III-391 REAL-TIME OBSERVATION OF THE INNER DEFORMATION AND FAILURE PROCESS IN A BEARING CAPACITY TEST

Peter Rangelow, *Member, Grad. Student, Institute of Industrial Science, University of Tokyo*
Kazuo Konagai, *Member, Assoc. Professor, Institute of Industrial Science, University of Tokyo*
Tsutomu Namikawa, *M.Eng., Researcher, Takenaka Research and Development Institute*

The Laser-Aided Tomography [1] is a new experimental method which enables the visualization of all particles interlocking one another in a three-dimensional granular model. It is a very powerful tool for studying the behavior of submerged sand models. In accordance with this method **(Fig.1)**, 9 layers of crushed optical glass, with characteristics summarized in **Table I** and a total depth of 161 mm, are heaped in a water tank (W300 x D150 x H300) containing a liquid with physical properties very similar to that of water. Consequently, the model becomes invisible because the liquid's refractive index has been tuned to that of the glass material. An intense laser-light sheet, which is passed through the model, illuminates the contours of eight "sheets" of fine glass powder which are placed between the layers of the model [2]. These sheets appear as grid lines in the cross-section that is "cut" by the laser sheet, thus enhancing the observation of the inner deformation process. An acrylic cylindrical footing (D = 70 mm) is driven at constant speed during one experiment.

Table I Characteristics of Crushed Glass

Mean particle size	0.47 mm
Coefficient of uniformity	1.31
Specific gravity	2.52
Maximum void ratio	1.52
Minimum void ratio	0.881

More than ten tests were performed, for two different speeds: 1 mm/min and 10 mm/min. Due to difficulties related to the LAT experimental procedure, which fall outside of the scope of this paper, only one test is considered here -- for 1mm/min loading speed. The load-settlement curve recorded in this test is shown in **Fig.2**. An image of the middle cross-section of the model at the initial stage, i.e. before deformation, is shown in **Photo 1**. The deformation of the middle cross-section at the first peak load. -- corresponding to an abrupt change of the rate of induced load from positive to negative -- is shown in **Photo 2**. Apparently, no failure surface is observed. Later on, at 56 kgf and 30.8 mm (cf. **Photo 3**), clear kinks on the second, third and fourth grid lines prove the presence of a failure slip surface -- as observed by a general shear failure. **Fig.3** depicts a three-dimensional image of the deformation of the model's half after scanning it by the laser and processing the data for the third grid surface. It confirms the presence of a general shear failure surface.

CONCLUSIONS

The bearing capacity of submerged sand underlying a circular footing was studied in this paper. The visualized inner deformation and failure process through the LAT experiment, for the loading velocity of 1 mm/min, confirmed the generally accepted hypotheses, i.e. dense sands, under slow to moderate loading speeds, fail in general shear failure. However, no failure surface was observed at the first peak load, corresponding to a settlement of 8 percent of the footing's diameter. A failure slip surface, which is typical of a general shear failure, appeared at much larger strain. Furthermore, the load-settlement curve recorded in this test is not representative for a general shear failure, but for a punching failure [3]. The boundary conditions of the model and the angularity of the crushed glass grains may also have contributed to the observed phenomenon. Future LAT experiments should clarify the above mentioned discrepancies and help to better understand the failure process in submerged sands.

REFERENCES

(1) Konagai, K.; Tamura, C.; Rangelow, P.; Matsushima, T. (1992): Laser Aided Tomography: a Tool for Visualization of Changes in the Fabric of Granular Assemblage, Proc. of the JSCE, Structural/Earthquake Eng., No.445/I-21, pp.25-33.
(2) Rangelow, P.; Konagai, K.; Matsushima, T. and Park, C.S. (1992): Visualization of granular Material Deformation trough Laser-Aided Tomography, Bull., Earthquake Resistant Structure Research Center, Univ. of Tokyo, No.25, pp.61-67.
(3) Vesic, A.S.; Banks, D.C. and Woodard, J.M. (1965): An Experimental Study of Dynamic Bearing Capacity of Footings on Sand, Proceedings, 6th International Conference on Soil Mechanics and Foundation Engineering, Montreal, Canada, Vol. II, pp. 209-213.

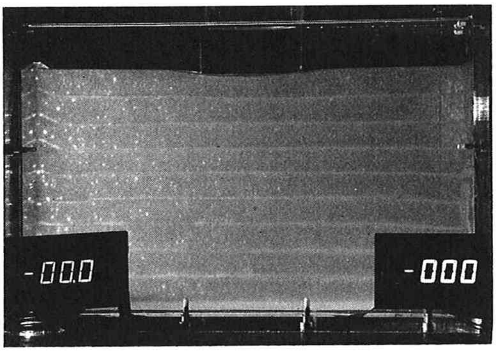

Photo 1 Middle cross-section, initial condition.
Settlement = 0.0 mm; Load = 0.0 kgf.

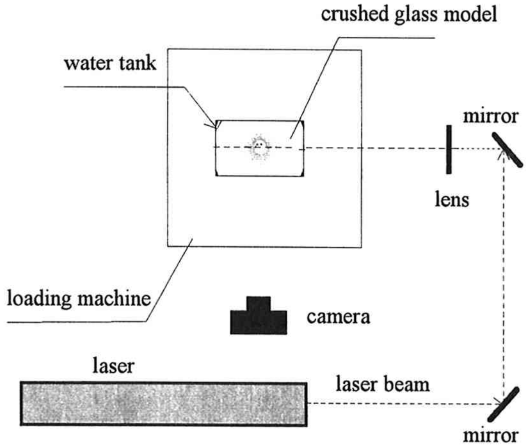

Fig.1 Setup of the LAT experimental apparatus.

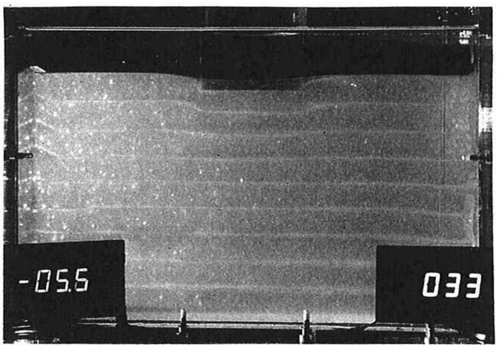

Photo 2 Deformed middle cross-section.
Settlement = 5.5 mm; Load = 33 kgf.

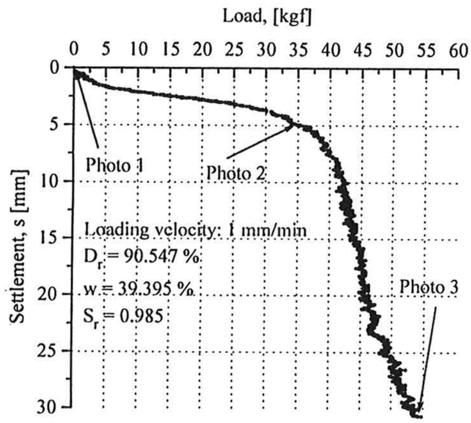

Fig.2 Load-settlement curve for crushed glass model.

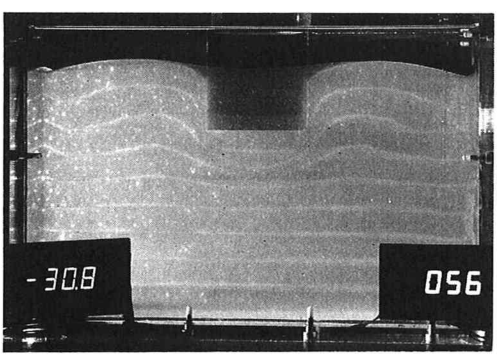

Photo 3 Deformed middle cross-section.
Settlement = 30.8 mm; Load = 56 kgf.

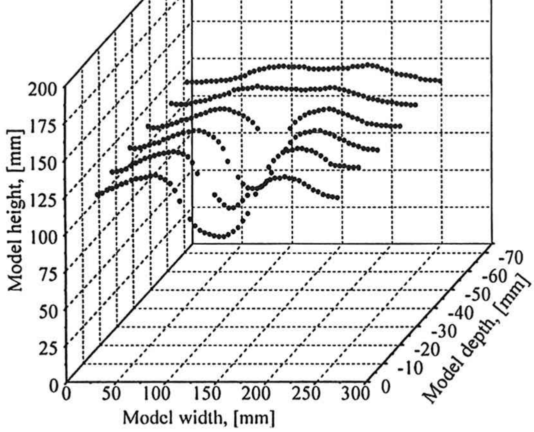

Fig.3 Deformation of the third grid surface of the model.