YNU ResearchNo.3 | Associate Prof. Mamoru Kikumoto Lab.

# Why does the ground collapse?

## The Forefront of Geomechanics Research related to Geohazards

**Associate professor Mamoru Kikumoto's group is trying to develop models for soils to explore the mechanism of deformation and failure of the ground. Why, when, and how do embankments collapse due to earthquakes or heavy rains? He and his group tackle this issue through laboratory testing, field observations, and computer simulations.**

### Research subject in geomechanics

The ground supports all structures including buildings and roads. Because the ground consists of a mixture of natural materials, which are solid particles, water, and air, its deformation and strength characteristics vary greatly and cannot be described easily—unlike other artificial materials such as concrete or steel. The mechanism of geohazards caused by earthquakes or heavy rains cannot be clarified without a proper understanding of the characteristics of soils. The field of scientific research on the physical and chemical phenomena of soils and rocks is called geotechnical engineering.

### Mysteries in the underground

The ground deforms or collapses suddenly by earthquakes and heavy rain. On the other hand, weathering weakens soils and rocks very gradually over a long period, and it may finally cause issues as slope failure. What is happening under the ground? The underground is full of mysteries. Associate professor Mamoru Kikumoto's group challenges such secrets of the ground.

Two examples of researches of his group are herein introduced: one is regarding the collapse mechanism of the stone walls of Kumamoto Castle due to the 2016 Kumamoto earthquake, and the other is regarding deformation issues of the highway embankments.

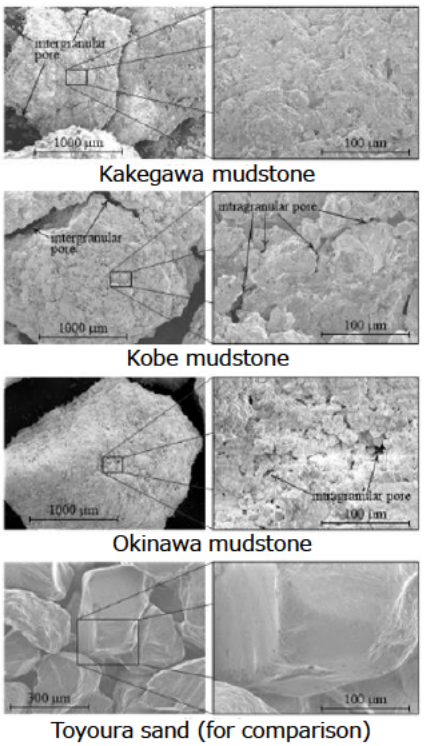
## The stone walls of Kumamoto Castle damaged severely by a series of strong earthquake motions in April 2016

Kikumoto's group has been conducting comprehensive research since the earthquake. They first tried to detect the damage by a 3-dimensional laser scanning of the stone walls. By comparing the measured results with past observation data, they discovered the characteristics of the deformation of the stone walls. They further conducted shaking table tests and computer simulations to investigate the seismic stability of the stone walls and mechanism of the collapse of the walls, and they revealed that the vertical earthquake motion, as well as the horizontal one, affected the destructio n of the stone wall.


Damage of stone walls at Kumamoto Castle by the 2016 earthquake: Multiple failure modes, detaching of stone walls and active failure of the backfill ground could be seen (photo provided by Dr. Kikumoto)

## Deformation of the highway embankment caused by weathering of geomaterials

When the 2009 Surugawan earthquake struck, a highway embankment in the Makinohara district of the Tomei Expressway collapsed, resulting in the road being closed for five days. The direct cause of the failure was the earthquake, but the technical committee looking into this issue indicated that the crushed mudstone used in the embankment had been weathered and lost its strength. Soils derived by the excavation of tunnels and cut slopes are often used for the construction of embankments, but it usually contains weak rocks such as mudstone and shale. Such materials are easily weathered and disintegrated into clay-like fine particles, especially when crushed mudstones are subjected to repeated drying and wetting. The research group collected twelve soil samples from highway embankments in Japan and three




The Scanning Electron Microscopic (SEM) image of several mudstones derived from highway embankments (photo provided by Dr. Kikumoto)

samples from overseas, and they investigated the weathering process and weathering-induced deformation of the ground. As a result, they found out that weathering mechanisms were entirely different depending on the minerals of the materials. Although this research work is being carried out on a continuous basis, it is expected to significantly contribute to the practical geotechnical engineering.

## Challenging research

Two kinds of challenging research topics of associate professor Mamoru Kikumoto's research group were introduced. The time scale of the deformation and failure of the ground varies much: an earthquake triggers the deformation and failure of the ground in a short period, whereas the weathering of the geomaterials will take place over a long period. However, his research group is trying to theorize the deformation and failure behavior of soils in a unified manner and is trying to contribute to disaster prevention and mitigation through advanced simulations.

There are many challenging research topics in geomechanics such as liquefaction; erosion; ground contamination; bearing capacity of the foundations of high buildings and large bridges. Associate professor Mamoru Kikumoto said, "Our ultimate goal is to develop models of soils and rocks to clarify the mechanism of the deformation and failure of the ground. This is a challenge of the human knowledge regarding nature."