A DEM study of the damping properties in uniaxially loaded granular material mixtures

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Abstract

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Particle damping technology is a widely used approach for vibration and noise reduction based on the use of various energy dissipation mechanisms in granular materials. In most cases, particle dampers do not have a load-bearing function and their use often leads to an increase in structural weight and indirect energy loss. It has been shown that by using so-called "force-chain based granular damping elements" it is possible to utilise the advantageous vibration damping properties of granular materials while maintaining a load-bearing capacity similar to that of bulk material (1–3).

Understanding the behaviour of these damping elements is challenging due to the numerous influencing parameters involved. In particular, the size of the granules is closely linked to many of these parameters and significantly affects both the load-bearing capacity and the damping performance of granular materials. Given that granular materials consist of collections of solid particles, analysing their behaviour at the grain scale is difficult to achieve experimentally. To address this challenge, the Discrete Element Method (DEM) (4), a numerical tool that allows detailed monitoring of particle interactions and behaviour under different loading conditions, has been employed. This study focuses on investigating the behaviour of granular material samples with various particle size distributions during uniaxial compression. An in-depth analysis of several parameters – including the volume ratio, the distribution of contact forces between particles, the evolution of the coordination number, and the load transmission - has been conducted. The relationships among these parameters and their influence on the load-bearing and vibration-damping capacities of the samples are discussed.

The results provide valuable insights into inter-particle interactions, which are a fundamental operating mechanism of force-chain based granular damping elements. In addition, the further development of such damping elements offers the possibility of using waste materials (such as plastic and rubber) and environmentally friendly alternatives (like sand), thereby reducing negative environmental impacts.

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