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# Simulation of Tracked Vehicle Performance on Deep Sea Soil Based on Soil Mechanical Laboratory Measurements in Bentonite Soil

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## ABSTRACT

The evaluation of trafficability of a tracked mining vehicle for manganese nodule mining is one important aspect of the complete mining system. A shear stress – shear displacement relationship is proposed for deep sea soils and deep sea soil imitate (bentonite) for the calculation of the traction potential force of a tracked vehicle. Static sinkage calculation and sinkage with respect to time are briefly outlined as well as ground failure assessment. With the main components of evaluation of trafficability, the main parameters of the tracked vehicle and the values describing a layered soil, some aspects of traction potential force, resistance forces and vehicle speed are briefly simulated. Furthermore an evaluation of the relation of soil contact pressure due to vehicle weight and ultimate bearing capacity is briefly outlined.

KEY WORDS: Tracked vehicle, trafficability, shear stress – shear displacement, dynamic sinkage, static sinkage, traction potential force, ground failure

## INTRODUCTION

Evaluation of trafficability for tracked vehicles for manganese nodule mining is essential. A lot of research work has been done with respect to the components of manganese nodule mining systems as well as to the behavior of the complete systems. Also in the field of evaluation of trafficability of the deep sea soil and optimization of traction potential of tracked vehicles much work has been done (e.g. Bode, 1991, Kim, 2005, Dörfler,1995). The most shear stress shear displacement functions have been proposed for the terrestrial field of terramechanics so far. Therefore a shear stress shear displacement relations has been developed for deep sea soil based on deep sea soil measurements and bentonite soil measurements (Schulte, 2003). With further improvements, this function gives grids for the experimental behaviour of track segment and shear ring with good approximation. With a basic correction function proposed here shear ring measurements can be adapted to track segment measurements and further be used for traction potential calculation.

Combining a layered soil model and the evaluation of trafficability (with respect to traction potential force, dynamic sinkage, static sinkage and ground failure) with the main characteristics of a tracked vehicle, it is tried to outline a system that contains the most important components for trafficability assessment.

## SHEAR STRESS - SHEAR DISPLACEMENT RELATION

Many shear-stress shear displacement relations have been developed for various types of soils (Bekker, 1956, Janosi, Hanamoto, 1961, Sela, 1964, Taylor, Van den Berg, 1966, Kacigin, Guskov, 1968, Wong, 1989). Three criteria for the quality for such a relation appear important, firstly, the ability of the relation to adapt to the measurements and secondly the use of physically meaningful parameters. Thirdly, the relation should have as few parameters as possible, still being able to adapt to the measurements.

For the evaluation of trafficability of deep sea soils, a relation (eq. 1) was developed on the basis of tests in bentonite soil (Schulte, Handschuh, Schwarz, 2003).

$$\tau(x_s) = \left(\tau_{max} \cdot e^{-b\cdot(x_s - \Delta x_s)} + \tau_R\right) \cdot \frac{1}{\left(f \cdot e^{-d\cdot x_s} + 1\right)} \tag{1}$$

with $x_s$ = shear displacement
$\tau_{max}$ = maximum shear strength
$\tau_R$ = residual shear strength
$\Delta x_s$ = shear displacement at maximum shear strength
b,f,d = empirical parameters

This relation had six parameters of which three seemed promising to reveal their physical meaning, and three were empirical parameters. It proved that the parameters could not be assigned satisfyingly to physical parameters. Furthermore this relation had a small offset for $x_s = 0$.

The modified relation (IKS-function, eq. 2) has five parameters and the value of the relation for $x_s = 0$ in now 0. $\tau_R$ is very clear in its physical meaning and the other parameters ($\Lambda_1$ - $\Lambda_4$) are empirical.

$$\tau(x_s) = \left(\Lambda_1 \cdot e^{-\Lambda_2\cdot x_s} + \tau_R\right) \cdot \frac{1 - e^{-10\cdot\Lambda_4\cdot x_s}}{\left(\Lambda_3 \cdot e^{-\Lambda_4\cdot x_s} + 1\right)} \tag{2}$$

The IKS-function was applied to shear strength measurements, conducted with a vane tester in deep sea soil probes from the CCF-Zone