

**EXTENDED PRESENTATION AT ICCRRR IN CAPE TOWN IN 2018 OF**

**MAINTENANCE AND REPAIR OF STEEL REINFORCED CONCRETE STRUCTURES BY GALVANIC CORROSION PROTECTION – FIELD EXPERIENCES OVER 10 YEARS**

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**CAS**

COMPOSITE - ANODE - SYSTEMS GMBH

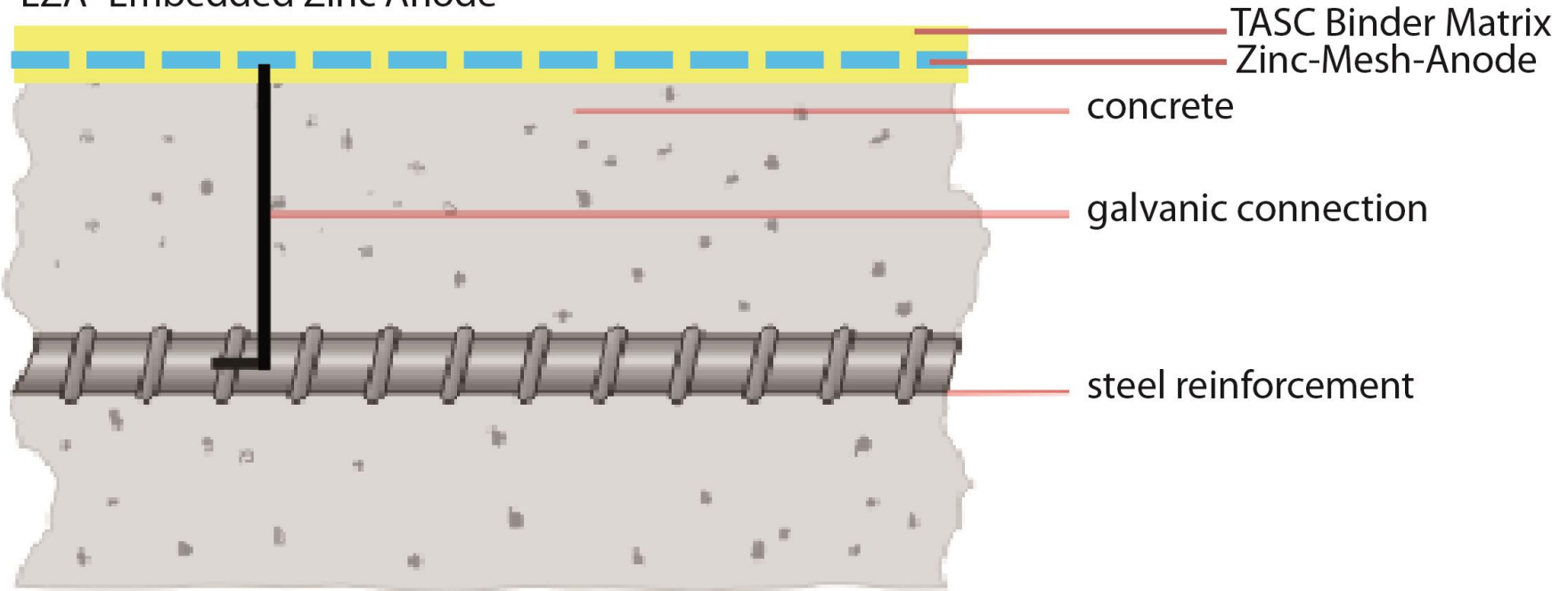
## **00 CONTENT**

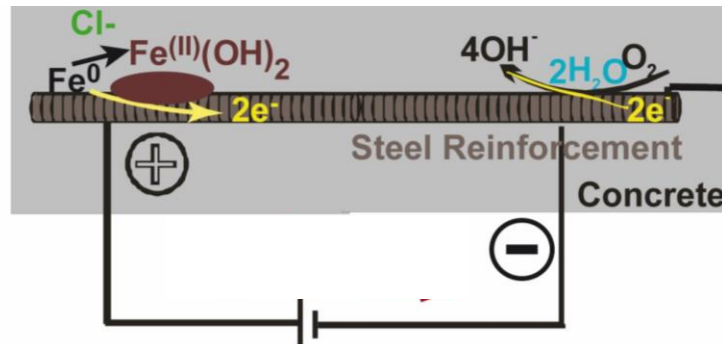
- 01 CONCEPT**
- 02 WORKING PRINCIPLE**
- 03 EZA PROPERTIES**
- 04 ALPLGRABEN BRIDGE**
- 05 HUBERTUS VIADUCT**
- 06 DE MEERBRUGG BRIDGE**
- 07 SAAS FEE - PARKING DECK**
- 08 RECENT INSTALLATIONS**
- 09 CONCLUSIONS**



EZA – Embedded Zinc Anode

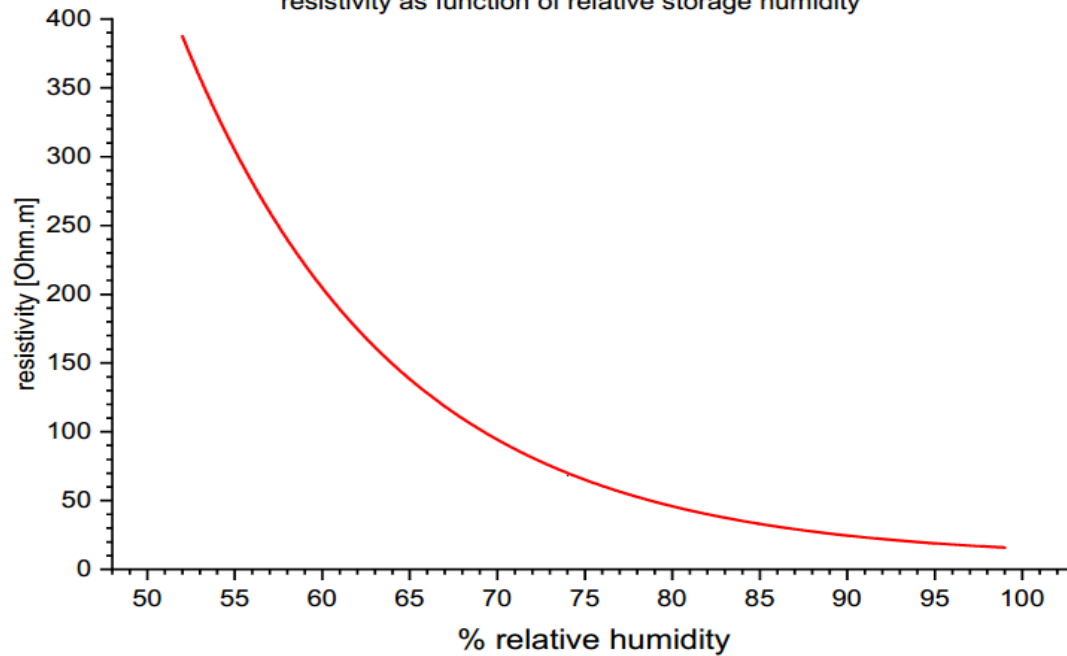
EZA- Embedded Zinc Anode





$I_{galv}$

SEZAC binder 07-07-2017  
resistivity as function of relative storage humidity



### Binder Matrix

**SEZAC - Shrinkage reduced  
Embedding Zinc Anode Cement**

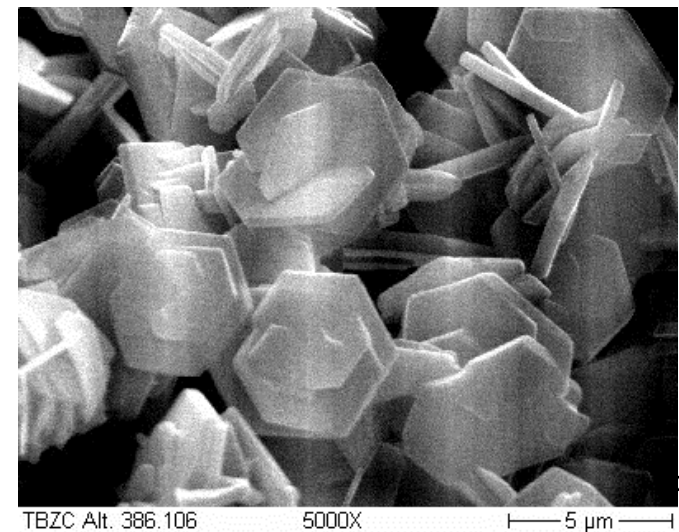
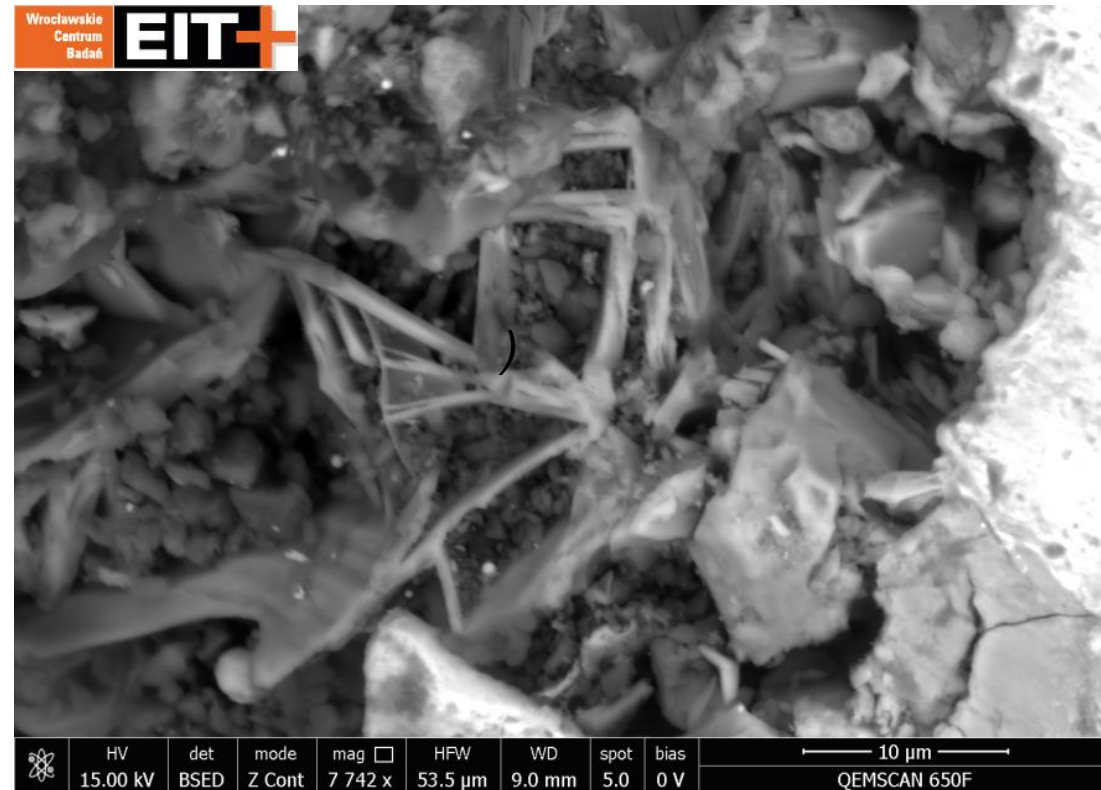
Function:

- ✓ embedding matrix for zinc mesh
- ✓ glue
- ✓ coating
- ✓ electrolyte
- ✓ activates zinc at pH < 12
- ✓ transport of anodic products into the matrix
- ✓ minimizes autocorrosion



### FIELD SAMPLES INDICATE CHLORIDE EXTRACTION:

Chloride, migrated to the zinc-anode  
& eventually immobilized as zinc-  
hydroxide-chloride,  
a natural mineral **Simonkolleite**





### CHLORIDE MIGRATION

Studied under laboratory conditions:

Mortar (SikaMonotop 612N with 3,5% Chloride/wt. Cem.), EZA applied with a chloride free embedding binder.

Element Analysis by **LIBS**

**Laser Breakdown Spectroscopy**

at BAM

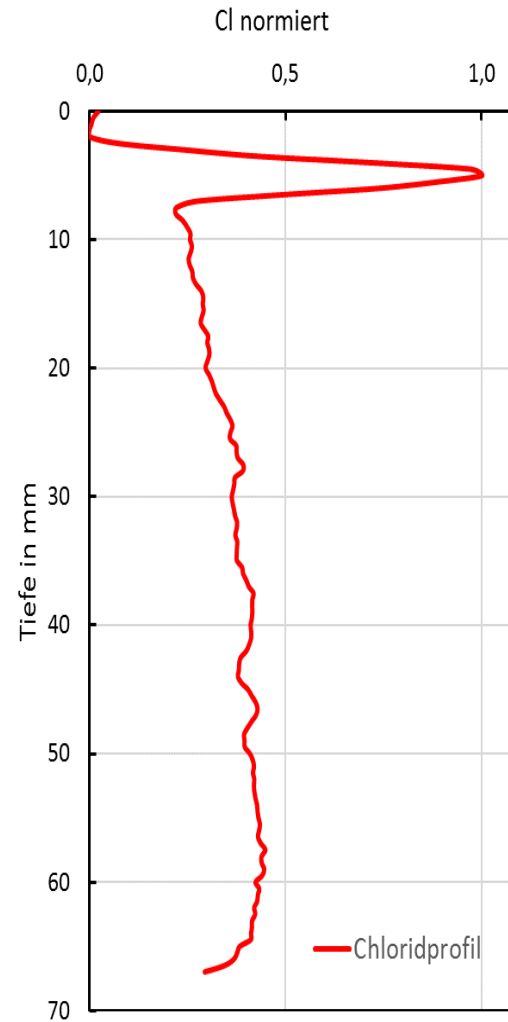
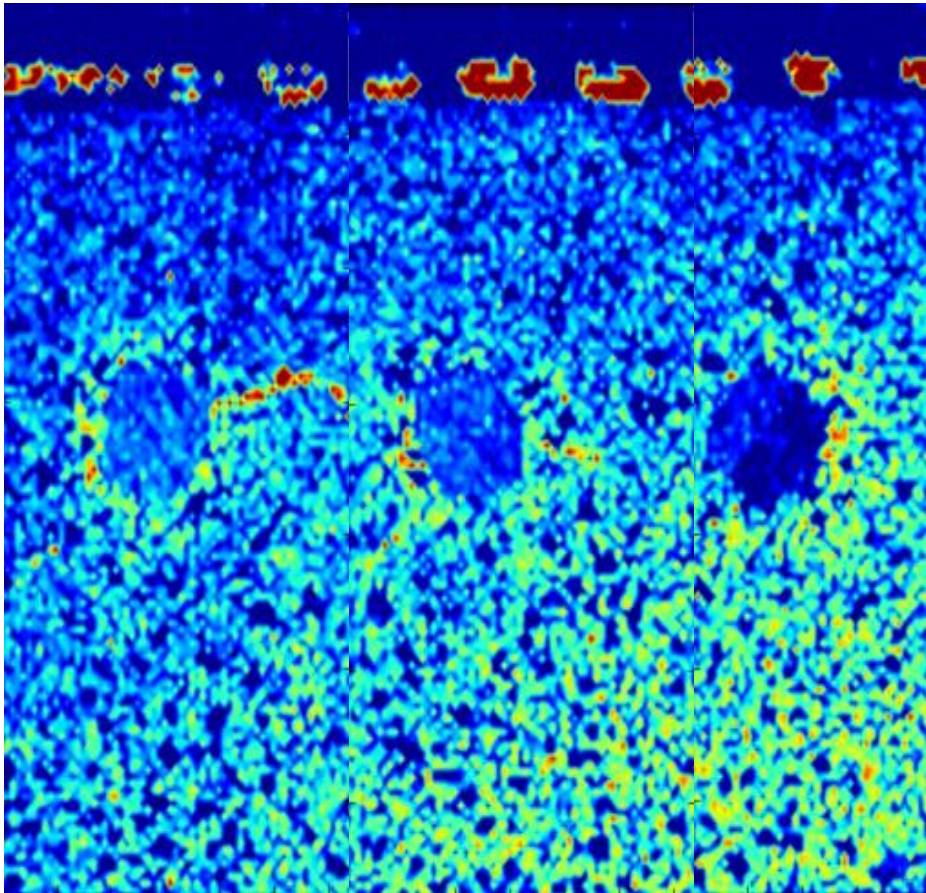
[http://en.wikipedia.org/wiki/Zinc\\_chloride\\_hydroxide\\_monohydrate](http://en.wikipedia.org/wiki/Zinc_chloride_hydroxide_monohydrate)



CL-freies Bindemittel 8/11/18

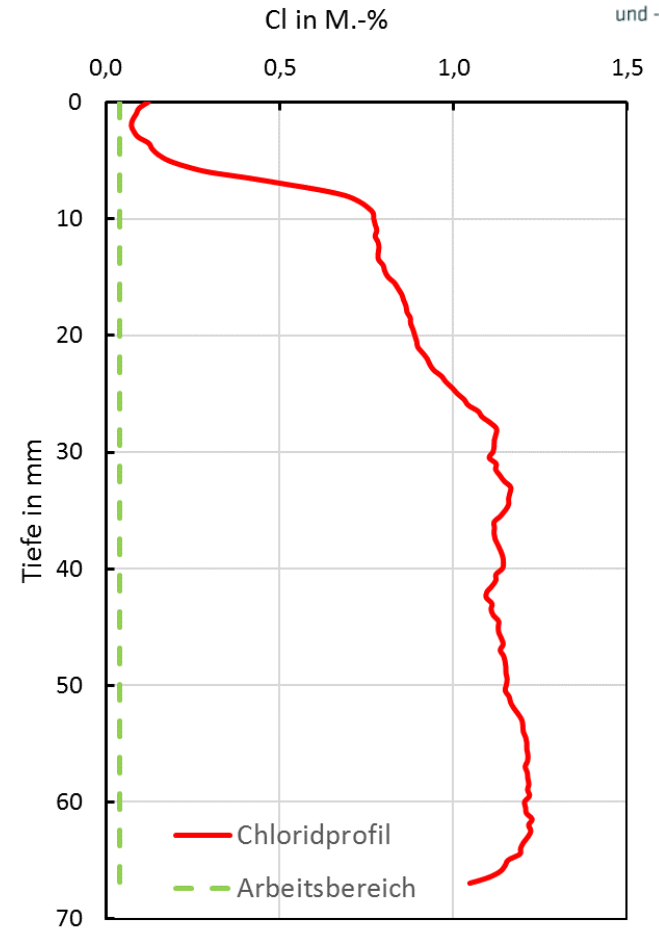
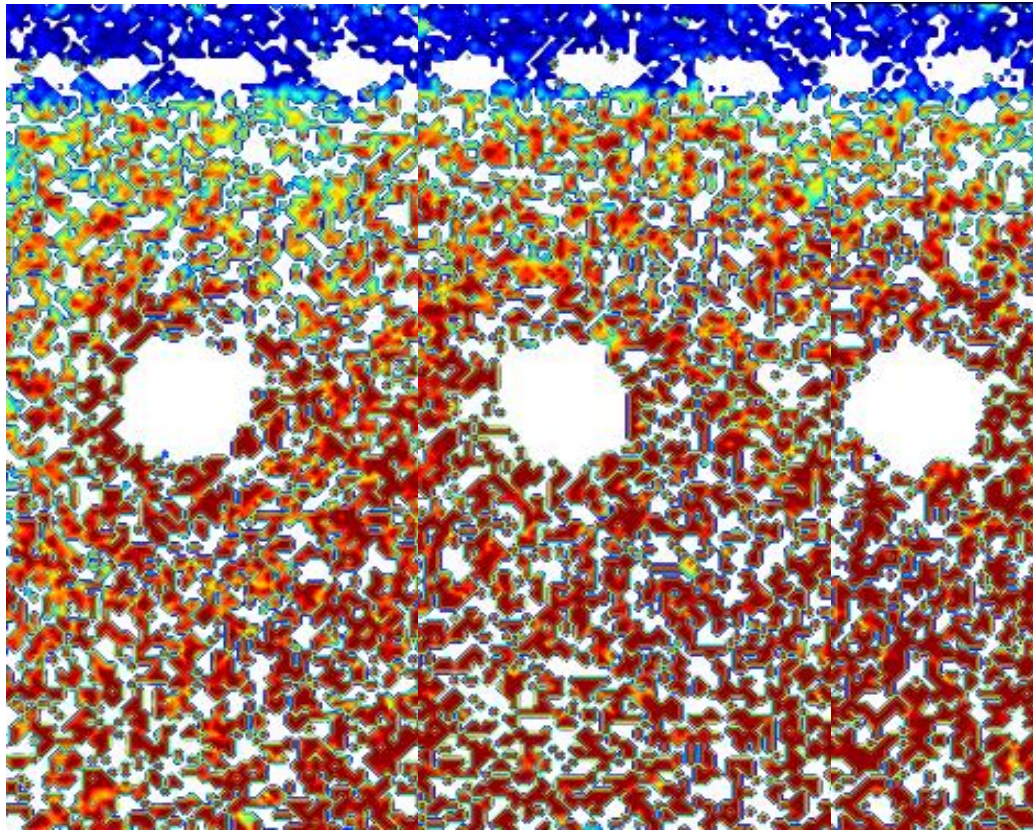
SEZAC-LOZ  
22-3-18

Cl (inclusive Agreggate and Zn)  
**Chloride migrates towards anode**





**Chlor (aggregate, metallic iron und Zn excluded)**





**EZA – Embedded Zinc Anode**

**Alpl Graben bridge in Styria, Austria**

**In the Styrian Alps at an altitude of  
1000 m above sea level**

**System installed  
October 2007**

**Start of Operation  
November 2007**



**Alplgraben bridge in Styria, Austria**

**Total area protected: 50 m<sup>2</sup>**

**- start up November 2007**

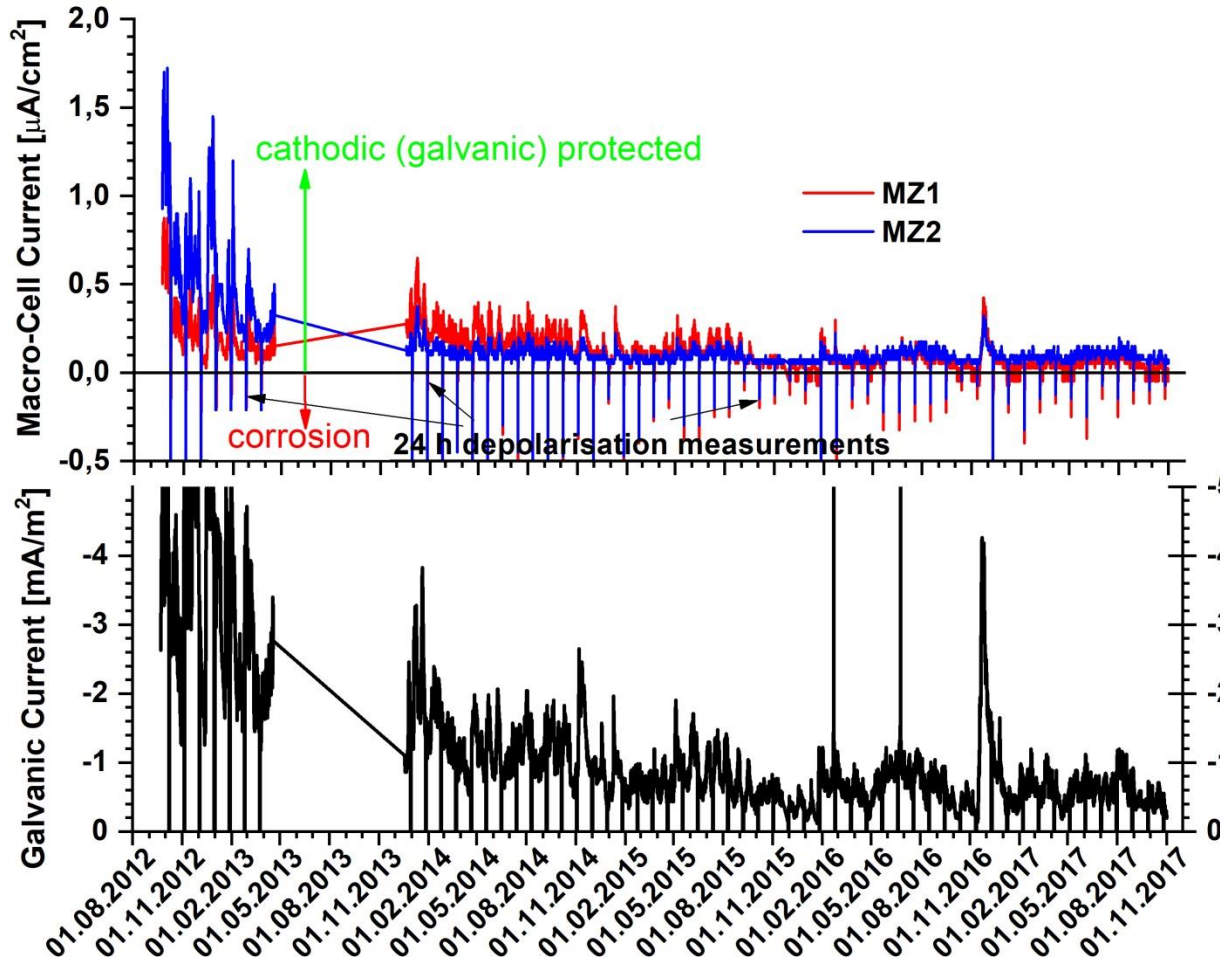
**- monitoring & control by  
LE-DAC system – 20 mW power  
requirement**

**- automated 24 h depolarization  
measurements every 4 weeks**

**- resistant less measurement of  
macro cell currents (efficiency of  
corrosion protection)**

During the general rehabilitation of the Alplgraben bridge June – August 2012, the EZA system, applied on the abutment, was coated with an acrylic coating from STO





System was refurbished July/August 2012 (zinc mesh replaced was replaced on 1 m<sup>2</sup>, a cover coat applied) and restarted on 10 August 2012

Galvanic current in relation to macrocell currents indicating efficiency of galvanic corrosion protection

**2008**

**Installation  
on concrete  
members of  
4 bridges**



## Performance data of Onderzijde in mV according to EN 12696 provided by CPS (NL)

Date	Ref. Cell	On-pot.	Inst.off	5h off	24h off	24h Depol
30 June 2011	Ag/AgCl	-547	-457	-386	-288	169
	Ti*	-366	-278	-183	-91	187
30 July 2013	Ag/AgCl	-551	-499	-404	-245	254
	Ti*	-356	-314	-237	-70	244
25 May 2016	Ag/AgCl	-486	-402	-367	-250	152
	Ti*	-325	-291	-244	-77	221
24 Mai 2017	Ag/AgCl	-552	-512	-417	-234	278
	Ti*	-338	-309	-233	-75	234
28 Nov. 2017	Ag/AgCl	-568	-535	-399	-343	192
	Ti*	-350	-321	-264	-169	152





## Performance data of Bovendzijde in mV according to EN 12696 provided by CPS (NL)

Date	Ref. Cell	On-pot.	Inst. off	5h off	24h off	24h Depol.
30 July 2013	Ag/AgCl	-559	-507	-466	-327	180
	Ti*	-288	-245	-194	-115	130
25 May 2016	Ag/AgCl	-430	-416	-353	-302	114
	Ti*	-279	-256	-185	-118	138
24 Mai 2017	Ag/AgCl	-565	-515	-439	-322	193
	Ti*	-299	-259	-198	-135	124
28 Nov. 2017	Ag/AgCl	-551	-526	-454	-392	134
	Ti*	-294	-289	-192	-172	117



Corrosion protection of the  
abutments of the  
De Meerbrugg Steel bridge over  
the Amsterdam-Rijn canal in the  
Netherlands

with the TAS-EZA system

Installation April 2010

Total 200 m<sup>2</sup>, 4 kg Zn/m<sup>2</sup>





In Saas Fee in Switzerland, no cars are allowed,

Cars have to be parked in parking deck with a total of 60'000 m<sup>2</sup> of parking area

The parking deck was erected 1979/80 and extended 1981/82

The decks are made from prestressed concrete

**Chloride content 0,5 – 3,0%**

EZA installed in cooperation with Sika Services AG (CH)

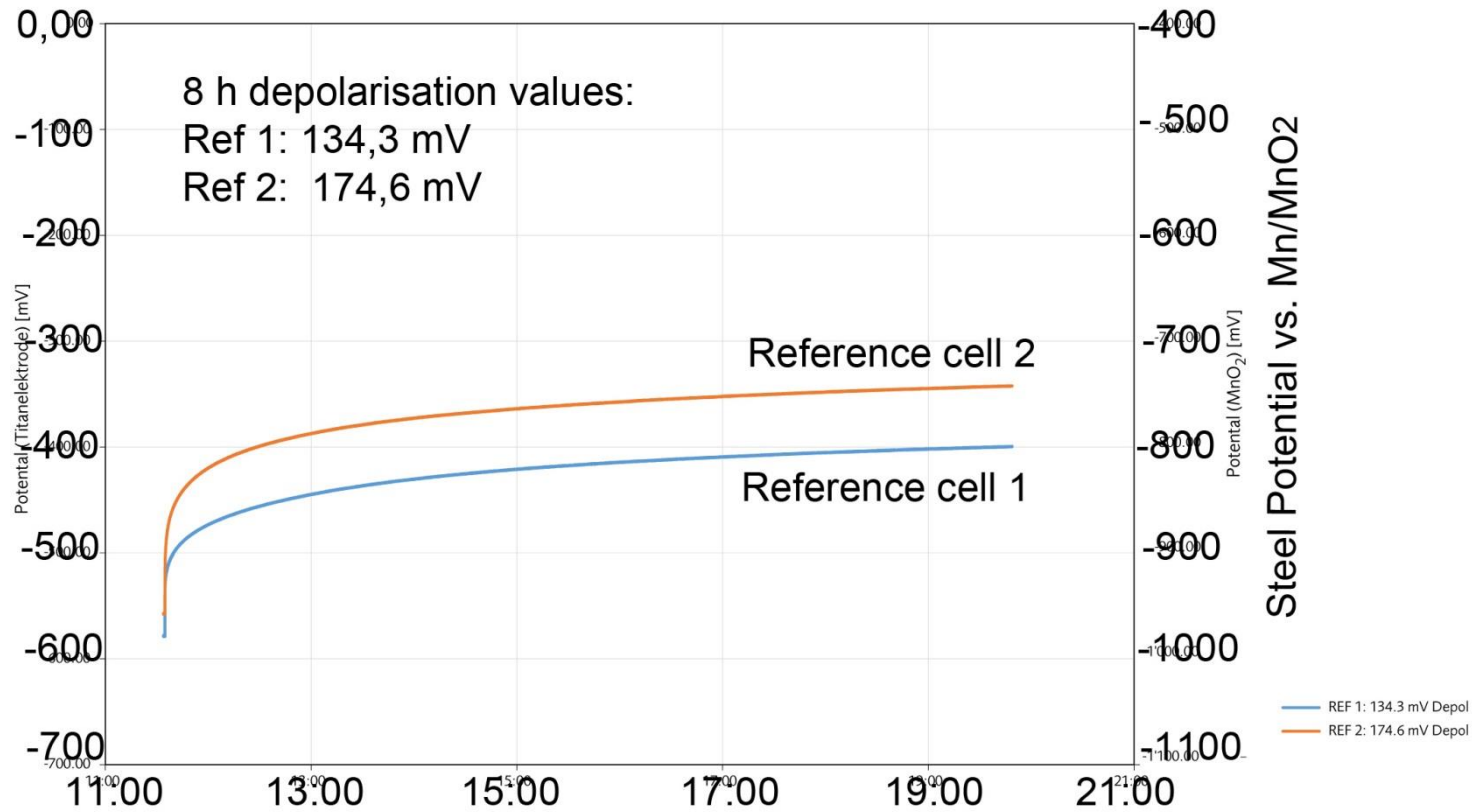
August 2011 on 30 m<sup>2</sup> (1 parking box) for demonstration purposes



Saas Fee; Parkhaus  
kathodischer Korrosionsschutz

CAS: Depolarisation vom 18.08.2016

SUICORR



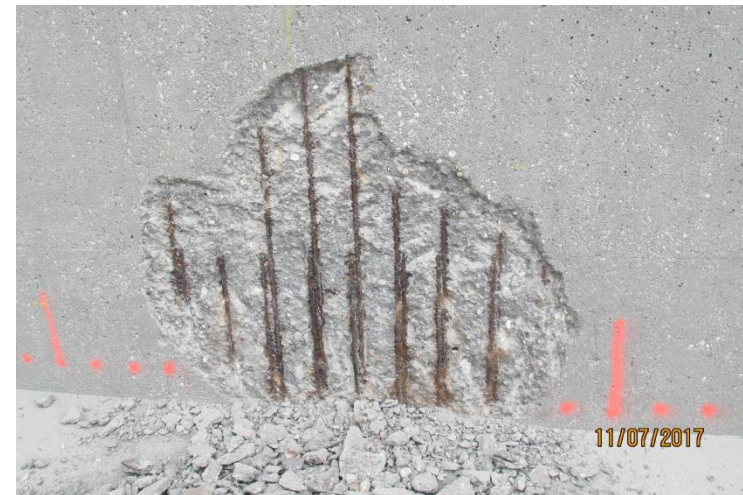
S:\01 Projekte\300 359 0 Saas Fee; Parkhaus Burgergemeinde\08 Qualitätssicherung\Depolarisationen\2016 08 19 CAR Messfeld CAS-System.FPD



The retaining walls, part of a „white tank“ system at the tunnel entrance in Obdach in the Styrian Alps are exposed to high deicing salt loads during winter time:

**Salt loads 1,6 – 6 wt.%/wt. Cement**

**Cross section loss up to 70%**



**Styrian Alps (Obdach, national road B78):  
EZA installation July/August 2018**

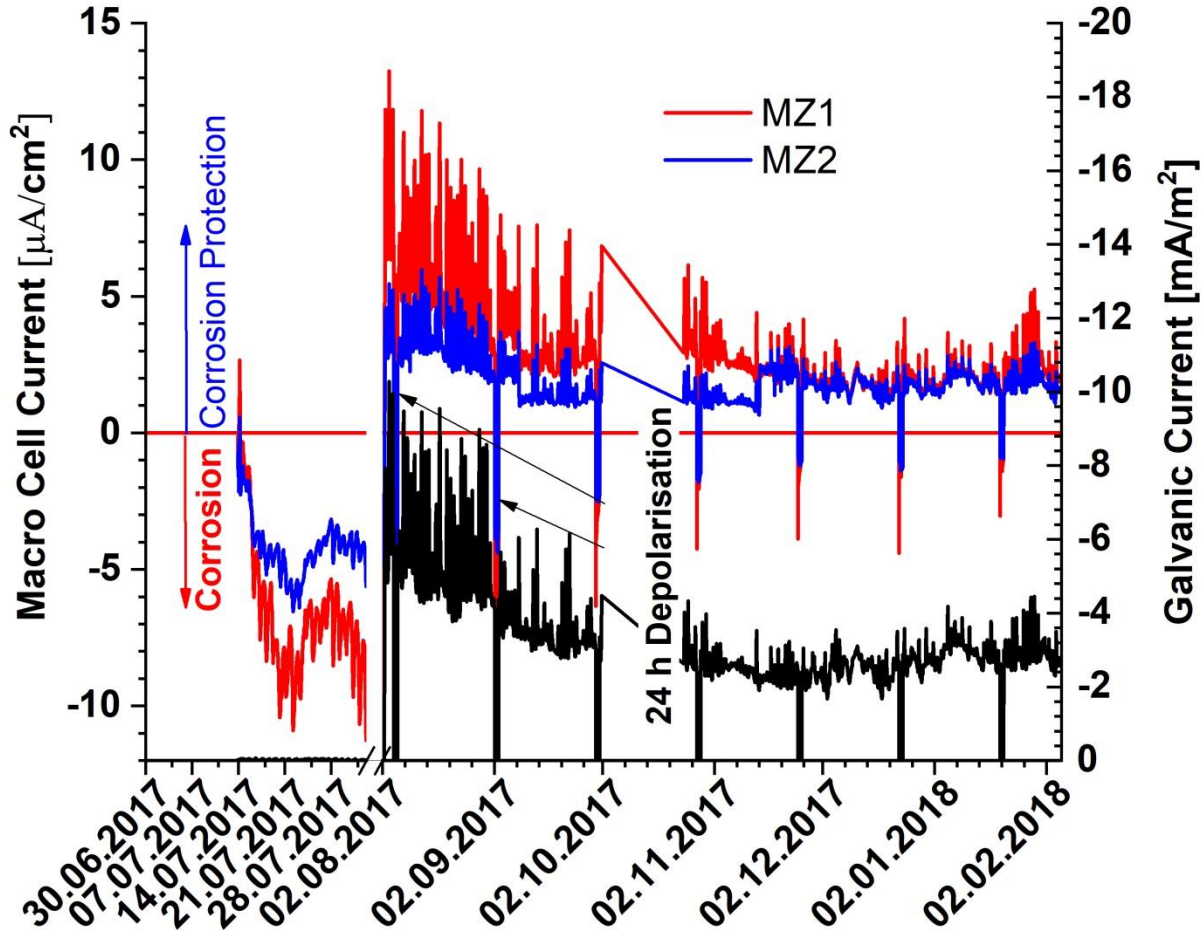


Test Field for demonstrating the efficiency of Galvanic Corrosion Protection by EZA under the impact of the salt exposure intensified by the wind-channel effect caused by the tunnel resulting in strong climbing winds emanating from the tunnel.

EZA coated with epoxy coating from SIKA certified for tunnel applications- Sikagard-332 TU, topped with Sikagard-260 WPU as a UV protective dirt repellent coating.

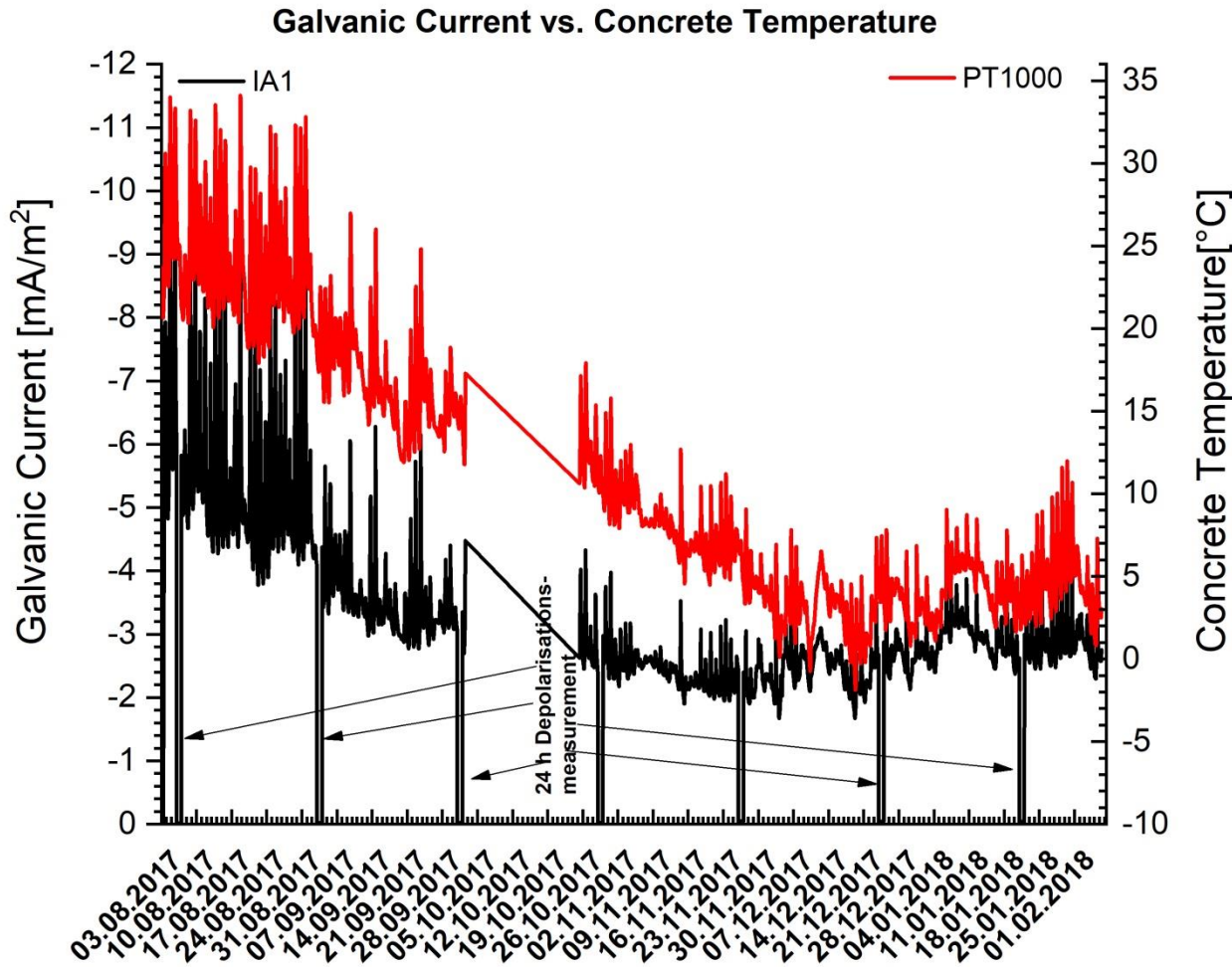


Macro Cell Currents vs. Galvanic Current



Performance Control with  
embedded Macro-Cell-  
Sensors, e.g. TFB  
Switzerland





The galvanic current varies with the concrete resistance that varies with temperature

The 100 mV 24 h  
Depolarisation Criterion of  
EN 12696 is fulfilled, also at  
low temperatures during  
wintertime

Depol No	Datum	IA1	R1	R2	R3	MZ1	MZ2	T [°C]
<b>2</b>		mA/m2	[V]	[V]	[V]	[μA/cm2]	[mA/cm2]	T [°C]
On	03.09.2017 00:00	-4,050	-0,643	-0,706	-0,620	<b>2,820</b>	<b>1,930</b>	18,700
Inst. Off	03.09.2017 00:00	-0,025	-0,616	-0,660	-0,591	-7,980	-2,210	18,700
4h Off	03.09.2017 04:00	-0,025	-0,486	-0,508	-0,479	-6,570	-3,850	17,900
24h Off	04.09.2017 00:00	-0,025	-0,469	-0,487	-0,462	<b>-4,580</b>	<b>-3,570</b>	19,200

4h Depol **0,130 0,152 0,112**

24h Dep EN 12696 > 100 mV **0,147 0,173 0,129**

Depol No	Datum	IA1	R1	R2	R3	MZ1	MZ2	T [°C]
<b>8</b>		mA/m2	[V]	[V]	[V]	[μA/cm2]	[mA/cm2]	T [°C]
On	21.01.2018 00:00	-2,625	-0,644	-0,709	-0,625	<b>1,310</b>	<b>1,220</b>	2,600
Inst. Off	21.01.2018 00:00	-0,025	-0,613	-0,655	-0,592	-2,310	-0,530	2,600
4h Off	21.01.2018 04:00	-0,025	-0,481	-0,520	-0,477	-1,370	-0,620	2,550
24h Off	22.01.2018 00:00	-0,050	-0,438	-0,475	-0,432	<b>-0,920</b>	<b>-0,910</b>	3,050

4h Depol **0,132 0,135 0,115**

24h Dep EN 12696 > 100 mV **0,175 0,180 0,160**



Application of the EZA

September 2018 on columns in  
marine environment in Florida by  
Structural Technologies

[www.structuraltechnologies.com](http://www.structuraltechnologies.com)



Application of the EZA on columns  
in marine environment in Florida  
by Structural Technologies  
[www.structuraltechnologies.com](http://www.structuraltechnologies.com)

Galvanic Current: 17 mA/m<sup>2</sup>

September 2018



Application of the EZA in marine environment on the ceilings in the parking deck of Arab Bank Abu Dhabi Branch Al Nada Street

October 2019



by Structural Technologies Middle East

500 m<sup>2</sup> EZA installed by embedding zinc-mesh (2,7 kg/m<sup>2</sup>) into SEZAC binder (10 kg/m<sup>2</sup>) by airless spray.

<https://www.structuraltec-me.com/>



4000 m<sup>2</sup> EZA installed by embedding zinc-mesh (2,7 kg/m<sup>2</sup>) into SEZAC binder (10 kg/m<sup>2</sup>) by airless spray.

Application of the EZA in marine environment on the ceilings in the parking deck of

Zabeel Saray Beach Resort – Palm Jumeirah, Dubai

<https://www.jumeirah.com/en/stay/dubai/jumeirah-zabeel-saray>

August - October 2019

by Structural Technologies

Middle East

<https://www.structuraltec-me.com/>



Overseas Hwy

Power Line at Indian Keys, Overseas Highway, Florida



Aufgenommen: März 2019 © 2021 Google

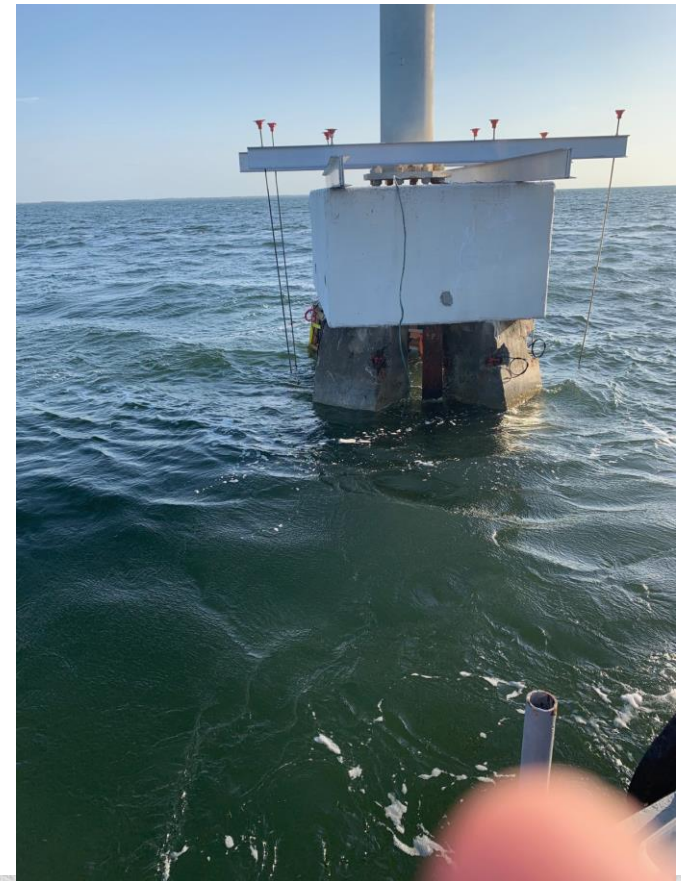


Application of the EZA in marine environment on the basements of the powerline columns along the Florida Keys by Structural Technologies on total of 750 m<sup>2</sup> August - October 2021

<https://www.structuraltec.com/>



**structural**  
TECHNOLOGIES





First Application of carbon quantum dot (CQD)  
doped EZA: QEZAC as embedding glue







- The EZA System proved to protect steel reinforcement reliably and durably
- No indication of passivation of zinc over a operational period of 14 years
- Expected service time of an EZA with 2,5 kg zinc/m<sup>2</sup> steel is 15 – 30 years
- Strong indication for chloride extraction and immobilization into EZA, coated with a water impermeable membrane
- The EZA allows reliable protection and rehabilitation of RC structures under conditions ranging from alpine (low temperature, very dry periods) to marine environment (high temperature, high humidity, high chloride)

### CHARACTERISTICS OF the EZA – SYSTEM

**THANK YOU FOR YOUR ATTENTION**

**ARE YOU NOW GALVANIZED?**