# Case on: (Failure mechanism) and (Technique(s) used)

*This template can be used to describe:*

* + - *A case study of a reinforcement or retrofitting that has been carried out, and or*
    - *A case study of a pilot or demonstration project in the development of an innovative technique and/or*
    - *A case study of experiments investigating the feasibility of innovative techniques.*

**Authors**: Please fill in names and affiliations of authors.  
*Note: all who contributed to this case, writing or reviewing can be added here. The TC 201 core team for this initiative will review all contributions.*

**Keywords**: Please select the relevant keywords from the lists of keywords provided here:

* Failure mechanisms: Liquefaction and breach flow sliding (in under water slopes); Slope sliding; Internal erosion; External erosion on the water side; External erosion on the land side; failure due to animal behavior or vegetation; failure due to objects on or in the levee.
* Type of setting: River levees; coastal levees; estuarine levees; mountain stream levees.
* Subsurface characteristics: soft clay; stiff clay; peat; sand; gravel; rock.
* Additional design considerations or uncertainties for design: increasing hydraulic loads (intensity or frequency) due to climate change; dryer periods and possible cracking in levees; land subsidence; multifunctional levees; requirements to make levees warn before failure or to fail slowly; material prices; environmental consideration; population growth or increasing economic value in areas sensitive to flooding.

### Setting

Examples of information needed are as location, subsoil, type of embankment, characteristics of embankment prior to reinforcement or retrofitting (e.g., presence of drainage), height, width of the levee, cross-section/profile of levee, *plan view(s)* hydraulic regime, length of the levee needed reinforcement vs total length of the system, information about protected area, …

If a proof of concept or pilot application is described, please include the relevant information regarding this.

### Problem description

Why does this embankment require a retrofitting or reinforcement? Has there been an assessment / failure mode analysis to understand what are the failure mechanisms / failure paths involved and what are these?

### Remediation measure(s)

**Description the selected remediation methods**

Description of application of the method(s). Please indicate whether this is an innovative pilot application or common practice.

Explanation why the method(s) was/were selected.

**Performance**

If the measure was implemented has there been a hydraulic loading effect since the retrofitting. What was the effectiveness? Does it work as intended, and if there were difficulties, were additional measures taken?

*Notes:*

* *If the method has not yet been implemented feel free to remove this section.*
* *This section gives an overview of the techniques, the detailed description of the techniques comes in the Technique Factsheets.*

### Other information about this case

Considerations for maintenance, extreme flood conditions, …

# Factsheet Technique: *name of technique*

*This factsheet can be used to describe a technique for reinforcement or retrofitting.*

**Authors**: Please fill in names and affiliations of authors.  
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## Failure mechanism(s) and/or Basic function

Which failure mechanism(s) is the technique used against? Please select from the list below, or add your situation. If multiple failure mechanisms or processes are relevant, please indicate those in the order of importance.

Liquefaction and breach flow sliding (in under water slopes); Slope sliding; Internal erosion; External erosion on the water side; External erosion on the land side.

Other aspects that are relevant for selecting the technique are for example animal behavior or vegetation; failure due to objects on or in the levee.

## Description technique

Describe the technique, including pictures, typical cross sections showing how it is applied,

Describe for which failure mechanism/failure paths the technique is intended.

Describe the physical principle on which the technique is based.

If relevant which other failure mechanisms or paths are influenced?

## Applicability

In which environments is the technique applicable? Can include aspects as:

* Which type of setting: River levees; coastal levees; estuarine levees; mountain stream levees.
* Subsurface characteristics: soft clay; stiff clay; peat; sand; gravel; rock.
* What type of levee (e.g., with/without other included structures? (such as a sheetpile wall, or a pipeline, a ramp/road, houses, …))
* what characteristics of the levee (e.g., urban or rural area)

## Design

### Design criteria

Please list the design criteria (for ultimate limit state and serviceability limit state) that you consider important.

### Which factors affect the dimensioning?

Please provide an overview of the main factors that affect the dimensioning. Which models (empirical, conceptual, analytical, numerical,…) can be used for design?

### How are key parameters for this technique Measured or estimated?

### Other design considerations

What other considerations affect the selection of the method or design? For example, considerations related to: increasing flood frequency, intensity, or duration due to climate change; dryer periods possibility of cracking in levees; land subsidence; requirements to make levees warn before failure or to fail slowly material prices; environmental considerations; population growth/ increasing economic value in areas sensitive to flooding, etc.

## Construction

### Which methods of construction are available?

### Other construction considerations?

Influence on surrounding, ….

## Variants on the technique or construction method

E.g., which different types of materials can be used

## References

If available, please include links. Please indicate in which language the reference is. URL’s can also be provided to websites which are not written in English.

### Design manuals/standards/codes of practice

*To do: provide a standard format for the references. Extended format.*

### Publications