Green Technology in Concrete Industry : Geopolymer Concrete

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Abstract

TNowadays, the global warming is the most serious problem in the world and the cement industry is one of the factors which are responsible for it. Therefore, the development of new binders with enhanced environment and durability performance is needed. In this regard, the geopolymer technology is one of the breakthrough developments as an alternative to the portland cement. This paper shows some points of view on the development of geopolymers by reviewing previous researches including historical background, constituents of geopolymers, process of geopolymerization and several applications of geopolymer. Hence, the author proposes two research trends which are finding the best combination between the source materials and alkali liquid then, evaluating the corrosion for the metal bars.

Keywords : geopolymerization, geopolymer concrete, environmentally friendly concrete, alkali-activated.

1. INTRODUCTION

Portland cement is a main component of concrete, however, it is not an environmentally friendly material. The production of portland cement not only depletes significant amount of natural resources but also emits a huge quantity of carbon dioxide (CO_2) and CO_2 contributes about 65% of global warming. The cement industry is responsible for about 6% of all CO_2 emissions, because the production of one ton of portland cement emits approximately one ton of CO_2 into the atmosphere. Therefore, to preserve the global environment from the impact of cement production, it is imperative to search and explore new possibilities to develop a concrete material that is more environmentally friendly as well as an efficient construction material to replace conventional portland cement concrete. In this regard, the geopolymer concrete is one of the revolutionary developments related to novel materials resulting in low-cost and environmentally friendly material as an alternative to the portland cement.[1)]

2. GEOPOLYMERS

In 1978, J. Davidovits developed and patented binder obtained from the alkali-activation of metakaolin and termed it as 'geopolymer'. Geopolymers belong to the family of inorganic polymers, and are chain structures formed on a backbone of Al and Si ions. The sialate network is composed of tetrahedral anions $[SiO_4]^{4-}$ and $[AlO_4]^{4-}$ sharing all the oxygen which is needed positive ions such as (Na^+, K^+, Li^+, Ca^{2+}, Ba^{2+}, NH_4^+, H_3O^+) to compensate the electric charge of Al3+ in tetrahedral coordination (after dehydroxilation the aluminium changes from coordination 6 (octahedral) to coordination 4 (tetrahedral)). The polysialiate has the following empiric formulate:

$$M_n\{-(SiO_2)_z-AlO_2\}_n, wH_2O \quad (1)$$

Where M is an alkali cation, such as potassium or sodium; n is the degree of polymerization; z is 1, 2, 3 or higher, up to 32 and w is the amount of binding water.

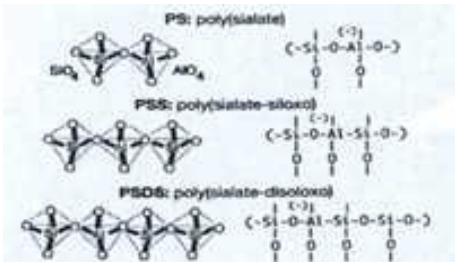

Figure 1. Poly(sialates) structures according to Davidovits[2)]

3. CONSTITUENTS OF GEOPOLYMERS

There are two main constituents of geopolymers: the source materials and the alkaline solutions.

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a) Source materials

Source materials play an important role in the formation of geopolymers. Wide range of solid aluminosilicate based source materials has been investigated for the synthesis of geopolymers.

b) Alkaline liquids

Alkaline liquid/solution plays an important role in geopolymer synthesis. Glukhovsky[3] have classified the alkaline activators in the following six groups, where M is an alkali ion:

1) Alkalis, MOH.
2) Weak acid salts, M_2CO_3, M_2SO_3, M_3PO_4, MF.
3) Silicates, $M_2O \cdot nSiO_3$.
4) Aluminates, $M_2O \cdot nAl_2O_3$.
5) Aluminosilicates, $M_2O \cdot nAl_2O_3 \cdot (2\text{-}6)SiO_2$.
6) Strong acid salts, M_2SO_4.

4. GEOPOLYMERIZATION

The geopolymerization process is an exothermic polycondensation reaction involving alkali activation by a cation in solution. The most proposed mechanism for geopolymerization may comprise the following three steps [4]:

- Dissolution of Si and Al atoms from the alumino-silicate source material in the strongly alkaline solution through the action of hydroxide ions.
- Diffusion or transportation or orientation or condensation of precursor ions into monomers.
- Setting or polycondensation/polymerisation of monomers into solid inorganic polymeric structures.

5. GEOPOLYMER APPLICATIONS

Geopolymers have potential to be a very useful engineering material and are gaining increasing attention as viable alternative to conventional materials for a wide range of applications. The Si to Al molar ratio in the poly (sialate) structure determines the properties and type of application of geopolymeric materials It can be seen from Table 1 that for many applications in the civil engineering field a low Si to Al ratio is suitable.

Table 1 . Application of Geopolymeric materials based on silica to alumina ratio[5]

Si/Al ratio	Application
1	– Brick – Ceramics – Fire protection
2	– Low CO2 cementsandconcretes – Radioactive and toxic waste enca-psulation
3	– Fibre glass composite – Foundry equipment – Heat resistant composites
〉3	– Sealants for industry
20-35	– Fire resistant and heat resistant fibre composites

6. CONCLUSION

Nowadays, global warming is the most serious problem in the world and portland cement industry is one of the factors which causes by emitting CO_2. Therefore, alternative cement technologies have become an interesting field and geopolymer technology is one of the revolutionary developments related to novel materials as an alternative to the portland cement. The development of geopolymer concrete is an important achievement. It suits the modern trends: low-cost and environmentally friendly.

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