

Dynamic simulation for rigid body system coupled with hydraulic system considering digging behavior of soil

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As the hydraulic excavator is a digging machine, the system analysis considering digging behavior of the soil is important for evaluating the digging performance. To date, the majority of research in digging analysis has focused on using the Discrete Element Method (DEM) which is proposed by Cundall and Strack[1]. Coetzee and Els[2] have demonstrated the validity of the simulation results using DEM by comparing the experimental ones, while the simulation of the digging force acting on the bucket is conducted in the digging operation. Tsuji[3] et al. have conducted the simulation of the leveling operation and digging operation of the ground using by the bulldozer. Using the co-simulation technique combined multibody system dynamics and DEM, the digging performance has been examined on the construction machinery such as the wheel loader.

This paper presents a dynamic simulation technique for the rigid body system coupled with the hydraulic system considering the digging behavior of the soil. The rigid body/hydraulic system is modeled based on the Newton-Euler formulation, while the soil is modeled by DEM using the cohesive model proposed by Utili and Nova[4]. The co-simulation is carried out for the rigid body/hydraulic system and the soil as shown in Fig.1. Firstly, the digging simulation of the soil for the bucket of the hydraulic excavator is carried out for the cohesive soil and the sandy soil. The digging behavior of the soil and the digging force are discussed. Secondly, the co-simulation technique for the rigid body/hydraulic system and the soil is presented. Finally, the dynamic simulation of the hydraulic excavator is carried out for the digging operation, the behavior of the hydraulic system and the soil is discussed for the cohesive soil and the sandy soil. It is shown that the digging power of the arm for the sandy soil can be reduced by considering the cohesive force. It is clarified that the present technique can evaluate the hydraulic system of the hydraulic excavator for any characteristics of the soil.

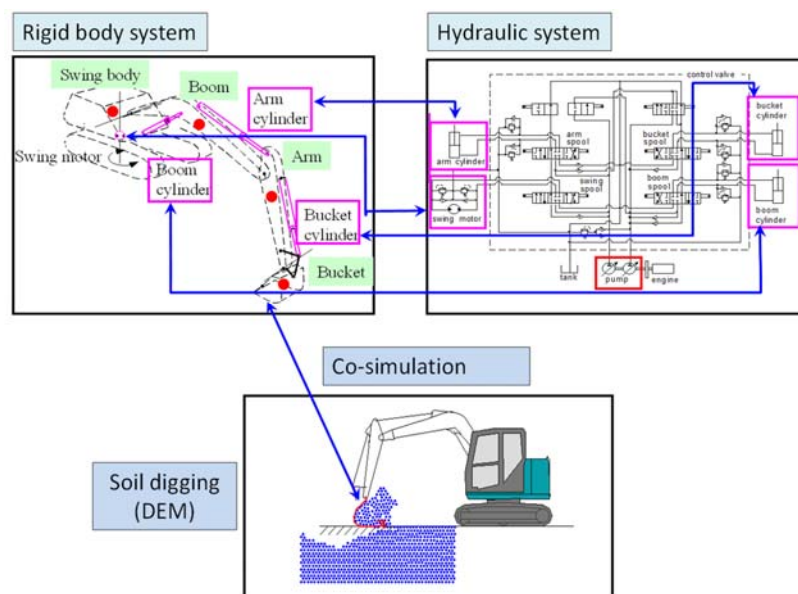


Fig.1 Computing environment of co-simulation with rigid body/hydraulic system and soil digging by DEM.

Fig.2 shows the simulation results of the motion of the hydraulic excavator on the digging operation in the case of cohesive soil and sandy soil. The attachments of the hydraulic excavator are extended to forward in the initial condition, the digging operation is conducted by actuating the hydraulic cylinder of the boom, the arm, and the bucket. In 1s, it is observed that the insertion of the bucket in the sandy soil is faster than that in the cohesive soil. In 3s, it is observed that the clods of soil occur in the cohesive soil while the fluidity of soil improves in the sandy soil. It is considered that these phenomena occur due to the criteria of failure that are characteristics of the soil.

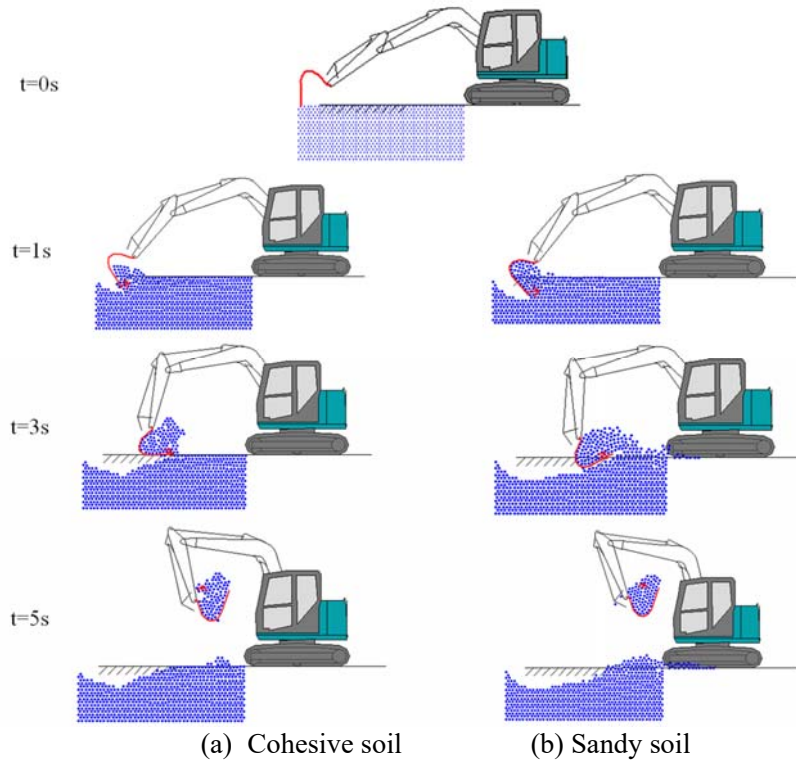


Fig. 2 Digging behavior of the hydraulic excavator for cohesive soil and sandy soil

References

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