Risk Based Assessment of Dams*

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Extended Abstract

The work deals with various methods of Risk Assessment of Dam gates with limited maintenance dedicated to aging dam spillway gate structures, there is an increased risk of gate inoperability and corresponding dam failure or inadequate design. This study summarizes research on methodologies to assist in quantifying risks related to dam gates and associated operating equipment, and how those risks relate to overall spillway failure risk. The objective of this research was to demonstrate how fault tree analytical methods may be applied to improve the quality of dam gate risk analysis.

Two different methods of prescreening analysis are presented and evaluated. The first uses probabilities for more events, defined more precisely than in standard practice, and adds criticality ranking; the second uses more traditional estimation of failure probabilities in conjunction with subsystem importance-ranking factors to estimate overall gate system failure probability. Both methods can be linked qualitatively with the Laffitte risk method event costs and consequences to determine the overall risk for a dam spillway system.

Enhancement of the two demonstrated methods would require a direct application of the methods to an existing dam gate system. Also, additional research would be necessary to better determine the risk consequence factor , α, used in the Lafitte equation for calculating overall risk.

The focus of this study was the development of analysis tools for risk assessment related to dam gates and associated operating equipment. Specifically, the applicability of detailed fault tree analysis to a dam spillway system is examined, with a concentration on the failure of the dam gates and operational subsystems.

While there are many methods of probabilistic analysis, this report concentrates on two different methods of prescreening analysis which are presented and evaluated. The first method uses probabilities for more events defined more precisely than in standard practice, and adds criticality analysis to rank each of the potential failure modes in a failure modes and effects analysis. The second method uses more traditional estimation of failure probabilities in conjunction with importance-ranking factors for the gate subsystems to estimate the probability of failure for the overall gate system. Detailed examples for gate subsystems are presented to show how the methodologies can be applied to dam gates. These methods can then be linked qualitatively with the Lafitte risk method through event costs and consequences to determine the associated overall risks for a dam spillway system.

So, mainly, the scope of the research reported here was limited to the risk analysis of dam gates and associated operating equipment, but not to an entire dam spillway system.

In order for any dam spillway system risk analysis method to be effective, it is critical to have a valid data set on the failure rate of dam gate components, or at least methods for the timely acquisition of such data. Without better data, the methods proposed in this report, and any other risk-based methods, will lack the accuracy necessary to provide useful quantitative measures of risk. Systematic collection of data

on the performance of gate components and all other critical components of the civil works inventory* is essential to the success of an overall risk management program. Besides basic failure rate data for civil works applications, there are at least two other related data points that must be considered: maintenance history / condition and failure mode. Most failure rate databases include little or no consideration of component maintenance history and condition even though these obviously have a substantial impact on the equipment failure rate. Also, and specifically with respect to this report, some risk assessment methods presented here require some detailed information on the modes of failure for each component. This type of data is important because, for example, the impact of a locked brake is quite different from the consequences of a brake that will not hold.

The risk assessment method discussed in this chapter provides a prioritization ranking procedure that accounts for both time and event dependencies. The procedure also determines a quantitative value for risk that can be compared at the component, project, or system-wide portfolio level. This risk assessment method is adaptable to the level of inputs but provides a consistent methodology for the prioritization and reduction of risk based on both component and dam. Therefore this procedure is flexible enough to be used for both pre-screening levels and more complex, detailed dam safety investigations.

The method has been adapted from a literature search and a summary of risk assessment methods by Putcha and Patev (2000). Putcha and Patev summarize various risk assessment procedures available in the literature that could be used to best analyze the risk assessment for dam gates. Putcha and Patev recommend using an adapted Lafitte method in combination with failure modes and effects criticality analysis to address the risk for spillway gates based on the levels for structural, geotechnical, mechanical, and electrical components.

The use of this time-dependent procedure for risk calculations will permit the development of hazard functions for risk that can be used in the economic calculations of benefit/cost ratio. The damages associated with the risks could include downstream flood damage costs, dam repair costs, emergency action costs, environmental costs, security costs, and potential loss of life. An optimized solution can be determined that coordinates current and future budgets with available funding and the priorities of the structures while also conforming to Office of Management and Budget requirements for using benefit/cost ratio in funding proposals (much as it is done in the major rehabilitation process). In addition, this method also presents an equal priority ranking of all dam components over time, based on risk calculations which in turn are based on fault-tree analysis illustrated in this paper.

References

Putcha, C.S., and Patev, R.C. (2000), *Investigation of Risk Assessment Methodology for Dam Gates and Associated Operating Equipment*, ERDC/ITL TR-00-3, Engineer Research and

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