Experimental Study on Performance of Concrete by using Combination of Flyash and Ggbs as Blended Material

M .G. Kamaldeep, K. Shyam Chamberlin

Abstract: ***Cement is the most important material of the construction industry, but its manufacturing inflicts bad to the environment by emitting carbon dioxide into the atmosphere. Reduction of these emissions, while meeting the ever increasing demand for the infrastructure across the globe is a challenge for the sustainability of the industry that attracted the focus of academicians, domain experts and researchers to objectivise their work to explore the alternatives to the cement. Many alternatives have come into discussions, as result of such work by the researchers, to examine further to substantiate their use in the industry. Some of such alternatives for the partial replacement of cement are Fly-ash, GGBS, Rice Husk, Silica Fumes, Meta Kaolin etc., and many of them are industrial by-products. This project deals with replacement of cement content in concrete with the combination of fly-ash and GGBS as blending material with the limiting percentages individually. As recommended by the respective IS standards, 25-55% of Fly ash is replaced with cement. The optimum value is noted and considered as constant throughout. In this paper, Fly ash (obtained) content is kept constant and different percentages (up to a maximum of 60%) of GGBS content is tried to conclude and report the findings on variations of concrete properties like flexural strength, compressive strength, Load vs. Displacement for different combination of varied GGBS content for a constant Fly ash content. The load carrying capacity is noted comparatively for Conventional and Composite concrete.***

Index Terms: Fly ash, GGBS, Flexural Strength, Load carrying capacity.

I. INTRODUCTION

Concrete, which acts as the most important used material in and around the constructional world. The basic natural, cheap and easily available ingredients of concrete are cement, sand, aggregates and water. Due to the enhancement of demand of concrete, a new-fangled methods and materials were made on the board for the production of concrete. Cement stands second after water for the most used constructional material in the world. But it creates the environmental problems by releasing CO2 directly into the atmosphere and which may be one of the reasons for depletion of Ozone layer. Fly ash is a fine grey powder which contains spherical particles that are produced from the coal industries. It increases the workability of fresh concrete. GGBS is known as the Ground Granulated Blast Furnace Slag. It is the by-product of pig iron which was from the iron industries. With the combination of ordinary Portland cement and other pozzolonic materials, it is used to make durable concrete structures.

Compressive strength increases when cement replaced with Fly Ash. As Fly Ash percentage increases, compressive and split strength increases. It also increases the final compressive strength. Longer hydration time results in the slowing down the strength which was gained and decreases the short term strength [1]. The strength increases with increasing amount of fly ash up to an optimum value, beyond which strength starts to decrease with further addition of fly ash. The optimum value of fly ash for the four test groups is about 40% of cement [2]. Making concrete with the combination of Fly ash and GGBS and cement with different percentages gives good results compared to control concrete. So the best way to use these materials is in combination. In low volume replacement Mix M2 (20%Fly ash, 20%GGBS and 60% OPC) gives good workability and strength. In high volume replacement Mix M7 (40%Fly ash, 20%GGBS and 40%OPC) gives good workability and strength. The study reveals that low volume replacement mix M2 (20% Fly ash, 20% GGBS and 60% OPC) is giving good result than high volume replacement Mix M7 (40%Flyash, 20% GGBS and 40% OPC) at all ages of curing [3]. The objective is to find out the effect of Fly ash and GGBS based binder on its physical properties and unbound compressive strength of the soil. When the increase in the binder content, there will be increase in the maximum dry density. As the longer was the curing period, there will be increase in the unconfined compressive strength of soil. The strength significantly increases with the addition of small quantity of lime (1%) [4]. The compressive strength of concrete continues to increase with the increase in the curing period and maximum compressive strength is obtained when 30% of the fine aggregate is replaced with foundry sand. Compared to control mixture, the tensile strength increases with the replacement of sand by 10% of GGBS [5]. Due to the replacement of 40% of cement with GGBS, the optimum compressive strength of high performance of concrete is obtained. As the percentage of GGBS increases, the compressive, split tensile, flexural and pull out strengths are increased [6]. The higher ratios of replacement of Fly ash i.e., greater than 40% can be treated and considered as a good adaptive alternative material for the manufacturing construction materials. The physical and mechanical properties of Fly ash were improved by the increasing offering temperature [7]. Cement is replaced by GGBS for

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M. G. Kamaldeep, Department of Civil Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Guntur District , Andhra Pradesh ,India. India.

K. Shyam Chamberlin , Department of Civil Engineering,, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Guntur District, Andhra Pradesh, India.

about 40%. The compressive strength for 7 days and 28 days reaches the maximum strength of 45.44 N/mm^2. Similarly 30% of replacement of cement by GGBS attains the strength of 44 N/mm^2. Fly ash replacement of 40% attains the compressive strength of 27.7 N/mm2 [8]. GGBS content increases the flow rate of the concrete melange. So, GGBS will not absorb the water content whereas Fly ash absorbs the water. Up to 70% replacement of Fly ash with GGBS gives high compressive strength, flexural strength and split tensile strength [9].

II. RESEARCH SIGNIFICANCE

The following were the main objective of this paper. The maximum fly ash that can be used is 15-35 % [10]. High amount of Fly ash will be replaced with cement by 25%, 35%, 45%, and 55%. The maximum compressive strength for the corresponding Fly ash percentages will be noted for 7days, 28days and 60 days. The maximum percentage will be noted and considered as constant Fly ash value. The maximum GGBS content which can be used is 25-65 % [11]. The percentages of GGBS (25%, 35%, 45%, 55%, 60%) will be replaced from the total amount of cement and fly ash (which was obtained as constant). The maximum compressive strength of all the above corresponding GGBS percentages will be obtained (for 7, 28, 60 days) and considered as the constant GGBS value. Finally constant percentages of Fly ash and GGBS will be obtained and the rest is considered as cement percentage.

III. MATERIALS USED

The concrete mix was designed as per code [12] .It was prepared by using the following materials:

A. Cement

The commercially available Ordinary Portland cement of grade-53 was used in this work which was having the specific gravity of 3.14.

B. Fly ash

Fly ash is available in dry powder form and is procured from Vijayawada Thermal Power Station, Vijayawada, Andhra Pradesh. It was the residues from the combustion of coal collected by mechanical or electrostatic precipitators from the flue gases of thermal power plants. The maximum Fly ash content that can be used is 15-35 % [10].

C. GGBS

GGBS is known as Ground Granulated Blast Furnace slag. Use of GGBS significantly reduces the risk of damages caused by Alkali Silica reaction and reinforcement corrosion. The maximum GGBS content which can be used is 25-65 % [11].

D. Fine Aggregate

Fine aggregates used were of reddish in colour which was obtained from the local surrounding Slag. It is the by-product of the pig iron from the iron industry. Use of GGBS significantly reduces the risk of damages caused by Alkali Silica reaction and reinforcement corrosion. The maximum GGBS content which can be used is 25-65 % [11].

E. Coarse Aggregate

The coarse aggregates used were of sizes 10mm and 20mm which were obtained from the surrounding areas of Vijayawada. It was having the specific gravity of 2.8.

F. Water

Potable water which was available near the laboratory is used for mixing and curing of concrete.

G. Super Plasticizers

Super plasticizer which was used in this project is MYK PC-20.

IV. CONCRETE MIX DESIGN

Mix design is made for M40 concrete accordance with the Indian Standard Recommended Method as shown in Table I, Table II [12].

V. CASTING AND CURING OF TEST SPECIMENS

After the mixing of concrete, the specimen mix is poured into the cube dimension of 150 mm × 150 mm × 150 mm and the compressive strength values were obtained. Finally the obtained mix proportion was 45% of GGBS, 35% of Fly ash and 20% of cement of the consideredM40 mix design. The proportion was mixed accordingly and poured into the beam of dimension 220 mm × 300 mm × 150 mm. In this work, different mixes were done according to the considered percentage of replacement of Fly ash and GGBS with cement.

After 1 days of casting, the moulded cubes as shown in Fig. 1 are to be demould and then placed in the water which is having normal room temperature. The compressive strength test was to be done after 7 days, 28 days and 60 days of curing.

Fig. 1: Cube specimens

The experimental results are compared with partial replacement of Fly ash with Cement and the other mix by Fly ash and GGBS with Cement.

TABLE I : Compressive strength results for partially replaced Fly ash with Cement mix

MIX	FLY ASH %	CEMENT %	QUANTITY (Kg/m^3)						AVG. COMPRESSIVE STRENGTH
			CEMENT	FLY ASH	C.A.	F.A.	WATER	SUPER PLASTICIZER	
M1	0	100	400	-	1332	674	140	2.40	29.8
M2	25	75	300	100	1307	661	140	2.40	26
M3	35	65	260	140	1298	656	140	2.40	31.2
M4	45	55	220	180	1230	622	140	2.40	24.6
M5	55	45	180	220	1278	646	140	2.40	21.8

TABLE II : Compressive strength results for partially replaced Fly ash and GGBS with Cement mix

MIX	FLY ASH %	GGBS %	CEMENT %	QUANTITY (Kg/m^3)							AVG. COMPRESSIVE STRENGTH (N/mm^2)
				CEMENT	FLY ASH	GGBS	C.A	F.A	WATER	SUPER PLASTICIZER	
M1	0	0	100	400	-	-	1332	674	140	2.40	29.8
M2	35	25	40	160	140	100	1292	653	140	2.40	30
M3	35	35	30	120	140	140	1290	645	140	2.40	25.11
M4	35	45	20	80	140	180	1288	644	140	2.40	33.55
M5	35	55	10	40	140	220	1287	643	140	2.40	18.13
M6	35	60	05	20	140	240	1285	642	140	2.40	16.35

Fig. 2: Beam specimen

VI. TESTING OF SPECIMENS

A. Workability Test

By using the conventional slump test, the workability of the fresh concrete was determined. Before the casting of concrete was done into the moulds, the slump value was taken with the slump cone test.

B. Compressive Strength Test

The compressive strength of cubes for the mix of M40 concrete was done by the compressive strength test. Specimens are: Fly ash as partial replacement of Cement and Fly ash, GGBS as partial replacement of cement were tested in order to find out its compressive strength.

C. Flexural Strength Test

Flexural strength test was done to the beam specimen of dimension 2200 mm × 300 mm × 150 mm. The mix for the beam was done with M40 concrete. The test considered and made for this beam was two point load test.

VII. RESULTS AND DISCUSSIONS

A. Workability

It is observed that the slump value with the mix of Fly ash and cement decreases with the increase of the Fly ash content. It concludes that Fly ash absorbs the water content. So the increase in Fly ash content will decrease the slump value and wise versa. Whereas GGBS will not absorb the water content and which results in the increase of the slump value with the increase of GGBS content in the mixture.

B. Compressive Strength Test of Conventional Concrete

The following Fig. 3 shows the results of Compressive Strength vs. Number of days (7 days, 28 days and 60 days).

C. Compressive Strength Test of Composite Concrete

The following Fig. 4, Fig. 5, Fig. 6 shows Compressive strength vs. % of Fly ash for 7 days, 28 days, 60days.

From the below Fig. 4, Fig. 5, Fig. 6 compressive strength test, the maximum compressive strength of Fly ash obtained was 35%. So Fly ash percentage was considered constant as 35% through out in the mix of Fly ash + GGBS + cement.

The below Fig. 7, Fig. 8, Fig. 9 shows Compressive strength vs % of GGBS for 7 days,28 days,60days.

From the below compressive strength tests, the maximum compressive strength obtained for GGBS is 45%. So GGBS percentage was considered constant as 45% through out for the mix of Fly ash, GGBS and Cement.

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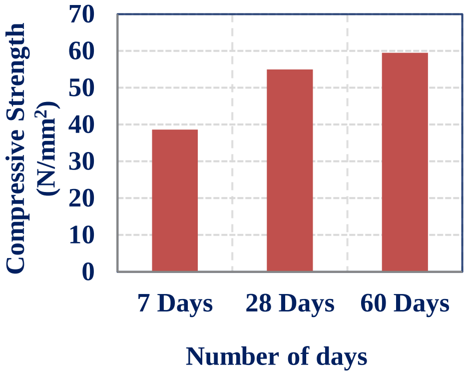

Fig. 3: Compressive Strength of Conventional Concrete

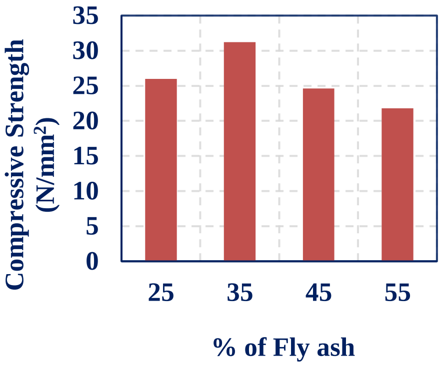

Fig. 4: 7 Days compressive strength for Fly ash

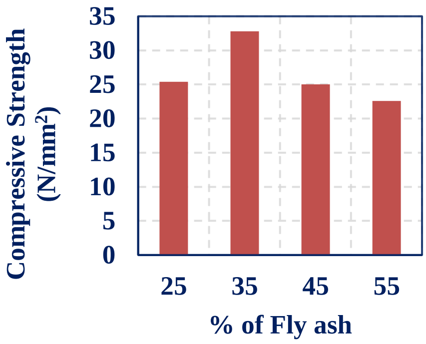

Fig. 5: 28 Days compressive strength for Fly ash

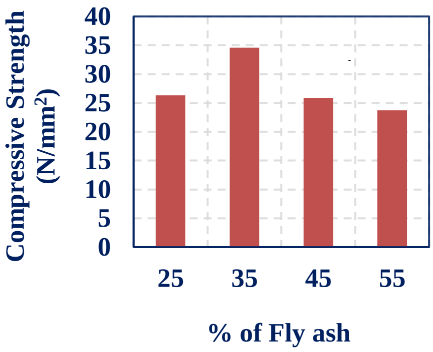

Fig. 6: 60 Days compressive strength for Fly ash

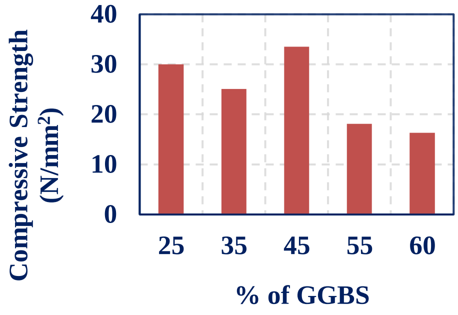

Fig. 7: 7 Days compressive strength for GGBS

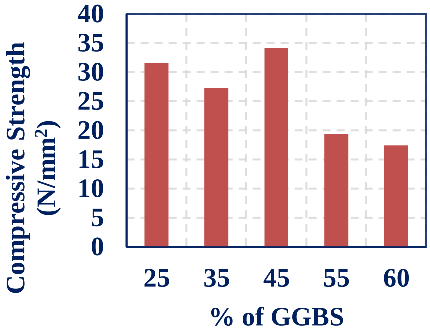

Fig. 8: 28 Days compressive strength for GGBS

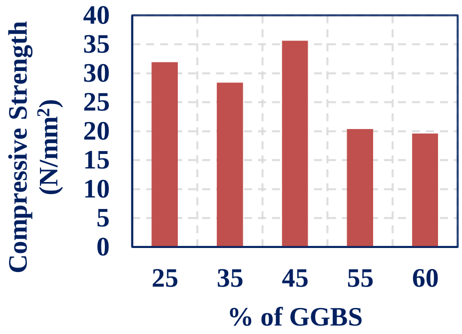

Fig. 9: 60 Days compressive strength for GGBS

D. Flexural Strength Of Beam With Conventional Concrete (M40)

Flexural Strength of beam for Conventional Concrete was tested after 28 days of curing. It attains maximum flexural strength at the load of 151.5 KN by using Load vs. deflection graph as shown in Fig. 10.

E. Flexural Strength of Beam with Composite Concrete

35% of Fly ash, 45% of GGBS and 20% of Cement were the corresponding mix of the concrete. Flexural strength of the beam was calculated after 28 days of curing by plotting a graph between Load vs. Deflection are as shown in Fig. 11. It attains maximum strength at the load of 146.7 KN.

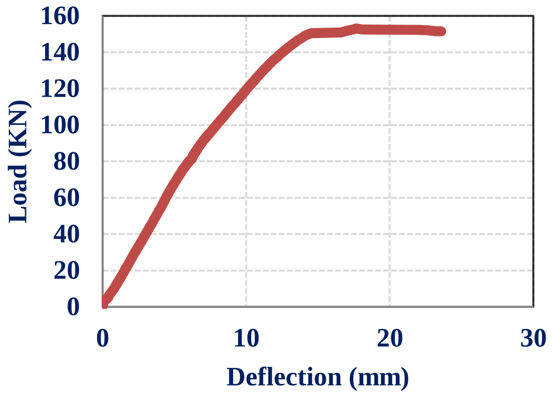

Fig. 10: Flexural strength of beam with Conventional Concrete

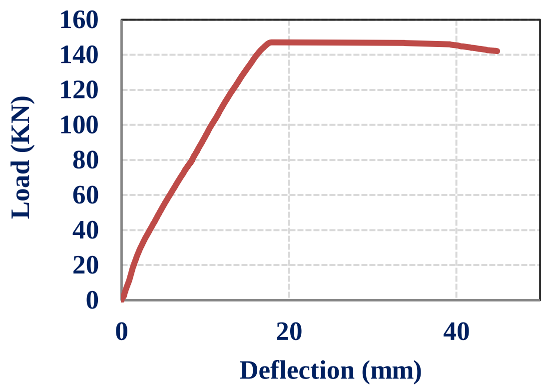

Fig. 11: Flexural strength of beam with Composite Concrete

VIII. CONCLUSIONS

The specimens of M40 by partially replacing Fly ash and Fly ash, GGBS, to cement were cast and are tested for Compressive strength at 7, 28, 60 Days. Flexural strength values were also obtained at 28 days. The obtained results were compared with conventional concrete.

1. The slump value decreases with the increase in the percentage of replacement of Fly ash in the cement.
2. GGBS doesn't absorb the water content and hence there will be the increase in the flow rate of the specimen with increase in the added GGBS.
3. Due to the higher smoothness and fineness of the slag, the slump value will be increases with increase in the volume of paste.
4. The water permeability character of the structure decreases with the percentage increase of GGBS.
5. The maximum compressive strength of cubes containing the mixture of Fly ash and cement is obtained for 35% of Fly ash content. Its compressive strength is 31.2 N/mm for 28 days and 34.6 N/mm.
6. The maximum compressive strength of cubes containing the mixture of Fly ash, GGBS and cement is obtained for 45% of the GGBS content. Its compressive strength is 33.55 N/mm for 7 days, 34.2 N/mm for 28 days and 35.6 N/mm for 60 days.
7. For 7 days curing of mixture of Fly ash and cement, the compressive strengths of 25%, 35%, 45%, 55% are 26 N/mm, 31.2 N/mm, 24.6 N/mm, and 21.8 N/mm.
8. For 28 days curing of mixture of Fly ash and cement, the compressive strengths of 25%, 35%, 45%, 55% are 25.4 N/mm, 32.8 N/mm, 25.02 N/mm, and 22.6 N/mm.
9. For 60 days curing of mixture of Fly ash and cement, the compressive strengths of 25%, 35%, 45%, 55% are 26.3 N/mm, 34.6 N/mm, 25.9 N/mm, and 23.7 N/mm.
10. For 7 days curing of mixture of Fly ash, GGBS and cement, the compressive strengths of 25%, 35%, 45%, 55%, 60% are 30 N/mm, 25.11 N/mm, 33.55 N/mm, 18.13 N/mm, and 16.35 N/mm.
11. For 28 days curing of mixture of Fly ash, GGBS and cement, the compressive strengths of 25%, 35%, 45%, 55%, 60% are 31.6 N/mm, 27.3 N/mm, 34.2 N/mm, 19.41 N/mm, and 17.43 N/mm.
12. For 60 days curing of mixture of Fly ash, GGBS and cement, the compressive strengths of 25%, 35%, 45%, 55%, 60% are 31.9 N/mm, 28.36 N/mm, 35.6 N/mm, 20.36 N/mm, and 19.60 N/mm.
13. Finally from the above values, the mix of the beam was considered as 35% of Fly ash, 45% of GGBS and 20% of Cement.
14. Comparatively the Flexural strength of Conventional concrete beam (100% Cement) was 4.8 kN more than the beam with the mix of Fly ash (35%), GGBS (45%), Cement (20%) which can be considered as a minute difference.
15. So we can consider the combination of high volume of Fly ash and GGBS as blended materials in order to control the Environmental effect, chemical attacks, and cost of the concrete.

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AUTHORS PROFILE

M. G. Kamaldeep is doing his Masters of technology in Structural Engineering at Koneru Lakshmaiah Education Foundation (Deemed to be University), Vaddeswaram, Guntur Dt., Andhra Pradesh, India. He completed his graduation in the stream of Civil Engineering from Sathyabama University, Chennai. He actively participated in the workshops in and around the University.

K. Shyam Chamberlin is working as Associate Professor in Department of Civil Engineering at Koneru Lakshmaiah Education Foundation (Deemed to be University), Vaddeswaram, Guntur District, Andhra Pradesh, India. He has completed Master of Technology in Geotechnical Engineering from JNTU Kakinada. His research interests include Ground Improvement Techniques. He has published 32 research papers in international journals and guided 20 numbers of Masters and 10 numbers of Bachelor's dissertation work.

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