CONCRETE DURABILITY INSPECTION AND TESTING AT SCHOOL BUILDINGS STRUCTURE

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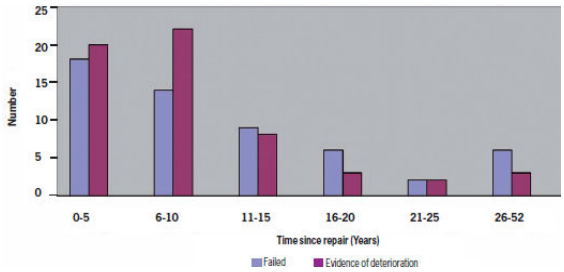
1. Reinforcement corrosion in concrete structures

• The **reinforcement corrosion** occurred in 55% on the 230 analyzed cases. The **repairs performance are disappointing**: 20% failed in 5 years, 55% failed in 10 years and 90% failed in 25 years.



• The **causes of failure** in repair operation were attributed to **incorrect diagnosis**, **incorrect repair design type**, poor workmanship, use of inappropriate techniques or materials, etc..

Font: Concrete repairs: Performance in service and current practice, CONREPNET Concrete Repair Network, 2007

1. Corrosion of reinforcement in concrete structures

• diagnosis study of the reinforcement corrosion of a secondary school buildings structure, which was commissioned following the remodeling works of another school, with identical characteristics, involving specific work, **not foreseen**, structural repair at upper floors slabs due to **concrete contamination by chlorides**, which resulted in **extra costs too high**

2. Methodology

• Part 9, **NP EN 1504**, is instructive about the need of the anomalies diagnosis, present in the structures, for the definition, clear and objective, of the intervention strategy. In particular, define the steps to be followed in the evaluation process, including most importantly:

a) Visual inspection for raising the apparent structure condition;

b) Non-destructive testing for concrete and reinforcement characterization;

c) Original project analysis;

d) Environment characterization which the structure is subject;

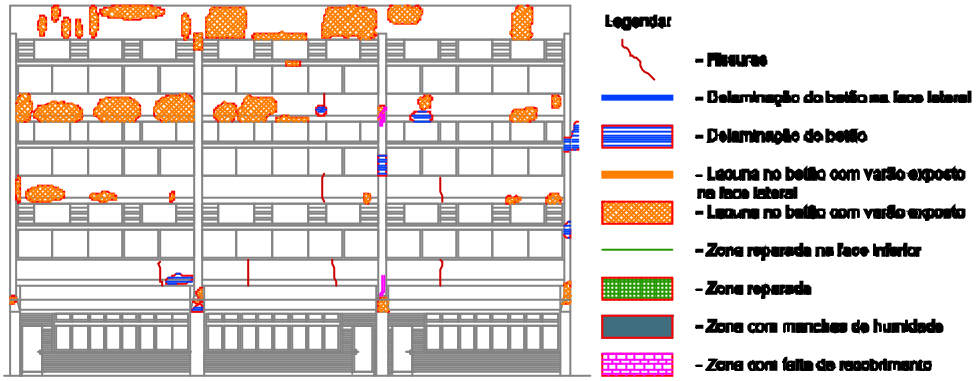
e) The **structure history** research;

f) Characterization of the **use types**;

g) Future requirements definition.

2.1 - Visual inspection of the buildings

• **detection**, **identification** and **assessment** of the **importance** of the **anomalies** related to reinforcement **corrosion**, such as, for example, **delamination cracks**, **small gaps**, with exposure of **corroded rebars** with possible section reduction



2.2 - Summary evaluation of reinforcement corrosion

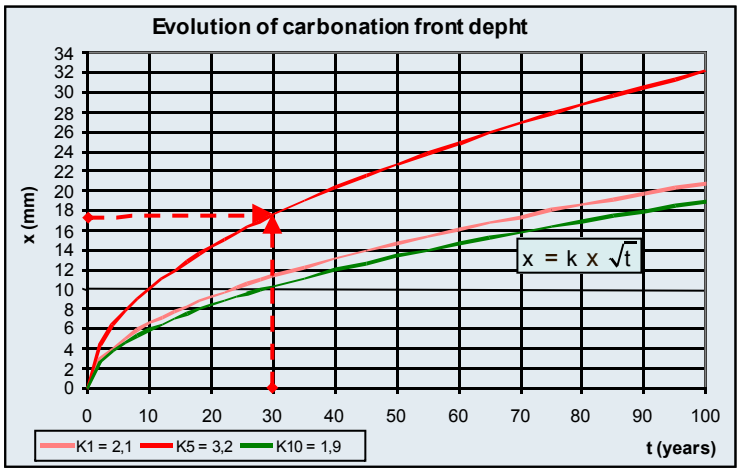
I. Measurement of rebar cover (BS 1881: Part 204)

• **19 reinforcement meshes** were detected (tests zones) in the different structural elements types, divided as follows:

- Façades:
  - Walls: 2 tests
  - Slabs / board: 2 tests
  - Prefabricated elements: 2 tests
- Indoor of the buildings:
  - Walls/columns: 2 tests
  - Prefabricated elements: 2 tests
  - Slab/ bottom face: 4 tests
  - Slab/ upper face: 5 tests

2.2 - Summary evaluation of reinforcement corrosion

II. Measurement of carbonation depth (EN14630-2006)



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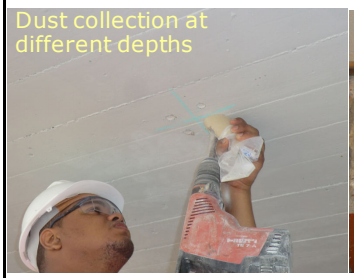
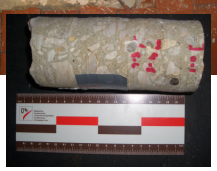
2.2 - Summary evaluation of reinforcement corrosion

III. Evaluation of chloride content in concrete (prEN14629-2003)

• Tests were conducted on **powder samples** collected by drilling bit, up to three deeps (surface layer, rebars level and behind the rebars). Were performed **8 tests**, 4 of which from the **cores**.





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3. Collected information and its analysis

3.1 - Visual inspection of the buildings

• the **façades**, which were **recently painted**, was detected frequent presence of **small surface irregularities**, whose features seemed to **repaired parts** of the structure due to **reinforcement corrosion**. Were located more frequently on the walls and, secondly, in the façades prefabricated elements.

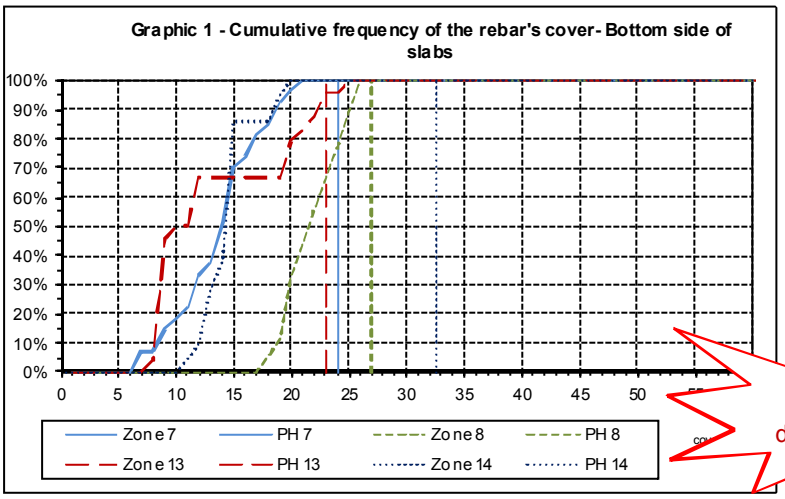
3.2 - Summary evaluation of reinforcement corrosion

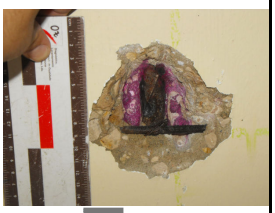
I. Measurement of rebar cover

Test Zones	Element	Cover measured with the covermeter (mm)					Carbonation depth (mm)
		min.	med.	max	S.D.	C. Var.	
1	B1/façade wall	10	**30**	49	11	38%	24
11	B3/façade wall	10	**22**	33	8	37%	14
2	B1/Prefabricated ext.	16	**25**	42	6	25%	9
12	B3/Prefabricated ext.	10	**34**	48	7	22%	6
9	B1/Prefabricated int.	20	**31**	43	6	19%	25
17	B3/Prefabricated int.	21	**26**	30	3	11%	45
3	B1/slab /Board	11	**18**	24	5	27%	19
10	B3/slab /Board	16	**18**	21	2	11%	27
7	B1/Slab/ bottom face	7	**14**	21	4	27%	24
8	B1/Slab/ bottom face	18	**22**	26	2	11%	27
13	B3/Slab/ bottom face	8	**14**	25	6	43%	23
14	B3/Slab/ bottom face	11	**15**	20	2	15%	33
6	B1/column int.	18	**35**	49	9	26%	4
16	B3/column int.	23	**29**	41	5	17%	30
4	B1/Slab/ upper face	67	**68**	69	1	2%	3
5	B1/Slab/ upper face	70	**71**	72	1	2%	5
15	B3/Slab/ upper face	70	**83**	92	8	9%	4
18	B3/Slab/ upper face	60	**64**	67	3	4%	3
19	B3/Slab/ upper face	40	**40**	40	0	0%	2

3.2 - Summary evaluation of reinforcement corrosion

II. Measurement of carbonation depth



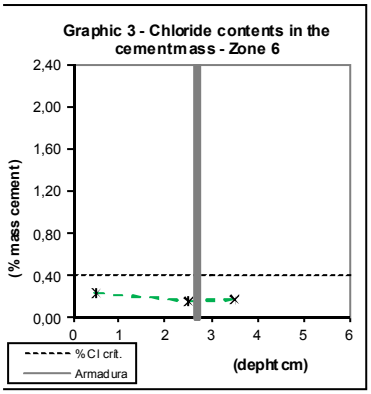


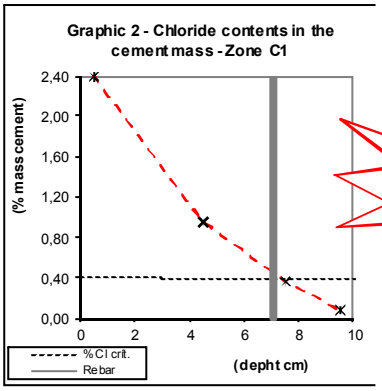
Steel despassivation

3.2 - Summary evaluation of reinforcement corrosion

III. Evaluation of chloride content in concrete

- the chloride contents of the **slabs upper face**, very consistent, are **mostly higher** than the critical value indicated in the standard NP ENV 206 of 0,4 % of the cement mass



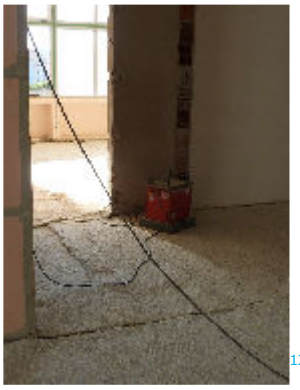


CORROSION HIGH RISK

4. Intervention strategy recommendations

• It was concluded that **slabs top face** at upper floors was the **most severely compromised** structures part, susceptible to **severe and rapid deterioration**, due to reinforcement corrosion, provided by **high levels of present chlorides**.

• The **repair durability** of the corroded reinforcement of upper floors slabs (roof excluded) must be the **maximum possible**. Accordingly, in addition to repair of visibly affected areas have to be eliminated salts in excess of concrete by means of **electrochemical treatment of desalination** or alternatively choose the introduction of **cathodic protection of reinforcement**, immunizing them of corrosion.



5. PLAYERS QUALIFICATION

- Must have a **Quality Management System** (NP EN ISO 9001:2008)
- **Operators** qualification through the annual implementation of **training plans**, by inspection and testing type
- **Calibration** and **maintenance** of inspection **equipment**, measuring and testing, according to an annual **plan**
- Procedures implementation for **evaluating** the relevant **suppliers** for Quality
- Quality **Audits**, including "in-situ" work audits
- Setting the **control** mode of Nonconformities through the development and monitoring of **Corrective and Preventive actions**
- **Quality Plans** preparation, with the aim to locate and describe the service cycle implementation, the checks to be carried out by the performer, so planned and systematic

6. Final remarks

- We tried to emphasize the **inspection and nondestructive testing**, "in situ", importance as **support** for decision-making **strategy** of **structural** or **maintenance** interventions. The different actors responsibilities and the implementation technical control should be clearly specified, in particular the **normative level**, that does not happens.

- We tried to also draw attention to the actors qualification, which must have a **Quality Management System** (NP EN ISO 9001:2008), properly implemented. The scope should cover the type of service provided and ensure, in particular, adequate operator training and calibration of equipment used.

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Thanks for your attention

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