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SOIL DISTURBANCE EFFECT ON UNDISTURBED SOFT CLAY UNDER ISOTROPIC AND ANISOTROPIC STRESS CONDITIONS

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ABSTRACT: Soil disturbance has been defined as the simultaneous reduction in the peak shear strength and stiffness of undisturbed soft clay (UDS) under cyclic loading, as reported in numerical simulations by previous studies. Furthermore, anisotropy is classified as a dynamic property and strongly influences the mechanical properties of UDS soft clays. A recent study investigated the influence of soil disturbance in both UDS and reconstituted (REC) soft clay; however, the effect of stress-induced anisotropy and its interaction with soil disturbance has not been sufficiently discussed. To address the research gap, the present research aims to provide experimental evidence on the interaction between anisotropy and soil disturbance, which simultaneously act on soft clays under an embankment/structure during cyclic loading. Specifically, this study conducts a series of undrained cyclic triaxial shear tests and post-cyclic monotonic shear tests on UDS specimens under both isotropic (ISC) and anisotropic (ASC) stress conditions to determine the effect of stress-induced anisotropy on soil disturbance. Based on experimental results, the mean effective stress of both specimens under ISC and ASC progressively decreased during cyclic loading; both eventually failed after 1295 and 134 cycles, respectively. The peak shear strength of the specimens under ISC and ASC also decreased by 13% and 43% after 960 cycles and 48 cycles, respectively. It is evident that the specimen under ASC failed during cyclic shearing and exhibited a more pronounced reduction in peak shear strength, despite a significantly shorter cyclic loading history. Therefore, ASC amplifies the effect of soil disturbance on UDS soft clays.

Keywords: Soil disturbance, Anisotropic stress condition, Undisturbed soft clay, Cyclic loading

1. INTRODUCTION

Soft clay foundations exhibited accelerated settlement damage immediately after the Chuetsu Offshore Earthquake (2007) and the 2011 off the Pacific coast of Tohoku Earthquake [1,2]. This behavior is attributed to the destruction of natural structure, leading to strain softening and a reduction in stiffness of soft clay. Furthermore, UDS soft clays are characterized by having high water content, low density, and high sensitivity ratio, making them highly vulnerable to subsidence damage under cyclic loading.

Soil disturbance has been defined as the simultaneous reduction in the peak shear strength and stiffness of undisturbed soft clay (UDS) under cyclic loading, as reported in numerical simulations by previous studies [3,4]. Furthermore, a recent study investigated the soil disturbance mechanism in UDS and REC specimens derived from the same original material by conducting a series of post-cyclic monotonic shear tests. Based on the experimental results, they concluded that soil disturbance can be defined as a drastic reduction in the stiffness of REC. The specimens and a simultaneous reduction in the peak shear strength and stiffness of UDS soft clay under ISC during cyclic loading, thereby supporting the numerical simulations reported in previous studies. The REC specimens did not experience a reduction in peak shear strength due to the absence of soil structure and aging effects [5].

Considering all these factors, soil disturbance is the macroscopic consequence of destructuration and excess pore water accumulation during cyclic loading, quantified by peak shear strength and stiffness degradation [6,7]. Figure 1 shows the large deformation directly below the embankment and the minimal deformation in areas without embankment within the same layer. This simulation result emphasizes the effects of varying stress conditions (stress-induced anisotropy) on soil disturbance in highly structured clays [4]. Therefore, it is important to consider the effects of ASC on soil disturbance in UDS soft clays. Previous studies have also found that anisotropy strongly influences the mechanical properties of UDS clays, thereby

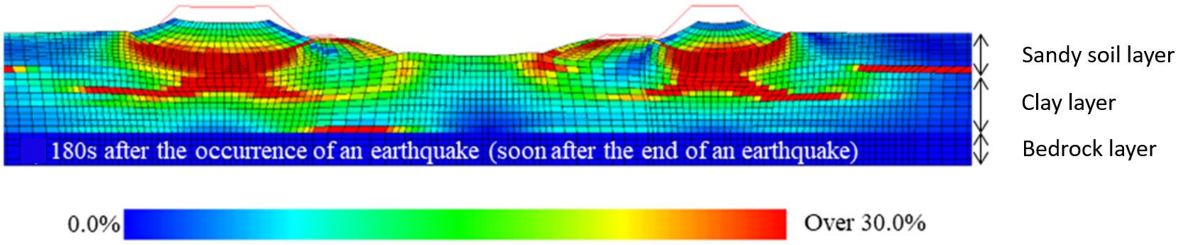

Fig. 1. Numerical simulations on highly structured clay soon after the end of an earthquake

affecting their behavior under cyclic loading [8-10].

Anisotropy is the directional dependence of the mechanical properties of soils, such as strength, stiffness, and permeability. Several studies have concluded that inherent anisotropy is primarily observed in UDS clay soils, reflecting the natural arrangement of soil particles during prolonged deposition. Furthermore, they found that the properties of UDS clays are highly affected by anisotropy [8-10]. In contrast, past studies have shown that reconstituted (REC) clays can develop anisotropy during consolidation under varying loading conditions, a phenomenon referred to as stress-induced anisotropy [11-13]. However, this anisotropy is not comparable to the inherent anisotropy formed in UDS clays during prolonged deposition. A study investigated the development and degradation of anisotropy and concluded that anisotropy is a dynamic property of clay that develops/diminish with loading history [14]. Despite the presence of anisotropy and soil disturbance effects during cyclic loading, there is still no discussion of their interactions and their effects on the behavior and properties of UDS soft clays under cyclic loading.

To address the research gap, this study aims to determine the influence of ASC on soil disturbance and experimentally visualize their interaction and their effect on UDS soft clays. To achieve this, the researchers conducted undrained cyclic triaxial tests on specimens under ISC and ASC conditions to determine the effects of stress-induced anisotropy on axial strain propagation and mean effective stress reduction in UDS soft clays. Moreover, post-cyclic monotonic shear tests on UDS specimens under both ISC and ASC were performed to determine the effect of ASC on peak shear strength degradation.

2. RESEARCH SIGNIFICANCE

Most studies focused either on the mechanical properties of UDS and REC under ISC or on the effect of anisotropy on REC specimen behavior. In contrast, the results of this study provide direct experimental evidence of the soil disturbance amplification effect of ASC on UDS soft clays, highlighting the novelty of this study. Furthermore, naturally deposited soft clays beneath an embankment or structure often experience anisotropic rather than isotropic stresses, making the results of this study a more suitable representation of the actual behavior of the soft clay foundation during an earthquake.

3. MATERIALS AND METHODS

3.1 Soil Specimen Information

The soil in this study was extracted from Kaizu City, Gifu Prefecture, Japan. The geological cross-section of the area reveals a thick clay deposit from depths of 8.5 m to 36.5 m. Specifically, the researchers used soft clay layers extracted from depths of 22.0 m to 26.5 m, which had a liquid limit of 85% and a compression index of 0.23, both of which were higher than those of other layers.

3.2 Index Properties of Soft Clay Specimen

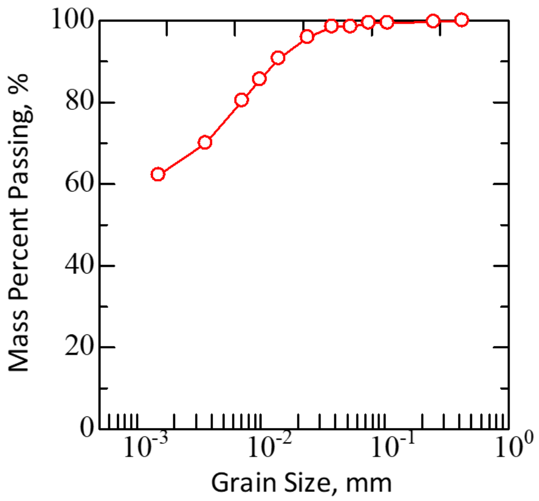

Fig. 2 Grain Size Distribution Curve of Kaizu Soft Clay

The index properties of the soft clay specimen were determined by conducting specific gravity tests, grain size analysis, and Atterberg limits tests. Table 1 summarizes the experimental results. Furthermore, Fig. 2 shows the grain size distribution curve for the soil specimen. Based on the Japanese Geotechnical Society (JGS) standards and the Unified Soil

Classification System (USCS), the soil specimen was identified as clay with high plasticity.

Table 1. Summary of Index Properties of Kaizu Soft Clay

Index Properties	Index Value
Specific Gravity, G_s	2.69
Percent Passing No. 200 Sieve (%)	99.00
Liquid Limit, LL (%)	83
Plastic Limit, PL	33
Plasticity Index	50
USCS Classification	Clay, HP (CH)

3.3 Experimental Procedures

Undisturbed soft clay specimens were carefully extracted from Shelby tube samplers and stored with plastic wrap and a wax coating to preserve the in situ moisture content. The UDS specimens were then trimmed using a trimming apparatus per JGS 0520 [15] according to the required dimensions (d = 35 mm, h = 80 mm).

The researchers conducted a series of isotropic and anisotropic consolidated-undrained monotonic triaxial tests in accordance with JGS 0523 [16] and JGS 0525 [17] to determine the initial and subsequent monotonic shear behavior of soft clay under cyclic loading. Additionally, cyclic shear tests in accordance with JGS 0541 [18] were conducted to determine the dynamic response of soft clay. As for specimen preparation, the researchers found that stepwise loading/pressure application, while maintaining a 10 kPa difference between cell and back pressures, is the most effective method for saturating the soil specimen. A minimum B-value of 95% is preferred to ensure that the specimen is fully saturated.

The overburden pressure used in the experiment was 180 kPa during consolidation, as reported in the site's soil report. The specimens were consolidated with drainage from top and bottom for at least 24 hours or until the axial strain graph converged. Since the actual lateral pressure applied to the specimen was unknown, the horizontal effective stress was calculated using Eq. 1, considering the actual vertical stress applied to the specimen.

$$\sigma'_H = K_0 \sigma'_V \quad (1)$$

The experiments consisted of two stress conditions, corresponding to K_0 values of 1.0 (isotropic) and 0.6 (anisotropic). The K_0 value under anisotropic conditions was determined using the average of K_0 values from the Jaky equation for normally consolidated clays [19]. Since this study used only two stress conditions, the experimental results cannot provide a statistically generalizable estimate of ASC's effect on soil disturbance in UDS soft clays. However, these stress conditions are sufficient to characterize the interaction between ASC and soil disturbance and their effects on UDS soft clays, which is the focus of this research. Table 2 summarizes the shear tests conducted under isotropic and anisotropic conditions. Although the initial mean effective stresses of the specimens under ISC and ASC differ, the comparison remains valid because these values are calculated from the actual vertical stress applied to the specimen at the site.

Table 2. Stress Conditions of the Experiments

Spec. Type	K_0	σ'_V (kPa)	σ'_H (kPa)	q (kPa)	p' (kPa)
UDS	1.0	180	180	0	180
UDS	0.6	180	108	72	132

The cyclic triaxial tests were conducted at a constant amplitude of 72 kPa and a period of 20 seconds under stress-controlled conditions. A constant loading rate of 0.007 mm/min. was applied during monotonic shear tests. The loading speed is fast enough to induce soil disturbance and reduce the mean effective stress, as adapted from the previous study [20].

3.4 Reproducibility of Experiments

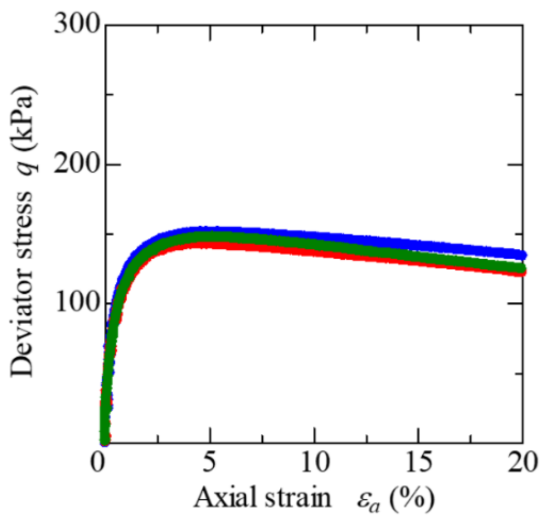

Fig. 3 Stress-strain behavior of UDS specimens under ISC after Undrained Triaxial Shear Tests

The researchers conducted reproducibility tests by performing undrained monotonic shear tests on specimens from the same depths but from a different borehole to verify the reliability of experimental results. Figures 3 and 4 show the stress-strain relationship and effective stress paths of the specimens, respectively. It is noticeable that the stiffnesses (E_{50}) and peak shear strength (q_{max}) of all the specimens have minimal differences. Therefore, the experimental methodology yields consistent results, given that the specimens are homogeneous.

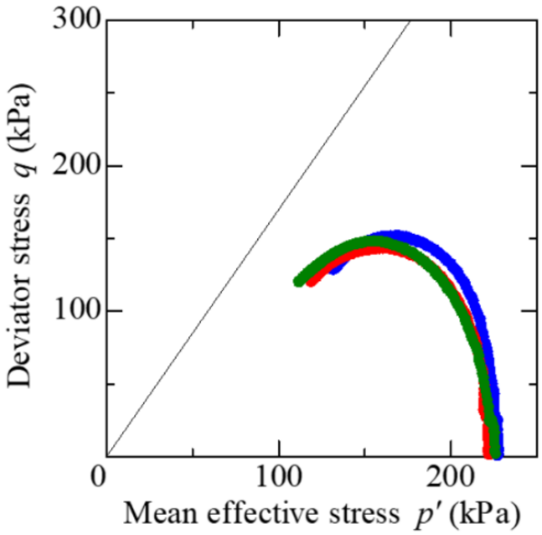

Fig. 4 Effective Stress Paths of UDS specimens under ISC after Undrained Triaxial Shear Tests

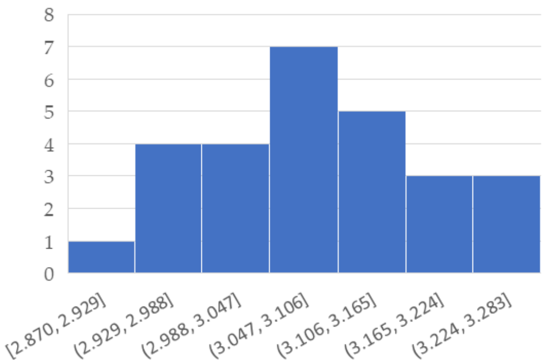

Fig. 5 Histogram of Initial Specific Volumes of Specimens used

Figure 5 shows the histogram of the initial specific volumes of the specimens used in this study, highlighting a normal distribution. Based on statistical analysis, the standard deviation is 0.09. The low standard deviation indicates that the initial specific volumes of the specimens cluster around the mean of 3.087. Table 3 summarizes the physical properties of specimens before and after the experiments. Based on the values, there is a minimal difference among the parameters.

Table 3. Physical Properties of UDS Specimens after Undrained Triaxial Shear Tests

Parameters	Trial 1	Trial 2	Trial 3
Initial Specific Volume, v_0	3.031	3.175	3.224
Specific Volume, v	2.646	2.701	2.648
Peak Shear Strength, q_{max}	151.93 kPa	143.41 kPa	148.26 kPa
Secant Young's Modulus, E_{50}	238.13	225.99	217.61

4. RESULTS AND DISCUSSIONS

4.1 Cyclic Shear Test on UDS Specimens under ISC

The cyclic shear test was conducted to determine the axial strain accumulation and the mean effective stress reduction behavior of the UDS specimens under ISC. Based on the results, the specimen failed after 1295 cycles on the extension side, resulting in necking. Initially, axial strain accumulated on both compression and extension sides of the specimen (Fig. 6). This shows that damage from cyclic loading may also occur in clay soil under soft conditions. The mechanism of this plastic deformation in UDS soft clay is strongly influenced by destructuration and the generation of excess pore water pressure. The failure on the extension side is due to naturally deposited soil being weaker in extension than in compression under isotropic conditions.

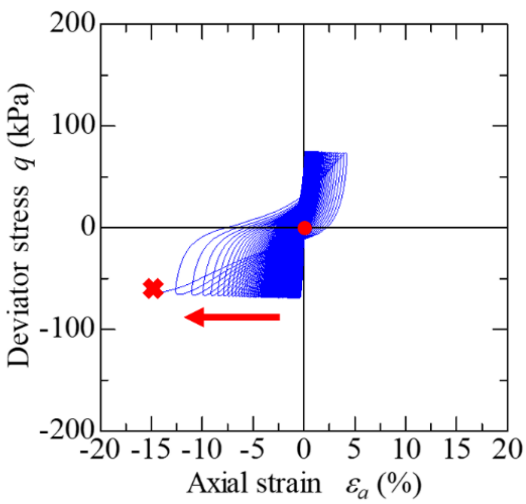

Fig. 6 Stress-strain behavior of the UDS Specimens under ISC after Cyclic Triaxial Test

Furthermore, it is noticeable that there is a constant reduction in the mean effective stress, p', during cyclic loading (Fig. 7). At failure, p' is reduced to 20 kPa. The mechanism in p' reduction is due to the generation of excess pore water pressure during cyclic loading, proving that such a phenomenon is also possible in soft clay foundations. Table 4 summarizes the physical properties of the specimen.

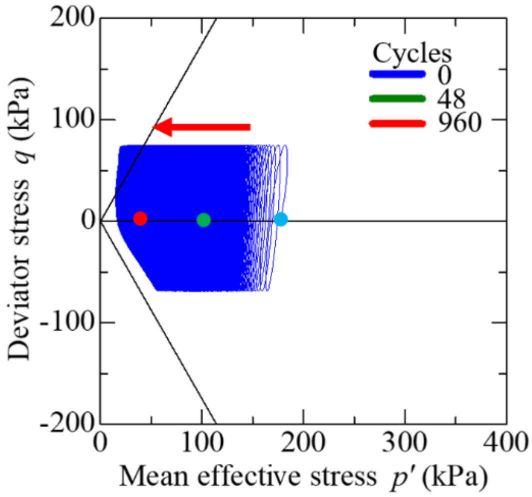

Fig. 7 Effective Stress Paths of the UDS Specimens under ISC after Cyclic Triaxial Test

Table 4. Physical Properties of UDS Specimens under ISC after Cyclic Triaxial Test

Parameters	Values
Initial Specific Volume, v_0	3.190
Specific Volume, v	3.092

4.2 Post-Cyclic Undrained Shear Test on UDS Soft Clay under ISC

Subsequent monotonic shear tests were conducted at different numbers of cycles (0, 48, and 960). This experimental program aims to determine the effect of cyclic loading history on the peak shear strength (q_{max}) and the secant Young's Modulus (E_{50}) of the UDS specimens. Figure 8 presents the stress-strain behavior of the specimens, showing a reduction in initial stiffness under cyclic loading. Furthermore, the specimen exhibited strain softening behavior without a cyclic loading history, suggesting the presence of structure. The mechanism of stiffness degradation lies in particle rearrangement and destructuration under cyclic loading, resulting in weakened particle bonding and behavior akin to that of reconstituted clay.

On the other hand, Fig. 9 presents the effective stress paths of the specimens with and without cyclic loading histories. The peak shear strength of the specimen without cyclic loading histories is 162.448 kPa. The peak shear strengths of the specimens after 48 and 960 cycles are 148.501 kPa and 141.586 kPa, representing reductions of 8.6% and 12.8%, respectively. The mechanism of this shear strength degradation is the destruction of the natural soil structure and the loss of aging effects as described by the previous study [5]. Table 5 summarizes the physical properties of the specimens used.

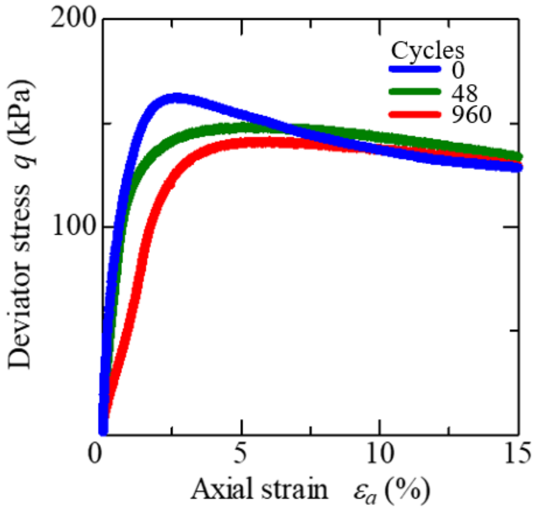

Fig. 8 Stress-strain behavior of UDS Specimens under ISC after Post-cyclic Undrained Shear Test

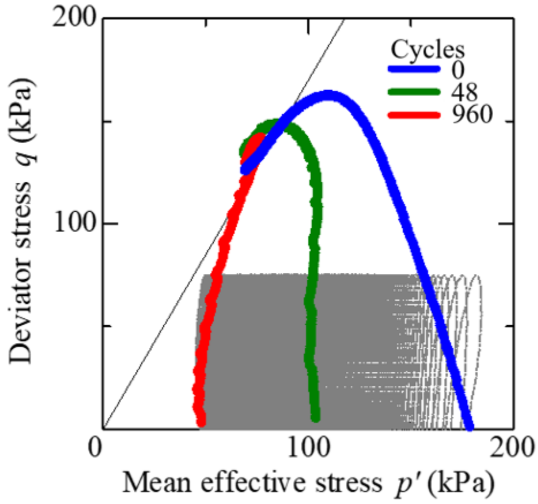

Fig. 9 Effective Stress Paths of UDS Specimens under ISC after Post-cyclic Undrained Shear Test

Table 5. Physical Properties of UDS Specimens under ISC after Post-cyclic Undrained Shear Test

Parameters	0 cycles	48 cycles	960 cycles
Initial Specific Volume, v_0	2.965	3.152	3.041
Specific Volume, v	2.757	2.783	2.854
Peak Shear Strength, q_{max}	162.45 kPa	148.50 kPa	141.59 kPa
Secant Young's Modulus, E_{50}	212.63	167.27	57.42

4.3 Cyclic Shear Test on UDS Specimen under ASC

Anisotropic consolidation was achieved by adjusting the mean effective stress applied to the specimen to 132 kPa. This is calculated using the Jaky equation from the actual vertical stress applied to the UDS specimen [20]. Then, the cyclic shear test was conducted in accordance with JGS 0541 [19], using a constant amplitude of 72 kPa and a period of 20 seconds, as for the specimens under ISC. Based on the results, axial strain accumulated only on the compression side, and the specimen eventually failed after 134 cycles (Fig. 10). In addition to the development of excess pore water pressure and the onset of destructuration, the anisotropic stress conditions accelerate axial strain accumulation, resulting in faster failure of the UDS specimen under cyclic loading.

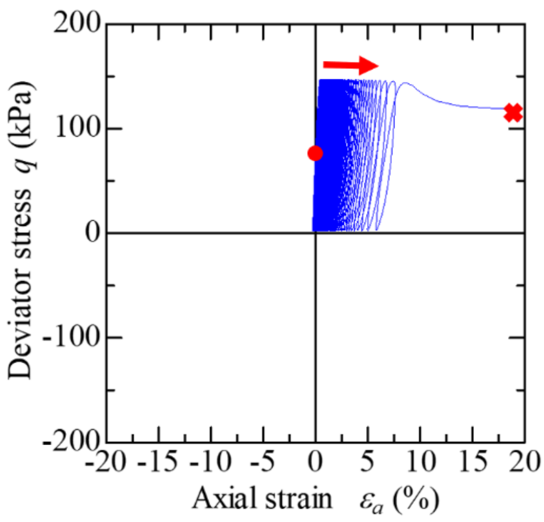

Fig. 10 Stress-strain behavior of the UDS Specimens under ASC after Cyclic Triaxial Test

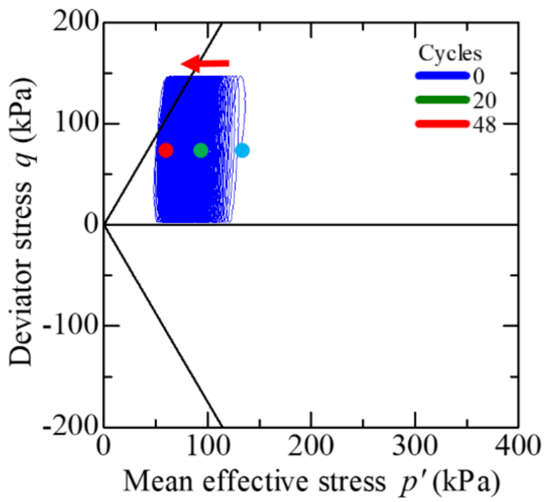

Fig. 11 Effective Stress Paths of the UDS Specimens under ASC after Cyclic Triaxial Test

Furthermore, Fig. 11 shows that p' decreased continuously as cyclic loading progressed, and the recorded p' at failure was 50 kPa. The reduction in p' of the UDS specimens was also amplified by the ASC, failing significantly at lower cyclic loading history. Table 6 summarizes the physical properties of the specimens.

Table 6. Physical Properties of UDS Specimens under ASC after Cyclic Shear Test

Parameters	Values
Initial Specific Volume, v_0	3.075
Specific Volume, v	3.022

4.4 Post-Cyclic Undrained Shear Test on UDS Soft Clay under ASC

Subsequent monotonic shear tests were also conducted at different numbers of cycles (0, 20, and 48) based on the number of cycles at failure to determine the effect of cyclic loading on the q_{max} of the UDS soft clay soil under ASC. Based on the results, more pronounced strain softening behavior and stiffness degradation were observed (Fig. 12).

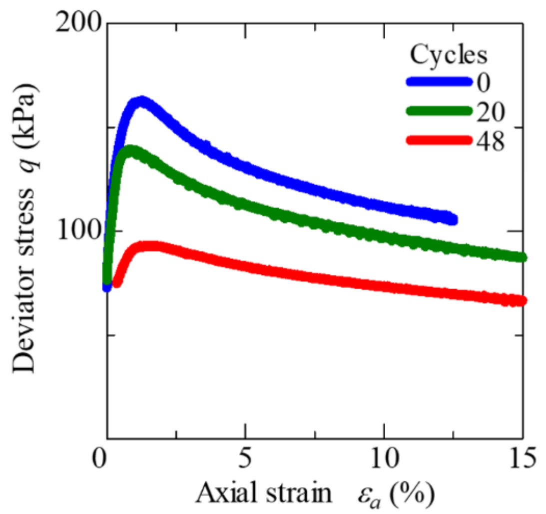

Fig. 12 Stress-strain behavior of UDS Specimens under ASC after Post-cyclic Undrained Shear Test

Figure 13 presents the effective stress paths of the UDS specimens, illustrating the drastic reduction in peak shear strength under cyclic loading. The peak shear strength of the UDS specimen without a cyclic loading history is 162.913 kPa. The peak shear strengths of the UDS specimens after 20 and 48 cycles are 139.549 kPa and 93.256 kPa, representing reductions of 16.7% and 42.8%, respectively. Anisotropic consolidation temporarily created a new particle arrangement, slightly increasing shear strength and stiffness while greatly increasing vulnerability to strain softening, thereby amplifying the effect of soil disturbance on UDS specimens. Table 7 summarizes the physical properties of specimens.

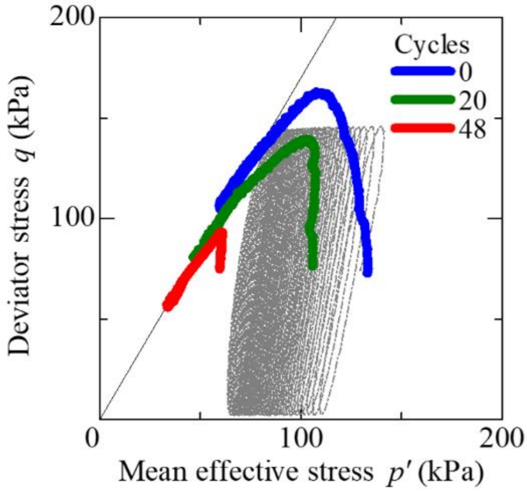

Fig. 13 Effective Stress Paths of UDS Specimens under ASC after Post-cyclic Undrained Shear Test

Table 7. Physical Properties of UDS Specimens under ASC after Post-cyclic Undrained Shear Test

Parameters	0 cycles	20 cycles	48 cycles
Initial Specific Volume, v_0	3.148	3.159	3.283
Specific Volume, v	3.078	3.081	3.184
Peak Shear Strength, q_{max}	162.91 kPa	139.55 kPa	93.26 kPa
Secant Young's Modulus, E_{50}	594.27	563.57	136.35

Considering the results of cyclic and post-cyclic monotonic shear tests under isotropic and anisotropic stress conditions, it can be concluded that ASC amplifies soil disturbance in UDS specimens. Therefore, it is essential to consider the ASC of the soft clay and its response to earthquake loading when designing to avoid overestimating cyclic shear resistance and bearing capacity.

5. DISCUSSIONS

5.1 Effect of Soil Disturbance on UDS specimens under ISC and ASC

Stiffness reduction of the specimens after cyclic loading was determined by calculating the Secant Young's Modulus, E_{50}, and graphing it against the Mean Effective Stress Reduction Ratio (MESRR), $\Delta p'/p_0'$ (Fig. 14). On the other hand, the peak shear strengths of the specimens were graphed against MESRR to determine peak shear strength degradation (Fig. 15). Based on the experimental results, the specimens under anisotropic conditions have a more significant stiffness reduction compared to isotropic conditions. Furthermore, the peak shear strength of specimens under anisotropic stress conditions decreased more sharply as cyclic loading progressed. Therefore, it can be concluded that anisotropic stress conditions amplify the effect of soil disturbance on UDS specimens. This is similar to the numerical simulations in Fig. 1, in which the highly structured soft clay layer directly beneath the embankment (under anisotropic stress conditions) exhibited greater deformation. During the 1985 Mexico City earthquake, structures underlain by soft clays experienced overturning failure. On the other hand, there is no visible damage in the nearby areas. This is also attributed to the amplifying effect of ASC in soil disturbance under cyclic loading.

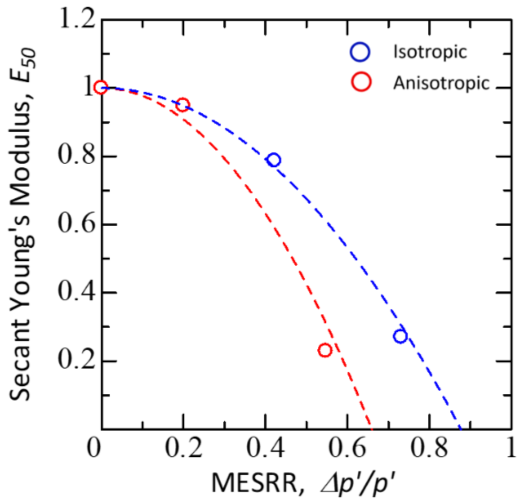

Fig. 14 Stiffness Degradation Graph vs. MESRR of UDS Specimens

Based on the stiffness degradation graphs for specimens under ISC and ASC, a parabolic curve is appropriate for representing their behavior. From the relationship of stiffness and mean effective stress reduction ratio, Eq. 2 can be formulated, where α is the coefficient of stiffness degradation. The calculated α values for specimens under ISC and ASC were 1.3 and 2.3, respectively. The higher the value of α, the faster the stiffness degrades. The coefficients of determination (R^2) were 0.995 and 0.978 for the proposed equation under ISC and ASC, respectively. Therefore, the proposed equation closely represents the trend observed in the experimental data, explaining 99.5% and 97.8% of the variability.

$$\frac{E_{50}}{E_{50,0}} = 1 - \alpha \left(\frac{\Delta p'}{p'_0}\right)^2 \quad (2)$$

On the other hand, Eq. 3 is formulated based on the peak shear strength degradation graph for specimens under isotropic and anisotropic stress conditions, which represents a linear relationship. The coefficient of peak shear strength degradation is denoted by β. The calculated β values of specimens under isotropic and anisotropic stress conditions are 0.178 and 0.781, respectively. The higher the value of β, the more drastic the peak shear strength reduction. The calculated R^2 values were 0.989 and 0.999 for the proposed model in representing the degradation of peak shear strength of specimens under ISC and ASC, respectively. Therefore, the proposed equation closely matches the experimental data.

$$\frac{q_{max}}{q_{max,0}} = 1 - \beta \, \frac{\Delta p'}{p'_0} \quad (3)$$

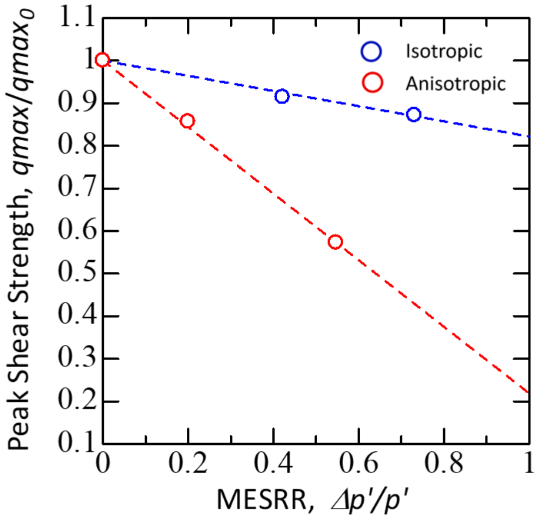

Fig. 15 Peak Shear Strength Degradation Graph vs. MESRR of UDS Specimens

The proposed equations, however, only represent the peak shear strength and stiffness degradation of Kaizu soft clay under a specific loading amplitude, period, and degree of anisotropy. Further studies on the effects of varying these key parameters will be conducted to improve the applicability and effectiveness of the proposed model for statistically generalizing the effect of soil disturbance on soft clay soils.

5.2 Effect of Soil Disturbance on REC specimens under ISC and ASC

Edora & Nakai (2026) found that, unlike UDS specimens, REC specimens do not experience peak shear strength degradation under cyclic loading. This is due to the absence of strain softening behavior and aging effects in REC specimens. Figure 16 shows the effective stress paths of the REC specimens under ISC after the post-cyclic monotonic shear test. Table 8 summarizes the physical properties of the specimens used.

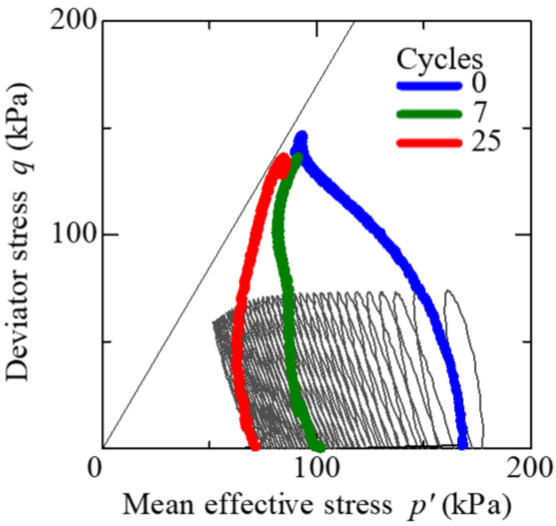

Fig. 16 Effective Stress Paths of REC Specimens under ISC after Post-cyclic Undrained Shear Test [5]

Table 8. Physical Properties of REC Specimens under ISC after Post-cyclic Undrained Shear Test [5]

Parameters	0 cycles	7 cycles	25 cycles
Initial Specific Volume, v_0	2.994	3.056	2.984
Specific Volume, v	2.627	2.553	2.601
Peak Shear Strength, q_{max}	138.58	138.28	135.97
Secant Young's Modulus, E_{50}	225.29	62.37	64.93

In this study, the researchers also conducted post-cyclic monotonic shear tests under ASC to determine the effect of stress-induced anisotropy on soil disturbance in REC specimens. All parameters and methodology used in this test were consistent with the previous study [5]. However, the amplitude was adjusted to 48 kPa because the previous amplitude exceeded the peak shear strength of the REC specimens under ASC, resulting in immediate localized failure. The amplitude used in this experiment is calculated based on 85% of the difference between the maximum and minimum values of shear strength to ensure the specimen will not fail immediately.

Figure 17 shows no significant changes in the peak shear strengths of the REC specimens under ASC, consistent with the results of the previous study.

Despite the differences in the amplitude and the cyclic loading histories applied to the REC specimens under ASC, the absence of peak shear strength degradation on these specimens emphasized the greater vulnerability of UDS to soil disturbance. Table 9 summarizes the physical properties of the specimens used.

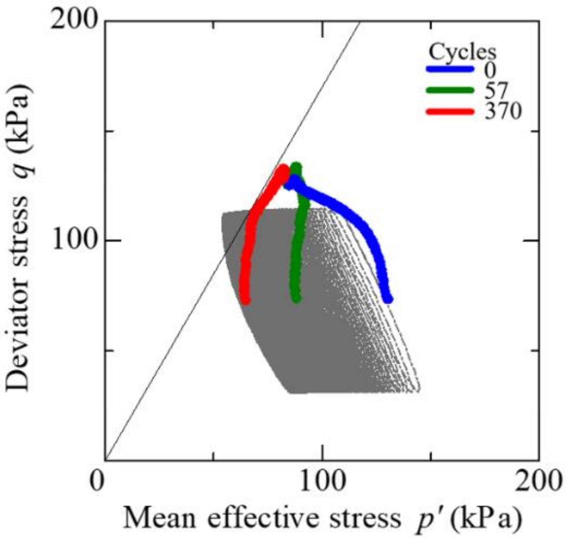

Fig. 17 Effective Stress Paths of REC Specimens under ASC after Post-cyclic Undrained Shear Test

Table 9. Physical Properties of REC Specimens under ASC after Post-cyclic Undrained Shear Test

Parameters	0 cycles	57 cycles	370 cycles
Initial Specific Volume, v_0	2.983	3.060	3.063
Specific Volume, v	2.532	2.571	2.592
Peak Shear Strength, q_{max}	127.74	125.21	126.32
Secant Young's Modulus, E_{50}	847.57	567.69	444.57

6. CONCLUSION

Based on the experimental results, the objectives of this study have been met. Specifically, this research was able to establish the following conclusions:

1. The cyclic shear tests on UDS specimens under ISC and ASC reveal that the mean effective stresses of soft clays were also reduced during cyclic loading. This emphasizes that cyclic damage can also be manifested in clay soil under soft conditions. Furthermore, such damage is being amplified by ASC, which is the more realistic stress states of soft clay in the site.
2. Post-cyclic monotonic shear tests on UDS specimens under ISC and ASC show that stiffness degradation was enhanced on specimens under ASC. This is due to the initial particle rearrangement and bond degradation induced by anisotropic consolidation, which increases the specimen's vulnerability to plastic deformation.
3. Furthermore, ASC also amplifies the strain softening behavior and peak shear strength degradation of the UDS specimen through uneven principal stresses, soil fabric reorientation, and increased excess pore water pressure generation.
4. The effect of ASC and soil disturbance is more pronounced in UDS specimens due to the intensified peak shear strength reduction, indicating the greater susceptibility of UDS soft clays to soil disturbance.
5. The interactions of ASC and soil disturbance and their combined effects on UDS soft clays have important implications in the design of structures. It is essential to consider the amplification effects of ASC on shear strength and stiffness degradation to avoid overestimating the cyclic shear resistance and bearing capacity of the soft clay foundation.

7. FUTURE WORKS

The present study provided experimental evidence of the interaction between ASC and soil disturbance in soft clay soils. However, it is also necessary to consider a broader range of soil properties and loading conditions to achieve a more comprehensive understanding and representation of soil disturbance. Therefore, future studies will investigate other types of soft clays and the effects of varying stress ratios and cyclic loading amplitude to achieve broader statistical generalization of this concept on soft clays. Furthermore, numerical simulations based on experimental results will be conducted to formulate an equation that will generalize the soil disturbance phenomenon.

8. ACKNOWLEDGEMENTS

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