CAS
COMPOSITE - ANODE - SYSTEMS GMBH
Lerchenfelderstrasse 158/7/51-53
A-1080 Wien
T +43 1 990 59 95
F +43 1 990 59 96
office@cas-composite.com
www.cas-composite.com

Project: **Sustainable Restoration of Highway Structures: Cathodic Protection (CP) of Concrete Structures Along the Danube River Bank Highway A22, Vienna (A).**

Subject: Description of the Project

Date: 05. 08. 2010

Author: W. Schwarz/CAS

CC:

ABSTRACT

Concrete members (abutments, walls, columns) of two bridges crossing the Danube river bank highway A22 were repaired and restored during April/Mai 2010 by applying CP with a dual anode system – titanium-ribbon-mesh anode and the CAS Composite Anode: The titanium-ribbon-mesh anode (TRMA) was installed from 50 to 100 cm above down to 50 cm below the ground line. The CAS Composite Anode was installed on the concrete members in the areas above the TRMA.

All concrete works and all works for the installation of the CP systems were completed within six weeks. The final wiring works and the installation of the CP data acquisition and control systems – the MO-DAC systems – required additional 2 weeks.

The installation was accepted 5 August 2010 by the ASFINAG Service GmbH Ost free of defects.

The installed dual anode system excels by high sustainability - minimal interruption of traffic (six weeks), nearly 0-waste, minimal use of materials and minimal transport of materials from and to the construction site -, rapid realization (6 weeks), comparable low cost (for the CP systems inclusive start-up, without concrete and pavement works, about 150 €/m^2) and high durability – warranty was given for 10 years.

1. Introduction

The tender, published on 26 August 2009, for the repair and restoration of two civil structures – two bridges crossing the Danube river bank highway A22 - was a conceptual tender. The competition brief was to propose a concept to protect, restore and maintain abutments, sustaining walls and bridge columns by cathodic corrosion protection (CP):
The contract was awarded to Zeiss Chemie GmbH. CAS provided project management and the CP know-how and technologies. CAS proposed a dual anode system:

(1) Titanium ribbon mesh anodes (TRMA) for the areas 50 cm below and up to 50 cm above the ground line.

(2) The Composite Anode System based on the conductive CAS-T^{+} paint for the areas above the TRMA.

The concept of the dual anode system was accepted by the customer (ASFINAG Service GmbH Ost) April 2010.

The construction and installation works started 19 April 2010. The entire works had to be completed within six weeks, latest on 31 Mai 2010. Composite Anode Systems GmbH (CAS) managed the installation, start-up and operation of the CP systems and provided the appropriate technologies, anode systems, materials and equipments. The construction works were completed and all traffic impairments were removed on time.

2. Description of the Condition of the Structures

Both civil works - bridge B2134 crossing the river bank highway A 22 (figure 1), bridge ramp B2136 (figure 2) from the bridge „Nordbrücke“ to the A 22 - were planned and constructed in the year 1980.

Figure 1: Bridge B2134 crossing the Danube river bank highway A 22.

Figure 2: Highway Ramp B2136 to the Danube river bank highway A 22.

The condition of the structures with respect to the corrosion of the steel reinforcement was assessed by the University of Applied Arts of Carinthia June 2009 through steel potential mapping, determination of chloride profiles (drill powder) and determination of the carbonation depth of the concrete overlays.

According to the results of the steel potential mapping, a high risk for corrosion of the steel reinforcement persists in all evaluated structures (abutments, walls and bridge columns). The chloride content in the concrete overlay is significantly above the critical value of 1 M% per weight of cement according to the national standard ÖNORM B 4706. The values for the chloride content 1,5 cm – 3,0 cm below the concrete surface range from 1,4 to 5,2 M%/ weight of cement, and near the concrete surface (0 – 1,5 cm) from 1,5 to 7,8 M%/ weight of cement. The depth of carbonation of the concrete overlay is in the range of 0,6 to 3,0 cm, in to weathering exposed areas in the range of 2,5 – 3,0 cm – thus in the range of the first layer of steel reinforcement.

As a result of the high chloride contents, there is a high risk for active corrosion of the steel reinforcement, corroborating the results of the potential mapping. Damages in the concrete overlay due active corrosion of the steel reinforcement were repaired during the past years by conventional repair with cement mortar with limited success with regard to its durability (figure 3 & 4). With regard to the high chloride contamination of the concrete up behind the first layer of the steel reinforcement and with regard to the associated high corrosion risk, CP is the most efficient, sustainably and durable method for the restoration.

3. Concept of Restoration based on CP

The conventional restoration of steel reinforced concrete structures, contaminated with high chloride loads (> 1 wt. %/ wt. cement in the range of the steel reinforcement), entails high expenditure of work, materials and cost. According to the national standard ON B4706, the conventional restoration requires the removal of the concrete contaminated with chlorides up behind the steel reinforcement, applying a corrosion protecting coating to the steel reinforcement and reprofiling of the damage areas.

Following the rules of the ON B4706 – especially the removal of the with chloride contaminated concrete up behind the steel reinforcement – to insure a safe and durable restoration, the incidental costs of the conventional restoration are high: traffic impairment for several months, high traffic load due to the transport of materials to the construction site and concrete waste material from the construction site, high work deployment. CP with the CAS dual anode system allows a sustainable restoration of steel reinforced concrete structures contaminated with chlorides at competitive costs and in short time with minimum traffic impairments in comparison with conventional restoration techniques.

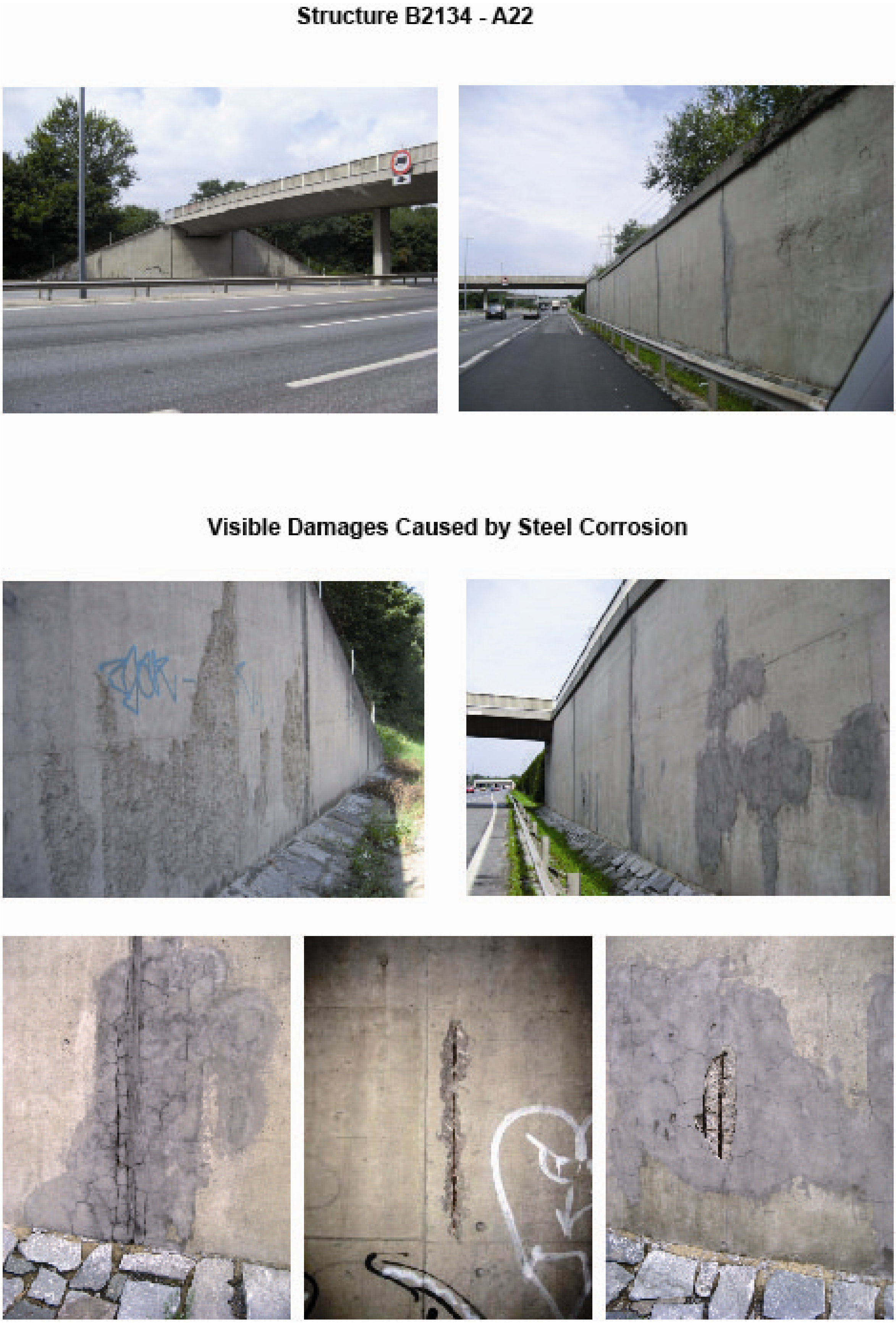

Figure 3: Visible damages to the sustaining wall of the bridge B2134.

Figure 4: Visible damages to the bridge columns of the bridge B2136.

The restoration concept offered by CAS has the following objectives:

- competitive costs
- high sustainability
- minimum impairments of the traffic
- high durability (warranty 10 years)

CP with the **CAS Composite Anodes** based on the electrically conductive coating CAST$^+$ requires minimum concrete pre-treatment (sand blasting or high pressure water jetting max. 800 bars). The CAS Composite Anode is installed easily and rapidly (analogously to conventional coatings for concrete) at low cost (60 – 150 €/m^2 total cost). The CAS Composite Anode System is used successfully for the restoration and maintenance of steel reinforced concrete structures contaminated with chlorides since over 12 years.

The **titanium ribbon mesh anode** was chosen for the restoration and the corrosion protection of the steel reinforced structures up to 50 cm below the ground line. Titanium ribbon mesh anodes consist of 13 – 20 mm wide and 1 – 1,5 mm thick activated[1] titanium mesh ribbons (DeNora) that are applied on the concrete surface on top of a thin mortar sludge layer, fastened to the concrete with appropriate synthetic dowels and embedded into shotcrete suitable for CP. As a suitable mortar, Sika MonoTop-412N was chosen.

Overall, five protection zones were defined, one zone per structure (figure 5 & 6). Dimensions, installed sensors and CP-components are summarized in table 1.

Table 1: KKS-A22 - Dimensions of the Anode Systems and CP-Components

Bridge			Area m^2	CAST$^+$ m^2	Primary-Anode (PA) m	TNBA* m	Ref. Cells pcs	Anode Connections CAST pcs	Anode Connections TNBA pcs	Cathode Connections. pcs
B2134	**SZ1**	**Sustaining Wall****	526,61	431,87	214,48	378,96	4	5	5	13
	SZ2	**Abutment**	138,97	109,73	69,24	116,95	3	2	2	6
	SZ3	**Bridge Column**	11,59	5,54	7,24	22,00	2	2	1	3
		Sum B2134	**677,17**	**547,15**	**290,96**	**517,91**	**9**	**9**	**8**	**22**
B2136	**SZ4**	**Sustaining Wall 1**	123,74	86,94	70,74	147,22	3	4	4	8
		Abutment 1	78,51	64,24	45,17	147,22				
	SZ5	**3 Bridge Columns**	48,00	37,89	47,56	75,15	3	6	3	7
		Sum B2136	**250,25**	**189,06**	**163,47**	**369,59**	**6**	**10**	**7**	**15**
		Sum B2134 + B2136	**927,43**	**736,20**	**454,43**	**887,49**	**15**	**19**	**15**	**37**

TNBA*...Titanium ribbon mesh anode, applied on a total area of 191,22 m^2
Makrocellsensors in SZ 2 (B2134) & in SZ4 (B2136)

[1] Titanium anodes are activated by coating the titanium surface with IrO_2, ReO_2 or Pt.

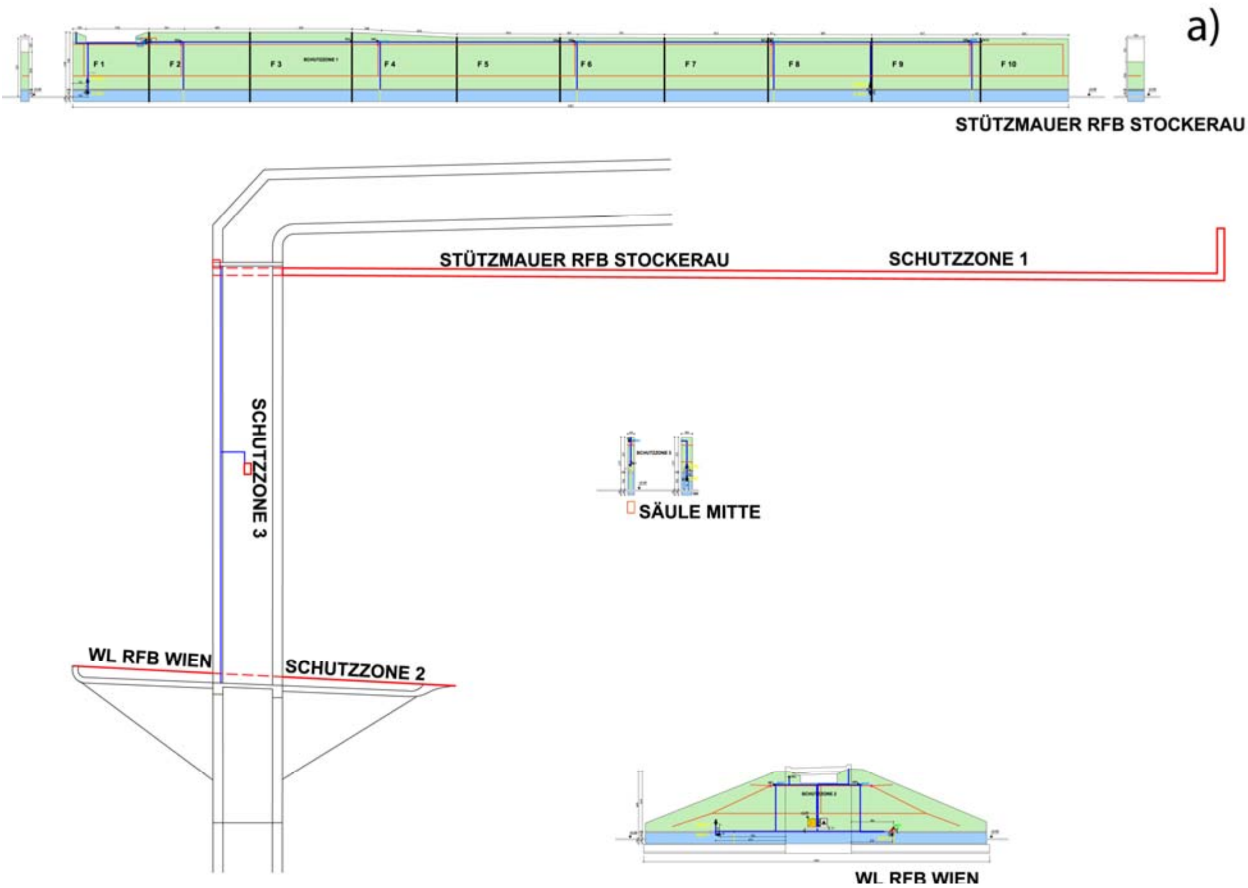

Figure 5: Schematic representation of the CP protection zones & anode system: B2134, sustaining wall – zone 1, bridge column – zone 3, abutment – zone 2.

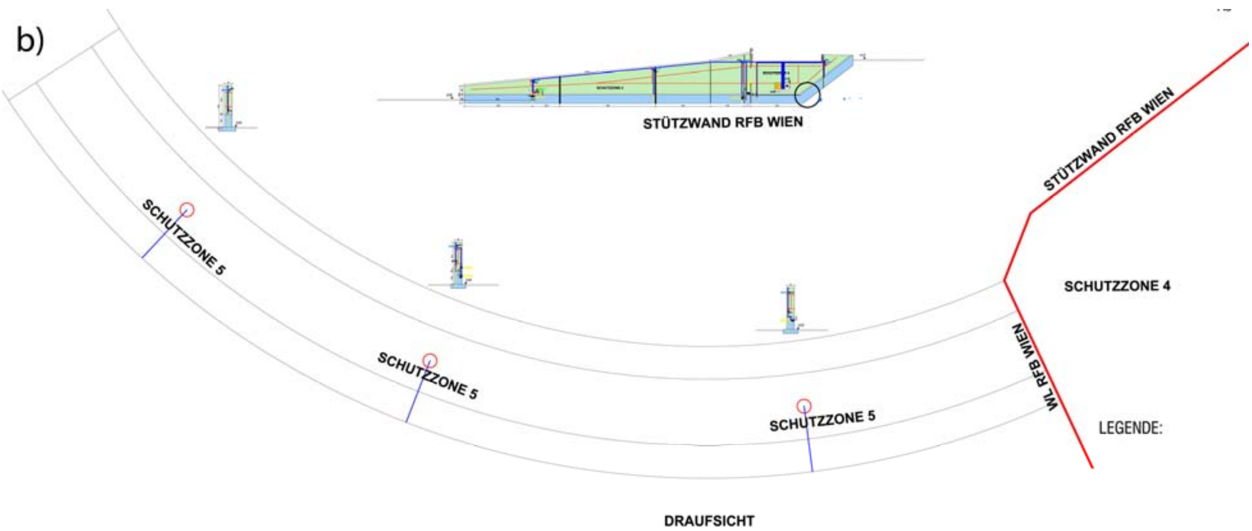

Figure 6: Schematic representation of the CP protection zones & anode systems: B2136, abutment and sustaining wall – zone 4, three bridge columns – zone 5.

4. Installation of the Anode Systems

Construction works started 19 April 2010, installation works for the anode systems started 10 Mai 2010:

The CAS Composite Anodes were installed as follows: the concrete surfaces of the areas on which the CAS-T^+ Composite Anode paint was to be applied were sandblasted, areas with loose overlays (loss of the connection between concrete and rebars) were repaired with repair mortar suitable for CP according to EN 12696. Cracks in the concrete overlay were sealed and filled by injecting cement grout.

After completion of these preliminary works, connections to the steel reinforcements (cathode connections) were made by prizing open the concrete cover, soldering a CAS-steel electrode to the steel reinforcement and filling the orifice with epoxy mortar. The concrete cover was measured with a cover meter and areas with insufficient cover were marked.

Exposed steel parts connected to the steel reinforcement that could lead to short circuits between the anode and the steel reinforcement were detected by using a holiday detector and marked on the concrete surface. These areas and areas with insufficient cover were insulated. A fine cement based plaster was applied to level off large pores and blowholes.

Sensors – reference cells, macro-cell sensors – were installed in the concrete according to the standard practice. The first layer of the CAS-T^+ coating was applied on the fully hardened cement plaster (figure 7).

Figure 7: Installation of the CAS-Composite Anode in Zone 1 (sustaining wall, B2134 RF Stockerau) – 1st layer of CAS-T^+ coating.

The CAS CNP primary anode was installed on the first CAS-T+ layer and covered with a glass-fiber ribbon-mesh (figure 8). The CAS CNP primary anode was then embedded into the second layer of the CAS-T+ coating (figure 8). The CAS Composite Anode was then covered with two layers of a frost-thaw salt proof acrylic coating (figure 9).

Figure 8: Installation of the CAS-Composite Anode B2134: bridge column – zone 3, CAS-CNP primary anode on 1st layer of CAS-T+ coating; abutment – zone 2, second layer of CAS-T+ coating embedding the CAS-CNP primary anode.

Figure 9: Coating of the CAS Composite Anode with a cover coat (Sikagard 550W elastic) on the structures of B2134

The Titanium-Ribbon-Mesh Anode was installed as follows:

The concrete surface areas on which the titanium-ribbon-mesh anodes were to be installed were treated with high pressure water jetting. The titanium-mesh-ribbons were applied on top of a thin mortar sludge layer, fastened to the concrete with appropriate synthetic dowels (figure 11) and embedded into shotcrete (figure 12). After completion of the installation works, the mortar was covered with the same acrylic coating as the CAS Composite Anode.


Figure 11 Titanium ribbon mesh anode on the sustaining wall above and below the ground line, B2134, zone 1.


Figure 12: Installation of the titanium ribbon mesh anode on the sustaining wall above and below the ground line, embedded into shotcrete, left picture zone 1. B2134; right picture zone 4, B2136.

The construction works and the installation of electric components were completed and all traffic impairments (closure of highway lanes) were removed on 31 Mai 2010. The installation and wiring of the cabinets containing the MO-DAC data acquisition and control units was finished 11 June 2010. Start-up of the CP systems was on 5 August 2010.

Thus, the construction and the CP-installation works were completed within the contractual 6 weeks. During installation works, two emergency lanes and one traffic lane out of four were closed, one out of three traffic lanes were closed during the night (08:30 – 03:00 h) for two weeks during the installation works on the bridge columns. Therefore, there were only minor traffic disruptions during installation works.