National Research Institute for Earth Science and Disaster Resilience

Development and Popularization of Environmentally-friendly Disaster Resilience Technology by Effective Utilization of Gabions

"NIED Large-Scale Earthquake Facilities and Gabion Project."

Oct. 31, 2018 14:00-16:30
Session 4: Space-based technology and Affordable solutions facilitating DRR

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This presentation

1. Introduce of NIED Earthquake Facilities

- E-Defense
- Large-Scale Earthquake Simulator

2. Gabion Project

- Introduce of Our Project
  - Damage survey
  - Small scale model test
  - Full scale shake table test
  - Numerical analysis
  - Test Construction

1. Introduce of NIED Earthquake Facilities

- E-Defense
- Large-Scale Earthquake Simulator

Miki, Hyogo, Japan

Tsukuba, Ibaraki, Japan

HYOGO EARTHQUAKE ENG. RESEARCH CENTER

600km

LARGE-SCALE EARTHQUAKE SIMULATOR

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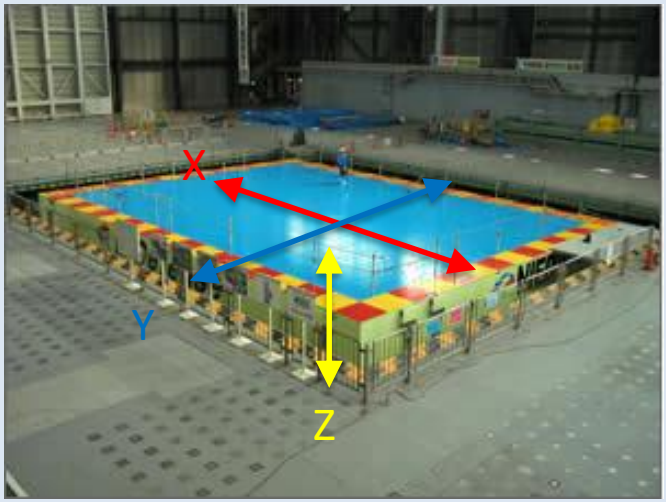
LARGE-SCALE EARTHQUAKE SIMULATOR

What's E-Defense?



Shaking Table

Logo mark

"E-Defense" is a nickname of "Three-Dimensional Full-Scale Earthquake Testing Facility".

The symbol "E" indicates "Earth", suggesting the critical need for the promotion of research and development on the mitigation of earthquake disasters and protection of our lives and properties in a global scale.

E-DEFENSE PAST RESEARCH PROJECTS (-2017)

By the end of this fiscal year, 91 series of experiments have been completed…

Schools constructed in the 1970s

Liquefaction-induced Lateral Spreading

Traditional Wooden Houses

High-rise Buildings (jointly with Hyogo Prefecture)

4-story Steel Frame Building

7-story Wood Panel Building (jointly with an Italian Research Institute)

RC Bridge Column constructed in the 1970s

High-rise Building under Long-period Ground Motions

Estimation of Earthquake-Resistant Performance of Embankments

Please visit to http://www.bosai.go.jp/hyogo/research/movie/movie.html

1. Introduce of NIED Earthquake Facilities

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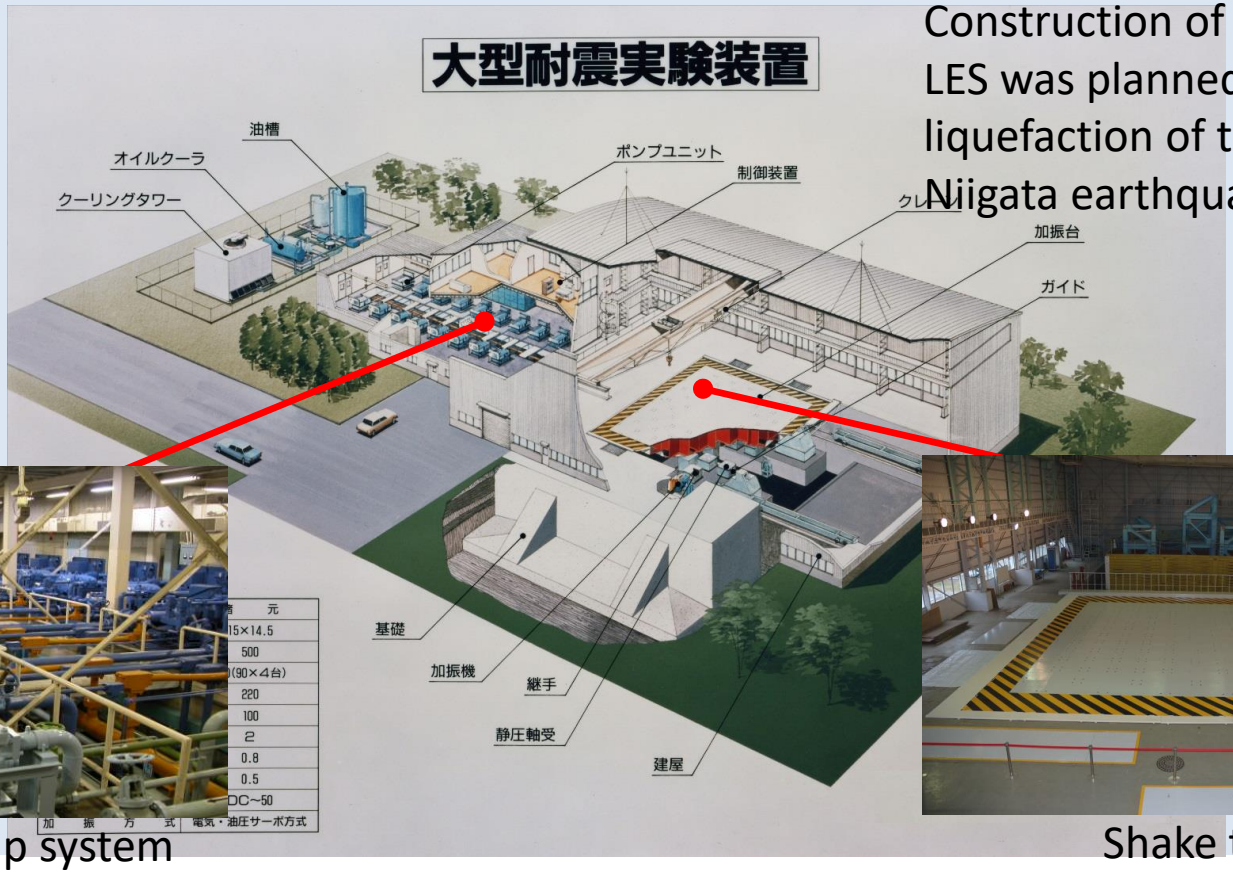


Construction of this facility, LES was planned due to liquefaction of the 1964 Niigata earthquake.

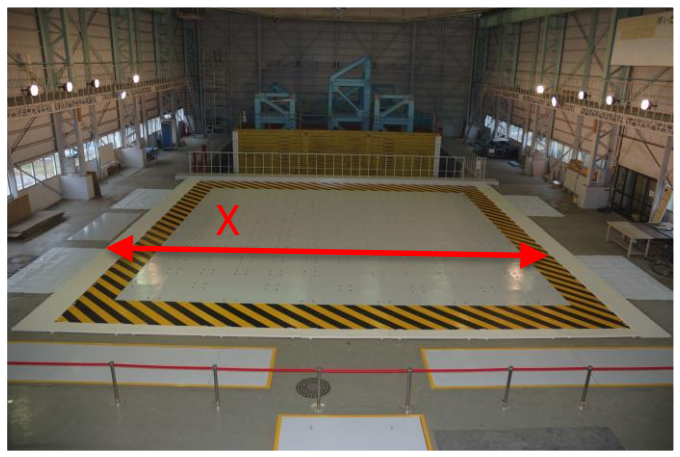
Hydraulic pump system

Shake table

Large-Scale Earthquake Simulator

What's Large-Scale Earthquake Simulator

- The "Simulator" is a testing facility, starting its operation in 1971 as the first research facility in Tsukuba Science City.
- The facility has a 1-D shake table that applies strong motion to a full-scale prototype structure or a large-scale model of buildings, industrial facilities, foundations, soil structures, etc.
- The table can simulate ground motion recorded in a large earthquake in order to observe model's collapse process and to obtain the data for analyses.
- The simulator is a common-use testing facility.
- NIED performs collaborative research themes with universities and institutes, and consignment experiments or researches for public institutes and private companies.

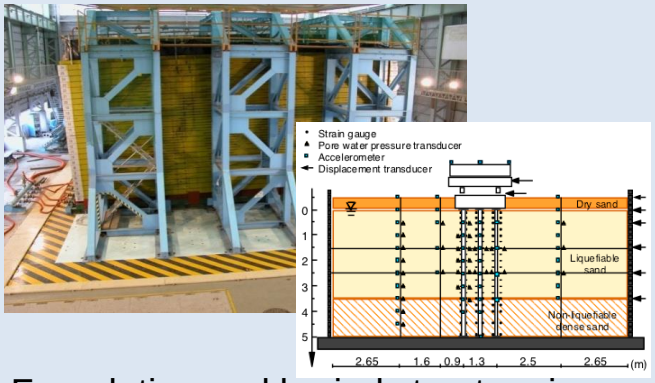


Shake table

Observation of model's collapse process

Examples of models for shake tests

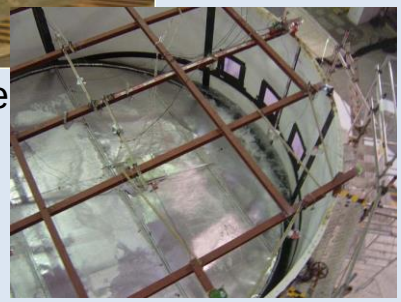
One-third (1/3) scale reinforced concrete building



Foundation and buried structure in liquefiable ground modeled in a large-scale laminar shear container

Five-storied woodn pagoda “Goju-no-to”

Petroleum storage tank with inner floating roof



Sloshing and overflow of liquid to the roof

Wood structure built with CLT

Wooden-frame brick structure

Comparison of Existing Large Shake Tables

COMPARISON OF EXISTING LARGE SHAKE TABLES

Organization	Max. Weigh (ton)	Table Area (m^2)	Directions	Acc. (cm/s^2)	Vel. (cm/s)	Disp. (cm)
NIED Facilities)						
E-Defense, NIED (Miki)	1200 (Guiness Record!!)	300	3 (X, Y, Z)	900 (X, Y) 1500 (Z)	200 (X, Y) 70 (Z)	100 (X,Y) 50 (Z)
LSE Simulator NIED (Tsukuba)	500	217	1 (X)	500	75	22
PWRI (Tsukuba)	300	64	3 (X, Y, Z)	1000	200	60
UC San Diego (San Diego)	2000	93	1 (X)	1000	180	75

Capacity of LSE simulator is much less than E-Defense.
However, total cost of experiment is also much less.

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What are Gabions?

Introduced in Japan in the 360-480 A.D.

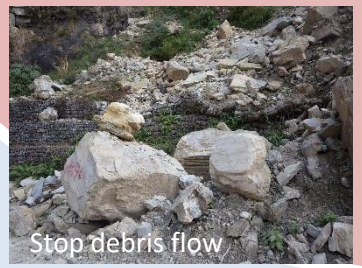
Ways of Using Gabions

Mountains

- Retaining Walls for roads
- Stops falling rocks, debris flow
- Landslide countermeasure
- Crash barrier
- Erosion control dam


Retaining Walls


Crash barrier


Stop debris flow


Landslide countermeasure


Erosion control dam

Urban

- Scenery （flora）
- Temporary housing/emergency restoration
- Simple reinforcement of structures

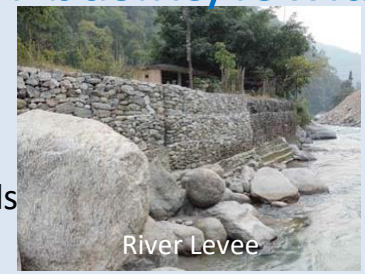

Scenery （Flora）


Emergency restoration


Temporary foundation of bridge pier

Coast and River basins/lowlands/urban

- River levee
- River bulkhead
- Groin
- Bridge designed to be submerged during floods


River Levee


River bulkhead


Groin


Bridge designed to be submerged during floods

Introduce of Our Project

Development of Environmentally-friendly Disaster Resilience Technology by Effective Utilization of Gabions

A) Purpose

- A large number of gabions have been often used in Nepal because it is cheap and easy for anyone to make. And it also makes it easy to get the material.
- Construction of the gabion wall depends greatly on the experience knowledge of local engineers.
- Although the design standards have been prepared, the content is not enough. Additionally, it does not consider the influences of earthquake.
- It is necessary to investigate the static and dynamic stability of the gabion retaining wall in order to make the rational design and construction method.

- To reveal behavior of gabion retaining wall during earthquake.
- To understand and evaluate effects of the flexibility on stability of the gabion retaining wall.
- To establish a reasonable construction method and a design manual for the gabion retaining wall considering its flexibility.

Regarding multipurpose and effective utilization of gabion for adaptive disaster resilience that is Low-tech, Low-cost and Local utilization (3L Technique)

Introduce of Our Project

Development of Environmentally-friendly Disaster Resilience Technology by Effective Utilization of Gabions

B) Member and Funds

Joint Research between Kochi Univ., Saga Univ., industrial partners comprising two design consultants, a manufacturer and a construction company in Japan, and also Tribhuvan University in Nepal.

the Grant-in-Aid for Scientific Research of the Japan Society for the Promotion of Science (JSPS)

- Basic Research B (Oversea Academic Research) 16H05746, and
- Basic Research B (General) 16H04413.

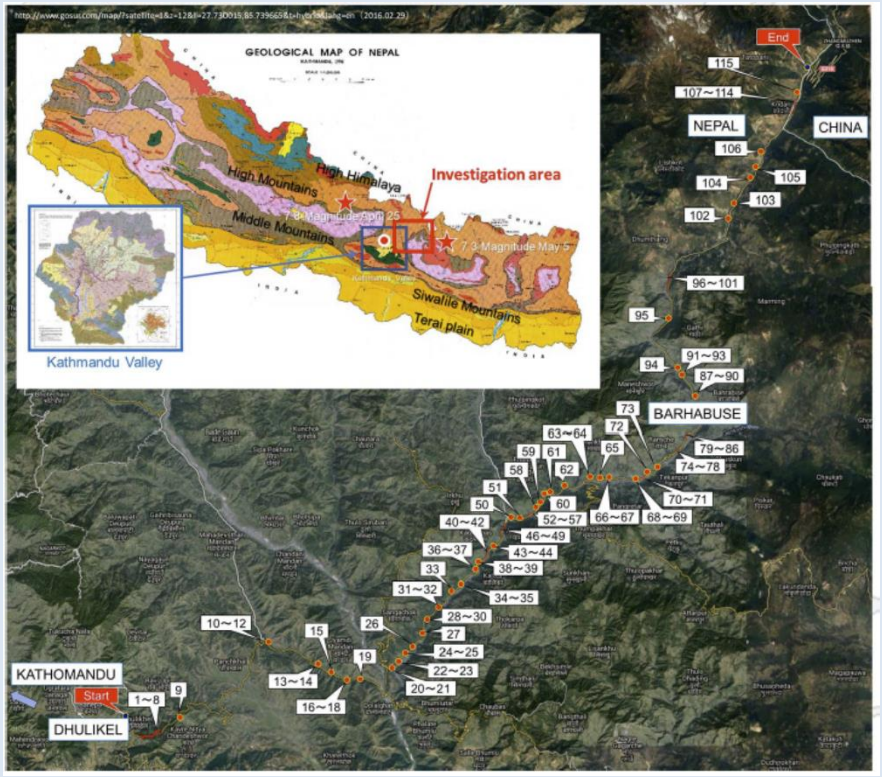
Introduce of Our Project

Development of Environmentally-friendly Disaster Resilience Technology by Effective Utilization of Gabions

C) Research Content

- Damage survey.
  - Damage survey of the 2015 Nepal-Gorkha earthquake.
  - Analysis of Usage pattern of the gabion and the ratio of classified damaged gabion walls.
- Small scale model test.
  - To investigate the basic mechanical characteristics of the gabion wall.
- Full scale shake table test.
  - To investigate the dynamic behavior of the gabion retaining wall.
- Numerical analysis.
  - To establish FEM analysis and earthquake resistant design method.
- Test Construction.
  - Construction on site and follow-up after construction.

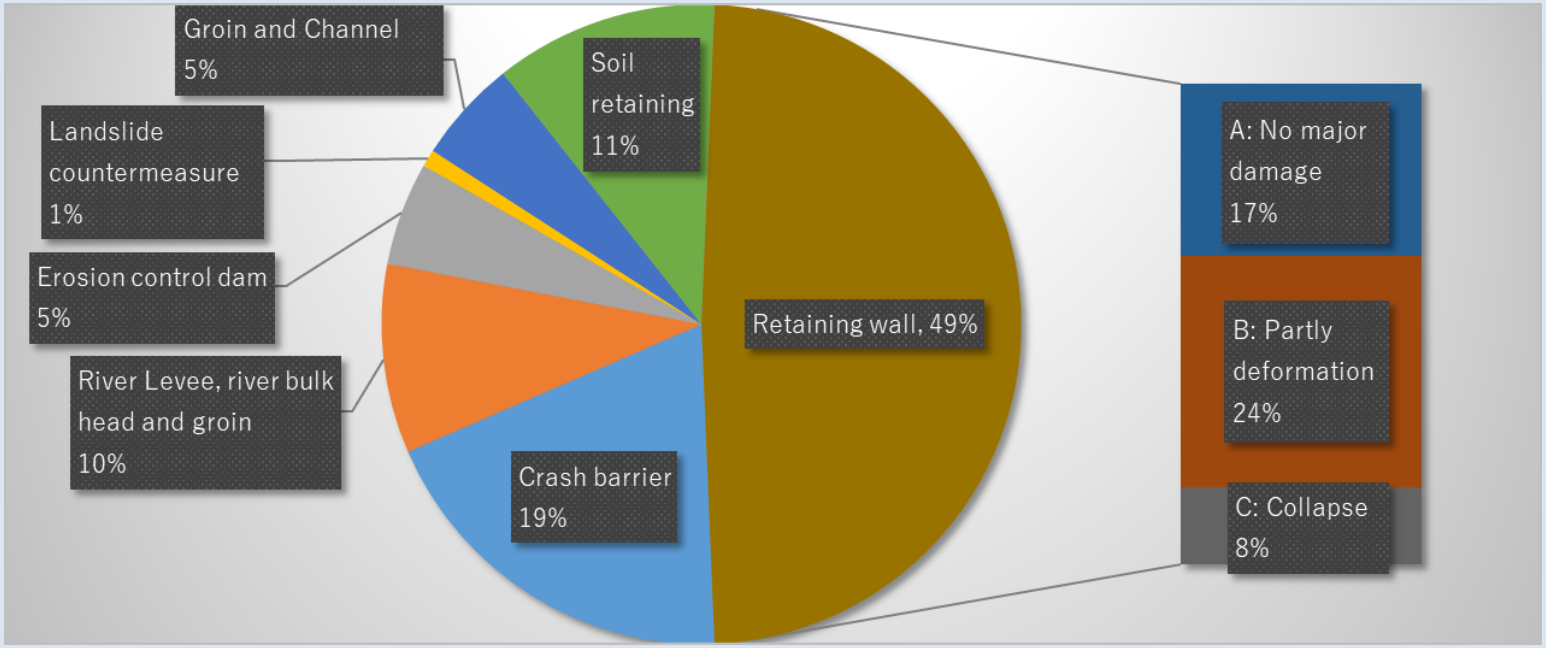
Damage survey



Damage survey on gabion structures along Araniko Highway, Nepal

- Damage survey was carried out along Araniko Highway from Kathmandu city to the Chinese border
- In this highway, the gabion is widely used in the sabo dam and the crash barrier, including the retaining wall.
- The state of the gabion retaining wall could be classified into the usual, the swelling and the collapse state.

Damage survey



(Nakazawa et al, 2018)

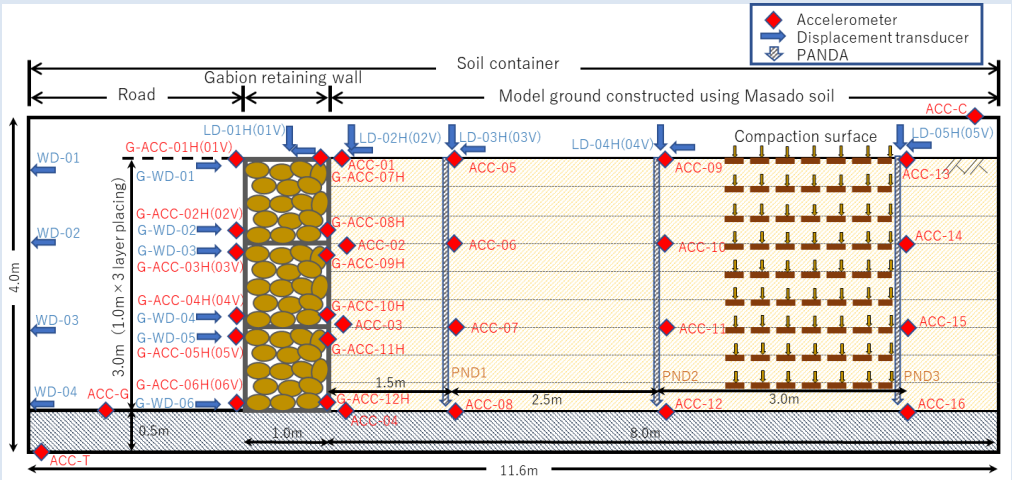
Usage pattern of the gabion and the ratio of classified damaged gabion walls.

- Along this highway, the gabion is used as a member of many structures.
- The retaining wall is 49% of the whole.
- The retaining wall in the usable state was 80% of the total number of retaining walls.
- The shape of the retaining wall has a **vertical-type** and a **stepwise-type**, use ratio was 44% and 56%, respectively.

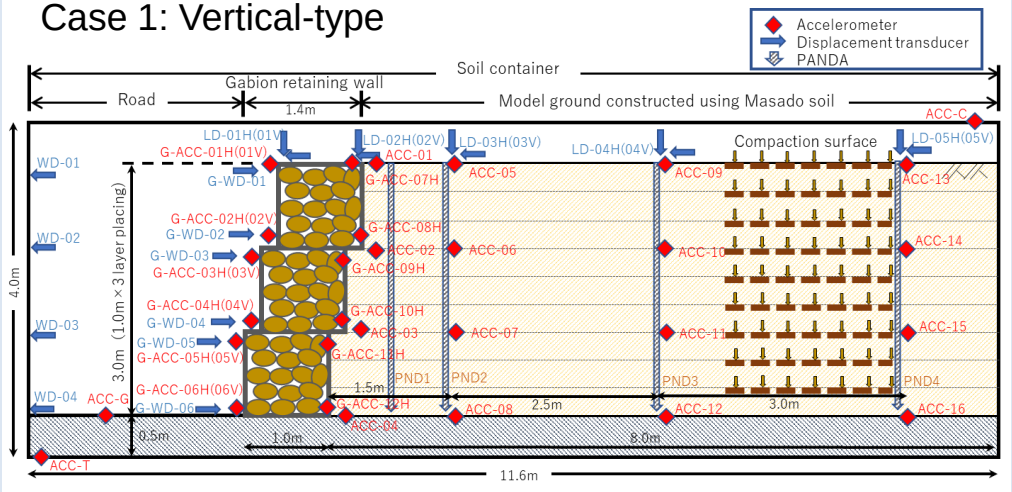
Full scale shake table test

Shake table and Soil container:
- Table size: 14.5m x 15.0m
- Shaking direction: Horizontal(one-direction)
- Soil container size: 4.0m x 11.6m x 3.0m

Test condition:
- Input: sinusoidal wave 3Hz, 8sec
- Amplitude of target input acceleration: 50, 100,150, 200Gal (in four stage)



Case 1: Vertical-type

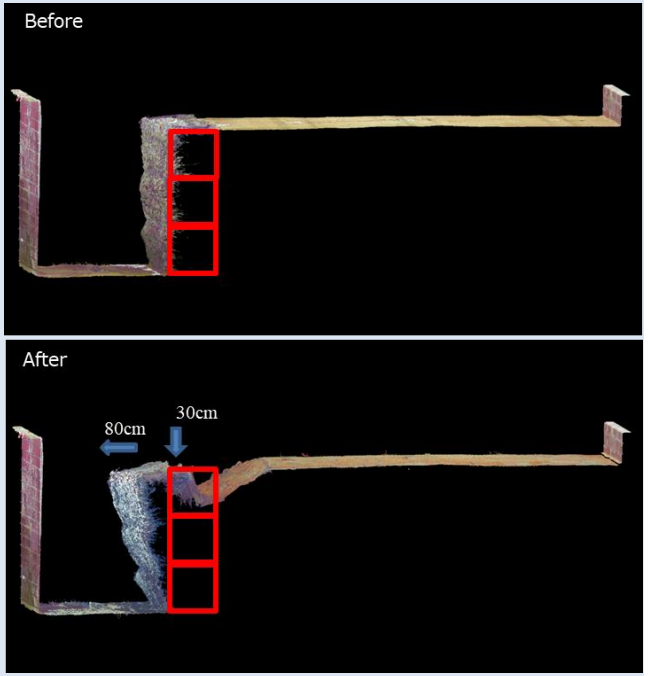


Case 2: Step wise-type

- The gabion retaining wall dimension is 3 m in height, 1m in width and 3m in depth.
- The ground behind the wall is 3m in height, 8m in width and 3m in depth.
- To observe the behavior during shaking, accelerometers and displacement transducers are installed on the gabion and the ground.
- Sinusoidal wave are input with a frequency of 3 Hz.
- Amplitude of acceleration is provided in four stages.

Full scale shake table test (Case1 Vertical type)

Seismic behavior of gabion walls



Case 1: Vertical-type
Sinusoidal wave 3Hz (257Gal in fourth step)

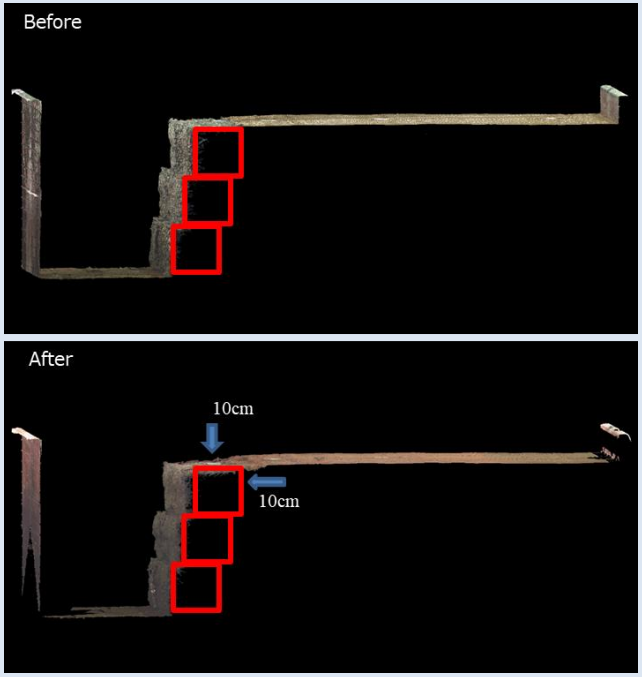
Case 1: Vertical-type
Final deformation by 3D Territorial Razer Measurement (in fourth step)

- The head of the retaining wall tilted forward 80cm and the ground behind the gabion wall largely collapsed.
- The gabion retaining wall stood tenaciously without falling.
- This is an important feature representing the flexibility of the gabion retaining wall.

Full scale shake table test (Case2 Step-wise type)

Seismic behavior of gabion walls

Case 2: Step wise-type
Sinusoidal wave 3Hz (313Gal in fourth stage)



Case 2: Step wise-type
Final deformation by 3D
Territorial Razer Measurement
(at fourth stage)

- This step wise-type retaining wall displaced forward 10 cm.
- It almost retains the initial shape after shaking.
- The step wise-type retaining wall is more stable than the vertical-type.

Summary and Future works

- Examine the collapse mechanism of the gabion retaining wall in detail.
- Investigate the relationship between the collapse form and the flexibility of the gabion wall by a small scale model test and numerical analysis.

- To establish a reasonable construction method and a design manual for the gabion retaining wall considering its flexibility.

Multipurpose and effective utilization of gabion for adaptive disaster resilience that is Low-tech, Low-cost and Local utilization (3L Technique) for various gabion structures.

The END

Thank you for your attention!