Chapter 3
The Effect of Alccofine on Blended Concrete Under Compression

A. Narender Reddy and T. Meena

Abstract Nowadays cement had become the most extensively used construction material worldwide. The global demand of cement had reached about 5.2 billion metric tons. These lead to huge consumption of raw material and in production of cement huge amount of greenhouse gases like CO_2 was released, about 5% of total man-made CO_2 emission is through cement manufacture industry. To safeguard the environment, efforts are being made to recycle different industrial by-products and utilize them in value-added applications. The use of industrial wastes, which are pozzolanic in nature, can minimize the use of cement. Fly ash (FA) and slag (GGBS) are the most common pozzolan and are being used worldwide in concrete works. Recently, some researchers notified that a new by-product from iron ore industry, namely Alccofine, also processes pozzolanic nature. The objective of the present investigation is to evaluate the effect of Alccofine with fly ash and Alccofine with ground-granulated blast furnace as the supplementary cementitious material with reference to the compressive strength property of hardened concrete and to probe the optimal replacement level of cement with combination of fly ash with Alccofine and ground-granulated blast furnace with Alccofine.

Keywords Alccofine · Fly ash · Ground-granulated blast furnace · Blended concrete

3.1 Introduction

The advancement in concrete technology has been widely improved in line with the rise of options of material combination to replace ordinary Portland cement (OPC) [1]. The ultimate purpose of the replacement is likely to increase the strength and to provide sufficient serviceability of a structural element. Besides the economic con-

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siderations toward the material cost of conventional concrete, it is also necessary to utilize industrial wastes such as Fly Ash (FA), Slag (GGBS), Silica Fume, and Alccofine (AL), [2–5]. The mineral admixture considerably increases the workability of concrete. A number of investigations show that the minimum capacity of modified concrete could be increased by multiple replacement mechanisms, thereby improving the performance of concrete [6–9]. This practical idea tends to be a promising alternative in terms of concrete strength and green construction [10, 11]. As the material AL is a newly introduced pozzolanic material and from literature review, it proves better results in binary mixes as cement replacement [12, 13]. We tried using AL along with our pozzolanic materials to form blended concrete [14, 15]. Two pozzolanic materials which are most commonly in construction nowadays such as FA and GGBS are selected and compressive strength were found to check the compatibility nature of AL with other pozzolanic materials.

The characteristics of combination of mineral admixtures such as FA with AL and GGBS with AL to replace partially cement in concrete have been tested. The aim of this study is to determine the optimum percentage of combination of AL with other pozzolanic materials like FA and GGBS forming a blended concrete (BC).

3.2 Materials

3.2.1 Cement

OPC 53 grade cement confirming the requirements according to IS 12269 was used in our investigation having specific gravity of 3.12, normal consistency of 32%, fineness modulus of 6.5%, initial setting time of 50 min, finial setting time of 420 min, and soundness of 1.2 mm.

3.2.2 Fly Ash (FA)

Class F type of FA was used in the entire investigation; it was acquired from Dr. NTR-VTPS, Vijayawada, AP having a specific gravity 2.3 and fineness modulus of 1.1% (Table 3.1, Figs 3.1 and 3.2).

3.2.3 Slag (GGBS)

GGBS is the by-product from blast furnace in steel industry. It is a by-product which consists of high silicates and aluminosilicates of calcium and other bases, which are

Table 3.1 Properties of FA by EDAX analysis

Characteristics of element	Results for EDAX	
	Weight %	Atomic %
C K	59.19	68.02
O K	31.99	27.60
Al K	2.75	1.41
Si K	6.07	2.98

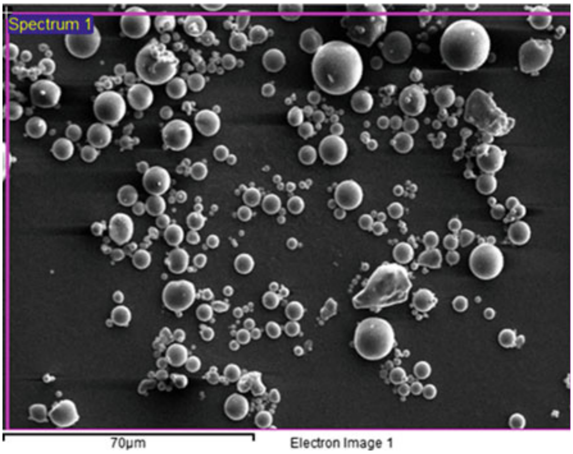

Fig. 3.1 SEM image of FA

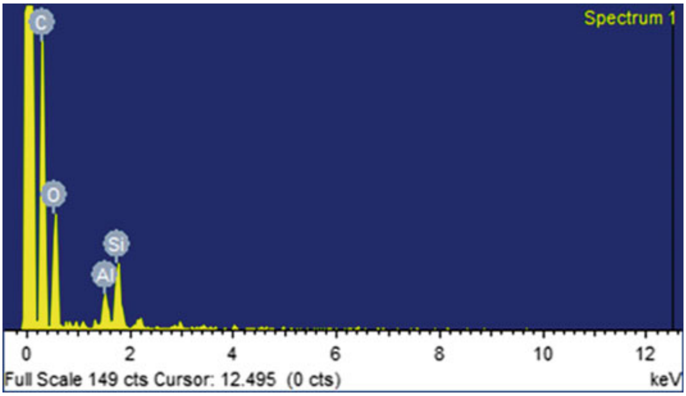

Fig. 3.2 EDAX image of FA

Table 3.2 Properties of GGBS by EDAX analysis

Characteristics of element	Results for EDAX	
	Weight %	Atomic %
C K	38.52	51.43
O K	36.19	36.27
Al K	3.84	2.28
Si K	8.36	4.77
Ca K	13.09	5.24

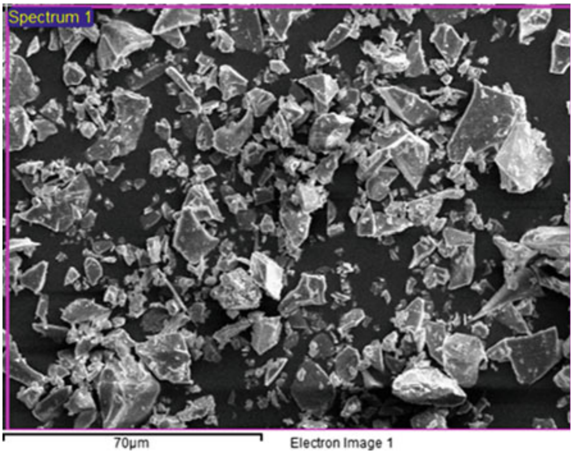

Fig. 3.3 SEM image of GGBS

developed in molten condition in blast furnace. GGBS was acquired from Salem Steel Plant Salem, TN having a specific gravity of 2.8, particle size of 97 µm and fineness (m/kg) of 390 (Table 3.2, Figs. 3.3 and 3.4).

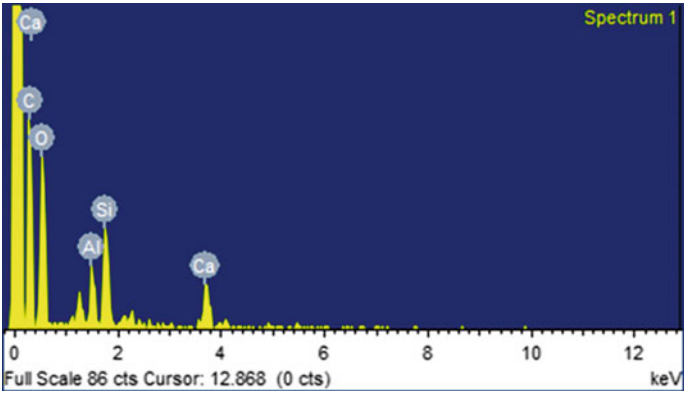

Fig. 3.4 EDAX image of GGBS

Table 3.3 Chemical properties of AL by EDAX analysis

Characteristics of element	Results for EDAX	
	Weight %	Atomic %
C K	45.69	57.64
O K	35.26	33.39
Al K	4.01	2.25
Si K	6.38	3.44
Ca K	8.66	3.27

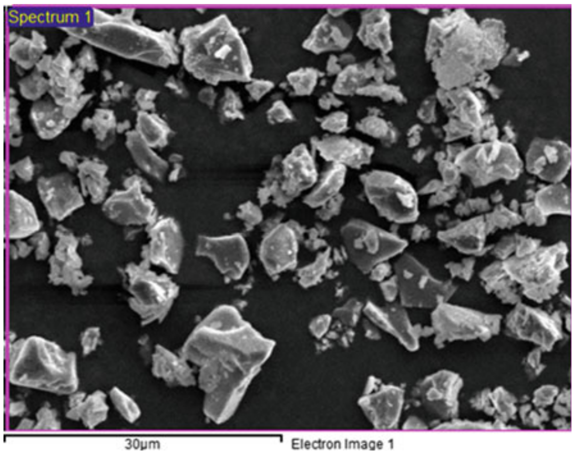

Fig. 3.5 SEM image of AL

3.2.4 Alccofine (AL)

AL is a slag-based product produced by control granulation of iron waste with high glass content. AL-1203 type is used in our investigation having specific gravity of 2.9; particle size varies from 1.5 to 9 µm (Table 3.3, Figs. 3.5 and 3.6).

3.2.5 Fine Aggregate

Regionally accessible river sand confirming to IS 383 specifications were used in our investigation having fineness modulus of 2.7%, water absorption of 1.02%, specific gravity of 2.68 and belongs to the grading zone of II.

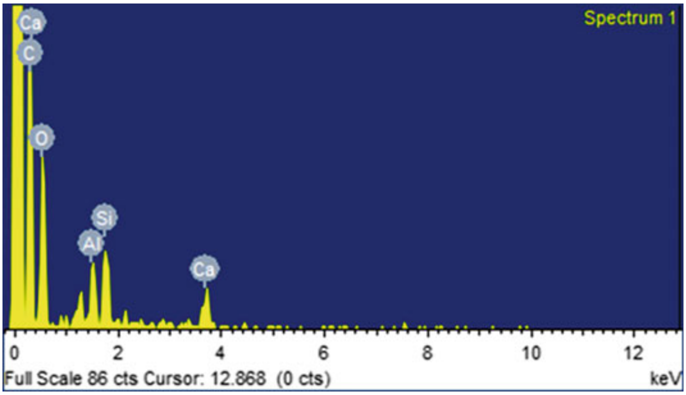

Fig. 3.6 EDAX image of AL

3.2.6 Coarse Aggregate

Locally available crushed stone passing through 20-mm sieve confirming to IS 383 was used as coarse aggregate in our investigation having fineness modulus of 7.2%, specific gravity of 2.78, water absorption of 0.8%.

3.2.7 Water

Water with pH of 7.0–8.0 available in our campus was used in our investigation.

3.2.8 Superplastizer

High-performance superplasticizer based on poly-carboxylic ether was used in the investigation.

3.3 Mix Proportions

In the present investigation, M30 grade concrete standard mix design is carried out according to Indian standard code 10262. The proportions of concrete mix are given below in Table 8 and the compression strength test was conducted as per Indian standard code 516. The 100 × 100 × 100 mm cube specimens are tested at 7 and 28 days (Tables 3.4 and 3.5).

Table 3.4 Mix design

Material	Cement	Fine aggregate	Coarse aggregate	w/c ratio
Quantity (kg/m^3)	350.2	721.5	1273.8	150.6

Control Mix Proportion = 1:2.06:3.63:0.43

Table 3.5 Mix proportions (kg/m^3)

Mix ID	Cement	FA	GGBS	AL	Fine Agg.	Coarse Agg.	Water
CM	350.2	–	–	–	721.5	1273.8	150.6
F1	332.69	17.51	–	–	721.5	1273.8	150.6
F2	315.18	35.02	–	–	721.5	1273.8	150.6
F3	297.67	52.53	–	–	721.5	1273.8	150.6
F4	280.16	70.04	–	–	721.5	1273.8	150.6
F5	262.65	87.55	–	–	721.5	1273.8	150.6
F6	245.14	105.06	–	–	721.5	1273.8	150.6
F7	227.63	122.57	–	–	721.5	1273.8	150.6
F8	210.12	140.08	–	–	721.5	1273.8	150.6
G1	332.69	–	17.51	–	721.5	1273.8	150.6
G2	315.18	–	35.02	–	721.5	1273.8	150.6
G3	297.67	–	52.53	–	721.5	1273.8	150.6
G4	280.16	–	70.04	–	721.5	1273.8	150.6
G5	262.65	–	87.55	–	721.5	1273.8	150.6
G6	245.14	–	105.06	–	721.5	1273.8	150.6
G7	227.63	–	122.57	–	721.5	1273.8	150.6
G8	210.12	–	140.08	–	721.5	1273.8	150.6
FA1	246.9	87.55	–	15.75	721.5	1273.8	150.6
FA2	241.63	87.55	–	21.01	721.5	1273.8	150.6
FA3	236.38	87.55	–	26.26	721.5	1273.8	150.6
FA4	231.13	87.55	–	31.51	721.5	1273.8	150.6
FA5	225.87	87.55	–	36.77	721.5	1273.8	150.6
FA6	220.62	87.55	–	42.02	721.5	1273.8	150.6
GA1	263.35	–	70.04	16.80	721.5	1273.8	150.6
GA2	257.74	–	70.04	22.41	721.5	1273.8	150.6
GA3	252.16	–	70.04	28.01	721.5	1273.8	150.6
GA4	247	–	70.04	33.16	721.5	1273.8	150.6
GA5	240.94	–	70.04	39.22	720.8	1273.7	150.6
GA6	235.34	–	70.04	44.82	720.8	1273.7	150.6

3.4 Results and Discussions

3.4.1 Evaluation of Optimum Percentage of FA and GGBS

The cement is replaced with FA and GGBS separately at 5, 10, 15, 20, 25, 30, 35, and 40% to evaluate the optimum percentage of cement replacement by FA and GGBS separately. The results are graphically represented as in Figs. 3.7 and 3.8.

Figure 3.7 represents the evaluation of optimum percentage of FA content and Fig. 3.8 represents the evaluation of optimum percentage of GGBS content. From Fig. 3.7, the higher compressive strength is achieved for F5 mix (concrete mix with 25% Flash), and from Fig. 3.8, the higher compressive strength was achieved for G4 mix (concrete mix with 20% GGBS). So, it is concluded that the optimum replacement percentage of cement by FA is 25% and for GGBS is 20%. Therefore the mixes F5 and G4 are selected for further studies.

3.4.2 Evaluation of Optimum Percentage of FA with AL and GGBS with AL

By maintaining the constant FA content at 25% and GGBS at 20%, the remaining cement content was replaced with AL at 6, 8, 10, 12, 14 and 16% with FA and GGBS separately to find the compatibility nature of the AL the results are graphically represented in Figs. 3.9 and 3.10.

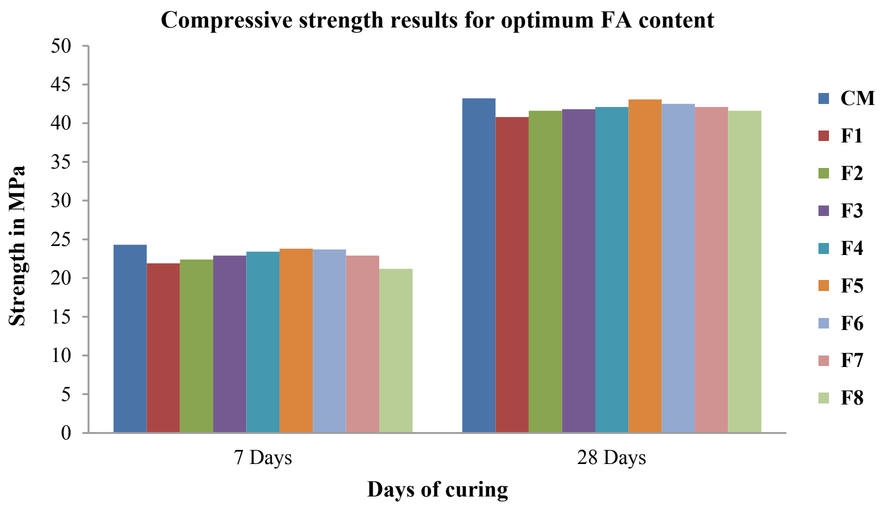

Fig. 3.7 Graphical representation for optimum percentage of FA content

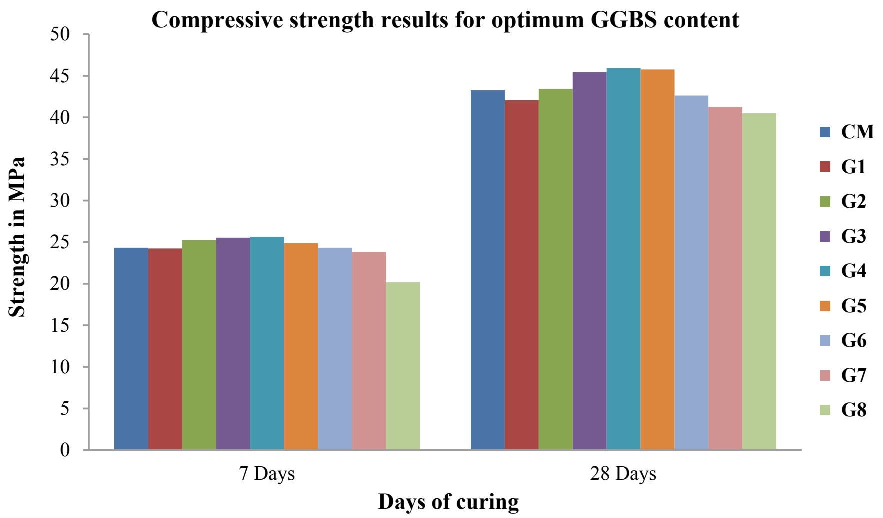

Fig. 3.8 Graphical representation for optimum percentage of GGBS content

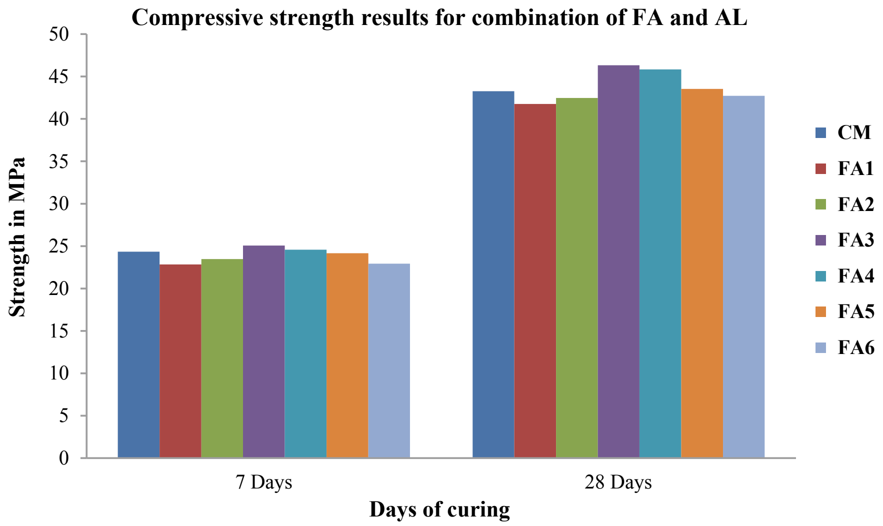

Fig. 3.9 Graphical representation for combination of FA and AL

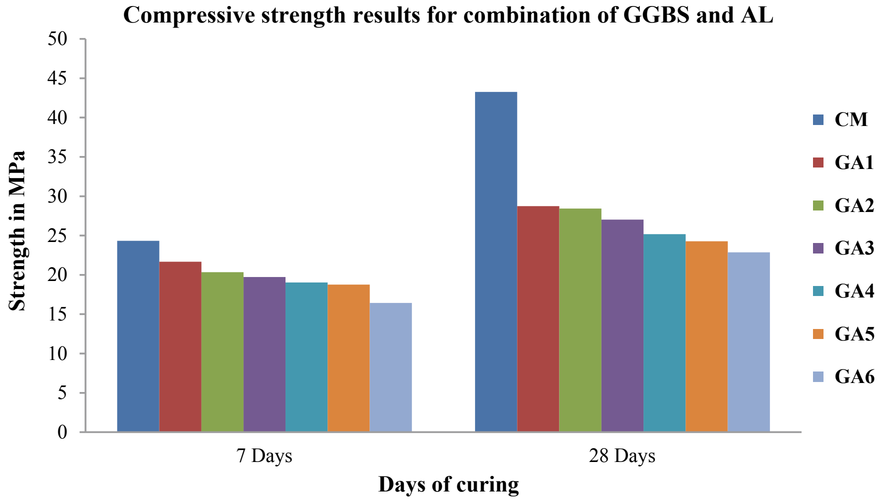

Fig. 3.10 Graphical representation for combination of GGBS and AL

Figure 3.9 represents the optimum percentage of FA and AL content, and Fig. 3.10 represents the optimum percentage of GGBS and AL content. From Fig. 3.9, the maximum compressive strength is achieved for FA3 mix (concrete mix with combination of 25% FA with 10% AL totally 35% as replacement of cement), and from Fig. 3.10 result, it is clearly seen that the combination of GGBS and AL had failed to achieve the design strength. Also it is clearly observed that as the AL percentage in the concrete mix increases the compressive strength decreases. This is may be due to the in compatibility nature of these two pozzolanic materials.

3.5 Conclusion

From the investigation, it is clearly observed that the mix containing AL sets very quickly than all mixes. The results of compressive strength on BC with combination of 25% FA and 10% AL had shown highest strength than that of all other mixes. But the mixes with combination of GGBS and AL compressive strength were not superior when compared to normal concrete. It is clearly seen from Fig. 3.10 as the AL percentage in the concrete mix increases the compressive strength decreases. This is may be due to the incompatibility nature between AL and GGBS. From Fig. 3.9, it is clearly seen that the compatibility nature of FA and AL is good, and the strength had increased 7.08% at 28 days with total cement replacement of 35%. The highest compressive strength for BC mix was achieved for FA3 mix (Mix with combination of Cement–FA–AL at 65–25–10%), respectively. The cement replacement with combination of FA and AL materials leads to eco-friendly and sustainable concrete and at the same time results in the reduction of overall cost of manufacture of blended concrete.

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