Numerical evaluation of the effects of ground reinforcement method in double-deck tunnel junction

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ABSTRACT: Densification of the city with the rapid industrial development was accelerated to build complex social infrastructure. And numerous structures have been designed and constructed in accordance with these requirements. Recently, to solve complex urban traffic, many research of large-diameter tunnel under construction downtown are in progress. The large-diameter tunnel has been developed with a versatile double-deck of deep depth tunnel. For the safe tunnel construction, ground reinforcement methods have been developed in the weakened pillar section like as junction of tunnel. This paper focuses on evaluation of the effects of new developed ground reinforcement methods in double-deck junction. The values of reinforcement determined from the existing and developed methods were compared to each other by numerical simulation.

KEYWORDS: Double-deck tunnel, weakened pillar, ground reinforcement method, numerical simulation

1 INTRODUCTION

Utilization of tunnel is increasing to improve residential environment such as Seoul-Busan express underground highway project in domestic. Construction of double-deck tunnel have gradually increased over the world to optimizing tunnel space and solving urban traffic problem.

Network-type tunnel and double-deck tunnel is needed for constructing underground junction. Closed twin tunnel is needed for saving construction cost and environment. As a result, there is a zone of weakened ground at cross section, pillar of junction and portal.

2 REINFORCEMENT METHOD

The loop-type steel wire reinforcement method is applied to binding a multi-axial direction in pillar between main tunnel and branch tunnel for stability of pillar using loop-type steel wire. The sequence of construction is 'Excavation of main tunnel – Drilling of steel wire insertion hole – Insertion of steel pile and grouting – Excavation of branch tunnel – Installing of loop-type steel wire and binding' (Lee et al. 2015).

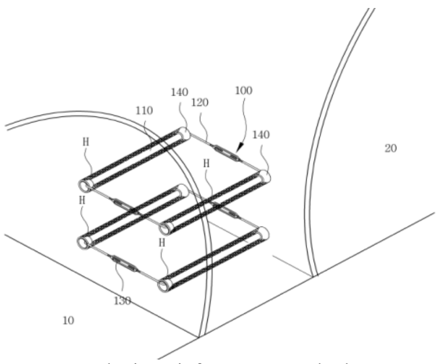

Figure 1. Loop-type steel wire reinforcement method

3 STRENGTH/STRESS RATIO

The strength/stress ratio is rock strength to a major principal stress. Bearing progressive failure and stress transfer process in mind, Hoek and Brown (1980) suggest that overall pillar instability can occur when the average strength/stress ratio across the center of the pillar falls below 1.0. Hence, this average strength/stress ratio is equivalent to the factor of safety. And, they consider that a factor of safety in excess of 1.5 should be used for pillar which is required to provide permanent support in an underground.

$$strength / sterss\ \ ratio = \sigma_{1s} / \sigma_1 \tag{1}$$

where σ_{1s} is the rock strength at the confining stress (σ_3), and σ_1 is the major principal stress.

4 NUMERICAL ANALSIS

3D analysis was performed to consider the characteristics of multi-axial direction reinforcement using loop-type wire and the variation of pillar width between main tunnel and branch tunnel. Analysis range was set in consideration of the excavation impact area. It was applied to the standard support pattern of Korea Highway Corporation that generally applies in domestic. The stability of the 3-grade, 4-grade rock conditions according to the pillar width was studied to calculate the strength/stress ratio based on the rock failure criteria using the major principal stress acting on the pillar obtained by the numerical analysis.

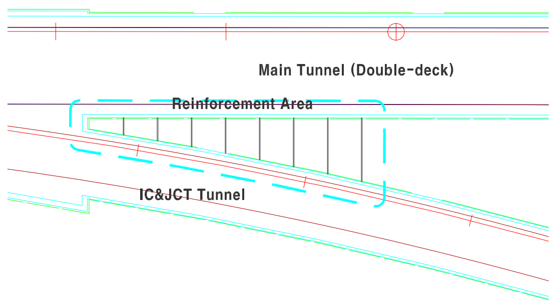

Figure 2. Floor plan of double-deck tunnel junction

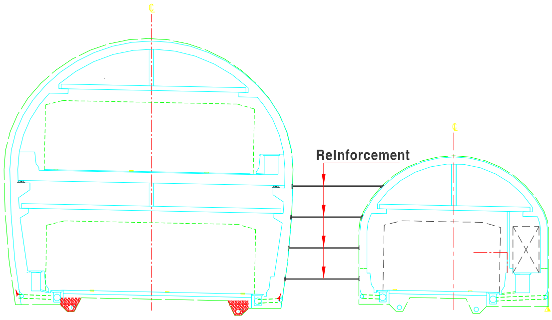

Figure 3. Cross section of double-deck tunnel junction

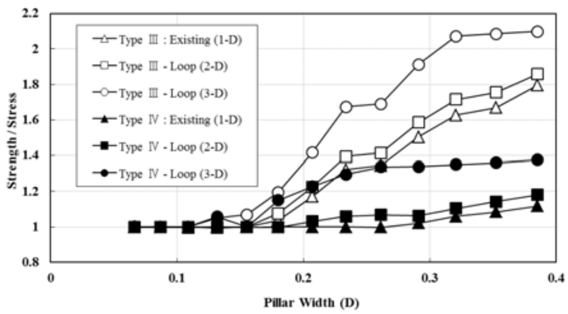

Figure 4. Loop-type steel wire reinforcement method

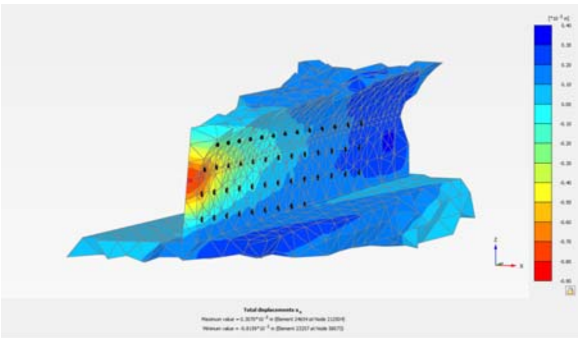

Figure 5. Horizontal displacement of pillar: Existing-type

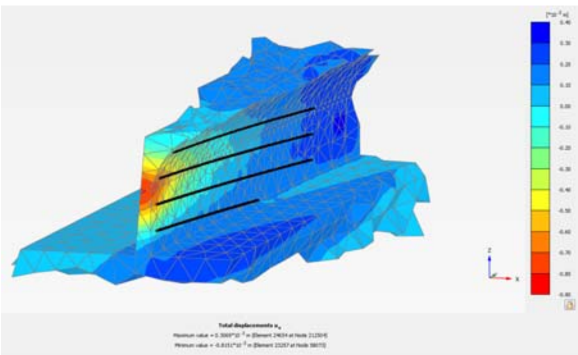

Figure 6. Horizontal displacement of pillar: Loop-type (2-D)

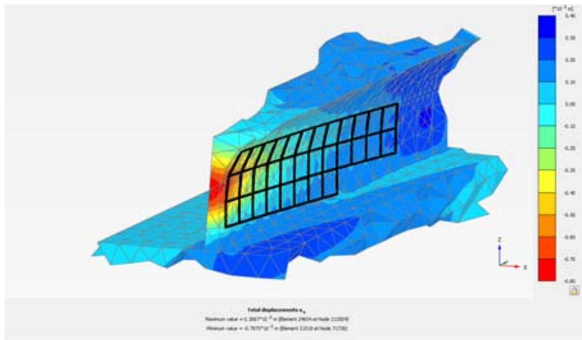

Figure 7. Horizontal displacement of pillar: Loop-type (3-D)

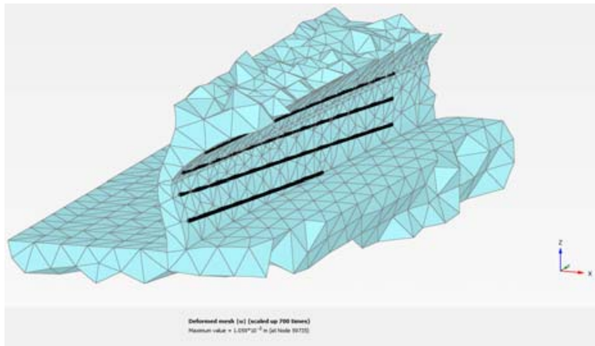

Figure 8. Deformation shape of pillar

5 CONCLUSION

In this paper, 3D analysis was performed to consider the characteristics of multi-axial direction reinforcement using loop-type wire and the variation of pillar width between main tunnel and branch tunnel. According to the results, the following conclusions can be drawn.

1. In less than 0.2D rock pillar width, regardless of the conditions, strength/stress ratio is about 1.0, it was shown unstable.
2. It was shown that since more than 0.2D showing a tendency to increase the strength/stress ratio, and 3-grade rock of strength/stress ratio increased significantly than 4-grade.

6 ACKNOWLEDGEMENTS

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