College of Engineering, Nihon University
日本大学工学部

International workshop on the soil element test for liquefaction analysis

(pre-LEAP event at March 13, 2019.
Venue:M804, Kansai University-Takatuski Muse campus)

Liquefaction test results of the sand in LEAP (1)

Nihon University

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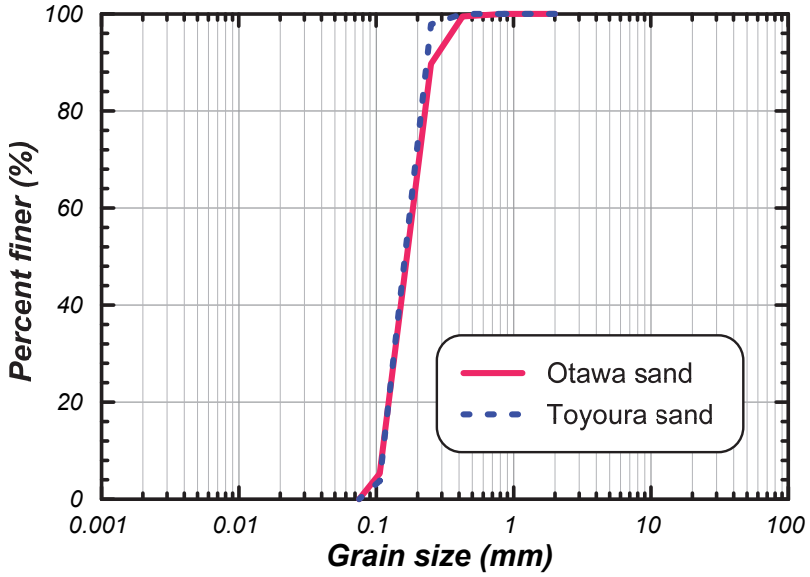
Soil Properties of Otawa sand

	ρ_s (g/cm^3)	e_{max}	e_{min}	D_{50}(mm)
Otawa sand	2.636	0.838	0.504	0.18
Toyoura sand	2.628	0.958	0.587	0.17

Soil properties are measured based on
JIS A 1202
JIS A 1204
JIS A 1224

JIS : Japanese Industry Standard

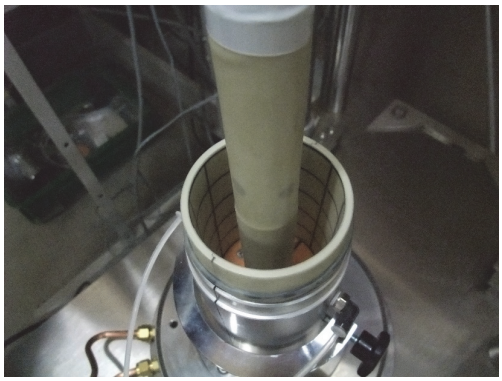


Otawa sand and Toyoura sand (Japanese famous sand) are quite similar characteristics of soil particle density and grain size distribution

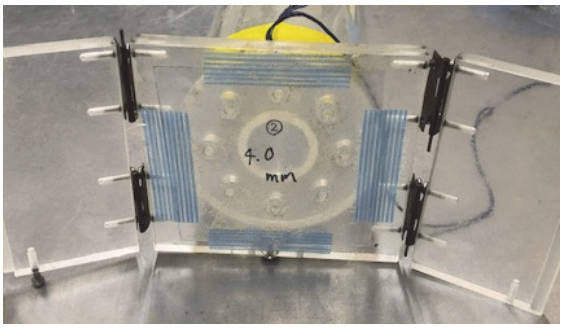
Method

- Air pluviation method is conducted, target dry density was 1.612g/cm^3 before cyclic shear test.
- Specimen size is 70 mm of outer diameter, 30 mm of inner diameter and 100 mm of height
- Supplied De-aired water and CO_2 at 10kPa effective overburden pressure
- Back pressure of 100 kPa was applied for specimen saturation, B-value > 0.98
- Isotropic Consolidation at effective confining pressure of 100kPa was applied to the specimen
- Strain rate of 1%/min at strain controlled cyclic shear tests
- 0.1Hz sinusoidal shear stress in stress controlled cyclic shear tests

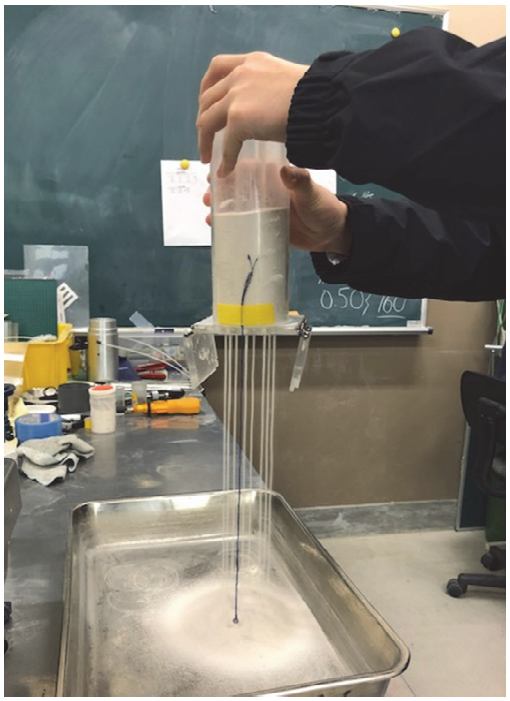
Specimen preparation (Air pluviation method)



Specimen mold and inner and outer membranes



Sand hopper (bottom)



Specimen density was controlled by number of holes, diameter of holes and height of sand hopper

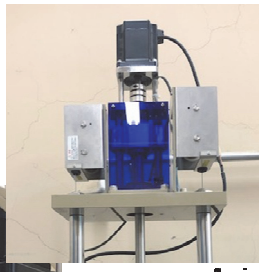
Hollow cylinder torsion test equipment

Reference Standards: JGS 0550, JGS 0551, JGS 0541 JGS 0543
JGS : Japanese Geotechnical Standard

List of Shear tests

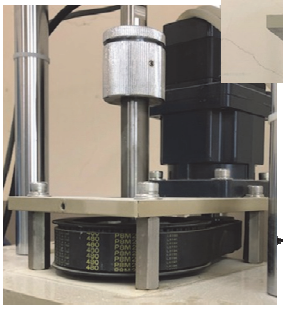
No.	Title	Volume
JGS 0525	Method for K0 Consolidated-Undrained Triaxial Compression Test on Soils with Pore Water Pressure Measurements	2
JGS 0526	Method for K0 Consolidated-Undrained Triaxial Extension Test on Soils with Pore Water Pressure Measurements	2
JGS 0527	Method for Triaxial Compression Test on Unsaturated Soils	2
JGS 0541	Method for Cyclic Undrained Triaxial Test on Soils	2
JGS 0542	Method for Cyclic Triaxial Test to Determine Deformation Properties of Geomaterials	2
JGS 0543	Method for Cyclic Torsional Shear Test on Hollow Cylindrical Specimens to Determine Deformation Properties of Soils	3
JGS 0544	Method for Laboratory Measurement of Shear Wave Velocity of Soils by Bender Element Test	3
JGS 0550	Practice for Preparing Hollow Cylindrical Specimens of Soils for Torsional Shear Test	3
JGS 0551	Method for Torsional Shear Test on Hollow Cylindrical Specimens of Soils	3

Torque is applied by belt drive system using stepping motor



Axial force is controlled by screw and nut driving by stepping motor

Shear strain is measured by Laser Rotary Encoder in the cell

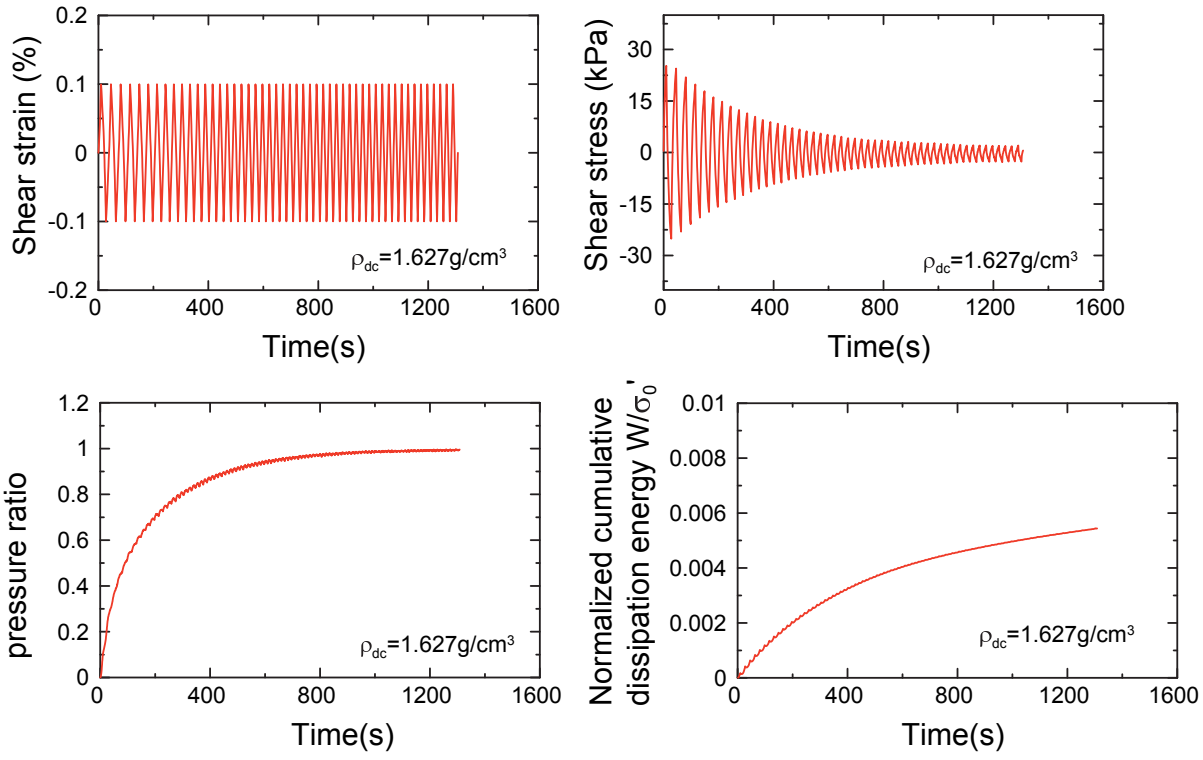


Test Case

Case	ρ_{dc} (g/cm^3)	shear strain amplitude (%)	CSR	control method
1	1.620	0.1	-	strain
2	1.640	0.1	-	strain
3	1.617	-	0.15	stress
4	1.608	-	0.18	stress
5	1.620	-	0.20	stress

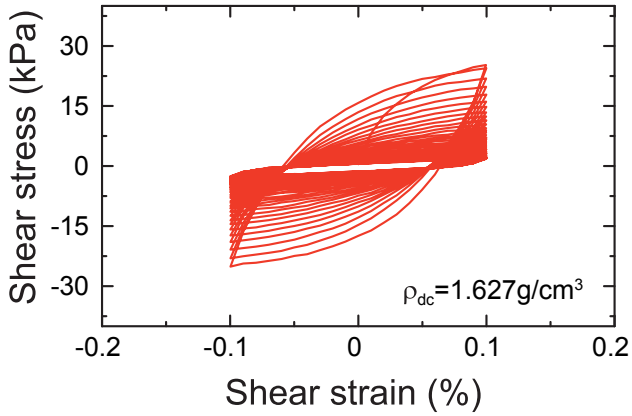
Case 1 and 2 are strain controlled test of single shear strain amplitude of 0.1%. Case 3, 4 and 5 are stress controlled test. Cyclic shear stress ratio (CSR) is 0.15, 0.18 and 0.20

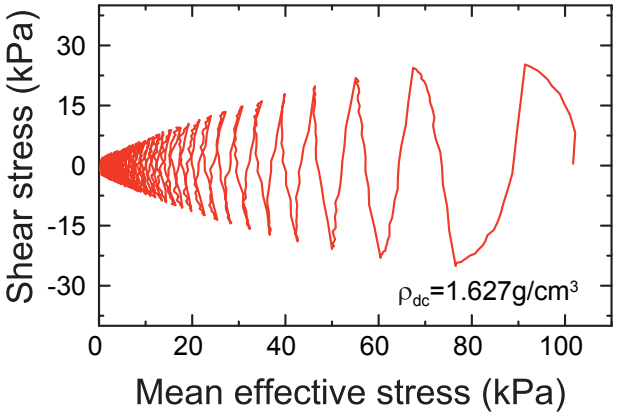
Result (Case1 Time history)



Time history of shear strain, shear stress, excess pore water pressure ratio and Normalized cumulative dissipation energy are shown. This energy is defined as cumulative area of hysteresis loop of stress-strain relation normalized initial effective overburden pressure

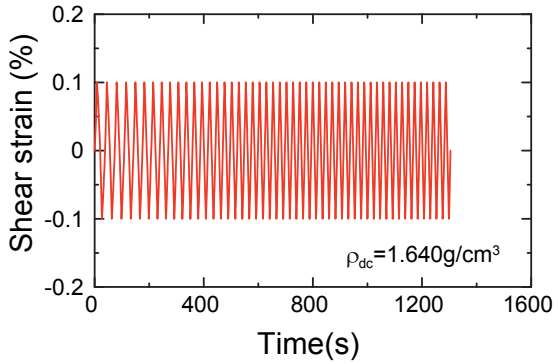
Result (Case1 Stress strain & stress path)

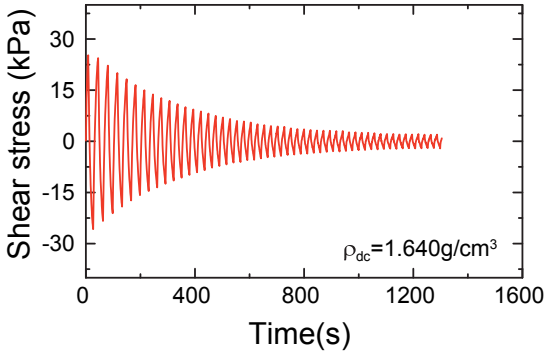


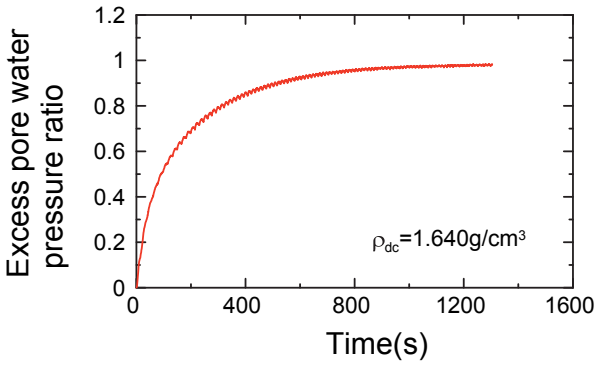


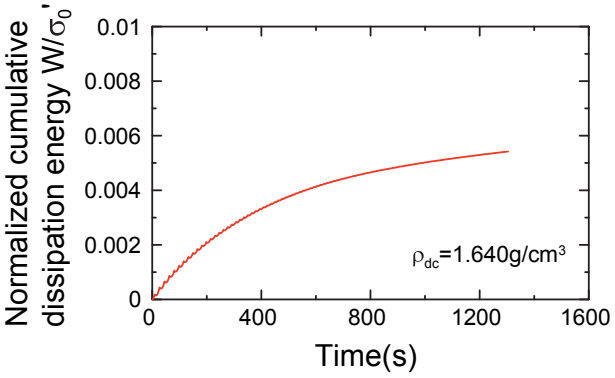
τ_1=25.3kPa
$N_{(ru=0.95)}$=32
W/σ_0'=0.0054

Result (Case2 Time history)

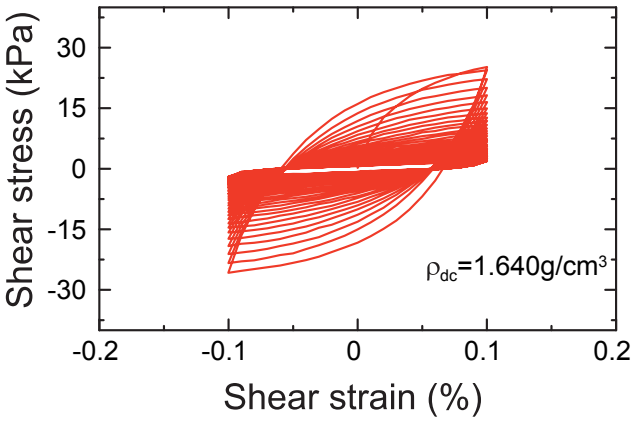


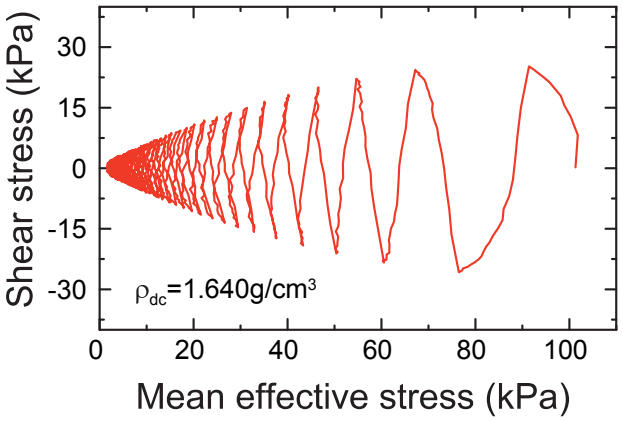






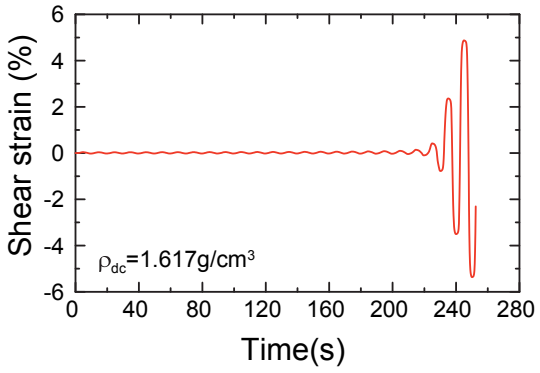
Result (Case2 Stress strain & stress path)

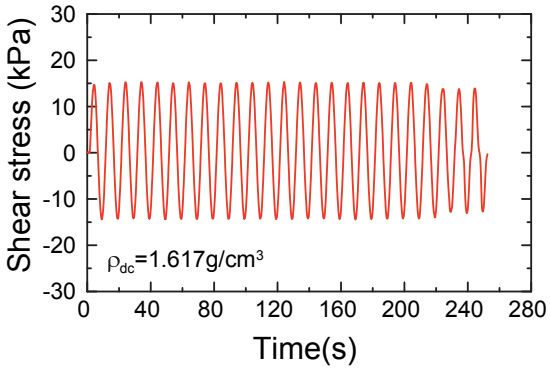


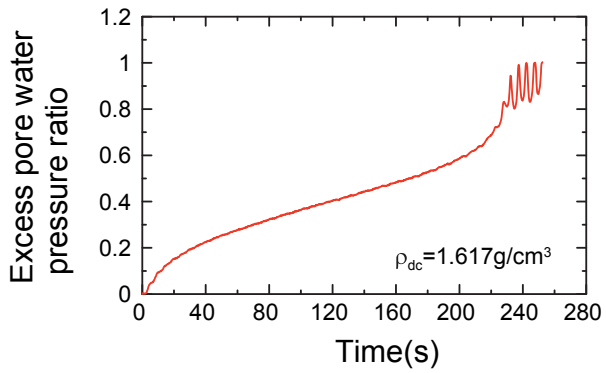


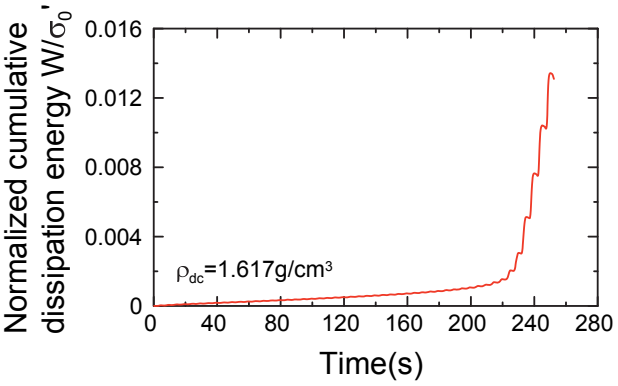
τ_1=25.2kPa
$N_{(ru=0.95)}$=38
W/σ_0'=0.0054

Result (Case3 Time history)

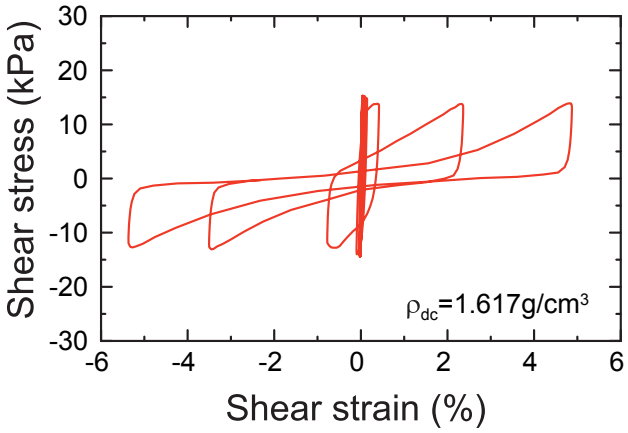


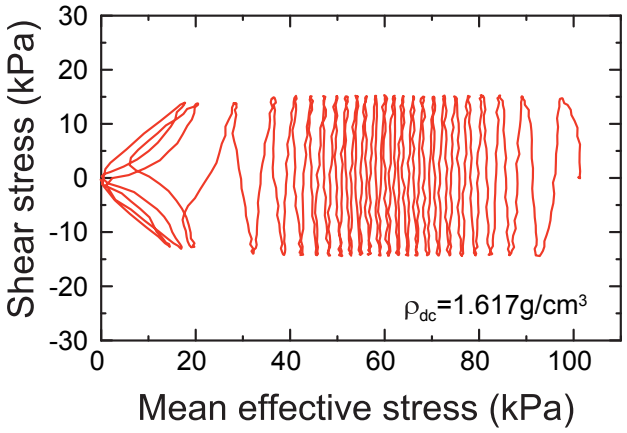






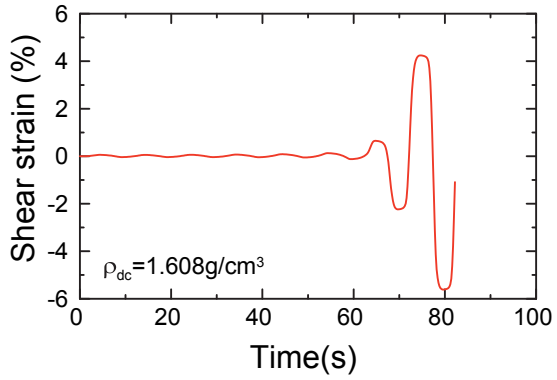
Result (Case3 Stress strain & stress path)

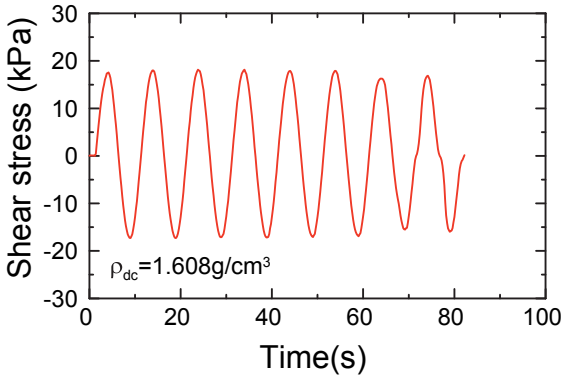


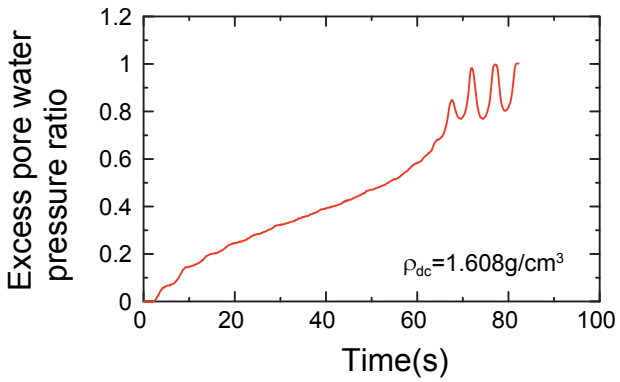


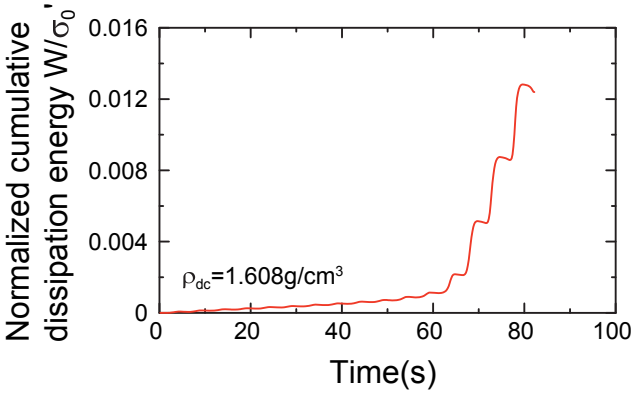
$N_{(DA=7.5\%)}=25$
$N_{(ru=0.95)}=24$
$W/\sigma_0'=0.013$

Result (Case4 Time history)

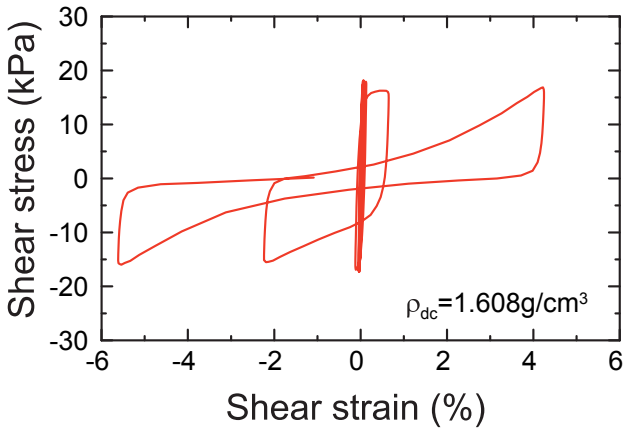


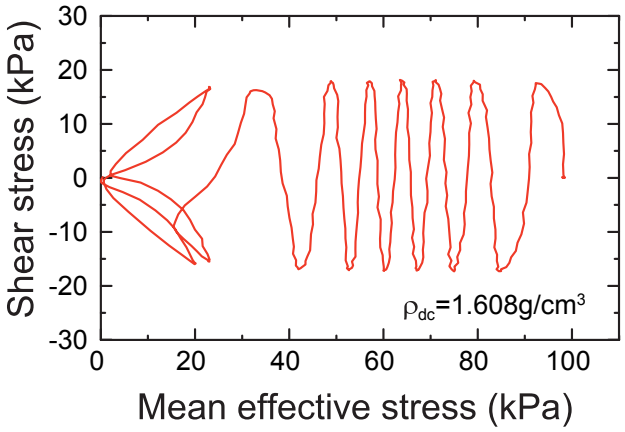






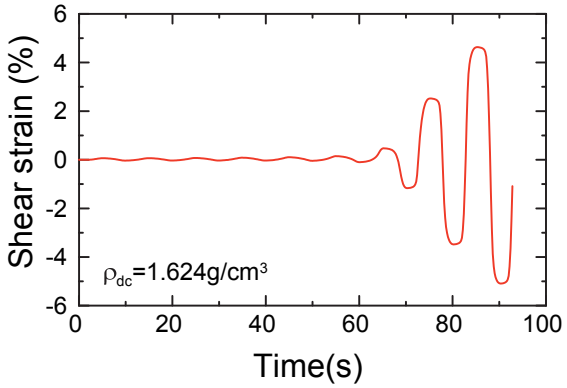
Result (Case4 Stress strain & stress path)

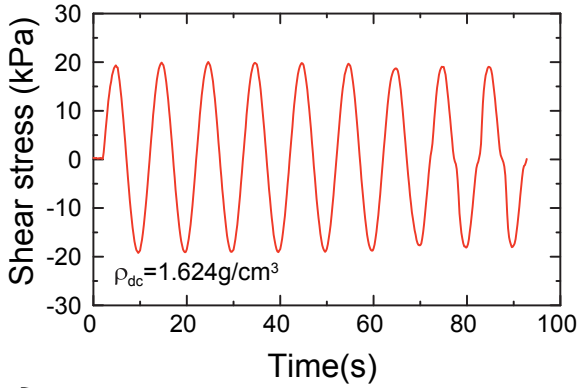


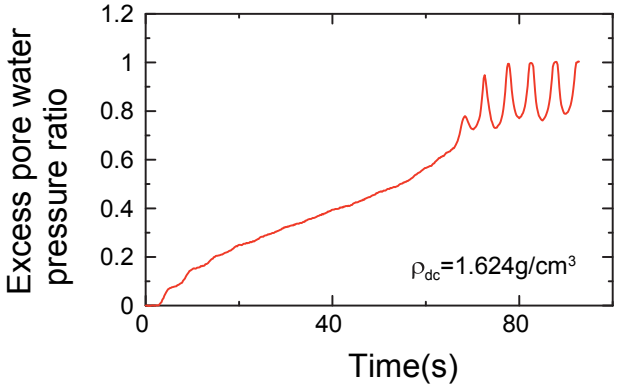


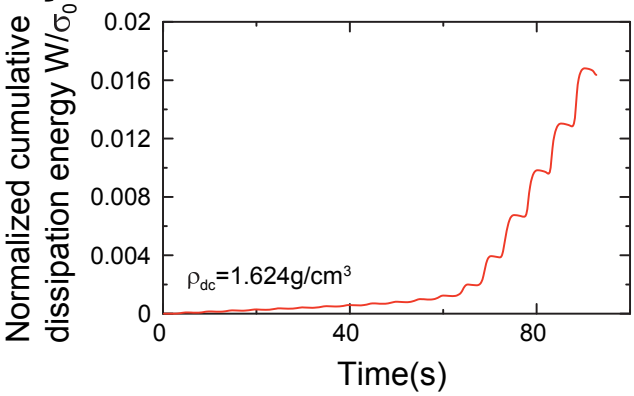
$N_{(DA=7.5\%)}=7.5$
$N_{(ru=0.95)}=7$
$W/\sigma_0'=0.012$

Result (Case5 Time history)

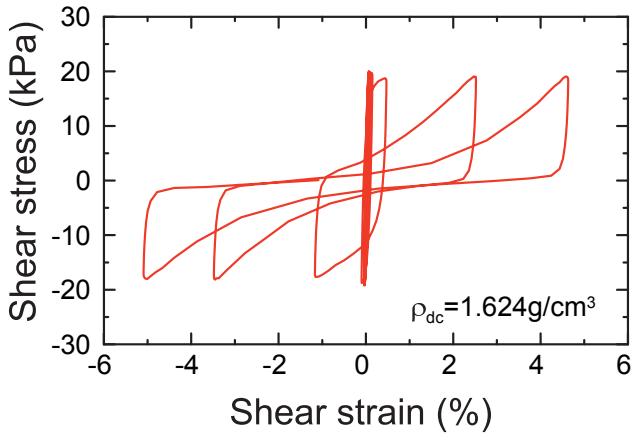


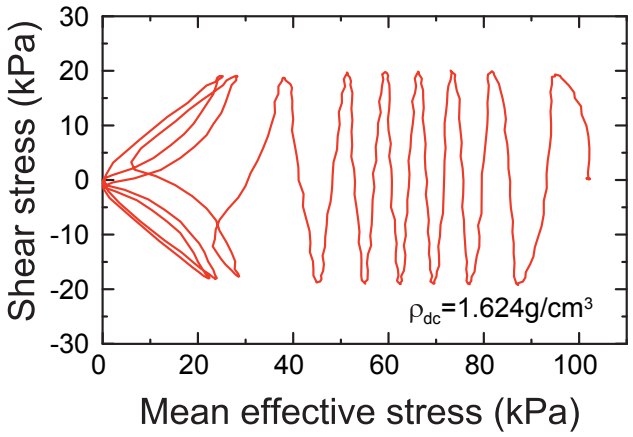






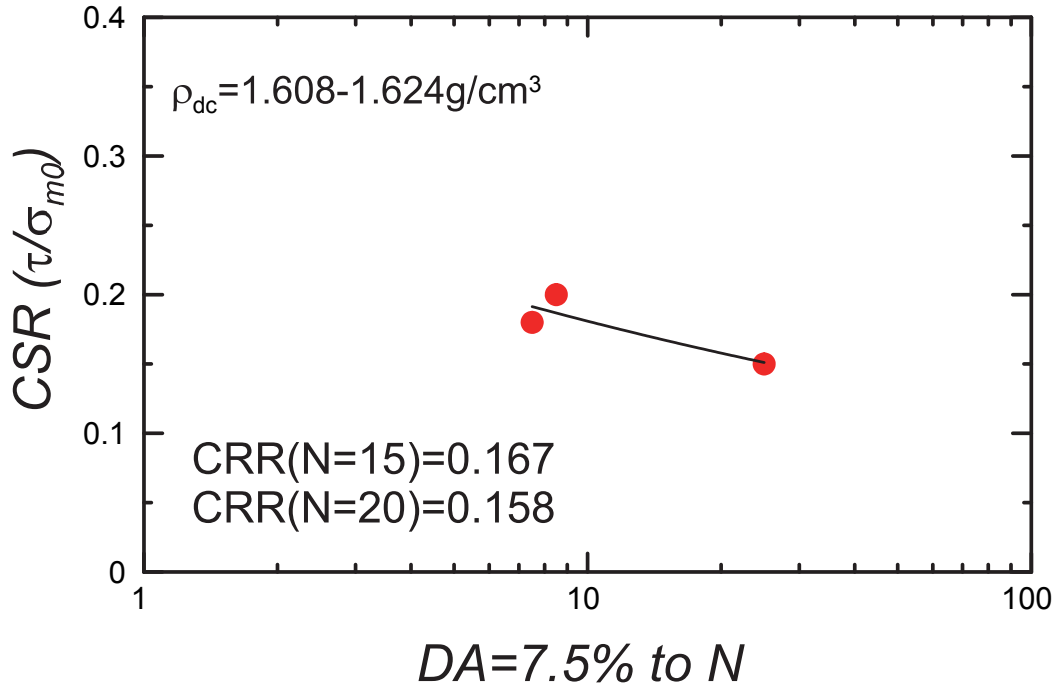
Result (Case5 Stress strain & stress path)





$N_{(DA=7.5\%)}=8.5$
$N_{(ru=0.95)}=8$
$W/\sigma_0'=0.016$

CSR-N of Otawa sand (DA=7.5%)



Liquefaction is defined as double amplitude of 7.5 %. CRR of N=20 is 0.158 and CRR of N=15 is 67

Summary of test results

Case	ρ_{dc} (g/cm^3)	τ_1(kPa)	$N_{ru=0.95}$	$N_{DA=7.5\%}$	W/σ_0'	CRR
1	1.627	25.3	32	-	0.0054	-
2	1.640	25.2	38	-	0.0054	-
3	1.617	15	24	25	0.013	0.167
4	1.608	18	7	7.5	0.012	
5	1.620	20	8	8.5	0.016	