Numerical Simulation of Coastal Town Planning against Tsunami by DEM-base Human Behavior Simulator

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ABSTRACTS
Investigation of the evacuation process from tsunami disaster is quite important for coastal town planning against tsunami disaster. Reproduction of imminent situation in a real disaster is impossible in an ordinary evacuation training. For this reason, a numerical simulation is an effective tool to investigate the evacuation process in tsunami attack. We have developed the DEM-base human behavior model to reproduce an evacuation behavior. In the present study, a disaster prevention planning against tsunami in a small model town is conducted from the viewpoint of appropriate selection of evacuation places.

KEY WORDS: DEM; human behavior; tsunami; coastal town.

INTRODUCTION
Development of a supporting tool for evacuation planning is required. Expression of a difference of locomotive power and age of individual are required to simulate an evacuation process in a human scale. Development of the evacuation simulator in a human scale is also indispensable for simulation of the blockage condition of crowd evacuation around a stricture of evacuation passage. The DEM-base evacuation simulator is effective for dealing with evacuation behavior of individual. We have developed the DEM-base evacuation simulator, and investigated the crowd evacuation process in tsunami disaster (Gotoh et al., 2004) and crowd evacuation process from underground space by inundation due to interior runoff (Harada et al., 2006). In this study, the disaster prevention in town planning was discussed from the viewpoint of appropriate selection of the evacuation places. The effectiveness of this kind of evaluation planning method based on the DEM-base evacuation simulator is clarified.

CROWD EVACUATION SIMULATOR
In this study, DEM-base crowd evacuation simulator, which is proposed by Gotoh et al. (2004) is used. The motion of person is described with translational and rotational equations as follows:

\[ M \frac{d^2 \mathbf{u}_i}{dt^2} = F_{\text{hot}} + F_{\text{aw}} \]  
\[ I_i \frac{d\omega_i}{dt} = \frac{d_i}{2} \sum f_{ij} \]  
\[ I_i = \frac{\varepsilon_s \omega_i d_i^4}{32} \]

in which \( F_{\text{hot}} \) = inter-elements force between person/person or person/wall; \( F_{\text{aw}} \) = walking force of person; \( \mathbf{u}_i \) = moving velocity; \( M_i \) = mass of person which is assumed as cylinder shape; \( \varepsilon_s \) = specific density of person element (=0.98); \( \omega_i \) = angular velocity of person element; \( f_{ij} \) = external force in the tangential direction between \( i \)- and \( j \)-th person elements; and \( I_i \) = moment of inertia of person element. The force between person/person or person/wall elements are described by following the standard DEM. These force act in the area as shown in Fig.1 in consideration of the view range of person as follows:

Figure 1. Modeling of influence area of each person