Wave propagation in glass-rubber granular mixtures

K. Taghizadeh*, H. Steeb†, V. Magnanimo* and S. Luding*

* Multi Scale Mechanics (MSM), Faculty of Engineering Technology, MESA+, University of Twente, Enschede, The Netherlands

† Institute of Mechanics, University of Stuttgart, Germany

e-mail: k.taghizadehbajgirani@utwente.nl

ABSTRACT

Granular mixtures made by one or more components play a significant role in many industrial processes. For instance, stones of different cases are often mixed with other materials (rubber granulates, fibers, etc) to improve effective physical properties and reduce costs. Exploring and understanding the effect of the components help in optimizing the behaviour of the overall aggregate.

The study of wave propagation allows inferring fundamental properties of granular materials such as elastic and dissipation characteristics. A small perturbation is generated on one side of a dense, static packing and its propagation is investigated until it arrives at the opposite side. In this work, wave propagation is studied experimentally and numerically by using mixtures of rubber and glass beads with various content properties and different confining pressures in order to explore the effect on stiffness and frequency absorption.

The experiments consider cylindrical samples made of rubber and glass beads of equal size, homogeneously poured in a latex membrane, and then compressed to reach different hydrostatic stress levels. At various stress levels, P-waves have been excited and the time of flight is measured for each sample and pressure level. The Discrete Element Method (DEM) is a modern numerical tool that allows the exploration of the macro-scale and micro-scale of a granular assembly. Numerical simulations allow following the path of the wave in the granular mixture, we believe that the wave velocity in this require when observation of physical experiments are confirmed. The numerical study offers striking insights into the material behaviour at the transition between glass-dominated and rubber-dominated regimes. Along with the dependence on the volume content, also the influence of the stiffness ratio between the two materials is addressed.

By summarizing our observations, a three regime scenario shows up. In the glass-dominated regime G, waves do transmits via a glass beads network, where simulations based on Hertzian interactions are able to reproduce the macroscopic behavior. In the intermediate regime I, waves still have a preferential path via glass bead chains. Here two mechanisms concur to shape the bulk behavior: i) the density of glass beads in the sample reduces with respect to case G and the actual values of the moduli get lower; ii) the number of contacts increases with pressure faster than in the G-regime due to easy rearrangement of the rubber particles, that is the slope M(P) gets higher. Finally, in the third regime R, the behavior of the mixture is dominated by the rubber beads, and the present simple DEM contact model cannot offer an accurate representation of the system.

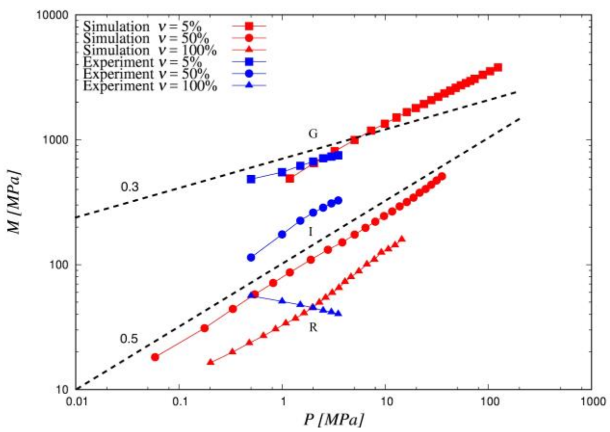

Fig.1: Experimental and numerical P-wave modulus plotted against pressure; comparison of DEM and experimental glass-rubber mixtures for different rubber contents (n = 0.05; 0.5 and 1.0).