

***Japan Academy Prize to:***

Tsutomu KIMURA  
 Specially Appointed Professor and  
 Professor Emeritus, National Institution  
 for Academic Degrees and University  
 Evaluation  
 Professor Emeritus, Tokyo Institute of  
 Technology  
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for “Mechanical Behaviour of Foundation  
 Soils”

***Outline of the work:***

Dr. Tsutomu Kimura’s special field is geotechnical engineering, which used to rely very much upon empirical approaches. He has made every effort to introduce theoretical approaches based on the theory of elasticity and plasticity combined with observation of real phenomena created through centrifuge model tests. The effect of self-weight is a dominant factor in the mechanical behavior of soil. This gives rise to great difficulty in creating real behaviour through small-scale model tests in the 1g field, where stress by self-weight of soil is by far smaller than that in reality. This difficulty, however, can be overcome by placing a small-scale model in a high centrifugal field as doing so satisfies the similitude of stress as well as of geometry. Dr. Kimura built a geotechnical centrifuge in early 1960’s and made full use of the apparatus in his research to observe the real behavior of various soil structures over the course of his career.

Dr. Kimura’s contributions are summarized as follows.

- (1) Successful utilization of radiographs to observe failure lines in sand: The radiograph technique had been utilized mainly for analyzing earth pressure problems of retaining walls in which the axis of the principal stress does not rotate. He attempted to apply this technique to bearing capacity problems where the axis of the principal stress rotates by 90 degree. He succeeded in producing radiographs showing very clear failure lines known as shear bands. He used the observed failure mechanisms for upper-bound plasticity analyses that give bearing capacity very close to observations. He also succeeded in observing failure mechanisms for dense sand deposits subjected to loading by a footing with a smooth base, in which symmetrical shear bands starting from the centre of a footing form as predicted by the theory of plasticity for metal. The radiograph he produced is believed to be the first in the world.
- (2) It has been long known that the bearing capacity of sand deposits decreases with increased width of the footings, which is inconsistent with prediction using the theory of rigid plasticity. In an attempt to find the reason for the so-called scale effect of footings, Dr. Kimura built a displacement tracing apparatus with high accuracy combining a high-precision TV camera with an electronic brightness detector. Using this device, he found that shear strains develop progressively along failure lines or shear bands even in dense sand. He concluded that this progressive failure is the major reason for the scale-effect.
- (3) From 1978 to 1979, Dr. Kimura spent a year at Cambridge University where he engaged in research on clay using a geotechnical centrifuge. He helped the Cambridge geotechnical engineering group to develop an accurate pore-pressure transducer needed for controlling the stress history of clay used in experiments. Using this transducer, Dr. Kimura was successful in creating clay deposits with various strength profiles. He carried out a series of centrifuge model tests on these soft clay deposits improved with sand compaction piles, lime columns and other methods.

He produced a set of data useful in the practical design of soil improvements.

He found that this transducer was able to measure negative pore-pressure if the porous stone at the tip is very carefully deaired. He succeeded in measuring the amount of disturbance of a soil sample as a result of unloading, squeezing out of a thin-walled tube and trimming prior to strength testing.

- (4) There have been many cases of failure in soft clay deposits during excavation. Dr. Kimura developed a miniature excavator for centrifuge model tests by using robots and carried out model excavation tests with this excavator. He found that the magnitude of passive earth pressure is considerably smaller than the theoretical values, which led him to conclude that this is a major cause of failure at sites.
- (5) Dr. Kimura has also challenged a liquefaction problem. He built an earthquake simulator which can be used in a centrifuge. This device enabled him to carry out model tests in which the similitude of stress holds for models and in which seismic acceleration and velocity as well as displacement amplitude can be modeled properly. He successfully observed that pore-pressure shoots up at the instance when liquefaction takes place. He provided useful design parameters for soil improvements to prevent liquefaction.

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