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Capital University of Science and Technology, Islamabad Pakistan

EVALUATING THE BLEND OF NAOH AND KOH ACTIVATORS FOR ECO-FRIENDLY GEO-POLYMER CEMENT MORTAR

[a,*] Lahiba Imtiaz, [a,*]Sardar Kashif Ur Rehman, [a] Muhammad Khizar, [a] Muhammad Haseeb, [a] Haris Sajjad, [a] Sadam Munir and [a] Muhammad Sher Yar

a: Civil Engineering Department, COMSATS University Islamabad Abbottabad Campus.
***:** Corresponding Author, laibaimtiaz01@gmail.com ; skashif@cuiatd.edu.pk

Abstract- Geo-polymer concrete is attaining the interest of scientific communcity as it is significantly addressing the ash disposal and CO_2 emission issues. In this study influnece of Sugarcane Bagasse ash (SCBA) was investigated on cement mortar specimens. NaOH and KOH with different molarities were used as alkali-activaots in prepartion of SCBA based geo-polymer mortar. Forty two mortar mixtures were prepared having water to binder ratio of 0.5. Test specimens were prepared with 20% change of cement weight with bagasse ash. Compression test was conducted to find the strength properties of bagasse ash based cement composite. Additionaly, water absorption test and permeable porosity test were also performed.7 days compressive strength was found less as compared with control specimens due to less geopolymerization process. Moreover, geopolymer specimens posses higher water absorption values and found depended on pH of molar solutions. In non-structural concrete member, the use of geopolymer will leads to green environment.

Keywords- SCBA, molar ratio, geo-polymerization, NaOH and KOH.

1 INTRODUCTION

Construction industry makes an important contribution in the economic growth of any country. Constant increase in demand of infrastructure is leading to its rapid growth. Nowadays, concrete is most widely used construction material due to its properties such as; high strength, durability, low cost, moldability, high-temperature resistance and low or no maintenance requirement and versatility. Consumption of concrete around the globe was around four million Metric tons in 2014 and hence; after water, it is the second most used material on earth [19]. Production of concrete imparts detrimental effects on the environment because of carbon dioxide (CO_2) emission, nitrogen oxides and sulphur oxides due to excessive use of OPC. Studies reveal that manufacturing of cement emits an almost equal quantity of carbon dioxide into the atmosphere [1].

Sugarcane Bagasse ash (SCBA) is the alternative supplementary cementitious material that can be used as a mineral admixture in concrete and mortar due to presence of huge amount of amorphous silica. It is a combustion by product from sugar boilers and alcohol factories, and has been used to improve both durability and strength properties of concrete when replaced partially with cement [18]. Accordingly, performance of SCBA concrete, comprising of SCBA, had much improved than control concrete with regards to water permeation and compressive strength. Furthermore, efficiency of ash has been enhanced by increasing the surface area with the help of grinding [8]. Geo-polymer concrete is produced by polymerizing reactive alumina silicates; metakaolin (MK), rice husk ash (RHA), fly ash (FA) and high calcium wood ash (HCWA) with alkaline activators such as potassium hydroxide (KOH), sodium hydroxide (NaOH), potassium silicate or sodium silicate that may be temperature cured or cured at room temperature. The efficacy in producing geo-polymer concrete is greatly dependent on the activators as well as types of alumina silicate resources [3, 8, 13]. The research studies on geo-polymer concrete and alkali activation had emerged in 1950's.Glukhovsky model has been widely used for alkali activation of alumina silicates materials in past years [14, 15] . Later on, researchers have conducted experimental investigations and extended the Glukhovsky's theory on geo-polymerization process involved in geo-polymer concrete and mortar [17]. Mostly, earlier studies have been conducted on FA based geo-polymer concrete. Later, SCBA in combination with rise husk ash and with other alumina silicates were used to produce geo-polymer concrete[2].

Many recent studies have also been conducted on binary mixtures of FA-SCBA and blast furnace slag (BFS) mixed with SCBA by using alkali hydroxides and silicates mixtures mainly (Na or K) alkaline activators [7, 9]. However, as per author's best knowledge, up till now no systematic study is conducted, to access the properties of geo-polymer concrete, consisting of SCBA activated with the combination of two activators such as NaOH and KOH activators. Endorsing that idea, SCBA based geo-polymer concrete activated with a blend of NaOH and KOH is intended to be investigated in this study. Influence of molarity was also determined on compressive strength and water absorption.

2 EXPERIMENTAL PROGRAM

2.1 Materials

Ordinary Portland cement (OPC) as per ASTM C 150 Type I was used throughout the research work. Blaine air permeability apparatus was used to determine the fineness of cement and found to be 2670 cm^2/gm. Moreover coarse and fine aggregate was sieved and analyzed. It was noted that it fulfill the requirements as per ASTM standards. ASTM C136 – 04 [4] .Distilled water was used in this study. SCBA was acquired from open burning. It was sieved through # 50 sieve to remove both course and fine fibrous carbon particles [13]. SCBA was then subjected to grinding for 120 min to achieve its maximum pozzolanic activity [14]. Its fineness was found to be 2863 cm2/gm after grinding for 120 min.

2.2 Specimen Designation

GxN_ayK_b represents the geo-polymer concrete sample prepared by adding solutions of two bases i-e 'xN_ayK_b' showing 'a' percent of 'x' molar NaOH and 'b' percent of 'y' molar KOH. Table 1 shows the mix proportions and specimens designations used in this study.

Table 1: Mix proportions used for preparing

Mix	Activator to Binder Ratio (A/B)	Cement (%)	Bagasse Ash (%)	Sodium Hydroxide (NaOH) (mol)	Potassium Hydroxide (KOH) (mol)
G4Na4Kb	0.5	80	20	4	4
G4Na8Kb	0.5	80	20	4	8
G4Na12Kb	0.5	80	20	4	12
G8Na4Kb	0.5	80	20	8	4
G8Na8Kb	0.5	80	20	8	8
G8Na12Kb	0.5	80	20	8	12
G12Na4Kb	0.5	80	20	12	4
G12N8K	0.5	80	20	12	8
G12N12K	0.5	80	20	12	12

2.3 Solution preparation and their pH Test

Solutions were prepared 24 hours before the casting and their pH test was conducted to find alkalinity of different NaOH and KOH molar solutions in the environmental lab, K block.

2.4 Specimen preparation

The SCBA based geo-polymer cement paste were prepared by mixing different combination of molar solution of NaOH and KOH in mix containing cement with 20% replaced bagasse ash mix having water to binder ratio of 0.5. The prepared mix was casted in 5cm x 5cm x 5cm mortar cubes' molds and after 24 hours samples were demolded and immersed in curing tank for 7 days and 28 days. The testing involved the compression test, water absorption test and the permeable porosity test at 7 and 28 days curing stage.

2.5 Compression Test

Compressive strength test was performed to check the strength of different SCBA based geo-polymer cement paste. Standard 5cm x 5cm x5cm cubes were prepared. Testing was carried out at the age of 7 days and 28 days.

2.6 Absorption test

Performed to experimentally determine water absorption capacity for different samples of geo-polymer cement paste. This test was performed in accordance with ASTM C 642-97 [5].

3 RESULTS:

Three samples of each mixtures were prepared and tested under same experimental conditions and the average value was reported in this section. The variation of the individual result was kept at less than 5% of the average value, otherwise, the mixtures were casted again

3.1 pH Test

pH values of solutions ranges from 12.17 to 15.35. The pH test of different solution is shown in the Figure 1.

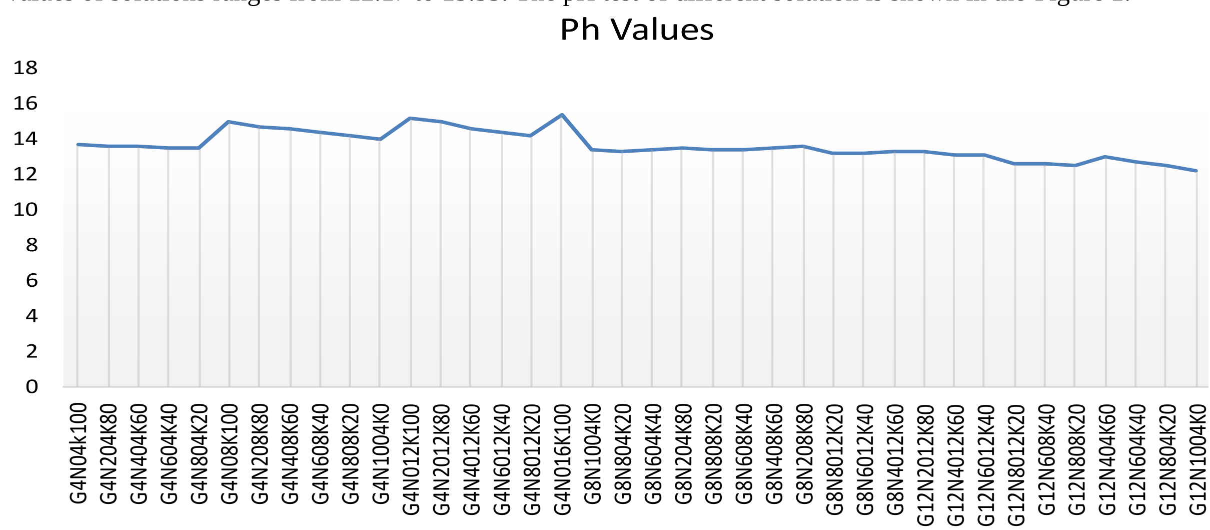

Figure 1: pH values of SCBA based geopolymer cement composites samples

3.2 Compressive strength

Strength of mortars samples that have bagasse ash was more other than the normal samples for long period. Samples having high bagasse ash content observed low compressive strength at early age i.e 7 days after casting. The compressive strength of mortar samples at early stages was less because C-S-H bond and polymerization phase was not completed. Furthermore, [20] observed that the compressive strength of geo-polymer samples decreases when cured at ambient temperature. Increase in the porosity of concrete with a large amount of SCBA incorporation resulted in the reduction of the amount of CT concrete and calcium hydroxide (from the hydration reaction). As a result, it was not sufficient for inducing the reaction with silica from the bagasse ash.

With the increase in NaOH molarity the compressive strength of alkali activated slag increases due to increase in alkalinity that results in greater formation of hydrated products. Moreover, increase in alkaline solution to drag ratio results in decreased compressive strength. Increasing the Na_2SiO_3/ NaOH increase the compressive strength and enhanced the porosity. Figure 2 shows the compressive strength values of 12 molar specimens. In addition to this, it was found that the measurement of strength and porosity and shrinkage cracks depend on type of Na^+ and K^+ ion present in activator [6].

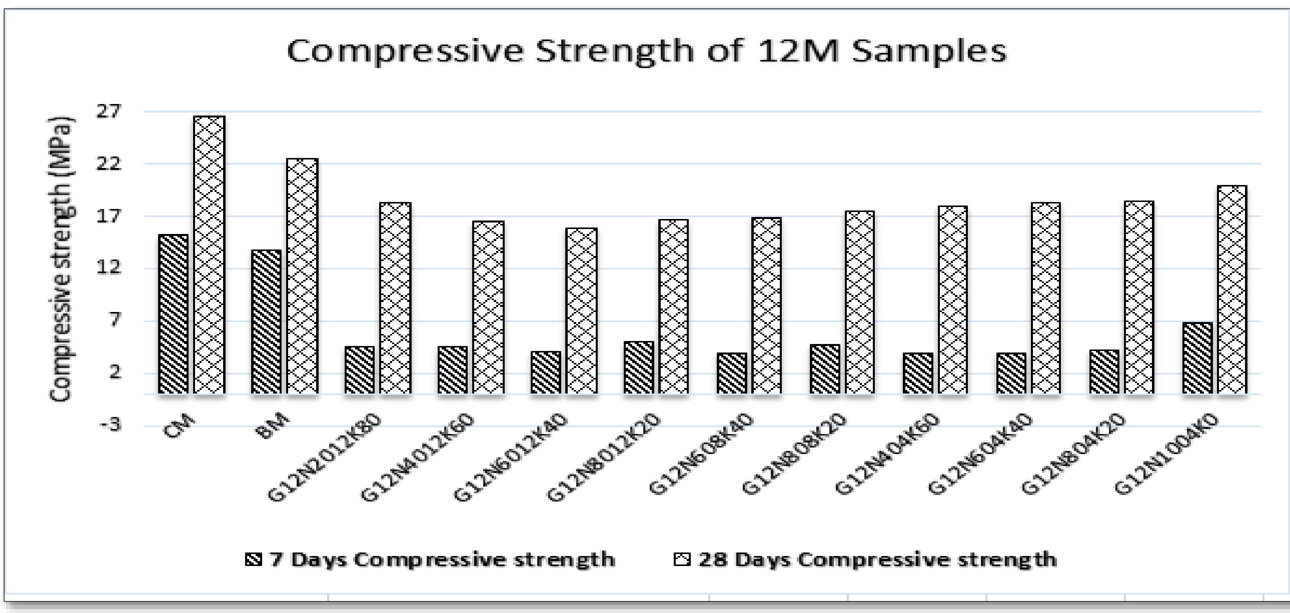

Figure 2: Compressive strength of 12M SCBA based geopolymer cement composites

3.3 Water Absorption Test

Decrease in the water absorption having high cement was change by bagasse ash. Figure 3 presents the water absorption values for various mix at 7 day and 28 days of casting. With time, reaction was time consuming, which has an important bearing on the durability of the hydrated paste; secondly, pore size distribution has shown that the reaction products are very efficient in filling up large capillary space, thus improving the strength and impermeability of the system [16]. Furthermore, with increasing molarity the temperature release become higher resulted in small cracks causing more absorption [12]. Moreover, absorption values also depend on the pH values of molar solutions [6, 10, 11].

3.4 *Reactivity Index*

From the results it is clear that reactivity of all the mixes, at 7 and 28 days, was lower than the CM. This was because of the fact that as the time passes more hydroxide were generated during hydration process, which was needed for continuity of pozzolanic activity. Furthermore, it can be seen that, up to 20 per cent replacement of cement with bagasse ash, met the limitation laid down by ASTM C618 for strength activity. In order to overcome this low strength issue, use of accelerator and curing at elevated temperature is recommended.

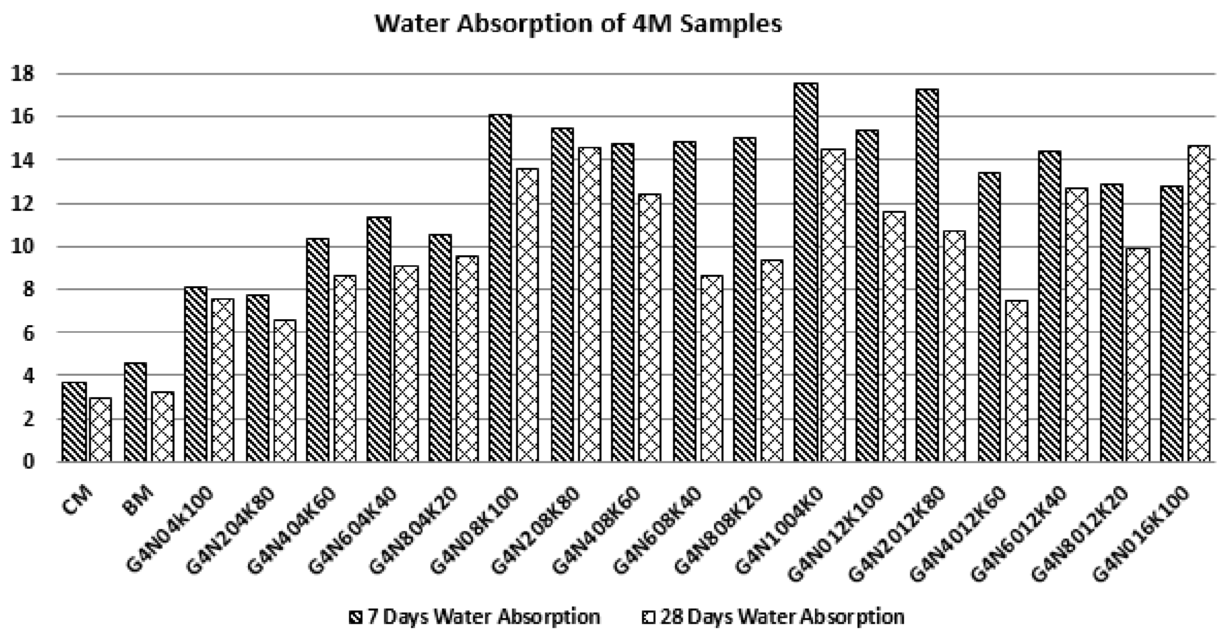

Figure 3: Water absorption of 4M SCBA based geopolymer cement composites

3.5 *Application of Geopolymer concrete*

The blend of NAOH and KOH activators with aluminosilicate source (e.g., metakaolin, SG, RHA, FA, HCWA etc.) results in the obtainment of geopolymer which is an amorphous material. The SCBA utilization as a source of aluminosilicate with the blend of NAOH and KOH, eventually improved the durability of geopolymers. It has excellent potential for fire resistance structures, alkali-silica reaction, and acid resistance. The utilization of bagasse ash as a source of aluminosilicate for supplementary cementing material for geopolymers through systematic processing and characterization offer a profitable and environment friendly alternative to its disposal. Moreover, the use of geopolymer leads to green environment.

4 CONCLUSION:

This study was performed to evaluate the effect of NaOH and KOH blend on preparation of eco-friendly geo-polymer concrete . Following conclusions have been drawn from the experimental work.

- Production of bagasse ash as industrial waste is quite high and likely to further increase in Pakistan. Technically and financially bagasse ash has lots of potentials to be used as pozzolan in concrete construction industry.

Furthermore, its usage as construction material will also solve pollution problem. Moreover, ash is a cost-effective option without compromising on the strength parameters.

- SCBA is to be used as alumina silicate source for geo-polymer concrete after grinding for 120 min, by using blend of NaOH and KOH as activator.
- Absorption of water decreased with increase in the ash for cement replacement.
- Compressive strength of SCBA geopolymer concrete was less as compared with control specimen. However, curing at elevated temperature and use of accelerator will overcome this issue.

Eco-friendly, low cost concrete can be produced by incorporating bagasse ash as partial replacement of cement.

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