A Review of Morphology Analysis on Dolomite as an Additive Material in Geopolymer

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Abstract. Dolomite is a carbonate mineral in nature. Dolomite (CaMg(CO3)2) is an anhydrous carbonate mineral composed of calcium, magnesium, and carbonate. The word dolomite is also used to describe the sedimentary carbonate rock, which is composed predominantly of the mineral dolomite (also known as dolostone). Dolomite had been one of the frequent used materials in most of researches due to its accessibility to acquire and the properties. The composition of Ca and Mg became one of the main attractions for the usage of this natural mineral. One of the main properties needed to be studied when using any materials is morphology of the material. Morphology analysis can give much valuable information about the surface topography and composition of the sample. Other than that, detailed three-dimensional and topographical imaging can also be obtained. This can helps the researches to finds the core value or the novelty in their study. Thus, reviews for the morphology analysis of dolomite were done to investigate how the structures of dolomite develop for certain study and usage. Besides that, dolomite as an addition into certain materials were reviewed and compared to observe the interactions and changes happened.

1. Introduction

Every year, more than 13 billion tons of carbon dioxide (CO2) was produced by the production of Portland cement (OPC). From the total CO2 emission of CO2 in this world, 7% of them were from the CO2 produced by OPC. This high CO2 emission may lead to environmental problems such as global warming and greenhouse effect [1][2]. To overcome this problem, geopolymer in introduced. Geopolymer is an inorganic materials that containing aluminosilicate materials which are Si and Al that undergo polymerization of the materials in strong alkali environment [3]. Besides that, geopolymer have attracted increasing attention in recent years for their potential uses as construction materials that would partly replace ordinary Portland cement (OPC) usage these days [4].

Geopolymers are amorphous to semi-crystalline three-dimensional aluminosilicate materials synthesized at low temperature in a short time [5]. Geopolymerization occurs in highly alkaline solution with aluminosilicate oxides and silicates as the reactants. It is carried out by putting the
aluminosilicate materials in contact with the alkaline activator solution which produce the polymeric chain of Si-O-Al-O bonds [6][7][8]. The most used alkaline solution for geopolymer is sodium hydroxide or potassium hydroxide and sodium silicate or potassium silicate solution. Based on latest study, alkaline activator that would give the most effective reaction towards geopolymerization would be the usage of sodium hydroxide solution with sodium silicate solution [9]. During geopolymerization, removal of water from the system occurs which makes that reaction exothermic in nature due to polycondensation [10]. Geopolymer synthesis involves dissolution, hydrolysis and condensation of aluminate and silicate species to form geopolymeric structure which occurs at room temperature [11]. The types of geopolymer was shown in Figure 1 which includes poly(sialate), poly(sialatesiloxo) and poly(sialate-dixoloxo) [12].

![Figure 1: The types of geopolymer](image)

Geopolymers have a wide range of properties and characteristics that depends on the raw materials used and the processing conditions. The characteristics of geopolymer includes high compressive strength, low shrinkage, fast or low setting, acid resistance, fire resistance, and low thermal conductivity[14]. With these advantages, geopolymers are considered to be suitable for a broad range of engineering materials applications [15][16].

2. Dolomite as a raw materials
Dolomite is one of the most common carbonate minerals in the geologic record. It is an anhydrous carbonate mineral composed of calcium, magnesium, and carbonate, ideally CaMg(CO$_3$)$_2$ [14][15]. Dolomite is widespread sedimentary rocks that are abundant and generally inexpensive natural minerals [19]. There are two main mechanisms by which dolomite can form in the natural environment: (1) “directly from solution” or primary dolomite, and (2) dolomites that formed during diagenesis or burial, most often through secondary replacement (dolomitization) of previously precipitated calcite or aragonite [20]. Dolomite is commonly used in road and building construction for foundation bases and as an aggregate for cement and asphalt concrete. Table 1 shows the chemical composition of dolomite.

| Element | CaO | SiO$_2$ | Al$_2$O$_3$ | Fe$_2$O$_3$ | MgO | K$_2$O | Na$_2$O |
|---------|-----|---------|-------------|-------------|-----|-------|--------|
| Value   | 33.4| 2.5     | 0.7         | 0.3         | 17.1| 0.1   | 0.1    |

Based on the chemical compositions, the highest composition content in dolomite is CaO with 33.4% and then followed by MgO with 17.1%. Besides that, dolomite also maintains SiO$_2$ and Al$_2$O$_3$ which is the backbone for the geopolymerization to occur. Due to the low Si and Al in the dolomite, the usage in geopolymer is quiet rare. Therefore, the study of dolomite in geopolymer would be a great
interest. The study for the compressive strength, morphology, phases, and chemical bindings can be discovering as a novelty.

3. Morphology analysis

3.1. Dolomite morphology

Figure 22 shows the morphology of dolomite raw material from different study. Figure 22a) show the finding from Ehud Cohen et al., [22]. The surfaces of dolomite on this study showed that it has a very rough surface with some of it have pointy shapes at the end. This dolomite have irregular shape and different of size.

Meanwhile in Figure 22 b), finding from Ana I. Casado et al., [23] shows that the dolomite had a smoother surface compared dolomite before. Although they have irregular shape, but here are no pointy ends that can be observed on the surface of the dolomite form Figure 22 b). Both of dolomite observed, have different surface. This will affect the reaction occurred when be used as a geopolymer.

![Figure 2. The morphology of dolomite raw material.](image)

3.2. Fly Ash/Dolomite Geopolymer Morphology

Figure 33 shows the morphology for dolomite/fly ash geopolymer for solid to liquid ratio of 1.0, 2.5, and 3.0 obtained from E. A. Aizat et al. It shows that 1.0 S/L ratio non-homogeneous reaction because most of the dolomite and fly ash particle were not fully surrounded by the geopolymer matrix. The 1.0 S/L also shows a large void is present in the surface of the geopolymer. Another S/L ratio is 2.5. This S/L shows most of the particles in the geopolymer were surrounded by the geopolymer gel. This proved that the reaction for this S/L ratio is better than 1.0 S/L. Besides that, the voids in 2.5 S/L became smaller compared to 1.0 S/L. The morphology analysis for 3.0 S/L observed had different
interaction. Some agglomeration occurred that can be observed and the material and geopolymer gel seems to be separated away from each other [24].

![Image of morphology for dolomite/fly ash geopolymer for solid to liquid ratio of a) 1.0, b) 2.5, and c) 3.0.](image)

**Figure 3.** Morphology for dolomite/fly ash geopolymer for solid to liquid ratio of a) 1.0, b) 2.5, and c) 3.0.

3.3. *Metakaolin/Dolomite Geopolymer*

Figure 4 shows the morphology of metakaolin/dolomite geopolymer. The results were based on the optimum compressive strength obtained by the addition of dolomite into metakaolin. There was a few these that can be observed. Firstly, A is the geopolymeric gel. This shows that the geopolymerization had been occurred there. Most of the surfaces were covered by the geopolymer gel. Label B show the unreacted of silica and alumina from the raw materials. There are only a small amount of unreacted silica and alumina. The unreacted is not due to the low reactivity, it was due to geopolymerization haven’t fully completed.

Besides that, label D scattering of sodium aluminosilicate material with a high proportion of calcium. The pores can’t be seen in this morphology due to the best mix ratio and dolomite addition into the systems. The morphology of fly ash/dolomite and metakaolin dolomite can’t be compared because of different surface appearance. However, it still can be seen that both of the surface become cloud shape at certain places.
4. Conclusion

As for conclusion, dolomite can be used as a geopolymer material and it gave different effect towards different addition usage. Besides that, dolomite addition will produce cloud shape to the geopolymer surface. Besides that, there are less study on the dolomite that the morphology can be fully compared and studied. Thus, more study should be done with dolomite as a geopolymer material which can give novelties to the researchers.

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