

Simulation of effect of large movement of ground on underground pipe

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ABSTRACT: The Cundall's Distinct Element Method (DEM), in which soil is represented as a system of numerous discrete particles, does not account for two factors; continuity of the medium and wave propagation.

The extended method (EDEM), proposed by Iwashita and Hakuno, has a physical structure that presents the effect of the internal material between the particles as pore water or clay. We simulated the two-dimensional dynamic fracture of surrounding ground of a pipe using this method. During fracture many small cracks occur throughout the medium, after which they form fracture lines. Results confirmed that the EDEM can simulate a medium composed of continuous and discontinuous elements.

1 INTRODUCTION

The present study aims to simulate the dynamic fracture process of soil surrounding a pipe by developing Cundall's Distinct Element Method (DEM) (Cundall P.A. 1971) in which soil is represented as a system of numerous discrete particles and dynamic behavior of all those particles is calculated individually. This method is based on the idea that each particle satisfies the equation of motion and the interaction among them simply. The conventional DEM could not consider, however, some important problems: continuity of the medium and wave propagation. The extended DEM (Iwashita and Hakuno 1990, Meguro and Hakuno 1989) consists of two structures: primary structure and secondary structure. The primary structure is the conventional DEM and is used to transmit the force through the contact points and to calculate particle movement. The secondary structure is used to present the continuity of the medium. For instance the first structure corresponds to rock or gravel and the second structure to internal clay between gravels. As a consequence, it can simulate wave propagation as well as dynamic fracture.

The present method is applied to dynamic fracture of underground structure caused by an earthquake and succeeds in simulating the fracture process of surrounding soil of a pipe.

These results suggest the applicability of the presented method to the study of the fracture problems of the soil and soil structures.

2 EXTENDED DISTINCT ELEMENT METHOD

In our research on cohesive soil, we have considered in idealizing cohesion additional pore springs in the normal and tangential directions between particles.

$$m_i \ddot{u}_i + C_i \dot{u}_i + F_i = 0 \dots\dots\dots (1)$$

$$I_i \ddot{\phi}_i + D_i \dot{\phi}_i + M_i = 0 \dots\dots\dots (2)$$

in which F is the sum of all the forces acting on the particle,
 M the sum of all the moments acting on it,
 C and D the damping coefficients, the displacement vector and the angular displacement.

The time histories of and can be obtained by step-by-step numerical integration of these equations. The force exerted on one particle by another was estimated from the deformation of the spring between them. The elastic constant of the spring was estimated from the propagation velocity of the P wave for the normal spring and the S wave for the tangential spring.

SIMULATION RESULTS

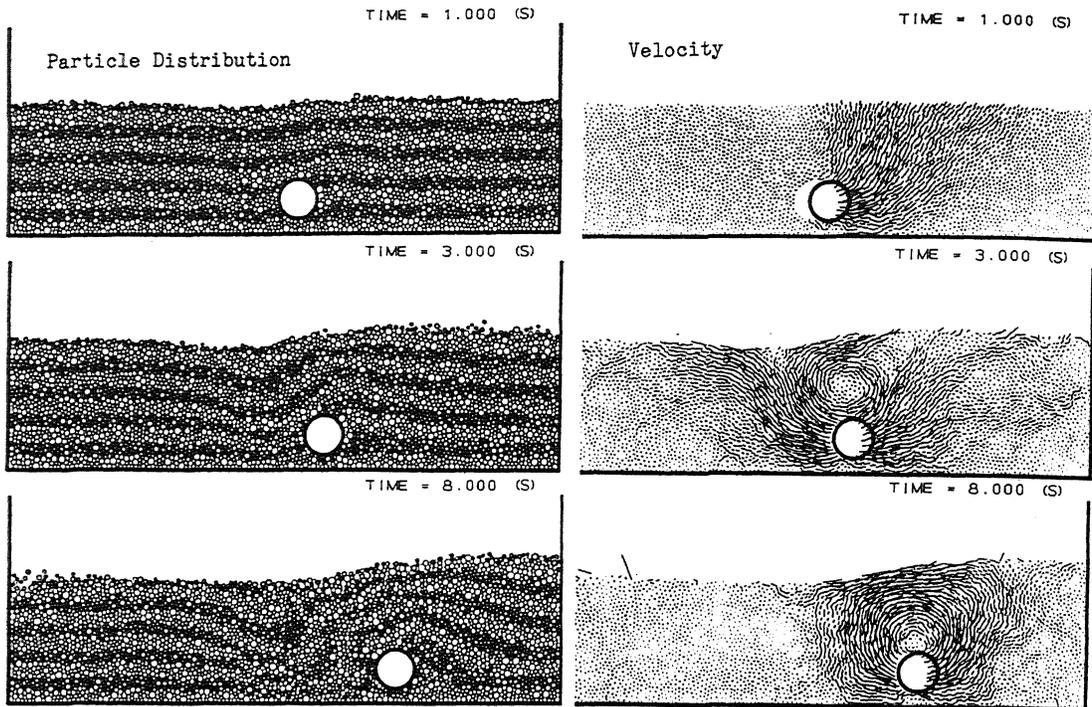


Fig.1 Large horizontal displacement of a buried pipe in cohesionless ground

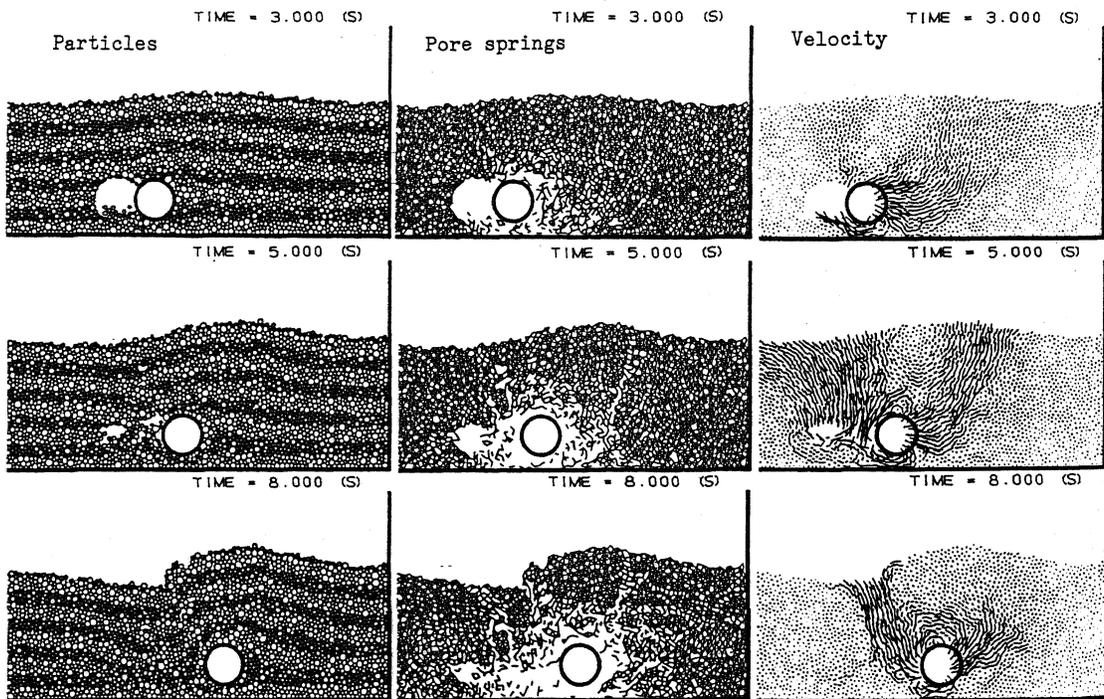


Fig.2 Large horizontal displacement of a buried pipe in cohesive ground

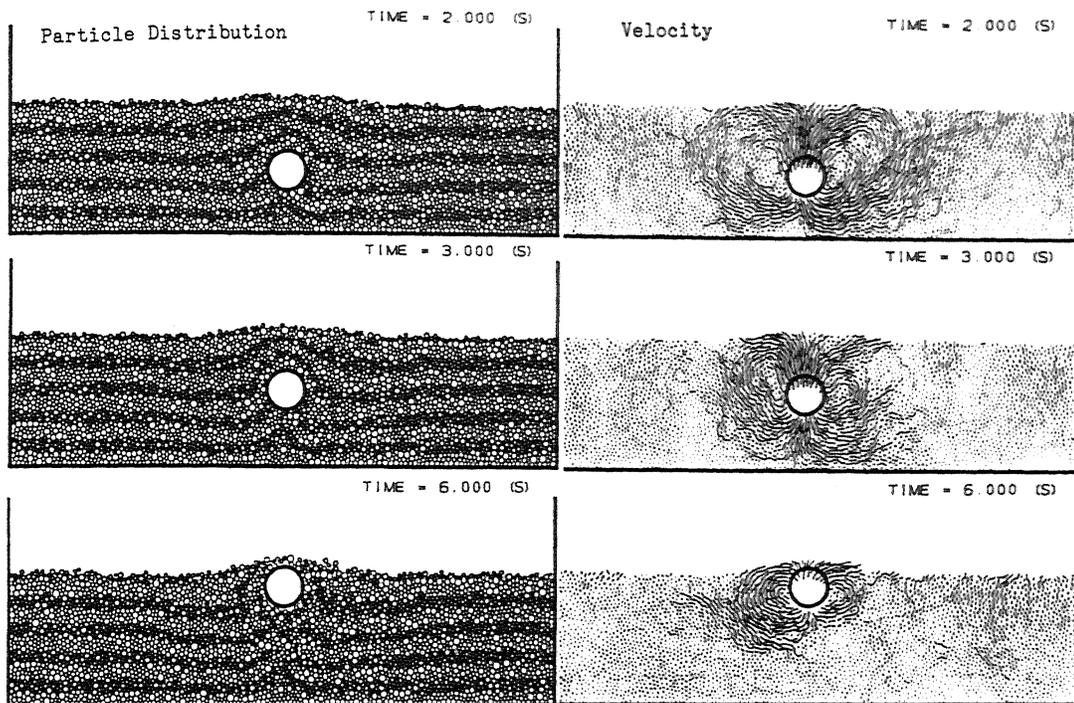


Fig.3 Large vertical displacement of a buried pipe in cohesionless ground

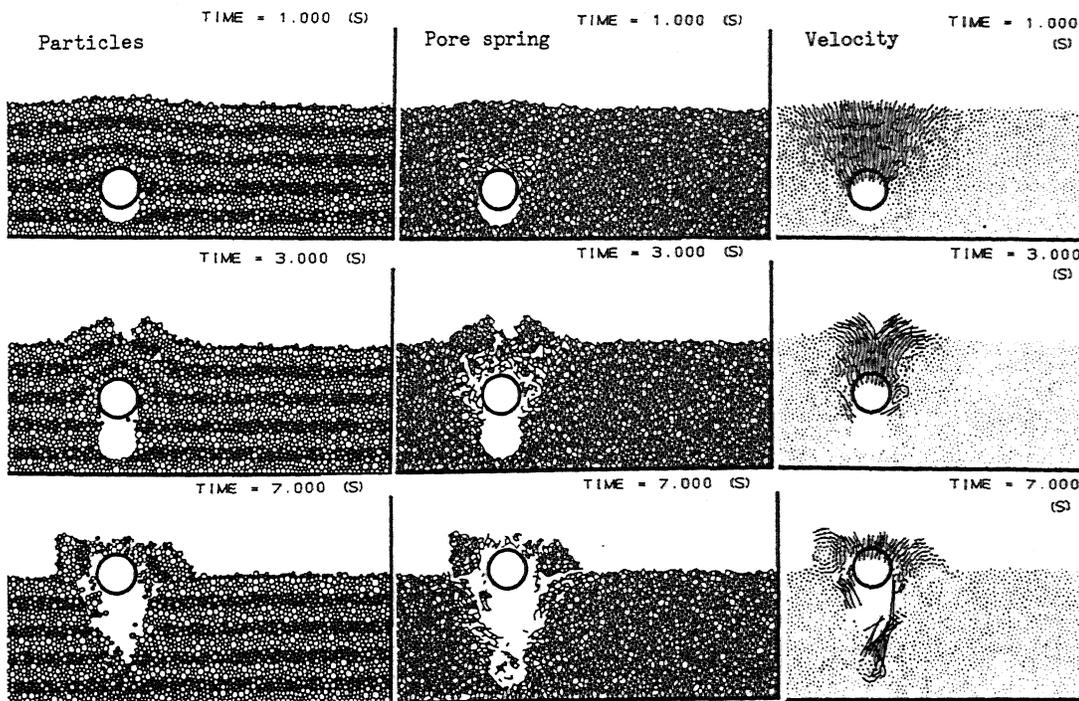


Fig.4 Large vertical displacement of a buried pipe in cohesive ground —

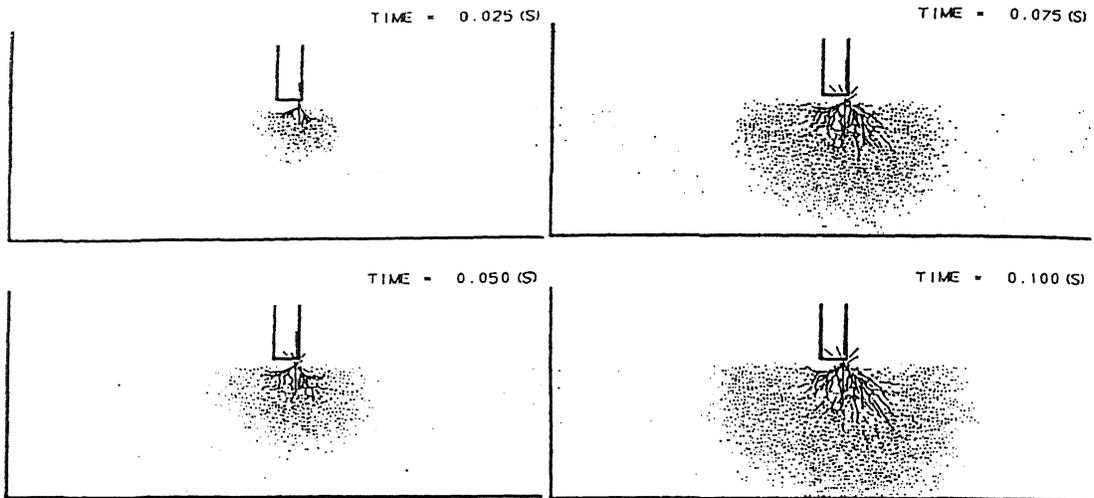


Fig.5 Propagation of stress wave

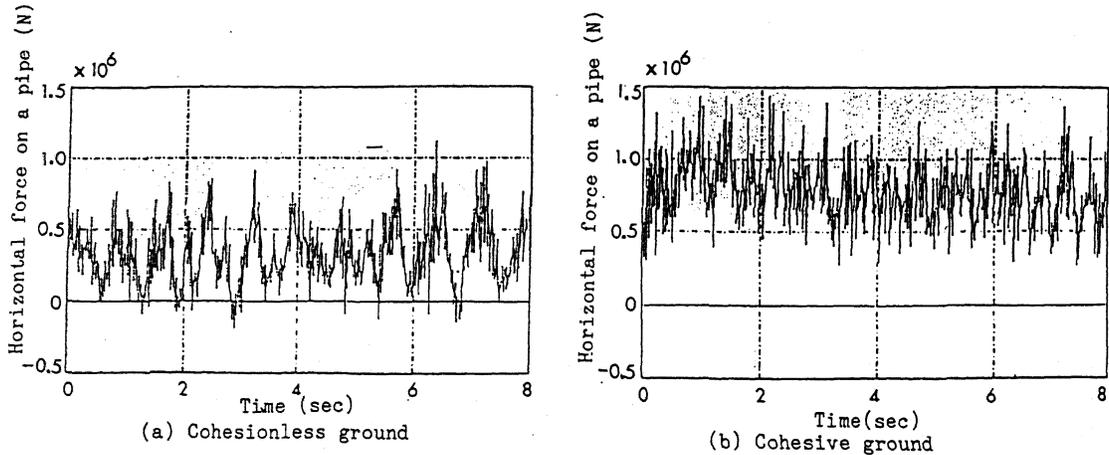


Fig.6 Total horizontal force acting on a buried pipe

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