A Basic Study on Fly Ash Lime Gypsum composite with Sodium Carbonate and Sodium silicate as Admixtures

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Abstract - *In this paper, we have explored the properties of Fly ash-Lime-Gypsum (FAL-G) composite, when sodium carbonate and sodium silicate are added in various percentages viz.1%,3%,5%,7%,9%. In FAL-G the ingredients are fly ash 65%, lime 30%, and gypsum 5%. We conducted the tests for the density, water absorption and compressive strength. We have modified existing eco-friendly FAL-G composite assuming that carbon di oxide in carbonate will form calcium carbonate thereby increasing the strength and other properties of FAL-G and silicate in Sodium silicate will form calcium silicates, thereby increasing the strength and other properties of FAL-G. From the results it is evident that sodium carbonate excels as an admixture to FAL-G than sodium silicate.*

Key Words: Fly ash1, Lime2, Gypsum3, Sodium carbonate4 and sodium silicate5.

1. INTRODUCTION

1.1 FAL-G

FaL-G was invented and developed at the INSWAREB by Mr. N Kalidas[1] and Dr Bhanumathidas. According to them, FAL-G is a technological renaissance of the age-old pozzolonic chemistry proven for its strength and durability. FAL-G is a blend of fly ash (Fa), lime (L) and gypsum (G) in suitable proportions which, upon hydration, yields strengths in the range of 6 - 40 MPa, rendering a highly water impervious hard matrix, with the formation of mineralogical phases during hydration similar to those of Ordinary Portland Cement (OPC).

1.2 Fly ash

Fly Ash, an industrial by-product from Thermal Power Plants (TPPs), with current annual generation of approximately 184.14 million tonnes in the year 2015 [2]. Its proven suitability for variety of applications as admixture in cement/concrete/mortar, lime pozzolana mixture (bricks/blocks) etc. The fly ash used in this research is obtained from Tuticorin Thermal Power station.

1.3 Lime

Nancy L Holland [3] et al. States that Lime has been used as the basis for the pozzolonic material in concrete for thousands of years. Lime used in this research is from local industry with brand name JanathaCem. It's a slaked lime with main usage of whitewashing.

1.4 Gypsum

Gypsum is a widely used material as plaster of Paris, to control setting time of cement, to condition the soil in agricultural practices, etc. The gypsum used in this research was procured from local agriculture store retailer.

1.5 Sodium carbonate

Sodium carbonate (Na_2CO_3) is also called soda ash and is widely used in paper, glass industries. It is also used in water softening. The reaction of sodium carbonate with calcium hydroxide is as follows: -

$$Na_2CO_3 + Ca(OH)_2 \rightarrow CaCO_3 + 2NaOH \quad (1)$$

1.6 Sodium silicate

Sodium silicate is also called as water glass. It is mainly used in manufacturing Geopolymer [4] and other industrial applications such as soap manufacturing, dyeing etc. The sodium silicate used for our research was procured from local whole sale chemicals store.

2. LITERATURE REVIEW

Jayasudha R K, et al. [5] suggest that FAL-G is one among the best options available to replace conventional bricks and to safely dispose the toxic industrial wastes such as fly ash from thermal power plants and gypsum from phosphoric acid manufacturing factories.

Arati Shetkar, et al. [6] emphasize that, the fly ash generation is increasing in such a proportion that it will not be possible for the cement industry alone to utilize the same. New avenues of gainful utilization of fly ash have to be found and promoted. The basis of FAL-G technology is that, fly ash lime pozzolanic reaction does not need external heat under tropical temperature condition, and strength of fly ash-lime mixtures can be greatly augmented in the presence of gypsum.

A. R. Pradeep et al. [7] suggest a mix ratio 60-80% of fly ash 10-20% lime, 10% Gypsum and 10% sand for FAL-G.

V. Venkateswara Reddy, et al. [8] studied effect of sodium carbonate(Na_2CO_3) and sodium bicarbonate in setting and strength development of concrete. They observed that sodium carbonate accelerates the initial as well as the final setting times. Sodium carbonate decreases the compressive and tensile strength of concrete specimens.

Mohammed Azhar et al. [9] concluded from their study that, Presence of Na_2CO_3 in water of concentrations more than 4.2 g/l and 3.5 g/l accelerates significantly the initial and final setting times respectively. Further a concentration higher than 3.10 g/l results in significant decrease in compressive strength.

Coleman A. O'Flaherty, et al. [10] mentioned that The beneficial effects of the addition of sodium carbonate are most noticeable after short curing periods. Sodium carbonate can be detrimental over a long period of time to soil-cement and soil-cement-fly ash mixtures containing low cement contents.

Taewan Kim et al., [11] studied mechanical properties of Na_2CO_3 activated high volume GGBFS cement paste. In their paper, the results indicated that Na_2CO_3 was effective for improving the strength of high volume slag cement samples at both early and later ages.

Ivan Janotka [12] researched on the early stage hydration of Portland cement paste modified by 2 and 4% wt. of sodium carbonate. He concluded that the rate of carbonation of Na_2CO_3 modified cement pastes is progressively accelerated in each time interval due to the excess of $CO_3{}^{2-}$ ions in paste mixture composition at early stage of hydration relative to that of control cement paste. A destructive effect of carbonation is evidently demonstrated by decreased compressive strength and dynamic modulus of elasticity values and increased total porosity in Na_2CO_3 modified cement pastes relative to those in control specimens cured 720 days in dry and wet air.

Ranjitkumar Panda [13], et al. observed that the compressive strength of the fly ash compacts increased with addition of sodium silicate and the particles were dispersed and deviated from their globular equiaxed shape to multifaceted type in microstructure.

Andreas Nataatmadja [14] concluded that a combination of 70/30 for fly ash/common sand with 15% liquid sodium silicate and 5% lime would produce the best performing brick in terms of strength, mouldability and water absorption.

Dr. N. Srinivasa Reddy et al. [15] concluded that, the properties of soil-gypsum-fly ash mix improves with the addition of calcium chloride and sodium silicate (1%).

2. PROPERTIES OF MATERIALS USED

The fly ash used is F class, with specific gravity of 1.8 and fineness modulus 1.65. The water used has total dissolved solids of 60ppm and chloride content 37ppm with pH 7. The liquid sodium silicate had 32.65% of water and 67.35% solids (found through evaporation method).

3. METHODOLOGY

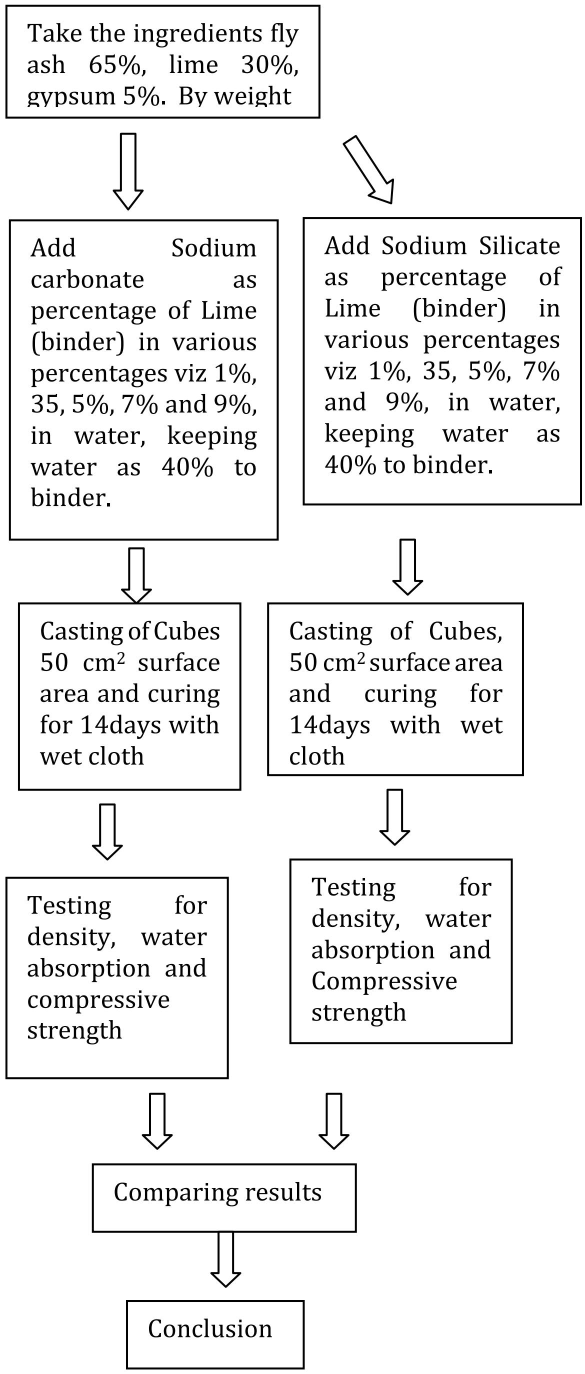

Fig -1: Mixing of Ingredients

Fig -2: Casting

Fig -3: Before compression strength test

Fig -4: After compression strength test

4. TEST RESULTS

Table -1: Density of Cubes

Density of Cubes kg/m³		
Mix	Sodium Carbonate	Sodium silicate
Plain	1414.85	1569.3
1%	1216.77	1564.6
3%	1301.4	1564.6
5%	1476.14	1564.6
7%	1485.59	1662.42
9%	1542.187	1648.45

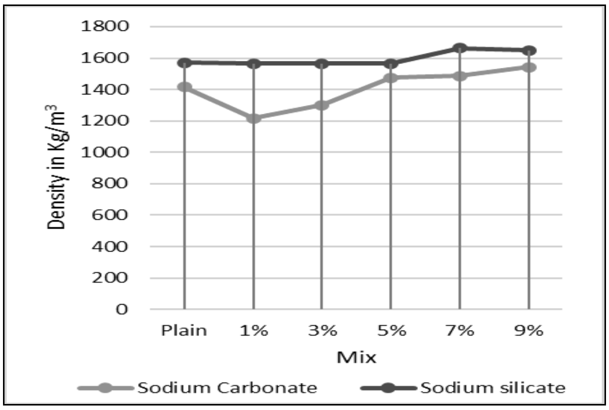

Chart -1: Density of cubes

Table -2: Water Absorption

Water Absorption in Percentage		
MIX	Sodium Carbonate	Sodium silicate
Plain	4.49	20.3
1%	5.62	16.65
3%	3.17	13.95
5%	1.916	15.46
7%	2.23	15.54
9%	1.83	14.93

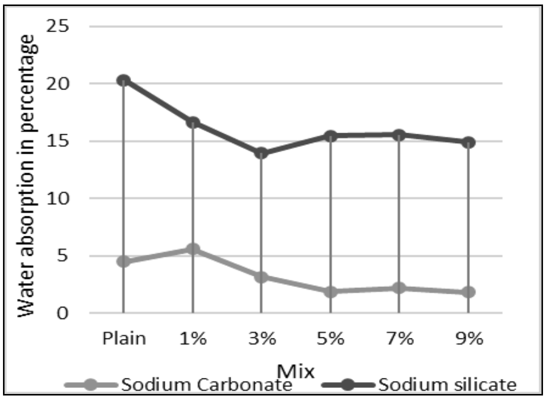

Chart -2: water absorption in percentage

Table -3: Compressive strength

Compressive strength in N/mm3		
MIX	Sodium Carbonate	Sodium silicate
Plain	2.3	3.53
1%	1.29	4.15
3%	3.23	4.74
5%	6.01	3.77
7%	4.87	2.04
9%	5.26	4.77

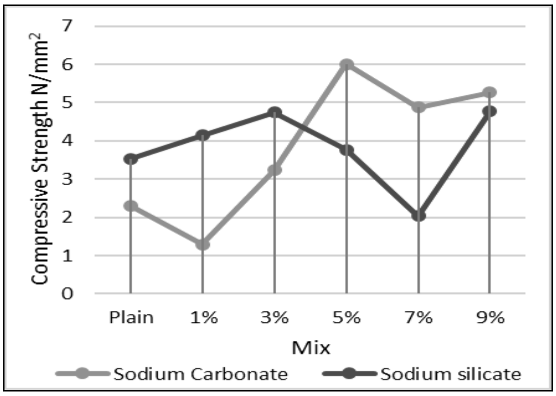

Chart -3: Compressive strength

5. CONCLUSIONS

- Density of cubes goes on increasing with increase in percentage of sodium carbonate. Water absorption reduces with increase in percentage of sodium carbonate. The compressive strength also increases with increase in sodium carbonate up to 5% mix then reduces. Overall 5% of sodium carbonate will give better results in density, water absorption as well as in compressive strength.
- Density of cubes hovers around 1600kg/m^3 for sodium silicate. Water absorption al hovers around 15%. Compressive strength is maximum for 3% sodium silicate. But 9% also shows higher strength.
- Sodium carbonate shows lesser density, lesser water absorption in all percentages and higher compressive strength above 5% mixes. Hence sodium carbonate is a better admixture than sodium silicate for FAL-G.

REFERENCES

[1] N Kalidas and Dr Bhanumathidas, "patented invention" http://www.fal-g.com/aboutus.php.

[2] Lalit Kumar, Chief Engineer (TCD) "Report on fly ash generation at coal/lignite based thermal power stations and its utilization in the country for the year 2014-15" Central Electricity Authority, New Delhi October, 2015.

[3] Nancy L Holland, Anne B. Nichols, John M. Nichols, "The use of lime in concrete as a cement replacement", Conference Paper, July 2012, https://www.researchgate.net/publication/271327514

[4] J. Davidovits, Emeritus Professor, Geopolymer Institute, Saint-Quentin, France, geopolymer.org

[5] Jayasudha R K, Radhakrishna, Niranjan PS "Properties Of FAL-G Masonry Blocks" International Journal of Research in Engineering and Technology eISSN: 2319-1163 | pISSN: 2321-7308, pp384-389.

[6] Arati Shetkar, Nagesh Hanche, Shashishankar A, "Experimental Studies on Fly Ash Based Lime Bricks" International Journal of Recent Advances in Engineering & Technology, ISSN (Online): 2347 - 2812, Volume-4, Issue -7, 2016, pp102-109.

[7] A. R. Pradeep, M. I. Basava Lingana Gowda, "Low Cost Bricks by Fal-G Technology" International Journal of Innovative Research & Development, ISSN 2278 – 0211 (Online), October, 2016 (Special Issue), PP45-47.

[8] V. Venkateswara Reddy, H Sudasana Rao and K N Jayaveera, "Inflluence of strong alkaline substances in mixing water on strength and setting properties of concrete", Indian Journal of Engineering and Materials sciences, Vol13, April 2006, pp 123-128

[9] Mohammed Azhar, Mohammed Mohsin Ali Qureshi, "Strength development in concrete by incorporating metakaolin", International Journal of Advanced Trends in Computer Science and Engineering, Vol.2, No.1, (2013), pp 634 – 639

[10] Coleman A . O'Flaherty, Manuel Mateos and Donald T. Davidson, "Fly ash and sodium carbonate as additives to Soil-Cement mixtures", http://onlinepubs.trb.org/Onlinepubs/hrbbulletin/353/353-007.pdf, pp108-123

[11] Taewan Kim and Yubin Jun, "Mechanical Properties of Na2CO3-Activated high-volume GGBFS cement paste", Hindawi, Advances in Civil Engineering, Volume 2018, Article ID 8905194, 9 pages

[12] Ivan Janotka, "Hydration of the cement paste with Na_2CO_3 addition" Ceramics – Silikáty 45 (1) (2001), pp16-23

[13] Ranjit Kumar Panda, Jyoti Prakash Dhal and Subash Chandra Mishra, "Effect of sodium silicate on strengthening behaviour of fly ash compacts", International Journal of Current Research, ISSN: 0975-833X, Vol. 4, Issue, 02, February,2012, pp.244-246

[14] Andreas Nataatmadja, "Development of low-cost fly ash bricks" https://www.researchgate.net/ publication/ 229025029_Development_of_low-cost_fly_ash_bricks, pp831-843

[15] Dr. N. Srinivasa Reddy and Sona Adeep, "Stabilization Technique for local soils using Fly-Ash, Gypsum and chemical additives in rural housing and infrastructure", International Journal of Innovations in Engineering and Technology, ISSN:2319-1058, Volume 6 Issue 3, February 2016, pp381-386.