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Fraunhofer Institute for Nondestructive Testing IZFP is committed to fundamental and application-oriented research to enlarge the understanding and acceptance of nondestructive testing methods and develops economical methodologies and market-oriented quality control products and procedures on behalf of and under contract to industry. The results of IZFP research and development efforts are made available to all of industry through the accredited Application Center at IZFP.

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NMR-INSPECT

Nuclear Magnetic Resonance Surface
Technique



Fraunhofer Institut
Zerstörungsfreie
Prüfverfahren



Nuclear Magnetic Resonance Surface Technique

The Situation

Moisture in building materials (e.g., concrete, masonry, wood) can cause severe damage, and therefore the damages must be stemmed or removed by efficient building renovation. The renovation of old buildings requires a reliable estimate of costs and technical expenditures. And for safety relevant structures, such as bridge piers, the moisture-related damage is an important factor in determining the overall life expectancy of the structure.

Highly efficient, cost-saving structure renovations require precise location of the moisture damage and accurate diagnosis of the load-bearing capacity of the moisture-damaged components for an accurate assessment of the overall structure's condition. Until now, conventional measuring techniques required obtaining core-samples, which were then analyzed in a laboratory off-site.

This destructive testing process is particularly undesirable for historical structures and buildings, and it is insufficient for safety-relevant structures that require a complete and comprehensive damage analysis. Core-sample cutting and transportation to the off-site lab, plus the reconditioning of the structure due to the sample removal is very expensive.



Foundation Damage

The Solution

The Fraunhofer-Institut für Zerstörungsfreie Prüfung IZFP (Institute for Nondestructive Testing) has developed a method to diagnose moisture content and distribution using portable nondestructive technique. Based on Hydrogen Nuclear Magnetic Resonance ($^1\text{H-NMR}$; see frame on the right), the moisture content of construction components such as concrete, masonry, and wood can be determined with a fast and reliable method.

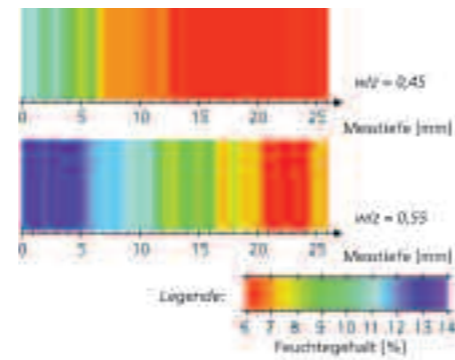
For the first time, the NMR-INSPECT system provides a portable, in situ, nondestructive inspection system for construction components. Unlike conventional NMR techniques, the NMR-INSPECT system works with a portable surface sensor that only requires one-sided access to the structure to be analyzed. Core-sampling and the subsequent reconditioning of the structure - even on large structures such as masonry walls - is not required any more.

The NMR-INSPECT system provides nondestructive blanket coverage for the detection and analysis of moisture content and distribution in buildings and structures at costs that are greatly reduced in comparison to the traditional core-sample methods.

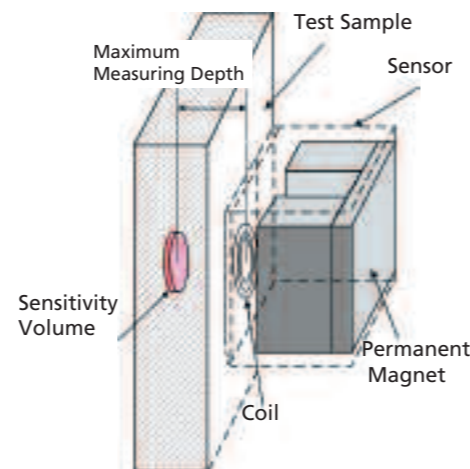
Advantages

- Definition of load-bearing capacity and water permeability
- Contact-free surface sensor
- Core-sampling is not required

- Portable system with optional battery operation
- Modular concept: Various custom-designed sensors are available for a large range of applications
- We deliver custom-designed, application-oriented systems and inspection services



Moisture distribution in various qualities after one-sided water damage, detected with NMR-INSPECT



Test Sensor Principle.

Nuclear Magnetic Resonance - NMR

NMR is a measuring and testing method traditionally used in chemical analysis and medical diagnostics (MRI - Magnetic Resonance Imaging). The method is based on the interaction of transmitted radio waves and the magnetic properties of nuclear particles contained in a strong magnetic field. The nucleus of the hydrogen atom possesses a significant magnetic moment and therefore provides the best effect: the nuclei contained in the sensor's field are brought to resonance by short-pulsed energy. During relaxation, i.e., transportation of the energy to adjacent nuclei and other masses, the resonance decays. The amount of the resonance amplitude and the relaxation time are parameters for the number of hydrogen atoms involved and their molecular bond in the current inspection volume. A disadvantage of conventional NMR systems is that the test objects have to be placed inside an encircling sensor. In medical applications, for example, the patient has to be placed inside the scanning tube of the MRI apparatus. Moisture content and distribution of construction materials can be determined using the NMR method, without the need for an encircling sensor. The NMR method can also be used to determine porosity and density distribution in wood and wooden materials as well as hydration conditions in concrete structures.

Applications

- Construction materials: Moisture content and distribution, moisture-transport
- Wood and wooden materials: Dryness profiling, density distribution
- Synthetics and bonded materials: Hardening, aging
- Mortar and concrete: Hydration, hardening

Inspection System

The system sensors, which include the electronic tuning components, consist of a strong permanent magnet and a high-frequency antenna. A disk-shaped testing-volume (sensitivity volume) is generated in the external cavity of the sensor. The distance between the sensor and the sensitivity volume can be varied by changing the antenna transmitter frequency to vary the measuring depth.

The integral part of this system are the electronic components, which, despite their physical size, are very powerful - power output of the pulse can reach 30 kW.

Technical Data

- Measuring time of approximately 30 seconds per value
- Measuring parameters: Spin density and relaxation time T_1 and T_2
- System weight: 10 kg (22 lbs.)
- Sensor weight: 2 - 30 kg (2.2 - 66 lbs.), depending on application
- Frequency range: 5.0 - 9.5 MHz (measuring depth: 2 - 30 mm), depending on sensor design
- Transmitter: 30 kW (maximum) output power
- Signal averaging
- 220 V (110 V) or battery power supply
- Windows NT® user interface



Testing device NMR-INSPECT