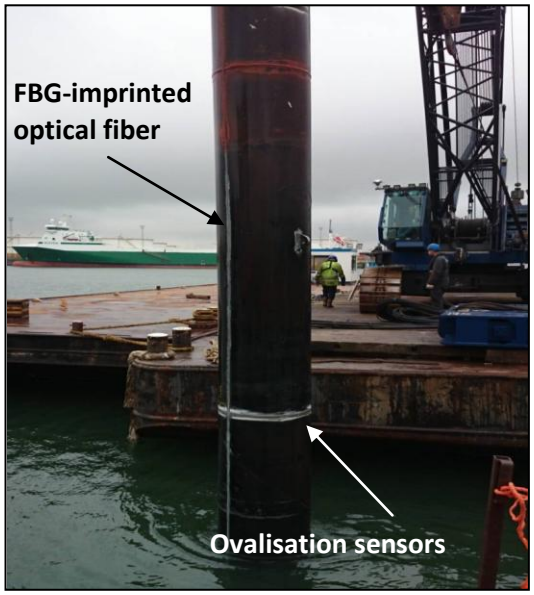
EXPERIMENTAL TESTS ON FLEXIBLE DOLPHINS

THE PROJECT

The objective of this testing programme organised by the Rotterdam Port Authority was to obtain a more in-depth knowledge on the structural behaviour of tubular steel mooring and breasting dolphins. For this purpose 8 sensor instrumented tubular piles having a diameter of 914mm and a length varying from 20 to 22m were vibration driven into the bottom of the Beneluxhaven in Rotterdam. Subsequently each of the piles was loaded horizontally both dynamically and statically and finally brought to failure (i.e. buckling). Throughout the testing programme Inventec was responsible for monitoring the deformation of the piles as well as the resulting geotechnical effects on the subsoil.

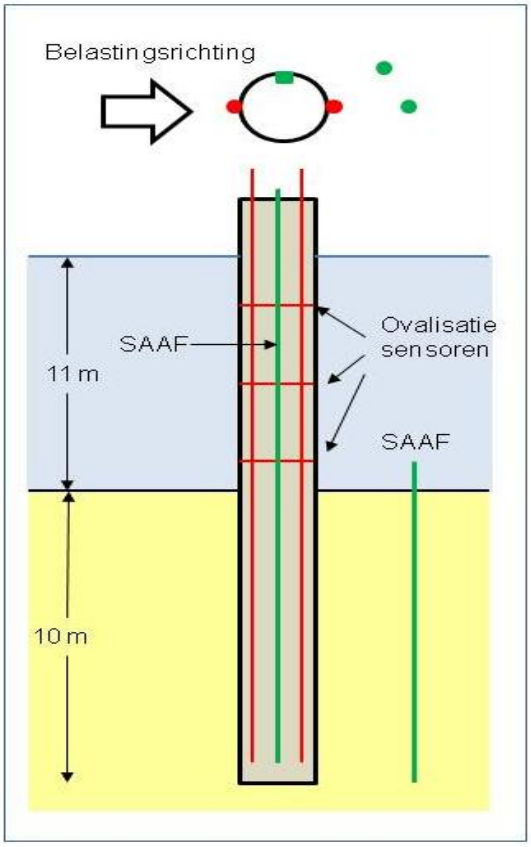


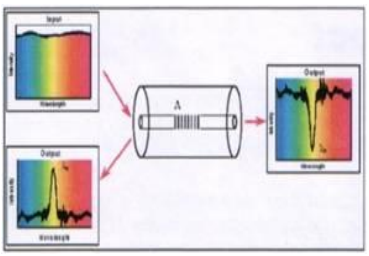
THE MONITORING

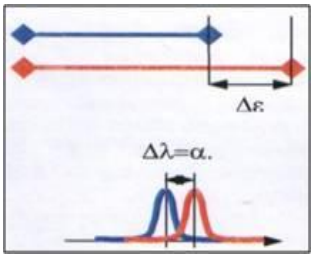
The monitoring performed by Inventec comprised four phenomena:

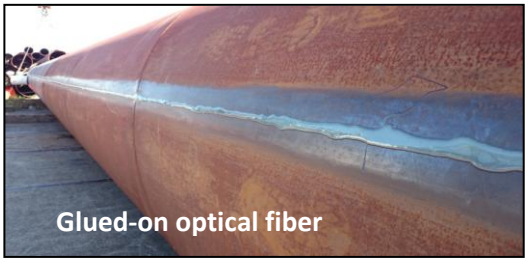
- **Bending strains along the length of the pile.**

  Each of the piles was fitted with two glued-on FBG-imprinted optical fibers over its full length. Each of these fibers had 8 imprinted FBG's (Fiber Bragg Gratings) in series. An FBG is a location on the fiber that backscatters to the reading unit only one specific wavelength of the full spectrum that is launched into the fiber. When the fiber is put under strain, this wavelength undergoes a shift that has a defined relation with the actual strain occuring on that spot. So by putting more FBG's in series on one and the same fiber it is possible to interrogate them all via one single connector. The fiber has a diameter of only 0,25mm.









- **Ovalisation of the pile's cross section.**

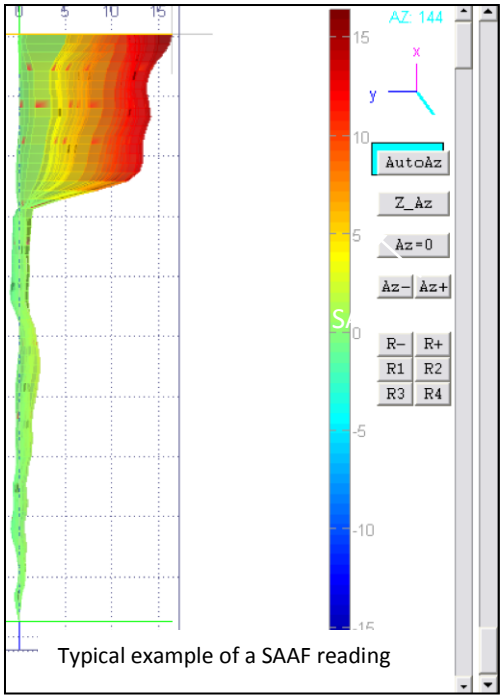
  This was measured at a number of levels along the height of the pile with an optical fiber having 4 FBG's divided over the cross section.
  During a dynamic loading cycle all sensors were interrogated simultaneously with a frequency of 10Hz (a frequency up to 1 kHz is possible).

- **Deformation of the pile.**

  Each time before the start of a static load cycle a SAAF was mounted in a tubular profile welded to the inside of the pile. The SAAF (Shape Accel Array / Field) consists of a chain of 0,50m long inclinometer sections that are interconnected such that they can move in all directions in relation to one another. As a result interrogating a SAAF produces the distributed deformation over the full length of the pile in both X- and Y-direction.

- **Deformation of the subsoil.**

  In order to monitor the effect of the pile load tests on the subsoil a number of SAAFs were mounted under water in PVC tubes that had been placed in the harbour bottom in the vicinity of each pile.



Typical example of a SAAF reading


Optical fiber fully intact after extraction of the piles


Test site Beneluxhaven

Inventec is front runner in fiber optic monitoring for civil engineering, geotechnical, piping and power applications.

inventec b.v.
P.O. Box 497
8070 AL NUNSPEET, THE NETHERLANDS
Tel. +31-341-274470
Email: info@inventec.nl
Website: www.inventec.nl