Data-Driven Mitigation Strategies for Dam Safety, Emergency Preparedness and Asset Management

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Data-driven decision-making is essential for both regulators involved in emergency management and dam owners focused on asset management. The effectiveness of emergency preparedness for dams facing natural disasters is improved with a practical approach that merges thorough inspections with strong quantitative assessments within a risk assessment database. For smaller dams, this method involves building and maintaining a detailed database that includes each dam. Within this database, standardized inspection forms equipped with a scoring system for typical failure modes are crucial, enabling quick detection and prioritization of potential hazards. For larger dams, this practical strategy is broadened to include a quantitative analysis of each dam's specific components. This type of assessment is vital not just for regular monitoring of the dam's condition, but also for determining an overall risk profile and breaking down the risk into major contributors. Linking this specific data with historical instances of dam failures creates a substantial pool of information, which aids in making informed decisions for those managing the dams and for regulators. This integrated database system thus becomes a key resource in managing dam emergencies, facilitating preventative measures and quick action plans in response to natural disasters, as well as assisting large dam owners in forming risk-informed asset management plans. Utilizing the data collected from standardized and quantitative assessments, alongside historical failure patterns, allows dam authorities or owners to make smart, prompt decisions to reduce risks and protect downstream communities.

Rapid Drawdown: Looking Beyond the Factor of Safety

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Rapid drawdown occurs when the water level on the slope of an embankment dam is quickly lowered after a prolonged period at a given elevation. For soil slopes that are not free-draining, the change in porewater pressure and reduction in shear strength may result in slope instability. Rapid drawdown slope stability is commonly evaluated with the pre-drawdown water level defined at some elevation where steady-state seepage conditions have developed and the post-drawdown water level defined at the lowest gated outlet. One approach for rapid drawdown stability analysis uses a multi-stage undrained shear strength model to calculate a limit equilibrium factor of safety. Finite element methods, including uncoupled transient seepage and coupled transient seepage stress-strain methods, and probabilistic methods are becoming more common. Design guidelines by the U.S. Army Corps of Engineers (USACE), Federal Energy Regulatory Commission (FERC), Natural Resources Conservation Service (NRCS), as well as various state dam safety programs, require a minimum factor of safety for rapid drawdown stability of 1.1 to 1.3. Some regulators recognize rapid drawdown stability of existing embankment slopes as an issue to be addressed through physical modifications. The goals of this paper are to promote consideration beyond satisfying factor of safety criteria and to advocate for risk-informed decisions when planning dam modifications to address perceived rapid drawdown stability issues. This paper will discuss considerations such as whether rapid drawdown can actually occur based on the dam's outlet capacity, the function of the project after a potential rapid drawdown failure, and the progression of instability through the crest that could result in a breach. Costly mitigation measures may not be warranted when the failure mode progression and consequences of failure are considered in detail.