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Lagrangian Particle Finite Difference Method (LPFDM)
地盤の大変形解析のためのラグランジアン・ポイント有限差分法

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ABOUT LPFDM

LPFDM (Lagrangian Particle Finite Difference Method) is presented for analyzing large deformations of soils. The method embodies an explicit, time-marching solution scheme, in which no global matrix is formed, and thus reduces the computational time considerably. All the Lagrangian parameters calculated at each time step are carried by Lagrangian points, which, as a cluster, describe a mass of the material. The updated Lagrangian parameters are then mapped back, for the next cycle of calculation, on the Eulerian lattice, which has been shifted back to its original position. LPFDM is thus viewed as an Eulerian way of describing solid motions (MPM, Sulsky et al., 1994) obtained through the *Fast-Lagrangian* scheme of calculation (FLAC, Cundall, 1979). And thus retains the merits of both FLAC and LPM.

NUMERICAL EXAMPLES

The material in the following examples is assumed to be elasto-plastic, obeying the simple Mohr-Coulomb's yield criterion (Table 1). Once the peak strength is reached in one Lagrangian point, chemical bonds or granular fabrics among grains are assumed to be broken causing the material strength to be reduced to some prescribed extent. Both the internal friction angles and the cohesions for Lagrangian points were modified to fluctuate randomly around the values given in Table 1 so that the deviations eventually exhibit the Gaussian distributions with the standard deviations of 33% of the mean values.

(I) Failure of Cliff

Figure 1 shows a soil mass that collapses under its own weight. A form of damping, called local non-viscous damping, was used to damp the motion of the cliff material. Despite the coarse discretiza-

Table 1 Mechanical properties

Young's modulus :	Poisson's ratio	Density	Internal friction angle :	Cohesion	Strength reduction
5×107 N/m^2	0.47	1700 kg/m^3	0.5 rad	9800 N/m^2	Cohesion is reduced by 50%

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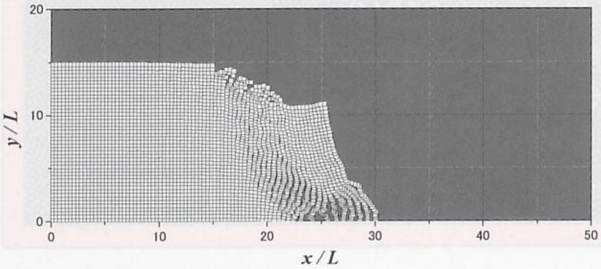

Figure 1 (above). Cliff failure (Δt=0.001s) (8000 steps after the cliff was put in the gravitational field)

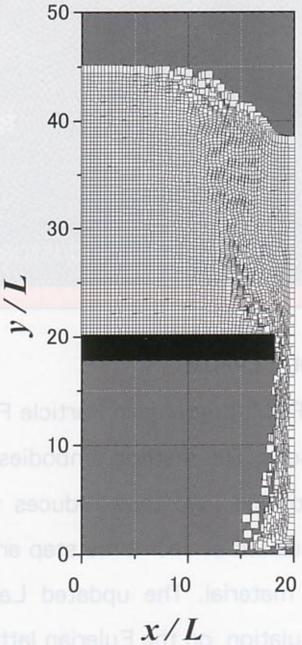

Figure 2 (right). Mass flow through a trapdoor ($\Delta t 1\times(10^{-4}$s, 16000 steps after the flow started)

tion, detailed features of this cliff failure were vividly described. Initially the deformation is slow, but as plastic strains begin to accumulate, certain regions become softened and rapid shear-band formation occurs. The corner wedge of the soil mass then starts sliding down the softened slope, being followed by some surface Lagrangian points that has come off and rolled down scarps formed in succession behind the sliding wedge. These Lagrangian points are stop moving when the slope angle corresponds to the angle of repose.

(2) Mass Flow through a Trapdoor

A mass flow through a trap door was simulated (Figure 2). The gravitational acceleration was given at once to the mass with mechanical properties listed in Table 1, and the mass started flowing under its own weight. The opening of the door is just twice the cell size L, and yet, the mass exhibiting a noticeably flexible nature can flow through the narrow opening.

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