

Influence Evaluation Of An Alkaline Activator On The Strength Of Alkali Activated Concrete With Supplementary Cementitious Materials

Tushar More^{1*}, S. S. Kadam², G.D. Lakade³

¹PG Student, Department of Civil Engineering, S. K. N. Sinhgad College of Engineering Korti, Pandharpur, Maharashtra, India. Email Id- tusharmore2020@gmail.com¹

²Associate Professor, Department of Civil Engineering, S. K. N. Sinhgad College of Engineering Korti, Pandharpur, Maharashtra, India

³Assistant Professor, Department of Civil Engineering, S. K. N. Sinhgad College of Engineering Korti, Pandharpur, Maharashtra, India

Citation: Tushar More, et al. (2024) Influence Evaluation Of An Alkaline Activator On The Strength Of Alkali Activated Concrete With Supplementary Cementitious Materials, *Educational Administration: Theory and Practice*, 30(4), 4084-4095,

Doi: 10.53555/kuev.v30i4.1818

ARTICLE INFO

ABSTRACT

It is one of the most significant contributions to the emission of greenhouse gases that the cement sector provides. The manufacture of cement uses up a significant quantity of virgin materials in the atmosphere, which is one of the factors that contributes to the phenomenon of global warming. It is also worth noting that India generates more than one hundred million tons of fly ash every year. It was decided that fly ash would be the primary ingredient that would be activated via the geopolymerization process in order to serve as the binder for the concrete, therefore completely replacing the need for Portland cement. In order to fulfil the polymerization process, researchers used both sodium hydroxide and potassium hydroxide in three different combination processes. Based on the previous literature study, researchers presumed that certain parameters were fixed. We analyzed the other parameters, including temperature, curing duration, and testing age, using various types of activators. We made use of activators such as sodium hydroxide, potassium hydroxide, and a mixture consisting of fifty percent sodium hydroxide and fifty percent potassium hydroxide. Optimizing the temperature and cure time of alkali activated concrete involves using the compressive strength test. For the purpose of this inquiry, a solution-to-fly ash ratio of 0.35 was used, along with a 13-mole concentrated sodium hydroxide solution and potassium hydroxide. The investigation selected grade M30 for the study. All of the specimens were cured in an oven at temperatures of 600 degrees Celsius, 1000 degrees Celsius, and 1400 degrees Celsius for a period of 12 and 24 hours, respectively. We conducted every test following the process outlined in the Indian standard code. In this section, the findings of the tests for compressive strength, split tensile strength, and flexure strength are tabulated and examined in depth, and some significant conclusions are drawn.

Keywords- Geopolymerization, Compressive Strength, Potassium Hydroxide, Sodium Hydroxide.

INTRODUCTION

In many researches, the alternative for Portland cement is described as 'Alkali activated concrete, because of its wide advantages and applications such as strength, light weight, mechanical properties, acid resistance and fire resistance [1,2]. This type of concrete is developed in 1978 by Joseph Davidovits. Due to the huge demand in the construction industry; the usage of cement is also increasing. In those circumstances, an enormous amount of CO₂ is emanated and that leads to the issues of global warning. The development of alkali activated concrete will have the solution to prevail this problem and moreover this will be a eco-friendly in nature [1]. The foremost constituents of alkali activated concrete comprises of sodium or aluminium which is the alkaline solution (in this study, combination of sodium silicate and sodium hydroxide) and thermally activated natural material [3, 4]. The setting time of alkali activated concrete is rapid when compared to conventional and other types. The alkali activated concrete is allowed under the curing of ambient

temperature which intends to save the water in the normal curing [5,6]. Hence an attempt is made to study the influence of various alkaline activator ratios such as 0.3, 0.35, 0.4, 0.45 and 0.5 on the strength parameters of Ground Granulated Blast Furnace Slag (GGBS) based alkali activated concrete.

LITERATURE REVIEW

S. V. Patankar and colleagues [7] examined the water-to-geopolymer binder ratio in fly ash-based alkali activated concrete. This research examines how altering the proportion of water in the mix affects the mechanical characteristics of both newly mixed and cured concrete while maintaining the other mix components constant. An empirical study has shown that raising the water-to-geopolymer binder ratio may enhance the flow characteristics of alkali activated concrete. Even when all other variables are kept constant, this is still the case. This implies that a thick and desiccated combination occurs at low ratios, but a separated mixture forms at high ratios. When the ratios were examined, this was shown. Additionally, investigations have shown that a decrease in the compressive strength of alkali activated concrete occurs when the proportion of water to geopolymer binder is increased. According to research, the optimal water-to-geopolymer binder ratio is between 0.24 and 0.35 [8].

Sayyad and Patankar [9] investigated the effects of steel fibre and low-calcium fly ash on the elastic and mechanical characteristics of alkali activated concrete composites. They focused on the effects that these elements had on the composites. Numerous other tests, including the flow table test, the wet density test, and the dry density test, were performed on newly poured concrete. In addition, the relationship between steel fibre and low-calcium fly ash was evaluated in relation to the bond strength, compressive strength, and flexural split tensile strength of hardened concrete. According to experiments, adding more steel fibre to alkali activated concrete results in the material being denser but also less flexible. Additionally, studies have indicated that 0.2% is the ideal fiber-to-cement ratio for alkali activated concrete. This ratio produces the strongest results.

R. Anuradha et al. [10] modify their recommendations for mixing alkali activated concrete in order to comply with the criteria of the IS 10262-2009 standard. The success of previously used mix designs was also examined, as was their suitability for usage with alkali activated concrete. For the purposes of this experiment, class F fly ash and type M sand, respectively, were used in place of all the cement and sand. The authors created a fly ash-based, low-calcium alkali activated concrete via a process of trial and error. Those who support the idea promote the use of heat curing as an alternative to Portland cement in the creation of alkali activated concrete. Due to its quick curing period of just around 24 hours, alkali activated concrete may be used for structural reasons and has a high compressive strength. The results of this experiment show that M-sand is much less compressible than common sand.

Early alkali activated concrete that was reinforced with steel fibres was the focus of research conducted under the direction of Susan Bernal and her team [11]. According to the results of the trials, adding steel fibres to alkali activated concrete reduces the material's compressive strength sooner while significantly boosting its tensile strength, flexural strength, and toughness. Additionally, while utilising the same ratios of binder and steel fibre, the researchers discovered that alkali activated concrete had higher levels of strength and hardness than conventional Portland cement.

K. Vijai and associates [12] investigated the effects of steel fibre addition on the characteristics of alkali activated concrete composites and discovered some intriguing findings. The results of this study show that alkali activated concrete has many drawbacks, the most noticeable of which are a prolonged setting time and the need for heat treatment to accomplish solidification. The alkali activated concrete mixture was changed to replace 10% of the fly ash with normal Portland cement in an attempt to allay these worries. The compressive strength, split tensile strength, and flexural strength of the alkali activated concrete mixture increased by 73%, 128%, and 17%, respectively, when 10% fly ash was used in place of Portland cement in the formulation. It has been shown that the addition of fibre to alkali activated concrete composites may improve the material's mechanical properties. Increased compressive strength, split tensile strength, and flexural strength of the material are indications of these advancements. Concrete's fibre content, as a proportion of the overall weight, may range from 0.25% to 75%.

3. METHODOLOGY

3.1 Material used Fly Ash

According to the American Concrete Institute (ACI), fly ash is described as the residual fine particles that remain after the burning of coal, and are transported by flue gases from the combustion area to the particle treatment system (ACI Committee 232, 2004) (24). According to the American Concrete Institute, the following definition is provided. This term is presumably included in the report submitted by the ACI Committee 232 (2004). The dust collection system employs mechanical or electrostatic techniques to first

separate the combustion gases and fly ash. The size of the spherical particles comprising fly ash has a range spanning from one mm to 150 centimeters. When comparing this cement to lime and Portland cement, it can be seen that the particles in this cement exhibit a higher degree of fineness in their distribution. The composition of fly ash may be significantly influenced by the kind and amount of non-combustible particles present in coal.

The compounds with the highest concentrations include calcium oxide (CaO), silicon dioxide (SiO₂), aluminium oxide (Al₂O₃), and iron oxide (Fe₂O₃). In addition, lesser quantities of magnesium, potassium, sodium, titanium, and sulphur are also seen. The kind of coal combusted significantly influences the chemical composition of fly ash. When sub-bituminous coal is combusted, it produces a higher amount of calcium and a lower amount of iron compared to bituminous coal. Additionally, subbituminous coal has a higher calcium concentration. The combustion process of coal, together with its origin and particle morphology, may potentially influence both the combustion behaviour and the resultant physical and chemical characteristics of the coal.

Alkaline Liquid

The sodium silicate solution and the sodium hydroxide solution were both components of the alkaline liquid that was created. The decision was made to go with solutions based on sodium rather than potassium due to the lower cost of sodium-based solutions. The solid sodium hydroxide was either used in flake form or was of a technical grade when it was used.

Aggregate:

Fine Aggregate: (Natural Sand):

The qualities of concrete are mostly determined by the quality of the cement paste that is used to bind the individual bits of aggregate together into a cohesive whole. Concrete is an assembly of these individual aggregate particles. This strength is also dependent on the link that is formed between the aggregate and the cement paste. In spite of the strength of the aggregates, the quality of the concrete that is produced will be poor if either the strength of the paste or the bond that forms between the paste and the aggregate is lacking. However, strong aggregates are an absolute necessity for producing concrete that is of high strength. Which types of naturally occurring aggregate are suitable for use in the production of concrete with normal strength?

Coarse Aggregate:

The optimal size of coarse aggregate should be selected within the permissible range, with consideration given to maximizing its notional maximum size while ensuring it does not exceed one-fourth of the required minimum thickness of the component. In order to achieve the desired outcome, it is essential that the concrete be applied in a manner that allows for its effective penetration through the whole of the reinforcement and thorough distribution inside the voids of the form. In accordance with the specifications given in IS 383-1970, aggregate with a diameter of 20 millimeters was used.

3.2 Mixing, Casting & Compaction of Alkali activated concrete:

Fly ash, fine aggregate, coarse aggregate, and a polymerization solution made of sodium hydroxide, sodium silicate, potassium hydroxide, and potassium silicate were used to make alkali activated concrete. The phases include the following components: Initially, an alkaline liquid, including a solution of silicate and hydroxide, is mixed. Subsequently, more water may be included if deemed essential.

1. The necessary ratios of fly ash, fine aggregates, and coarse aggregate were manually mixed in the concrete mixer for around three minutes.
2. The dry materials were then combined with the alkaline liquid, and the process was generally repeated for a further four minutes.
3. The workability of the newly mixed concrete was assessed using the traditional slump test after the homogenous mixture had been prepared.
4. Then, three layers of 150 mm by 150 mm by 150 mm cubes were cast. To establish a consistent surface, expel air from the concrete, and smooth the edges, each layer was firmly crushed with a tamping rod and vibrated on a vibrating table.
5. The top surface of the concrete was vibrated and then leveled using a trowel.
6. In order to help the cube formwork de-mould, this cube was then exposed to the air for 24 hours or a day. Following this, specimens were kept for curing.

4. RESULT AND DISCUSSION

4.1 General

Testing alkali activated concrete is done in accordance with the specifications. This chapter presents several tables that detail the test results for alkali activated concrete. We cast the alkali activated concrete using three different combinations of sodium hydroxide and potassium silicate, sodium silicate and potassium hydroxide, and a 50% blend of the two with the same quantity of silicate.

4.1.1 Slump Flow Test

The slump flow test is performed in accordance with the protocol outlined in I.S. 516-1959(26). Alkali activated concrete grades M30 provided the guidelines and test results shown in Table 4.1. The table displays the findings.

Table 4.1: Evaluation of alkali activated concrete slump flow.

No.	Grade	Ratio of solution to fly ash	Slump Flow for Alkali activated concrete (millimeters)
01.	M30	0.45	130

I.S. 516-1959(26) is followed in order to carry out the slump flow, and the test readings are included in the table 4.1 that is located above. When compared to normal concrete, alkali activated concrete's workability is noticeably greater.

4.2 Results of the Alkali activated concrete Test

The testing of alkali activated concrete plays a significant part in the process of regulating and validating the quality of cement concrete work. Researchers cast cubes, beams, and cylinders using real concrete to conduct the experiment. Researchers looked at the impact that compressive strength, flexural strength, split tensile strength, and alkali activated concrete had on the material.

4.2.1 The effect of Sodium hydroxide solution molarity.

Tables 4.2 and 4.1 illustrate the molarity variation investigated using compressive strength. This fluctuation was identified in connection to the curing temperature, curing period, and concrete testing age (in days).

Table 4.2: Molarity has an effect on the compressive strength of Alkali activated concrete.

	Molarity	Sample No.	Temperature (°C)	Curing Time (Hrs)	(Days) Rest Period	Load (KN)	Compressive Strength (N/mm ²)	Average (N/mm ²)
1		C5				700	34.06	
		C6				730	35.4	
2	13	C10	90°C	24	7	750	36.28	37.47
		C11				780	37.62	
		C12				800	38.51	
3	16	C13	90°C	24	7	830	39.84	40.58
		C14				840	40.28	
		C15				870	41.62	

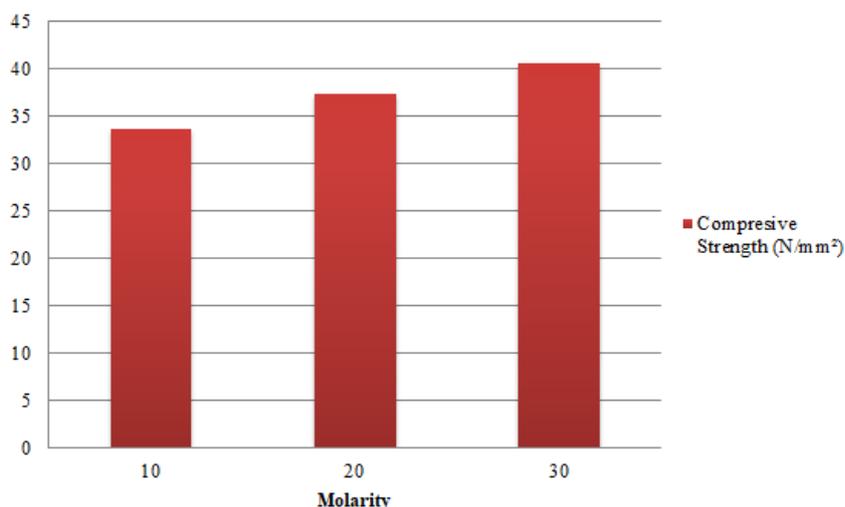


Figure 4.1: Molarity has an effect on compressive strength.

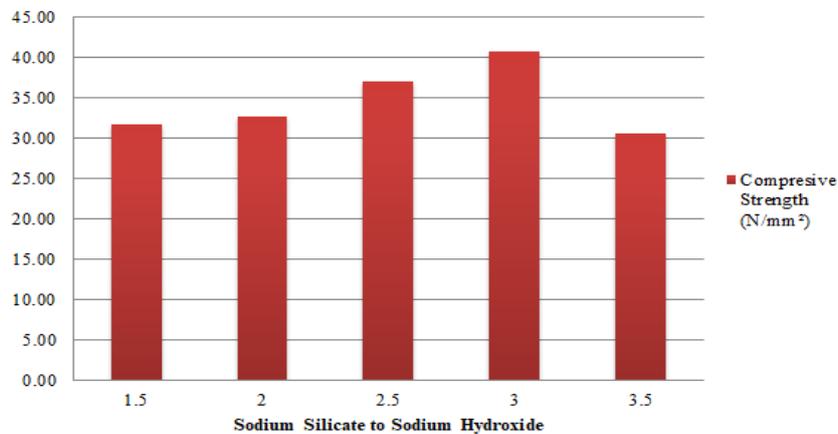
A compressive test was performed in accordance with I.S. 516-1959(26) using a cube measuring 150 mm in length, 150 mm in width, and 150 mm in height. There was compression testing equipment with a capacity of 3000 KN that was utilized for the compressive test.

4.2.2 Effect of sodium silicate to sodium hydroxide ratio on AAC.

We conducted a compressive strength test with varying ratios of 1.5, 2, 2.5, 3, and 3.5 to determine the optimal ratio of sodium silicates to sodium hydroxide. Table 4.3 and picture 4.2 both display the results of the test at hand.

Table 4.3: The effect of alkaline solution ratio on AAC compressive strength.

Sr No	Alkaline solution ratio	Sample No	Temperature	Curing Time (Hours)	Rest Period (Days)	Compressive Load (KN)	Compressive Strength (N/mm ²)	Average Compressive Strength (N/mm ²)
1	1.5	OC-C43	90°C	24	7	660	31.59	31.74
		OC-C44				640	30.7	
		OC-C45				690	32.92	
2	2	OC-C46	90°C	24	7	720	34.26	32.78
		OC-C47				640	30.7	
		OC-C48				700	33.37	
3	2.5	OC-C49	90°C	24	7	780	36.92	37.07
		OC-C50				760	36.03	
		OC-C51				810	38.26	
4	3	OC-C52	90°C	24	7	840	39.59	40.77
		OC-C53				890	41.81	
		OC-C54				870	40.92	
5	3.5	OC-C55	90°C	24	7	640	30.7	30.55
		OC-C56				620	29.81	
		OC-C57				650	31.15	

**Figure 4.2:** Influence of the alkaline solution ratio on compressive strength.

4.2.3 Compression Strength Test:

Oven-cured concrete that was subjected to temperature variations of 80 degrees Celsius, 120 degrees Celsius, and 160 degrees Celsius yielded findings of compressive strength. As part of this test, a solution of sodium hydroxide with a concentration of 13 molars was created. Within the context of alkali activated concrete, the influence of temperature on compressive strength is shown in Table 4.4. Figure 4.3 offers a graphical representation of the information. If the curing temperature was higher, the compressive strength would be greater, but at 1400 degrees Celsius, the compressive strength would significantly drop.

Table 4.4: Impact of Heat on Alkali activated concrete's Compressive Strength.

No.	Sample	Temperature (°C)	Curing Time (Hrs.7)	(Days) Rest Period	Load in (KN)	Compressive Strength in (N/mm ²)	Average in (N/mm ²)
1	OC-C4	80°C	12	7	180	9.43	12.09
	OC-C5				260	12.98	
	OC-C6				280	13.87	
	OC-C10		24		400	19.2	24.09
	OC-C11				560	26.32	
	OC-C12				570	26.76	
2	OC-C16	120°C	12	7	620	28.98	30.17
	OC-C17				650	30.32	
	OC-C18				670	31.2	
	OC-C22		24		880	40.54	42.02
	OC-C23				920	42.32	
	OC-C24				940	43.2	
3	OC-C28	160°C	12	7	780	36.09	35.20
	OC-C29				760	35.2	
	OC-C30		24		740	34.32	24.39
	OC-C34				460	21.87	

	OC-C35				540	25.43
	OC-C36				550	25.87

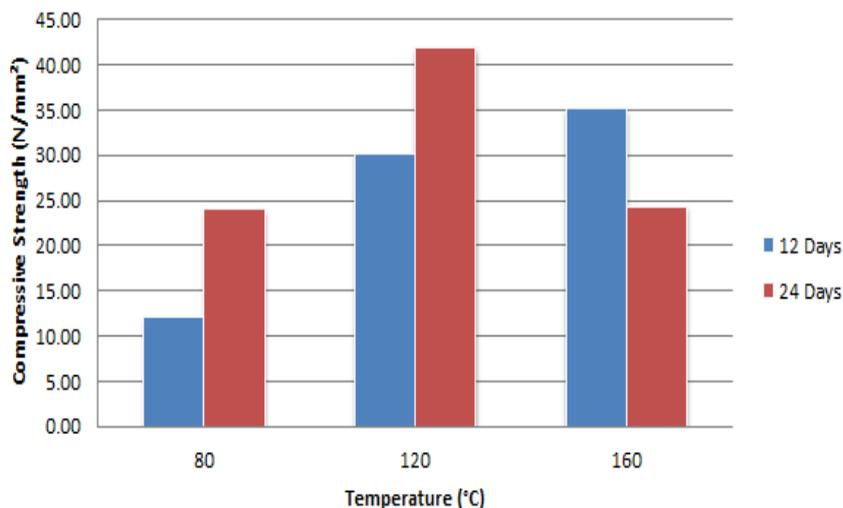


Figure 4.3: The relationship between temperature and compressive strength.

4.2.4 Split tensile strength.

Following the standards, a solution of sodium hydroxide with a concentration of 13 molar was made, and sodium silicate was used. In accordance with I.S. 5816-1999(27), we carried out the test for tensile strength. We optimized the temperature to 100 degrees Celsius for measuring the tensile strength of oven-cured concrete. The test received the results at seven and twenty-eight days of age. The output of the test, which can be seen in table 4.5 and picture 4.4,

Table 4.5 Optimized Temperature Effect on Split Tensile Strength of AAC.

No.	Sample	Temperature in (°C)	Curing Time in (Hrs)	Rest Period in (Days)	Load in (KN)	Split Tensile Strength in (N/mm ²)	Average in (N/mm ²)
1	OCCy1	100°C	24	7	185	3.35	2.43
	OCCy2				190	3.42	
	OCCy3				200	3.56	
2	OCCy4	100°C	24	28	230	3.98	2.93
	OCCy5				220	3.84	
	OCCy6				230	3.98	

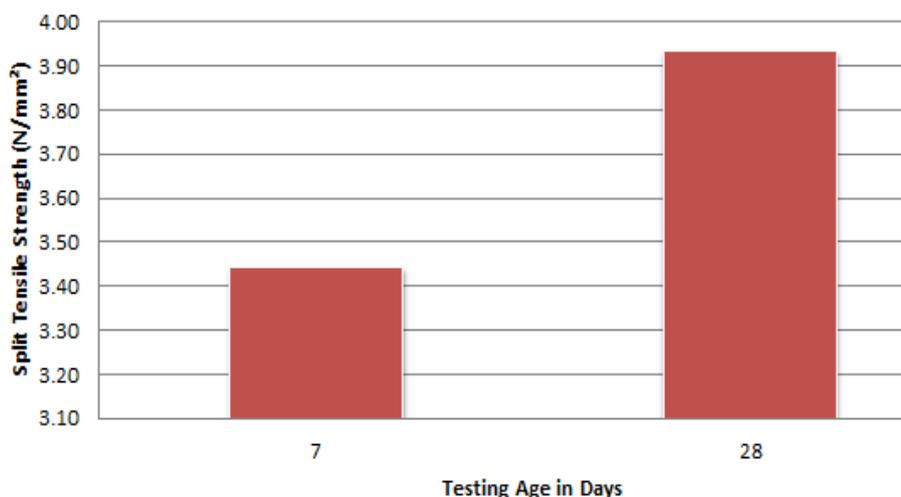


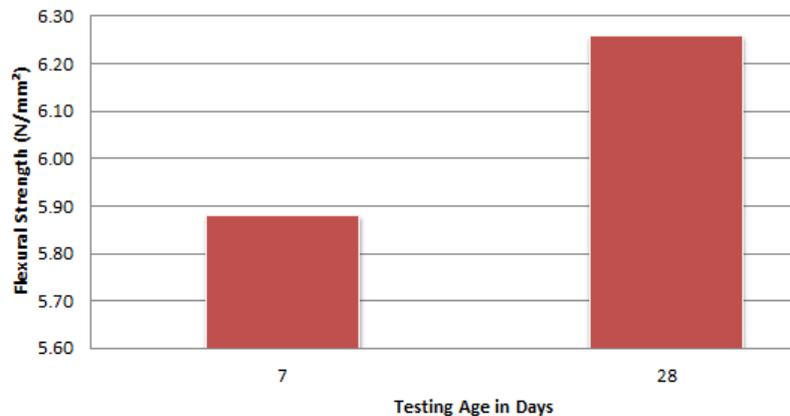
Figure 4.4: Split tensile strength of AAC

4.2.5 Flexure strength on AAC

The flexure test was carried out in accordance with the code requirements of I.S. 516-1959(26). The results of the flexure test are shown in tables 4.6 and 4.5, respectively. During the flexure test, we used an optimal oven temperature, a predetermined curing period, and tested the specimens at ages ranging from seven to twenty-eight days.

Table 4.6 Optimized Temperature Effect on Flexure Strength of Alkali activated concrete.

Number	Sample	Temperature in (°C)	Curing Time in (Hrs)	Rest Period in (Days)	Flexural Load in (KN)	Average Flexural Load in (KN)	Fcr in (Mpa)
1	OCB1	100°C	24	7	11.19	11.76	5.88
	OCB2				11.99		
	OCB3				12.09		
2	OCB4	100°C	24	28	12.29	12.52	6.26
	OCB5				12.49		
	OCB6				12.79		

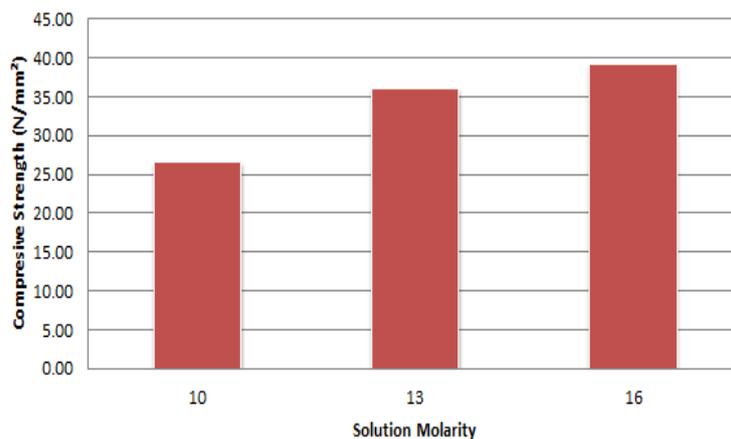
**Figure 4.5:** Flexure strength of AAC.

4.2.6 Effect of molarity of potassium hydroxide solution.

The potassium hydroxide solution was made with 10 molecules, 13 molecules, and 16 molecules. Using a cube of 150 mm in length, 150 mm in width, and 150 mm in height, a compressive test was performed in accordance with I.S. 516-1959(26). The variations in molarity that were examined by using compressive strength in relation to curing temperature, curing time, and the testing age of concrete (in days) are shown in tables 4.7 and 4.6, respectively.

Table 4.7: Effect of molarity on compressive strength of Alkali activated concrete.

No.	Molarity	Sample	Temperature in (°C)	Curing Time in (Hrs)	Rest Period in (Days)	Load in (KN)	Comp Strength in (N/mm ²)	Average in (N/mm ²)
		C52	80°C	24	7	570	26.89	36.08
		C53				590	27.78	
		C54				750	34.89	
2	13	C55	80°C	24	7	780	36.23	36.08
		C56				800	37.12	
		C57				830	38.45	
3	16	C58	80°C	24	7	840	38.89	39.19
		C59				870	40.23	

**Figure 4.6:** The Influence of Molarity on Compressive Strength.

4.2.7 Compressive Strength of AAC.

Figures 4.7 and 4.8 both illustrate the influence that temperature has on the compressive strength of alkali activated concrete. Table 4.8 also includes the figure. Oven-cured concrete that was subjected to temperature variations of 60 degrees Celsius, 100 degrees Celsius, and 140 degrees Celsius yielded findings of compressive strength. We performed a compressive test in accordance with I.S. 516-1959(26) using a cube measuring 150 mm in length, 150 mm in width, and 150 mm in height. We made use of the potassium hydroxide solution that had a concentration of thirteen millimolar molecules.

Table 4.8: Effect of temperature on compressive strength of Alkali activated concrete.

No.	Sample	Temperature in (°C)	Curing Time in (Hrs)	Rest Period in (Days)	Load in (KN)	Compressive Strength in (N/mm ²)	Average in (N/mm ²)
1	OC-C44	80°C	12	7	280	13.12	13.86
	OC-C45				300	14	
	OC-C46				310	14.45	
	OC-C47		24		450	20.67	22.30
	OC-C48				510	23.34	
	OC-C49				500	22.89	
2	OC-C50	120°C	12	7	540	24.67	26.74
	OC-C51				630	28.67	
	OC-C52				590	26.89	
	OC-C53		24		770	34.89	35.34
	OC-C54				740	33.56	
	OC-C55				830	37.56	
3	OC-C56	160°C	12	7	830	37.56	38.60
	OC-C57				860	38.89	
	OC-C58				870	39.34	
	OC-C59		24		410	18.89	32.67
	OC-C60				470	21.56	
	OC-C61				440	20.23	

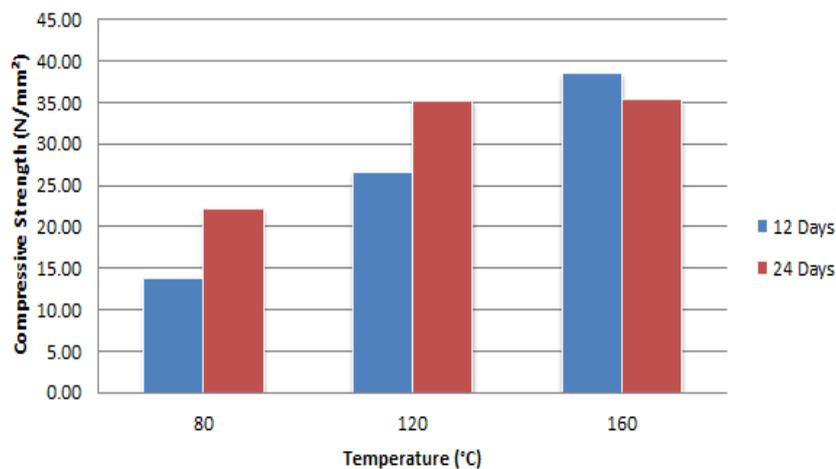


Figure 4.7: Effect of temperature on compressive strength.

4.2.8 Split tensile strength.

According to I.S. 5816-1999(27), the test for tensile strength was conducted. Using an optimal temperature of 100 degrees Celsius and a concentration of potassium hydroxide solution that was 13 millimolars, the tensile strength of oven-cured concrete was determined. The test received the results at seven and twenty-eight days of age. The results of the test are shown in tables 4.9 and 4.8. We measured the split tensile strength on a cylinder with a diameter of 150 millimeters and a depth of 300 millimeters.

Table 4.9 Optimized temperature effect on split tensile strength of Alkali activated concrete.

No.	Sample	Temperature in (°C)	Curing Time in (Hrs)	Rest Period in (Days)	Load in (KN)	Split Tensile Strength in (N/mm ²)	Average in (N/mm ²)
1	OCCy22	100°C	24	7	160	3.35	3.30
	OCCy23				150	3.21	
	OCCy24				160	3.35	
2	OCCy25	100°C	24	28	230	4.34	4.34
	OCCy26				220	4.2	
	OCCy27				240	4.49	

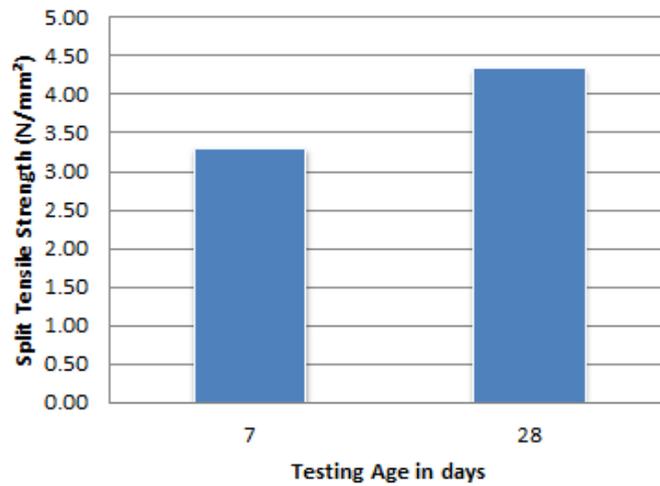


Figure 4.8: Split tensile strength of AAC.

4.2.9 Flexure Strength test.

The flexure test was carried out in accordance with the code requirements of I.S. 516-1959(26). The flexure test results are shown together in table 4.10 and figure 4.9. During the flexure test, we used an optimal oven temperature, a predetermined curing period, and seven to twenty-eight days of testing age. At a temperature of 100 degrees Celsius, the concentration of potassium hydroxide solution was 13 molar, and the oven was employed to cure the solution.

Table 4.10 Optimized temperature effect on flexure strength of Alkali activated concrete.

No.	Sample	Temperature in (°C)	Curing Time in (Hrs)	Rest Period in (Days)	Flexural Load in (KN)	Average Flexural Load in (KN)	Fcr in (Mpa)
1	OCB7	100°C	24	7	10.46	10.76	5.38
	OCB8				10.86		
	OCB9				10.96		
2	OCB10	100°C	24	28	12.06	12.19	6.09
	OCB11				12.16		
	OCB12				12.36		

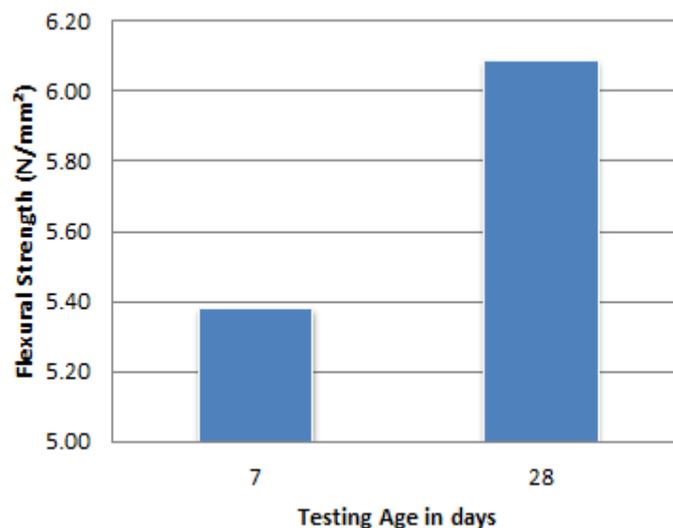


Figure 4.9: Flexure strength of AAC.

4.2.10 Compressive Strength of AAC.

We used both sodium hydroxide and potassium hydroxide in equal proportions, and we also utilized the silicates in equal proportions. The ratio of one for the hydroxide and silicate worked as well. This test for geopolymerization included a mixture of fifty percent sodium hydroxide and fifty percent potassium hydroxide. Oven-cured concrete that was subjected to temperature variations of 60 degrees Celsius, 100 degrees Celsius, and 140 degrees Celsius yielded findings of compressive strength. A compressive test was

conducted in accordance with I.S. 516-1959(26) using a 150 mm x 150 mm x 150 mm cube. In this experiment, a solution of potassium hydroxide and sodium hydroxide with a concentration of 13 molar has been used. Table 4.11 and picture 4.10 demonstrate the effect of temperature on the compressive strength of alkali activated concrete.

Table 4.11: Effect of temperature on compressive strength of Alkali activated concrete.

No.	Sample	Temperature in (°C)	Curing Time in (Hrs)	Rest Period in (Days)	Load in (KN)	Compressive Strength in (N/mm ²)	Average in (N/mm ²)
1	OC-C61	80°C	12	7	330	15.34	14.67
	OC-C62				350	16.23	
	OC-C63				370	17.12	
	OC-C64		24		530	24.23	23.56
	OC-C65				550	25.12	
	OC-C66				570	26	
2	OC-C67	120°C	12	7	710	32.23	31.70
	OC-C68				730	33.12	
	OC-C69				760	34.45	
	OC-C70		24		830	37.56	36.00
	OC-C71				800	36.23	
	OC-C72				860	38.89	
3	OC-C73	160°C	12	7	910	41.12	40.59
	OC-C74				940	42.45	
	OC-C75				950	42.89	
	OC-C76		24		530	24.23	23.70
	OC-C77				580	26.45	
	OC-C78				550	25.12	

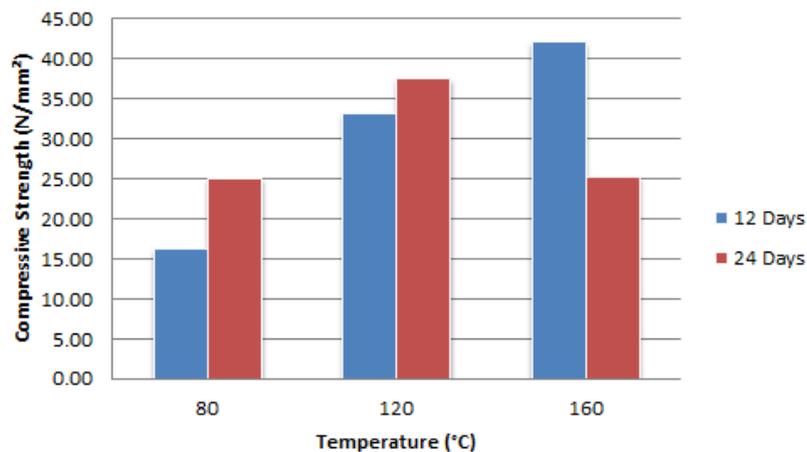


Figure 4.10: The relationship between temperature and compressive strength.

4.2.11 Split Tensile Strength.

For the polymerization, we employed a mixture of fifty percent sodium hydroxide and fifty percent potassium hydroxide. We used both sodium hydroxide and potassium hydroxide in equal proportions, along with the silicates. The outcome of the test, which is shown in table 4.12 and picture 4.11, we measured the split tensile strength on a cylinder with a diameter of 150 millimeters and a depth of 300 millimeters, confirming the requirements of I.S. 5816-1999(27).

Table 4.12 Optimized temperature effect on split tensile strength of AAC.

No.	Sample	Temperature in (°C)	Curing Time in (Hrs)	Rest Period in (Days)	Load in (KN)	Split Tensile Strength in (N/mm ²)	Average in (N/mm ²)
1	OCCy22	100°C	24	7	220	3.5	3.36
	OCCy23				200	3.22	
	OCCy24				210	3.36	
2	OCCy25	100°C	24	28	260	4.07	4.26
	OCCy26				270	4.21	
	OCCy27				290	4.49	

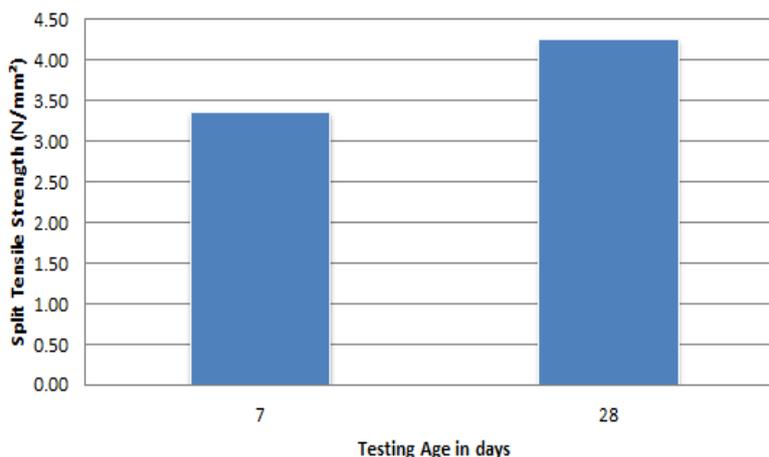


Figure 4.11: Split tensile strength of AAC.

4.2.12 Flexure Strength test.

For the polymerization, we employed a mixture of fifty percent sodium hydroxide and fifty percent potassium hydroxide in this test. The flexure test was carried out in accordance with the code requirements of I.S. 516-1959(26). Figure 4.12 and Table 4.13 both display the results of the flexure test taken. An optimal oven temperature, a predetermined curing period, and seven to twenty-eight days of testing age were the only conditions used during the flexure test. At a temperature of 1000 degrees Celsius, the concentration of potassium hydroxide solution was 13 molar, and the oven was employed to cure the solution.

Table 4.13 Optimized temperature effect on Flexure strength of Alkali activated concrete.

No.	Sample	Temperature in (°C)	Curing Time in (Hrs)	Rest Period in (Days)	Flexural Load in (KN)	Average Flexural Load in (KN)	Fcr in (Mpa)
1	OCB21	100°C	24	7	11.52	11.42	5.71
	OCB22				11.32		
	OCB23				11.42		
2	OCB24	100°C	24	28	12.52	12.44	6.22
	OCB25				12.12		
	OCB26				11.82		

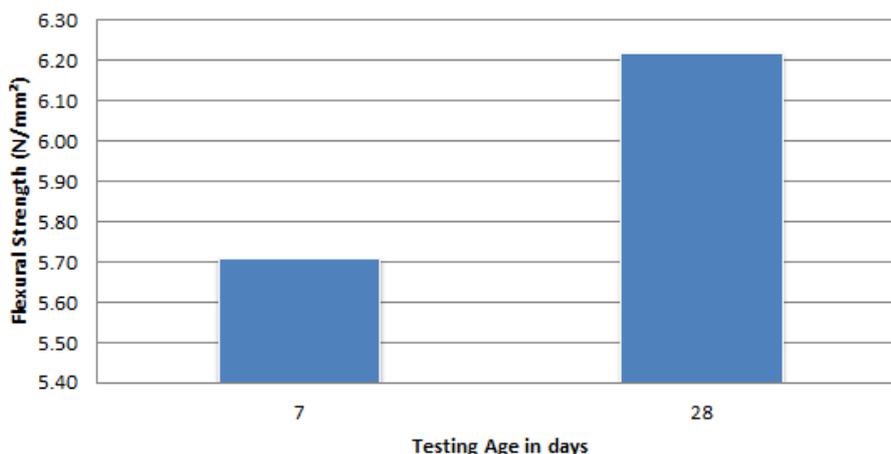


Figure 4.12: Flexure strength of AAC.

5. CONCLUSION

Following the casting and testing of the fly ash-based alkali activated concrete for its workability and compressive strength, the following findings are obtained about the material:

- To achieve optimal workability and compressive strength, set the mass ratio of sodium silicate to sodium hydroxide at 2.5. Increasing the ratio beyond 2.5 will decrease the compressive strength. Therefore, it is necessary to maintain the ratio of sodium silicate to sodium hydroxide by mass at 2.5. Additionally, it was shown that the curing time and temperature change of alkali activated concrete have a significant impact on the polymerization process.

- The ratio of potassium hydroxide to sodium hydroxide in alkali activated concrete demonstrates its major features, resulting in a value of 1. It is sluggish at 600 degrees Celsius, but it is high at 1000 degrees Celsius, and it decreases at 1400 degrees Celsius. For a curing time of twenty-four hours, the compressive strength is not significant above 1400 degrees Celsius.
- While potassium hydroxide is more expensive, sodium hydroxide has almost identical mechanical qualities to those of alkali activated concrete. Sodium hydroxide costs less. A longer curing period enhanced the polymerization process, resulting in improved compressive strength of alkali activated concrete when the temperature was optimized.
- G.P.C., which stands for heat-cured low-calcium fly ash-based alkali activated concrete, has a number of advantages over Portland cement concrete in terms of its economic benefits. It is important to note that the cost of one ton of fly ash is a negligible amount in comparison to the cost of one ton of Portland cement. Therefore, considering the cost of alkaline liquids required for producing alkali activated concrete, experts predict that alkali activated concrete based on fly ash will be around ten to twenty percent cheaper than traditional concrete.

References

1. Singh B, Ishwarya G, Gupta M and Bhattacharyya 2015 Alkali activated concrete: A Review of Some Recent Developments” Const. and Building Mat. 85 pp78-90.
2. Daniel L.Y. Kong, Jay G. Sanjayan 2010 Effect of Elevated Temperatures on Geopolymer Paste, Mortar And Concrete” Cement and Conc.Res. 40 pp334-339.
3. Ramesh BabuChockalingam and Ganesan N 2017 A Study on the Strength Development of Alkali activated concrete Using Fly Ash Int. J. of Engg. and Tech. 6 pp163-167.
4. Chindaprasirt P and Chalee W 2014 Effect of Sodium Hydroxide Concentration on Chloride Penetration and Steel Corrosion of Fly Ash Based Alkali activated concrete Under Marine Site Const. and Building Mat. 63 pp303- 310.
5. TianyuXie and TogayOzbakkaloglu 2015 Behavior of Low Calcium Fly and Bottom Ash Based Alkali activated concrete Cured at Ambient TemperatureCer. Int. 41pp5945-5958.
6. PradipNath, Prabir Kumar Sarker 2014 Effect of GGBS on Setting, Workability and Early Strength Properties of Fly Ash Alkali activated concrete Cured in Ambient Condition Const.and Building Mat.66 pp163-171.
7. S. V. Patankar, S. S. Jamkar, and Y. M. Ghugal, “Effect of sodium hydroxide on flow and strength of fly ash based geopolymer mortar,” Journal of structural Engineering, vol. 39,no. 1, pp. 7–12,2012.
8. D. Hardjito, S. E.Wallah, D. M. J. Sumajouw, and B. V. Rangan,“On the development of fly ash-based alkali activated concrete,”ACI Materials Journal, vol.101, no. 6, pp. 467–472, 2004.
9. A.T.Sayyad, and S. V. Patankar , “Effect of steel fibre s and low calcium fly ash on mechanical and elastic properties of alkali activated concrete composites,” Indian journal of material science,vol.2013, artical ID 357563.
- 10.R. Anuradha, V. Sreevidya, R. Venkatasubramani, and B. V.Rangan, “Modified guidelines for alkali activated concrete mix design using Indian standards,” Asian journal of Civil Engineering, vol. 13, pp. 353–364, 2012.
11. Susan, Bernal; Ruby, De Gutierrez; Silvio Delvasto; Rodriguez, “Performance of geopolymeric concrete reinforced with steel fibres,” IIBCC 10th Int. Inorganic bonded fibre composite conference, November 15-18, 2006, Sao Paulo-Brazil.
12. K. Vijai, R. Kumutha, and B. G. Vishnuram, “Effect of inclusion of steel fibre s on the properties of alkali activated concrete composites,” Asian Journal of Civil Engineering, vol. 13, no. 3, pp. 377– 385, 2012.