Corrosion Overview

Corrosion Process and Testing

Background and Introduction

- Corrosion is the single most important problem in concrete structures
- NACE estimates the cost of corrosion (in the USA) to be approximately

  400 Billion!!!
- It's estimated that 25-30% of this cost is attributed to corrosion of concrete structures

Causes of Corrosion

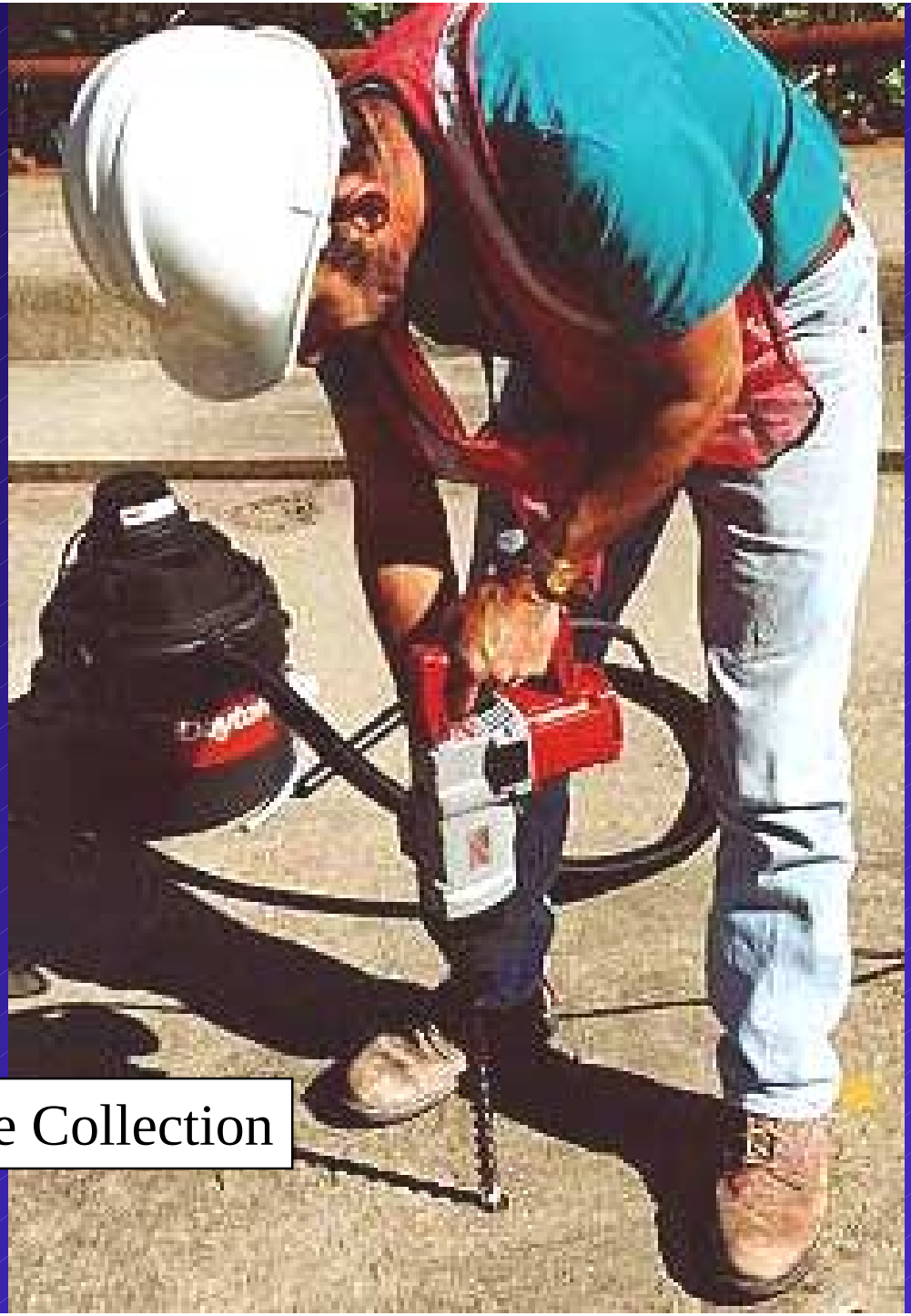
- Chlorides
- Carbonation
- Dissimilar Metals

Destruction of Steel's Passive Oxide Layer

Chloride Induced Corrosion

- Caused by chlorides breaking up passive oxide layer
- Sources of chlorides:
  - Marine Environments
  - De-icing Salts (NaCl, CaCl2)
  - Chemical Plant Environment
- Vicious Circle: Chlorides are never consumed

Chloride Testing



Concrete Sample Collection

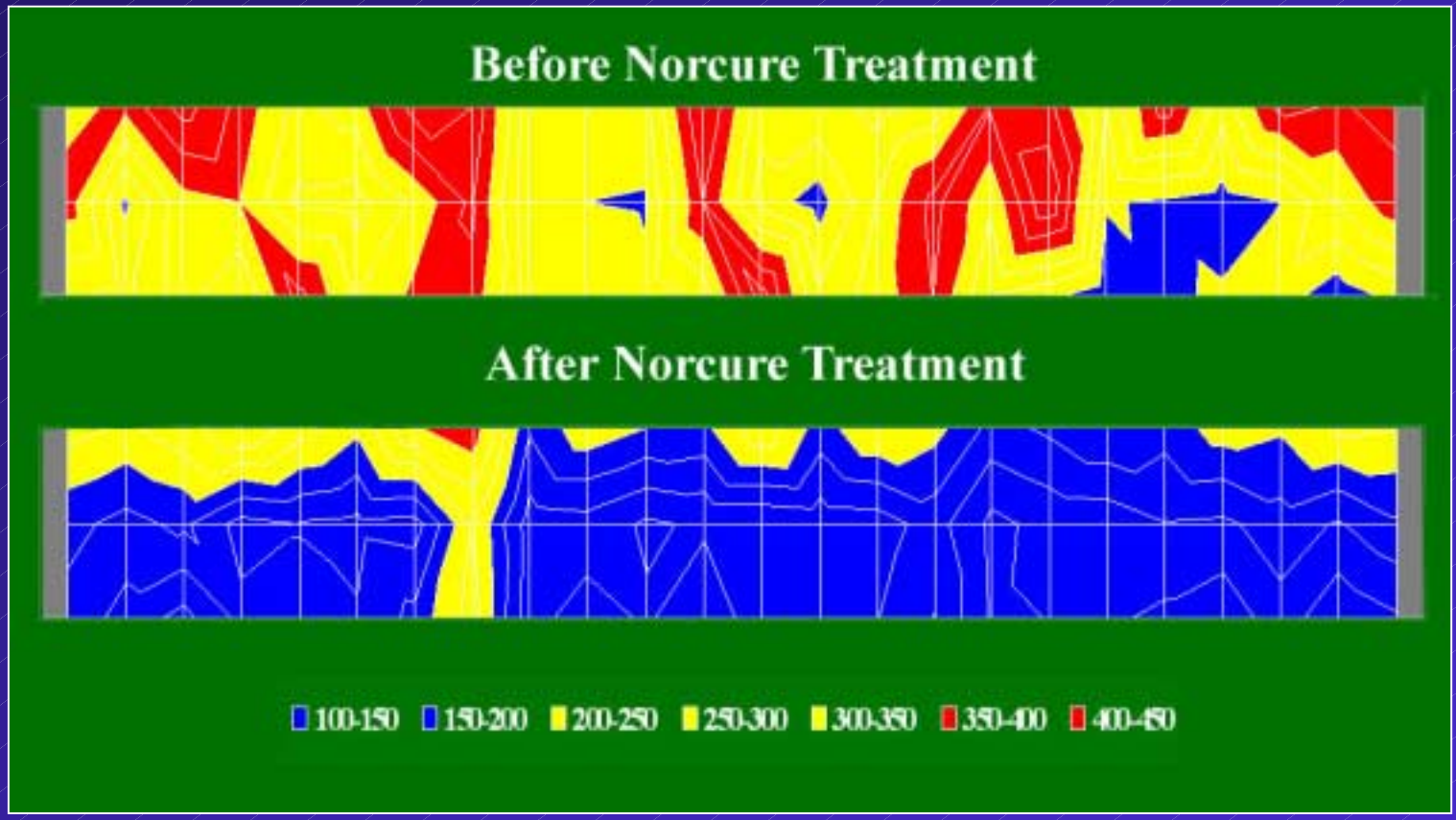

Rapid Field
Chloride Test Kit
© Norcure


Cover Meter Survey
© Norcure


Corrosion Potential Survey
© Norcure

Corrosion Potential Mapping

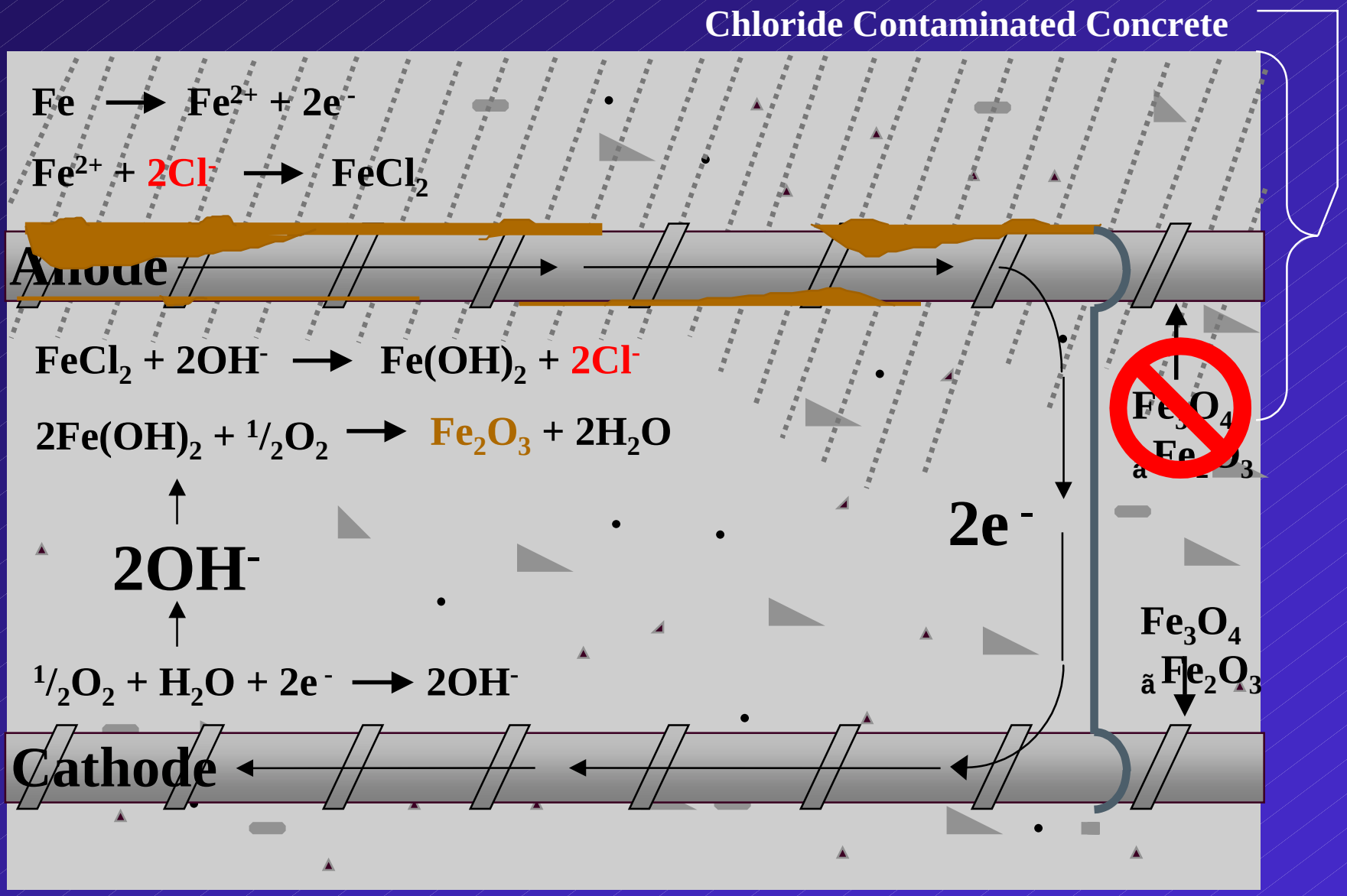
- Example: Norcure Treatment of Starbuck Bridge



GECOR6 Corrosion Rate Measurement Kit

Measuring Corrosion Rate with GECOR 6

Corrosion Cell in Concrete




Corrosion Ravaged Columns
© Norcure

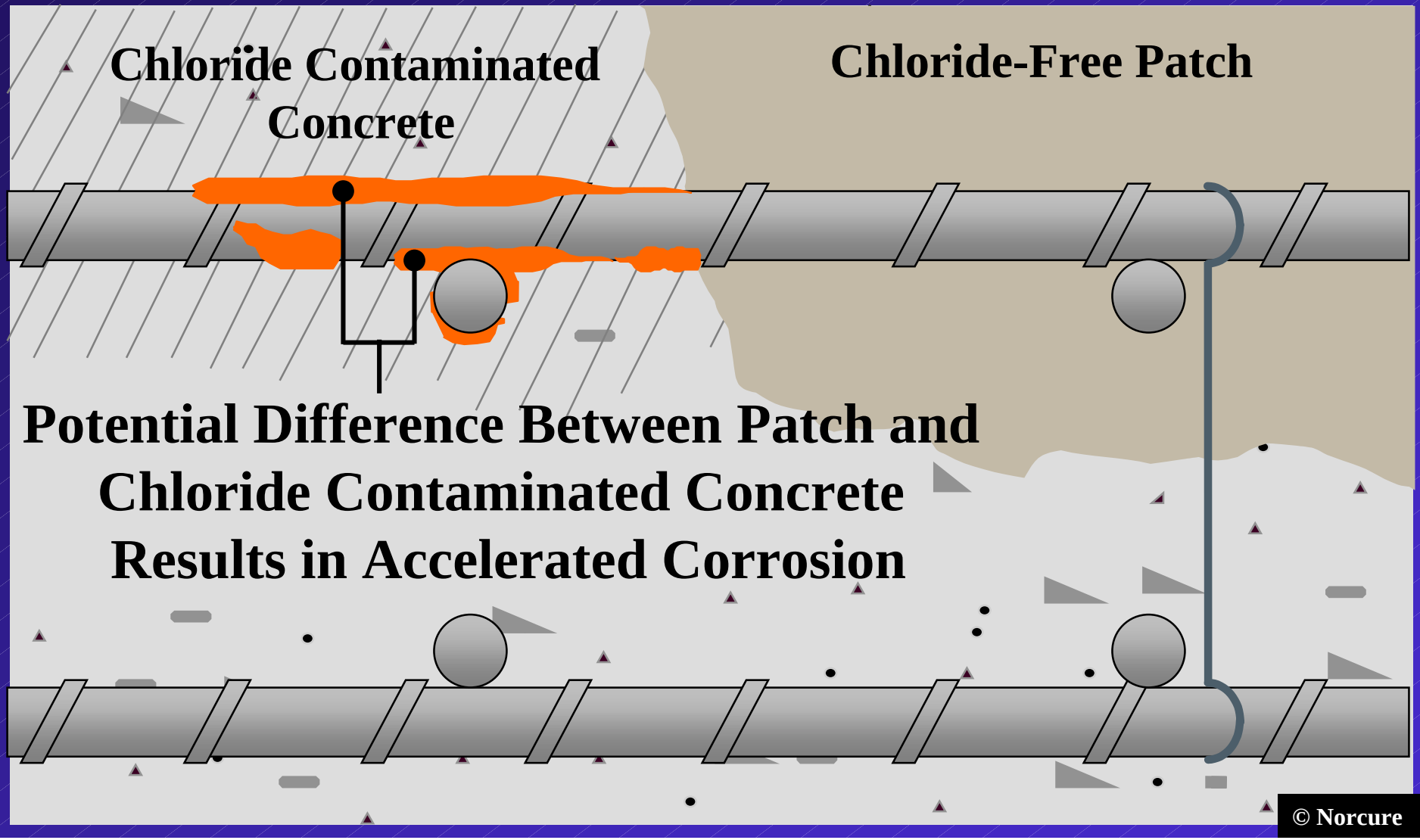
Deep Pitting Caused by Chloride Attack

Options for Repair

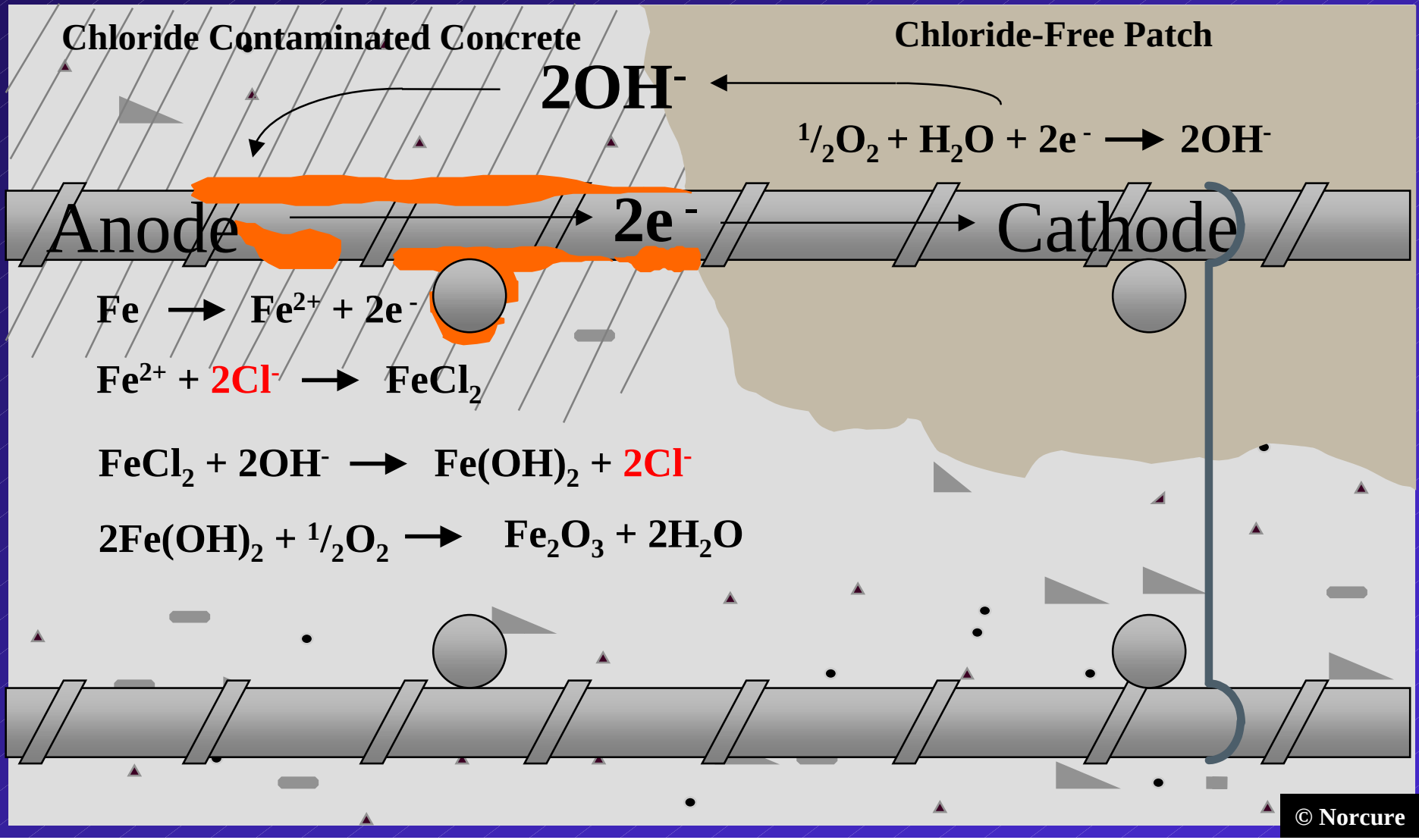
Patch Repair

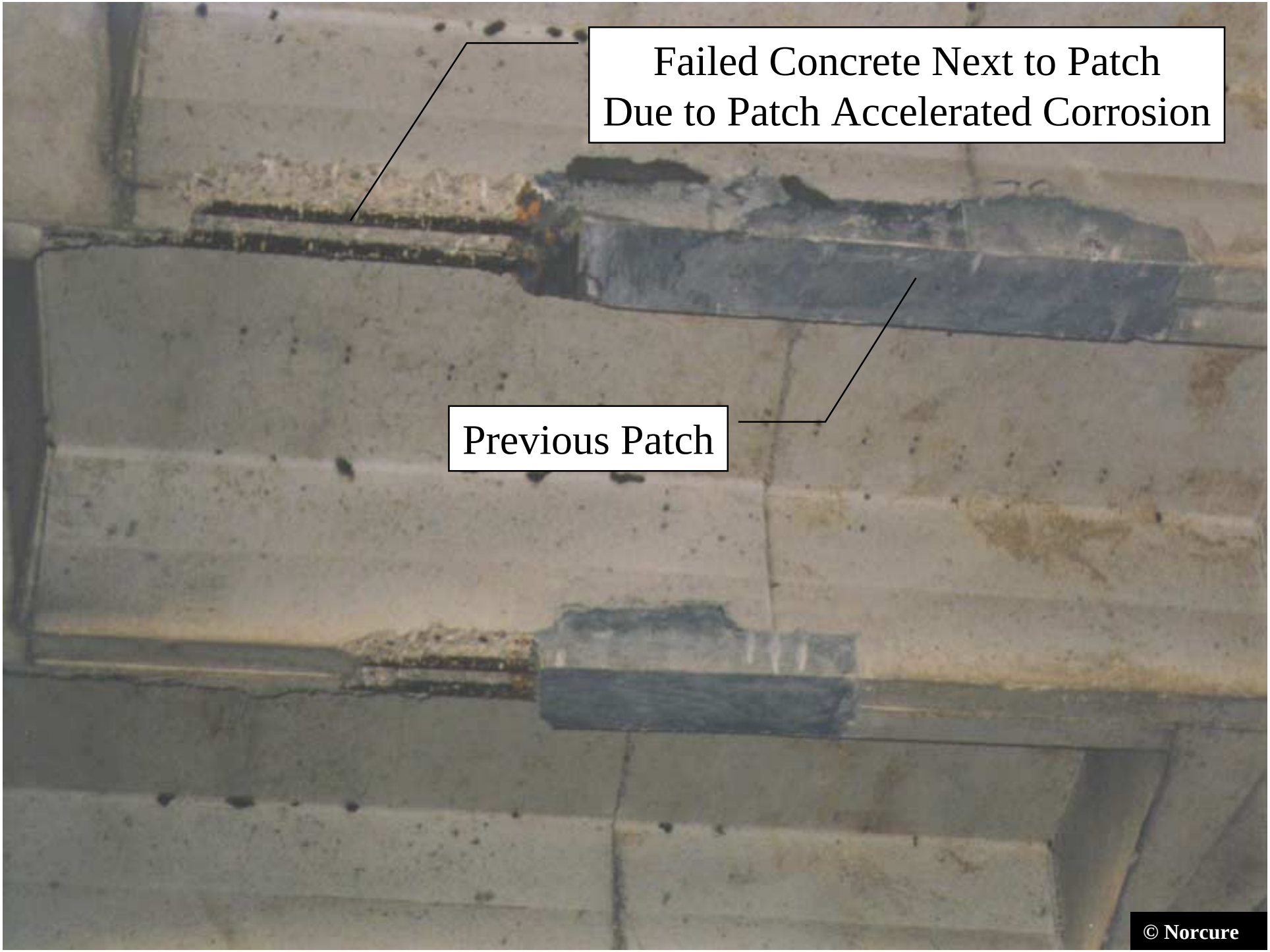

“Chip and Patch” Repair Method
Bridge Deck in Arlington, Virginia
© Norcure

Patch Accelerated Corrosion



Patch Accelerated Corrosion




Failed Concrete Next to Patch
Due to Patch Accelerated Corrosion
Previous Patch
© Norcure

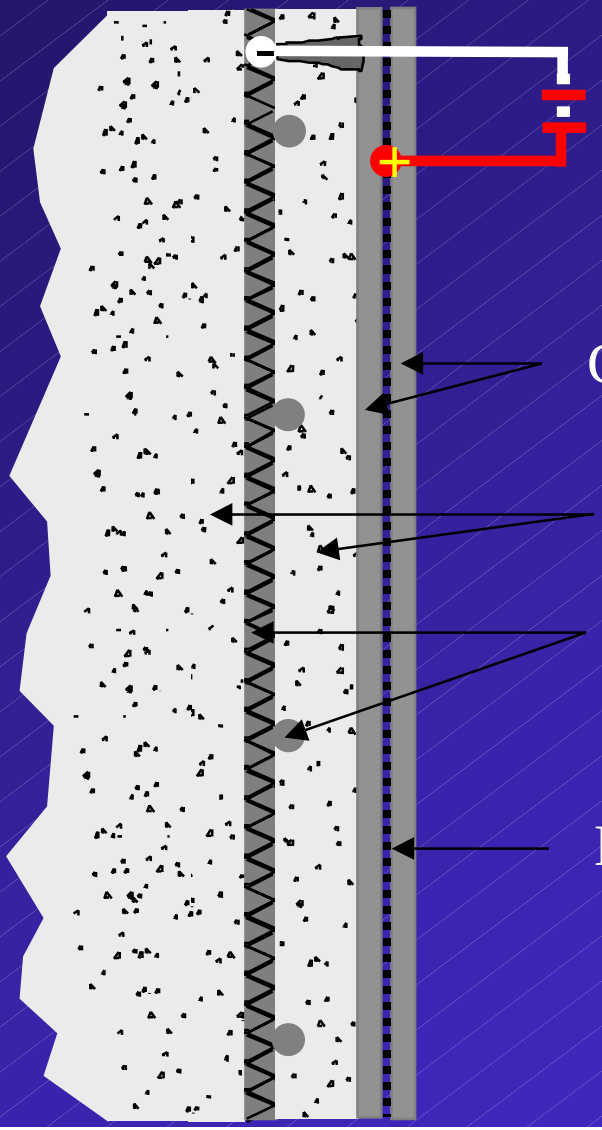

New Concrete Jacket
Rust Staining From Steel
© Norcure

Cathodic Protection

Cathodic Protection Systems

- Work by applying current to reinforcing steel to overcome the corrosion process
- Impressed Current Systems: D.C. power makes electrons flow from anode to reinforcement (cathode)
- Galvanic Systems: Sacrificial metal corrodes to provide electrons

Distributed Anode CP System



Permanent
DC Power
Supply

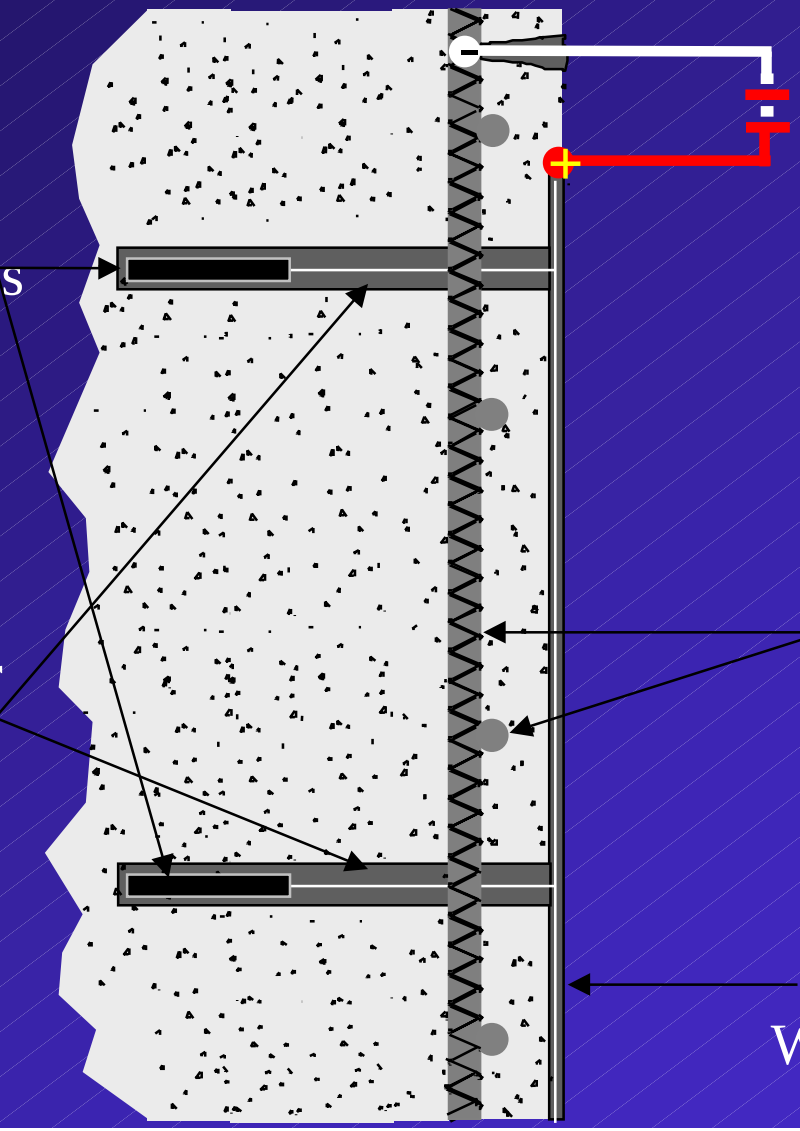
Concrete Overlay

Concrete

Rebar

Embedded Anode

Discrete Anode CP System



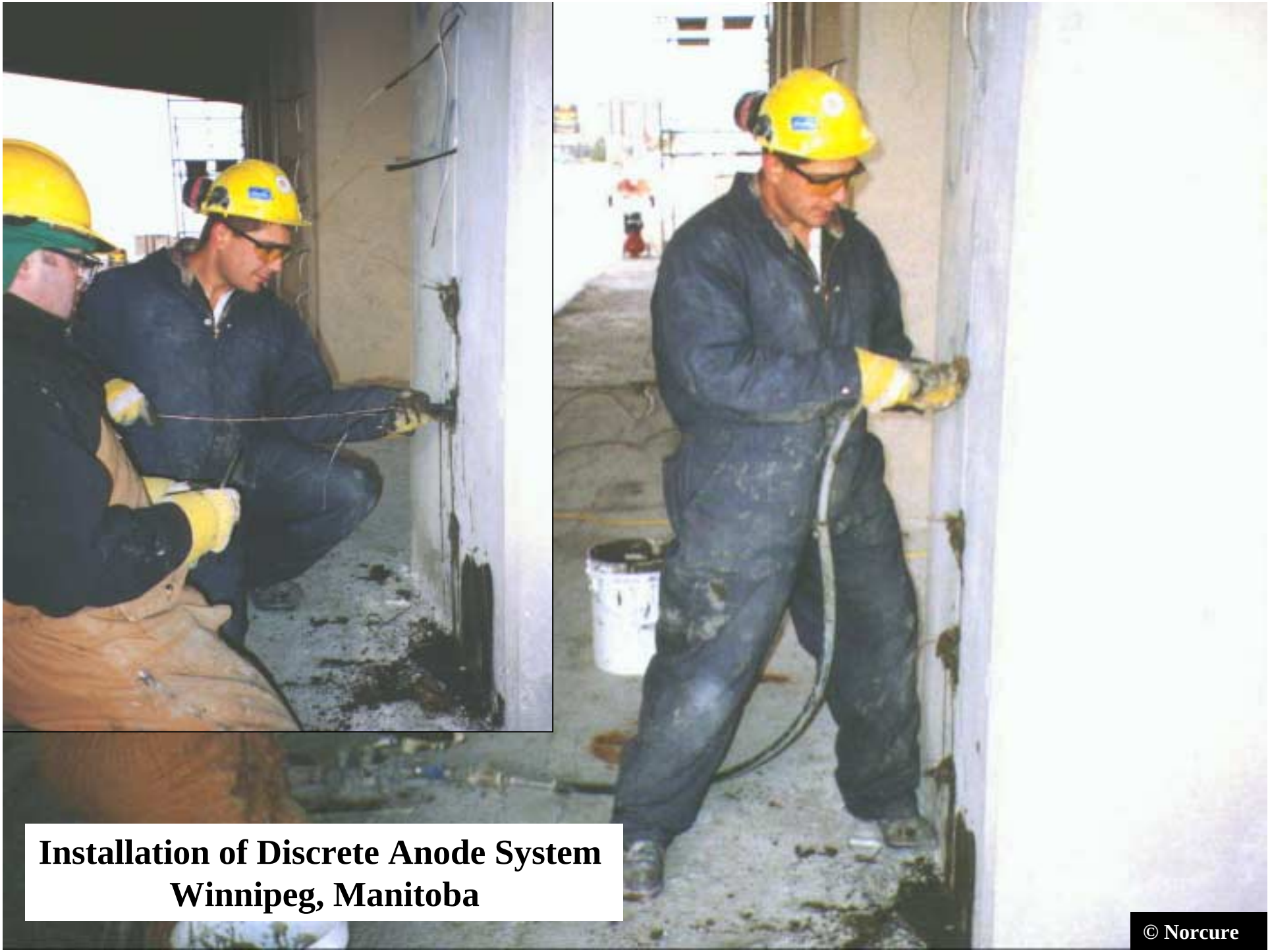
Permanent DC Power Supply

Discrete Anodes

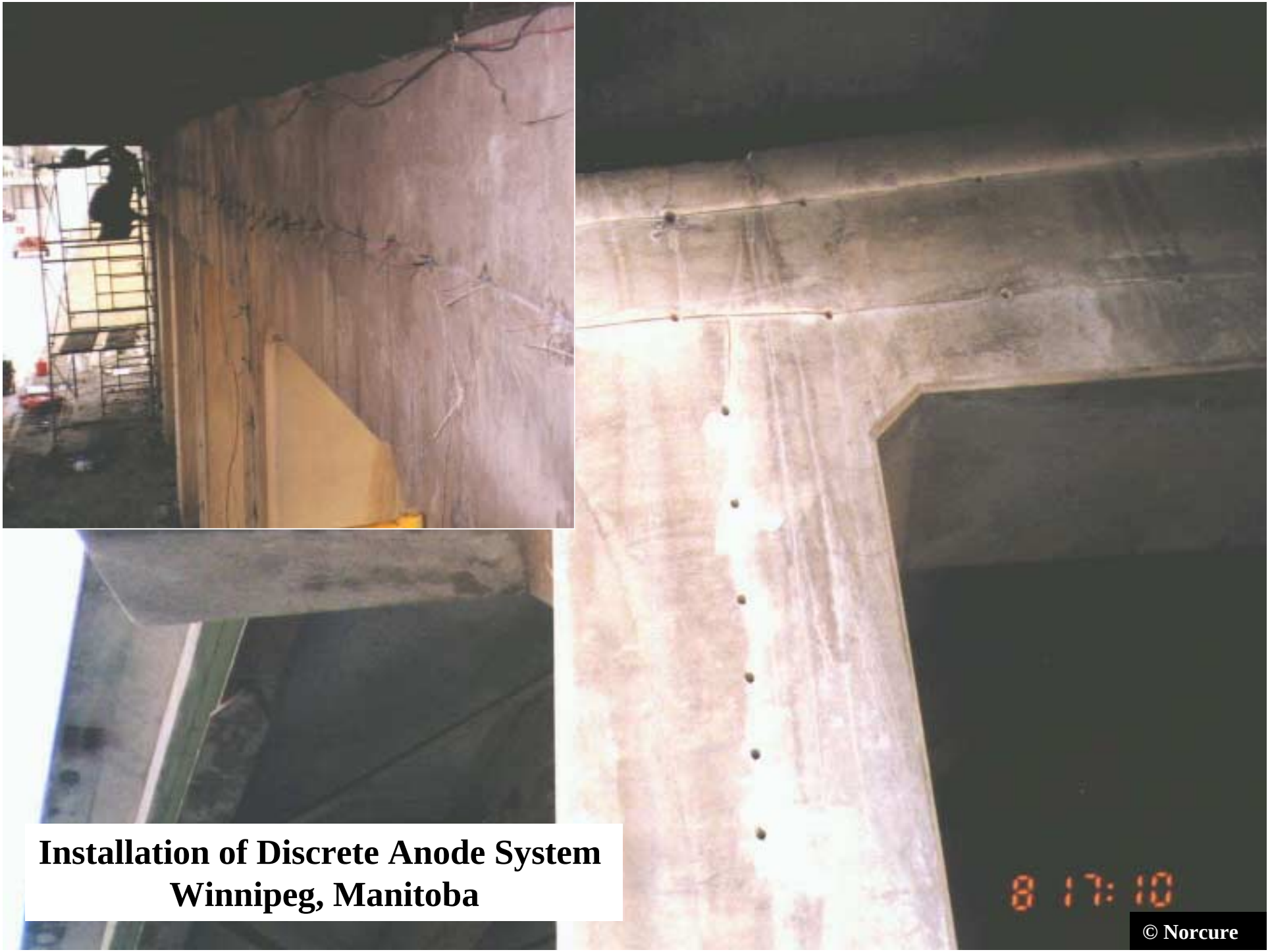
Drilled Holes for Discrete Anodes

Rebar

Slot Cut for Wiring Anodes



Installation of Discrete Anode System
Winnipeg, Manitoba



Installation of Discrete Anode System
Winnipeg, Manitoba

Rehabilitation Using Distributed Sacrificial Anode CP System

Memorial Bridge
Daytona Beach, Florida
181 Pile Jackets

Norcure Electrochemical Chloride Extraction

How does Norcure ECE work?

- Removes Chlorides from the Concrete
- Regenerates the Protective Passive Layer around the Reinforcing Steel

St. Adolphe Bridge over Red River
St. Adolphe, Manitoba
Manitoba Highways and Transportation

Net Result - Chloride Extraction

- Chlorides removed from concrete
- Hydroxyl ion formation increases pH around reinforcement
- Corrosion pits are deactivated
- Life of structure is extended

See the Norcure Chloride Extraction Presentation for more Information

Norcure Realkalization

Carbonation

- Reduction of pH in cover concrete which causes loss of passive oxide layer
- Low pH caused by reaction of free lime ($Ca(OH)_2$) in concrete with atmospheric Carbon Dioxide (CO_2)

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$$

lime (soluble) (insoluble)

pH 12-13 pH < 9


Phenolphthalein Testing of
Newly-Exposed Concrete
© Norcure

Realkalisation

- Restores alkalinity to carbonated concrete
- Reinstates passivity of steel reinforcement

Reakalisation Project
Grant MacEwan Community College
Edmonton, Alberta

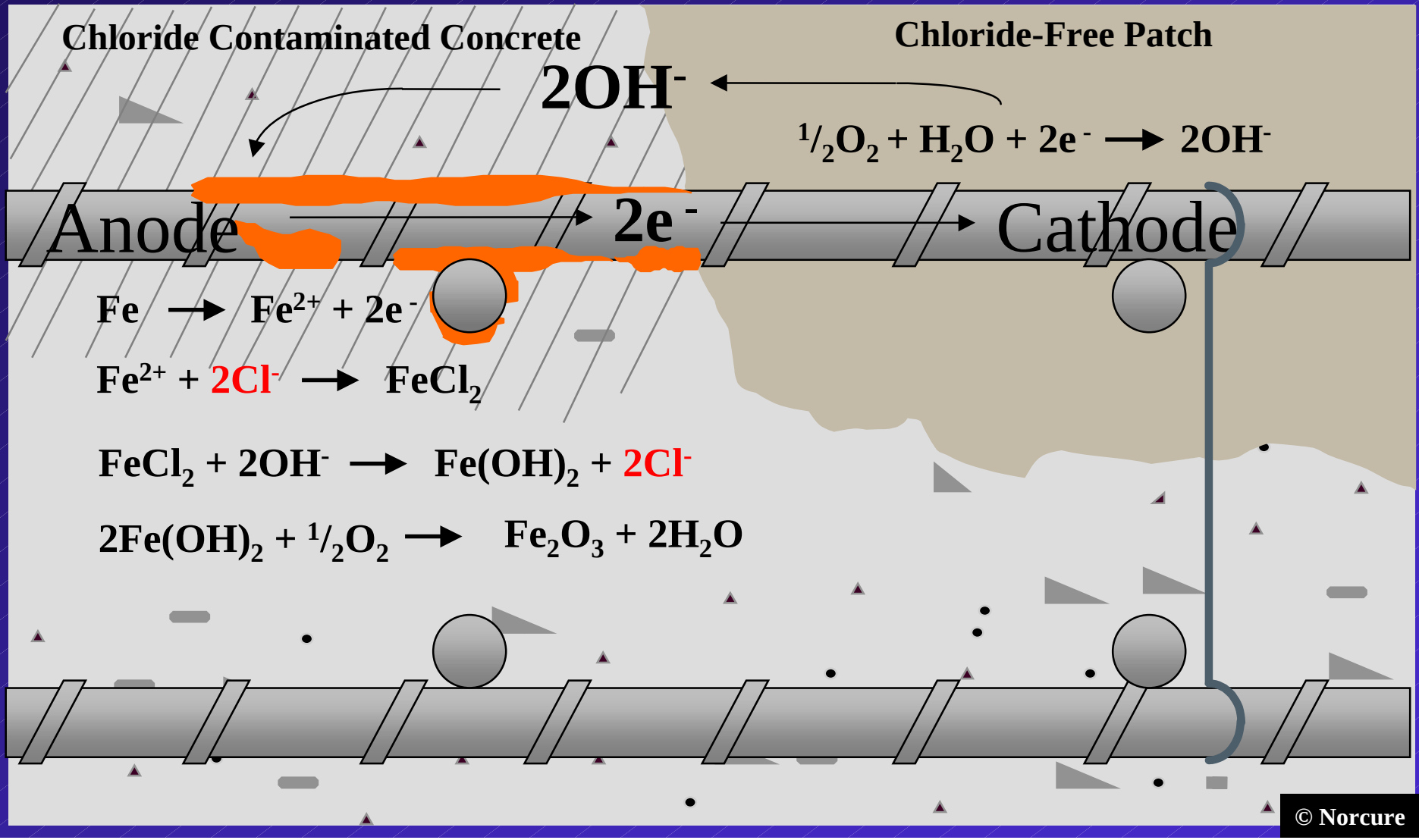
Net Result - Realkalisation

- Cover zone impregnated with high pH solution
- Low alkalinity rectified
- Entire surface treated
- Life of structure is extended

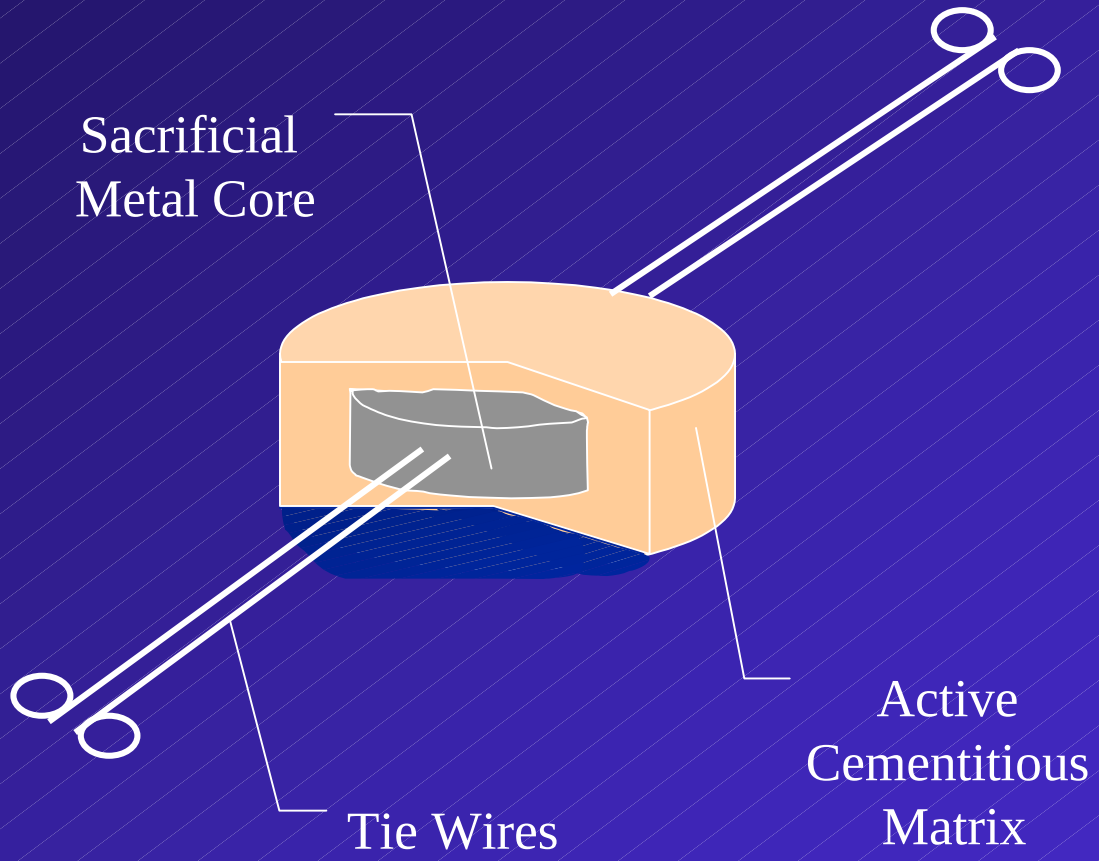
See the Norcure Re-alkalization Presentation for more Information

Galvashield XP
Embedded Galvanic Anodes

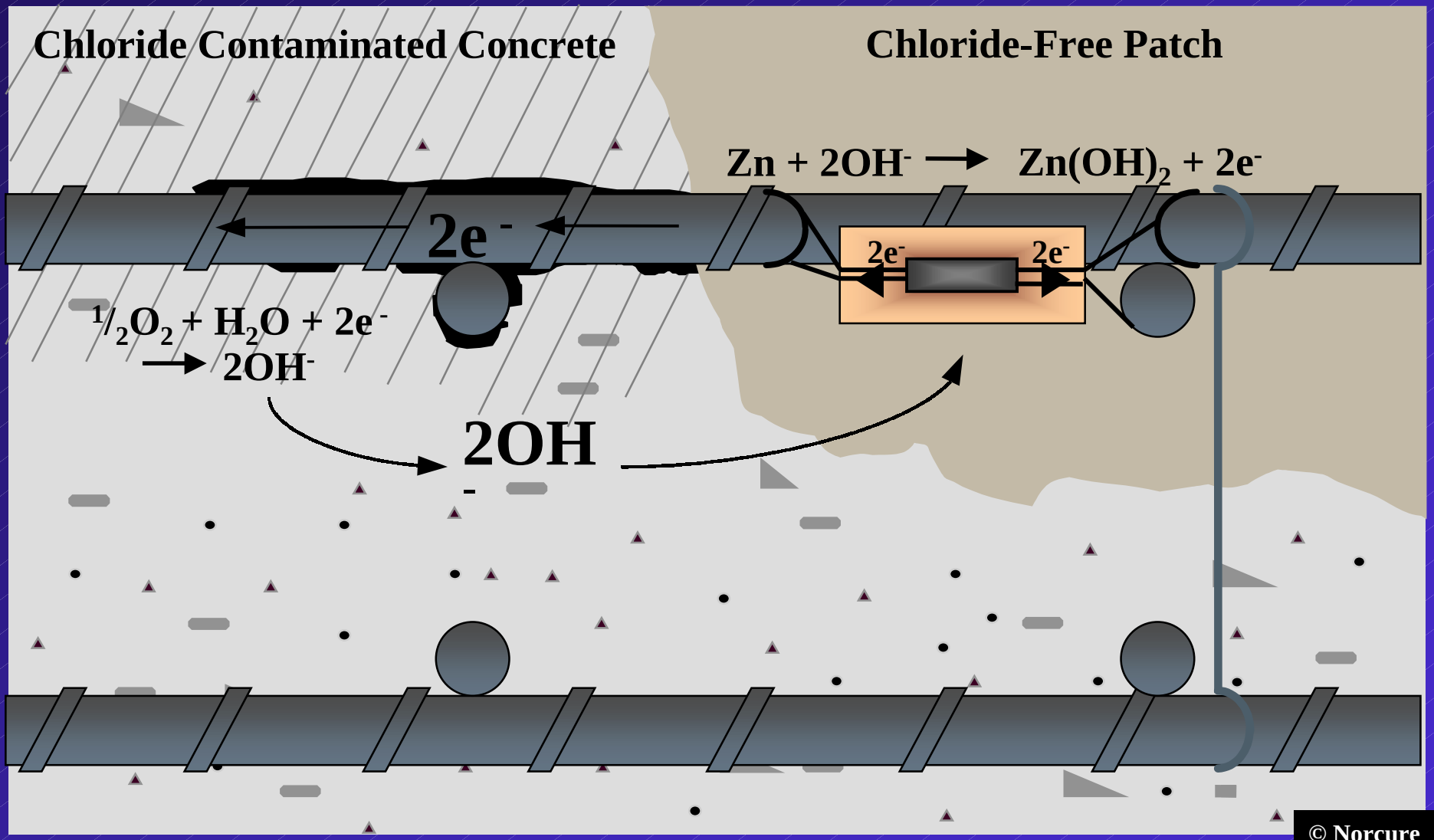
Patch Accelerated Corrosion



Embedded Galvanic Anode



Installed Galvanic Anode



Parking Garage, North York, Ontario
Read Jones Christofferson

See the Galvashield Presentation for more Information