Practical example for the application of CANIN ProVista

concrete concepts Ingenieurgesellschaft mbH
Brandes | Lay | Rucker
www.concrete-concepts.eu

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Summary

Rebar corrosion in reinforced concrete structures can be detected by applying the measurement system CANIN. The new software CANIN ProVista is an effective tool, which optimizes the practical application and the benefits of CANIN. Processing of the measurement data with this analyzing software offers the basis for an optimum interpretation and appraisal of the corrosion potential of the reinforcement. The application of CANIN ProVista is demonstrated here by showing the example of a parking deck, which was damaged by rebar corrosion induced by de-icing salts. The Parking deck was investigated to this respect.

Keywords

reinforcement, chloride, corrosion, "Potential Map", CANIN, software, graphic, statistic, "Relative Frequency", "Cumulative Frequency", "Chipping Graph"

1 Introduction

The corrosion of steel in concrete is an electrochemical process. It can be detected as an electrical potential field at the concrete surface by using the system CANIN. The half-cell potential of the steel embedded in concrete is measured with a high-impedance voltmeter as the voltage difference to the half-cell potential of a $Cu/CuSO_4$-reference-electrode placed on the concrete surface. The data are stored to a memory and graphically depicted on the display in the chosen measurement grid. Single measurement fields can be transferred to a personal computer using the integrated interface of CANIN.

The Windows Software CANIN ProVista, recently developed by the PROCEQ SA, enables the data transfer, the graphical presentation of the potential fields and a statistical analysis of the measurement data. In addition CANIN ProVista allows the automatic derivation of a chipping plot for concrete replacement. All graphics can be exported and easily integrated into reports. In addition all graphics can be edited in drawing programs and hereby be inserted into plans for the execution of repair measures.

To demonstrate the possibilities of CANIN ProVista the condition assessment of a floor slab of the parking levels in a commercial building in Munich is presented here.

2 Easy processing of the measurement data

At first the data of all investigated single measurement fields are transferred separately from the CANIN data storage device to a PC and stored into respective files. The division into separate measurement fields is due to the geometric circumstances as e.g. joints or corners, the limited length of measurement cables or the limited number of reading points. The single files can be opened and processed separately. By rotating or mirroring in intervals of 90° the single potential maps can be combined in a coordinate system to form a complete picture representing the total investigated surface area.

Figure 1 shows the graphical presentation of two investigated sub-areas in the program modus "Potential Map". The two areas were combined in the depicted user interface of CANIN ProVista.

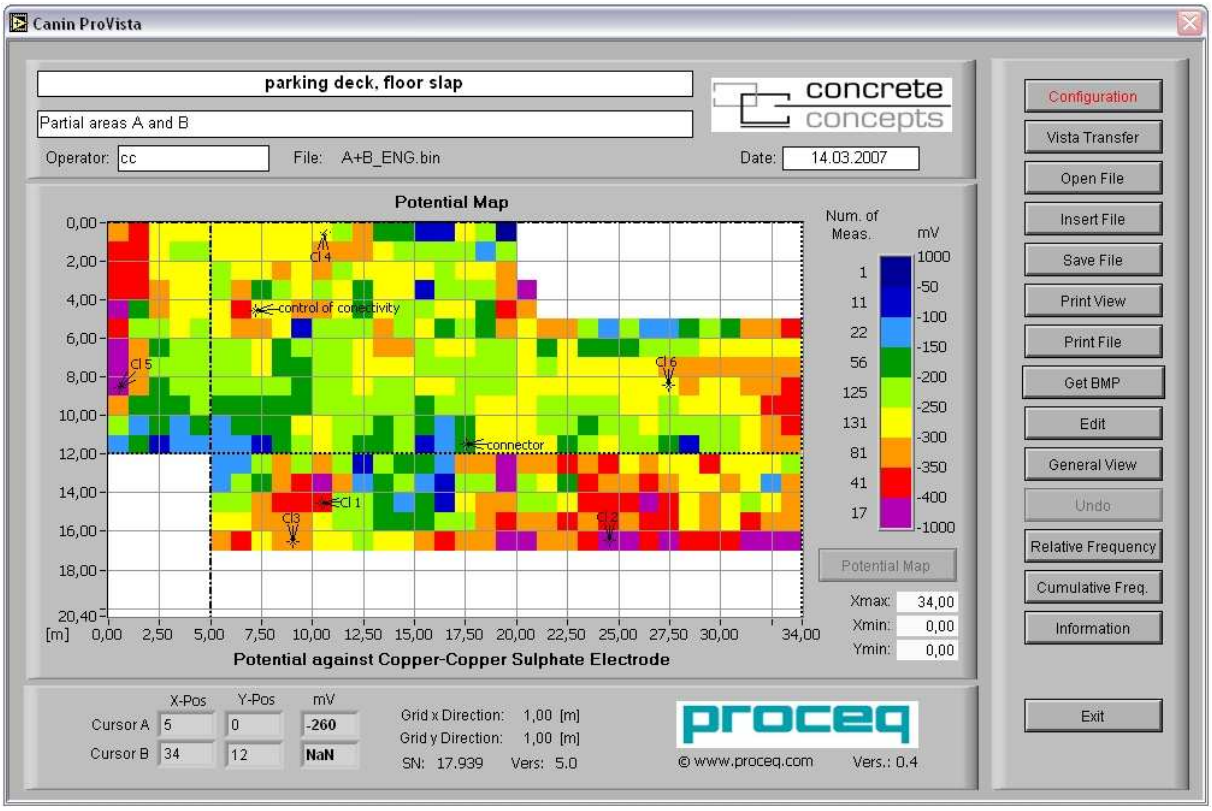


Figure 1: Graphical combination of two separated measurement areas of a floor slab; additional "annotations" mark the position of sites for drilling samples for chloride analysis and at the same site openings for visual inspection of the rebar condition as well as openings for connections and the control of the electrical connectivity of the reinforcement

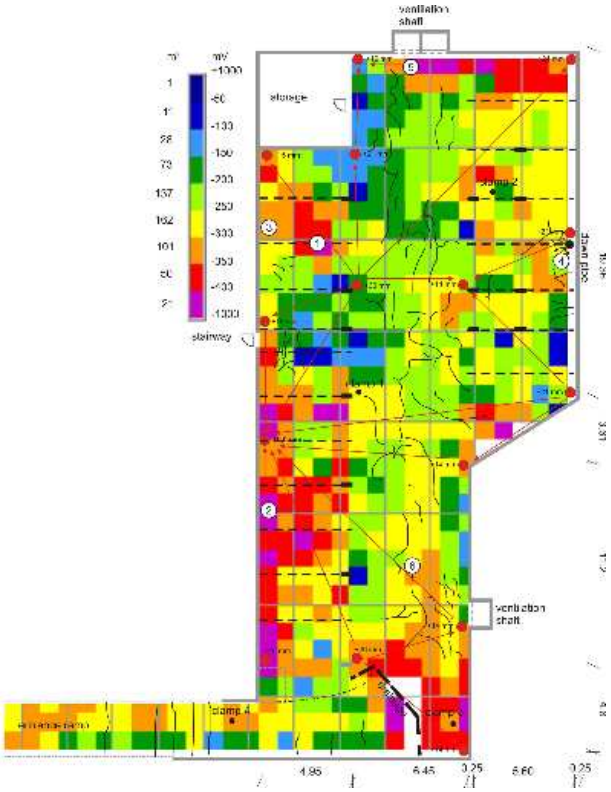
The half-cell potentials measured in the chosen grid are presented in colors corresponding to the measurement values. The width of the color intervals can be chosen freely. Besides the correlation of measurement values and colors the legend shows the absolute frequency of measurement values in each potential interval.

Cells of the grid in the "Potential Map", which are not intended to be visible after integrating the graphics into documents or plans, can be deleted with the program.

In addition to the combination of the raw measurement data determined with CANIN, the software CANIN ProVista enables the input of further "annotations". These annotations can be used for the documentation and planning of sites for further sampling, for spots where the concrete cover was removed, photos, etc.. The direct assignment of these sites to the potential field measurements promotes an optimum interpretation.

All graphics as the "Potential Map" shown in Figure 1 can be exported as a BMP-file for direct integration into reports. The export of the color legend and the grid scale is optional. By importing the exported BMP-files into graphics software (e.g. Corel Draw or AutoCAD) the results of potential field measurements can be graphically combined with further inspection data. These graphic programs enable a superimposition of all single investigation results in layers. Thus all information relevant for the interpretation and the further planning are available at a glance.

Figure 2 exemplifies the integration of potential field measurement data into the floor plan of the investigated parking deck including further information from the condition assessment of the structure.



Site	Chloride at Rebar [M.-% CEM]	Visual Rebar Condition
1	0.43	depassivated
2	0.85	depassivated
3	1.28	depassivated
4	0.07	passive
5	0.43	depassivated
6	0.07	passive

Figure 2:
floor plan, parking slots, drainage, cracks, height (slope) at characteristics sites, connections for measurements, "Potential Map" imported from CANIN ProVista, sites for drilling samples for chloride analysis and for visual inspection of the reinforcement at the same site, portion of surface area per potential interval (legend)

Active corrosion occurred in the floor slap primarily in the left parking zone and along the drainage. The drainage at the entrance ramp corresponded to a depression of the slap, where water from the entrance ramp accumulated severely. Close to relatively fine

cracks, which mainly exist in the lane, the corrosion risk is not necessarily increased. This is verified by the low chloride contents at the sampling sites depicted in Figure 2.

The possibility of the combination of the measurement data graphically edited with CANIN ProVista with further information thus enables a rapid interpretation of all inspection results in the overall context.

3 Determination of the object-related threshold potential

Active corrosion is to be expected at such sites, where negative potentials are surrounded by increasingly positive potentials. For the estimation of the corrosion risk universal threshold values for the half-cell potential, as e.g. included in ASTM C876-91, may only be understood as rough guiding values. This is caused by the numerous influences upon the half-cell potential. As long as the conditions inducing corrosion as the chloride content and the carbonation of concrete are comparable, the major influences are the concrete cover, the electrical resistance of the concrete and the oxygen concentration at the reinforcement. These influences vary for different structures as well as locally within single surface areas.

The threshold potential is hence to be understood as a stochastic variable, which must be determined for each individual concrete component using statistical methods and further inspection information. For the evaluation of the measurements CANIN ProVista offers two statistical presentations, which are the "Relative Frequency" and the "Cumulative Frequency". With these an individual determination of the threshold potential is easily possible for each structure and for single sub-areas.

The graphical presentation of the data as a "Relative Frequency" fulfills the purpose to provide an overall impression of the statistical distribution of a data set, Figure 3. The "Relative Frequency" of sub-areas with a different constructional setup and environmental exposure condition, as e.g. floor slab sections divided by expansion joints, entrance ramps, etc. can be evaluated separately. The comparability of relative frequency plots representing partial areas indicate that the single measurement data sets can be grouped for the determination of the threshold potential and for the further planning process. A deviation of the "Relative Frequency" denotes that the thresholds should be separately assigned to each partial area.

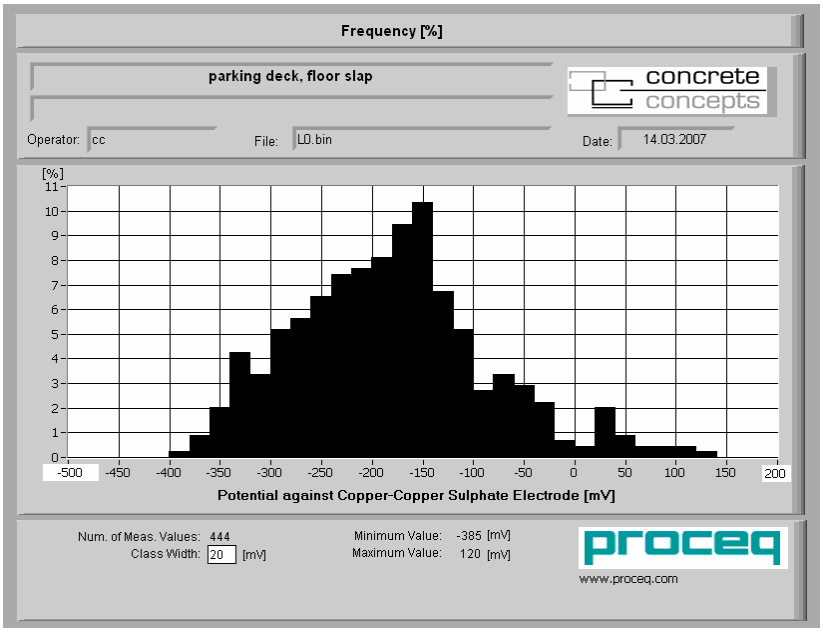


Figure 3: "Relative Frequency" of half-cell potentials of a floor slab

The setting of the potential threshold for individual areas results from the presentation of the measurement data as a „Cumulative Frequency". For this a so called "normal graph paper" is included in the software CANIN ProVista. Data sets, complying with a Gaussian normal distribution, are therein presented as a single straight line. Provided that the concrete cover and concrete moisture content of investigated areas are sufficiently homogenously distributed, active macro-cell corrosion is visible by at least two line segments of different slope. The most negative inflexion point marks the end of the active corrosion domain and hence represents the threshold potential.

Significant variations of the concrete moisture content or the concrete cover thickness within a considered surface area may be identified as a third, intermediate line segment in the „Cumulative Frequency". For this segment no unambiguous assignment is possible regarding the active or passive corrosion state. An unerring interpretation of the corrosion risk of these surface areas demands additional investigations as e.g. opening the concrete cover for visual inspection of the reinforcement at characteristics sites.

For the present example of a floor slap in the investigated park deck an unambiguous transition from active to passive could be determined at a threshold potential of $E_{threshold}$ = -300 mV using the „Cumulative Frequency" mode of CANIN ProVista, Figure 4. This threshold was verified by comparison with the gradient of the potential in the "Potential Map", the chloride profiles and visual examination of the rebar corrosion state according to Figure 2.

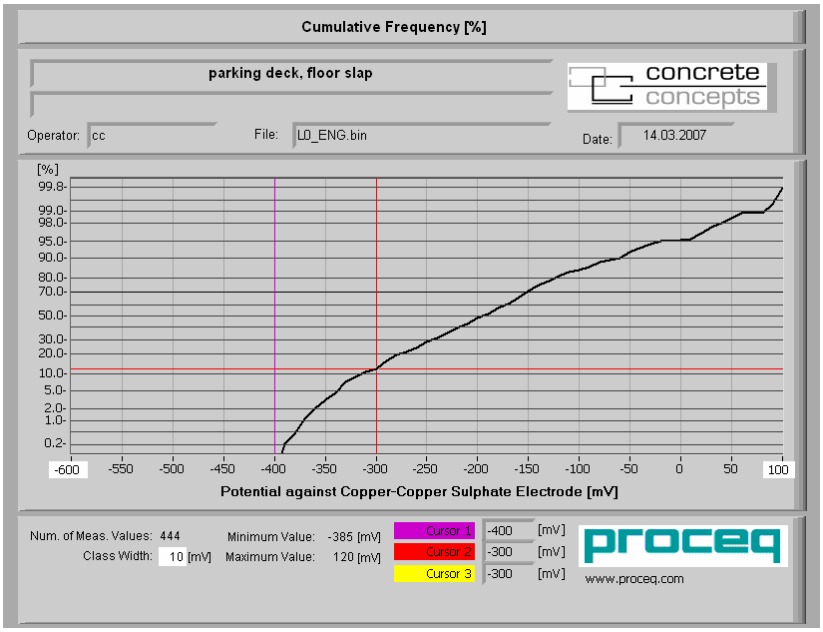


Figure 4: "Cumulative Frequency" of half-cell potentials measured on a floor slap (at left active corrosion state, at right the passive state)

The measured half-cell potentials of the investigated floor slap, at which corrosion was already detected, are relatively noble. This is due to the rather large distance between the reinforcement and the reference electrode placed on top of the concrete surface. This distance is the consequence of the thick assembly of the floor slap, caused by the application of a floor screed of 45 mm thickness on top of the construction concrete, which was partially hollow and undermined by water containing de-icing salts.

4 Planning of concrete replacement according to the threshold potential

As a tool for the planning of concrete replacement measures the software CANIN ProVista provides the module "Chipping Graph". On the basis of the determined threshold potential, up to four characteristic potential intervals can be chosen. The corresponding partial areas are marked with different colors in the presentation of a „Chipping graph". Areas, where a concrete replacement is advisable, can be simply presented in an automatic fashion.

Figure 5 gives an example for a "Chipping Graph" created with CANIN ProVista for the floor slap already shown in Figure 2, which was imported to the floor map as a BMP-file. According to the threshold potential in Figure 4 areas are distinguished with the reinforcement being in an active or passive corrosion state, respectively areas with or without concrete replacement.

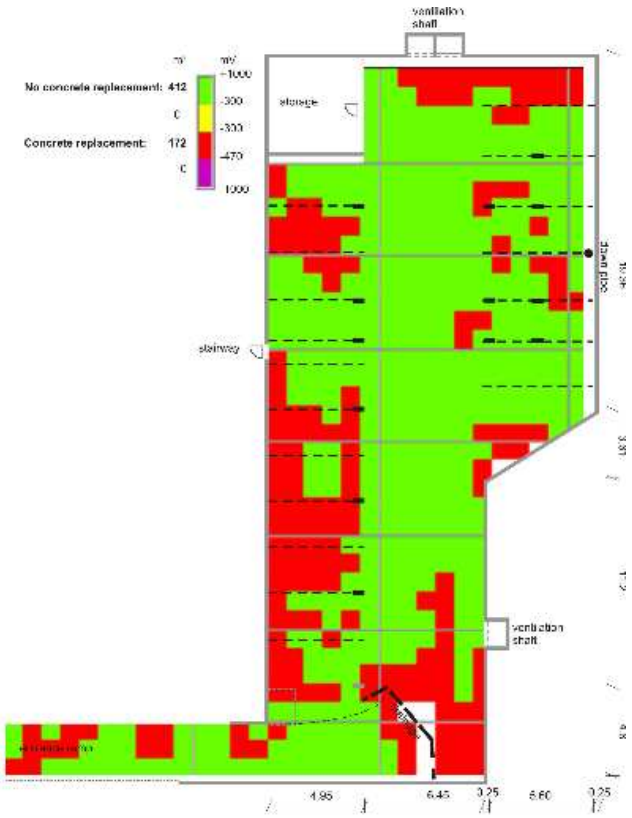


Figure 5:

"Chipping Graph" for local concrete replacement of the floor slap given in Figure 2

According to this plan the relevant areas can be marked on the concrete surface of the floor slap and the concrete replacement can take place accordingly.

5 Conclusions

In summary, the software CANIN ProVista is a supplement to the proven measurement system CANIN, which enables a rapid presentation and interpretation of the data as well as an unerring detection of areas with corroding reinforcement. It thus allows in an economic and precise fashion the condition assessment and the respective planning of repair measures of reinforced concrete structures.

6 Recommendations for further sources of information

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