

Paradise Dam

Fact Sheet: Anchor Trials Results

August 2021

Background

Strengthening and stabilising work is required as part of the long-term remediation of Paradise Dam. The options to achieve this include large post-tensioned anchors or, alternatively, mass concrete buttressing (widening the base of the dam and increasing the wall thickness by mass concrete) or a combination of the two, amongst other improvement works.

Post-tensioned anchors are a bundle of steel cables that are installed vertically through the dam and into the bedrock to improve the dam's resistance to sliding and overturning from the force that floodwater places on the dam wall (refer to the [Essential Works Risk Reduction](#) Fact Sheet for more information about what could cause Paradise Dam to fail). These steel cables are secured into the bedrock, stretched (tensioned) then locked in place at the top of the dam.

Information about the anchor trials, before they were conducted, was shared in the following Fact Sheet: [Anchor Trials Updated January 2021](#).

Introduction

This year, Sunwater has conducted anchor trials to determine whether post-tensioned anchoring can be an effective long-term solution to stabilise and strengthen Paradise Dam and to confirm design assumptions. The anchoring trials tested:

- the capacity of the existing dam foundation/ground conditions to hold post-tensioned anchors
- potential settlement that could occur within weak foundation materials.

Other important studies were also undertaken in parallel to assess the ability of the roller compacted concrete (RCC) in the dam to handle the force of the post-tensioned anchors.

How and where were the anchors installed?

Full-size trial anchors were installed at six locations downstream of Paradise Dam as shown in Figure 1. The locations were selected to represent the varying ground conditions that are expected below the dam foundation.

The anchors are bespoke, and each was fabricated onsite then transported (refer to Figure 2), installed and tested by specialist contractor, SRG Global.

Four anchors were made up of 91 strands of steel cable, and two anchors were made up of 35 strands. The 91 strand anchors (anchors 1-4) were installed downstream of the primary spillway, with the bond zone of each anchor targeted for particular foundation material.

The 35 strand anchors (anchors 5 and 6) were installed downstream of the secondary spillway, with the intent to test both the bond zone and the potential settlement of the foundation material. Each anchor was installed within a vertical borehole (refer to Figure 3) and the bottom locked into place with cement grout.



Figure 1 – Anchor trial locations at Paradise Dam.



Figure 2 – Transporting a post-tensioned anchor from the fabrication yard to installation site.



Figure 3 – Lifting anchor to lower into vertical borehole.

How were the anchors tested?

The anchors were tested using a large 2200 tonne capacity hydraulic jack and monitored for any loss in tension that occurred over time. The jack was placed on a reinforced concrete block, connected to the anchor, and the strands were then pulled to tension the cables (refer to Figure 4). Each anchor was then tested through a series of load cycles, including loads beyond those that would be applied if they were to be installed in the dam to help strengthen and stabilise it.

Anchors that did not fail during the load cycle process were “locked off” into the anchor head block via the strand wedges, leaving the anchor in tension and effectively pulling the concrete block into the ground (refer to Figure 5). A 28-day lift off test was then undertaken to document any change in load and loss of tension.



Figure 4 – A 2200 tonne hydraulic jack stressing a 91 strand anchor.



Figure 5 – Locked-off anchor following stressing.

Results

- Four of the six full-sized anchors (anchors 3, 4, 5 and 6) tested without failure, i.e., there was no failure through the foundation or bond zone before the maximum test load was reached (being 80 per cent of the capacity of the steel anchors). This means that anchors in these locations could potentially work well.
- The other two anchors (anchors 1 & 2) were “successfully” tested to failure – reaching 50-80 per cent of the maximum test load (cable capacity). This means that anchors in these locations would need a larger bond zone (i.e., increased depth of anchor through the foundation material) to perform as required. This is the first known test of the world's largest ground anchors to be tested to failure.
- The strength of the anchors was checked over a month and one was found to have lost tension outside normal limits, again suggesting modifications to the anchor design would be required.
- An analysis was also undertaken to assess the ability of the RCC in the dam itself to withstand the very large stresses imparted by the anchors (as opposed to the foundation material below the dam). The analysis found that, given the quality of the RCC at Paradise Dam, post-tensioned anchors are not recommended as the primary means of strengthening the structure.

How do these results help plans for the next phase of work?

Anchoring could not have been reliably planned and implemented without the results of these trials. This proof-of-concept data provides greater certainty for design, construction and operational performance of post-tensioned anchors within the materials expected to be encountered within Paradise Dam’s foundation.

This work has given Sunwater confidence that post-tensioned anchors can’t be the primary means for remediating Paradise Dam. Mass concrete buttressing (widening the base of the dam and increasing the wall thickness by mass concrete) is the preferred approach to strengthen and stabilise the dam, regardless of the final spillway height. Post-tensioned anchors are, however, likely to be used in discrete locations where downstream buttressing isn’t practical.

Independent reviews

The Paradise Dam Project Technical Review Panel has overseen the anchor trials process.

Rizzo International, based in the United States of America, was also engaged by Sunwater as an additional engineering peer reviewer. These independent parties have reviewed the anchor trial results and have provided important feedback for the long-term remediation options of the dam.

Next steps

Post-tensioned anchors are likely to be one component of the long-term remediation of Paradise Dam and the data from the anchor trials will be used to refine the design of the post-tensioned anchors, where they are required, i.e., where downstream buttressing isn't practical, as noted above.

The Queensland Government is expected to make a decision about the scope of work required for this remediation by the end of 2021, ensuring that both dam safety and water security objectives can be met.

Stakeholder engagement

Sunwater is committed to ongoing engagement with the community to ensure transparency during the works at Paradise Dam. We will continue to share updates as the work progresses with a dedicated Community Reference Group and Paradise Dam Industry Forum that include representatives from local government, peak bodies, customers, and downstream residents. Information is also regularly shared on Sunwater's Paradise Dam Facebook [page](#) and the project webpages on the Sunwater website.

Questions?

Please contact us on 3120 0270 or paradise.dam@sunwater.com.au with any questions.