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Measuring rockfill deformation by digital image correlation

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This study focuses on the behaviour of rockfill media under compression. Rockfill media are coarse media composed of quarry rock debris or crushed rock fragments with a characteristic size of up to one meter. This medium has been used in a large number of high embankment dams. Rockfill dams are subjected to deformation processes, which can occur long after the construction of the dam, even during periods when no changes occur in the loading. This issue, which has been previously studied by several authors, is of great importance to dam engineers [1-3].

Usually, rockfill materials have seldom been tested, because of the size apparatus required, and the corresponding costs and delays for testing, even for small-sized rockfill. However, the trend towards larger works, such as higher rockfill dams with steeper slopes, should be associated with improved knowledge of their behaviour [4]. Significant incidents have recently marked the commissioning of various rockfill dams [5], attributed to excessive unforeseen deformations, under normal service conditions.

Concern is then rising within the profession to return to more rational approaches in design in rockfill dams and underlines a growing need for progress in knowledge in the behaviour in rockfill material, which can be considered as a granular material.

The mechanical behaviour of granular materials is complex essentially due to their discrete nature. To improve the understanding of these granular media it is necessary to understand the evolution of the internal state of this heterogeneous material. Experimental work has been developed here to give insights into the strain behaviour of this rockfill media. Many authors have worked on this topic, but mainly from theoretical and numerical approaches. Recently, some of them have introduced an intermediate scale, called meso-scale, at which strain can be defined using the tools of continuum mechanics [6]. Establishing a link between particle level displacements and macro-level deformations is important for researchers who intend to develop micromechanically based constitutive theories [7]. The aim of this work is to measure the displacement of each individual grain and then to compute macroscopic strains from grain displacements.

In this paper, we present the results of an experimental study based on the development on a Digital Image Correlation (DIC) tool to analyse strain of a rockfill media under oedometric

compression. The study of granular materials containing large particles such as rockfill requires suitable laboratory facilities whose dimension must be in proportion to the maximum size of the grains. The oedometric cell used here has been developed by IRSTEA laboratory in Aix-en-Provence (France) and has a square surface of 30cmx30cm and is 40cm high, whereas the grains have a maximum size of 4cm. Some of the cell walls are in Plexiglas, to guarantee the optic accessibility of surfaces. DIC techniques are then used to measure the grains displacements field in 2D and in 3D using 2 cameras.

To compute strain, the assembly is replaced by a continuous domain, and displacement of the characteristics points of the equivalent continuum media is equal to the displacement of the particles centers. To define local strain, a meso-scale is defined, whose branches connect the centers of three particles in contact, using Delaunay triangulation. The rotation of each grains is also up-scaled for higher order continuum model evaluation.

The gradient of the displacement field of each triangle is then determined on the basis of particle displacements and microlevel geometrical characteristics (see Figure 1).

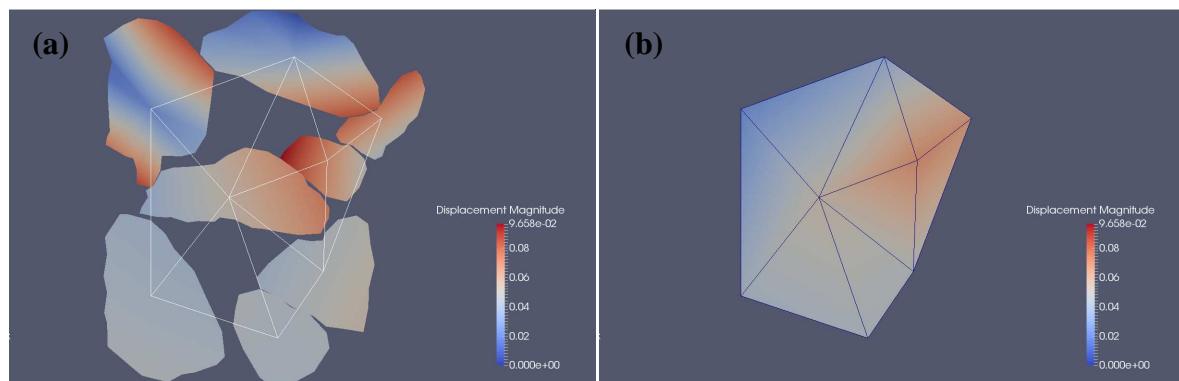


Figure 1: Principle of strain computations: grains displacements fields and Delaunay triangulation (a) and displacement field in Delaunay cells (b)

REFERENCES

- [1] Hunter, G., & Fell, R. Rockfill modulus and settlement of concrete face rockfill dams. *Journal of Geotechnical and Geoenvironmental Engineering*, 129(10), 909-917, 2003.
- [2] Justo, J. L., & Durand, P. Settlement-time behaviour of granular embankments. *International journal for numerical and analytical methods in geomechanics*, 24(3), 281-303, 2000.
- [3] ICOLD. Rock materials for rockfill dams, review and recommendations. International Commission on Large Dams, Bulletin No. 92, Paris, 1993.
- [4] Frossard, E., Hu, W., Dano, C., & Hicher, P. Y. Rockfill shear strength evaluation: a rational method based on size effects. *Geotechnique*, 62(5), 415-427, 2012.
- [5] CBDB-ICOLD. Proceedings on the 3rd Symposium on Concrete Face Rockfill Dams, Florianopolis, 2007.
- [6] Bagi, K. Analysis of microstructural strain tensors for granular assemblies. *International Journal of Solids and Structures*, 43(10), 3166-3184, 2006.
- [7] Chaze, M., & Cambou, B. Analysis of internal state and strains in granular material at meso-scale: influence of particle shape. *Granular Matter*, 16(5), 657-673, 2014.