研究紹介，京都大学大学院　工学研究科　社会基盤工学専攻
地盤力学講座　地盤力学分野，木村研

研究テーマ－X 線マイクロ CT による薄層に支持された杭の鉛直支持力機構に関する研究

研究背景と目的

支持杭（Figure 1）とは，杭先端が固い支持層に到達して支持される杭である．ここで，杭先端以深の支持層厚（有効層厚）が小さい薄層（Figure 1-(b)）に杭が支持された場合，支持層下部の軟弱層が杭の鉛直支持力に影響を及ぼすため，不同沈下の恐れ等が考えられる．このメカニズムを解明するためには，薄層に支持された杭の支持力特性を把握することが重要である．

そこで本研究では，杭先端の地盤変形に着目して，薄層に支持された杭の鉛直支持力機構に関する検討を行っている．ここでは，有効層厚の相違が杭の鉛直支持力に与える影響の把握を目的に実施した，杭の押込み試験時における X 線 CT 撮影および画像解析の結果を示す．

研究手法

X 線マイクロ CT は焦点寸法が非常に小さく，数百～数千倍の幾何学的 X 線画像拡大率を得ることができる装置である．本研究では，等方拘束圧条件の下，有効層厚の異なる三種類の供試体（Figure 2 を参照）を用いた杭の押込み試験と X 線マイクロ CT による撮影を同時に行う．その後，画像解析を実行することで，杭先端地盤の微視構造変化を可視化する．これにより，ミクロな観点から，発揮される支持力の大小について検討した成果を以下の研究成果に示す．

研究成果

Figure 2 に CT 撮影時の荷重-変位関係を示す．図より，有効層厚が小さいほど発揮される支持力も小さいことが分かる．Figure 3 に得られた CT 画像，Figure 4 に画像解析結果を示す．図より，有効層厚が杭径と等しい Case-3 において，杭底面直下には押し込みに伴うくさび型高密度領域は明瞭には現れない．加えて，鉛直下方へ大きくせん断ひずみが発達することが分かる．これが，Case-3 で発揮される支持力が最小となる原因の一つだと考えられる．

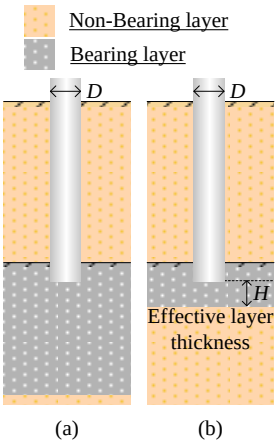

Figure 1: Two types of bearing pile

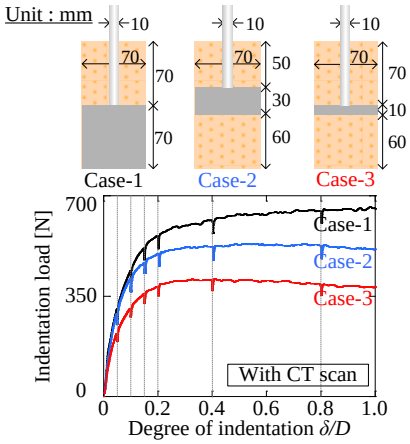

Figure 2: Load-displacement ratio

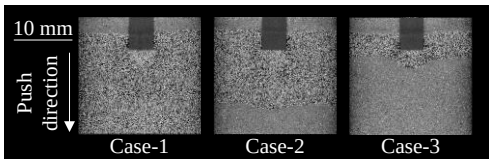

Figure 3: CT images (Degree of indentation 0.8 *D*)

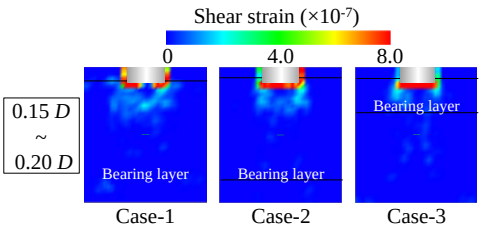

Figure 4: Image analysis (Shear strain)

Research theme −Investigation of mechanism of bearing capacity under vertical loading for pile supported in thin bearing layer.

Research background and objective

Bearing pile (Figure 1) is a type of pile that transmits their loads once it reaches to the bearing layer. When the pile is supported by a thin bearing layer (effective layer thickness) under its tip, the soft ground under the bearing layer might affects the vertical bearing capacity of pile, resulted in risks of uneven settlements. To clarify this mechanism, it's important to understand the characteristic of bearing capacity of these piles.

In this research, focusing on the ground deformation of the pile tip, the bearing capacity mechanism of the pile supported by thin bearing layer has been investigated. Here, the results of pile indentation tests, CT imaging, and image analysis on the bearing capacity of the pile due to the difference in effective layer thickness are reported.

Research method

X-ray micro CT has a very small focal dimension and can obtain image magnification factor of several hundred times to several thousand times. In this research, pile push-in tests and CT imaging under the isotropic confining pressure condition are conducted simultaneously. Three types of specimens (Figure 2) with different effective layer thickness are used. After that, the microstructural changes of the pile tip ground are visualized by performing image analysis. Following section shows the results of investigation on the magnitude of the bearing capacity exerted from the microscopic point of view.

Results & Discussion

Figure 2 shows the load-displacement ratio during CT imaging. The smaller the effective layer thickness, the smaller the bearing capacity exerted. Figure 3 shows the CT images, and Figure 4 shows the shear strain under the bottom of the pile. At Case-3 (effective layer thickness is equal to the pile diameter), wedge-shaped high density region along the pull-in direction does not appear clearly right under the pile, and large shear strain develops downward. It is considered to be the reason of the small bearing capacity in Case-3.

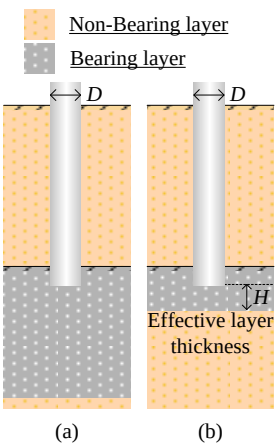

Figure 1: Two types of bearing pile

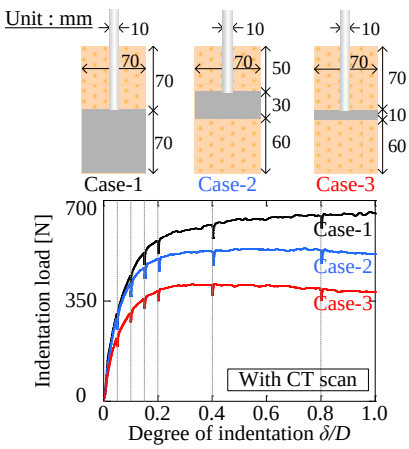

Figure 2: Load-displacement ratio

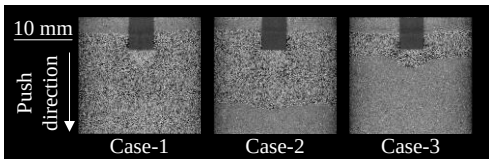

Figure 3: CT images (Degree of indentation 0.8 *D*)

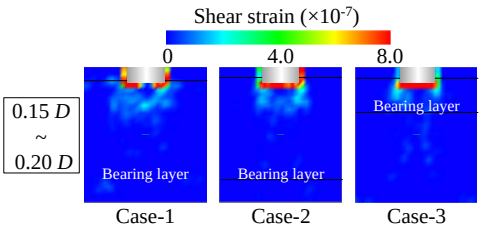

Figure 4: Image analysis (Shear strain)