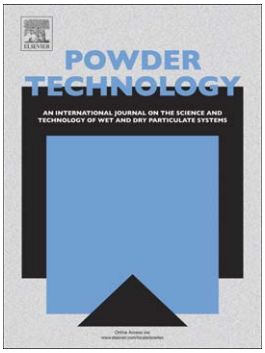

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Wei Chen, Alan Roberts, Andre Katterfeld, Craig Wheeler

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MODELLING THE STABILITY OF IRON ORE BULK CARGOES DURING MARINE TRANSPORT

Wei Chen[1*], Alan Roberts[1], Andre Katterfeld[2] and Craig Wheeler[1]

[1]Centre for Bulk Solids and Particulate Technologies, The University of Newcastle, Callaghan, Australia 2308

[2]Otto von Guericke University of Magdeburg, Magdeburg, Germany 39106

ABSTRACT: The safe maritime transport of bulk commodities, such as iron ore, by large bulk carriers is vitally dependent on the stability of the cargo. During transport there is a propensity that cargo shift may be triggered under the vessel's rolling motion. The study presented in this paper aims to model the critical stress conditions within iron ore bulk cargoes from a bulk solids flow perspective, from which the maximum roll angle of the vessel prior to cargo slip can be predicted. Comparison of the new theoretical approach to the classic slope stability model was conducted with similar results achieved. The influence of the failed material mass after the cargo slip event on the overall cargo stability is then examined using the discrete element method. The new theoretical and numerical approaches provide a means to predict the stability and evaluate the potential safety hazards during maritime transport of iron ore bulk cargoes.

KEYWORDS: Iron Ore; Cargo Stability; Cargo Slip; Bulk Solids; Discrete Element Modelling

1. INTRODUCTION

A subject of particular importance to the resources industry concerns the safe trans-oceanic transport of large tonnages of iron ore [1]. It is most important that the stability of the loaded bulk cargo be guaranteed under all dynamic conditions due to the rolling and pitching motion of the vessel induced by waves. Historically, many vessels transporting iron ore bulk cargoes have listed or capsized, with cargo shift being the suspected cause [2]–[6]. Therefore, safety precautions are urgently required during shipping the iron ore bulk materials. As shown in Figure 1, there are two main failure modes that result in cargo shift, namely, liquefaction and cargo slip [7], [8].

Figure 1. Two different modes of cargo shift during iron ore maritime transport.

Liquefaction occurs due to the cyclic motion of the ship and may lead to the loss of shear strength, and subsequent cargo shift [4], [9]. Liquefaction of an iron ore bulk cargo is a process where the bulk material flows in a manner resembling a liquid under the monotonic or cyclic ship motion. Under the regulation of the International Maritime Solid Bulk Cargo Code (IMSBC Code) [10], a Transportable Moisture Limit (TML) test shall be conducted on all eligible iron ore fines commodities to determine the upper moisture threshold for safe maritime transport. If an iron ore cargo is eligible for a TML, the gross water content of the material on board the vessel must not exceed the TML value to eliminate the risk of liquefaction.

Corresponding author: Wei Chen
Centre for Bulk Solids and Particulate Technologies, Newcastle Institute for Energy and Resources, The University of Newcastle, Callaghan, Australia 2308. Email: wchen3@uon.edu.au; w.chentbs@gmail.com