Case Study: Katwijk aan Zee

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Figure 1 (below). Cross-section of the dike-in-dune alternative (Kustwerk Katwijk, 2012).

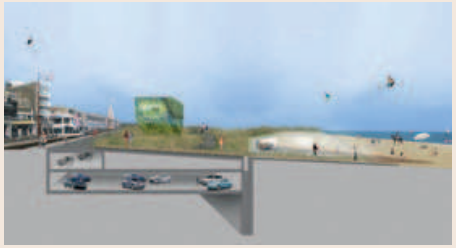
Figure 2 (mid below). Katwijk: overview of the area wih location of the dike-in-dune and parking garage. (Kustwerk Katwijk, 2012).

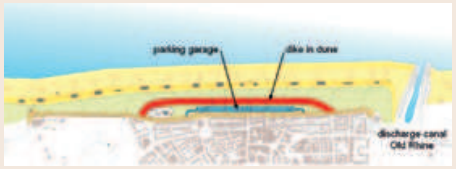
Figure 3 (bottom below). Design of dike in dune and materials used.

Figure 4 (top right). Artist impression of wall-in dune design alternative (DP6 architectuurstudio, Delft).

Figure 5 (mid right). Dike under construction (Photo Courtesy Mark Voorendt, 2014).

Figure 6 (bottom right). Entrance to the parking garage (Photo Courtesy Mark Voorendt, 2014).





Mark Voorendt

CASE STUDY: KATWIJK AAN ZEE

Katwijk aan Zee is a Dutch town on the North Sea, near the original mouth of the Rhine. At the end of the twentieth century, part of the town of Katwijk appeared to be insufficiently protected against storm surges from sea (Figure 2). About 3000 inhabitants were in fact exposed to risks that were higher than what is considered acceptable in the Netherlands.

Katwijk was one of the last weak links along the Dutch coast, according to a 2001 report from the *Steering Committee Coastal Vision 2050* (in which the provinces of North and South Holland, Rijkswaterstaat, the National Planning Department, Water Boards and coastal communities participated). Several designs have been made to improve the flood protection of Katwijk, while also addressing the growing parking problems along the boulevard. The final design is described in the following section, followed by another section that presents the alternative design, which has been rejected by the municipality of Katwijk.

The final 'dike-in-dune' design
The weak part of the dunes was reinforced between October 2013 and February 2015 with a dike embedded in the dunes. A sub-soil parking garage for 663 cars was then constructed between the dike and the boulevard, and the dune area was re-shaped and widened. The dike-in-dune has been designed by engineering bureau Arcadis and the parking garage by engineering bureau Royal HaskoningDHV.

The dike-in-dune is constructed along the part of the boulevard that was too low to retain critical water levels that could occur during a 1 in 10,000 year flood, which is the flood safety standard for this area (figure 2). This is a stretch of about 900 m, where the boulevard is lower than NAP + 10.00 m. The total erosion volume of the dune and beach in a cross-shore direction is the major factor when calculating flood protection offered by the dune. It is not really important whether this volume is present in the height or in the width, so for aesthetic reasons (the view from the boulevard), it was decided to make the dunes lower but wider, with a seaward extension of the beach.

To achieve an even lower dune, a 'hard structure' was needed to prevent further erosion. The total width of the dunes over the dike, from boulevard to dune toe, is about 120 m. This is 90 m wider than in the original situation. The dike has a sand core and is covered by concrete blocks on top of a filter layer and geotextile (Figure 3). The crest level of the dike could have been as low as NAP + 7.50 m, but for aesthetic reasons the dike is now covered with sand, which brings the top of the dunes to about NAP + 8.00 m.

At locations where the original dunes were already higher than 7.50 to 8.00 m, the existing dune top was maintained. The crest of the dike is 5.00 m wide, and the dike will only be exposed to wave attack when the sand on and in front of it has eroded. In that case, the remaining sand in front of the dike will be sufficient to reduce wave overtopping. In addition, the dike can be relatively easily adapted in future, as needed (Arcadis, 2013).

The parking garage is located between the dike-in-dune and the boulevard. Although it is covered with the same sand as the dike and therefore gives the impression that it is integrated into the dune, it is not actually part of the flood defense. The development of the parking garage, therefore, does not fall under the Dutch Water Act and therefore it is not a multifunctional flood defense regarded from a structural point of view.

A rejected wall-in-dune design alternative
In an early stage of concept development, several alternative designs to improve the coastal defenses of Katwijk were made. One of these designs was developed by the Delft University of Technology, Netherlands Organization for Applied Scientific Research (TNO), Rotterdam's municipal engineering department, the Dutch 'knowledge partner for construction' (SBRCURnet), and other research agencies. This design proposed a parking garage in the dunes, but no dike. The seaward wall of the garage would be a flood-retaining diaphragm flood wall 15 to 20 m deep (Figure 4).

The idea was that the diaphragm wall would still have to resist the waves after erosion of the 30 meter wide dune in front of it. Dune erosion - when it occurs - can proceed quite rapidly: 80 to 100 meters in a few hours; so a 30 m wide dune can reasonably be expected to completely erode during a major storm. A computer simulation showed that these 30 m would be completely eroded after 15 hours. Waves would than directly hit and overtop the wall.

The parking garage was designed at the land side of the flood wall. The flood wall had a double function: in addition to retaining water, it would provide stability to the garage structure. The flood wall was sufficiently strong and stable on its own, so that even if the parking garage were to collapse, that would not affect the flood protection. Similarly with the restaurants proposed on the beach side, adjacent to the flood wall: they are not part of the flood defenses.