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MEASURING INCLINATIONS IN CABRIL DAM WITH AN OPTOELECTRONIC SENSOR

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- The Cabril dam
- Optoelectronic Sensor
- Sensors placed at Cabril dam
- Results
- Conclusions

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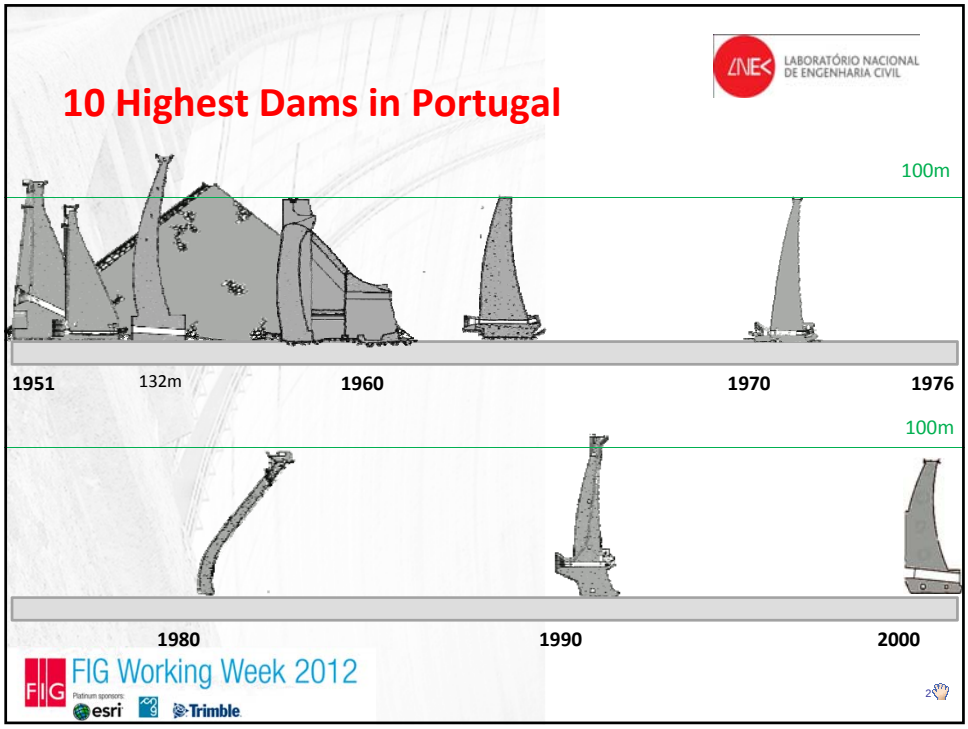
10 Highest Dams in Portugal
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100m
1951
132m
1960
1970
1976
100m
1980
1990
2000
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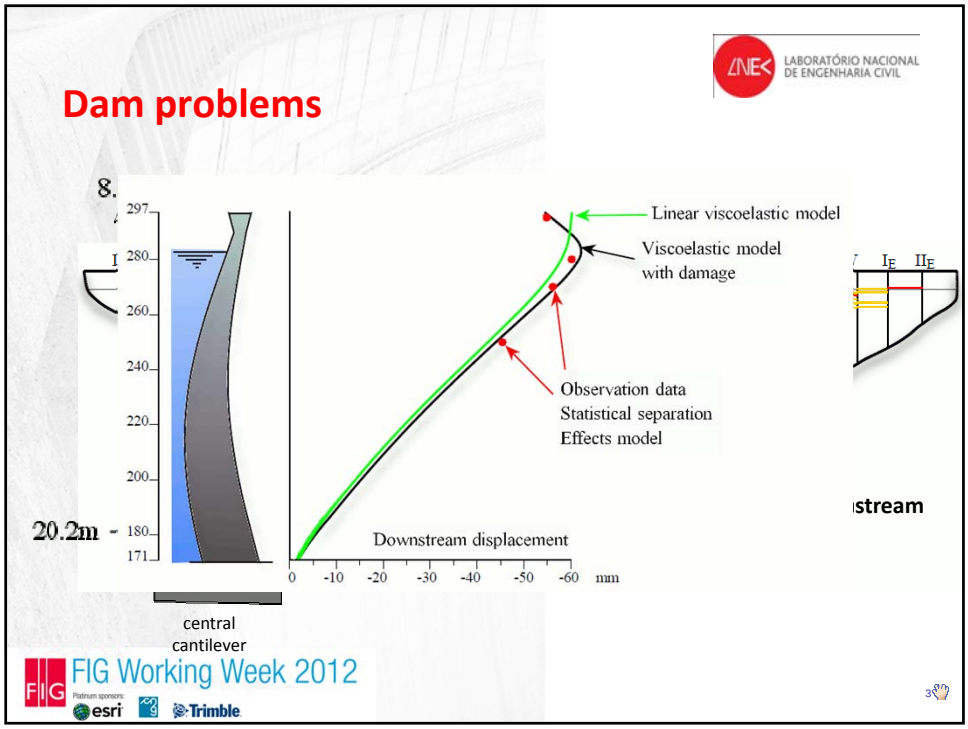
Dam problems
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297
280
260
240
220
200
20.2m
180
171
central cantilever
Linear viscoelastic model
Viscoelastic model with damage
Observation data
Statistical separation
Effects model
Downstream displacement
0 -10 -20 -30 -40 -50 -60 mm
IE IIE
stream
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Design Changed During Construction

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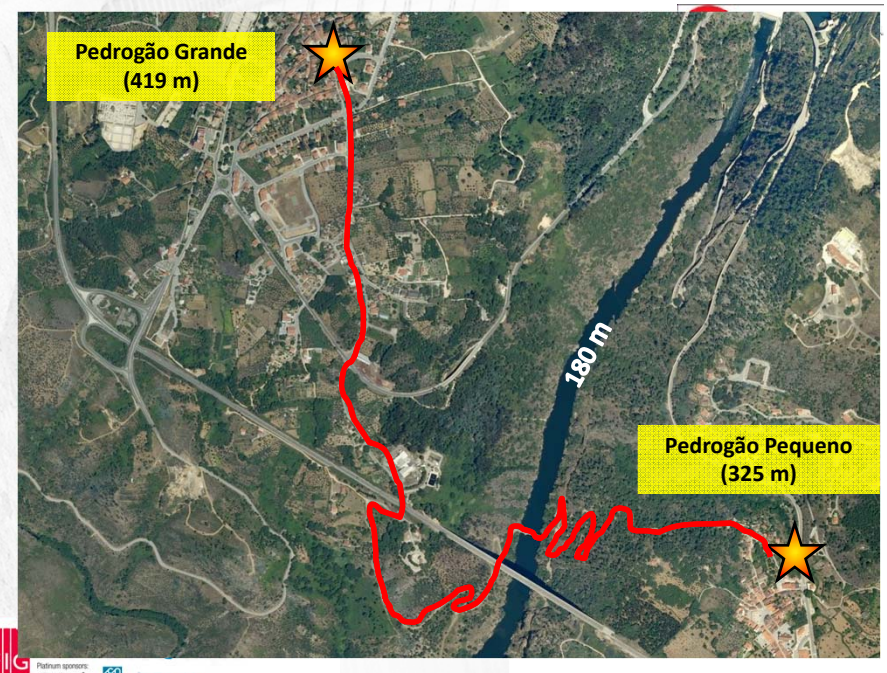

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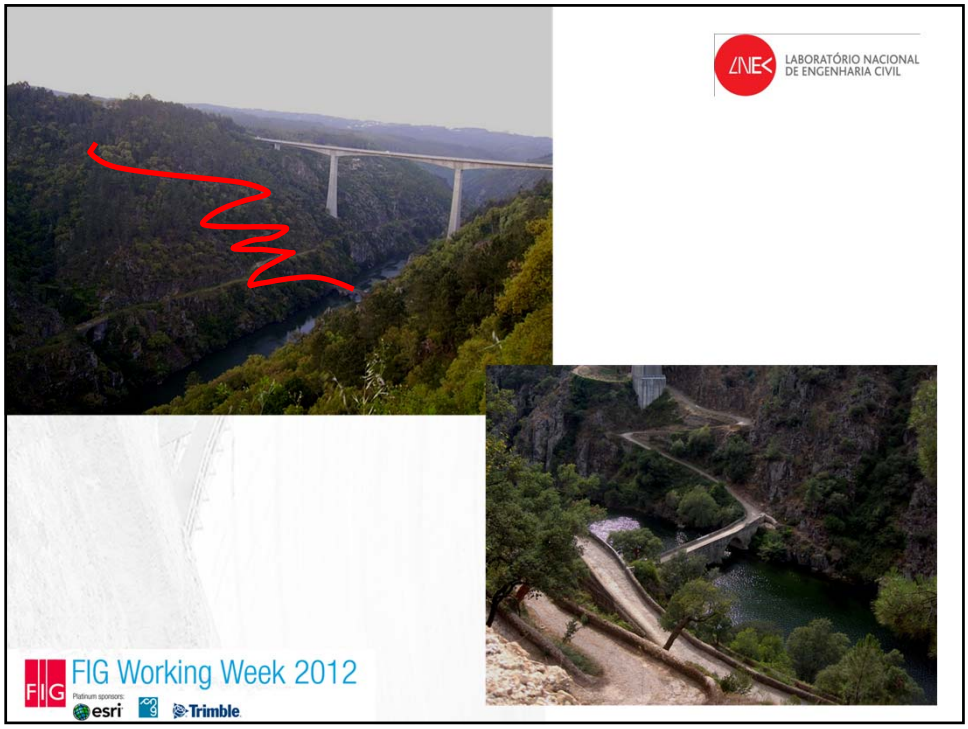
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(2008) Test to analyse the response of geodetic methods to continuous monitoring

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Inclination Measurements

Leica Nivel 210

drift free dual axis inclinometer
range[-310”, 310”] accuracy: 1”

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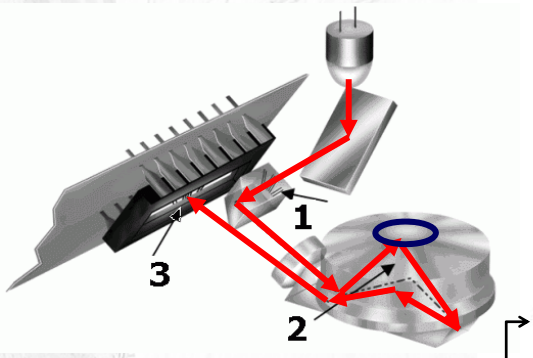
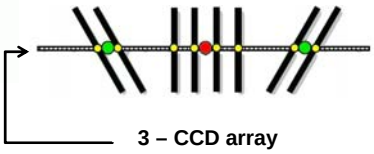
Optoelectronic sensor



2 - Tank (silicone oil)

1 – Detail of the prism: line pattern



3 – CCD array

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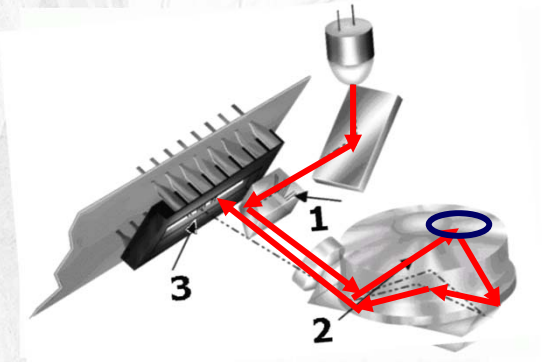
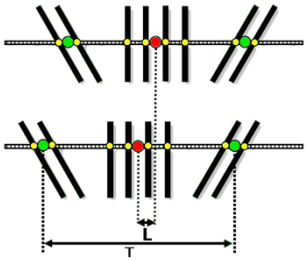
Optoelectronic sensor





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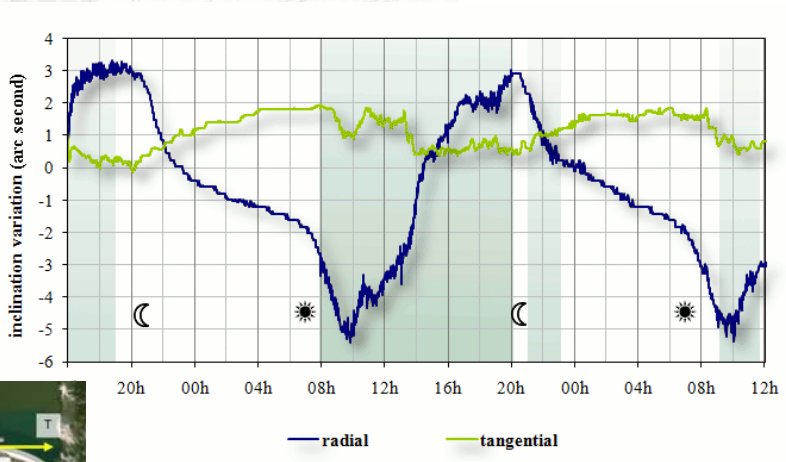
Cabril dam: Sensors

Leica Nivel 210
1Hz

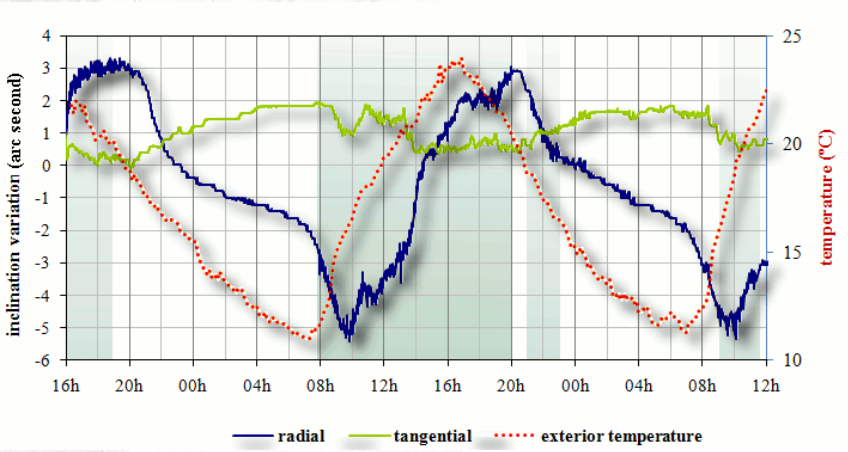
Comet D4130
digital thermo-hydro-barometer
10 min

Sensors positions

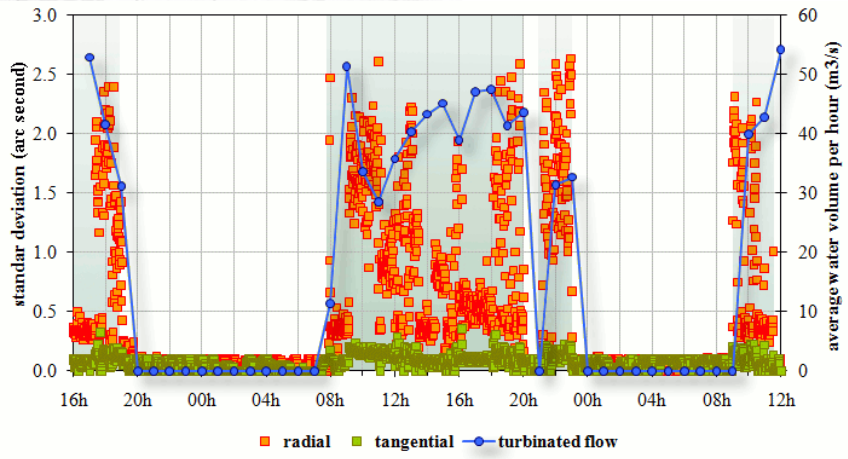
Inclinations variations



Inclinations variations+temperature



Inclinations: standard deviations



vibration of the structure induced by the operation of the electricity generator group

Modelling the variations

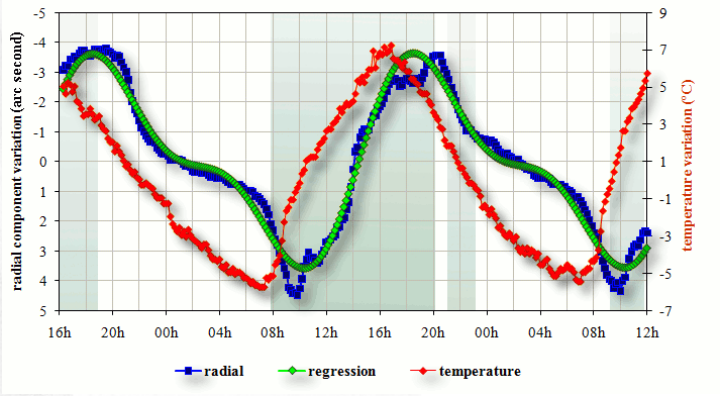
$$i(h,t) = a\,h + b_1 \cos\frac{2\pi t}{24} + b_2 \sin\frac{2\pi t}{24} + b_3 \cos\frac{2\pi t}{12} + b_4 \sin\frac{2\pi t}{12} + c$$

i - inclination component
h - the reservoir level
t - the time of day

Periods, of 12 and 24 hours, identified as relevant through a Fourier analysis

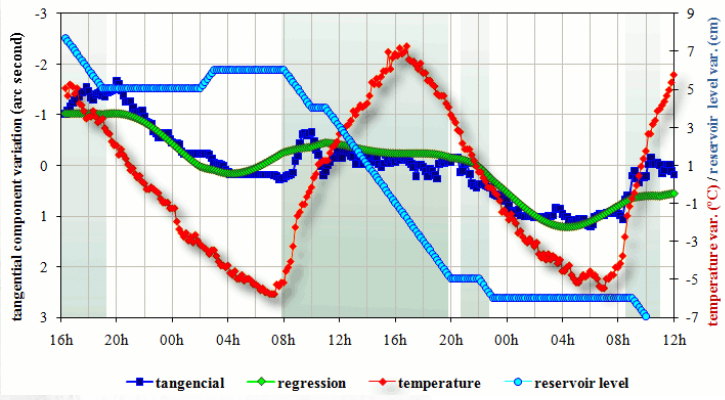
Modelling the variations (radial component)

temperature variation – inclination variation: time lag ≈ 4 h 40min



variations of inclination are mainly influenced by the variations of daily temperature (correlation coefficient equal to -0.94)

Modelling the variations (tangential component)



tangential component has a more obvious correlation with the variation of water level than with the outside temperature (correlation coefficient equal to -0.70 and -0.50, respectively)

Conclusions

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> **Inclinómetro Leica Nivel 210 was able:**

- **to detect the influence of temperature and reservoir level in dam Cabril behaviour.**
- **to record the vibration of the structure induced by the operation of the electricity generator group.**

> What would be desirable:

- **to install this equipment during a longer period of time, if possible during several years, in order to detect the influence of other quantities in the behaviour, including annual variations in temperature, significant variations of reservoir level and possible long term effect.**

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Thank you for your attention

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