DETECTION OF BACKWARD EROSION USING MULTIPLE GEOPHYSICAL TECHNIQUES

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FAILURE OF DAM IN BRAZIL  (January, 2019)
TWO-MINUTE MADNESS

Not detected during Visual Inspection

Initiation

Continuation

Progression

Stages of Erosion

Breach/Failure ➔ Fast mechanism

Failure

Short time between visual signs and failure
Laboratory Setup ➔ Controlled Environment

Use of Geophysics ➔ Monitoring and Detection of Internal Erosion
TWO-MINUTE MADNESS

Appearance of Events prior to Failure

Increase in RMS at 80-120 HZ prior to failure
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INTRODUCTION

METHODOLOGY

RESULTS

CONCLUSIONS
INTRODUCTION

What is Internal Erosion?

Erodible Material
Seepage Path
Material sustaining a pipe
Exit Point

i > i_c
Therefore use of Non – Destructive Techniques (NDT) essential to detect early stages of internal erosion and prevent failure.
METHODOLOGY

- Controlled testing
- Controlled hydraulic gradient
- Water flow only in weak zone
- Many soil mixtures can be conducted
Methodology (Cont’d)

Setup in the lab:

- 2 Horizontal Geophone
- 1 Vertical Geophone
Methodology (Cont’d)

Materials Properties:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Sand</td>
<td>65</td>
</tr>
<tr>
<td>% Clay</td>
<td>35</td>
</tr>
<tr>
<td>% Fines</td>
<td>&gt;12</td>
</tr>
<tr>
<td>ERI</td>
<td>2</td>
</tr>
<tr>
<td>% Water Content</td>
<td>10.3</td>
</tr>
<tr>
<td>Dry Unit Weight</td>
<td>17.01 kN/m³</td>
</tr>
<tr>
<td>Soil Classification</td>
<td>SM (Silty Sand)</td>
</tr>
</tbody>
</table>
RESULTS

Data of Geophones:

- Monitor
- Horizontal perpendicular to flow
- Horizontal parallel to flow
- Vertical

TIME SERIES

SPECTROGRAM

RMS
Results (Cont’d)
Results (Cont’d)

Energy due to water seepage
Results (Cont’d)

Increase in energy due to water seepage
Results (Cont’d)

Appearance of Events prior to Failure
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Results (Cont’d)

Increase in RMS during seepage
Results (Cont’d)

Increase in RMS at 80-120 HZ prior to failure
CONCLUSIONS

✓ Controllable laboratory $\rightarrow$ backward erosion

✓ Horizontal geophone, parallel $\rightarrow$ flow of water

✓ Vertical geophone $\rightarrow$ events
  
  ➢ Grain rearrangement
  ➢ Grain movement

Aqoura Dam Failure – Lebanon, 2015