STRENGTH OF HIGH VOLUME FLYASH CONCRETE WITH CURING

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Abstract— *The increase in emission of carbon dioxide is a matter of concern over decades. The toxic coal waste product like fly ash is being utilized as a binder material in construction industry. The idea of high volume fly ash concrete is used in the research area lately as it is having an immense effect on environment. It is used as a partial replacement of cement whose production leads to huge emission of carbon dioxide. The present work focuses on the strength of high volume fly ash concrete with ages. The compressive strength of different proportions of HVFA concrete at 7, 28 and 56 days and tensile strength for 56 days are analyzed. This also stresses on the weight reduction in each mix in comparison with ordinary concrete. The percentage replacement of cement by fly ash is 40%, 50% and 60%. The effect of high amount of superplastisizer and reduced amount of water in this concrete is studied.*

Keywords—HVFA concrete, cement, compressive strength, tensile strength

1. INTRODUCTION

The green house effect is a natural procedure leading to the global warming. But the green houses gases like carbon dioxide is being emitted due to lots of manmade activities. One of the key material in construction industry being cement which is the product of crushing and heating of limestone liberating a large amount of carbon dioxide. Hazardous waste materials are also produced in different fields especially in the excavation and mining of coals, oils etc, whose disposal is a great threat to the environment. In the recent decades researches are being carried out in green concrete which is a technology whose main aim is to reduce the environmental effects of concrete. Later on different waste materials were incorporated in cement and their effects were studied and one the successful products being fly ash. A proportion of cement is replaced by fly ash being a byproduct in coal combustion. Fly ash chemically consists of calcium, silica, alumina and iron. The fly ash has lot of advantages over cement such as corrosion resistant, sulphate and acid resistant, great durability and workability and also being a waste product that is difficult to be disposed is economical as well as environmental friendly. The fly ash reduces permeability in the concrete since it is pozzolan. Hence it increases the strength and durability of the product. Depending on the amount of lime they are mainly classified into class F and class C. When the amount of lime is less than 20%, it has lesser binding properties and requires a cementing agent for cementitious compounds. This is class F. Whereas class C fly ash has self cementing properties with amount of lime more than 20%. It gains strength over time. Different mix designs produces a variety of strength ranges. The use of superplastizer is increased to get good workability and also to keep the water cement ratio at a reduced level.

HVFA concrete is one of the economical methods of construction where some amount of the cement is replaced by the fly ash. 35% of replacement of cement by fly ash is recommended by IS 456;2000. When replacement is more than that it is high volume fly ash concrete. The outlook of people has changed and HVFA concrete is being used in pavements and also for marine structures nowadays as it is ecofriendly as well as economical. The strength of fly ash increases with curing which is acknowledged in the present work from the strengths of high volume fly ash concrete at 7 days , 28 days and 56 days of curing.

2. OBJECTIVES OF STUDY

- To analyze the strength of different proportions of fly ash in concrete.
- To study the effect of curing period in HVFA concrete.
- To determine the reduction in the weight of HVFA concrete at different proportions.
- To compare the strength and weakness of HVFA concrete with normal concrete.

3. LITERATURE REVIEW

T. Ch. Madhavi , L. Swamy Raju and Deepak Mathur (2014) studied durabilty and strength properties of high volume fly ash concrete. The behavior of concrete on 28days and 91 days are studied here. According to this study lower water binder ratio and proper curing is adequate for HVFA concrete. The strength gain of HVFA is in the later stages than in early stages. The properties of HVFA concrete like heat of hydration, drying shrinkage, compressive strength, tensile strength, creep strain and flexural strength are studied. It is concluded that HVFA concrete can be used in mass concreting as it is effective in temperature controlling. It is also concluded that HVFA concrete can be used for construction that requires durability such as pavements safely. This work also highlights on the shortcomings of HVFA such as extended setting time, slow development of strength etc.

A. Camoes (2014) studied durability of high-volume fly ash concrete. This work is an investigation of mechanical, workability and durability properties of HVFA concrete. Here the 60% cement is replaced by fly ash. Three different mixtures with 400kg/m^3, 500kg/m^3 and 600kg/m^3 of cementitious material for 60% HVFA concrete property comparison is done. Compressive strength, splitting-tensile

strength, capillary absorption, porosity, oxygen permeability, water permeability, rapid migration test and electrical resistivity are the tests conducted in this work. The results shows that higher the cementitious content higher will be the strength. The 28 days compressive strength of concrete with 400 kg/m^3, 500 kg/m^{3}and 600 kg/m^3 cementitious material is 33.9 MPa, 47MPa, 52.8MPa respectively. The concretes produced have an extremely high resistance against chloride penetration. For the oxygen and water permeability, the increasing of the binder content improves the concrete performance. The capillary absorption is great irrespective to the cementitious content.

Hafiz A. Alaka and Lukumon O. Oyedele (2016) studied high volume fly ash concrete: The practical impact of using superabundant dose of high range water reducer. In this paper high volume fly ash concrete of 50%, 60% and 65% replacement of cement are tested with 2%, 3% and 4% of super plasticizers in each. The water/ binder ratio is in the range of 0.28 to 0.38. Here the relationship between superabundant dose of super plasticizer and HVFA concrete properties is investigated. The compressive strength, flexural strength, splitting tensile strength and abrasion resistance are studied for 7, 28, 90 and 365 days. Fly ash and high dose super plasticizer has adverse effect in concrete when abrasion resistance is concerned. The smaller amount of water and higher amount of super plasticizer lead to achieving early compressive strength. The overall split tensile strength, flexural strength is reduced with increase in fly ash.

4. MATERIALS USED

A. *Cement*

Ordinary Portland cement of 53 grades was used in this work. The physical properties of the cement are given in table I.

TABLE I. PROPERTIES OF CEMENT

Physical properties	**Results**
Fineness	2.34
Standard consistency	34%
Initial setting time	40 min
Specific gravity	3.2
Soundness	1mm
Compressive strength of cement For 7 days	49.49MPa

B. *Coarse aggregate*

The coarse aggregates used are crushed stone those retaining in 4.75mm sieve. The maximum size of the aggregate used is 20mm.

C. *Fine aggregate*

M sand or manufactured sand is used in this thesis. The aggregate used are those passing through 4.75mm sieve. The tests are conducted according to IS 2386;1963. From gradation curve it was found that the fine aggregate is of zone 2.The obtained values are given in table II.

TABLE II. PROPERTIES OF AGGREGATES

Physical properties	**Results**	
	Coarse Aggregate	*Fine aggregate*
Bulk density	1.65	1.82
Specific gravity	2.78	2.68
Void ratio	0.76	0.47
Fineness modulus	8.105	3.22
Uniformity coefficient	1.75	5.55
Coefficient of curvature	0.822	0.68

D. *Fly ash*

The flyash used for this work is from Kunnamkulam in Thrissur district. The flyash used here belongs to class C category and its physical properties are given in the table III.

TABLE III. PROPERTIES OF FLY ASH

Physical properties	**Results**
Fly ash density	1480 kg/m^3
Specific gravity	2.7
Water absorption	1.55 %
Fineness	15%
Water to binding ratio	0.35%

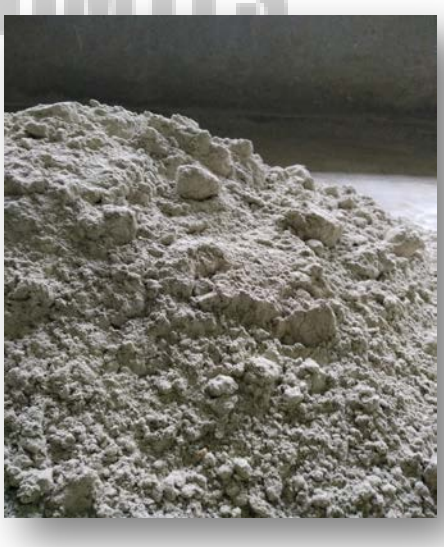

Fig. 1 Fly ash

E. *Superplasticizer*

In HVFA concrete the water to Cementitious material ratio is kept below 0.3 and so usage of superplasticizer is inevitable. CERA PLAST BLOCK IV , an admixture that helps to increase the workability has being used here. It is chemically Polycarboxylate (Ether) with a specific gravity of 1.11.

F. Water

In the concrete mix portable water that is free from oils and other impurities is used. The water used has no acidic or alkaline content in it.

5. METHODOLOGY

- The physical properties of materials used in the thesis such as cement, aggregates, fly ash etc are tested.
- The mix design for M40 concrete is done as per IS 10262: 2009.
- Mix designs for HVFA concrete is done for 40%, 50% and 60% replacement of cement. The mix design is done by making changes in the cementitious material of M40 concrete.
- Compressive strength of M, M1, M2 and M3 mixes are tested for 7 days, 28 days and 56 days.
- Split tensile strength of M,M1,M2 and M3 mixes are analyzed for 56 days.
- The cube of 15cm x 15cm x 15cm is weighed for each mix and the reduction in weight is observed.

6. CONCRETE MIX DESIGN

The mix design for M40 grade concrete is done according to IS 10262: 2009 and this mix is represented by letter " M" . Further in the mix the cement is replaced by fly ash. M1 represents the mix where 40 % of the cementitious material is fly ash and the rest is OPC. As per IS 10262: 2009 , in a mix containing fly ash the amount of cementitious material can be increased. In the mix M1 Cementitious material is increased by 30%. M2 represents the mix containing 50% of cementitious material as fly ash. The increase in cementitious material here is 45%. M3 represents the mix where 60% of cement in cementitious material is replaced by fly ash. The cementitious material is increased by 60%. In all the mixes the amount of water used is kept constant. But the amount of superplasticizer changes with workability.

TABLE IV. MIX DESIGN

Mix	Cement kg/ m^3	Fly ash kg/ m^3	Fine aggregate kg/ m^3	Coarse aggregate liters/ m^3	Water	Admixture liters/ m^3
M	400	-	680	1226	160	3.6
Ratio	1	-	1.7	3.06	0.4	
M1	312	208	628.5	1134	160	4.8
Ratio	1	0.67	2.02	3.63	0.30	
M2	290	290	605	1091	160	5.6
Ratio	1	1	2.08	3.76	0.275	
M3	256	384	579	1045	160	6.9
Ratio	1	1.5	2.26	4.08	0.25	

7. EXPERIMENTAL INVESTIGATION

In order to find the compressive strength of different mixes 15cm x 15cm x 15 cm mould were filled with concrete. 36 cubes were casted. Three samples for each mix were casted and cured for 7 days, 28 days and 56 days.

Fig. 2 M2 cube samples

12 cylinders were casted to find the tensile strength of the mixes after 56 days of curing. The curing was done through ponding in a large water tank. The weight of each cubes of volume 0.003375 m^3 was taken for each sample after it was cured and the surface moisture was dried out.

Fig. 3 Split tensile strength testing

8. RESULTS AND DISCUSSIONS

The compressive strength of cubes were tested after curing for 7 days. It was seen that M has highest compressive strength followed by M3. Least compressive strength is for M2 mix. The result is same for 28 days compressive strength. After 56 days of curing it was seen that M2 mix has the highest compressive strength. The other three mixes has almost same compressive strength. The compressive strength of M has not increased considerably after 28 days. But for HVFA concrete with increasing days of curing, the

compressive stresses has increased The weight of each cubes were taken and analyzed. As the amount of fly ash in the concrete increased the weight of the cube decreased to an appreciable amount. M3 has the least weight. The split tensile stress of different the design mixes were tested after 56 days of curing. Maximum tensile strength is obtained for M2 mix.

TABLE V. COMPRESSIVE STRENGTH

Sample	Average stress for 7 days (MPa)	Average stress for 28 days (MPa)	Average stress for 56 days (MPa)
M	33.77	49.96	50.36
M1	27.99	42.22	50.4
M2	25.92	40	56.29
M3	32.17	45.18	49.2

The graphical representation of compressive strengths of the mixes with ages is shown below.

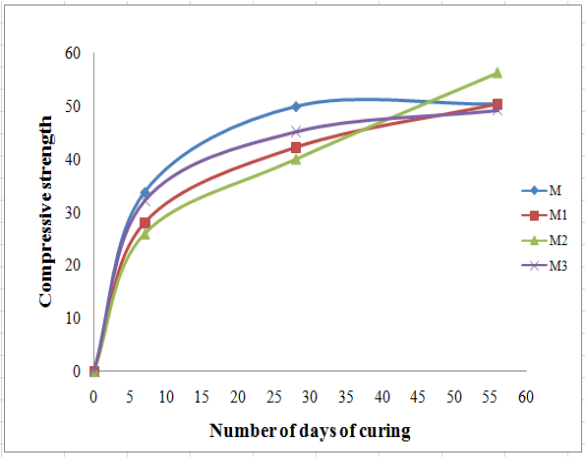

Fig. 4 Compressive strength graph

The results of tensile stresses of the design mixes for 56 days of curing are given in table VI.

TABLE VI. TENSILE STRENGTH

Sample	Average stress for 56 days (MPa)
M	5.66
M1	5
M2	5.75
M3	5.188

The graphical representation of split tensile of different mixes after 56 days of curing is shown below.

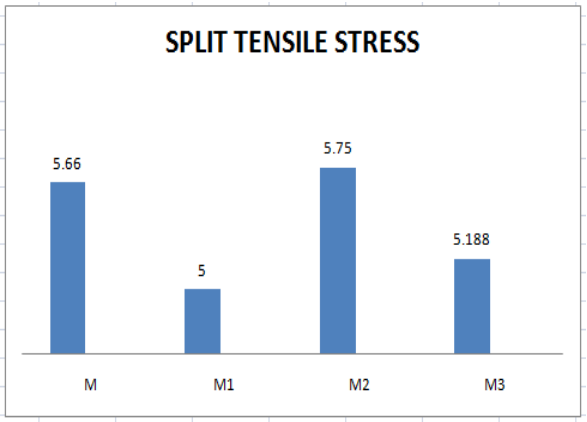

Fig.5 Split tensile strength for 56 days

The weight of different mixes is given in table VII.

TABLE VII. WEIGHT OF CONCRETE

Sample	Average weight of concrete cube samples (kg)
M	8.886
M1	8.33
M2	8.17
M3	7.98

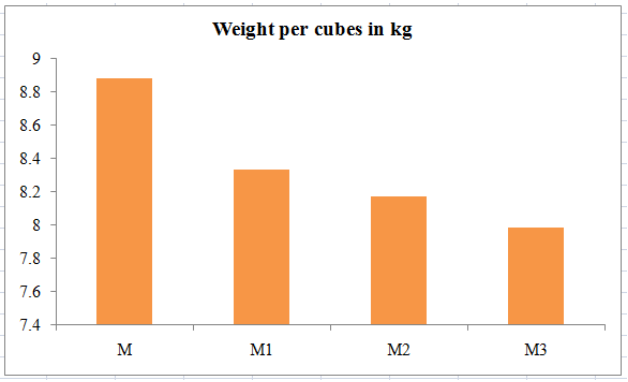

Fig. 5 Weight per cubes in kg

9. CONCLUSION

This research concludes the effect of different proportions of fly ash in the concrete. As the amount of fly ash increased the weight of concrete decreased. It is seen that initially the strength of HVFA concrete is lower than the ordinary concrete. But M3 mix which has a 60% replacement of cement has gained almost the same amount of strength as that of ordinary concrete may be because of its greater amount of cementitious material as a whole. However the M3

mix weighs 10.13 % less than the ordinary concrete. M2 mix where 50% cement is replaced, the initial strength is low. The ordinary concrete achieves 95% of its strength within 28days. But as the curing is greater for HVFA concrete the effect of fly ash has increased the compressive strength as well as tensile strength of the mix. The increase in compressive stress from 28 days to 56 days for ordinary concrete was just 0.8% but for M3 mix it was 40.7%. Also there is a decrease in weight of about 8%. This experimental work helped to understand the strength of HVFA concrete developed through various mix designs and its performance with an increased curing.

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