

Assessment of slip behavior due to non-uniform normal stress distribution by deformation analysis with super/subloading surface friction model

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ABSTRACT

The boundary conditions for solid deformation analysis are given by either the Dirichlet boundary condition (prescribed displacement) or the Neumann boundary condition (prescribed load), but actual contact surfaces exhibit frictional behavior causing boundary nonlinearity accompanying a continuous transition between stick and slip states. It is essential to consider this influence to understand friction-induced phenomena such as negative friction in geotechnical engineering and occurrence of earthquakes in seismology. We proposed the super/subloading surface friction model^[1], which incorporates the superloading surface concept^[2] to the existing subloading surface friction model^[3]. The constitutive model describes the elasto-plasticity of a contact surface regarding the state in which the static friction coefficient is larger than the kinetic friction coefficient as a state of developed the "structure" (adhesion) and describing the decay and healing of the structure with an evolution rule for capturing the state transition between static and kinetic frictions.

In this study, we developed the dynamic elastic infinitesimal deformation analysis code incorporating the model into the contact force boundary and investigated the influence of the normal stress distribution at the contact surface on the global slip behavior under a simple shear condition (Figs. 1 and 2). The time histories of the horizontal displacements at Nodes 1-6 are shown in Fig. 3. The frequency of slip occurrence and the amount of displacement were strongly influenced by the magnitude of normal stress. The results are consistent with the reduction tendency of the number of earthquakes with the increase of confining pressure known in seismology^[4]. As for the slip propagation, the slip triggered at the low normal stress area (left side on Fig. 1) did not propagate to other areas, but the slip triggered at the high normal stress area (right side on Fig. 1) propagated through the entire surface due to the difference of the incremental load capacity at the surrounding sliding surface.

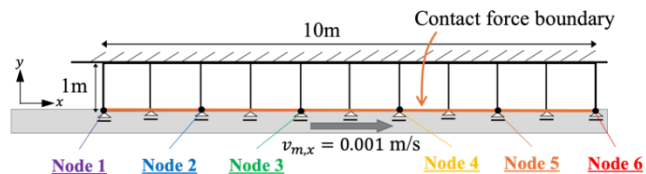


Fig. 1 Finite element mesh and boundary condition

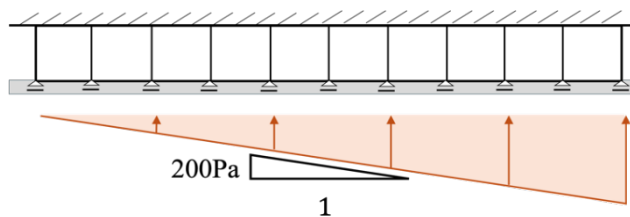


Fig. 2 Distribution of normal stress

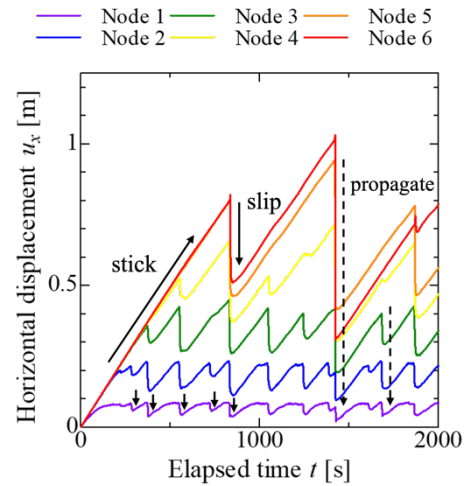


Fig. 3 The results of analysis

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