National Infrastructure Protection Plan
NIPP Challenge

Condition Assessment Procedures for Concrete Dams with Post-Tensioned Anchors

SITUATIONAL AWARENESS

Researchers at the US Army Engineer Research and Development Center (ERDC) sought to develop engineering procedures to estimate the current load-carrying capacity of ground anchorage, and other factors related to the deterioration and lifespan of dam anchors. Based on previous work developed during the FY2017 NIPP Challenge by the team of researchers from Harvey Mudd College and Engineering Innovations, the ERDC needed to fully understand the benefits and limitations associated with the techniques developed by the 2017 project team.

Early research into the use of Performance Based Testing (PBT) for evaluating the condition of anchors in concrete dams was conducted in 2017. The research procedures established during the 2017 project relied upon the dam's ability to pull the anchors into resonance. This process deviated from current testing procedures because typical post-tensioned anchor tests are designed using basic equilibrium (static) equations.

However, the project team recognized that all components— including the dams themselves—are dynamic components, and the engineer identifies the frequency ranges within which these components are activated. The PBT technique introduces vibrations into the dam that produce transient responses with frequency content broad enough to include both the dam and anchor behavior. The technique for separating the dam and anchor responses rests with the use of a model that focuses on the anchor. This model can be used to extract the desired behavior.

METHODOLOGY

This project utilized an innovative testing procedure to evaluate the condition of concrete dams. The procedures employ the use of a device that delivers a short duration, impulse load to the dam that contains enough energy to excite the anchors and monoliths into measurable dynamic response. Spectral analysis techniques are used to separate anchor and monolith responses, and an analytical model of the anchor is used to develop an Anchor Condition Indicator (ACI) to evaluate the in-situ condition of the anchor.

Source: FEMA Photo Library

RESULT

The project team made improvements to the existing post-tension anchor tension model and investigated the importance of vertical anchor response measurements to the determination of tension load in a post-tensioned anchor. The team developed an analytical model to add the vertical response of the anchor if it is determined to be important for evaluating the load in a post-tensioned anchor.

Additionally, the project team developed a refined process of anchor testing by identifying precise positions of accelerometers, locations of excitation devices, desired peak load levels, and specifications for the accelerometers. This established a process for baselining the condition of a post-tensioned concrete dams and implemented a "test point" approach in which a select number of (discrete) locations in the dam are used to characterize the dam's existing condition. In July 2019, the project team conducted 192 tests of the PBT procedures on an additional 42 anchors to understand the baseline performance of Bluestone Dam in Hinton, West Virginia. The additional testing of the PBT procedures improved the accuracy of the PBT procedures to within a 3 percent range of error.

Source: FEMA Photo Library

To learn more about this project, contact the CISA National Risk Management Center (NRMC) Technology Development and Deployment Program (TDDP).