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Mechanical properties of High Strength Alkali Activated Concrete

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Abstract

The cement production which causes environmental pollution cannot be eliminated completely but its use can be reduced by utilizing other cementing materials. The production of High strength Alkali Activated Concrete (HSAAC) with fly ash consume less energy and this technology has the ability to minimize the emissions by 80%. For the present work, a High strength Alkali Activated Concrete prepared from fly ash and Ground granulated blast slag (ggbs) is used by replacing cement to produce M60 Grade concrete. The experimental program consists of two main stages. In the first stage, mix design was done to prepare M60 Grade concrete for both High strengthTraditionally vibrated concrete (HSTVC) and High strength Alkali Activated Concrete. In the second stage, strength parameters of the concretes were assessed by testing cubes (for evaluating the compressive strength), prisms (for flexural strength) and cylinders (for split tensile strength) using those two concrete types.. From this study it was observed that the High strength Traditionally Vibrated Concrete showed slightly higher compressive strength and tensile strength when compared with High strength Alkali Activated concrete with flyash and ggbs of same grade.

Keywords: High strength Alkali Activated Concrete, fly ash,ggbs, Mechanical properties

Introduction

Present day construction practice is more dependent on concrete, in which ordinary Portland cement (OPC) is the main constituent. The production of cement causes the emission of harmful pollutants such as carbon dioxide which results in environmental pollution.

High Alkaline concrete is one of the latest construction material as a substitute for normal cement concrete as it completely avoid the usage of OPC. High Alkaline concrete is one such material which substitiute cement completely by waste materials such as flyash, ggbs, etc.

The development of Alkaline concrete is one of the recent developments in concrete which shows considerable promise to construction industry as an alternative binder to Portland cement. Davidovits found out that an alkaline liquid can be used to react with theAluminum (Al) and Silicon (Si) in a source material of geological origin or in by product materials such as fly ash and GGBS to produce binders.

Materials

Fly ash :Fly ash is the cementations supplementary material obtained as the by-product from burning pulverized coal in an electric power generation plant. class F flyash was used for this experiment.

Table 1-Physical properties of fly ash

Property	Result
specific gravity	23
Colour	Whitish grey
Form	Powder
Fineness	0.4-0.04mm

Table 2-Chemical composition of fly ash

Mix No.	Alkaline liquid: Binders	Cube strength 1 day
CaO	9.7	-
SiO_2	57	Minimum 35%
Al_2O_3	31	SiO_2 + Al_2O_3+ Fe_2O_3 >70%
Fe_2O_3	10	SiO_2 + Al_2O_3+ Fe_2O_3 >70%
MgO	4	Maximum 5.0%
SO_3	1.1	Maximum 3.0%
Alkalies (K_2O,Na_2O)	0.9	Maximum 1.5%

GGBS*:* Ground granulated blast furnace slag is a non-metallic product consisting silicates and aluminates of calcium and other bases that is formed in molten condition along with iron in blast furnance.

Table 3 -Physical properties of GGBS

Property	Result
specific gravity	3
Form	Powder

Table 4-Chemical composition of GGBS

Chemicals	% present in GGBS
CaO	30 to 50
SiO2	28 to 38
Al2O3	8 to 24
MgO	1 to 18
MnO	0.68
TiO2	0.58
K2O	0.37
N2O	0.27

Preparation of alkaline liquid:The alkaline liquid is a mixture of sodium hydroxide pellets and sodium silicate solution for geopolymerization. Alkaline solution is manufactured by mixing the twosolutions in a water bath for about 24 hours beforer to useage

Sodium Hydroxide solution:sodium hydroxide pellets are mixed in a water bath one day prior to casting of specimen. The mass of NaOH solids in a solution variesdepending upon the concentration of the solution which is expressed in terms of molar(M).

Sodium Silicate solution: This is commercially available in different grades in gel form and it is mixed with NaOH solution.

Cement: In present study, ordinary portland cement 43 grade cement (Zuari cement), confirming to IS 8112-1989 was used.

Table 5- Tests results on Cement

Property of cement	Result
% fineness	93%
Specific gravity	3.15
standard consistency	29%
Setting time	Initial-65 min
	Final-5hr 47 min

Aggregates:

fine aggregate: manufactured sand was used

coarse aggregate : crushed granite aggregate passing through an IS sieve of size 12.5mm and retaining on 4.75mmis used.

Silica fume: Silica fume is a byproduct of silicon metal**.** Silica fume is also called as microsilica.It is a product obtained by reducing high purity quartz with coal in a furnace

Table 6-physical properties of Silica Fume

Property	Result
specific gravity	2.3
Form	Powder

Superplasticer*:* The super plasticizer used was Conplast SP-430 a product conforming to IS:9103-1979.

Mix proportions:

Mix design of HSAAC (M60) is as per Rangan's method and HSTVC (M60) is as per Permual's method. The quantities used are mentioned below:

Table 7: Mix design of HSAAC and HSTVC

Materials	Units	HSAAC	HSTVC
Coarse Aggregate	kg/m³	1293	1050
Fine Aggregate	kg/m³	552	716
Cement	kg/m³	-	375
Fly Ash	kg/m³	190	-
GGBS	kg/m³	190	-
Silica Fume	kg/m³	-	42
NaOH solution	kg/m³	122.8	-
Sodium silicate solution	kg/m³	49.14	150
Water	kg/m³	12.5	10.43
Super Plasticizer	kg/m³	12.5	150

Preparation of HSTVC specimens

Initially Cement and coarse and fine aggregates including silica fume which were weighed and batched were put into the pan mixer of capacity 100 kg and dry mixing was done for about 3 minutes, then superplasticizer water and alkaline liquid was added in parts and mixing was done until a homogeneous, uniform in colour and proper consistency of concrete mixture was achieved.

Preparation of HSAAC specimen

In case of HSAAC sodium silicate and sodium hydroxide pellets were first mixed in a water bath atleast one day prior to useage and then on the day of casting the alkaline liquid was mixed with superplastizer and extra water to constitute the liquid component of the mixture.TheGGBS,fly ash and coarse and fine aggregates were dry mixed in the pan mixer for nearly 3 minutes.Then the liquid component of the mixture was put into the mixer and mixing was allowed until a standard consistency of uniform colour and homogeneity was achieved.

Curing

The HSTVC specimens are cured continously for 28 days by keeping them in a water tank.For the HSAAC specimens a steam chamber was artificially created using flex banners and the specimens were kept in this chamber for aboutone day and care was taken to ensure that steam doesn’t escape from the chamber. PVC pipes were used to supply steam to the chamber, the steam curing was continued uninterrupted for 24 hours maintaining the average temperature inside the chamber above 70°C.

Results and Discussion

Compression Test Results:The compressive strength of concrete cubes(100x100x100mm) for both HSTVC (M60) and HSTVC (M60) were tested by using the Compression testing machine as shown in the figure below**.**

fig. 1 specimen subjected to Compressive strength for high strength Traditionally vibrated concrete (M60)

Table 8-compression strength values for HSAAC and HSTVC

Specimen	7days(MPa)	14days (MPa)	28 days (MPa)
HSTVC	51.3	60	64.33
HSAAC	41	57	60.33

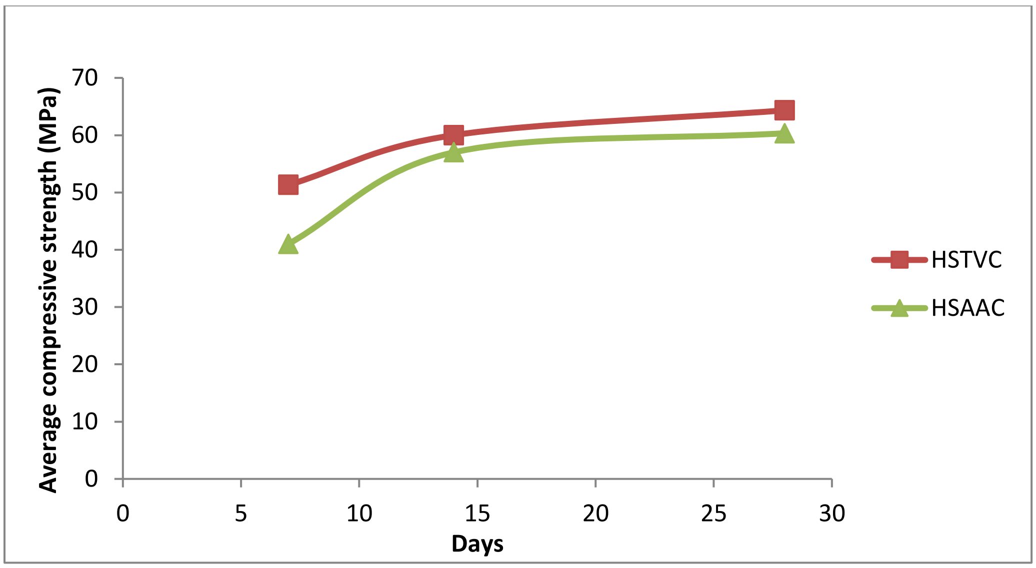

fig 2- compressive strength v/s days

Fig. 3 - after testing of cube in CTM

Split tensile test: The cylindrical specimens of size (100mm dia and 200mm height) were tested under compression testing machine. The failure load was noted.

Table 9-split tensile test values of HSTVC & HSAAC

Specimen	7days(MPa**)**	14days **(**MPa)	28 days **(**MPa**)**
HSTVC	4.2	5.8	6.1
HSAAC	3.7	4.51	6.95

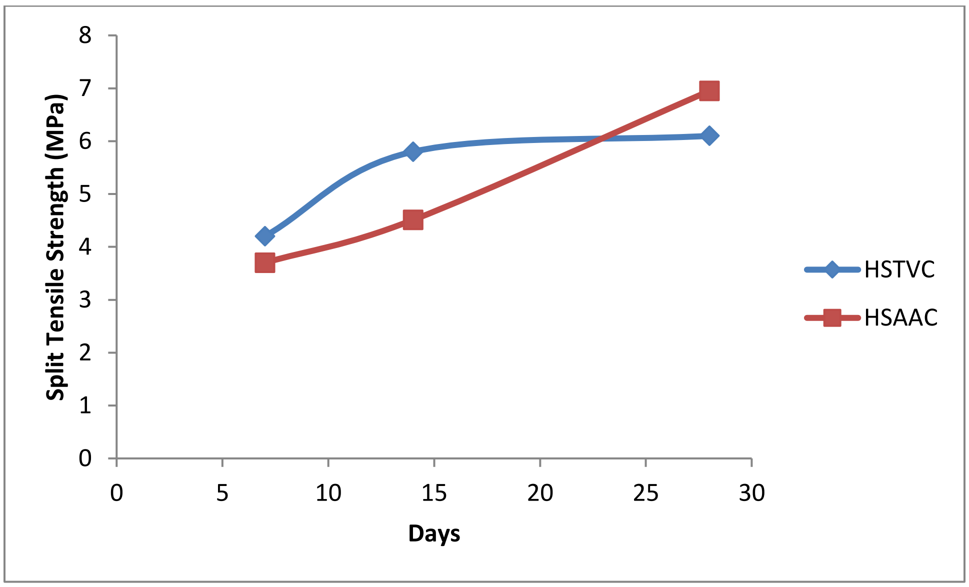

Fig. 4- split tensile strength v/s days

Flexural Test -Flexural Test was conducted on prisms (450mm x 75mm x 75mm) to obtain the modulus of rupture or first crack developed and full collapse of the prism.

Fig. 5- after testing of prism sample for flexural strength

Table 10-flexural strength values of HSTVC & HSAAC

Specimen	7days(MPa)	14days (MPa)	28 days (MPa)
HSTVC	5.6	7.2	8.3
HSAAC	5.3	6.54	8.18

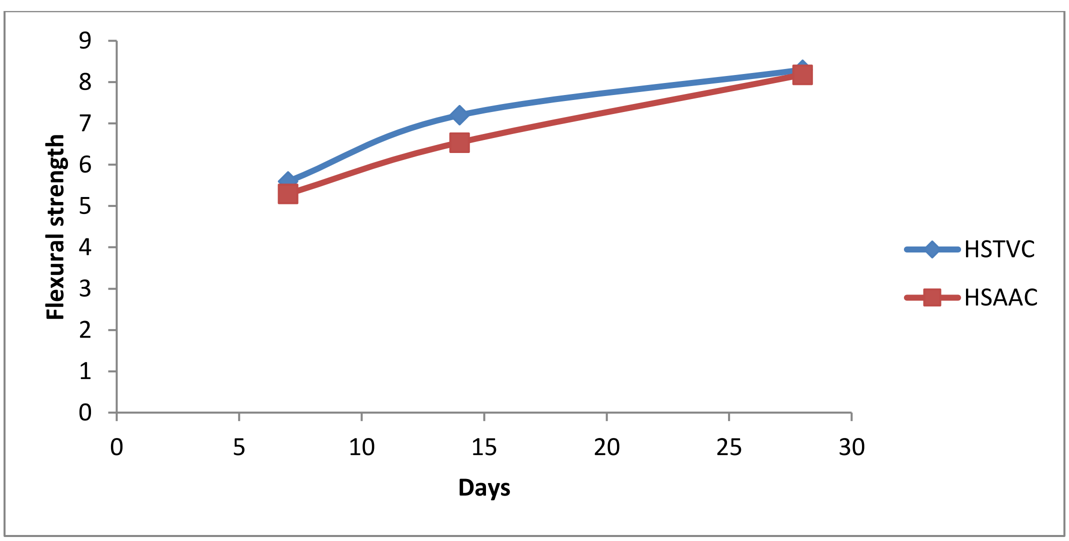

Fig. 6- flexural strength v/s days

Conclusions

The High strength Alkali Activated concrete has gained importance due to its environmental benefits has been studied to evaluate its characteristics with respect to strength. The High strength Alkali Activated concrete was prepared with low-calcium fly ash and GGBS and trial mixes corresponding to M60 grade were done .The compressive strength test results ofHSAAC and HSTVC showed that there is a marginal increase inHSTVCwhen compared with HSAAC. There was a slight reduction in tensile and flexural strengths of HSAAC but the differences are very minimal. From this research work, it can be concluded that, HSAAC has goodcharacteristics and is fit for structural applications.

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