Geophysical Techniques to Monitor Embankment Cracking (Laboratory Scale)

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Introduction

• Problem:
  – Internal Erosion (IE) represents one of the major hazards to earthen embankments
  – Current practices make it difficult to detect IE in its early stages
    • IE often not discovered until the emergency state
  – No means by which to determine a Factor of Safety against IE
  – IE can manifest after decades (or centuries!) of good performance

• Can geophysics aid in the early detection of IE?
  – Could provide continuous, remote monitoring
  – Could detect the onset or early progression of IE
  – Many different techniques to explore
Potential Techniques

- **Passive Acoustic Emission (AE)**
  - Passively “listening” for acoustic energy released during soil cracking, internal erosion, seepage, etc.
  - Can locate source via triangulation from several sensors
  - Other industries are able to extract information about the nature of the defect… geotech is not there yet!
Potential Techniques

• Cross-hole Sonic Tomography (CT)
  – P- and S-waves transmitted between boreholes (active)
  – Direct measurement of wave velocities $\rightarrow$ material properties
  – Can perform imaging similar to CAT scan medical technology
Potential Techniques

• Self Potential (SP)
  – Measure the surface expression of very small electric fields created by fluid flow through porous media (and other sources)
  – Raw voltage measurements can indicate flow/gradient pathways directly, or can be used to perform inverse modeling for flow and geotechnical properties
Laboratory Model – Soil Crack Box

- Laboratory model created to study performance of granular filter materials:
  - Materials (filter and/or core) are compacted with box “closed” and then cracked by pivoting around a central axis using jacks
  - Constant head reservoir allows water to impinge on crack
  - Floor drains in the base of the model simulate filter drains, or can be closed to simulate an isolated filter or clogged drainage
  - Much more information available in Redlinger et al. ICSE-6 paper!
Instrumented Crack Box Tests

Test 1 (single stage filter)
Instrumented Crack Box Tests

Test 2 (two-stage filter)
Preliminary Results

- Self Potential allows you to track to seepage
  - Migration of water into filter zone
  - Downward flow of water towards drains
Preliminary Results

- **AE**
  - Clear contrast between no flow and concentrated flow (uncontrolled seepage)
  - Collapse of filter material crack (i.e., filter healing) leads to reduction in flow
Conclusions

- The geophysics methods investigated hold promise for early detection of cracking and IE
  - Signatures associated with cracking, self-healing, concentrated flow exist in the data and were well above the ambient noise in the challenging laboratory environment

- Time-lapse geophysics can show spatial and temporal changes in the subsurface of any embankment structure, at higher resolution (space and time) than traditional methods
  - More effective monitoring of several different failure modes
  - Very cheap and easy measurements, possible to install a widely distributed sensor network
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