Inspection Methods for Corrosion Evaluation of Conventionally Reinforced Concrete Structures

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ABSTRACT

This NACE International standard practice provides testing procedures and investigative techniques for the evaluation of conventionally reinforced concrete structures. The investigation and evaluation techniques described in this standard focus on degradation resulting from corrosion of the reinforcing steel. These techniques range from simple visual inspections that identify rust staining, cracks, and delamination to physical and chemical inspection methods, which use hammer rebound, ultrasonic testing, electrical resistance, chemical analyses, or electrochemical potential and corrosion rate measurements.

This standard is intended for use by corrosion specialists, civil engineers, and structural engineers involved with evaluating corrosion of reinforcing steel in concrete. It also may be useful to owners of reinforced concrete structures whose service life may be affected by reinforcing steel corrosion. It includes commentary for screening corrosion control methods that might be considered for restoration of the reinforced concrete structure being evaluated.

KEYWORDS

Reinforced concrete, reinforcing steel, concrete structure inspection, corrosion survey, delamination, cover thickness, corrosion potential, corrosion rate, carbonation depth, concrete resistivity, electrical continuity testing, chloride content measurement, chloride profile, TG 055.

Foreword

This NACE International standard practice provides testing procedures and investigative techniques for the evaluation of conventionally reinforced concrete structures. This document does not include epoxy coated, galvanized, stainless, stainless cladded, or fiber reinforcing materials. Inspection methods discussed in this standard may not pertain to these other reinforcing materials. The investigation and evaluation techniques described in this standard focus on degradation resulting from corrosion of the reinforcing steel. When distress of a structure is evident, it is important to determine the nature of the degradation to select the best restoration strategy. Although this standard does not specifically address restoration options, additional information on repairs and corrosion mitigation techniques can be found in other NACE International standard practices, test methods, and state-of-the-art reports and publications from other organizations.[1-16]

This standard is intended for use by corrosion specialists, civil engineers, and structural engineers involved with evaluating corrosion of reinforcing steel in concrete. It also may be useful to owners of reinforced concrete structures whose service life may be affected by reinforcing steel corrosion.

NACE Task Group (TG) 055 prepared this standard. The TG is composed of manufacturers, users, consulting engineers, and other interested parties, and this standard represents a consensus of those members. This standard is not intended to be all encompassing. However, it provides information that allows the user to perform testing and evaluation of atmospherically exposed reinforced concrete structures. Note that the information gathered during this investigation may require subsequent investigation and evaluation by qualified structural engineering personnel, depending on the nature and extent of degradation.

This standard was prepared in 2008 and reaffirmed in 2018 by NACE TG 055, "Inspection Methods for Corrosion Evaluation of Conventionally Reinforced Concrete Structures," which is administered by Specific Technology Group (STG) 01, "Reinforced Concrete" and sponsored by STG 62, "Corrosion Monitoring and Measurement: Science and Engineering Applications." It is published under the auspices of STG 01.

In NACE standards, the terms *shall, must, should,* and *may* are used in accordance with the definitions of these terms in the *NACE Publications Style Manual.* The terms *shall* and *must* are used to state a requirement, and are considered mandatory. The term *should* is used to state something good and is recommended, but is not considered mandatory. The term *may* is used to state something considered optional.

NACE International Standard Practice (SP0308-2018)

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Section 1: General

1.1   Inspecting and monitoring the condition of conventionally reinforced concrete involves the use of a number of evaluation techniques, ranging from simple visual inspections that identify rust staining, cracks, and delamination, to physical and chemical inspection methods, which use hammer rebound, ultrasonic testing, electrical resistance, chemical analyses, or electrochemical potential and corrosion rate measurements. A number of relevant standards and overview technical papers that discuss issues germane to corrosion inspection of reinforced concrete structures are available.[17-30] In 1993, a manual related to this topic was published.[31]

1.2   The purpose of this standard is to provide the corrosion specialist, engineer, or owner a framework for evaluating the corrosion condition of a reinforced concrete structure beyond simple visual inspection and basic sounding techniques. Evaluation techniques that identify general and localized corrosion of conventional reinforcement are provided. Although this standard specifically addresses conventionally reinforced structures, many of the techniques also apply to prestressed and post-tensioned reinforcement. Commentary is included for screening corrosion control methods that might be considered as part of recommendations for restoration of the reinforced concrete structure being evaluated. However, it is beyond the scope of this standard to fully address all factors associated with the design, criteria, and implementation of such corrosion control measures.

Section 2: Definitions

Terms not included in the Definitions section may be found in NACE/ASTM[(1)] G193, "Standard Terminology and Acronyms Relating to Corrosion."[32]

Electrometer: A highly sensitive electronic voltmeter whose input impedance is so high that the current flowing into it can be considered, for practical purposes, to be zero. To obtain accurate potential measurements in high-resistivity concrete, the required impedance may exceed 10^9 Ω.

Fickian Behavior: A process that follows Fick's laws of diffusion.

Laitance: A milky white deposit of fine particles on the surface of cement or concrete.

Pozzolan: A material that, when combined with water and calcium hydroxide or alkali oxides, exhibits cementitious properties.

Section 3: Technique Selection

3.1   The selection and application of specific techniques depends on the particular structure and the purpose of the survey. A detailed program of inspection for one structure is not necessarily directly applicable to a different structure.

3.2   Basic surveys, carried out at regular intervals, e.g., every one or two years, normally rely on relatively simple inspection methods. However, if corrosion or premature deterioration is suspected, or has occurred, a detailed survey involving additional techniques is required to ascertain the extent and degree of damage. In some cases, this may require sophisticated techniques to identify the nature and cause of the deterioration, highlight areas of particular damage or concern, and estimate the remaining life expectancy.

3.3   Procedures for inspecting concrete structures on site include:

(a)   Visual inspection techniques;
(b)   Crack inspection;
(c)   Delamination survey;
(d)   Cover thickness survey and reinforcement location;
(e)   Assessment of concrete strength and condition;
(f)   Corrosion potential measurements;
(g)   Corrosion rate measurement;
(h)   Carbonation depth measurement;
(i)   Concrete resistivity measurement;
(j)   Electrical continuity testing of reinforcement;
(k)   Chloride content measurement and chloride profile determination in the concrete; and
(l)   Other advanced techniques.

[(1)] ASTM International (ASTM), 100 Barr Harbor Dr., West Conshohocken, PA 19428-2959.