LABORATÓRIO NACIONAL DE ENGENHARIA CIVIL

THIRTY YEARS OF STRUCTURAL MONITORING OF SÃO JOÃO BRIDGE

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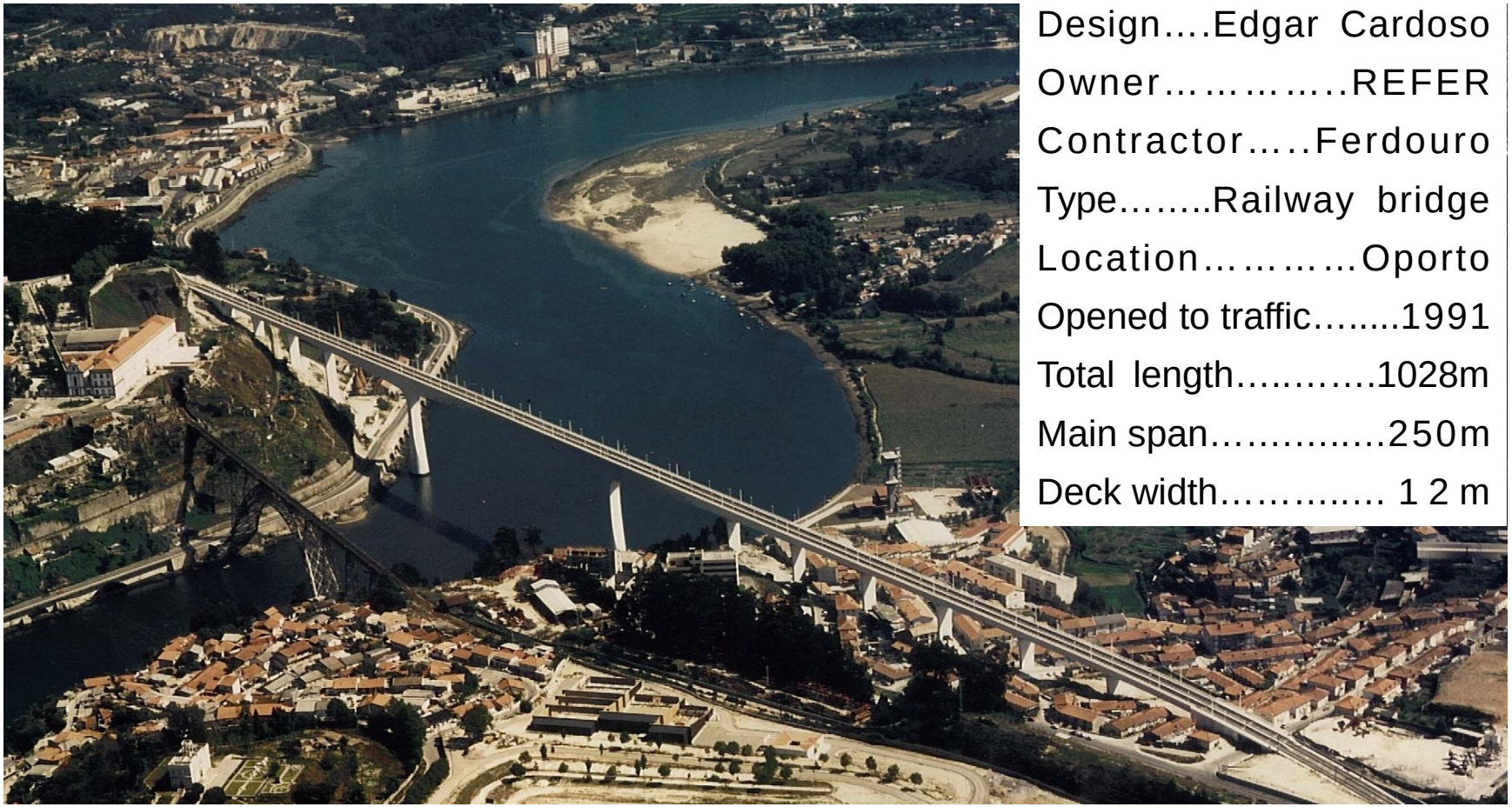
Objectives

- Present the SHM of an important railway bridge
- Exemplify the general procedures that has been used over the last 30 years in more than twenty bridges monitored by LNEC

Outline

- Bridge presentation
- The structural health monitoring system
  - The original system
  - The upgraded SHM
  - The management of the experimental information
- Structural analysis
- Experimental results
- Conclusions and challenges

São João Bridge



Design....Edgar Cardoso
Owner.....REFER
Contractor.....Ferdouro
Type.....Railway bridge
Location.....Oporto
Opened to traffic.....1991
Total length.....1028m
Main span.....250m
Deck width..... 1 2 m

São João Bridge

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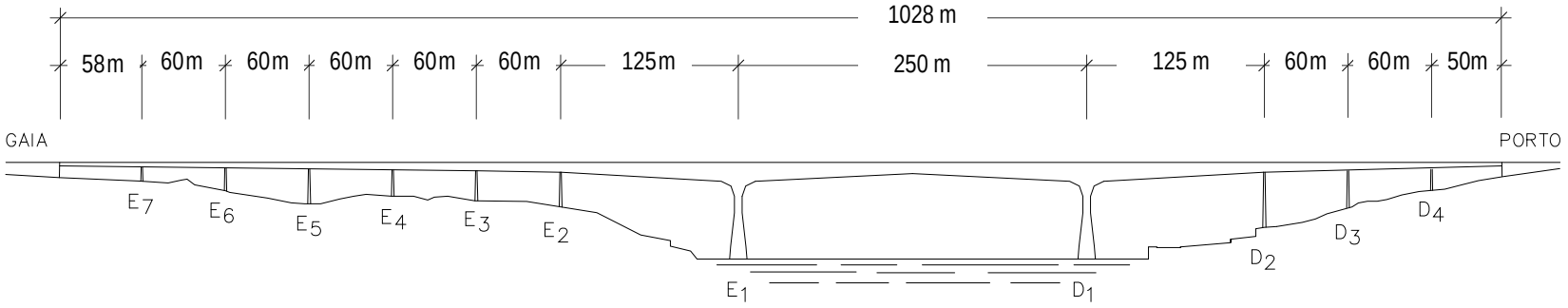
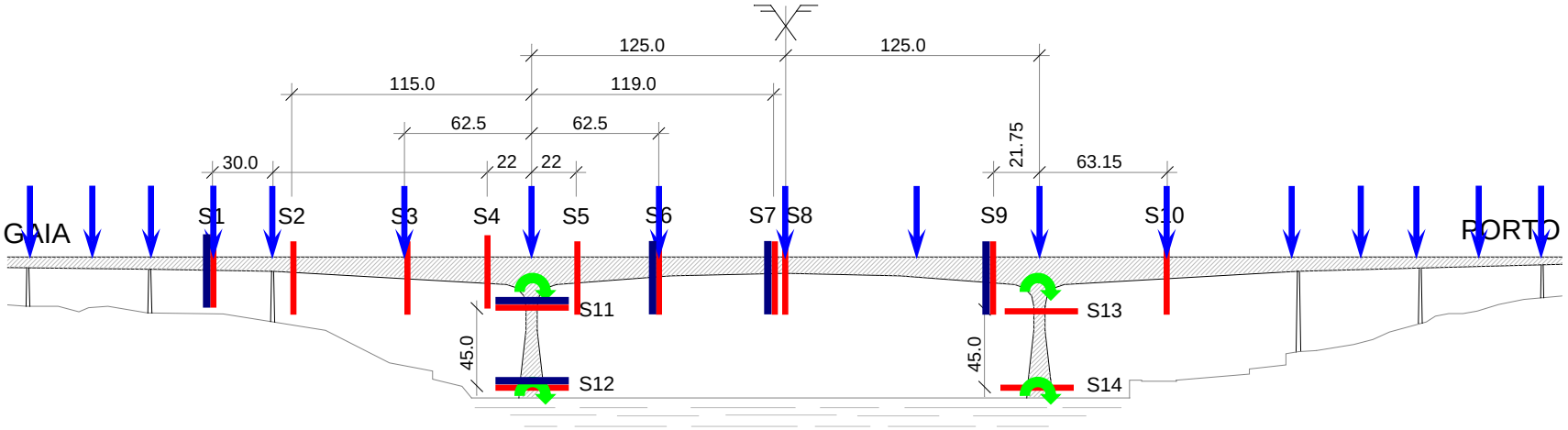


1985

Original instrumentation plan



Strains – Vibrating-wire strain gauges

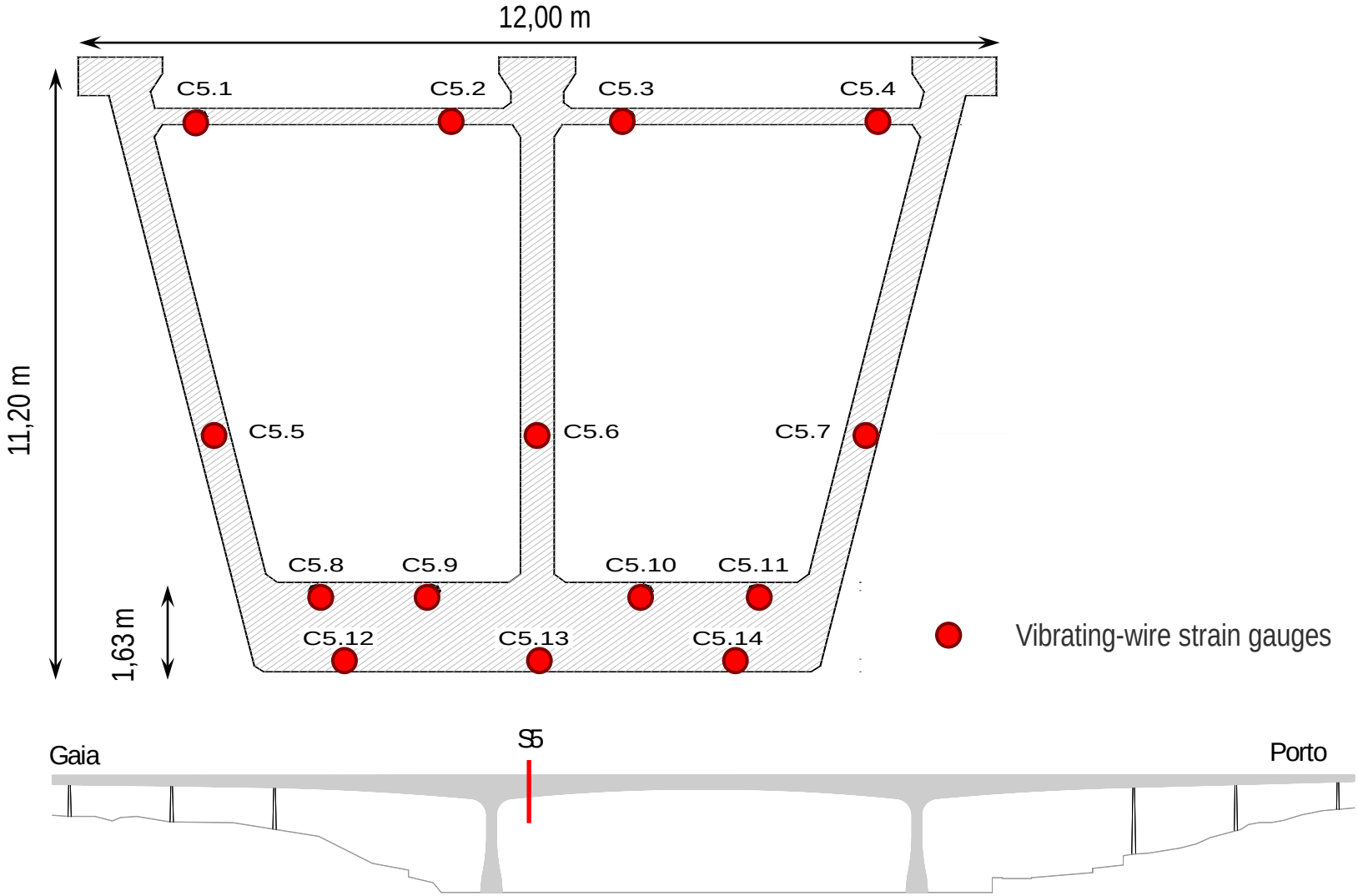
Temperature – Thermocouples

Vertical displacements – Geodetical leveling

Rotations – Air-bubble inclinometers

Movements of the expansion joints – Mechanical strain gauges

Original instrumentation plan

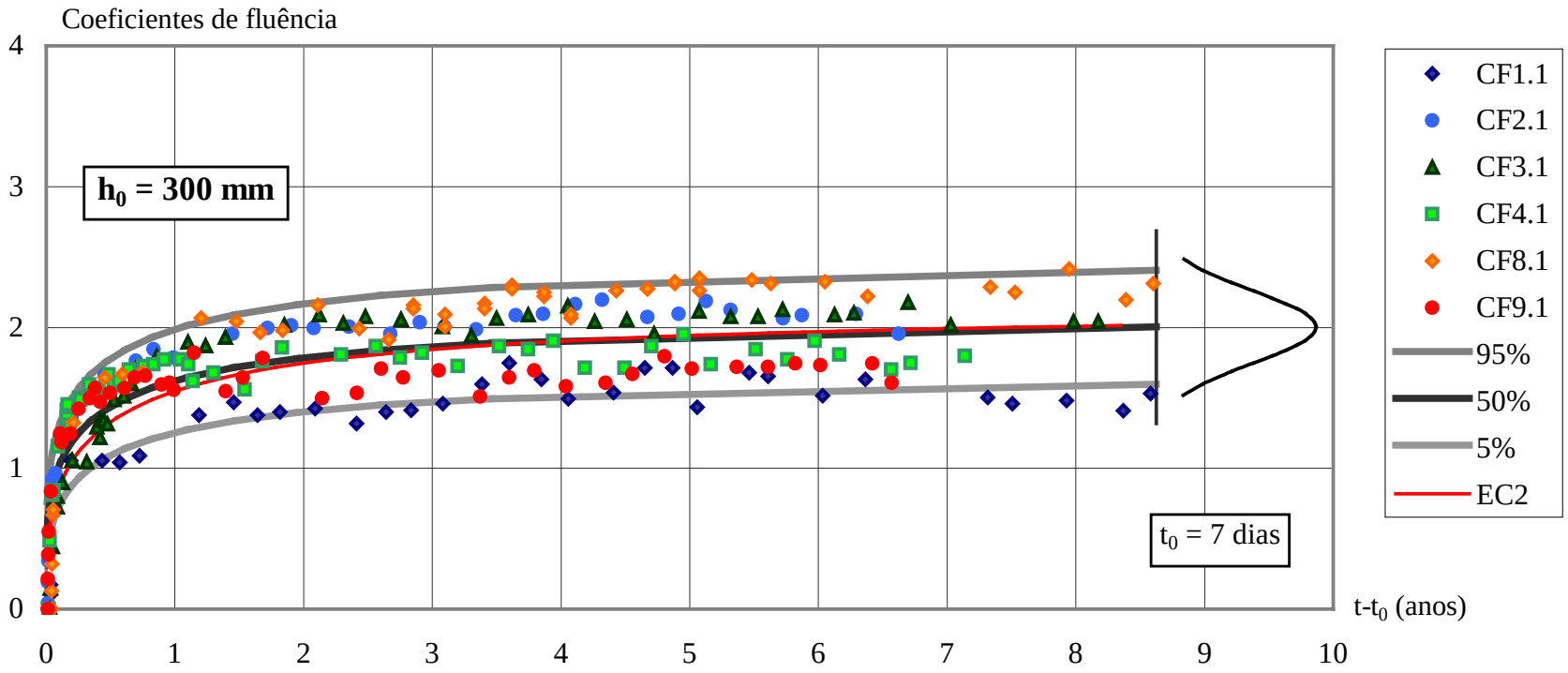


Shrinkage and creep of concrete

Shrinkage specimens

Creep specimen

Creep coefficients



2005

Upgraded SHM system

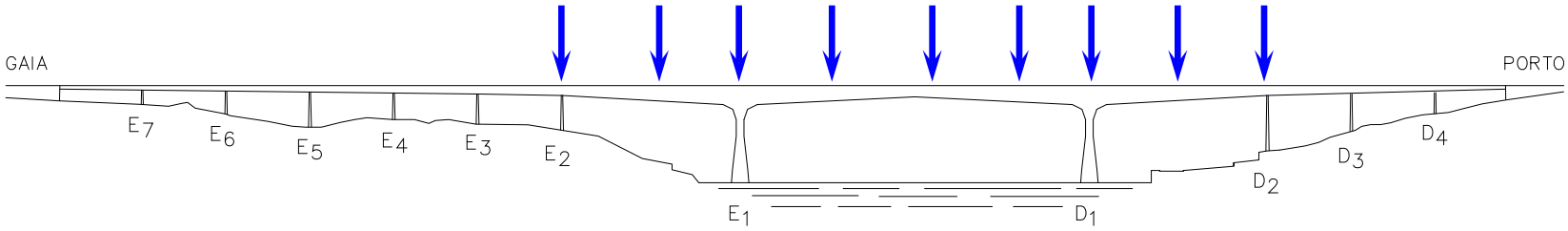
Main purposes

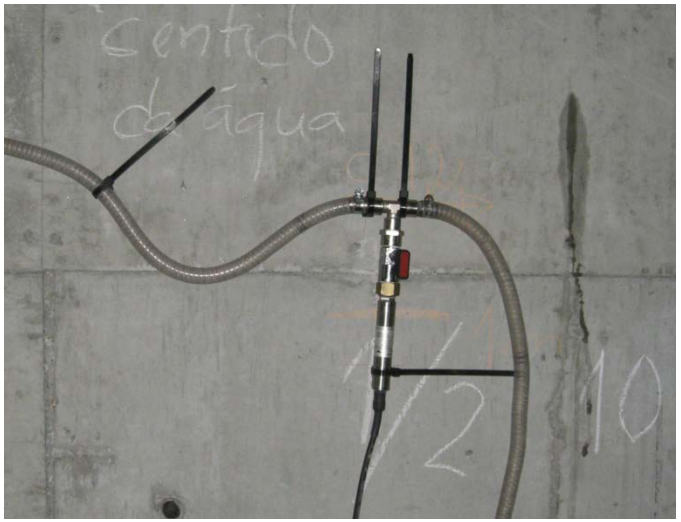
- Automatic data acquisition
- Remote access
- Data Processing in Real Time
- Dynamic monitoring

Sensors

Original sensors	Vibrating-wire strain gauges	118
	Thermocouples	73
New sensors	Pressure cells (Hydrostatic levelling system)	18
	Magnetostrictive position sensors	4
	Gravity-referenced inclinometers	4

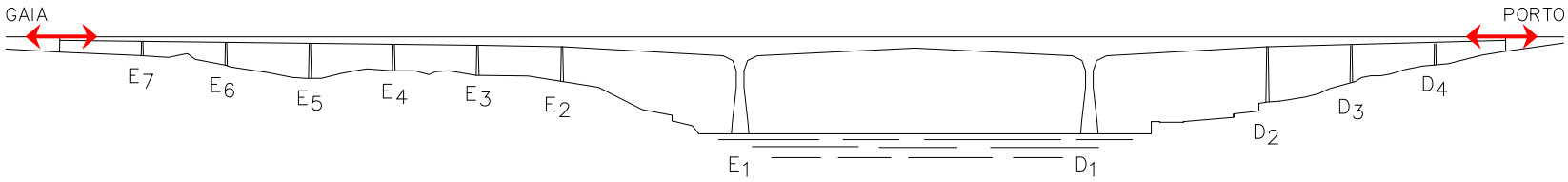
Hydrostatic levelling system with pressure cells





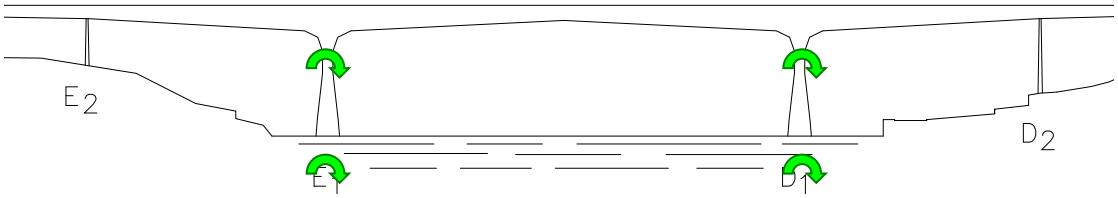
Measurement of vertical displacements (9 sections)

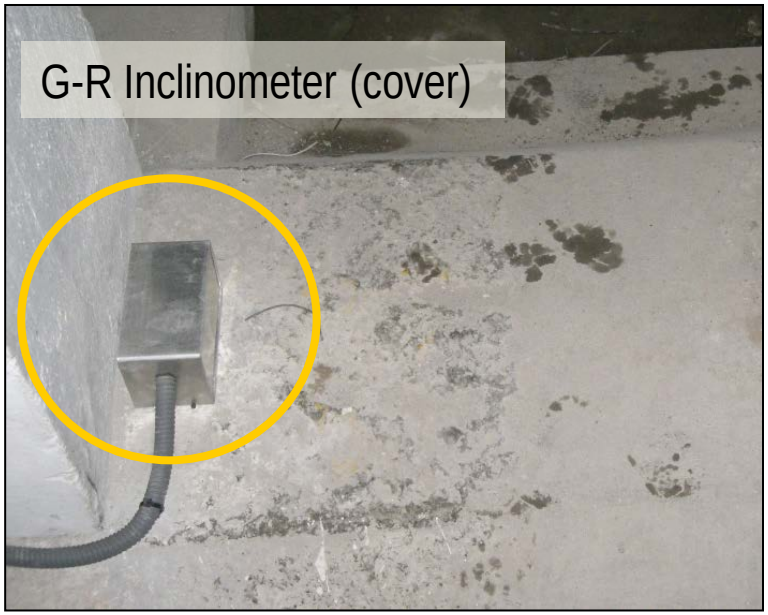
Magnetostrictive position sensors

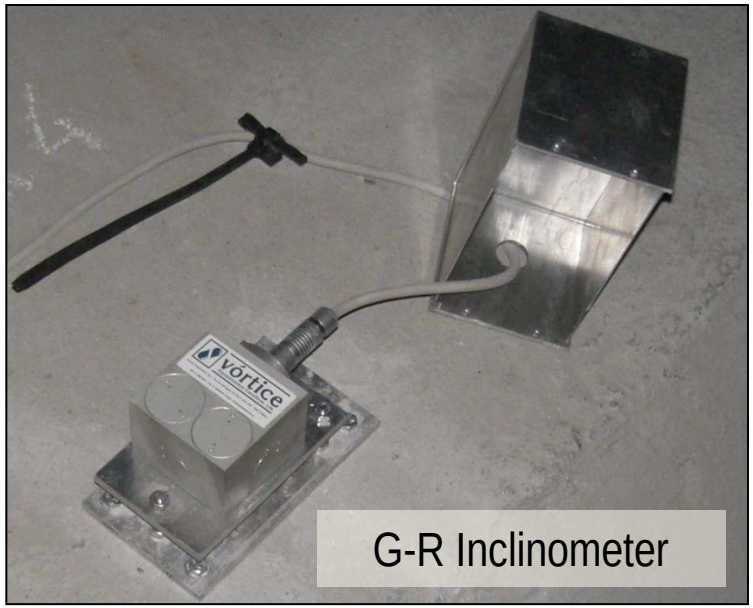


Measurement of displacements at expansion joints

Gravity-Referenced Inclinometers







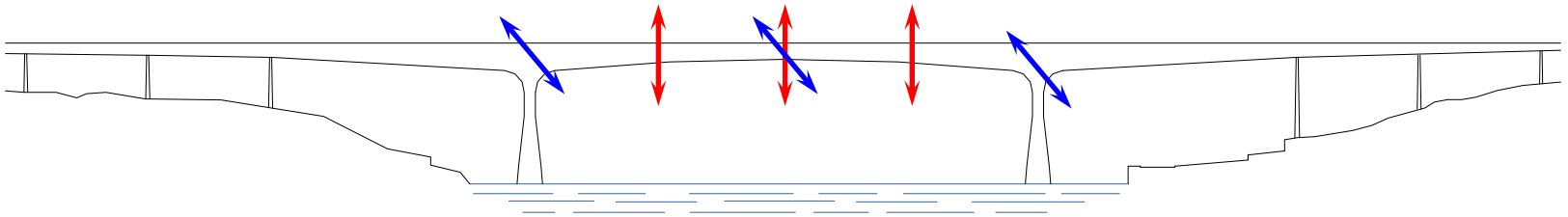
Measurement of rotations (Biaxial)

Automatic data acquisition

Datalogger (9)

Fiber optic based LAN

Dynamic monitoring



Vertical acceleration

Transverse acceleration

Accelerometer

DAQ

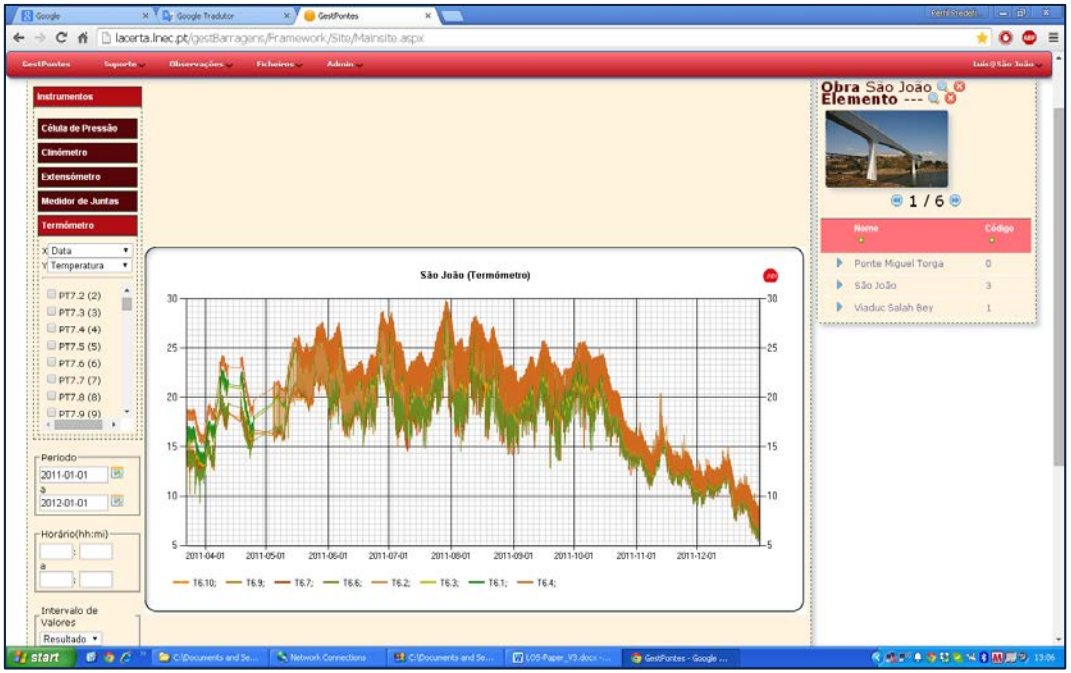
Information to be extracted:

- Natural Frequencies
- Modal shapes

Management of the experimental information

Integrated system:

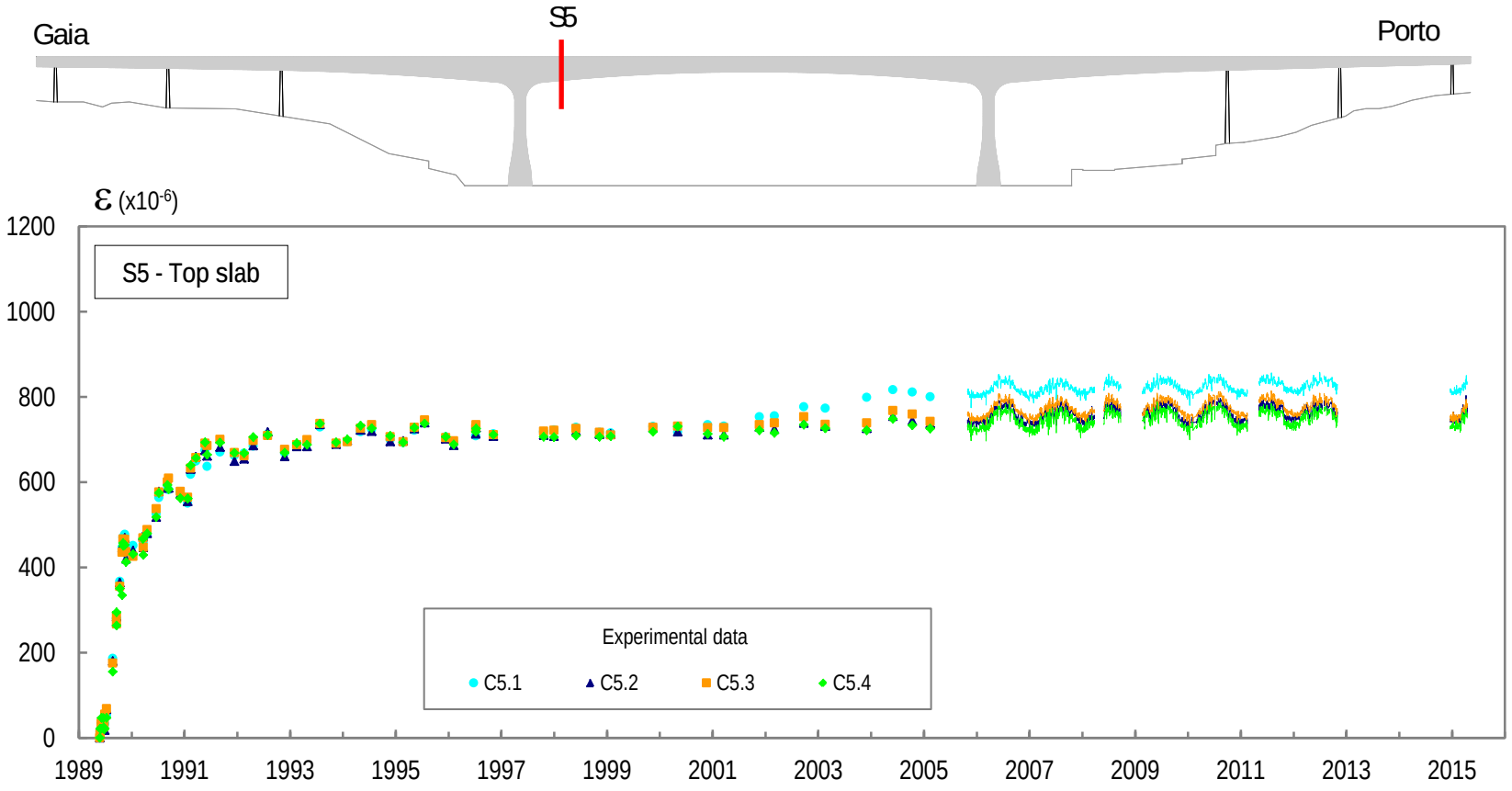
- data uploading
- processing of data
- web portal



Structural analysis

- Probabilistic-based analysis of time dependent behaviour
- Random variables: concrete creep and shrinkage
- Monte Carlo simulation

Experimental results
Concrete strains



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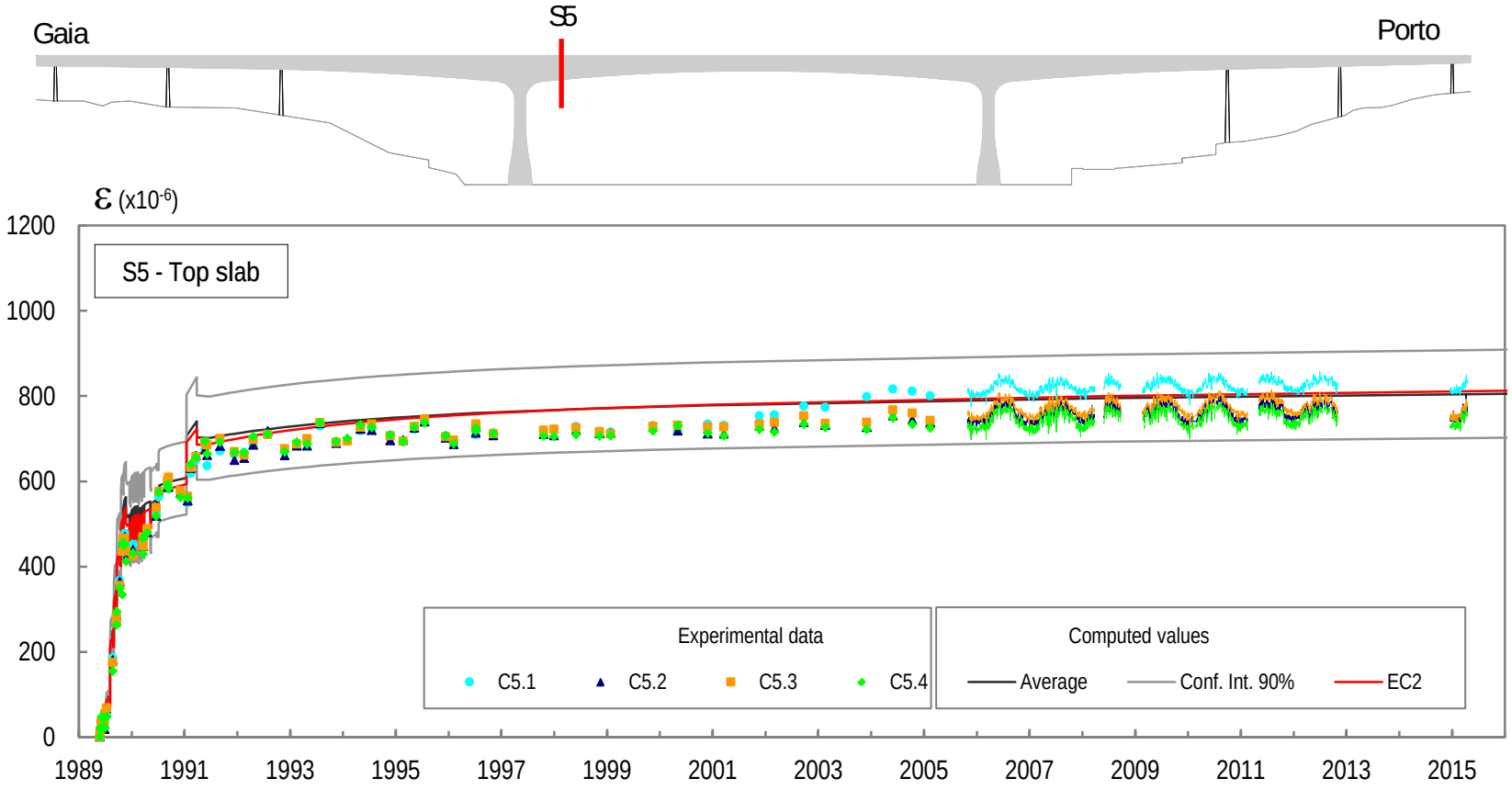
Concrete strains



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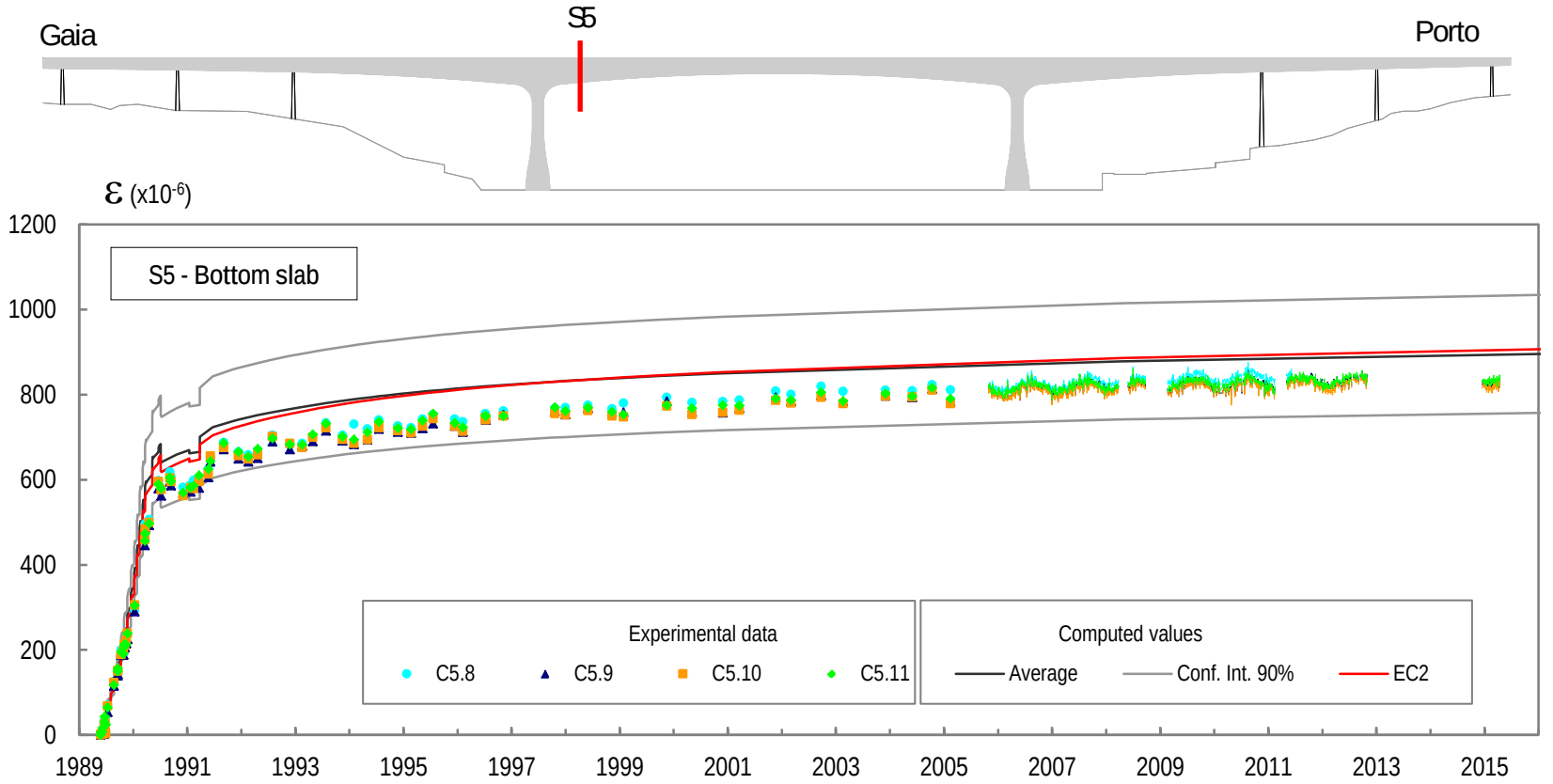
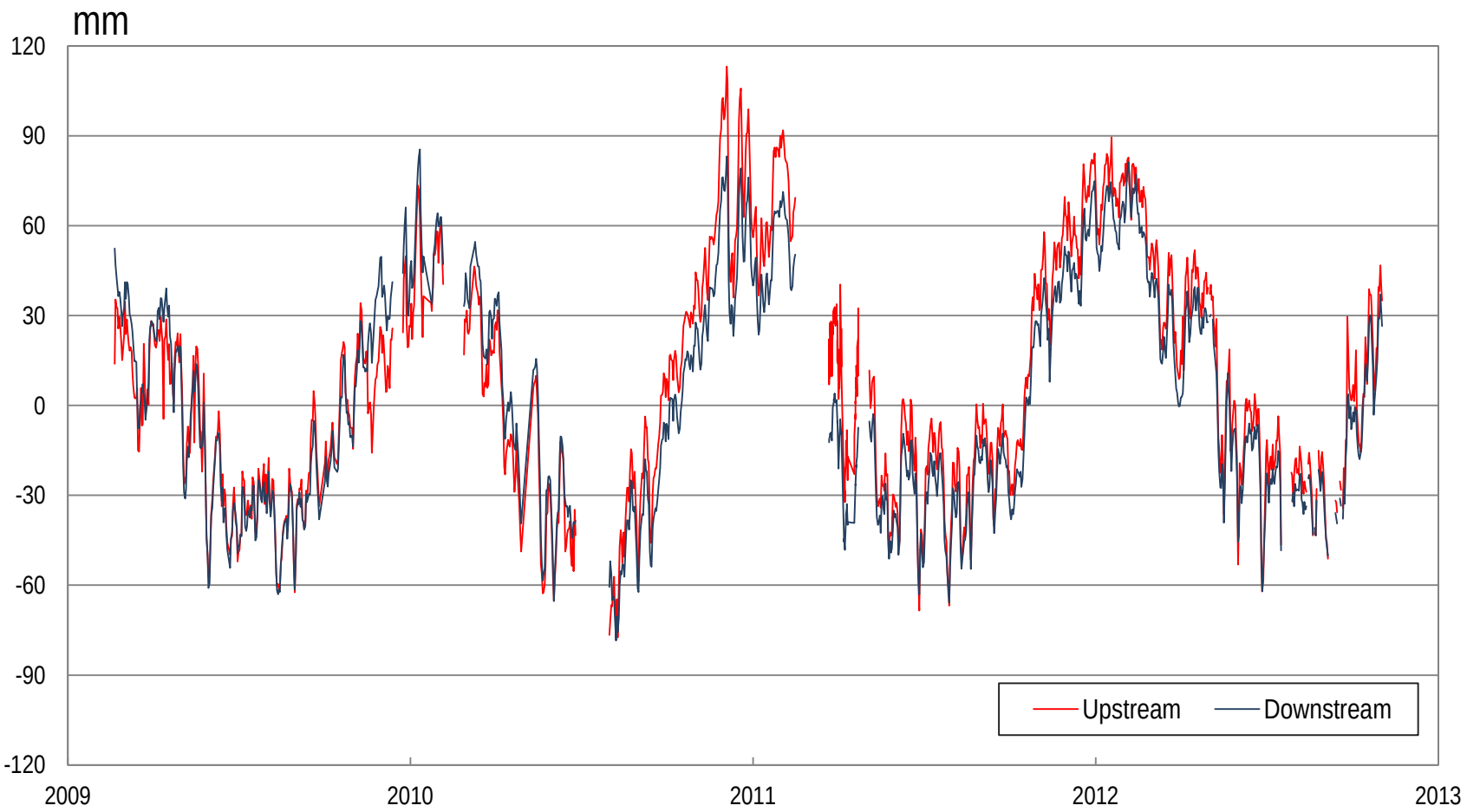


Experimental results

Displacements at expansion joints



Conclusions

- S. João Bridge has a long history of measurement data.
- The evolution of the SHM system of São João Bridge reflects the evolution of the procedures used by LNEC in the field of BHM.
- This case illustrates the possible contribution to this WG

Challenges

- Integration of monitoring systems to assess the corrosion of reinforcement in concrete and chemical attacks on concrete structures (Pereira *et al*, 2015).
- Detection of damage from SHM (Santos *et al*, 2013).
- Monitoring and assessment of concrete structures affected by alkali-aggregate reactions.

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