第 III 部門

STUDY ON SHEAR DEFORMATION OF SOIL CUTTING PROBLEM

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1. INTRODUCTION

The shear deformation in soil cutting problem as well as the resistance force acting on a cutting-blade was studied by using 2D DEM simulation and the results were compared with those of a 2D model experiment. This simulation deals with the action of a simple flat rigid blade. The blade partially stuck into the model ground was moved horizontally at a constant speed. The particles used in this simulation were assumed by assembly of rigid circular disks and the Voigt model was applied to calculate the contact interaction between particles. In this study, calculation results including shear deformation, displacement vectors, and resistance force acting on the cutting-blade were obtained and compared with the model experiment conducted in a pile of aluminum bars regarded as a soil.

2. EXPERIMENTAL PROCEDURE

The experimental apparatus used in this research are showed in Fig.1. They consist of a soil box which could be moved in the horizontal direction by a motor and a simple flat cutting-blade was set on the vertical frame. A 6-axis force sensor was attached behind the cutting-blade for measuring the resistance force acting on blade when soil box is in the motion. A camera was irradiated at the soil box in order to continuously take photograph of soil failure in front of cutting-blade when soil box was pulled to the left side at the constant velocity v = 1cm/s.

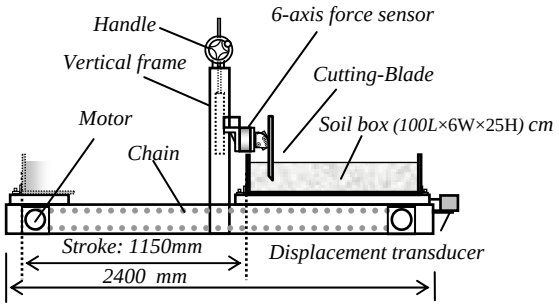

Fig. 1: Experimental apparatus

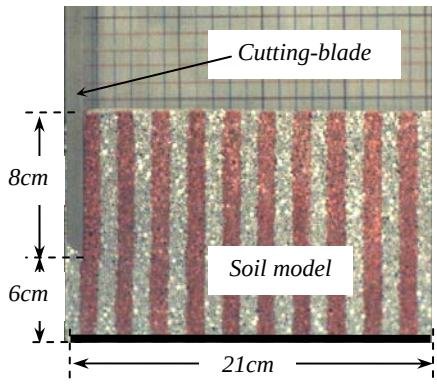

Fig. 2: Initial setup condition for 2D experiment

In this experiment in order to have a good comparison with DEM simulation, aluminum bars having 0.3cm and 0.15cm diameter were used, they were regarded as the soil material for the model ground. The cutting-blade was set vertically (90 degree from the horizontal direction) and it was initially stuck 8cm deep into soil as shown in Fig.2. After that the aluminum bars was filled into the soil box in both sides of cutting-blade at the same time so that we can reduce as much as possible the remained pressure on cutting-blade before experiment was done.

3. SIMULATION MODEL

The conventional DEM, which was proposed by Cundall and Strack (1979), was used in this research to simulate the properties of soil deformation under the action of the cutting-blade. The particles used in this simulation have same size with the aluminum bars used in the experiment. The DEM parameters used for simulation were decided by trial and error method and are displayed in the table 1.

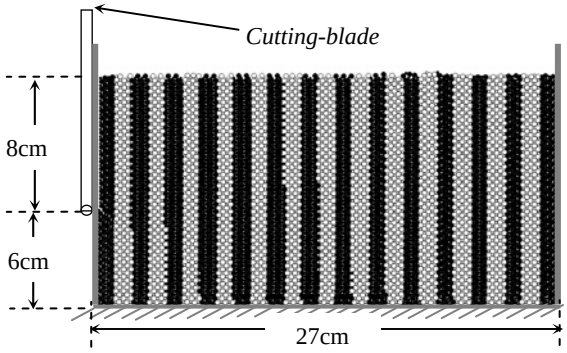

Fig. 3: Initial setup condition for simulation.

The particles were first distributed randomly in a soil box and then compacted by the gravity themselves until all of particles are stable. The cutting-blade was initially put outside particles system and after that it will horizontally moved at constant velocity v = 1cm/s.

Table 1: Parameters used in simulation

Number of particles:	*7680*
Particle diameter:	*0.3cm, 0.15cm*
Density:	*$2.7g/cm^3$*
Normal stiffness:	*$4.25\times10^3N/cm$*
Shear stiffness:	*$1.25\times10^3N/cm$*
Time step:	*$0.3351\times10^{-5}s$*
Friction coefficient:	*0.3*

4. RESULTS AND DISCUSSION

The results are shown in terms of comparison between simulation and experiment. Fig.4 shows the progress of developing shear deformation of soil region in front of the cutting-blade when it is in motion.

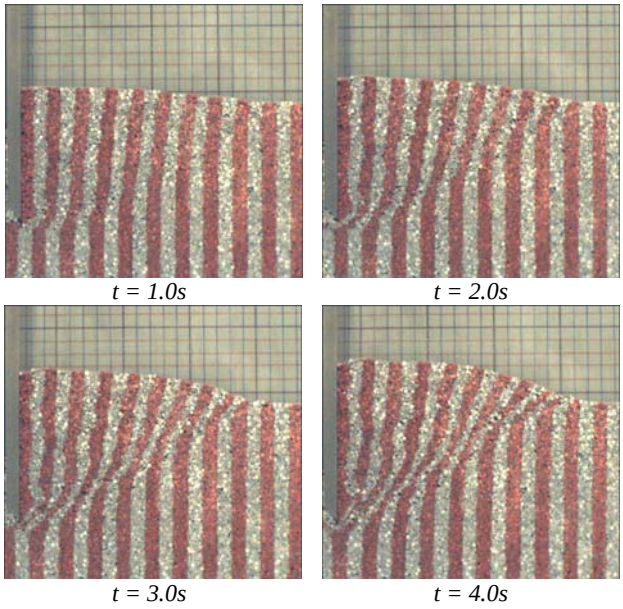

Fig.4: The formation of shear deformation of soil in experiment.

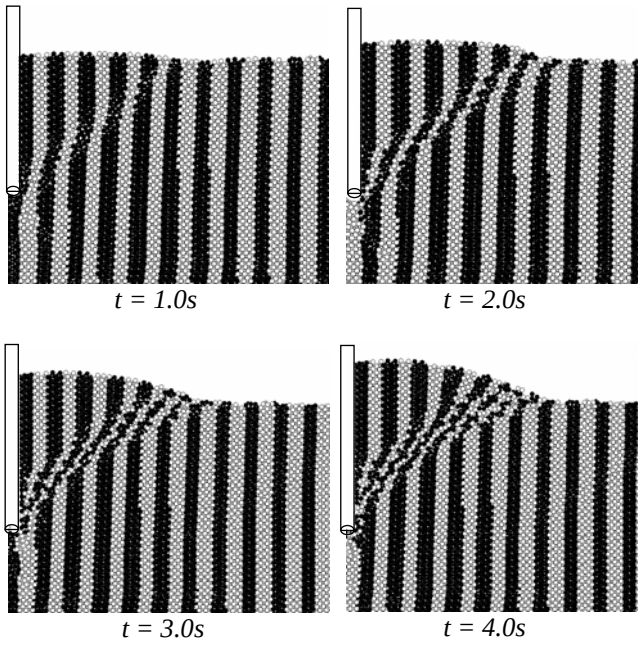

Fig.5: The formation of shear deformation of soil in simulation.

It is clearly that the slip line occurred firstly from the tip of the blade to soil surface because of excavated region of soil moving upward and forward after that the sliding began along this path. Because of this slide the soil particles around this slip line were dragged on that volume and forming the shear deformation area of soil in front of the cutting-blade. This phenomenon also occurred in the same way in the simulation as shown in Fig.5. From this figure it could be observed that the volume of soil failure in front of cutting-blade in simulation is smaller than in experiment.

The behavior of slip line during the motion of cutting-blade was described by analyzing the vector displacement of the particles in front of the cutting-blade in experiment and comparing with the vector velocity in simulation which was shown in Fig.6, 7. In both experiment and simulation, each successive slip line intersected the soil surface at increasing distances from blade and angle of intersection decreased.

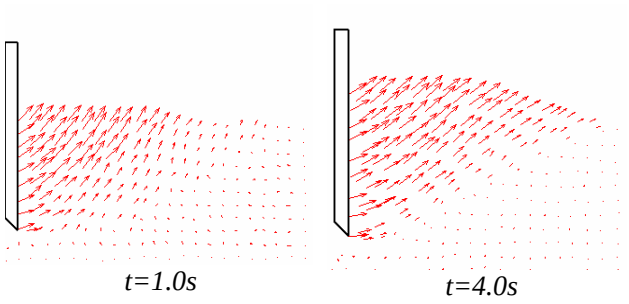

Fig.6: Displacement vector of soil particles in experiment

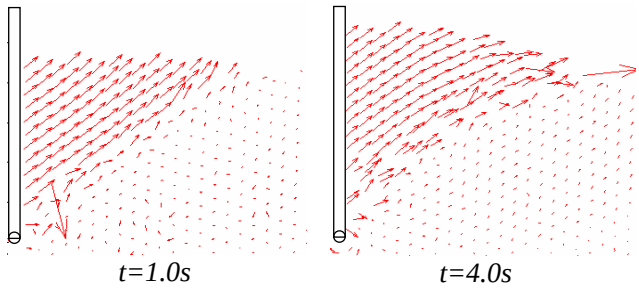

Fig.7: Vector velocity of particles in simulation.

The force acting on cutting-blade in experiment and simulation was shown in Fig.8. These forces have a big fluctuation and they tend to increase linearly with respect to time in 2D. Furthermore, from this research it could be found that these forces reach each peak when a new slip line is formed. The vibration of forces in this case was explained by the discontinuous properties of soil which was represented by aluminum bars used in this experiment and circular disks used in DEM simulation.

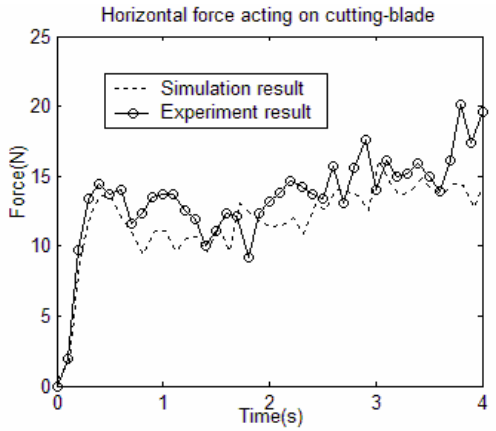

Fig.8: Force acting on cutting-blade in horizontal direction.

5. CONCLUSIONS

This research proposes to understand more about the shear deformation in soil cutting problem by using DEM simulation. The shear deformation of soil in front of cutting-blade and the resistance force acting on cutting-blade in DEM simulation appeared in the same way with the experimental model. With the same the mean force acting on blade, the volume of soil failure in experiment is slightly bigger than in simulation.

REFERENCES

1. P. A. Cundall and O. D. L Strack: A discrete numerical model for granular assembles, *Geotechnique, 29(1979), No. 1, 47.*