Chemical Composition, Distribution and Morphology of Beranang Laterite and Granite Aggregate

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Abstract. Imbalance ecosystem due to massive construction projects taken by the government and developers need to be tackled seriously. Replacement on the construction material nowadays become a trend in solving the part of the issue or as a whole. Investigation on the most popular concrete material, concrete need to be done properly in order to find potential replacements especially on the aggregate as it takes approximately 60 to 70% of concrete constituents. Laterite aggregate seems to have the potential as it is abundantly available in most region in Malaysia. This paper presents the chemical composition, distribution and morphological study on the Beranang laterite aggregate as compared to granite aggregate. The size use in the study is 20 mm maximum. The aggregates were subjected to, chemical elements, chemical elements distribution and the morphology analyses. From the results, it can be discussed that the main compositions such as carbon, silica, and oxygen were detected on the surfaces of both aggregates with similar peaks trend. Furthermore, the structural and morphology of both aggregates were also similar. In conclusion, based on the experimental carried out, Malaysian laterite aggregate has the potential to be acted as coarse aggregate in concrete mix. However, further experiments must be conducted to investigate the physical properties of it.

1. Introduction
Economic growth has propelled rapid infrastructure development in Malaysia and indirectly increased the demand curve for construction aggregates. Uncontrolled usage of natural aggregates is contributing to depletion issue of existing natural aggregate reserves, which is not sustainable for future developments (Wong. et al., 2015). Due to increasing demand of construction materials, the gates for many issues such as ecosystem interruption and depletion of natural aggregate sources were opened. This situation contributes to the shortage of natural aggregates curve of supply in several locations especially in urban areas which utilizes more concrete materials. The increase demand of concrete indirectly causes environmental issues as the ecosystem will be affected negatively (Khairunisa et al., 2015). The effect of these construction materials shortage will result to increase total construction project cost, and then transferring the bad effects to the end users (Hamid et al., 2006). Thus, the situation has created an urgency to find and study the potential of alternative materials in concrete production and at the same time preserve the nature. Previous researchers (Nima et al., 2013) and (Ramakrishna et al., 2018) studied the potential of alternative materials in concrete production and concluded that they help in protecting the environment. Utilization of laterite rock at 20% as partial aggregate replacement in concrete production is seen as one of the alternative to reduce the high dependency of concrete industry on granite aggregate supply (Khairunisa et al., 2015).
Laterite aggregate can be obtained within tropical regions especially on the hilly area with a lot of rainfall and sunlight throughout the year (Eyles, 1970). It is reported that in Malaysia, the laterite aggregate is available extensively in Malacca, Johor, Negeri Sembilan, Kedah, Pahang, Kelantan and Selangor throughout the year (Malaysia Meteorology Department, 2018). It can be categorized as one of the natural aggregate where the production is coming from a weathering process. The longer the weathering process happens, the stronger the particle would be as the crushing value will be increasing accordingly. The previous researchers have studied about the specific gravity (Abhilash, 2020), crushing value and impact value (Afolayan et al., 2019), moisture content (Muthusamy et al., 2015), permeability, plastic limit and liquid limit (Abdulwahid et al., 2015). Although there have been studies on the physical properties of laterite aggregate around the world, as partial aggregate replacement in concrete mix, but there is no further information on chemical properties that have been reported so far. Therefore, this paper addresses to present the chemical composition, the elements peak and the morphological properties of Beranang laterite and granite aggregate.

2. Methodology
Beranang laterite and granite aggregate was obtained from a location in Selangor with the particle size of 20 mm maximum. They consist of dark brown and greyish coloured particles. Laterite aggregate is found on the earth surfaces whereas granite aggregate produced through blasting work in quarry. Generally, the climate was affected the colour of the laterite aggregates as they go through a very long and continuous weathering process while exposed to numerous alternate drying and wetting cycles. In addition, the properties of the laterite aggregates were affected by the oxidation and level of exposure to the surrounding. Figure 1 and 2 exhibit the Beranang laterite and granite aggregate respectively.

**Figure 1** Laterite aggregate with maximum particle size of 20 mm

**Figure 2** Granite aggregate with maximum particle size of 20 mm
2.1. Sample preparation
A set of 6 samples consist of 20 mm particle size of Beranang laterite and granite aggregate were prepared by cleaning them up using tap water before being oven dried with the temperature of 105 °C for 60 minutes to eliminate the moisture on the surface and inside the pores. The preparation of the samples was based on the British Standard, BS 812-100 (1990). The samples then were put on the SEM-EDX stage and was set to 100x magnificient to have a better resolution after being cooled at the room temperature (approximately 27 °C) for several hours. The samples were tested upon chemical compositions, the morphological analysis, the composition peak and their distributions by using different section of the SEM-EDX equipment.

2.2. Sample Testing
The samples were attached to the SEM mount that constructed from carbon where the presence of carbon peak in the spectrum was not interfere with the elemental comparisons. The adhesive was removed from the backing to eliminate contribution of it upon the spectrum results. A backing was attached directly to a mount by using the tape’s own adhesive where it was typically not a concern during backing analysis. Thus double sided tape was used as mounting adhesive for each samples. The samples then adjusted to the focus area of analysis. The chemical compositions, the morphological analysis, the composition peak and their distributions were being tested by using SEM-EDX equipment by referring to the ASTM E1508-12a (2019). The results of chemical composition were digitally tabulated in term of qualitative and quantitative graphs, whereas chemical composites distribution were focus on scanned area only. The morphology of both aggregate samples were taken on the scanned surface area. In conclusion, the computational results on the chemical elements, the peak of elements and their distributions and morphology were appeared simultaneously on screen and ready to be saved.

3. Result and Discussion

3.1. Chemical compositions and peak
The petrological aspect is a considerable factor that cause to affect the serviceability and durability of concrete. Table 1 presents the chemical element content of the Beranang laterite and granite aggregate. There is variation in the percentages for elements content of Beranang laterite and the granite aggregate. From the tabulated results, laterite consisted of high silica element which assists in producing higher silica oxides during the weathering process. Lekshmy et al. (2016) stated in the previous research that silica fume improves the bonding as well as compressive strength of laterite, the Beranang laterite aggregate becomes harder and is able to achieve higher covalent bonds. It can be seen in Table 1 that the Beranang laterite aggregate has a carbon element. This is because it consumes this element during the weathering process. This fact has been highlighted by Basavana (2018) who mentioned the workability of concrete with unprocessed laterite are substantially lower compared to those with processed laterite. There were different chemical compositions detected since both aggregates come from a different origin which contribute to the peaks exhibits in Figure 3 and 4. Granite aggregates are a type of coarse aggregates or igneous rocks that are rich in quartz and feldspar, and laterite aggregate is a type of coarse aggregate that appears from a tropical region which is rich in secondary oxides of aluminium, iron or both and highly weathered. At the same time, only granite has natrium and magnesium elements but there are none in laterite aggregates. The difference in the type of elements present in these aggregates is because of the different background of production. Granite is formed from cold magma (Joseph, 2012) Laterite is a highly weathered material rich in secondary oxides of iron, aluminium or both (Asiedu, 2014). Laterite aggregate undergoes weathering and laterization process which involve chemical and physico-chemical transformation of primary rock-forming minerals that are rich in secondary oxides of iron, aluminium or possibly both laterite constituents and clay minerals. During the weathering process, ferum element produces Fe₂O₃ (hematite) which is brownish in colour.
Table 1 Chemical compositions for laterite and granite aggregate

| Element (%) | Type    | C   | O    | Na  | Mg  | Al  | Si   | K    | Ca  | Ti  | Fe  |
|-------------|---------|-----|------|-----|-----|-----|------|------|-----|-----|-----|
|             | Laterite| 1.32| 62.24| 0   | 0   | 15.98| 11.38| 0.77 | 0.23| 0.9 | 7.18|
|             | Granite | 0   | 58.01| 0.89| 1.26| 6.91 | 17.76| 3.01 | 0.92| 0.96| 10.28|

Figure 3 The chemical composition of laterite aggregate

Figure 4 The chemical composition of granite aggregate

3.2. Distribution of chemical elements
The element’s content and distribution of Beranang laterite and granite aggregate were analysed by using EDX and elemental mapping. Figure 5 and 6 present the distributions of three major chemical elements that were detected on both aggregate surfaces. These major elements were carbon, silicon and oxygen. This is in line with previous researcher results on chemical elements of laterite and granite aggregate (Khairunisa et al., 2015). From the experiments, it can be highlighted that the presence of large carbon feature was originated from the carbonaceous material. It is due to carbonation process during the weathering cycle. Due to that, the other elements which are silicon and oxygen were also features in the major elements due to the natural elements hence validating the claim that these two aggregates are sustainable materials suitable to be used in construction projects.
3.3. Morphology of aggregates
The morphological of laterite and granite aggregate was carried out through FESEM analyses as exhibit in Figure 7 and 8 respectively. The observation on the shapes and roughness surface proposed that both aggregates are suitable to be used in concrete mix where the sharp edges help bonding formation of each concrete constituents for a long duration.

![Figure 7 The morphological analyses of laterite aggregate](image-url)
4. References

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