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A Study on the Influence of Mineral Admixtures in Cementitious System Containing Chemical Admixtures

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Abstract:- Reducing the percentage of cement in concrete makes it more economical and environmental friendly. The cement replacement with various mineral admixtures improves the properties of concrete. The chemical admixtures are materials added in concrete to enhance the properties in fresh and hardened state. A strength study was conducted on concrete and the results are compared and analyzed. The optimum percentage replacement of cement with mineral admixtures for better strength was found out.

Keywords:- concrete, mineral admixtures , chemical admixtures, replacement, strength

I. INTRODUCTION

Modern concrete contain cement, aggregate, water, chemical admixtures and mineral components. The mineral component and chemical admixtures give specific properties to fresh and hardened concrete. The strength of concrete depends on the binding property of cement paste and the adhesive property of the aggregate particles. The cement replacement with various mineral admixtures improves the properties of concrete. Mineral admixtures are finely divided siliceous materials which are added to concrete in relatively large amounts. The commonly used mineral admixtures are fly ash, ground granulated blast furnace slag, metakaolin, silica fumes, rice husk ash etc [1]. The chemical admixtures are those which usually used to reduce the water demand and to maintain workability in concrete and cement paste . Reducing the percentage of cement in concrete makes it more economical and environmental friendly.

II. LITERATURE REVIEW

In the paper of Monosi et al a study on the compressive strength of fly ash concrete mixes by varying cement type super plasticizer type and dosage. For an aqueous solution of 40% , the optimum dosage of SNF and SMF obtained was 1%. When the dosage was increased it caused retarding effect. At a given workability with the addition of super plasticizer strength of concrete was increased in the presence of fly ash [2]. From the study of Tamilarasan V. S., P. Perumal it is found that the 30% replacement of cement with GGBS gives maximum increase in strength. When super plasticizer was added to concrete, it was found that 40% replacement of cement gives maximum increase in strength for M20 and M25 grade concrete. However, it was said, 60% replacement of cement is possible using GGBS since the compressive strength of concrete was higher than that of conventional concrete. The tensile strength of GGBS added to concrete with and without super plasticizer was higher than the tensile strength of conventional concrete in both M20 and M25 grade concretes. The flexural strength of GGBS added concrete without and with Super plasticizer are higher than the flexural strength of conventional concrete for both M20 and M25 grade concretes. The increase in tensile and flexural was found to be maximum at 60% replacement[3].

III. MATERIALS FOR THE STUDY

Cement: Ordinary Portland cement of 53 grade confining to IS 12269 [4] was used for the experimental programme. Various experiments were conducted to determine the initial and final setting time, specific gravity and standard consistency.

Fly ash: Fly ash is a by-product of the combustion of pulverized coal in thermal power plants. Dust collection system removes the fly ash, from the combustion gases before they are discharged into the atmosphere. Fly ash (Class F) was used for cement replacement. The major constituents of fly ash are SiO_2, Al_2O_3, and CaO

***Ground granulated blast furnace slag (GGBS)*:** Blast furnace slag is a by-product of pig iron manufacture. The main components of blast furnace slag are CaO (30-50%), SiO_2 (28-38%), Al_2O_3 (8-24%), and MgO (1-

18%). Using GGBS for cement replacement gives more water tightness, chemical resistance and law heat of hydration.

Fine aggregate: Locally available manufactured sand was used as fine aggregate. Laboratory tests were conducted on fine aggregate to determine the different physical properties confining to IS 2386 [5]. The results depicted that the manufactured sand conformed to zone II confining to IS 383[6].

Coarse aggregate: Coarse aggregates of 20mm and 12mm nominal size were used for making PCC. Laboratory tests were conducted on coarse aggregate to determine the different physical properties confining to IS 2386 [5]. The results showed that the coarse aggregate conformed to specifications in ARE 2386[5].

Super plasticizer: Super plasticizer used for the study was polycarboxilic ether . Super plasticizer was used to improve the workability of the mix.

Water: Water used for the experimental study was potable water.

IV. POZZOLANIC REACTION

In the hydration reaction of cement tri-calcium silicate, di-calcium silicate and calcium hydroxide $Ca(OH)_2$ are formed. The calcium hydroxide produced in the reaction does not have any cementitious property. When mineral admixtures are added to the concrete, the silica in mineral admixture will react with calcium hydroxide in the presence of water to form C-S-H gel. This calcium silica hydrate gel is having high cementitious property and provides strength. Thus when mineral admixture is added to cement the strength will be increased [7],[8].

V. EXPERIMENTAL STUDY

A design mix was prepared for M35 grade concrete based on IS 10262 [9]. Slump tests were conducted on fresh concrete mix of each trial . Compressive strength test was conducted on concrete cubes of size 15cm x15cm x 15cm. For the study, cement was replaced with fly ash and GGBS. Mixes were prepared by replacing cement with 15%, 30% and 45% of fly ash and 40%, 50% and 60% of GGBS. A mix was prepared with cement without any replacement. Super plasticizer was also added to the concrete to improve its properties.

A. Strength Of Concrete when cement replaced with fly ash

Compressive Strength Test:

The Concrete mixes were prepared by replacing 15%, 30% and 45% of cement with fly ash. A control mix was prepared with cement without any replacement. All the concrete mixes were prepared with 0.5% of super plasticizer. Nine cubes were cast for each mix for the compressive strength study. The strength of the concrete cubes were found after 3 day, 7 day and 28day. Workability of concrete was also tested with Slump test [10]. Chemical admixtures were added to concrete to improve workability. The results of Compressive strength test are tabulated and given in Table I.

Table I: Compressive strength of concrete cubes when cement is replaced with fly ash

Specimen	Slump value	Average compressive strength (N/mm²)		
		3 day	7 day	28 day
Cement + sp	100	24.1	28.9	**40.3**
Cement +sp + 15%fly ash	135	20.9	29.1	**42.3**
Cement +sp + 30% fly ash	133	14.4	24.2	**39.5**
Cement +sp + 45% fly ash	**130**	**12.2**	**23.5**	**37.8**

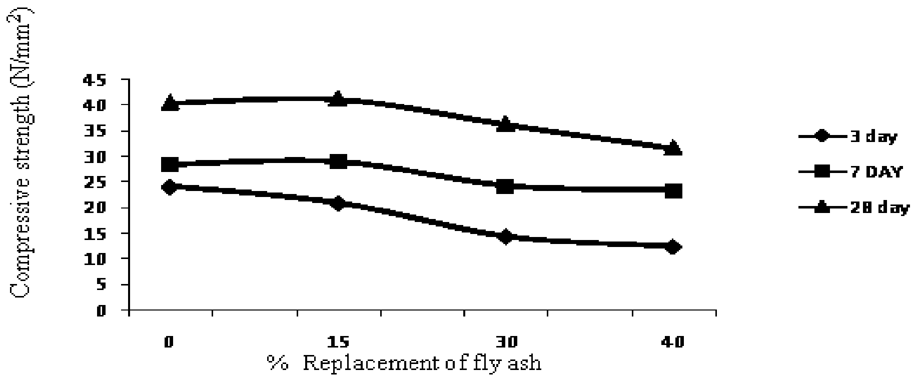

Fig.1: Day 3, day 7 and day 28 compressive strength of concrete when cement is replaced with fly ash

From the compressive strength study, it was observed that in the 3 day test, the control mix without any replacement has higher strength than the concrete with cement replacement. In the seven day and twenty eight day tests, it is observed that strength of the concrete with 15% cement replacement has higher strength than the control mix. In the twenty eight day strength it was observed that all the four mixes have higher strength but fly ash replace concrete with 15% replacement has highest strength. When fly ash is added to concrete, the workability was again improved.

Split Tensile Strength Test:

Split tensile strength test was conducted on concrete cylinders of 15cm diametre and 30cm height. Six cylinders were prepared for each combination. A control mix was also prepared for the split tensile strength. The cylinders were subjected to compression load along two axial lines which are diametrically opposite. The load was applied continuously at a constant rate. The split tensile strength was found for 7days and 28 days. The results are tabulated and were given in Table 2. The graphs are plotted between split tensile strength and percentage replacement.

Table 2: Split tensile strength of concrete cubes when cement is replaced with fly ash

Specimen	Average split tensile strength (N/mm²)	
	7 day	28 day
Cement + sp	2.8	**4.6**
Cement +sp + 15%fly ash	2.5	**5.2**
Cement +sp + 30% fly ash	2.3	**4.6**
Cement +sp + 45% fly ash	**2.3**	**4.3**

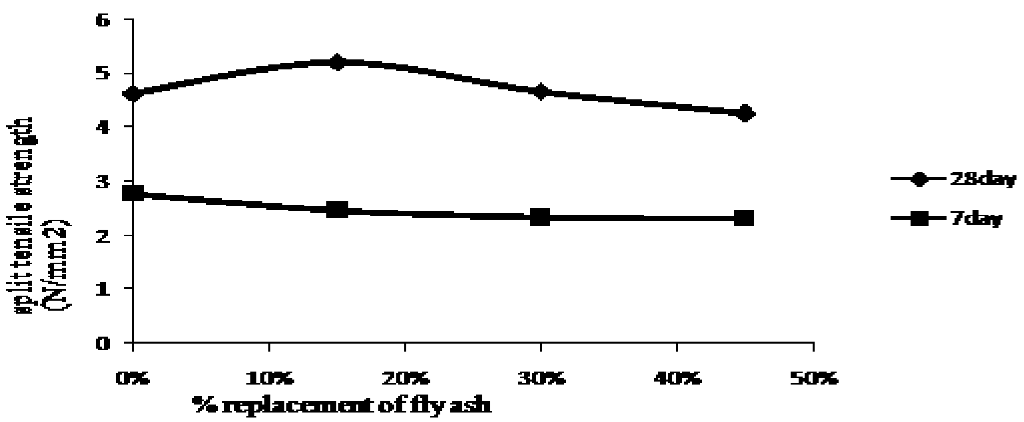

Fig.2: Day 7 and day 28 Split tensile strength of concrete when cement is replaced with fly ash

In the split tensile strength, test it was observed that, after seven days, the mix without any cement replacement showed higher strength. But after twenty eight days, the mix prepared with 15% cement replacement with fly ash gives higher strength. This shows that for fly ash replaced concrete the initial strength development for compressive strength and split tensile strength is slow.

Flexural Strength Test:

The concrete is relatively strong in compression and weak in tension. In reinforced concrete members, steel reinforcement bars are provided to resist all tensile force. Tensile stresses may also be developed in concrete due to drying shrinkage, rusting of steel reinforcement, temperature gradients and many other reasons. So the knowledge of tensile strength of concrete is important. Flexural strength test was conducted on specimens cast and cured with a universal testing machine. Specimens of size 100mmx100mmx500mm confining to IS 516[11] was prepared and stored in the water curing tank for the specified time period. Three specimens were cast for each mix and tested on the 28th day. A control mix was also prepared with cement and super plasticizer without any cement replacement. Mixes were prepared with 15%, 30%and 45% replacement of cement with fly ash. The test results are tabulated in Table 3.

Table 3: Flexural strength of concrete cubes when cement is replaced with fly ash

specimen	Average flexural strength (N/mm^2)
	28 day
Cement + sp	7.7
Cement +sp + 15%fly ash	7.9
Cement +sp + 30% fly ash	7.3
Cement +sp + 45% fly ash	6.9

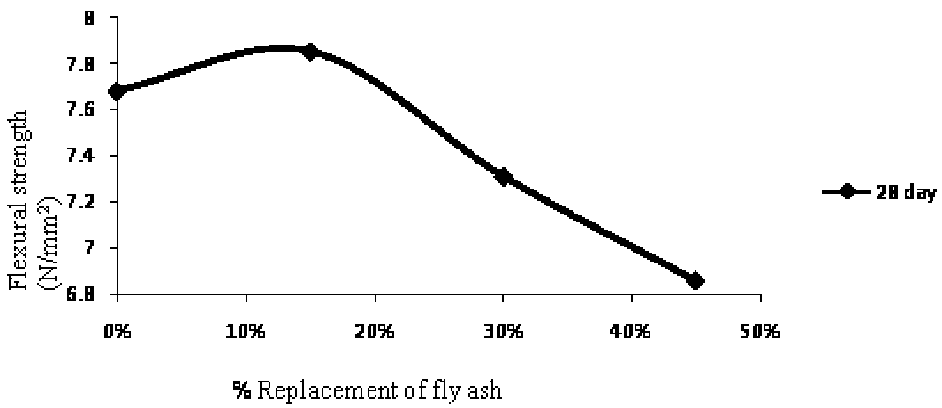

Fig.3: 28 Day Flexural strength of concrete when cement is replaced with fly ash

B. Strength Of Concrete when cement replaced with GGBS

Compressive Strength:

For the experimental study, three mixes were prepared by replacing 40%, 50% and 60% of cement with GGBS. A control mix was also prepared without any cement replacement. All the concrete mixes were prepared by adding 0.5% of super plasticizer. Nine cubes were cast for each mix for the compressive strength study. The strength of the concrete cubes were found after 3 day, 7 day and 28day curing. When GGBS was added to the concrete, the workability of concrete has increased. The slump values and the compressive strength values are tabulated in the Table 4 below.

Table 4: Compressive strength of concrete cubes when cement is replaced with GGBS

Specimen	Slump (mm)	Average compressive strength (N/mm²)		
		3 day	7 day	28 day
Cement + sp	100	24.1	28.9	**40.3**
Cement +sp + 40% GGBS	130	29.8	29.8	**41.5**
Cement +sp + 50% GGBS	160	32.4	32.4	**43.6**
Cement +sp + 60% GGBS	**150**	**31.5**	**31.5**	**42.3**

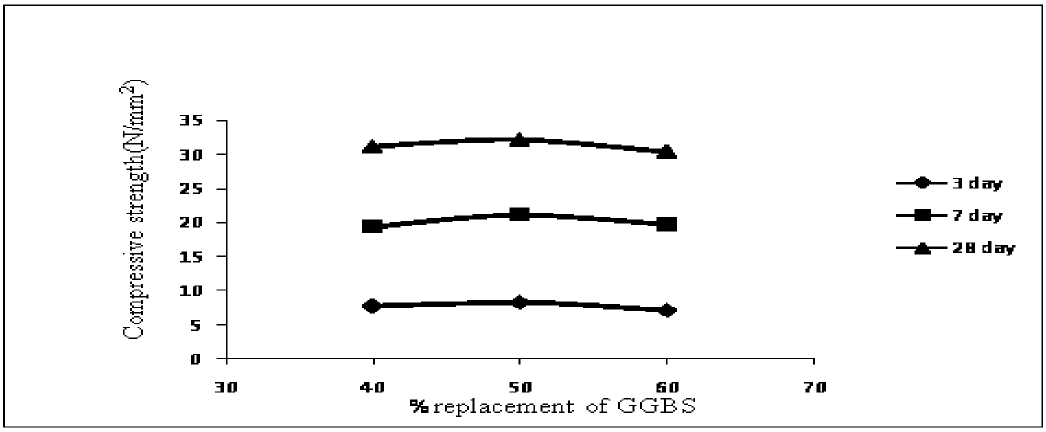

Fig.4: 3 day, 7 day, 28 day Compressive strength of concrete when cement is replaced with GGBS

Split Tensile Strength:

Split tensile strength test was conducted on concrete cylinders prepared by replacing cement with GGBS. Six cylinders were prepared for each mix. A control mix was also prepared without any cement replacement. The results are tabulated and the graphs are plotted.

Table 5: Split tensile strength of concrete cubes when cement is replaced with GGBS

Specimen	Average split tensile strength (N/mm²)	
	7 day	28 day
Cement + sp	2.8	**4.6**
Cement +sp + 40% GGBS	2.8	**4.7**
Cement +sp + 50% GGBS	3.2	**5.1**
Cement +sp + 60% GGBS	**2.7**	**4.5**

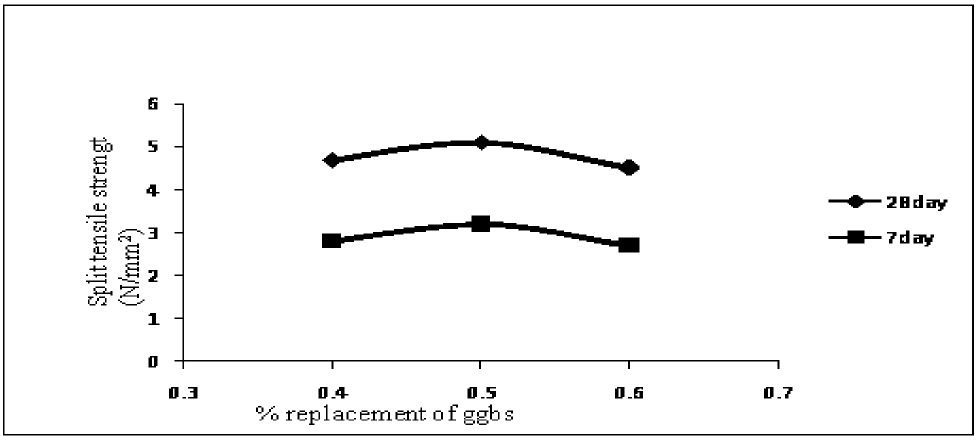

Fig 4.4 7 day and 28 day split tensile strength of concrete when replaced with GGBS

For seven day strength and twenty eight day strength maximum strength was obtained for 50% cement replacement with GGBS.

Table 6: Flexural strength of concrete cubes when cement is replaced with GGBS

Specimen	Average Flexural Strength (N/mm^2)
	28 day
Cement + sp	7.7
Cement +sp + 40% GGBS	7.8
Cement +sp + 50% GGBS	8.2
Cement +sp + 60% GGBS	7.9

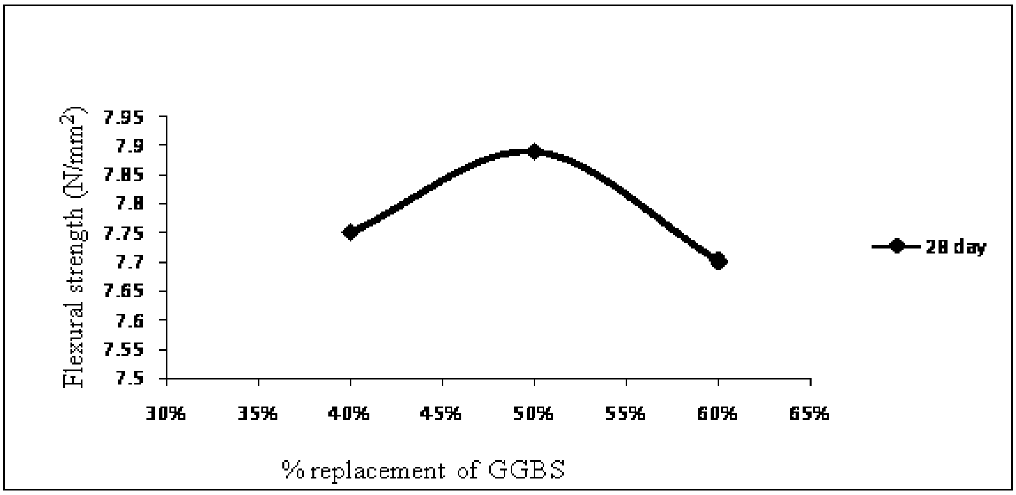

Fig4.5 28 Day flexural strength when cement replaced with GGBS

VI. RESULTS AND DISCUSSIONS

Studies were conducted to find the influence of mineral admixtures in cementitious system containing chemical admixtures and the following observations were made.

In fresh concrete, when cement was replaced with mineral admixtures, the workability of concrete has increased. When cement was replaced with fly ash the slump value was increased by 12%. Replacement of cement with GGBS, the slump value has increased with 20%. In the strength study conducted on hardened concrete, it was observed that in the three day strength, maximum strength was obtained for control mix. In the

7 day test results, 15% cement replacement with fly ash has a higher strength of more than 3.5%. When 50% cement was replaced with GGBS, an increase in strength of 12% compared to control mix was observed. In the 28 day strength it was observed that cement replaced with 15% fly ash has higher strength of more than 5% compared to that of control mix and when 50% cement replaced with GGBS the strength of ordinary concrete has increased by 7%. In the split tensile strength conducted on hardened concrete it was found that when 15% cement is replaced with fly ash there would be an increase in strength of 13% compared to control mix. When 50% cement was replaced with GGBS, the strength has increased with 11%. In the flexural strength test also, concrete with 15% cement replacement with fly ash has higher strength. When GGBS was used as the replacement material 50% cement replacement has better results.

VII. CONCLUSIONS

From the study, it is concluded that cement replaced with mineral admixtures give better workability and strength. When fly ash is used as the mineral admixture, the mix prepared by 15% replacement with fly ash has given higher strength. Thus cement with 15% replacement fly ash can be considered as optimum replacement for an M35 concrete mix. When GGBS was used for cement replacement, 50% cement replacement was found to be optimum replacement for an M35 mix. This gives higher strength and workability.

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