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EXPERIMENTAL CHARACTERISATION AND VALIDATION OF A MULTIPHASE MODELLING APPROACH FOR EXPLOSIVELY DRIVEN SAND

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Abstract: The behaviour of sand and soil under explosive loading is of interest to the defence community because of the widespread use of landmines and buried improvised explosive devices (IEDs), and the threat these devices pose to military vehicle occupants. An additional application also exists where sand and soils are used in protective structures in forward operating bases and in civilian and military constructions to mitigate against incoming explosive and kinetic energy threats, which exposes the material to blast and shock loading.

The paper describes the experimental methodology for characterising porous geological materials, such as sand and soil, which is a necessary step for closure of the constitutive equations employed by a multiphase model implemented in the CTH hydrocode. The model is suitable for accurate simulation of the momentum transfer to a target from explosively driven sand. The multiphase approach takes into account the solid and gaseous phases within a porous/granular geological material, and specifically the thermodynamic interactions occurring between the phases and the effect this has on energy dissipation within the material. Additionally, the model accounts for the material strength in the case of microstructural changes occurring within the material, such as shock consolidation or sintering.

The experimental characterisation for the model development includes high strain rate compaction response tests, where this information is used to populate the constitutive equations within the model. Under higher pressure and temperature conditions, changes to material microstructure are also investigated experimentally using explosively loaded capsule recovery tests, focusing on shock consolidation or sintering within the material. The results from the capsule recovery tests are used to tune a sintering kinetic within the multiphase model for controlling a transition between a granular low strength state to a consolidated/ sintered higher strength state, while taking into account the energy dissipated in this process.

The multiphase modelling approach is validated using a specially designed experimental setup. This consists of an explosive charge buried in sand with a target plate offset from the surface, and the plate deformation in time recorded using the flash x-ray technique. The multiphase model for the sand is used to predict the plate deformation and shows good agreement with the experimental results.