NACE SP0390-2019
Item No. 21044
Reaffirmed 2019-09-03
Revised 2009
Reaffirmed 2006
Revised 1998
Approved 1990

Maintenance and Rehabilitation Considerations for Corrosion Control of Atmospherically Exposed Existing Steel-Reinforced Concrete Structures

ABSTRACT

Presents corrosion control guidelines that are applicable to existing atmospherically exposed structures made of concrete conventionally reinforced with carbon steel. These guidelines should be used primarily when repair or rehabilitation is being implemented because of deterioration resulting from the corrosion of steel reinforcement. Includes sections on Periodic Inspection and Routine Maintenance of reinforced-concrete structures (site survey, structural survey, repair options), Assessment of Reinforced Concrete Structures, and Corrosion Control Techniques and Repair Strategy. Corrosion control techniques that are described include surface treatments, removal of concrete, and electrochemical treatments, including ECE, ER, and cathodic protection.

KEYWORDS

Reinforced concrete, reinforcing steel, electrochemical chloride extraction, ECE, electrochemical realkalization, ER, cathodic protection, ICCP, GACP, TG 324.

ISBN 1-57590-059-9

Foreword

Corrosion of reinforcing steel in concrete is a serious problem in certain environments throughout the world. This corrosion is directly attributable to the presence of significant amounts of chloride or other aggressive substances at the steel surface. Parking structures, bridges and roadways, buildings, sanitary and water facilities, marine structures, concrete pipe, storage facilities, and other reinforced concrete structures are being damaged by corrosion.

Corrosion of the reinforcing steel can weaken or destroy a structure. Corrosion of the reinforcing steel in concrete and the resulting cracking and spalling of concrete cost billions of dollars each year. These losses can be reduced if proper corrosion control factors are considered during rehabilitation and maintenance repair of reinforced concrete structures.

The purpose of this standard is to give maintenance personnel, engineers, and facility owners the necessary considerations for corrosion control of existing atmospherically exposed steel-reinforced concrete structures. These considerations include guidelines to control corrosion of reinforcing steel in portland cement concrete structures.

The provisions of this standard should be applied under the direction of a registered professional engineer or a person certified by NACE as a Corrosion Specialist or Cathodic Protection (CP) Specialist. His or her professional experience should include suitable experience in corrosion control of reinforced concrete structures.

This NACE standard was originally prepared in 1990 by NACE Task Group (TG) T-3K-5, a component of Unit Committee T-3K, "Corrosion and Other Deterioration Phenomena Associated with Concrete." To provide the necessary expertise on all aspects of the subject and to gain input from all interested parties, TG T-3K-5 was composed of corrosion consultants, consulting engineers, architect-engineers, CP engineers, researchers, structure owners, and representatives from industry and government. Unit Committee T-3K became Group Committee T-11, "Corrosion and Deterioration of the Infrastructure," and later Specific Technology Group (STG) 01, "Reinforced Concrete." This standard was revised by TG T-11-4a in 1998 and reaffirmed by STG 01 in 2006. It was revised in 2009 and reaffirmed with editorial changes in 2019 by TG 324, "Reinforced Concrete: Maintenance and Rehabilitation Considerations for Existing Structures." It is published by NACE 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.

Maintenance and Rehabilitation Considerations for Corrosion Control of Atmospherically Exposed Existing Steel-Reinforced Concrete Structures

Figure

Section 1: General

1.1 This standard presents corrosion control guidelines that are applicable to existing atmospherically exposed structures made of concrete conventionally reinforced with carbon steel (ASTM[(1)] A615).[1] These guidelines may be used to develop specifications involving repair and rehabilitation of steel-reinforced concrete structures. These guidelines should be used primarily when repair or rehabilitation is being implemented because of deterioration resulting from the corrosion of steel reinforcement.

1.1.1 Reinforcing steel is compatible with concrete, not only because of similar thermal expansion characteristics, but also because the highly alkaline portland cement allows a stable, protective oxide film to form on the surface of the encased steel. If the film does not form or is weakened or destroyed so that it does not protect the steel, corrosion can occur. The protective oxide film does not form or is destroyed if (1) the cement paste is not in contact with the reinforcing such as at voids and cracks; (2) alkalinity is lost by reaction with certain gases and liquids; or (3) excessive amounts of chloride or other aggressive ions are present. It has been shown that chloride ion content as low as approximately 0.2 percent by weight of cement (or approximately 0.6 kg/m^3 [1 lb/yd^3] of concrete, depending on the cement content of the mix) at the steel depth can initiate the corrosion process. If one or more of these conditions are present, and moisture and oxygen are available to the embedded reinforcing steel, an electrochemical cell forms, resulting in corrosion.

1.1.2 Corrosion most commonly proceeds by the formation of an electrochemical cell. This electrochemical cell is composed of four elements: (1) an anode; (2) a cathode; (3) an electrical connection between the two; and (4) an ionic connection provided by an electrolyte (concrete). Direct current (DC) caused by electrochemical potential differences, such as between different metals or the same metal in different environments, flows from the anodic area to the cathodic area through the electrolyte. Corrosion occurs at the anode, where the current leaves the metal. If any one of the elements of the electrochemical cell is eliminated, corrosion can be prevented.

1.1.3 The corrosion product of iron occupies several times the volume of the base metal. The expansive pressure exerts a significant tensile force on the surrounding concrete. The resulting cracks propagate either to the surface or to nearby reinforcing steel, resulting in a delamination. Steel sectional losses, which may or may not have structural significance, can generate cracking of the concrete. Bond forces and corrosion both put concrete in tension and are additive. Relatively small amounts of metal loss at the surface of the reinforcing steel can be sufficient to crack the concrete cover and result in the loss of bond and anchorage. Other problems resulting from delamination and spalling include danger from falling concrete, increased corrosion, loss of fireproofing, and safety considerations.

1.1.4 Dissimilar metal couples and DC stray currents can initiate and accelerate corrosion.

1.2 This standard describes various approaches that may be taken with respect to corrosion control of existing structures. The flow chart in Figure 1 delineates the repair or rehabilitation strategy covered in this standard. Because of the complexity of corrosion problems on individual structures, advice from a professional engineer or a corrosion specialist, whose professional qualifications include suitable experience in corrosion control of reinforced concrete structures, should be sought before proceeding with repair and rehabilitation programs. Also, a structural engineer may be required if a decision on structural integrity is needed.

1.3 This standard does not cover pretensioned and post-tensioned reinforced concrete.

Section 2: Definitions

Anode: The electrode of an electrochemical cell at which oxidation occurs. Electrons flow away from the anode in the external circuit. Corrosion usually occurs and metal ions enter the solution at the anode.

Cathode: The electrode of an electrochemical cell at which reduction is the principal reaction. Electrons flow toward the cathode in the external circuit.

Cathodic Protection: A technique to reduce the corrosion of a metal surface by making that surface the cathode of an electrochemical cell.

Corrosion: The deterioration of a material, usually a metal, that results from a reaction with its environment.

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