Study on Environmentally Friendly Concrete-High Strength Alkali Activated Concrete

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Abstract - It is well known that the production of ordinary Portland cement consumes a sizable amount of energy and emits a large volume of CO_2 into the atmosphere. Therefore, industrial byproducts have an important place in today's concrete technology owing to their positive effect on the durability and strength of concrete besides the lower production cost and greenhouse gas emissions. Some of the by-products are fly ash and GGBS. When these by-products are used as a replacement of cement and activated with alkali activators, they form alkali activated concrete. Alkali activated concrete is a viable alternative to typical normal concrete. In the present study experimental studies were performed on the Normal concrete and alkali activated concrete of M60 grade. Comparative analysis has been done for normal concrete and alkali activated concrete in relation to their compressive strength, split tensile strength and flexural strength. Alkali activated concrete performed well in terms of compressive strength. Split tensile strength and flexural strength compared to normal concrete when measured at the age of 7,14,28 days. It is effectively proved that alkali activated concrete is best alternative to traditional concrete.

Key Words: Fly ash, GGBS, alkali activated concrete, Normal Concrete, Strength

1.INTRODUCTION

Concrete is the second most utilized substance on earth after water. It is the most used material by the construction industry all through the world. Hence every day, the prerequisite of cement in the construction field is expanding alarmingly. It is estimated that the global cement production will increase from 3.27 billion metric tons in 2010 to 4.83 billion metric tons in 2030. However, it is also well known that the production of Ordinary Portland Cement not only utilizes a significant amount of natural resources and energy but also releases a considerable amount of carbon dioxide to the atmosphere. About one ton of carbon dioxide is released into the atmosphere in the production of one ton of cement. Unfortunately, carbon dioxide is a major contributor to the greenhouse effect and global warming.
The utilization of industrial and agricultural by-products as the replacement or as the additional cementitious material has had a constructive effect in minimizing greenhouse gas emissions. Each year millions of tons of industrial by-products are produced and most of these by-products are unutilized. Increasing anxiety about the ecological significances of by-products disposal has led researchers to investigate the consumption of the by-products as potential construction materials. By using these by-products materials, we can minimize the emission of CO_2 in environment and can also solve the problem of waste disposal. Hence it is essential to find alternatives to make eco-friendly concrete, one of such alternatives is alkali activated concrete where Fly Ash is used instead of cement. Utilization of these industrial by-products has several important benefits in environment and economical front because its production utilizes less energy compared to that of OPC production and there is no emission of carbon dioxide into the atmosphere.

2. EXPERIMENTAL INVESTIGATIONS:

2.1 Materials and Properties:

2.1.1 Cement: It is a grayish fine substance made by calcinating lime and clay together as shown in figure 2.1. In present study, ordinary Portland cement OPC 53 grade, confirming to IS 8112-1989 was used. The physical parameters obtained from the characterization tests carried out at the laboratory are tabularized below in table 2.1 .

Figure 2.1 Cement

Table 2.1: Physical Parameters of OPC

Sl.No	Property	Values Obtained
1	Specific gravity	3.15
2	Initial setting time	35 minutes
3	Standard consistency	30%
4	Fineness	3%
5	Compressive strength (28 days)	58 MPa

2.1.2 Fly Ash

It is the cementitious supplementary material obtained as the by-product during the combustion of coal in thermal power plant. In this study class F fly ash is used and is shown in figure 2.2 and its physical properties are shown in table 2.2.

Figure 2.2 Class F fly ash

Table 2.2 - Physical properties of fly ash

Property	Result
specific gravity	2.2
Colour	Whitish grey
Form	Powder
Fineness	0.4-0.04 mm

2.1.3 Ground granulated blast furnace slag (GGBS)

The GGBS is produced as byproduct in the manufacture of pig iron. It forms when slagging agents such as iron ore, coke ash, and limestone are added to the iron ore to remove impurities. The physical properties obtained from the characterization tests carried out at the laboratory are tabularized in table 2.3. GGBS is shown in figure 2.3

Figure 2.3 GGBS

Table 2.3: Physical properties of GGBS

Physical Property	Test Value
Colour	Off-white
Texture	Fine
Particle Size	0.1 to 40 microns
Fineness	5%
Specific gravity	2.78

2.1.4 Alkaline Liquids

There are different alkali activators that are used for alkali activation of slag such as Potassium hydroxide(KOH) and Potassium silicate(K_2NiO_3) or Sodium hydroxide (NaOH) and Sodium silicate (Na_2SiO_3).In this experimental work we have used the combination of Sodium hydroxide and Sodium silicate for alkali activation.

a)Sodium hydroxide solution

Sodium hydroxide solution was prepared by diluting NaOH pellets in water as per the concentration of solution required according to the mix design. The dilution of NaOH pellets has to be done 24 hours prior to its usage in order to ensure its complete dilution o in water. Sodium hydroxide pellets are shown in figure 2.4 and its dilution in water bath is shown figure 2.5. In the Present work 8M NaOH is used.

Figure 2.4 Sodium hydroxide pellets

Figure 2.5 Dilution of pellets in water in presence of water bath

b)Sodium Silicate solution

Sodium silicate solution (Na_2SiO_3) is also known as water glass. The solution is highly viscous in nature.

2.1.5 Fine Aggregate

In the recent years, Manufactured-sand popularly called as M-sand is used as substitute for the natural river sand in the construction field. It is obtained by crushing of granite stones. M-sand is as shown in figure 2.6 and its physical characteristics are tabulated in table 2.4

Figure 2.6 M-Sand

Table 2.4 Physical Characteristics of M-sand

Property	Values Obtained
Fineness modulus	2.983
Specific gravity	2.67

2.1.6 Coarse Aggregate

Gravel or crushed granite stones whose size is greater than 4.75mm are usually used as coarse aggregate. In this experimental work, coarse aggregate of 12mm downsize was used for casting. Coarse aggregate is shown in figure 2.7 and its physical characteristics are listed in table 2.5

Figure 2.7 Coarse aggregate

Table 2.5: Physical characteristics of Coarse aggregate

Property	Value Obtained
Specific gravity	2.76
Fineness Modulus	6.24
Bulk density	1589 kg/m^3

2.1.6 Super plasticizer

The superplasticizer called Complast SP 430 was used for casting of concrete specimens.

2.1.7 Water

Potable tap water is used for mixing and curing of concrete.

2.2 Manufacture of geopolymer concrete test specimens

2.2.1 Mixing

The Fly ash and aggregates were dry mixed in the concrete mixer for about 3 minutes. Then the alkaline solution that was prepared one day prior to usage along with super plasticizer and extra water was added to blend for about 4 minutes.

2.2.2 Casting: After the determination of slump, the fresh concrete was then cast into standard cylindrical moulds and cubes in three layers. Each layer was compacted using vibrating table. Casting of specimens is shown in figure 2.8

Figure 2.8 Casting of Specimens

2.2.3 Curing: All specimens, were then transferred to steam chamber set at a temperature of 80°C, and stored for 24 hours. After 24 hours of curing, the specimens were allowed to cool in air, kept in open until the day of testing

2.3 Strength Studies

2.3.1 Compressive Strength: Compression test was conducted on cubical specimens of size 150mm X 150mm X 150mm; in Compression Testing machine (CTM) as shown in below figure 2.9, at the end of the specified curing period's.i.e.7, 14 and 28 days. Average of three specimens was reported to be the compressive strength of specimen. Compressive strength results are shown in table 2.6.

Figure 2.9: Compression test

Table 2.6 Compressive strength values AAC and NC concrete in Mpa

Curing stage in days	Compressive Strength (Mpa)	
	AAC	NC
7	51.33	43.33
14	55.33	53.33
28	60.23	63.43

2.3.2 Split tensile strength

Split tensile strength of AAC and conventional concrete specimens with size 100mm in diameter and 200mm height was evaluated by testing it in CTM as shown in figure 2.10. Three specimens were tested for each proportion and average of three results was taken as split tensile strength for each molarity considered. Split tensile strength values are listed in table 2.7

Figure 2.10 Specimen for split tensile testing

Table 2.7 Split tensile strength values AAC and NC concrete in MPa

Curing stage in days	Split tensile strength (Mpa)	
	AAC	NC
7	4.03	3.61
14	5.62	4.46
28	6.05	6.90

2.3.3) Flexural Strength

The specimens were tested for 7,14 and 28 days strength after casting. The modulus of rupture is determined by testing standard test specimens of 75x75x450mm as shown in figure 2.11. The modulus of rupture is determined from the moment at failures as fr = M /Z . Flexural strength results are tabulated in table 2.8

2.11 Specimen for flexural strength testing

Table 2.8 Flexural strength values AAC and NC concrete in MPa

Curing stage in days	Flexural Strength (Mpa)	
	AAC	NC
7	5.49	5.42
14	7.10	6.60
28	8.15	8.22

3. CONCLUSIONS

- Compressive strength of AAC is higher than normal concrete at 7 and 14 days but slightly lesser at 28 days.

- There is not much difference in Split tensile strength and flexural strength results of AAC and normal concrete.
- All the three strength test results shows that AAC concrete can be a best alternative to normal concrete.
- The use of industrial by products in concrete production reduces the carbon footprint in environment thus making AAC an environmentally friendly concrete.

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