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博士論文内容の要旨

論　文　内　容　の　要　旨

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Nowadays, underground construction becomes popular as the demand for infrastructure in urban areas increases. To develop underground space in an urban area, it is important to investigate ground surface settlement and damage to existing neighboring structures. The shield tunneling method has been widely applied for underground construction in soil and soft rock with a support system called segmental lining. In addition, computer-aided technology have been continuously applied to solve geotechnical problems under complex analysis conditions. The 2D beam spring model with a stress boundary and the 3D FEM model with a stress boundary are generally adopted to design tunnel lining. Consequently, 2D beam spring model with a displacement boundary has been developed.

This study developed 3D finite element continuum model (3D FEM) with a displacement boundary, considering longitudinal joints, circumferential joint, and non-tension boundary between the lining and the ground. The effect of the boundary condition at the tunnel end and the ground stiffness on the lining behavior (i.e., bending moment, axial force, segment displacement, and normal effective earth pressure) in the case of staggered building was examined by using the 2-ring model and the 12-ring model. The influence factors on the lining behavior were examined through parameter study on both soft and stiff ground conditions. The developed 3D finite element continuum model was validated by comparing the calculated results with the construction site data. Moreover, the sectional force of lining calculated by the existing 2D beam spring model with a displacement boundary was compared with that by the proposed 3D FEM model, to obtain the relationship between Young's modulus, E, and the coefficient of subgrade reaction, k_n, of each ground model.

As a results, it was found that the boundary condition at the tunnel end does not significantly affect the sectional force of the segmental lining in the case of staggered building for both soft and stiff ground, except for the axial force in soft ground. Since the two-ring model provides the safe side results from the viewpoint of segment design, it can be adopted for segmental lining design and lining behavior simulation. In the case of the following conditions: 1) Half-width model at model ends, and 2) Vertical roller and rotation around tunnel axis direction only at the side wall perpendicular to tunnel axis, the 2-ring model provides the shield behavior under a quasi 2D strain condition even in soft ground. Moreover, the overall tunnel lining behavior calculated by the proposed 3D FEM model shows a reasonable agreement with the field observations. Furthermore, the relationship between Young's modulus and coefficient of subgrade reaction was proposed, so that the sectional force of segmental lining by the 2D beam spring model with a displacement boundary is equal to that by the 3D FEM model with a displacement boundary.