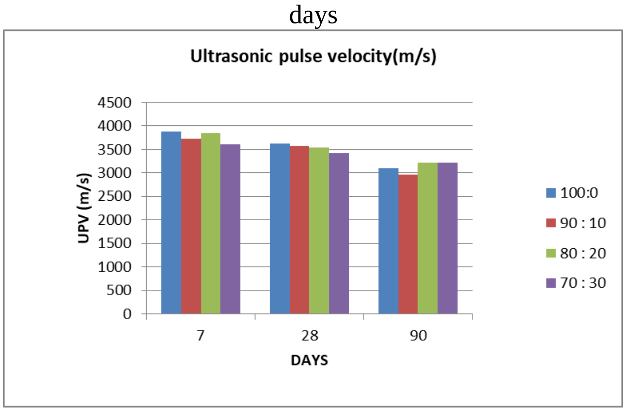

Fig. 6: Comparison of UPV at 7, 28 and 90 days

Mix Type	Copper slag 28 days test		Granite Slurry 28 days test	
	Compressive strength	Rebound Number	Compressive strength	Rebound Number
100:0	43.42	36.59	43.42	36.59
90:10	44.02	36.10	44.18	35.51
80:20	44.4	35.59	46.86	37.03
70:30	42.3	37.44	46.81	34.41

Table 6: Copper slag and Granite slag at 28 days of curing

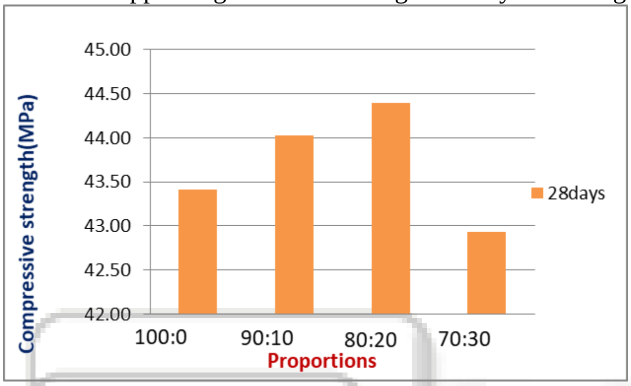

Fig. 7: Compressive Strength of Copper Slag

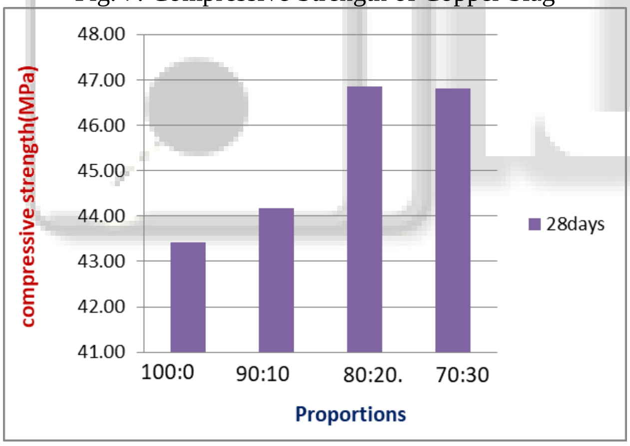

Fig. 8: Compressive Strength of Granite Slurry

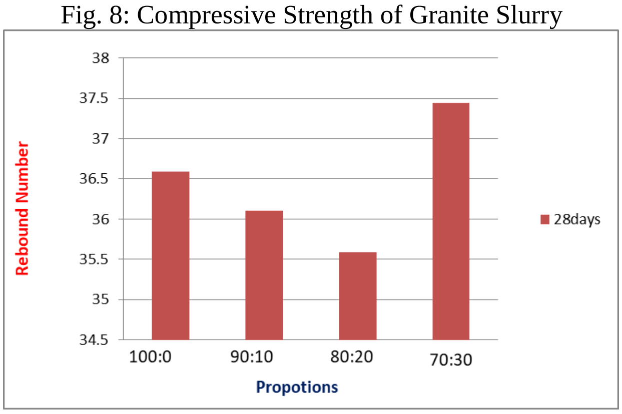

Fig. 9: UPV of Copper Slag

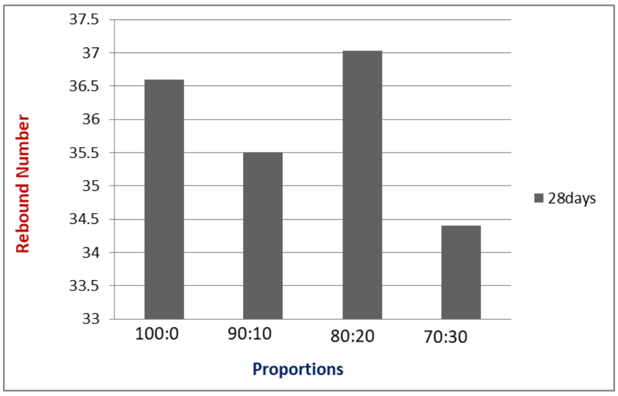

Fig. 10: Rebound Number of Granite Slurry

By using regression analysis formed the equations shown below.

In silica sand the regression analysis relationship between the compressive strength and Rebound number is in the proportion of 80:20 is

$f'c=2.112R^{0.8312}$ (for power function)

$f'c=6.07+0.984R$ (for polynomial function)

In copper slag the regression analysis relationship between the compressive strength and UPV is in the proportion of 80:20 is

$f'c=22398.80U^{-0.7565}$ (for power function)

$f'c=77.768-0.00892U$ (for polynomial function)

In granite slurry the regression analysis relationship between the compressive strength and UPV is in the proportion of 70:30 is

$f'c=6993.017\,U^{-0.6117}$ (for power function)

$f'c=75.358-0.00797U$ (for polynomial function)

IV. Conclusions

Primarily based on the studies, the following conclusions were drawn.

- There was a significant increase in compressive strength with the increase in percentage of Silica sand, Copper slag and Granite slurry from 0% to 30% in all curing periods.
- When the percentage of silica sand, copper slag and granite slurry increased from 0 % to 30%, rebound number and ultrasonic pulse velocity (UPV) also have been enhanced.
- The significant improvement in compressive strength and NDT tests values up to 30% SS,CS and GS replacement is mainly due to the silica and alumina content present in SS,CS and GS were reacts with NaOH it forms polymeric chain .
- In silica sand the regression analysis relationship between the compressive strength and Rebound number is in the proportion of 80:20 is
  $f'c=2.112R^{0.8312}$ (for power function)
  $f'c=6.07+0.984R$ (for polynomial function)
- In copper slag the regression analysis relationship between the compressive strength and UPV is in the proportion of 80:20 is
  $f'c=22398.80U^{-0.7565}$ (for power function)
  $f'c=77.768-0.00892U$ (for polynomial function)

- In granite slurry the regression analysis relationship between the compressive strength and UPV is in the proportion of 70:30 is
  $f'c=6993.017\ U^{-0.6117}$ (for power function)
  $f'c=75.358-0.00797U$ (for polynomial function)

REFERENCES

[1] Rangan, B.V. (2008), Fly ash-based geo-polymer concrete, Curtin University of Technology.
[2] J. Guru Jawahar, D. Lavanya, C. Sashidar. "Performance of flyash and ggbs geopolymer concrete in acid environment", International Journal of Research and scientific Innovation (IJRSI), 3(2016), 101-104.
[3] Guru Jawahar J, mounika G. Strength properties of flyash and GGBs based geopolymer concrete, Asian journal of Civil Engineering, 17(2016) 127-135.
[4] Davidovits, J. (1994), Properties of Geo-polymer cements, First international conference on alkaline cements and concretes, 131-149.
[5] Davidovits, J. (1988), Geo-polymer chemistry and properties, paper presented at the Geo-polymer '8, First European Conference on Soft Mineralogy, Compiegne, and France.
[6] Vijaya Rangan (2008), Studies on fly ash based geo-polymer concrete, Malaysian Construction Research Journal 3 (2):1-20
[7] Hardjito, D. (2005), Studies of fly ash-based geo-polymer concrete, Ph.D. Curtin University of Technology, Dept. of Civil Engineering.
[8] IS 3812 (1981), Specifications for fly ash for use as pozzolana and admixture. Bureau of Indian Standards, New Delhi.
[9] IS 12089 (1987), Specifications for granulated slag for manufacture of Portland slag cement. Bureau of Indian Standards, New Delhi.
[10] IS 516(1991), Methods of tests for strength of concrete, Bureau of Indian standards, New Delhi, India