13. STRAY CURRENT

Stray current originating from either alternating current (AC) or direct current (DC) can result in corrosion of metals. Alternating current is generally considered insignificant (more than a thousand times less) when compared to corrosion from direct current (DC). This section will only look at direct current.

Stray current (interference current) is corrosion caused by direct current from an external source that travels through paths other than the intended circuit. These currents are typically classified as static or dynamic. Static currents maintain a constant amplitude and constant path such as high voltage direct current (HVDC), ground electrodes, and cathodic protection system rectifiers. Sources for dynamic currents are direct current railways or light rail transit systems, direct current welding equipment, some signal circuits and telluric (natural sources of stray current such as disruptions in the earth's magnetic field).

For the Department, stray current corrosion is far less common compared to other sources of corrosion such as marine exposure, freeze/thaw exposure and corrosive soils. That said, stray current can result in accelerated corrosion of structural reinforcement if not addressed. Accelerated corrosion from a DC source occurs in a structure when stray current enters the reinforcing steel at one location and exits at another. The location where the current enters becomes cathodic and can experience material gain. The location where the current exits the reinforcement becomes anodic and will experience corrosion at an accelerated rate. The rate of corrosion is dependent on the frequency of exposure, and strength of the direct current. Stray currents in bridge structural elements can be caused in two ways, either through direct connection or through a soil gradient.

Direct connection involves attaching a pipeline, electric railway track, or high-voltage contact system to bridge structure elements. Installation requires an approved insulator between the pipe or rail and the bridge element, and the high-voltage contact system requires double insulation for safety. It is difficult to retrofit an existing structure to accommodate stray current. The owner of the stray current source is responsible for providing the necessary isolation details, mitigation plans and specifications for review by the Department.

Discharging current into the soil produces soil gradients. The most common source is a cathodic protection system for a pipeline, which produces a steady DC voltage in the soil near the anode(s). Pipeline cathodic protection anode bed(s) to be located near a bridge (within one bridge length) should be reviewed prior to approval. Pipelines attached to a bridge structure or located within two pipe diameters should also be reviewed. By contrast, the DC soil voltage near a traction power substation (TPSS) is zero for a totally ungrounded TPSS, pulsing for a diode-grounded TPSS, and pulsing/reversing for some heavy rail TPSS.

For new structures designed to carry rails protection against stray current comes from proper design of the direct current source with isolation of the rails from the concrete and use of concrete with high resistivity and impermeability properties. If the reinforcement steel is passivated by the high alkalinity of the concrete, then stray current can be partially if not totally mitigated. A highly impermeable concrete made with a corrosion resistant supplementary material such as silica fume and slag are recommended for mitigation purposes. Chloride levels below that needed to initiate corrosion can still be sufficiently high to result in accelerated corrosion when stray current enters and exits the reinforcement. Reducing the permeability of the concrete and application of a deck sealer such as polyester concrete will help minimize any potential chloride intrusion.

Epoxy coated reinforcement (ECR) can be used to mitigate stray current flow as the coating electrically isolates the steel. However, damage done to the ECR during placement can lead to locations of high current densities and significant localized damage. Since the ECR is electrically isolated, there is no simple way to monitor any stray current damage.

For new bridge decks, lap weld all continuous top longitudinal rebar splices within the width of the trackway. For reinforced concrete bridge decks within the width of the trackway, provide an extra (non-structural) lap welded continuous top longitudinal #4 rebar in the deck slab at each girder and within one foot of the inside face of any future concrete barriers. Weld connect the continuous top longitudinal bars to a transverse collector #9 rebar at each bent cap, hinge diaphragm, abutment diaphragm and abutment backwall.

For pre-tensioned or post-tensioned bridges, it is vital that the tendons and anchorage assembly be electrically isolated from the rest of the bridge. Tendon ducts should be plastic and the grout should be corrosion resistant for additional protection. Where ducts are in contact with stirrups, duct protection should be provided. A system to monitor the electrically isolated strand should be installed as part of the construction.

For both existing structures and new structures, the optimum source of stray current mitigation is built into the system by the agency that owns it. It is recommended that plans submitted by outside agencies for attaching pipelines, electric rails or other sources of direct current be reviewed by the Corrosion Branch. The Corrosion Branch maintains a set of previously published bridge design railway notes and details developed by the Department regarding electrified rails on bridge structures which can be provided on request.

Measures must be taken to mitigate possible stray current problems whenever they are anticipated or suspected. The above considerations given for bridge structures also apply to long steel culverts and pipes.

13.1 Other Structures Requiring Stray Current Protection

A. Retaining Walls

B. Reinforced concrete walls or mechanically stabilized embankment systems (MSE) with metal elements shall be provided with stray current **provisions** if they are within 30 feet of light rail tracks (LRT). For other direct current sources, it is recommended that a risk assessment be conducted along with a field survey.

C. Pumping Plants

1. Epoxy coated bar reinforcing steel shall be used throughout the entire box structure except in the dry pit shaft when the LRT travelway is 20'-0" or closer to the pumping plant endway. The epoxy coated bar reinforcement shall have all ends coated and any damaged bars shall be recoated with epoxy. When the LRT travelway is greater than 20'-0" from the pumping plant endways, reinforcement shall be as per standard plans. See Detail 13.

2. Increase bottom slab thickness by 1" to provide 3" clearance from bottom of slab to the bar reinforcing steel.

3. Permit only high density mortar blocks.