

LIQUEFACTION RISKS ON BULK CARGOES
CARRYING BUKIT GOH BAUXITE IN
ACCORDANCE INTERNATIONAL MARITIME
SOLID BULK CARGOES (IMSBC) CODE

SYAZWAN BIN SUKRI

B. ENG (HONS.) CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHANG



SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor Degree of Civil Engineering.

(Supervisor's Signature)

Name of Supervisor : ASSOC. PROF. DR. MUZAMIR BIN HASAN

Position : ASSOCIATE PROFESSOR

Date : 29 December 2017



STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

(Student's Signature)

Name : SYAZWAN BIN SUKRI

ID Number : AA14012

Date : 29 December 2017

LIQUEFACTION RISKS ON BULK CARGOES CARRYING
BUKIT GOH BAUXITE IN ACCORDANCE TO
INTERNATIONAL MARITIME SOLID BULK CARGOES
(IMSBC) CODE

SYAZWAN BIN SUKRI

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

Faculty of Civil Engineering and Earth Resources
UNIVERSITI MALAYSIA PAHANG

December 2017

ACKNOWLEDGEMENTS

Firstly, I would like to thank God for his greatness for lending his power all these while for me to complete this Final Year Project course.

I would like to express my highest sincere appreciation to my supervisor Assoc. Prof. Dr. Muzamir Bin Hasan for his valuable supervision, continuous encouragement, cooperation and guide me to the right direction in making this research a success. His wide knowledge, experiences and skills in the has allowed me to perform better and sharpen my capabilities in many areas, especially in the field of Geotechnical Engineering.

I would also like to thank all the lab assistants in Soil and Geotechnics Laboratory, Universiti Malaysia Pahang, Mr. Ziunizan, Mr. Nor Azmi and Mr. Haliman who provided me trainings and equipment during my laboratory testing to complete my project.

Next, I want to thank all my friends especially Muhammad Fathi for their support, guidance, sharing and suggestions throughout my research as their helps are important for the completeness of this project.

Finally, thank you to my family members especially my parents for their love, moral supports and encouragement in completing this research work.

TABLE OF CONTENT

DECLARATION

TITLE PAGE

ACKNOWLEDGEMENTS **ii**

ABSTRAK **iii**

ABSTRACT **iv**

TABLE OF CONTENT **v**

LIST OF TABLES **viii**

LIST OF FIGURES **x**

LIST OF SYMBOLS **xi**

LIST OF ABBREVIATIONS **xii**

CHAPTER 1 INTRODUCTION **1**

1.1 Background of Research 1

1.2 Problem Statement 4

1.3 Objective 5

1.4 Scope of Research 6

1.5 Significance of Research 7

CHAPTER 2 LITERATURE REVIEW **8**

2.1 Introduction 8

2.2 Bauxite 8

2.2.1 Bauxite Production 10

2.2.2 Bauxite Process 15

2.2.3	Alumina and Aluminium	19
2.3	Bauxite Geotechnical Properties	20
2.3.1	Moisture Content	21
2.3.2	Particle Size Distribution	22
2.3.3	Specific Gravity	22
2.4	Mineralogy	23
2.4.1	Alumina Mineral	23
2.4.2	Impurities	24
2.5	Chemical Properties	25
2.5.1	Formation Process	25
2.5.2	Bauxite Chemical Compositions	27
2.5.3	Morphological	28
2.6	Bauxite Liquefaction	30
2.6.1	Cargo Classification	32
CHAPTER 3 METHODOLOGY		33
3.1	Introduction	33
3.2	Sampling	35
3.2.1	Beneficiation Procedure	36
3.3	Determine of Geotechnical and Chemical Properties of Material	37
3.3.1	Moisture Content	37
3.3.2	Particle Size Distribution	38
3.3.3	Specific Gravity	40
3.3.4	X-ray Fluorescence (XRF)	41
3.3.5	Field Emission Scanning Electron Microscopic (FESEM)	42

CHAPTER 4 RESULTS AND DISCUSSION	44
4.1 Introduction	44
4.2 Particle Size Distribution	45
4.2.1 Results for PSD Between 2 Samples Bauxite based on Graph	52
4.2.2 Comparison between Raw and Processed Bauxite	55
4.3 Specific Gravity	56
4.4 Moisture Content	59
4.5 X-Ray Fluorescence (XFR)	61
4.5.1 Comparison Bukit Goh Bauxite with Other Area	64
4.6 Field Emission Scanning Electron Microscopy (FESEM)	65
4.7 Comparison with IMSBC Code	67
 CHAPTER 5 CONCLUSIONS	 69
5.1 Conclusions	69
5.2 Recommendations	71
REFERENCES	72

LIST OF TABLES

Table 2.1:	Approximate mineralogical compositions of lateritic and karst bauxites	21
Table 2.2:	Typical properties of (Iron Ore Fines) IOF samples	21
Table 2.3:	Bauxite Specific Gravity	22
Table 2.4:	The main alumina containing minerals that in bauxites	23
Table 2.5:	Types of impurities found in bauxite	24
Table 2.6:	Bauxite deposits occur in rocks ranging in age from Precambrian to Holocene	25
Table 2.7:	Major element composition of bauxite rock samples	28
Table 2.8:	Liquefaction accidents	31
Table 2.9:	The characteristics of the bauxite in IMSBC code	32
Table 3.1:	Quantity of bauxite samples for each testing.	35
Table 3.2:	Tests and Standards for the materials	37
Table 4.1:	Result of sieve analysis for (M2L1B1) – Raw	45
Table 4.2:	Result of sieve analysis for (M2L2B1) – Raw	46
Table 4.3:	Result of sieve analysis for (M2L2B2) – Raw	46
Table 4.4:	Result of sieve analysis for (PTSTL1B1) – Raw	47
Table 4.5:	Result of sieve analysis for (PTSTL2B1) – Raw	47
Table 4.6:	Result of sieve analysis for (M2L1B1) – Processed	48
Table 4.7:	Result of sieve analysis for (M2L2B1)– Processed	48
Table 4.8:	Result of sieve analysis for (M2L2B2) – Processed	49
Table 4.9:	Result of sieve analysis for (PTSTL1B1) – Processed	49
Table 4.10:	Result of sieve analysis for (PTSTL2B2) – Processed	50
Table 4.11:	Summary of percentage passing of Raw Samples.	51
Table 4.12:	Summary of percentage passing of Processed Samples	51
Table 4.13:	Percentage of fine particles between raw and processed Bukit Goh Bauxite	55
Table 4.14:	Specific gravity raw sample	56
Table 4.15:	Specific gravity of processed sample	56
Table 4.16:	The Calculation for Specific Gravity test for processed sample	57
Table 4.17:	Average moisture content of raw sample	59
Table 4.18:	Average moisture content processed sample	59
Table 4.19:	Calculation Moisture Content for Processed Sample	60
Table 4.20:	Raw and processed Bukit Goh Bauxite (M2L2B1) elements	62

Table 4.21:	Raw and processed Bukit Goh Bauxite (M2L2B1) oxides	62
Table 4.22:	Comparison between Bukit Goh with other region	64
Table 4.23:	Magnification of raw and processed Bukit Goh bauxite sample under 1000x and 2000x magnification	65
Table 4.24:	Magnification of raw and processed Bukit Goh bauxite sample under 5000x and 10 000x magnification	66
Table 4.25:	The International Maritime Solid Bulk Cargoes (IMSBC) Code	67
Table 4.26:	Comparison table of fine particles and moisture content with IMSBC code	68

LIST OF FIGURES

Figure 1.1:	World Bauxite Provinces	2
Figure 1.2:	Bauxite mining area in some place in Kuantan	3
Figure 1.3:	Bauxite sample location	6
Figure 2.1:	Bauxite with a core of unweathered rock	9
Figure 2.2:	Location of IAI surveyed bauxite mining operations in 2006	11
Figure 2.3:	Bauxite mining process	12
Figure 2.4:	Bauxite production and land use from 1991 to 2006 (tonnes per m ²)	14
Figure 2.5:	Bauxite production	14
Figure 2.6:	The Flow Chart Bayer Processing of Jamaican Bauxite	18
Figure 2.7:	Bauxite Processing	19
Figure 2.8:	The composition of bauxite samples from a range of deposits	27
Figure 2.9:	High-resolution bright field SEM image of the bauxite residue (A), mineral acids (B, C and D) and organic citric acid (E and F)	29
Figure 2.10:	Major incidents investigated during this study along with the main vessel and incident details	32
Figure 3.1:	The methodology proposes for the research	34
Figure 3.2:	Example bauxite sample at Stock Pile that use	35
Figure 3.3:	Raw bauxite underwent beneficiation process	36
Figure 3.4:	Raw bauxite sample and Processed bauxite sample (Beneficiated)	36
Figure 3.5:	Raw and Processed bauxite being placed in oven at 105–110 °C	38
Figure 3.6:	Bauxite being weighted for moisture content test	38
Figure 3.7:	Bauxite sample in the Sieve Shaker	39
Figure 3.8:	Hydrometer Test Equipment	39
Figure 3.9:	Small pycnometer filled with bauxite in the vacuum chamber	40
Figure 3.10:	All the bauxite sample was put into small pycnometer	40
Figure 3.11:	The XRF (BRUKER S8 TIGER) equipment	41
Figure 3.12:	The FESEM (JSM-7800F) equipment	42
Figure 4.1:	Particle size distribution of M2L1B1	52
Figure 4.2:	Particle size distribution of M2L2B1	53
Figure 4.3:	Particle size distribution of M2L2B2	53
Figure 4.4:	Particle size distribution of PTSTL1B1	54
Figure 4.5:	Particle size distribution of PTSTL1B2	54
Figure 4.6:	Tabulation of average specific gravity	58
Figure 4.7:	Tabulation of average moisture content	60

LIST OF SYMBOLS

c'	Cohesion angle
ϕ'	Friction angle
τ_f	Effective stress
u	Pore water pressure
ω	Moisture content
%	Percentage
nm	Nanometer
mm	Millimeter
m	Meter
μm	Micrometer
cm	Centimeter
g	Gram
kg	Kilogram
$^{\circ}\text{C}$	Degree Celsius
kV	Kilovolt

LIST OF ABBREVIATIONS

Al	Aluminium
ASTM	American Society for Testing and Materials
BR	Bauxite Residue
DWT	Deadweight Tonnage
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
TML	Transportable Moisture limit
Si	Silicon
XRF	X-Ray Fluorescence