Strength Properties of Ternary Concrete

G. VIJAYA[1], A. B. N. V. PRASAD[2], B. S. NAGA RAJU[3], G. LALU SEKHAR[4], S. ARUN CHAITANYA[5]

[1, 2, 3, 4] Graduate Student, Department of Civil Engineering, Gudlavalleru Engineering College, Gudlavalleru, A.P, India

[5] Assistant Professor, Department of Civil Engineering, Gudlavalleru Engineering College, Gudlavalleru, A.P, India

Abstract- Concrete is the most widely utilized building material in civil engineering projects of all kinds. Concrete is more attractive than other construction materials due to its strength properties. Cement, which accounts for about 5% of worldwide CO_2 emissions, is a key component of concrete. To make concrete more environmentally friendly, appropriate replacements will be added to the cement. The present study deals with fly ash and alccofine as supplementary cementitious materials for the M40 grade of concrete. The cement is replaced with 5%, 10%, 15% and 20% of fly ash by weight of cement and fly ash is optimized. The optimized cement concrete is further replaced with 5%, 10%, 15% and 20% alccofine by weight of fly ash optimized cement to form a ternary concrete. The strength properties are studied to establish a ternary concrete for M40 grade.

Indexed Terms- Fly Ash, Alccofine, Compressive strength, Split tensile strength, Flexural strength

I. INTRODUCTION

Concrete is the most adaptable building material since it can be constructed to endure the roughest surroundings while still taking on the most creative shapes. With the help of innovative chemical admixtures and supplemental cementitious materials (SCM's), engineers are always pushing the boundaries to increase their performance. Most concrete mixtures now include supplemental cementitious material as a cementitious component. The majority of these materials are byproducts of other processes. SCM's key advantages are its capacity to replace a specific proportion of cement while still retaining its cementitious properties, lowering the cost of using portland cement. Fly ash, silica fume, powdered granulated blast furnace slag, steel slag, alccofine and other by products or waste materials that can be used as SCM's have accumulated as a result of rapid industrialization. These byproducts not only help to recycle waste materials, but they also improve the qualities of concrete in both fresh and hydrated forms.

1.1 Objective of the present work

The main purpose of this project is to investigate the effects of partial cement replacement with fly ash and alccofine in concrete under various curing conditions. An experiment was conducted to see if fly ash and alccofine might be used to partially replace cement. The concrete grade of M40 and the curing times of 7 and 28 days of the concrete specimens were among the criteria taken into account in this investigation.

The cement is replaced by 5%, 10%, 15% and 20% fly ash by weight, and the fly ash is tuned. To make ternary concrete, the optimal cement concrete is further replaced by 5%, 10%, 15% and 20% alccofine by weight of fly ash optimized cement. The strength characteristics of ternary concrete for M40 grade are currently being investigated.

II. MATERIALS USED IN PRESENT STUDY

2.1 Cement

For this study, ordinary portland cement of grade 53 was preferred. Cement's physical qualities are classified according to IS 456-2000. Cement is a bonding medium with cohesive and adhesive qualities that allows it to bind together various construction components and form a compacted assembly.

2.2 Fine Aggregate

The fine aggregate in this investigation was river sand that passed through a 4.75mm sieve and was kept on a

600mm sieve, confirming to zone II as defined by IS 383-1970. Clay, silt and organic contaminants are not present in the sand. In the line with IS: 2386-1963, the aggregate was evaluated for physical specifications such as gradation, fineness modulus, specific gravity and bulk modulus. Only a few types of sand are acceptable for use in the construction sector, such as in the production of concrete.

2.3 Coarse aggregate

Crushed coarse gravel of 20mm was obtained from nearby crusher mills and used throughout the research. Physical properties of the aggregate were assessed, including gradation, fineness modulus, specific gravity and bulk modulus. IS: 2386-1963 and IS : 383-1970 are the standards to follow.

2.4 Water

The concrete is mixed with clean, fresh water that is free of organic debris and oil. Water was added to the concrete in the proper amounts, as measured by a graduated jar. Weight batching was used to obtain the remaining components for preparing the concrete mix. A pH of less than 6 is not recommended.

2.5 Fly ash

Fly ash is a finely split residue that occurs from the combustion of pulverized coal and is carried away by exhaust gases from the combustion chamber. Coal-fired power and steam generating stations emit fly ash. In this investigation, class F fly ash was employed.

2.6 Alccofine

Alccofine is a micro-fine substance manufactured in India that has a particle size significantly smaller than other hydraulic materials such as cement, fly ash, ground granulated blast furnace slag, silica fume and others. Because of its optimized particle size distribution, alccofine has unique characteristics that improve concrete performance in fresh and hardened stages.

III. MIX PROPORTION

In the present work, a proportion for concrete mix design of M40 was carried out according to IS: 10262 – 2019 recommendations. The mix proportion is presented in Table 1.

Table 1: Mix proportion used in this study

w/c ratio	Cement content (Kg)	Fine Aggregate (Kg)	Coarse Aggregate (Kg)	Water (liters)
0.38	430	691.6	1245.58	163.2

IV. TESTING OF SPECIMENS

4.1 Compressive Strength:

The major and prevalent attribute noticed while testing the cubes is compressive strength. Cubes are tested to determine compressive strength using a compression testing machine that applies progressive stress to the specimen. The reading of the failure load occurs on the top of the machine, which is known as an indicator.

The compressive strength has been calculated by the formula,

Compressive strength = applied load / cross sectional area

= P/A

= load/area N/mm^2

Figure 1: Compression testing machine

4.2 Split Tensile Strength:

Concrete's essential attribute is split tensile strength. Split tensile strength is calculated using cylinders. The compression testing equipment is also used to test cylindrical specimens. By presenting the cylindrical face to the loading surface, the cylinders are arranged horizontally. Here the cylinder split into the two parts and reading is observed in the indicator.

The split tensile strength has been calculated by the formula,

Split tensile strength = $2P / \pi LD$

Where, P = compressive load on the cylinder

L = length of the cylinder

D = diameter

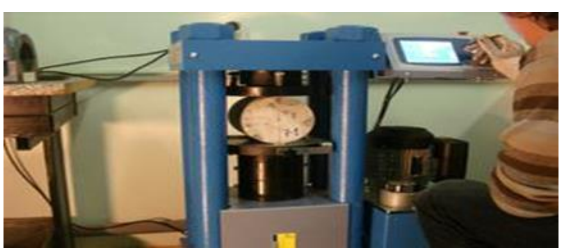


Figure 2: Split tensile test

4.3 Flexural strength:

The majority of beam failures are due to flexural strength failure. To decrease failure difficulties in beams, it is critical to estimate flexural strength by computing the modulus of rupture. In casting beam specimens, the primary goal is to determine the modulus of rupture in terms of flexural strength. In this, the modulus of rupture is calculated by testing the specimen in the universal testing machine. In this line, fracture is the main important property in formatting the modulus of rupture.

The modulus of rupture is denoted by "f_{cr}".

The 'f' value is mainly based on the shortest distance of line fracture 'a'

If 110mm < a < 133mm, $f_{cr} = 3PL/bd^2$

If a > 133mm, $f_{cr} = PL/bd$

If a < 110mm, the test shall be discarded.

Figure 3: Flexural strength test

V. EXPERIMENTAL INVESTIGATION, TEST RESULTS AND GRAPHS

5.1 Compressive strength test:

The compression strength test is performed on a 150mm x 150mm x 150mm cube specimen for 7 days and 28 days of curing.

Table 2: compressive strength of conventional mix

Mix details	Compressive strength (Mpa)	
	7 days	28 days
Conventional	31.82	49.73

5.2 Split tensile strength test:

The tensile strength is calculated by testing cylindrical specimens of size 300mm height and 150mm diameter. Here each set of specimens are tested for 7 days and 28 days of curing.

Table 3: Split tensile strength of conventional mix

Mix details	Split tensile strength (Mpa)	
	7 days	28 days
Conventional	2.68	3.35

5.3 Flexural strength test:
Flexural strength for concrete is determined by casting beam specimens for 7 days and 28 days of curing. The beam dimensions are of 500mm x 100mm x 100mm.

Table 4: Flexural strength of conventional mix

Mix details	Flexural strength (Mpa)	
	7 days	28 days
Conventional	3.97	4.98

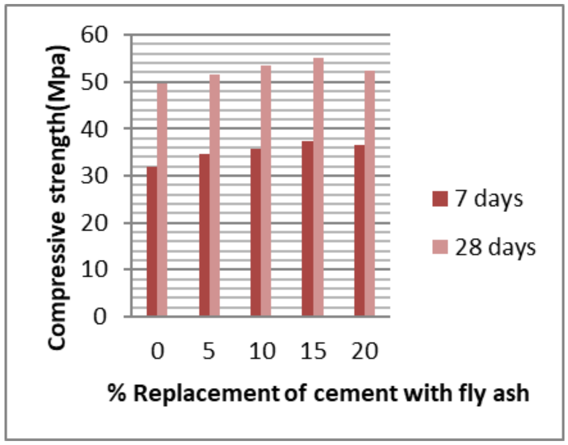
5.4 Replacing cement with fly ash:
Cement is replaced with fly ash in proportions of 5, 10, 15 and 20%. The values obtained are as follows.

Table 5: Results for % replacement of cement with fly ash

% of fly ash	Compressive strength		Split tensile strength		Flexural strength	
	7 days	28 days	7 days	28 days	7 days	28 days
0	31.82	49.73	2.68	3.35	3.97	4.98
5	34.76	51.67	2.82	3.48	4.23	5.13
10	35.83	53.48	3.07	3.57	4.49	5.32
15	37.24	55.22	3.21	3.73	4.57	5.51
20	36.45	52.32	2.89	3.61	4.24	5.26

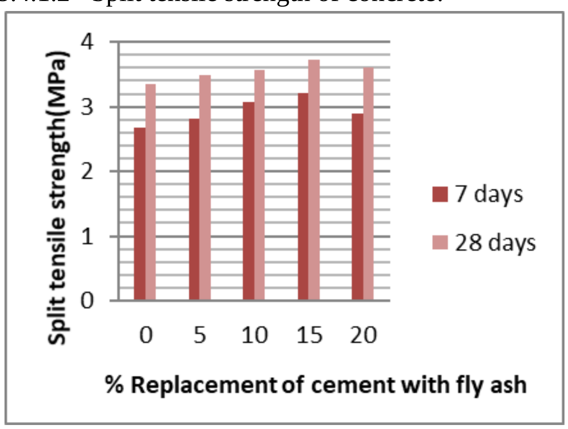
The strength has been increased up to 15% replacement of fly ash with cement and then it can start decreasing by increasing fly ash.

5.4.1 Graphs
5.4.1.1 Compressive strength of concrete:



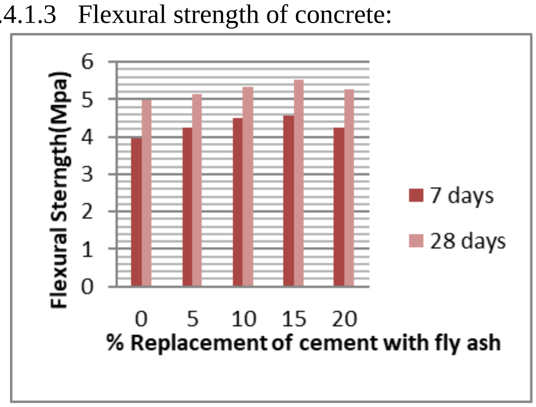
Graph 1: Compressive strength for fly ash mix

5.4.1.2 Split tensile strength of concrete:



Graph 2: Split tensile strength for fly ash mix

5.4.1.3 Flexural strength of concrete:



Graph 3: Flexural strength for fly ash mix

5.5 Replacing of cement with 15% fly ash + alccofine

To the optimum of 15% fly ash, alccofine were added in 5, 10, 15 and 20%. The results were as follows.

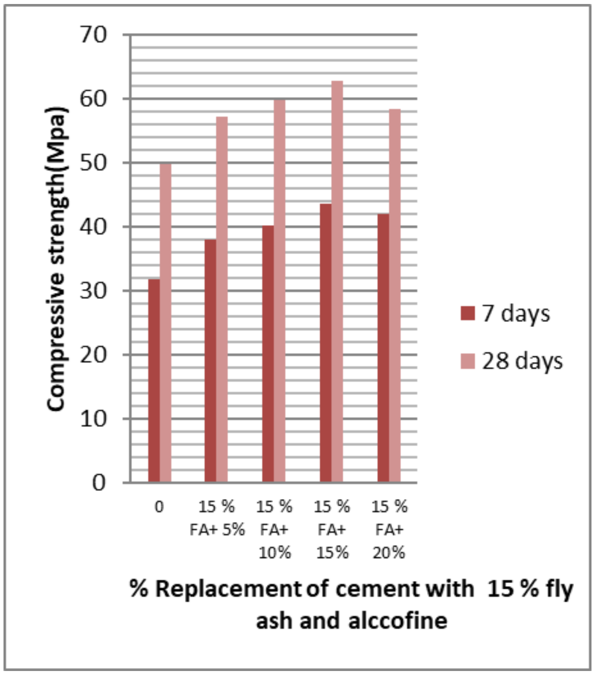
Table 6: Results for % replacement of cement with 15% fly ash and alccofine

Optimum fly ash (FA)	% alcco-fine	Compressive strength		Split tensile strength		Flexural strength	
		7 days	28 days	7 Days	28 days	7 days	28 days
15%	0	31.82	49.73	2.68	3.35	3.97	4.98
	5	38.09	57.25	3.35	3.95	4.62	5.69
	10	40.21	59.79	3.48	4.07	4.83	5.71
	15	43.56	62.74	3.64	4.27	5.09	5.94
	20	41.95	58.32	3.56	4.13	4.79	5.64

The strength at optimum 15% replacement of fly ash and alccofine in cement, the optimum strength was obtained at 15% and then it can starts decreasing by increasing alccofine.

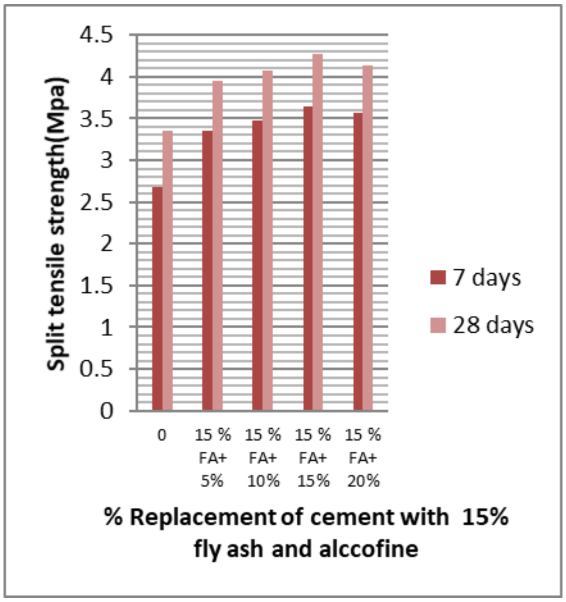
5.5.1 Graphs:

5.5.1.1 Compressive strength of concrete:



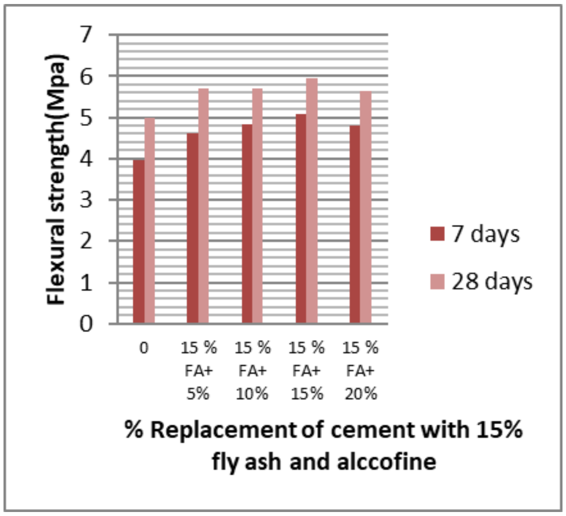
Graph 4: Compressive strength for fly ash and alccofine mix

5.5.1.2 Split tensile strength of concrete:



Graph 5: Split tensile strength for fly ash and alccofine mix

5.5.1.3 Flexural strength of concrete:



Graph 6: Flexural strength for fly ash and alccofine Mixt

CONCLUSION

- When cement was replaced by 15% of fly ash and 15% of alccofine gives high compressive strength of 62.74 N/mm^2. It was observed that the increase in compressive strength was 20.7% when compared with the nominal mix. Further replacement of alccofine leads to decrease in compressive strength.
- It was observed that split tensile strength was increased by 21.54% when the concrete mix containing 15% fly ash and 15% alccofine as a replacement of cement, when compared with the nominal mix. Further replacement of alccofine leads to a decrease in the split tensile strength.
- The flexural strength was increased by 16.16% when the concrete mix containing 15% fly ash and 15% alccofine as a replacement of cement, when compared with the nominal mix. Further replacement of alccofine leads to a decrease in flexural strength.

REFERENCES

[1] Various Codes were used: IS: 8112-1989, IS: 383-1970. IS: 2386 (PART-1)-1963, IS: 456-2000, IS4031(PART-6)-1988.

[2] Seyed M.Joorabbchian "Durability of concrete exposed to sulfuric acid attack/http://digitalcommons.ryerson.ca/dissertations(2010).

[3] Vikas[1], Parveen Singh[2] "Analysis of Strength Optimization of Blended Cement using FLY ASH and Alccofine" (ISSN 2347 – 6435, Volume 4, Issue 9, September 2015).

[4] S. Kavitha and T. Felix Kala, "Evaluation of Strength Behavior of Self-Compacting Concrete using Alccofine and GGBS as Partial Replacement of Cement", Indian Journal of Science and Technology, Vol. 9, Issue 22, 2016, Page No.1-5.

[5] Devinder Sharma, Sanjay Sharma and Ajay Goyal, "Utilization of Waste Foundry Slag and Alccofine for Developing High Strength Concrete", International Journal of Electrochemical Science, Vol. 11, Issue 1, 2016, Page No.3190 – 3205.

[6] M. Vijaya Sekhar Reddy, K. Ahsalatha and K. Surendra, "Studies on eco-friendly concrete by partial replacement of cement with Alccofine and fine Fly ash", ARPN Journal of Engineering and Applied Sciences, Vol. 11, Issue 5, 2016, Page no. 3445-3448.

[7] K. Gayathri, K. Ravichandran and J. Saravanan, "Durability and cementing efficiency of Alccofine in concretes", International Journal of Engineering Research & Technology, Vol. 5, Issue 5, 2016, Page No. 460-467.

[8] Alexander K M. Observation on Blaine method for determining fineness and on the relationship between surface and pozzolanic reactivity. Australian Journal of Applied Science, Vol. 6, No. 3, September 1955, pp 316-326.

[9] Georg Dirk, chairman, "potential for developing 3-way high performance concrete mixes using class f fine and ultra-fine fly ash" in 2000.

[10] Hendriks, C. A. Worrell, E., de Jager, D., Block, K., and Riemer, P. (2000). "Emission reduction of greenhouse gases from the cement industry." IEA Greenhouse Gas R&D Program.

[11] K. S. Kulkarni, S. C. Yaragal and K. S. Babu Narayan, Department of Civil Engineering, National Institute of Technology Karnataka, Surathkal, Srinivasnagar-575025, Manglore, India.

[12] Alok Kumar, Oshin Parihar, Rahul Chaudhary, Shiv Prakash Singh, "Use of alccofine 1206 to achieve high performance durable concrete" ISSN: 2348 – 8352, volume 3 Issue – May 2016.

[13] Abhish M S, Kamalakara G K, Srikanth M Naik "Study on Blended Cement Composites with 53 Grade OPC Composite for Marine Condition/Environment"(ISSN: 2278-0181, Vol.4 Issue 03, March-2015).

[14] Priyanka A. Jadhav, Dilip K. Kulkarni "Effect of replacement of natural sand by manufactured sand on the properties of cement mortar"(ISSN 0976-4399 Volume 3, No 3, 2013).

[15] Mehta, P.K.(1987). "Natural pozzolans : Supplementary cementing materials in concrete". CANMET Special Publication 86: 1-33.

[16] Effect of Elevated Temperatures on Mechanical Properties of Micro Cements Based High Performance Concrete. By K.S, Kulkarni, S. C. Yaragal And K. S. Babu Narayan.