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Shock-Compression of Porous Materials and Diagnostic Development

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This thesis is primarily concerned with the shock-consolidation of granular materials, and the experimental techniques associated with plate-impact. The thesis is divided into two parts; the first detailing an experimental investigation of the response of granular materials during plate-impact, and the second, the modification of standard techniques and diagnostics fielded during shock-wave experiments which are not specific to granular materials.

A robust experimental design for measuring the shock-response of granular materials at ambient and higher densities is described. The method employed Lagrangian sensors embedded in anvils surrounding a sample cavity. The shock-consolidation of silica powders with a range of initial densities, structural forms of silica, morphologies, and water-content were investigated. Data on the principal Hugoniot and off-Hugoniot states were measured for; fused-silica powders of initial density r_{00}=0.1, 0.25, and 0.77 g cm^{-3}, quartz-sand of varying water-content (0%, 10%, 20%, and 22% by mass), and statically compacted soil with initial density r_{00}=2.29 g cm^{-3}. The presence of a high water-content (20% and 22%) between the sand grains significantly altered the shock-response of the material. For most materials a dramatic stiffening in the material behaviour was observed upon reshock, an observation consistent with data from the literature. A phenomenological description of the compaction process in terms of grain rearrangement, particle fracture, and plastic flow is offered. The P-alpha compaction model in various functional forms is applied to the fused-silica data. The exponential and power-law descriptions are observed to best fit the experimental results.

The state of the art of measuring lateral stress using manganin gauges is reviewed, particularly in light of recent published results from hydrocode simulations. A series of recommendations for how best to use manganin gauges to measure lateral stress is presented. These suggestions result in small modifications to current analysis techniques by Rosenberg et al. and are based on modelling conducted by Winter et al. An experimental investigation of the behaviour of T-gauges, a manganin gauge commonly used to measure lateral stress, is presented. It is conclusively demonstrated for the first time that T-gauges behave approximately as wire gauges in the longitudinal orientation, and not as grid gauges as previously believed. The measured relative resistance change of the T-gauges is observed to agree with that predicted by Rosenberg et al.'s analytical description, ultimately supporting their use during lateral stress measurements.

A VISAR system is only sensitive to changes in optical phase difference. Generally, different types of motion and different experimental configurations can yield the same phase difference. Consequently the VPF constant used during data reduction has evolved to incorporate a number of correction terms which account for the experimental configuration. It is demonstrated that the standard correction terms are a poor approximation for the VISAR probes used at the Cavendish, and two alternative methods of calculating the necessary correction are presented. These methods, based on previous research, are extended to incorporate the atypical features of the probes used at the Cavendish, namely an extended source, and angular illumination/collection, but may also be simply applied to other configurations. The developed correction terms are verified using simple plate-impact experiments, and alternative diagnostics such as HetV.

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