Post-Processing Physically Based Model Results
Using the RMC Overtopping Erosion Toolbox
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About

The Risk Management Center (RMC) of the U.S. Army Corps of Engineers (USACE) has developed a suite of Microsoft Excel spreadsheets to support risk assessments for dam and levee safety. Each analysis suite is composed of multiple toolboxes (Microsoft Excel workbooks), and each toolbox contains multiple spreadsheet tools or calculation worksheets (Microsoft Excel worksheets).

The Physically Based Breach Model worksheet in this toolbox deterministically and probabilistically assess the likelihood of embankment breach from overtopping erosion using physically based model results (such as WinDAM C) and user-specified erodibility parameters for the embankment.

The information from these spreadsheet tools, along with other pertinent information, informs judgment when developing a list of more and less likely factors and estimating probabilities. USACE best practice for estimating probabilities is to use the best available and multiple methods, but all final probabilities are estimated using team elicitation based on the totality and strength of the evidence.

The RMC continuously works to improve the performance of RMC software; report possible bugs directly to the RMC at the address listed below. Ideally, report suspected errors in written form with a description of the problem and the steps that lead to its occurrence. Suggestions for improvement are also welcomed.

U.S. Army Corps of Engineers
Institute for Water Resources
Risk Management Center
RMC.software@usace.army.mil

Overtopping Evaluation Process using WinDAM C

To inform the evaluation of embankment overtopping performance (i.e., likelihood of failure given the loading), a table (or matrix) of conditional probability of failure (i.e., system response probability, SRP) as a function of erodibility coefficient (k_d) and undrained shear strength (s_u) is constructed using WinDAM C. For efficiency, critical shear stress (τ_c) is typically conservatively assumed to be zero, and the other input parameters are modeled as discrete variables.

If the selected combination of k_d and s_u result in a breach initiation time greater than zero in WinDAM C (i.e., headcut breaches upstream crest regardless of breach size), a value of 1 is entered in the table. Otherwise, a value of 0 for no failure/breach is entered in the table. Users typically quickly get a feel for where failure occurs to focus their efforts and efficiently populate the matrix.

The process is repeated for a series of hydrographs that are scaled so that the peak stage corresponds to the peak overtopping depths of interest (e.g., 0.5, 1, 1.5, 2, 3 ft, etc.) to fully assess the system response. The end-product of this phase of the evaluation is a series of system response matrices corresponding to the peak overtopping depths of interest. A generic example is shown below.

SRP		◄ Increasing s_u (psf)				
		s_{u1}	s_{u2}	s_{u3}	s_{u4}	s_{u5}
▼ Increasing k_d ((ft/hr)/psf)	k_{d1}	0	0	0	0	1
	k_{d2}	0	0	0	1	1
	k_{d3}	0	0	1	1	1
	k_{d4}	0	1	1	1	1
	k_{d5}	1	1	1	1	1

The toolbox performs a probabilistic analysis using 1,000 iterations. Values of k_d and s_u are randomly sampled based on a user-specified triangular distribution. The toolbox assumes k_d and s_u have a -1.0 correlation (perfectly negative). This will be conservative.

Although not required to perform a probabilistic analysis, Palisade @RISK software (standalone version or as part of the Palisade DecisionTools Suite) can customize the probabilistic analysis. If a probabilistic analysis is selected using @RISK to customize the probabilistic analysis, the minimum, most likely, and maximum values are input, and an @RISK formula for a triangular distribution is used as a default. However, a valid @RISK distribution can be input in lieu of this default formula. The correlation matrix named "Corr" must be added to the end of the user-specified input distributions for k_d and s_u using the @RISK RiskCorrmat property function. Use RiskCorrmat(Corr,1) for k_d and RiskCorrmat(Corr,2) for s_u.

A user-defined function (UDF) performs two-way linear interpolation to obtain the SRP for each iteration (k_d-s_u pair). The iteration results are tabulated, and the average SRP value is calculated as shown in the generic figure below.

Iteration	s_u	k_d	SRP
1	s_{u1}	k_{d1}	SRP_1
2	s_{u2}	k_{d2}	SRP_2
3	s_{u3}	k_{d3}	SRP_3
…	…	…	…
N	s_{un}	k_{dn}	SRP_n
Average			SRP

This process is repeated for each peak overtopping depth.