

Utilizing new binder materials for green building has zero Waste by recycling slag and sewage sludge ash

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ABSTRACT

As known, more than 1600 million tons of Portland cement is produced annually with nearly one ton of CO₂ per ton of clinker produced. Due to the environmental impact of cement industries and high energy cost many researchers try to produce new binding material to save energy and to produce new innovative zero materials waste. The current research aims to investigate new binder materials as alternative of Portland cement. Alkali activated slag (AAS) blended with sewage sludge ash (SSA) will be studied in this research. Sewage sludge was conducted with at 650 °C(SSA1) and 850 °C(SSA2) for 4hour. ground granulated blastfurnace slag GGBFS was partially replaced by SSA1 and SSA2 at both conducted conditions with 0, 5, 10, 20 and 30% by GGBFS weight. 18% of Sodium hydroxide was used as alkali activator in this study the pastes were hydrated up to 90 days. The investigation included compressive strength and the microstructure of alkali activated GGBFS pastes without and with replacement by SSA1 and SSA2 was assessed through a variety of Infrared (IR) spectroscopy and Scanning Electron Microscopy (SEM) to evaluate the best degree of incineration for SSA. The results indicated that 10% SSA1 incinerated at 650 °C replacement of alkali activated slag replacements the optimum replacements to produced geopolymers building materials as green building materials.

1. Introduction

Green building has now become a flagship of sustainable development in this century that takes the responsibility for balancing long-term economic, environmental and social health. It offers an opportunity to create environmentally efficient buildings by using an integrated approach of design so that the negative impact of building on the environment and occupants is reduced.

The amount of various wastes being re-used to produce various raw materials such as cement. M. Daimon, (1998) is increasing but it is important to

develop other applications for waste materials to increase the ratio of their re-use. Since many inorganic wastes mainly consist of SiO₂, Al₂O₃ and CaO, one possible applications is as glass-ceramics.

Therefore, various glass ceramics have been prepared from ashes such as coal fly ash from a thermal power station, Kim et al. (2004), sewage sludge fly ash, municipal waste incinerator fly ash, incinerator bottom ash and steel plant fly ash, L. Barbieri et al. (2002), slag from blast furnace M.L. Ovecoglu., (1998), silicon manganese and steel furnaces. Manufacturing of Portland cement is an energy intensive process that releases a very large amount of greenhouse gas, Maholtra, (2002). Therefore the use of pozzolans to replace part of portland cement is receiving a lot of attention. Other efforts have also been made to develop alternative cementitious materials. One promising finding is the use of an alumino-silicate material called "geopolymer".

The world production of slag from iron and steel industries per year reaches almost 50 000 kt, whereas approximately 12 000 kt per year is produced in Europe. Europe. S. Kourounis., (2007). Czech Republic ranks among the important producers of steel and pig iron in 17 million ton of steel and 5,2 million ton of pig iron was produced in the year 2006. International steel and iron steel and thus approximately 1,2 million ton of steel slag and 1,9 million ton of blast furnace slag. Approximately 55 % of blast furnace slag production undergoes a granulation process and granulated blast furnace slag (GBFS) originates. A significant part of blast furnace slag is utilized for the production of aggregate. GBFS is commonly utilized in the cement industry for preparation of blended cement CEM II, CEM III and CEM V where cement clinker substitution by GBFS ranges from 6 to 95 wt % CSN, EN. (2001). Steel slag is more variable in chemical composition. From this point of view the utilization of steel slag for inorganic binder preparation is more complicated. Slag with a high content of iron (ladle slag) is returned to the blast or steel furnace in the form of agglomeration charge. Another part of steel slag is utilized for production of dense synthetic aggregate.

The majority of ladle slag production is stored in slag disposal areas without any profit

With the increase in population, mainly in urban areas, an increase in the production of solid wastes is a common result. However, due to the limitation in land space, municipal solid waste (MSW) disposal requires integrated management landfills. Incineration is an efficient method of reducing (MSW). This paper investigates the strength durability of four different mixtures compacted using the modified effort. Induced cementitious properties of slag by suitable alkali activators allow effective usage of this secondary metallurgical product in the building industry as a valuable binding system which represents an alternative to cement binders. Apart from the value of slag for the building industry, raw materials and energy savings occur as well as CO₂ emission decreases even though the mortars range significantly increase Alkali activation process has been studied and discussed throughout from a chemical and micro structural perspective, F.Puertas et al., (2003), to mention a few. At this point, the role of water during activation process should be stressed especially in the contrast to the system of Portland-based materials. During geopolymerization, water acts as a wetting agent, a carrier of ions (NaOH), soluble water glass), and a donor of H⁺ and OH⁻ ions while dissolving aluminosilicate P.DUXSON et al., (2005). A portion of water is returned back in the polycondensation step of gelation, where it pools within the submicron pores. In the presence of Ca⁺⁺ possibly introduced from, e.g. admixed slag, a portion of capillary water is bound physically and chemically inside C-S-H gels I. Lecomte, et al., (2006). Not so in fly ash type F where water enters and leaves polycondensation process without much being consumed during geopolymerization. In such a particular case, ultimate capillary porosity is predetermined by the amount of activator and RFA inner porosity. Cumulative porosities in a similar metakaoline system yielded values between 8% and 20% sewage sludge has been disposed off mainly by three methods, such as landfilling, sea dumping and soil application Dritte Allgemeine et al., (1993). Difficulties for come from the high moisture state and large content of volatile solids in the sludge. For soil application, heavy metals, which cause a problem of human toxicity as well as aquatic and terrestrial eco-toxicity, are released from the sludge. While sea dumping causes ocean pollution and does harm to the ocean biology. Therefore, it is imperative to investigate new environmentally sustainable applications for this type of waste. Ceramic, as a kind of lightweight aggregate, can be used to produce concrete mixtures. Using clay to produce ceramic is very common nowadays Horan N, et al., (1996) but this method requires too much natural resources.

Sewage sludge as a possible substitute of clay can be used to slow down the consumption of resources and to solve the environmental problems caused by this waste. Earlier studies on making lightweight aggregate.

Novel lightweight bricks have been produced by sintering mixes of dried water treatment sludge and rice husk. Samples containing up to 20 wt.% rice husk have been fired using a heating schedule that allowed effective organic burn-out. Rice husk addition increased the porosity of sintered samples and higher sintering temperatures increased compressive strengths. Materials containing 15 wt.% rice husk that were sintered at 1100 °C produced low bulk density and relatively high strength materials that were compliant with relevant Taiwan standards for use as lightweight bricks. Kung-Yuh Chiang, (2009).

Martin Cyr et al., (2007), Sewage sludge ash (SSA) is a waste material obtained from the incineration of wastewater sludge. The physical, chemical and mineralogical characteristics of SSA, and the evaluation of its use in cement-based materials, are presented in this paper. Results show that SSA is composed of irregular grains having a high specific surface area and thus leading to a significantly high water demand. A fraction of the ash is rapidly soluble (sulfates, aluminum and silica) and can create new-formed products in presence of lime. SSA induces short delays of cement hydration, probably due to both minor elements of the ash and dilution effect. Compressive strengths of mortars containing 25% and 50% of SSA are always lower than those of reference mortars but it is shown that SSA has a long-term positive effect which might be related to a slight pozzolanic activity. The amount of elements leached from SSA mortars is slightly higher than from the reference mortar without residue but it remains of the same order of magnitude. An extensive literature review was performed in order to compare the residue used in this study with others included in the same category. This analysis highlighted the principal characteristics that must be taken into account to use SSA correctly in cement-based materials.

Kuen et al., (2005) Pore structure significantly affects the lightweight characteristics and thermal performance of materials. Therefore, in this study sewage sludge ash (SSA) was used to make lightweight materials. Physical and chemical properties, and how the mixing proportions affected the foaming behavior were investigated, including the lightweight characteristics and pore structure of the materials produced. The experiments showed that the minimum required cement amount was determined by the compressive strength of the sewage sludge ash foamed material (SSAFM), not

its alkali content. The hydration of cement and SSA mainly generated pores with diameters of less than 0.1 μm , but cement added with metallic aluminum powder produced pores with diameters larger than 10 μm . The addition of SSA increased the volume of pores smaller than 10 μm . The thermal conductivity of SSAFM was between 0.084 and 0.102 W/mK. Therefore, SSA could be used as the lightweight filler and heat-insulating material.

C.R. Cheeseman, et al., (2005) This study investigates the sintering behavior of dried sewage sludge and the related sintering mechanisms, considering sintering temperature and sintering time. Experimental results indicate that the characteristics are primarily influenced by sintering temperature. When the sintering temperature is increased from 1020 to 1050 °C, the specimens' compressive strength and bulk density increase significantly, while water absorption decreases obviously, indicating an improvement of densification due to sintering. However, the compressive strength cannot meet the requirement for traditional ceramic products due to the release of organic matters and the formation of big pores in the products. Phosphorus in sewage sludge initially takes reactions with the formation of calcium magnesium phosphate and aluminum phosphate during sintering, which are helpful for enhancing the compressive strength. So, some materials with high contents of Al could be used to enhance the compressive strength of products. Heavy metals are fixed primarily inside the sintered specimens, with the As, Pb, Cd, Cr, Ni, Cu, Zn concentrations in the leachate found to be in the range of China regulatory requirements. These results reveal the feasibility of recycling dried sewage sludge by sintering as a construction material.

The physical, chemical and mineralogical characteristics of SSA, and the evaluation of its use in cement-based materials, are presented in this paper. Results show that SSA is composed of irregular grains having a high specific surface area and thus leading to a significantly high water demand. Martin Cyr et al., (2007). A fraction of the ash is rapidly soluble (sulfates, aluminum and silica) and can create new-formed products in presence of lime. SSA induces short delays of cement hydration, probably due to both minor elements of the ash and dilution effect. Compressive strengths of mortars containing 25% and 50% of SSA are always lower than those of reference mortars but it is shown that SSA has a long-term positive effect which might be related to a slight pozzolanic activity. The amount of elements leached from SSA mortars is slightly higher than from the reference mortar without residue but it remains of the same order of magnitude. An extensive literature review was

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Previous studies of the kinetics of geopolymerisation have generally focussed on the application of different experimental techniques primarily calorimetry to obtain a largely empirical understanding of geopolymer setting rates. A preliminary form of the reaction kinetic model presented here has been applied to calorimetric data Provis et al., (2005a), however, this implementation of the model was only valid for a single $\text{SiO}_2/\text{Al}_2\text{O}_3$ ratio and was subject to certain difficulties in its implementation Provis., (2006). Buildings have a significant and continuously increasing impact on the environment because they are responsible for a large portion of carbon emissions and use a considerable number of resources and energy.

The green building movement emerged to mitigate these effects and to improve the building construction process. This paradigm shift should bring significant environmental, economic, financial, and social benefits.

The aim of this study is to evaluate the technical quality of two thermal treating for recycling sewage sludge used as pozzolanic materials replacement of GGBFS to produce geopolymer building materials as friendly environmental materials. The pastes were made using two thermal treating 650 °C and 850 °C for 4 hrs producing SSA1 SSA2 raw materials respectively. The physical and mechanical properties for alkali activated GGBFS replacement of different ratio from SSA1 and SSA2 pastes were then compared to those of similar pastes with no added SSA1 or SSA2. So as to assess whether the quality of Thermal treatment for SSA. The use of this additive in geopolymer binding materials instead of cement as produce cost savings in raw materials and serve as an efficient means of recycling a waste product.

2. Experimental

2.1 Starting materials :

In this study the sewage sludge was collected from the primary and secondary settling tanks from Zinine wastewater treatment plant in Giza and left dried in open area. The sludge was thermal treating at 650 °C and 850 °C for 4 hrs producing SSA1 and SSA2 respectively.

Granulated blast furnace slag is a by – product of the pig iron manufacture from iron ore in Hellwan city . Grinding the (GGFS) and also called slag cement . It is a metallic hydraulic cement consisting essentially of silicates and aluminosilicates of

calcium which developed in a molten condition simultaneously with iron in a blastfurnace . The molten slag at a temperature of about 1500°C (2730F) is rapidly cooled by quenching in water to form a glassy sandy like granulated material. GGBFS, SSA1 and SSA2 were ground and pass completely from 150µm mesh. The chemical composition of GGBFS and both SSA are given in Table (1), all these binding materials are rich in silica and alumina , which are required for the formation of the strength used for replacement the cement . The silica –alumina ratio (SiO_2/Al_2O_3) by mass were found to be approximately 1.9 ,4.3 ,4.6 for GBFS and SSA fired at 650 °C and 850 °C respectively. Also, GBFS has a high CaO contents 34% while the CaO content in both SSA fired at 650 °C and 850 °C are 14 and 13.45 % respectively.. X-ray diffraction (XRD) patterns showed that GGBFS and both SSA are amorphous which suggests their better activity.

Table (1): Chemical composition of the starting materials, wt%

oxides	GBFS	SSA1 (at 650 °C) 4h	SSA2 (850 °C) 4h
SiO ₂	28.83	51	50.3
Al ₂ O ₃	14.57	11.03	10.6
Fe ₂ O ₃	0.01	6.19	6.1
Ca O	37	14	13.45
Mg O	7.24	3.44	3.4
Na ₂ O	11.29	0.8	0.75
K ₂ O	0.88	0.13	0.14
SO ₃	1.99	4.4	4.5
P ₂ O ₅	0.12	0.01	0.01
TiO ₂	0.01	0.03	0.02
L.O.I	0.01	8.61	10.5

2.2 Grain size test

Grain size distribution was performed by the Leaser Size Analyzer (Horiba(LA-950)).The grain size for the applied materials are shown in Table (2) and Fig. (1) .

Table (2) : Grain size for the starting materials

ITEMS	GBFS	SSA(650 °C)	SSA(850 °C)
Size	%Siz (µm)	%Siz(µm)	%Siz (µm)
Median size	24.422 µm	14.91 µm	13.67 µm
Mean size	52.95 µm	25.81 µm	39.29 µm
Mode size	18.59 µm	41.84 µm	10.79 µm
Diameter on cumulative %	(1)10.00%, 4.0185 µm (2)50.00%, 24.4225 µm (3)90.00%, 153.591 µm	(1) 10.00%, 2.005 µm (2) 50.00%, 9.5108 µm (3) 90.00%, 80.0880 µm	(1)10.00%2.796 µm (2)50.00%13.6732 µm (3)90.00%112.1935 µm

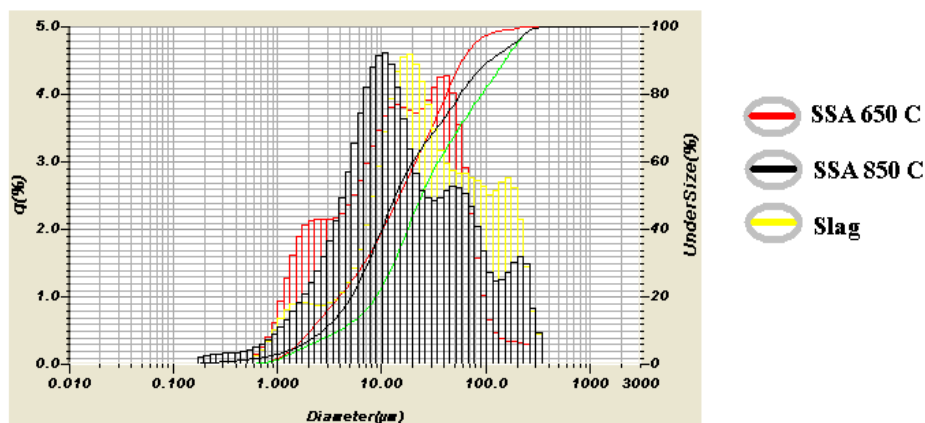
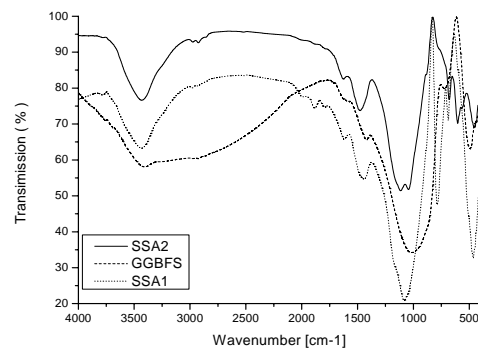


Fig.(2). Particle size distribution of SSA and GGBFS

2.3. FTIR analysis

IR spectra obtained for the starting materials (GGBFS, SSA1 and SSA2) are shown in Fig.(3). Some variations are observed in the FTIR spectra depending on the chemical composition and the condition of preparation. The bands at 3404, 3436, and another band at 3434 cm^{-1} are due to O-H water; a broad band centred at these bands is due to the symmetric and antisymmetric stretching vibration boundary (O-H) denoted that the GGBFS is less active than SSA1 and SSA2 but SSA1 is more active than both other. Also the bands at 1013, 1083, 1115 and 1038 cm^{-1} indicated intensive absorption bands characteristic for silicate Si-O-Si and aluminates AlO_4 for GGBFS, SSA1 and SSA2 respectively but in SSA2 the spectrum the band at 115 cm^{-1} is divided into two bands at 1144 and 1044 cm^{-1} as have been identified. The broad bands 1013 cm^{-1} is strong intensive bands characteristics for Si-O-Si asymmetric which of stretching for SSA1 has high SiO_2 content.

Clayden, et al., (1991). In 722,787 cm^{-1} band spectrum intensive sharp in case of SSA1 than those of GGBFS and SSA2 which explained why SSA1 is has a more pozzolanic activating than that of GGBFS and SSA2.



Fig(3) : FTIR Spectra for the starting materials

2.4. Microstructure

Fig. (4) showed the SEM micrographs obtained for the GGBFS (a), SSA1 (b) and SSA2 (c). From the SEM micrograph shown in Fig, (4.a) the rough and angular shaped particles are characteristic for the granulated blast furnace slag. In the Fig(4a and b), the SEM micrograph of SSA1 and SSA2 displayed spherical particles of different sizes with some gel- layers around the small particles. The particles of SSA1 (Fig 4b) are larger in size than those of SSA2 (Fig4c).

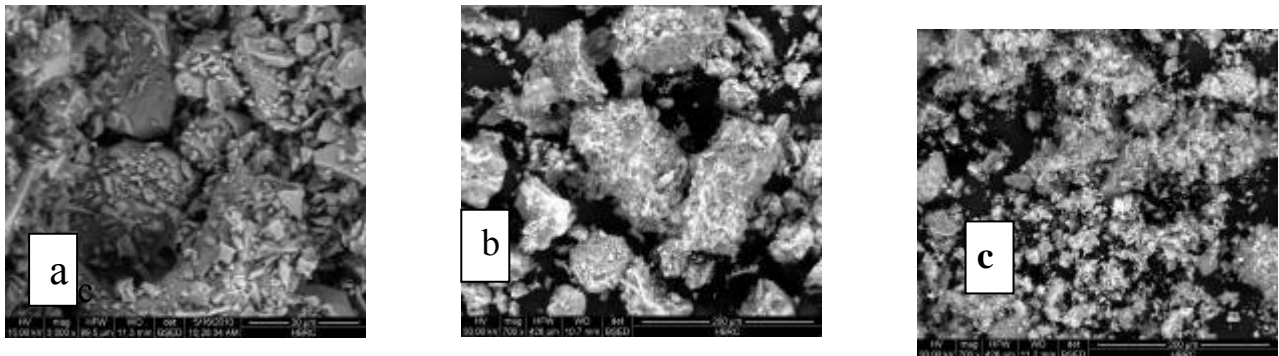


Fig. (4): SEM micrographs of starting materials ;(a)GBFS, (b) SSA1 and (c) (SSA2).

2.5 Mix preparation :

- The variable considered in this activation process were GGBFS(100%) and GGBFS /SSA ratio by (mass)of 95/5,90/10,80/20 and 70/30 using either SSA1 or SSA2 and SSA2
- Activator solution concentration was 18% NaOH and water ratio 0.3 weight of 100% GGBFS
- Added a super plasticizer a modified sulphonated naphthalene base to every mixes gradually until obtained suitable workability .The mass of superplastizer for the mix GGBFS(100%) was 118 ml, the

mass for mix SSA1 or SSA2 are shown in Table (3).

Table (3) % of superplasticizer add to SSA1 and SSA2

Ratio of SSA, %	superplasticizer add to SSA1, %	superplasticizer add to SSA2, %
5	19.6	33.75
10	18.13	33.0
20	17.65	29.68
30	15.78	25.78

The effect of the admixtures on the mechanical properties of the different tested depends on the type of binder and admixture used and, in the case of alkali-activated slag paste depends on the nature of the alkaline activator. The naphthalene-based admixture has a substantially different effect than any of the other admixtures on NaOH activated slag: it significantly reduces the 1/s ratio, thereby greatly enhancing mechanical strength.. The only admixture whose formulation is not altered—when the alkaline solution used NaOH is the naphthalene-based, which consequently originates a rise in mechanical strength values, improved workability and retardation of the initial and final sets times compared to slag pastes and mortars with no admixtures. And, it is in this case only that the performance of the admixture is comparable to its superplasticizing effects on Portland cement pastes and mortars.

At the day of testing, the pastes were removed from their batches and they were fractured into pieces. The crushed samples were immersed with acetone and diethyl ether in order to terminate the hydration reactions and finally they were dried to constant weight in a vacuum pump overnight. After the specimens were brought into powder form (all passing the 125 μ m

- Curing temperature: The paste specimens were maintained at 60°C during the first 8 hour of mixing. The rest of curing time, the specimens were maintained at ambient temperature 40°C and 90% \pm 5 of RH, considering these parameter, the pastes were elaborated in cubic (2.5x2.5x2.5 2.5) cm at determined ages (3,7,14,28,and 90 days).

2.3 Testing technique :

- The mechanical test performed for all mixes up to 90 days. Determination the pH value. At the day of testing, the pastes were removed from their batches and compressive performed for all mix up to 90 days they were fractured into pieces. The crushed samples were immersed with acetone and diethyl ether in order to terminate the hydration reactions and finally they were dried to constant weight in a vacuum pump overnight. After the specimens were brought into powder form (all passing the 125 μ m sieve).

- The micro structures of the specimens were studied on the specimens up to 28 days.

- Infrared spectroscopy (FTIR)

This test operated on the starting materials and fore all mixes after 28 days .Test sample was ground and uniformly mixed with KBr at eight ratio KBr: specimens =100:1. The mixture,0.2g % pressed to disk of 13mm in diameter for analysis.

The wave number was ranging from 400 to 4000 cm

- SEM study

For Scanning electron microscope (SEM) study of materials GBFS, SSA1 and SSA2 .After mix study the microstructure for blank B and for mix design at 28 days of curing.

3. Results and Discussion

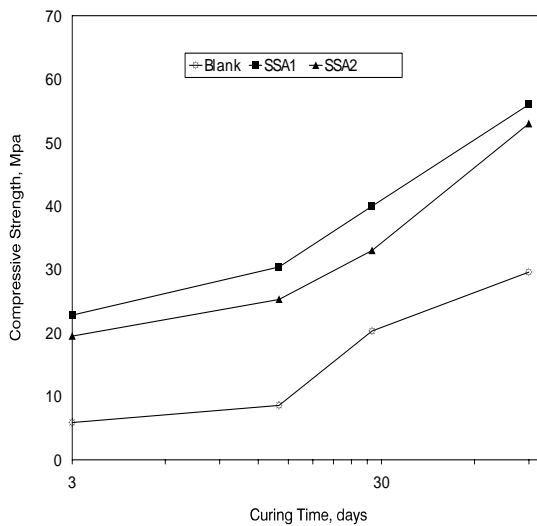
3.1 Compressive strength

The compressive strength of the hardened GBFS pastes activated with 18% NaOH is plotted as a blank for the comparison between the replacement GBFS by SSA1 and SSA2 (5, 10, 20, and 30%) to evaluate the effect of the replacement ratio and the suitable incineration conditions for the preparation of SSA replacement of alkali activated slag up to 90 days are presented in Fig 5. (a) 5%, (b) 10%, (c) 20% and (d) 30% for blank, SSA1 and SSA2. These graphs indicated that, in all mixes and at all ages studied, the compressive strength for all pastes increases with increasing time of hydration up to 90 days. According to the test results the compressive strength values of the replacement ratio 5% and 10% in (a), and (b) for both SSA at early and later ages are higher than those the blank B. The best compressive strength value 64 Mpa was obtained from the pastes made of 10% SSA1 up to 90 days as compared to blank mix (100% activated GGBFS) .

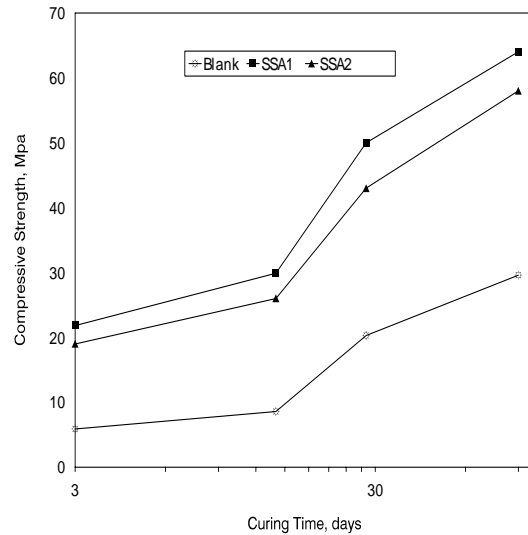
As it can be observed from Fig. 5, (a) and (b) that , the highest strengths are reached 56, 45, 64,

and 58 Mp at (a) and (b) for both SSA1 and SSA2 replacement than the blank, respectively, up to the 90 days. This result may be due to high alkali active silica, which binds with CH forming accessory pozzolanic C-S-H. The strength development is closely related to the activator 18% NaOH weight of GGBFS in case of replacement of 20, and 30% of SSA and SSA2 from GGBFS and the decrease in strength is due to the decrease of (CaO) ratio as a results

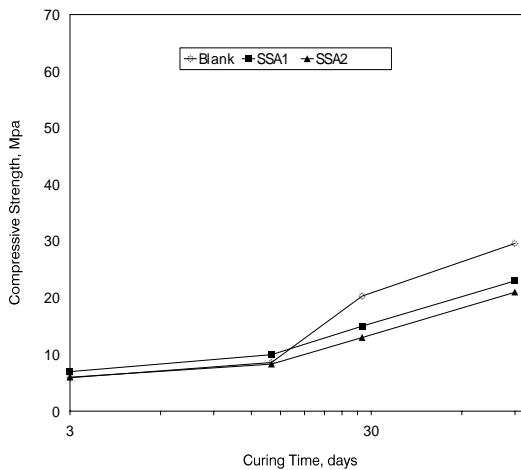
of the highest replacement of SSA1 and SSA2. The decrease in lime content (CaO) which is responsible to performed the CSH, This facilitates the formation of cross-linked structures that give rise to high strength values. When NaOH is the activator, however, since the hydrate calcium silicate contains a high proportion of SiQ2 but no Q3 (Al₂O₃) units, the mechanical strength values are decreased due to leaser C-S-H content.



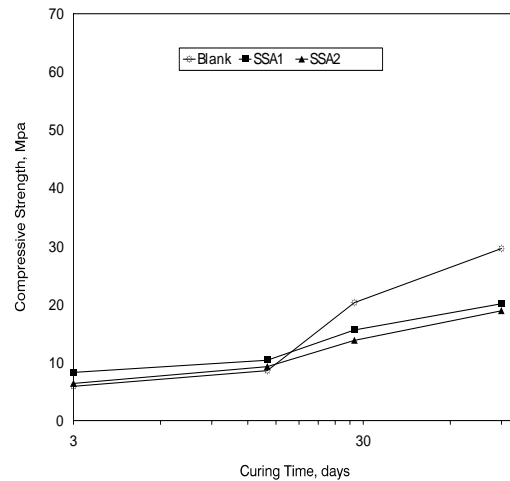
(a)



(b)



(c)



(d)

Fig. (5) : Compressive Strength of hardened pastes for (a) 5% , (b) 10%,(c) 20% and (d) 30% for blank , SSA1 and SSA2 cured up to 90days

3.2 . FTIR

Davidovits et al., (1991) clears up the theory of geopolymerization. This process represents the controlled synthesis of phases, so-called geopolymers or polysialates, whose properties are similar to natural zeolites. From the polycondensation reaction, unordered systems containing SiO_2 and Al_2O_3 in high alkali environment can result. The chemical name polysialate represents the fact that the 3D sialate network is built up by chains of SiO_4 and AlO_4 tetrahedra linked up by shared oxygen atoms. The negative charge of Al in IV coordination is balanced by Na^+ , K^+ , Ca^{2+} ions which are linked in the structure. With the growing content of CaO, the sequence of origination of new phases is changed during alkali activation as in the case of slag. Hydrated almost amorphous phases C-S-H ($\text{CaO-SiO}_2\text{-H}_2\text{O}$) which originate as a consequence of alkali activation significantly harden the resulting structure similarly as in the case of C-S-H Portland cement hydration products. The process of geopolymerization develops as a consequence. The necessary condition for latent hydraulicity of slag is the occurrence of an amorphous glassy phase. The presence of an activator causes the interruption of Si-O, Al-O and Ca-O bonds.

FTIR spectra of alkali activated GBFS (blank) and replacement with different ratio (5, 10, 20, and 30%) of SSA1 (A) and SSA2 (B) up to 28 days are shown in Fig. (6 A and B). From IR spectroscopy, two main types of compounds can be identified in the samples: silicates and carbonates. As can be seen in Fig. (6A) strong absorption zone between 900 and 1100 cm^{-1} with four maxima at 969, 987, 988, 954 and 958 cm^{-1} is produced for the reacted blank and SSA1 Fig. (6A) and 969, 989, 991, 941 with two maxima at 970 and 870 cm^{-1} for reacted SSA2 as shown in Fig. 6.B). The presence of calcite produces a wide band 1444.42, 1428.99, 1439.6 and 1420 cm^{-1} ; with maxima 970, 870 and 760 cm^{-1} , intensities are lower in the case of reacted SSA2 Fig. 6.B). The hydrated calcium silicates formed during the hydrothermal treatment (α -C2SH and CSH gel) could be identified by the absorptions appeared at 1000 and 969, 987, 988 cm^{-1} for 5% and 10% respectively. The higher intensity of these bands for reacted SSA1 would indicate a higher pozzolanic reaction degree for the SSA1. The strong and broad band located between 3909 and 3444, 3450 cm^{-1} stretching region is due to the lattice water and OH^- group vibration, the latter at 3700 and 3560 cm^{-1} could be related to the AlO_4 and SiO_4 groups of the katoite series. There are the chemical pozzolanic reaction products to fill in the minute voids, leading to higher compressive strength as in case

of 5 and 10% of SSA1 and SSA2 rather than the blank. However, the Ca(OH)_2 absorption remains manifest and does not turn into C-S-H bonding leading to lower strength up to 90. These variations in FTIR spectra are in accordance with the results of compressive strength.

3.3. Microstructure analysis

It could be observed from the results Fig. (7), (a), (b) and (c) for blank, 5% SSA1 and 5% SSA2. (d, e) for 10% SSA1, 10% SSA2, (f and g), for 20% SSA1 and SSA2, and (h and i) for 30% SSA1, SSA2 up to 28 days that the geopolymerization structure which could be due to the effect of addition of the alkali (18% NaOH) and the addition of amorphous silica from SSA to the GBFS. As can be observed in these micrographs records have quite different microstructures for all mixes. In Fig. (7) (a) denoted to the activated blank has many pores due to the alkali activation, (b) and (c) suggested that the formation of CSH and Ca-Al-Si amorphous.

In Fig. (7) (f and g), shows many spherical particles believed to be geopolymeric matrix has small slag content. Fig. (7) (h and i) the phases have more spherical geopolymeric and has some destructive strength structure in (h-i)

All results are in agreement with the results of compressive strength

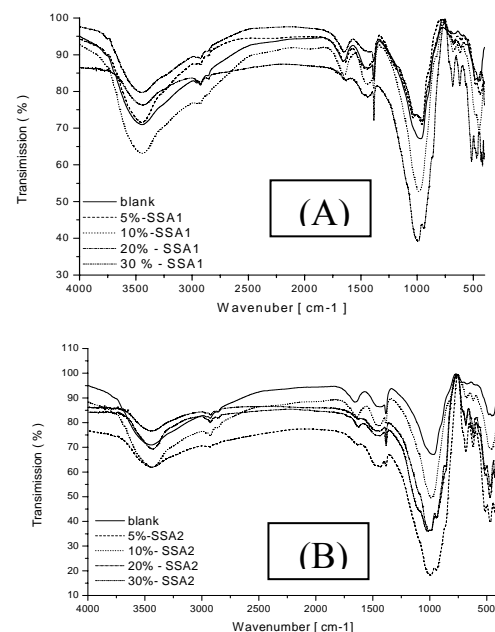


Fig. (6): FTIR spectra of alkali activated GBFS (Blank) and replacement with different ratios of SSA1 (A) and SSA2 (B) up to 28 days

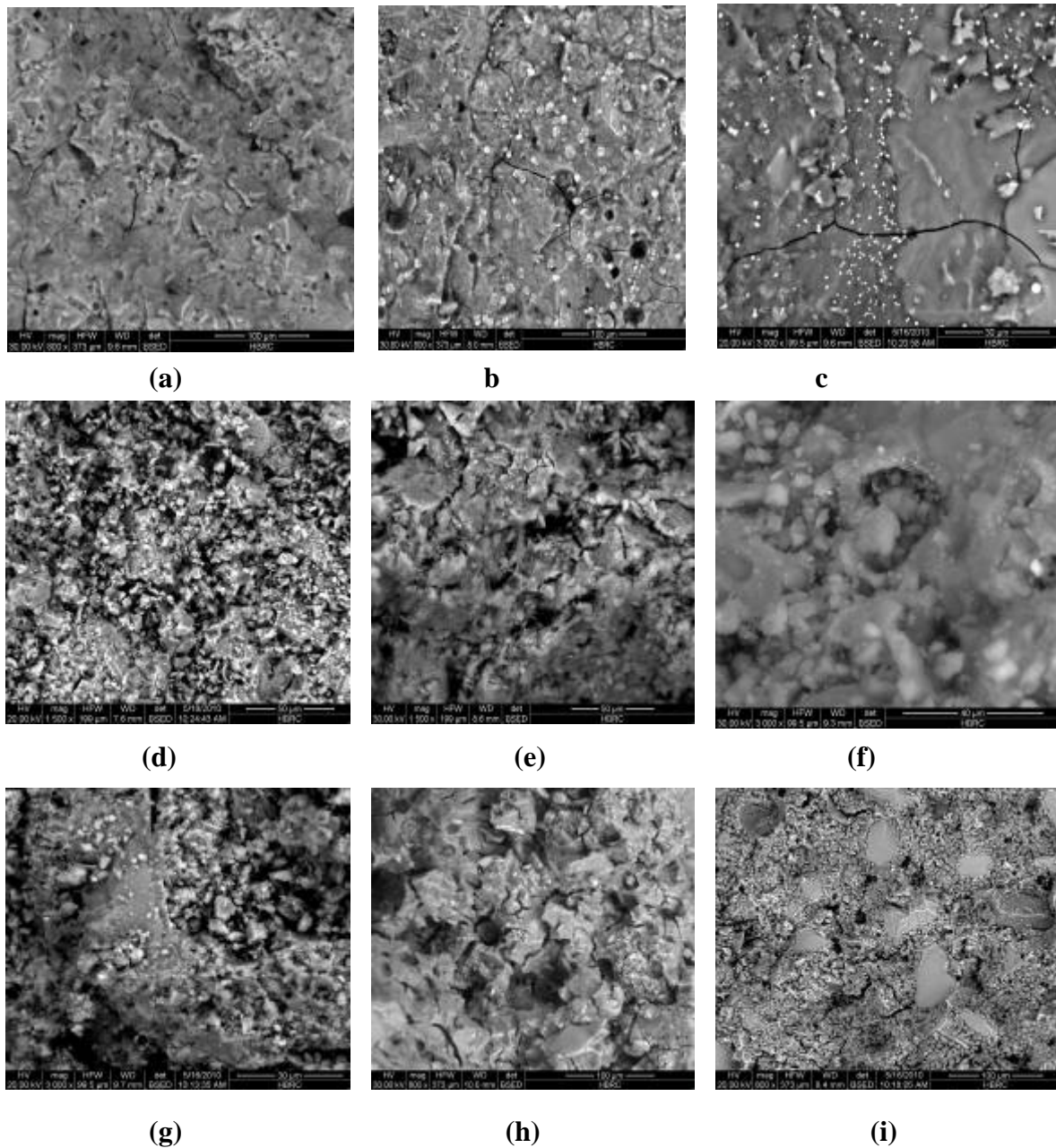


Fig. (7) : SEM micrographs of hardened pastes (a) 100% Activated GBSS, (b) with 5% of SSA1, (c) with 5% SSA2, (d) with 10 % SSA1, (e) with 10 % SSA2, (f) with 20 % SSA1, (g) With 20% SSA2, (h) with 30% SSA1 and (i) with 30% SSA2

Conclusions

- The Results obtained from of mixture waste of SSA1, and with replacement proportioned alkali-activator GGBFS prove that the possibility of producing geopolymer cementing from the mixing the both wastes.
- It was found that 5% and 10% of SSA1 and have relative compressive strength 253% and 270% more than the blank and greater than the

relative compressive strength for SSA2(137% and 222%) for the mix containing 5% and 10% replacements from the alkali activation GGBFS in early days up 3days. So sewage sludge ash has positive effect on GGBFS in early hydration time

- At later, ages the relative compressive strength for 10% SSA1 up to 90 days were 89.22% and 116.2%. greater than the blank, and higher than those of the mixes 5% and 10%

- SSA2(52% and 95.94%) from the alkali activation GGBFS up to 90 days
- From the resultant binder more residual holes resulting in strength reduction for the 20% and 30% replacement of SSA1 and SSA2 from alkali-activated slag, it may be due to the decrease of CaO and increase the ratios of alkalinity (NaOH), if there is an excess amount of hydroxide will be promoted. Subsequently, the strength decreased.
 - Precipitation of calcium hydroxide will inhibit any possible formation of CSH gel within a geopolymeric binder unless a significant amount of calcium is present initially.
 - From all results the 5% and 10% of SSA1 is economically stable for saving the energy of incantation, but must be performed more research to solve the wakens in the high ratio.
 - In Egypt, we have around 38 steel factories produce about 60 million tons / year from GBFS. This waste causes a big problem of pollution of surrounded areas (air, ground water, soil). Therefore, the recycling of this waste is very important to protect the environment and to have an economic benefit.
 - Also, we have about 100 million tons / year of sewage sludge produced from the wastewater treatment plants. This huge amount of sewage sludge is causing damage in the environment so the utilization of this waste is also important as previous reasons and it is the target of green building.
 - This paper summarizes the experimental results obtained for the alkali-activated technogenous pozzolana-granulated blast furnace slag, sewage sludge ash. The prepared materials, both dense and lightweight, displayed good product manufacturing qualities while their preparation is economically acceptable as well as being environmentally friendly by producing green building materials.
 - The durability effect must be studied.

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