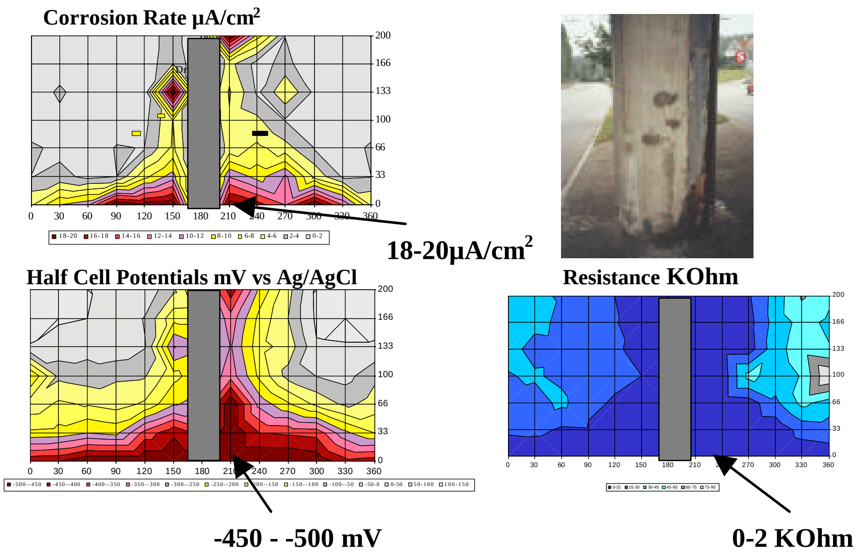
Corrosion rates determined by GalvaPulse© and Gecor 6 compared to corrosion rates determined by weight loss

Two selected studies, one from the field and one from the laboratory, are presented, comparing average corrosion rates by the GalvaPulse©, ref. (1) and the Gecor 6 to corrosion rates determined by weight loss measurements.

Field study

Two 30 year old highway bridges parallel to each other, in the Copenhagen area, have been examined regularly since the time of construction. The two bridges have been and are exposed to de-icing salts both from the highway on top as well as from the road below the bridge. After 10 years of service life reinforcement corrosion started out and one of the bridges was renovated for 1/3 of the construction price. It was decided not to renovate the other bridge. This bridge has been examined regularly during a 20 years period.

The chloride levels in concrete of the bridge were high as well as the humidity. In the month of April 2001, where the last measurements were performed, the temperature was 15^{o}C.



Typical values of corrosion rates, half-cell potentials and electrical resistance measured with the GalvaPulse? as of April 2001 at the bottom of a bridge pillar

The values pointed out on the maps are typical values from the GalvaPulse© recorded over the past years. The average corrosion rate at the bottom of the pillar of 19 µA/cm^2 corresponds to a yearly cross section-loss of approximately 200 µm (0.200 mm) using Faraday's Law. As the corrosion started out some 20 years ago, and assuming fairly constant corrosion rates over time, the estimated loss of cross-section would be approximately 4 mm.

At the same points corrosion rate measurements were made by a Gecor 6 instrument. The Gecor 6 results were in average 0.3 µA/cm^2. Using Faraday's Law, the estimated loss of cross-section would be 3.4 µm/year and the total loss of cross-section since the initiation of the corrosion some 20 years ago approximately 0.07 mm, provided fairly constant corrosion rates over time.

The reinforcement was exposed at the bottom of the pillar and an average diameter reduction of approximately 4 mm was measured.

Similar comparisons were made on different locations at the highway bridge structure with generally the same results.

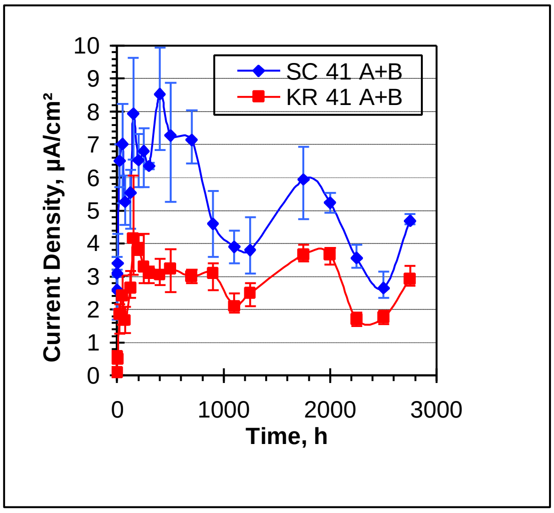
Laboratory study

The laboratory tests carried out by BAM (Federal Institute of Materials and Testing) in Berlin, Germany are reported in extracts from ref. 2.

Seven concrete test blocks were prepared each with two reinforcement bars. The blocks were exposed to chlorides for 2800 hours and the corrosion rate was measured regularly by the GalvaPulse© and Gecor 6 corrosion rate instruments to determine the variation of the corrosion rate over time.

At the end of the exposure time the blocks were crushed and the reinforcement was cleaned for corrosion products. The weight loss of every reinforcement bar was determined and by means of Faradays law translated to µA/cm^2.

As the weight loss is corresponding to the average corrosion rate it was necessary to integrate the corrosion rates, determined by the two different instruments over time to be able to compare to the actual weight loss measured.



Corrosion rates determined by GalvaPulse© on specimens type SC 41 A+B and KR 41 A+B

	Weight loss	GalvaPulse©			Gecor 6		
Description	Avg. Corr.rate µA/cm²	**mV vs. Ag/AgCl**	Avg. Corr.rate µA/cm²	Resistance kOhm	**mV vs. Ag/AgCl**	Avg. Corr.rate µA/cm²	Resistance kOhm
bar A	**4.6**	-345	**3.11**	0.50	-355	**0.21**	0.47
bar B	**4.8**	-334	**2.47**	0.90	-437	**0.23**	0.93
bar A and B connected	**4.7**	-345	**5.24**	0.50	-343	**0.54**	0.35

Typical results from laboratory tests made at BAM, Germany

The difference in corrosion rates determined at the single bars and the connected bars by the two instruments is probably due to the size of the reinforcement bars. Both instruments are provided with guardring systems to confine the current outspread from the sensor heads. When the bars are connected, the guard ring current will be able to spread out and, thereby, avoid influencing the confined area and the instrument calculations.

Conclusions

- In the field study illustrated the corrosion rate results from GalvaPulse© were in good agreement with the actual reduction in the cross-section of the reinforcement.

- Under laboratory conditions GalvaPulse© results corresponds even better to the corrosion rates determined by weight loss.

- In both studies as well as in other studies it was found that the good correspondence between the GalvaPulse© and the actual corrosion rate requires the corroding surface area of the reinforcement bar to be known. Therefore, when possible, it will be necessary to expose the reinforcement at a few locations for inspection.

- To make accurate estimates of the loss of cross-section of reinforcement in the field the variation of chlorides, carbonation, moist and temperature over time has to be taken into account. This can be done by performing GalvaPulse© measurements regularly over time, e.g. at 3-4 months intervals.

References

(1) Klinghofer,O., Riislund,E., Frolund, T., Elsener, B., Schiegg, Y., Bohni, H.: "Assessment of Reinforcement Corrosion by Galvanostatic Pulse Technique", Proceedings International Conference on Repair of Concrete Structures, Norway, 1997, pp 391-400.

(2) Baessler, R. & Burkert, A.: "Laboratory Testing of Portable Equipment", Brite/Euram project Integrated Monitoring System for Durability Assessment of Concrete Structures, Federal Institute for Materials and Testing (BAM), Berlin, Germany, 2001