Abstract of PhD Thesis

"Experimental and Numerical Studies on the Effects of Raft Foundation on Underground Tunnels in Cohesionless Material"

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The present research aims at investigating the effect of basement raft foundation excavation and loading on the existing tunnels using a comprehensive experimental and numerical (Finite Element: FE analysis) studies. The study includes characterization of materials, 1-*g* model experiments and two-dimensional (2D) and three-dimensional (3D) FE analyses. The direct shear tests and triaxial tests were conducted to determine engineering properties of the soil and the interface properties between soil and steel. Model experiments were carried out considering Yamuna sand as soil, which is filled at medium dense condition (60% relative density) based on typical field SPT-N values of Delhi region. An experimental model setup including tunnel excavation system was designed and fabricated in the laboratory for conducting the model experiments as per the experimental program. The results obtained from model tests are analyzed and used to validate the FE (2D and 3D) models.

Two-dimensional (2D) and three-dimensional (3D) analyses were carried out in PLAXIS software. Soil, tunnel lining basement excavation, and raft foundation were modelled with optimum mesh density. To minimize the boundary effects, sensitivity analysis was carried out in both 2D and 3D, and the dimensions of the model were arrived at. The behavior of Delhi silt is analysed using the Hardening soil constitutive model and response of the tunnel lining is compared with the Mohr-Coulomb constitutive model, widely used in practice. After analyzing the various geotechnical profiles of the Delhi region, it is noticed that water table is very deep therefore water table level is considered at a depth of 50 m below the bottom of the model. Standard boundary/support conditions are used. Fine mesh density was used for the overall soil model, but closer to the tunnel, fineness of mesh was increased. The parametric studies were carried out by considering the various important parameters: cover depth (*C/D* ratio), clear distance between tunnel and raft (*X/D* ratio), number of basements, width of raft foundation, and length of raft foundation (in 3D). It is found from

the results that the construction of basement excavation and foundation loading have pronounced effect on the existing urban metro tunnels. The effects are significant on all response parameters of tunnel lining, especially total displacement and strain. 2D-FE analysis indicated that the total displacement and strain are higher when excavation is closer to tunnel location and tend to become negligible when excavation is carried out at a distance greater than 2.5 times the tunnel diameter, for the loading conditions considered. Similar observation is found in 3D-FE analysis as well. The width of raft foundation and number of basements are also found to have significant effect on the tunnel response. Additional bending moments, axial and shear forces are mobilized in the tunnel lining due to excavation and foundation loading, for which the reinforcement details and thickness of tunnel lining may have to be verified. 3D-FE analysis indicated that the foundation with larger dimension placed across the tunnel and smaller dimension placed along the tunnel direction results in less influence on the tunnel lining due to the raft excavation and loading.