MECHANICAL PROPERTIES OF HIGH PERFORMANCE CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH GGBS AND FLYASH

G.KOTAIAH, M.Tech, Structural Engineering, Amara Institute of Engineering and Technology, Satuluru, Guntur, A.P.
Email:kotaiah3214@gmail.com

M.NAGESWARA RAO, HOD of CE, Structural Engineering, Amara Institute of Engineering and Technology, Satuluru, Guntur, A.P.

ABSTRACT

The use of high performance concrete offers advantages in durability, ease of placement, and reduced creep and shrinkage, as well as increased compressive, shear and tensile strength. Offsetting these advantages are potentially reduced ductility and fire resistance, and increased unit cost. The present paper focuses on the investigating characteristics of M60 grade concrete with partial replacement of cement with Ground Granulated Blast Furnace Slag (GGBS) and sand with the Fly ash(crusher dust). The cubes and cylinders are tested for compressive strengths and split tensile strength. It is found that by the partial replacements of cement with GGBS and the sand with Fly ash helped in improving the strength of the concrete substantially compared to nominal mix concrete. The compressive strength is studied at 7days, 28 days, 90 days. Water reducing admixtures are used to increase the workability characteristics. For all levels of cement replacement concrete achieved superior performance in the fresh and mechanical tests should be compared with the reference mixture.

Keywords--*Hpc, Ggbs, Fly ash, Compressive strength, Split tensile strength.*

INTRODUCTION

Concrete is the key material used in various types of construction, from the flooring f a hut to a multi-storied high rise structures form pathway to airport runway, from an underground tunnel and deep sea platform to high-rise chimneys and TV Towers. In the last millennium concrete has demanding requirements both in terms of technical performance and economy while greatly varying from architectural masterpiece to the simplest of utilities. It is the most widely used construction material of construction which is as versatile as concrete.

Concrete is one of the versatile heterogeneous materials, civil engineering has ever known. With the advent of concrete civil engineering has touched highest peak of technology. Concrete is a material with which any shape can be cast and with equal strength or rather more strength than the conventional building stones. It is the material of choice where strength, permanence, durability, permeability, fire resistance and abrasion resistance are required.

Cement concrete is one of the seemingly simple but actually complex materials. The properties of concrete mainly depend on the constituents used in concrete making. The main important material used in making concrete is cement, sand, crushed stone and water. Even though the manufacturer guarantees the quality of cement, it is difficult to produce a fault proof concrete. It is because of the fact that the building material is concrete and not only cement. The properties of sand, crushed stone and water, if not used as specified, cause considerable trouble in concrete. In addition to this workmanship, quality control and methods of placing also plays the leading role on the properties of concrete.

LITERATURE REVIEW

The term fly ash was first used in the electrical power industry 1930. The first comprehensive data of its use in concrete, in North America, was reported the major practical application in 1937 by DEVIS et al. The United States bureau of data reported the major practical application in 1948, with the publication on the use of fly ash in the construction of Hungary Horse dam.

Worldwide acceptance of fly ash slowly followed these early efforts, but the interest has been particularly noticeable in the wake of the rapid increase in the energy costs that occurred during the 1970's and then a number of investigations were carried out both within and outside of this country on flyash concrete. Conservation of natural resources is the need of the hour throughout the world.

Steps are to be adopted in this direction which includes minimisation of production of energy consuming materials & bulk utilization of industrial by-products, thereby making a major contribution towards solving the global warming problem and also by bringing down the levels of environmental pollution. It is found that use of high volumes of fly ash, is the most effective and economical way to improve the durability of concrete.

CLASSIFICATION OF FLY ASH

ASTM-C 618-93 categories natural pozzollanas into the following categories.

Class N fly ash: raw or calcined natural pozzollanas such as some diatomaceous earths, opalinechert and shale, stuffs volcanic ashes and pumic comes in this category. Calcinedkaoline clay and laterite shale also fall in this category of pozzollanas.

Class F fly ash: fly ash normally produced from burning anthrdoete or bituminous coal falls in this category. This class of fly ash exhibits pozzollanic property but rarely if any, self-hardening property.

Class C fly ash: fly ash normally produced from liginite or sub-bituminous coal is the only material included in this category. This class of fly ash has both pozzollanic and varying degree of self cementitious properties.

PROPORTIONING OF FLYASH CONCRETES

Using of Flyash in concrete has to meet one or more of the following objectives.

- Reduction in cement content,
- Reduced heat of hydration,
- Improved workability and
- Gaining levels of strength in concrete beyond 90 days of testing.

Flyash is introduced into concrete by one of the following methods.

- Cement containing Flyash may be used in place of OPC.
- Flyash is introduced as an additional component at the time of mixing.

The first method is simple and problems of mixing additional materials are not there, there by uniform control is assured. The proportions of Flyash and Cement are predetermined, and mix proportion is limited.

The second method allows for more use of Flyash as a component of concrete. Flyash plays many roles such as, in freshly mixed concrete, it acts as a fine aggregate and also reduces water cement ratio in hardened state, because of its pozzolanic nature, it becomes a part of the cementitious matrix and influences the strength and durability.

The assumptions made in selecting an approach to mix proportioning Flyash concrete are

(i) It reduces the strength of concrete at early ages.

(ii) For same workability, concrete containing Flyash requires less water than concrete containing ordinary Portland cement.

The basic approaches that are generally used for mix proportioning are

- Partial Replacement of cement,
- Addition of Flyash as fine aggregates and
- Partial replacement of cement, fine aggregate and water

In the first approach, there is direct replacement of a percentage of cement by Flyash. Replacement of cement by Flyash (either by volume or by mass basis), results in lower compressive and flexural strength up to 90 days of moist curing and develops greater strengths beyond 180 days of curing.

At early ages, Flyash exhibits very little cementing effects and acts as a fine aggregate, but at later ages cementing activity becomes apparent and its contribution in the development of strength is observed.

In the second approach, Flyash is added to the mix without a reduction in the quantity of cement used. The cementitious content of the concrete is enhanced for long periods of moist curing.

In the third approach, proportioning of Flyash concrete requires a part of cement to be replaced by an excess mass of Flyash with necessary adjustments in fine aggregate and water content.

APPLICATION OF FLYASH

Flyash is highly recommended for mass concrete applications, i.e. large mat foundations, dams etc. The Hungry Horse dam, Conyan ferry dam and the Wilson dam, Hart well dam and sultan dam in USA, the Lednock dam in UK and sudagin dam in Japan are few examples abroad.

LUI center in Vancouver successfully used 50% Flyash for all structural elements. In India, some portions of Rihand dam in UP and some part of barrages in Bihar are some examples.

Flyash can be used for the following

1. Filling of mines,
2. Replacement of low lying waste land and refuse dumps,
3. Replacement of cement mortar,
4. Air pollution control,
5. Production of ready mix Flyash concrete,
6. Laying of roads and construction of embankments,
7. Stabilizing soil for road construction using lime-Flyash mixture
8. Construction of rigid pavements using cement-Flyash concrete,
9. Production of lime-Flyash cellular concrete,
10. Production of precast Flyash concrete building units,
11. Production of sintered Flyash light weight aggregate and concrete and
12. Making of lean-cement Flyash concrete.

EXPERIMENTAL INVESTIGATION

An experimental study is conducted to find out the compressive strength of concrete at 7daysand 28days. In concrete the partial replacement of cement by Flyash and GGBS are varied from (4+16)%,(8+12)%,(12+8)% and (16+4)% by weight.

- M60 grade of concrete is designed according to DOE method.
- The effect of partial replacement of cement by Flyash and GGBS(% by weight) on strength and workability of concrete are investigated.

MATERIALS:

Ordinary Portland cement 53 grade brand conforming to I.S.I standard is used in the present investigation. The cement is tested for its various properties as per IS code. The results on cement are shown in table below.

PHYSICAL PROPERTIES OF PORTLAND CEMENT 53 GRADE

S .No	PROPERTY	TEST RESULTS
1.	Normal consistency	28.66%
2.	Specific gravity	2.99
3.	Initial setting time Final setting time	30 min 160 min
4.	Soundness (expansion) lechatlier Method	2 min
5.	Fineness of cement	3050
6.	Compressive strength of cement mortar cubes a) 7 days b) 28 days	33 N/mm² 52 N/mm²

Compaction Factor test for measuring the Workability:

Compaction factor measures the workability in an indirect manner by determining the degree of compaction achieved by a standard amount of work done by allowing the concrete to fall through a standard height.

The sample of concrete to be tested is placed in the upper hopper up to the brim. The trap door is opened so that the concrete falls in the lower hopper. Then the trap door of the lower hopper is opened and the concrete is allowed to fall in to the cylinder. I n the case of a dry mix, it is likely that the concrete may not fall on opening trap door.

In such a case a slight pocking by the rod may be required to set the concrete in motion. The excess concrete remaining top level of the cylinder is then cut off with the help of plain blades supplied with the apparatus. The surface of the cylinder is wiped clean and weighed to the nearest 10gms. This weight is known as "weight of partially compacted concrete".

The cylinder is emptied and then refilled with the concrete from the sample in layers of each about 5cms depth. The layers are heavily rammed or preferably vibrated so as to obtain full compaction. The top surface of the fully compacted concrete is then carefully struck off and the cylinder is weighed to the nearest 10gms. The weight is known of fully compacted concrete.

Compaction Factor:
Weight of partially compacted concrete/ Weight of fully compacted concrete. The compaction factor is calculated for various percentages of Flyash concretes and various ordinary concretes keeping the water cement ratio constant.

Casting of Specimens:
For casting the cube, standard C.I metal moulds of size 100 x 100 x 100mm have been used. The moulds have been cleaned of dust particles and applied with mineral oil on all sides, before concrete is poured into the mould. Thoroughly mixed concrete is filled in to mould.

Curing the specimens:
After casting the moulded specimens are stored in the laboratory free from vibration, in moist air and at room temperature for 24 hours. After this period, the specimen are removed from the moulds and immediately submerged in the clean fresh water of curing tank. The curing water is renewed after every 5 days. The specimens are cured for 7, 28 and 60 days in present work.

Testing of Cube Specimens
The cube specimens cured as explained above are tested as per standard procedure after removal from the curing tank and allowed to dry under shade.

The cube specimens tested under digital compression testing machine of 2000 KN capacity. 1. Compressive strength test
2. Split tensile test.
3. Flexural strength

RESULTS AND DISCUSSIONS
36 Cubes, 24 prisms and 24 cylinders are casted with M60 grade concrete. Twenty per cent of cement is replaced by a combination of flyash and GGBS in different proportions. Compressive strength of cube specimen at 7 days and 28days, flexural strength of prisms at 7 days 28 days and split tensile strength of cylinder at 7 days and 28days are noted below.

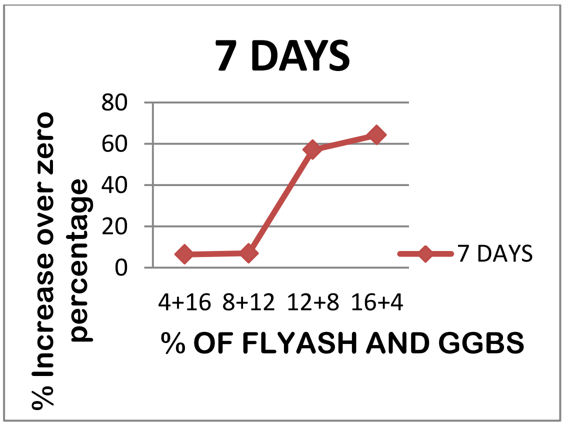
Variation of Split Tensile Strength at 7 Days with various % of Flyash and GGBS

S.No	% of Flyash	% of GGBS	7 Days Split Tensile Strength in (N/mm²)		
			Strength	% increase over 0%	% increase over preceding
1	0	0	3.24	--	--
2	4	16	3.45	6.27	6.26
3	8	12	4.01	27.61	19.00
4	12	8	4.34	32.8	3.75
5	16	4	4.60	41.125	6.89

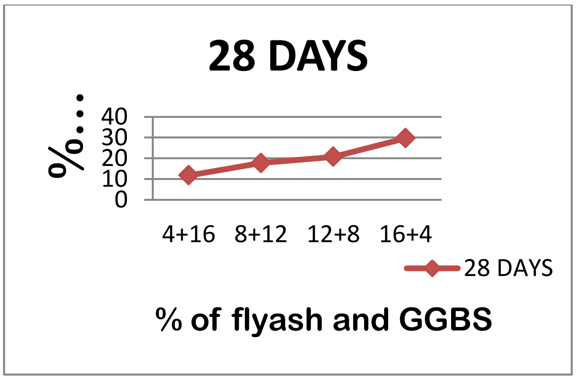
Variation of Split Tensile Strength at28 Days with various % of Flyash and GGBS

S.No	% of Flyash	% of GGBS	28 Days Split Tensile Strength in (N/mm²)		
			Strength	% increase over 0%	% increase over preceding
1	0	0	3.73	--	
2	4	16	4.68	23.05	23.09
3	8	12	4.96	30.66	6.26
4	12	8	5.29	39.46	6.69
5	16	4	5.39	41.8	1.9

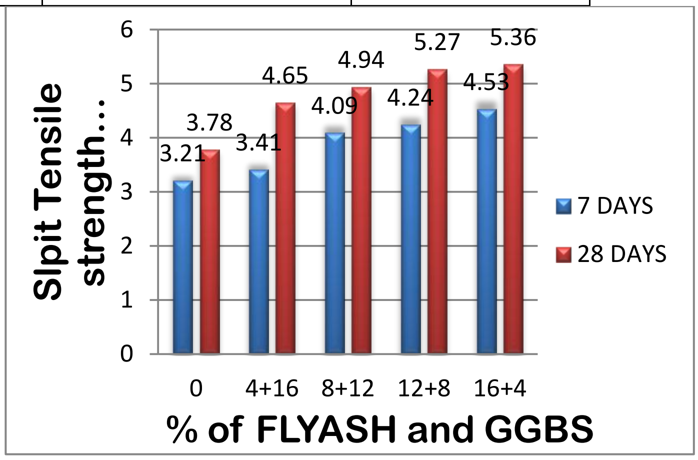
Percentage increase over 0% Vs percentage of FLYASH and GGBS at 7 days flexural strength



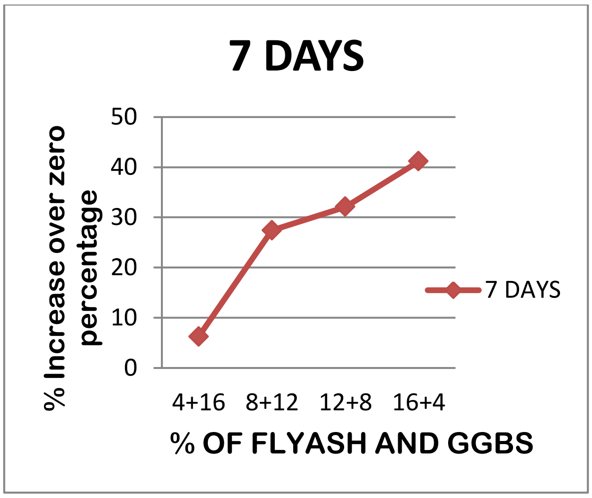
Percentage increase over 0% Vs percentage of FLYASH and GGBS at 7 days flexural strength



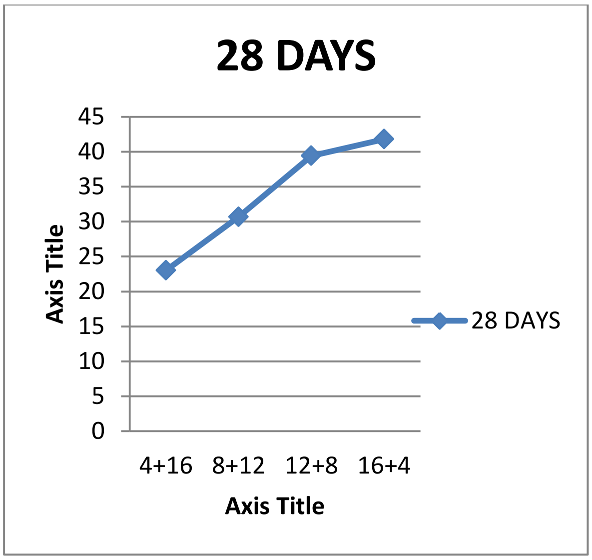
Split tensile strength N/mm^2 Vs percentage of FLYASH and GGBS at 7 days and 28 days



Percentage increase over 0% Vs percentage of FLYASH and GGBS at 7 days split tensile strength



Percentage increase over 0% Vs percentage of FLYASH and GGBS at 28 days split tensile strength



CONCLUSION

From the experimentation carried out and from the results obtained it can be concluded that

1. The compressive strength, flexural strength and split tensile strength of concrete are improved with the addition of flyash and GGBS as partial replacement to cement.
2. The compressive strength of concrete is increased by a maximum of 65.95 % at 28days with (4+16) % replacement.
3. The flexural strength of concrete is increased by a maximum of 29.64% at 28days with (4+16) % replacement.
4. The split tensile strength of concrete is increased by a maximum of 41.79% at 28 days with (4+16) % replacement.

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