



Strengthening of Dams by post tensioning

Identifying needs

Dams are critical infrastructure which provide significant benefits to communities in many ways including provision of water supply, flood mitigation, power generation or irrigation. These structures may require upgrades or remedial works because of a need for increased storage or as a result of deterioration due to age, changes in design standards or inadequate original design. For concrete gravity and arch dams, spillway structures and outlet works, one efficient means of strengthening an existing structure is the installation of post-tensioned strand or bar anchors.

Respond to the need

GHD has one of the largest dedicated dams engineering teams across the globe. We have experienced dams engineering professionals who are able to respond to any need identified, whether in an emergency situation or as part of a formal dam improvement program.

As part of this service offering, our broad range of capabilities and extensive experience related to the upgrade and strengthening of concrete dams, spillways and outlet works provide our clients with confidence in the final outcome.

Service offering

The services we offer in relation to the strengthening of dams using post-tensioned anchors include:

- Dam safety reviews and risk assessments
- Upgrade option and selection studies
- Field investigations to establish the material properties of the foundations and structures
- Design of anchor installations from concept through to detailed design

- Finite element analysis of structures including two- or three-dimensional dynamic non-linear analyses
- Other design and analysis services related to dams and associated structures including engineering geology, geotechnical engineering, hydrology, hydraulics, mechanical, electrical, instrumentation and controls
- Preparation of technical specifications and tender documentation
- Review of constructability aspects
- Provision of construction phase services including supervision and design support
- Supervision and review of anchor load testing

Experience

As part of GHD's dams engineering business, our team has extensive experience in the delivery of complex upgrades of dams, spillways and outlet works utilising post-tensioned anchoring. GHD has designed some of the world's largest post-tensioned ground anchors including 91 strand anchors at Wellington and Canning Dams in Western Australia. At Canning Dam, the anchors are up to 144 m long which it is understood are still the world's longest strand anchors.

GHD applies its client relationship focus and in-depth dams engineering experience, working closely with clients to address key concerns, constraints and issues. Once identified and analysed, sound engineering options are developed to provide tailored solutions to suit the project at hand.

Details are provided below of projects that GHD has delivered for our clients and which detail our experience and capabilities in the upgrade and strengthening of concrete dams, spillways and outlet works through post-tensioned anchoring



Canning Dam Strengthening, Western Australia

The Water Corporation of WA undertook a comprehensive remedial works project between 1999 and 2001 to enable the dam to meet contemporary design standards. GHD was responsible for the dam safety review, options development and comparison, detailed design, and preparation of tender documents. Post-tensioning with multi-strand ground anchors was identified as the preferred strengthening option. A total of 166 anchors with up to 91 strands each were installed. These were the world's largest capacity strand anchors at that time. The anchors were up to 144 m long which it is understood are still the world's longest strand anchors. Given this was the first use of 91 strand anchors, a range of trials were undertaken to address technical challenges including the integrity of the bond zone.



Wellington Dam Upgrade, Western Australia

Wellington Dam is a 37 m high concrete gravity dam which is 200 km southeast of Perth. The dam experienced the design flood shortly after construction of a raising was completed in 1961. Subsequent reviews of the flood hydrology resulted in significant increases in the required design flood, triggering the need for remedial works to stabilise the dam. GHD's scope included design of remedial works for the outlet works (2002), options study for the planned strengthening works (2004), detailed design of the post-tensioned anchoring system (2005-7). Construction was undertaken from 2009-2011. The strengthening works included 45 anchors with up to 91 strands each and a new bridge on the dam crest for improved access. The post-tensioned anchors are the equal world's largest capacity ground anchors with a minimum breaking load of approximately 25,400 kN each.



Lake Manchester Dam Upgrade, Queensland

The aim of the Lake Manchester Dam Upgrade was to ensure the dam meets current Australian guidelines. The project involved raising and strengthening the dam wall for flood security purposes. Working with Brisbane Water and McConnell Dowell Constructors, GHD delivered the detailed design and assisted with community consultation for the Lake Manchester Dam. This project involved installing 69 post-tensioned anchors to the existing dam to stabilise the structure and allow the crest to be raised by 5.8 m. Two rows of 65 strand anchors, up to over 100 m long each, were adopted. One row of anchors was on the dam crest and the other inclined upstream at the toe, with both rows required. A significant safety and constructability innovation was the use of precast 'buckets' fitted to the crest of the dam to allow the highly reinforced load spreading beam to be constructed without putting construction personnel at safety risk of falling into the reservoir.



Kangaroo Creek Dam Upgrade, South Australia

GHD was engaged for the design of upgrade works to increase the flood capacity of the concrete-faced rockfill dam and side-channel spillway. The upgrade works included raising of the CFRD, modifying the outlet works and widening and strengthening of the spillway. As part of the spillway works, it was identified that the spillway crest structure was not stable under the increased flood loading and anchoring was required. GHD undertook the detailed design of the 31 strand anchors. Given the concrete gravity crest structure had been raised in the past, finite element analysis was undertaken to assess the interaction of the original concrete and the raised section under the anchor load.



Tallebudgera Dam Upgrade, Queensland

The Tallebudgera Creek Dam upgrade project was delivered through a D&C model. GHD as designer for a Contractor provided a design that resulted in the lowest tender price for the project. Tallebudgera Dam comprises an 11.9 m high concrete gravity spillway section in the main river channel flanked by an earthfill embankment with central concrete core wall on the right bank and a composite concrete/grouted rockfill/rockfill embankment on the left bank. Post-tensioned anchoring was required to stabilise the spillway. This was achieved by the installation of re-stressable 12 strand anchors extending through the spillway ogee concrete into the foundation rock. The need for a reinforced capping beam was eliminated by utilising smaller capacity anchors at reduced spacing.

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