

Characterizing pullout stiffness of geogrid considering the interaction with soil

(土との相互作用を考慮したジオグリッドの引抜剛性に関する検討)



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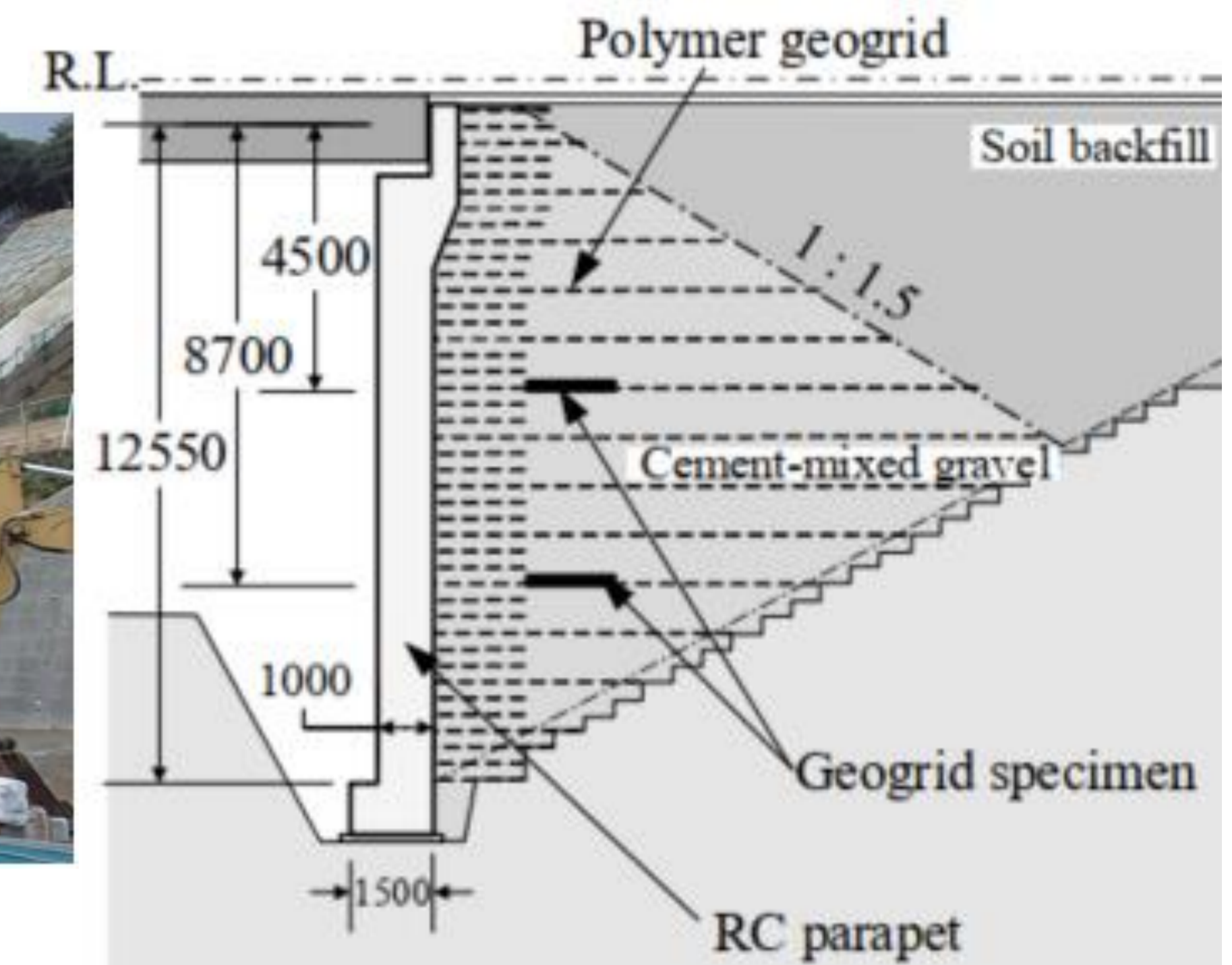


Research Introduction

In the Geosynthetic reinforced soil structures (GRS structures) design, the in-isolation stiffness (E) is used rather than the actual stiffness, which is pullout stiffness (J), considering the soil's contribution. This is due to the complexity of understanding the characteristics of pullout stiffness (J), compared to the in-isolation stiffness (E). Which causes the underestimation.



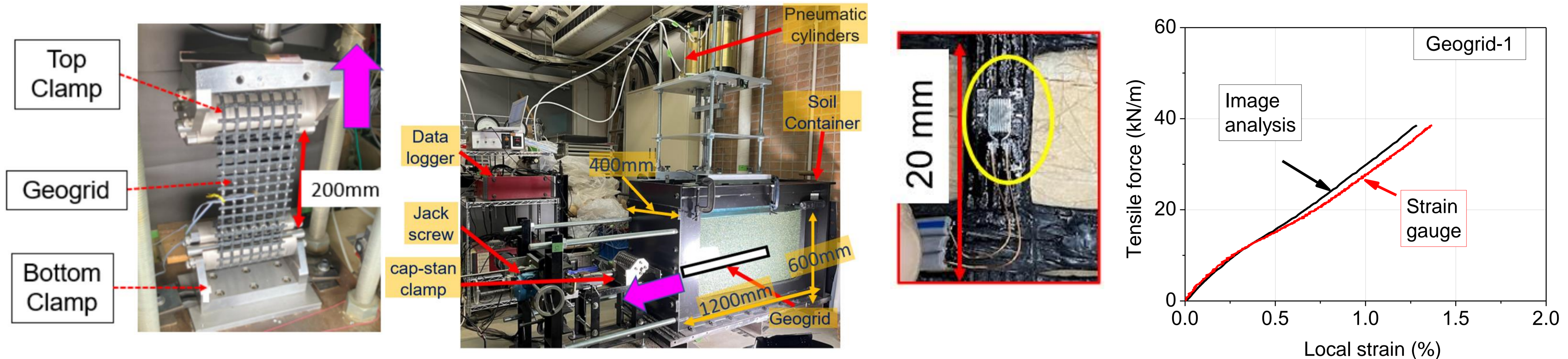
GRS Integral Bridge at Genshu for Kyushu Shinkansen, 2018



GRS bridge abutment

Testing apparatus and methodology

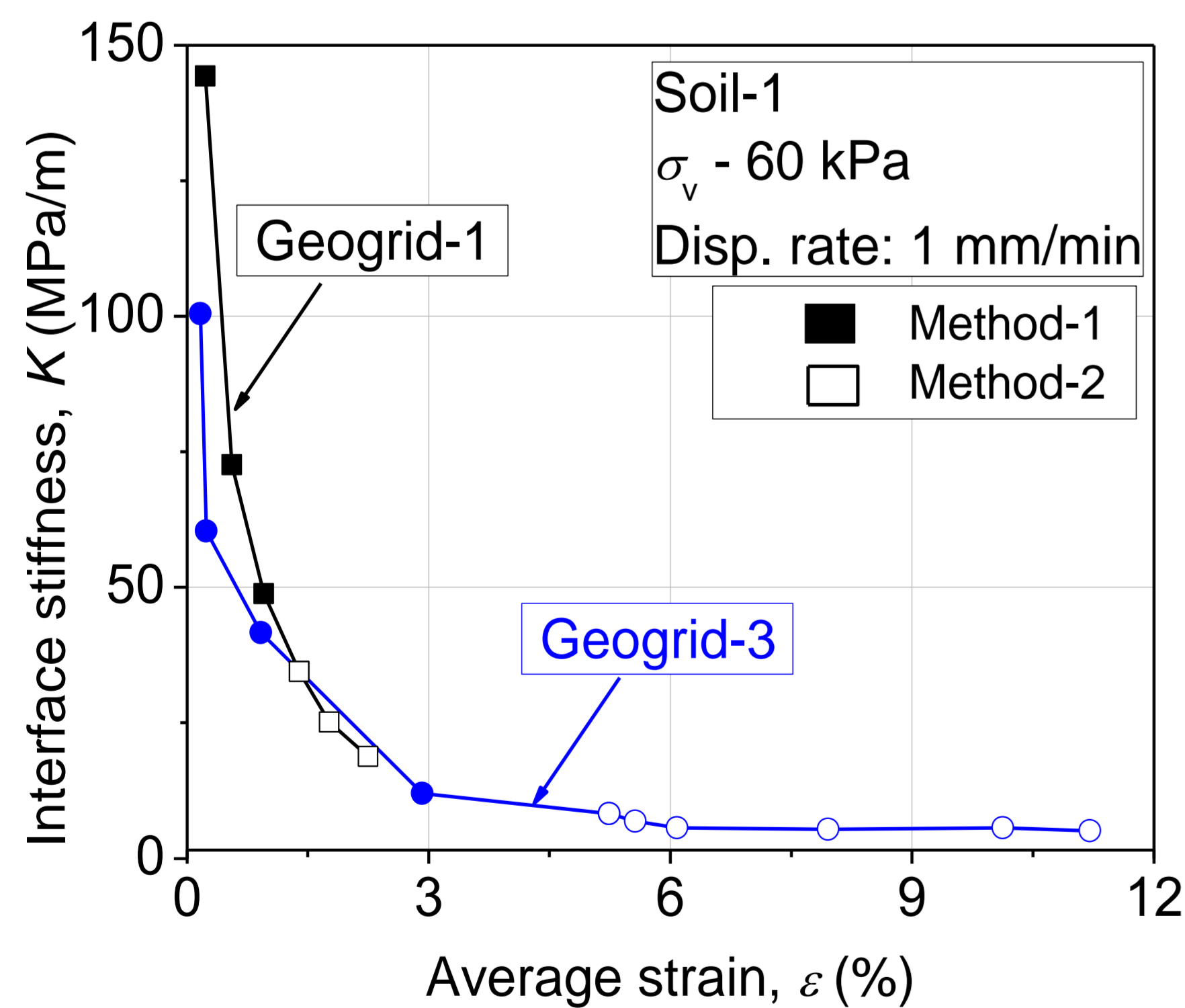
To understand the characteristics of the pullout stiffness, the in-isolation experiments and pullout experiments were performed at a similar displacement rate and similar loading path. The technique with the strain gauge was developed to understand the interface in detail.



Characteristics of interface stiffness (K)

The K was successfully evaluated in a novel way using **tensile force distribution** data and Tatusoka's model.

$$J = \frac{P_0}{s_0} = \sqrt{K \cdot E} \cdot \frac{[\exp(2L/\alpha) - 1]}{[\exp(2L/\alpha) + 1]}$$



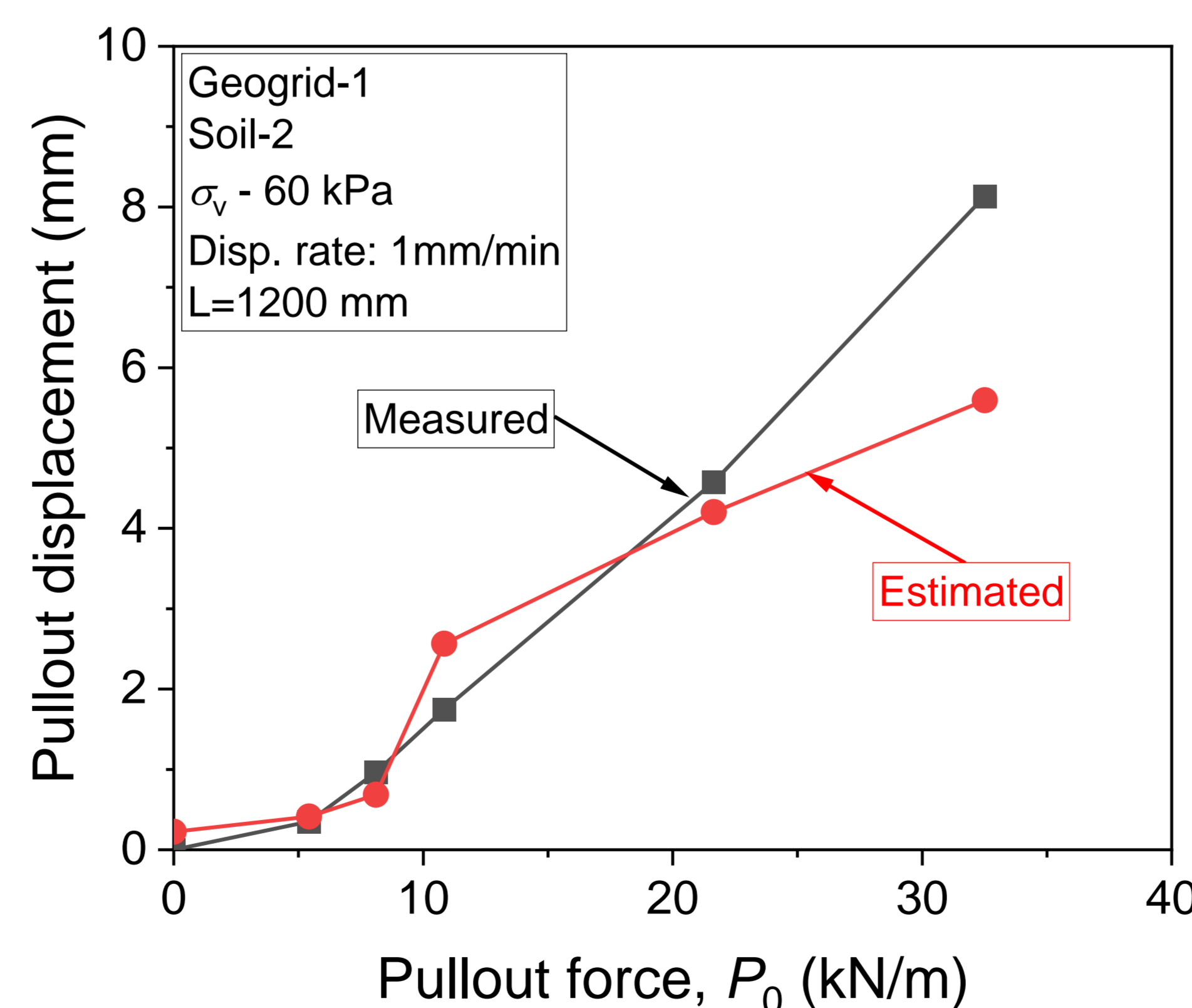
- ✓ The soil confinement positively influenced pullout stiffness. This is due to the surrounding soil, which generates interface shear stiffness.
- ✓ The evaluated K exhibited a decreasing trend with strain. K rapidly decreases at small strains and becomes an almost unique line.

Influence of cyclic loading

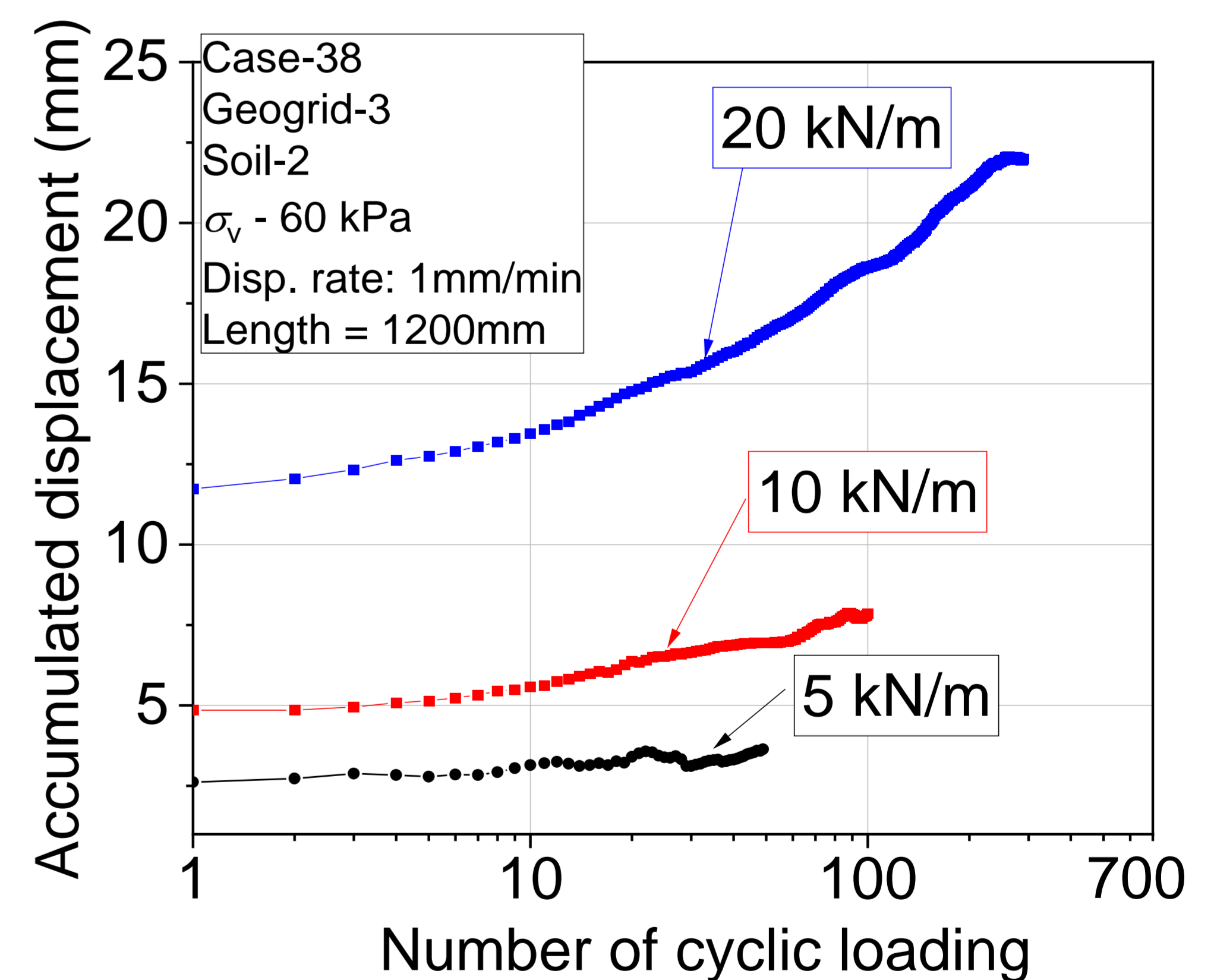
To address the response of the Japanese GRS integral bridge for the seasonal temperature variations, the pullout tests were conducted under cyclic loading.

Pullout displacement prediction

The pullout displacement prediction model was developed based on the theoretical model and the experimental results.



- ✓ The J is significantly high at the small strains since E and K are both high at the small strains. However, at large strains, J shows the residual behaviour as K decreases to the residual stage, and only E may influence J



- ✓ Under the influence of cyclic loading, the geogrid in the air doesn't show the displacement accumulation as it shows while inserted in the soil.
- ✓ The accumulated displacements are high in the softer geogrid; therefore, a stiffer geogrid with suitable soils is recommended for GRS structures.

ジオシンテックス補強土擁壁の鉛直繰り返し载荷 に対する変形特性に関する研究

Deformation characteristics of Geosynthetic-Reinforced Soil Wall under Vertical Cyclic Loading

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(2021年度 修士論文概要)

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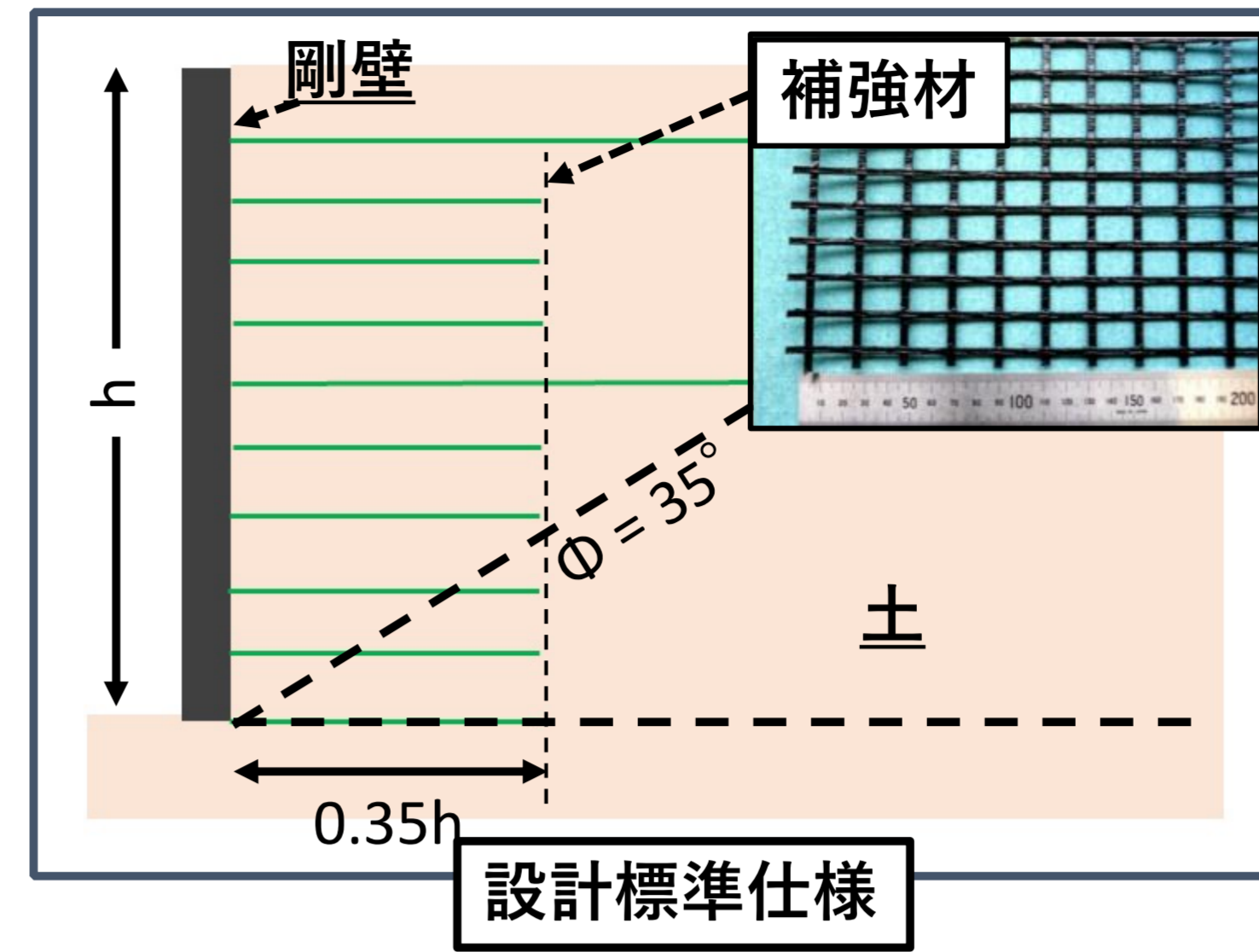


背景

補強土擁壁に関する研究が本格化したのは約30年前。現在の設計指針は経験的あるいは実証実験に基づき定められており、大地震による許容変形量が小さい構造物(鉄道等)への適用を目標に開発された。

現在の状況

要求性能・施工条件が多様化。(例:L2地震動が作用しない条件、良質ではない土の適用など)

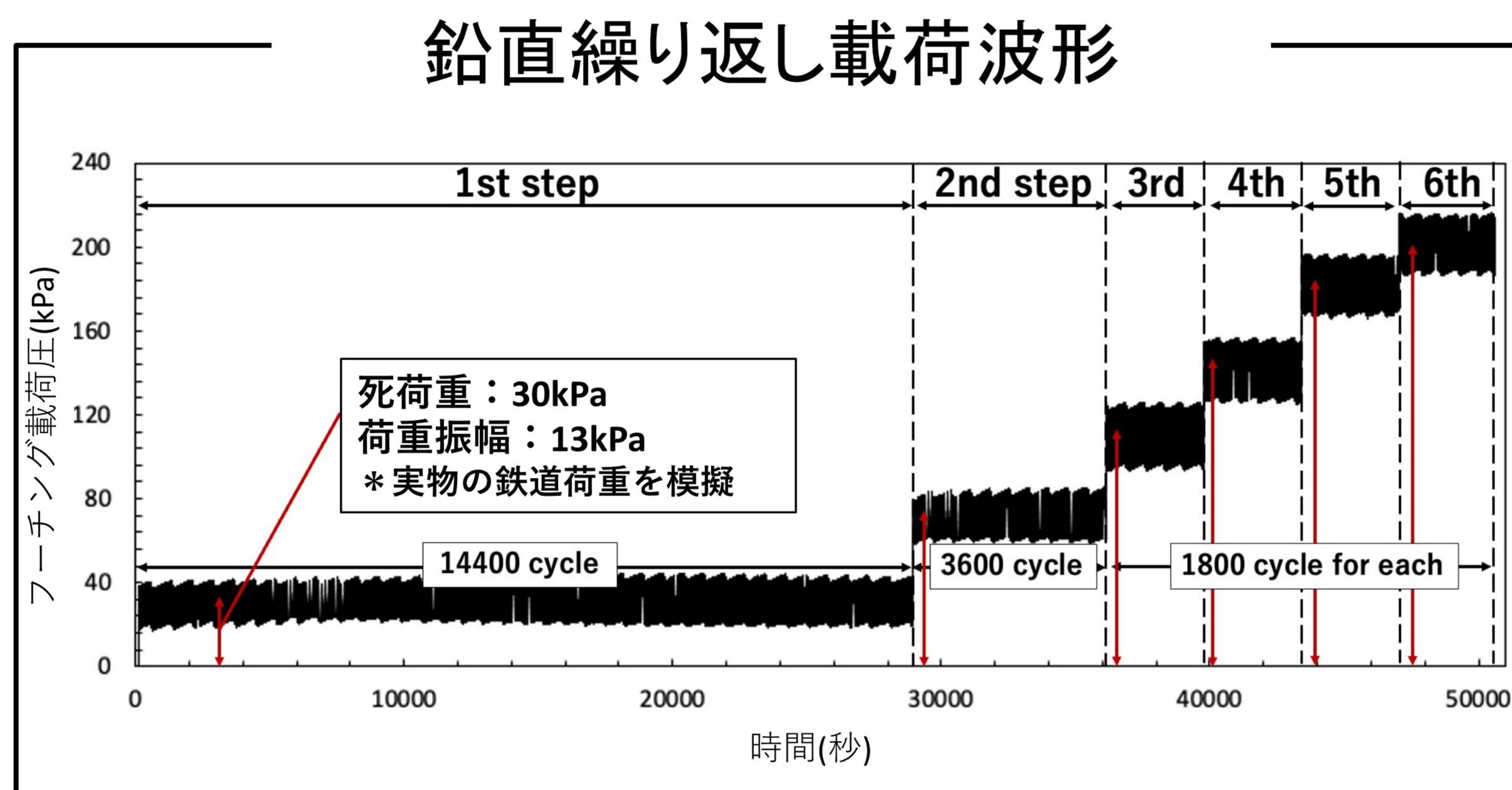


多様化する要求性能・ニーズに応じた合理的な設計・施工法を確立するため、
補強土擁壁の安定性、変形性能を再評価

実験概要

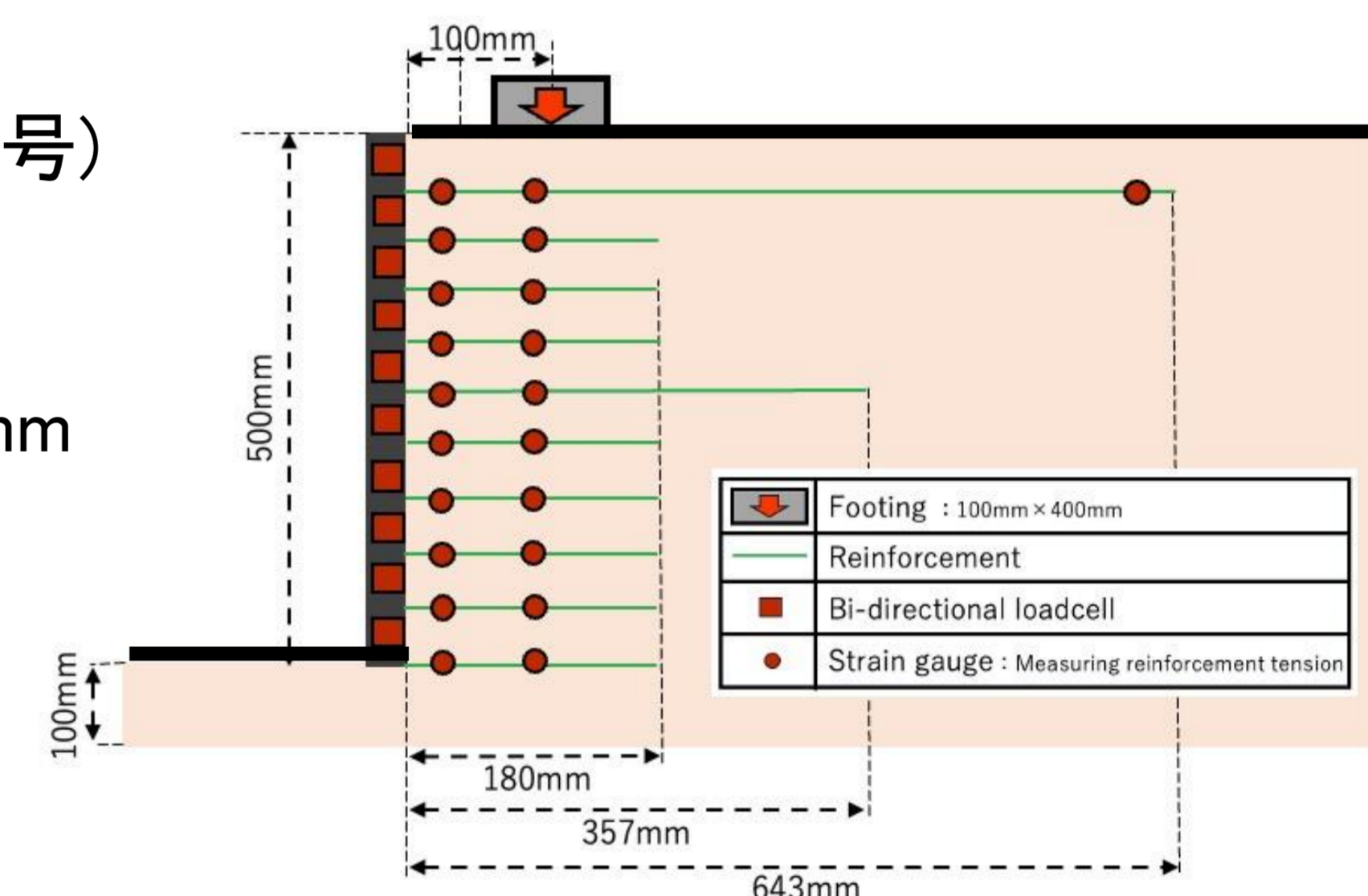
1/6スケールの模型鉛直繰り返し载荷実験を15ケース実施。

擁壁における直応力・せん断応力、補強材における引張力、擁壁・フーチング変位を計測。



基準ケース(鉄道標準仕様): Case-4

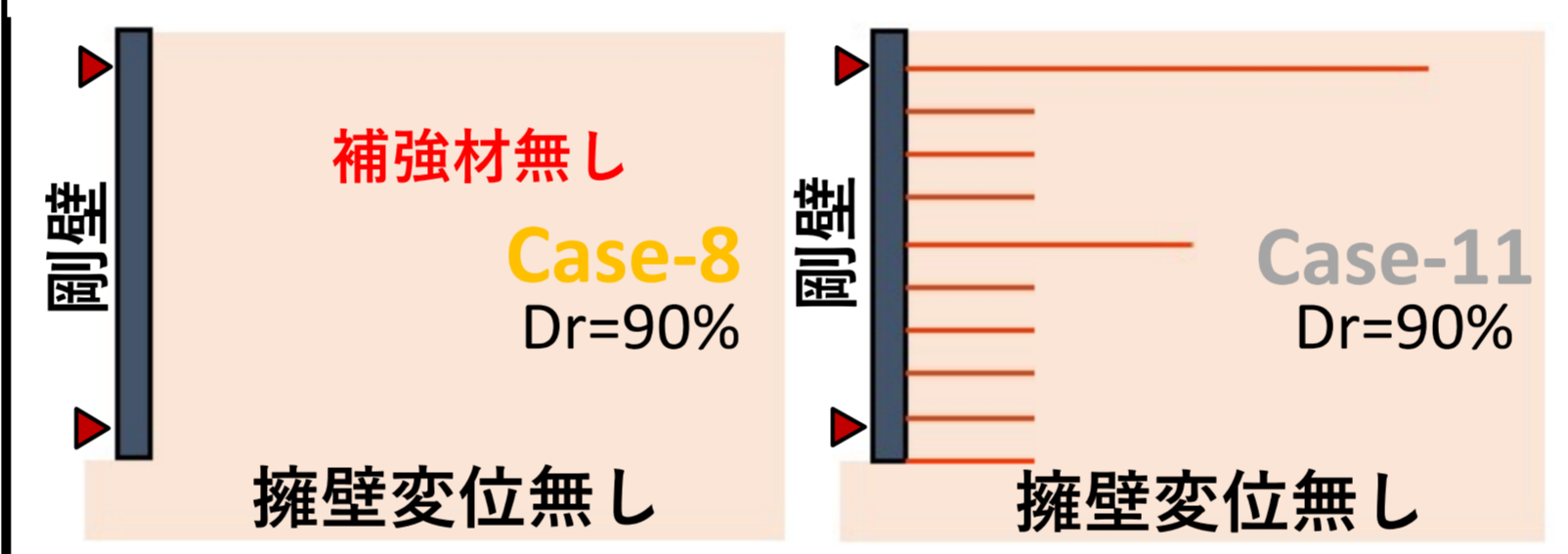
- ①地盤模型(乾燥珪砂7号)
: 相対密度90%
- ②载荷位置
: 擁壁から50mm~150mm
- ③総载荷時間
: 14時間
- ④総载荷回数
: 25200回



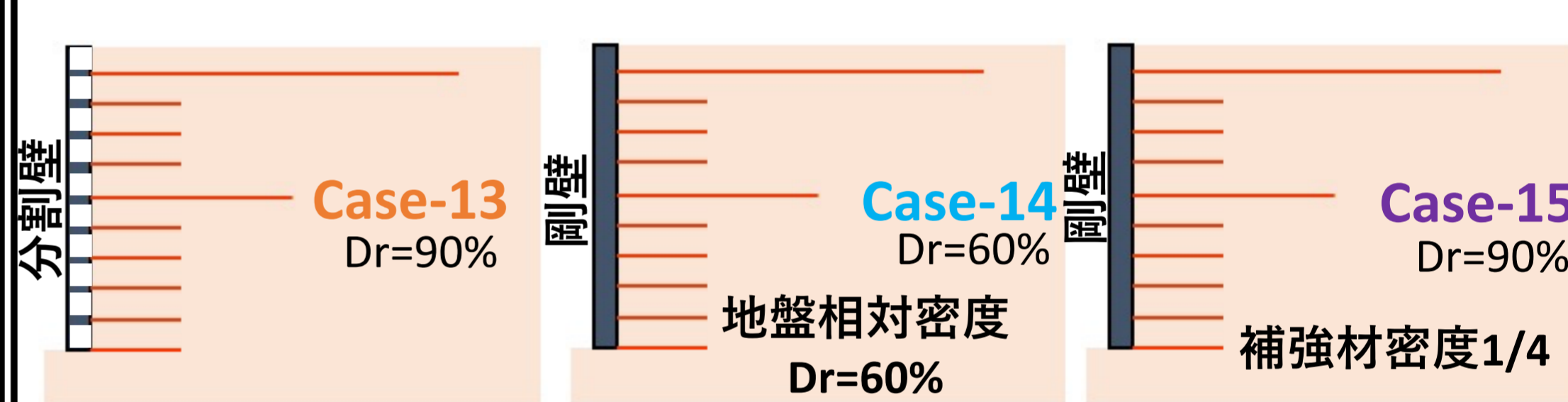
①補強材敷設間隔、補強材長さの影響



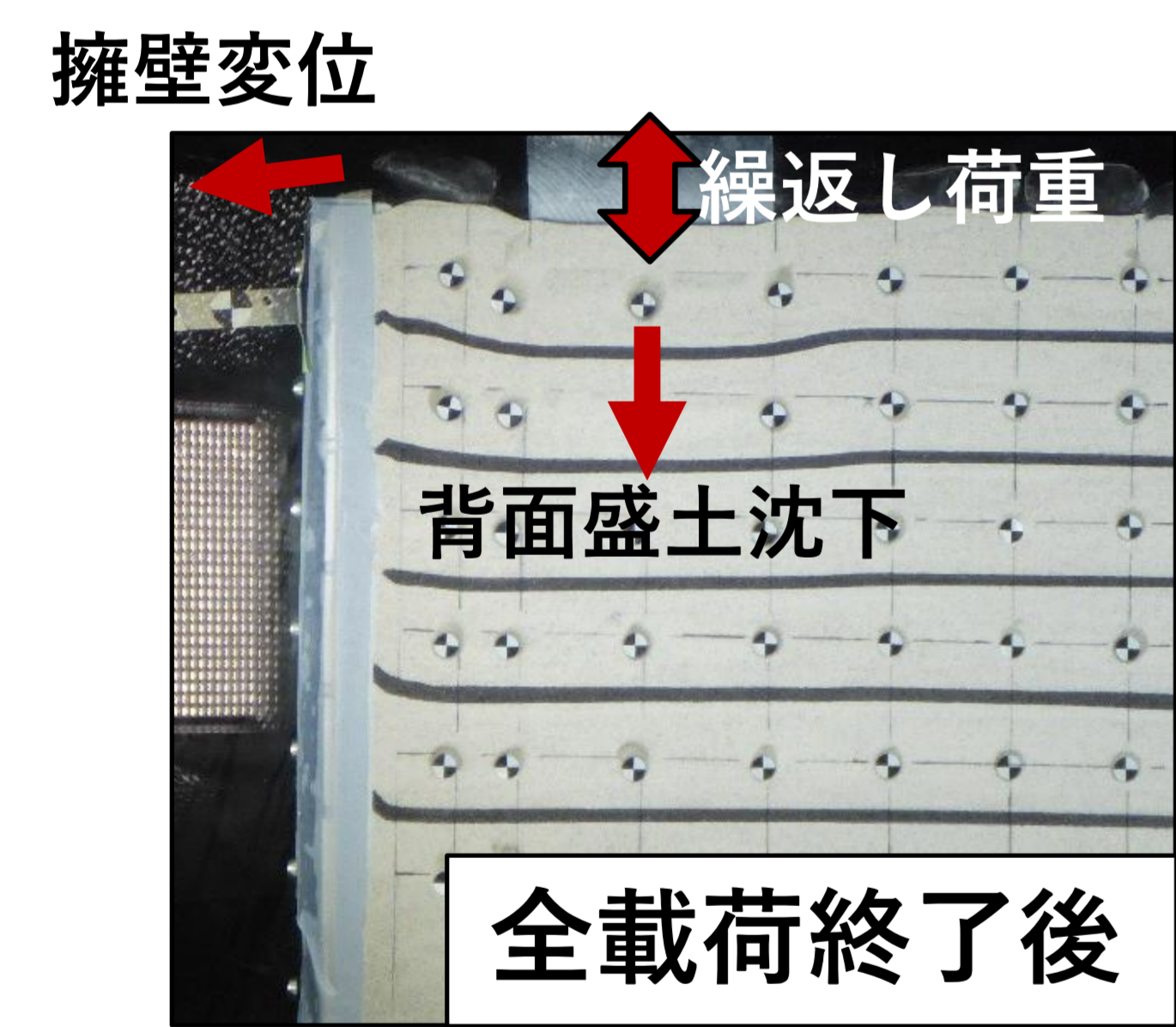
②壁体の固定度の影響



③壁体、地盤、補強材の剛性を下げた場合の影響



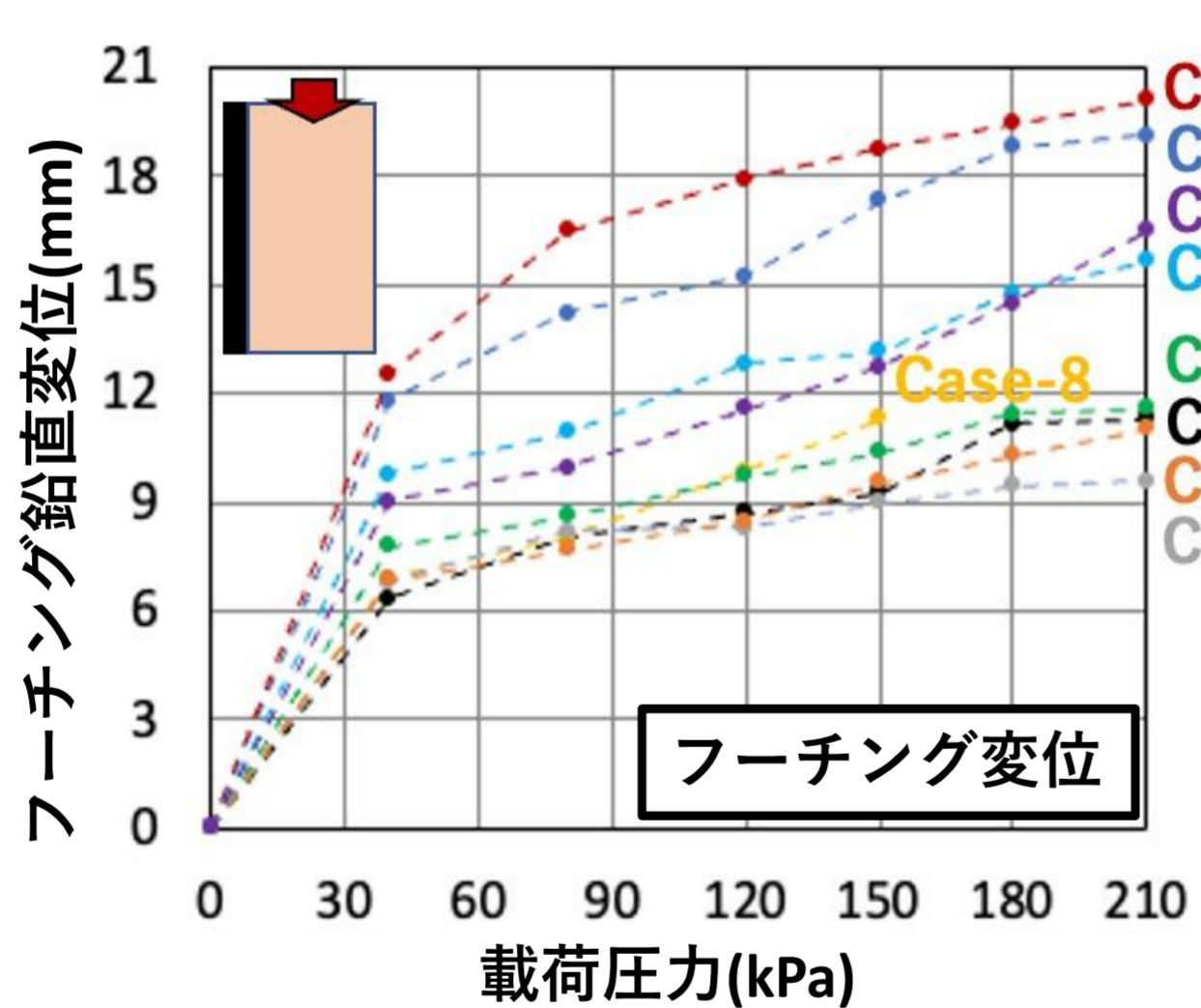
実験結果



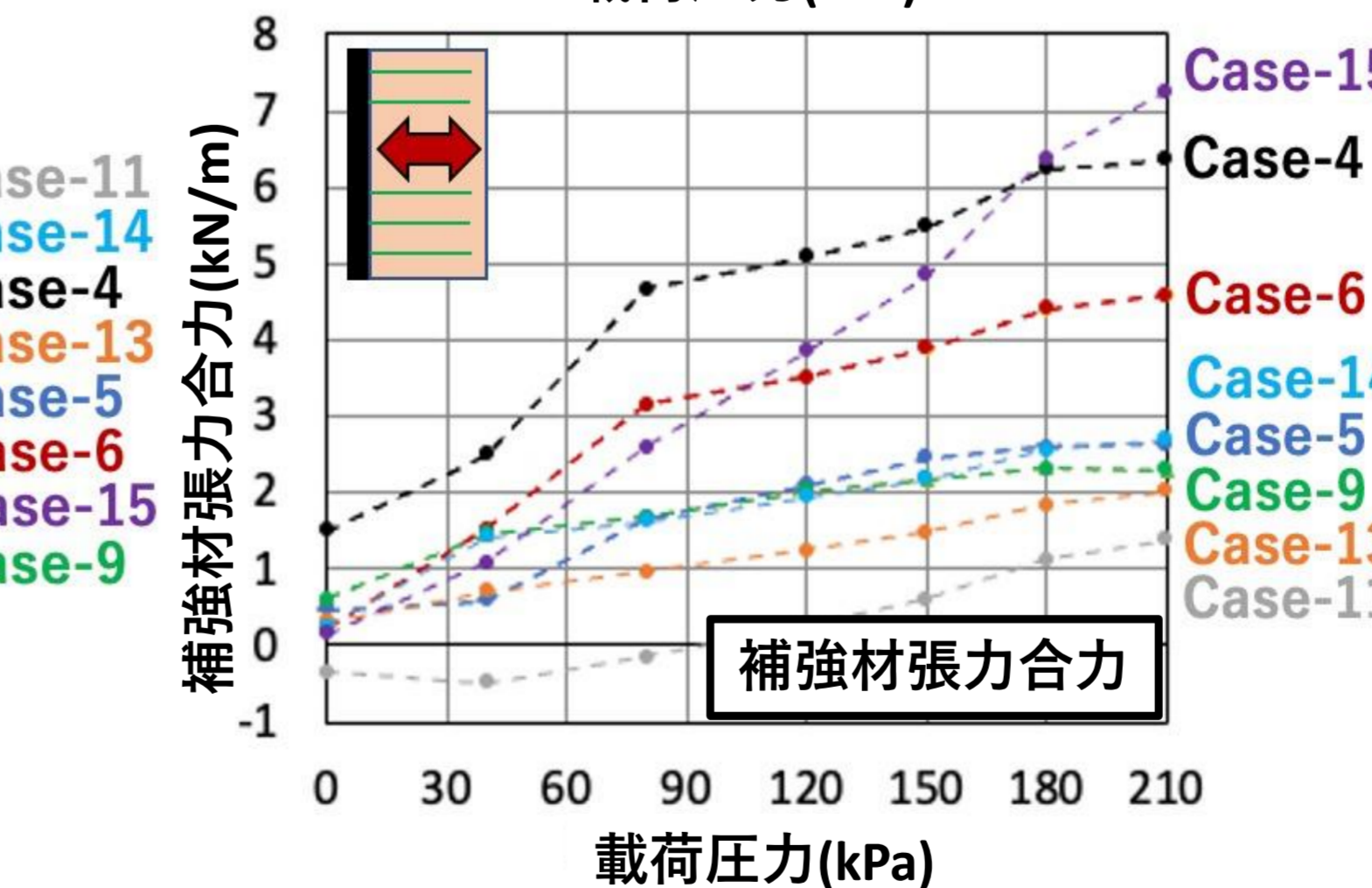
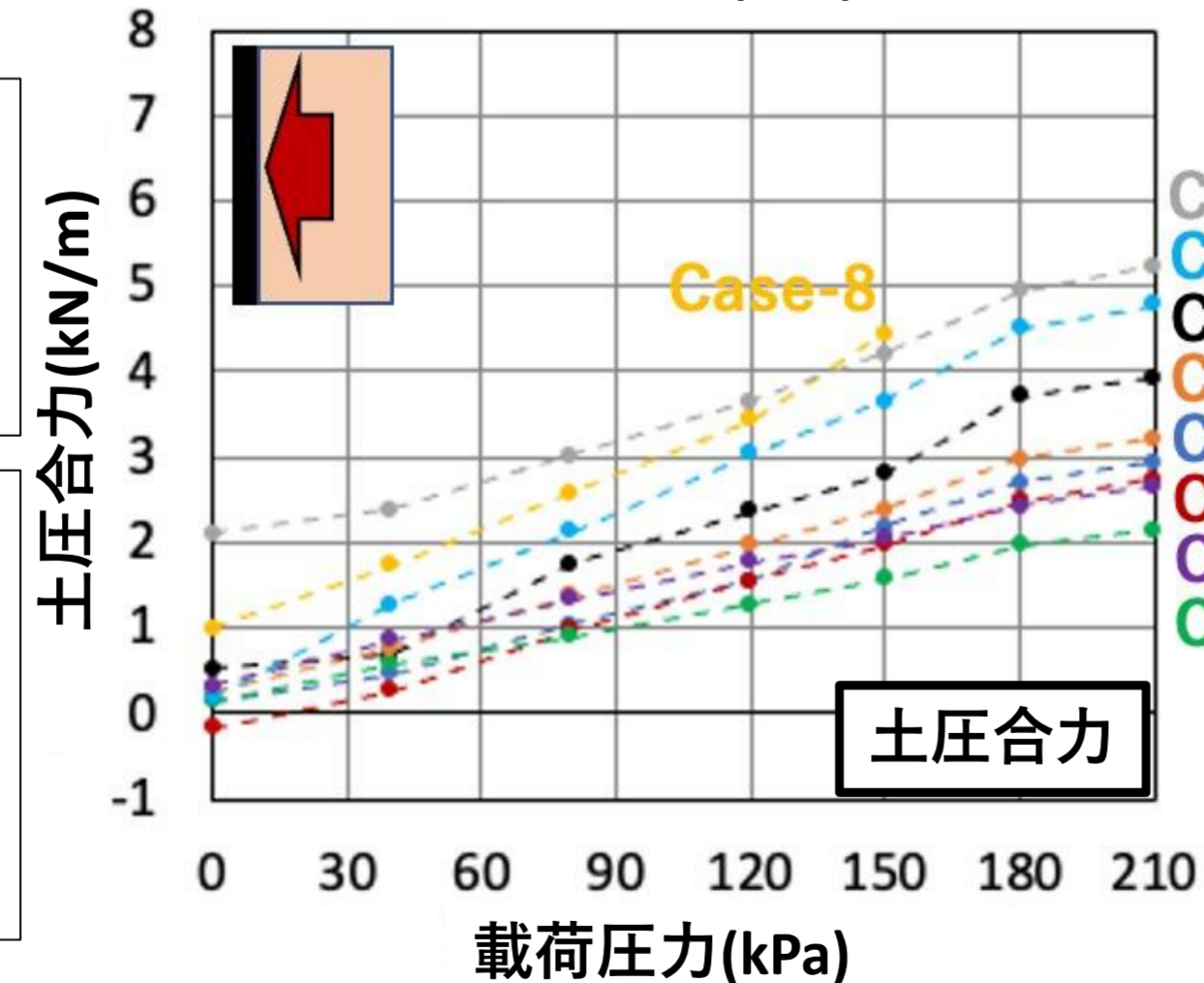
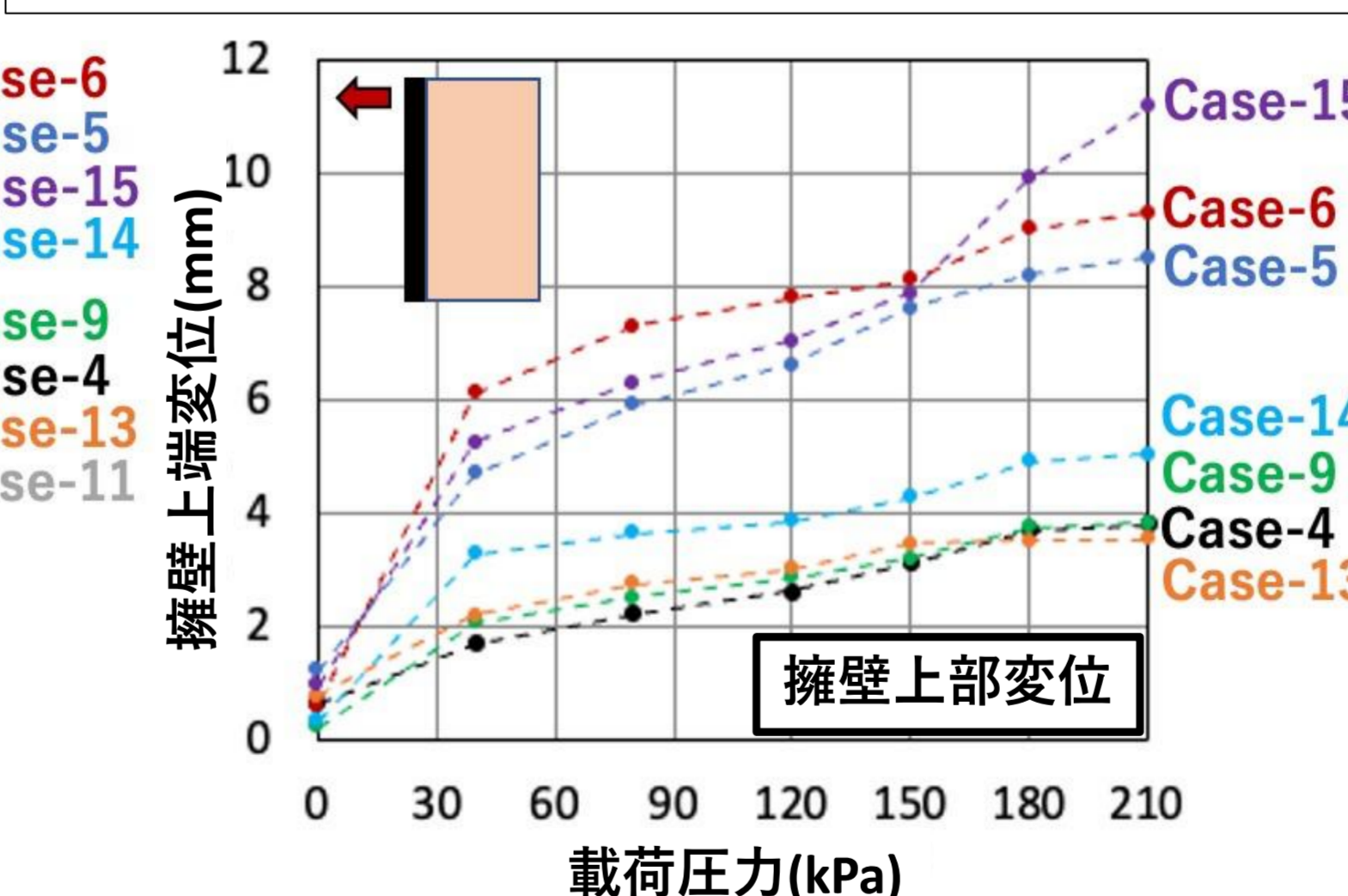
繰り返し载荷による地盤の変形

全ケースの傾向
擁壁変位が小さい時、土圧合力、補強材張力が大。
鉛直繰り返し载荷の結果、Case4が最も高い性能を示した。しかし、振動実験ではCase5が最も高い性能を発揮。

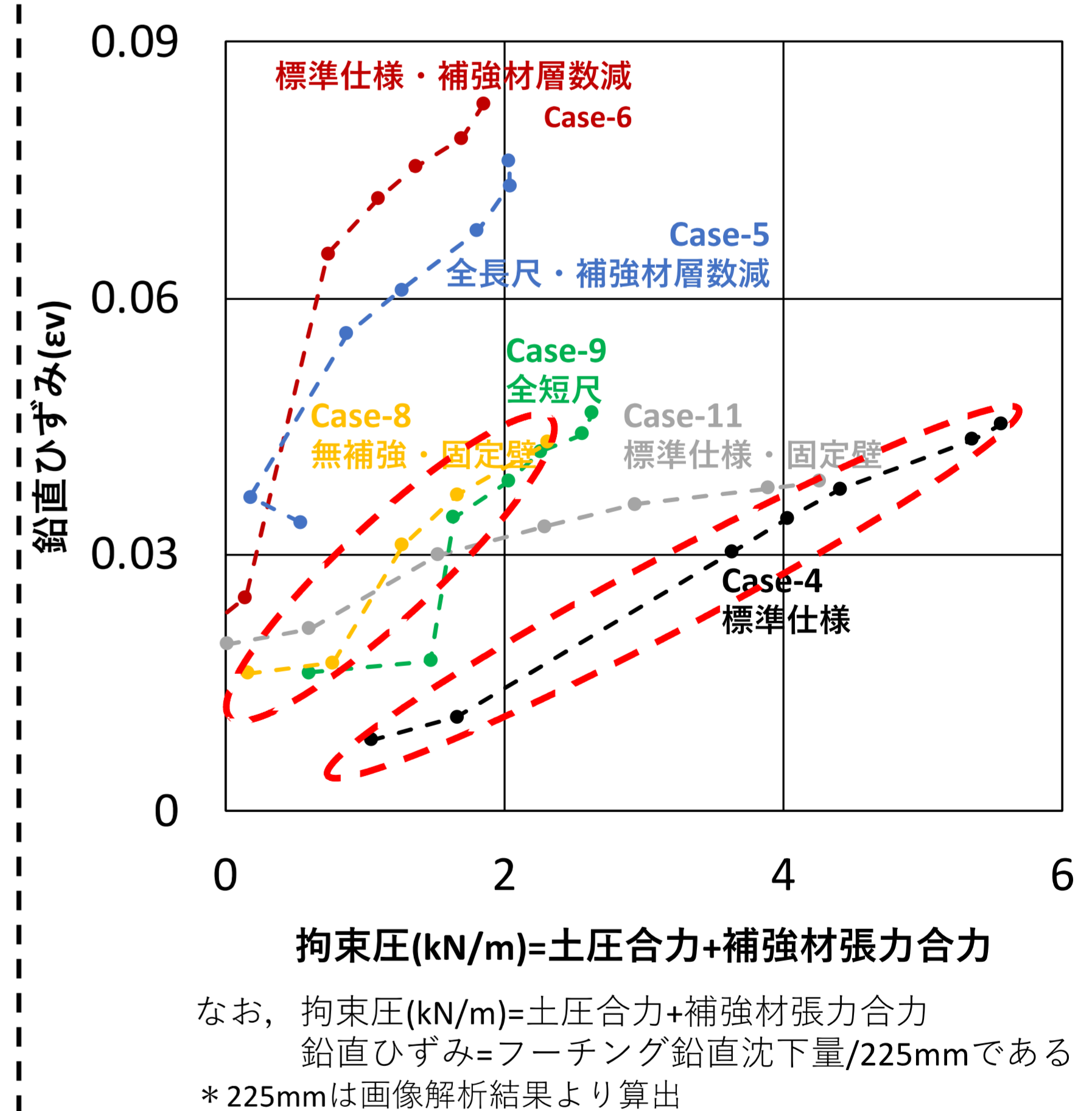
フーチング鉛直変位増加傾向
補強材の敷設間隔、総長さに依存しており、標準仕様補強材配置が最も高い性能。



補強材の効果
Case-8よりもCase-4の方がフーチング変位小。補強材張力が有効に発揮された事で、補強領域全体の拘束圧が高まったと解釈。



拘束圧～鉛直ひずみ関係



全ケースで共通し、高い拘束圧を示した場合、鉛直ひずみは小さい値を取る事を確認。

結論

- 鉛直支持性能は土圧・補強材張力によって補強土体影響範囲に作用する拘束圧が大きな影響を及ぼしている。
- 長尺補強材が耐震性能(外的安定)性能向上に寄与しており、载荷点近傍の補強材敷設層数が鉛直支持特性に寄与している。
- 本研究結果より構造の合理化を提案可。(例:L2地震動が作用しない場合、長尺補強材減、壁体の簡素化が可能)