REPAIR AND MAINTENANCE OF STEEL REINFORCED CONCRETE STRUCTURES BY SIMULTANEOUS GALVANIC CORROSION PROTECTION AND CHLORIDE EXTRACTION

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CAS
COMPOSITE - ANODE - SYSTEMS GMBH

00 CONTENT

Corrosion of Steel Reinforcement

Iron - Air Battery

Galvanic Corrosion Protection

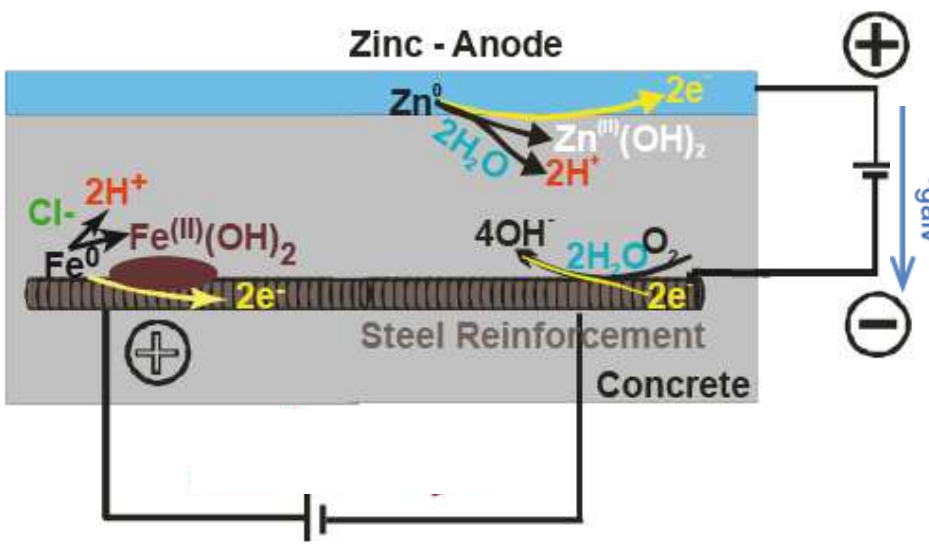
Zinc - Air Battery

$E^0_{Fe/Fe(II)}$ = - 0,61 Volt

(pH $\leq$ 9, $c_{Fe^{2+}} = 10^{-6}$ mol/l)

$Fe^{2+} + 2e^- = Fe^0$

$Fe^{2+} + 2OH^- = Fe(OH)_2$



$E^0_{Zn/Zn(II)}$ = - 1,25 Volt

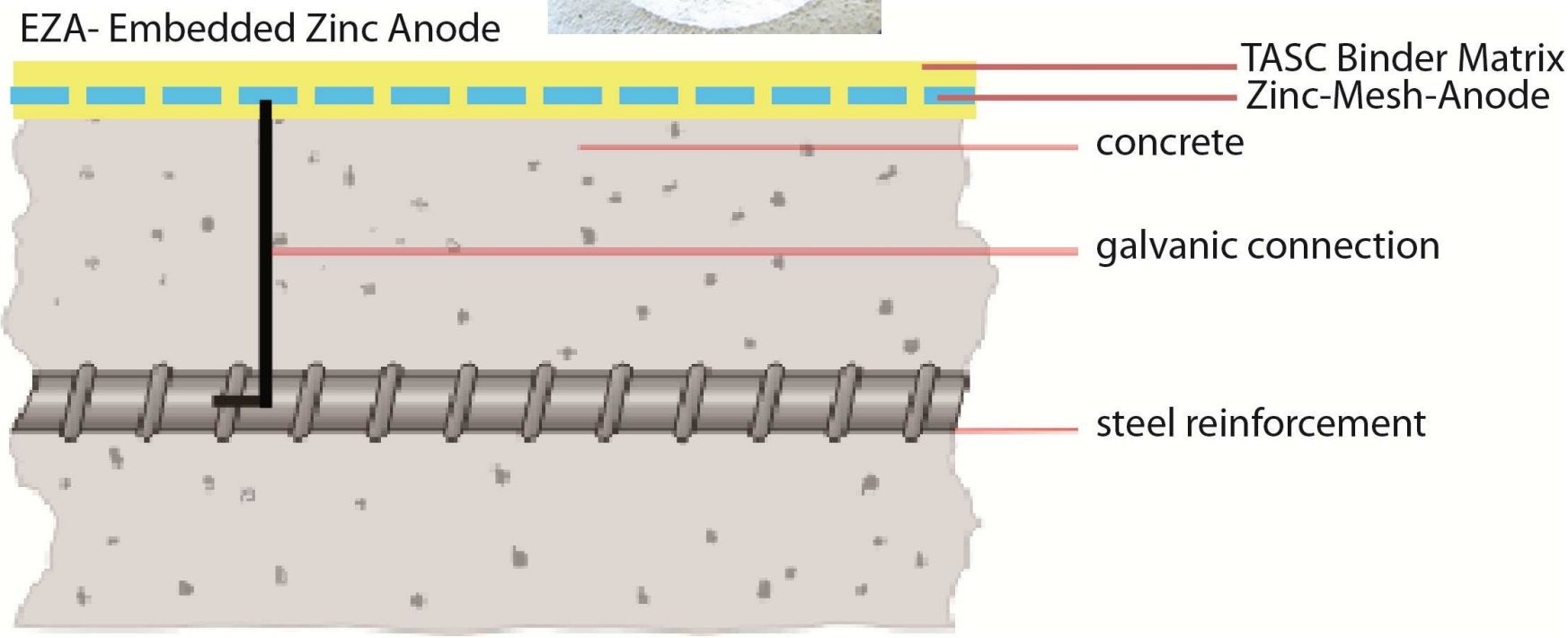
$Zn(OH)_4^{2-} + 2e^- = Zn + 4OH^-$

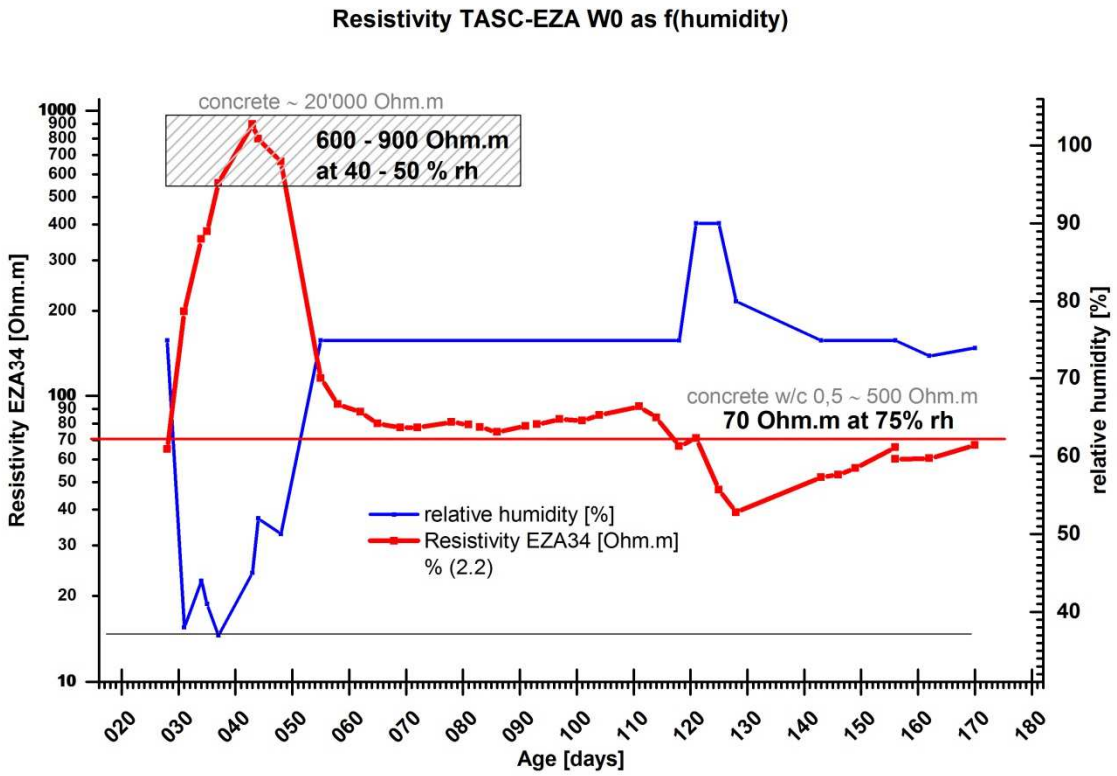
ΔE_{real} 0,4 - 1,2 Volt

$E^0_{O2/OH-}$ = + 0,34 Volt (pH 11)

$O_2 + 2H_20 + 2e^- = 4OH^-$

EZA – Embedded Zinc Anode





Binder Matrix

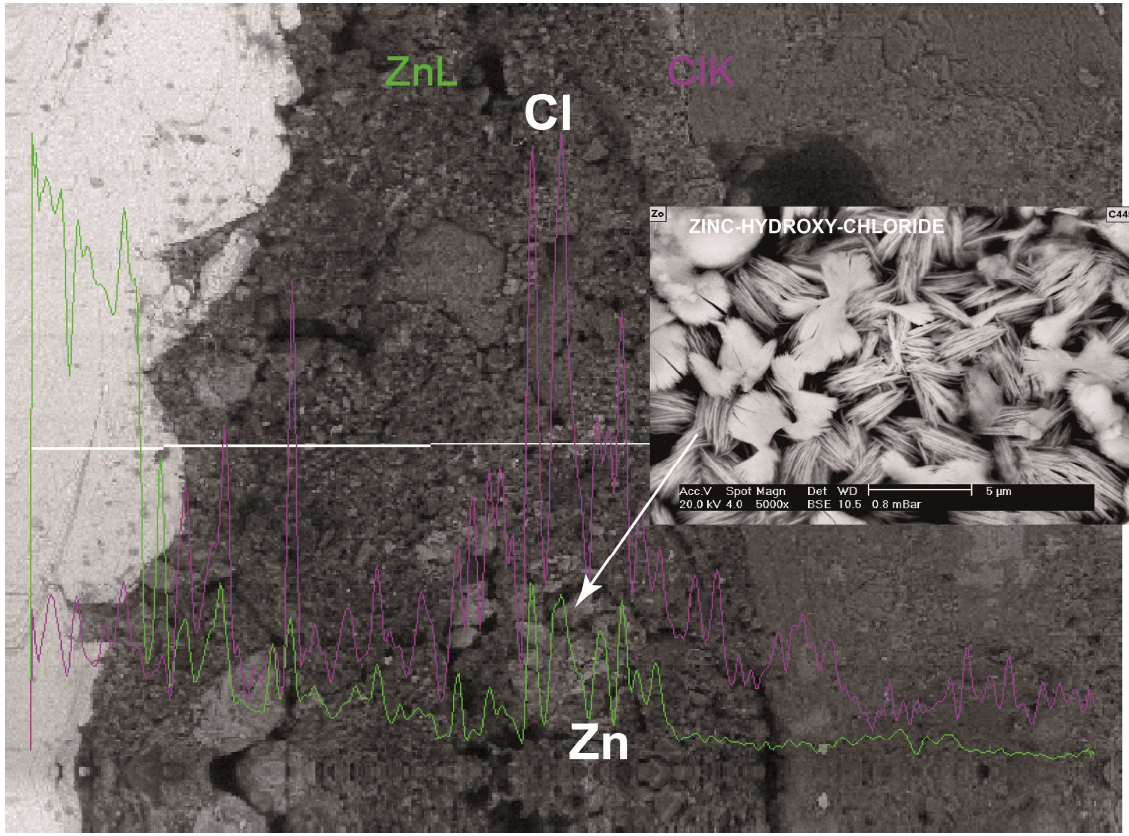
Tecto-Alumo-Silicate-Cement-TASC

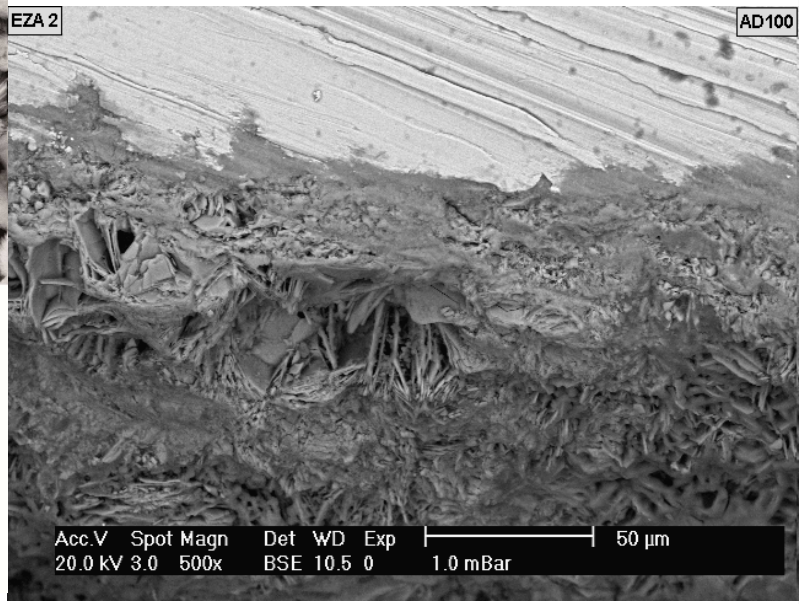
Function:

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

Chloride Extraction:

Chloride, migrated to the zinc-anode is immobilized within the matrix (in a AS-binder similar to EZA) as zinc-hydroxide-chloride





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

Alpl Graben bridge in Styria, Austria

Total area protected: 50 m^2

- **start up November 2007**

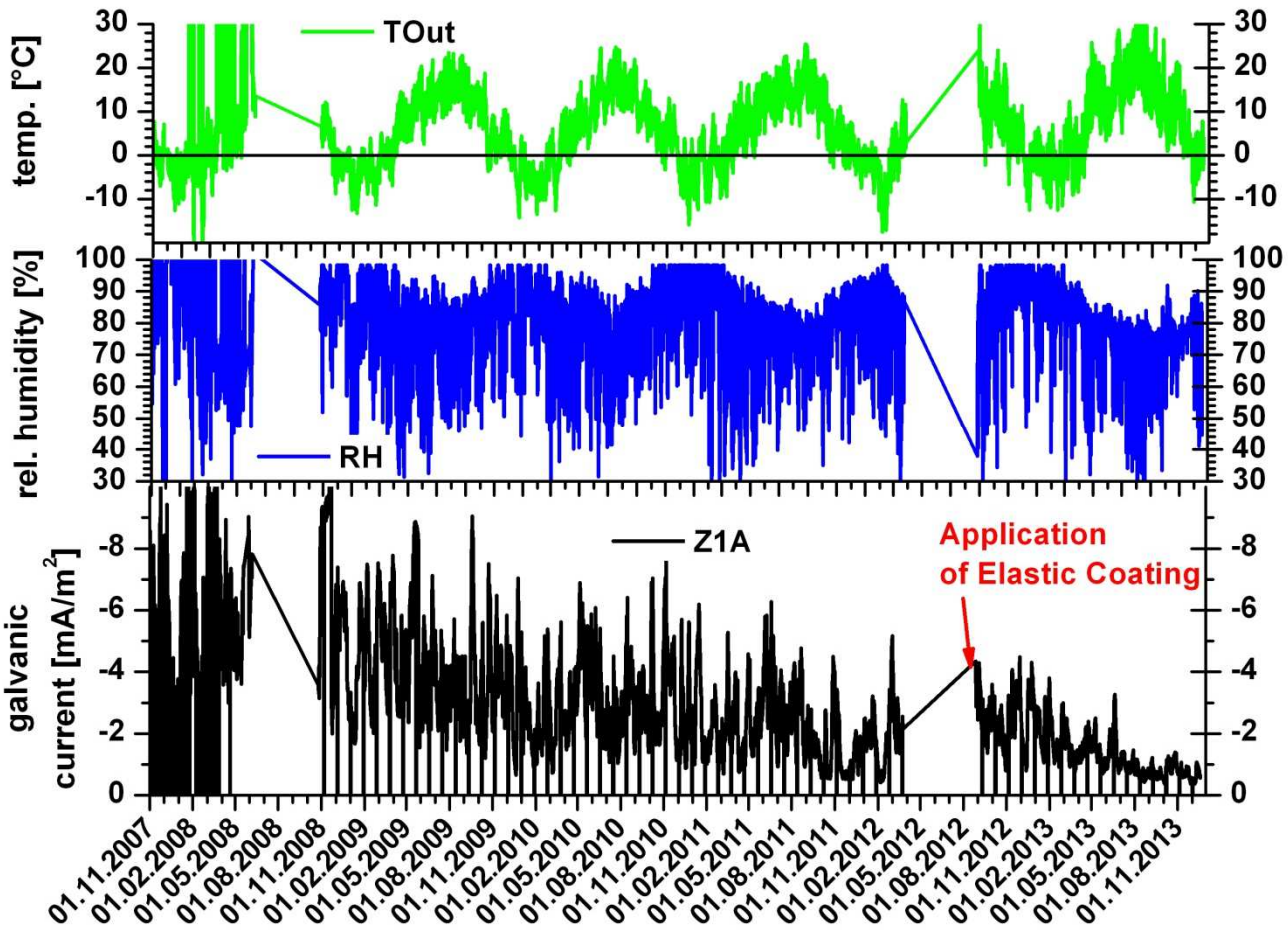
- **monitoring & control by LE-DAC system – 20 mW power requirement**

- **automated 24 h depolarization measurements**

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

04.1 Alplgrabenbridge

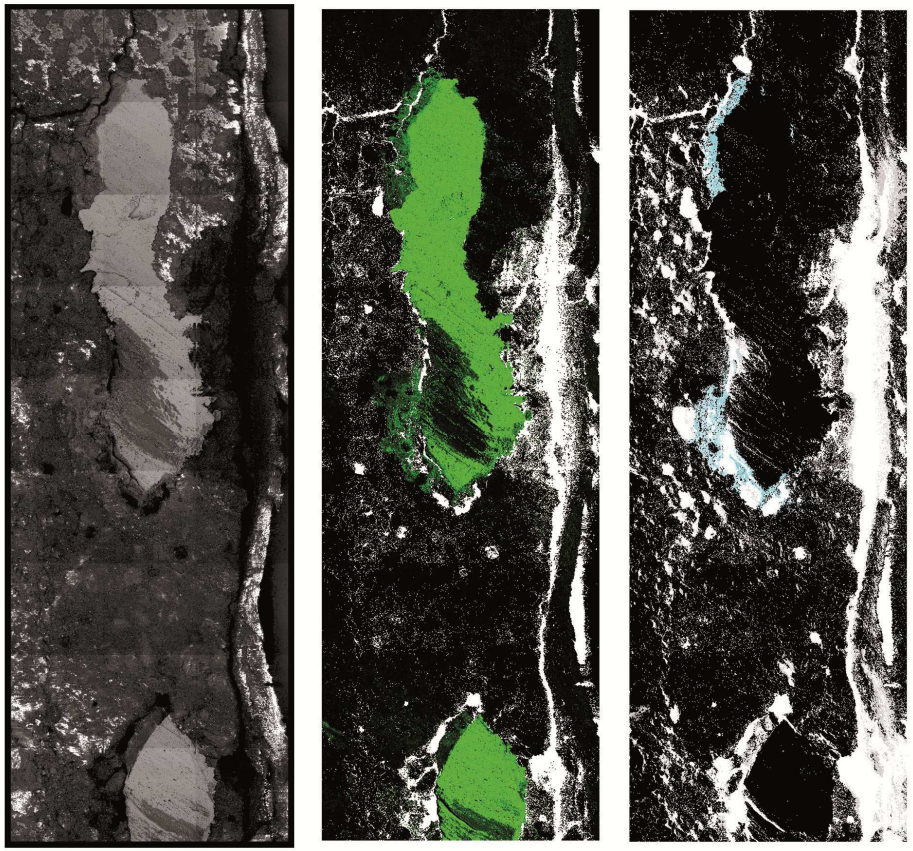
During the general rehabilitation of the Alplgraben bridge June – August 2012, the EZA system, applied on the abutment, was coated with an acrylic coating and taken over by the Styrian Road Authority as a accepted technology for corrosion protection.



Galvanic current in relation to ambient temperature and relative humidity:

Application of a cover coating reduces the influence of climatic conditions.

Chloride MIgration in an EZA sample drawn 19 December 2013 from Alplgrabenbridge/Styria: accumulation of chloride near the zinc-anode

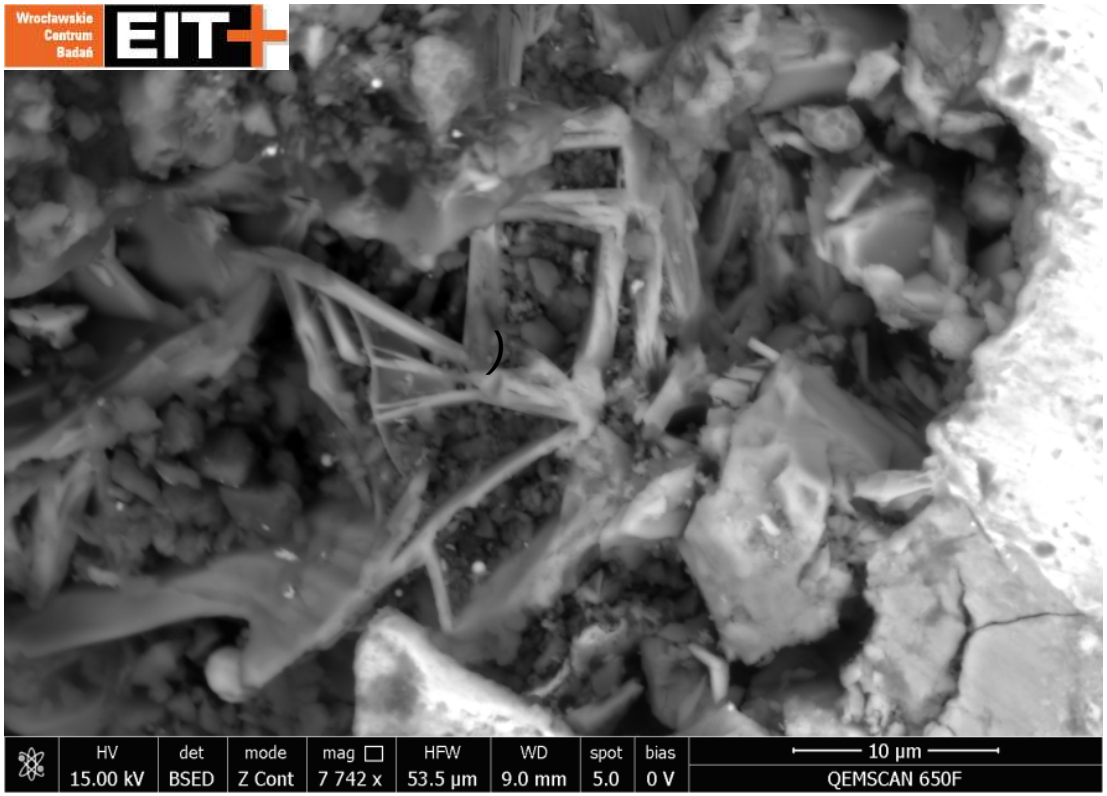


Chloride Extraction:

Chloride, migrated to and accumulated at the zinc-anode

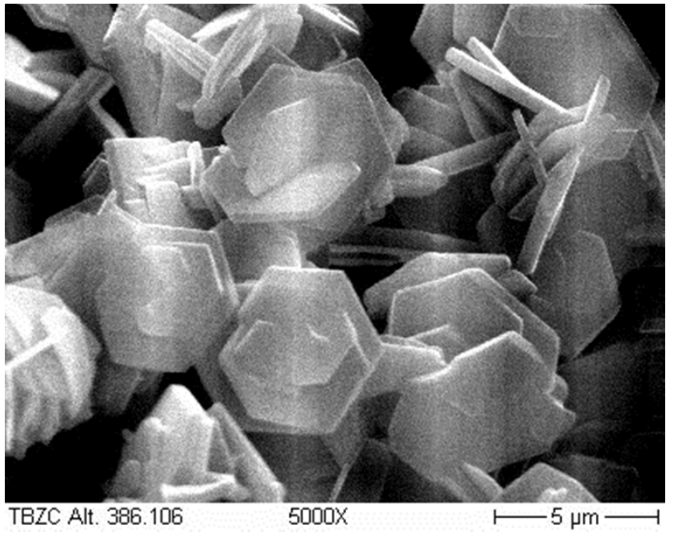
Mineral Name
Background
Zn:0%
Zn:10%
Zn:20%
Zn:30%
Zn:40%
Zn:50%
Zn:60%
Zn:70%
Zn:80%
Zn:90%
Low Confidenc
Low CR
Unclassified
Pores

Mineral Name
Cl:0%
Cl:10%
Cl:20%
Cl:30%
Cl:40%
Cl:50%
Cl:60%
Cl:70%
Cl:80%
Cl:90%
Background
Low Confidenc
Low CR
Unclassified
Pores

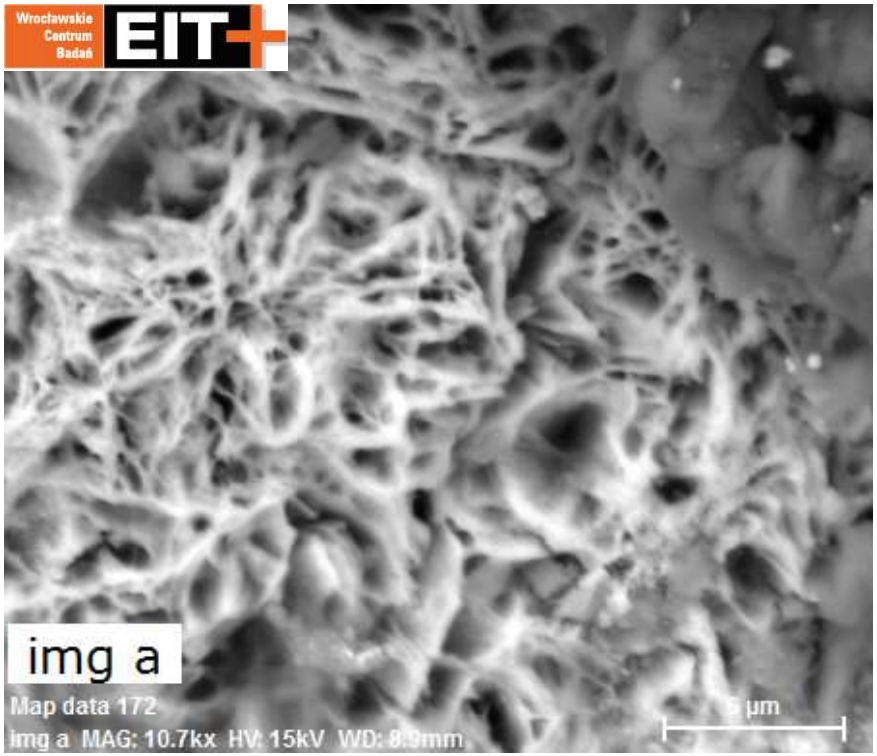


Chloride Extraction:

Chloride, migrated to the zinc-anode is immobilized within the EZA-binder as zinc-hydroxide-chloride, a natural mineral Simonkolleite



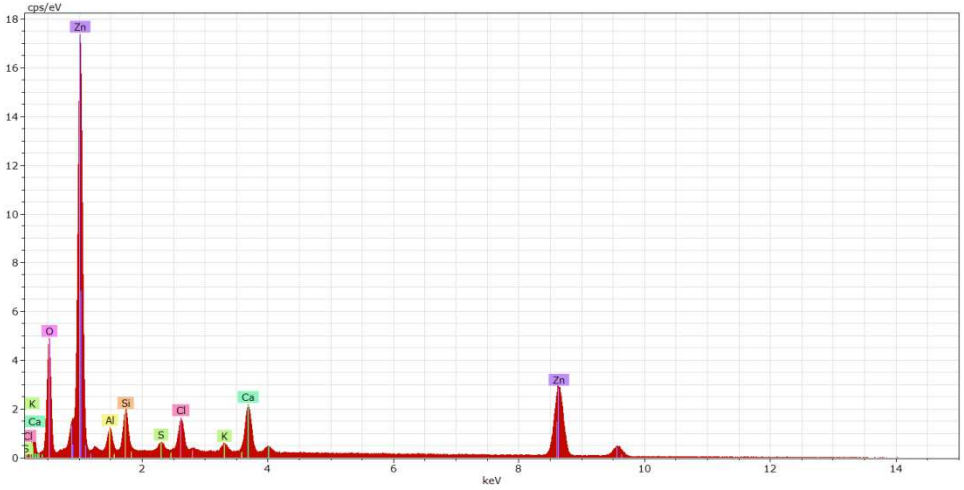
http://en.wikipedia.org/wiki/Zinc_chloride_hydroxide_monohydrate)



Element	AN	series	[wt.%]	[norm. wt.%]	[norm. at.%]
Oxygen		8 K-series	13,51149	13,50438012	34,19856912
Aluminium		13 K-series	2,966567	2,965004553	4,452414707
Silicon		14 K-series	4,612924	4,610494868	6,651236048
Sulfur		16 K-series	0,947146	0,946646816	1,196134917
Chlorine		**17 K-series**	**3,847061**	**3,845035239**	**4,394282633**
Potassium		19 K-series	0,891314	0,89084514	0,923169225
Calcium		20 K-series	7,170808	7,167032175	7,245532204
Zinc		**30 K-series**	**66,10537**	**66,07056109**	**40,93866114**
		Sum:	100,0527	100	100

In the vicinity to the zinc anode, zinc-hydroxide chloride intermixed with zinc-hydroxide:

porous structure that does not inhibit ion transport



04.2 Hubertus Viaduct Den Haag

Installation on concrete members of 4 bridges In 2008

04.2 Hubertus Viaduct Den Haag

Performance data according to EN 12696 provided by CPS (NL)

	Cell	Reference Cell Type	On-potential	Instant-off	1h off	24h off	24h Depolarisation
30 June 2011	Re1	MnO_2	547	457	386	288	169
	DP2	Ti*	366	278	183	91	187
30 July 2013	Re1	MnO_2	551	499	404	245	254
	DP2	Ti*	356	314	237	70	244
bridge 2 30 July 2013	Re1	MnO_2	559	507	466	327	180
	DP2	Ti*	288	245	194	115	130

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^2, 4 kg Zn/m^2


EZA
HERAS
bilmetal

04.4 Parking Deck in Saas-Fee

In Saas Fee in Switzerland, no cars are allowed,

Cars have to be parked in parking deck with a total of 60’000 m2 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^2 (1 parking box) for demonstration purposes

Embedding the zinc mesh into the TASC-EZA

Application of PU-coating

In Egmond aan Zee, 2014 - balconies at sea side apartments in which the steel reinforcement corroded due to exposure to sea salt were rehabilitated with EZA by Vogel Kathodische Bescherming B.V.

corrosion of the steel reinforcement

In Egmond aan Zee, balconies at sea side apartments – rehabilitation with TASC-EZA

EZA finalized application on balcony

- The EZA System proved to protect steel reinforcement reliably and durably
- Expected service time of an EZA with 2,5 kg Zinc/m² Steel is about 15 years
- Chloride extraction of EZA coated with a water impermeable membrane (e.g. acrylic coating) extracts chlorides from the concrete cover and immobilizes them within the EZA-matrix
- The EZA allows reliable protection and rehabilitation of RC structures at about 50% of the cost of conventional concrete repair

CHARACTERISTICS OF

the EZA – SYSTEM

THANK YOU FOR YOUR ATTENTION