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Tailings facility review and evaluation standards

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ABSTRACT

Peer review of dams and tailings facilities has been done for a long time. Independent tailings facility review is, however, still not standard practice. This paper describes the authors' stories of early peer review in which they were involved. Hence the paper surveys some early and current expert opinions on what constitutes reasonable tailings facility peer review. Finally the paper addresses some current issues facing those who convene or sit on Independent Tailings Review Boards. The opinions and recommendations in this paper are personal, probably controversial, and certainly not universally implemented.

1 INTRODUCTION

Peer review of dam design and construction is not new. Peer review has been standard practice for water dams in major jurisdictions since at least the 1970s. Yet peer review of tailings facilities is still not common practice. There are many reasons: cost considerations; confidence of consultants; failure to demand such review by regulators; and a general standard of practice not yet in sync with that of water dams.

Recent failures of tailings dams has raised the issue of whether peer review could have precluded the failures. In the case of the failure of the Mt Polley tailings facility in British Columbia, Canada in 2014, the panel that reviewed the causes of failure recommended that the use of Independent Tailings Review Boards and application of Best Management Technologies should be considered in an attempt to preclude future failures.

The authors have both worked in tailings facility design, construction, operation, and closure for over forty years. These days the senior author spends most of his time on tailings review boards. The junior author is still involved in the design, construction, operation, and closure of tailings facilities as a design engineer and as such his work is often peer reviewed—and as frequently not peer reviewed.

Accordingly, the authors write this paper to explore the issues, methods, and responsibilities of peer reviewers as a contribution to a practice that both believe can decrease the risk of tailings facility failure.

2 HISTORY: A FIRST STORY

The first project in which the authors were involved that included formal peer review was the design and oversight of construction of the Cannon Mine tailings facility near Wenatchee, Washington State. At that time, the early 1980s, the proposed dam was high: ultimately 340 ft high. The foundations were the same rocks that had led to the failure of the Teton dam in Idaho some eleven years before.

The senior author was concerned about the difficulty of the task of designing so significant a tailings facility. He sought and gained the help as peer reviewers of two great engineers, both still here to verify this story. John Gadsby was a leading mine tailings dam engineer. Syd Hillis was an independent consultant who for many years had acted as a peer reviewer of dams financed and constructed pursuant to financing by the Asian Development Bank and other agencies.

The junior author was introduced to these august persons and told to make sure they peer reviewed everything he did. And they did this over the following two years as design, construction, and the start of operations proceeded.

Their approaches differed. John Gadsby focused on the mining issues: the type of tailings, their properties, their performance, the mining constraints, the public perspectives, and how the tailings facility could contribute to a profitable mine. He succeeded for the mine was a success, made money, and was supported by the local community.

Syd Hillis was pure geotechnical. He focused on geotechnical detail. He spent a week a month on the project. Recall that no design was done prior to start of construction. The miners, conscious of costs, dictated that we come to live near the site, start stripping the soil, see what was there, and design as we go. For Syd Hillis this was as different an approach to dam design and construction as could be imagined, but he threw himself into the challenge.

He would walk the site. Hammer into the bedrock. Measure joint spacings. Put the soil to his tongue to gauge its plasticity and gradation. He made us carry out rock compaction tests—measure the settlement as a function of the number of passes of standard construction equipment and the rate of applied water.

He spent a whole morning in the on-site laboratory watching us do Atterberg Limit tests. He examined the firmness of the table, the levelness of the surface, the cleanliness of the equipment, the measurement of the quantity of soil used, and the rolling technique of the test technician. He once made us change the rate at which we rotated the handle of the cup to determine Liquid Limit.

He challenged us on every detail of the design: the gradation of the filters placed over the friable foundation rock to prevent piping; the thickness of the clay/silt core; the inclination of the outer slope of the embankment. We finally settled as 1.73:1 on the basis of judgment.

3 A SECOND STORY

The junior author, acting for once as a peer reviewer and not a designer, was one of three on a peer review board for a new tailings facility in a South American country. The first morning was spent listening to the tailings facility designers explain the design. After lunch to preclude us falling asleep, one of the old men of the peer review group suggested that we examine the core.

Beneath the shade of a flimsy tent, we looked at the core of many boreholes. Without fail the core was rock: sound, hard, and of high quality. Then the oldest of us called me over and said: “This is unusual: a meter of fine sand at thirty meters depth between two layers of good rock?”

Something was wrong with this picture. We called in the client and the design engineers. To cut a long story short, it turns out that the sand was drilling sand placed there by the drillers. Examination of the geologist logs showed that no core had been obtained for this meter. And the meter turned out to be the contact between old volcanic rocks and overlying sedimentary rock. The upper surface of the volcanics had weathered to broken rock and soil before emplacement of the sediments. And this pervasive layer was of high permeability and a potential zone of high flow from the proposed tailings facility. The design had to be changed.

4 A THIRD STORY

The senior author, acting as a sole peer reviewer of a tailing facility in full operation, noticed that the freeboard was not as required, the perimeter embankment was not as large as required, and delivery pipelines were literally hanging, suspended across a low zone of the perimeter embankment. He judged this to be a dangerous situation.

By sheer force of will, he summoned the chief engineer of the company, the CEO, and the safety officer of the company to a Saturday meeting, a Sunday site visit, and immediate action.

5 SINGLE PERSON PEER REVIEW

For the past eight years, the junior author has acted as a "peer reviewer" to a remote mine in the far north of Canada. The original tailings facility was designed by the senior author and two other great engineers about eighteen years ago. Ever since, the three original designers have continued to be involved. Over time they have delegated their responsibilities to younger engineers. Today the junior author looks to tailings deposition, a talented young engineer deals with geotechnical issues as did his old boss, and the environmental issues are dealt with by successors (in the same company) to the original environment engineers.

These parties meet on site, discuss issues, and are friends.

This system of tailings facility operation and now closure is not considered formal peer review. In fact the Canadian Mining Association (CMA) to whose procedures the mine subscribes and who annually audit the facility does not consider this independent peer review. Yet the CMA accepts this procedure as sufficient to contribute to the advancement of dam safety and quality.

This "peer review" approach is not used at any other mine that the authors are aware of. Yet it works. The tailings facility is well operated, is safe, and has received high reviews from CMA.

6 CO-ENGINEERING

The junior author has designed and overseen construction and operation of a new filter pressed tailings facility in central America. Contrary to conventional practice and wisdom, the senior author has acted as in-company peer reviewer.

This may be viewed simply as prudent company policy and procedure: a consultant should undertake peer review on all its projects of work done by its engineers. When the junior author worked for a major geotechnical company in the United States, this was standard practice. Every report, every deliverable, every written opinion, drawing, and deliverable had to be peer reviewed by an in-company senior engineer whose name was recorded on the deliverable. J. P. Giroud was the one who pioneered this system, and his success is history.

7 FINDINGS

These stories highlight the range of issues and the variety of action a peer reviewer may be called on to address. They are but a small sample of the many roles and contributions a peer reviewer may make to safer tailings facility design, construction, operation, and closure. In the remainder of this paper, the authors attempt to collate these issues into a formal philosophy and system. The ideas are based on practice over many years at many tailings facilities worldwide.

But a caveat: each tailings facility is unique, each mining company is different, and every design team is composed of talented individuals with their own biases and blind spots. The peer reviewer has to be engineer, technical specialist, psychologist, politician, and persuader. The engineers being peer reviewed have to be receptive to new ideas, humble, contrite, and not adversarial. For successful peer review has to be undertaken by all in a spirit of non-accusatory enquiry.

8 PEER REVIEW VARIETIES

On the basis of the stories we narrate above, it may be concluded that the following are the many varieties of peer review:

Coworker Checking. Essentially any work done by a single engineer is checked by a coworker. This is as simple as taking a look at the equations, the solution of equations, computer input, drawings, reports for typos and conceptual blunders, and to catch all the little silly mistakes we make as we transcribe numbers, solve equations, run computers, and write things down.

In-House Peer Review. A person working for the same company as the engineer generating the products, and who is somewhat more senior should peer review the deliverables as they are produced and certainly before they are issued. The in-house peer reviewer is looking to protect the consulting company's reputation for quality by seeking to make sure the recommendations in the deliverable are sound, logical, consistent, and safe. By extension, this ends up protecting the client and ultimately the public.

External Peer Review. As we did for the Cannon Mine, senior engineers from other companies may act as project peer reviewers. In essence they are almost like senior project engineers there to make sure good work is done by the young engineers and the contractors building the facility. In practice they answer only to their own professional reputation, although the client and the senior engineers in the producing consulting company respect them and accept their recommendations which may be made only to the junior engineers on a day to day basis.

Peer Review Consulting. Here we think of the situation where one or more engineers, not necessarily from the same consulting company go to the mine on a regular basis and consult to the mine as in essence reviewers. This may occur for example at mines where the mine is themselves, with their own work force, constructing and operating the tailings facility. Such review is intended to make sure the mine staff are doing a good job, complying with designs and operating manuals, and following accepted practices. Such reviewers have to bring to the table a greater degree of knowledge and experience than the mine staff who are after all somewhat isolated on the remote mine.

Peer Review Board. Here a formal board is appointed. It may consist of two or more specialists not necessarily and preferably from separate companies. They meet at regular designated intervals to review work products produced by others, usually the mine's consultants. Then they report to upper mine management. In what follows, we take an in-depth look at the roles of such review boards.

9 FIRST WRITINGS ON THE SUBJECT

As Evert Hoek (1995) wrote:

> A Review Board is highly desirable for major civil and mining engineering projects. Those working on such a project can often become so involved in the details of the work that they find it difficult to stand back and take an impartial view of alternative approaches. The Review Board, with its requirement to be impartial and its years of practical experience on similar projects, can usually pin-point problems and possible solutions very quickly. Once these problems have been brought to the attention of the geotechnical team, it is surprising how often an effective solution can be found. Even in cases where a highly competent geotechnical team exists, an occasional independent review can provide the Mine Manager with the assurance that all is in order.
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> A Review Board should be composed of a small number of internationally recognized authorities in fields relevant to the principal problems encountered on the mine. The purpose of the Board should be to provide an objective, balanced and impartial view of the overall geotechnical activities on a mine. The Board should not be used as a substitute for normal consulting services since members do not have time to acquire all the detailed knowledge necessary to provide direct consulting opinions.

10 OIL SAND TAILINGS REVIEW BOARDS

The high point of the practice of Independent Tailings Review Boards is the system implemented on the Alberta Oil Sands Mines. The senior author has for many years been on the peer review board of the Suncor tailings facilities. The junior author has made presentations to the Suncor board on work he has done for projects involved in Suncor tailings facility closure and polymered tailings management.

Norbert Morgenstern (2011), the senior author of the Mt Polley panel and the lead of both the Suncor and the Syncrude tailings review boards writes of the practice of the oil sands ITRBs. He notes that such boards should:

- Be appointed by and responsible to mine management.
- Reflect corporate values and international standards of care.
- Assist the Owner in assessing risks when it is perceived that regulatory requirements are unreasonable.
- Should ideally be involved from the conceptual design phase, and should certainly be involved at the bankable feasibility stage. The board should continue through construction, startup, and operation.
- Regularly examine the Construction Report which is intended to document that construction proceeds as intended.

11 MT POLLEY RECOMMENDATIONS

The Mt Polley Independent Expert Engineering Investigation and Review Panel (2015) notes that an ITRB should be asked to provide opinions on the following:

- Whether the design, construction and operation of the TSF are consistent with satisfactory long-term performance.
- Whether design and construction have been performed in accordance with the Board's expectation of good practice.
- Whether safety and operation of the TSF conform to the Board's expectation of good practice.
- Whether there are weaknesses that would reasonably be expected to have a material adverse effect on the integrity of the TSF, human health, safety, and successful operation of the facility for its intended purpose.

The report proceeds to caution that an IRTB should:

- Not be used exclusively as a means for obtaining regulatory approval.
- Not be used for transfer of corporate liability by requesting indemnification from Board members.
- Should be free from external influence or conflict of interest.
- Should have a means to assure that its recommendations are acted upon.

12 THEORY

On the basis of the stories we tell above, and the writings of the experts as quoted above, it may be concluded that at its simplest, peer review is the act of an individual or group that knows a lot about the subject, reviewing the work product of another individual or group. And the same is true of an Independent Technical Review Board, however constituted.

The following are essentials of peer review:

- The Peer Reviewers should be independent of the peer reviewed.
- The Peer Reviewers should know as much as or more than the peer reviewed about the subject of the work being reviewed.
- The Peer Reviewers should have no stake in the outcome of their recommendations.

The peer reviewers may come from the same company as the peer reviewed as long as they report up the chain-of-command to somebody with more authority than the highest ranking member of the peer reviewed group. Peer reviewers may be outsiders assembled only for the review at hand.

Peer review is undertaken to ensure and enhance the adequacy, completeness, consistency, accuracy, and quality of program and project work products. Peer review is not the routine checking of a work product. It is not the simple review of a document by a reviewer, even if the checker is at or above the author's peer level. It is not the auditing of a project to check compliance with standard operating procedures. It is not Value Engineering which is really an attempt to find ways to reduce costs.

13 THE BASICS OF REVIEW BOARDS

Audits and reviews are typically completed by professional specialists and consist of:

- Information collection, review and analysis of all site investigation (geotechnical, hydrology, hydrogeology, geochemistry, environmental and socio-economic), design and 'as-built' plans and reports;
- Field inspection of the sites and structures;
- Review of the operating history and compliance of the structure/facility, operating plans, management systems, emergency response plans and closure plans;
- Identification of the relevant risks for each of the structures;
- Completion of an FMEA for the structure/facility;
- Development of recommendations to mitigate the risks and address issues identified;
- Prioritization of the mitigation measures into a 'Risk Management Plan';
- Preparation of a report summarizing the work and preparation of a Plan; and
- Follow-up on execution of Plan

Here is a list of some questions a good peer reviewer should ask and answer:

- Have the governing laws, rules, and regulations been identified and provided for?
- Have qualified staff been involved in all aspects of the work?
- Are appropriate procedures, models, methods, analyses, and tests being use?
- Is the solution identified and adopted reasonable, practical, and cost effective?
- Do the deliverables comply with the client's needs, specifications, and stated requirements?
- Would it be appropriate to have other experts review all or selected aspects of the project?

14 DETAILS OF ITRBS

Recent calls to establish Independent Tailings Review Boards and to adopt Best Available Technology raise many questions about what level of review is necessary and appropriate and what standards should be used by reviewers in evaluating tailings facility designs and operation.

Different types of peer review of tailings facilities may be undertaken for specific situations and mines. For example, reviews may be formal in-depth audits at one to five-year intervals in which the appropriately qualified auditor group examines the investigations, designs, analyses, construction, operation, monitoring and closure to levels sufficient to independently confirm that each aspect has been completed to adequate standards and results for the facility to be fit for service.

Alternatively there may be reviews performed by an Independent Review Board with an appropriate range of expertise on a formal, regular, and a typically more frequent basis (one to several times a year) and over several to many years as the facility evolves through the stages of investigation, designs, trade-off studies, analyses, construction, operation, monitoring and closure. Such review is often performed with lesser levels of detailed checking of calculations and quantities, but higher levels of assessment of technical approach, design bases, application of appropriate standards of practice and technology, design and construction team competence, and evaluation of risk and management of liability.

There are no international standards of practice that pertain to reviewing a tailings facility. Such standards may vary from international best practice, through generally good practice, to practice appropriate to a specific mine considering site conditions and tolerable risk. Conflicts may arise when best available technology applicable for tailings facility stability is not consistent with what is best available technology for control of contaminant generation and migration into the environment.

All that can be said at present is that the mine establishing and funding the ITRB should think hard about what it expects from it board; the board members should initially make clear what they consider the appropriate range and scope and basis for their review; and all parties should be open to change as the project proceeds and understanding advances.

15 THE ENGINEER OF RECORD

A final word on the Engineer of Record (EOR). No matter how much peer review is undertaken, in the absence of an EOR it may all be for naught. Duty number one of any peer reviewer or ITRB is to make sure there is an EOR that meets the criteria noted below.

The objective of having an Engineer of Record is to ensure that there is a person in a position of authority that has the technical knowledge and experience, as well as the dam specific knowledge of the dam design, construction, operational requirements and dam performance available at all times and who is required to guide and approve all design, construction, operation and performance monitoring changes to ensure that the dam remains in a condition that it is safe and fit for the service intended in the design. The Engineer of Record (EOR) for a tailings or water dam has to have:

1. Technical capability and experience required for the position.

   The EOR must have the technical training and experience necessary to perform design and technical oversight, quality assurance, specification of operating requirements and monitoring and performance assessment for a dam of the nature and complexity for which they are responsible.

2. The knowledge of the design, construction and operation of the dam

   The EOR must have the knowledge of the design, construction, operational requirement and performance of the dam to thoroughly understand all aspects necessary for the continued evaluation of on-going design, construction, operation and performance monitoring of the dam. If the EOR is not the dam designer, than the EOR must review and study the designs, construction, operation and construction records to a level sufficient to obtain such knowledge and have the knowledge base to be able to make informed decisions regarding the dam.

3. The current information of dam performance

   The EOR must be kept informed of all aspects of the dam design, construction, operation and performance such that the EOR's knowledge base remains current and the EOR can advise on the dam's performance and requirements to maintain performance to meet the design intent.

4. The time and authority to fill the roll of EOR.

   The EOR shall devote adequate time to ensure that the EOR inspects the dam, performs or reviews designs, reviews operating and performance records such that the EOR remains intimately familiar with the dam and its performance. The EOR should have the authority to request and obtain information relevant maintaining his/her knowledge base and review and approve all design, construction, operation and performance monitoring changes and procedures. The EOR shall be supported by the Dam owner and Dam management to ensure that this authority is maintained and is effective. An EOR cannot be effective if the terms of his appointment are restrictive as to time commitment and means, including budget, such that he/she is unable to satisfy the obligations of the EOR in items 2 to 4 above.

Independence of EOR: The EOR is an individual who may be a member of the corporation owning the tailings facility, a member of a consulting company or an individual consultant that meets requirements of the EOR. A consulting company can be the contracting organization to provide an EOR, but the EOR shall be a named individual who will satisfy the requirements of the EOR.

EOR succession: Provision needs to be made for succession of the EOR. Succession can be initiated by either the facility owner/manage or the EOR. Succession involves the selection and appointment of the succeeding EOR who shall take over the functions of the EOR on an agreed transfer basis or as soon as possible in the case of loss of an EOR no longer able to perform their duties.

16 CONCLUSIONS

Review of all phases on the conception, design, construction, operation, and eventually closure of a tailings facility is key to the safety of the facility. Such review protects the interests of the mine, of the people involved in the work, the regulators approving the work, and ultimately the public and environment.

In practice peer review is cost-effective. While some may balk at the invoices from expensive consultants, the overall cost is but a very small part of a very expensive undertaking, and a miniscule part of the cost if the facility fails.

Text books may teach; codes of practice may guide; professionalism may reign. But at the end of the day, tailings facilities are engineering structures born of the practice of the art of applying science. And those practicing the art are fallible humans who sometime err. Friendly, competent, no-fault review, we know, makes the process more efficient, more effective, and beneficial to all involved or effected. It is the only way to reduce the incidence of tailings facilities that we know of.

17 REFERENCES

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