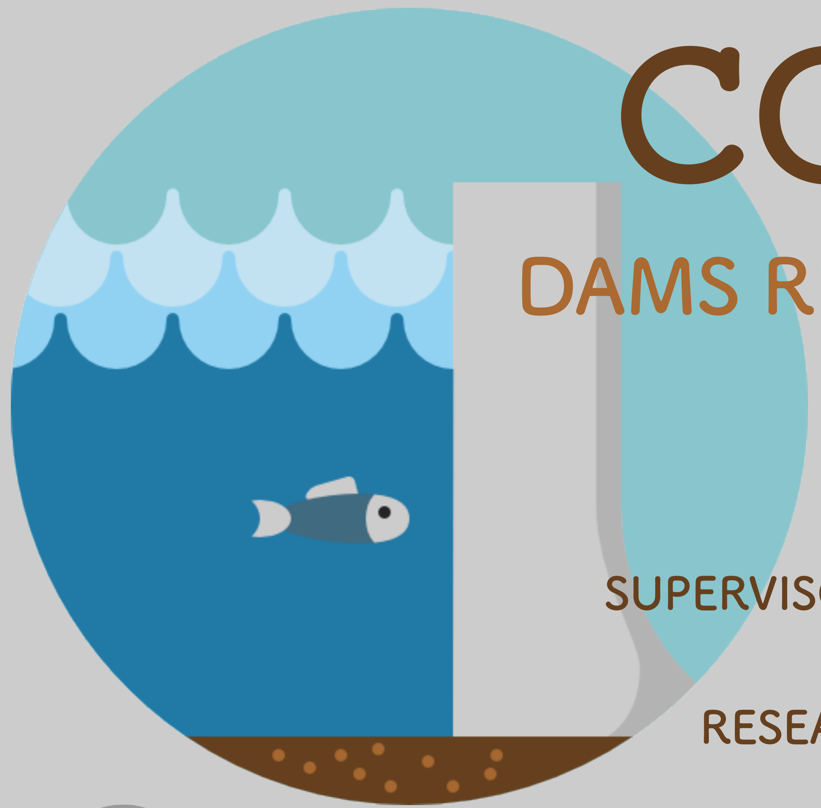

COBB DAM

DAMS RESILIENCE RESEARCH PROGRAMME (DRRP)

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Background

Cobb Dam is an earth embankment dam situated in Kahurangi National Park on the Cobb River; construction for it finished in 1956. The dam was the first hydro-electricity dam built using modern soil control methods. It is also the first to include internal water pressure, seismic, magnetic survey measurement devices and radiographic testing of penstock welds. Water is stored at 794m in altitude, and it has the highest hydraulic head of almost 600m. The power station has a 32MW capacity, and its average annual output is 192GWh, is enough to meet Nelson's full electricity requirements. The power station was commissioned in 1944; Trustpower took over the ownership/operation of Cobb in 2003 and they are responsible for the monitoring and surveillance of the dam.[1]

Like most hydropower dams in New Zealand, Cobb Dam was constructed before modern dam safety practices and guidelines - such as NZSOLD Dam Safety Guidelines (2015) - were established. Therefore, it is crucial to determine if the dam adhered to the standards. Dam safety is crucial so that harmful effects on people, property and the environment can be mitigated through an appropriate Dam Safety Assurance Programme.

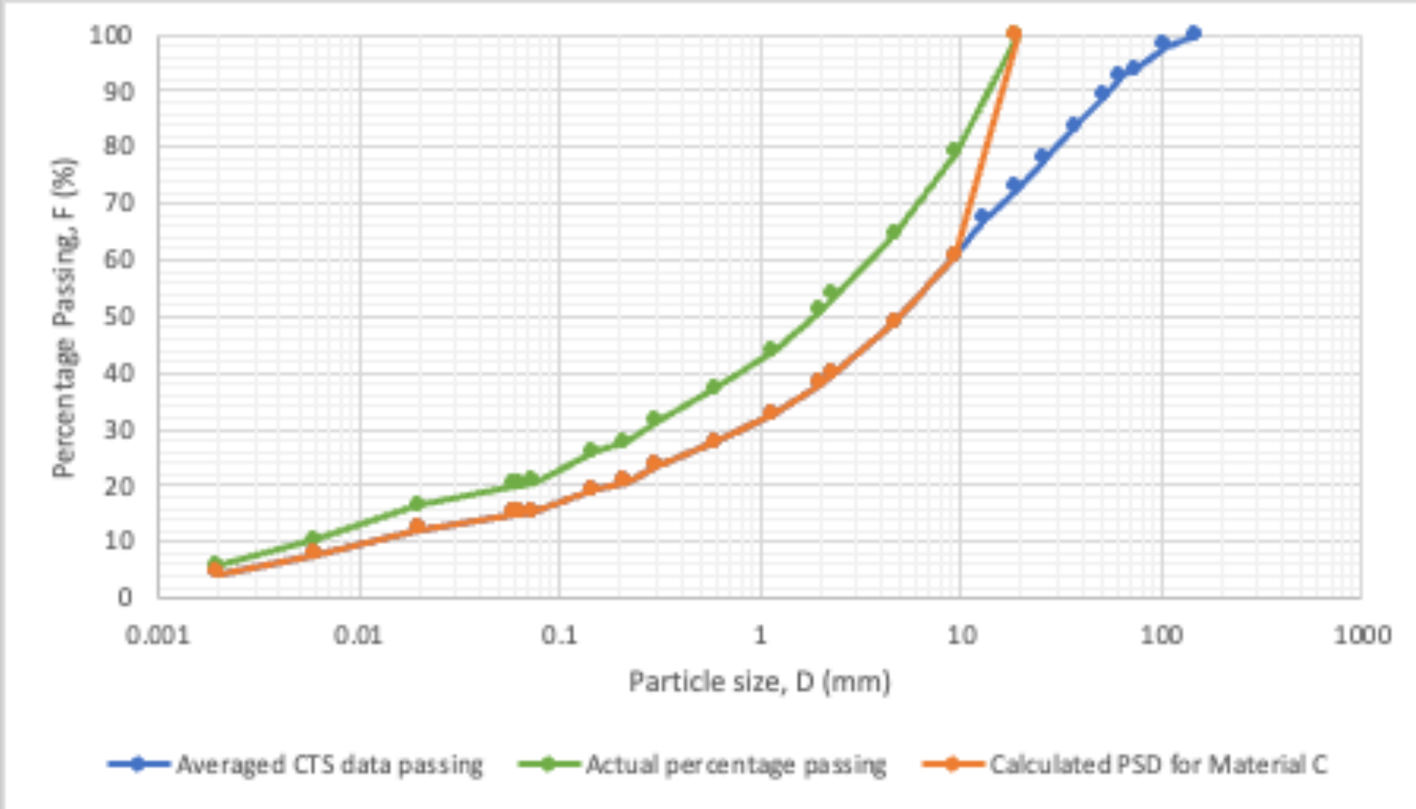
The main experiment undertaken as part of this summer research programme was Sand Castle Tests (SCT) to look at the soil's self-healing capabilities and its ability to withstand a crack. Soils that do not self-heal and withstand a crack can provide pathways for erosion to occur and this can have detrimental consequences to the dam.

Materials

SCTs can evaluate the collapsibility, cracking and self-healing potential in soils. The test is based on the phenomenon when water hits a sandcastle at the beach, causing collapse. Basic soil properties such as moisture content, relative density, fines content influence soils' ability to hold a crack. If the structure collapses, the soil behaves in a non-cohesive way. If collapse does not occur, the material can sustain an open flooded crack or defect and fail to protect the dam from concentrated seepage and/or erosion.[2] While SCTs were developed to assess the collapsibility of filter materials, we conducted this test on a gravelly core material to assess its likelihood to sustain a crack or defect.

To perform the SCT, we had to produce a grading curve representing the Cobb Core accurately but also be able to fit into the proctor mould. To do this, we averaged the three gradation curves undertaken on core samples taken from the field to produce the entire particle size distribution (PSD). Using core sample fractions in the lab (re-used following other testing), we calculated the particle size distribution of the re-used sample. Given the size of the proctor mould, we limited the maximum particle size to 19 mm and calculated the Material C grading using mass replacement of coarser gravels and cobbles. We then used our gradation curve to calculate required masses of different particle sizes, mixed everything, and the "Material C" soil was ready to test.

Particle Size Distribution Curve (PSD)



The graph shows the following:

- PSD for the average of Material A, B and C from CTS data
- PSD of the Cobb Core from CTS data
- Mass-replaced PSD of Cobb Core Material C

The mass-replaced PSD was used to perform the SCTs.

Methodology

There is no definitive method for SCTs; however, we established a suitable procedure from literature reviews. The maximum dry density (MDD) of the Cobb Core material from commercial laboratory data of 2.13 t/m³ was used to determine the mass of material required for the proctor mould for 100% relative compaction. The material was cured overnight in containers with distilled water to a moisture content of 8%. After curing, a tamping rod was used to compact the material into 4 layers to fill up the proctor mould and cured over a second night. The test was performed in a fish tank with a stopwatch because the key measurement was the time to collapse, a ruler for sizing references, a camera for record collapse patterns and the specimen taken out of the mould sitting on a sieve with water just below to allow seepage of water from the bottom. Once the specimen was on the sieve, the timing began, and the tank was filled to 30mm above the initial water level to allow seepage into the sides. After the test was done, the material was taken out and oven dried to determine the mass and density of the material and hence the relative compaction of that test.

Figure 1: SCT Set Up

Figure 2: No Collapse

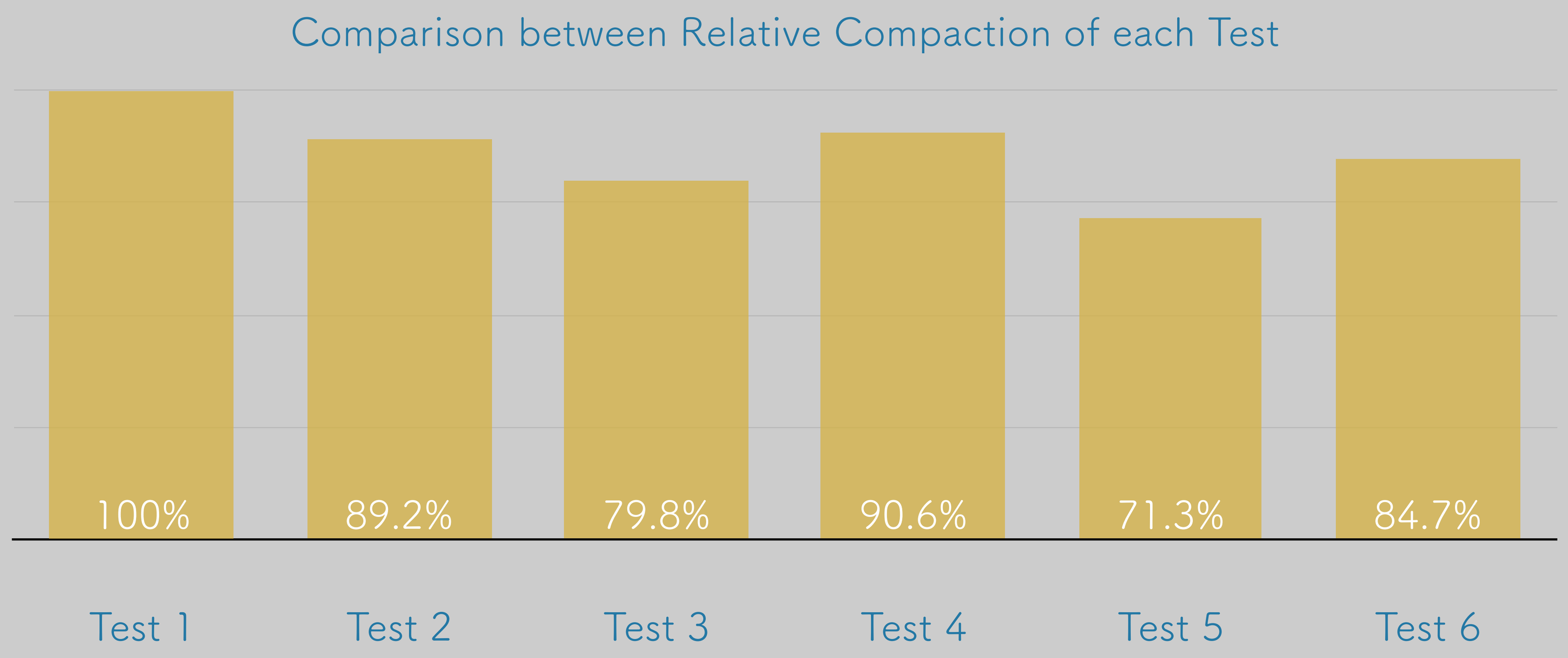
Figure 3: Collapse

Figure 4: Partial Collapse

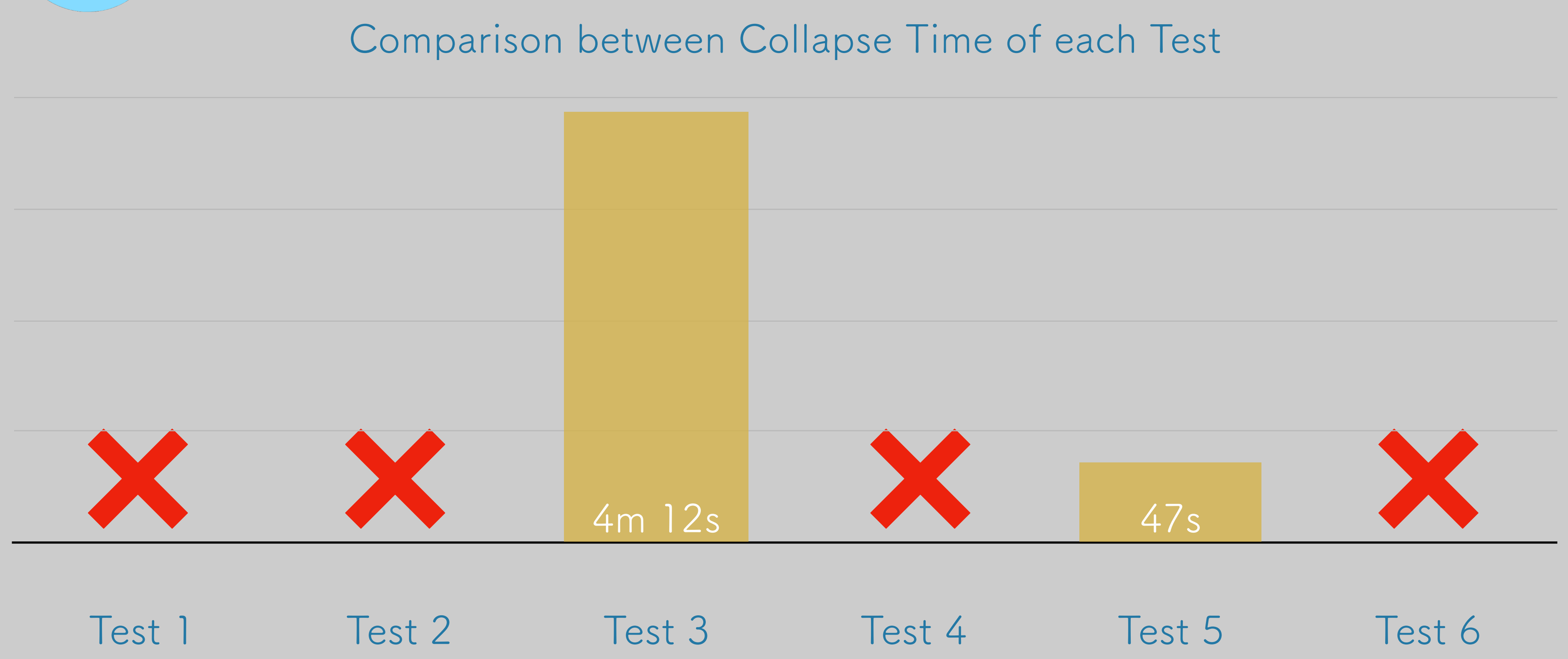
Results

Relative Compaction

Relative compaction is the specimen mass to the MDD mass. Different relative compactions resulted in either collapse, partial or no collapse of the specimen. The target moisture content (MC) for each test was 8%, as this was the optimum moisture content (OMC) from commercial laboratory data.



Collapse Time



Test 3 (relative compaction 80%) and Test 5 (relative compaction 70%) collapsed. Indicating the soil is self-healing at these levels of compaction. Above 80%, it is not self-healing.

Discussion

The collapse time with respect to relative compaction shows that above 80% relative compaction, the Cobb Core material - like most fine-grained dam core materials - is not self-healing. The soil is no longer self-healing between 80-85% as the 85% relative compaction did not collapse. We conclude that compaction is significant in regards to the self-healing properties of the dam core. Field sampling in 2017 showed that the core was well-compacted, with relative compaction likely to be in the range of 90-100% MDD. If a crack, void or defect were to form and the soil was unable to collapse to infill the crack, the core soil would likely be reliant on a downstream filter zone to arrest possible concentrated seepage/and or erosion. Further research is required to conclude the extent to which Cobb Dam follows modern geotechnical guidelines.

References

1. Trustpower. (2020). Cobb Power Station. Retrieved from https://www.trustpower.co.nz/our-assets-and-capability/power-generation/cobb
2. FEMA. (2011). Filters for Embankment Dams: Best Practices for Design and Construction. Federal Emergency Management Agency, United States