MPC-390
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Project Title:

Design and Construction Monitoring of Surcharged Embankment

University:

University of Utah (U of U)

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Research Needs:

Preserving the health of pavement and bridges, particularly on the National Highway System (NHS) is critical to the structural integrity, functionality, and cost effectiveness of the Nation's transportation system (*DRAFT DOT Strategic Plan 2010-2015).* In areas along the urban Wasatch Front in Utah, soft, clayey deposits can cause excessive differential settlement and pre-mature pavement damage at bridge approaches resulting from secondary consolidation settlement of the foundation soils. Such settlement is long-term in that it accumulates over many years and can produce a significant bump at the bridge approach. In some cases, the approach fills need to be reconstructed, or frequently maintained using asphalt overlays in the damaged area.

Surcharging of the embankment is a common strategy used by the Utah Department of Transportation (UDOT) to reduce secondary consolidation settlement of the underlying foundation soils. Surcharging entails the construction of additional embankment above the final design subgrade in order to overconsolidate the foundation soils. Such surcharging must be sufficiently high and left in place for sufficient duration to overconsolidate the foundation soils effectively; hence reducing the amount of secondary settlement. Unfortunately, design and monitoring of surcharged embankment is not well understood by local geotechnical practice and is often misapplied. The research proposes to develop guidance for the design, monitoring and release of surcharged fills.

Research Objectives:

Determining the amount of surcharge and the corresponding time that such surcharge should remain in place is paramount to accelerated bridge construction on soft ground. Often, the surcharge duration time strongly affects or even controls the construction schedule; hence this aspect of the construction monitoring is vital to timely project delivery for accelerated construction. No such guidance for developing and controlling this process exists in the geotechnical literature or within UDOT design guidance.

1. Develop design guidance for determining the amount of surcharge required in terms of settlement performance goals and pavement life-cycle-cost.
2. Recommend the appropriate type of geotechnical laboratory testing to support surcharge design.
3. Recommend in situ geotechnical methods that may be coupled with laboratory testing to develop the design and reduce the cost of the geotechnical evaluations.
4. Develop methods to monitor and release surcharge fills that are consistent with the design data, project performance goals and field monitoring data.
5. Evaluate the consequences of underestimating the amount of primary consolidation settlement when surcharging is used as a method to accelerate primary consolidation without the aid of PV drains.
6. Develop a technical report to assist UDOT and its consultants in applying these methods to future projects.

Research Methods:

Surcharging was used as part of the I-15 Reconstruction Project in Salt Lake Valley to reduce the amount of secondary settlement (Saye and Ladd, 2000). This document and other geotechnical literature will be reviewed to assess and document the state-of-the-art in surcharge design. In addition, the University of Utah has gather approximately 10 years of secondary consolidation field monitoring data from a long-term research arrays funded by UDOT (Farnsworth et al., 2008). These data from these arrays can be used to quantify the effectiveness of surcharging and assist in evaluating the performance of the design methods used by the I-15 Reconstruction Project Design-Build Team. Subsequently, geotechnical sampling will be done at key array locations to obtain samples for geotechnical laboratory testing. This laboratory test program will be conducted to define the rate of secondary consolidation of the subsurface soils at various amounts of surcharging. In addition, geotechnical in situ testing (primarily cone penetrometer testing) has been done at the research arrays, and these data will be correlated with the test results from the laboratory test program. Ultimately, the combination of the laboratory, field performance and in situ data will be used to develop the recommended design approach for design and monitoring surcharged fills in order to achieve the project settlement goals.

Expected Outcomes:

This research will develop methods to design and monitor surcharged fills for future construction projects on soft ground sites. The design methods will include a description of the design methodologies and the supporting laboratory and field monitoring methods that are need to

develop the design. In addition, a technical report will be developed to assist UDOT in implementing the recommended methods by its geotechnical consultants.

Relevance to Strategic Goals:

The "bump at the bridge," caused by differential settlement between the bridge approach and the adjacent pavement settlement can affect the safety of the bridge approach, and in extreme cases, vehicular speeds must be reduce at the bridge. Therefore, if secondary settlement is not controlled or mitigated, it can significantly impact the life-cycle-cost of the pavement system and bridge approach; hence reducing the sustainably of these systems. The primary goal of this research is to develop design methods that produce settlement performance that is consistent with the life-cycle-cost of the pavement system.

Educational Benefits:

The College of Engineering at the University of Utah has developed a engineering camp for high school students (http://www.coe.utah.edu/k12/programs.php). In this program, the students explore new technologies and use problem-solving skills to engineer a cleaner, more sustainable environment. The results of this research will be used to develop a learning experience as part of this camp. This will consist of laboratory experience in the Civil Engineering geotechnical laboratory and an associated worksheet.

Work Plan:

Task 1 - Literature review and summary (1 month)

Task 2 – Gathering, review and evaluation of existing long-term settlement monitoring data from UDOT Research Arrays (2 months)

Task 3 – Drilling and obtaining geotechnical samples at research array sites (3 months). (Note that this drilling will be subcontracted and is included in the budget as Contractual Costs.)

Task 4 – Development and implementation of a laboratory test program using the soil samples obtained in Task 3 (2 months).

Task 5 – Review of existing in situ data and correlation with laboratory and field monitoring data obtained at UDOT research arrays (2 months)

Task 6 – Development of recommended surcharge design procedure based on the results of Tasks 4 and 5 (1 month).

Task 7 – Evaluate the consequences of underestimating the amount of primary consolidation settlement when surcharging is used as a method to accelerate settlement without the use of PV drains (1 month).

Task 8 – Development of a construction monitoring and surcharge release procedure for use in UDOT construction projects that considers the required amount of surcharge, its settlement duration time and the consequences (in terms of additional settlement) incurred by early release of surcharged fill. The procedure will also recommend the types of field monitoring required to implement the construction monitoring program (2 months).

Task 9 – Final technical report that includes a summary of all the tasks, their supporting data and recommendations for implementation (3 months).

Task 10 – Development of a technical presentation of the findings (2 weeks).

Task 11 – Development of an education activity for high schools students (2 weeks).

Tasks 7 through 10 are the primary deliverables for this project.
The total project time is 18 months.

Project Cost:

Total Project Costs: $80,650
MPC Funds Requested: $39,888
Matching Funds: $40,762 Utah Department of Transportation

TRB Keywords:

Geotechnical engineering, differential settlement, Pavement performance

References:

Farnsworth C. F., Bartlett S. F., Negussey, D. and Stuedlein A. (2008). "Construction and Post-Construction Settlement Performance of Innovative Embankment Systems, I-15 Reconstruction Project, Salt Lake City, Utah," Journal of Geotechnical and Geoenvironmental Engineering, ASCE (Vol. 134 pp. 289-301).

Saye, S., and Ladd C. C. (2000). "Design and Performance of the Foundation Stabilization Treatments for the Reconstruction of I-15 in Salt Lake City, Utah," URS Specialty Conference, June 24, 2000, 92 p.