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Influence of Geological Conditions on Deformation Behavior of Tunnel-A Case Study on Tseng-Wen Reservoir Transbasin Diversion Tunnel, Tainan, Taiwan

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Taiwan is an island located at a tectonically active collision zone between the Eurasian Plate and the Pacific Plate. The inherent complexities of geologic nature create numerous discontinuities through rock masses and steep hillside slopes on the island. Due to the difficult geological conditions, a systematic monitoring plays an important role during the tunnel excavation. In the last decades, several researches have been reported that traditional tunnel convergence has been replaced with geodetic methods to determine the three-dimensional displacement patterns of tunnel roof and tunnel face. Geodetic methods of absolute displacement monitoring allow determining the spatial displacement vector of each measured point. These methods to a large extent have replaced relative displacement measurements in many countries. The increase in information has led to additional possibilities in data evaluation. The plotting of displacement histories, deflection curves, trend lines or displacement vectors in a plane perpendicular to the tunnel axis have become common practice.

Recently, an analysis method of displacements to predict the variation in geological condition ahead of tunnel face was proposed by Schubert and Vavrovsky [Schubert, P., Vavrovsky, G.M., 1994. Interpretation of Monitoring Results. World Tunnelling, November] and Schubert and Steindorfer [Schubert, W., Steindorfer, A., 1996. Selective Displacement Montoring Tunnel Excavation. Felsbau, 14.2, pp. 93–97]. It was revealed by aforementioned studies that the existence of a weak ground ahead of the tunnel face induces a typical displacement tendency of convergence caused by excessive stress concentration in the vicinity of the tunnel the face.

However, numerical analysis could only provide limited warning information for tunneling because the excavated tunnel surface was mainly influenced by the in-situ geological condition. Many serious disasters caused by the geologic conditions happened during excavation. Several papers and reports were indicated the variations of longitudinal deformations of the tunnel depend on the geological conditions ahead of its face. To the excavation of tunnels, precise prediction of the geological conditions ahead of the tunnel face is important for the economy, safety and efficiency of the project. In particular, sections of poor ground, such as faults and fracture zones, are likely to require changes in construction methods as well as tunnel support patterns, and could thus impede the progress of construction. Therefore, it is desirable to obtain high quality data on geology and properties of rock masses in advance.

In this study, a three-dimensional numerical code, called FLAC3D, was used to analyze the Tseng-Wen Reservoir Transbasin Diversion Tunnel, Taiwan deformation when excavation through the interface of different geological conditions. This study presents the results from a systematic three-dimensional analysis in varying ground conditions, which compares vertical (radial) displacements measured at the roof, vector orientations associated with these roof displacements and tunnel face displacements. These numerical results suggest that the vector orientation provided additional information not obtained from traditional radial displacements or face extrusion.

The deformations of crown and longitudinal of tunnel would be increased if the rock is weak ground ahead of the excavation. If the rock is hard ground ahead of the excavation, the deformation would be decreased. The plots of influence lines and trend lines were used to predict the geological condition ahead of the excavation face. The

results showed that the variations of influence lines and trend lines were depended on the geological conditions. Additionally, the numerical analyses were also carried out with the transition interface inclined at the degrees of 90 and 120 with respect to tunnel axis. The results were found that when the transition interface is at an angle, vertical settlements become less reliable in predicting the presence of weak ground ahead of tunnel face. However, the changes in vertical orientation become much more abrupt and clearly indicate changing geological conditions.