



COURSE
Testing techniques for structures inspection 29th and 30th May 2012

Course on testing techniques for structures inspection

Introduction


Manuela Salta
LNEC

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Tópicos


- 1.General considerations
- 2.Main applications of NDT
- 3.Reliability of NDT

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Non-Destructive Testing (NDT)


- ✓ **non invasive techniques to determine the integrity of a material, component or structure or to measure quantitatively some characteristic of an element**
- ✓ NDT technology development for steel evaluation is more mature than for concrete. NDT are use on quality control of steel products.
- ✓ For concrete many techniques give similar insight into an element state, but the understanding of what can be achieved for concrete structures is not yet well known for several techniques.

Destrutive testing (DT)

- ✓ Techniques aplied in samples collected from the structure)




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NDT application in concrete structures :

- ☐ quality control of new construction;
- ☐ troubleshooting of problems with new construction;
- ☐ assessment and condition evaluation of existent concrete structures for rehabilitation purposes;
- ☐ quality assurance of concrete repairs.




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***In-situ* testing (NDT) during construction or repair for :**

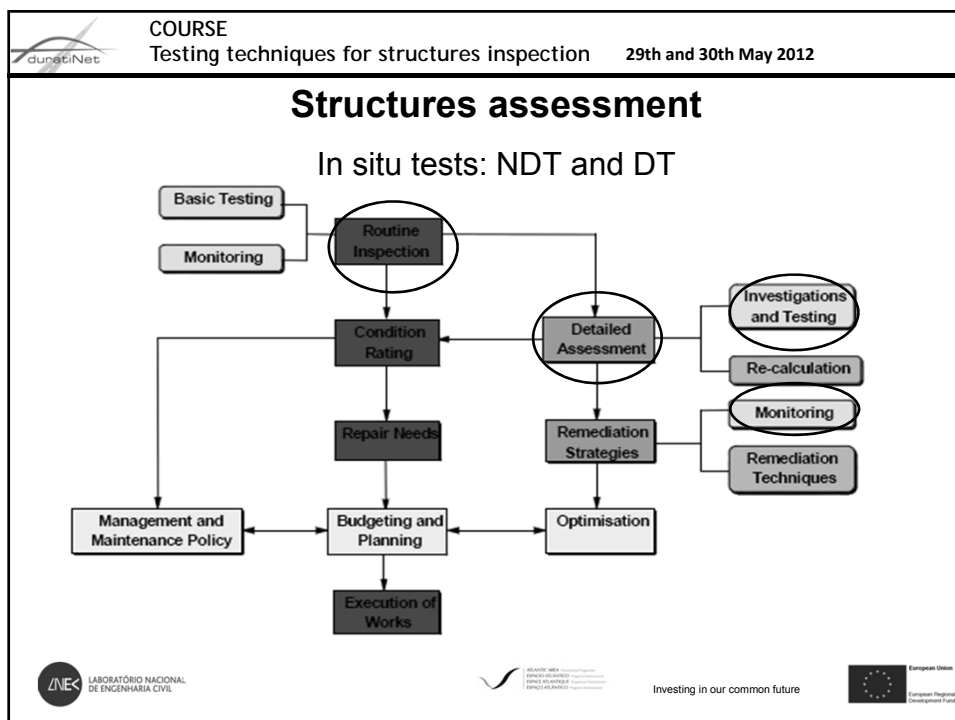
- control testing*: quality assurance - by the contractor or concrete producer;
- compliance testing*: to test the compliance with the product specification or design specifications
- secondary testing*: on samples extracted from the structure, not necessarily planned before construction.

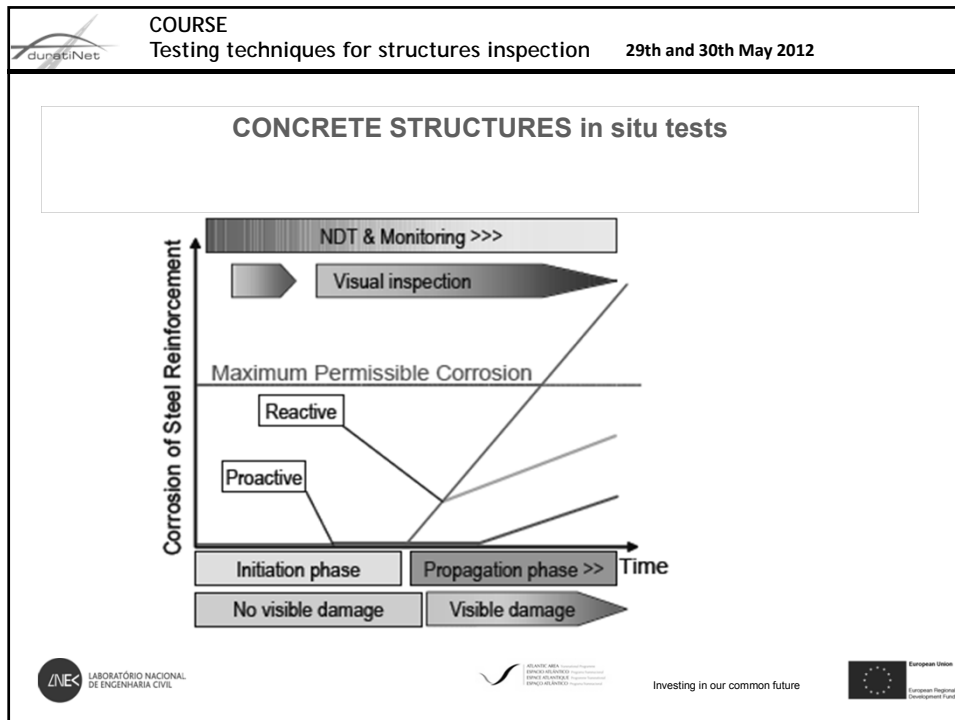
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In- situ testing (NDT) for structural assessment

- to investigate the current condition of the structure;
- to diagnose the causes of defects or deterioration;
- to know what is the severity level of the problem, its location and extent;
- to support the selection of an appropriate solution (repair) to the problem;
- to check the quality and the efficiency of a repair.

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Type of information to obtain by NDT testing techniques on concrete structures:


- ☐ concrete member dimension;
- ☐ steel reinforcement and prestressing location;
- ☐ degree of concrete consolidation- stiffness and strength
- ☐ identification of non visible damage (delaminations, debonding,);
- ☐ construction defects identification, cracks, voids, honeycombing;
- ☐ location, distribution, size and causes of cracking;
- ☐ corrosion state and extension;
- ☐ concrete damage due to external impact, fire, chemical action...

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Three requirements should be satisfied by NDT on structures condition assessment


- to detect defects or variation of properties, between structures or within one structure,
- to build a hierarchy of a property (i.e. to rank on a scale) (i.e. mapping corrosion or stiffness, plotting changes in dimensions...), between several areas in a given structure or between several structures,
- to quantify properties, i.e. comparing them to allowable thresholds or reference values (e.g. expected strength or planned dimension).

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***In-situ* testing are expensive and it is essential that:**


- ☐ The aims of the investigation should be established right from the start.
- ☐ The development of a properly structured plan, with interpretation as an on-going activity is essential before beginning any in-situ testing.
- ☐ The choice of the testing techniques, the number of tests to be performed and the order in which they are performed depend on the aims of the investigation and of spatial variability and time variability of measured parameter

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Sampling for DT must consider:

- the size, form, location, orientation, age and structural design of the structure;
- the results of visual surveys and any other available information about localization of rebars and deterioration;
- the aggregate size and the heterogeneous nature of the concrete;
- type of exposure conditions, e.g. salt water splash zones, immersion,


Core samples :

$$\Phi > 3 \times d_{\text{max aggregate}}$$

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Spatial and time variability

$D = g(di(x))$

Distribution type:

- Chloride threshold
- D Chloride, surf. content
- Corrosion rate, potential
- Concrete cover
- Resistivity
- Potential

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Spatial and time variability of measurements limit condition assessment and service life prediction


What is the relevancy of a specific set of measurements, performed at a location X and time T ?

How can they be used to assess the actual condition?

How can they be used to forecast the reliability along time ?

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Selection of NDT should consider the main characteristics:


- 1. Resolution of the technique** (it must be sensitive to any variation of the potential influential factor).
- 2. Discrimination**, since it is better to use a technique which is not sensitive to “everything” putting at risk the capacity of being able to discriminate the possible explanations. The magnitude of the result variation should not be a noise, which is frequent with heterogeneous materials.

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- 3. Ability to uncouple effects** between the influence of intended material property and other parameters (environmental parameters like temperature and humidity).
- 4. Ability to quantify the material properties.**
A NDT could be sensitive to some concrete physical property (e.g. material porosity) but we can be interested on properties like stiffness and strength. The relation between the NDT result and the intended property is not straightforward and it requires calibration.
If the calibration is not done with the same material the quantification remains a problem.

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NDT reliability is limited by the uncertainties associated due to:

- systematic influence of the environment conditions
- random interference (due to intrinsic variability of materials)
- adequability , robustness of testing technique
- calibration of equipment
- human factors
- data interpretation





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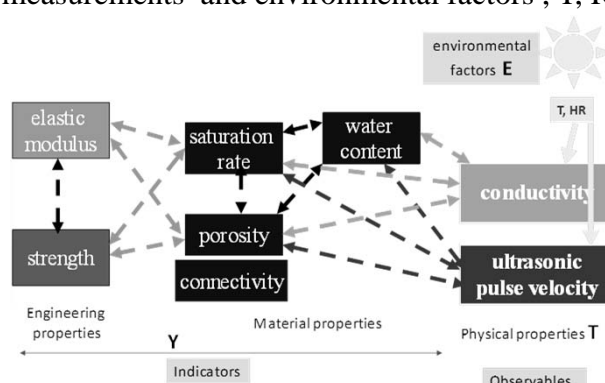



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Reliability of Non-Destructive Testing interpretation

Relations between engineering and material properties Y,
NDT measurements and environmental factors , T, RH,....







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Reliability of Non-Destructive Testing

- NDT methods, in general, give values which are called as independent variables, i.e, Ultrasonic Pulse Velocity or Hammer tests (Mechanical Sclerometer)
- after statistical correlation methods should predict the property of concrete - strength, elastic modulus etc which are called dependent variable Y.
- A regression model assuming straight line relation between dependent and independent is usually used as
$$Y = a x_1 + b x_2 + c$$
where, Y = dependent variable
x1, x2, x3= independent variables
- laboratory data on strength of cubes and corresponding UPV reading & hammer reading could be collected to find the values of constants.




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Accuracy and Reliability of Non Destructive Testing depends on:

- Size & quality of database for determining statistical coefficients (relating indepent and dependent variables.
- Method of Sampling and size of sample
- Kind of statistical tools that are used for arriving at results and their interpretation
- Quality of instruments used and proficiency of personnel using it.




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In some cases it is also important to combine techniques:

- confirming with a second technique what has been observed with a “quick” first one and detail more,
- zoning the area where a more sophisticated investigation will be performed for better results interpretation,
- decreasing the number of cores for DT by identifying the areas where cores will be more informative.

ex: potential /corrosion rate/chloride profile



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