1. Introduction

Nondestructive evaluation (NDE) of reinforced concrete (RC) has become a widely used tool for quality control/quality assurance (QC/QA) during construction and the assessment of existing structures. There are international committees dedicated to this subject. Workshops and conferences are being held regularly. Typically, RC structures are different in many aspects including, but not limited to, construction process, structure, material properties, and environmental factors (e.g. moisture and heat). As a consequence, there are only limited possibilities to establish a general testing solution that can be used on every structure, and most of the testing methods have to be individually adapted for each RC structure. The variations of solutions to a given testing task may be almost limitless and make it impossible to answer general assessment questions by a single NDE method. A generalized approach for NDE of concrete structures requires a view strictly from the testing task point of view. The global assessment tasks must be broken into subtasks that can then be solved by NDE methods, which are already available or will be developed, validated, and provided by research. This paper addresses the identification of tasks and subtasks into which an assessment can be broken down. The selection of tasks and subtasks is done entirely from a client point of view, without any reference to a test method or an instrument. This selection is also unrelated to types of damages or other motivations for conducting an assessment. On the subtask level, the parameters for a test are being defined and the typical ranges are being estimated. A key role is assigned to the reference specimens which represent the testing problem described and quantified in the corresponding subtask. Reference specimens are also used for validation of NDE methods for a given test problem and also for qualification of service providers (to provide certified NDE to the owner). This system depends on a systematic and structured definition of a limited number of NDE subtasks.

2. Global Parameters

Common parameters exist for most testing scenarios on RC structures. The following list is common parameters to most NDE test tasks:

- Material related topics
- Reinforcement related topics
- Accessibility to the test object
- Geometry of test object/test area
- History of structure
This list summarizes many points which have to be discussed and clarified between the owner and the service provider to evaluate a testing scenario. An evaluation of a testing scenario may prove to be much easier to discuss if the points in this list have been clarified before starting a detailed analysis of a testing task. It is obvious that the information about limited accessibility may limit the possible solutions for assessment of the structure immediately. The same is true for other points, for instance, metallic fiber reinforcement in a structure will rule out radar for any testing on this structure.

3. **Classification of NDE Tasks**

Four main groups of testing tasks have been identified in this paper which should cover the majority of NDE requirements in condition assessment of RC structures. These groups are related to 1) construction, the 2) concrete structure, 3) physical/chemical processes, and 4) material properties. For each of these groups, a number of subtasks have been identified and discussed in a certain scheme.

**Construction Task**
The first group of testing tasks is related to the design and construction of a RC structure. Obviously, the main motivation for NDE is QA/QC to verify if design specifications have been met in the construction process. The tasks relate to the geometry of the structure and the built-in components like reinforcement and post-tensioning systems.

**Concrete Structure Task**
The second group of testing tasks is related to the internal structure of concrete, from the nano scale to meso and macro.

**Physical/Chemical Processes Task**
The next group of testing tasks is related to physical/chemical processes in concrete, which take place over a wide time range, from seconds to years or decades. The NDE related tasks refer either to the measurement of the current state of a process or the speed at which it takes place. Latter can be determined through comparative measurements in time intervals.

**Material Properties Task**
The last group of testing tasks is related to material properties of concrete, which describe the quality of concrete in a global quantitative way. Concrete material properties characterize performance of material, its load bearing capacity and durability. Typically, these properties are determined destructively in the laboratory on samples.

4. **DISCUSSION**

Small specialized companies are the main drivers for the development of new NDE instruments. However, in the daily business of maintenance and construction, the focus is on solving a given testing problem. The search for a solution for the given problem is the starting point in practical situations. More importantly, a generally accepted and well known data base for the applicability and reliability of a given method or instrument does not exist. Compared to other areas of nondestructive testing, such as metal component inspection in nuclear facilities or aircrafts, the situation in civil engineering, regarding RC structures, is not strictly
organized e.g. in standards. Certification of testing services is not generally available and reputation is mainly based on previous reports on successful applications. At the same time, only a few techniques have been standardized by ACI and ASNT. Apart from very specialized tasks, NDE tasks can be grouped into four major classes, which in itself are very wide and cover many different testing problems. Breaking them down into subtasks puts them into items which can be the subject of research. Over time, a grid of validated solutions for NDE of RC structures may be developed. The natural extension of this scheme is the use of well-defined reference specimens for quantitative and qualitative validation. With a general accepted validation scheme in place, NDE of RC structures has a roadmap leading towards certified instruments and service providers. In order to allow a comparison between different instruments and methods, the testing problem should be defined and established in a way which is easily reproducible in any laboratory. Adequate research effort should target the development of well-designed and accepted reference specimens and the recipes for construction of those specimens. This part of research requires high attention to ensure that the reliability of a test method is to be quantified. Education and training is an area often mentioned when the necessity for improved NDE is discussed. There are training courses offered from a variety of institutions, individuals, or equipment distributors. However, a widely accepted curriculum for such training is not available or in use. The proposed classification scheme may prove helpful in establishing a training course for potential users or even for certification of service providers.

5. CONCLUSIONS

NDE methods play an increasing role in condition assessment of RC structures. The utilization of these methods depends on understanding of the underlying principles and performance of the methods. Validation of NDE for RC structures is not widely applied and accepted. Classification of the NDE tasks into four major groups and assigning subtasks to each of them is provided in this paper. Most NDE assessments on real structures can be understood as a combination of subtasks listed in the tables. Each testing problems can be manifested in a reference specimen which is accepted as a benchmark for the performance of a test. These reference specimens should be easily reproducible in any laboratory. The reference specimens may serve for research, instrument development, validation and certification purposes. The proposed classification scheme can also serve as a long term research outline, as it contains all measurement tasks independent of the present ability for a solution.

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