Looking into the gouge layer within a fault under stresses by photo-elasticity and discrete element method

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1. Introduction

We have so far performed a series of experiments in which elastic waves were transmitted across a fault with a gouge layer. The changes in waveform were observed during the whole loading process up to a final stick-slip event. Prior to the final stick-slip, a precursory slip and a dilatancy of the gouge layer were observed to occur, which significantly reduced the amplitude of the transmitted waves.

A numerical simulation was performed for the gouge layer using the discrete element method (DEM). The results show that the horizontal and vertical movements of the upper block are well reproduced by the simulation. The initial stress chains which are homogeneously distributed in the gouge later are drastically changed by shear stress application, reducing the number of passes to transmit waves. The mechanism of experimental observations is well understood in the light of the numerical simulation.

In order to check the results above directly by eyes, we have tried an experiment using a photo-elastic material. The followings are the results of the experiment.

2. Experiment

A polymer named PSM-4 of Measurement Group Inc., VISHAY Micro-measurement Co. Ltd., USA was used as the photo-elastic material. We adopted GFP1200 Delta Vision of Stress Photonics Co. Ltd., USA as a stress analytic system.

Disks with a diameter of 9 mm and 12 mm were cut off from a 1/4 inches thick PSM-4 sheet. These disks were put into a 7 mm wide gap between two acrylic walls, which were regarded as a two-dimensional gouge layer. A weight was put on the layer, which was slowly loaded horizontally. Photographs of photo-elasticity were taken at several stages of the shear stress during the loading process.

3. Results

We have succeeded in detecting the change in force chains inside the gouge layer by comparing two photographs successively taken. An example is shown in the Figure which shows that a few strong columns are created in 45 degrees from horizontal direction (black dots) and the stress is reduced in the perpendicular direction (white dots) as the shear stress is increased, which well agrees with the results of the simulation by DEM.