MODELLING OF F WAVE-STRUCTURE INTERACTION FOR THE BELGIAN COAST: reasons and objectives

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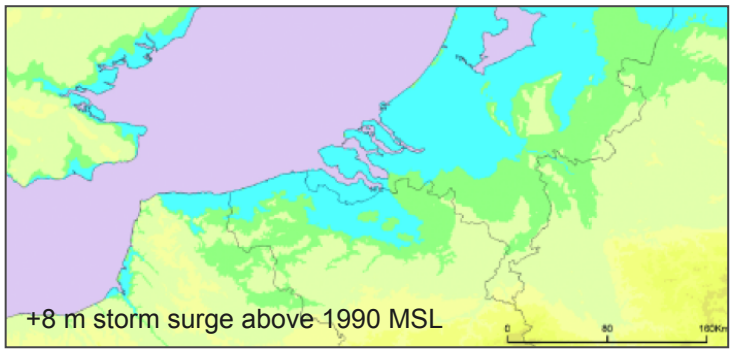
BACKGROUND

- Flemish coast is low-lying and densely populated ⇒ high coastal flood risk
- In 2011 the "Coastal Safety Masterplan" was approved by the Flemish Government and provides solutions to protect the entire Belgian coast from erosion and flooding considering the possible effects of climate change to the year 2050
- Implementation of these solutions (which includes **beach nourishment** and **upgrade of existing dikes**) is scheduled to be completed by 2015

Afdeling Kust (2009)



Marbaix, et al. (2004)

The Flemish Coast

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- Length: 67 kms
- Area: 600 km²
- 650 inhabitants/km²
- **Situated below high-water level**
- Coastal lowlands
  - dense population
  - high economic value
  - high recreative value
  - high ecologic value

- How much protection is needed ?
- Where do we need extra measures ?
- How to protect the coast ?

Coastal Safety Masterplan

The Harbours

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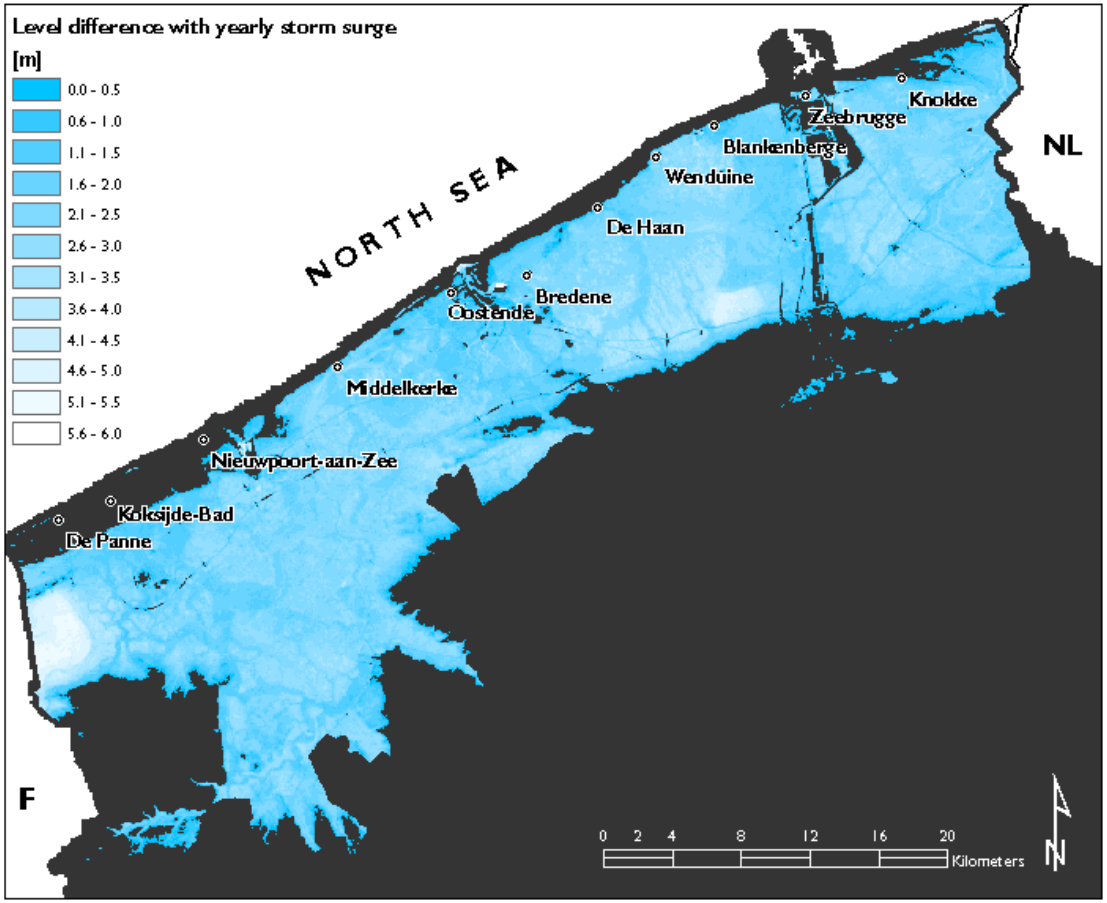
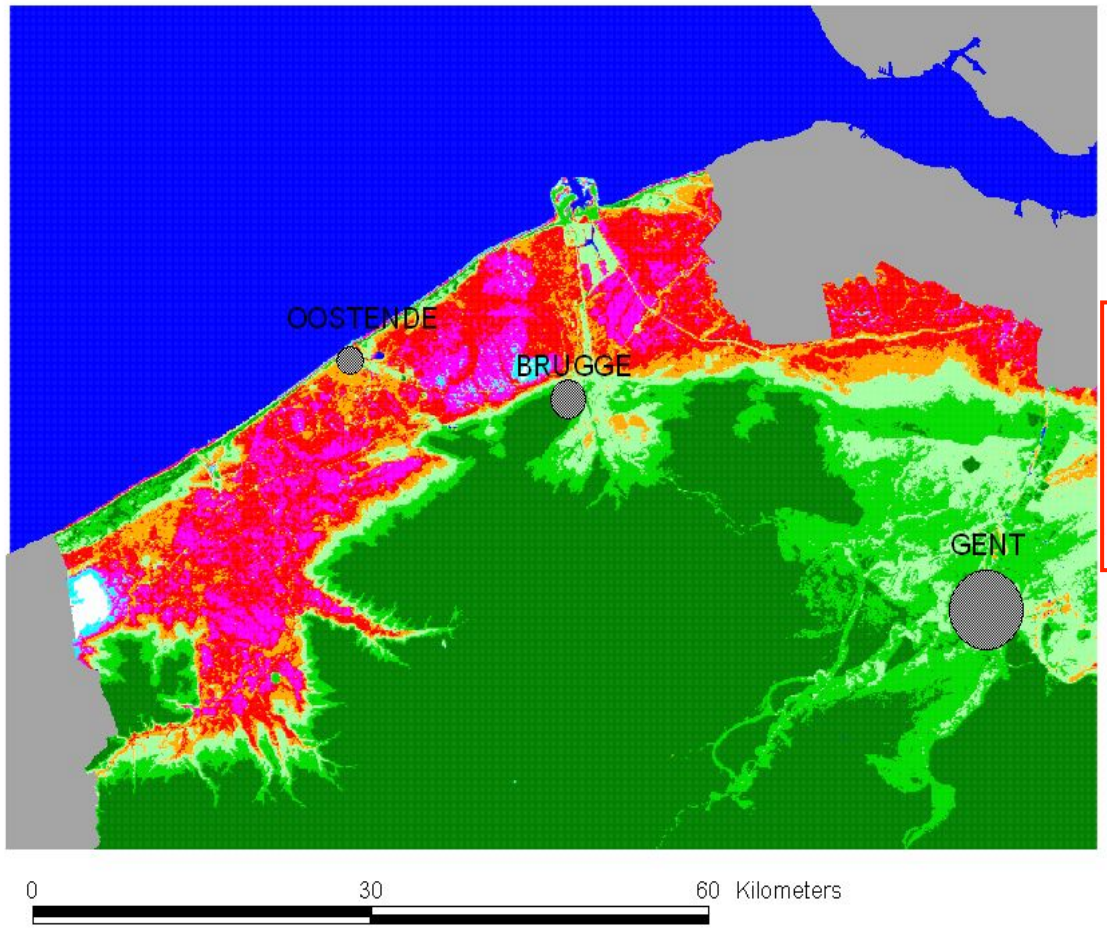
A ‘man-made’ coastline

Low-lying, densely populated coastal zone



- **Risk of damages (billions €) and casualties (thousands) in worst case**

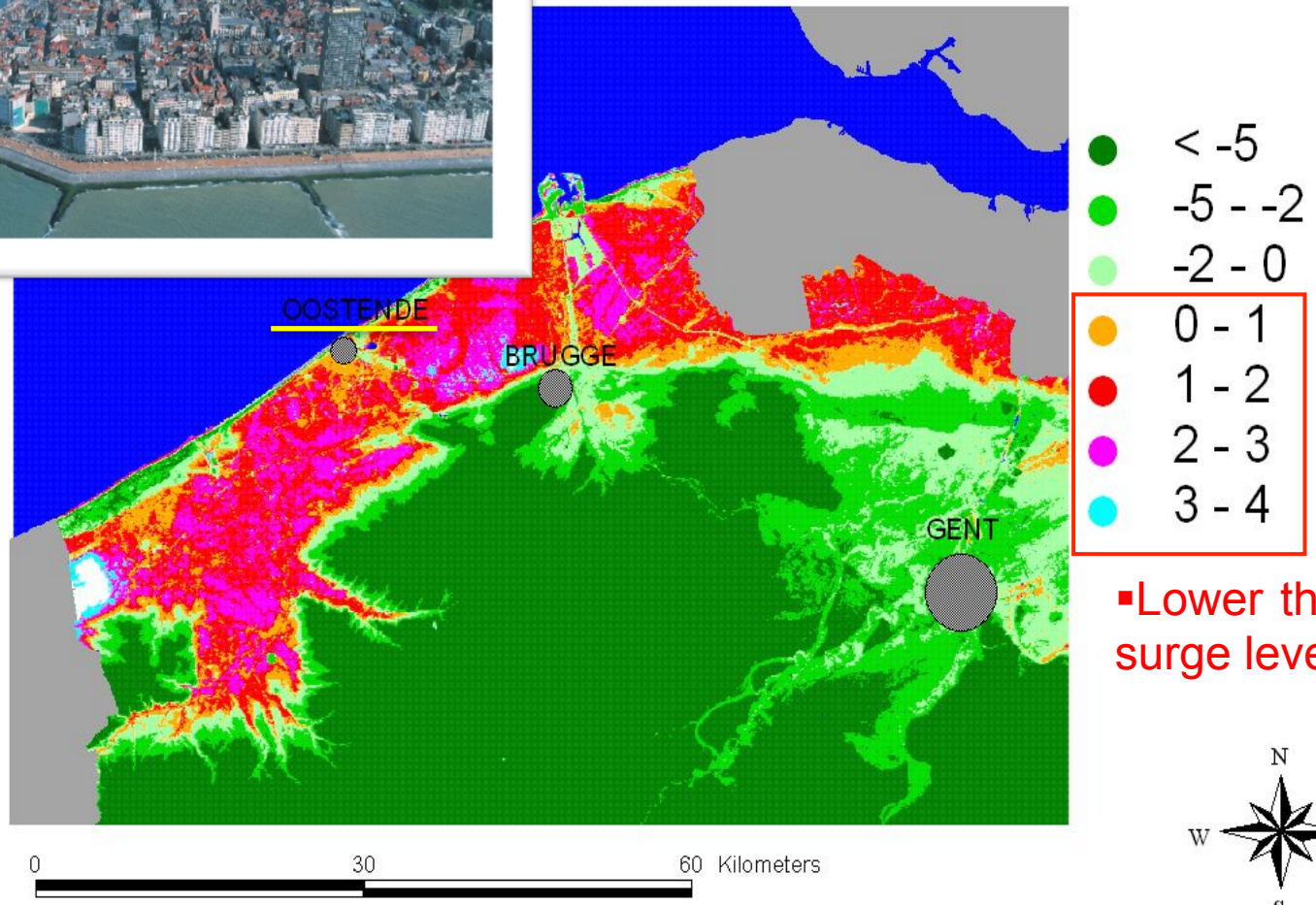
▪Land level (relative depth from storm surge level) in the Flemish coast



▪Lower than storm surge level

▪ low-lying, densely populated coastal zone

epth from storm
mish coast



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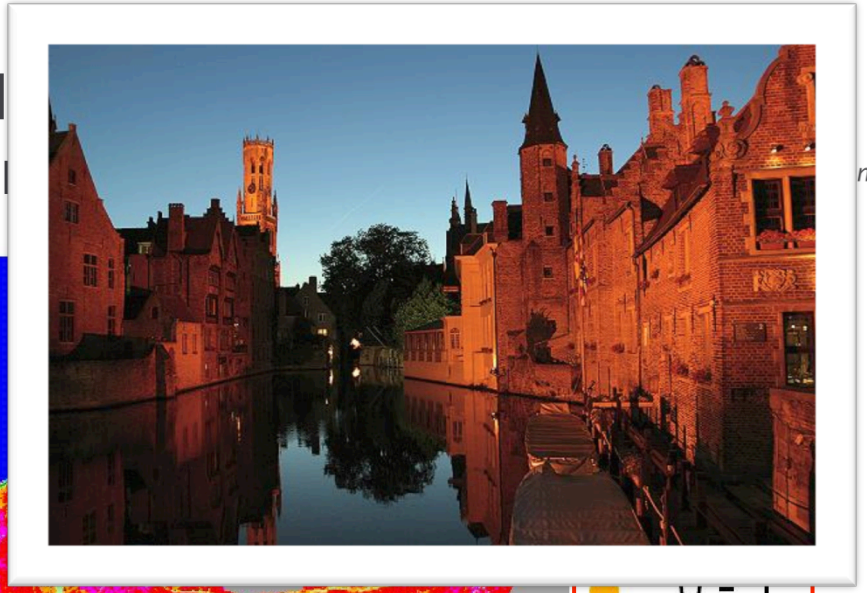

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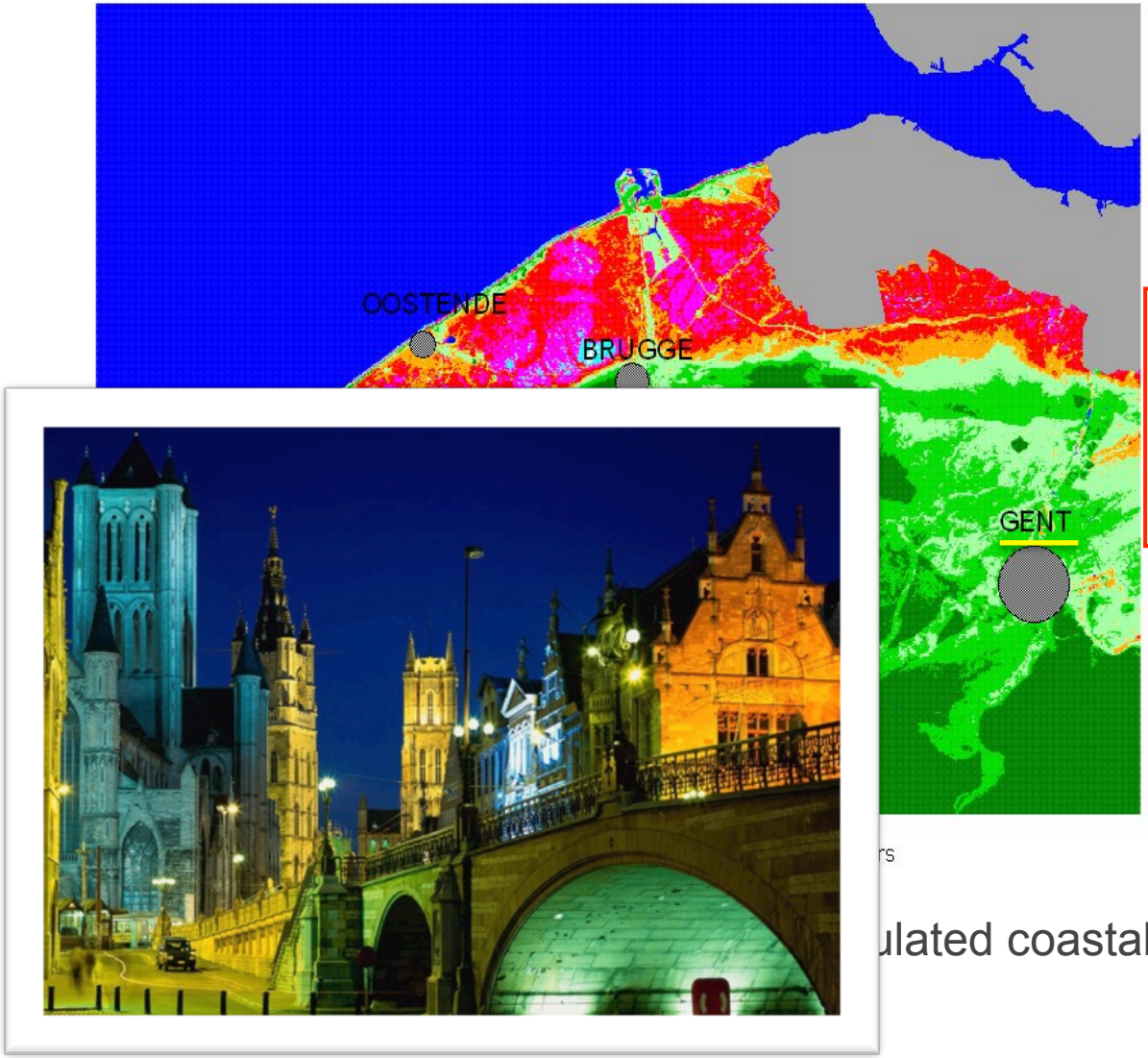


- Lower than storm surge level

ulated coastal zone

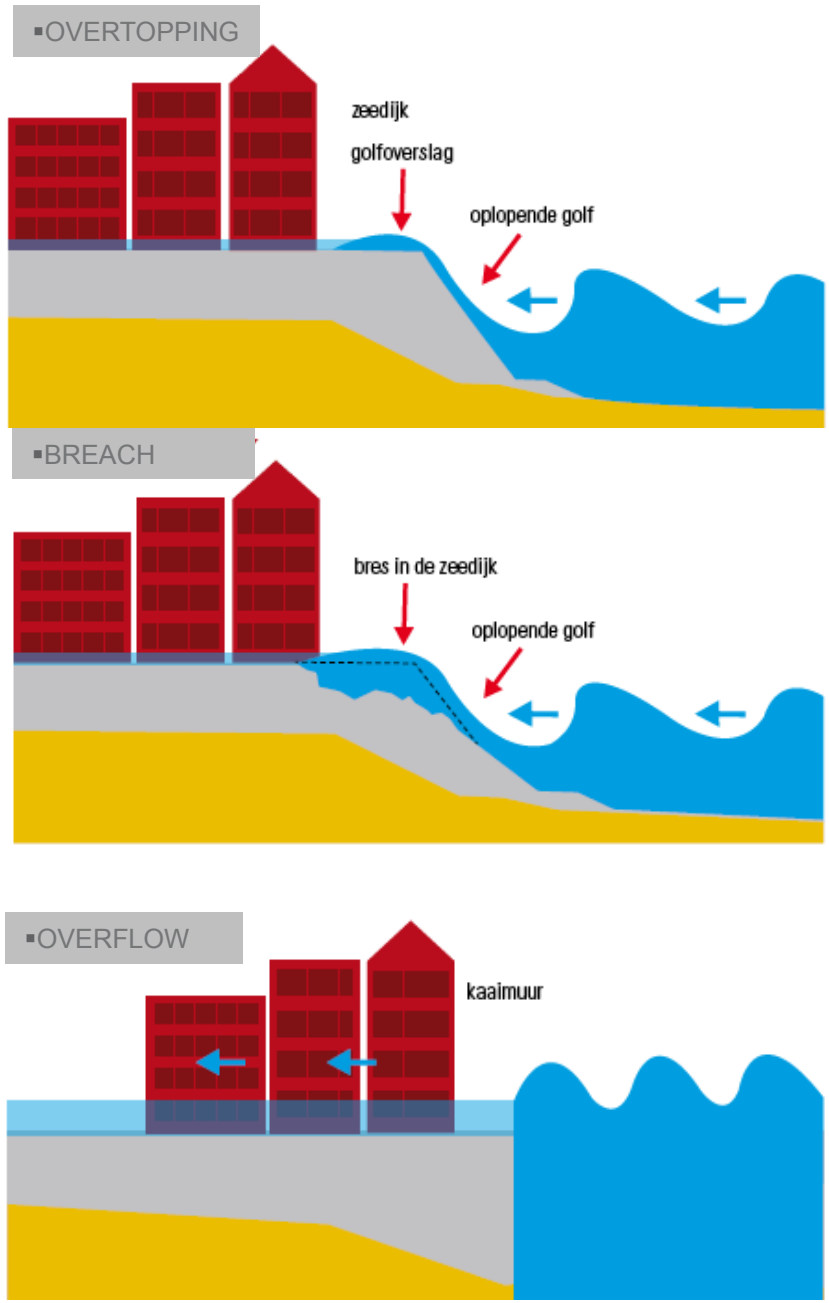
- 1953 storm +6.66m TAW
- RP = 250 year
- 7.5 million euros (with prices of 1953!) damage repair of sea walls
- 7 victims at the coast (Ostend)

Failure mechanisms

- Coastal towns
  erosion beach & high overtopping discharges
  1. failure of revetment → erosion dike volume → critical volume → breach growth
  2. stability loss buildings on sea wall

- Dunes
  erosion dune volume → critical volume → breach growth or failure of buildings

- Harbours
  overflow & high overtopping discharges
  1. erosion of volume → critical volume → breach growth
  2. structural failure locks & weirs



Coastal safety plan

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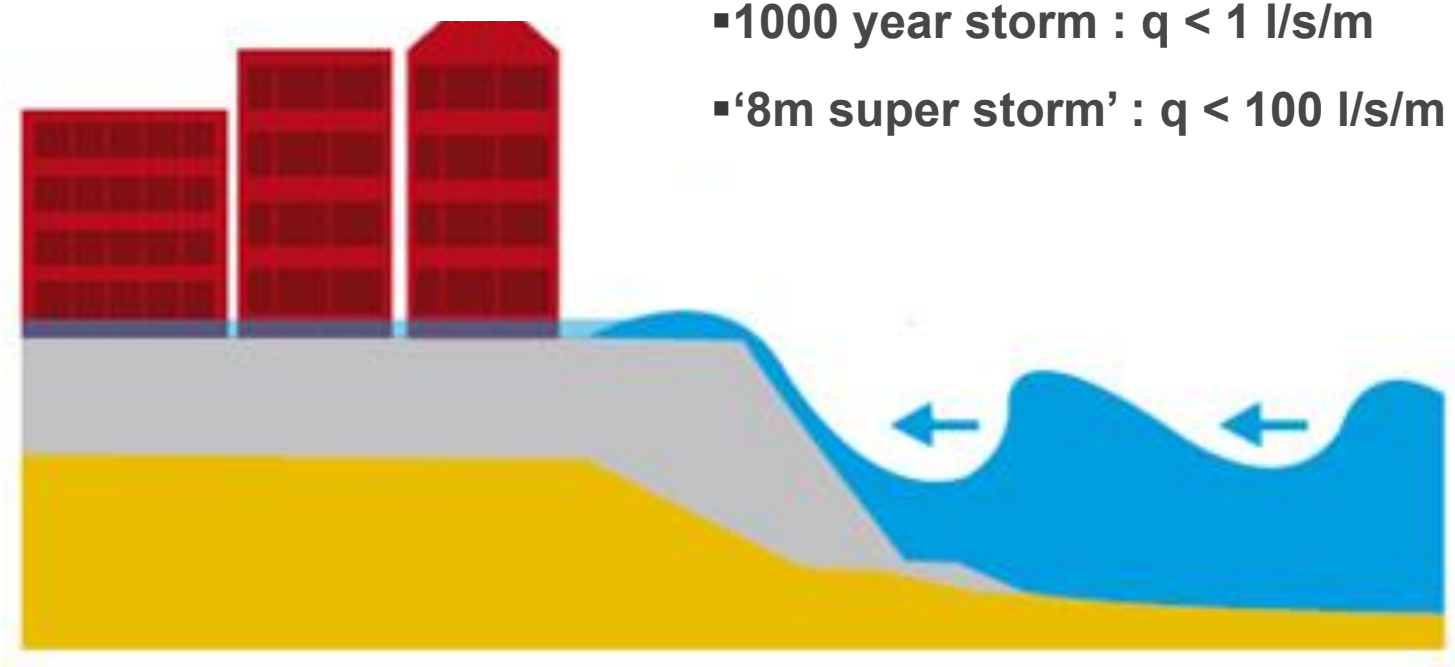
- **Wave overtopping discharge**
- **1000 year storm : q < 1 l/s/m**
- **'8m super storm' : q < 100 l/s/m**



▪Coastal safety plan

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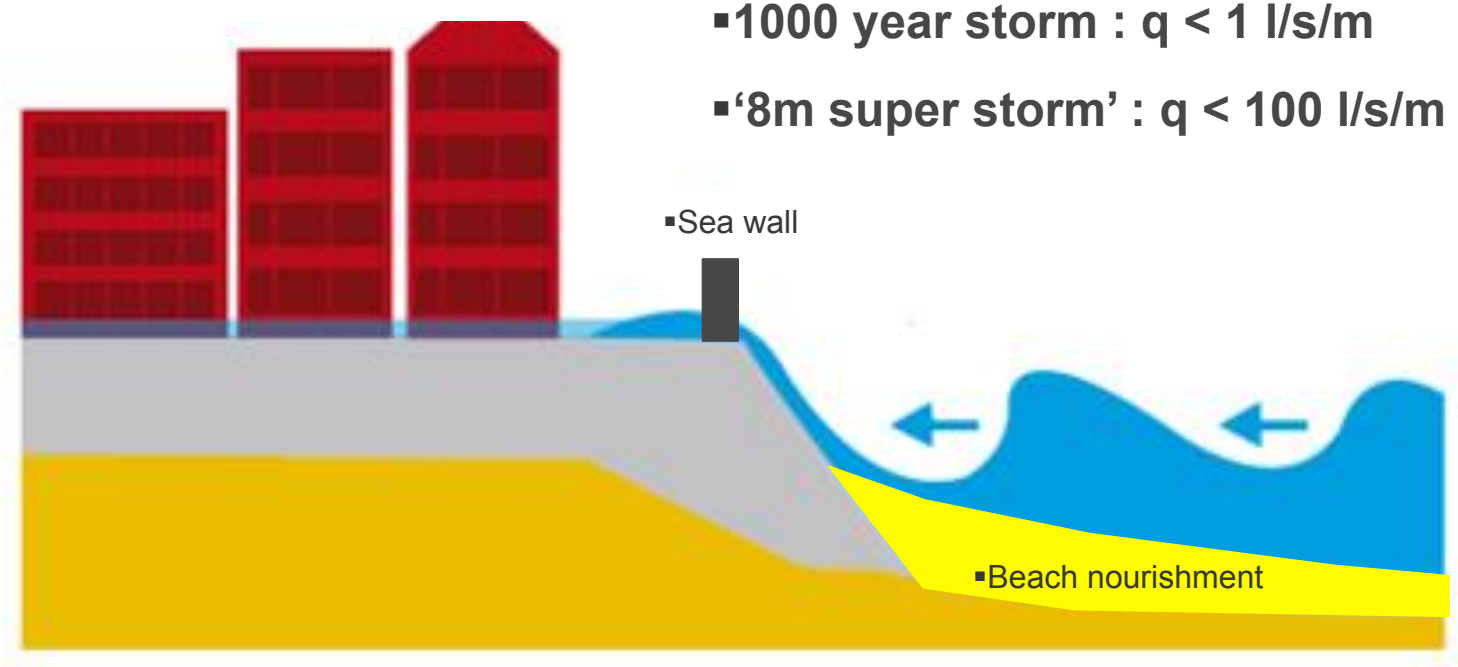
▪+ beach nourishment
▪+ sea wall

▪Wave overtopping discharge
▪1000 year storm : q < 1 l/s/m
▪'8m super storm' : q < 100 l/s/m



What is the effect of beach nourishment and seawalls?

▪Research motivation

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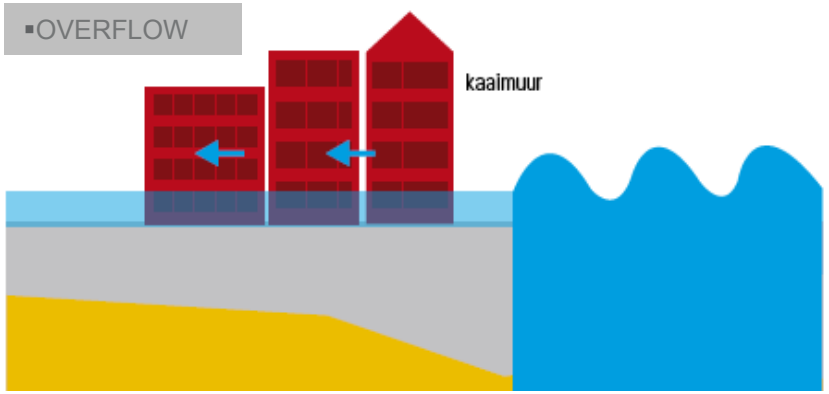
- **Failure mechanisms considered in the Coastal Safety Masterplan**

- Coastal Towns and Harbours:
  - structural failure due to overtopping and overflow

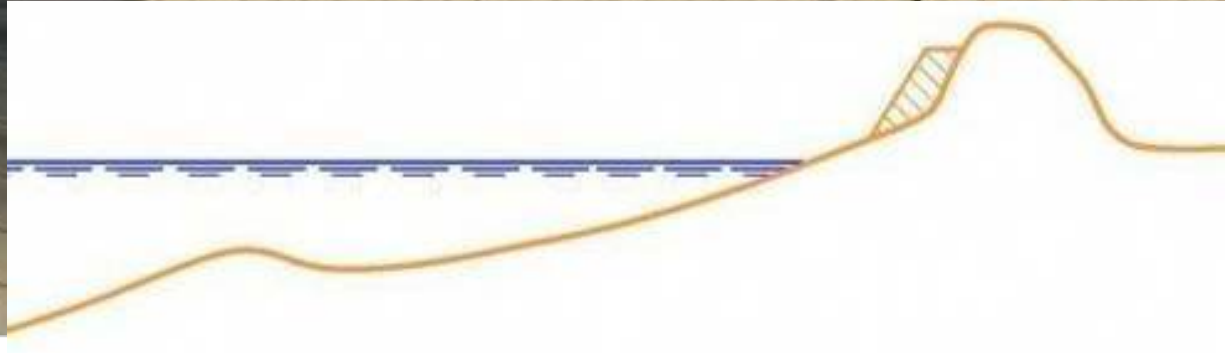
▪OVERTOPPING

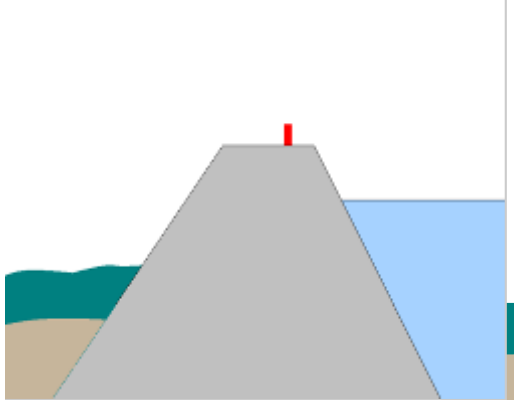
▪OVERFLOW

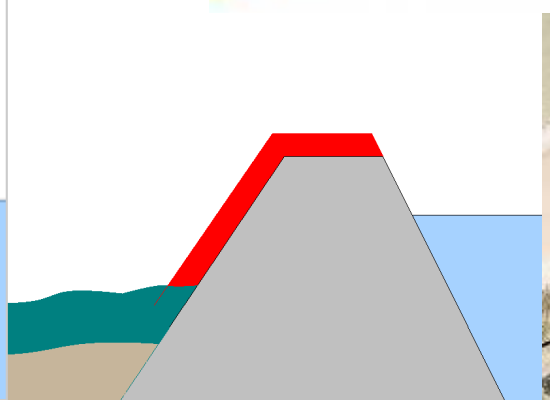


▪Assessment of wave run-up, overtopping, flow velocities and wave forces and pressures on coastal structures

▪From engineering design …







… to architecturale design

WENDUINE: Existing coastal defense

- The Coastal Safety Masterplan identifies **Wenduine** as a weak link in the Belgian coastal defense line due to the low freeboard of the existing dike

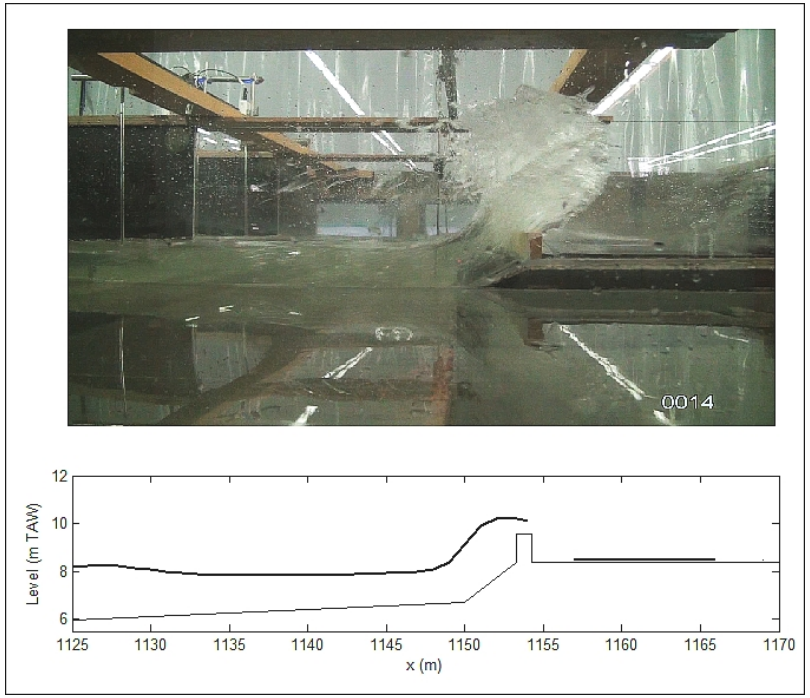
- Key features of the existing sea dike:
  - Sandy, shallow foreshore (1:35 beach slope)
  - Low lying hinterland behind dike
  - High touristic and recreational value (high wave walls not acceptable)
  - Multi-functional (coastal defense, road, promenade, cafes/restaurants, beach access)

Testing of the coastal defences

- Tests have been carried out at Flanders Hydraulics Research
- Physical and numerical (SWASH) models used to test coastal defense designs

Physical Modelling:
Large wave flume
1:25 scale

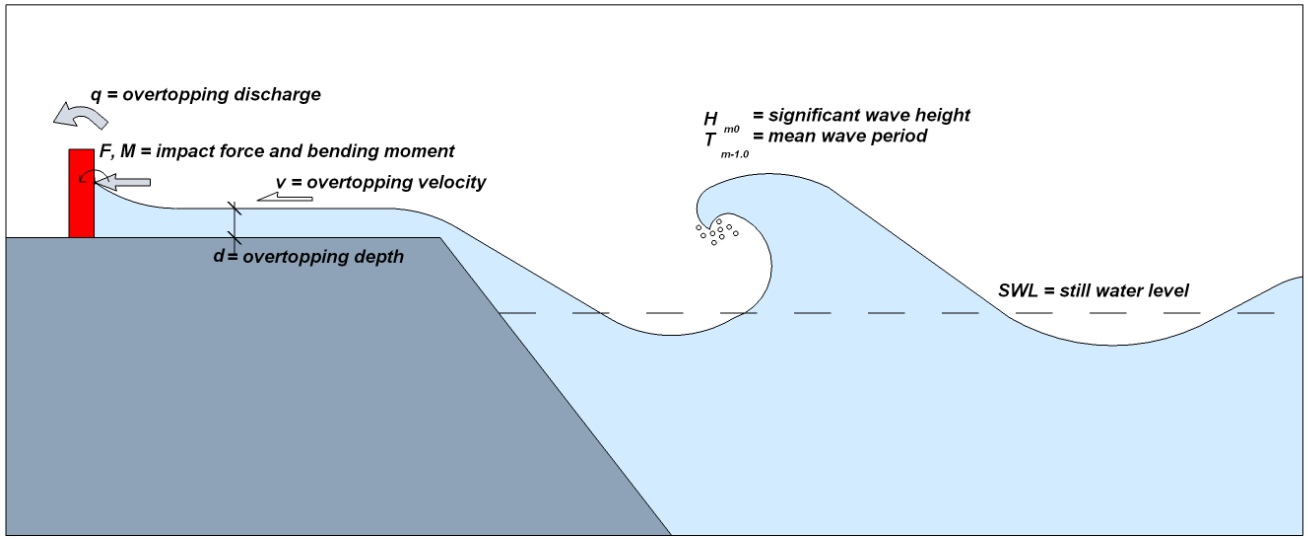
Numerical Modelling:
SWASH



Purpose of the model

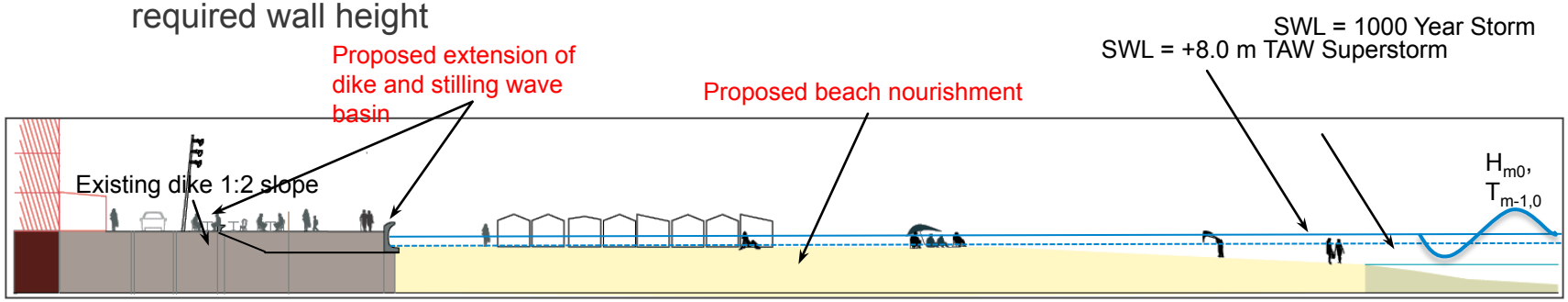
- Measure mean wave **overtopping** for Wenduine sea dike during the storm events:
  - 1000 Year Toetsing
  - +8.0m Superstorm

- Measure wave impact **forces** on wall configurations:
  - vertical walls
  - recurves



WENDUINE: Proposed coastal defence

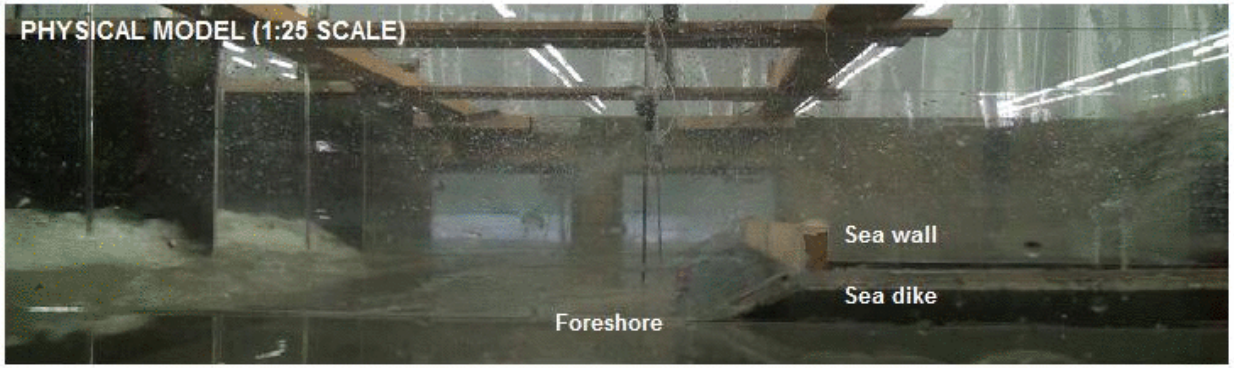
- Construction of new wave return wall + beach nourishment is proposed to meet tolerable mean wave overtopping discharge criteria (q < 1 l/s/m for 1000 year storm)
- Geometry of new wave return walls has been optimized by wave overtopping tests performed at Flanders Hydraulics Research
- Stilling wave basin concept (Geeraerts, et al, 2006) has been adopted to minimize required wall height

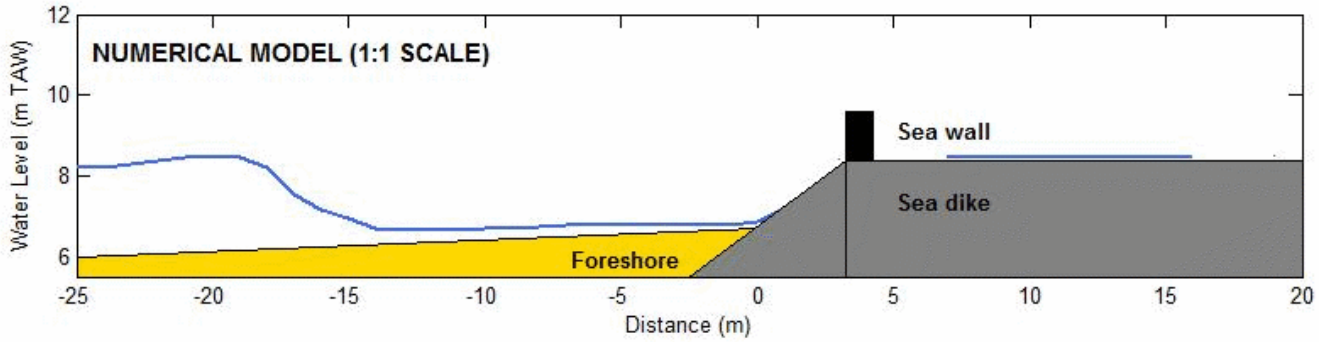


Antea Group (2012)

WENDUINE WAVE OVERTOPPING MODELS

Largest overtopping wave from model simulation of 1000 Year storm





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▪Why DualSPHysics?

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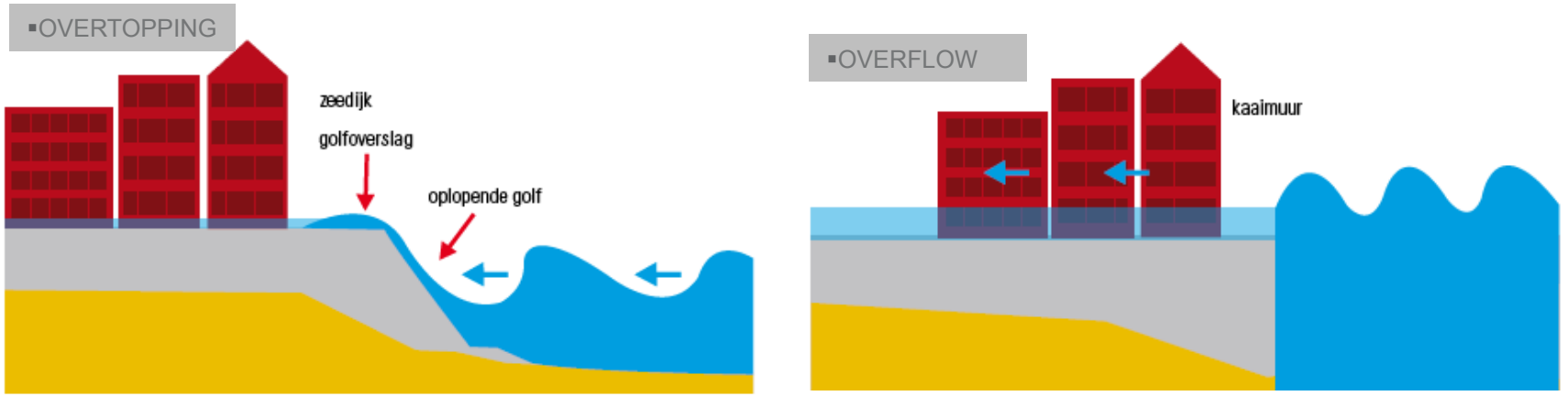
Remember:

Failure mechanisms considered in the Coastal Safety Masterplan

- **structural failure due to overtopping and overflow**



Because DualSPHysics is able to deal with wave-structure interaction phenomena with high accuracy in reasonable computational time.

Concluding…

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1. We need numerical modelling as preliminary approach in engineering design.

2. The drawbacks of physical modelling and measurements can be overcome using a numerical model.

3. We face every day problems where it is not possible or reliable applying solution from literature.

4. We aim to provide reliable results in reasonable time to the client necessary for the upgrading of the existing coastal structures and increasing of coastal safety.

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