Discrete element simulation of cyclic behavior of granular media

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1. INTRODUCTION

The fundamental idea of DEM is that each particle is modeled as an element obeying Newton's second law of motion. Equilibrium contact forces and displacement are found in a stressed assembly of particles though a series of calculations tracing the movement of each particle. The movement of particles in the stressed assembly is a result of the propagation of disturbance due to external application of forces and displacements. The particles try to rearrange themselves such that equilibrium is attained. The movement of each particle is tracked by solving a set of Newton's equation of motion. DEM employs an explicit time-finite-difference scheme in which each calculation cyclic includes the application of force-displacement laws to each contact. Therefore, in DEM the calculations alternate between application of Newton's second law of motion and force displacement law for the contacts to determine equilibrium contact forces and displacement. The resultant force vector on each element is the vectorial sum of contact forces, damping force and body forces. Each element is assumed to translate and rotate rigidly and can overlap slightly. It was like that and it compared a real experiment result and the DEM result.

2. SIMULATION METHOD

The fundamental idea of DEM is that each particle is modeled as an element obeying Newton's second law of motion. The resultant force vector on each element is the vectorial sum of contact forces, damping force and body force. The movement of each particle is tracked by solving a set of Newton's equation of motion. The resultant force vector on each element is the vectorial sum of contact forces, damping force and body force. Each element is assumed to translate and rotate rigidly and can overlap slightly. The constitutive law is applied to each contact and the law of motion to each sphere during a time step. It is as follows outline of the main features of DEM. SPi is produces acceleration of particle and SMi is produces angular acceleration (spin) of particle. Acceleration and spin are computed as if neighboring particles do not exist. Time step is assumed to be small such that accelerations and velocities are constant in this small time. Particle occupies new position due to acceleration and new Pi's and Mi's are computed for new positions. SPi, SMi and the process are repeated. The program Trubal is Fortran code that is discrete element method-3-D granular assemblies. Table 1. shows the program interpretation of parameter.

Particle	density, size and contact type
Contact	Kn, Kt, friction and cohesion
Input	damping, time step, strain rate, contact law and loading path
Processing	law of motion and contact law is applied to each contac

Table 1. Used parameter

3. CONSTANT STRAIN AMPLITUDE TEST

Figure 1.shows the result of various confining pressure (5, 10, 15, 20, 25, 50 and 100 kPa) at constant strain amplitude tests. Figure 1. (a) the confining pressure 5kPa shows the number of cyclic from one case and the number of cyclic is one time it means that the destruction. The case of (a) is from (a) until the (h) shows a most loose condition from in and also it is appearing with void ration is 0.6. Case of from (b) until

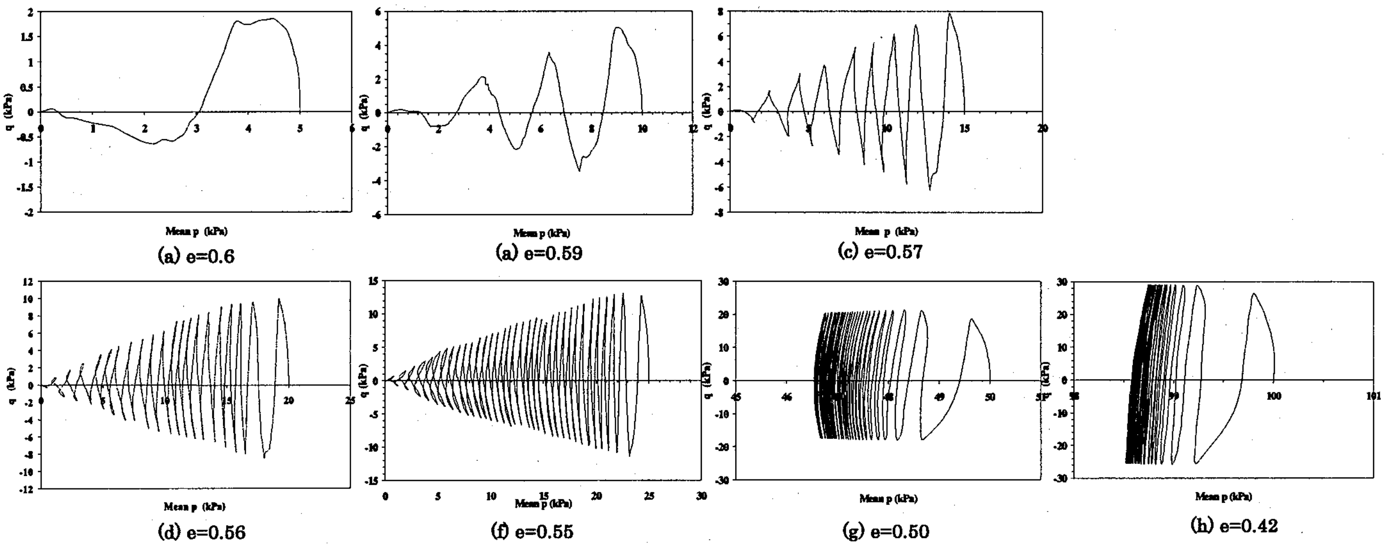

Figure 1. Stress pate response (a)~(h)

(h) each the arrest pressure 10, 15, 20, 25, 50 and 100 and appeared with void ratio 0.59, 0.57, 0.56, 0.55, 0.50, and 0.42. Recording void ratio where the confining pressure will increase diminishes. The figure 2 result of figure 1 is the graph that shows a confining pressure and number of cyclic relationship. The confining pressure increases until 5, 10, 15, 20 and 25kPa to be, number of cyclic possibility it is a result of 1, 4, 8, 19 and 35 times. The figure3. is the curve which shows the relationship of the Modulus ratio and the shear strain. Area of 2 lines which it sees from the figure. 3 the result and the points of the laboratory test are result of DEM analysis.

In view of the above, points were calculated with modeling at confining pressure =50, 100, and 200kPa, corresponding to void ratio 0.48, f = 1.42 Hz. The possibility of seeing from the figure. 3 it is there is a possibility of knowing the fact that the calculation result of most enters the inside line of this area.

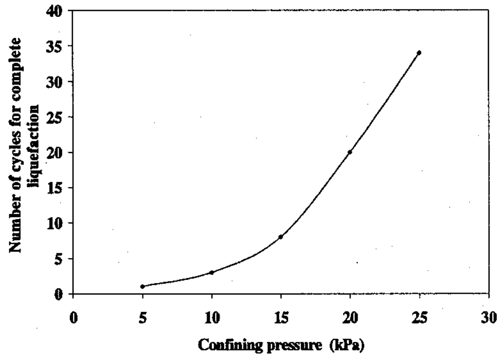

Figure 2. Used parameter

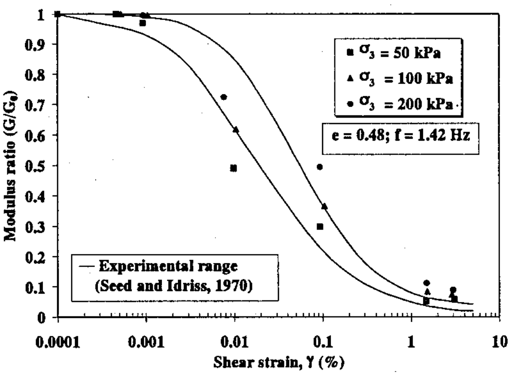

Figure 3. Modulus degradation curve

4. CONCLUSION

1. The DEM numerical simulation results can capture realistic behavior of granular media.
2. DEM simulations show qualitatively realistic macroscopic behavior of cyclic behavior of granular assemblies under different stress path conditions.
3. DEM simulations facilitate Micromechanical analysis of the behavior of granular media

5. REFERENCES

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