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Overturning of multiple-block stacks - dynamic sensitivity parameters and scaling effect

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Abstract

There is a general lack of well controlled benchmarks to validate predictive capabilities of computational simulations (DEM and non-smooth contact dynamics, NSCD) relevant for multiple-block structural configurations. Closed form analytical benchmarks are largely restricted to 2D single or double rigid block stacks, typically concerned with rocking and overturning conditions due to harmonic or step base excitation. Herein both experimental and computational dynamic sensitivity study of multiple-block stacks subjected to pulse base excitation are examined. Advanced noncontact optical measuring technique (GOM Aramis and Pontos system and the associated processing software) have been applied to replace conventional measuring techniques.

The NSCD simulation framework SOLFEC is adopted here, which effectively ignores the high frequency content of the contact interactions. Instead of a specified interpenetration-force relation, this paradigm employs the complementarity relation between the relative velocity and the contact force at an existing contact point. This velocity-force relation is added as an algebraic constraint to the implicitly integrated momentum balance and the ensuing nonlinear contact problem is therefore solved implicitly at every time.

Series of test experiments were conducted in the Oxford Impact Engineering Laboratory on a bespoke platform for a controlled pulse base excitation. Impact is generated by a pin-ball mechanism attached to an optical bench, where the teflon guide and stopper were aligned to the impact device and also attached to the optical bench. Rubber cushions were used to control the shapes of initial and reverse impact signal. Every experiment was recorded with Phantom or Photron video camera with frame rate of 2000 fps.

Comparative SOLFEC analyses were conducted as a validation study. For the simulations the base was subjected to a constant acceleration of a finite duration. Overturning modes in simulations and experiments were characterized as a function of projectile velocity (or initial velocity of the base) and the stop gap distance. Well conducted set of benchmarks for the validation of simulation paradigms for discontinuous media is valuable for researchers and code developers (NSCD, DEM, DDA), as well as for safety case engineers and industry regulators.