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REVIEW ARTICLE

GREEN CONCRETE: CEMENT-LESS CONCRETE

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Green Concrete: Cement-Less Concrete

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  1. Materials
  2. Setting time
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Geopolymer is a type of amorphous alumino-silicate cementations material. Geopolymer can be synthesized by polycondensation reaction of geopolymeric precursor, and alkali polysilicates. Comparing to Portland cement, the production of Geopolymer has a relative higher strength, excellent volume stability, better durability. Geopolymer concrete based on pozzolana is a new material that does not need the presence of Portland cement as a binder.

1- GENERAL

An important ingredient in the conventional concrete is the Portland cement. The production of one ton of cement emits approximately one ton of carbon dioxide to the atmosphere. Moreover, cement production also consumes significant amount of natural resources.

Figure 1. Cement production consumes Figure 2. A huge volume of fly ash is not a lot of limestone and emits carbon dioxide effectively used On the other hand, already huge volume of fly ash is generated around the world; most of the fly ash is not effectively used, and a large part of it is disposed in landfills. In Viet Nam, volumes of fly ash are generated about 600,000 tons, but 100,000 is used to produce concrete. As the need for power increases, the volume of fly ash would increase. It is necessary and significant to use fly ash as material to produce concrete without Portland cement.

2- THE POLYMERIZATION AND MICROSTRUCTURE

2.1. The chemical composition, polymerization of the Geopolymer cement

The polymerisation process involves a substantially fast chemical reaction under alkaline condition on Si-Al minerals, those results in a three dimensional polymeric chain and ring structure consisting of Si-O-Al-O bonds.

A geopolymer can take one of the three basic forms (Fig.3).

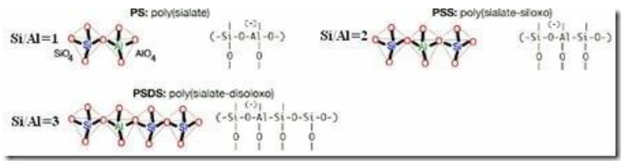
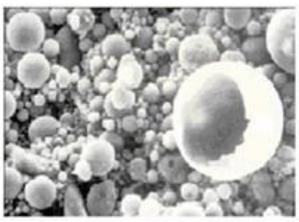


Figure 3. Three basic forms of geopolymer.

Figure 4. Polymeric structures from polymerisation of monomers.

2.2 MICROSTRUCTURE OF THE GEOPOLYMER CEMENT

Unlike ordinary Portland/pozzolanic cements, geopolymer do not form calciumsilicate-hydrates (CSHs) for matrix formation and strength, but utilize the polycondensation of silica and alumina precursors and a high alkali content to attain structural strength. Composition of the geopolymer is similar to natural zeolitic materials, but the microstructure is amorphous instead of crystalline. Fly ash particle: SEM was used to investigate the surface of fly ash, before and after reacting with NaOH. NaOH reacted with fly ash particles resulted in the roughness of surface as shown in Figure 5, 6, 7.



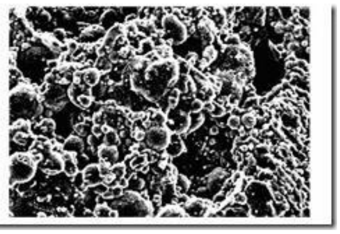


Figure 5. Fly ash before reacting with NaOH Figure 6. Fly ash after reacting with NaOH

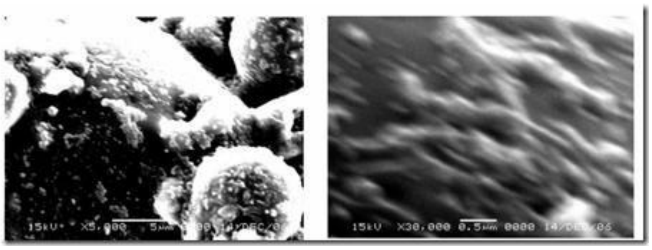


Figure 7. Fly ash after reacting with NaOH (x5000 and x30 000)

3- THE PROPERTIES OF GEOPOLYMER CEMENT

3.1. MATERIALS

Materials includes Fly ash (FA), sand Aggregates (SA), Alkaline Liquid (AL), water (W), Super plasticizer (SP). In the batches of fly ash, the molar Si-to-Al ratio was about 1-3.

A combination of sodium silicate solution and sodium hydroxide solution was chosen as the alkaline liquid. The sodium hydroxide (NaOH) solution was prepared by dissolving either the flakes or the pellets in water. The mass of NaOH solids in a solution varied depending on the concentration of the solution expressed in terms of molar, M.

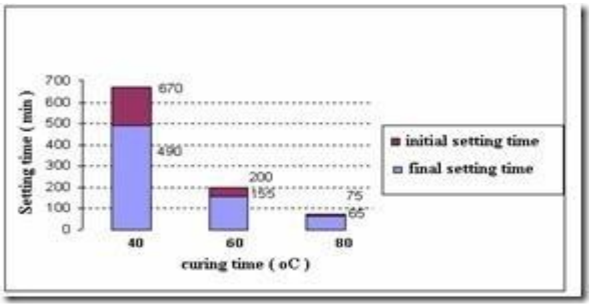
Sand is small Aggregates in geopolymer mortar. To improve the workability of the fresh geopolymer mortar, Super plasticizer was used in most of the mixtures.

3.2. SETTING TIME AND STABLE VOLUME OF GEOPOLYMER MORTAR

Setting time of geopolymer mortar depends on many factors. Such as types of fly ash, composition of alkaline liquid and ratio of alkaline liquid to fly ash by mass. However, the curing

temperature is the most important factor. Figure 8 shows the effect of curing temperature on setting time. As the curing temperature increases, the setting time decreases. The effect of curing temperature on initial setting and final setting time is similar to setting time.

Table 1. Composition of Fly Ash (mass %)



Oxides		Oxides	
SiO2 (%)	52.0	Na2O (%)	0.27
Al2O3 (%)	33.9	MgO (%)	0.81
Fe2O3 (%)	4.0	SO3 (%)	0.28
CaO (%)	1.2	LOI (%)	6.23
K2O (%)	0.83	SiO2 /Al2O3	1.5

Figure 8. Effect of curing temperature on setting time

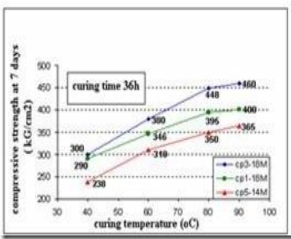
The stable volume of geopolymer mortar depends on many factors. However, curing temperature and curing time are primary factors. Geopolymer mortar specimen cakes are boiled in water about 4 hours after curing at 600C for 2 hours. It is not cracked. That means its volume is still stable.

3.3. COMPRESSIVE STRENGTH.

Table 2. Mixture proportion

Kí hi?u (kg)	FA	SA	AL	W	SP	AL/FA	W/AL
Cp1	527	1586	157(18M)	40	5.27	0.3	0.25
Cp2	527	1586	182(18M)	46	5.27	0.35	0.25
Cp3	527	1586	211(18M)	52		0.4	0.25
Cp4	527	1586	237(18M)	59		0.45	0.25
Cp5	527	1586	192(14M)	48			

Compressive strength depends on curing time and curing temperature. As the curing time and curing temperature increase, the compressive strength increase. Curing temperature in (600C- 900C), curing time in (24h-72h), compressive strength 400-500 kG/cm2.



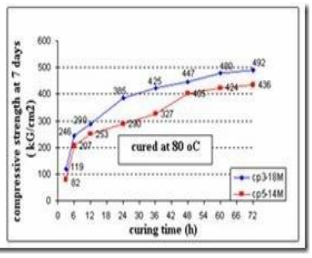
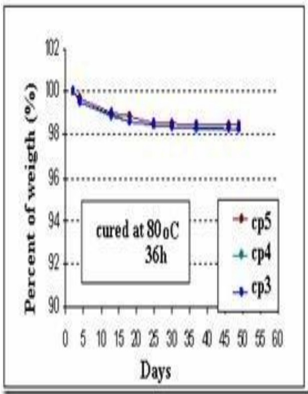


Figure 9. Effect of extra water on Figure 10. Effect of curing time on compressive strength. compressive strength.

3.4. RESISTANCE TO CORROSION

Since no limestone is used as a material, Geopolymer cement has excellent properties within both acid and salt environments. It is especially suitable for tough environmental conditions. Sea water can be used for the blending of the geopolymer cement. This can be useful in marine environments and on islands short of fresh water. (It is impossible to make Portland cement with sea water).



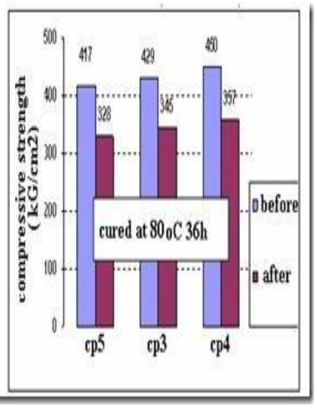


Figure 11. The loss weight of samples Figure 12. Change compressive strength after put into 5% HCl putting into 5% HCl for 7 weeks

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