LANDING IMPACT TRANSFER CHARACTERISTICS OF SPORTS SHOES TO THE GROUND CONDITION

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INTRODUCTION

The transfer characteristics of the landing impact force[1-2] of sports shoes to the sports surface are numerically investigated by the explicit finite element method. A 3-D coupled foot-shoe-ground finite element model, in which not only the detailed geometry of foot and shoes is considered but also the mutual interaction is fully reflected, is used, and four different sports grounds made respectively by asphalt, urethane, clay and wood are modeled by taking their complex material and structural composition into consideration. The dependence of the ground reaction force, the acceleration transfer and the frequency response are parametrically examined with respect to the ground condition.

METHODS

Every sports ground is commonly in the lamination structure of several different material layers. The material and structural composition and the dimensions of each ground are dependent upon the type of sports game and standardized by the regulations of the corresponding international sports association. Here, four representative sports grounds are considered, asphalt, urethane, clay and wood. In case of the asphalt ground, asphalt, base and subgrade layers are assumed to be linear isotropic. On the other hand, rubble and base layers in the urethane ground are modeled as linear isotropic. In the similar manner, clay and granite clay layers in the clay ground are combined into a clay layer, and the resulting two material layers are modeled as linear isotropic. Meanwhile, beech panel in the wood ground is modeled as orthotropic, assuming white pine as isotropic, and support layer is excluded by letting it as rigid.

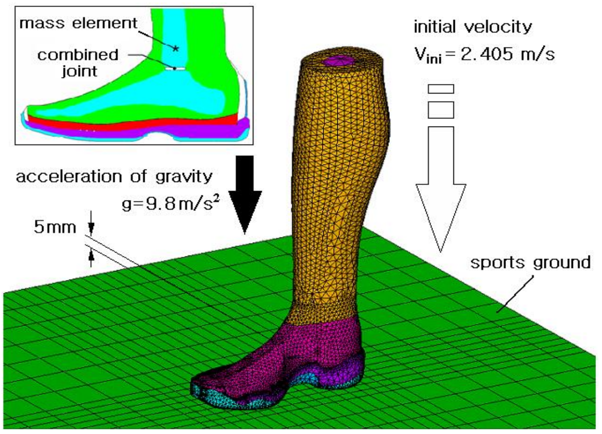

Figure 1: 3-D coupled foot-shoe-ground finite element model for the landing impact analysis of sports shoes.

A coupled 3-D foot-shoe-ground finite element model is represented in Figure 1 3(a). The most prominent feature of this state-of-the-art model is the realization of the in-shoe lower limb, so that any kind of foot motion that can be occurred in actual sports events can be simulated with perfect freedom. This model is highly distinguished from the conventional simulation models which are not only simplified and restricted but also relying on experimental data for accounting for the interaction effect between foot and shoes.

A vertical straight landing event of a human foot from $h = 300mm$ above the ground with the zero initial velocity is taken for an illustrative numerical simulation. The total weight of the human body is set by $60kgf$ and its dynamic effect is reflected by adding the total body mass to the mass center of the foot-shoe coupled model. In order to shorten the total CPU time, only the landing interval from the vertical position of $5mm$ just above the ground is simulated, by specifying the initial velocity to the entire foot-shoe coupled model. The simulation was carried out by the explicit finite element method [3].

RESULTS AND DISCUSSION

Figure 2 represents the amplitudes and center frequencies at four locations of the lower extremity for four different ground conditions. The reductions in the peak acceleration and the center frequency through the lower extremity are schematically summarized, for four different sports grounds. To the evaluation position, the peak acceleration and the center frequency are reduced respectively by 60~70% and 87~89% from heel to knee. On the other hand, the reductions in both to the ground condition are 20~40% and 5~18%, respectively. Thus, the reduction of the landing impact through the lower extremity is significant, particularly from heel to ankle, but the influence of the ground condition can not be ignored.

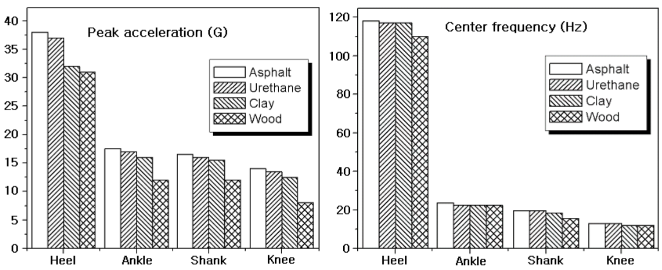

Figure 2: Transfer of the peak acceleration and the center frequency to the ground condition.

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