# GEOTECHNICAL AND MORPHOLOGICAL PROPERTIES OF RAW AND PROCESSED BUKIT GOH BAUXITE

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B.ENG (HONS.) CIVIL ENGINEERING

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Thesis submitted in fulfillment of the requirements for the award of the degree of Bachelor in Civil Engineering

Faculty of Civil Engineering and Earth Resources
UNIVERSITI MALAYSIA PAHANG

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## SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering (Hons.) Civil Engineering.

Signature :
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Date : 3 January 2017

## STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

Signature :
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| | |
|---|---|
| $c'$ | Cohesion angle |
| $o'$ | Friction angle |
| $\tau_f$ | Effective stress |
| $u$ | Pore water pressure |
| $\omega$ | Moisture content |
| $c'$ | Cohesion angle |
| $\%$ | Percentage |
| $mm$ | Millimeter |
| $m$ | Meter |
| $g$ | Gram |
| $kg$ | Kilogram |
| $°C$ | Degree Celsius |
| $\mu m$ | Micrometer |

## LIST OF ABBREVIATIONS

| | |
|---|---|
| Al | Aluminium |
| ASTM | American Society for Testing and Materials |
| Fe | Iron |
| FESEM | Field Emission Scanning Electron Microscope |
| IMSBC | International Maritime of Solid Bulk Cargoes |
| LI | Liquidity Index |
| LL | Liquid Limit |
| Na | Sodium |
| O | Oxygen |
| pH | Potential Hydrogen |
| PI | Plasticity Index |
| Ti | Titanium |
| Si | Silicon |
| XRF | X-Ray Fluorescence |

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## ABSTRACT

This study focus on the differences of geotechnical properties between raw and processed Bukit Goh bauxite. As bauxite material has high clay content which mostly composed of silicate minerals, it has high risk to cause cargo liquefaction which in turn causes catastrophic incident. This paper includes the analysis of raw and processed bauxite where its fine particle contents has been minimized using beneficiation method to reduce the risk of liquefaction by referring to the International Maritime Solid Bulk Cargoes Code (IMSBC Code) standard. To analyze these characteristics of the bauxite, five samples were selected at Bukit Goh, Kuantan; three of the samples from the Bukit Goh mine and two samples from stock pile were tested to identify the bauxite geotechnical properties by referring to GEOSPEC 3: Model Specification for Soil Testing; particle size distribution, moisture content, specific gravity, morphological properties as well as its elemental and oxide properties. Laboratory tests involved including Small Pycnometer test, Dry Sieve test, Specific Gravity test, X-ray fluorescence test (XRF) and Field emission scanning electron microscopy test (FESEM). The results show that average moisture content of raw bauxite is 24.81% which exceeded the recommended value of maximum 10% while the average moisture content of processed bauxite is only 6.69%. The average fine material for raw bauxite is 38.40% which should not be greater than 30% per IMSBC standard while for processed bauxite is 21.40%. From the FESEM image, it was clearly shown that the fine particles of processed bauxite is lesser than raw bauxite. In conclusion, the quality and safety of processed bauxite is better than raw bauxite.

# ABSTRAK

Kajian ini memberi tumpuan kepada perbezaan ciri-ciri geoteknik dan ciri-ciri morfologi diantara bijih bauksit Bukit Goh yang mentah dengan yang telah diproses. Bijih bauksit mengandungi kandungan tanah liat yang tinggi dimana ia terdedah kepada risiko yang tinggi untuk fenomena likuifaksi kapal kargo untuk berlaku yang boleh mencetuskan kemalangan yang serius. Kajian ini mengandungi analisa bauksit mentah dan bauksit yang telah diproses dimana zarah halusnya teleh dikurangkan melalui proses benefikasi untuk mengurangkan risiko likuifaksi kapal kargo dengan merujuk kepada Kod Maritim Antarabangsa Kargo Pukal Pepejal (Kod IMSBC). Bagi menganalisa ciri-ciri bauksit ini, lima sampel telah diambil dari Bukit Goh, Kuantan, tiga daripada sampel itu adalah dari kawasan lombong Bukit Goh, dan dua daripada simpanan stok dimana kesemuanya diujikaji untuk mengetahui ciri-ciri geotekniknya dengan berpandukan kepada GEOSPEC 3: Model Spesifikasi untuk Ujian Tanah (Model Specification for Soil Testing); taburan saiz zarah, kandungan kelembapan, berat jenis, sifat-sifat morfologi dan juga ciri-ciri elemen dan oksida. Ujian makmal yang terlibat adalah ujian Piknometer Kecil, ujian Ayak Kering, ujian berat jenis, ujian XRF dan ujian FESEM. Keputusan analisis mengindikasi bahawa purata kandungan lembapan tanah mentah adalah 24.81% yang mana ia melebihi nilai maksima yang disyorkan iaitu 10% manakala purata kandungan lembapan tanah yang diproses adalah 6.69% sahaja. Taburan purata saiz zarah halus bauksit mentah adalah 38.40% dimana ia melebehi peratusan 30% yang dinyatakan dalam kod IMSBC manakala 21.40% bagi bauksit yang telah diproses. Dari gambar FESEM, ia menunjukkan bahawa zarah halus bauksit diproses adalah kurang berbanding dengan bauksit mentah. Kesimpulannya, tahap kualiti dan keselamatan bauksit yang diproses lebih baik dari bauksit mentah.

# CHAPTER 1

# INTRODUCTION

## 1.1 BACKGROUND OF RESEARCH

Aluminium is a silvery, white, soft, nonmagnetic, ductile metal that is the most abundant metal and it is the third most available element in the earth's crust. The main ore of aluminum is bauxite which a mixture of hydrated aluminum oxide ($Al_2O_3.H_2O$) and hydrated iron oxide ($Fe_2O_3.H_2O$). It is a metal that have high valuable properties. It has a density of 2.70 g/cm which is light, non-toxic, and can be cast easily or machined. It has lower density and is used widely for electrical transmission lines as it has an electrical conductivity 60% that of copper. Pure aluminum are strengthened by alloying with little amounts of silicon, magnesium, and copper despite it is very brittle and soft (Shakhashiri, 2012).

Bauxite is the principal ore of alumina ($Al_2O_3$), which is used to produce aluminum (Al). Iron oxides, hydrated iron oxides, hydrated aluminum oxides, hydrated aluminosilicates, silica, and titanium oxide are the main compound that made up bauxite. Bauxite also contains minerals such as, boehmite, ilmenite, hematite, Al- quartz, anatase, gibbsite kaolin, rutile goethite, and goethite. It is a residual rock that formed from the weathering of various, metamorphic rocks, igneous and sedimentary and these relative rocks are exposed to weather under tropical, subtropical, or very humid conditions of ninety percent of the world bauxite resources are in tropical locations for around millions of years. Other deposits besides the latitudes mentioned were exposed to a long intense weather condition in their geologic past.

Places like West Africa, South and Central America, and then in India, Australia, and Vietnam are where the greatest abundance of bauxite are in. Besides that, bauxite deposits also found in the center of Saudi Arabia and north of Russia. Basically, bauxite occurs near the surface of the earth with only 1 or 2 meter of overburden and common deposits range in thickness from 3 to 15 meter, but there are phenomenon of buried bauxite deposits where the bauxite are covered by other materials like the post-formation of bauxite. The recent global bauxite resource is estimated more than 70 billion tonnes and the greatest abundance is in Guinea, with resources of around 25 billion tonnes. The underground buried bauxite deposits are normally related to a surface occurrence where the land that helps the formation of the bauxite has tilted, so the ore found on the surface will gradually be deeper, and to economically extract for this material, underground mining is needed. In China, there was around 165 million tonnes of bauxite mined each year (Donoghue, 2014).

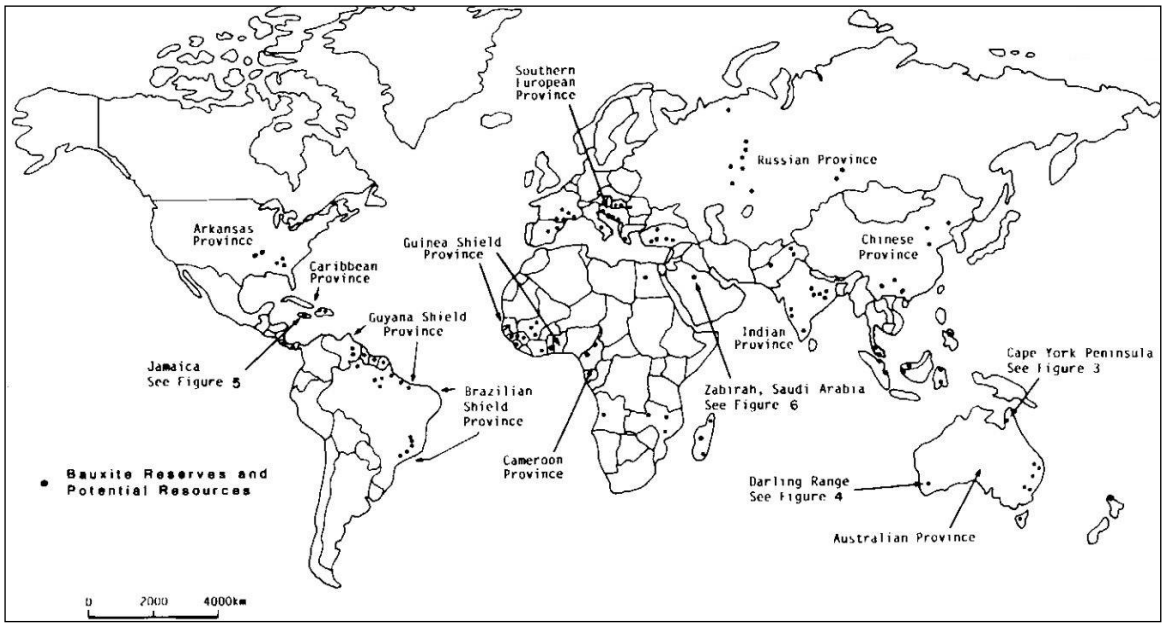


**Figure 1.1**: World Bauxite Provinces

Source: Geoscience Canada: Bauxite (1993)

Long time ago, Malaysia was very active in mining activities especially tin mining and other minerals but recently, Malaysia had suddenly emerged to become the source of bauxite worldwide. This incident happened in a flash back in January 2014, when Indonesia government banned the exports of bauxite ore to China to grow its own aluminium-smelting industry. Indonesia has stop as China's major bauxite supplier up to that point of time. After that, as the mining activities has stopped in Indonesia, some mining companies started to look at the hills above Kuantan where there are abundances amount of bauxite which is lower quality than in Australia and Indonesia. The Malaysia bauxite ore production raised from a small amount of 200,000 tonnes in 2013 to approximately 20 million tonnes last year in 2015 and now Malaysia is the world's top of bauxite ore producer as nearly half of the supply is sent to China.

In Pahang, most of the land has been used for settlers for development. Therefore, companies had to approach small companies whose land contain bauxite and offer them some large sums of money in exchange to mine their land (BBC, 2016).

However, the environmental disaster at Kuantan bauxite mining site is the consequences from the stacked with poor regulations, greed and corruption and enforcement. In less than five years, Malaysia’s bauxite reserves may be depleted based on last year’s sales to China alone. According to Jackie Wang, researcher from CRU Group Chinese, alumina refineries may seek bauxite from suppliers in Guinea and Australia instead (Bloomberg, 2016).

Tremendous problems have been cause by the uncontrolled bauxite mining activities in Kuantan that lead to water and air pollutions. Researcher and society has been fighting to tackle the problem arise. In addition, after the mining activities, the leftover mine site will be left unattended. Miners have no proper mining guidelines that leads to uneven soil level and leads to drain clogging that may cause flood to occur. Uneven level of soil produced a dangerous slope at the area that can cause landslide and another catastrophe. There is an uncertain doubt that what the people and society can do after all the surface bauxite have been mined in the future. The geotechnical properties and other data of Kuantan bauxite is very less and we need to know more about it to help the society moving forward.

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