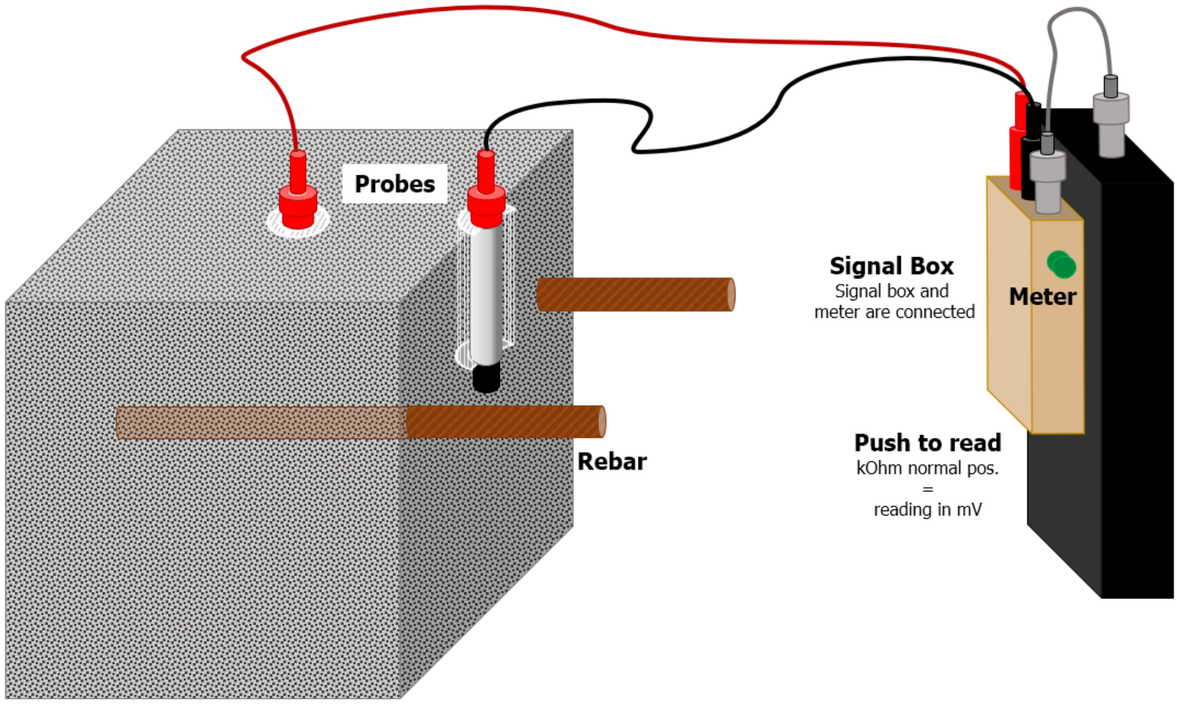
HUM-Meter for concrete humidity



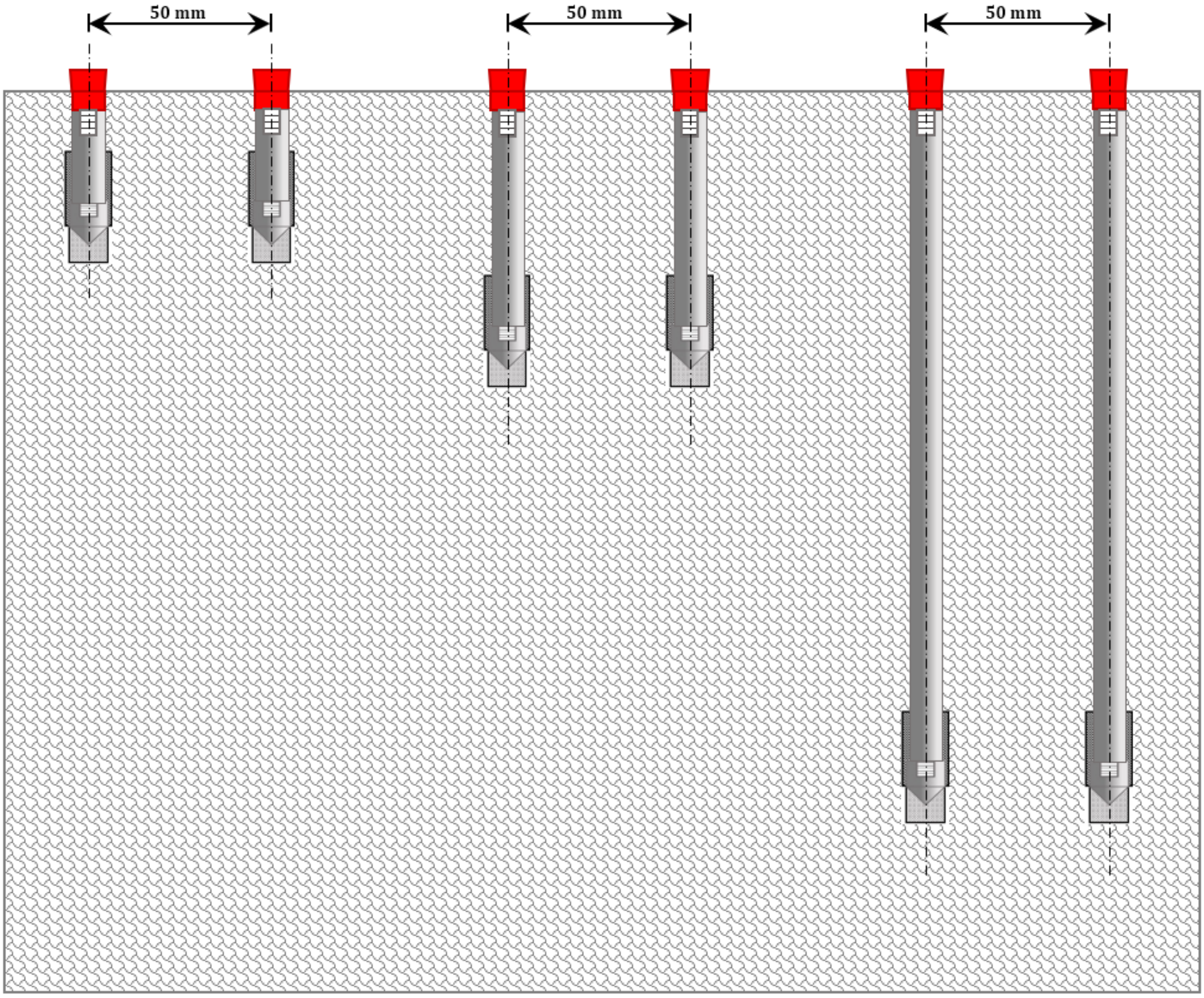
The moisture content is one of the most important parameters for both the corrosion process and for reactions like the Alkali Silica Reaction (ASR) to occur and drying out the concrete structure is one obvious way to stop both reactions.

For the corrosion process one of the primary parameters is the electrical resistance. The electrical resistance expresses the capillary pore system at a given temperature, chloride content and porosity.

The humidity and the porosity have a major influence of the oxygen transport. If the pore system is water filled, the transport of oxygen will be very slow due to low solubility of oxygen in water.

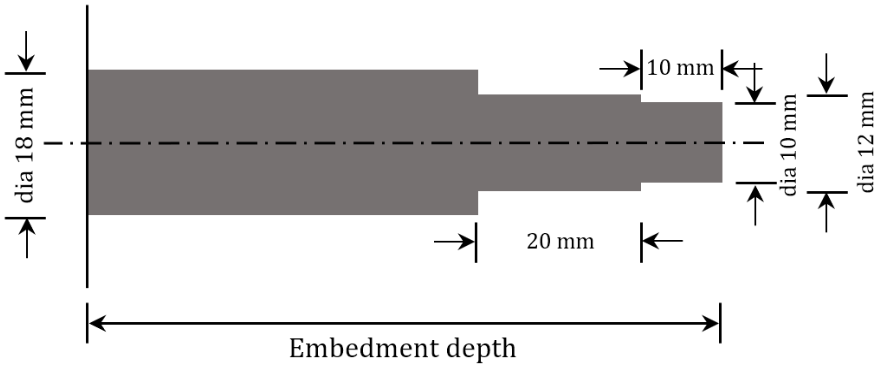
It is generally accepted that the relative humidity is a good measure for assessment of concrete´s sensibility for ASR. When the relative humidity is less than 75-85%, ASR is not likely to occur (Nilsson 1983, Stark 1991 ref.1 and ref. 2.)

With the Hum-Meter, the electrical resistance of the concrete is measured between two steel probes attached permanently in the concrete at a predetermined depth. The electrical A/C-resistance between the probes is measured and used to evaluate the moisture content of the concrete and the relative fluctuation of the moist content over time, e.g. prior to and after waterproofing membranes have been applied to the concrete surface.

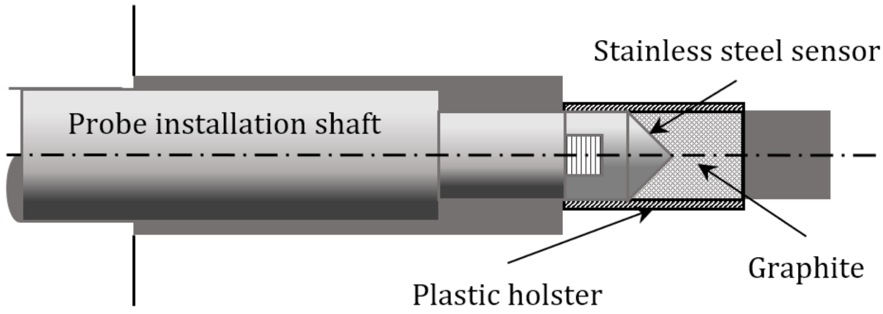


HUM-Meter probes (three sets of two) shown installed in the concrete at different depth.

Drilling of the holes is made first with a 10 mm masonry drill bit to a required depth, then a 12 mm diameter bit is used to drill out the hole up to a distance of 10 mm from the bottom of the 10 mm hole. Finally, the 18 mm drill bit is used to drill to a depth of 30 mm from the bottom of the 10 mm hole. **Figure 3**.



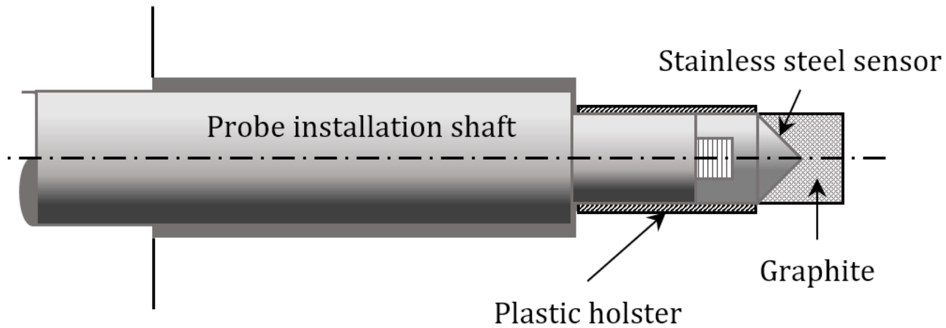
The GSS-probe is placed in front of the 12 mm hole with the probe installation shaft, with its 12 mm face resting against the probe. Using light hammer strokes, the probe is forced into the 12 mm hole.



GSS-probe inserted

The other end of the installation shaft - the 9 mm recessed end - is made to rest against the stainless-steel sensor of the probe. By tapping the shaft with the hammer, the sensor is forced towards the front position at the bottom of the hole.

Remove the shaft and thread the proper length attachment pin (or a combination of them) into the sensor. Force the steel sensor by light hammer tapping the remaining 3-4 mm into the holster to the final position.



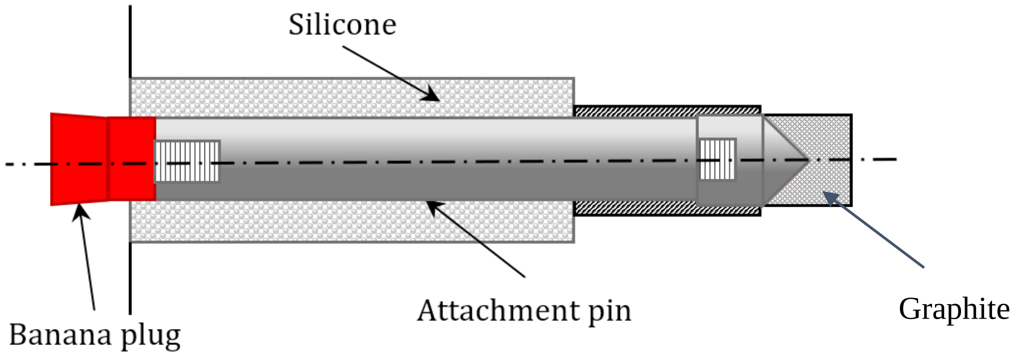
Activated GSS-probe

The stainless-steel sensor is now placed in the front position of the probe by which the graphite has broken the seal and filled the cavity 10 mm long in front if the installed probe.

Fill the space between the pin and the 18 mm hole with the silicone and thread the banana bushing into the pin. Seal also the banana bushing with silicone. Allow the installation to dry and stabilize for 24 hours.

Alternatively, only one probe may be installed, similarly, and measurements taken in relation to the reinforcement, again in about a 5 cm distance.

Attach the banana cables to the meter's signal box and plug them into the two probes (or the probe and the reinforcement adaptor if this is the case).



The meter is turned on and the mV-range chosen. The green button on the signal box is activated. When the green button is activated, the current submitted through the cables will be an AC-current with a frequency of 300 Hz, and the readings will be in kOhm, with 1 mV indicating 1 kOhm.

After the electrical resistance has been measured, the meter-range is switched to Centigrade, the temperature probe is plugged into the meter-plug adjacent to the BNC-plug and the temperature of the concrete is recorded as well.

Using the electrical resistance measured

From the electrical resistance (R) the specific resistance (or resistivity) is calculated using the following equation (ref. 3, p. 56):

$$\rho = \frac{R \cdot 2 \cdot \pi \cdot L}{\left(\ln \frac{8 \cdot L}{D} - 1 \right)}$$

ρ is the specific resistance of the concrete (resistivity)

R is the resistance in kOhm (for two probes the value is the resistance measured divided by two, for one probe in relation to the reinforcement the value is the resistance measured)

D is the diameter of the graphite cavity, 10 mm

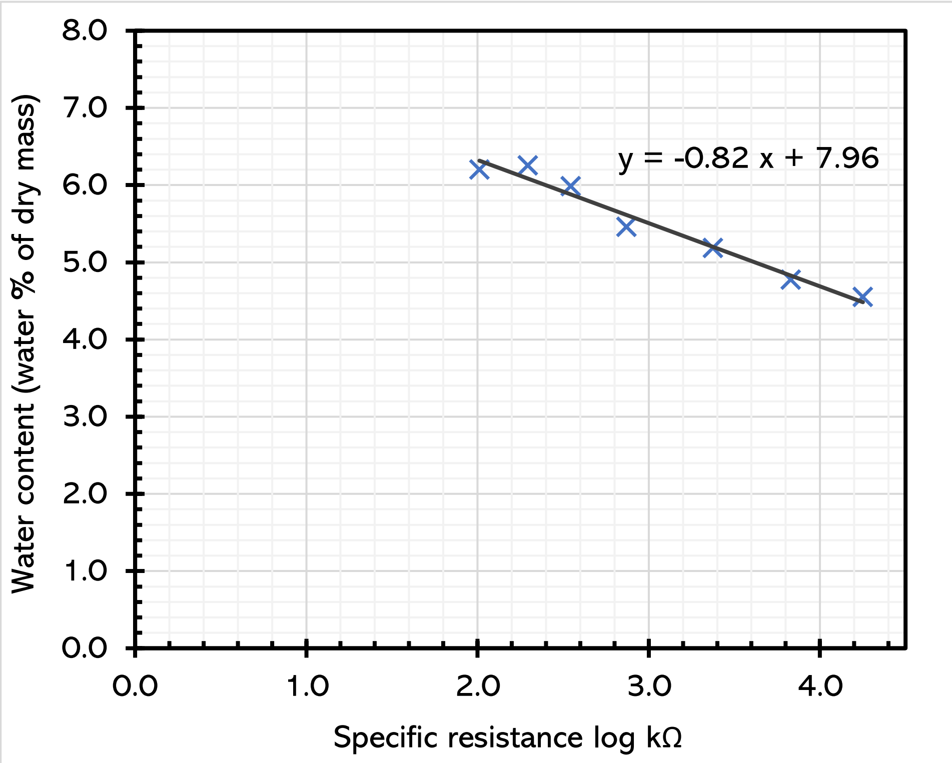
L is the length of the cavity, 10 mm

The resistivity is depending on the concretes ability to carry the electrical charge, which is depending on the moist content, the porosity of the concrete (W/C-ratio), the presence of ions such as chlorides and the temperature.

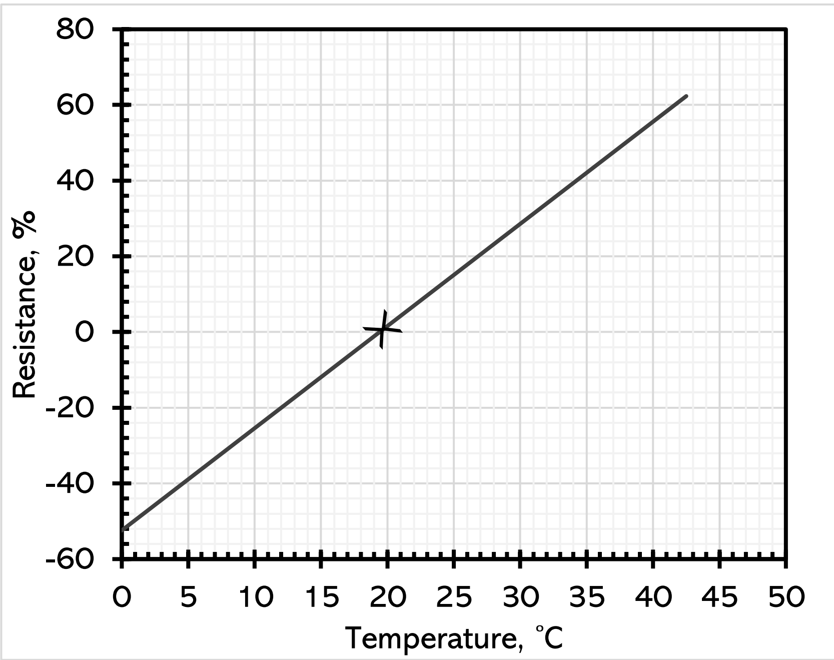
The presence of chlorides may be tested using the drill-out dust analyzed with the RCT (Rapid Chloride Test) kit. If such chlorides are present in substantial amount (more than about 0.050% chloride ions by concrete weight), the resistivity may drop by about 50%.

For a given w/c-ratio and a given chloride content, an increasing moist content and/or temperature will cause a decrease of the electrical resistance. To make accurate, absolute measurements of the moist content for a given concrete the resistivity has to be correlated to physical weight measurements of drilled out cores, before and after the cores have been dried out, at a specific temperature.

Years of experience from practice have, however, shown a fairly stable correlation for "normal" concretes between the moist content and the resistivity at a given temperature. This correlation is shown in for concretes with a W/C-ratio between 0.50 to 0.60

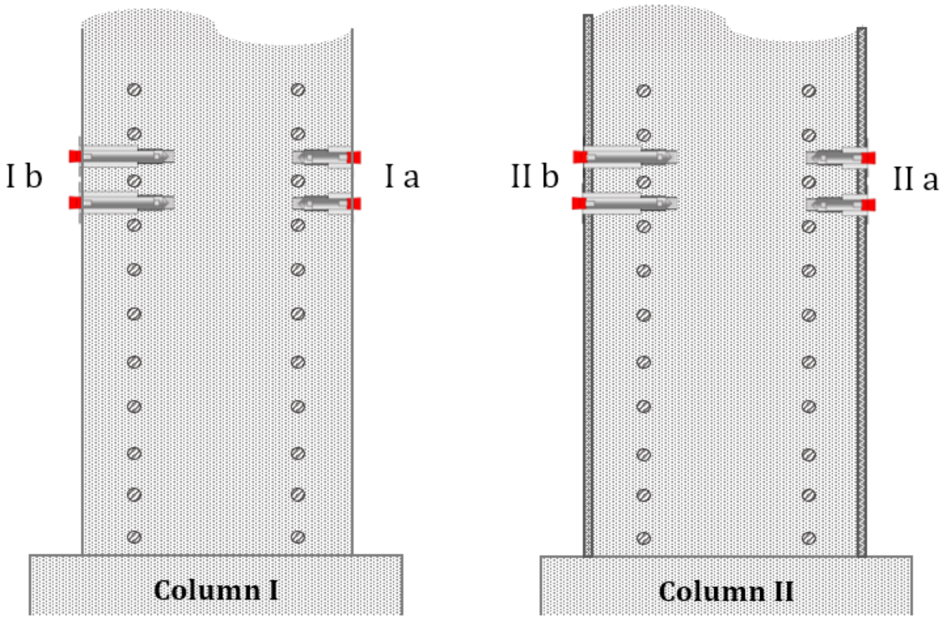


If the temperature is different from 20 °C, the correction shown has to be applied.

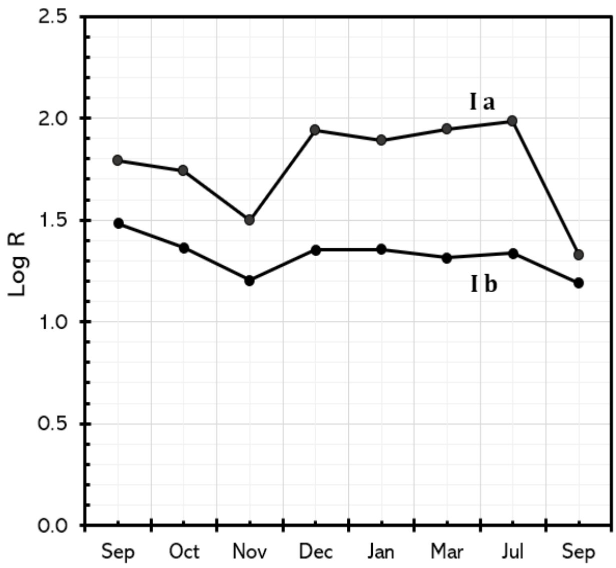


Testing example

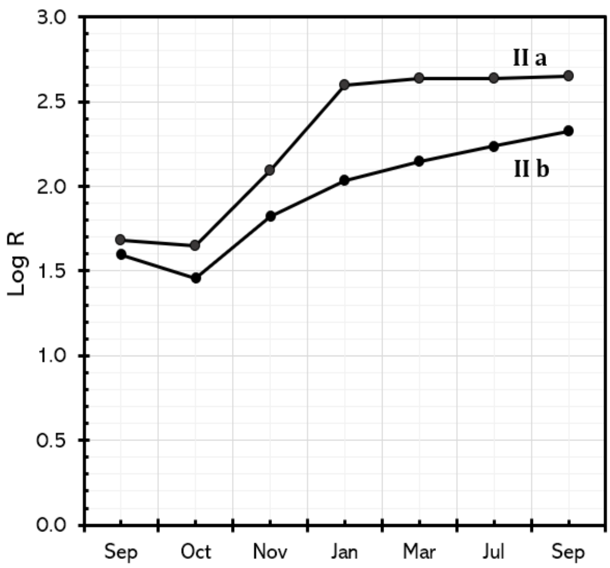
Two columns were tested over 1 year. One column was prior to the testing coated with a polymer waterproofing membrane, the other was left unprotected. Two sets of probes were installed in each of the columns, one set at a depth of 2 cm and the other at 6 cm, approximately the thickness of the cover layer protecting the reinforcement. The installment of the probes is shown below



The resistivity measurements transformed to a log-scale are shown below for a period of 12 months.



The resistivity (log-scale) of the unprotected column I at a depth of 2 cm (I a) and 6 cm (I b) over a 12-month period



The resistivity (log-scale) of the protected column II at a depth of 2 cm (II a) and 6 cm (II b) over a 12-month period

In average, the effect from the waterproofing membrane on the moist content of the concrete close to the reinforcement was measured to be a reduction from 5.8% to 4.1% in water content, after temperature corrections were made.

References

1. Nilsson, L.O.,1983 "Moisture Effects on the Alkali-Silica Reaction" , Proceeding 6TH Int.Conf. on AAR in Concrete. Copenhagen, Denmark pp 201-208
2. Stark, D. 1991."The moisture condition of field concrete exhibiting Alkali-Silica Reactivity" SP 126/52, pp 973-987, Second Int. Conf. on Durability of Concrete, Canada
3. The Danish committee for Cathodic Protection, The Danish Corrosion Centre, Copenhagen, Denmark, 1975 pp 56.
4. Henriksen, C.F.: "In-Situ Monitoring of Concrete Structures", Concrete Across Borders, International Conference 1994, Danish Concrete Association, Danish Concrete Institute, ACI, Proceedings I+II, pp. 165