

Risk & Safety



Institute of Structural Engineering, ETH Zurich
 Prof. Dr. Michael H. Faber,
 Dipl.-Ing. Vasiliki Malioka, Dipl.-Ing. Kazuyoshi Nishijima

Project SS 2006
 Linda Cavasin, Daniela Michel,
 Mara De Zanet, Melanie Hubacher

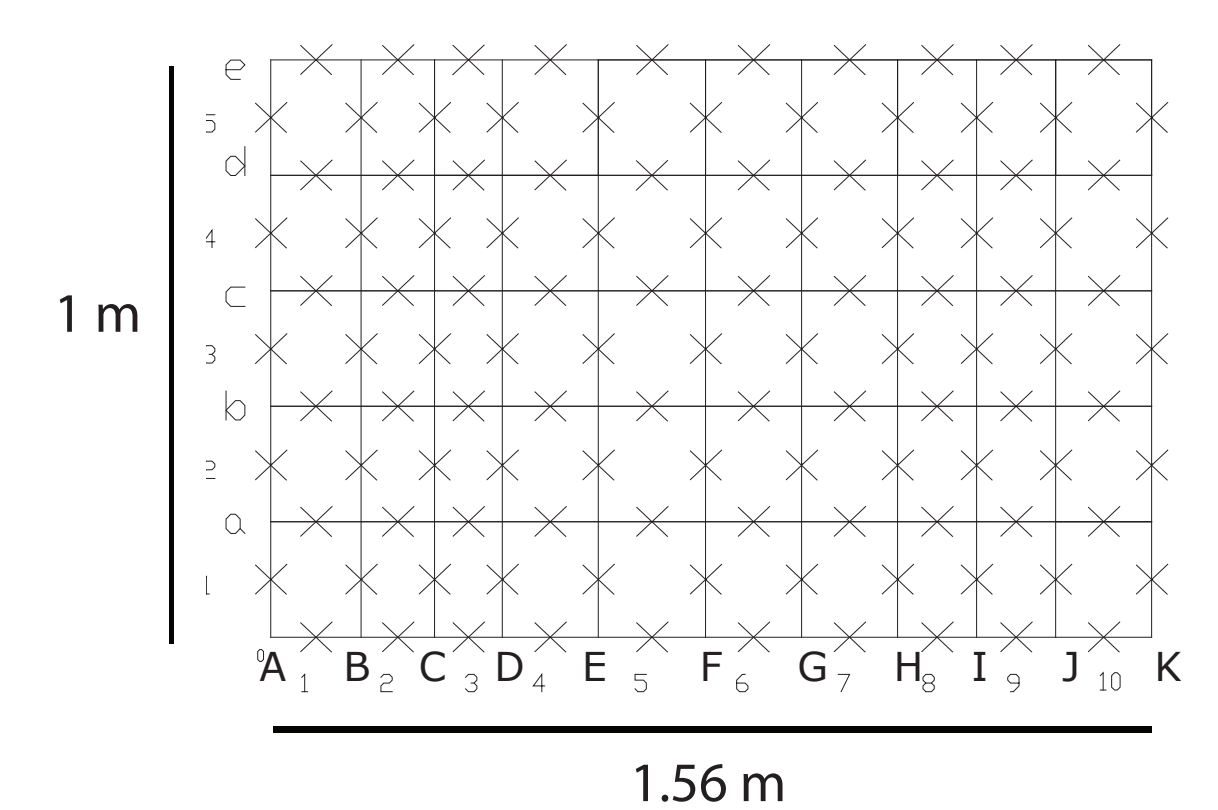
Non-destructive testing of concrete elements and investigation of the data using statistical methods

Starting position

The object used for this study was a concrete beam with the size and dimensions of 1 m x 1.56 m. The concrete beam was continuously exposed to the weather, as it is located in front of the "Bauhalle". It was our task to find out if corrosion has already initiated and/or to detect areas where corrosion may initiate in the future by using non-destructive testing methods. In order to do so, we examined the concrete element applying different testing methods.

Sketch of the concrete cover beam

First of all we detected the reinforcement rebars with the Profometer and drew the pattern on the concrete beam. Then we have chosen 105 locations on the rebars to take measurements. For all tests we used the same points.

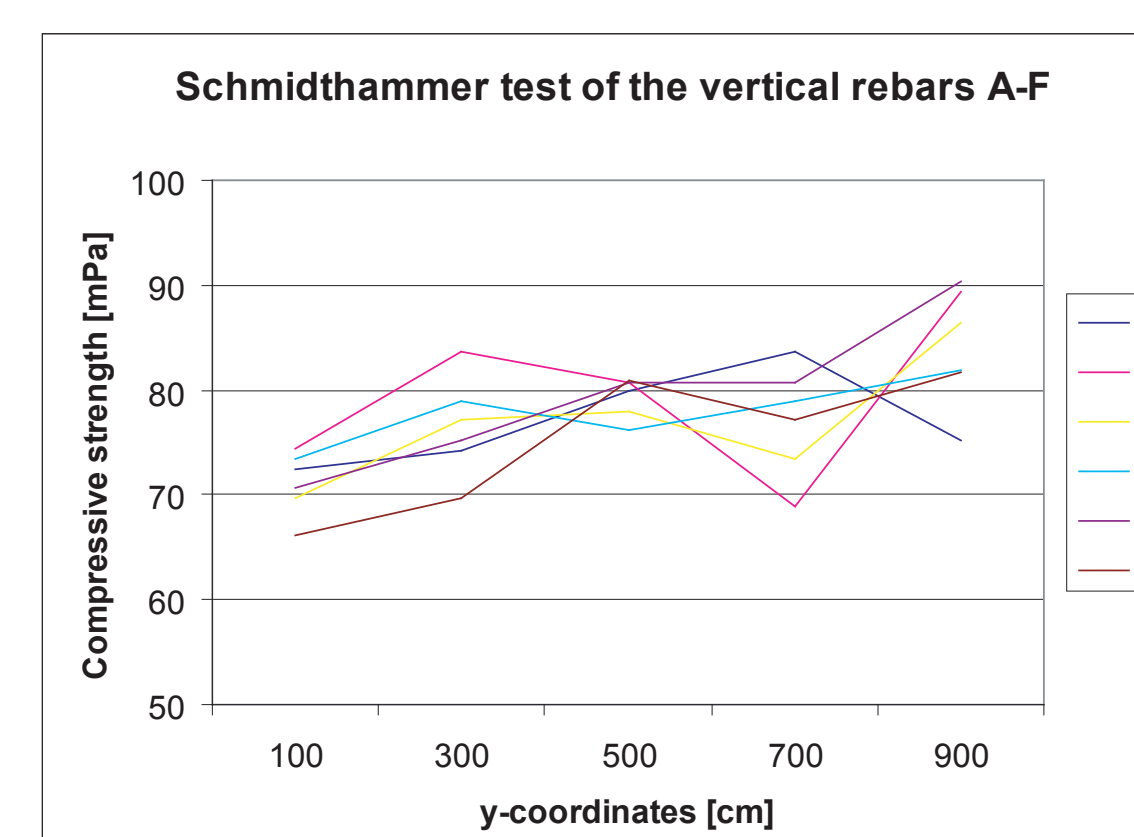


Modelling

To lead this investigation the following tests have been chosen:

- concrete cover depth: With profometer 5 it's possible to detect the location of the steel bars and the respective depth. The concrete cover protects the rebars from environmental conditions.
- half-cell-potential: With this test corrosion can be detected by measuring the difference of potential between 2 points of the rebar.
- Schmidthammer: It measures the uniformity of the concrete. If the concrete is damaged, corrosion is more likely to initiate.
- electrical resistivity: This test measures the moisture of the concrete. Too much humidity favours the initiation of corrosion.

Part of Schmidthammer results



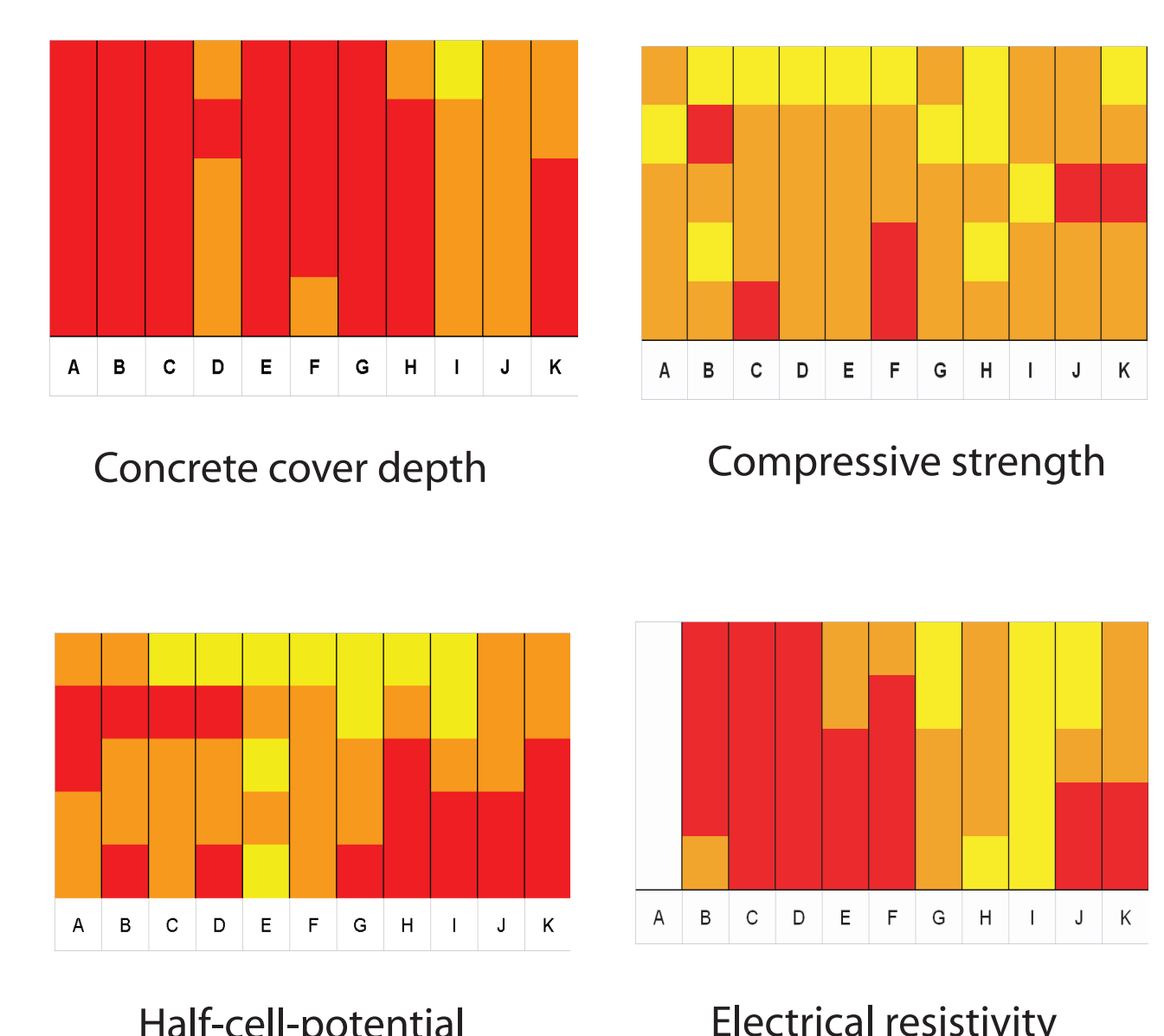
Schmidt Hammer is a test used to measure the surface hardness and composition of the concrete. The results from the Schmidthammer test were quite satisfying because there are very little variations of the compressive strength. The diagram on the left, a plot of some vertical rebars, shows this very well. The measured values lie between 59 and 91 N/mm, but most of them are seen in the interval from 70 to 81, a sign of a very high compressive strength.

Statistical analysis

To analyse the data the descriptive statistics are very helpful. It's possible to see if the values follow any trend and if the data of the different tests are correlated. Furthermore there can be built models by estimating parameters and trying to find the best distribution with probability papers. With the Chi-square-test it is controlled if the distribution really fits. The hypothesis, which were made considering the data, can be verified or falsified. This permits to take the right decisions and precautions to protect the concrete structure.

Colour maps

To compare the test results the colour maps allow the identification of the different areas of the concrete beam. Even if some of them show more similarities than others, they all indicate more or less the same areas with corrosion risk. Considering all the colour maps it can be seen that the most endangered area is located in the lower left part of the beam and that in the upper part and on the right the risk of corrosion is not that high.



higher risk
 lower risk

Conclusions

Nearly all of the data/values from the tests indicate no or very low corrosion risk. Only in the electrical resistivity test is shown a higher risk for some areas, but they are not really problematic either. Still it is important to remember that the environmental conditions changed for the different testing days. There were days with rain, wind and low temperature (concrete cover) while on the opposite the electrical resistivity and the half-cell-potential were done on a hot, dry and sunny day. This should also be considered when evaluating the results, especially for the last two mentioned tests, as they depend very much on the humidity of the concrete. Taking into account all results, we come to the conclusion that the concrete beam is not specially endangered to corrosion. Nevertheless, it is better to keep an eye on the red areas of our colour maps, as in the future, they may be potential areas for corrosion.

Our Group



Being the only group consisting of four women, we always managed to have fun. :o) Even if sometimes we were near to desperation, because of the probability paper, electrical resistivity or chi-square tests: We became fond of our concrete beam!