Chapter 1: Introduction

It has usually been assumed that installation of seepage barriers (slurry walls, concrete walls, secant pile walls, jet grouted walls, deep soil mixed walls, and sheetpile walls) will result in permanent mitigation of seepage problems in embankment dams and foundations. However, there are several cases where seepage barriers have not performed as expected. The most extreme example of this is Wolf Creek Dam in Kentucky, where a concrete seepage barrier was installed between 1975 and 1979. In the 28 years since the seepage barrier was completed, seepage problems at Wolf Creek Dam have redeveloped to levels equal to or exceeding those observed prior the barrier construction. In 2007, the U. S. Army Corps of Engineers began lowering the reservoir level behind Wolf Creek Dam in response to an unacceptably high risk of failure resulting from the seepage problems. Wolf Creek Dam is a dramatic example of a seepage barrier not performing as intended during design.

The experience at Wolf Creek Dam has been the inspiration for this study. The study is founded on case studies of 30 dams that have had seepage barriers in place for more than 10 years, with the objective of assessing long-term performance of the barriers. The performance of the dams and seepage barriers was assessed by reviewing monitoring data, observations made during inspections, and maintenance records obtained from the dam owners and dam regulatory agencies. Analyses were performed to provide better understanding of the behavior of dams with seepage barriers. Based on these observations, and the results of the analyses, conclusions were developed regarding the overall behavior of dams with seepage barriers and the mechanisms that are key to this behavior.

What makes dams with seepage barriers different from other dams is the unique seepage regime that develops in response to the construction of the seepage barriers. Because the purpose of a seepage barrier is to reduce the seepage of water through the pervious portions of the embankment, foundation, or abutments, it can radically change the seepage conditions. The result is increased water pressures and hydraulic gradients

behind and around the barrier. These increased pressures and gradients have potential to provide the catalyst for initiation of several modes of internal erosion that were either unlikely or less likely without the seepage barrier. In most cases seepage barriers have significantly increased the reliability of the dams in which they have been installed. However, there are several potential modes of seepage, internal erosion, and piping that are unique to dams with seepage barriers. Understanding these potential failure modes is essential to predicting the behavior and assessing the associated risks for dams with seepage barriers.

The objectives of this research are to produce a compendium of long-term performance case histories of dams with seepage barriers, and to enhance the understanding of the mechanisms that have potential to cause deterioration of seepage barrier performance over time. With this improved understanding, design and monitoring practices can be developed to assess and address these mechanisms. It is envisioned that the results of this study will provide dam owners and engineers with a better understanding of the issues involved with dams having seepage barriers and that this understanding will lead to improved practices in designing, assessing, and monitoring of dam seepage barriers. In addition, by improving the means by which seepage barriers can be designed and assessed, it is hoped that the confidence level dam engineers have with properly designed seepage barriers will be increased so that they can be viewed as a safe viable alternative for mitigation of seepage issues.

Research Outline

This study is based on observation of past performance of seepage barriers, distilling these observations into theories of the mechanisms responsible for deterioration of seepage barrier performance over time, and analyses conducted to enhance understanding of the deterioration mechanisms. The research consisted of the following tasks:

1. Data was compiled on 30 dams that have had seepage barriers in place for 10 or more years. The data was collected from the files and reports of dam owners and dam regulatory agencies.

2. Assessments were made of how these dams have performed with respect to issues related to the seepage barriers, and the observations and insights garnered from these assessments were compiled.
3. Finite element seepage and deformation analyses were performed to provide better understanding of the performance of seepage barriers and the mechanisms that affect the performance.
4. Potential failure modes that are specific to dams with seepage barriers were identified and the phases required for the propagation of these failure modes were developed.
5. The observations and insights acquired in objectives 1 through 4 were distilled into conclusions regarding the long-term performance of dams with seepage barriers.