LABORATÓRIO NACIONAL
DE ENGENHARIA CIVIL

TERCENAS BRIDGE

A chloride induced corrosion case

Luís Oliveira Santos

Location


© Nations Online Project
ATLANTIC OCEAN
SPAIN
Lisbon
Leiria
Coimbra
Santarém
Évora
Faro
Viseu
Guarda
Castelo Branco
Portalegre
Beja
Setúbal
Aveiro
Porto
Braga
Viana do Castelo
Vila Real
Bragança
Chaves
Cáceres
Badajoz
Seville
Huelva
Gulf of Cádiz
PORTUGAL
National capital
District capital
City, town
Major airport
International boundary
Expressway
Main road
Railroad
0 25 50 75 100 km
0 25 50 mi

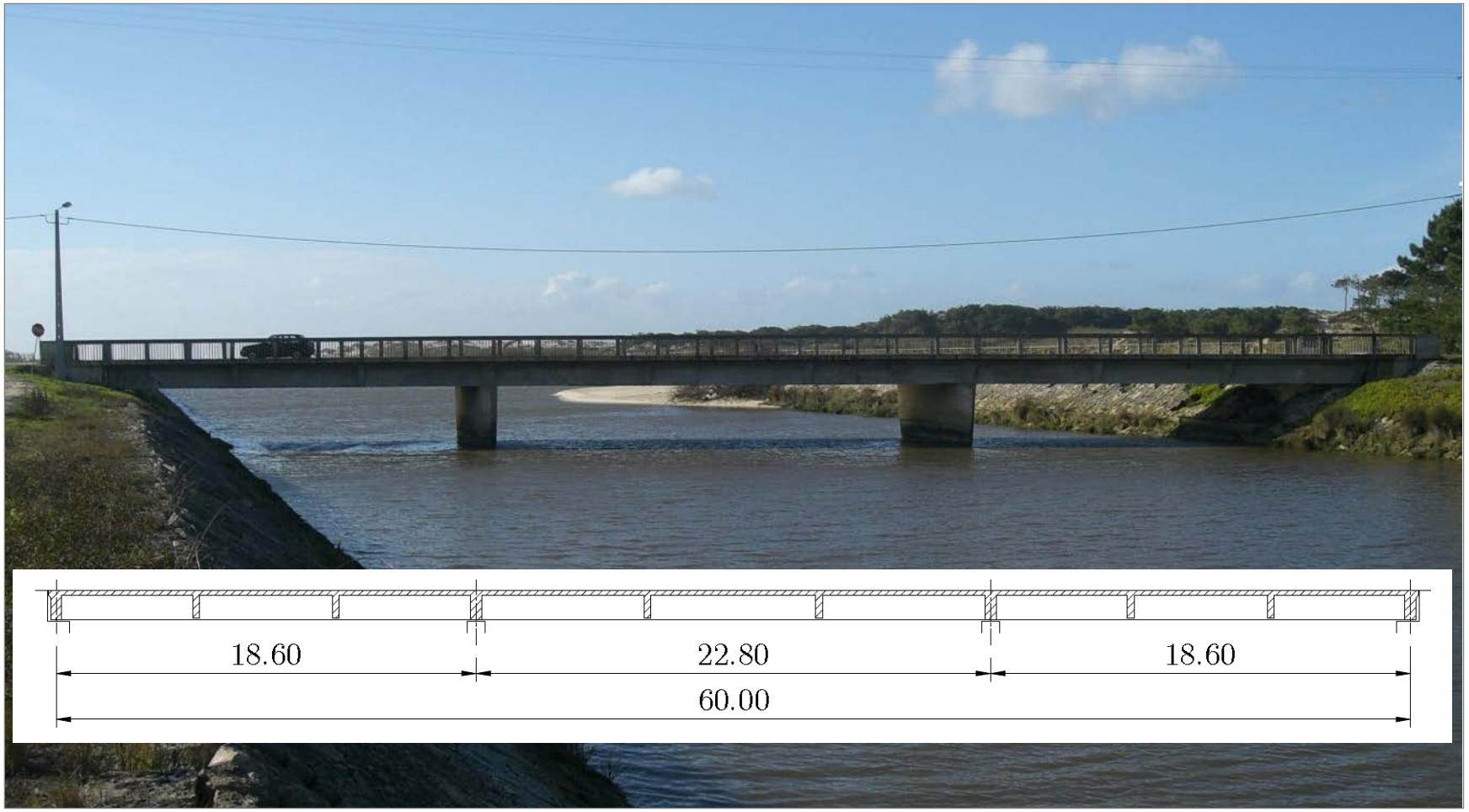
Location

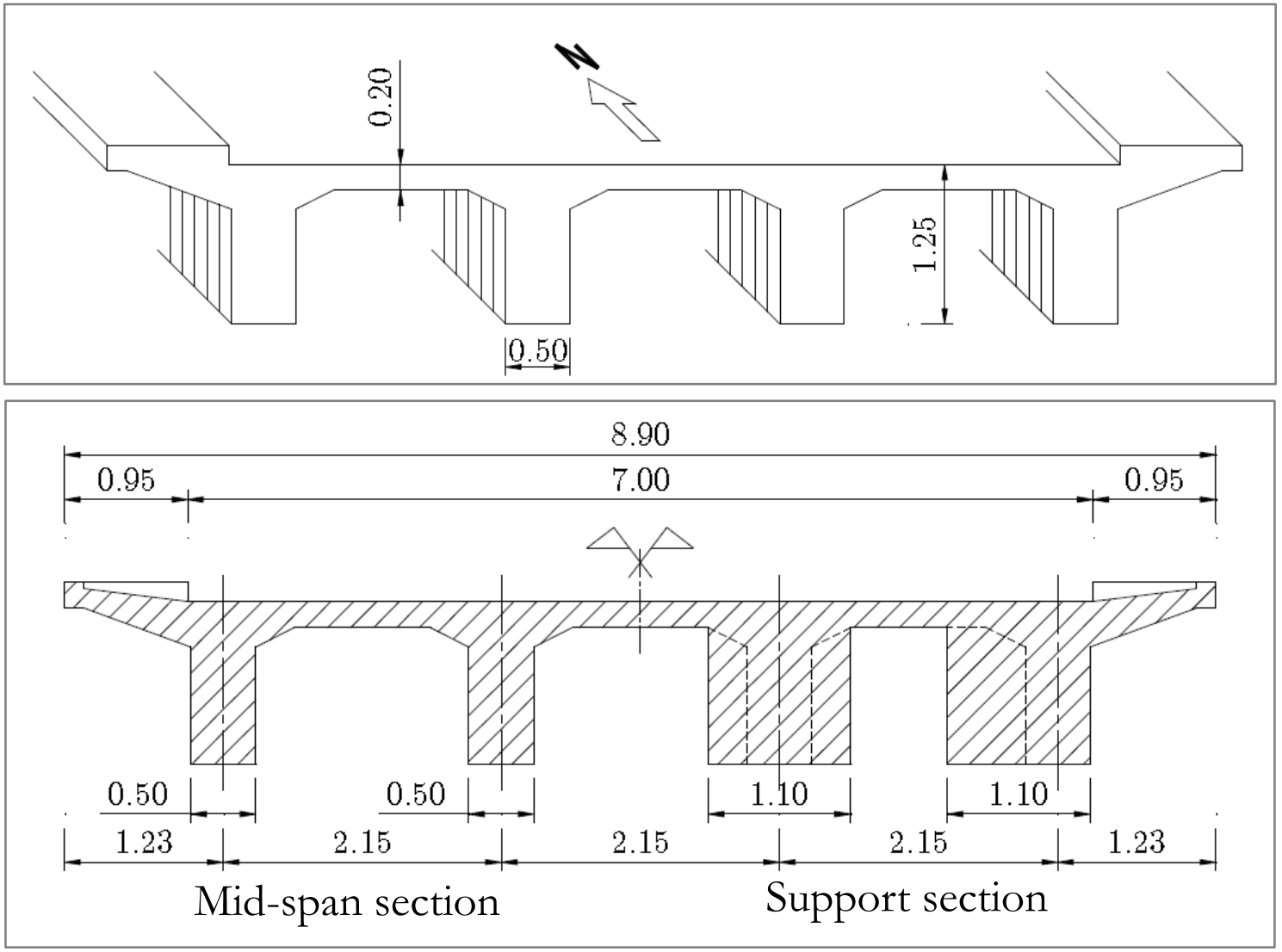

500 m
Bairro da PSP
Estrada Florestal
Rua das Tercenas
Rua da Lagoa
Praia da Vieira
N349
Rua do Mar

Tercenas Bridge

Owner.....Office of Water Services
Construction……1970

Tercenas Bridge





Jacinto, L. (2011). *Safety assessment of existing bridges. Bayesian Probabilistic Approach*, PhD thesis, FCT/UNL. http://run.unl.pt/handle/10362/7601.

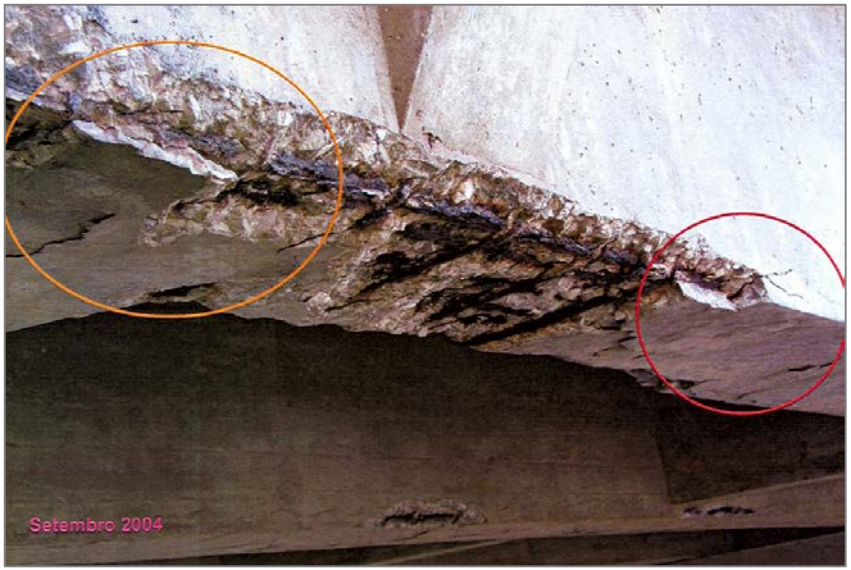
Visual inspection
Minor damages

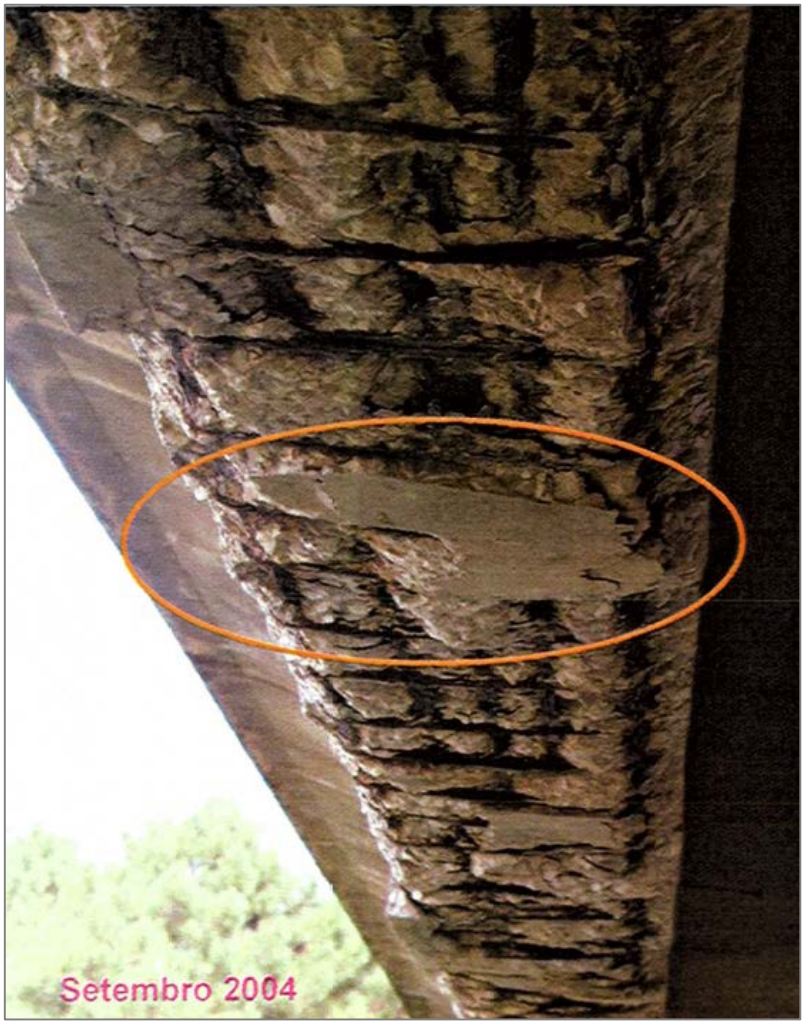
Sep. 2004

Visual inspection
Structural damages

Sep. 2004

- Cracking
- Concrete delamination
- Corrosion of reinforcement bars





Nov./Dec. 2004

On-site tests

In areas without apparent degradation of the concrete:

- Determination of concrete cover depth
- Measurement of carbonation depth
- Measurement of corrosion potential (ASTM C876:91)
- Measurement of corrosion rate (RILEM TC-154-EMC, 2002)
- Measurement of resistivity of concrete

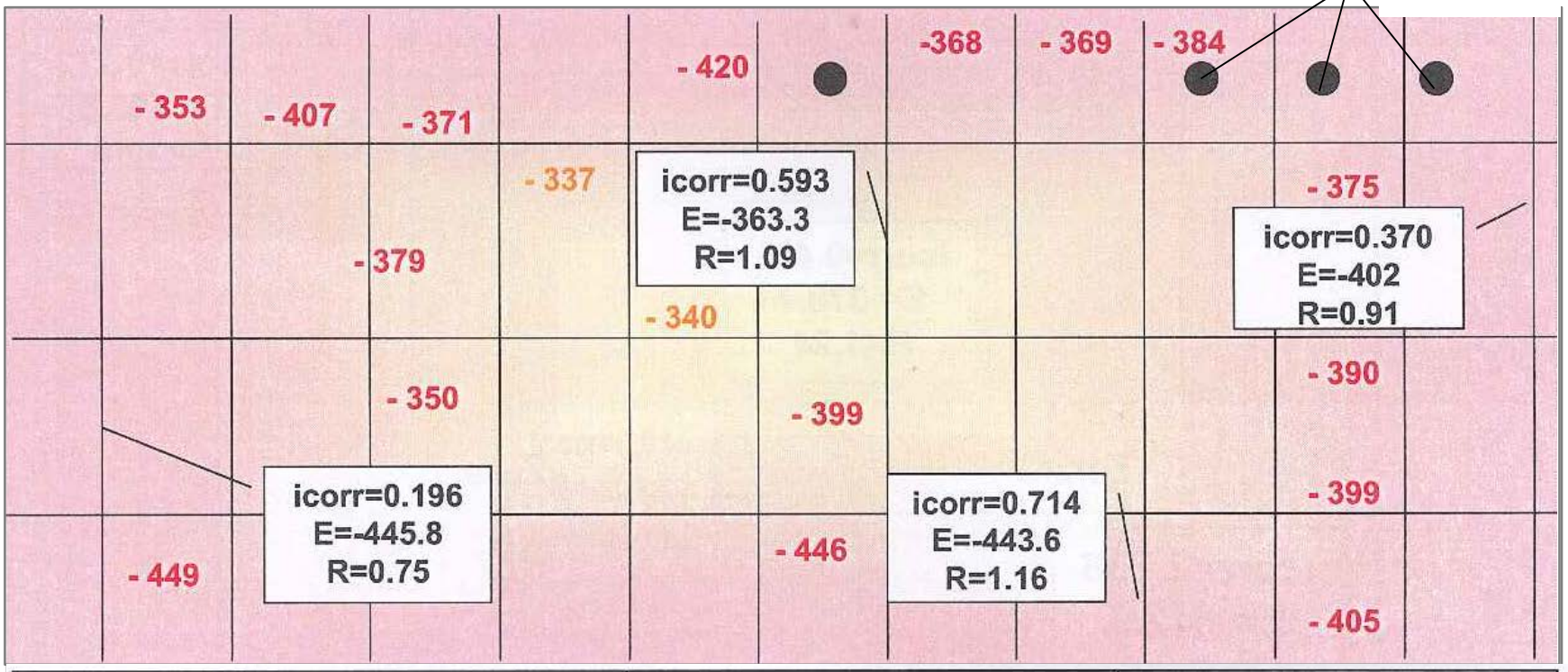
Measurements at Beams 1, 2 & 4; South pier; South Abutment

Manuel Salta *et al* . (2005).

On-site tests

Nov./Dec. 2004

Corrosion potential, corrosion current & resistivity of concrete

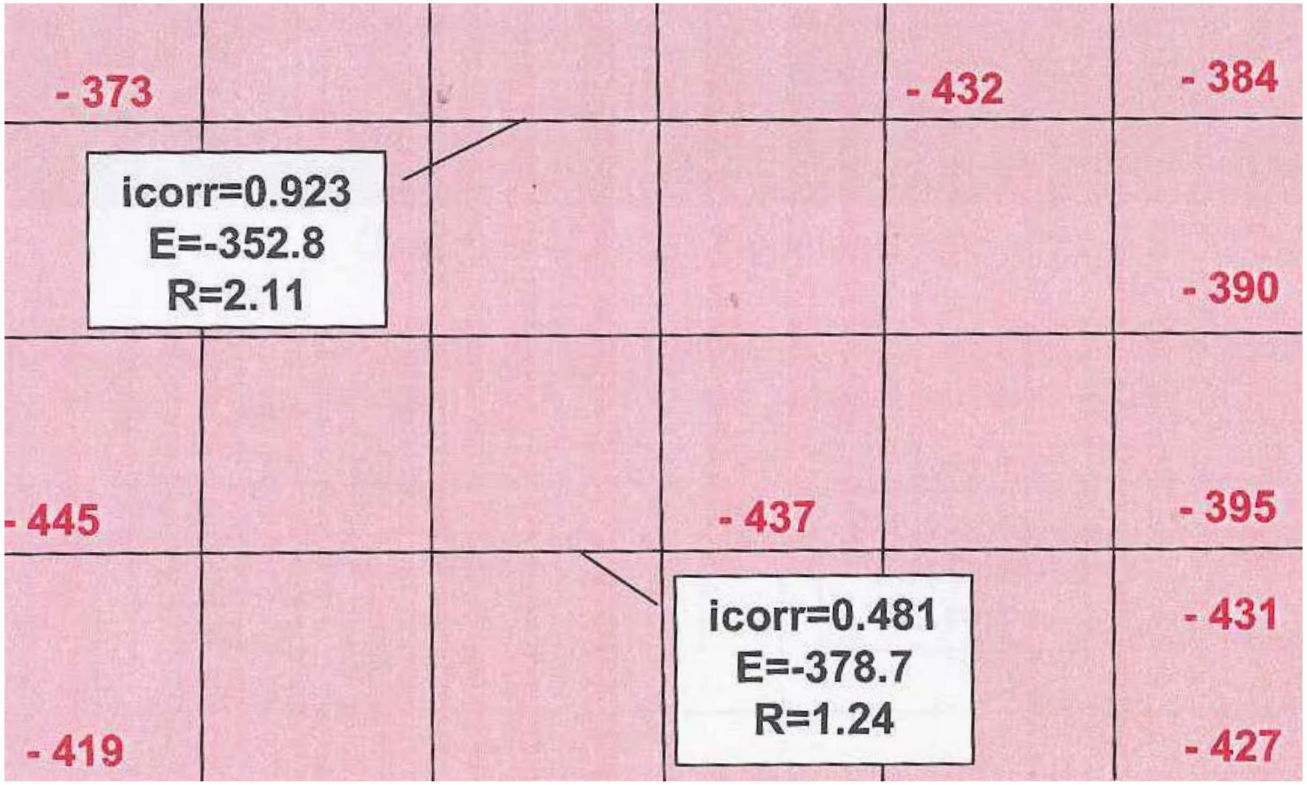


Icorr - Corrosion current ($\mu A\ cm^{-2}$)	Probability of corrosion	Symbology
E - Corrosion potential (mV)	90 %	
R - Resistivity of concrete ($k\Omega$)	10-90%	
Manuel Salta et al . (2005).	10%	

On-site tests

Nov./Dec. 2004

Corrosion potential, corrosion current & resistivity of concrete



South pier

Manuel Salta et al . (2005).

Laboratory tests

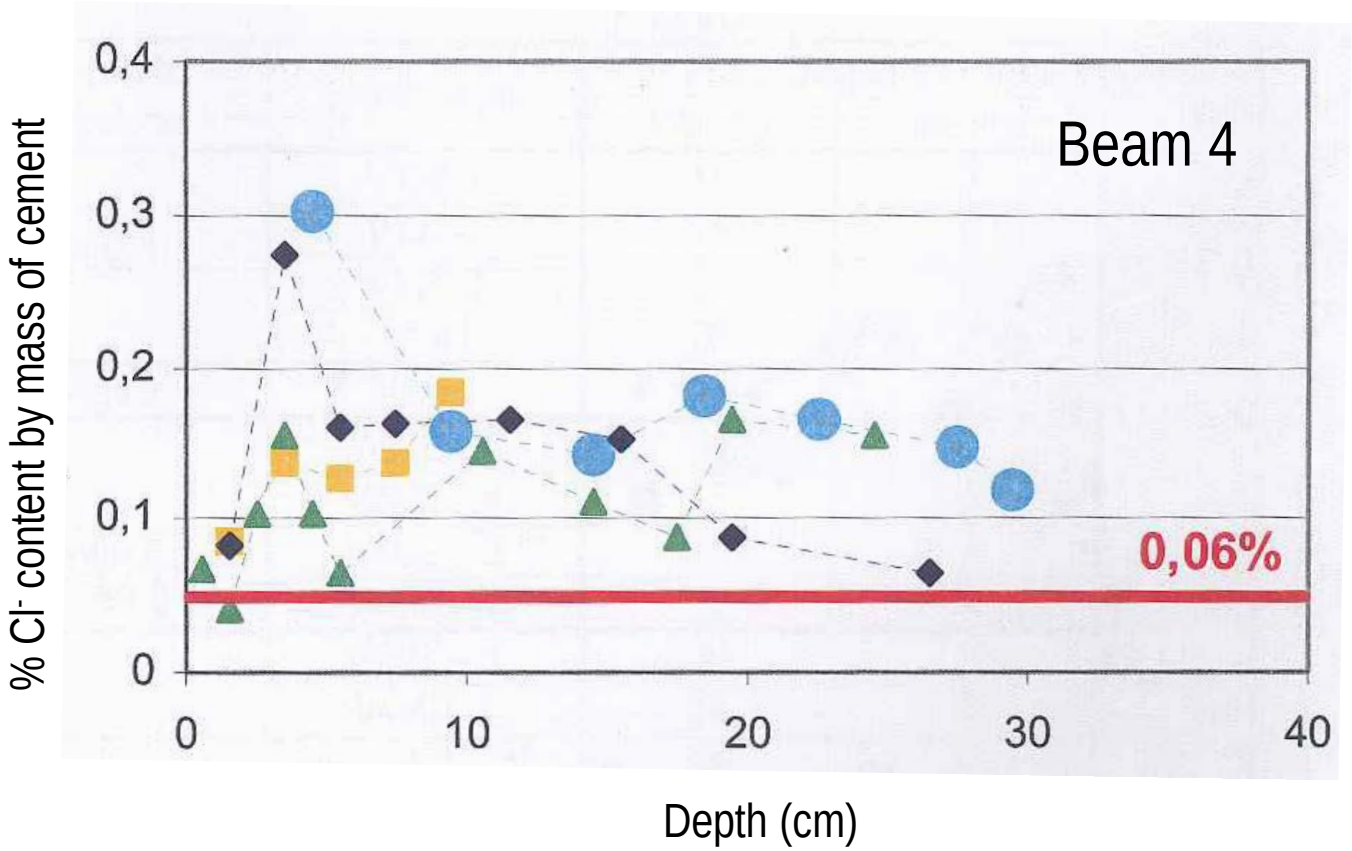
Taking cores for testing:

- Chloride content of concrete
- Carbonation of concrete
- Compressive strength of concrete
- Microscopic analysis

Laboratory tests

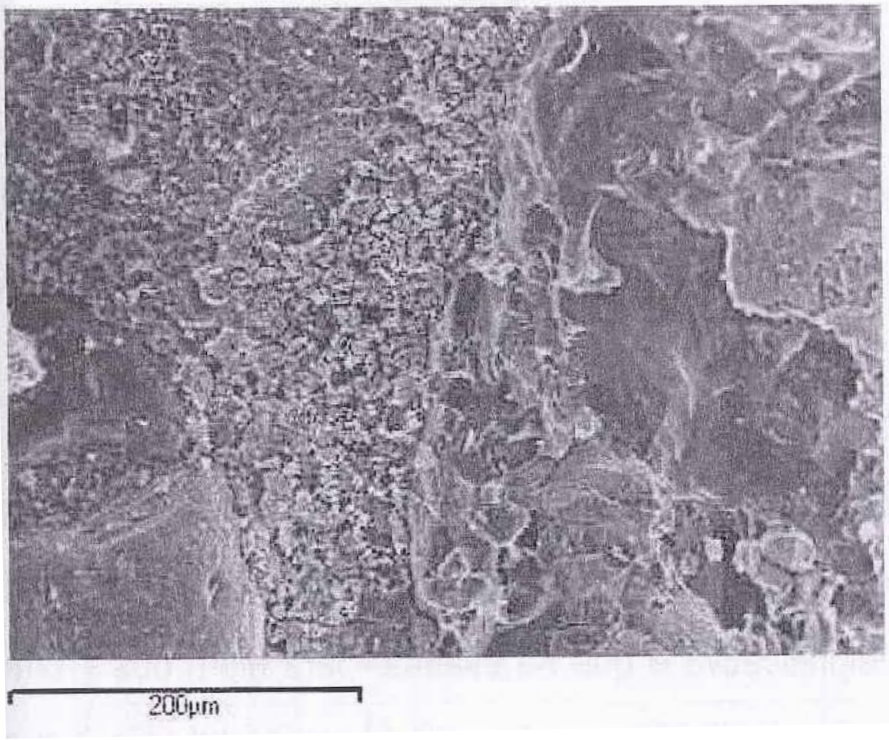
Nov./Dec. 2004

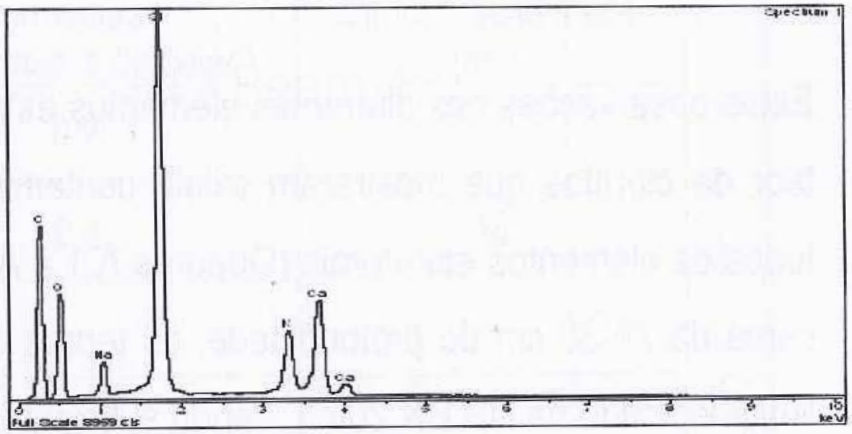
Chloride penetration profile



Laboratory tests
Microscopic analysis

Nov./Dec. 2004





Element	Ca	O	Al	Si	Na	K
Content(%)	17	42		30	4	9

Conclusions and recommendations from the tests

Taking into account:

- The advanced state of degradation of the bridge
- The very depth contamination of concrete with chlorides.

Bridge replacement was recommended.

Safety until replacement ?

- Traffic restrictions
  - Speed limit
  - Maximum weight
  - Avoid traffic over the left beam

- Frequent visual inspections

Traffic restrictions

Bridge visual inspection
Structural damages

Jan. 2008

Bridge visual inspection
Structural damages

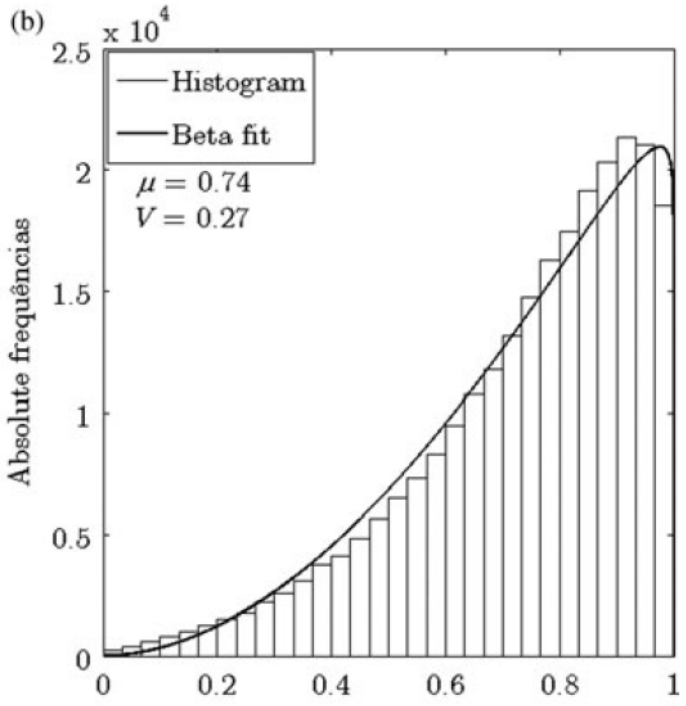
April 2009

Bridge visual inspection
Structural damages

March/Dec. 2011

Safety until replacement ?

- According to the Portuguese national code: NO
- Target reliability index, β_T=3,8
- The mid-span section of beam 4 was critical (bars residual section).
- A probabilistic analysis with Bayesian updating was carried out: the value of β_T=3,9 achieved showed that the risk of failure of the bridge could be considered acceptable for the time needed for bridge replacement



Residual section index
Posterior histogram

Bridge demolition

2012

New Tercenas Bridge

2014

Is this case study valuable for VoI analysis ?

Pros

- Strongly damaged concrete bridge
- Chloride induced corrosion
- Relevant data available: visual inspections, on-site & laboratory tests

Cons

- No use of SHM
- Bridge already replaced