Probability Curves for Multi-Mode Levee Failure

PEER Internship Program – Summer 2012

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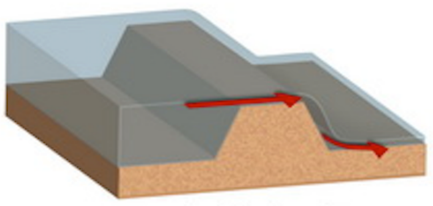
INTRODUCTION

Public agencies often run preliminary risk analyses in order to optimize the cost to benefit ratio of infrastructure projects. In order for risk analysis to be effective, accurate estimates of the probability of system failure are required. Traditionally, risk analysis of riverine levees assumes overtopping as the only mode of failure. This assumption greatly underestimates the probability of levee failure which in turn leads to an underestimation of overall risk. This underestimation of risk means that levee systems cannot be optimally designed, which poses a threat to life, land and property within the protected floodplains of California's Central Valley. The objective of this research is to investigate the probability of failure associated with multiple modes of levee failure so as to better characterize overall risk.

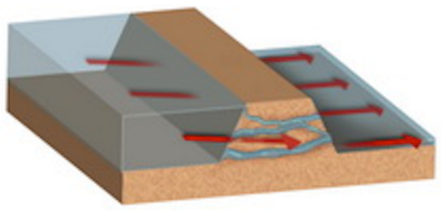
LEVEE FAILURE MODES

Overtopping



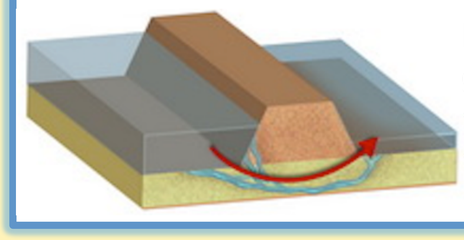
Floodwater height exceeds levee height
- Probability of given flood flow neglected

Through-Seepage



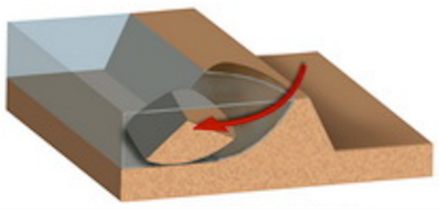
Rock Island Method
- Relative erosion susceptibility
- Maximum erosion susceptibility

Under-Seepage



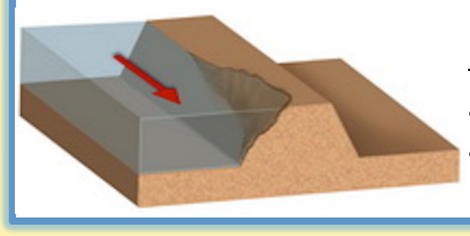
Ratio of critical exit gradient to actual
- Pressure head
- Soil layers defined

Slope Stability



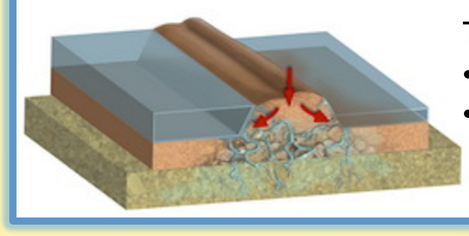
Simplified Bishop
- Ratio of moments inducing and resisting sliding

Erosion



Ratio of critical velocity to actual water velocity
- Manning's equation
- Duration neglected

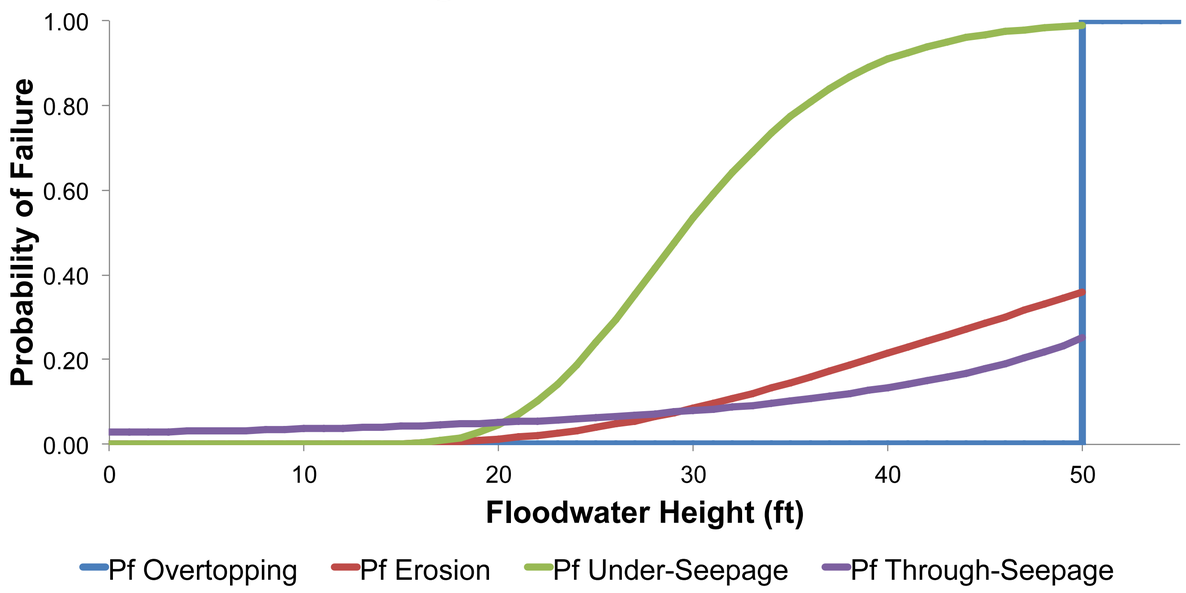
Seismic Vulnerabilities



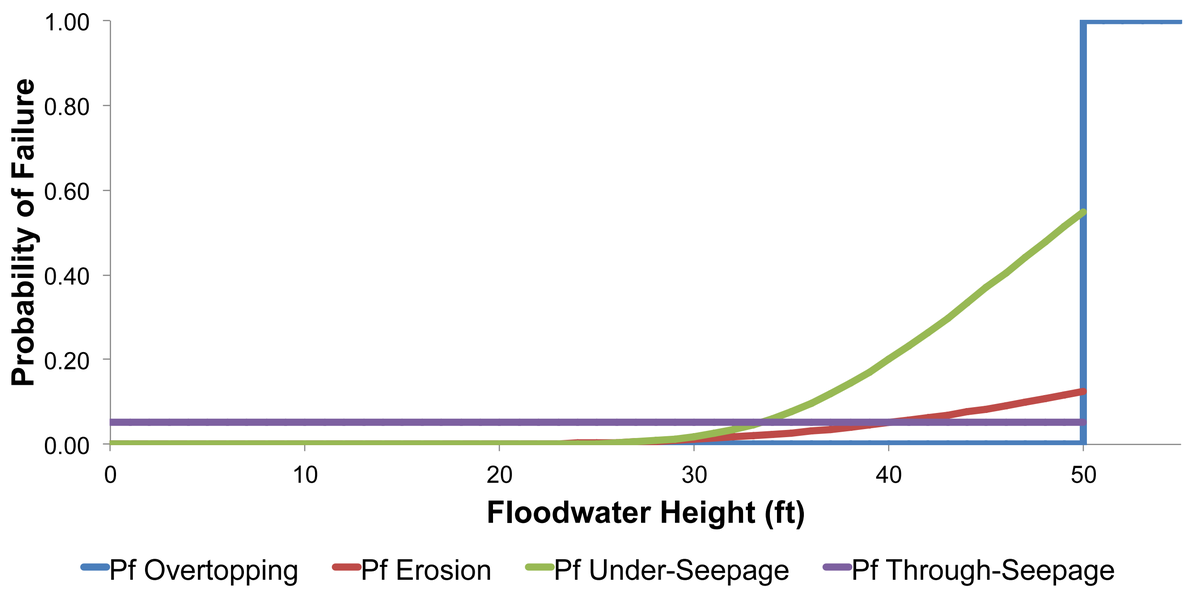
Two possible methods
- Yield acceleration
- Soil susceptibility to liquefaction

RESULTS

Agricultrual Levee



Urban Levee



CONCLUSION

When failure modes other than overtopping are considered the probability of levee failure is increased. This demonstrates a need to account for as many failure modes as possible so that system design may be optimized. Optimization may be better achieved by noting these trends:

- Levee geometry is the main factor in determining a levee's susceptibility to the failure modes of through-seepage and overtopping.
- Increasing the velocity at which scour begins, through the addition of vegetation and armor, is most effective in mitigating erosion.
- Failure due to under-seepage is primarily influenced by the soil layers underlying the levee. Increasing the thickness and impermeability of the top most soil blanket was most effective in reducing the likelihood of failure due to under-seepage.

FUTURE RESEARCH

Further work is needed to refine the failure modes of this report. Risk can be better characterized with methods accounting for slope stability and seismic vulnerabilities. Additionally, research that investigates the interactions between individual failure modes would be beneficial to system optimization.

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