Utilization of MatPIV program to different geotechnical models

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The Particle Imaging Velocimetry (PIV) technique is being used to measure soil displacements. PIV has been used for many years in fluid mechanics; but for physical modeling in geotechnical engineering, this technique is still relatively new. PIV is a worldwide growth in soil mechanics over the last decade owing to the developments in digital cameras and laser technologies. The use of PIV is feasible provided the surface contains sufficient texture. A Cambridge group has shown that natural sand contains enough texture for applying PIV. In a texture-based approach, the only requirement is for any patch, big or small to be sufficiently unique so that statistical tracking of this patch is possible.

In this paper, some of the soil mechanic's models were investigated such as retaining walls, slope failures, and foundations. The photographs were taken with the help of the high resolution digital camera, the displacements of soils were evaluated with free software named as MatPIV and the displacement graphics between the two images were obtained.

Nikon D60 digital camera is 10.2 MB and it has special properties which makes it possible to use in PIV applications. These special properties are Airflow Control System and Image Sensor cleaning for protection against dust, Active D-Lighting for highlighted or shadowy areas while shooting, advanced three-point AF system for fast, efficient and precise autofocus. Its fast and continuous shooting mode enables up to 100 JPEG images at three frames per second. Norm Sand (DIN 1164) was used for all the models in a glass rectangular box. For every experiment, MatPIV was used to calculate the velocities from the two images. MatPIV program was used in two ways such as easy way and difficult way:

In the easy way, the two images with 64*64 pixels with 50% or 75% overlap of the interrogation windows were taken into consideration and the calculation was performed with a single iteration through the images and the result consisted of four matrices measured in pixels and pixels/second. At the end of the iteration, the results were visualized.

In the application of difficult way of MatPIV, a grid of points into the research model was inserted and the first image was taken with the Nikon D60 digital camera. Afterwards, how large a pixel in the image and the orientation of the coordinate system were calculated. If there are no particles to perform PIV calculations in the investigated region, the best way is to mask out this empty region.

The crucial step in PIV is the particle image analysis, which is to determine the displacements between two successive images. The first image was divided into a grid of test patches. Each test patch consisted of a sample of the image matrix of size $L * L$ pixels. To find the displacement of the test patch between images 1 and 2, a search patch was extracted from the second image. The cross-correlation of test patch and search patch was evaluated. The resulting normalized correlation plane indicated the "degree of match" between the test and search patch. The highest peak in the normalized correlation plane indicated the displacement vector of the test patch. The procedure described above for evaluation a single displacement vector was repeated for the entire grid of test patches, producing the displacement field between the image pair.

After having performed the calculations, there were so many wild vectors due to low image quality in some parts of the images to be removed with the help of the different filters. There are four different filters in MatPIV, these are: signal-to-noise ratio filter, peak height filter, global filter, and local filter. The filters were used step by step to decide which filter could give the best result for the related images. As a last step, both of the ways were compared in each geotechnical model.