Overview of flood retaining structures in the Netherlands

Fourth International Symposium on Flood Defence; 6-8 May 2008

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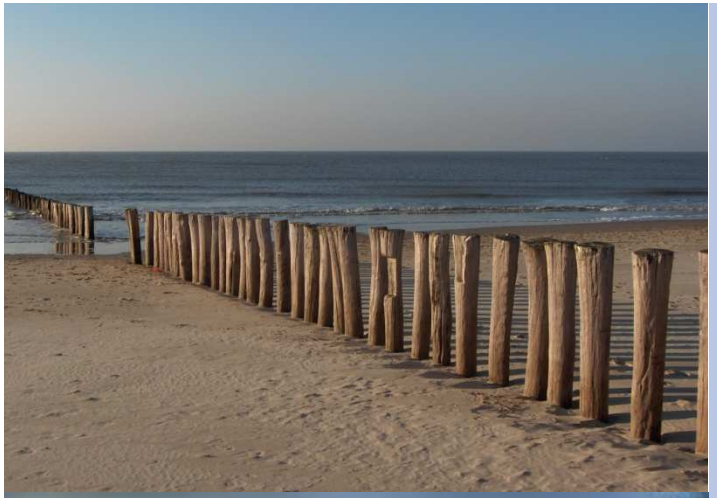
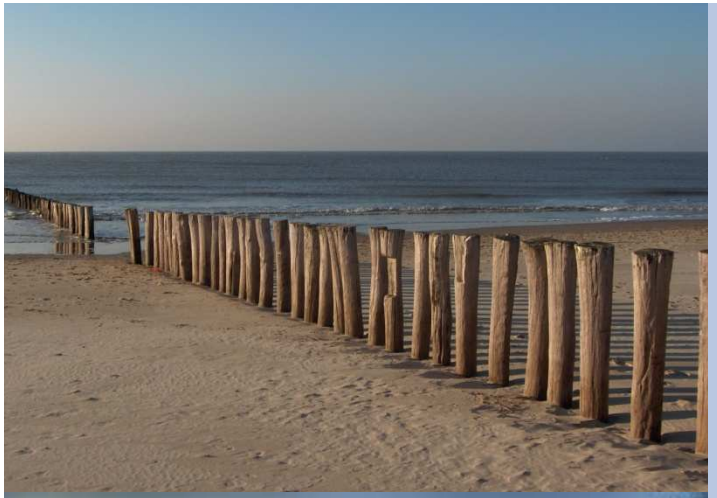


The Dutch lowlands



The Dutch lowlands

The Netherlands is a rather flat country.

Lowest point is found in the city of Rotterdam: 6.7 meters below mean sea level.

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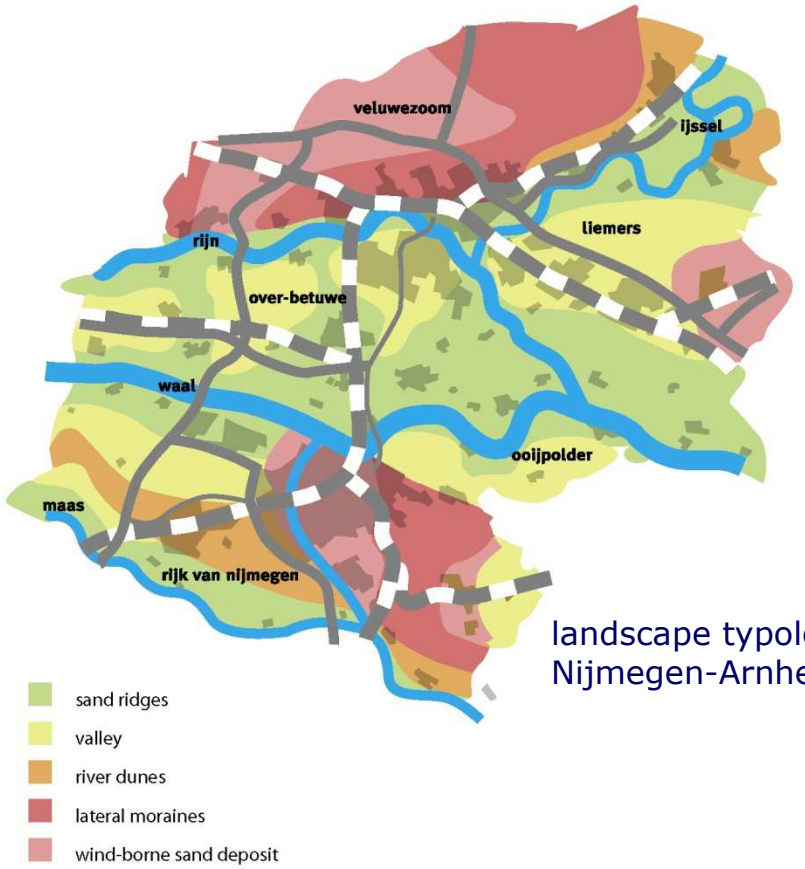
Flood protection – history

- River dunes were very popular for settlements;
- They can be seen as the first protection against flood in the Dutch river area;
- The first dikes were built in the tenth century;
- A closed dike system was established around 1300;



landscape typology Nijmegen-Arnhem

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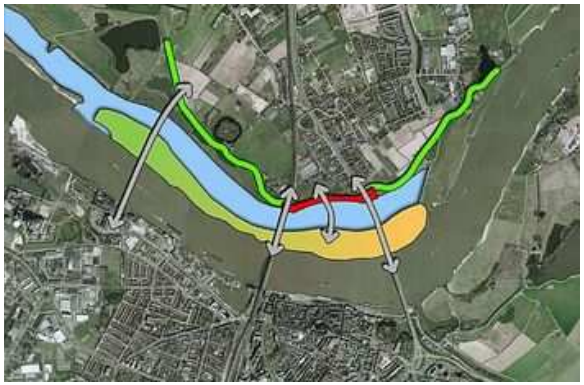
Flood protection – nowadays



'fighting the water' => 'living with water'

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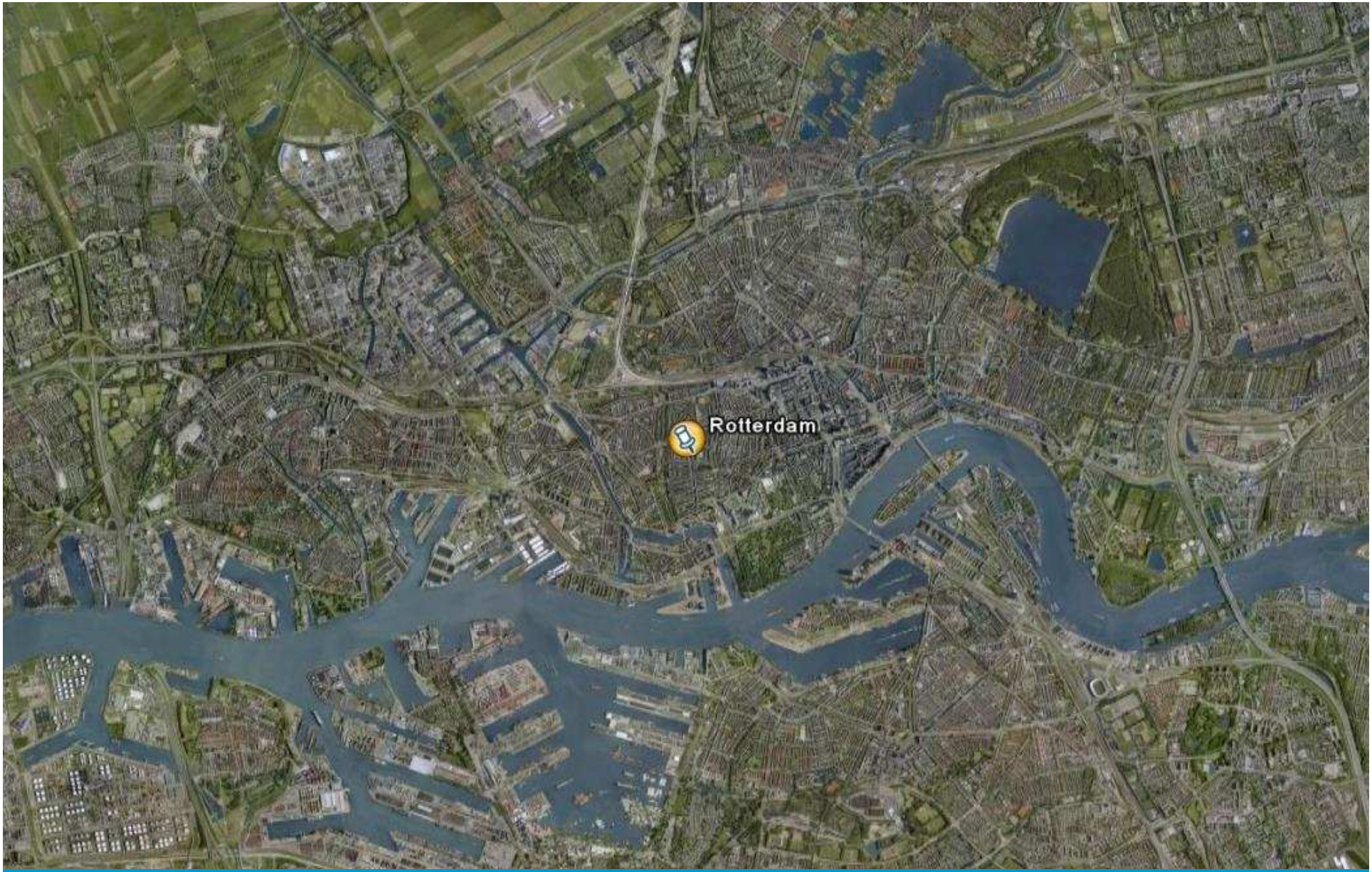

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Objective

Objective is to give an overview of flood retaining structures applicable to urban areas in the Netherlands.

Research approach

- Field work: ten Dutch river cities
- Literature study: e.g. material of the Expertise Network of Flood Protection (ENW)

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Classification of flood retaining structures

main level	sub level	subsub level
water - water	earth structures	temporary structures
water - earth	special water retaining structures	permanent movable structures
	hydraulic artifacts	permanent immovable structures
		combined structures

Classification of flood retaining structures

back

Sublevel

Earth structures:
These structures are weight structures which are naturally formed by morphology or which are constructed with mainly earth materials.

Special water retaining structures:
These structures are used in areas where other functions are present causing insufficient space for earth structures.

Hydraulic artefacts:
These structures are mainly applied at utilitarian crossings and cause gaps in the flood defence. Examples are structures for navigation and water management.

Classification of flood retaining structures

back

Subsublevel

Temporary structures:
These structures are only placed and used during a short period of time. They are stored elsewhere.

Permanent movable structures:
These structures are constructed at location and cannot be stored elsewhere. The structures are (partly) movable which minimizes the hinder for other activities during normal circumstances.

Permanent immovable structures:
These structures are constructed at location and cannot be stored elsewhere. They are not movable and therefore always present in the urban realm.

Combined structures:
These structures are a combination of the above mentioned structures.

water - earth

back

sub level	subsub level	structures
earth structures	permanent immovable structures	dikes
		high grounds
special water retaining structures	temporary structures	sand bags
	permanent movable structures	gate flood defences
	permanent immovable structures	quay walls
		fortification
		floodproof houses
		stairs
	combined structures	stop logs
		Adaptable Flood Defences

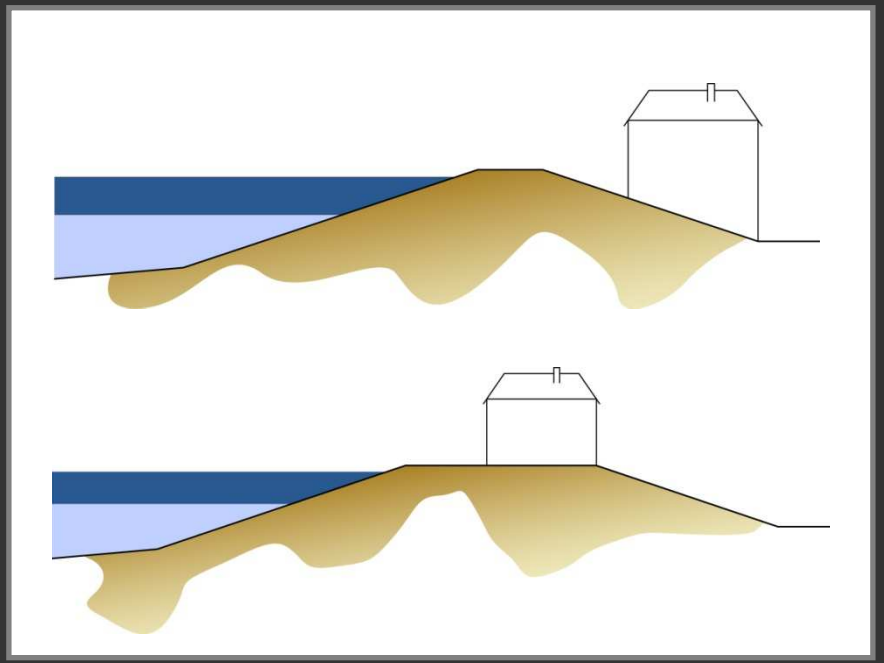


back

dikes

Specifications

Material core	Clay or sand
Material revetment	Clay or sand with turf / asphalt / block revetment
Retaining principles	Dimensions and shape of the cross section
Dimensions	B = large, needs space h = according to demanded safety level L = flexible line element
Applicability	Coastal shore line, river shore line, lakes, channels, polders

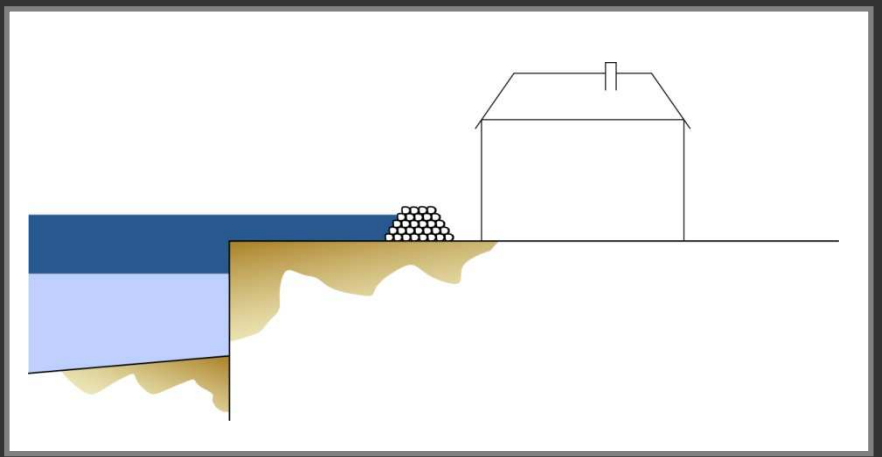


back

sandbags

Specifications

Material	Bag: jute or synthetic material Filling: sand
Retaining principles	Dimensions and shape of cross section
Dimensions	B = medium, depending on the height difference h = according to demanded safety level L = flexible line element
Applicability	At every transition zone with enough space for piling up



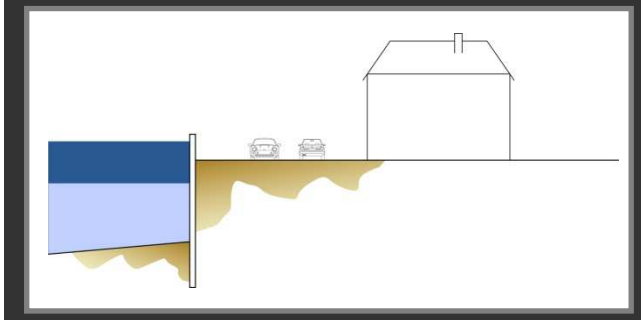
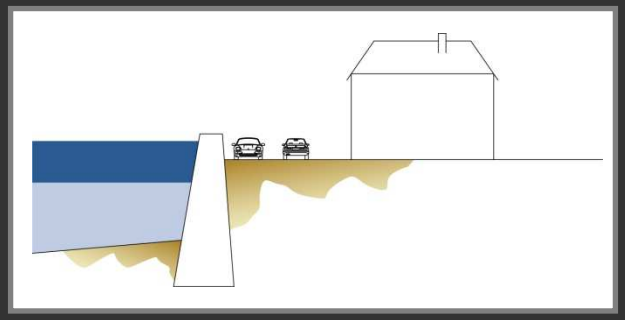
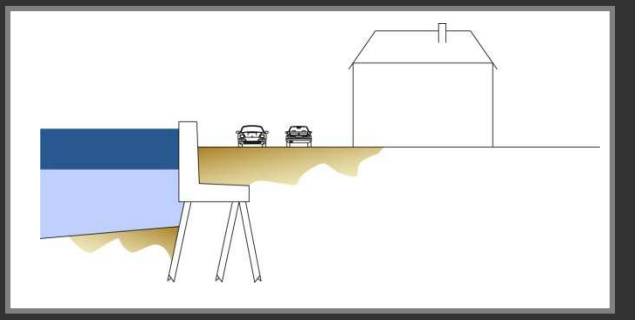


back

quays

In general, these walls can be divided into three types (Technical Advisory Committee on Water Defences 1997):

- slender retaining wall
- gravity dam
- L-shaped wall

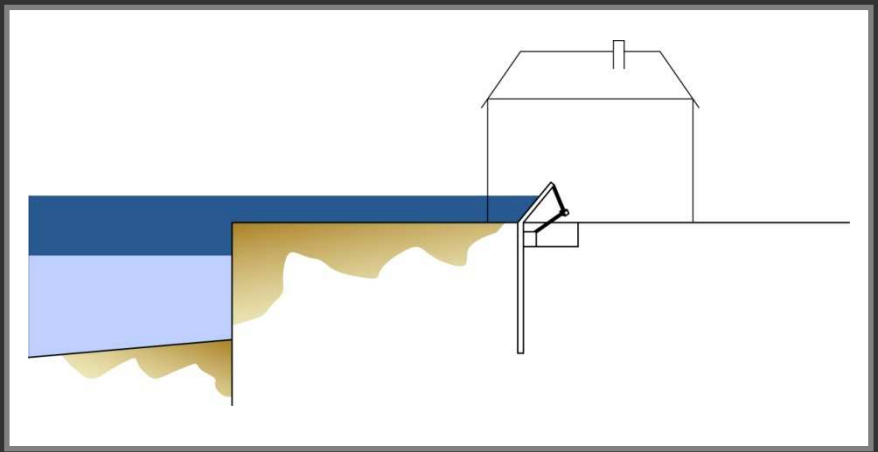




back

gate flood defenses

Specifications

Material	Steel
Retaining principles	Dimensions and shape of the cross section
Dimensions	B = medium h = according to demanded safety level L = flexible line element
Applicability	Locations with paved surface and easy access for usage

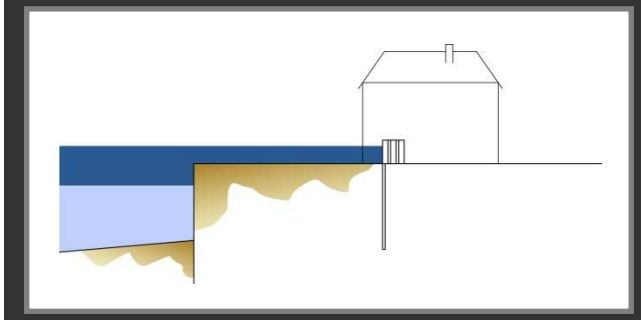
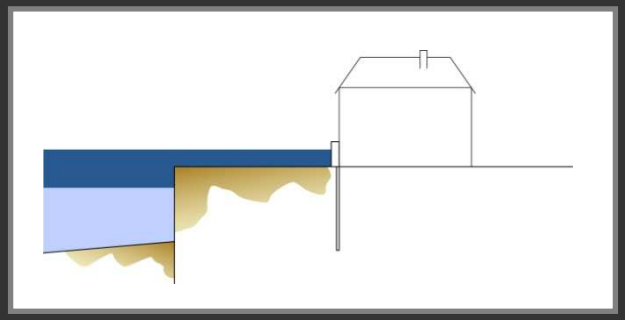
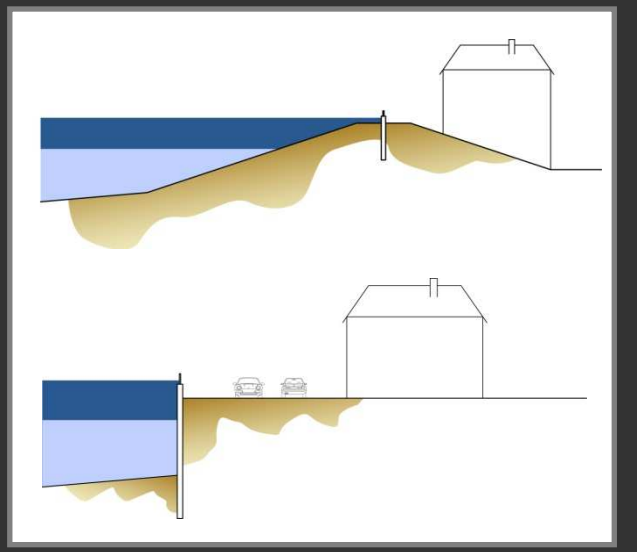


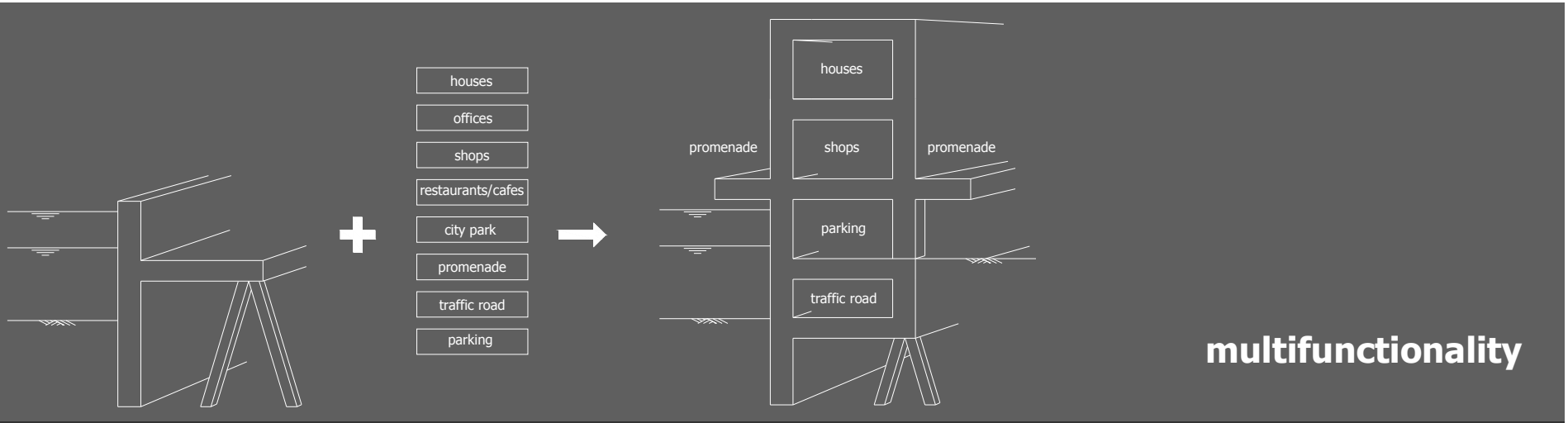


back

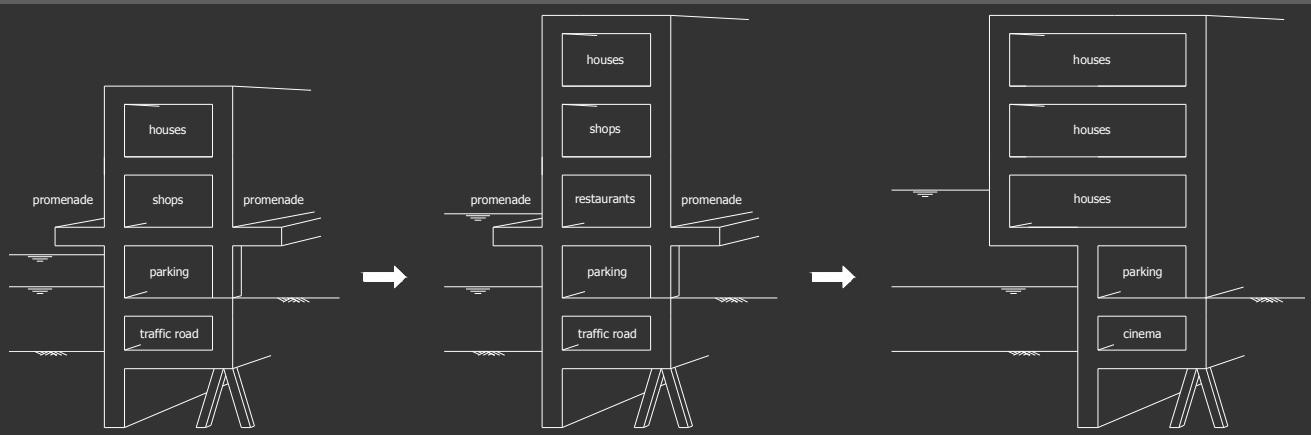
stoplogs

In general, these stoplogs can be used in three situations:
- stoplogs at cross roads
- stoplogs at doorways
- stoplogs at line elements

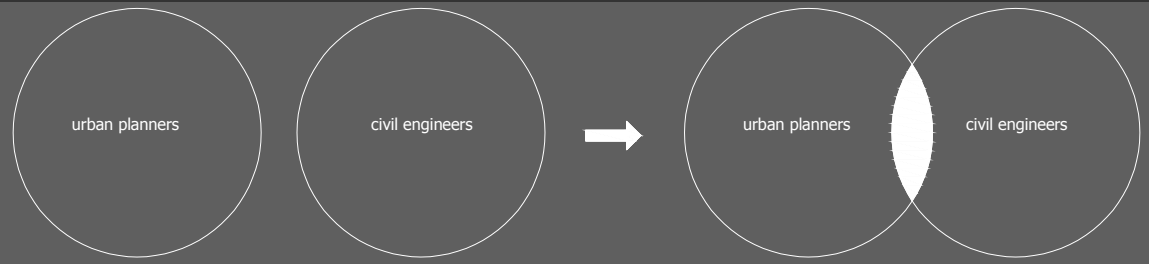






multifunctionality



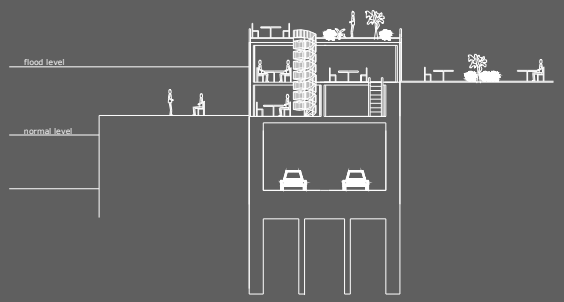
adaptability



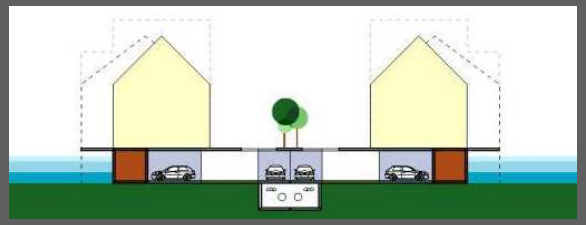
synergy

Adaptable Flood Defences (AFD)

visionary concepts



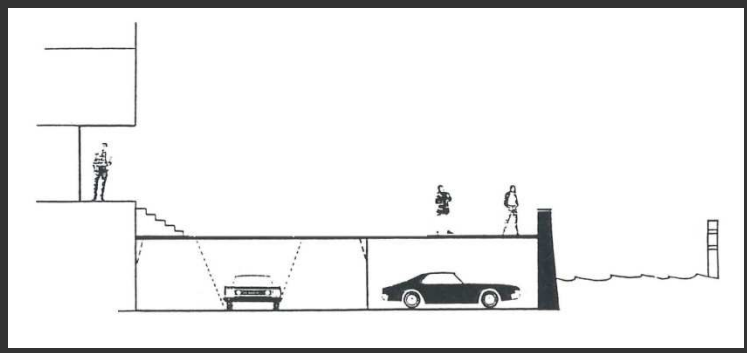
'adaptable building'
Deventer (NL)



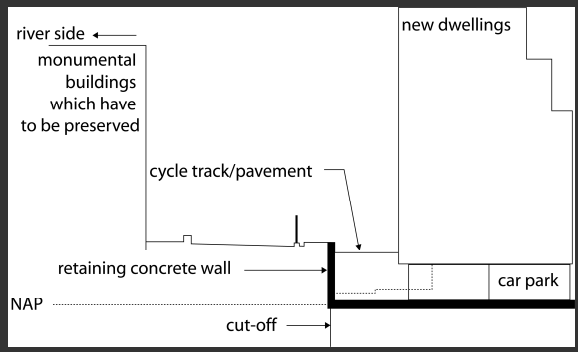
'holle dijk'
Haarlemmermeer (NL)

realized projects

'Westkeetshaven'
Zwijndrecht (NL)



'dordtse wand'
Dordrecht (NL)



Adaptable Flood Defenses (AFD)

Conclusions

This presentation has shown an overview of flood retaining structures applicable in urban areas in the Netherlands

Match of applicability depends on the spatial boundary conditions of the urban areas and the specifications of the flood retaining structures.

The concept of Adaptable Flood Defenses is added value to the overview.

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Overview of flood retaining structures in the Netherlands

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water - water

back

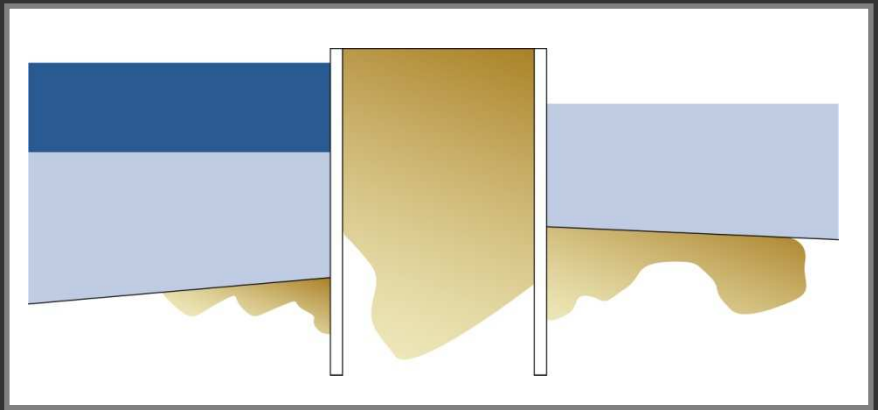
sub level	subsub level	structures
earth structures	permanent immovable structures	earth dams
special water retaining structures	permanent immovable structures	cofferdams
hydraulic artifacts	combined structures	storm surge barriers
		dams
		Adaptable Flood Defences

back

cofferdams

Specifications

Material	Sheet piles (concrete or steel) in combination with earth
Retaining principles	Vertical waterproof wall with enough length to provide sufficient stability
Dimensions	B = small h = according the demanded safety level L = flexible line element
Applicability	In areas with difference in height of water and / or earth

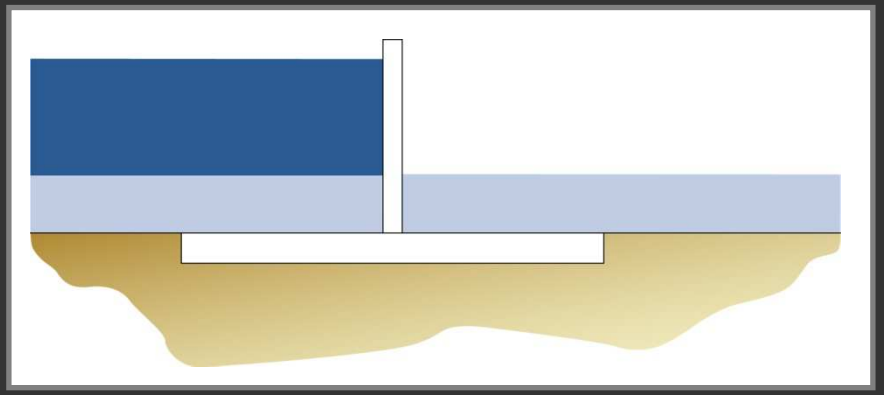


back

storm surge barriers

Specifications

Material	Concrete / steel / fabric
Retaining principles	Weight of the structure / pile foundation in combination with gates
Dimensions	B = medium / large, depending on the gate h = according to the storm level and crest of surrounding dikes L = large, depending on the canal width
Applicability	At transition zones of river – sea or river - lake



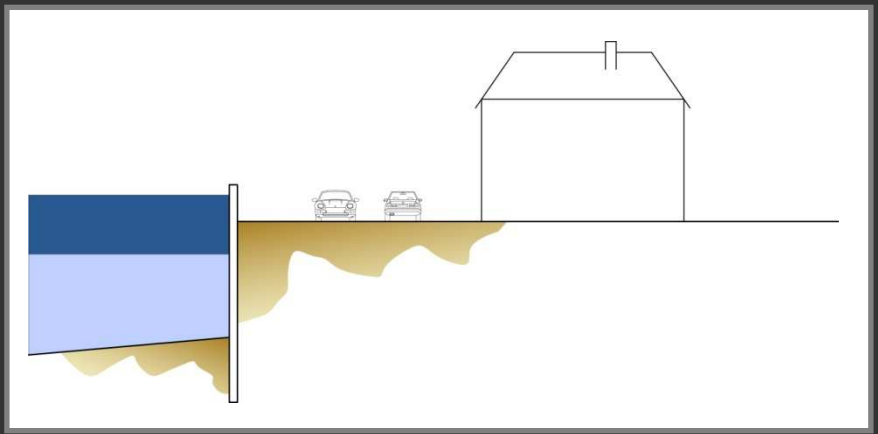


back

slender retaining wall

Specifications

Material	Wall: steel (sheet pile) or concrete (e.g. slurry wall) or wood Anchor (e.g. screw anchors or grout anchors)
Retaining principles	Drive depth of wall in combination with earth pressure
Dimensions	B = very small (without earth section) h = according to demanded safety level L = flexible line element
Applicability	At every transition zone with space for anchors: often applied in harbour areas

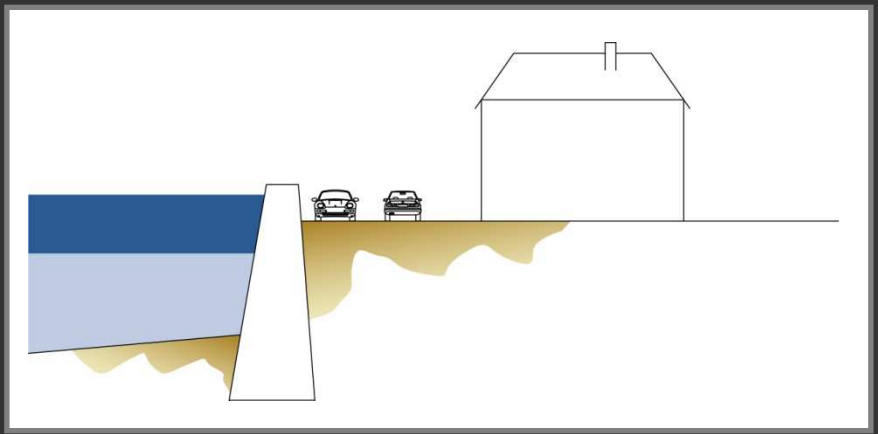


back

gravity dam

Specifications

Material	Concrete caisson / cofferdam / wall: concrete or bricks Subsoil foundation or pile foundation Cut off
Retaining principles	Wall: weight of structure / pile foundation Cut off: expansion of saturation line due to its length
Dimensions	B = medium width, according to demanded safety level h = according to demanded safety level L = flexible line element
Applicability	At every transition zone with space: often applied in harbour areas

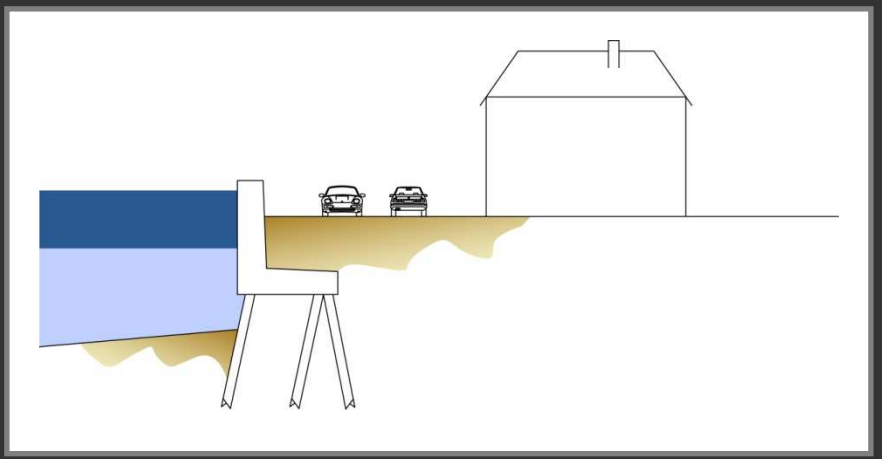


back

L-shaped wall

Specifications

Material	Wall: concrete Pile foundation Cut off
Retaining principles	Wall: weight of structure combined with earth and foundation Cut off: expansion of saturation line due to its length
Dimensions	B = medium width, according to demanded safety level h = according to demanded safety level L = flexible line element
Applicability	At every transition zone: often applied in harbour areas



back

gate flood defenses

Specifications

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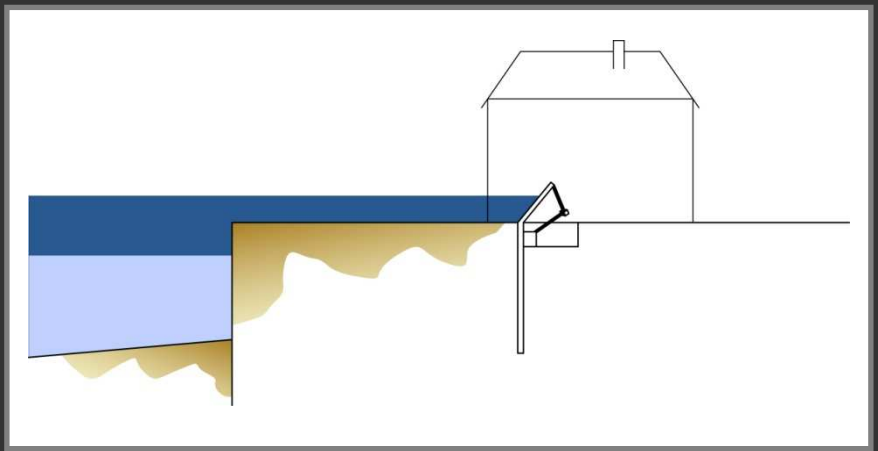
Applicability	Locations with paved surface and easy access for usage

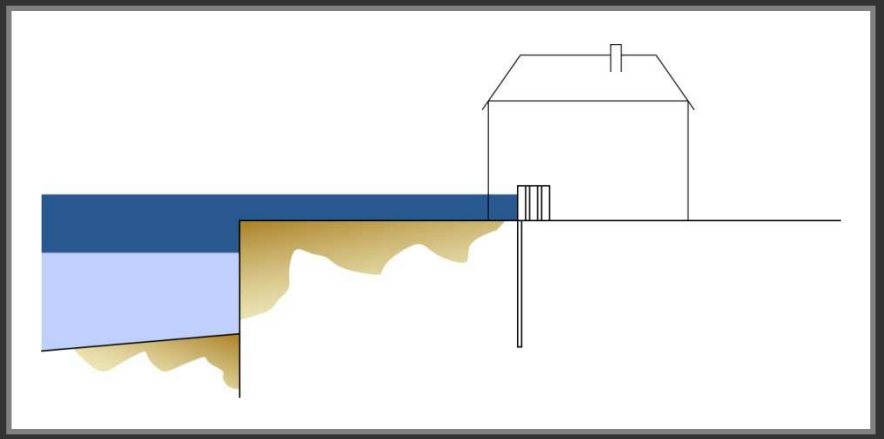


back

stoplogs at cross roads

Specifications

Material	Wood (in combination with horse manure) Aluminium with rubber profiles
Retaining principles	Extension of the permanent structures: Drive depth of the structure in combination with earth pressure
Dimensions	B = small h = according to demanded safety level L = flexible line element
Applicability	In gaps caused by cross roads In gaps caused by buildings In combination with dikes and quays to gain extra height





back

stoplogs at doorways

Specifications

Material	Wood (in combination with horse manure) Aluminium with rubber profiles
Retaining principles	Extension of the permanent structures: Drive depth of the structure in combination with earth pressure
Dimensions	B = small h = according to demanded safety level L = flexible line element
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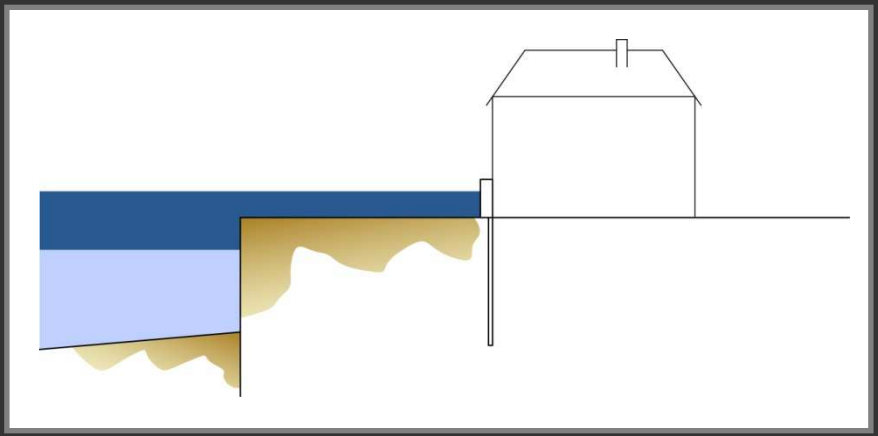

back

stoplogs at line elements

Specifications

Material	Wood (in combination with horse manure) Aluminium with rubber profiles
Retaining principles	Extension of the permanent structures: Drive depth of the structure in combination with earth pressure
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