Investigation on alkali activated fly ash and slag concrete using neutral grade water glass as activator

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Abstract : The utilization of cement in concrete was an ancient method as well the utilization of cementitious materials in concrete not only improves mechanical properties but also improves workability and durability etc., Today urbanization expands in many folds, so that the usage of cement became more due to this the production of cement increases. The production of cement on one hand affects the environment in form of Carbon dioxide gases on other hand depreciation of raw materials like lime stone and sand etc. Globally many construction industry and researches focussed in reduction of cement content in concrete by production of new alternatives like Geo polymer concrete etc. In this investigation Alkali-Activated Fly Ash slag concrete (AAFSC) is introduced as an alternative for ordinary Portland cement concrete (OPCC). Researchers developed AAFSC with NaOH and Na_2SiO_3 as activators. In this study AAFSC produced is with neutral grade sodium silicate solution with silica modulus 2.9 (Ms).For production of AAFSC the quantity of binder content is 500kg/m3 by varying binders proportions like Fly Ash and GGBS along with solution/binder ratios varying from 0.6 to 0.7. During this experimental investigation the workability and compressive strength of AAFSC is tested.

1. Introduction

Concrete is most commonly used material in construction industry due to so many advantages like easily moulded and easily available raw materials. Globally many cities are developing along with Industrialization. Fly Ash and GGBS are the common materials used as alternative for cement as they are alumina-silicate materials. The AAFSC is one solution for replacement of cement concrete. G.Vikas, and T. D. Gunneswara Rao [1] stated that workability and setting times improved when GGBS is activated using sodium silicate solution and summarized, AASC with sodium silicate can be used to produce high performance concrete. P.Vinod kumar, and G.V.V Satyanarayana [2] resulted that compressive strength improved when cement is replaced 25% with lime powder and GGBS .There was decrease in strength with increased lime powder. Farhan and Nabeel et al [3] stated OPCC has high dry density and UPV than FAGP and AASC with same compressive strength. Tensile strength is similar for FAGP, AASC, OPCC where compressive strength was 35MPa it increased for higher compressive strengths. Fang and Guohao et al [4] studied for different proportions of slag content, solution/binder ratio, molarity of sodium hydroxide and Na_2SiO_3/ NaOH ratio. And Summarized that with increase in slag content, molarity of sodium hydroxide and decrease in alkali activator to binder ratio setting time, workability decreased where as compressive strength increased. The optimal mix was at 20% to 30 % of slag replacement, alkali activator/binder ratio of 0.4, 10M of sodium hydroxide Na_2SiO_3/NaOH between 1.5 to 2.5. Vinai and Raffaele, et al. [5] studied replacing Fly Ash and GGBS and activated with Na_2SiO_3, NaOH concluded setting time is influenced by water content where as workability and compressive strength depends on paste content for AAFSC. Water /binder plays important role to setting time and no effect on strength for water/binder more than 0.4. G. Mallikarjuna and TD Gunneswara Rao [6] investigated AAFSC for different molarities (8M, 12M, 16M) and Na_2SiO_3/ NaOH (2.5:1) activator and resulted less final setting time and more compressive strength by adding GGBS. With increase in sodium hydroxide compressive strength increased. Nath and Pradip et al [7] studied Fly Ash based GPC can be used without heat curing by adding some amount of GGBS resulting similar properties of OPC. On adding GGBS to Fly Ash it reduces workability and setting time. With increase in alkaline activator setting time increased but compressive strength decreased.

AAFSC activated with Na_2SiO_3 and NaOH are discussed in existing literatures but AAFSC activated with only Na_2SiO_3 is focused rarely. In this present study AAFSC is activated using neutral grade water glass with silica modulus 2.9 to examine setting time, workability and compressive strength with no water content added.

2. Materials

Low calcium Fly Ash and GGBS are Alkali activated materials used as binder in AAFSC and their chemical

composition noted in Table 1 and characteristics are in Table 2. Fine aggregate having grains of maximum size 2mm conforming to zone II (IS383-2016). Crushed granite of size 20mm is used as coarse aggregate. Locally collected activator used in this investigation is Sodium silicate solution (Neutral grade) of silica modulus SiO_2:Na_2O=2.9:10 having 28.92% SiO_2, 9.96% Na_2O by weight and pH 12.6.

Table 1 Chemical composition of Fly Ash and GGBS

Sample	Fly Ash(%)	GGBS(%)
SiO_2	50	32.46
Al_2O_3	28.15	14.3
Fe_2O_3	13.45	0.61
CaO	1.78	43.1
MgO	0.87	3.94
Na_2O	0.32	0.24
K_2O	0.46	0.33
SO_3	0.38	4.58
P_2O_5	0.98	0.02
TiO_2	1.54	0.55
Loss of ignition	0.64	0.09

Table 2 Characteristics of Fly Ash and GGBS

Characteristics	100%		70%	50%
	Fly ash	GGBS	Fly ash 30% GGBS	Fly ash 50% GGBS
Normal consistency (%)	27	36	28	31
Initial setting time (minutes)	30	40	35	45
Final setting time(minutes)	240	280	220	200
Specific gravity	2.54	2.96	2	2.5

Experimental Procedure

This study mainly focused on basic properties of AAFSC activating with neutral grade water glass. The normal consistency and setting times are measured using Vicat's apparatus for composition of Fly Ash, GGBS and combination of Fly and GGBS. The workability is measured and the mix design adopted is similar to that of OPCC. The mix proportions used for AAFSC mentioned in Table 3 and Table 3.1. The compressive strength for 6 batches of concrete are conducted. The cubes are casted by mixing dry aggregates for 2-3 minutes in pan mixer than activator is added and mixed for 5-7 minutes. The moulds of 100mmX100mmX100mm are casted, vibrated for 20 seconds and cured at room temperature. The cubes are demoulded after 24 hours and cured at room temperature. The compressive strength is tested as per code.

TABLE 3 Weight of contents in the mixes

Binder content(Kg/m^3)	500	500	500
Solution/binder	0.6	0.65	0.7
Fine aggregate (Kg/m^3)	765	753.3	742.5
Coarse aggregate (Kg/m^3)	935	921	907.1
Solution (Kg/m^3)	300	325	350

TABLE 3.1 Mix proportions

Binder content: liquid/binder: F.A: C.A: Liquid
1:1.53:1.87:0.6
1:1.50:1.82:0.65
1:1.45:1.814:0.7

FA = Fine aggregate, CA = Coarse aggregate

3 CONCRETE MIX

The concrete mixes used in this AAFSC are mentioned below.

Nomenclature of mixes	FLY ASH (%)	GGBS (%)	L/B Ratio
M1	70	30	0.6
M2	50	50	
M3	70	30	0.65
M4	50	50	
M5	70	30	0.7
M6	50	50	

4 Experimental Results

Workability

The workability of the six mixes are graphically represented in Fig 1. It is clear that solution/binder ratio effects the workability of AAFSC.

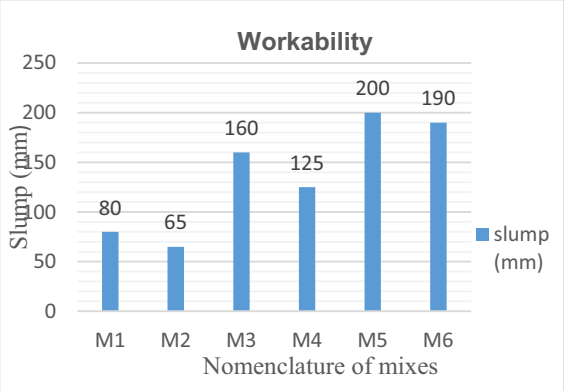

Fig 1: workability with different solution/binder and binder contents

Compression test

The compressive strength of the six mixes are calculated and presented in Fig 2. It is seen that mixes with solution/binder ratio 0.65 has High strength.

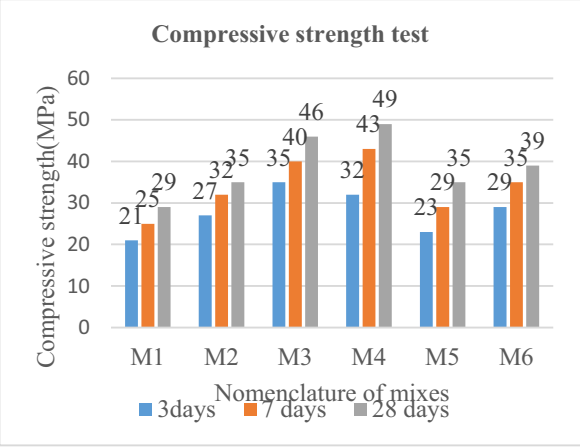

Fig 2: compressive strength for different solution/binder and binder contents

5 Conclusion

1. In this investigation, it is observed the initial setting time and final setting time of mixes increased when neutral grade water glass added to AAFSC.
2. Slump values ranges from 80-200 mm, with increased solution/binder ratio. Mixes with 70% replacement of Fly Ash have more slump compared to Mixes with 50% Fly ash replacement.
3. For binder content of 500 kg/m^3 the compressive strength for 28 days of Mix 1, 3, 5 ranged from 29 MPa-46 MPa whereas for Mix 2, 4, 6 it ranged from 35 MPa- 50 MPa .
4. Mix 4 shows highest compressive strength that is 49 MPa. In this mix the binder content replaced with 50% Fly Ash and 50% GGBS at solution/ binder 0.65.
5. Further increment of solution/binder ratio the compressive strength decreased.
6. The replacement of Fly ash and GGBS shows better performance in workability and compressive strength in AAFSC by this we can reduce environmental effects.

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