



Mixed-in-place



Dike nailing

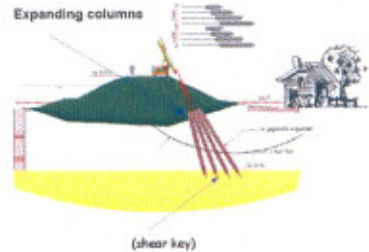


Expanding columns

## Expanding columns

### What

A crane installs a pipe from the crown of the dike through the soft soil substrate down to the Pleistocene sand layer. The pipe is sheathed in a mantle that expands when a filler of cement-bentonite is pumped into it. The column 'expands' and in time the filler sets.



### How

The expanding column stands with its 'heel' in the sand and sets with several columns simultaneously its shoulders under the dike. The so-called 'shear key' anchors the dike in the Pleistocene sand layer. The expansion of the mantle ensures compression of the surrounding soft soil that consequently becomes firmer.

### Who

Consortium ▲-dike: DHV, Fugro, Arcadis, Ballast Nedam Nederland, Midden Betuwe Aannemings Mij.

Ministerie van Verkeer en Waterstaat



Rijkswaterstaat



WaterINNovatiebron



**INSIDE - INNovations on Stability Improvements enabling Dike Elevations**





Dike reinforcement in the future not discounted overall:

- due to climate changes;
- due to higher river water levels;
- due to surface subsidence.

Restricted space for traditional dike reinforcement:

- the dike is reinforced by widening with soil;
- government policy of Increasing the Amount of Space for the River' does not allow dike widening on the river side;
- there are often buildings on the polder side of the dike.

INSIDE has developed a solution for this!

INSIDE has developed via 3 consortia innovative procedures for reinforcing dikes without widening them:

1. Mixed-in-place
2. Dike nailing
3. Expanding Columns

Important features of these new techniques are:

- sustainable
- safe
- space saving
- cost effective
- friendly to the surroundings
- socially accepted

Initiative:

- Rijkswaterstaat (Directorate-General for Public Works and Water Management) (WaterINNOvatiebron)
- CUR
- GeoDelft (geotechnical advisor)

Intensive cooperation with:

- Water control authorities
- Provinces
- Commercial partners

## More information

[www.waterinnovatiebron.nl](http://www.waterinnovatiebron.nl)



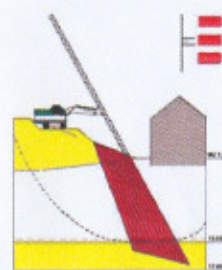
## Mixed-in-place

### What

A mixer blends a binding agent (including cement) with the soft soil substrate in and under the dike body. After setting a stabilized soil column is created. The stabilized columns form together one block that increases the stability of the dike.

### How

The stabilized blocks serve as underground buttresses anchored in the Pleistocene sand layer. Mixed-in-Place is a method of ground improvement that has been applied in the Scandinavian countries and in Japan for prevention of vertical deformations. It is now being applied in a dike for the first time to increase lateral stability.



### Who

Consortium HKR: Hakkers Werkendam, Keller Funderingstechnieken & Royal Haskoning.

## Dike nailing

### What

A crane inserts tension elements into the inner embankment of the dike at a suitable angle and in a particular pattern. The tension elements are flexible. Grout around these elements guarantees the interaction with the surrounding soil. Dike nailing is based on the familiar principle of 'soil nailing'.

### How

A possible displacement of the dike body is resisted by the nails that retain by means of slide and tension forces retain the soil in its place. The part of the dike that is prone to displacement is as if it were 'pinned down' by the stable section of the dike.

### Who

Consortium Inside Squad B+G+V+W: Boskalis BV, Grontmij Advies & Techniek BV, Van Hattum & Blankevoort BV, Witteveen + Bos.

