# ABSTRACT

It has been long recognized that particle crushing leads to a significant change in the properties of sensitive crushable soil. Thus, it is essential to study the deformation and failure of ground exhibiting particle crushing. The aims of this study are (1) to establish a mutual relationship between particle size distribution curve and grading index (2) to develop a new elastoplastic constitutive model considering particle crushing using grading index $I_G$ and its evolutional rule (3) to analyze the deformation and failure of ground exhibiting particle crushing using the proposed model.

In the first part of this research, an elastoplastic constitutive model considering particle crushing . Next, the effect of particle crushing was implemented to the critical state soil model (Roscoe, Schofield et al. (1963), Muir Wood (1990)) by incorporating the grading index $I_G$ and its evolution law due to crushing. Finally, the model was extended to incorporate the effect of density on the stress-strain characteristics by employing the concept of subloading surface (Hashiguchi and Ueno (1977)). The validation of the proposed model via a number of experimental laboratory triaxial tests under isotropic consolidation, consolidated undrained, and consolidated drained conditions has revealed the good performance of the model to capture the response of crushable soil. Furthermore, the effect of fine contents on the behavior of uncrushable soil was also discussed by our model. The advantage of our model is not only shearing and compression effect, but consolidation effect was also considered to the initiation of particle crushing. Also, the model can be used to study the behavior of both crushable and uncrushable soils.

The second part of this study is to numerically analyze the deformation and failure of ground exhibiting particle crushing. To solve the non-linear equations with boundary conditions, the widely used numerical technique, Finite Element Method (FEM) was chosen. However, to overcome the volumetric locking problem in FEM with low order elements when dealing with critical state model, modified B-bar method (Commend, Truty et al. (2004)) was applied in this paper. The first practical application in this study is the analysis of bearing capacity of strip footing on Dogs Bay sand, a crushable soil. Parametric studies were conducted to evaluate the effects of parameters of the soil model to the bearing capacity of strip footing. It was found that (1) with 15 cm settlement, bearing capacity of strip footing slightly reduced (~10%) due to particle crushing in case of Dogs Bay sand, (2) the less crushing effect was observed for the larger the width of foundation. (3) with a specific allowable settlement, the effect of crushing on bearing capacity decreased when the footing size increased. (4) scale effect was also observed in our simulation; however, the ultimate bearing capacity was not observed in the simulation of Dogs Bay sand. (5) when assuming the bearing capacity under a certain settlement was “ultimate” bearing capacity, one interesting finding was that (the bearing capacity factor $N_\gamma$ – strip footing width B) line of crushable soil in ($log_{10}$-$log_{10}$) scale was a straight line being shifted

downward from the ($N_\gamma$-B) line of uncrushable soil. The second application is the analysis of passive and active earth pressure on Dogs Bay sand, a crushable soils. From the simulation results, it is observed that the occurrence of particle crushing significantly reduced passive earth pressure coefficient, around 25% (from 7.4 to 5.8, to be more specific). On the other hand, active earth pressure is not much affected by particle crushing phenomenon.