Geotechnical Aspects in the Vulnerability Assessment of Existing River Banks

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Flood risk maps in river areas protected by levees typically consider the only risk of overtopping, implicitly disregarding potential failures of the defence structures.
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From: The National Flood Risk Analysis for the Netherlands, Final Report
But levees problems are both hydraulic and geotechnical.

From: Zina Deretsky, National Science Foundation
But levees problems are both hydraulic and geotechnical.

Activation of piping phenomena during flooding events, Po river, 20.11.2014
But levees problems are both hydraulic and geotechnical.

Secchia river bank collapse, 19.01.2014
But levees problems are both hydraulic and geotechnical.

Secchia river bank collapse, 19.01.2014
The available data show that the probability of river bank failure is not negligible.

<table>
<thead>
<tr>
<th></th>
<th>Po River, from Cremona to Borgoforte</th>
<th>Tagliamento River, from Pinzano to the river mouth</th>
<th>Piave River, from Nervesa to the river mouth</th>
<th>Adige River, from Merano to San Michele</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. bank failures</td>
<td>24</td>
<td>166</td>
<td>82</td>
<td>69</td>
</tr>
<tr>
<td>Monitoring period</td>
<td>1800 to 1951</td>
<td>1800 to 1966</td>
<td>1800 to 1966</td>
<td>1872 to 2011</td>
</tr>
<tr>
<td>Length of the monitored river stretch (km)</td>
<td>98</td>
<td>91.4</td>
<td>65.1</td>
<td>50</td>
</tr>
<tr>
<td>Density of bank failures</td>
<td>0.16</td>
<td>1.1</td>
<td>0.8</td>
<td>1.0</td>
</tr>
<tr>
<td>(failures/km/100 years)</td>
<td></td>
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</tbody>
</table>

Bank failures occurred in four Italian rivers of Northern Italy (Ranzi et al., 2013)
Examples of main causes of river bank collapse to be verified in geotechnics.

Global stability in static and seismic conditions.

Consolidation settlement of foundation.

Backward erosion piping.
Remarks

There is no perfect flood risk management plan.

Consider and combine three approaches:

- Prevention
- Risk reduction
- Response management

Not only focus on the hydraulical conditions but also take the strength of levees into account.

Levees are part of the built environment, which is constantly changing, in maintenance schemes this should be incorporated.
AGI Guidelines on geotechnical aspects of river banks design and maintenance.

- design criteria
- intervention criteria of adaptation and reinforcement
- maintenance
- monitoring and control

USACE (1999) - Risk-Based Analysis in Geotechnical Engineering for Support of Planning Studies
USACE (2000) - Design and construction of levees

The International Levee Handbook
CIRIA, Ministry of Ecology, 2013
Focus on the importance of an accurate geotechnical model of the river bank system.

SISMAPO Project
Focus on the importance of monitoring and control systems.

Artificial levees are long-stretching structures that protect large areas from flood risk.

\[ \text{Risk} = f(p \times I) \]

**Probability of occurrence**
(stable or increasing due to climate change)

- **Economic impact**
  (economic value of possible flooded property)
- **Human impact**
  (loss of lives, permanently injured)
- **Social impact**
  (risk aversion in the population)

European Commission. 2010 Risk Assessment and Mapping Guidelines for Disaster Management; Brussels.
Focus on the importance of monitoring and control systems.

\[ \text{Impact} = \text{Exposure} \times \text{Vulnerability} \]

(increasing population, increasing anthropization of territory)

(reduce vulnerability by increasing resilience and reliability of protection structures to reduce the overall flood related risk)

**STRUCTURAL HEALTH MONITORING OF LEVEES**

European Commission. 2010 Risk Assessment and Mapping Guidelines for Disaster Management; Brussels
STRUCTURE HEALTH MONITORING OF LEVEES
Combining dike & sensor technology for floodrisk management and real-time prognoses of dike stability.

Smart Levees Project
STRUCTURE HEALTH MONITORING OF LEVEES
Use information also to optimize levee maintenance and levee improvement programmes.

Smart Levees Project
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AGI TC Guidelines on geotechnical aspects of river banks design and maintenance
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