

# Characterization of Liquefaction and Seepage Properties under Different Saturation Conditions of Bauxite During Maritime Transport



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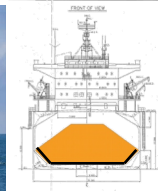
## Introduction

Similar to liquefaction of soils during earthquakes, liquefaction of a solid bulk cargo can occur when excessive cyclic or dynamic loading, induced by rough seas and vessel vibrations, is transmitted to the cargo. In Jan 2015, MV Bulk Jupiter carrying 46.4 kDWT (Handymax Type) of bauxite (aluminum ore) capsized on its way to China from Malaysia.

Handymax Type



Front View

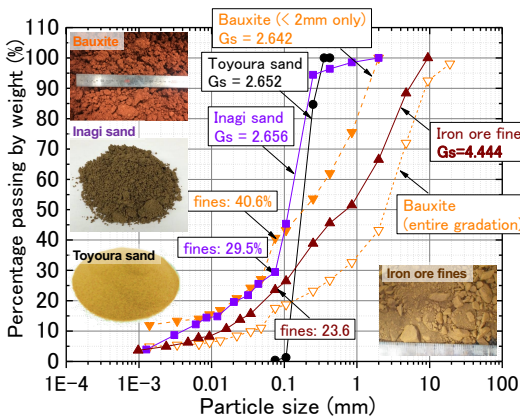


Capsizing

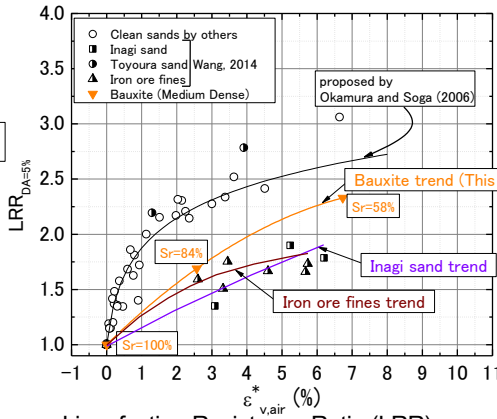


## Bauxite Liquefaction Properties

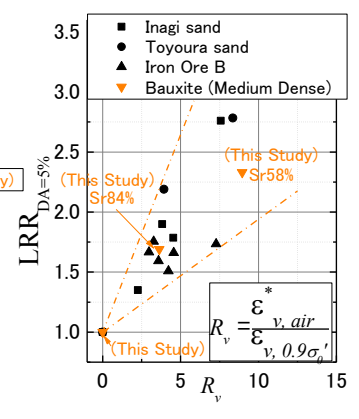
Bauxite was characterized on its liquefaction resistance properties in comparison with other geomaterials. It was found out that bauxite behaves closer to a silty sand (Inagi sand) on its liquefaction properties in both saturated and unsaturated conditions.



Particle Size Distribution of Geomaterials Used



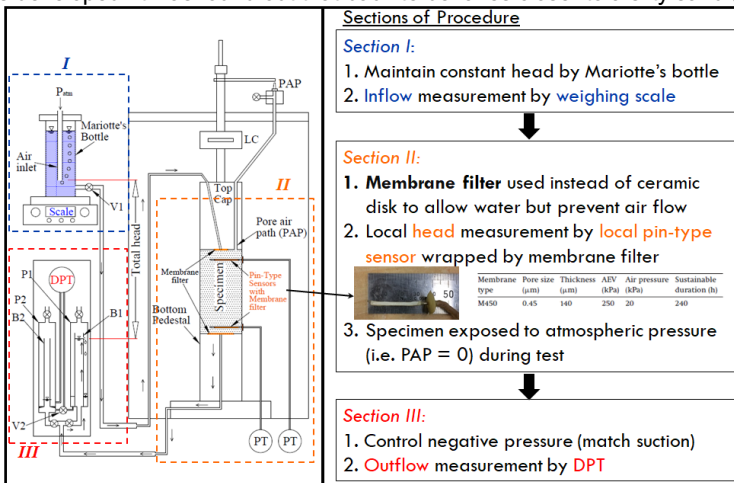
Liquefaction Resistance Ratio (LRR) vs Potential Volumetric Strain Plot ( $\epsilon_{v,air}^*$ )



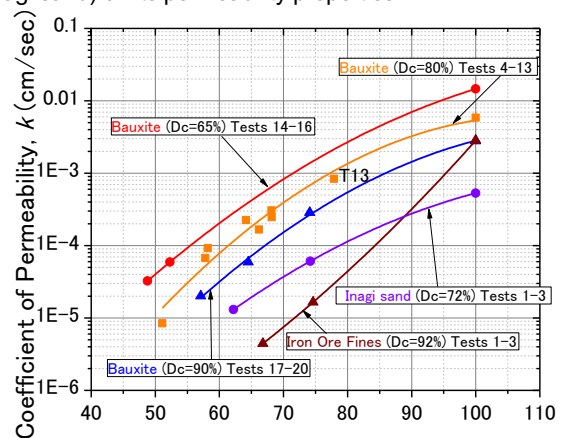
LRR vs Volumetric Strain Ratio ( $R_v$ )

## Bauxite Water Flow Properties and Development of a New Method for Permeability (k) Measurement

Bauxite was also characterized on its water flow properties in comparison with other geomaterials. A new triaxial permeameter system was developed. It was found out that bauxite behaves closer to a silty sand (Inagi sand) on its permeability properties.



Triaxial Permeameter System with Description of General Methodology



Coefficient of Permeability  $k$  vs Degree of Saturation  $S_r$

## Numerical Analysis: Seepage and Dynamic Response

Using commercially available software, seepage analysis using Guslope 2.0 and dynamic response using UWLC ver.2 were used to analyze the heap. This study provided qualitative understanding of the behavior of heap during maritime transport. The results suggest thresholds and extents for different heap densities and wet base, which can affect the safety of the carrier.

