Transition zones: how to improve resilience of our flood defences
Jonathan Simm & Marta Roca (HR Wallingford); Jaap Flikweert (RHDHV)

Wednesday 19th June 2019

Flood & Coast 2019, Telford
Project team

Project Board
Help risk management authorities:

1. To consider the presence of transitions during flood defence condition assessment;
2. To quantify the effects of transitions on defence performance (fragility) and flood risk;
3. To manage the risk of transitions with improved design and retrofitted solutions for existing defences
What can we see?

Transition between concrete steps and grass slope

Change in cross section of levee

Transition between concrete revetment and grass
• 167,500 transitions
• 12% involving embankments (about 20,000)

3/4 of hard structures are flood walls

1/3 embankment to embankment interfaces are between hard and soft revetments
Levee transition types being considered

<table>
<thead>
<tr>
<th>Longitudinal transitions</th>
<th>Cross-sectional transitions</th>
<th>Crossing pipelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between an embankment and a flood wall</td>
<td>Between soft and hard embankment revetments</td>
<td>Between an embankment and a crossing structure</td>
</tr>
<tr>
<td>Between an embankment and a non-linear structure (point asset)</td>
<td>Between the embankment and a flood wall above</td>
<td></td>
</tr>
</tbody>
</table>

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Longitudinal change: flood wall to earth embankment

External erosion
Flow velocity increases and focussing of flow on vulnerable areas

Internal erosion
Via cracking along interface
External erosion (cf New Orleans)

Internal erosion and deep sliding need to be considered as well
PRODUCT 1

Improved guidance for the inspection of transition zones

PRODUCT 2

New methods and tools for the reliability analysis of flood defences with transitions

PRODUCT 3

New methods to account for transitions in flood risk systems analysis

PRODUCT 4

New guidance supporting design, maintenance & repair; focus on retrofitting
Product 2 - Fragility curves

Express varying probability of failure with load

Can be generalised for broad scale or bespoke for local system or individual asset

Generated by evaluation of Limit State Equations, but expert judgement can also be used to adjust them
Modifying limit state equations (LSEs)

\[ Z = R - S \quad (< 0 \rightarrow \text{Failure}) \]

- Reliability
- Strength
- Load

Transitions

Area of influence of transition

Resistance decreases
Loadings increase

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Amplification of external erosion shear stress
### Weakness = 1/R (R, Strength)

- Uneven crest elevation
- Geometric irregularities at the contact surface
- Steep slopes
- Poor material condition at the transition
- Leakage from/into pipelines
- Poor grass cover
- Toe erosion
- Crack/fissures
- Debris accumulation
- Rainfall softening

### S, Loads

- Water levels
- Waves
- Longitudinal flow
- Overtopping
- Overflowing
- Turbulence
- Hydraulic gradient
- Pipeline vibration

\[ Z = R - S \]

Climate change will worsen these trends.
LSEs evaluate the ability of a defence to resist a certain failure mechanism under a certain type of loading.
Product 3: Incorporation of transitions in flood risk systems analysis

Fragility curve

Source
Extreme distribution of in-channel water levels or coastal overtopping

Pathway
Reliability analysis of assets e.g. defences (load dependent)

Consequences
Flood damage or harm related to depth. Risk is assessed by the probability that particular damage values are exceeded.

Source
River or sea

Pathway
E.g. beach, defence, floodplain

Receptor
E.g. property, agriculture, infrastructure, people in the floodplain

Fragility curve

Load
P(occurrence)

Load
P(fail)

Load
P(depth exceeded)

Impact
As damages, G

Depth
Product 3: Incorporation of transitions in flood risk systems analysis
Product 3 – Implications of transition type on fragility curve for systems analysis

- **Longitudinal transitions**
  - separate element in system risk analysis
  - separate fragility curve

- **Changes within a cross section**
  - affects component fragility curves within a segment

- **Embedments or encroachments**
  - cf. USACE EM 1110-2-2902 Conduits, Culverts and Pipes
  - affects segment fragility curve
## Tiered approach

<table>
<thead>
<tr>
<th>Tier</th>
<th>User</th>
<th>Techniques</th>
<th>Output</th>
<th>Format of guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Basic inspection</td>
<td>Field team</td>
<td>Visual</td>
<td>Condition Grade</td>
<td>Numerical report with comments</td>
</tr>
<tr>
<td>2. Intermediate Non-intrusive</td>
<td>Watershed Engineer or equivalent</td>
<td>Visual plus desk study</td>
<td>Condition Grade</td>
<td>Note with specific recommendations per type, typically 2-3 pages</td>
</tr>
<tr>
<td>3. Detailed</td>
<td>Specialist</td>
<td>Surveys, modelling</td>
<td>Condition Grade + parameter values</td>
<td>Detailed report with transition-specific comments</td>
</tr>
</tbody>
</table>
Product 4: Design & management guide

Users:
- Specialist designers and asset managers

Approach:
- Build on conceptual understanding & classification (Task 2)
- Tiered approach:
  - Standard details
  - Suggested approaches for special cases
1. Transitions between or within flood embankments and other structures are significant points of weakness where the probability of failure (especially due to internal and external erosion) is enhanced.

2. The reasons for the enhanced failure probabilities at transitions are due to locally increased hydraulic loading and/or reduced structural resistance.

3. EA funded research underway will enable assessment of these changed probabilities via structured inspection and determination of structural mitigation measures that can be designed and applied to new and existing transitions.
Thankyou

Transitions queries to j.simm@hrwallingford.com

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