

Orderly and Responsible Development

Briefing Note – Dam Integrity

January, 2015

Introduction

There are many dams in Alberta – about 1,400 – ranging from small local water retention dams to large irrigation, hydroelectric and tailings dams. Approximately 70 of these dams are operated by resource companies in the coal, electric utility, oil and gas, and oil sands sectors. Alberta has a very good record with respect to the safe operation of dams, a record built on a historically strong regulatory system plus a consistently strong commitment by dam owners to sound engineering and operating practices.

While dams are an integral part of many resource development projects, they are largely out of sight and out of mind for the public. The goal of this briefing note is to provide background information and basic facts about Alberta resource sector dams for interested readers.

Dams 101

When most people hear “dams”, their first mental image is of spectacular structures such as the 200 metre tall concrete arch Hoover Dam on the Colorado River. In Alberta, dams are typically engineered earth-fill structures – visually less awe-inspiring but nevertheless sophisticated engineered structures. Earth-fill dams use an embankment of soil, or sometimes rock, to support a water-tight barrier. The barrier can be a concrete slab on the upstream slope or an internal core of impermeable clay, if such soil is available nearby. The unspectacular gentle slopes of the dam are designed to be stable and the massive weight of the earth fill resists the force of the water behind the dam.

Engineering studies are conducted to determine the best location for a dam, where the topography is suited to retaining water and where the water-tight barrier can be keyed into impermeable foundation layers of soil or rock. The design of an earth-fill dam depends on the foundation conditions as well as the strength and slope stability of the soil or rock fill available. Dams for hydroelectric, irrigation or flood control purposes are constructed to their design height at the outset. Tailings dams for coal mines and oil sands mines are constructed in stages, adding another layer of height sufficient to contain the volume of tailings planned for the next stage. Like many large earthen structures around the world, tailings dam operators use sophisticated computer models plus the “observational method” to compare predicted performance to actual settlement and slope stability over months and years. Decisions are then made to modify the design, for example adding more fill in order to meet the design objectives of the dam.

Equally important to the design and construction is the vigilant operation and monitoring of the dam. This includes ensuring the water does not rise beyond the design level, ensuring that spillways and other critical infrastructure remain in good condition, and inspecting the dam regularly.

Dam Integrity in Alberta

Maintaining dam integrity (i.e. minimizing the risk of failure) is of the utmost importance to dam owners, given that dam failures have potential to release large volumes of water or tailings with possible significant consequences for public safety and/or the environment.

Dam owners have always taken seriously the responsibility of integrity. Beginning in the 1960's, government agencies (both dam operators and regulators), coal and oil sands companies, and irrigation districts hired well-qualified dam integrity engineers. This government and industry expertise was supplemented by world-leading geotechnical engineering professors and researchers at the University of Alberta, including long-time civil engineering professor (and, ultimately, distinguished university professor) Dr. Norbert Morgenstern, P.Eng. Dr. Morgenstern and his colleagues provided state-of-the-art advice to companies and provided hundreds of competent geotechnical engineering graduates for companies.

In Canada, dams are regulated provincially, typically through general legislation such as a water act. Alberta, British Columbia, Ontario and Quebec have specific dam safety legislation. Supplementing legislated requirements, the use of established guidelines is considered to be evidence of best practice by dam owners. Best practice guidelines developed by Canadian engineers are considered to be among the most comprehensive worldwide. The Canadian Dam Association (CDA) guidelines on dam design and the Mining Association of Canada (MAC) guidelines on tailings dam operations are compatible and mutually reinforcing. It is notable that Alberta experts are well represented among the technical committees that develop and update these guidelines.

Dam integrity is the responsibility of the dam owner, who must ensure:

- Dams are designed, constructed and operated to current standards
- Performance is monitored appropriately
- Required operational procedures are in place and documented
- Emergency plans are in place, periodically tested and improved
- Independent dam safety reviews are carried out at appropriate frequencies
- All necessary maintenance is carried out in a timely manner

Regulatory agencies have an oversight role inspecting and reporting to ensure that the above responsibilities are appropriately discharged.

In 2010, Dr. Morgenstern published a paper, *Improving the Safety of Mine Waste Impoundments*, in which he outlined the Alberta dam safety system as applied to the oil sands industry as a successful model:

“It is the view of the writer that the dam safety system applied to the Alberta oil sands industry is the best in the world.... It has the following components:

- Each owner is cognizant of its responsibilities to provide a tailings management system consistent with the MAC guidelines.
- Each owner has staff qualified in the management of tailings dams.

- Owners retain consulting engineers for design and construction supervision who are well-known for their expertise in tailings dam design with special reference to the circumstances associated with the oil sands industry; the designer acts as the Engineer-of-Record; senior internal review of design submissions is expected.
- Designs are compliant with at least CDA (Canadian Dam Association) guidelines.
- Designs rely on the detailed application of the observational method for risk management.
- Designs are reviewed by the Alberta Dam Safety Branch, the regulator, who have staff well-versed in dam design and construction.
- An annual report is submitted each year to the regulator by the owner, supported by the Engineer-of-Record, that the dam is behaving as intended; if not, actions that have been or need to be taken are indicated.
- In accordance with CDA guidelines, approximately every five years the owner retains an engineer, other than the Engineer-of-Record, to undertake an independent assessment of dam safety.
- Each owner retains an independent geotechnical review board comprised of senior specialists, to provide on-going third party review of geotechnical issues of significance to the operation. One of the major responsibilities of such boards is to review all aspects related to safety of tailings dams over the life cycle from design, construction, operation and closure.

The success of the dam safety system applied to the Alberta oil sands industry relies on responsibilities shared by the owner, the Engineer-of-Record, the regulator and various levels of independent review.”

Oil sands tailings dam owners have recognized from the outset the substantial engineering challenges inherent in large tailings dams, so implemented additional high level reviews by independent Geotechnical Review Boards. Hydro dam owners have similar reviews by external consultants. Other resource sectors follow the CDA guidelines or similar best practices.

The Risk of Dam Failure

While large dam failures are infrequent, they do occur. Worldwide, there have been 97 tailings dam failures since 1960, including 28 in the United States and five in Canada. In 2013 and 2014, after decades of no major incidents in Western Canada, two dams failed. The first, a surface water runoff impoundment at Obed Mountain Mine in Alberta released approximately 0.7 million cubic meters of water-suspended solids of clay, soil and coal dust sediment into tributary creeks and the Athabasca River. In 2014, a tailings dam at Mount Polley Mine in British Columbia released approximately 25 million cubic meters of water and tailings into Polley Lake, Hazeltine Creek and Quesnel Lake. Fortunately, there were no injuries as a result of these incidents. At the time of writing this briefing note, the respective investigations were still in progress with no conclusions issued on either root causes or lasting environmental impacts. Nevertheless, these incidents are close-to-home reminders to Alberta dam operators that the potentially high consequences of low probability events warrant conscientious management of the risk of dam failure.



Managing risk means proactively reducing the probability of dam failure as low as practicably possible (zero risk is not practical, whether commuting to work, flying on vacation or operating a dam). This is a multi-faceted challenge, as illustrated by the above bullets from Dr. Morgenstern's paper. Fortunately, Alberta's dam safety "system" – cultivated through the past five decades – is among the best in the world. Additionally, this system resides within a well-established culture of professionalism. More than 70,000 professional engineers and professional geoscientists are registered in Alberta; all hold foremost the responsibility for public safety and welfare, as well as accountability for technical decisions. All resource sector companies that operate dams have professional engineers on staff; many have senior management who are also professional engineers or geoscientists with a deep understanding of and commitment to managing dam integrity.

The Role of the Alberta Chamber of Resources

The Alberta Chamber of Resources (ACR) is unique as an industry association: it spans several resource sectors, addresses issues of common interest, and offers strategic perspectives on the orderly and responsible development of Alberta's natural resources.

Dam integrity is a significant social, environmental and operational responsibility of resource sector companies. Without waiting for the findings of the two recent incident investigations, ACR proactively brought together industry experts – collectively with more than 200 years of dam integrity engineering experience - to do a high-level review of Alberta's dam safety system. While there is always room for improvement, the overall conclusion was that Alberta regulations and best practices are among the best in the world, and that dam owners are appropriately discharging their dam integrity responsibilities. That said, industry must work even more closely with Alberta regulators to manage dam integrity on behalf of the people and environment of Alberta. As learnings from the two recent incident investigations become available, they will be adapted and implemented by resource sector dam owners.

The review also identified two ways in which ACR can contribute to dam integrity. The first is to establish a committee of technical experts from all dam owners, with the objective of facilitating the exchange of dam integrity information. This builds on the example of similar cross-industry committees for the exchange of information related to worker safety. The second is to expand the activities of an existing initiative, the ACR Mining Industry Advisory Committee (MIAC), with the objective of increasing the number of graduating engineers with training in dam integrity. Throughout the past 25 years, MIAC has worked closely with the Faculty of Engineering at the University of Alberta and has been very successful in increasing the supply of mining engineers.

ACR will continue to watch for opportunities to bring the resource sectors, regulators and government policy makers together to further enhance Alberta's already world class dam safety system.

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