DRISI
CALTRANS DIVISION OF RESEARCH, INNOVATION AND SYSTEM INFORMATION
TRANSFORMING IDEAS INTO SOLUTIONS

Research Notes

Geotechnical Resistance Capacity and Stress Distribution of Soil/Grout Interface of Ground Anchors

Develop Instrumentation Technology using Fiber Optics for Measurement of Strains along the Entire Length of Grout Column of Ground Anchors

Geotechnical/ Structures

MAY 2026

Project Title: Geotechnical Resistance Capacity and Stress Distribution of Soil/Grout Interface of Ground Anchors

Task Number: 3796

Start Date: December 1, 2022

Completion Date: June 30, 2027

Task Manager:

Seung Han Kim
Senior Bridge Engineer
Seung.H.Kim@dot.ca.gov

DRISI Division Chief:

Prakash Sah, PE
Prakash.Sah@dot.ca.gov

WHAT IS THE NEED?

Recent research has indicated that loads on ground anchors are transferred to the anchor unbonded length under current single stage grouting practice. However, the magnitude, distribution, and proportion of load transfer into the unbonded length of ground anchors at different geotechnical conditions are still unknown. Consequently, whether the anchor bonded length of a given ground anchor is providing sufficient geotechnical resistance is unknown and cannot be verified using current performance and proof test regime.

With better understanding of the stress distribution along the grout column, we can develop ground anchor design and construction protocols that ensure pullout resistance in the anchor bond length provides the required design pullout resistance.

WHAT ARE WE DOING?

For different soil and rock conditions, ground anchors will be installed and grouted differently. To account for various soil and rock conditions and installation and grouting methods, both vertical and sub-horizontal ground anchors are installed at selected test sites. The anchors are then loaded to monitor stress distribution along the grout column and ground anchor tendon.

The research will use the recently developed instrumentation technology, fiber optics, which is the only technology available now to measure the strains along the entire length of grout column of the ground anchors. The measurements will produce the distribution of strain and converted stress along the grout column and at the grout/ground interface at typical ground anchor load schedule.

Caltrans

DRISI provides solutions and knowledge that improves California's transportation system.

A finite element analysis of tendon-grout-ground behavior will also be performed. The parameters of the numerical model will be obtained from the field test results. A series of parametric study will be performed to develop design methodologies that account for verifiable and calibrated ground anchor geotechnical resistance capacity.

WHAT IS OUR GOAL?

With the understanding of the stress distribution along the anchor grout column, we can develop ground anchor design and construction protocols that ensure pullout resistance in the anchor bond length provides the required design pullout resistance.

WHAT IS THE BENEFIT?

The research will facilitate the development of verifiable and cost-effective design and construct protocols for ground anchor. The potential savings can be substantial and knowing that we are designing and building verifiable infrastructure is invaluable.

WHAT IS THE PROGRESS TO DATE?

Pull-out field tests have been completed under sand and weathered rock conditions. At each site, eight ground anchors were installed with different grouting methods and various bonded lengths. To more precisely analyze load transfer between bonded and unbonded lengths, anchors were installed with multiple bonded lengths, and for each bonded length both full grouting and partial grouting (grouting only the bonded length) were applied. In contrast to the clay field tests, both tendon strain and grout strain were successfully monitored in sand and weathered rock conditions. The monitored strain profiles are now being interpreted to evaluate stress distribution and tendon–grout–ground interface behavior and will be used to quantify load transfer between bonded and unbonded lengths under different ground and grouting conditions.

Numerical back-analysis is being conducted using the combined dataset from the previous clay tests and the recent sand and weathered rock tests. With successful tendon strain measurements now available, the research team is refining tendon, grout, and soil material properties, as well as tendon–grout–ground interface model parameters.