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Why Not Enlarge the Non-Destructive Testing (NDT) Experience in Construction Maintenance – Problems, Practice, Ideas etc.?

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Abstract

In the construction area evaluation visual methods and expertise predominate. But modern inspection needs quantitative mechanical parameters non-destructively (ND) received. Many ND techniques are developed in the NDT area.

The main problem is that the great success reached in NDT methods development is predominantly for the homogenous materials, as metals, in the most cases iron products – different steels. From the other hand most and widespread materials in construction activity are with heterogeneous nature as concrete, stones, bricks etc. So should be developed methods working with such media.

In this paper will be observed the methods used and discussed among the prestressed concrete structures professionals. As result the new approaches to be introduced from NDT practice, and possible problems arise.

The aim is to adopt from NDT area all possible methods, processes of inspection, analysis, values, certificates, documentation etc.

Of coarse there will be skeptics. But we think will be enough enthusiasts, who will be ready to apply significant efforts, to be developed this idea. The perspectives are too attractive!

We hope with this paper to provoke and establish more effective collaboration between non-destructive testing and prestressed concrete structures professionals. For the construction area it will be very useful and for non-destructive testing society will be huge new market.

Keywords: non-destructive testing, prestressed concrete structures, materials evaluation.

1. Introduction

Idea to provoke and establish more effective collaboration between non-destructive testing and prestressed concrete structures professionals arise due my participation in the COST Action 534 ”New materials and systems for prestressed concrete structures” chaired by Rob Polder (see the http://www.cost534.com/), Working Group 3 New Assessment Methods coordinated by Edoardo Proverbio. COST is one of the longest-running European initiatives for the support of cooperation among scientists and researchers across Europe. Set up in 1971 by 19 countries now has 34 member countries spanning the whole of Europe and totally about 58 from all over the world – maybe greatest research network bringing together more than 30 000 researchers. Rather than funding research itself, COST brings together research teams from different countries working on specific topics by supporting networking, conferences, short-term scientific exchanges and publications.

Prestressed concrete structures form an important part of Europe’s physical infrastructure for transportation, energy production, nuclear power plants, water and waste-water treatment and buildings. This method of construction as well as prestressing has now been in use for almost 50 years. As revealed by several national and international reports, these structures actually are in sufficiently good condition. The increasing age, the environmental impact and increasing traffic load may change this situation as documented by a small, but significant number of failures and collapses in the UK, Belgium, Italy, Germany etc. These collapses, premature demolitions, unforeseen extensive maintenance work all over Europe and created great concern about the durability and safety of these structures.

The main objective of the Action was to increase the knowledge on the durability of existing and newly built prestressed concrete structures in order to prolong their service life eventually to 80 instead of 50 years, to minimize repair and monitoring costs and to improve their long-term safety. In this concern to provide additional information, important for owners and maintenance authorities, construction industry, engineers and researchers with: new methods for assessment of the corrosion condition of existing prestressed concrete structures and development of non-destructive inspection methods and monitoring strategies for prestressing and post-tensioned structures

Huge number of prestressed and post-tensioned structures reach or approach the end of life age and state when they should be estimated for their capability to operate safely any more.

Only in Germany more than 20 000 brigades are in such situation and also a number of other structures. Totally in the world this figure could reach hundreds thousands even millions.

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The problem is that the great success reached in NDT methods development is predominantly for the homogenous materials, as metals, in the most cases iron products – different steels. From the other hand most and widespread materials in construction activity are with heterogeneous nature as concrete, stones, bricks etc. So should be developed methods working with such media.

Recently the NDT methods and technology development leads to the state, that a single NDT professional is able to perform much more work than before so less experts are necessary. Result is oversupply and their income decreasing. From other hand this new demand of NDT services in construction activity reduce the oversupply pressure and form new very perspective market.

2. Description of Assessment Methods

This article item is done on the basis of references compilation shown below using the passages and farces directly from the particular cited sources.

There is no commercial non-destructive instrument available for detecting the quality of tendons in concrete structures that is reliable and cost-effective (David Cleland[7]**)**. Tendons are essential to the structural stability of a large number of concrete structures and the quality of tendons (corrosion condition in particular) is one the major factors affecting the stability of this type of common structure. Tendons are buried in concrete so it is difficult to assess their mechanical quality.

Owners and operators of large concrete structures would like to have non-destructive inspections instruments to locate corrosion of tendons and other defects related to the mechanical quality of the structures. Owners and operators would also like to have monitoring instruments permanently installed on structures to give an early warning of a change in the mechanical quality of the structures so that repairs can be made where most needed. These two kinds of instruments would help to extend the working life of existing structures and avoid catastrophic failures and loss of life.

There are many types of NDE methods for inspecting concrete: thermography, gamma ray, X-radiography, vibration holography, neutron radiography, dye penetration, magnetic induction, electric potential mapping, radar, acoustic emission, ultrasonic time of flight, ultrasonic resonance spectroscopy, ultrasonic pulse-echo, ultrasonic guided-wave, and electromagnetic guided-wave testing. All of these methods have disadvantages. Radar is a method favored by some operators of structures but microwaves cannot penetrate the metal duct surrounding tendons. X-rays can penetrate the tendon duct and detailed images of steel forms in concrete can be made. But because of the hazard and because exposure times can be several hours X-ray inspection will never be cost-effective. Ultrasound is, in principle, a good probing method for concrete[1] because it is a mechanical wave. Also it is not an ionizing radiation so it can be used safely under normal operating conditions on structures. Research into guided ultrasonic waves[2] in tendons shows promise but the ends of tendons must be exposed at some stage and this is usually difficult or impossible. Recent advances in pulse-echo inspection of concrete[3, 4, 5, 6] have proved that ultrasound is capable of probing concrete to depths of 1 m or more, finding reinforcement bars, tendon ducts, honey-combing and back-wall echoes. An ultrasonic resonance spectroscopy test gives a unique frequency spectrum, like a "fingerprint", of the sample under test. The spectrum is sensitive to changes in the dimensions, mechanical properties and any flaws in the sample. Mass-produced, nominally identical parts have spectra that vary about an average and the degree of variation can be used to classify parts as either flawed or free of flaws. The test is quick and simple and gives a pass/fail result. AE source is also applied to localize the most damaged areas of bridge structures[8].

State of art in the field of assessment methods for prestressed concrete structures is discussed in materials on the CD of Cost 534 Final Workshop 26-27 November 2007 Toulouse, France, as following items:

WG 3: New assessment methods

GP 3A: Inspection methods for prestressed concrete structures

- Final technical report - Development of two new measurement and inspection methods to improve the quality and maintainability of large concrete structures (written by all GP 3A partners)

GP 3B: The impact echo method for detection of voids in tendon duct

- Abraham O. A laser interferometer robot for void detection in tendon duct by the impact echo method
- Forde - U Edinburgh - The impact echo method for detection of voids in tendon duct
- Taffe – BAM - The impact echo method for detection of voids in tendon duct

GP 3C: Acoustic non destructive techniques as new methods for evaluation of damages in prestressed concrete structures

- Proverbio E. Acoustic non destructive techniques as new methods for evaluation of damages in prestressed concrete structures
- Vilchinska N. Inspection and Monitoring of Foundation under Dynamic Load
- Balayssac - LMDC - Non destructive evaluation of cables corrosion in prestressed concrete
- Gaillet - LCPC – Assessment of cables by acoustic emission monitoring
- Golaski - TU Kielce - Assessment of concrete bridges deterioration by acoustic emission technique

GP 3D: Advanced techniques for monitoring of prestressed strands

- Krause - Julich - Development of a compact and robust sensing head using inexpensive magneto resistors
- Sawade G. Monitoring of prestressed tendons using the magnetic flux leakage measurement method
- Mietz - BAM - Verifying NDT methods for detection of prestressing steel damage at post-tensioned concrete structures
- Holst - TU Braunschweig - Detection and Localization of Fractures and Flaws in Prestressed Tendons by means of Electromagnetic Resonance RF-Measurements (ERM)

Klinghoffer - FORCE - Determination of capability of NDT (non-destructive test) methods for inspection of prestressed concrete structures
Scheel - TU Berlin - Monitoring of transverse tendons in bridge decks and tendons in parking lots by a magnetic scanning system
Sederholm – SCI - Methods for assessment of the corrosion status of tendons in prestressed concrete bridges

GP 3E: Structural condition evaluation of prestressed concrete structures based on acoustic monitoring

Barczewski - TU Poznan - Use of vibroacoustic signal analysis method, energy flow and power distribution for condition assessment of prestressed concrete structures
Radkowski S. Structural condition evaluation of prestressed concrete structures based on acoustic and vibroacoustic monitoring - outline of annual report
Du - Beijing Jiao Tong University - Ductility and flexural strength of externally prestressed concrete beams
Jurkiewicz - AGH - Assessment of the prestressing process of the concrete structures - outline of annual report
De Wit – Advitam - Structural condition evaluation of prestressed concrete structures based on acoustic monitoring
Farkas – BUTE - Condition monitoring of concrete bridges and civil engineering works based on dynamic characteristics
Gulikers – RWS - Long term acoustic monitoring of prestressed steel tendons in concrete
Wojtas – KWH - Use of vibroacoustic signals for diagnosis of defect development in prestressed concrete structures
Antoniades – NTUA - Advanced signal processing method for vibration monitoring of prestressed concrete structures

Also on the website http://www-lmdc.insa-toulouse.fr/cost534/index.htm you can see the next presentations:

WG3 “New assessment methods for tendons” - pdf
Cleland D. “Ultrasonic techniques” - pdf
Abraham O. “Impact-echo” - pdf
Proverbio E. “Acoustic emission” - pdf
Radkowski S. “Vibro-acoustic monitoring” - pdf
Sawade G. “Magnetic and electro-magnetic techniques” - pdf

3. Conclusions

We think it is obvious that cooperation between Non-destructive society and construction industry is necessary and could be very fruitful.

We hope with this paper to provoke and establish more effective collaboration between non-destructive testing and prestressed concrete structures professionals. For the construction area it will be very useful and for non-destructive testing society will be huge new market.

Of coarse there will be skeptics. But we think will be enough enthusiasts, who will be ready to apply significant efforts, to be developed this idea. The perspectives are too attractive! For the construction area it will safe the money and increase safety. For the Non-destructive society will be new market for many billions dollars.

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