Effect Of Mineral Admixtures On The Strength Properties Of Fly Ash Based Fresh Concrete

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Abstract: At the early age of concrete incorporation of fly ash alone reduces the compressive strength than the incorporation of blended mineral admixtures due to the lack of lime content in the concrete mix and also delays the rate of the hydration process. This paper investigates the impact on the early age strength of fly ash based concrete due to the incorporation of mineral admixtures. Concrete samples with the incorporation of the various percentage of GGBFS (Ground Granulated Blast Furnace Slag) and Metakaolin (0%, 25%, 50%, 75%) have been cast and tests have been conducted at the 7 days of concrete samples. Results have been compared with conventional concrete which containing fly ash as a certain percentage. Incorporation of GGBFS and Metakaolin with a control mix enhanced the 7 days compressive strength up to 22% compared to the conventional concrete. Hence, the present study suitable for early-age strength development of fly ash-based concrete.

Index Terms: concrete, mechanical strength, fly ash, mineral admixture, early age strength, metakaolin, slag.

1. INTRODUCTION

The demand for cement increasing day by day, due to the tremendous growth of the construction industry. In an account of this growth, among all greenhouse gases, CO_2 plays a vital role in global warming about sixty-five percentage [1]. The concentration of CO_2 has been increased from 280 PPM to 402.25 PPM due to the industrial revolution [2]. To decrease the CO_2 emission, some of the cement production industries find the alternative material which was called blended cement [3]. The addition of fly ash, Metakaolin, Ground Granulated Blast Furnace slag (GGBFS) is called blended cement. As per the expert's recommendation 10-25% of OPC (Ordinary Portland Cement) is replace with Mineral admixtures [4]. When incorporating the fly ash in concrete, the early age of the concrete reduced considerably compared to the normal concrete [5]. Some of the studies expose that when incorporating the silica fume, that has been led to the alkali-silica reaction as alkaline substance [6]. Most of the studies only around fly ash and GGBFS, but only limited studies available on the development of strength of fly ash based fresh concrete. Metakaolin is a calcined clay pozzolana, currently used in England, USA and India [7]. In India, Metakaolin has been incorporating with lime content, which has been used in the ancient sculptures and structures. Despite ancient structures, the use of calcined kaolinite in modern cement concrete is not very famous in this decade. Apart from its cost, these improving the mechanical strength and reduce the effect of alkali-aggregate reaction [6],[7]. Mechanical properties increased significantly by the addition of metakaolin [8]. In this paper, certain mix designs adopted with different proportions of mineral admixtures which are partially replaced with fly ash content, to improve the strength of fly ash-based fresh concrete.

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2 RESEARCH SIGNIFICANCE

This research aims to study the two main aspects. The first one was studying the effect on strength of fly ash based fresh concrete by partial replacement of fly ash content with metakaolin and the second one was studying the effect on strength of fly ash based fresh concrete by partial replacement of fly ash content with GGBFS. The main variable in this research is mineral admixtures and also replacement percentage. Provision of necessary data to the engineers and scientists, who all are looking to improve the strength of fly ash-based fresh concrete.

3 MATERIALS USED

3.1 Cementitious Material

Ordinary Portland cement (OPC- 53 GRADE) is used as the cementitious materials which are confirmed with IS: 4031-1968 for their physical properties and also cover the specifications as per IS: 12629-2009.

3.2 Fine Aggregate

Crushed rock sand, which is known as manufactured sand (M-sand) is free away from debris and sediment, used as fine aggregates. The physical properties like fineness modulus and specific gravity were tested as per IS: 2386 and also comes under Zone – II of IS: 383-1970.

3.3 Water

As per IS:456: 2000, Concrete is mixing by using physically, chemically free water, which does not contain solid matters.

3.4 Coarse Aggregate

Maximum size of 20 mm which is an angular shape use as a coarse aggregate in this project work. The angular crushed aggregate size of 12mm and 20mm secured from the Karur crushing plant procured and used for this research work. As per IS: 2386-1963, the physical properties of coarse aggregate tested and confirm the specifications. The specific gravity of coarse aggregate is found as 2.63.

3.5 Fly Ash

Class F fly ash which is procured from Mettur thermal power station, Mettur used as a replacement material for OPC.

3.6 Metakaolin
Metakaolin is a by-product of the paper industry which is procured from SNR paper mills, Erode. The end product was a disorganized structure that is chemically combined with calcium hydroxide during the cement hydration process.

3.7 Ground Granulated Blast Furnace Slag (GGBFS)
GGBFS is used as strength improvement mineral admixtures partially replaced with fly ash in concrete. GGBFS is obtained from end product of steel industry.

3.8 Super Plasticizer
The workability of concrete is improving by using the water-reducing admixtures. Master Glenium Sky 8777 was used as water-reducing admixtures as the size of 1% of the volume of cementitious materials while mixing the concrete.

4 EXPERIMENTAL INVESTIGATION

4.1 General
Measurement of impact on the strength of fly ash-based fresh concrete is the prime objective of this study. Concrete of grade M30 was evaluated for their strength properties with partial replacement of mineral admixtures in different proportions such as 0%,10%, 25%, 50%, 75% with fly ash content. The result is compared to the strength of the control mix. The specimens of cubes (150 mm x 150mm), cylinders (150mm x 300mm) were cast and tested at 7 days of curing period.

4.2 Mixing and Casting of Concrete
By using the pan mixtures OPC, fly ash and mineral admixtures were mixed in dry state and then water and super plasticizers added to the dry mix. Super plasticizers only required during the addition of GGBFS in the concrete as partial replacement with fly ash content. Slump cone test used to measure the workability of the concrete. Figure 1 represents methodology adopted in this study.

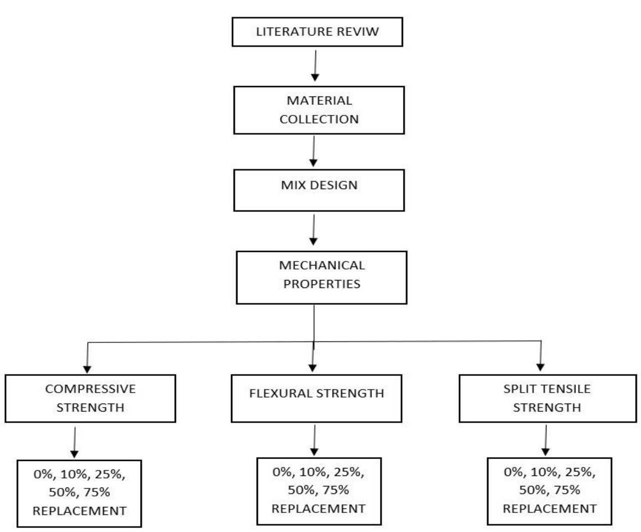


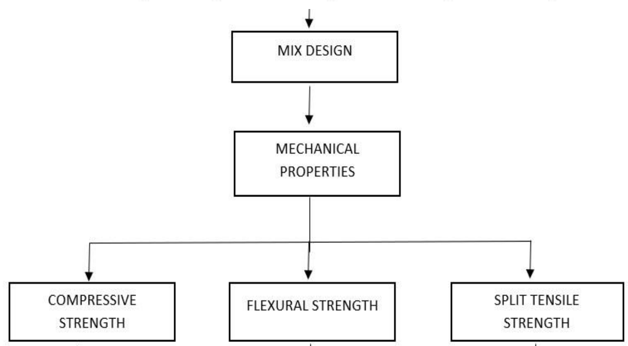
***Fig. 1**. The methodology of the study. Flow charts represent the sequence of steps followed during the research work.*

5 TEST RESULTS
The following sections explore the results of the tests which were carried out by mentioned above for both mineral admixtures.

5.1 Compressive Strength
Table 1 explores the compressive strength test results of concrete samples at 7 days curing periods.

TABLE 1
COMPRESSIVE STRENGTH (AT 7 DAYS)

Mineral Admixtures	% of Replacement in Fly ash content				
	0%	10%	25%	50%	75%
GGBFS	26.5	27.75	29.42	30.65	32.35
Metakaolin	26.5	26.90	27.80	28.53	30.78



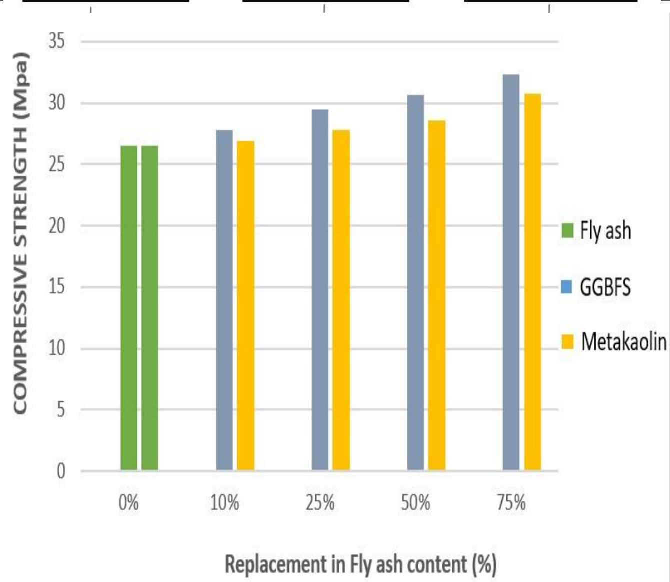
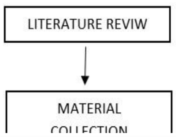


***Fig. 2**. Graphical Representation of Compressive strength at 7 days Curing Period. The result indicates that the increase in the replacement of mineral admixtures in fly ash content leads to improvement in the early age strength.*

5.2 Split Tensile Strength

Table 2 explores the split tensile strength test results of concrete samples at 7 days curing periods. Graphical Representation of split tensile strength results (Fig .3) followed the same trends in the strength achievement as in the compressive strength results. An increase in the replacement level of mineral admixtures with fly ash content means strength also increased significantly. In terms of workability, GGBFS incorporated fly ash concrete had a higher slump value then metakaolin incorporated concrete. So GGBFS concrete required some addition of the superplasticizers to improve the workability. Superplasticizers of the volume of 1.5% in the cementitious material were used as an admixture in



Mineral Admixtures	% of Replacement in Fly ash content				
	0%	10%	25%	50%	75%
GGBFS	2.65	2.85	2.96	3.15	3.60
Metakaolin	2.65	2.70	2.82	2.94	3.25

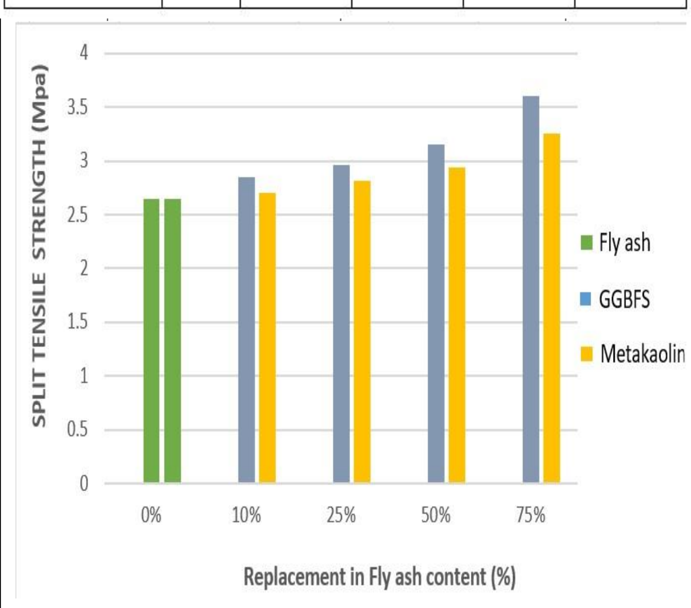


***Fig. 3**. Graphical Representation of Split Tensile strength at 7 days Curing Period. The result indicates that as same as compressive strength. An increase in the replacement of mineral admixtures in fly ash content leads to improvement in the early age strength.*

6 CONCLUSIONS

This study outcome the following conclusions:

1. Partial replacement of mineral admixtures in Fly ash based fresh concrete plays a vital role in the strength improvement at an early age.
2. Specifically, GGBFS improved strength considerably. So, GGBFS is the primarily preferable one.
3. Cost-wise also GGBFS is the preferable one then the Metakaolin. Metakaolin is a demandable one and also a higher cost than the GGBFS.

4. Cost and ease of availability are the main factors which make GGBFS is the preferable mineral admixtures for the replacement.

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