

Investigation on the Underground Joining of Sewer Shield Tunnel with Large Depth

Whole term

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(Objectives)

Due to the urbanization in principal areas of large cities, the construction of underground sewer facilities by using shield tunneling methods becomes deep and deep. Since the construction of vertical shaft with large depth for shield tunnel usually does not have good cost performance in addition to the difficulties of securing construction site in concentrated urban area, the shield tunnel construction by using direct underground joint method instead of the method by using vertical shaft is expected to be increasingly used. Therefore, the design and construction methods of underground joint have not been established yet. Since the allowable stress criterion is basically used in current design method, the deformation behavior of the segments close to the opening of the shield liner for the underground joint can not be estimated. Also, several unexpected deformation cases of the segments closed to the opening of the shield liner constructed using the underground joint method together with the ground freezing method.

In this study, the technical issues of the design and construction methods for the underground joint of the shield tunnel were clarified first through analyzing current design and construction methods and the related subjects. The deformation behavior of the segments close to the opening of the shield liner for the underground joint was verified using two-dimensional frame analyses by focusing on the effects of the cover height, ground conditions, dimensions of the opening, swelling pressure due to ground freezing and joint types. On the basis of the analytical results, the basic information for establishing a new technical guideline on the underground joint for the construction of shield tunnels with large depth was obtained.

(Results)

(1) Classification of the current subjects

1) Subjects about the design

- (a) the deformation of the segments close to the opening of the shield liner can not be considered in the traditional design using allowable stress criterion
- (b) the range of ground freezing is not clear because of the uncertainties of the swelling pressure and its distribution

2) Subjects about the construction

- (a) separation of freezing soil due to the deformation of segments around the opening of the shield liner
- (b) uncertainties in the control method for the surface of the freezing soil under the construction using ground freezing method

(2) Study on the countermeasures for the above subjects

1) Countermeasures for the design

- (a) clarify the deformation behavior of segments under the conditions of large depth and high hydraulic pressure

On the basis of the analytical results, it is clear that the segments close to the opening of the shield liner will deform towards the inside of the shield tunnel and go beyond the allowable deformation to cause a separation from the freezing soil independent to the joint methods, when the sectional forces of the segments due to the earth and hydraulic pressures and swelling pressure of the freezing soil are released under large depth condition. The installation of a supporting system where preload can be induced should be considered as a countermeasure.

- (b) Framework of a new technical guideline by adopting the allowable deformation design method

As an important issue, it is necessary to adopt the allowable deformation design method by focusing the deformation behavior of the segments closed to the opening of the shield liner instead of the allowable stress method for the design of underground joint together with the ground freezing method of the sewer shield tunnel. It is recognized that the risk of large scale water leakage due to the deformation of the segments closed to the opening of the shield liner exists according to the analyses. To establish a new technical guideline by adopting the allowable deformation design method, it is necessary to accumulate measurement data for clarify the separation of the freezing soil and the structure and do basic investigation and research.

2) Countermeasures for the construction

(a) displacement control method

The proposed displacement control method by using supporting system has better cost performance comparing with the method by widening the range of the freezing soil to prevent from the separation at the boundary, and is recognized as the more applicable method for controlling the displacement of the segment close to the opening of the shield liner in the underground joint of the shield tunnel with large depth.

(b) study on the control method of the surface of the freezing soil

As the control of the surface of freezing soil, the concerning issues of the temperature measurement for temperature control were studied. It was show that the installation of temperature sensor for the three dimensional control of the temperature distribution, and carefully watching on the freezing situation at the boundary between the structure and soil as a structural weak point which is easily to cause the insufficient of freezing due to the temperature rising of the freezing soil close to the opening of the shield liner after removing the freezing tube, are the important issues.

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Key words

shield, underground joint method, freezing method