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Standard
Recommended Practice

Design Considerations for Corrosion Control of Reinforcing Steel in Concrete

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Foreword

Corrosion of reinforcing steel in concrete is a serious problem in certain environments. The major cause of this corrosion can be attributed directly to the presence of significant amounts of chloride or other aggressive ions at the surface of the steel. Parking structures, bridges and roadways, buildings, sanitary and water facilities, marine structures, concrete pipe, prestressed concrete pipe, storage facilities, and other reinforced concrete structures are being damaged by the corrosion of reinforcing steel.

The purpose of this standard is to give architect-engineers and facility owners design considerations for controlling corrosion of proposed reinforced concrete structures. These considerations include guidelines that provide the architect-engineer with information about the causes of and control methods for the corrosion of reinforcing steel in portland cement concrete structures.

This NACE standard was originally prepared in 1987 by NACE Task Group T-3K-5, a component of Unit Committee T-3K on Corrosion and Other Deterioration Phenomena Associated with Concrete. It was reaffirmed in 1990, revised in 1996, and reaffirmed in 2005 by Specific Technology Group (STG) 01 on Concrete and Rebar. It is published by NACE International 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*, 4th ed., Paragraph 7.4.1.9. *Shall* and *must* are used to state mandatory requirements. The term *should* is used to state something good and is recommended but is not mandatory. The term *may* is used to state something considered optional.

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Section 1: General

1.1 This standard presents corrosion control guidelines that are applicable to structures made of reinforced portland cement concrete. Reinforcing steel is compatible with concrete not only because of similar thermal expansion properties, but also because the highly alkaline portland cement allows a stable, protective oxide film to form on the surface of the encased steel.

1.1.1 If the film does not form or if it does not protect the steel, corrosion can occur. Corrosion of the reinforcing steel can weaken or even destroy a structure.

1.1.2 The protective oxide film is destroyed if (1) the concrete does not fully encase the steel, (2) alkalinity is lost by reaction with aggressive gases, or (3) excessive amounts of chloride or other aggressive ions are present. If any of these conditions occurs, and both moisture and oxygen are in contact with the steel, corrosion can occur.

1.2 Corrosion ordinarily proceeds by forming an electrochemical cell with anodic and cathodic areas, which are electrically coupled in an electrolyte, on the metal. If any one of the elements of the electrochemical cell is eliminated, corrosion can be prevented.

1.3 Other forms of corrosion such as those caused by dissimilar metal couples and direct current (DC) stray currents can initiate or greatly accelerate corrosion.

1.4 The result of the corrosion process can damage concrete in several ways.

1.4.1 The corrosion product of steel occupies several times the volume of the base metal. The expansive pressure exerts a significant tensile force on the surrounding concrete. Resulting cracks propagate toward either the surface or the nearby reinforcing steel, causing delamination. A small loss of steel can cause delamination, but structural integrity remains undiminished until corrosion has removed a significant amount of steel.

1.4.2 Structural integrity can be lost rapidly when corrosion occurs in an anchorage zone. Bond stresses and corrosion both put concrete in tension and are additive. Even insignificant metal loss at the surface of the reinforcing steel can be sufficient to crack the concrete cover and cause loss of bond and anchorage. Other problems caused by loss of cover include falling concrete, increased corrosion, and loss of fire resistance.

1.5 Because of the concrete damage caused by the corrosion products formed on reinforcing steel, the architect-engineer should consider certain corrosion criteria during the design of the structure. Design and construction considerations should be based on good engineering practices to eliminate conditions conducive to corrosion. Tests of soil and water should include but not necessarily be limited to pH, resistivity, chlorides, sulfates, sulfides, and bacteria.

1.6 This standard does not designate specific design practices for the control of corrosion because of the complexity of corrosion mechanisms in individual structures.

1.6.1 The guidelines in this standard give the architect-engineer several alternative methods of controlling the corrosion of a proposed atmospherically exposed concrete structure.

1.6.2 During the design phase of a structure that could be affected by corrosion, the services of a qualified Professional Engineer or qualified Corrosion Specialist shall be obtained so that proper materials selection and engineering practices for corrosion control are included in the design of the proposed concrete structure. His or her professional qualifications shall include suitable experience in corrosion control of reinforced concrete structures. The provisions of this standard shall be applied under the responsible charge of said Professional Engineer or Corrosion Specialist.

1.7 Corrosion of the reinforcing steel in concrete and the resultant cracking and spalling of concrete cost billions of dollars each year. These losses can be reduced if proper corrosion control factors are considered during the design phase. When the architect-engineer considers the corrosion of reinforcing steel to be a potential problem, provisions should be made for a cost-effective corrosion control system.

1.8 Although many of the recommendations in this standard are applicable to prestressed concrete structures, this standard does not fully address this type of reinforcing system.

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.