Dam Industry Challenges in New Zealand

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ENGINEERING BEYOND THE SURFACE

INTRODUCTION

This poster outlines a brief summary of the main challenges of dam safety management and engineering in New Zealand. Some of these challenges are common with many other countries around the world while others are more specific to New Zealand. The current challenges are of technical and socio-environmental nature and are underscored by the recent large seismic events in the country as well as extreme rainfall events.

(1) LACK OF DAM SAFETY REGULATIONS

There is currently no comprehensive legally binding scheme to monitor and maintain the structural integrity and safety of dams in New Zealand. Construction of new and modification of existing dams is governed by the Building Act (2004), requiring dams to meet standards outlined in the New Zealand Dam Safety Guidelines [1]. The Building Act also includes a framework for dam safety management of operational dams, however regulations are need to bring the scheme into full effect.

In 2019, Dam Safety regulations were proposed by the Government with the aim of providing a consistent and effective regulatory framework for dam safety [2]. The proposed framework is currently considered by the Government.

In the absence of a dam safety scheme, some dam owners have voluntarily adopted dam safety policies and procedures primarily based on the provisions of the NZ Dam Safety Guidelines. Also, some regional authorities have placed maintenance requirements on the dams in their regions based on the Guidelines.

(2) AGING DAMS REQUIRING MAINTENANCE & UPGRADE

Many of the dams of national significance in New Zealand have been built in an era circa 30 to 90 years ago. As these dams age, there is a growing recognition of the scale of hazards that dams are exposed to, such as earthquakes, floods and storms. They also increasingly require a high level of maintenance and refurbishment activities to remain operational and resilient. Refurbishment works do not always receive the required amount of attention primarily due to funding issues or more immediate commercial priorities.

Remediation of dam safety deficiencies may be technically difficult to achieve safely, especially if the reservoir cannot be taken out of service. Recognising these challenges, the NZ Dam Safety Guidelines [1] allow a risk management approach to be adopted to prioritise actions to reduce risk to levels that are as low as reasonably practicable.

In addition, there has been recently a proliferation of agricultural dams and new irrigation infrastructure. Many of these dams are constructed as off-river storage on flood plains, downstream of existing large dams.

Over time, increasing development is changing the risk profile of communities downstream of dams. Towns and communities (including irrigation infrastructures) are growing downstream of existing dams, increasing the number of people who could be impacted by a dam breach.

(3) SHORTAGE OF SKILLED EXPERTS

Many of the NZ dam engineers and geologists with decades of the experience involved in design and construction of the large schemes have already retired or are in the process of retirement. Younger engineers nowadays do not enthusiastically follow the profession as there are fewer large iconic dams being built. This could cause a skill and knowledge gap in the NZ dam engineering industry. Many of the engineering roles in the dam industry are increasingly filled by skilled engineers immigrated from overseas.

(4) HIGH SEISMICITY AND TECTONIC FAULTS

New Zealand is located along the so-called “Pacific Ring of Fire”, a tectonic plate boundary surrounding the Pacific Ocean, where many earthquakes and volcanic eruptions occur. It is associated with a nearly continuous series of oceanic trenches, volcanic arcs and plate movements. For many decades, geologists noted the high number of earthquakes and active volcanoes occurring around the rim of the Pacific Ocean basin[3].

Figure 1. New Zealand on Pacific ‘Ring of Fire’ . About three-quarters of all active volcanoes in the world lie within the Pacific Rim [3].

Considering extremely high seismic loading and associated fault displacements are now common for many dam sites in New Zealand. Design loads for dams can range from horizontal peak ground acceleration of 0.2g up to 1.2g. However, most of the existing dams (designed more than 30 years ago for 0.15g or less) have not been designed for the modern understanding of high ground accelerations, meaning that many of these require re-analysis of earthquake performance, and some require follow up mitigation works to reduce risk of dam breach.

At a few existing dam sites, an active fault is running underneath the dam foundation along the river which can potentially subject the dam to fault rupture displacements. Some of these dams have been designed to accommodate fault movement beneath the dam (e.g. Clyde concrete dam [4] and Aviemore embankment dam [5]), while others have received remedial measures such as filter buttresses to mitigate the effects of fault movement on the dam (e.g. Matahina Dam [6]).

Figure 2. Clyde Dam (the largest concrete gravity dam in NZ) incorporates a slip joint, designed to accommodate up to 2m of movement on the river channel fault [4]

(5) NEW ZEALAND GEOLOGY & DAM FOUNDATIONS

A strong and competent dam foundation is essential for providing stability and limiting deformation and dam seepage. However, rock foundations in New Zealand have been largely affected by one or a combination of volcanic, tectonic, glacial or landslide activities.

A simplified geology of New Zealand is illustrated in Figure 3 below. Most of the South Island is made of indurated sandstone (known as greywacke) which is often shattered or highly jointed by tectonism. In the west and south, the rocks have been transformed by heat and pressure to strong but foliated schist. Greywacke also forms most of the North Island, although much of it is covered by layers of more recent rock, such as volcanic deposits.

The volcanic sources continue to be active, with the last destructive caldera eruption from Lake Taupo only 1,800 years ago. Engineering properties of the different volcanic deposits can vary significantly over short distances due to its formation nature.

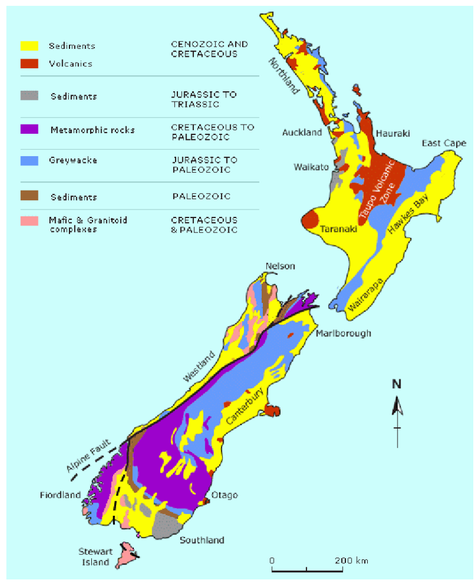

Figure 3. Simplified geological map of New Zealand [7]

(6) CLIMATE CHANGE IMPACT

Climate change is not likely to introduce any new types of hazards to the dams, but it is likely to change the nature and extent of the impact from flood hazards. This could include an increase in the frequency of significant extreme rainfall and storm events [8]. In particular, the effect of climate change on the Probable Maximum Flood is not well established and requires further research and guidance from the industry.

Climate change effects over the next decades have been predicted with some level of certainty. Effects will vary from place to place throughout New Zealand, however, recent projection by the NZ Ministry for the Environment considers extreme rainfall to be likely to increase in most areas, with the largest increases being seen in areas where mean rainfall is also increasing (see Figure 4). These effects could subject the existing dams to the extreme flood events for which they have not been designed.

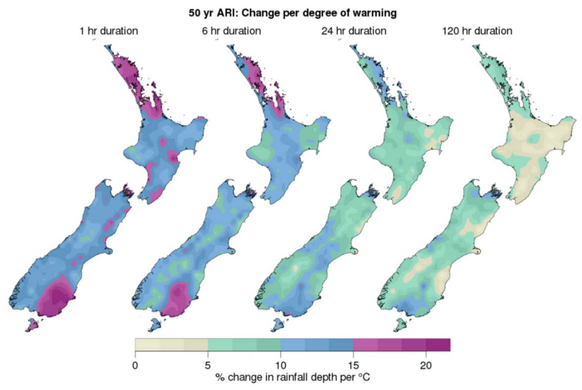

Figure 4. Change in the 50-year rainfall event magnitude for four different event duration [8]

(7) ENVIRONMENTAL AND SOCIAL ACCEPTABILITY OF DAMS

Despite all the positive functions of dams, they are still highly controversial in New Zealand as many other countries around the world [9]. While dams are providing recognised benefits to society and importantly are the basis for the strong renewable energy position of the country, there is strong well-organised opposition to new large dam developments.

Part of the controversy is based on environmental effects of dams on biodiversity, river sedimentation, and recreational activities. Reactions to the environmental effects from intensification of agricultural activities (on the back of irrigation dams) are a growing source of opposition to dams as well. Safety concerns about the risk of dam breach are also causes for opposition.

Nevertheless, environmental and safety risk mitigation actions have increased significantly in the last 20 years as the effects of dam construction on river environments is better recognised and successful mitigation measures are adopted.

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ACKNOWLEDGEMENT

The author is grateful to Peter Amos, managing director of Damwatch Engineering Ltd for his valuable suggestions & support.