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Project: Galvanic Corrosion Protection „Alplgraben Bridge"

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Summary

In the scope of a research project, the embedded zinc anode (EZA) was installed in September 2007 on concrete members especially endangered by steel reinforcement corrosion (bridge deck & cantilever underside, abutment) of the Alplgraben bridge in the Styrian Alps and put into operation on 1 November 2007. Operational data and performance were presented at the 4th International Conference on Concrete Repair – "Concrete Solutions", Dresden, Germany, 26 – 28 September 2011 and on the 3rd International Conference on Concrete Repair, Rehabilitation and Retrofitting, Cape Town, South Africa, 3 – 5 September 2012. The data proved that the steel reinforcement was reliably protected from corrosion by the EZA system.
From 21 June until 21 August 2012, the bridge was completely rehabilitated (renewal and sealing of the bridge deck, new edge beams, etc.). The owner – the Styrian department of bridge construction and repair – decided to take over the EZA on the abutment. To assure frost thaw salt resistance and to increase performance, especially with respect to the galvanic chloride extraction, the EZA was coated with an elastic acrylic coating - StoCryl RB. Before applying the acrylic coating, the EZA surface was cleaned by sand blasting the EZA surface. Areas with insufficient EZA – binder overlay were renewed coated with the EZA binder.

On an about 30 cm wide strip below a leaking joint, the EZA has been frequently exposed to de-icing salt solution. The embedded zinc was consumed to a large extent (up to 75%). In that area, a new zinc mesh was applied on top of the existing EZA.
Operation of the EZA was initiated 25 August 2012. Depolarisation measurements were carried out from 10 September until 11 September 2012. Results showed that the steel reinforcement is reliably protected from corrosion according to ISO EN 12 696. These results were corroborated by macro-cell current measurements on embedded macro-cell sensors.

1. Documentation

1.1. Preparatory Works

EZA on the abutment of the Alplgraben bridge after sand blasting (21 August 2012)

Detail after sandblasting: abutment hillside (left), middle part of abutment (right)

1.2. Local Rehabilitation of the EZA

Application of the EZA binder before applying the zinc mesh

Application of the new zinc mesh and fixation with dowel pins

Embedding the zinc mesh with the EZA binder

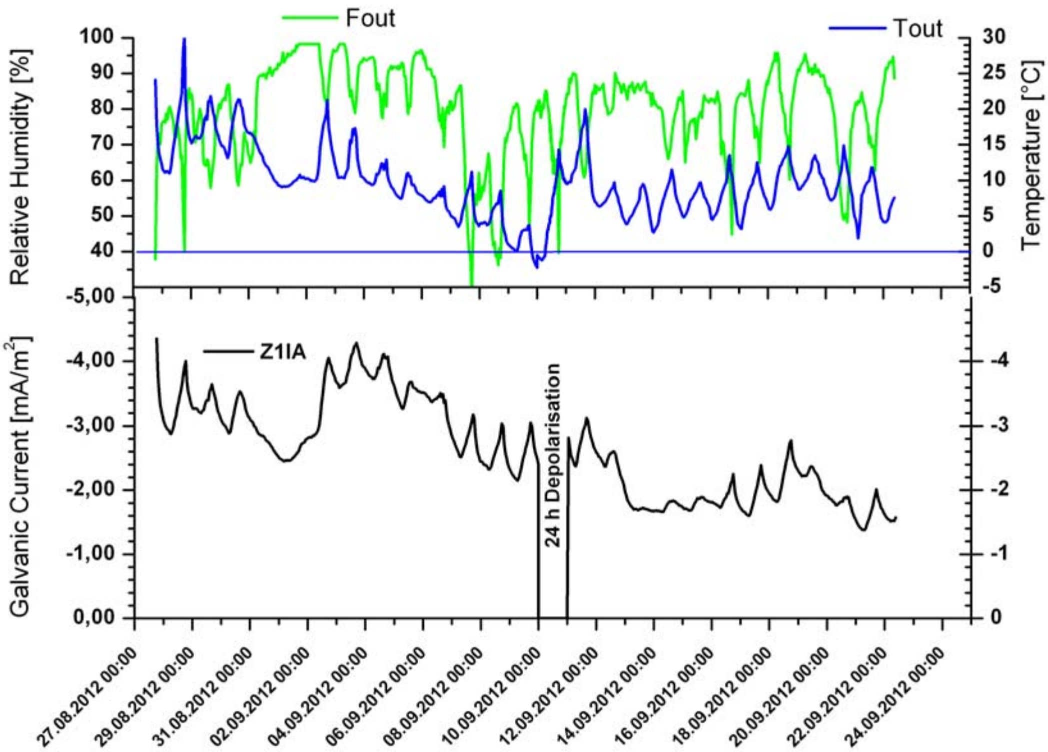
1.3. Potential field measurements

Potential field measurements with a $Cu/CuSO_4$ electrode (Canin – PROCEQ) – 25. 8. 2012 by coworkers of the Institute of Structural Engineering of Prof. Konrad Bergmeister, University of Natural Resources and Life Sciences, Vienna

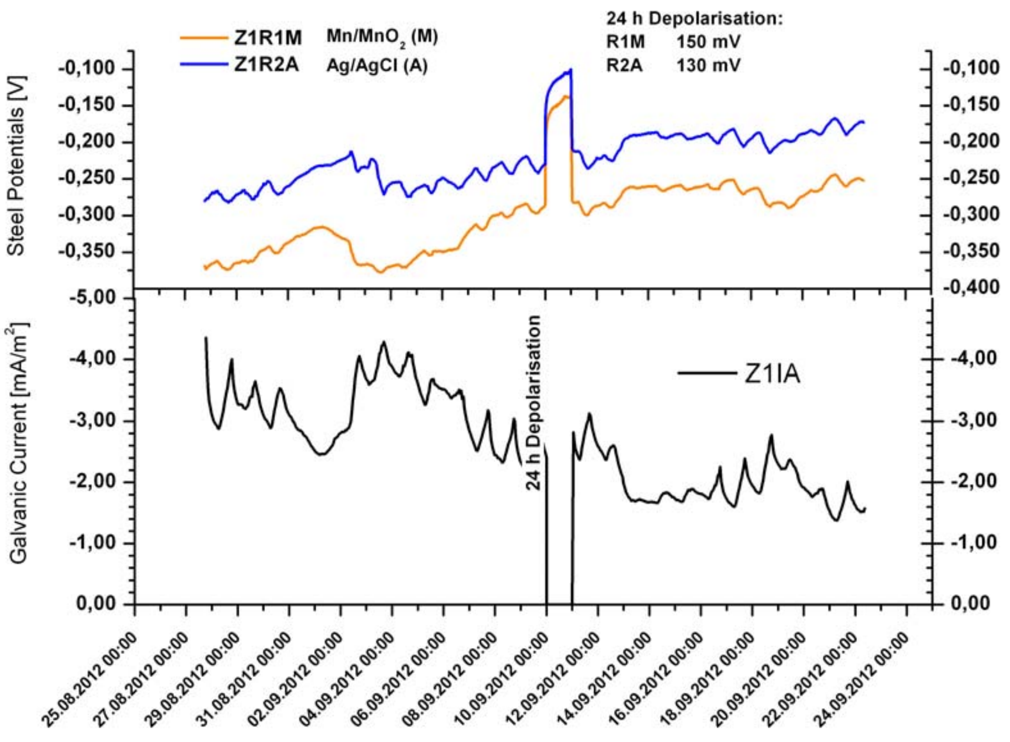
1.4. EZA after application of the elastic StoCryl RB coating

2. Function Control According to ISO ON EN 12696:2012

2.1. Function Control According to ISO ON EN 12696:2012, chapter 10.1.



Galvanic current in relation to the ambient temperature and relative humidity after start up



Steel potentials, measured against Ag/AgCl and Mn/MnO_2 reference cells, in relation to the galvanic current

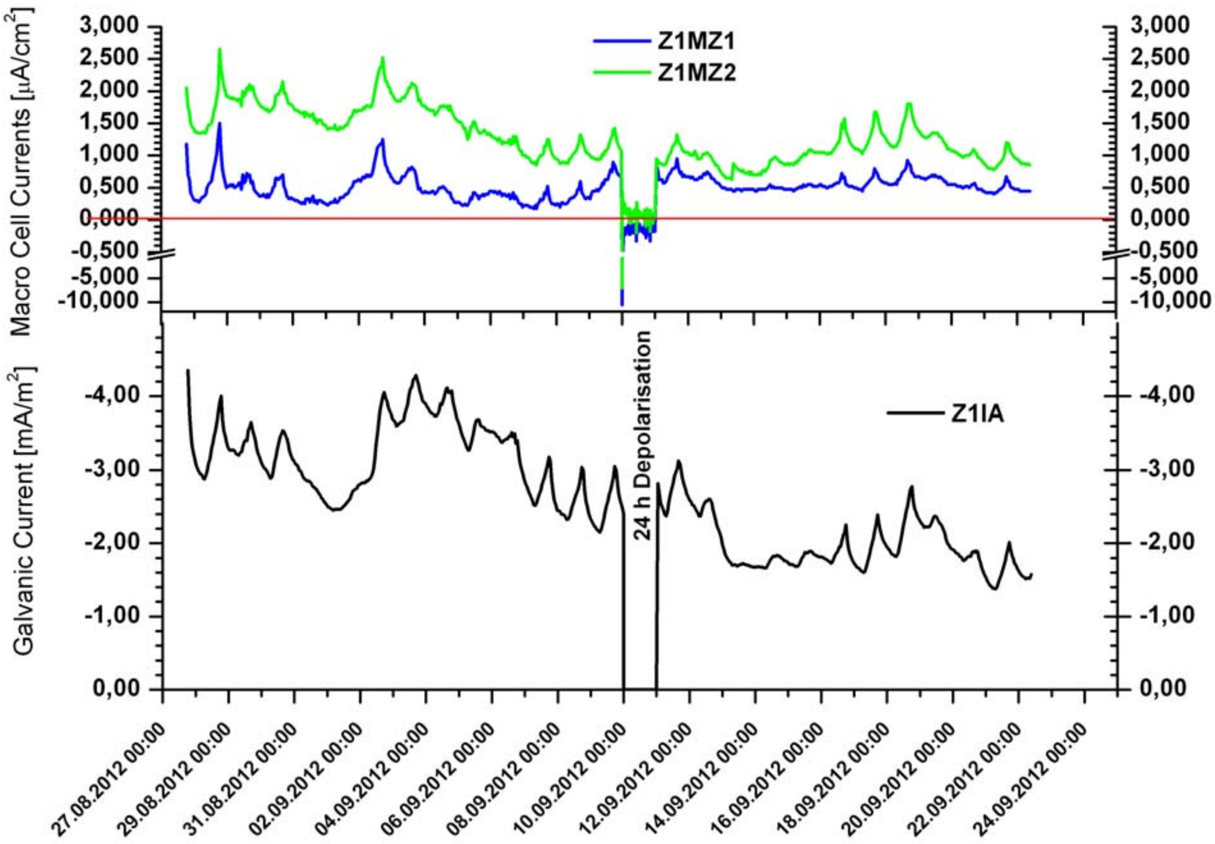
The function control of the EZA performance according to ISO ON EN 12696 proved the effectiveness of the galvanic corrosion protection. The galvanic current decreases from initially 3 – 4 mA/m^2 and stabilizes at 1,9 ± 0,44 mA/m^2 after two weeks of operation. The galvanic current of the EZA without the acrylic coating during the equivalent period of time in 2011 was 1,5 ± 0,50 mA/m^2 during comparably lower ambient relative humidity and higher temperature.

The data prove that due to the cover coat on the EZA the galvanic current is not influenced anymore significantly by the external humidity. The galvanic current is mainly influenced by the temperature.

The effectiveness of the galvanic protection by the EZA may be controlled in real time by the embedded macro-cell sensors. The macro-cell sensor set embedded into the concrete overlay is shown in the figure below. It consists of 3 macro-cell sensors with a surface of 1 cm^2 each, placed in the supporting tube at a distance of 2 cm from each other. The macro-cell sensors were embedded into the concrete overlay with an anchor mortar containing 1,5% Cl/weight dry mortar. The thickness of the embedding mortar was about 1 mm. To monitor the efficiency of the EZA, the upper two sensors, placed 1 cm and 3 cm from the concrete surface, are monitored.

Macro-cell sensor set: 3 sensors placed in a distance of 2 cm from each other with a surface of 1 cm^2.

During the operation of the EZA, a cathodic current in the range of 0,5 – 2,5 $\mu A/cm^2$ flows to the macro-cell sensors MZ1 and MZ2, corresponding to a galvanic current of 5 – 25 mA/m^2. During the 24 hour depolarisation measurement, a corrosion current of 0,15 – 0,20 $\mu A/cm^2$ from the macro-cell sensor MZ1 to the steel reinforcement whereas the macor-cell sensor MZ2 remains in the passive domain with a macro-cell current in the range of – 0,050 bis + 0,050 $\mu A/cm^2$.



Macro-cell currents measured during the galvanic protection of the steel reinforcement by the EZA and during the 24 hour depolarisation measurement according to ISO ON EN 12696

2.2. Function Control According to ISO ON EN 12696:2012, chapter 10.2.

According to the 24 h depolarisation criteria of ISO ON EN 12696, the steel potentials have to shift more than 100 mV towards positive values within 24 hours after interrupting the current. As shown below, the potential shift largely exceeds this value. Corroborated by the macro-cell current measurements that show cathodic current flowing to the macro-cells during operation of the EZA, the steel reinforcement in the area of the EZA is reliably protected from corrosion.

	Datum	Z1IA	Z1R1M	Z1R2A	Z1MZ1	Z1MZ2	PT1000	F-Out
		mA/m^2	mV	mV	μA/m^2	μA/m^2	°C	%
24h	11.09.2012 00:00	0,000	-137	-100	-0,150	0,050	9,600	82,704
instant off	10.09.2012 00:00	0,000	-256	-205	-8,050	-4,325	-2,150	80,784
ON	09.09.2012 23:30	-2,450	-287	-230	**0,675**	**1,075**	-2,050	81,048
24h Depol			**150**	**130**				