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How to drive a dam safely and win the race

By Charles F. Cobb, P. E.
Alaska Department of Natural Resources
Dam Safety and Construction Unit

A dam is like a car or truck: It is as safe as the one who drives it. However, if the tires are cheap or the brake lines faulty, even the safest driver is in danger from using the vehicle. Similarly diverse in form and function, a dam is an indispensible tool that provides significant direct benefits, from individuals to society at large, whether it creates a stock pond down on the ranch, or controls floods or produces hydroelectricity. Dams also provide indirect benefits to society as an essential element of mining, when water and tailings storage are critical to the development and operation of the mine. While most mines are in remote locations, where an accident with the dam may not actually kill somebody, the failure or mis-operation of a dam can have major impacts, and fatally injure a mining project. While rare in occurrence, safeguarding against such an event requires careful planning and performance. To avoid a fatal flaw, an interdisciplinary team of highly qualified experts is required to carefully select the appropriate location, and provide for the skilled design, construction, operation and closure of the dam.

A certain wise man once said, “Plans fail for lack of counsel, but with many advisors they succeed.” This proverb is especially true for dams, as a ”technical team” approach is required to competently develop the many investigations, evaluations, reports and plans that must come together to assure that the car stays on the road. The horsepower of the technical team comes from qualified professional engineers, engineering geologists, hydrologists, seismologists, tailings specialists, risk managers and other experts, depending on the unique aspects of the project. Figure 1 shows suspected causes of dam failures in the United States and Alaska that the technical team must guard against[1]. Figure 2 shows an international perspective on the threats to tailings dams[2]. Neglect these hazards at your peril!

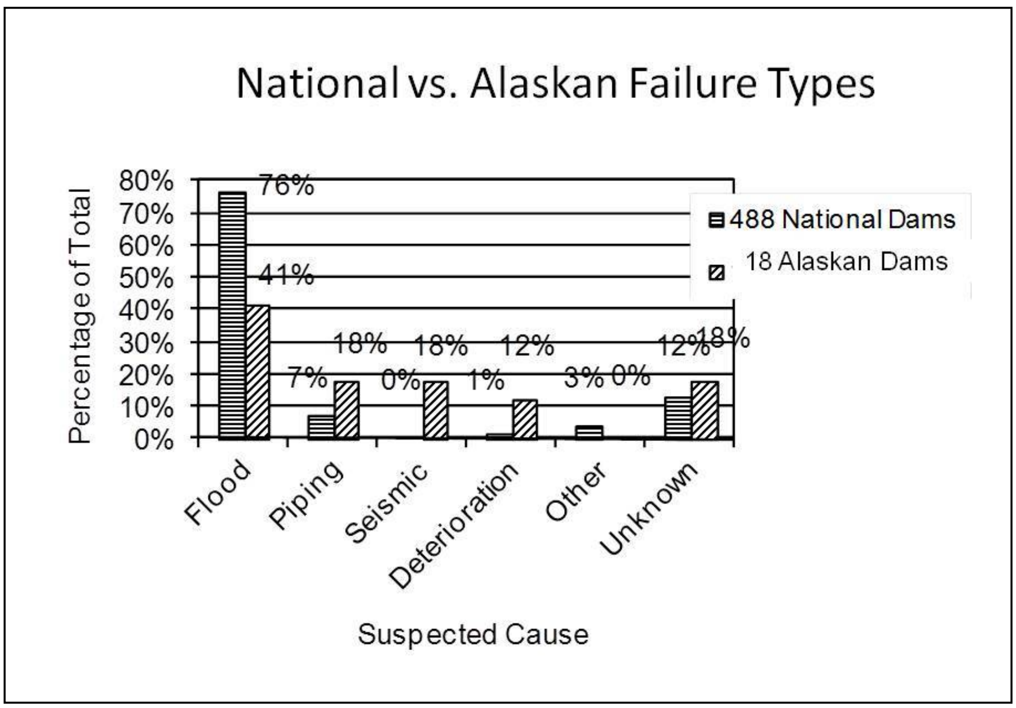

Figure 1. Suspected causes of water dam failures in Alaska and the Nation

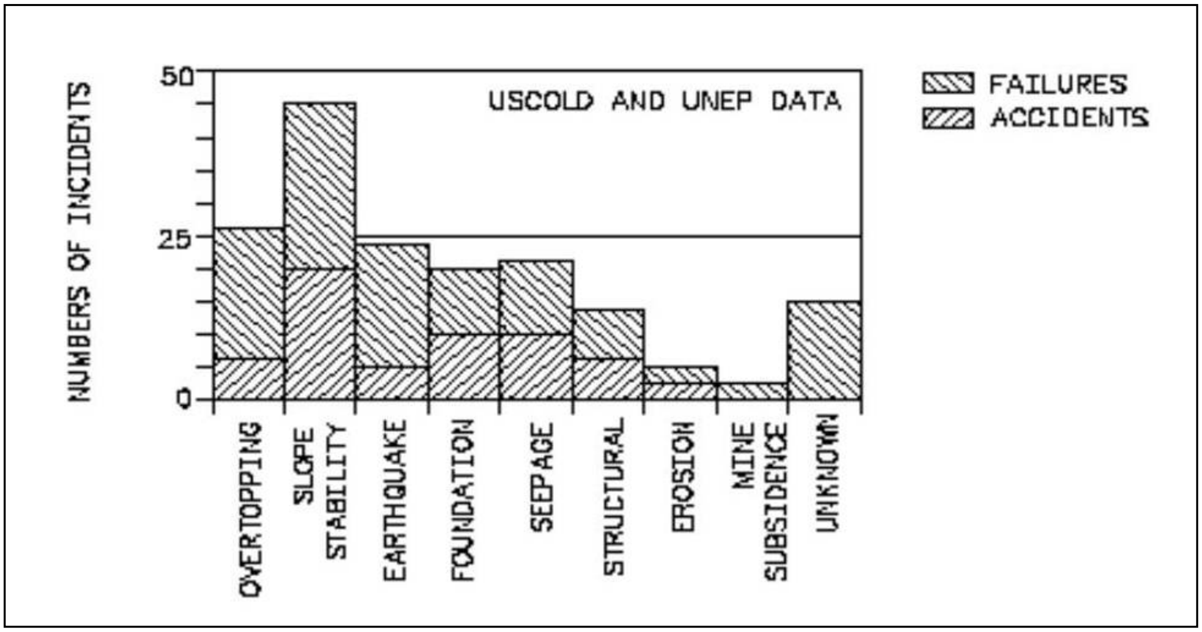

Figure 2. Tailings dam incidents during active operations, worldwide

A vehicle that doesn't start or stop when expected can have lethal consequences. When implemented from the top down, "design quality management" provides the synergy needed to keep the engine humming. Design quality management can be any formalized system to define the problem, develop the scope of work necessary to solve the problem, and then verify that the work product actually meets the scope of work as defined, and adequately addresses the requirements[3]. A well written scope of work may be one of the most effective methods to prevent a fatal flaw from developing and killing an otherwise viable project. Not only can it preclude a fatal flaw, it can also prevent misunderstandings between the various parties to the work. Constructability reviews are worth their weight in gold. Without design quality management, financial resources can be squandered on inefficient or misguided approaches to complex problems. Nothing will kill a project faster than running out of money, except perhaps when a bad design shows its weakness and the dam fails, causing an uncontrolled release of the reservoir, whatever its contents, and crashes the operation and wrecks the industry.

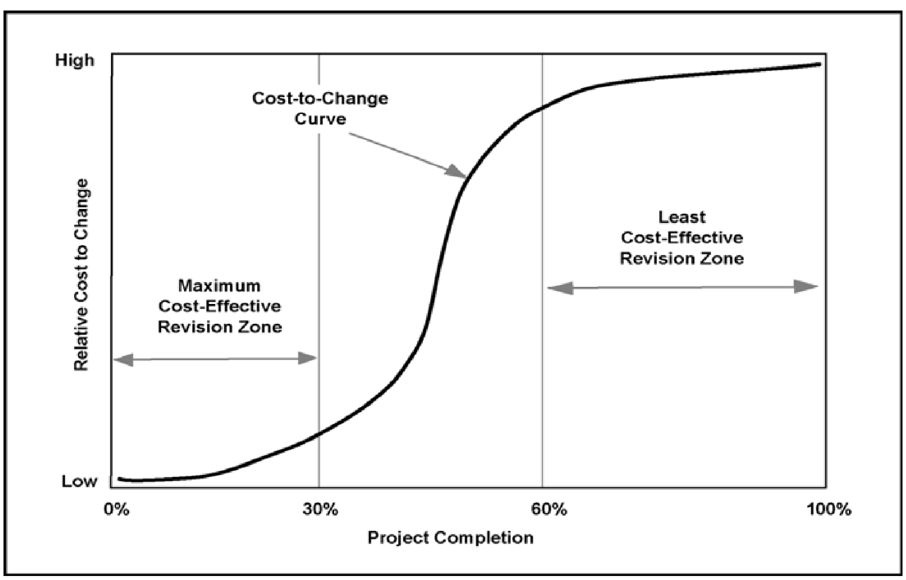

Figure 3. Relative cost to change based on percent completion

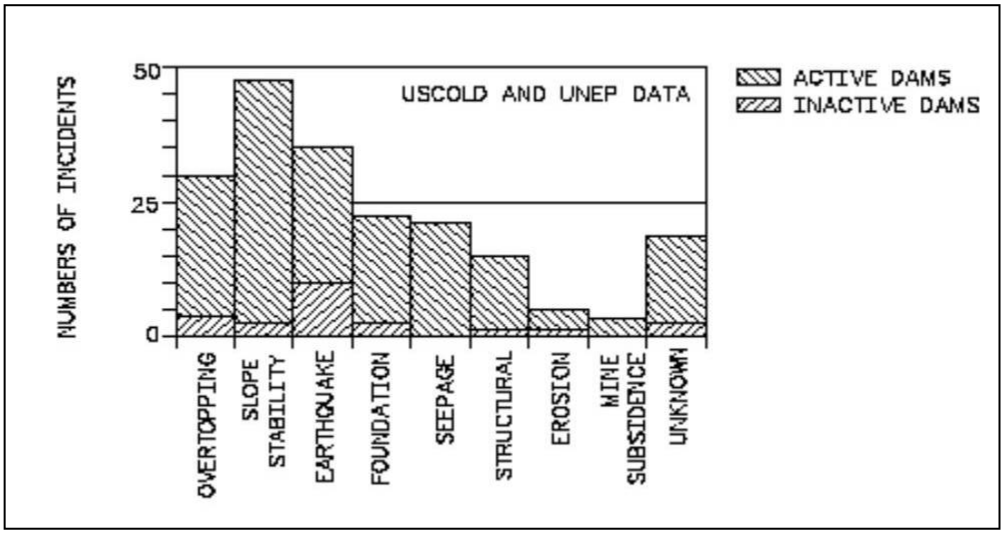

Figure 4. Tailings dam incidents for active versus inactive dams, worldwide

To keep the mining project in the race, in addition to vetting the plans through the technical team, the buy-in from regulatory agencies and other stakeholders early in the lap count can prevent other drivers from pushing the car into the wall. A "multiple accounts analysis"[4] or other objective, decision making method can identify critical considerations that, if ignored, may lead to a fatal pile-up. Siting studies must not only consider the potential technical issues to overcome such as a liquefiable foundation, but legal issues such as land use authorizations and long term responsibility for residual project features such as tailings storage dams. Early agreements on key issues can help avoid expensive challenges late in the race. Figure 3 shows the "relative cost to change" based on the percent completion of the project[5]. Note that this graph can apply to components, the same as it applies to the project as a whole. As seen in the diagram, the cost of change begins to go up dramatically soon after project development begins. Revisions and retrofits are expensive. In a challenging economic climate, wasting precious resources doing the work over is a sure way to drain the fuel and keep the project in the pit.

Understanding the relationship between the performance requirements of the dam and its physical setting is critical. For tailings dams, designing for closure is imperative. But poor construction and mis-operation can crash a dam and a mining project also. Construction quality assurance and quality control are required to confirm that the dam is constructed according to the design, and to accurately model and monitor its as-built performance. Accurate water balance modeling is needed to manage one of the highest risk factors for dams. Maintenance, periodic safety inspections and design and performance reviews must occur regularly to stay ahead of danger. As seen in Figure 4, active tailings dams have "incidents" more frequently than closed tailings dams[2]. This emphasizes the importance of careful operational planning and execution to preserve the life of the mine. The probability of a dam failing is eight times higher in the first five years of its life than in subsequent years[6]. For staged raise tailings dams, this means that for each lift of the dam, the risk stays high as the new load is applied. For all of the pit crew's efforts, the real test comes when the engine is running and the light is green. With proper design, construction, and operation, the mine operators can enjoy the benefits of winning the gold at the checkered flag.

1. Adapted from data from National Performance of Dams Program, Stanford University.
2. ICOLD, "Tailings Dams—Risk of Dangerous Occurrences…", Bulletin 121, 2001.
3. United States Army Corps of Engineers, "Quality Management", ER-1110-1-12, 1993.
4. Robertson and Shaw, "A Multiple Accounts Analysis for Tailings Site Selection", 1999.
5. URS and MWH, "ASDSO Technical Seminar on Plans and Specifications Review", 2003.
6. Foster, Fell, and Spannagle, "The Statistics of Embankment Dam Failures and Accidents", 2000.