Basic Properties of Solitary Waves in Granular Crystals

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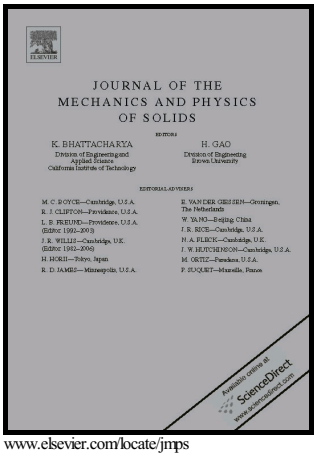

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ABSTRACT

We consider a chain of lightly contacting identical spherical elastic granules and provide explicit analytical expressions to fully characterize solitary waves (SWs) that may be generated in the chain by an impact or an applied shock force. These SWs consist of individual packages of linear momentum/energy transmitted across the granules through Hertzian contacts. They are nonlinear *translational waves* (*involving no vibrations*) that propagate through the granular chain without distortion, i.e., without any temporal evolution in shape or size. In particular, we focus on a fully-formed SW and provide analytical expressions for the associated peak value as well as the time variation of the granules' displacement, velocity, acceleration, and compressive contact force acting across any two contacting granules. In addition, by considering a SW as an "effective particle", we provide explicit analytical expressions for its linear momentum, total energy, equivalent (or effective) mass and effective velocity. All of the above mentioned results are shown to depend only on the peak value of the SW's contact force and the properties of the granules, i.e., their diameter, density, and elastic moduli. Then we provide a simple recipe to calculate the peak value of the SW's contact force in terms of a given shock force. Finally, we check by numerical simulations the accuracy of the analytical predictions.

Keywords

Granular crystals; nonlinear dynamics; nonlinear wave; solitary wave