SUMMARY OF DOCTORAL DISSERTATION BY SAQIB ASHRAF (D19WA902)

TITLE: Experimental investigation of the impacts of expansive soils on the long-term stability of mountainous tunnels

BACKGROUND: Presence of expansive soils in geological strata is a critical problem for construction in geotechnical engineering field. The unique ability of expansive soils of volume change and strength alterations upon saturation can be a threat to the long-term stability and security of adjoining structures like underground tunnels.

OBJECTIVES: The objectives of this study include the assessment of the time-dependent variation in the mechanical properties of expansive soils samples upon saturation, analyzing the time-dependent stress redistribution on the tunnel with expansive soil at different locations and variation of the surrounding ground stiffness through model tests, and evaluating the time-dependent displacements and strains in the vicinity of the tunnel due to the expansion of the expansive soils in the geological strata through image analysis.

METHODOLOGY: Compacted samples of highly expansive bentonite mixed with Toyoura sand in fixed weight ratios were considered as possible geological formations around the tunnels. The mechanical behavior of expansive soil and their disparity upon saturation were studied through free swell tests. The strength of expansive soil samples was evaluated through unconfined compression tests. Selected samples were utilized in model tests performed on a reduced scale (1:100) tunnel model. Expansive soil was placed at different sections of the tunnel to comprehend the time-dependent impacts of expansive soils on stability of tunnel. The time-dependent impacts of expansive soils on tunnels were evaluated by varying the stiffness of material around the tunnel. The surrounding ground movement upon saturation of expansive soils was further assessed through image analysis of the tunnel model experiment.

RESEARCH HIGHLIGHTS: Expansive soil upon saturation projected significant pressures with rise in bentonite content. The unconfined compression strength of the expanded samples reduced as compared to the un-expanded samples. Model tests projected high pressures on different sections of the tunnel with time based on location of expansive soil. The variation of pressure with time was the key outcome depicting the stress changes on tunnels with time under different zones of stresses. As the surrounding ground stiffness increased, more swelling pressure was experienced by the tunnel and a part of the swelling pressure was absorbed by the surrounding ground due to lower stiffness and shear strength. The surrounding ground moved in correspondence with the location of the expansive soil. The stiffness of the surrounding ground reflected upon the magnitude of the displacement and corresponding strains in the surrounding ground upon expansion of expansive soil in the vicinity.

CONCLUSIONS: The magnitude of swelling pressure and corresponding surrounding ground movements aided in comprehension of impacts of expansive soils on existing underground structures with respect to time. Such volume and strength changes in the geological repositories around underground structures can amplify the possibilities of long-term stability issues or even failure of the tunnel structures. Therefore, quantification and time-dependent stress-change behavior of underground structures and corresponding alterations in the surrounding ground is inevitable to carve-out mitigation strategies.