Experimental Study on Fresh Properties of Self Compacting Geopolymer Concrete on Replacement of Fine Aggregate with Copper Slag

B. Rohin[1] J. Guru Jawahar[2]
[1]PG Student [2]Professor
[1,2]Department of Civil Engineering
[1,2]Annamacharya Institute of Technology and Sciences, Andhra Pradesh, India

Abstract— An investigation is carried out on the development of Self Compacting geopolymer concrete , to the study the effect of molarity (8M) on strength properties of class F fly ash (FA) and ground granulated blast furnace slag (GGBS) blended geo polymer concrete (GPC) at 10%,20%,30%,40%, 50% replacement level (FA50-GGBS50). Sodium silicate (Na2SiO3) and sodium hydroxide (NaOH) solution has been used as alkaline activator. In the present investigation it is proposed to study the fresh properties and flyash based SCGC replaced with various percentages of copper slag. Hence the results showed that the Self-compacting geo polymer concrete was suitable for room temperature curing with copper slag as replacement to fine aggregate based GPC.

Key words: Fly Ash, Ground Granulated Blast Furnace Slag (GGBS), Copper Slag

I. INTRODUCTION

The economic strength and even degree of civilization of any country is mirrored by the expansion rate of the infrastructures and highlighted by the assembly rate of concrete. Concrete is one in every of the foremost so much used construction resources within the world. Portland cement (PC); a vital constituent of concrete isn't associate environmentally friendly material. The assembly of Portland cement not solely depletes important quantity of natural resources however conjointly liberates a substantial quantity of carbonic acid gas (CO_2) and alternative greenhouse gases into the atmosphere as a results of de carbonation of sedimentary rock and therefore the combustion of fossil fuels. It's reported that the world wide cement trade contributes around one.65 billion heaps of the greenhouse emission annually. Due to the assembly of Portland cement, it's calculable that by the year 2020, the carbonic acid gas emissions can rise by regarding five hundredth from the present levels. Therefore, to preserve the worldwide atmosphere from the impact of cement production, it's currently believed that new binder's area unit indispensable to exchange Portland cement. during this regard, the geopolymer concrete (GC) is one in all the revolutionary developments associated with novel materials leading to inexpensive and environmentally friendly material as an alternate to the laptop. Gig cycle is AN innovative binder material and is created by whole exchange the laptop. it's incontestable that the geopolymer cement generates 5–6times less CO_2 than PC .

Geopolymer concrete is new technology because it utilizes industrial waste and by products. Geopolymer concrete is emerging as a new environmentally friendly construction material for sustainable development, using Slag and alkali instead of PC as the binding material. This results in two benefits. i.e. reducing CO_2 releases from production of PC and also utilisation of industrial waste like fly ash, slag etc. Ground granulated blast furnace slag (GGBS) is a by-product from the blast-furnaces used to make iron. During the process, slag formed and it is then dried and ground to a fine powder.

FA, which is rich in silica and alumina, has full potential to use as one of the source material for Geopolymer binder. Many research studies have manifested the potential use of solfa syllable primarily based rate. For this reason, low-calcium solfa syllable has been chosen as a base material to synthesize geopolymer so as to higher employ this industrial waste.

In fact, all concretes nearly believe basically on being totally compacted. Just in case of huge and sophisticated structures; it's generally become troublesome to confirm full compaction. Despite the great combine style, inadequate compaction considerably lowers final performance of concrete. Placement of the contemporary concrete needs good operatives to confirm adequate compaction to realize the total strength and sturdiness of the hardened concrete .As concrete is created and placed at construction sites, underneath things distant from ideal, standard vibratory concrete in such things could cause risk to labour and there are continuously doubts regarding the strength and durability of concrete placed in such locations. One in every of the solutions to beat these difficulties is that the employment of Self- Compacting Concrete (SCC).

SCC may be a form of concrete which may be compressed into each corner of the shape work strictly by means that of its own weight. It's usually accepted that SCC was developed initial in Japan within the late Nineteen Eighties in response to the dearth of good labour and therefore the want for improved sturdiness. In line with Out, the requirement for SCC was initial known by Okamura in 1986 and therefore the initial model was developed in 1988. SCC offers several advantages and blessings over ancient concrete. These embody Associate in Nursing improved quality of concrete, reduced construction time, easier placement in full reinforcements, uniform and complete consolidation, enhanced bond strength, reduced noise levels because of absence of vibration, lower overall prices, and safe operating environment.. SCGC is an innovative type of concrete that does not require vibration for placing it and can be produced by complete elimination of ordinary Portland cement.

II. SELF-COMPACTING GEOPOLYMER CONCRETE MIX DESIGN PROCEDURE

8M:

1) Step 1: The wet density of geopolymer concrete=2400 kg/m^3
2) Step 2: Mass of combined aggregate = 72.8% of the mass of concrete

= (72.8*2400/100) = 1747.2 kg/m^3

3) Step 3: Mass of Binders and the alkaline liquid = 2400-1747.2 = 652.8 kg/m^3
4) Step 4: Alkaline liquid to Binders ratio by mass = 0.45
5) Step 5: Assuming flyash content = 450 kg/m^3 GGBS content = 450 kg/m^3
6) Step 6: Mass of alkaline liquid = 0.45*450 = 202.6 kg/ m^3
7) Step 7: Ratio of sodium silicate to sodium hydroxide solution = 2.5
8) Step 8: Mass of sodium hydroxide solution = 202.6/ (1+2.5) = 57.9 kg/ m^3
   For 1 molar sodium hydroxide solution, 40g of sodium hydroxide pellets are dissolved in 1 liter of water.
   i.e., for 1 molar: 40g pellets →1000g or 1000ml of water.
   For 8 molar: 8x40g of pellets→1000g or 1000ml of water.
   % of sodium hydroxide solids (pellets) in NaOH Solution = 32 %
   In sodium hydroxide solution, solids = 0.32x57.9 = 18.528 kg/m^3
   Weight of water in NaOH solution = 68% of 57.9
   = 0.68×57.9 = 39.372 kg/m^3.
9) Step 10: Water content in sodium silicate solution=55.9%

Mass of sodium silicate solution =2.5 ×57.9 = 144.75 kg/m^3

10) Step 11: Coarse aggregate=0.45 X 1747.2 = 786.24 kg/ m^3
11) Step 12 : Fine aggregate= 0.55 X1747.2 = 960.96 kg/ m^3

III. RESULTS & DISCUSSIONS

A. *Fresh Properties*

1) *Slump Flow Test*

Slump flow take a look at equipment is shown in Fig thirteen Slump cone has twenty cm bottom diameter, ten cm prime diameter and thirty cm tall. During this take a look at, the slump cone mould is placed precisely on the twenty cm diameter graduated circle marked on the glass plate, crammed with concrete (6 liter) and raised upwards. The next diameter of the concrete unfold is measured in 2 perpendicular directions and therefore the average of the diameters is rumored because unfold of the concrete. T50cm is that the time measured from lifting the cone to the concrete reaching a diameter of fifty cm. The measured T50cm indicates the deformation rate or consistency of the concrete.

Fig. 1: Slump Flow Test

Sl .no	Test	Percentage of replacement of fine aggregate	Molarity	Slump flow in mm	T50 cm slump flow in sec
1	Slump cone	10	8	710	2
2	Slump cone	20	8	705	2
3	Slump cone	30	8	680	2
4	Slump cone	40	8	650	3
5	Slump cone	50	8	645	3

Table 1: Concrete mix of slump flow test in mm

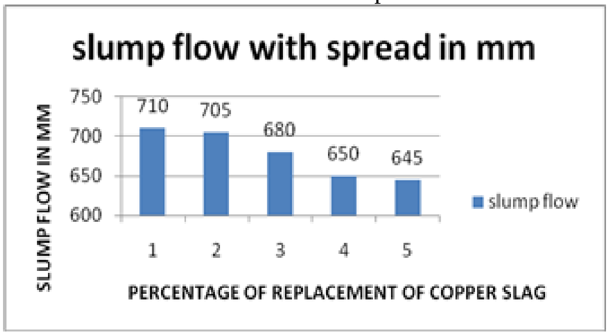

Fig. 2: Effect of slump flow on decrease in replacement of copper slag

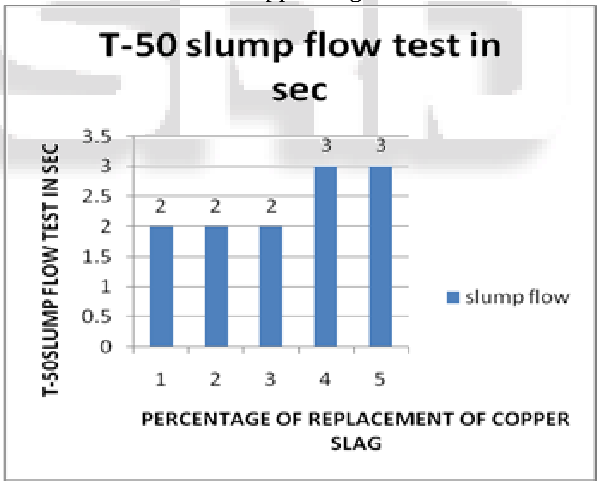

Fig. 3: Effect of T-50 Slump Flow on Increase in Replacement of Copper Slag

B. *V-Funnel Test*

V-funnel test apparatus dimensions are shown in Fig.14 In this test, trap door is closed at the bottom of V-funnel and V-funnel is completely filled with fresh concrete (12 litter). V-funnel time is the time considered from opening the trap door and complete empty the funnel. Once more, the V-funnel is filled with concrete, kept for 5 minutes and entrap door is release. V-funnel time is calculated again and this indicates V-funnel time at T_{5min}.

Fig. 4: V-Funnel Test

Sl.no	Test	Percentage of replacement of fine aggregate	Molarity	V-funnel in sec
1	v-funnel	10	8	7
2	v-funnel	20	8	7.2
3	v-funnel	30	8	8
4	v-funnel	40	8	9
5	v-funnel	50	8	9

Table 2: Concrete mix of V-funnel test in sec

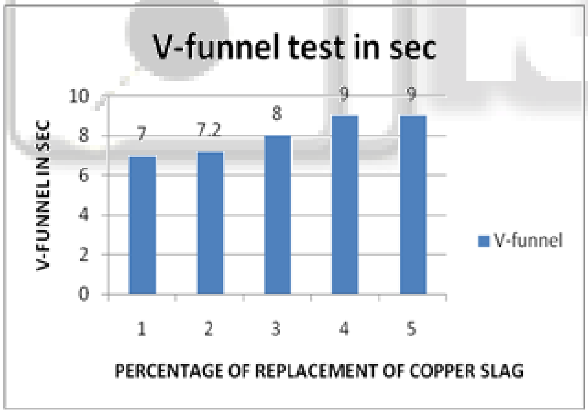

Fig. 5: Effect of V-Funnel on Increase in Replacement of Copper Slag

C. L-Box Test

L-box test apparatus dimensions are shown in Fig. 3.8. In this test, fresh concrete (14 liter) is filled in the vertical section of L-box and the gate is lifted to let the concrete to flow into the horizontal section. The height of the concrete at the conclusion of horizontal section represents h_2 (mm) and at the straight up section represents h_1 (mm). The ratio h_2/h_1 represents jamming ratio.

Fig. 6: L-Box Test

Sl.no	Test	Percentage of replacement of fine aggregate	Molarity	l-box ratio(h2/h1)
1	L-box	10	8	0.85
2	L-box	20	8	0.92
3	L-box	30	8	0.96
4	L-box	40	8	0.98
5	L-box	50	8	0.98

Table 3: Concrete mix of L-box test (h2/h1) in sec

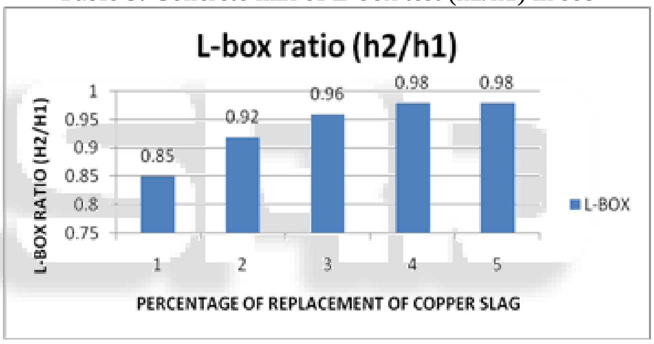

Fig. 7: Effect of L-box on increase in replacement of copper slag

IV. CONCLUSIONS

A. Conclusions Arrived At After The Trial Mixes

- The percentage of GGBS and Fly ash in the mix will affects the workability characteristics of SCGC.
- The inclusion of superplasticizer improved the workability characteristics of fresh concrete.
- Longer curing duration improves the process of Geo-polymerization resulting in higher compressive strength.

REFERENCES

[1] Bakharev, T. (2005c). Resistance of geopolymer materials to acid attack. Cement And Concrete Research, 35(4), 658-670.
[2] Balaguru, P., Kurtz, S., & Rudolph, J. (1997). Geopolymer for Repair and Rehabilitation of Reinforced Concrete Beams. The Geopolymer Institute. Retrieved 3 April, 2002, from the World Wide Web: www.geopolymer.org
[3] Comrie, D. C., Paterson, J. H., & Ritchey, D. J. (1988). Geopolymer Technologies in Toxic Waste Management.

Paper presented at the Geopolymer ’88, First European Conference on Soft Mineralurgy, Compiegne, France.
[4] Davidovits, J. (1984). Synthetic Mineral Polymer Compound of The Silicoaluminates Family and Preparation Process, United States Patent - 4,472,199 (pp. 1-12). USA.
[5] Davidovits, J. (1988a). Soft Mineralurgy and Geopolymers. Paper presented at the Geopolymer ’88, First European Conference on Soft Mineralurgy, Compiegne, France.
[6] Davidovits, J. (1988b). Geopolymer Chemistry and Properties. Paper presented at the Geopolymer ’88, First European Conference on Soft Mineralurgy, Compiegne, France.
[7] Davidovits, J. (1988c). Geopolymers of the First Generation: SILIFACE-Process. Paper presented at the Geopolymer ’88, First European Conference on Soft Mineralurgy, Compiegne, France. 82
[8] Davidovits, J. (1988d). Geopolymeric Reactions in Archaeological Cements and in Modern Blended Cements. Paper presented at the Geopolymer ’88, First European Conference on Soft Mineralurgy, Compiegne, France.
[9] Davidovits, J. (1999, 30 June - 2 July 1999). Chemistry of Geopolymeric Systems, Terminology. Paper presented at the Geopolymere ’99 International Conference, Saint-Quentin, France.
[10] Duxson, P., Lukey, G., & van Deventer, J. (2007). Physical evolution of Nageopolymer derived from metakaolin up to 1000 °C. Journal of Materials Science, 42(9), 3044-3054.
[11] Gartner E (2004), “Industrially Interesting Approaches to ‘Low-CO2’ Cements”, Cement and Concrete Research, 34(9), 1489-1498.
[12] Gourley, J. T. (2003). Geopolymers; Opportunities for Environmentally Friendly Construction Materials. Paper presented at the Materials 2003 Conference: Adaptive Materials for a Modern Society, Sydney.
[13] Gourley, J. T., & Johnson, G. B. (2005). Developments in Geopolymer Precast Concrete. Paper presented at the International Workshop on Geopolymers and Geopolymer Concrete, Perth, Australia.
[14] Hardjito, D., & Rangan, B. V. (2005). Development and Properties of Low-Calcium Fly Ash-Based Geopolymer Concrete. Research Report GC1, Perth, Australia: Faculty of Engineering, Curtin University of Technology.
[15] IS 383 (1970). Specification for coarse and fine aggregates from natural sources for concrete. Bureau of Indian Standards, New Delhi.
[16] IS 456 (2000). Plain and reinforced concrete code for practice. Bureau of Indian Standards, New Delhi.
[17] IS 516 (1991). Methods of tests for strength of concrete. Bureau of Indian Standards, New Delhi.
[18] IS 5816 (1999). Splitting tensile strength of concrete method of test. Bureau of Indian Standards, New Delhi.
[19] IS 10262 (2009). Concrete Mix Proportioning-Guidelines. Bureau of Indian Standards, New Delhi.
[20] Malhotra, V. M., & Mehta, P. K. (2002). High-Performance, High-Volume Fly Ash Concrete: Materials, Mixture Proportioning, Properties, Construction Practice, and Case Histories. Ottawa: Supplementary Cementing Materials for Sustainable Development Inc.
[21] Malone, P. G., Charlie A. Randall, J., & Kirkpatrick, T. (1985). Potential Applications of Alkali-Activated Alumino-Silicate Binders in Military Operations. Washington, DC: Department of the Army, Assistant Secretary of the Army (R&D).
[22] McCaffrey, R. (2002). Climate Change and the Cement Industry. Global Cement and Lime Magazine (Environmental Special Issue), 15-19.
[23] Mehta, P. K. (2002), Greening of the Concrete Industry for Sustainable Development, ACI Concrete International ;24(7): 23-28
[24] Neville, A. M. (2000). Properties of Concrete (Fourth and Final ed.). Essex, England: Pearson Education, Longman Group.
[25] Palomo, A., M.W.Grutzeck, & M.T.Blanco. (1999). Alkali-activated fly ashes A cement for the future. Cement And Concrete Research, 29(8), 1323-1329.
[26] Roy, D. M. (1999). Alkali-activated cements Opportunities and Challenges. Cement & Concrete Research, 29(2), 249-254.
[27] Siddiqui, K.S. (2007),”Strength and Durability of Low-Calcium Fly Ash-based Geopolymer Concrete”, Final Year Honours Dissertation, The University of Western Australia, Perth.
[28] Siddique R, Iqbal Khan M. 2011. Supplementary Cementing Materials. Springer-Verlag Berlin Heidelberg.
[29] Song, X. J., Marosszeky, Brungs, M. M., & Munn, R. (2005a, 17-20 April). Durability of fly ash-based Geopolymer concrete against sulphuric acid attack. Paper presented at the 10DBMC International Conference on Durability of Building Materials and Components, Lyon, France.
[30] Sumajouw, M.D.J. and Rangan, B.V. (2006), Low-Calcium Fly Ash-Based Geopolymer Concrete: Reinforced Beams and Columns, Research Report GC3, Faculty of Engineering, Curtin University of Technology, Perth, available at espace@curtin or www.geopolymer.org.
[31] Van Jaarsveld, J. G. S., van Deventer, J. S. J., & Lukey, G. C. (2003). The characterisation of source materials in fly ash-based geopolymers. Materials Letters, 57(7), 1272-1280.
[32] Van Jaarsveld, J.G.S., Van Deventer, J.S.J., Lorenzon (2008), The Potential Use of Geopolymeric Materials to Immobilise Toxic Metal: Part 1 Theory and Application, Minerals Engineering 10(7), 659-669.
[33] Wallah, S. E., & Rangan, B. V. (2006). Low-Calcium Fly Ash-Based Geopolymer Concrete: Long-Term Properties (Research Report GC 2). Perth: Faculty of Engineering Curtin University of Technology.
[34] Xu, H., & Van Deventer, J. S. J. (2000). The geopolymerisation of aluminosilicate minerals. International Journal of Mineral Processing, 59(3), 247-266.