

Arc Sprayed Zinc Metalizing for Cathodic Protection of Reinforced Concrete Structures

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ABSTRACT

Reinforced concrete structures can corrode if they are exposed to chlorides or if the pH of the concrete decreases over time. Arc-sprayed zinc coatings are versatile and can be used as part of a cathodic protection system to halt corrosion and extend service life. Arc-sprayed zinc coatings are multi-functional and can be used as part of impressed current cathodic protection systems or they can be used to provide galvanic cathodic protection.

This paper describes the development and use of arc-sprayed zinc coatings for cathodic protection of steel in reinforced concrete structures.

Arc-sprayed zinc coatings were first used in 1983 as part of an impressed current cathodic protection systems. Activated and inactivated arc-sprayed zinc coatings were first used for galvanic cathodic protection in 1988

System descriptions, project lists and performance data for arc-sprayed zinc in both impressed current cathodic protection and galvanic cathodic protection applications will be presented.

INTRODUCTION

Corrosion of reinforcing steel is the most significant cause of deterioration of reinforced concrete structures. Exposure to de-icing salts, seawater and chloride-containing set accelerators can play a significant role in reinforcing steel corrosion. Long-term exposure to carbon dioxide is also cited as a contributor to the corrosion of steel in concrete as well.

Cathodic protection has been demonstrated to be an effective technique to control corrosion and arc sprayed zinc has been found to be a favorite anode because the zinc coating is durable and effective. Arc sprayed zinc can be easily applied to complex concrete structure surfaces and the finished surface has a similar appearance to concrete.

Arc sprayed zinc was developed as a conductive coating anode by Caltrans in 1983 and was used as an impressed current anode in the first field trial on Pier 4 of the Richmond–San Rafael Bridge located in San Francisco Bay, California (1, 2). A large application of arc sprayed zinc in Oregon (3), where it has been used as an impressed current anode is the Yaquina Bay Bridge (290,000 ft²). Oregon started using this system in 1991 and was instrumental in the development of good specifications for the application of arc sprayed zinc systems and quality control. Oregon DOT installed 1,200,000 ft² of arc sprayed zinc as an impressed current anode between 1991 and 2017 (4).

FDOT started to use arc sprayed zinc on substructure and superstructure elements as a galvanic anode in 1988. By 2002, it had been applied to 13 bridges with a combined protected concrete surface of approximately 350,000 square feet (1, 5). To date FDOT has applied 1,155,000 ft² of galvanic arc sprayed zinc on bridge substructure and superstructure elements.

APPLICATION PROCEDURES AND CONSIDERATIONS

Application of Arc Sprayed Zinc Anodes on Concrete

The arc sprayed zinc process is used to apply a thin layer of zinc (typically 250 to 500 μm (10 to 20 mils) in thickness) to a clean concrete surface. Zinc application is typically performed after concrete repairs have been completed.

For impressed current applications the surface applied zinc anode is electrically connected to the positive terminal of a DC power supply. The negative terminal of the DC power supply is connected to the reinforcing steel. For these applications the zinc anode and the reinforcing steel must not contact each other since an electrical short circuit will prevent an impressed current cathodic protection system from operating.

For galvanic cathodic protection applications, the surface applied zinc anode is electrically connected to the reinforcing steel. No DC power supply is used for these applications. The potential difference between the zinc and the steel provides the driving voltage and causes current to flow to the steel. A humectant activator solution may be applied to the zinc anode to improve current output and performance of the system in less humid environments.

Concrete Repair and Surface Preparation

Repair all spalled and delaminated concrete using repair materials with normal resistivity. Cure repair materials for a minimum of 28 days or until they are sufficiently dry to allow good adhesion of the arc sprayed zinc coating. The surface of the concrete is cleaned by light abrasive blasting (Fig 1). Surface preparation techniques are used to provide sufficient profile for mechanical bonding while maximizing the amount of cement paste in contact with the zinc coating so ionic current between the zinc and the concrete is not restricted.



Figure 1: Abrasive Blast Surface Preparation



Figure 2: Arc Spray Zinc Anode Installation

Clean the surface of any dust and blast media using dry compressed air. Vacuum cleaning of the prepared concrete surface can also be used prior to application of the zinc coating.

Surface preparation of the concrete surface and any exposed steel should be in accordance with AWS C2.20/C2.20M: 2002, 'Specification for Thermal Spraying Zinc Anodes on Steel Reinforced Concrete'

Reinforcing Steel Connections

Electrical connection to the reinforcing steel is required for all cathodic protection systems. For arc-sprayed zinc cathodic protection systems (particularly galvanic systems) the reinforcing steel connection is often a 6 mm (¼ in.) diameter galvanized threaded rod that is drilled and tapped into the embedded reinforcing steel. The threaded rod is of sufficient length to protrude approximately 50 mm (2 in.) from the concrete surface. The connection between the threaded rod and the reinforcing steel is sealed with 100% solids non-conductive epoxy paste.

At least one reinforcing steel connection is provided for every 50 m² (500 ft²) of concrete surface area with a minimum of two connections per individual structural element to be protected (for redundancy).

Electrical continuity is verified, and discontinuous steel is connected such that all steel is electrically connected to the cathodic protection system.

Arc Sprayed Zinc Installation

Portable, electric arc type equipment is used to apply the zinc. The equipment is specifically designed for application of metallized zinc coatings. The equipment is designed to utilize 3.2 mm (1/8 in.) or 4.7 mm (3/16 in.) diameter high purity zinc wire.

High purity zinc is applied to the dry, prepared concrete surface using multiple 75 to 100 µm (3 to 4 mil) thick passes with a criss-cross or elliptical pattern until a nominal thickness of 250 to 500 µm (10 to 20 mils) is achieved (Fig 2).

After the zinc coating is metallized onto the concrete surface, the zinc anode must be connected in order for the cathodic protection system to work. For an impressed current cathodic protection system, the zinc is electrically connected to the positive terminal of a DC power supply and the negative terminal of the DC power supply is conducted to the reinforcing steel. For a galvanic cathodic protection