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Reply to discussion by Dr. Katalin Bagi

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The authors thank the discusser for giving them the opportunities of elaborating further on the assumptions in their paper. They fully agree that the application of virtual work on a single system should lead to the same results as the equilibrium of forces. However, our paper considers two different systems, i.e., a continuum system and a granular system. Two different systems can be rendered equivalent only by making some assumptions. As stated in Eq. (27), it is only at the location of the particle centers that these two different systems have the same displacement and rotation: i.e., $\delta\mathbf{u}(\mathbf{x}_a) = \delta\mathbf{u}_a$ where $\delta\mathbf{u}_a$ is the virtual displacement of the particle center in the granular media and $\delta\mathbf{u}(\mathbf{x}_a)$ is the virtual displacement of the equivalent continuum at the position $\mathbf{x}_a$ of the particle center.

In our representation of granular media, the points of application of the external forces are assumed to be external to the sampling volume V of granular material that has to be rendered equivalent to a continuum (Fig. 1 in our paper). We define the sampling volume using a spatial (i.e., Eulerian) description, while Dr. Bagi's defines it using a material (i.e., Lagrangian) description, which relates the sampling volume to the particles instead of referring to a fixed position in space. Using a Lagrangian interpretation, Dr. Bagi interpreted our spatial description as a truncation of volume. However, since we adopted a spatial approach, we never intended to define truncated sampling volume as suggested by the discusser.

The authors thank the discusser for bringing to their attention the work of Diebels et al. (2001), which appeared in a conference proceedings released after the publication of their paper in the International Journal of Solids and Structures.

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