



INTERNATIONAL
CONCRETE REPAIR
INSTITUTE

ICRI 2015 Spring Convention March 25-27, New York, NY
High Rise Repairs



e²chem
CONSULTANTS LLC



Impressed Current Cathodic Protection as a Means of Preventative Masonry Conservation: 20 Year Retrospective

Gina Crevello, Echem Consultants LLC

Paul Noyce, Axieom LLC

Content

- Steel Frame Evolution
- Early Signs
- Corrosion Basics
- Traditional Repairs
- Cathodic Protection
- Case Studies
- Rationale
- Summary



Steel Frame Evolution

Steel Frame Evolution

Monadock Building (1891) Burnham & Root

- ◆ Skyscraper Proto-type
- ◆ Tallest load bearing masonry structure in the world
- ◆ Base of Structure (6ft)



Steel Frame Evolution

Home Insurance Building (1884
demolished)
William Le Baron Jenney

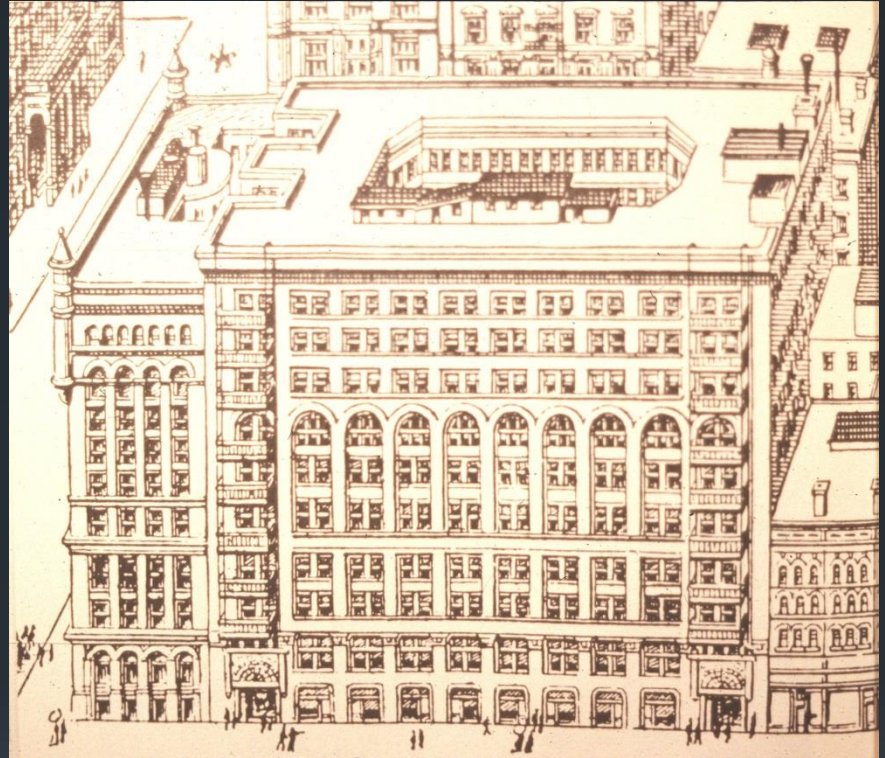
- Transition from Load Bearing walls to Skeleton Frames
- Three types of metal in early construction, steel preferred as technology advanced
- Early construction details have masonry tightly wrapped around frame



Steel Frame Evolution

Rand McNally Building (1890,
demolished) steel frame
Burnham & Root

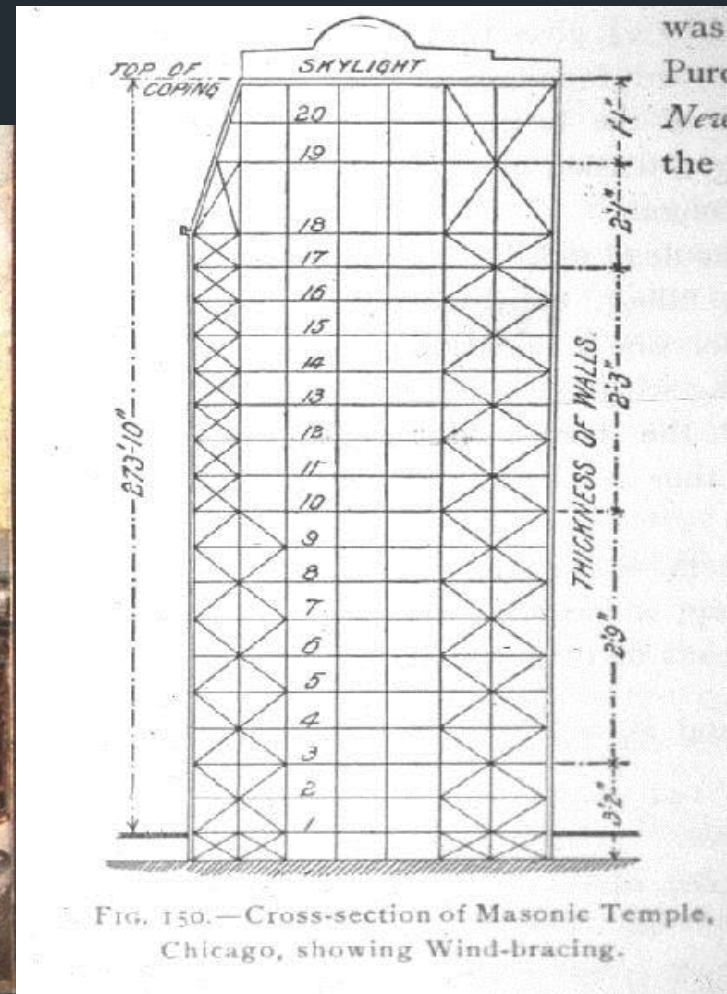
- Burnham and Root, Chicago Architects perfected steel frame construction
- Root Developed Foundations to spread load
- Masonry Cladding became obsolete after WWII



Steel Frame Evolution

Masonic Temple, 1892

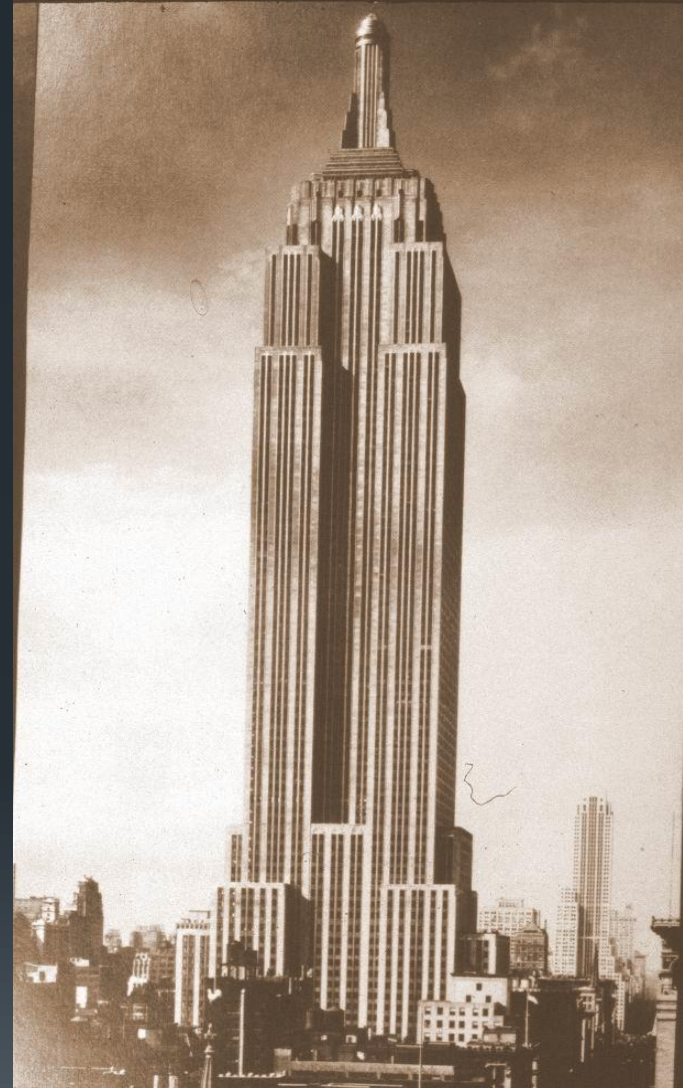
Demolished, x-braced
Burnham and Root



Steel Frame Evolution



Reliance Building, 1895
Burnham and Atwood



Empire State Building, 1930
Shreve, Lamb and Harmon



Early Signs

Early Signs

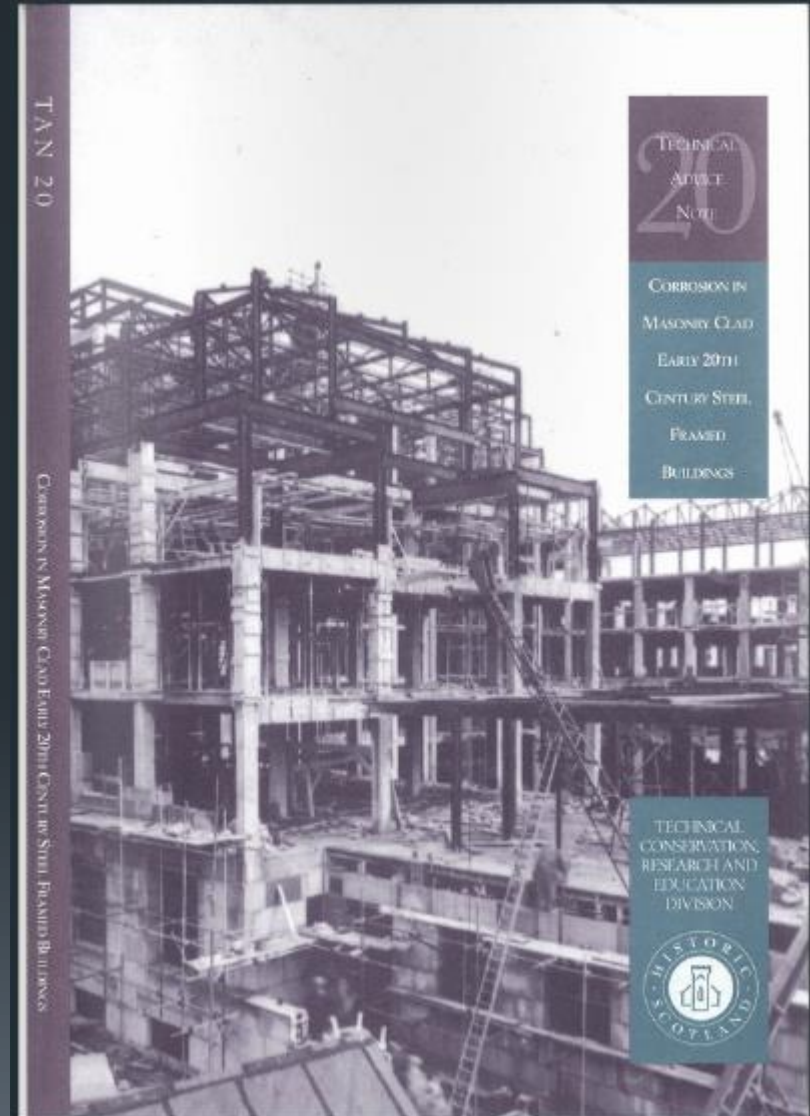
Issues in the UK labelled

Regent Street Disease

Deansgate Disorder

Damages to the façade found to be Primarily Corrosion

UK Department of the Environment and Historic Scotland Investigations led to the publication of TAN 20.



Early Signs

Issues in the US labelled

Corrosion noted in early 1900s

Façade Failures in NYC lead to
Local Law 10 now 11
Grace Gold Memorial

Killed from falling masonry

Grace Gold's Legacy: Safer Buildings

Posted on **March 24, 2015** by **Stephen A. Varone, AIA**

Those of us in the engineering and architecture industry in New York City are fully familiar with the **Facade Inspection and Safety Program (FISP)**, formerly known as Local Law 11/98 and in its original form, Local Law 10/80. But while many buildings industry professionals know about the facade inspection law, fewer know about the person whose tragic death was behind it.

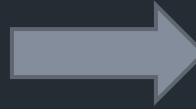
That person was Grace Gold, a 17-year-old freshman student at Barnard College who was killed in 1979 when a loose piece of masonry fell from a building on Broadway and 115th Street. Grace's death led to the original facade inspection law, New York City's **Local Law 10 of 1980**, which required buildings taller than six stories to have their street-facing facades inspected for unsafe conditions every five years by a qualified engineer or architect.



Grace Gold's death from a falling piece of masonry in 1979 led to New York City's facade inspection law.

Liability Issues (UK)

Liability High when **NO**
Corrosion Knowledge



Surveyor negligence claims for Regent Street Disease

If you have received a survey report from a professional surveyor which has failed to take into account structural damage such as that caused by Regent Street Disease, it may be possible to make a negligence claim against the surveyor responsible.

What is Regent Street Disease (RSD)?

Although it has a very place-specific name, Regent Street Disease (RSD) is not confined to London's Regent Street. In fact, it is known by various other names. For example, in Manchester the problem is referred to as Deansgate disorder.

Whatever its name, the "disease" is confined to buildings, usually from the early 20th century, which have been built using a steel frame then covered in facing stone, brick, faience or terracotta.

Problems arise when moisture permeates the stonework façade and begins to rot the internal steelwork, eventually causing the frame to corrode and potentially give way.

Bristol
Post



News Sport What's On Directory Jobs Property Notices

Crime | Business | Politics | Entertainment | Education | Health | Transport | Pubs

Warning of 'time bomb disease' that threatens to destroy city buildings

By **The Bristol Post** | Posted: October 31, 2012

Comments (0)

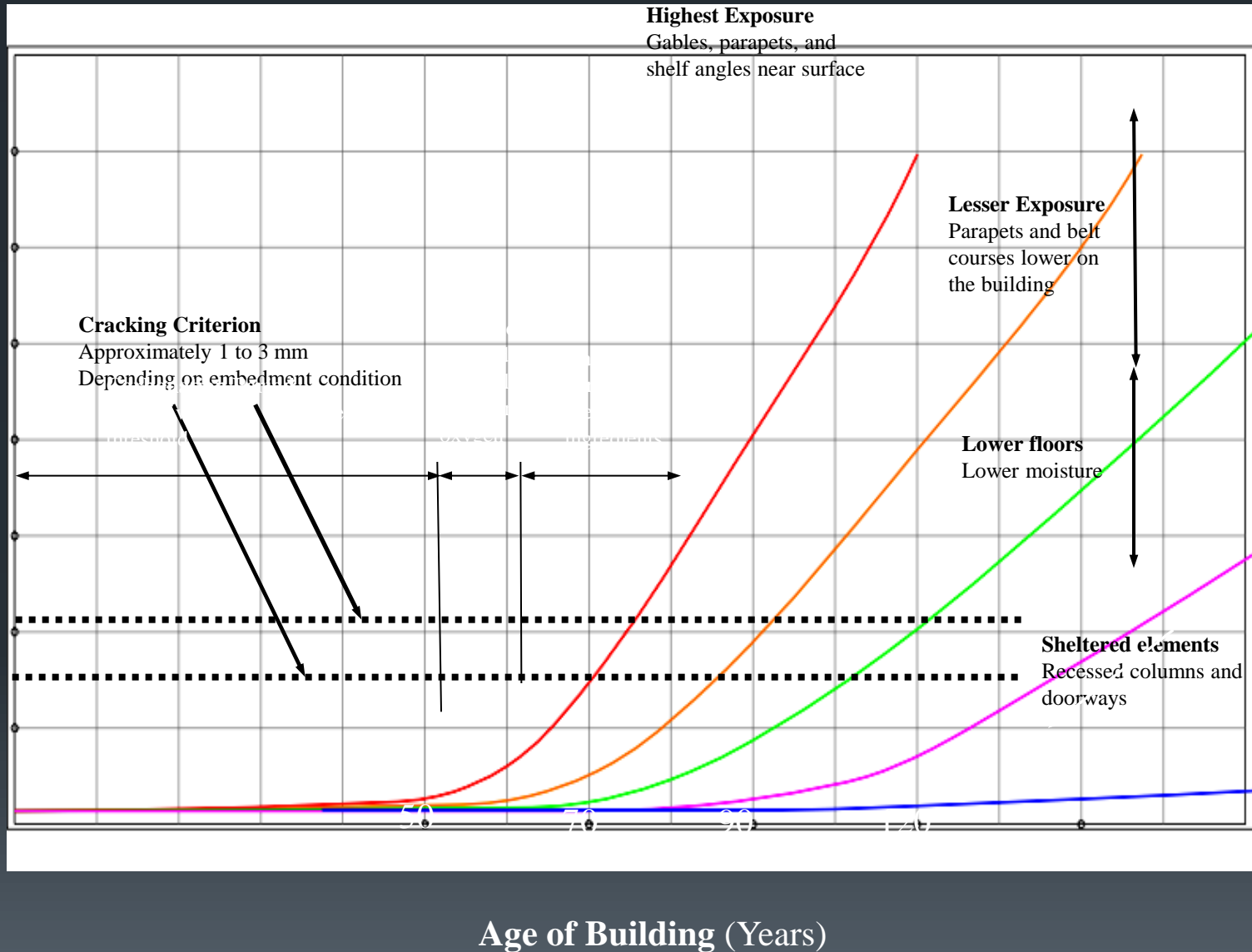
SCORES of buildings in Bristol are being attacked from within by a condition known as Regent's Street Disease – according to a leading property expert.

Steel framed properties which were built around a century ago are in danger of literally crumbling and falling apart.



Corrosion Basics

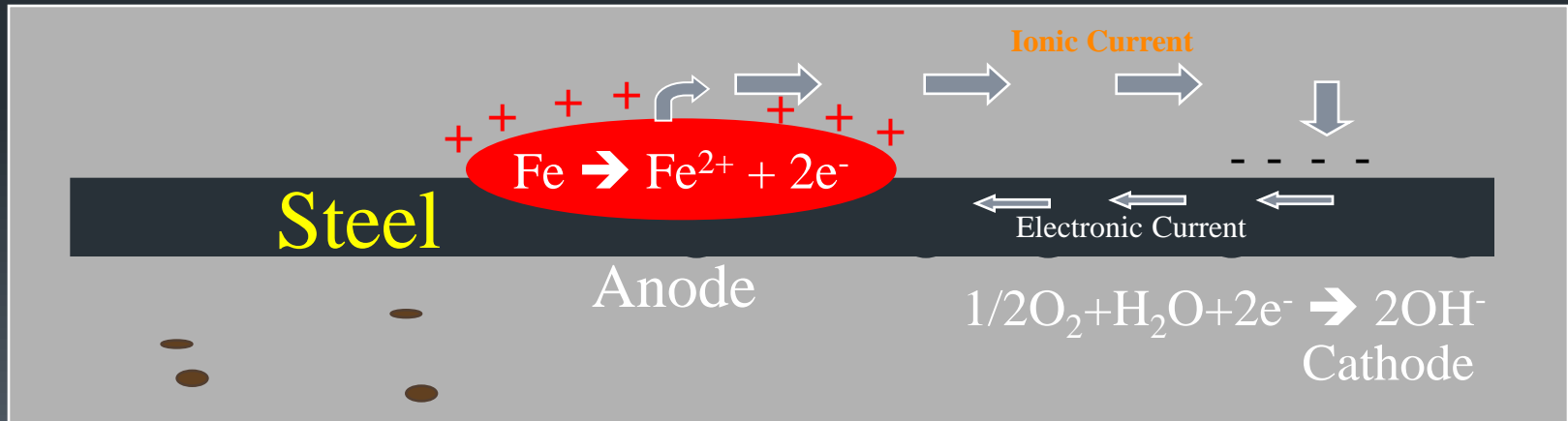
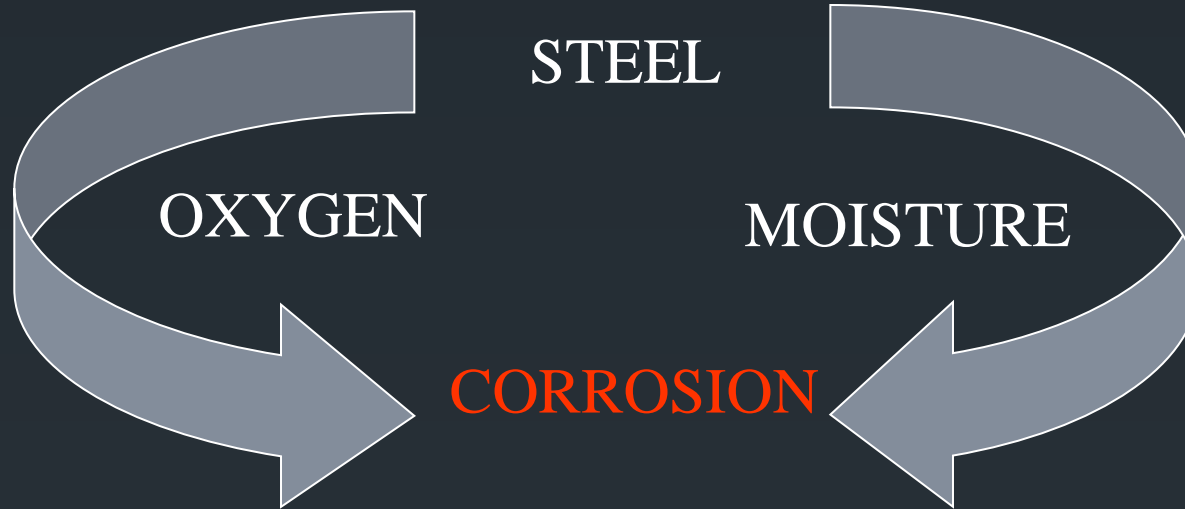
Corrosion Basics



The Corrosion Timeline: Three Phases

Corrosion Basics

THE REACTION



Corrosion Basics



- Loss of Section

Corrosion Basics – Cracking Effects



Corrosion Basics – Cracking Effects



Corrosion Basics – Cracking Effects



Corrosion Basics – Displacement



Corrosion Basics – Displacement



Corrosion Basics – Spalling



Corrosion Basics – Spalling



Corrosion Basics – Spalling



Corrosion Basics – Severe Corrosion



Corrosion Basics – Catastrophic Failures





Traditional Repairs

Current Practices

Traditional Repairs



Traditional Repairs



Traditional Repairs



Traditional Repairs



Traditional Repairs



Traditional Repairs





Cathodic Protection

The Black Magic

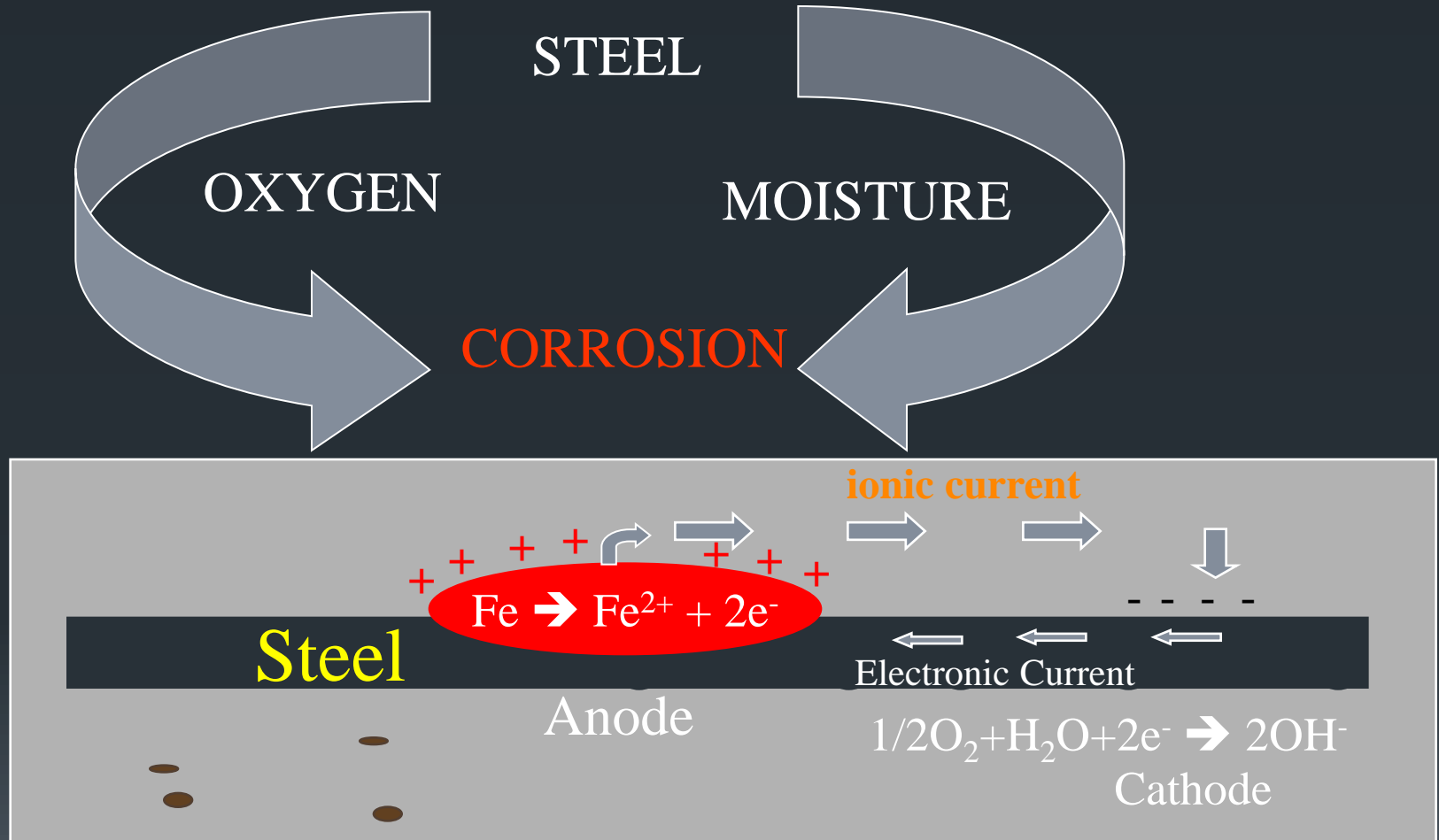
Cathodic Protection

- Ships 1824 GCP
- Pipelines 1928 GCP or ICCP
- Tanks 1930s GCP or ICCP
- Concrete 1959 ICCP
- Concrete FHWA Approval 1973 ICCP
- Concrete SHARP Report 1983 ICCP
 - GCP on Concrete in Marine or Contaminated Environments



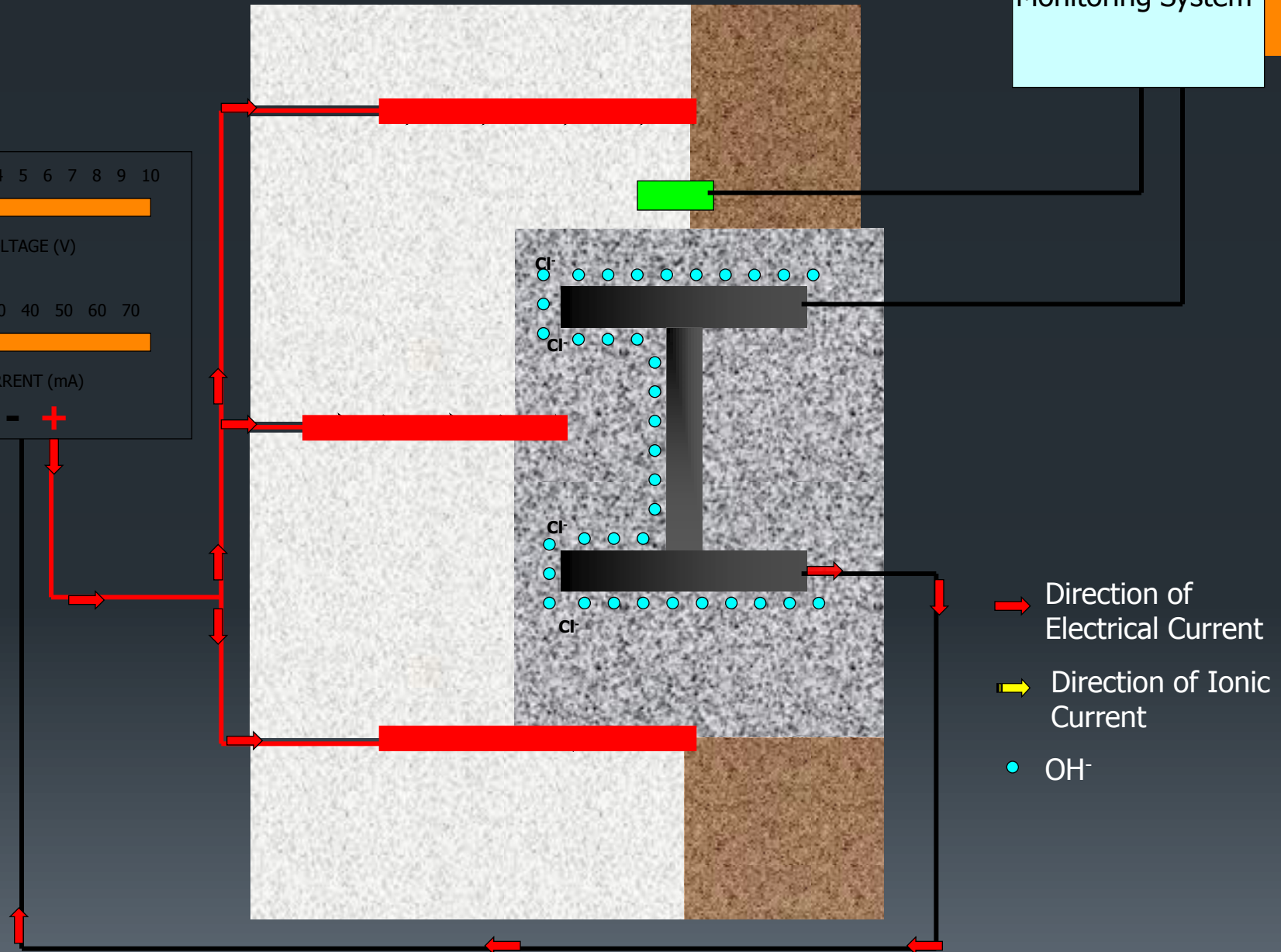
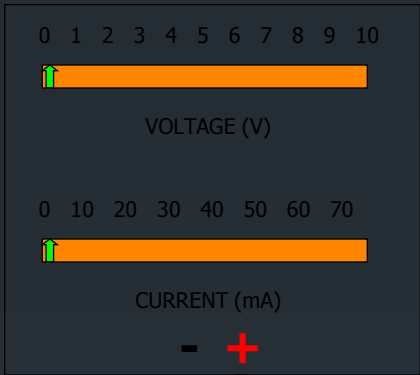
Cathodic Protection

CORROSION REACTION



Cathodic Protection

Monitoring System



- Direction of Electrical Current
- Direction of Ionic Current
- OH^-

Cathodic Protection

Early investigative work in the UK was Conservation Driven not Health & Safety or Cost Driven



Carraraware
FOR
MODERN ARCHITECTURE

The modern building demands a modern exterior designed for utility and attractiveness. It must be striking yet not flamboyant—tasteful yet not subdued. Doulton Carraraware possesses all these features and more: its hard glazed reflecting surface is excellent for lighting effects and is rapidly cleaned with soap and water ensuring low maintenance costs. It is highly resistant to all atmospheric conditions and retains its pleasing colourings indefinitely. Carraraware is ideal for Factories, Business Premises, Licensed Premises, Cinemas and other buildings where an attractive front is an asset. This distinctive “ODEON” Theatre at Chingford is a fine example of Carraraware used as the facade of a modern cinema. It is yet another instance of how Doulton Carraraware lends itself perfectly to Modern Architecture.

“Odeon” Theatre, Chingford. Architect: Andrew Mather, F.R.I.B.A.

DOULTON
AND CO., LTD.



Cathodic Protection

- Historic buildings ICCP
- First Trials (UK – English Heritage) 1990
- First full Scale Application UK 1996
- First Large Scale Use US 2004



Colonnade, Prime Minister's Residence, Dublin, Ireland
1990 Installation
2012 system still performing

Cathodic Protection

- Historic buildings ICCP



Inigo Jones Gateway Arch, Chiswick House Gardens, London, UK
1995 Installation - 2014 system still performing

Cathodic Protection

- First Full Scale Use on an Historic Steel Frame Buildings UK



Joshua Hoyle Building

Manchester, UK

1996 Installation - 2013 System still performing

Cathodic Protection

- First Full Scale Use on an Historic Building USA



Marshall Field's Flagship Store
Chicago, IL
2004 Installation
2013 System still performing

Cathodic Protection

- Early Anode Use for ICCP
- Ribbon Anodes installed in joints
- Probe anodes used for better current distribution

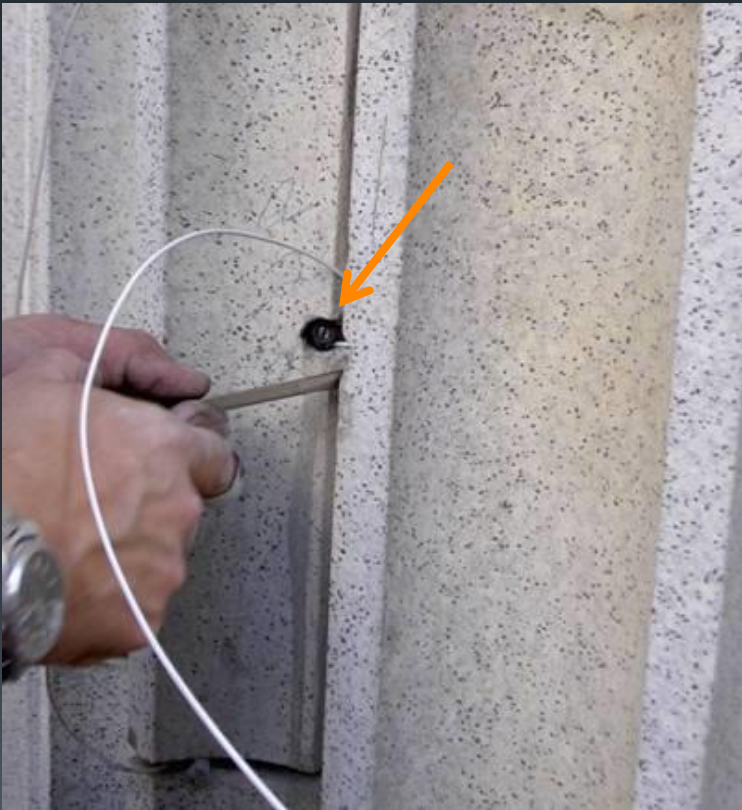


Cathodic Protection

- What happens when anodes are too close to the surface?



Cathodic Protection





Case Studies

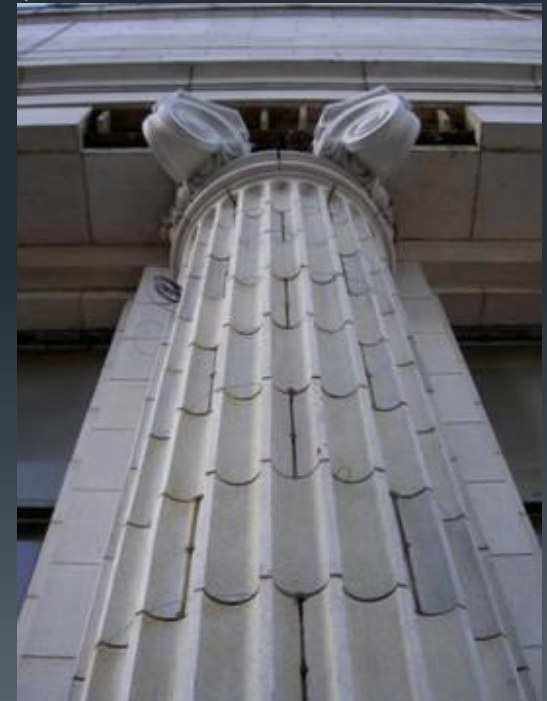
Case Study – Marshall Field's

- 1st Use of ICCP on Heritage Building in US (2004)
 - 1920s steel frame construction, addition to earlier structure
 - Third Repair Cycle
 - Water infiltration over many years lead to corrosion of the embedded steel
 - ICCP Trial was successful
 - Design of system at upper terra cotta clad pilasters



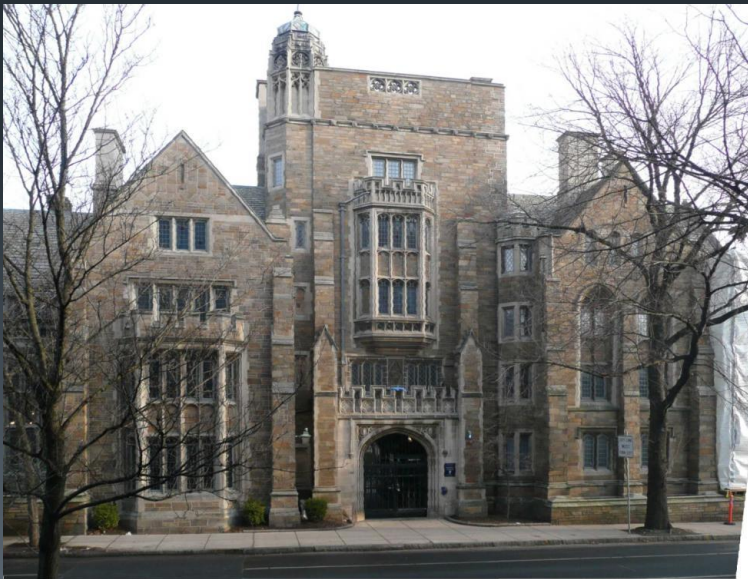
Case Study – Marshall Field's

- Four Zones
- Early ballasted rod anode with graphite paste
- Interconnected with Ti Wire
- Ag/AgCl Reference Electrodes installed for monitoring
- Touch Screen computer for ease of monitoring/ dial in
- Operating Currents at most recent monitoring trip
 - Z1 3V 25mA (7% Operating Current)
 - Z2 6.26V 34mA (8% Operating Current)
 - Z3 6.74V 270 mA (47% Operating Current)
 - Z4 4.16V 200mA (29% Operating Current)



Calhoun College

- 1931 Construction, extremely detailed collegiate gothic campus building
- Long Term Owner
- 50 year design life of restoration repairs.
- Corrosion deterioration cracking valuable masonry
- Masonry replacement is very costly



Case Study – Calhoun College

- Largest ICCP system in US on heritage building to date
 - 35 Zones, 140 AgAgCl Reference Electrodes
 - Over 6,000 LF of steel protected and 4161 anodes used
 - Better designed ballasted anodes allowed for larger anode zones with greater amounts of steel afforded protection
 - No concerns about acidification or current dump



Case Study – Calhoun College

■ Anode Performance

- Current density on anode surface 57.3mA/m^2 which is half of operating current density
- Average Current density is 43.3 mA/m^2
- All zones met the 100mV criteria at 30 days and at $3\frac{1}{2}$ years.
- Average current density per anode has dropped to 24.8



Anode Performance	Output per Anode (mA) 30 Days	Output (mA) 3 ½ Years
Max	0.405	0.405
Min	0.040	0.006
Average	0.306	0.175
Standard Deviation	0.117	0.121



Rationale

Rationale

- Preservation
- 38 Carraraware units removed in total



Rationale

- Cost
- Deconstruction not feasible



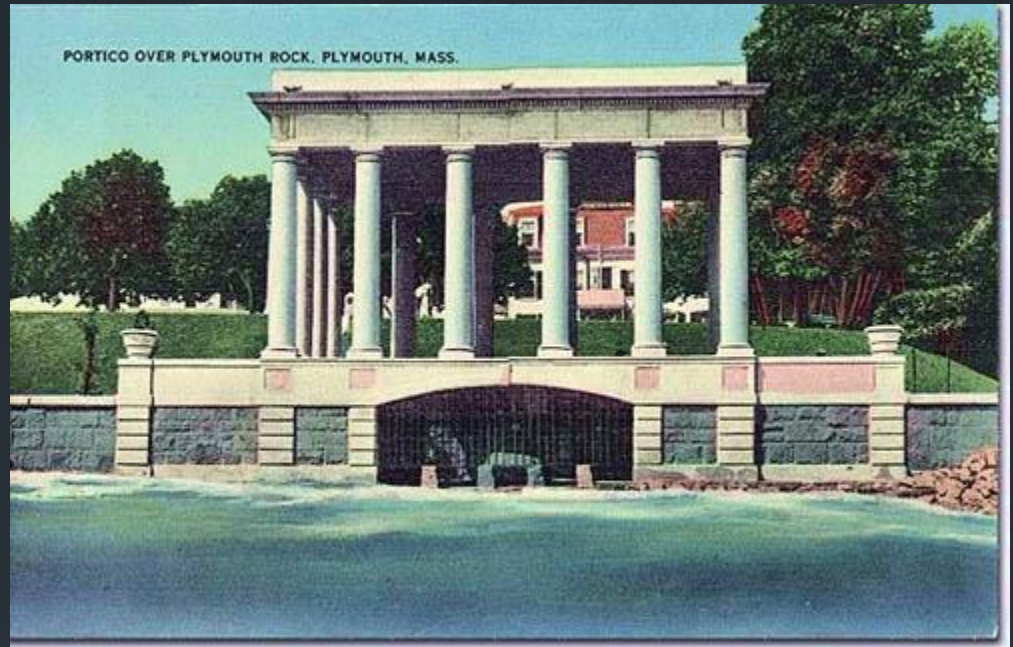
Rationale

- Long term durability of repair
- Desire for fewer repair cycles



Rationale

- Many of these buildings have landmark status
- Some cladding material cannot be replaced in kind
- Traditional repairs are costly, unsightly and/or a shorter term solution
- Stewardship for future generations





Summary

Summary

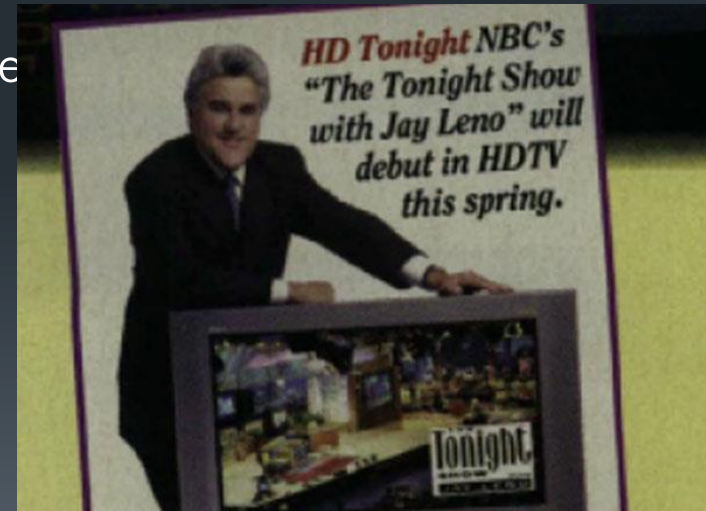
- Summary
- While most buildings of steel frame vintage will have experienced some deterioration, where masonry has not yet been damaged its use can be highly valuable
- ICCP used with traditional repairs provides at 50+ repair life.
- Minimizes future repair cycles
- Corrosion related deterioration can be predicted and known maintenance costs can be better projected
- Technology is constantly evolving,
- Systems can now run on battery operated super capacitors systems, solar panels, piso electric, etc.

Summary

- Summary – Not a new technology
- 1824 First discovered use of CP
- 1990 – First trial/ Same time as Sony PlayStation was brought to market
- 1994 - First full scale building UK / Same time as HDTVs were developed
- 2004 – First large scale application in US



the



Are you too busy to improve?



Corrosion Condition Assessments

Thank you.. Questions?

Gina Crevello

- Principal
- Echem Consultants LLC
- gcrevello@e2chem.com
- 845-215-4370
- 201-705-9050

Paul Noyce

Principal

Axieom LLC

pnoyce@axieom.com

845-215-4363

201-565-6461