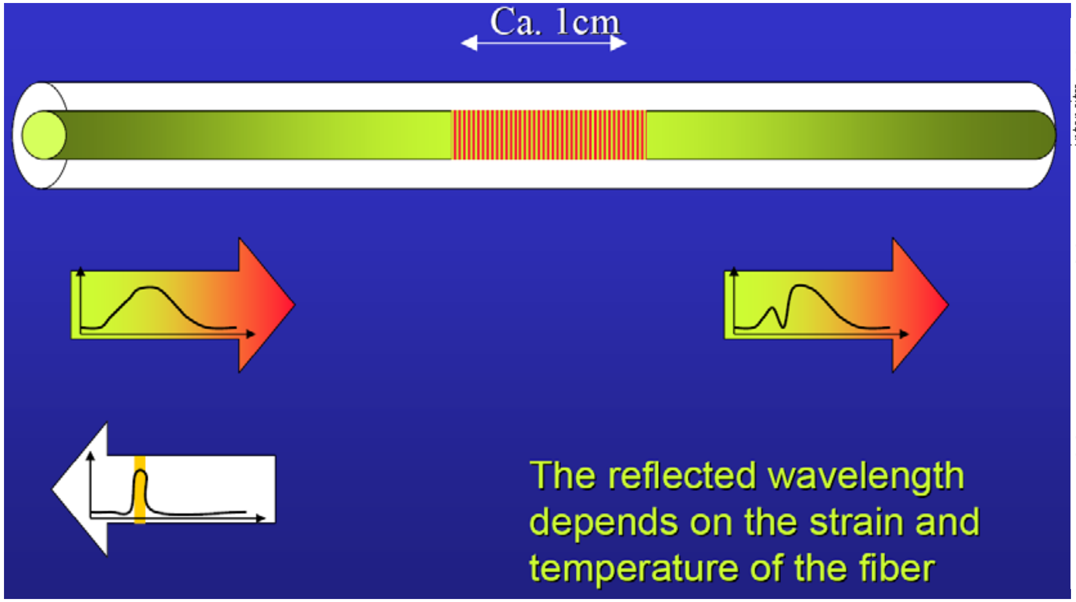
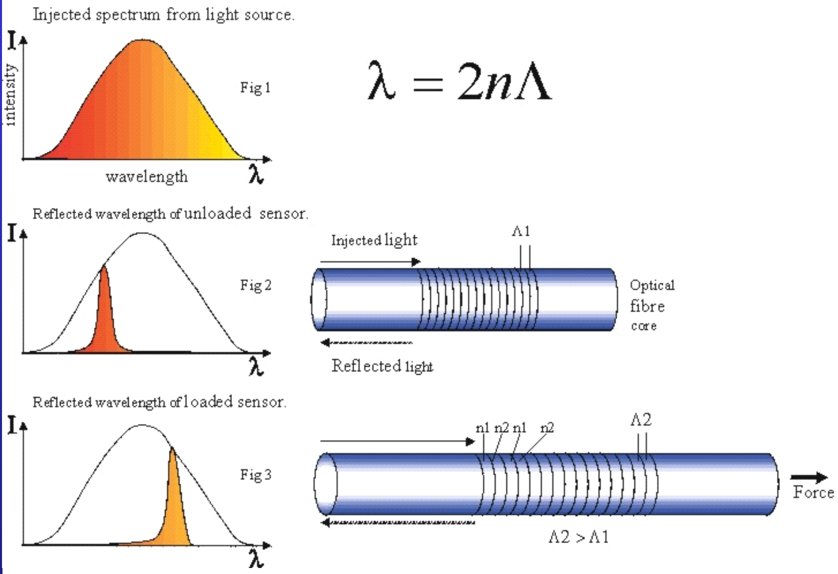
# New developments and experiences with instrumentation techniques for pile testing

## **Optical fibre technology** (FBG-DTG)

# Principles FBG (DTG) optical fibre technology (1/2)

- An optical fibre with ∅-195 µm optical fibre is locally treated (Bragg grating)
- At the local FBG zone incident light wave (1520-1600 nm) is reflected at a specific wave length
- The reflected wave length depends on temp. and strain of the FBG-zone (linear)
- The wave length which is reflected at the FBG can be determined up on fabrication
- Typical accuracies with FBG technology : <5 µstrain en <0.5 °C
- Specific Draw Tower Grating Technology of FOS&S (Geel) : tensile strength of the fibre up to 6 % (60 000 µstrain) - long term service : 1 to 2 %




$$\lambda = 2n\Lambda$$

# Principles FBG (DTG) optical fibre technology (2/2)

Advantages of the FBG/DTG principle:

→ high precision/accuracy

→ Read out equipment : low cost

→ Multiplexing (up to 20 or more FBG sensors on one ∅-195 µm fibre

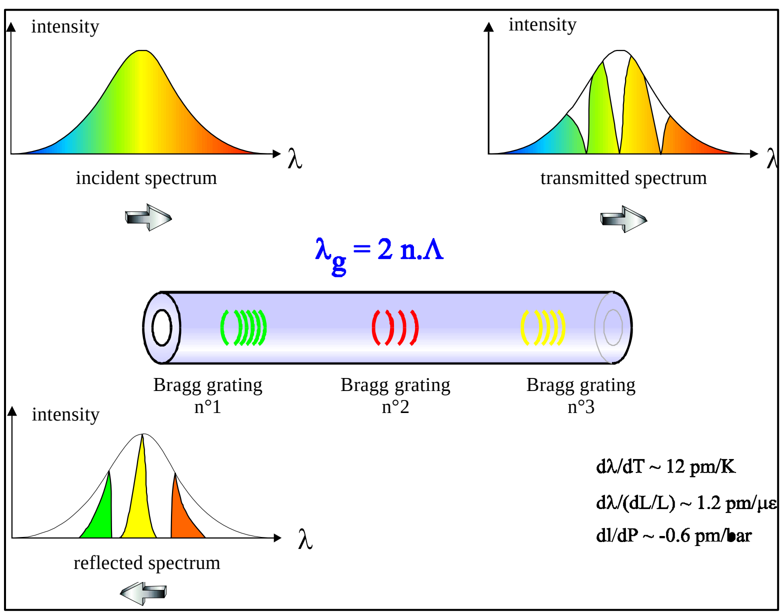
→ (*)long term stability

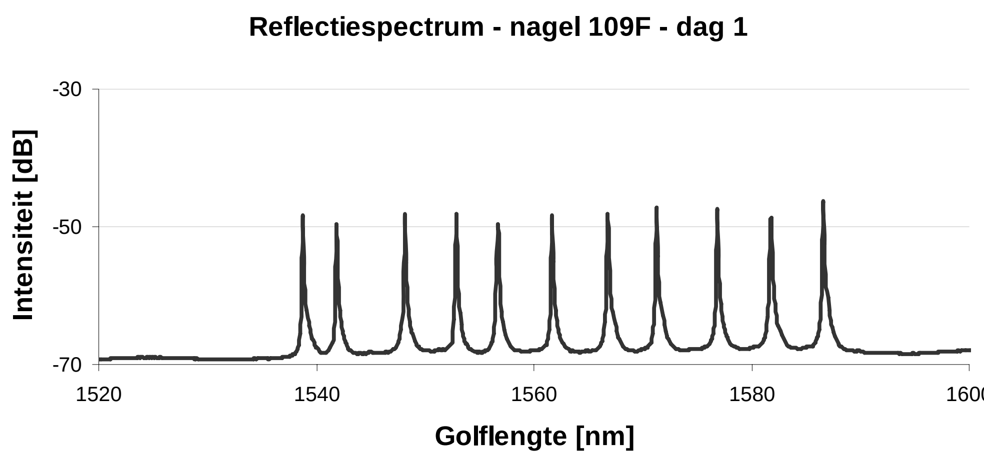
→ (*)no influence by elektromagnetic radiation, stray currents, etc.

→ (*)not sensible for corrosion, short circuits (H20), ...

→ very small dimensions: advantage for several (geotechnical) elements that need to be monitored ↔ Fragility

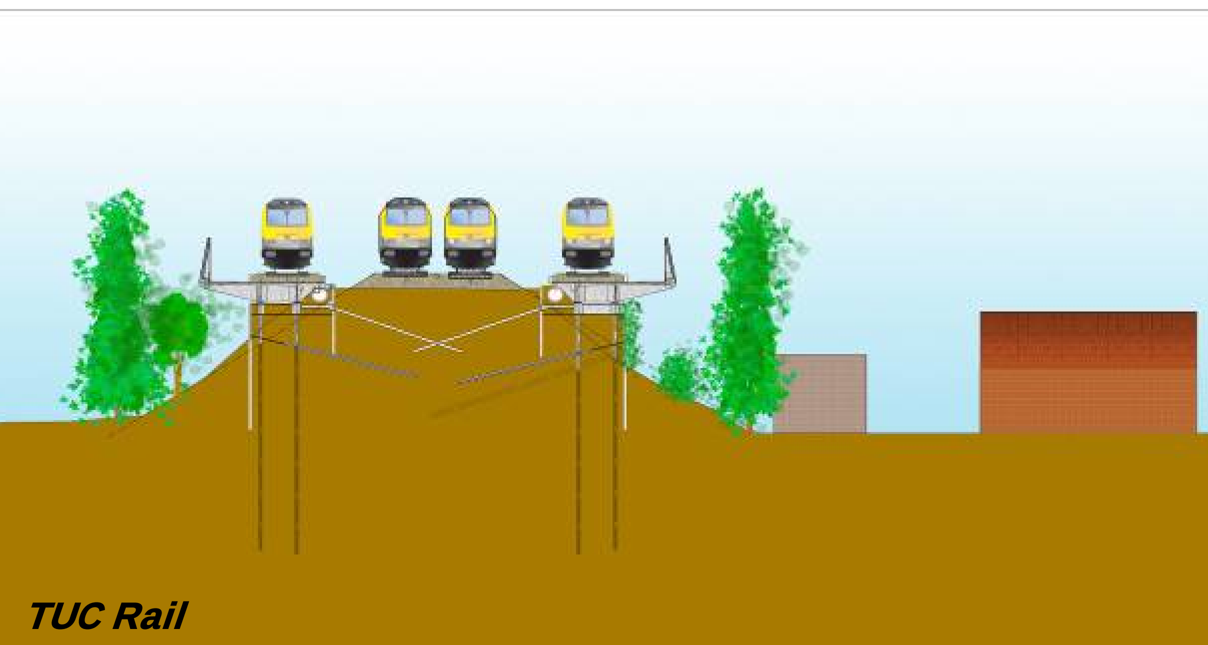
(*) Also for other fibre optic technologies as Brillouin scattering, ...

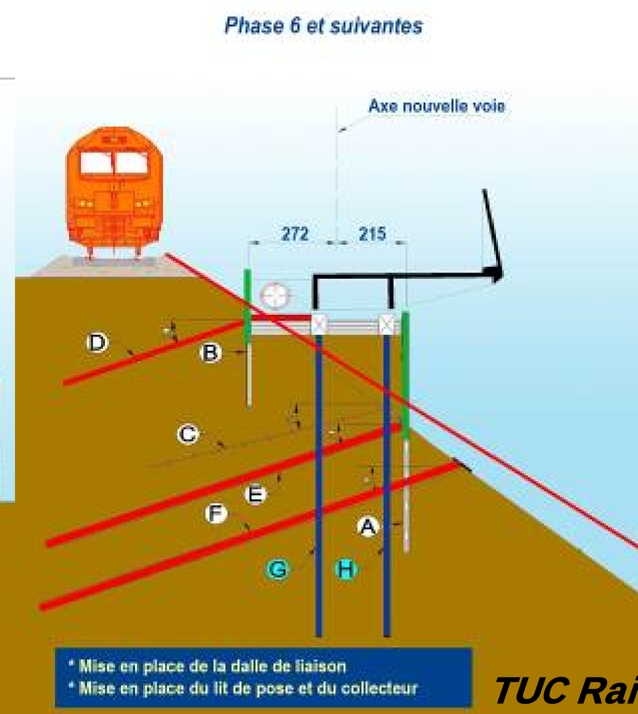


# Development of O.F.- system for installation in jet grout nails (hollow bars)

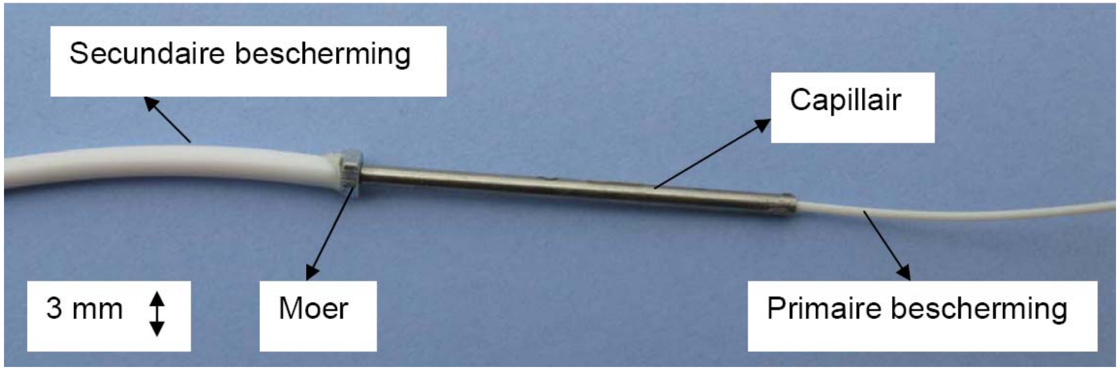
→ On demand of TUC Rail for long term monitoring purpose at RER site in Ottignies
→ Development of BBRI in collaboration with TUC RAIL, FOS&S and J. Maertens (KULeuven) to develop solution based on optical fibre technology in the framework of the TIS-SFT project



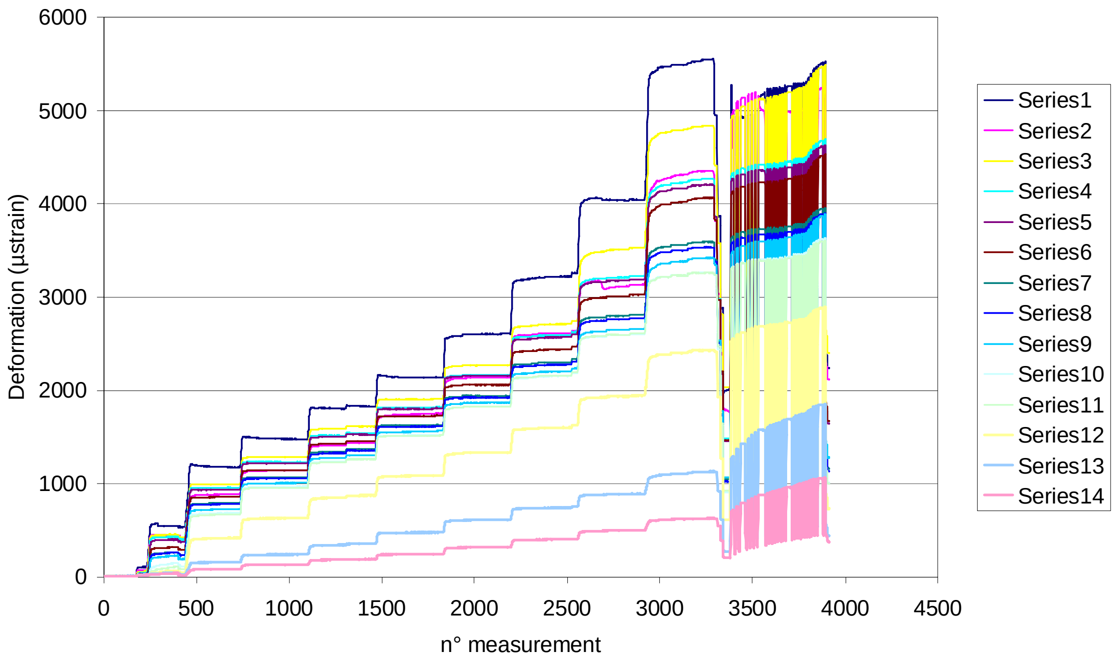
# Concept & Installation characteristics

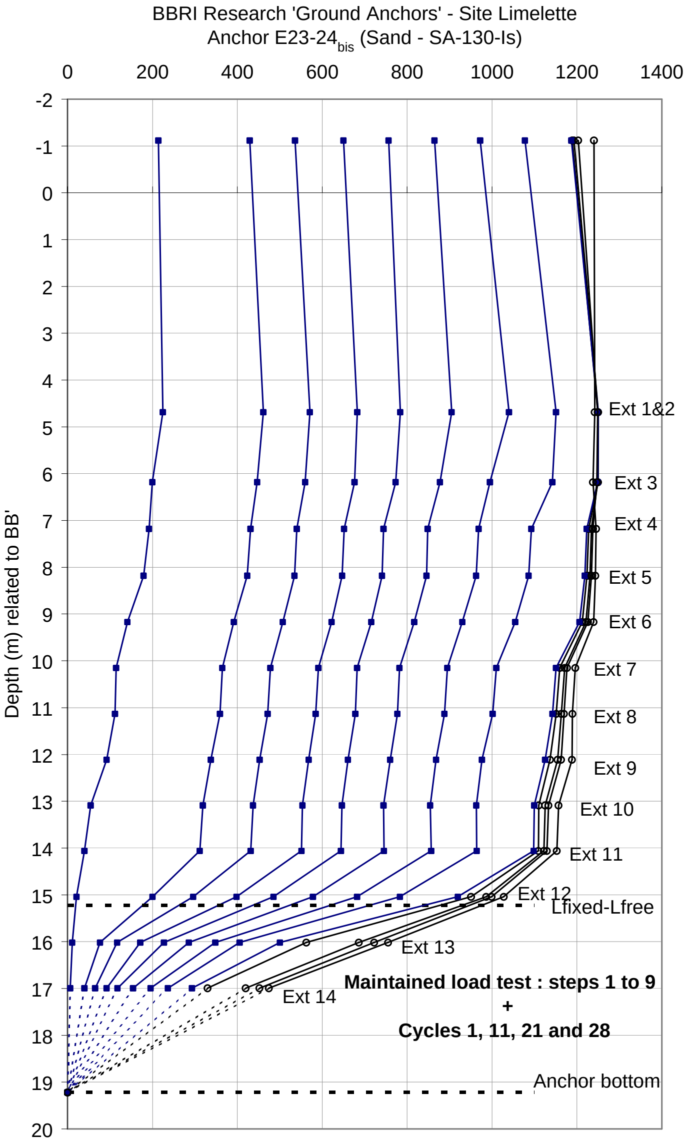
→ FBG chain provided with ∅6 mm anchors
→ between 2 anchors : 1 FBG sensor moving free from environment with double protection → extensometer principle
→ up to 20 FBG sensors (extensometers) on one fibre
→ Installation of sensors after installation of the nail (in the hollow section) – fixed to bar via injection of a special cement grout
→ Fibre-optic system + injection system = ∅15 mm




The same system can be applied in :
hollow bar anchors, micropiles and piles (reservation tube fixed to reinforcement cage) for load distribution measurements during load tests

# Example of la (Re)load test on hollow bar anchor in framework of BBRI Ground anchor research in Limelette




For Foundation elements **under tension**

→ Deformations up to 0.8% no problem

For (foundation) elements **under compression** the O.F. system has been adapted

→ Laboratory tests to find a suitable (stiff and deformable) grout mix (cement-bentonite,epoxy, ...)

→ System tests in compressive pile load tests & comparison with classical extensometers have been performed

→ Positive results up to deformations of ±1800 to 2000 µstrain (0.2%)

# In development ;

integration of optical fibre in **retrievable extensometer system for pile load tests (tension/compression)**

Advantage:
- number of extensometer modules quasi unlimited
- allows a smaller diameter of the reservation tubes

→ Laboratory tests are positive
→ a 20-m system with 18 extensometer modules is being assembled for the moment en will soon be tested in situ.