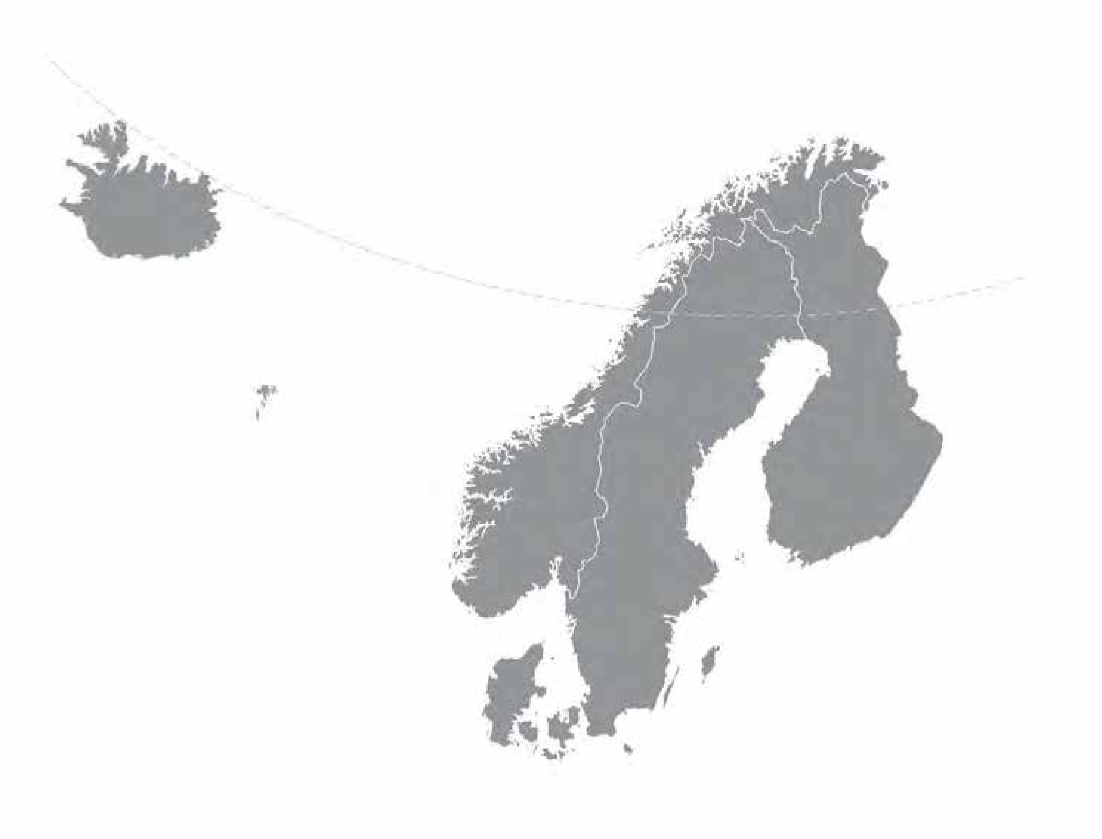
THE NORDIC CONCRETE FEDERATION 2019 Workshop Proceedings No. 13

Relative humidity (RH) in concrete

PROCEEDINGS FROM A NORDIC WORKSHOP

TRONDHEIM – NORWAY, 7. – 8. NOVEMBER 2018



NCF Nordic Concrete Federation

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WORKSHOP PROCEEDINGS NO. 13

FROM A

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Trondheim, Norway

7. – 8. November 2018

Nordic Concrete Federation

Preface

This publication contains presentations given at the Nordic workshop on *"Relative Humidity in concrete"* that was held at SINTEF in Trondheim 7. – 8. November 2018. The workshop was sponsored and organized by SINTEF.

Background and motivation for the workshop

Accurate and reliable determination of relative humidity in concrete is important for floors with various types of tight coating, but also for different research purposes in order to evaluate and compare materials, various concrete compositions, binders, surface treatments etc.

Measurement of relative humidity in concrete is not straight forward. There are different types of measuring devices available and several types of errors exist, leading to uncertain and/or unreliable results. The main purpose with the workshop is to exchange experience from the use of different RH devices and the different measuring procedures applied in lab and in-situ, as well as experience from use of concrete made with different binders and self-desiccation concrete.

Relevant topics for the workshop were:

- Requirements and experience from use of different RH measuring devices/sensors and procedures for in-situ measurements
- Experience from relative humidity measurements in the laboratory and in-situ for research purposes (incl. various sources of errors)
- Utilization of self-desiccation concrete and effect from different binders on humidity development
- The experience from the use of different computer humidity calculation programs

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CONTENTS:

Participants

Pauli Sekki, Tampere University of Technology, FI
Peter Brander, Polygon, SE
Kent Bergstrøm, Polygon, SE
Sami Niemi, Vahanen Building Physics Ltd, FI
Annika Gram, RISE, SE
Leif Wirtansen, Rambøll, FI
Stefan Nordmark, Elektrotech, SE
Jan Lindgård, SINTEF, NO
Bernt Kristiansen, AF-Gruppen, NO
Nina Plünnecke Borvik, Skanska, NO
Ola Skjølsvold, SINTEF, NO (organizer)

Presentations (enclosed in pdf-documents)

Paul Sekki: Modelling and measurement of RH in concrete

Peter Brander & Kent Bergstrøm: RH-measuring challanges. Moisture flow balance problems in vapor tight concrete & Heat effects from drilling

Sami Niemi: Finnish practice for RH measurements

Annika Gram: Zementestrich in Deutschland

Leif Wirtanen: New materials and design and the impact on RH in concrete, Finnish experience

Stefan Nordmark: The challenge of developing a moisture sensor that is cast into concrete

Jan Lindgård: Experience from RH measurements at SINTEF in general, with focus on use of Humigard

Bernt Kristiansen: Self-desiccation in concrete floors

Nina Plünnecke Borvik: Self-desiccation by the use of shrinkage reducing agents and other additives

Essence of presentations and discussions

Introduction

Questions about Relative Humidity (RH) measurements in concrete is a never-ending story both with respect to principle for measuring, equipment and accuracy. The recommended critical RH levels are the same as used the last 30-40 years. The procedures for determination of the RH in concrete have been improved over the last decades, but we are still wondering about what the real RH level in a given concrete is at a given time. At the same time, the concrete materials (i.e. type of cement, additions and w/c) and material combinations together with new knowledge have created new challenges regarding the relevance of the old critical RH levels. This was the basis for arranging a Nordic Workshop on Relative Humidity (RH) in concrete. The workshop was held at SINTEF Building and Infrastructure in Trondheim November 7th and 8th, 2018 (from lunch-to-lunch). In total, 11 participants took part.

Most presentations were connected to challenges with measurement of RH in concrete floors before applying the floor covering while other focused on the use of self-desiccation concrete. In the following a brief extract from selected presentations is given.

Principle for measuring RH

In most Nordic countries, the main technique for measuring RH in concrete (floors) is to drill holes before installing plastic tubes. Subsequently, calibrated RH sensors can be placed at the aimed depth. The RH is normally measured manually over time.

An alternative method is to collect concrete pieces from a structure, either by chopping or by drilling cores (with use of minimal water supply). In the laboratory, the collected samples are broken into smaller pieces that are put on a glass tube, before the RH sensor is installed and the glass tube is sealed and placed in a temperature stable chamber or room. This procedure is for example used extensively at SINTEF the last decade. The method is also used in Finland for documentation of RH in concrete floors, but it is banned in Sweden for floor measurements.

In Germany, different "floor concepts" and materials are used. Often, a mortar with earth-moist consistency is applied as the top layer. It is not usual to measure RH in-situ, rather (if measured) on chopped mortar lumps by use of Speedy moisture tester or similar.

Several RH sensors are also available for being cast into the concrete, but this principle and corresponding RH sensors are still not regarded accurate enough for being recommended for commercial use. Most of these RH sensors will also have problems at the highest moisture levels, and some sensors will also be destroyed if they are exposed to very high moisture levels (> 98 % RH) as you will have immediately after casting the concrete. However, in Sweden, a cast in system for wireless measurement of RH in concrete is soon ready for commercial sale. It has been difficult to find a RH sensor with satisfactory long-term durability, and it is still to see how this will work in practise.

Sources of errors – accuracy of RH measurements

Some countries allow repeatedly measurements over a long period with calibrated sensors in the same drilled hole. If the RH sensors meet the expire date (for example Humiguard sensors), they must be replaced with new sensors. However, this procedure is banned in Sweden due to the risk of permanent drying around the hole (connected to too low moist transport in low w/c concrete). Instead, new holes must be drilled if the measurements are to be continued over a long period. This conclusion is based on a Swedish study including different cement types and additives combined with a low w/c.

In Sweden, also the influence of any local heat development from different drills have been investigated. Some drills are specially designed for producing low heat development and thus to a lower extent increase the local temperature around the drill hole (that will influence the RH). "Normal" and worn drills can cause temperatures up to about 200ºC around the hole, while the temperature achieved by using specially designed drills can be as low as 50-60ºC. The local effects on the measured RH after heating to 200ºC is depended on the measurement procedure applied. It is suspected that the initial registered relative humidity will be too high.

The RH measurement procedures have changed over the last decades (separate holes for measurements over time, the time elapsed before stable readings etc), but as far as floor coating is concerned, the critical RH levels correspond to those used 30-40 years ago. At that time, the measuring procedures were hardly accurate enough to distinguish between smaller RH differences in concrete and thus to accurately measure whether the concrete floor was dry enough for starting the flooring process. It is thus expected that a lot of incorrect measurements have been conducted over the years and consequently that the floor covering was placed on "too wet" concrete. However, since the concrete normally used was rather open (high w/c), after a period of drying it was able to absorb some of the extra water supplied by the glue (and screed). In many cases, this absorption was enough for preventing problems with loss of adhesion and emission from the glue. Inaccurate measurements have therefore not necessarily caused problems.

Accurate measurements of the moisture and moisture development over time will still be an important issue in research and development purposes, for example when the effect from different moist reducing efforts is to be studied. We should therefore not stop improving various systems for RH measurements, rather continue to investigate how to perform more accurate and reliable RH measurements in concrete.

Critical moisture levels for various floor coatings – risk of emission from the glue

For many floor coatings the critical moisture level is usually 85 % RH, i.e. the concrete floor must dry out to a level below the "equivalent RH" before flooring. These requirements only differ slightly between the Nordic countries. For example, in Finland the requirement is 75 % RH at depth 10-30 mm (w/c applied is typically 0.6-0.7) and 85-90 % RH in larger depths dependent on the coating type. The 85 % limit is an old criterion, and this value is hardly valid for all coating materials, in any case not for all types of coating, glue, screed and concrete combinations. A modernization of this value that takes these new materials (new binders and low w/c concrete) and material combinations into account is long overdue. Example; will the moist level for all new concrete recipes ever reach as low as 85 % RH, which they according to traditional calculations should? Some measurements indicate that this RH level is hard to fulfil.

The glue applied is usually not alkali resistant. Thus, some problems are expected with the introduction of new binders (more tight concrete) and water-based screeds and glues. Often, the coatings applied are also tighter than the previous types. Consequently, any excess water from the glue will not or only to a minor extent evaporate through the coating material. In Finland, the w/c normally used in concrete floors is 0.6-0.7, i.e. a rather open concrete that can absorb some excess water from the glue. This is expected to give less problems than for example in Sweden, where the w/c normally is well below 0.4.

In Finland, the number of cases with too high RH when applying floor coating and the consecutive problems with too high emission values is usually low. However, indoor climate is a difficult topic and some problems are still reported. A low number of reported damages is also the situation in Sweden, while only a few problems are reported in Norway. But, before concluding about the extent of coating problems and on the reasons for these problems, a more comprehensive survey/review should be performed.

Use of low w/c concrete – self-desiccation

The self-desiccation for concrete can be calculated. Theoretically, a CEM I (OPC) concrete with w/c 0.4 will achieve a long-term relative humidity of about 75 %. In many cases, an epoxy coating can be applied within the first day when the temperature passes the maximum peak. Due to the "vacuum effect" (i.e. the concrete is in a suction state during the first day of hydration), the adhesion will be excellent, and the concrete moisture will not cause any problem when low w/c concrete is applied. In such cases there is no need for documentation by measurements of RH.

The use of self-desiccation concrete and the RH-level achieved is, however, disputed. On the one hand, accurate measurements are no longer necessary as these concretes are so tight that they do not expel any moisture in any case, and a moist profile is not likely to be achieved. On the other hand, these tight concretes without a moisture profile will hardly absorb any moisture from the screed and the glue. Thus, any water in the layer between the concrete and a tight coating will not have anywhere to go and might therefore cause problems if the glue contains water and is not alkali resistant.

However, theoretically all problems should be solved provided low w/c concretes are applied and the layer between the coating and the concrete (screed and glue) contains very little water.

Computer programs

Different computer programs exist for calculation of the RH development during drying. The accuracy of these calculations for new binders and "modern" concrete recipes are, however, disputed. In Finland, efforts are taken aiming to develop more accurate models for predicting the moisture development. The results are promising, but the work is far from completed. One of the major challenges is to make accurate measurements for calibration of the calculated values.

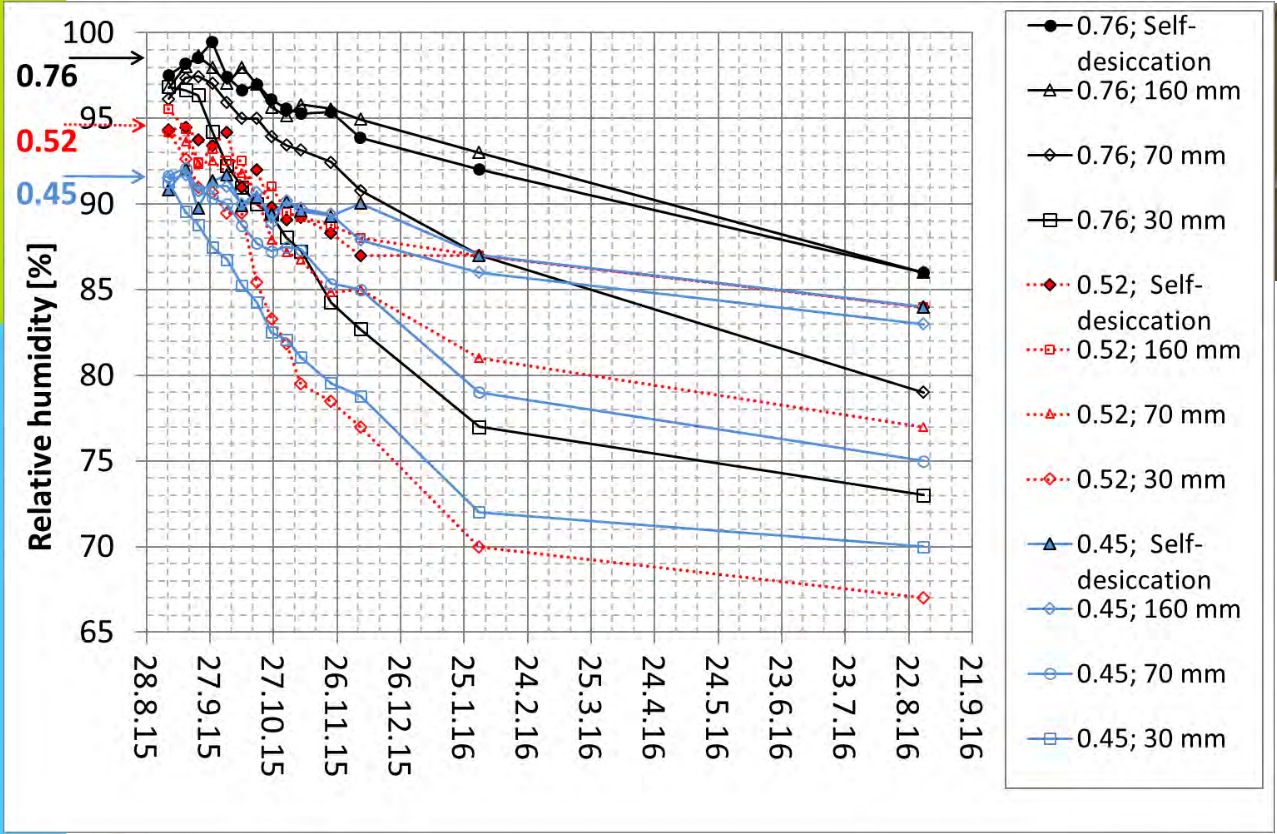
Modelling and measurement of RH in concrete

NORDIC Workshop on RH in concrete - Trondheim, November 7th - 8th 2018

Reasons for modelling?

- Geometry 2D and 3D
- Self-desiccation
- Temperature dependence
- Simulation of the construction phases

Hydration heat and moisture sink



Energy and mass balance equations

$$\rho C_p \frac{\partial T}{\partial t} = \nabla \cdot \left[k \nabla T + L_v \delta_p \nabla(\phi p_{sat})\right] + Q$$

$$Q = H_u \frac{d\alpha}{dt}$$

$$\xi \frac{\partial \phi}{\partial t} = \nabla \cdot \left[\xi D_w \nabla \phi + \delta_p \nabla(\phi p_{sat})\right] + S$$

$$S = -\rho_s M_{f,cem} w_n \frac{d\alpha}{dt}$$

Degree of hydratation and equivalent time

$$\frac{d\alpha}{dt} = \exp\left[\frac{E}{R}\left(\frac{1}{T_r} - \frac{1}{T}\right)\right] \frac{\alpha_u \beta}{t_e} \left(\frac{\tau}{t_e}\right)^{\beta} \exp\left[-\left(\frac{\tau}{t_e}\right)^{\beta}\right]$$

$$\frac{dt_e}{dt} = \exp\left[\frac{E}{R}\left(\frac{1}{T_r} - \frac{1}{T}\right)\right]$$

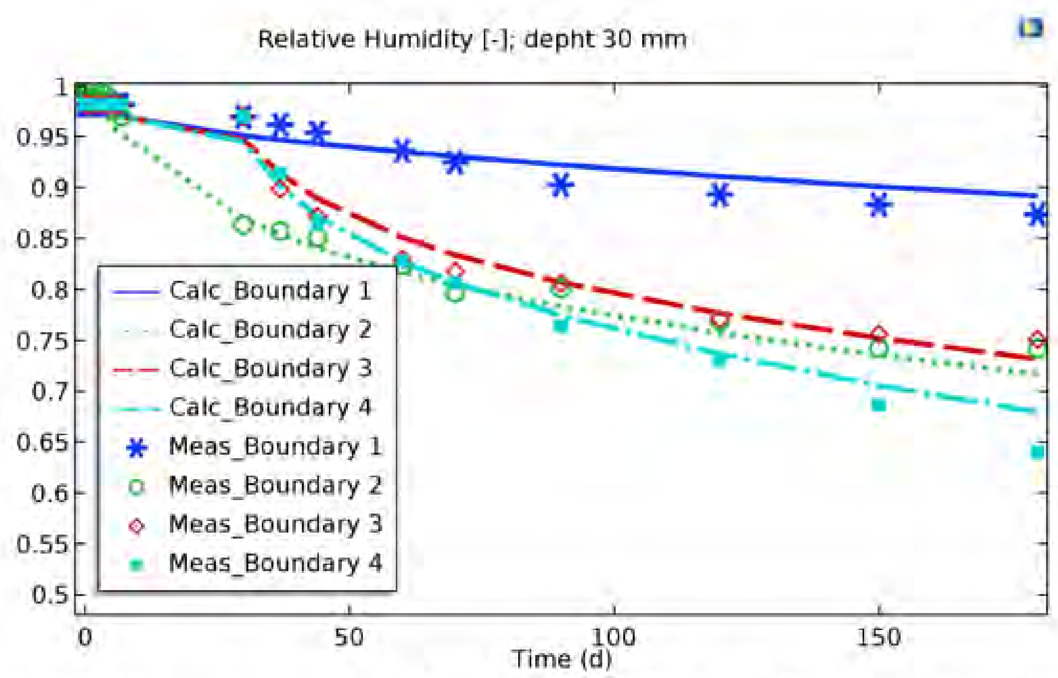
Diffusivity

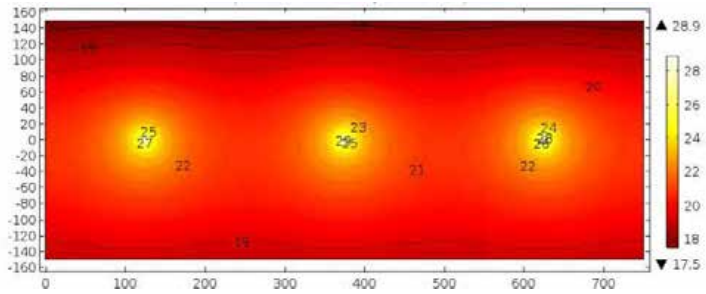
$$D_w = C_1 \left\{\alpha_0 + (1-\alpha_0) / \left[1 + \left(\frac{1-\phi}{1-\phi_c}\right)^n\right]\right\}$$

Optimized parameters: β, τ, C_1, α_0, ϕ_c, n

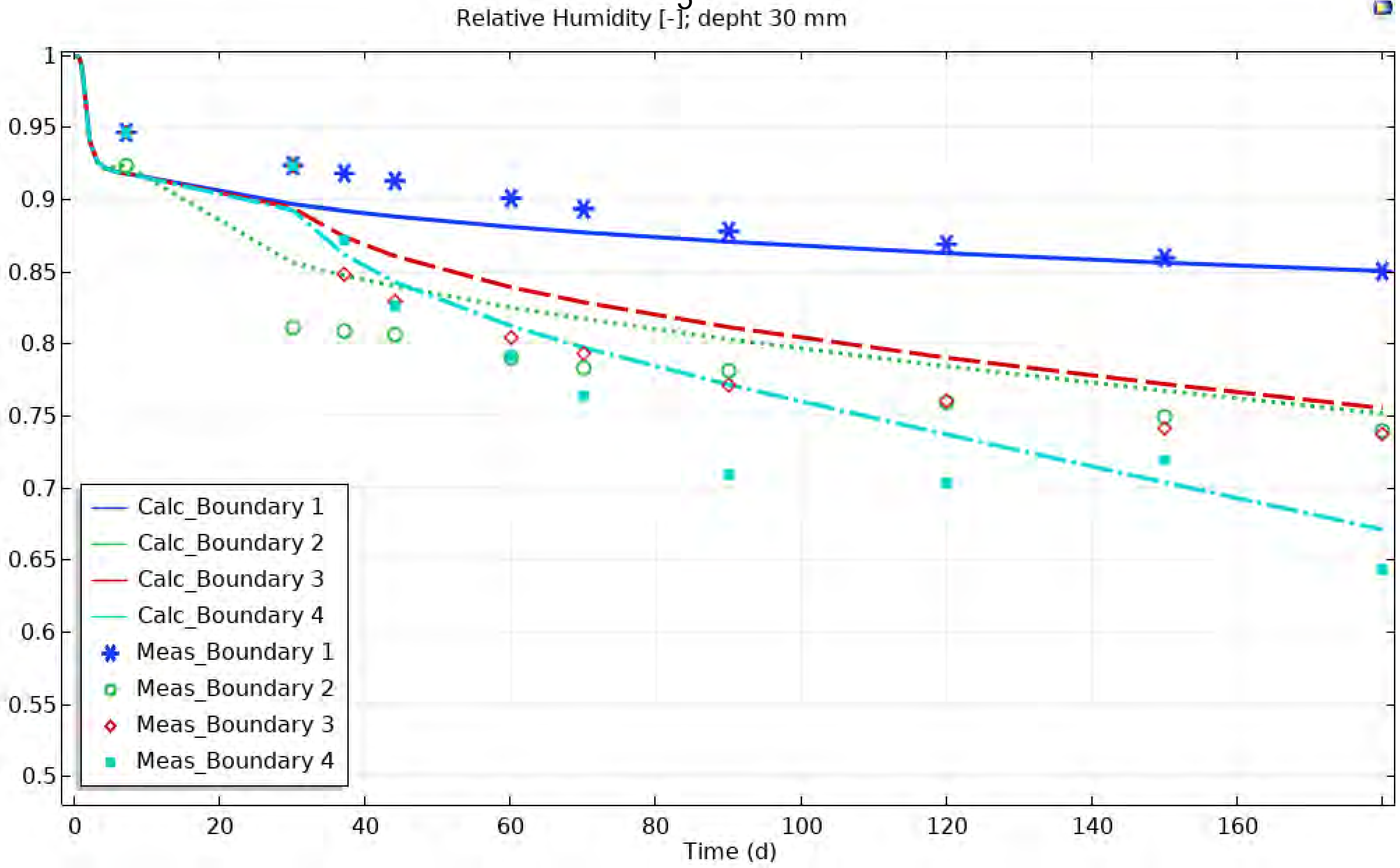
// NSB2017 Sekki & Karvinen //

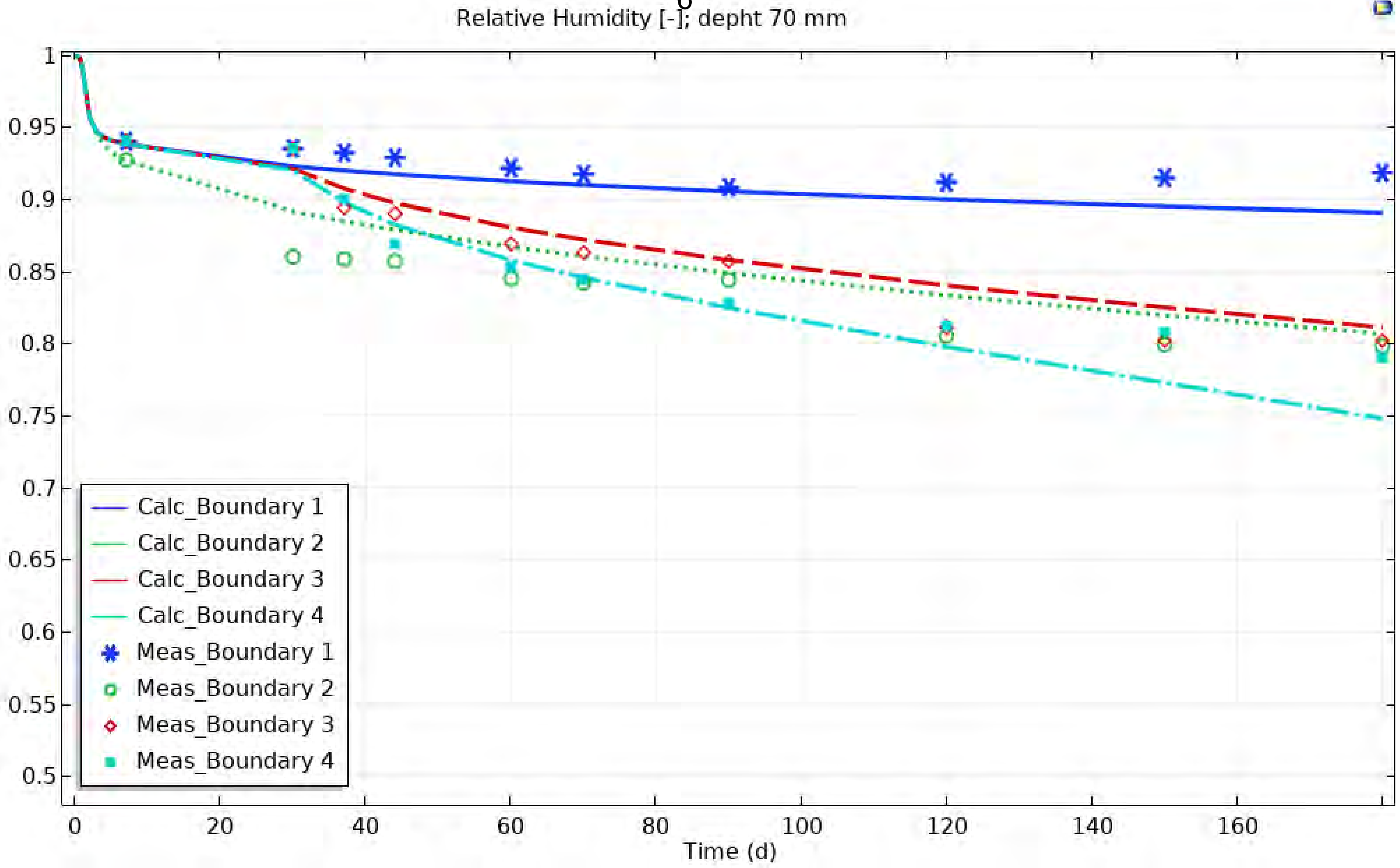
Temperature dependence

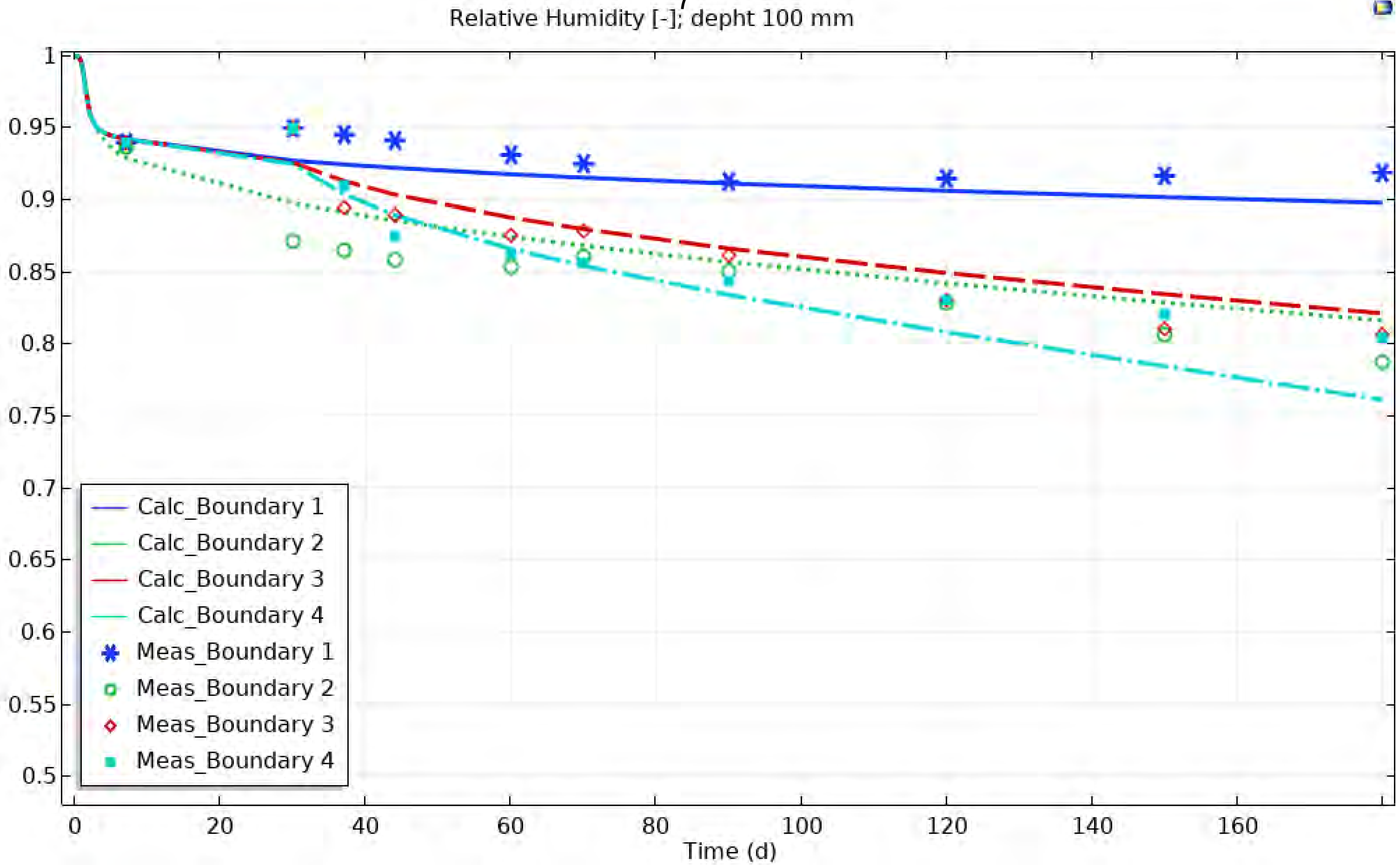




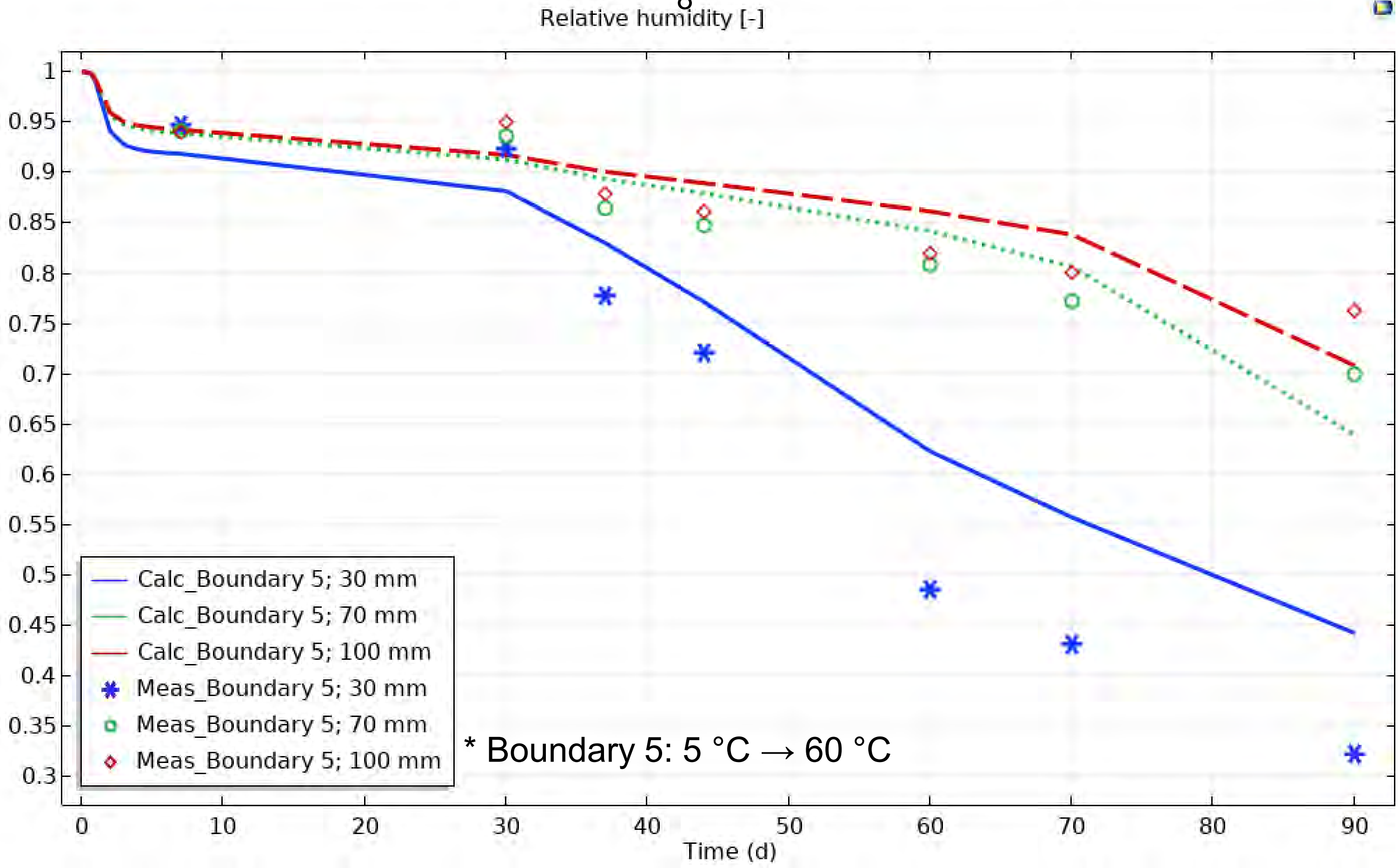
Kuva 3.10. Mallinnettu kuivuminen 30 mm syvyydellä C betonilla. Käyrien nimeäminen edelle esitetyn mukaisesti (Boundary 1 = 5 ℃, Boundary 2 = 23 ℃, Boundary 3 = 5 ℃ → 23 ℃ ja Boundary 4 = 5 ℃ → 30 ℃). // Timo Korkalan, master thesis 2018 //


Relative Humidity [-]; depht 30 mm
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0
20
40
60
80
100
120
140
160
Time (d)
Calc_Boundary 1
Calc_Boundary 2
Calc_Boundary 3
Calc_Boundary 4
Meas_Boundary 1
Meas_Boundary 2
Meas_Boundary 3
Meas_Boundary 4

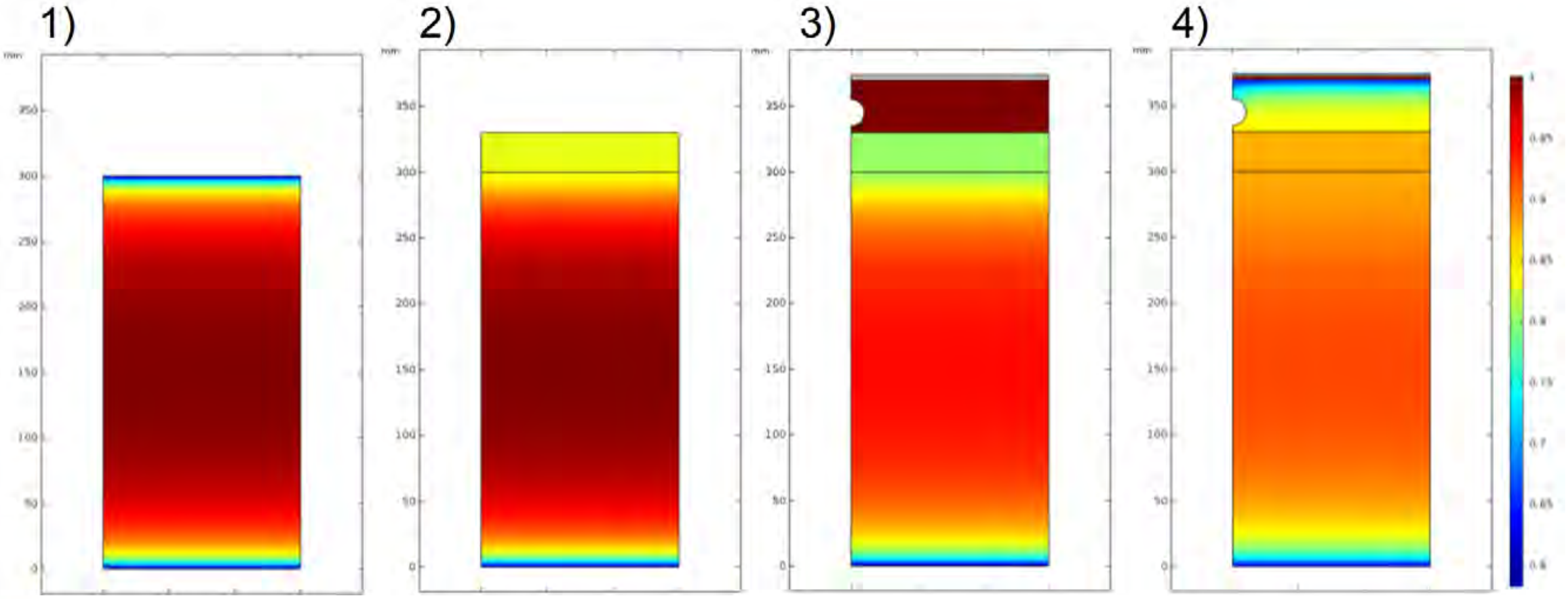

Relative Humidity [-]; depht 70 mm
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0
20
40
60
80
100
120
140
160
Time (d)
Calc_Boundary 1
Calc_Boundary 2
Calc_Boundary 3
Calc_Boundary 4
Meas_Boundary 1
Meas_Boundary 2
Meas_Boundary 3
Meas_Boundary 4



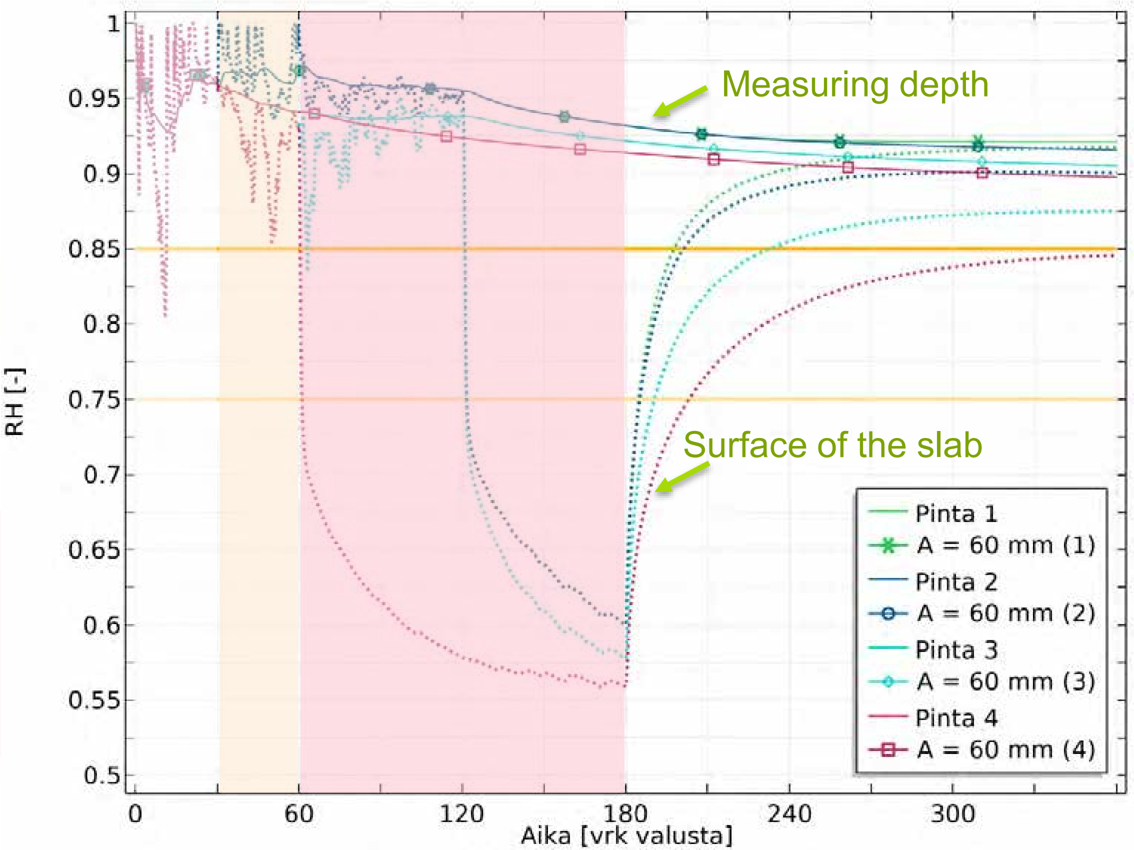
TAMPEREEN TEKNILLINEN YLIOPISTO


Relative humidity [-]
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0.45
0.4
0.35
0.3
0
10
20
30
40
50
60
70
80
90
Time (d)
Calc_Boundary 5; 30 mm
Calc_Boundary 5; 70 mm
Calc_Boundary 5; 100 mm
Meas_Boundary 5; 30 mm
Meas_Boundary 5; 70 mm
Meas_Boundary 5; 100 mm
* Boundary 5: 5 °C → 60 °C

Modelling ”Layer cake”



Constuction phases



1. Minimum effort
2. Flooring material
3. Shorter wetting time
4. Shorter wetting time and more time for drying

Exposed to rain

Exposed to humid condition

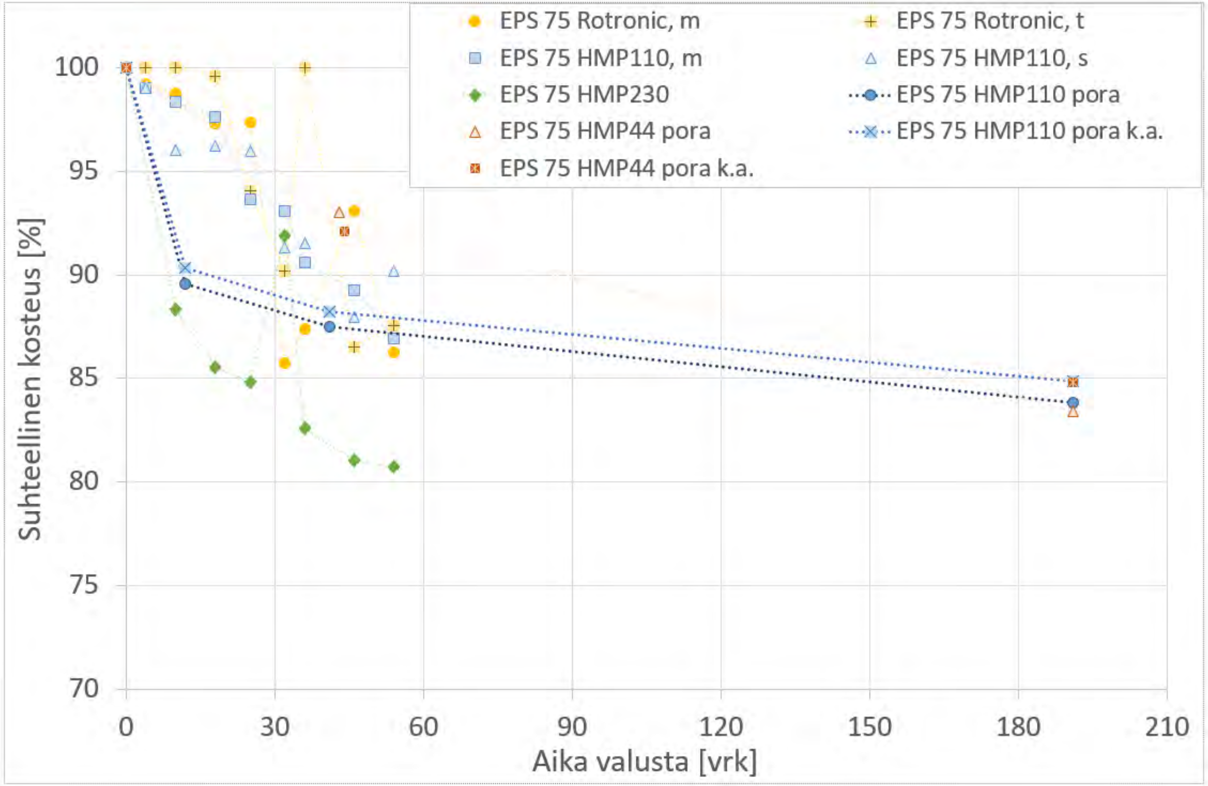
Drying condition

Testing and measuring

1. **Material properties**
2. **Moisture measuring**

www.tut.fi/rakennusfysiikka/combi

The Challenges of Measuring Moisture



1. Devices
2. Measuring methods
3. Temperature
4. Errors in several places

hoping to get some new ideas!

pauli.sekki@tut.fi

RH-measuring challenges

Moisture flow balance problems in vapor tight concrete

Heat effects from drilling

Trondheim 20181107

Kent Bergström, Johan Tannfors,
Peter Brander (until 20180801)
Lars-Olof Nilsson, Moistenginst AB
Field operatives

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Polygon/AK (regarding concrete)

- 33 RBK technicians
- Specialists in moisture safe design
- Specialists in moisture safe construction
- Laboratory capabilities
- Temporary climate soloutions
- Moisture damage control, investigation, mitigation

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It started out with a tool to evaluate field data High readings and fast drying with low wcr?

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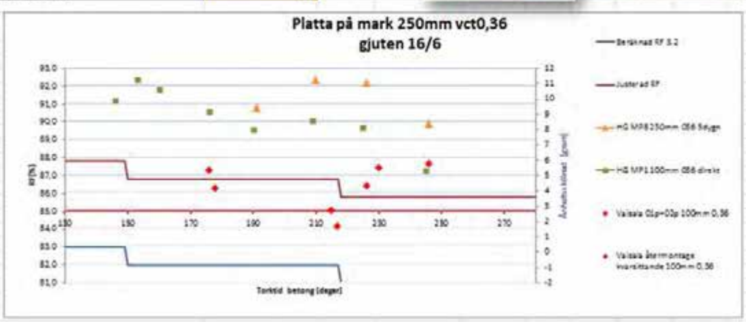
We noted big spread in readings (low wcr with ongoing screeding)

vct	0,36	
påslag vct 3,2 [%RF]	4,8	
påslag RBK osäkerhet[%RF]	0	
Påslag drift skiljer från 20 grader [%RF]	0,0	
Påslag avjämning [st dagar]	0,0	
Påslag försenad/forcerad torkstart [st dagar]	0,0	
ant. Torkmiljö [grader temp], [%RF]	24	60
ant. ånghalt 85 [g]	5,3	
ant. ånghalt 90 [g]	6,4	
ant. ånghalt 95 [g]	7,5	



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Crawled before we tried to run

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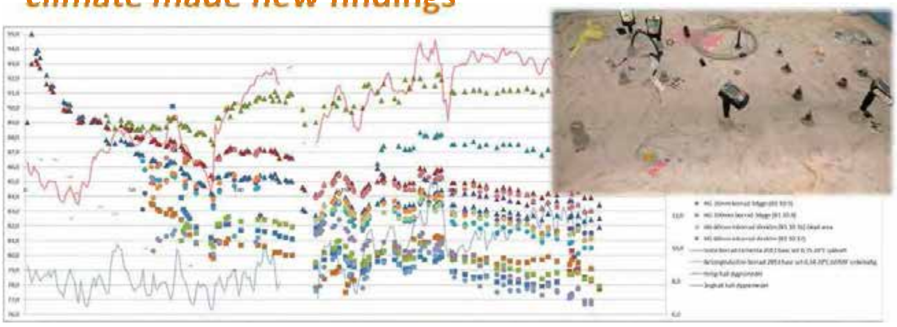
And then we made some more tests, and some more, and some more and… 2 years running now and still testing. What we found needs repeated readings over time to be able to see. Trends and behaviour not values put us on the right track. Mimicking field climate made new findings



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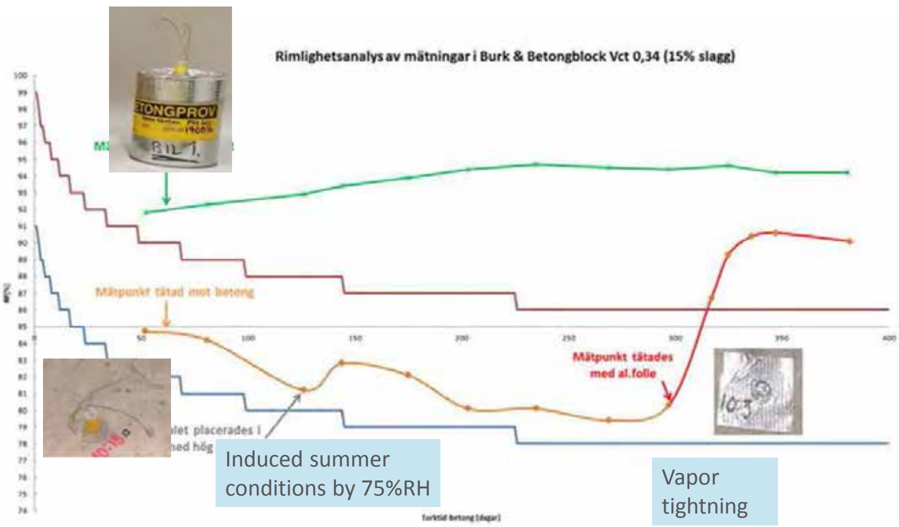
And it got really interesting.



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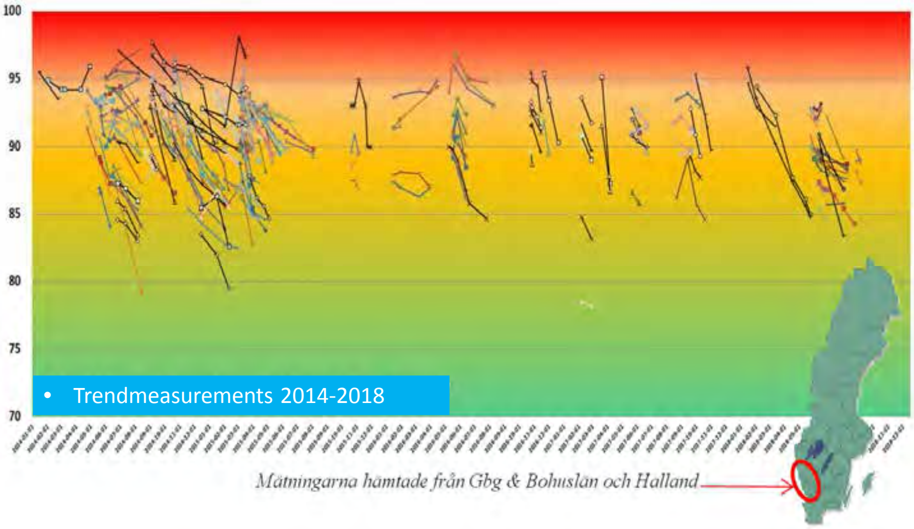
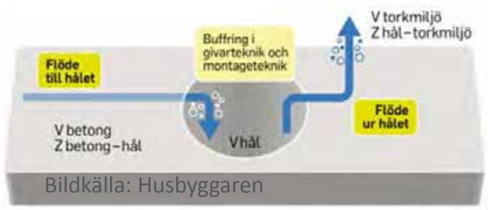
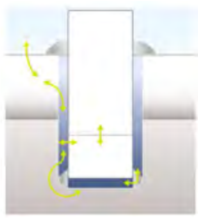
It matched in situ data (2014-2018 900 readings)



Flow balance = we will always miss the target





RH/vapor gradient	Relative resistance in concrete	relative resistance in sleeve	Measured value inside hole (concrete 85%RH)	Season effects
20°C 85-20 RH	1	200	84,7	Winter
20°C 85-20 RH	1	100	84,4	Winter
20°C 85-20 RH	1	10	79,1	Winter
20°C 85-60 RH	1	10	82,7	Summer

10

The ”balance error” will typically increase over time and vary by drying climate.

Will change by temperature (vaporcontent in concrete)

With decreasing total vapor gradient the error can vanish

Will change by vapor content in air

85% | Vapor gradient (concrete /hole) | 84,99999? | Vapor gradient (hole /drying climate) | 20%

Concrete resistance | Sleeve resistance

Will always increase by time due to drying of the surface in the hole and by maturing processes in the concrete that add resistance. Will decrease with higher temperature.

Can decrease by time due to mechanical damage… Decrease in vapor open materials

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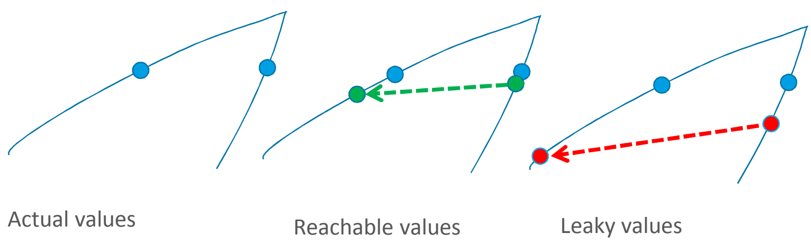
Leakage and resistance will effect how flowbalance is reached



We will always target **absorption first**. To reach desorption we need the surface in the hole to start drying. This will introduce a moisture profile in the hole that will increase the balance error. When desorption balance is reached is hard to predict and evaluate. The measured RH error can be huge if the desorptionisoterm is flat and the sleeve fitting is leaky.

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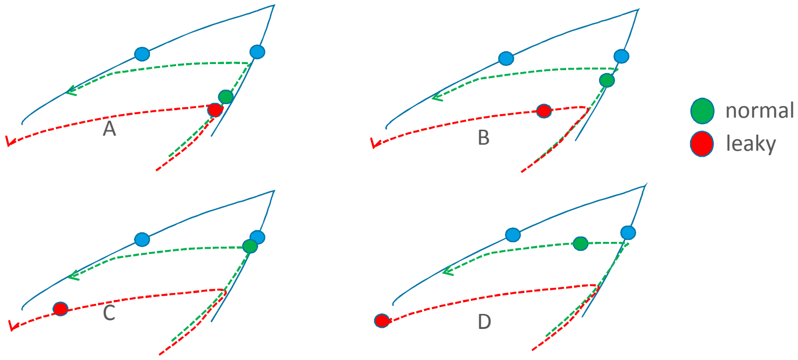
The timeframe depends by diffusion to and from the hole and also include buffering effects



Better sleeve techniques have transformed normal readings from red towards green. High sensor buffering will also slow down the absorption process and promote lower early readings . Note! No drying of concrete in this example.

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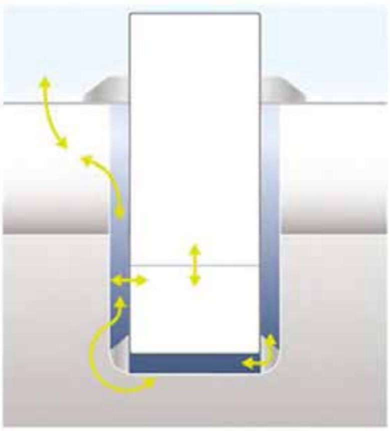
We get vapor transport around fittings (throgh concrete) and towards the vertical moisture profile



Leakage throuh levelling products was found to add big balance error.

Too high readings if wet
Too low if dry !

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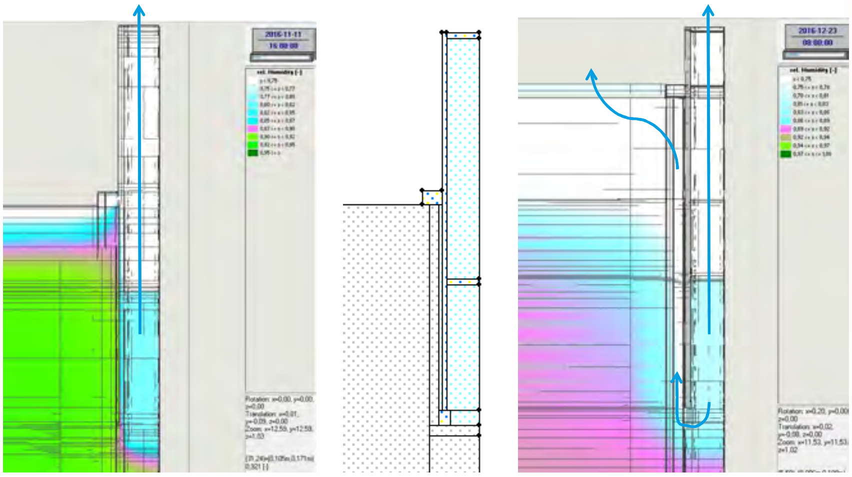
It´s possible to model the behaviour



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Left with no sleeve leakage in concrete
Right adding vapor open screed and airgap between sleeve and concrete

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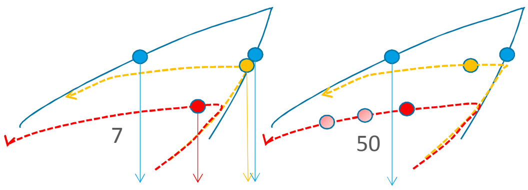
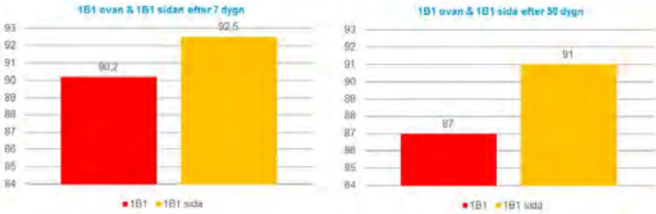
Steel jars from top and side 7 and 50 days, at same depht



Note: Not the actual moisture level that is measured. Moisture in the surface of the hole minus balance error is measured.



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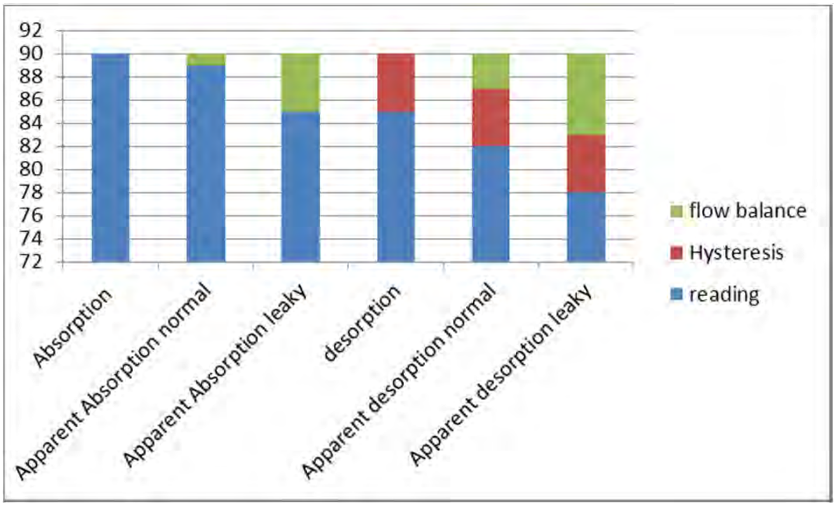
Flow balance issues will result in different readings



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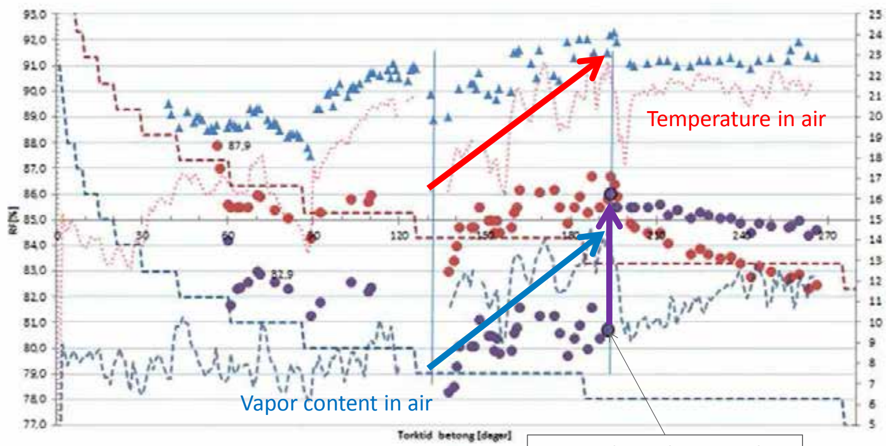
If the balance is changed after a formed drying profile in the hole we get change in readings



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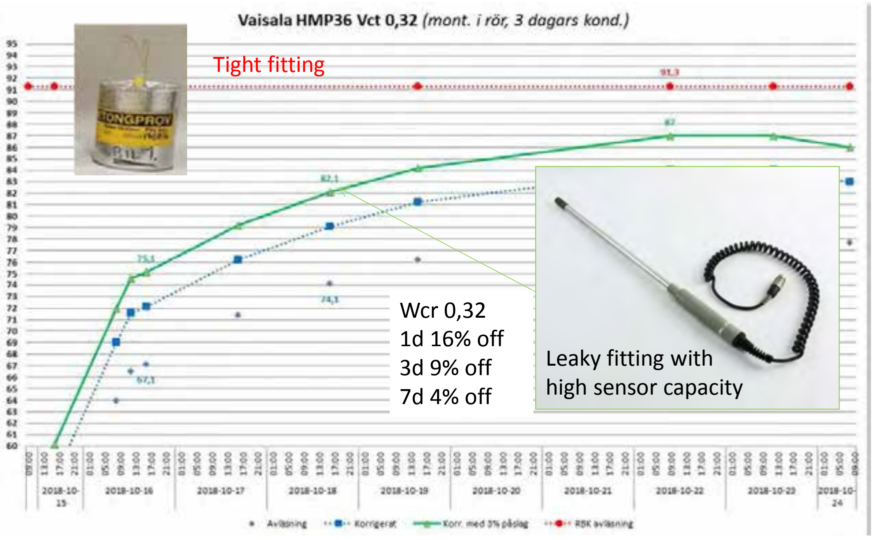
The good old days when concrete dried by itself?



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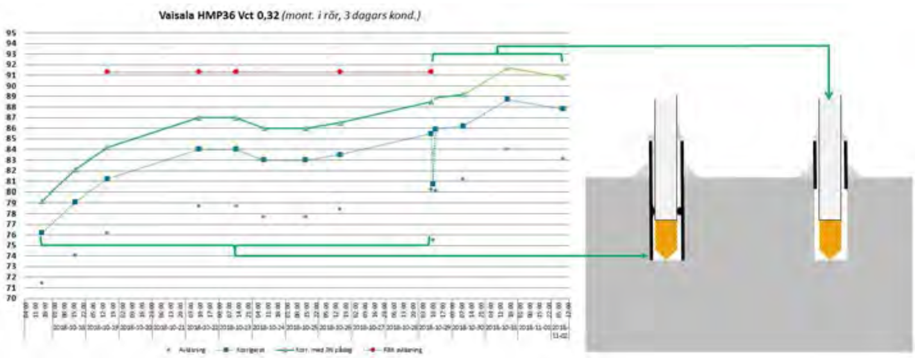
19

Or not?



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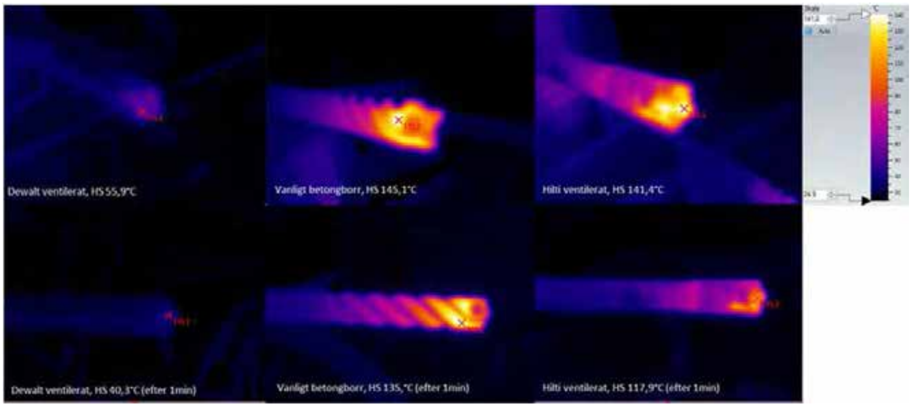
Heat effects will add issues



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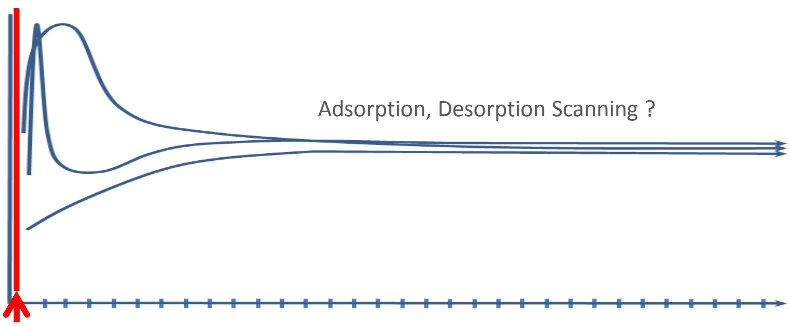
When does it happen?



- Three different flow balance behaviour depending on drillbits

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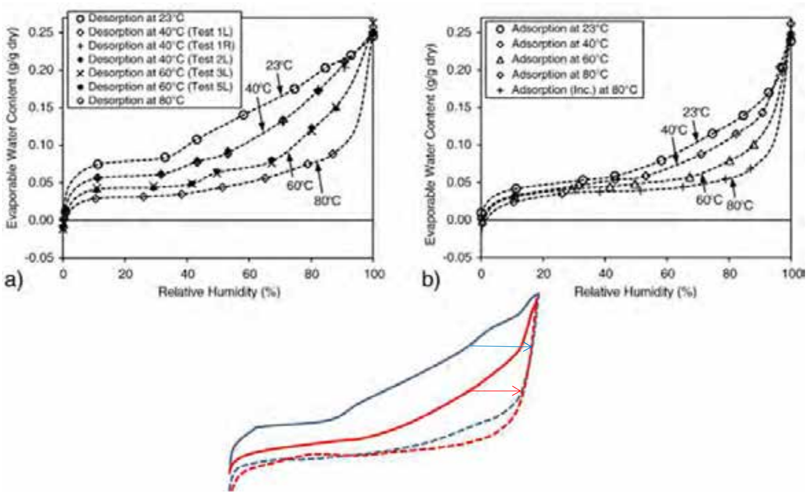
Concrete loose moisture capacity when heated (and loose vapor balance issuses?)



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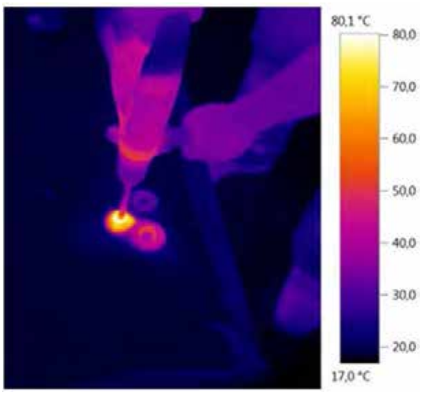
Drilling several holes in sequence (profile drilling) or deep holes will increase energy transfer. Low wcr concrete will get warmer (harder).



Depth [mm]	New drillbit [°C]	Weared drillbit [°C]
50	88	114
100	89	177
150	94	191

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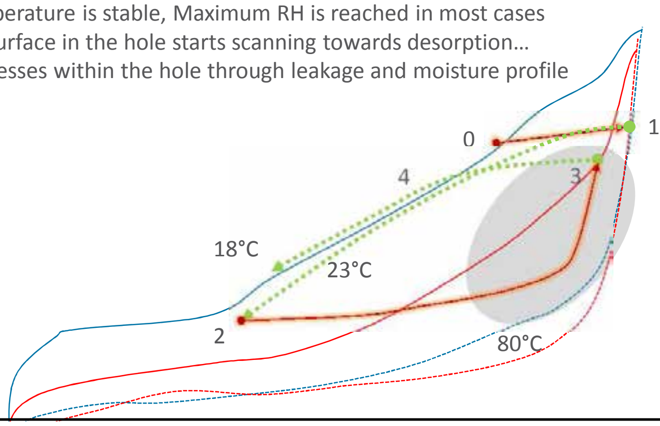
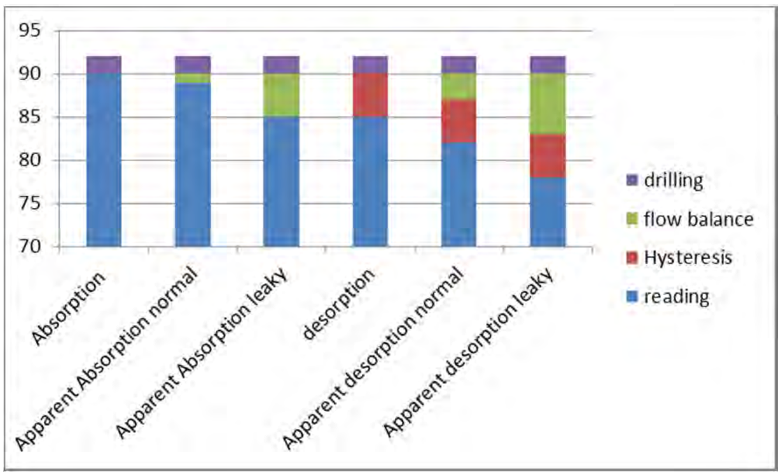
Heat effects when drilling without cooling

- **0-1 (appr. 30s)** Drilling (rapid heating, possibly additional moisture to holesurface from drilldust, high vapor content, steep vapor and heat profiles)
- **1-2 (1-10min)** Cleaning (rapid cooling and surface drying, recondensation in porestructure, steep vapor and heat profiles)
- **2-3 (0,1-3h)** Capped hole (surface is rewetted from within concrete, concrete is still cooling near the surface)
- **3 (3-48h)** Temperature is stable, Maximum RH is reached in most cases
- **3-4 (3h-14d)** Surface in the hole starts scanning towards desorption…
- **4** Drying progresses within the hole through leakage and moisture profile development.



Adding heat increase early readings, possibly mainly by better flow balance (higher vapor pressure)



High early readings often described as a drill error to wait for. Compared to capped steel jars it´s probably mostly absorption reading. More exposed concrete area and improved fitting delayed desorption

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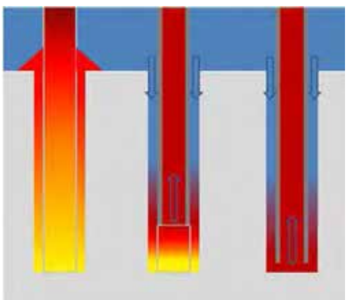
Drillbit strategy can change the intial conditions



Depth [mm]	Hilti 16mm [°C]	Hilti cooled [°C]	Dewalt cooled [°C]
60	55	34	26,8
100	59	34,8	26,2
150	65	35,2	28,1

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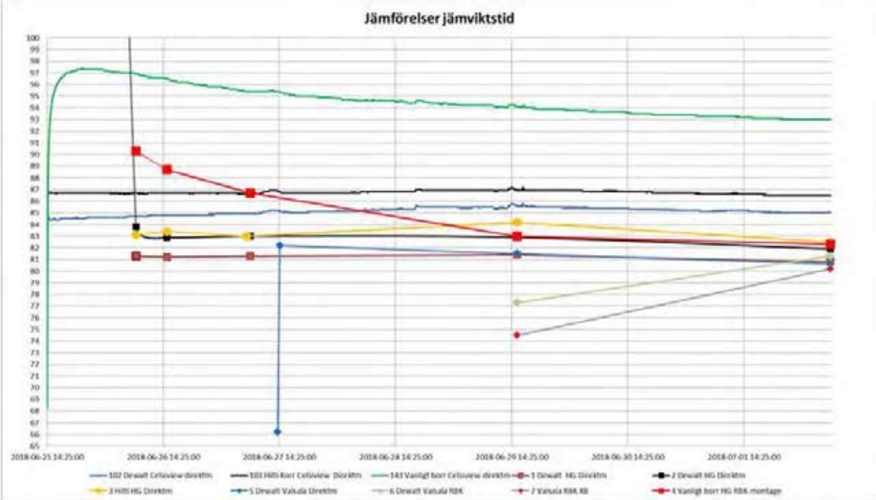
Change in behavior due to cooling and conditioning, different sensors. Early balance



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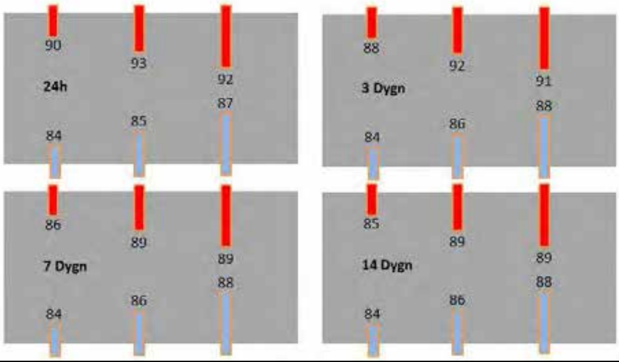
Horizontal drilling in a testbed (sholdn´t have a profile) different drill depths 50, 100, 150mm, warm vs cooled. Depth increase exposed concrete area!

Wcr 0,34,
15% slag
1,5 years old



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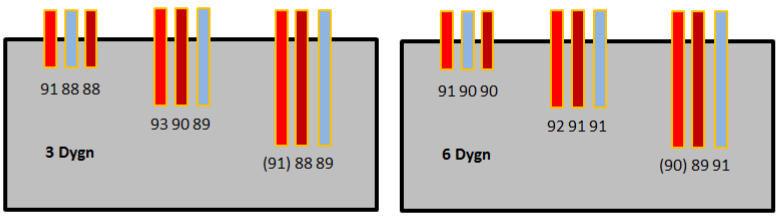
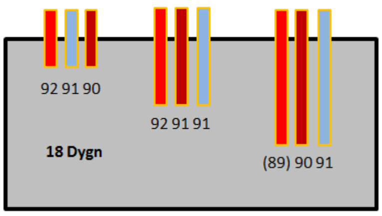
Old warm drilling in capped jars (dark red new sensors) vs New cooled (blue) and new varm (light red), 50, 100, 150mm drill depth.





With tight sleeve fittings we get no effect from drilldepth!
( ) probably leaky

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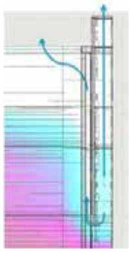
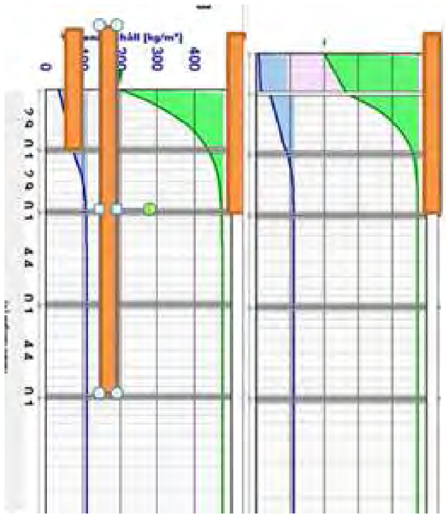
Measured profile probably often something else than drying?





Different drilldephts will show different vapor gradient towards the lower sleeve fitting and change the balance

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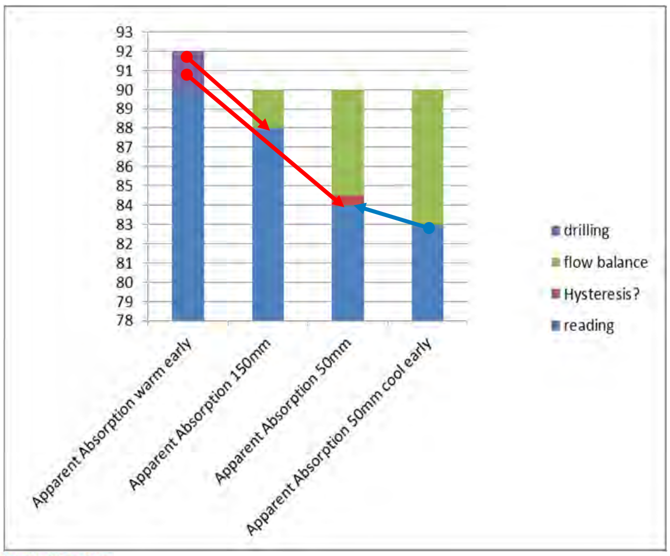
Could it be absorption readings altogether?



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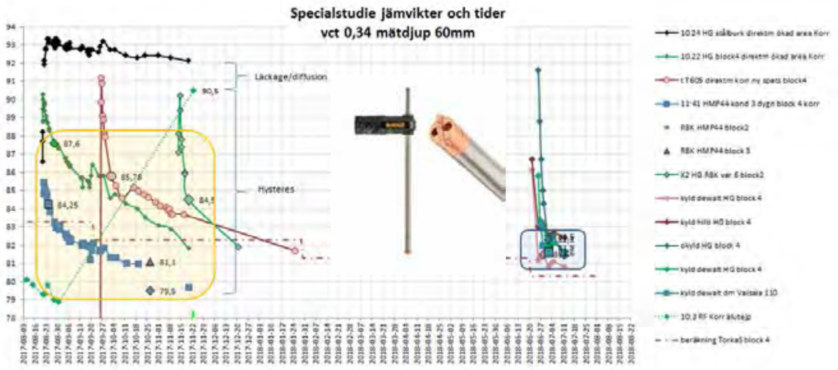
Cooled drilling without extra area is much faster to desorption readings (– extra balance error?)



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Conclusions

Challenges

- Risk = absorption situations
- Moisture flow balance needs to be better explained in standards.
- Heat effects when drilling need more testing to quantify
- Temperature effects in service is not fully explained yet, underfloor heating?
- Critical moisture limits on which sorptioncurve or both? Measured how? for which temperature?
- Desorption readings need leaking sleeves. Desorption readings include very flat scanningcurves which make it harder to get repetable readings with low wcr.

Possibilities

- We can use loggers to se trends
- We can reach fast flow balance on absorption (few hours)
- We can force readings near desorption fast by cooled drilling or crushed samples.
- We could adress moisture flow more than RH.
- We can make holes without adding heat.

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The actual risk depends on several additional factors. This is what we probably should discuss.

- climate above
- flooring
- adhesive
- levelling products
- concrete
- additional design layers
- climate beneath

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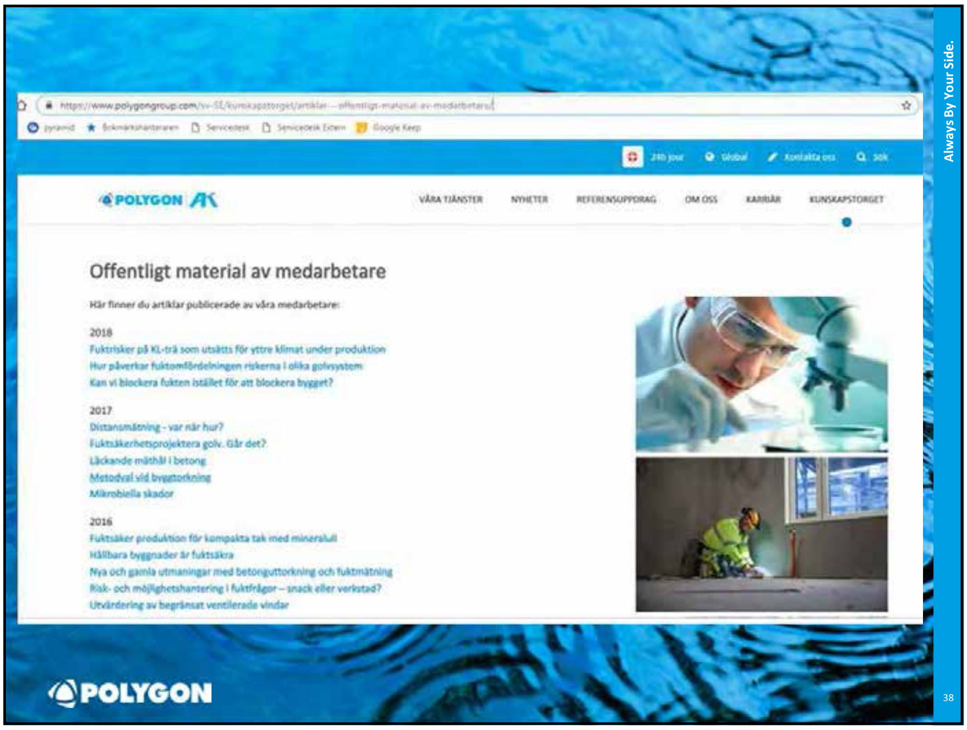

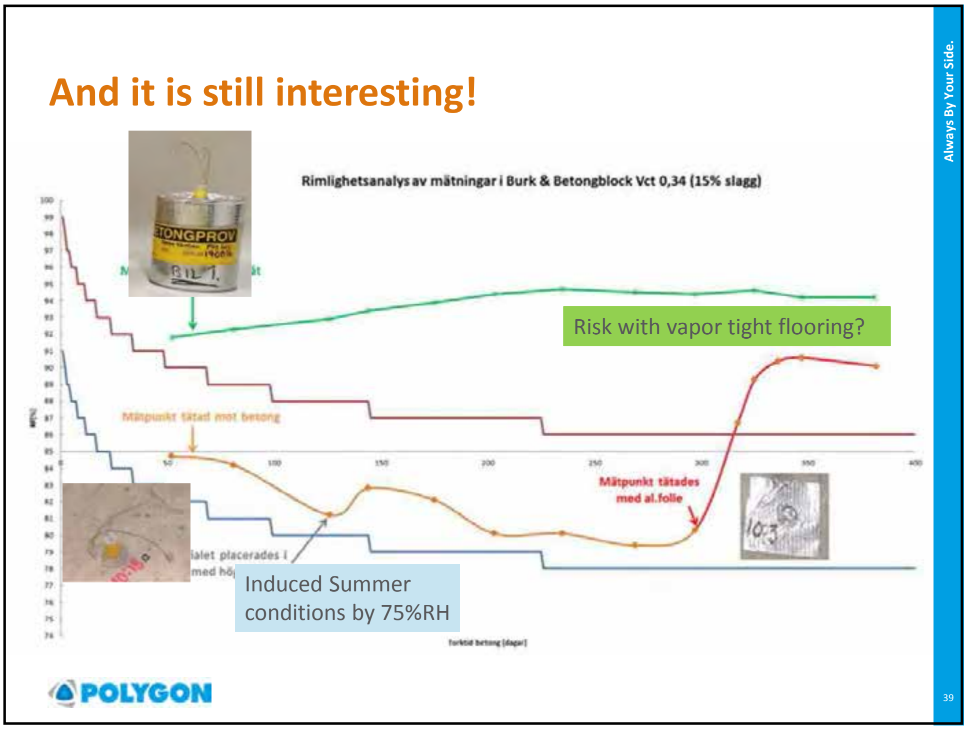
And it is still interesting!
Rimlighetsanalys av mätningar i Burk & Betongblock Vct 0,34 (15% slagg)
Risk with vapor tight flooring?
Mätpunkt tätad mot betong
Mätpunkt tätades med al.folie
Induced Summer conditions by 75%RH
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NORDIC Workshop on RH in concrete
Trondheim 7. – 8.11.2018

Finnish practice for RH measurements

Sami Niemi, M.Sc.
Vahanen Building Physics Ltd
VAHANEN

CORNERSTONES OF TODAY'S CITUATION IN FINLAND

- Vaisala and VTT since 80's
- 1995 learn from Sweden *(Humittest Ltd, joined Vahanen at 2006)*
- 1998 RT-instruction card *("normal quality of construction")*
- 2003 start of teaching of certified measurers *(VTT, Humittest/ Vahanen)*
- 2007 construction industry's measurement guidelines
- **2010** RT-instruction card = PRACTICAL
- 2010's focus has been in common moisture control of constucting

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RH MEASUREMENTS IN CONCRETE (RT 2010)

- Practical guide to get proper enough readings
- Exact measurements (10 of 16 pages about one RH-reading)
- Directional measurements
- Factors affecting measurement accuracy
- *Measurement before coating and coating rating*
- *Research of the finished structure*


RT

BETONIN SUHTEELLISEN KOSTEUDEN MITTAUS

BOREHOLE METHOD

- Temperature 15 … 25 °C
- If not in a hurry – easily lot of measuring spots

SAMPLE METHOD

- Temperature -20…80°C
- Poor conditions (hot or cold concrete)
- Better accuracy - more difficult, but the result becomes faster

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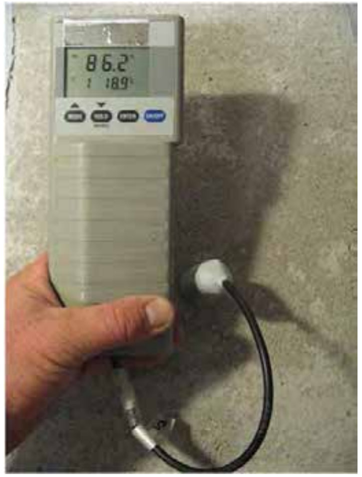

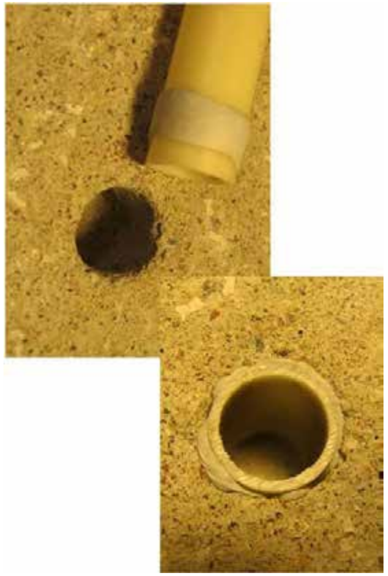

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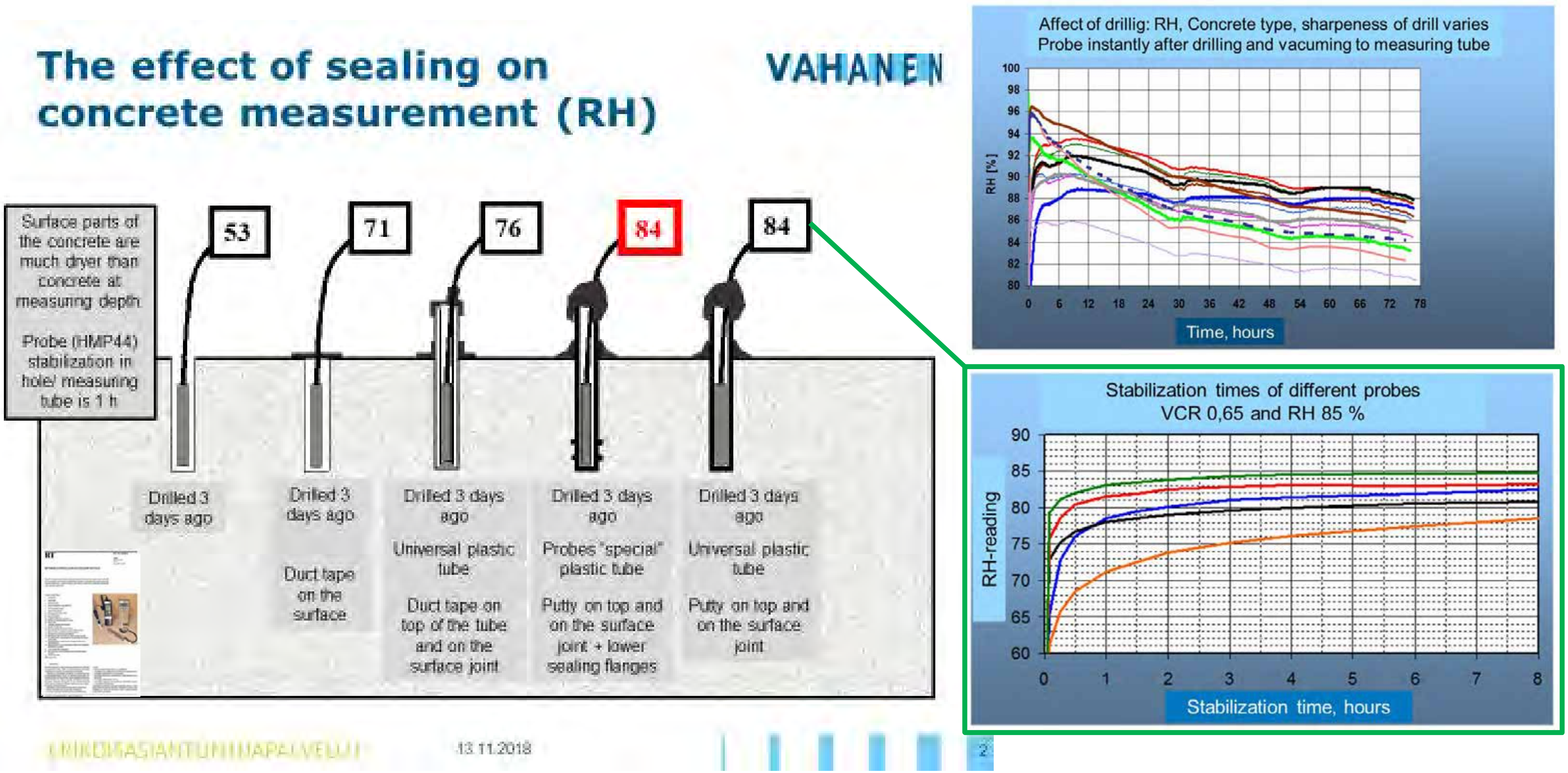
The effect of sealing on concrete measurement (RH)
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Surface parts of the concrete are much dryer than concrete at measuring depth
Probe (HMP44) stabilization in hole/ measuring tube is 1 h
53
71
76
84
84
Drilled 3 days ago
Drilled 3 days ago
Duct tape on the surface
Drilled 3 days ago
Universal plastic tube
Duct tape on top of the tube and on the surface joint
Drilled 3 days ago
Probes "special" plastic tube
Putty on top and on the surface joint + lower sealing flanges
Drilled 3 days ago
Universal plastic tube
Putty on top and on the surface joint
Affect of drillig: RH, Concrete type, sharpeness of drill varies
Probe instantly after drilling and vacuming to measuring tube
RH [%]
Time, hours
Stabilization times of different probes
VCR 0,65 and RH 85 %
RH-reading
Stabilization time, hours
13.11.2018

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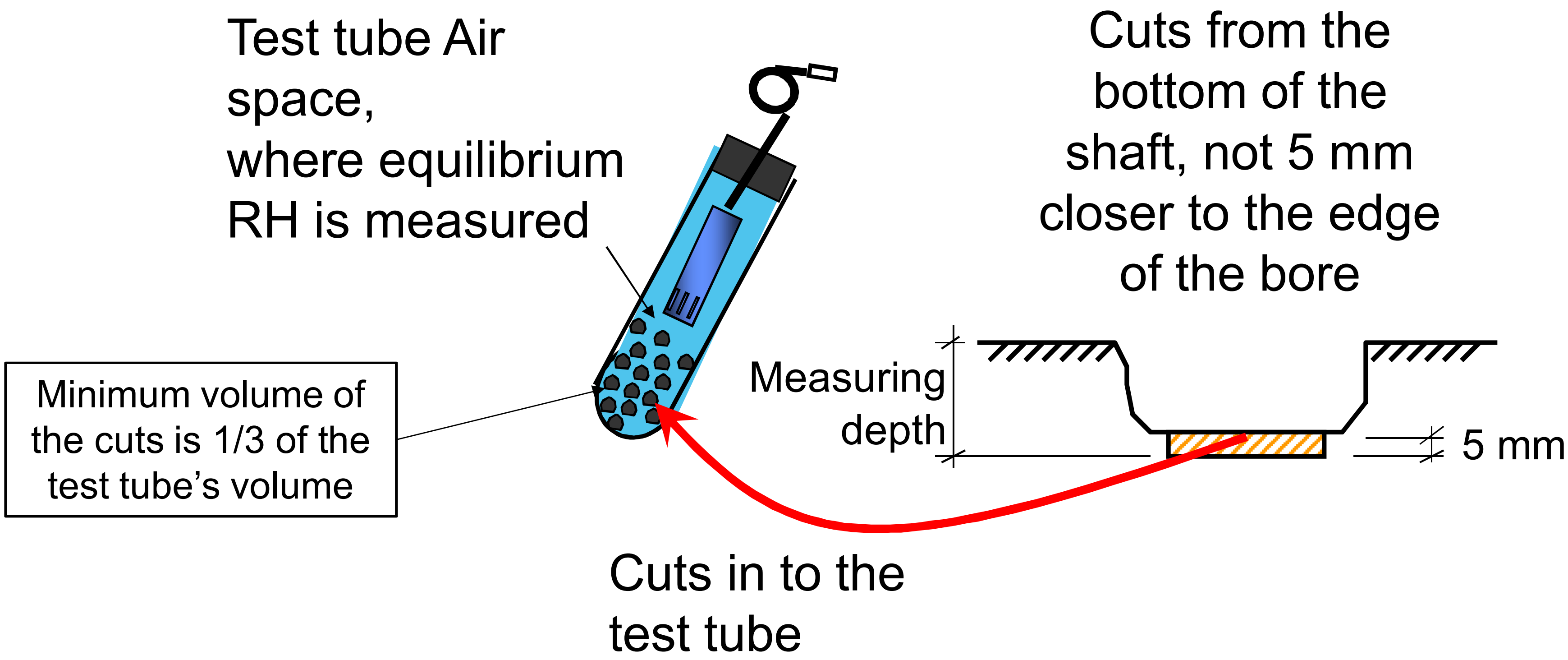
SAMPLE/ TEST TUBE METHOD



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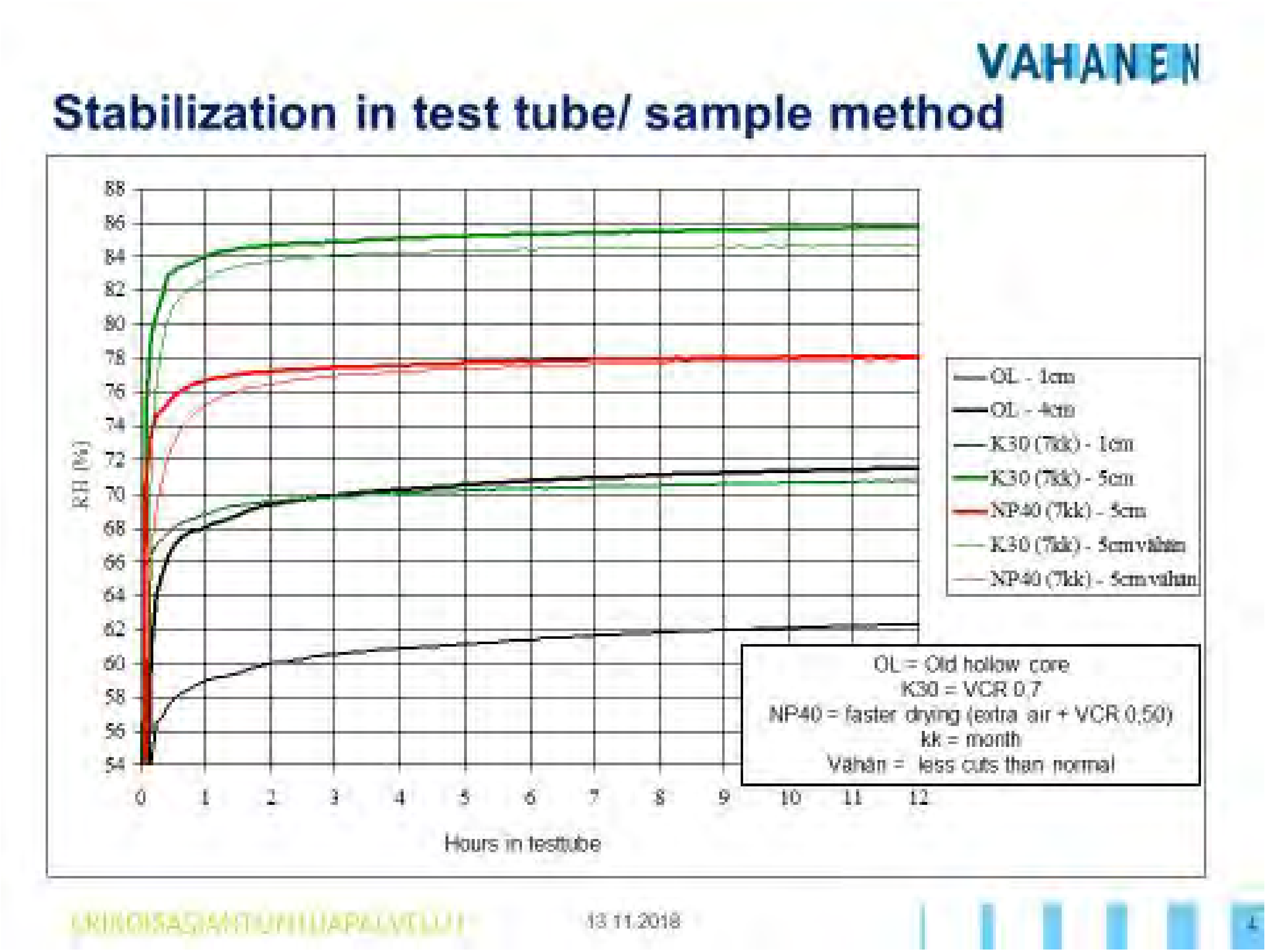
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Stabilization in test tube/ sample method
RH (%)
88
86
84
82
80
78
76
74
72
70
68
66
64
62
60
58
56
54
0 1 2 3 4 5 6 7 8 9 10 11 12
Hours in testtube
OL - 1cm
OL - 4cm
K30 (7kk) - 1cm
K30 (7kk) - 5cm
NP40 (7kk) - 5cm
K30 (7kk) - 5cm vähän
NP40 (7kk) - 5cm vähän
OL = Old hollow core
K30 = VCR 0,7
NP40 = faster drying (extra air + VCR 0,50)
kk = month
Vähän = less cuts than normal
13.11.2018

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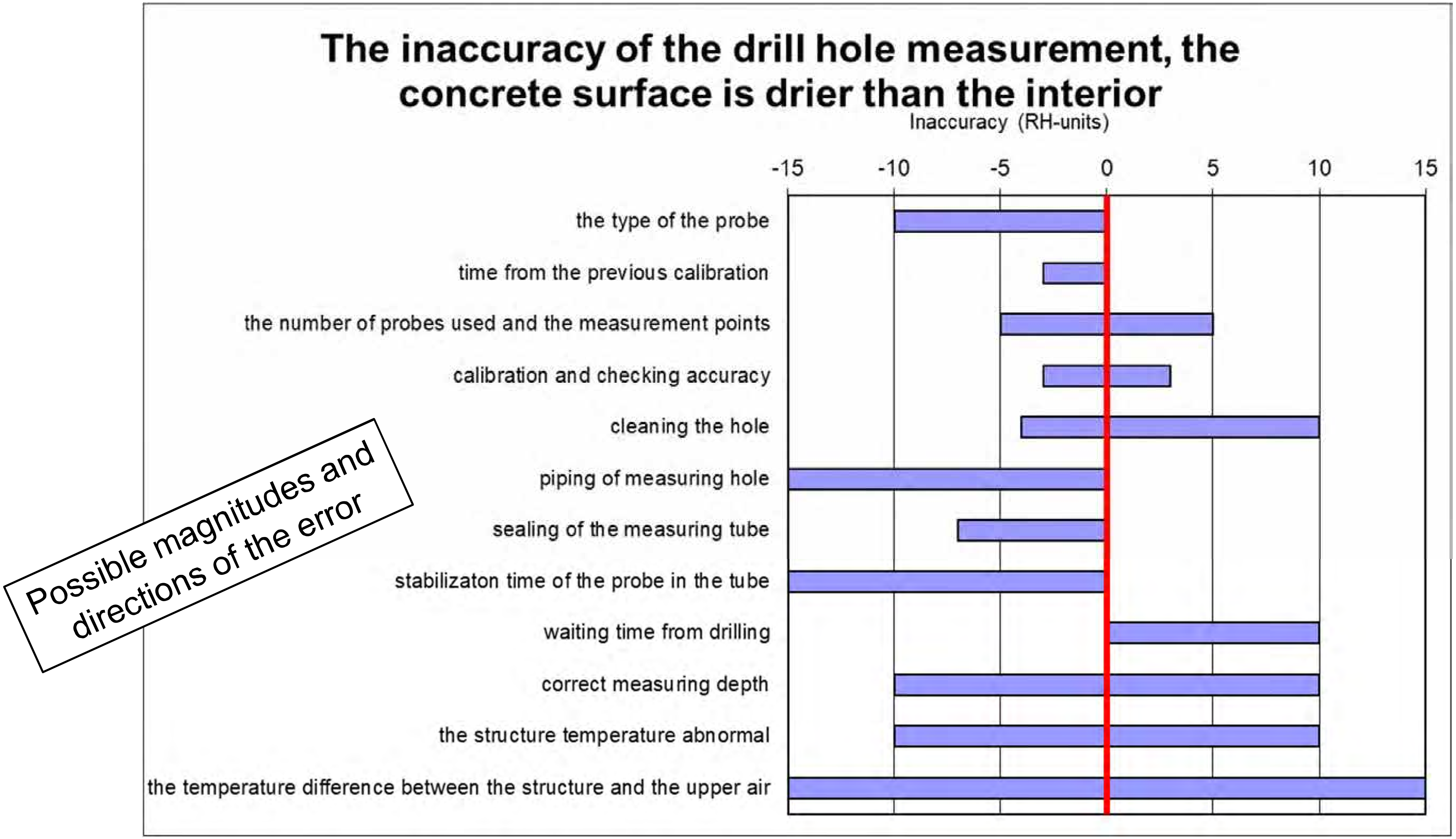
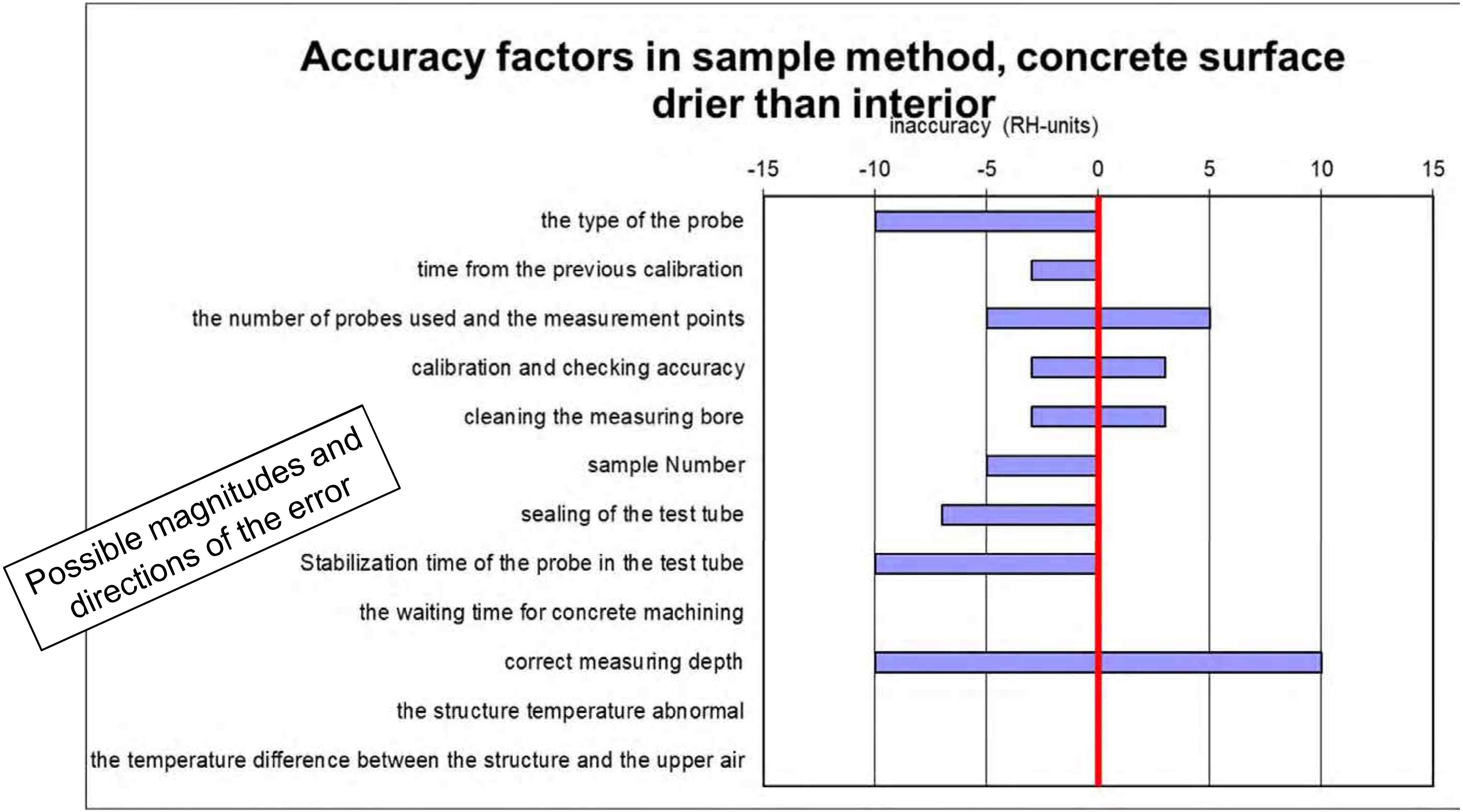

The inaccuracy of the drill hole measurement, the concrete surface is drier than the interior
Inaccuracy (RH-units)
-15
-10
-5
0
5
10
15
the type of the probe
time from the previous calibration
the number of probes used and the measurement points
calibration and checking accuracy
cleaning the hole
piping of measuring hole
sealing of the measuring tube
stabilizaton time of the probe in the tube
waiting time from drilling
correct measuring depth
the structure temperature abnormal
the temperature difference between the structure and the upper air
Possible magnitudes and directions of the error

VAHANEN


Accuracy factors in sample method, concrete surface drier than interior
inaccuracy (RH-units)
-15
-10
-5
0
5
10
15
the type of the probe
time from the previous calibration
the number of probes used and the measurement points
calibration and checking accuracy
cleaning the measuring bore
sample Number
sealing of the test tube
Stabilization time of the probe in the test tube
the waiting time for concrete machining
correct measuring depth
the structure temperature abnormal
the temperature difference between the structure and the upper air
Possible magnitudes and directions of the error

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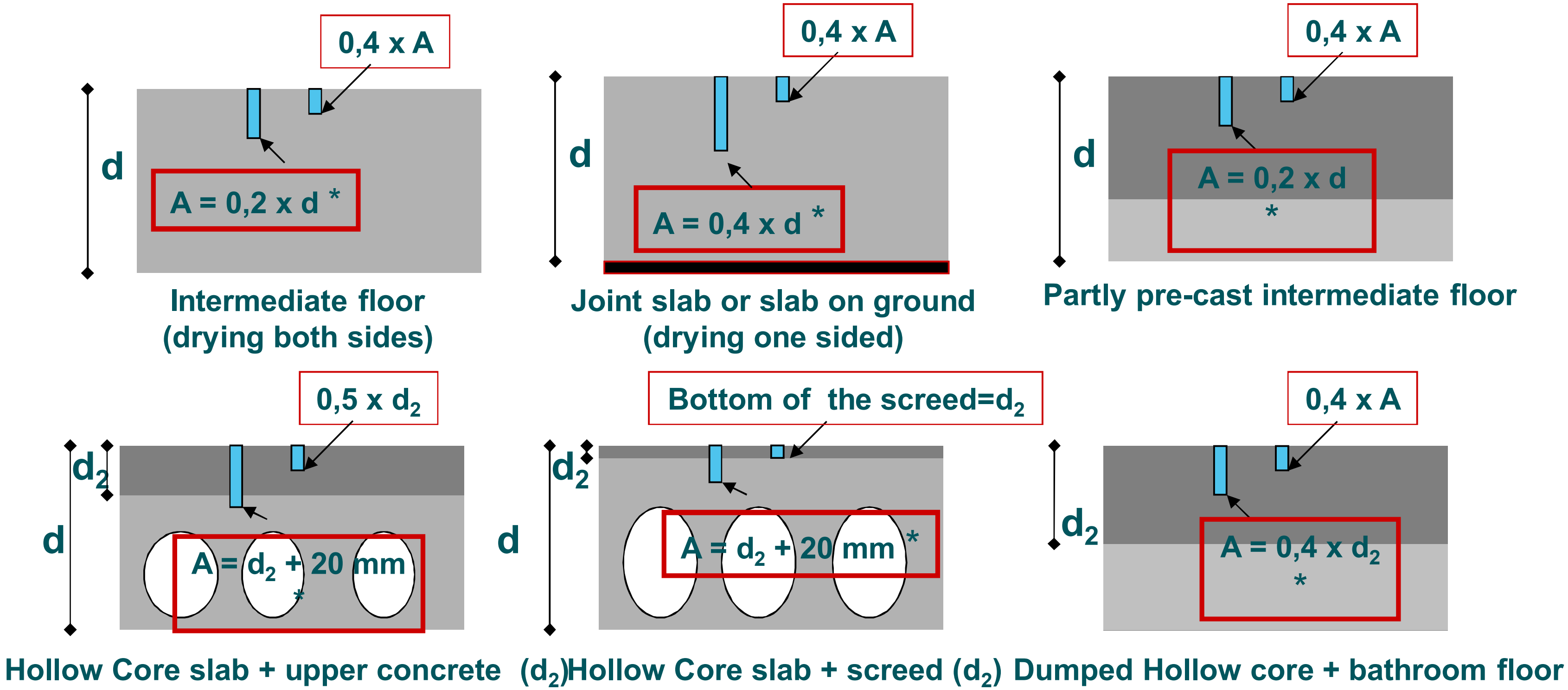
MEASURING DEPTHS BEFORE COVERING



2007

Always at least two depths
Maximum measuring depth 70 mm

the choice of measurement point place and the representativeness of the result

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COVERING LIMITS

Coating material	Evaluation of Concrete RH (%) by depth A	Concrete and / or smoothing RH (%) on the surface (0-5 mm) and 1-3 cm deep (0,4*A)
PVC carpets	85	75
Linoleum carpets	85	
Rubber carpets	85	
Textile mat, wapourtight base (pvc, rubber, rubber latex) or natural material	85	
Full synthetic textile mats without a substructure	90	
Plastic, rubber, linoleum tiles	90	

2007

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Observe the moisture content of the screed and the glue

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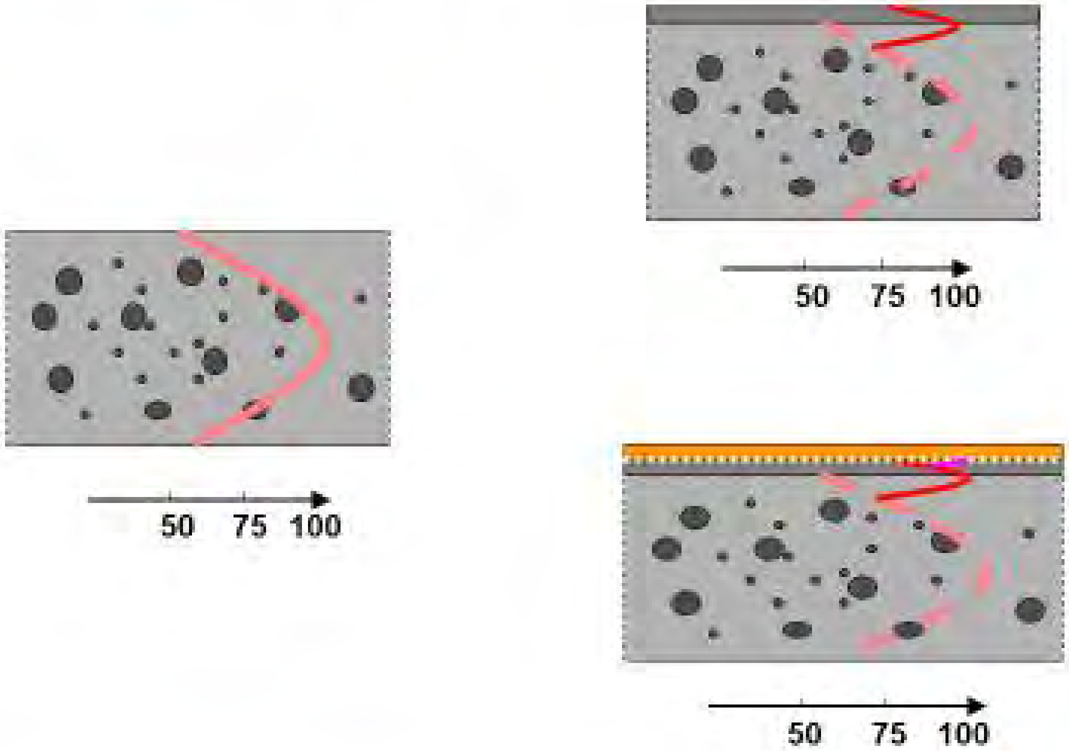

ERIKOISASIANTUNTIJAPALVELUT 12.11.2018 6

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“rapid RH-measuring under elastic covering, so called cut-method”

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DIRECTIONAL MEASUREMENTS

- Measurement of non-piped holes
- Measurement repeatedly from the same measuring tube
- Measurement of the measuring tube mounted on the cast
- Measuring soon after drilling
- Measuring continuously with the sensor inside the concrete
- Measurement outside the recommended temperature range
- Sample measurement without installing the probe immediately into the test tube
- Sample measurement with less than normal cuts or inaccurate depth

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MONITORING IS POPULAR

- IoT-based concrete drying conditions management - NCC
- Smart Concrete – Luja Betoni
- Construction site Digi engineer – Bliot Oy
- RamiSmartTM condition monitoring – Ramirent
- Monitoring probes + wireless data transfer
  - RFSensit
  - Viiste
  - Simap
  - Others
- Vaisala is still number one in Finland

Kuivaketju10

MORE MEASUREMENTS ARE DEMANDED AND DONE ALL THE TIME

NEW MEASURING EQUIPMENT AND TECHNIQUES ARE BEING DEVELOPED

MOISTURE PROPERTIES OF MATERIALS SHOULD BE KNOWN BETTER

THE INSTRUCTIONS SHOULD BE REFINED

FUKT OCH MÄTNING I TYSKLAND

Trondheim

Annika Gram

2018-11-07

RISE CBI Betonginstitutet AB

Research Institutes of Sweden

BUILT ENVIRONMENT
CBI SWEDISH CEMENT AND CONCRETE RESEARCH INSTITUTE

In Deutschland wohl die bekannteste Art des Estrichs: Zementestrich. Zementestrich ist feuchtigkeitsbeständig und daher bestens geeignet, um in Nassräumen, wie zum Beispiel dem Badezimmer, eingesetzt zu werden. Foto: Fotolia | Zur Fotostrecke

Schäden in der Praxis durch zu frühes Belegen

Quellen von feuchteempfindlichen Belägen

Schäden in der Praxis durch zu frühes Belegen

Blasenbildung (PVC)

Verseifung des Klebers

Vad är en Estrich?

Översättning: flytspackel, avjämningsmassa

Schwimmender Estrich – flytande golv

WAS IST ESTRICH?

Estrich ist die Abdeck- und Begradigungsschicht, die auf das Betonfundament gegeben und eben abgezogen wird. Estrich kann dabei aus ähnlichen Bestandteilen bestehen wie Beton, jedoch gibt es verschiedene Arten von Estrichen. Oder anders gesagt: ***Beton wird durch seine Bestandteile definiert; Estrich wird durch seine Funktion definiert.***

Diese Arten von Estrich gibt es:

- Zementestrich (CT)
- Gussasphaltestrich (AS)
- Kunstharzestrich (SR) (t ex epoxi)
- Calciumsulfatestrich (CA)
- Magnesitestrich (MA)

ZEMENTESTRICH

Bei Zementestrich handelt es sich um eine nach DIN EN 13 813 auch CT genannte Abdeck- und Begradigungsschicht. Zementestrich wird auch als Betonestrich bezeichnet, da die Inhaltsstoffe in etwa gleich sind. So kommen Sande und Zement zum Einsatz, etwa in einem Mischverhältnis von 3:1.
Der Sand weist dabei eine Körnungsgröße von unter 8 mm, teilweise von maximal 4 mm auf. Für das Anmachen der Mischung wird zudem ebenfalls Wasser verwendet. So wie es Schnellbeton gibt, gibt es auch beim Zementestrich eine Schnellestrich-Unterart. Diese weist verschiedene Zusätze auf, welche die Erhärtung begünstigen bzw. beschleunigen.

Zementestrich in Deutschland

→ Internationale Normen für Stoffe und Prüfungen

EN 13813: Eigenschaften und Anforderungen, Klassifizierung
EN 13892: Probenahme, Prüfverfahren

- **Druckfestigkeit**
- **Biegefestigkeit**
- ***Verschleißwiderstand***
- Oberflächenhärte
- Widerstand gegen Rollbeanspruchung
- Biege-E-Modul
- Haftzugfestigkeit
- Schlagfestigkeit
- Elektrischer Widerstand
- Chemische Beständigkeit

→ Nationale Anwendungsregeln

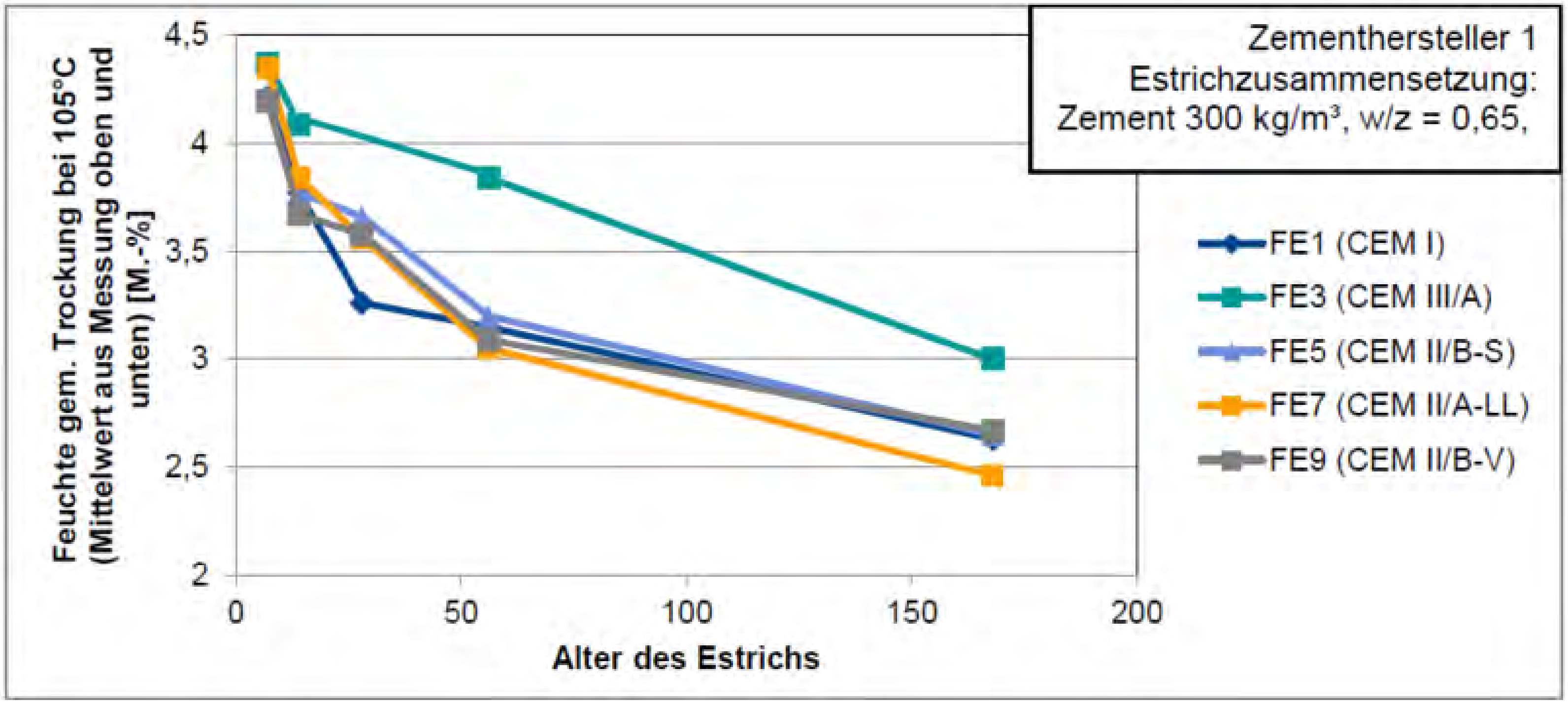
DIN 18560: Anforderungen, Dimensionierung, Ausführungen, Prüfumfang
DIN 18353: Technische Vertragsbedingungen

Die „Belegreife“ (max. Feuchte des Estrichs) ist nicht normativ geregelt!
Hierfür werden z.B. Merkblätter von Fachverbänden verwendet

Trocknungsverhalten von Zementestrich

- Estrichmörtel mit Hochofenzementen wiesen nach einer Lagerung von bis zu einem halben Jahr im Klima 20°C/65% r. F. höhere Feuchtegehalte (CM-Feuchte und mittels Ofentrocknung bei 105°C bestimmter Massenanteil der enthaltenen Feuchte) auf als Estriche mit anderen Zementarten (Bild 1).
- Zementsteine mit Hochofen- und Portlandhüttenzementen zeigten bei Lagerung in den Klimata 20°C/65 % r. F. und 40°C/30% r. F. deutlich geringere Massenverluste und beim Klima 20°C/65 % r. F. bereits nach wenigen Wochen Massenkonstanz, d. h. es wurde keine weitere Baustofffeuchte in die Umgebung abgegeben.

Der Ausgleichsfeuchtegehalt von Estrichen mit Hochofenzement ist bei üblich vorherrschenden relativen Luftfeuchten höher als der von Estrichen mit Portlandzement. Daher kann ein Maximalwert für den Feuchtegehalt, der anhand des Trocknungsverhaltens von Estrichen mit Portlandzement definiert wurde, z. B. bei Verwendung eines Hochofenzements möglicherweise nicht unterschritten werden. Gleichzeitig sind die Masse und Geschwindigkeit des zu erwartenden weiteren Feuchteverlusts, die letztlich entscheidend für das mögliche Auftreten von Schäden an Fußbodenkonstruktionen sind, i. d. R. bei der Verwendung von Hochofenzementen geringer als bei Estrichen z. B. mit Portlandzement. Die aufgrund des Trocknungsverhaltens bestehenden Vorbehalte bei Hochofenzementen und einigen Portlandkompositzementen erscheinen damit unbegründet.



Quelle: VDZ https://www.vdz-online.de/forschung/abgeschlossene-projekte/feuchte-in-beton-und-zementestrich/

Nutzungsbeginn und Belegreife

Zementmerkblatt Betontechnik – Zementestrich, InformationsZentrum Beton, 2015

begehbar nach	≈ 2 bis 3 Tagen
belastbar nach	≈ 10 Tagen [1]
belegbar nach	≈ 28 Tagen [2]
Belegreife für beheizte Estriche mit elastischen und textilen Bodenbelägen, Laminat, Parkett und Holzpflaster	≤ 1,8 [M.-%] Feuchte des Estrichs [3]
Belegreife für keramische Beläge auf beheizten oder unbeheizten Estrichen	≤ 2,0 [M.-%] Feuchte des Estrichs [3]
Belegreife für unbeheizte Estriche mit elastischen und textilen Bodenbelägen, Laminat, Parkett und Holzpflaster	≤ 2,0 [M.-%] Feuchte des Estrichs [3]
Belegreife für dampfdurchlässige textile Beläge bzw. Fliesen/Naturstein / Betonwerkstein im Dickbett, Estrich beheizt und unbeheizt	≤ 3,0 [M.-%] Feuchte des Estrichs [3]

[1] Bei Verwendung von Zement der Festigkeitsklasse CEM 42,5: ≈ 7 Tage
[2] Grober Anhaltswert. Gilt für Estrichdicken bis 50 mm; bei dickeren Estrichen mindestens ≈ 5 Tage/cm Mehrdicke zurechnen. Zur Kontrolle Feuchtigkeitsmessung durchführen.
[3] Feuchtigkeitsgehalte gelten bei Messung mit CM-Gerät (Calciumcarbid-Methode), siehe [26]; [16]

[16] Fachverband Deutsches Fliesengewerbe: Merkblatt Keramische Fliesen und Platten, Naturwerkstein und Betonwerkstein auf zementgebundenen Fußbodenkonstruktionen mit Dämmschichten, 2007
[26] Bundesverband Estrich und Belag: BEB-Merkblatt Beurteilen und Vorbereiten von Untergründen, 2008

Bodenbelag	Feuchtigkeitsgehalt bei Zementestrich %	Feuchtigkeitsgehalt bei Anhydritestrich %
Stein- und keramische Beläge im Dünnbett	2,0	0,5
Stein- und keramische Beläge im Mörtelbett auf Trennschicht	2,0	0,5
Stein- und keramische Beläge im Dickbett	2,0[1)]	0,5[1)]
Dampfdurchlässige textile Bodenbeläge	3,0	1,0
Dampfbremsende textile Bodenbeläge	2,5	0,5
Elastische Bodenbeläge z.B. PVC, Gummi, Linoleum	2,0	0,5
Parkett	2,0	0,5
[1)] Bei feuchtigkeitsabsperrenden Haftbrücken (geplante Änderung)		

Tabelle 1 Für die Belegreife der Bodenbeläge maßgebende maximale Feuchtigkeitsgehalte von Estrichen nach DIN 4725 Teil 4


M-Gerät
CALCIUMCARBID

Calciumcarbid-Methode

https://de.wikipedia.org/wiki/Calciumcarbid-Verfahren

$$CaC_2 + 2\,H_2O \longrightarrow Ca(OH)_2 + C_2H_2$$

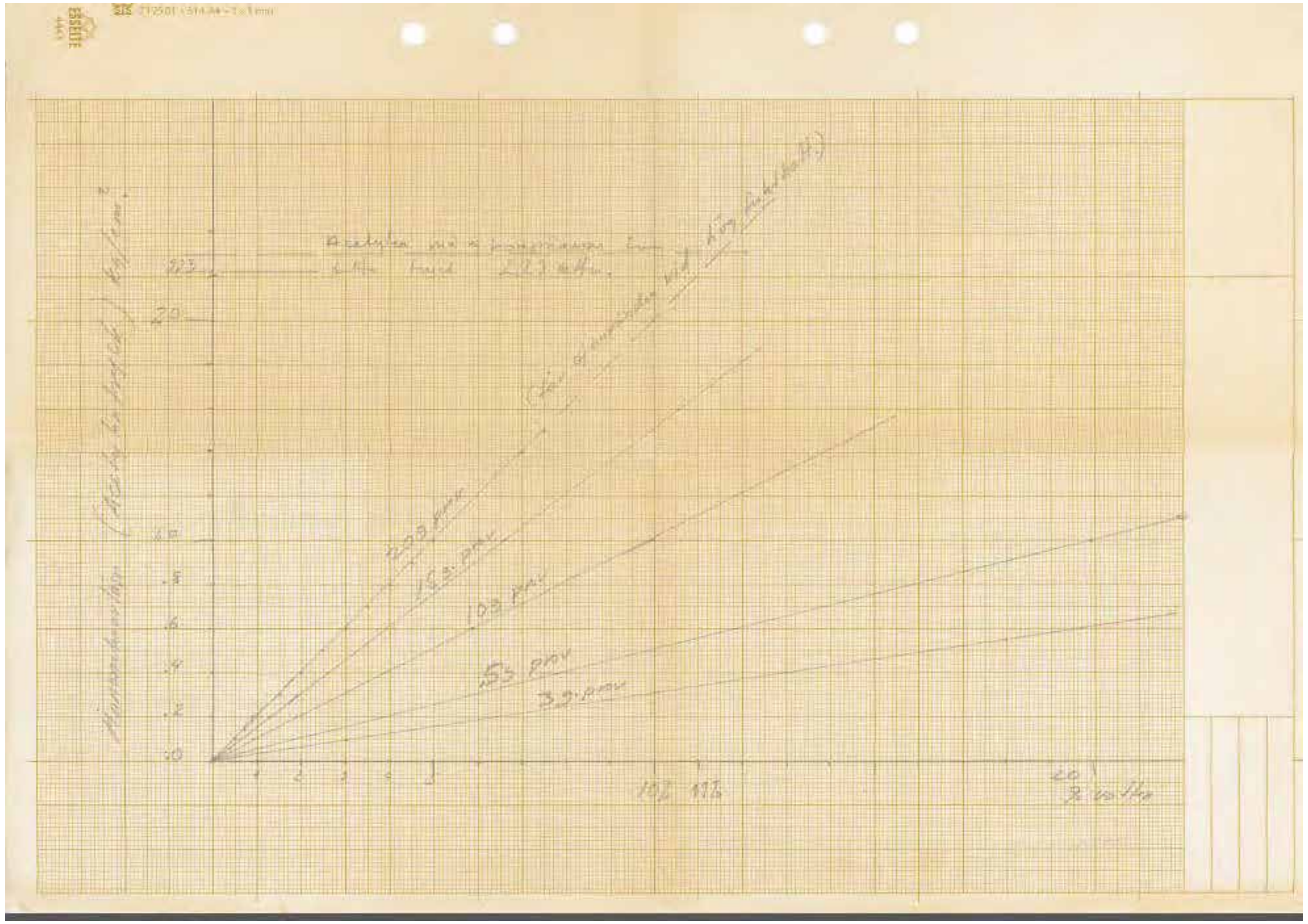
Wie hoch darf der Feuchtigkeitsgehalt in Bauteilen sein, damit sie zur Weiterverarbeitung geeignet sind?

A.	Beton und Leichtbeton	
	für Korkparkett, Korklinoleum, Spachtelböden, Steinholz	6,0 %
	für Linoleum	4,5 %
	für Holzparkett	3,5 %
	für sehr dichte Beläge (Gummi und PVC)	2,5 %
B.	Magnesit-Estriche (Steinholz)	9,0—11,0 % (je nach Füllstoff)
C.	Gips-Estrich, Anhydrit-Estrich	1,0 %
D.	Mauerwerk, Innen- und Außenputz	2,0 %
E.	Füllmaterialien zwischen Holzbalkendecken mit Holzdielung	3,0 %

Werden diese Feuchtigkeitsgrenzen überschritten, dann muß mit Isolierung gearbeitet werden.

Zur Beachtung:

Feuchtigkeitsbestimmungen sollen möglichst nicht bei Temperaturen unter 0 °C durchgeführt werden. Die Probenahme des Prüfgutes soll an den Stellen erfolgen, die dem Verleger als besonders feuchtigkeitsgefährdet bekannt sind oder erscheinen.



GEBRAUCHSANWEISUNG

für das C-M-Gerät

1. **Probeentnahme:** Die Probeentnahme richtet sich nach der stofflichen Beschaffenheit des zu untersuchenden Gutes.
   In allen Fällen muß ein gutes Durchschnittsmuster gezogen werden. Die Untersuchungsprobe muß in fein verteilter Form vorliegen.
   Körnige Materialien, die nur Oberflächenwasser enthalten, wie z. B. Zuschlagsstoffe (Kies, Sand etc.) werden direkt zur Untersuchung eingesetzt.
   Bei Unterböden, Innen- und Außenputz sowie Fertigbauteilen, wird das Prüfgut mit Hilfe des Meißels und Spitzhammers entnommen.
2. **Einwaage:** Probemenge richtet sich nach dem vermutlichen Wassergehalt

Vermutlicher Wassergehalt	Notwendige Einwaage
5 %	20 g
10 %	10 g
20 %	5 g
30 %	3 g

   Bei Manometeranzeige unter 0,2 atü oder über 1,5 atü: Versuch mit einer größeren bzw. kleineren Einwaage wiederholen.
3. **Messung:** Probe in Druckflasche einfüllen, die Stahlkugeln einbringen, Carbidampulle vorsichtig in die Flasche gleiten lassen, Verschlußstück mit Manometer auf das Gerät aufsetzen und Knebel bedienen. Durch mehrmaliges kräftiges Schütteln wird die Glasampulle zertrümmert, was am Steigen des Manometers zu erkennen ist. Durch gutes Vermischen der Prüfsubstanz mit dem Calciumcarbid stellt sich in wenigen Minuten ein konstanter Manometerdruck ein. Dieser Enddruck wird abgelesen.
4. **Reinigung:** Flasche langsam öffnen, Acetylen entweichen lassen (Nicht rauchen! Offenes Feuer vermeiden!) Inhalt ausschütten und Druckflasche mit beiliegender Flaschenbürste trocken auspulzen.

Feuchtigkeits-Gasdruck-Tabelle

Manometer-Enddruck	Wassergehalt in % – Einwaagen 20 g	15 g	10 g	5 g	3 g
0,10	0,5	0,6	0,9	1,8	3,0
0,15	0,7	0,9	1,4	2,8	4,7
0,20	0,9	1,3	1,9	3,8	6,3
0,25	1,2	1,6	2,4	4,8	8,0
0,30	1,5	1,9	2,9	5,8	9,7
0,35	1,7	2,3	3,4	6,8	11,3
0,40	2,0	2,6	3,9	7,8	13,0
0,45	2,2	2,9	4,4	8,8	14,7
0,50	2,5	3,3	4,9	9,8	16,3
0,55	2,7	3,6	5,4	10,8	18,0
0,60	3,0	3,9	5,9	11,8	19,7
0,65	3,2	4,3	6,4	12,8	21,3
0,70	3,5	4,6	6,9	13,8	23,0
0,75	3,7	4,9	7,4	14,8	24,7
0,80	4,0	5,3	7,9	15,8	26,3
0,85	4,2	5,6	8,4	16,8	28,0
0,90	4,5	5,9	8,9	17,8	29,7
0,95	4,7	6,3	9,4	18,8	31,4
1,00	5,0	6,6	10,0	19,9	33,2
1,05	5,2	7,0	10,5	20,9	34,9
1,10	5,5	[illegible]	11,0	21,9	36,5
1,15	5,7	[illegible]	11,5	22,9	38,2
1,20	6,0	8,0	12,0	23,9	39,9
1,25	6,2	8,3	12,5	24,9	41,6
1,30	6,5	8,7	13,0	26,0	43,3
1,35	6,8	9,0	13,5	27,0	45,0
1,40	7,0	9,3	14,0	28,0	46,7
1,45	7,3	9,7	14,5	29,0	48,3
1,50	7,5	10,0	15,0	30,0	50,0

RIEDEL-DE HAËN AG. SEELZE-HANNOVER

Kritiska fukttillstånd – RF_{krit} *enl. Åhs & Nilsson (TVBM-7203 ,2010)*

*De kritiska fukttillstånd som används idag har på sätt och viss ”**levt kvar” från 1970-talet**, men sänktes under 1990-talet, då en extra säkerhetsmarginal drogs ifrån.*

*”Gamla värden på kritiska fukttillstånd fanns i HusAMA fram till 1983, uttryckta som ”CM-%”(CM=karbidmätare). Lars-Olof Nilsson gjorde en ”**översättning” av dessa CM-% till Relativ Fuktighet RF** till Råd och Anvisningar till HusAMA RA78.*

*Denna ”översättning” hade **mycket liten vetenskaplig grund** och var mer baserad på vad som var rimligt och acceptabelt för materialleverantörerna respektive byggnads-entreprenörerna.*

*Översättningen utmynnade i ”**jämna siffror” som 95, 90 och 85 % RF.***

*På den tiden kunde man inte mäta RF särskilt noggrant så det fanns **ingen anledning att nyansera värdena mer***

Uttorkning av byggfukt i betongplatta med ingjuten värmekabel

Slutsatsen som kan dras i projektet är att uttorkningsmetoden med ingjutna värmekablar är bra uttorkningsmetod. Svårigheterna med metoden är det idag inte finns lämpliga bedömnings-hjälpmedel som kan användas för att uppskatta uttorkningstiden. De teoretiska bedömningarna försvåras av att det är temperaturgradienter i betongen. Vid val av mätmetod i projektet var kunskapen ej etablerad om att den mest lämpliga mätmetoden är uttaget prov vid fuktmätning i betonggolv med värmekablar. Den valda mätmetoden med kvarsittande givare visade sig ge osäkra mätresultat.

THANK YOU!

Uttorkning av byggfukt i betongplatta med ingjuten värmekabel

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NEW MATERIALS AND DESIGN AND THE IMPACT ON RH IN CONCRETE, FINNISH EXPERIENCE

NORDIC WORKSHOP ON RH IN CONCRETE, TRONDHEIM, NOVEMBER 7TH -8TH 2018

Dr. Leif Wirtanen, Ramboll Finland

RAMBOLL

AGENDA

1. CONCRETE
2. STRUCTURES
3. ADHESIVES
4. SCREEDS
5. FLOORINGS

RAMBOLL

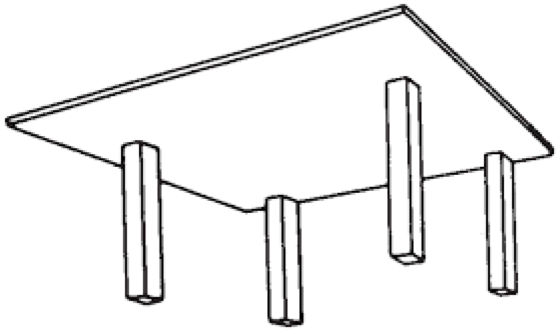
CONCRETE

Δ supplementary cementitious materials (GGBS)

Δ admixtures (superplasticizers)

STRUCTURES

- Δ thicker
- Δ more complex



ADHESIVES

- Δ binder (acrylic / EVA...)
- Δ additives (2EH)

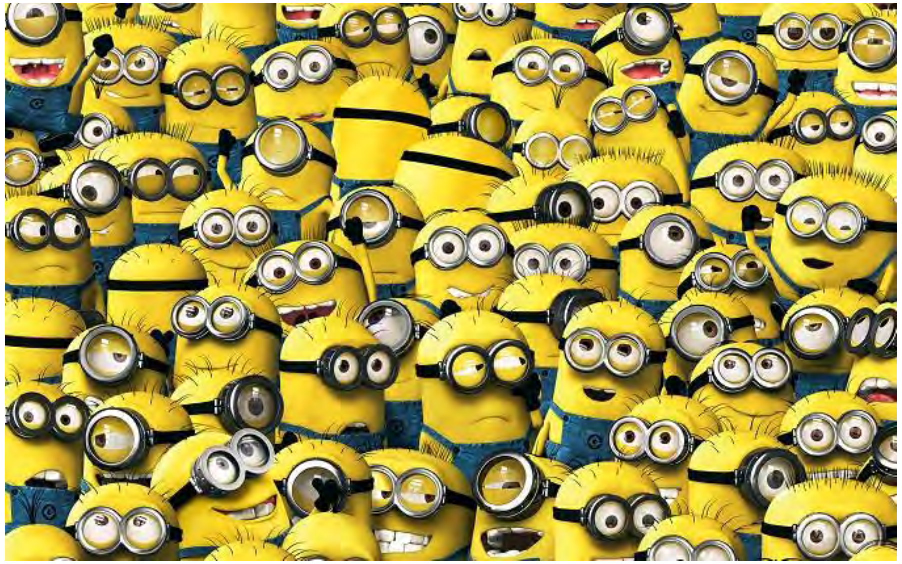
SCREEDS

- Δ alkalinity (aluminacement, gypsum)
- Δ layer thickness (increasing)

RAMBOLL

FLOORINGS

- Δ denser (PU treatment)
- Δ composition (phthalate free plasticizers/adipates, aliphatic esters...)



DO WE MEASURE THE RIGHT THINGS (RH, VOCs) IN THE RIGHT WAY?

RAMBOLL

QUESTIONS AND ANSWERS

THANK YOU

Stefan Nordmark

Electro-tech

Electro tech

Elara2

Elara2

We have been developing the humidity sensor during a period of 3.5 years and are now in the final phase of tests which be will done at University of Lund during 2019-Q1/Q2

Presentation by Stefan Nordmark

Electro tech

Elara2

Challenge

Sensor Chip
Will it work in concrete
Accuracy of the sensor over time

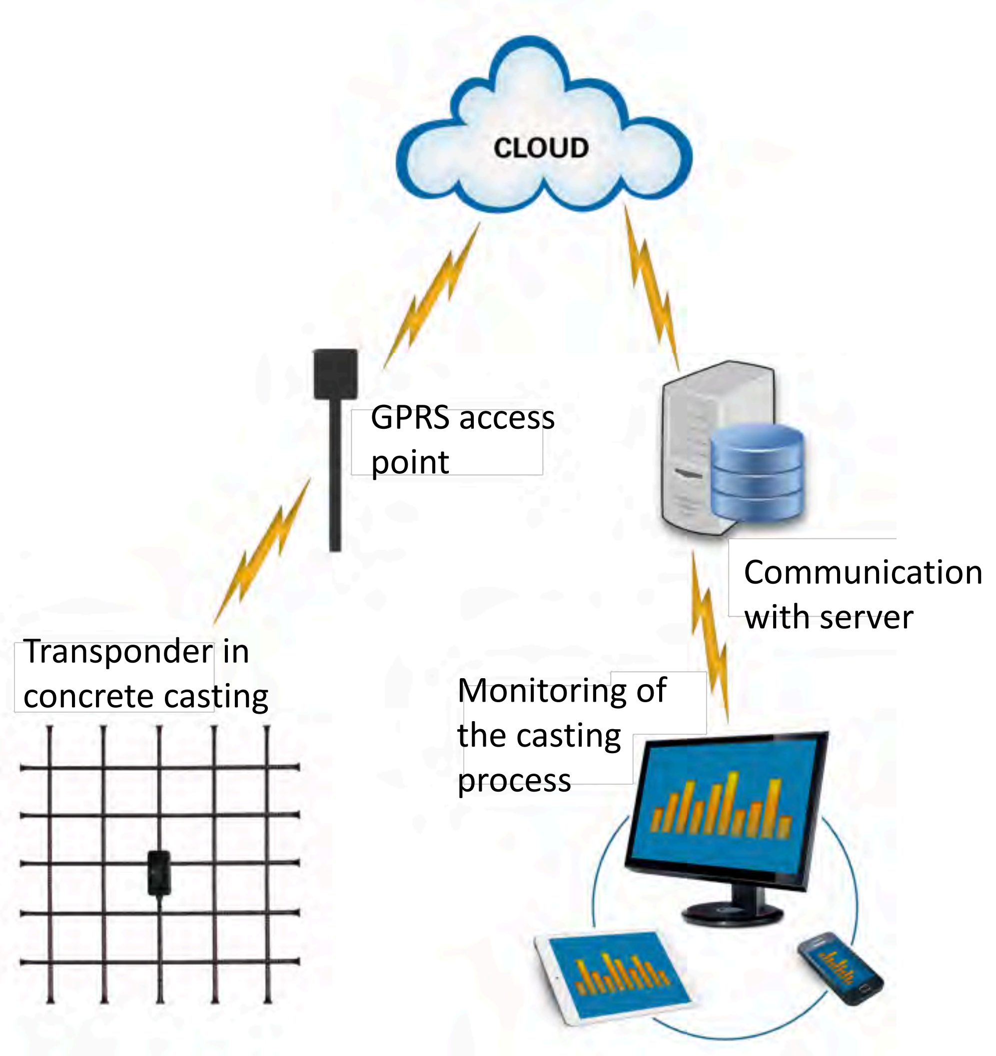
Mechanic
How shall it be designed
Membrane
Plastic housing

Communication
868 MHz
868 MHz Lora

Life span
Time 9 year

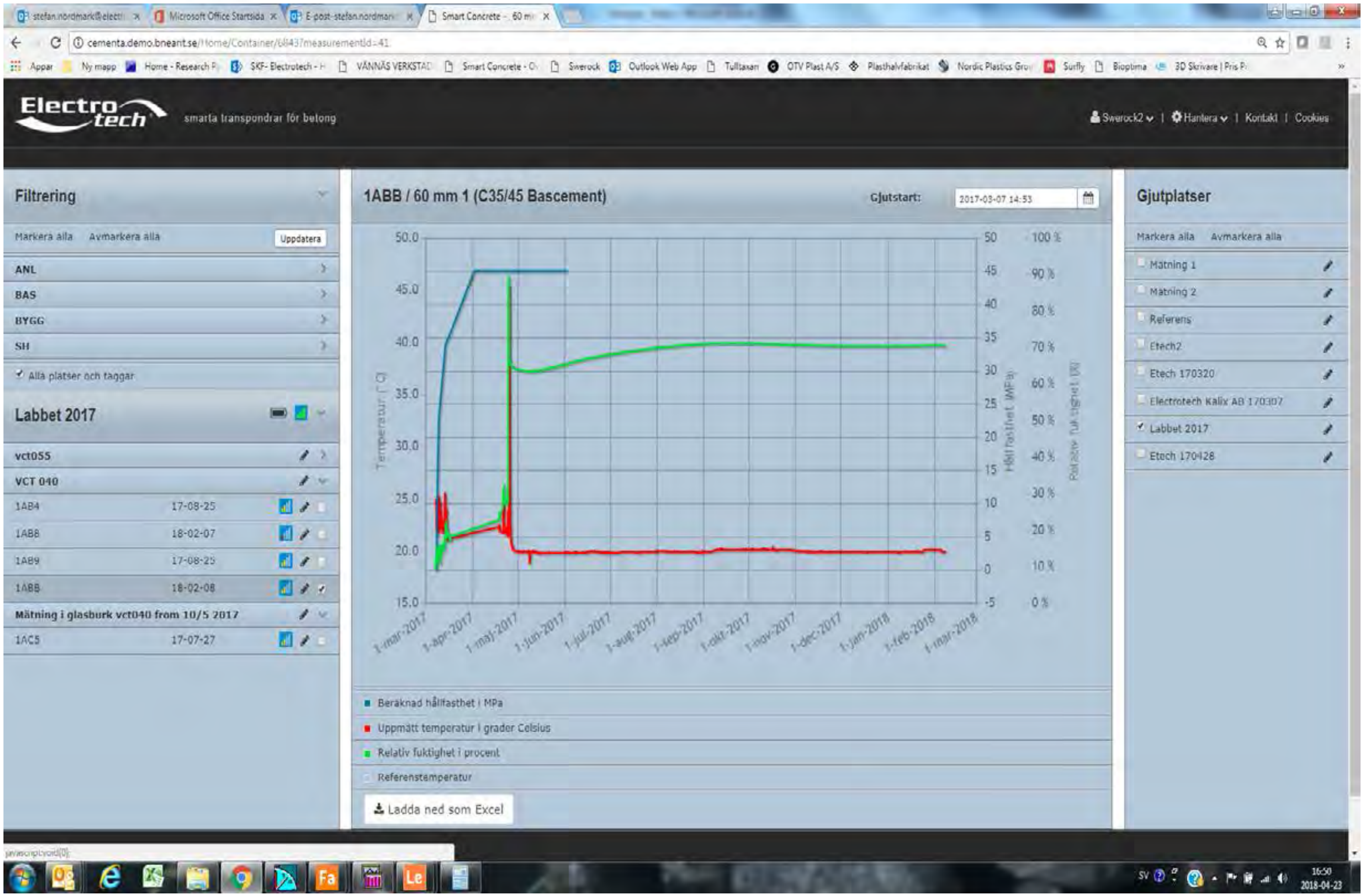
This is how the system works

Wireless measuring of the humidity in concrete



The RFID- tranponder, which contains a sensor and a transciever, is cast into a concrete structure. Data from the tag is transmitted to an external access point in the vicinity of the concrete structure.

The external access point is connected to internet via GPRS. The information is sent to a database.


smarta transpondrar för betong
Filtrering
Markera alla
Avmarkera alla
Uppdatera
ANL
BAS
BYGG
SH
Alla platser och taggar
Labbet 2017
vct055
VCT 040
1AB4 17-08-25
1ABB 18-02-07
1AB9 17-08-25
1ABB 18-02-08
Mätning i glasburk vct040 from 10/5 2017
1AC5 17-07-27
1ABB / 60 mm 1 (C35/45 Bascement)
Gjutstart:
2017-03-07 14:53
Temperatur [°C]
Hållfasthet [MPa]
Relativ fuktighet [%]
1-mar-2017
1-apr-2017
1-maj-2017
1-jun-2017
1-jul-2017
1-aug-2017
1-sep-2017
1-okt-2017
1-nov-2017
1-dec-2017
1-jan-2018
1-feb-2018
1-mar-2018
Beräknad hållfasthet i MPa
Uppmätt temperatur i grader Celsius
Relativ fuktighet i procent
Referenstemperatur
Ladda ned som Excel
Gjutplatser
Markera alla
Avmarkera alla
Mätning 1
Mätning 2
Referens
Etech2
Etech 170320
Electrotech Kalix AB 170307
Labbet 2017
Etech 170428
Kontakt
Cookies

Advantages

- 1. Continuous monitoring from day zero via computer, tablet or mobile phone
- 2. Installation of sensor in the design is less than 2 minutes
- 3. Archiving data as well as easily copying the information / data into your reports
- 4. We store all data in servers that you have access to
- 5. No physically need to be in place to decide on any action for the occasion
- 6. Documentation to easily show status
- 7. Planning tool Qa

The presentation is now over, thanks!

Experience from RH measurements at SINTEF in general, with focus on use of Humiguard

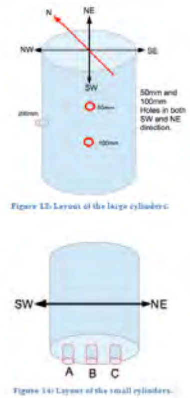
Senior Scientist (PhD) Jan Lindgård, SINTEF

Content

Background

- Long experience with use of RH measurements in various R&D projects
  - ✓ Often linked to PF/DCS measurements
- Laboratory measurements
  - ✓ Internal RH in various lab. cast samples (mainly ASR)
  - ✓ Internal RH in drilled cores from field (mainly ASR)
  - ✓ Simulating drying of concrete floors (various binders)
- In-situ measurements
  - ✓ Concrete structures (mainly bridges)
  - ✓ Field exposed samples (laboratory cast – stored at exposure sites)

<u>Example</u>: Field exposed samples in Trondheim. Are various surface treatments able to reduce the intern RH?



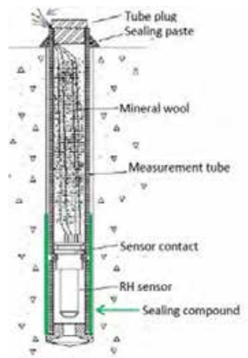
Main RH systems used at SINTEF

- Vaisala "HMP44" (www.vaisala.com)
  - ✓ Mainly lab. measurements
  - ✓ Long experience – extensively used last 10 years
- Humiguard (www.industrifysik.se)
  - ✓ Mainly field measurements
    - o RBK: concrete floors
  - ✓ About 20 years of experience
    - o Various R&D projects (incl. aim to improve the accuracy)
  - ✓ MSc study in 2017 (NTNU)

- Procedure for use of <u>Vaisala</u> sensors for lab. measurements
  - ✓ Calibration of each sensor before and after measuring
  - ✓ Splitting and crushing of concrete (avoid loosing moisture)
  - ✓ Collection of small paste samples (3-6 mm from the interior) on glass tubes
  - ✓ Installation of RH sensors after about 1-2 hours of pre-storage in the 20^{o}C climate room (avoid condensation)
  - ✓ Storage of the glass tubes in an "insulation block" (keep the temp. stable)

- Procedure for use of Vaisala sensors for lab. measurements
  - ✓ Daily measurements for 4-5 days (in the morning – stable temp.)
  - ✓ The readings after 2-3 days are normally used
  - ✓ Calculations based on the recent calibration performed (before and after)

- Procedure for use of <u>Humiguard</u> sensors for field measurements
  - ✓ Drill and clean the holes, install the plastic tubes (incl. use of a sealing compound along the tube; e.g. "Sikaflex") and seal the top
  - ✓ Install RH sensors 1-2 days after drilling
  - ✓ Insulate the plastic tube and seal (reduce the influence of temp. variations)
  - ✓ Wait 5-7 days before the first measurements
  - ✓ Measure when stable temp. over at least a 24 hours period and when cloudy (preferably stick to one temp. level; in Trondheim from 15-20^{o}C)
  - ✓ Avoid heating by the sun (protect the samples if sunshine)



Main experiences; some pros and cons

System	Vaisala (V)	Humiguard (HG)	Comments
Accuracy	0-90 % RH: ± 2 % 90-100 % RH: ± 3 %	About ± 2 % at 85 % RH	Data from the producers
Calibration	Yes, preferably before and after measuring (-)	No need (+)	The accuracy of the HG sensors has been improved* (+)
"Stability"	Normally only minor drift over time (+)	Drifting over time, thus need of ref. readings (-)	HG: the reference readings must be performed frequently (-)
Lifetime	Long (+)	Expire date 6 (2?) months (-)	Need to replace the HG sensors every season. Complicated* (-)
Costs	Rather expensive (-)	Rather cheap to buy (+), but costly over time (-)	Need of more manhours for using the HG system (-)
Temp. range	Long interval (?) (+)	0-40^{0}C, but basically in the interval 15 to 25^{0}C	HG: Can "fool" the system if the temp. is outside this interval
RH levels	0-100 % (+)	Only in the interval 75-98 % RH (-)	Vaisala: The accuracy decreases at very high RH
Calculations	Easy and fast (+)	Complicated. Must use an on-line program (-), but aut. calculation to 20^{0}C (+)	HG: Possible to "fool" the system if too old sensors or temp. outside the given interval
Measuring depth	If shallow boreholes, use an "installation cover"	Can measure in rather shallow boreholes (≈5cm)	Shallow boreholes more influ-enced by outdoor temp. & sun

- Examples on how to measure close to a concrete surface
  - ✓ Drill holes from the side (deep to be less influenced by the outdoor temp.)
  - ✓ Preferably, place the sensors away from the sun (NE) + insulate the tube

Humiguard

5. Fold the cable in the installation cover and close the lid. Leave the probe to stabilize before starting the measurements.

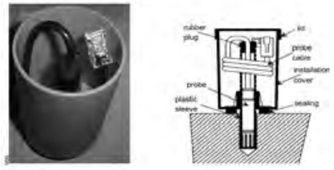


Figure 5.4 Cable folded in the installation cover

Vaisala

- Many important sources of error exist
  - ✓ Unstable (varying) temp. in the concrete (cold nights – warm and sunny day)
    - o Lack of equilibrium between the concrete and the air in the borehole (see examples*)
    - o Use of insulation in the tubes and covering the samples/structure will help

- o Importance of having the same temp. at the RH probe and the concrete
  - ✓ Example Vaisala (from the user manual)

Temperature of the probe and the concrete shall be the same!

In humidity measurement and especially in calibration it is essential that temperature of the probe and measured object is the same. Even a small difference in temperature between the measured object and the probe causes an error. As the curve below shows, if the temperature is +20 °C and the relative humidity 100 %RH, a difference of ±1 °C between the measured object and the probe causes an error of ±6 %RH. When the humidity is 90 %RH, the corresponding error is ±5.4 %RH.

A temperature difference of a few degrees can also cause water to condense on the sensor surface. HUMICAP® sensor starts to function normally as soon as the water has evaporated. If the condensed water is contaminated, the life span of the probe may shorten and calibration may change.

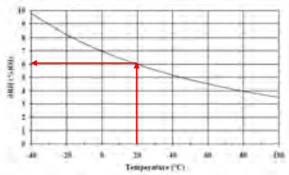
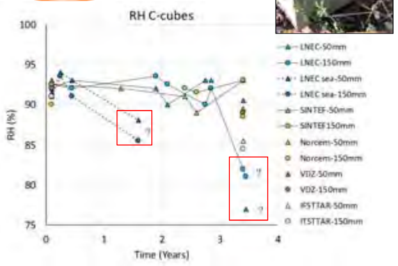


Figure 3.1 Measurement error at 100 %RH when the difference between the ambient and sensor temperature is 1 °C

- Importance of having the same temp. at the RH probe and the concrete
  - ✓ Example <u>Humiguard</u> (report prepared on-line)

Meas. point C-14_50mm   W/C ratio: 0.45

Time	Lot number	Wire RH	Wire T	RH	Temp	Correction	Uncertainty	Final RH		
2015-05-27 11:00	150409-1-6									
2015-06-29 11:00	150409-1-6									
2015-07-22 12:00	150409-3-6									
2015-10-08 12:00	150409-1-6									
2016-11-14 12:00	160608-1-6									
2016-11-18 12:00	160608-1-6									
2017-03-24 12:00	170222-1-6									
2017-03-28 12:00	170222-1-6									
2017-04-21 12:00	170222-1-6									
2017-05-19 12:00	170222-1-6									
2017-06-16 12:00	170222-1-6									
2017-07-14 12:00	170222-1-6									
2017-07-21 12:00	170222-1-6									
2017-08-11 12:00	170222-1-6									
2017-11-10 11:00	170919-3-6									
2017-11-14 11:00	170919-3-6									
2017-12-07 11:00	170919-3-6									
2018-01-08 11:00	170919-3-6									
2018-02-07 11:00	170919-3-6	20.00 µS	70.00 µS	92.4 %RH	17.0 °C	+0.61 %RH	2.5 %RH	95.5 %RH	6258	sunny shadow, 11 gr
2018-03-02 11:00	170919-3-6	16.00 µS	63.00 µS	91.8 %RH	14.8 °C	Temp < 15 °C			6258	cloudy, 15 gr
2018-10-17 23:17	180628-2-6	3.00 µS	83.00 µS	— %RH	20.8 °C	Relative humidity limits			6258	20 degrees, sunny shadow
2018-10-22 23:26	180628-2-6	3.00 µS	88.00 µS	75.7 %RH	16.4 °C	+1.04 %RH	2.5 %RH	76.3 %RH	6258	19.8 degrees, sunny



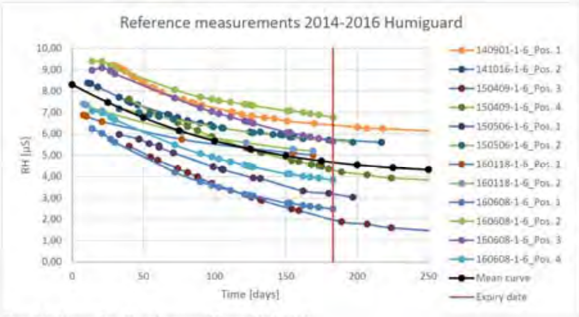
- ➢ Many important sources of error exist
  - ✓ Unstable (varying) temp. in the concrete (cold nights – warm and sunny day)
    - o Lack of equilibrium between the concrete and the air in the borehole
    - o Use of insulation in the tubes and covering the samples/structure will help
  - ✓ Too short time from installation of sensors to the readings are taken
    - o <u>General</u>: Many examples on too early readings (i.e. will measure a too low RH)
      - ▪ NS 3511: > 15 t (v/c>0.4) and > 48 t (v/c<0.4)
    - o <u>Vaisala</u>: (User manual)
      - ▪ Recommended to wait three days from drilling to measuring RH
      - ▪ The RH probe can be installed immediately after drilling or before measuring
      - ▪ If installed before measuring, seal with a rubber plug and wait about 30 minutes before measuring (too short time!)
  - ✓ Calibration and drift of sensors
    - o Humiguard (HG):
      - ▪ Do the reference sensors represent the installed sensors? (improved – see later example*)
    - o Vaisala (lab.):
      - ▪ How long should the RH sensors rest in room climate before moving from one glass tube to another? (relevant when moving to a dryer environment)

- ➢ Many important sources of error exist
  - ✓ Condensation any problem?
    - o SINTEF lab:
      - ▪ Installation of Vaisala sensors in the glass tubes after about 1-2 hours of pre-storage in the 20°C climate room (avoid condensation).
    - o Condensation problems in field?
      - o <u>NS 3511</u>: At installation, the RH probes should not have lower temp. than the concrete
      - ▪ <u>Vaisala</u>: (user manual)
        - • The RH probes starts to function again as soon as the water has evaporated
        - • If contaminated water, shortened life span and drift of the sensors
    - o Can HG sensors withstand condensation?
  - ✓ How long can a drilled hole be used for measuring?
    - o Dependent of the concrete quality and the moisture state?
      - ▪ Any leakage might influence the RH (normally reduced)
    - o Influence of the moisture capacity of the RH probe?
      - ▪ When replacing the sensors, will the time to reach equilibrium increase? (longer time for denser and dryer concrete?)

Improvement of the Humiguard system

- ➢ Production of RH sensors at Industrifysik
  - ✓ Previously rather large spread between individual RH sensors
  - ✓ Actions taken during the last years to increase the reliability and the accuracy
    - o New system introduced in 2018
      - ▪ All RH sensors are pre-tested
      - ▪ Automatic selection of RH sensors in a narrow range (various groups)
      - ▪ Ref. RH sensors selected from the "mid part" of each sensor group
- ➢ SINTEF activities
  - ✓ Aim to increase the reliability in RH measurements
  - ✓ Close dialogue with Industrifysik
    - o Previously: Received RH sensors from a "large group" with unknown spread
    - o Latest years: Hand selected RH sensors
  - ✓ MSc study in 2017 (NTNU)

- SINTEF: Example of spread measured between reference Humiguard sensors



Figur 2-1: Kurver for alle referansemålinger 2014-2016

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- SINTEF: Example of spread measured between reference Humiguard sensors

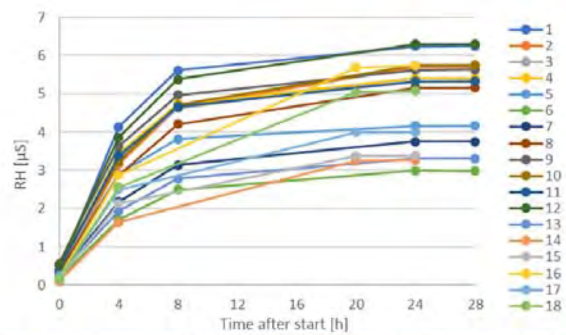
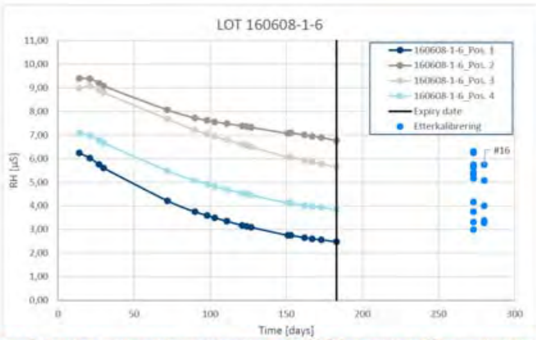


Figure 22: Calibration of old sensors at Voll test site. Calibration at 84,5 %RH

SINTEF | SINTEF Building and Infrastructure | 18

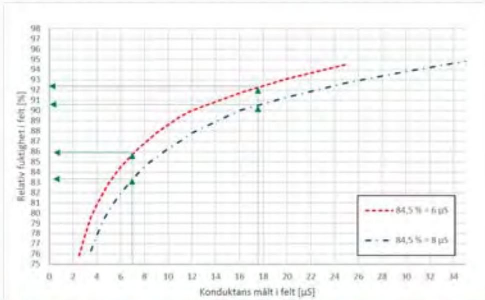
- SINTEF: Example of spread measured between reference Humiguard sensors



Figur 3-1: Endring av målt konduktans i referanseblokk ved 84,5 % RF og spredning for 18 sensorer brukt i felt målt ved etterkontroll ved 84,5 % RF.

SINTEF | SINTEF Building and Infrastructure | 19

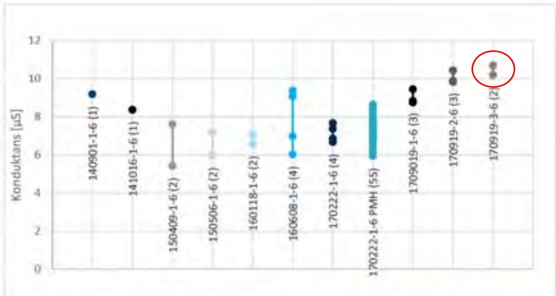
- SINTEF: Example of spread measured between reference Humiguard sensors



Figur 2-2: Figuren illustrerer hvilket utslag man kan få på beregnet relativ fuktighet dersom man bruker en LOT med stor spredning og man har referansesensor i det ene ytterpunktet og en feltsensor i det andre ytterpunktet.

SINTEF | SINTEF Building and Infrastructure | 20

- SINTEF: Example of spread measured between reference Humiguard sensors



Figur 4-1: Spredning blant referansesensorer i tidlig fase (11-40 døgn) for de ulike serienummer vi har brukt.

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Summary

- It is possible to measure RH rather accurate, provided care and actions are taken
  - ✓ If incorrect, often too low RH measured (many examples exist)
  - ✓ Main sources of errors
    - Unproper sealing leading to leakage
    - Temp. variations between the RH probe and the concrete
    - Reading after too short time
    - Lack of calibration of the RH probes
- SINTEF experiences
  - ✓ Vaisala (normally) works very well in the lab.
  - ✓ Humiguard accuracy improved
    - Despite short expire date, the system works pretty well for field measurements

SINTEF   SINTEF Building and Infrastructure   22

Self-desiccation concrete in floors

Bernt Kristiansen
AF Gruppen Norge AS

FOR 2010-03-26 nr 489: Forskrift om tekniske krav til byggverk (Byggteknisk forskrift – TEK 10)

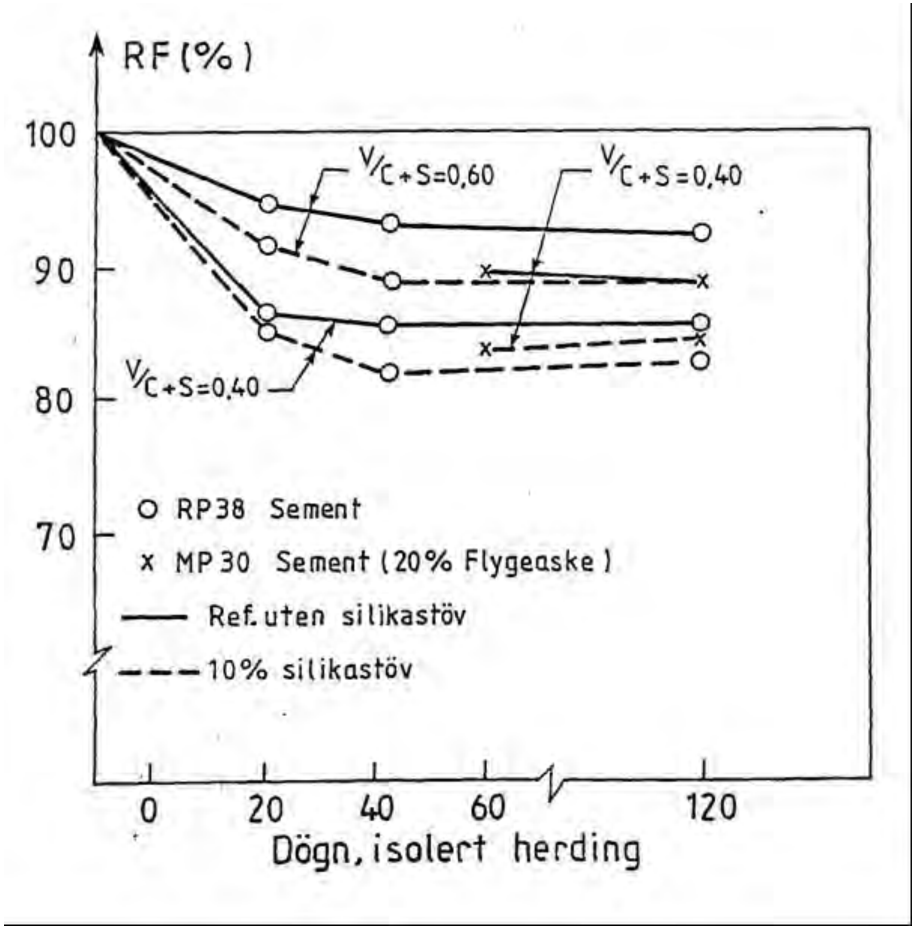
§ 13-19. *Byggfukt (Moisture in construction phase)*

Materialer og konstruksjoner skal være så tørre ved innbygging/forsegling at det ikke oppstår problemer med mugg- og soppdannelse, nedbrytning av organiske materialer eller økt avgassing.

Materials and structures should be so dry when installed / sealed that there are no problems with mold and fungus formation, organic matter decomposition or increased degassing

Self-desiccation concrete

Ref.: BETONGENS FUNKSJONSDYKTIGHET. Delrapport nr. 30, Erik J.Sellevold. STF 65, A 88093. FCB, Trondheim.

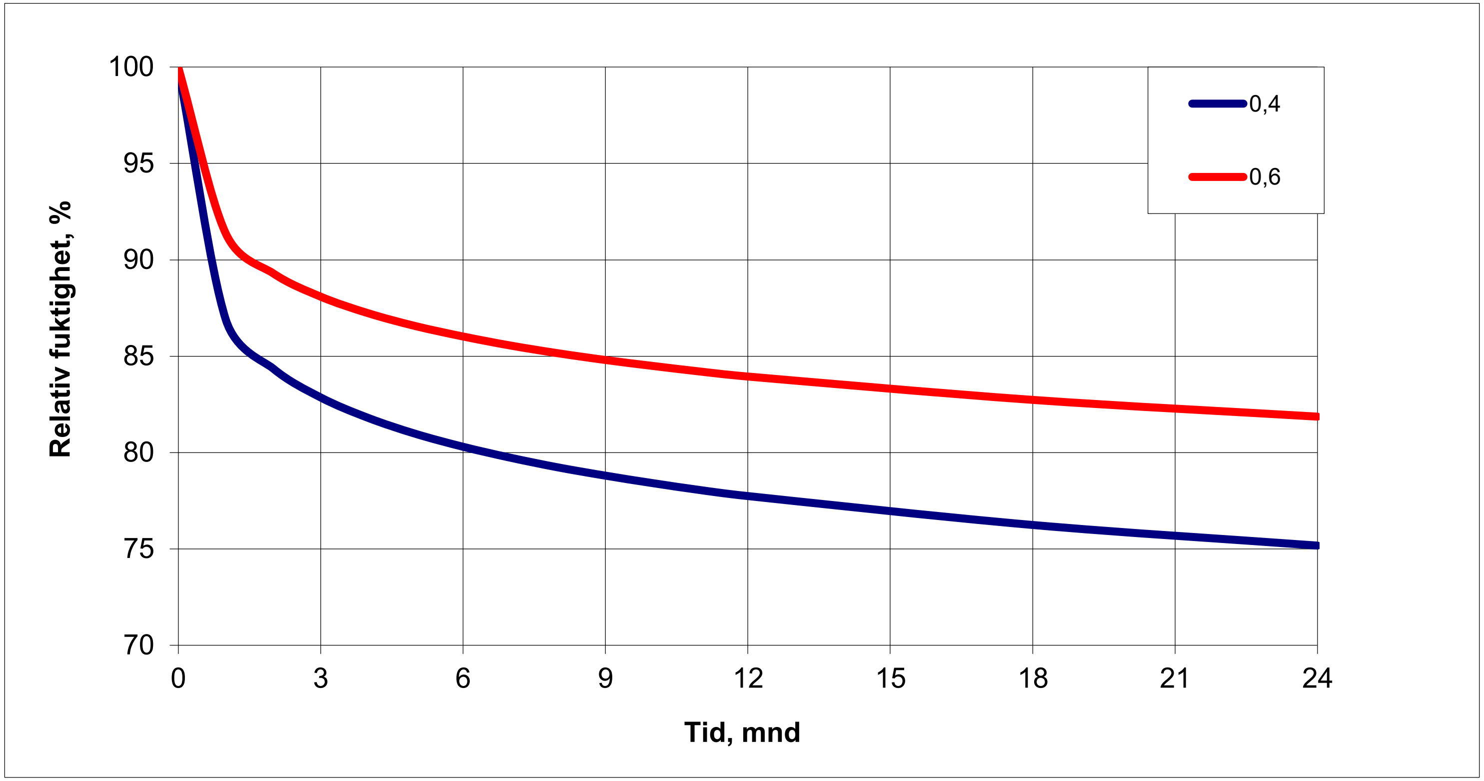


SINTEF report from 1988

Self-desiccation concrete

T.Kanstad 1990: Dr.avhandling

RF_{sf}	=	(0,0351* ln(t)+0,223)*(v/c)-0,051*ln(t)+0,78



Use of self-desiccation concrete i practise

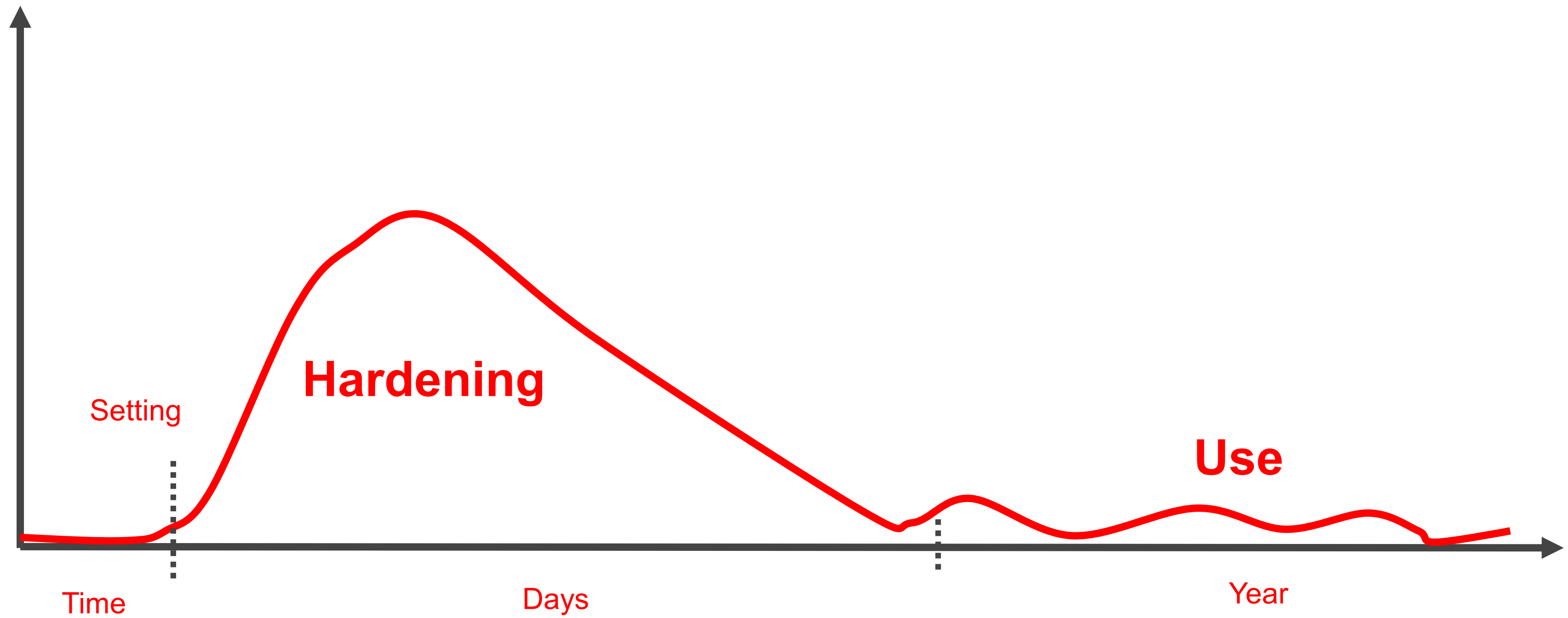
- Casting concrete floor at NORA, Brumunddal in 1989.
  - v/c-level 0,4
  - Epoxy mortar applied the day after casting.
- During 1990s it was several concrete floors in food industri casted with self-desiccation concrete and epoxy applied the day after casting.

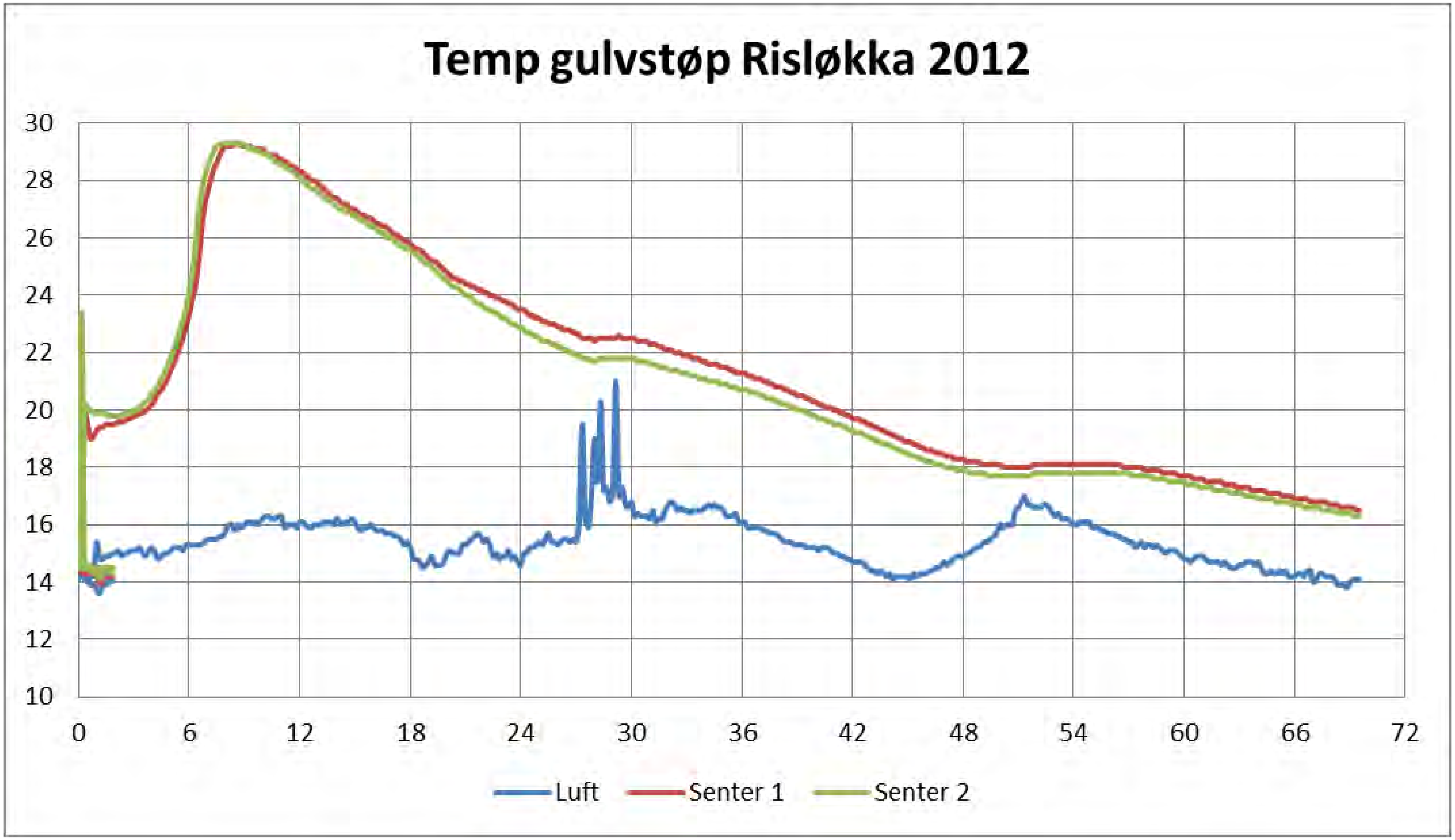
Use of self-desiccation concrete i practise

- Friday:
  - Concrete casting, v/c = 0,4.
    - Or dry mortar Confix with 2,3 l water and 0,2 l melamin pr. 25 kg bag.
  - Cover with plastic
- Saturday
  - Morning: Remove plastic
  - When the concrete surface is light gr
    - Atfer app. one hour
  - Epoxy primer applies
  - Evening: more epoxy
- Sunday
  - Topcoat epoxy
- Monday
  - Work at the food industri

Blanding
Mindre mengder kan blandes med drill og visp. Større volum blandes med mørtelblander eller tvangsblander. Blandetid minimum 3 minutter. Konsistensen reguleres med vanntilsetning, men vær oppmerksom på at høyere vannmengde enn anbefalt ca. 3,25 liter pr. sekk à 25 kg

Lifecycle concrete





Temp gulvstøp Risløkka 2012
30
28
26
24
22
20
18
16
14
12
10
0
6
12
18
24
30
36
42
48
54
60
66
72
Luft
Senter 1
Senter 2

Use of self-desiccation concrete i practise

- I started i AF 1998 and started to measure RH development in different concrete mixes.
- From year 2000 AF started to use concrete with self-desiccation properties in a bigger scale on «real» projects.

Measuring relative humidity in different concrete mixes

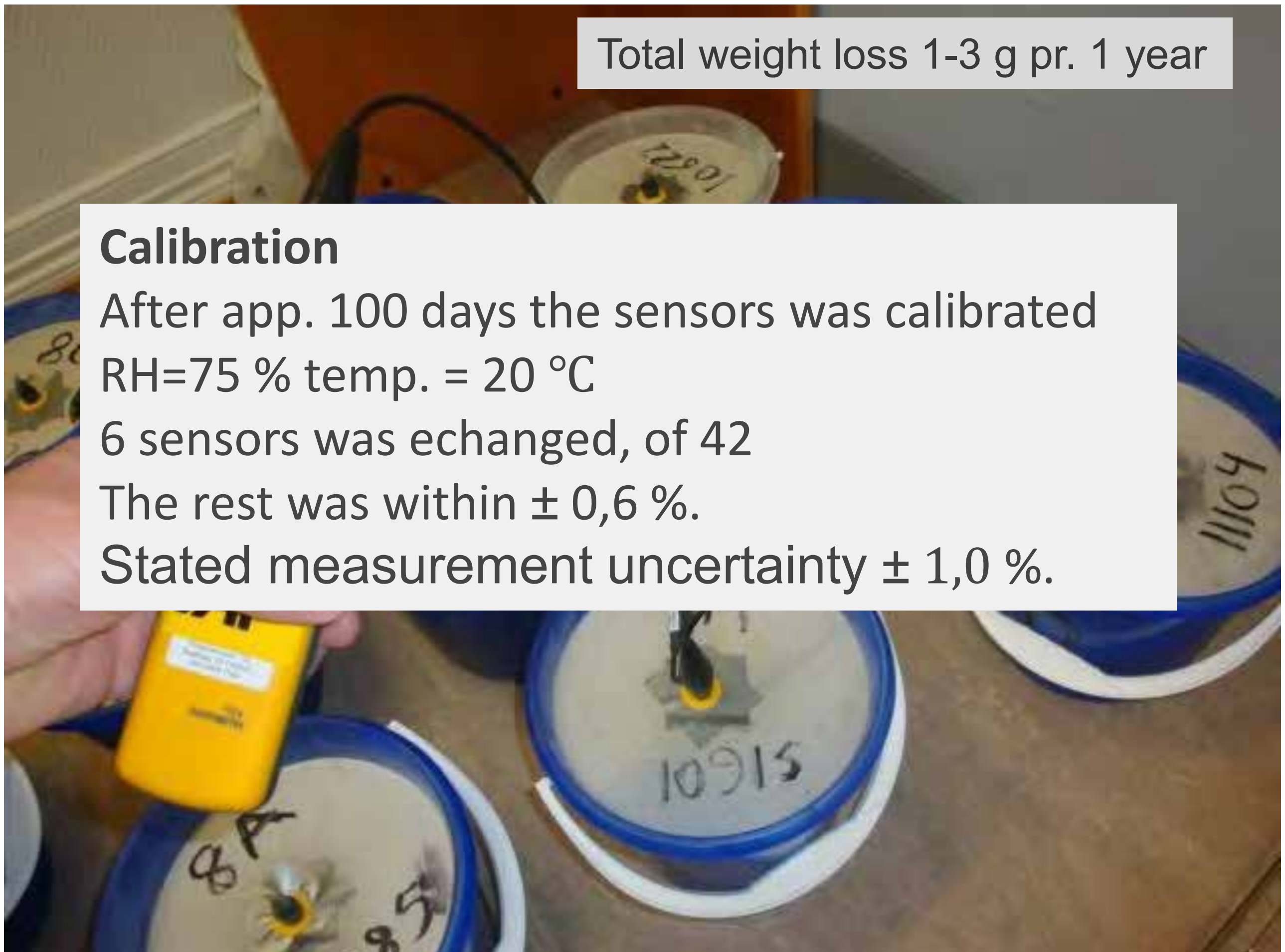
Resept nr.	Sementtype	V/C-tallet	Synkmål [cm]	Utbredingsmål [mm]
1	Aalborg Rapid	0,35	22,0	45-50
2		0,26	22,0	43-47
3		0,58	20,0	35-37
4		0,45	22,0	35-37
5		0,45	22,0	37-39
6		0,40	21,0	33-36
7		0,40	22,0	36-42
8		0,40	24,0	52-53
9		0,40	22,0	51-53
10	Svensk SR	0,40	20,0	30-34
11	Aalborg Rapid	0,35	20,0	37-38
12		0,60	21,0	37-39

Tabell 5-2. Oversikt over synkmål og utbredingsmål


10
9

Relative humidity in concrete

Relative humidity in concrete



Total weight loss 1-3 g pr. 1 year

Calibration

After app. 100 days the sensors was calibrated

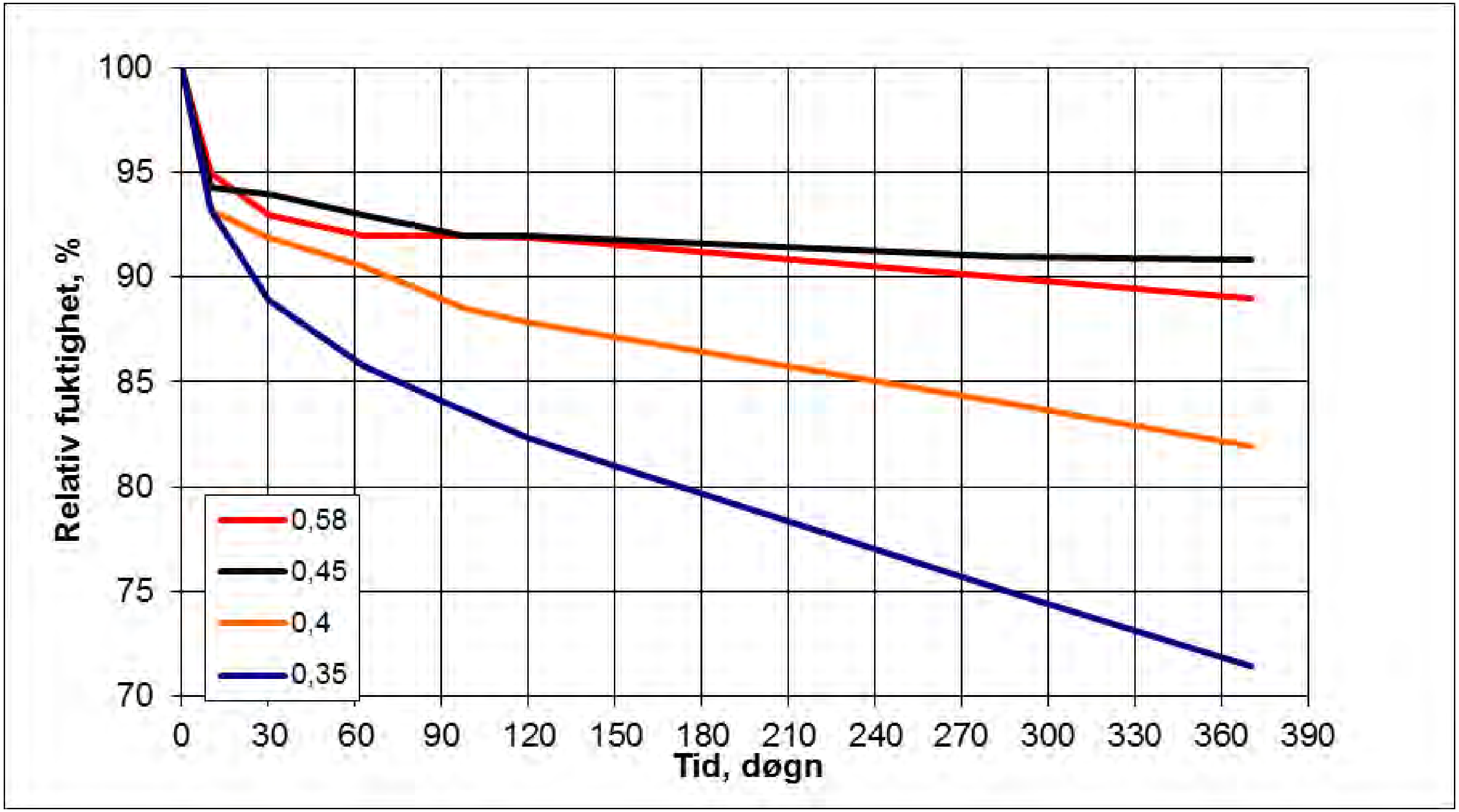
RH=75 % temp. = 20 ℃

6 sensors was echanged, of 42

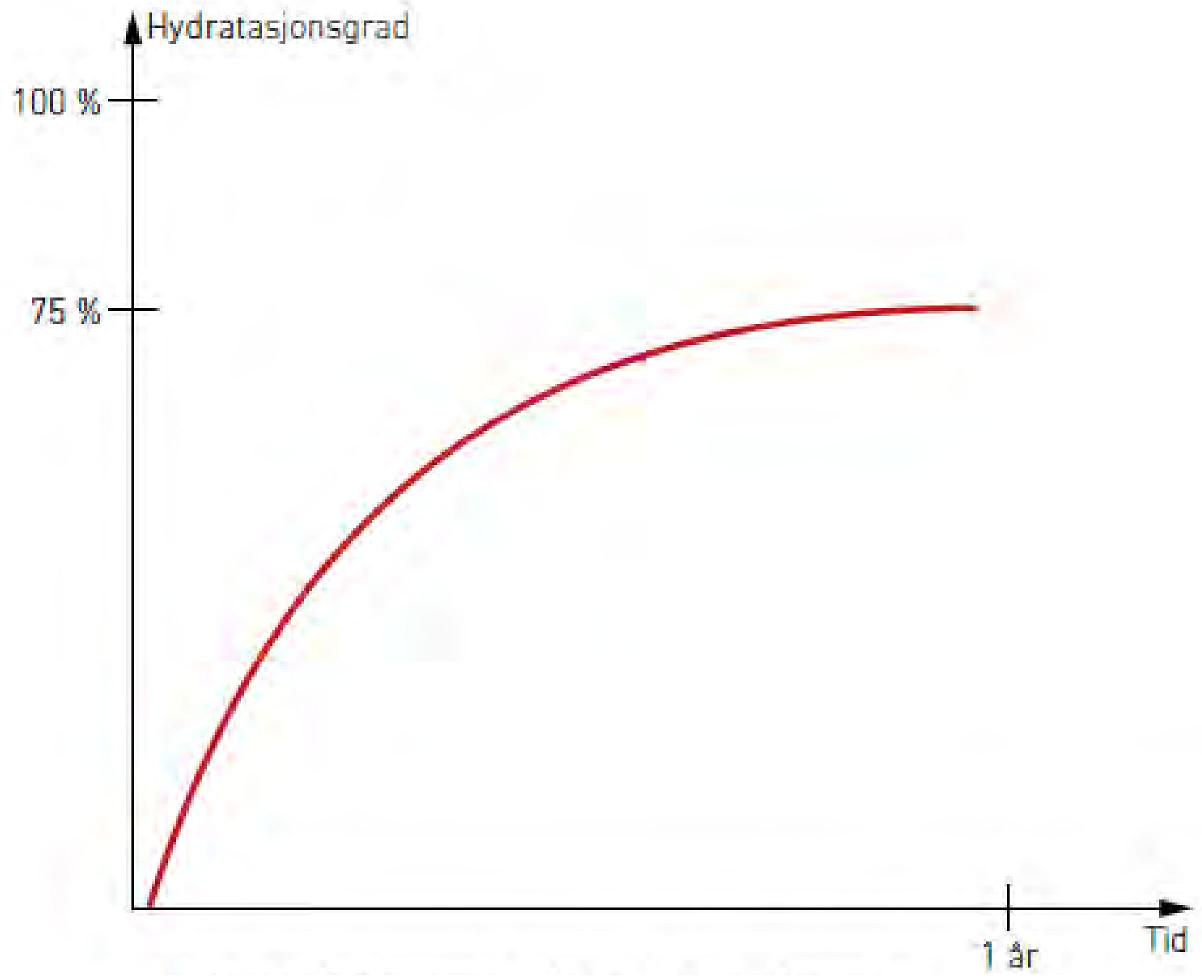
The rest was within ± 0,6 %.

Stated measurement uncertainty ± 1,0 %.

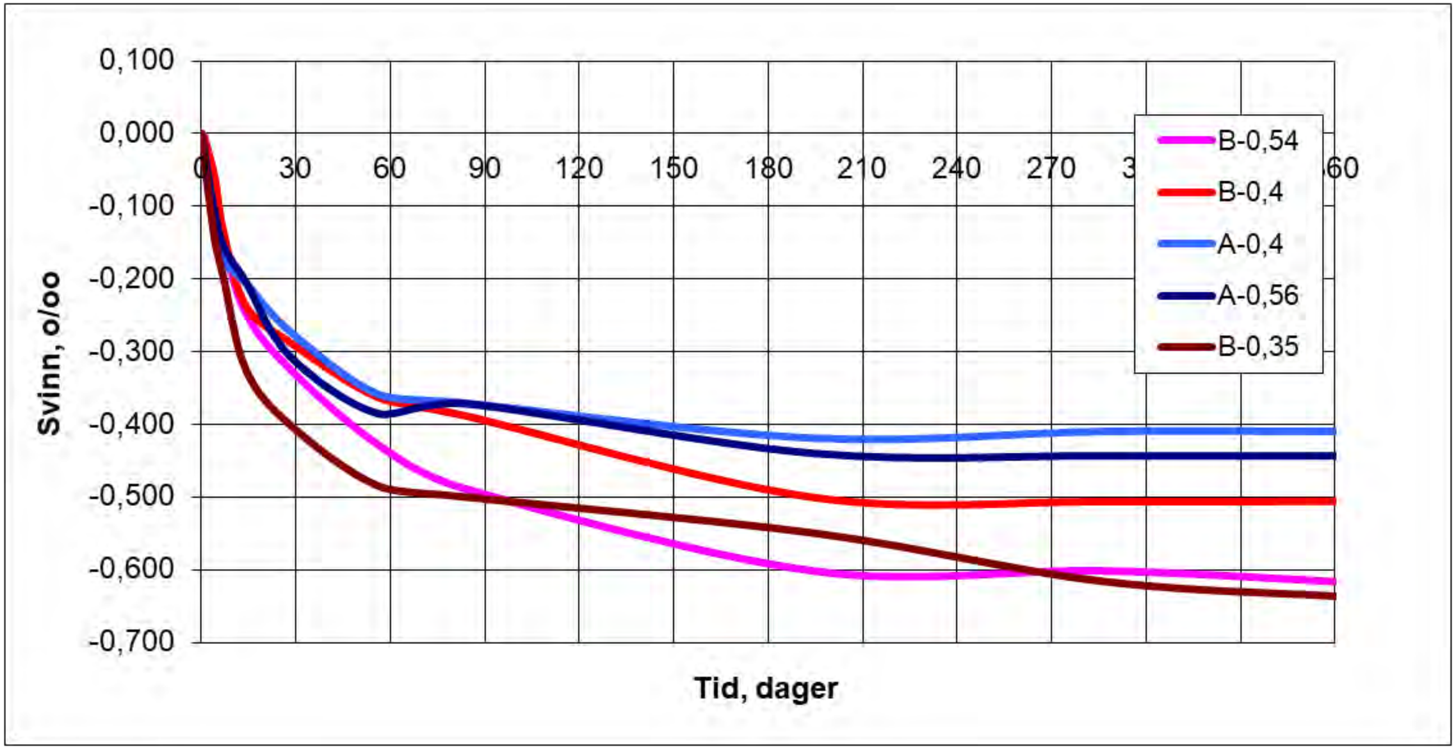
Relative humidity, self-desiccation



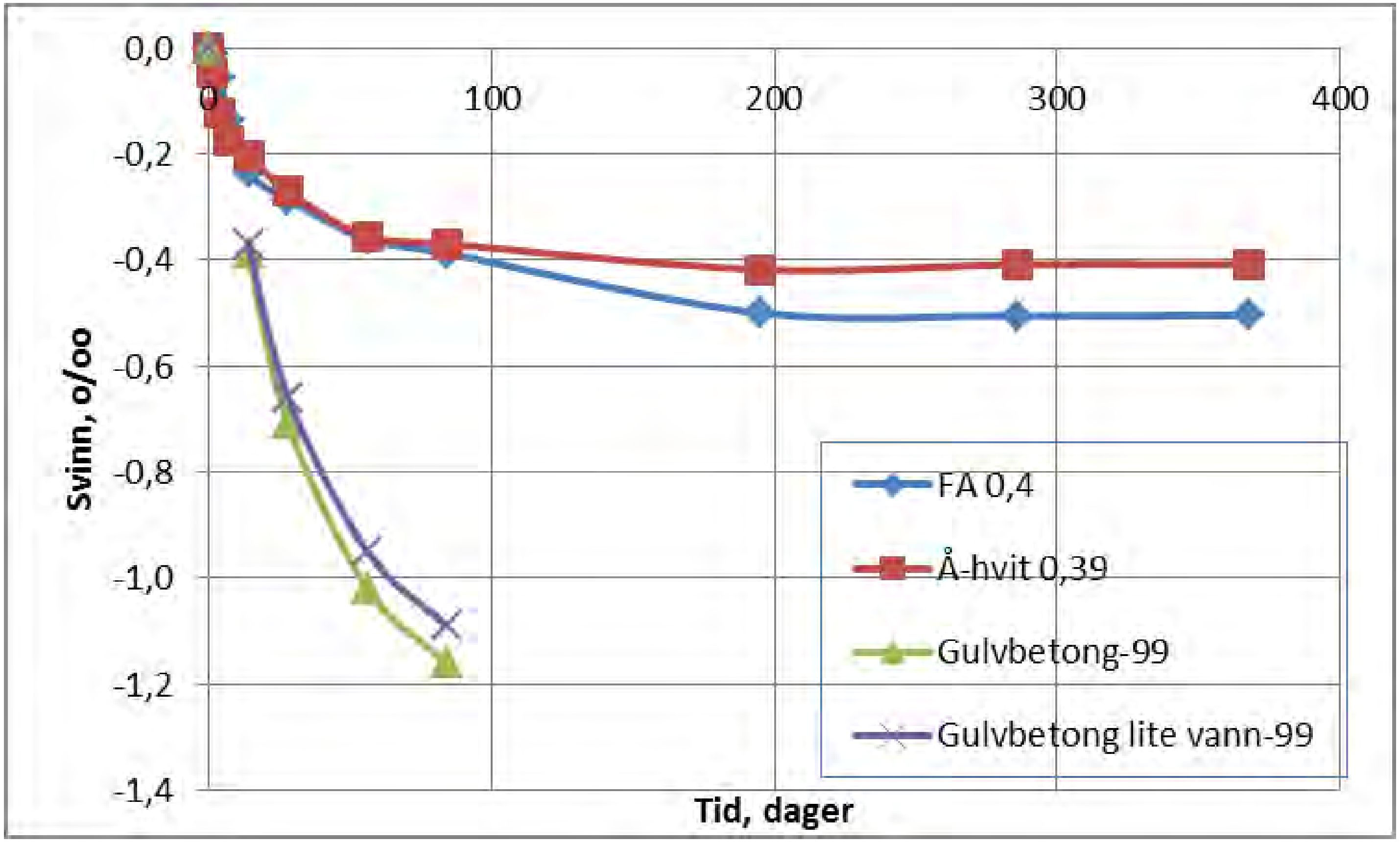
Hydratasjonsgrad



Shrinkage

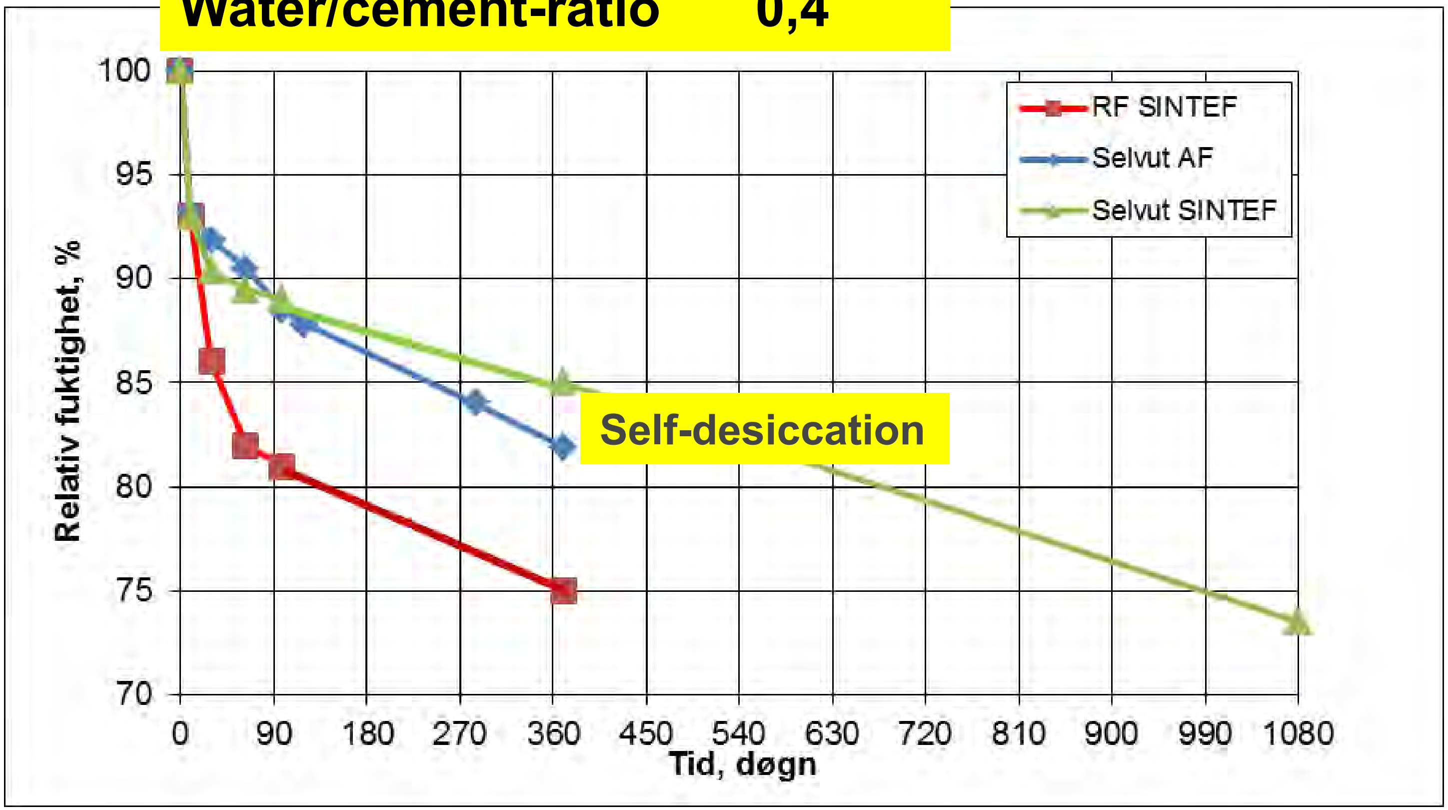

0,100
0,000
-0,100
-0,200
-0,300
-0,400
-0,500
-0,600
-0,700
Svinn, o/oo
0
30
60
90
120
150
180
210
240
270
3
60
Tid, dager
B-0,54
B-0,4
A-0,4
A-0,56
B-0,35

Shrinkage:
- C25 from 1999
- B35M40 from 2012

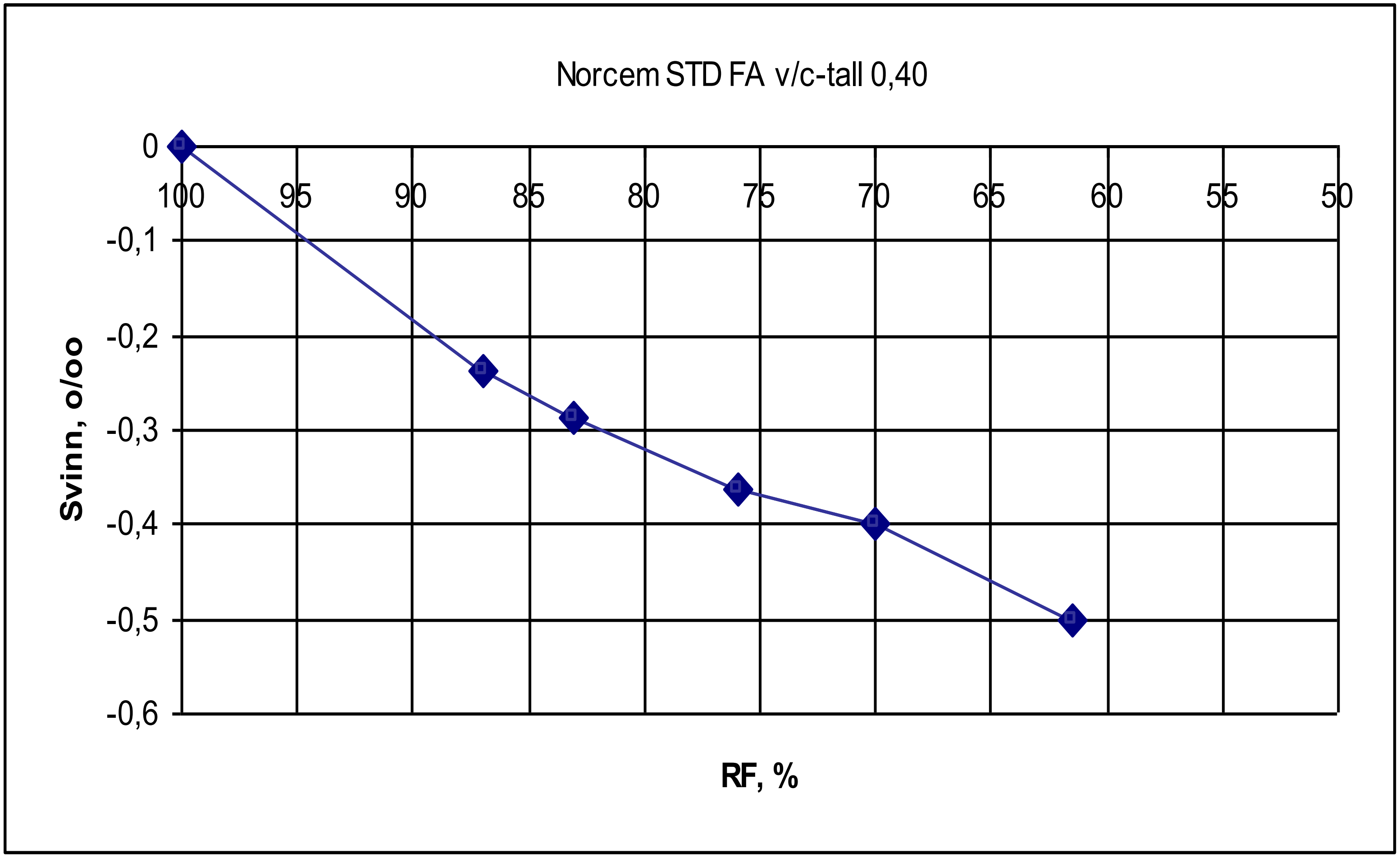


2008: «Low-heat» concrete

CEM I	260 kg
Flyveaske	130kg
Water/cement-ratio	0,4



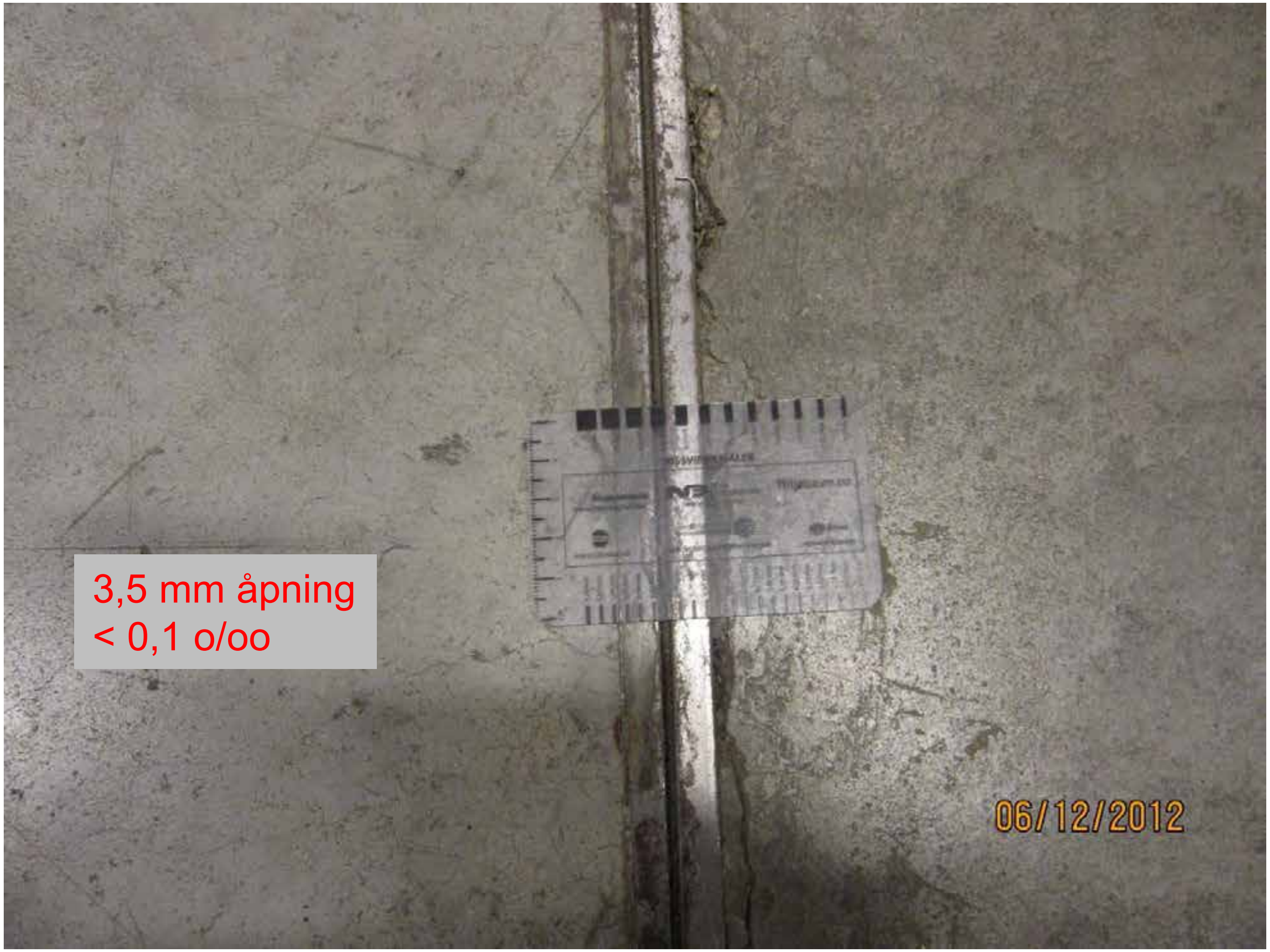
Shrinkage and relative humidity



Våler i Østfold, 2010

Våler, 2010

Målt 2012



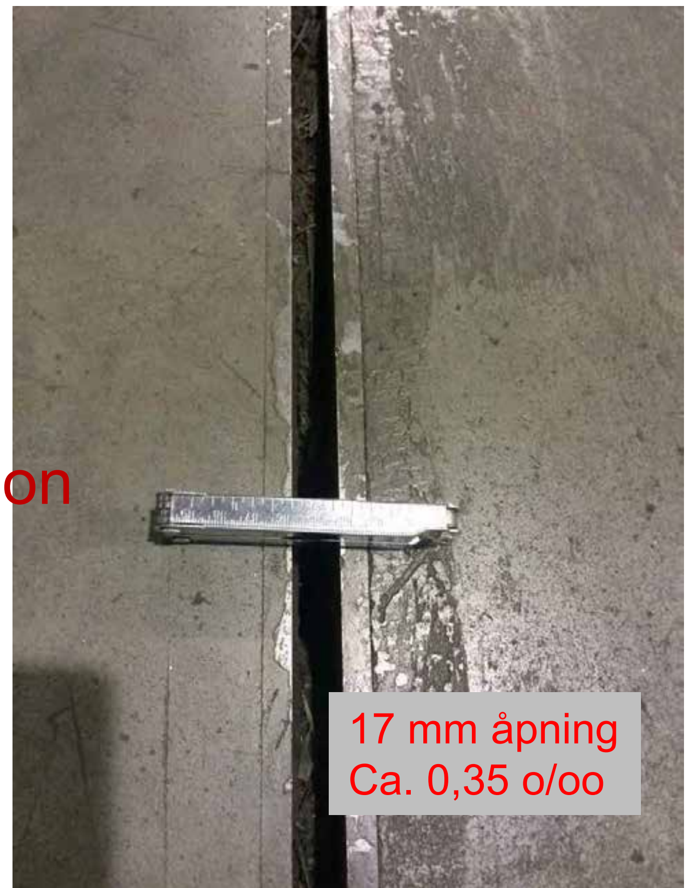
Våler, 2010

Målt 2016

Industrigulv Fredrikstad, 2012

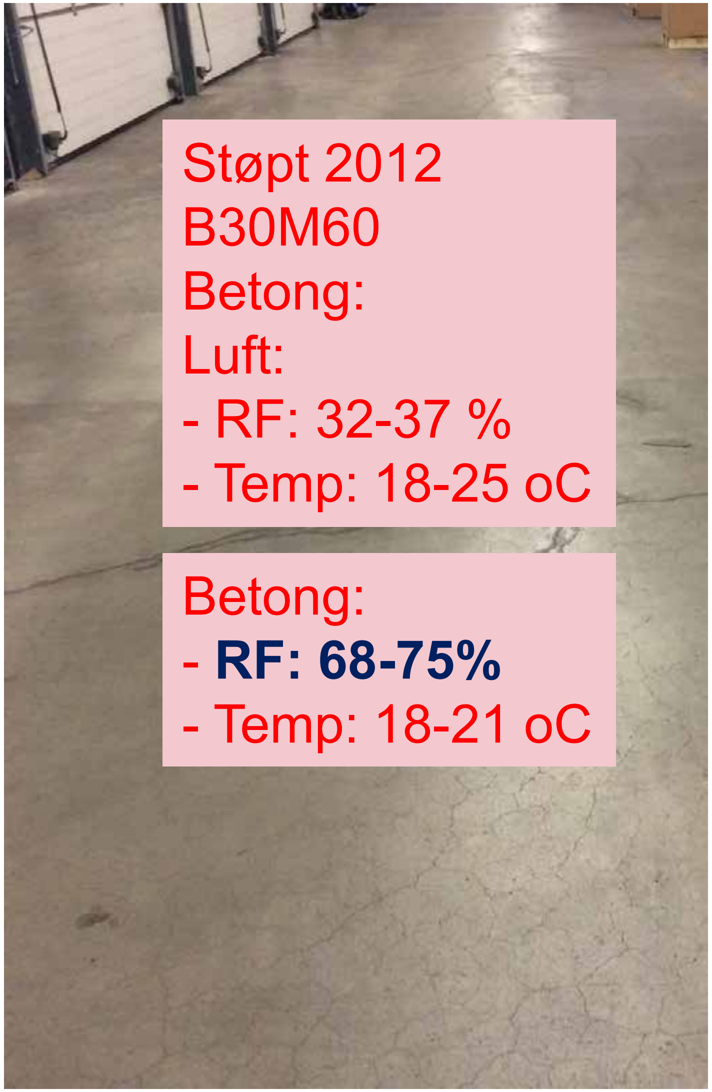
Befaring des. 2015

B30M60
Med hardbetong
Svinnkompensert med ekspansjon
Fiberarmert
Feltstørrelse: 50 x 30 m2



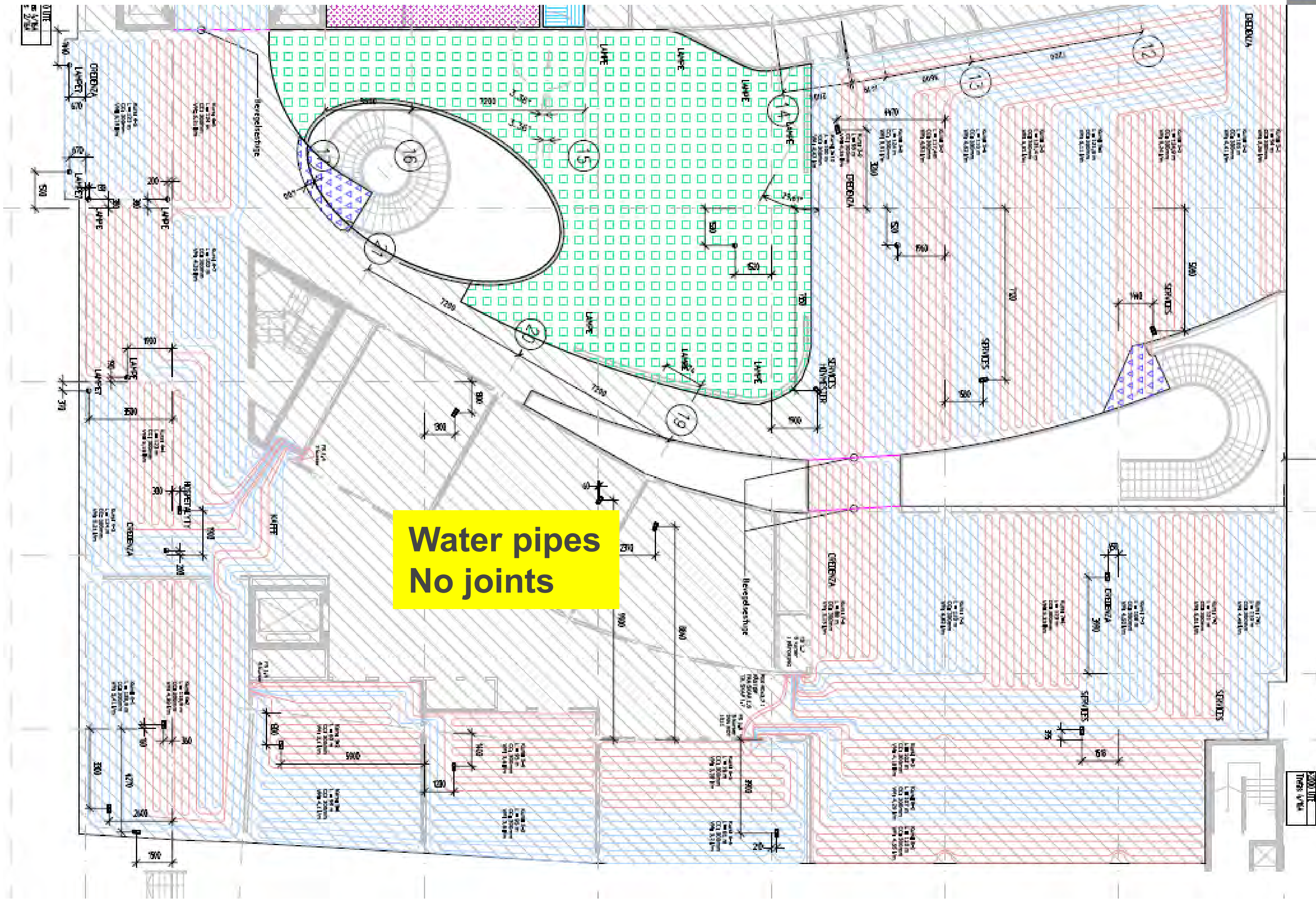
17 mm åpning
Ca. 0,35 o/oo

Hvorfor er gulvene så forskjellige?



AF GRUPPEN

Hotel Park Inn, Gardermoen



Water pipes
No joints


Concrete: B35M40
Reinforcement: 2 x A_{smin}
20 mm etafoam
12/02/2010


16/02/2010


HÆHRE
16/02/2010


01/03/2010

- Concrete composition
  - -least possible cement paste
  - -v/c-tall 0,4
- -Slump 20 cm, ” cream consistency”
- -pipe: 3”
- -Dissing + plastic
- -Tiles or screed with coating

Sykehuset i Østfold

30.000 m2 40-90 mm concrete floor on hollowhollow deck
No time for desiccation

40-90 mm concrete
Reinforcement K335

Sykehuset i Østfold

Sykehuset i Østfold

SCC, 58 cm
Dissing
Curing membrane
Grinding
Coating


• Grinding
• Coating
13/02/2013

HOW TO CONTROL THE RELATIVE HUMIDITY IN THE CONCRETE?

"Normal" concrete and desiccation

- RF must be measured according NS 3511:2014

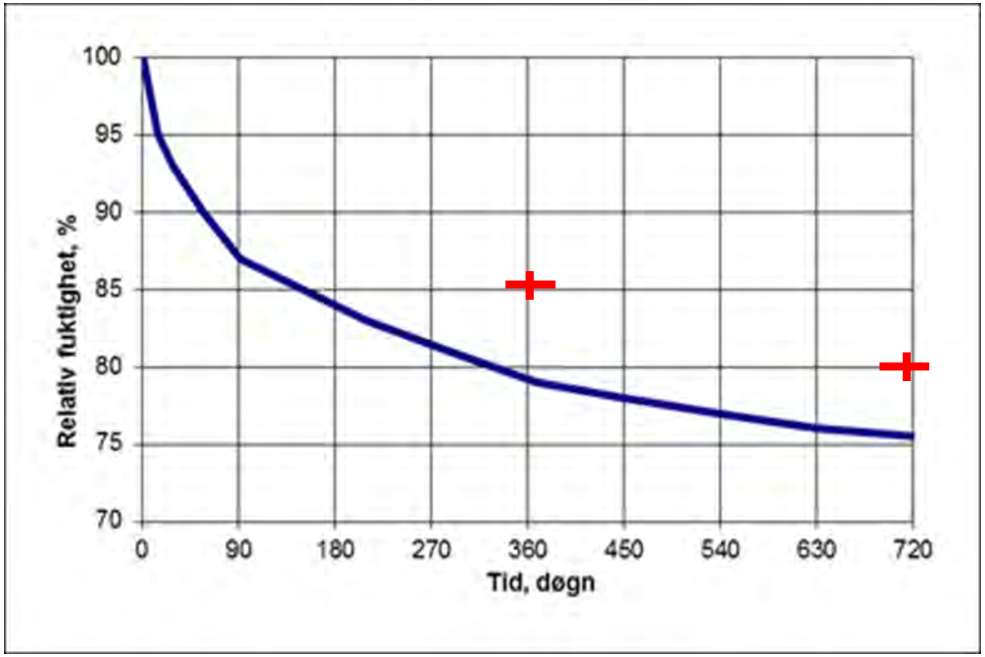
«Self-desiccation» concrete

- Documentation on each concrete mix, *NB15 Gulv på grunn*

Dokumentation of self-desiccation

Pb. 15: Gulv på grunn (Concrete floor on ground)

- Self-desiccation of concrete mixes must be after prosedure in NB15
- Self-desiccation is documentated by measuring relative humidity:
  - ≤ 85% after 1 år and/or
  - ≤ 80% after 2 år



I Norge i år 2000

EN 197-1:2000

Table 1- The 27 products in the family of common cements

Norcem Standard
Industri
Anlegg
SR
Embra Standard
Rapid

Norcem Standard FA

Main types	Notation of the 27 products (types of common cement)		Composition [proportion by mass[1]]										
								Fly ash		Burnt shale	Limestone*		Minor additional constituents
								…us	calcareous W	T	L	LL	
CEM I	Portland cement	CEM I							-	-	-	-	0-5
CEM II	Portland-slag cement	CEM II/A-S							-	-	-	-	0-5
		CEM II/B-S							-	-	-	-	0-5
	Portland-silica fume cement	CEM II/A-D							-	-	-	-	0-5
	Portland-pozzolana cement	CEM II/A-P							-	-	-	-	0-5
		CEM II/B-P							-	-	-	-	0-5
		CEM II/A-Q	80-94	-	-	-	6-20	-	-	-	-	-	0-5
		CEM II/B-Q	65-79	-	-	-	21-35	-	-	-	-	-	0-5
	Portland-fly ash cement	CEM II/A-V				-	-	6-20	-	-	-	-	0-5
		CEM II/B-V				-	-	21-35	-	-	-	-	0-5
		CEM II/A-W	80-94	-	-	-	-	-	6-20	-	-	-	0-5
		CEM II/B-W	65-79	-	-	-	-	-	21-35	-	-	-	0-5
	Portland-burnt shale cement	CEM II/A-T	80-94	-	-	-	-	-	-	6-20	-	-	0-5
		CEM II/B-T	65-79	-	-	-	-	-	-	21-35	-	-	0-5
	Portland-limestone cement	CEM II/A-L	80-94	-	-	-	-	-	-	-	6-20	-	0-5
		CEM II/B-L	65-79	-	-	-	-	-	-	-	21-35	-	0-5
		CEM II/A-LL	80-94	-	-	-	-	-	-	-	-	6-20	0-5
		CEM II/B-LL	65-79	-	-	-	-	-	-	-	-	21-35	0-5
	Portland-composite cement[3]	CEM II/A-M	80-94	<-- 6-20 --									0-5
		CEM II/B-M	65-79	<-- 21-35 --									0-5
CEM III	Blastfurnace cement	CEM III/A	35-64	36-65	-	-	-	-	-	-	-	-	0-5
		CEM III/B	20-34	66-80	-	-	-	-	-	-	-	-	0-5
		CEM III/C	5-19	81-95	-	-	-	-	-	-	-	-	0-5
CEM IV	Pozzolanic cement[3]	CEM IV/A	65-89	-	<------------- 11-35 ------------->					-	-	-	0-5
		CEM IV/B	45-64	-	<------------- 36-55 ------------->					-	-	-	0-5
CEM V	Composite cement[3]	CEM V/A	40-64	18-30	-	<---------- 18-30 ---------->			-	-	-	-	0-5
		CEM V/B	20-38	31-50	-	<---------- 31-50 ---------->			-	-	-	-	0-5

EN 197-1:2000

Table 1- The 27 products in the family of common

I Norge i år 2016

Norcem Industrisement CEM I 42,5 R

Cemex Rapid
Cemex Hvit

Aalborg Rapid CEM I 52,5 N- (LA)
Aalborg White CEM I 52,5 R – SR5

Cemex Miljøsement CEM II/B-S 52,5 N

Norcem Anlegg FA CEM II/A-V 42,5 N
Norcem Lavkarbonsement CEM II/A-V 42,5 N

Norcem Standard FA CEM II/B-M 42,5 R.

Cemex Miljøsement II CEM III/A 42,5 N
Cemex LH LC* CEM III/B 42,5 N

Main types	Notation of the 27 products (types of common cement)		Composition [proportion by mass 1)]										
			Main constituents										
			Clinker K	Blastfurnace slag	Silica fume	Pozzolana natural	Pozzolana natural calcined					LL	
CEM I	Portland cement	CEM I	95-100									-	0-5
CEM II	Portland-slag cement	CEM II/A-S	80-94	6-20					-	-	-	-	0-5
		CEM II/B-S	65-79							-	-	-	0-5
	Portland-silica fume cement	CEM II/A-D	90-94	-	6-10	-	-	-	-	-	-	-	0-5
	Portland-pozzolana cement	CEM II/A-P	80-94	-	-	6-20	-	-	-	-	-	-	0-5
		CEM II/B-P	65-79	-	-	21-35	-	-	-	-	-	-	0-5
		CEM II/A-Q	80-94	-	-	-	6-20	-	-	-	-	-	0-5
		CEM II/B-Q	65-79	-	-	-	21-35	-	-	-	-	-	0-5
	Portland-fly ash cement	CEM II/A-V	80-94	-	-	-							0-5
		CEM II/B-V	65-79	-	-	-							0-5
		CEM II/A-W	80-94	-	-	-							0-5
		CEM II/B-W	65-79	-	-	-	-	-	21-35	-	-	-	0-5
	Portland-burnt shale cement	CEM II/A-T	80-94	-	-	-	-	-	-	6-20	-	-	0-5
		CEM II/B-T	65-79	-	-	-	-	-	-	21-35	-	-	0-5
	Portland-limestone cement	CEM II/A-L	80-94	-	-	-	-	-	-	-	6-20	-	0-5
		CEM II/B-L	65-79	-	-	-	-	-	-	-	21-35	-	0-5
		CEM II/A-LL	80-94	-	-	-	-	-	-	-	-	6-20	0-5
		CEM II/B-LL	65-79	-	-	-	-	-	-	-	-	21-35	0-5
	Portland-composite cement 3)	CEM II/A-M	80-94	<------------------------------									0-5
		CEM II/B-M	65-79	<------------------------------ 21-35 ------------------------------									0-5
CEM III	Blastfurnace cement	CEM III/A	35-64						-	-	-	-	0-5
		CEM III/B	20-34						-	-	-	-	0-5
		CEM III/C	5-19						-	-	-	-	0-5
CEM IV	Pozzolanic cement 3)	CEM IV/A	65-89	-	<------------- 11-35 ------------->					-	-	-	0-5
		CEM IV/B	45-64	-	<------------- 36-55 ------------->					-	-	-	0-5
CEM V	Composite cement 3)	CEM V/A	40-64	18-30	-	<---------- 18-30 ---------->			-	-	-	-	0-5
		CEM V/B	20-38	31-50	-	<---------- 31-50 ---------->			-	-	-	-	0-5

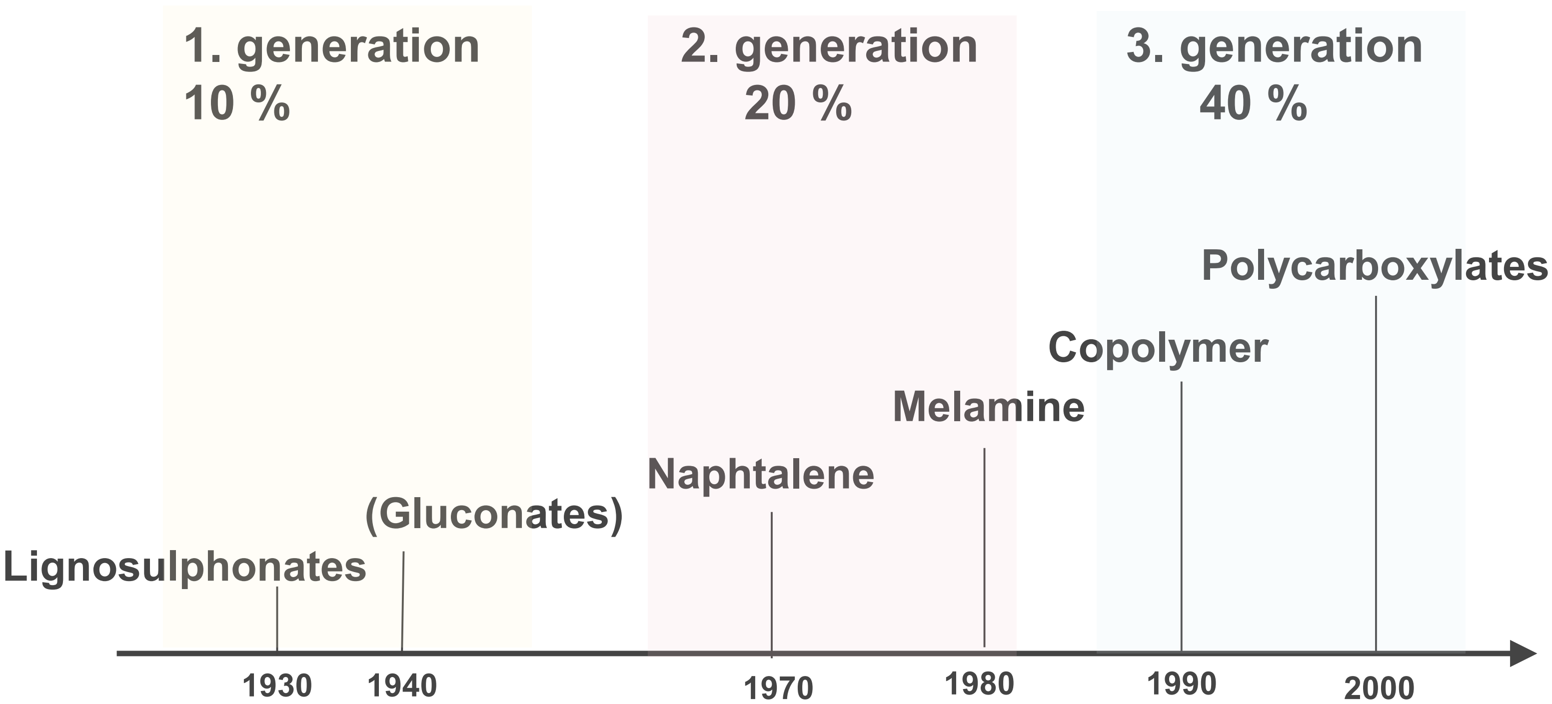
NB 37 Lavkarbonbetong

	B20 M90	B25 M90	B30 M60	B35 M45/MF45	B35 M40/MF40	B45 M40/MF40	B55 M40/MF40
	Maksimalt tillatt klimagassutslipp [kg CO_2-ekv. pr m^3 betong]						
Lavkarbon A	170	180	200	210	230	240	250
Lavkarbon B	200	220	240	270	300	310	320
Lavkarbon C	240	260	280	320	350	360	370
Bransjereferanse	280	300	320	370	410	420	430

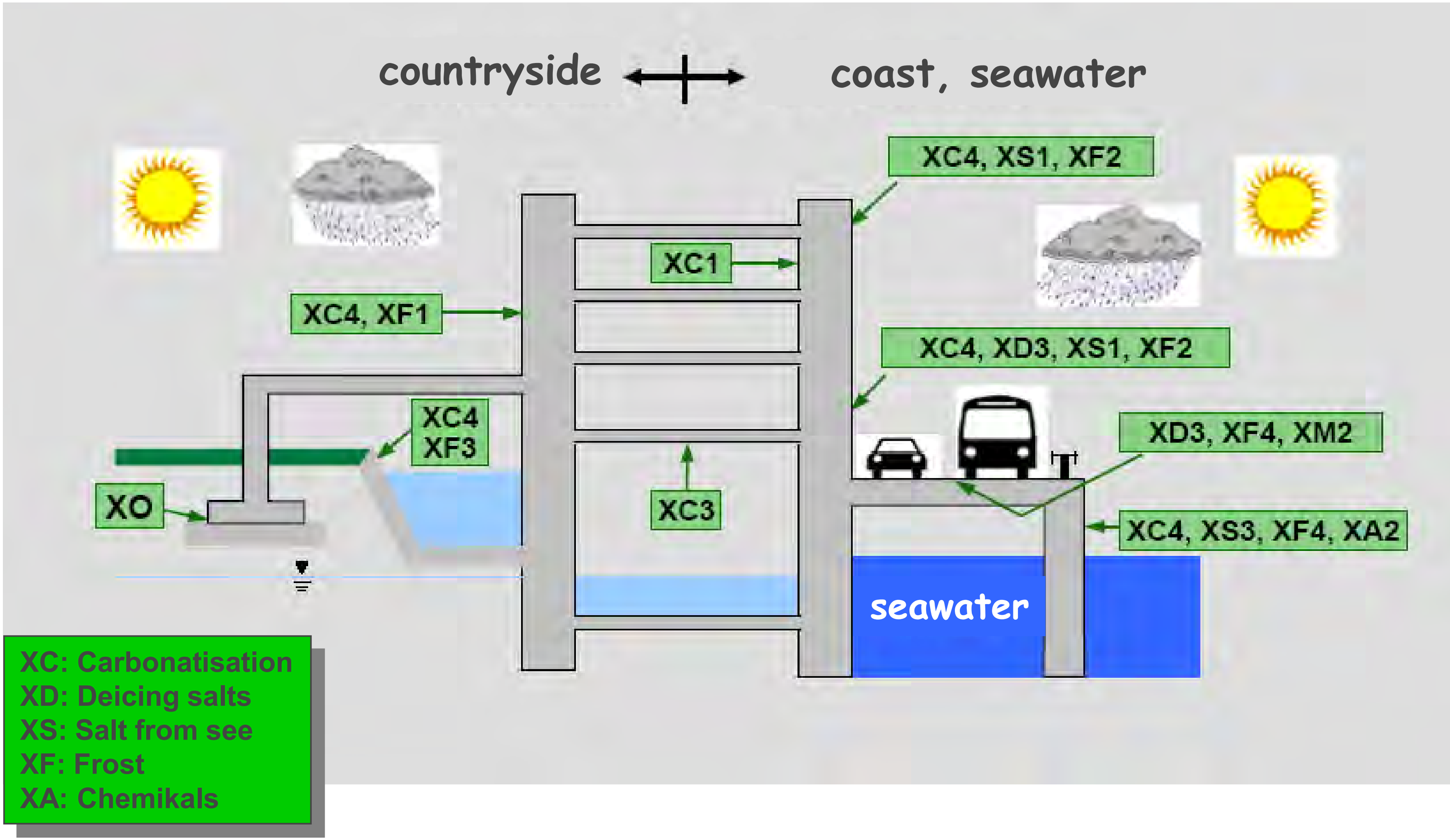
Klimagassutslippet oppgis for 1 m^3 betong og dekker livsløpet fra råvareuttak til betongprodusentens fabrikkport. Utslippet oppgis som kg CO_2-ekv./m^3 betong. Ved omregning fra kg/m^3 til kg/tonn brukes densiteten 2400 kg/m^3.

Admixtures, water redusers

Water reduction:



Exposure classes



Durabilityclasses (Bestandighetsklasser)

Tabell NA.15 – Valg av bestandighetsklasse, avhengig av eksponeringsklasse

Eksponeringsklasse	Bestandighetsklasse					
	M90	M60	M45	MF45	M40	MF40
X0	X	X	X	X	X	X
XC1, XC2, XC3, XC4, XF1		X	X	X	X	X
XD1, XS1, XA1, XA2 [a], XA4 [b]			X	X	X	X
XF2, XF3, XF4				X		X
XD2, XD3, XS2, XS3, XA3 [a]					X	X
XSA [a]	Betongsammensetning og beskyttelsestiltak fastsettes særskilt. Betongsammensetningen skal minst tilfredsstille kravene til M40.					

[a] Om det i eksponeringsklasse XA2, XA3 eller XSA er mulighet for kontakt med sulfater i konsentrasjoner høyere enn nedre grenseverdi for XA2, skal det i betongspesifikasjonen være angitt at det skal anvendes sulfatbestandig bindemiddel (SuR1 eller SuR2). Se også tabell NA.13.

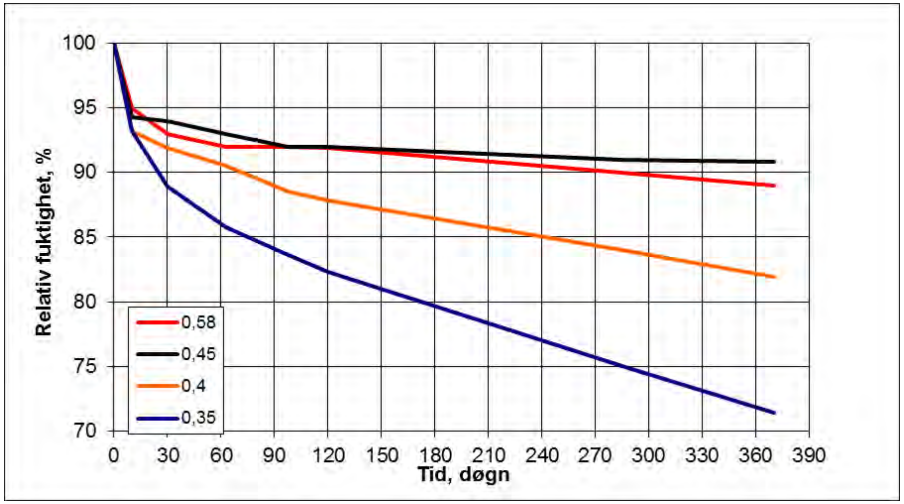
[b] For konstruksjoner utsatt for husdyrgjødsel skal det i betongspesifikasjonen være angitt at det skal anvendes minst 4 % silikastøv.

All construction under ground is v/c-ratio 0,4

Because of parking areas

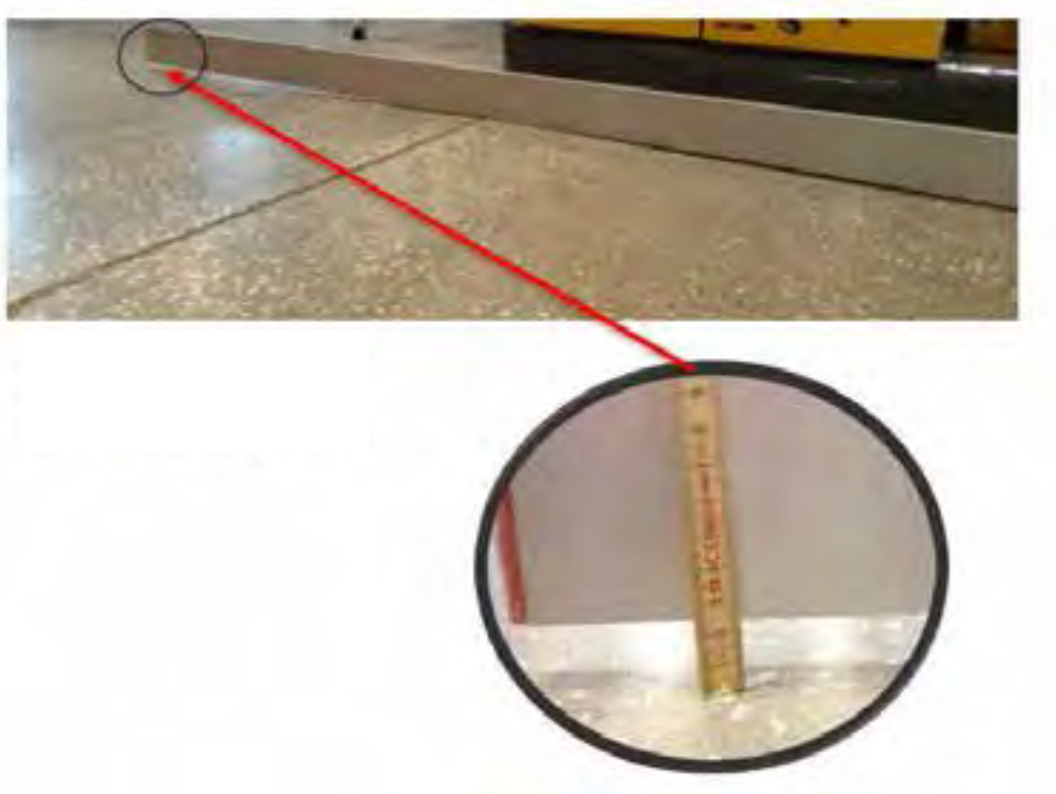
Building moisture

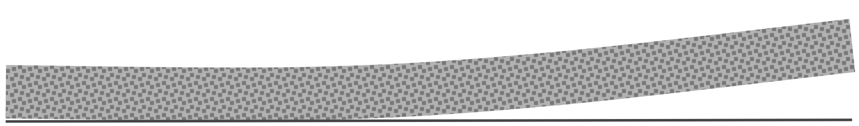
Building Technology Regulations (TEK17) require materials to be sufficiently dry during incorporation to prevent hygienic problems such as mold growth or chemical degradation.



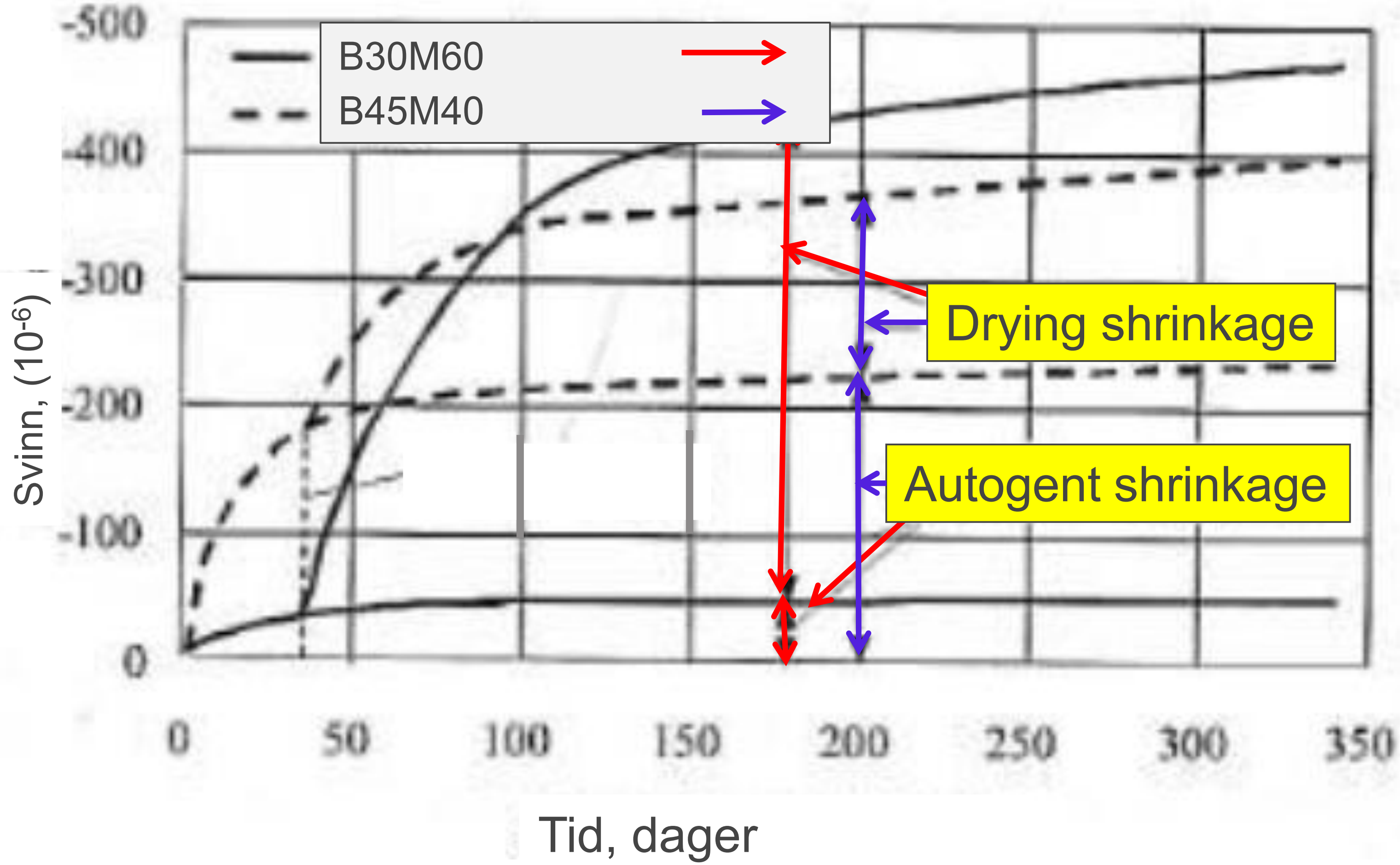
Other advantages by using a low v/c-ratio?

Edge lofting (kantreising)





Shrinkage


-500
-400
-300
-200
-100
0
B30M60
B45M40
Drying shrinkage
Autogent shrinkage
Svinn, (10-6)
0
50
100
150
200
250
300
350
Tid, dager

Edge lofting (kantreising)

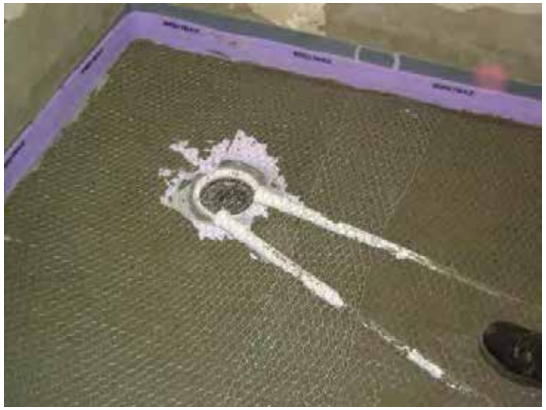
Edge lofting (kantreising)

- The surface dries out and contract
  - The concrete crumbles
- 1-2 m from edges or corners
- Can be reduced by
  - Thicker floor
  - Reinforcement
  - More covering of the concrete, slower drying
  - Lower v/c-ratio
- «MIGHT» be less after some years, when the concrete is«dry» (1-5år)

Rehabilitation of bathrooms

- AF started i 1999
- From 2002:
  - 800-1400 bathrooms/year
- Special mortar for bathrooms in 2006

Rehabilitation of bathrooms


TM Støpemørtel Bad

Trondheim Mørtelverk prodused TM Støpemørtel Bad for AF.

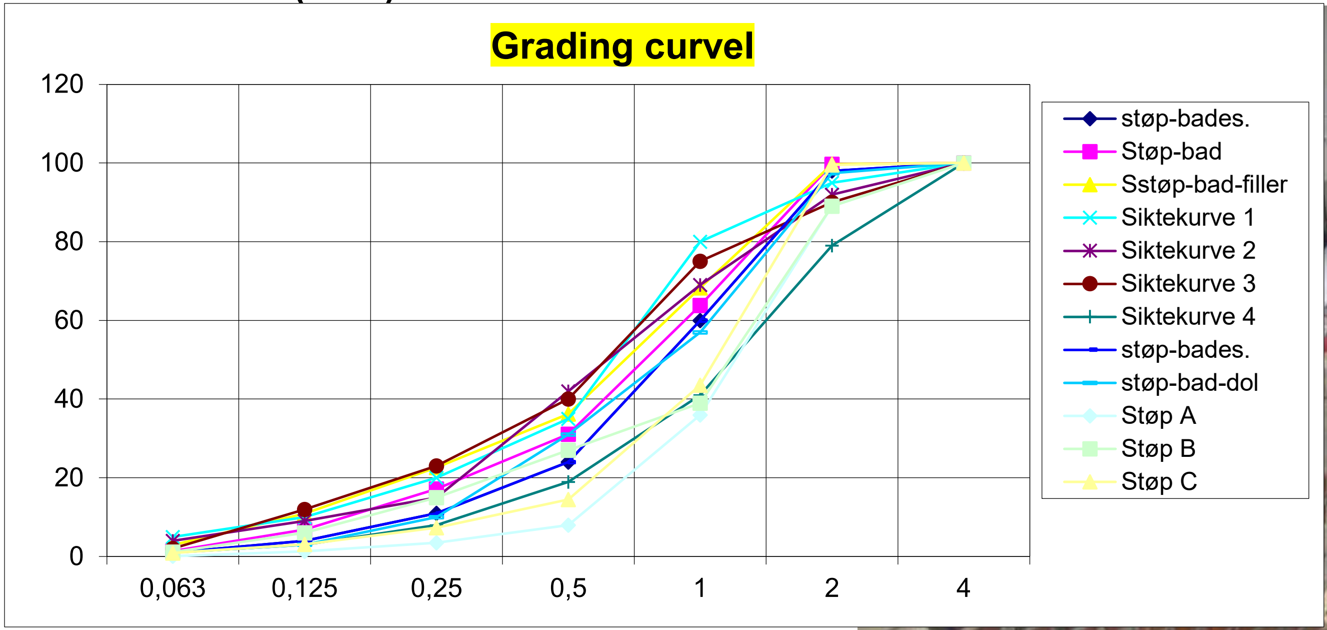
- Mortar B35M40 – «dry»
- v/c-ratio 0,37
- Standard FA-sement
- Melamin (SP)

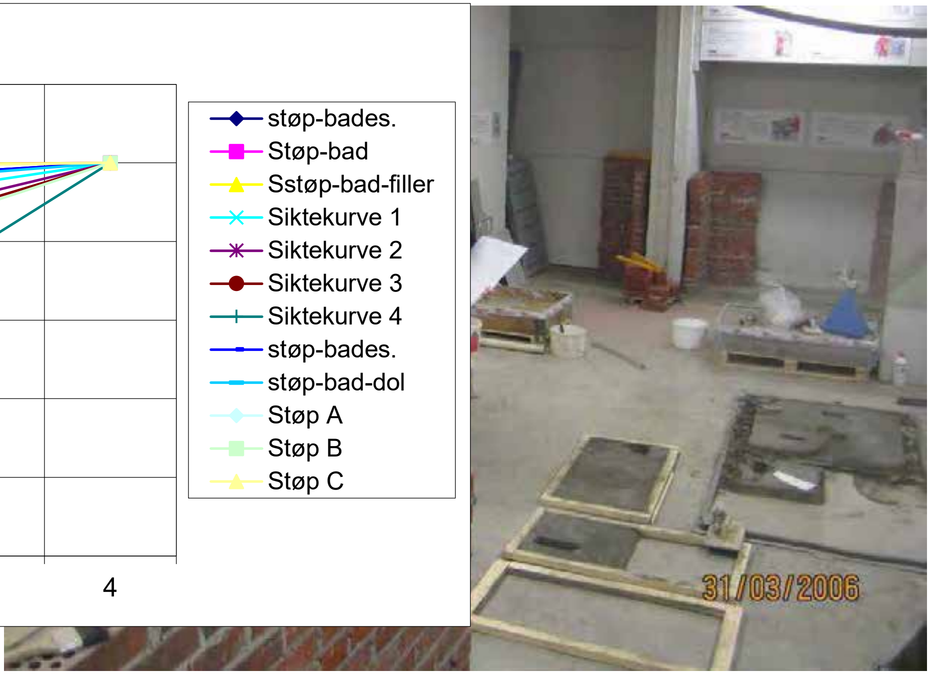
If the water-ratio happened to be 0,39, the mortar was impossoble to process, difficult for the craftsman.

TM Støpemørtel bad

Trondheim Mørtelverk prodused TM Støpemørtel Bad for AF.

- Mortar B35M40 – «dry»
- v/c-ratio 0,37
- Standard FA-sement
- Melamin (SP)





Weber is still selling this mortar:

Weber Støpemørtel Bad

Produktdatablad

weber
SAINT-GOBAIN

PRODUKTFORDELER

- Hurtigherdende selvtørkende
- Velegnet med både bunn- og toppmembran
- God varmeledningsevne med varmekabler

Quick hardening and Self-desiccation

We developped also a shrinkage compensated mortar with TM

AF GRUPPEN

Weber Industrimørtel HP

Produktdatablad

weber
SAINT-GOBAIN

PRODUKTFORDELER

Selvtørkende, svinnkompensert mørtel som kan belegges tidlig.

Self-desiccation, shrinkage compensated…….

Self-levelling floors (Avrettingsmasse)

3 types

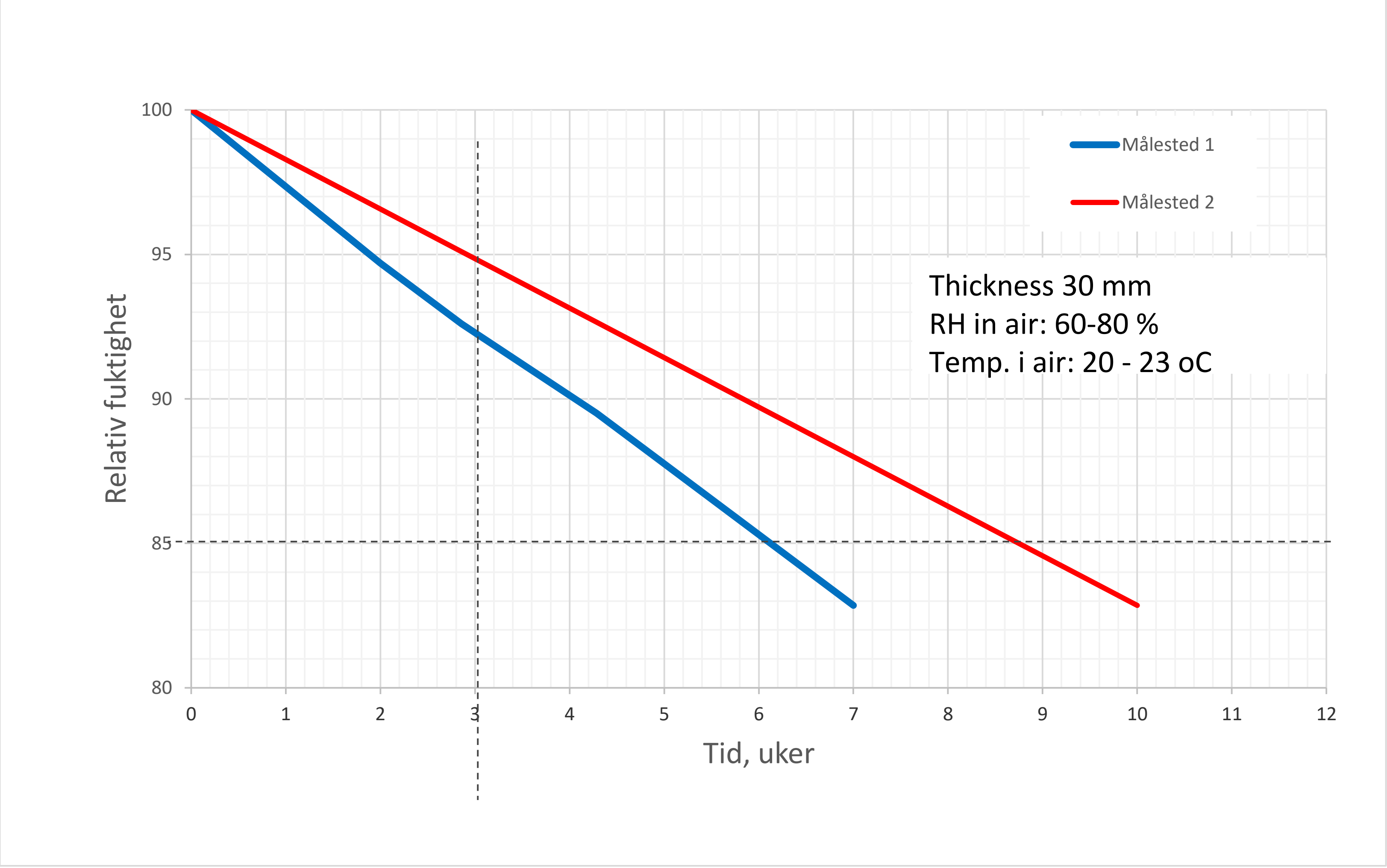
- Gypsum
  - Bind 18 % vann
- Portlandcement
  - Bind 23 % chemical og 18 % physical (using 40 %)
- ''Specialcement'', different types together
  - Aluminat, sulfoaluminat, portland, gips
  - Bind from 18 % and above

Self-levelling floors, desiccation

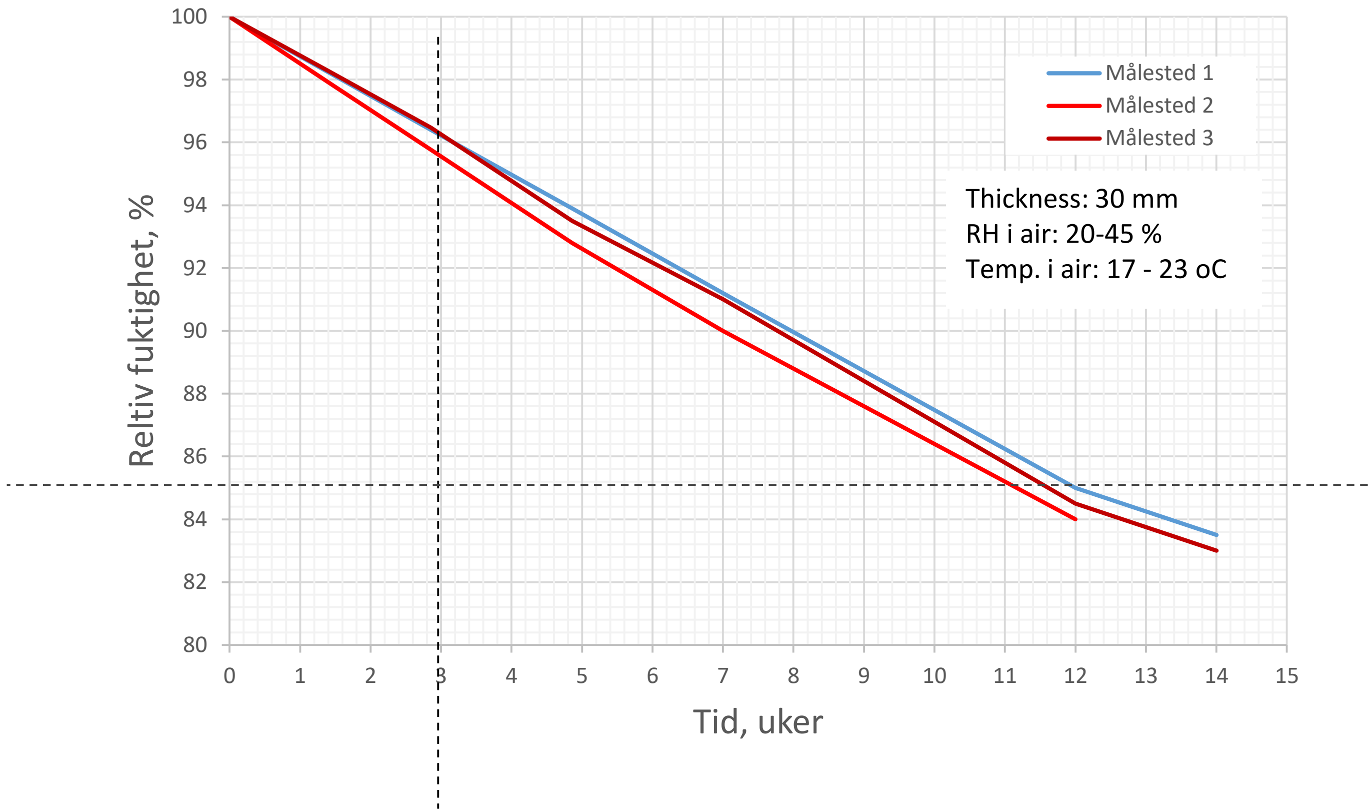
3 guiding principples

- «Normal»: drying 1 cm pr. uke
- «Quick»: drying 1 cm pr. dag
- «Selv-desiccation»: ?

Gypsum: 1 cm pr.week



Cementbased: 1 cm pr. week

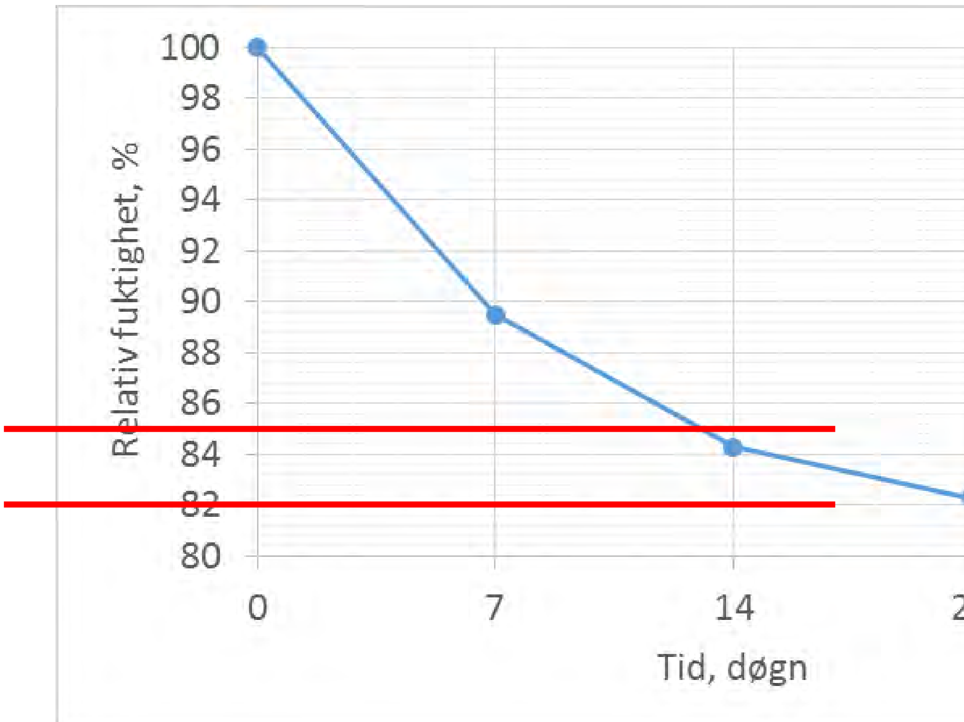


Quality on the surface has importance

Gypsum

Cementbased

Self-desiccation self-levelling floors




TAKK FOR OPPMERKSOMHETEN
Bernt Kristiansen
AF Gruppen

Self-desiccation by the use of shrinkage reducing agents and other additives

About the project

- The partners were;
  - Skanska (Contractor)
  - Norcem (cement producer)
  - NorBetong (concrete producer)
  - Sika (additives)
  - UCO Utleiecompagniet (RBK-measurements)
- The project period: 2013 – 2016
- Measurement methods and instruments that were used:
  - RH with the Swedish RBK method with Vaisala and “Byggforsk” method with protimeter
  - Shrinkage test

*474.531 Fuktmålinger i bygninger. Instrumenter og metoder

Scope

- Are concretes with low w/c-ratios self-desiccating?
- Does fly ash influence the self-desiccation effect?
- Do SRA influence the self-desiccation effect?

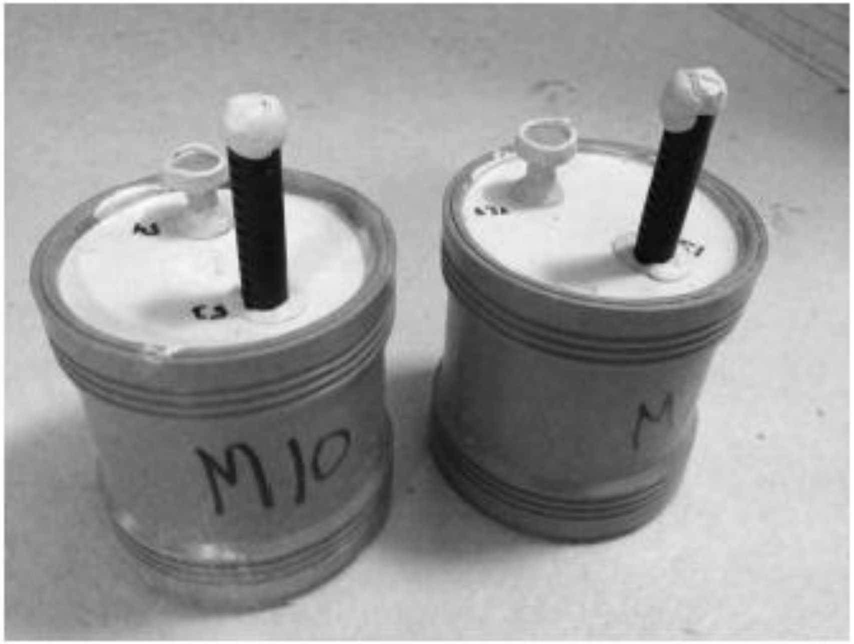
- The concrete that was studied
  - w/c = 0,39
  - Norcem Cements used; Industri, Standard FA, Anlegg FA, Lavkarbonsement
  - Two shrinkage reducing agents (SRA); Sika Control-50 and Mapecrete SRA-N

Method

- Cylinders were cast in closed containers and closed with epoxy

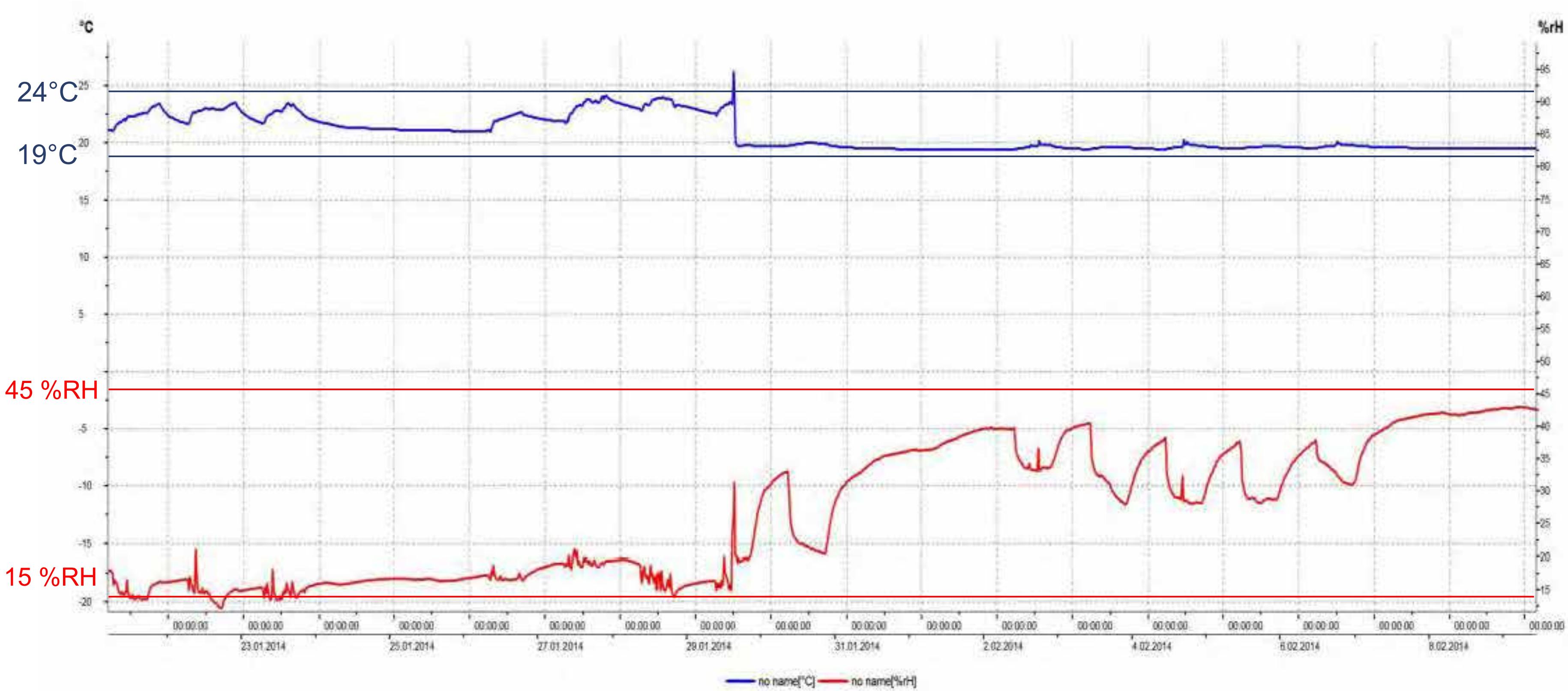
Method

- 3 samples for each concrete mix
- To different measurement methods
  - RBK with Vaisala
    - Calibration and validation according to the RBK method performed by RBK-certified personnel
  - SINTEF with Protimeter
    - Validation at 85 % RH at 20°C
    - Validation at 75 % RH at 20°C



Samples with D=110 mm and H=130 mm.

Ambient conditions



- The samples were stored in our office archives.

Concrete mixes

Name	v/(c+∑kp)	Cement	Cement [kg/m3]	Fly ash	Silika	SRA
1. Industri	0,39	Industrisement	475	-	-	-
2. Std. FA	0,39	Standard FA	450	-	-	-
3. Anl. FA	0,39	Anlegg FA	395	-	-	-
4. Tilsatt FA	0,39	Anlegg FA	360	9 %	-	-
5. SRA Sika	0,39	Anlegg FA	395	-	-	1,5 %
6. SRA Mapei	0,39	Anlegg FA	395	-	-	1,5 %
7. Høyfast	0,35	Anlegg FA	415	-	-	-
8. Høyfast + Tilsatt FA	0,35	Anlegg FA	388	9 %	-	-
9. Tilsatt Silika	0,39	Anlegg FA	365	-	4 %	-
10. Tilsatt Silika og FA	0,39	Anlegg FA	340	9 %	4 %	-
11. Lavkarbon	0,39	Lavkarbonsement	450	-	-	-

Basic concrete mixes: similar, but with different cements

Basic concrete mix #3 with different variations

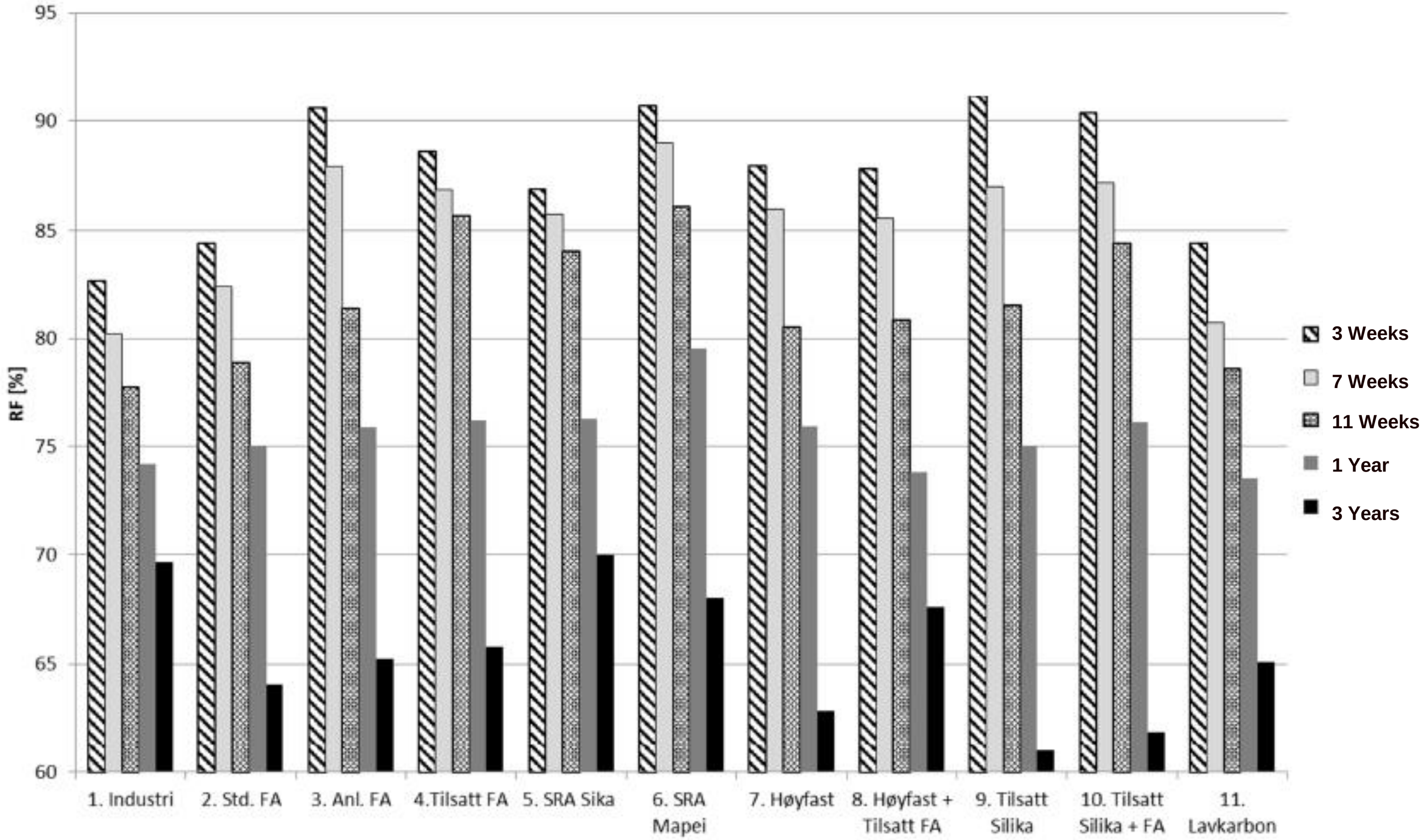
Anlegg FA=CEMII/A-V, Standard FA=CEMII/B-M, Industri = CEMI, Lavkarbonsement=CEMII/B-V

Concrete mixes

Name	v/(c+∑kp)	Slump [mm]	Slump flow [mm]	28-days strength [MPa]
1. Industri	0,39	220	350	66,7
2. Std. FA	0,39	240	480	69,1
3. Anl. FA	0,39	210	370	75,8
4. Tilsatt FA	0,39	220	390	76,4
5. SRA Sika	0,39	240	480	75,5
6. SRA Mapei	0,39	240	540	73,3
7. Høyfast	0,35	250	640	89,8
8. Høyfast + Tilsatt FA	0,35	240	570	78,3
9. Tilsatt Silika	0,39	230	470	78,5
10. Tilsatt Silika + FA	0,39	230	580	78,3
11. Lavkarbon	0,39	245	560	57,9

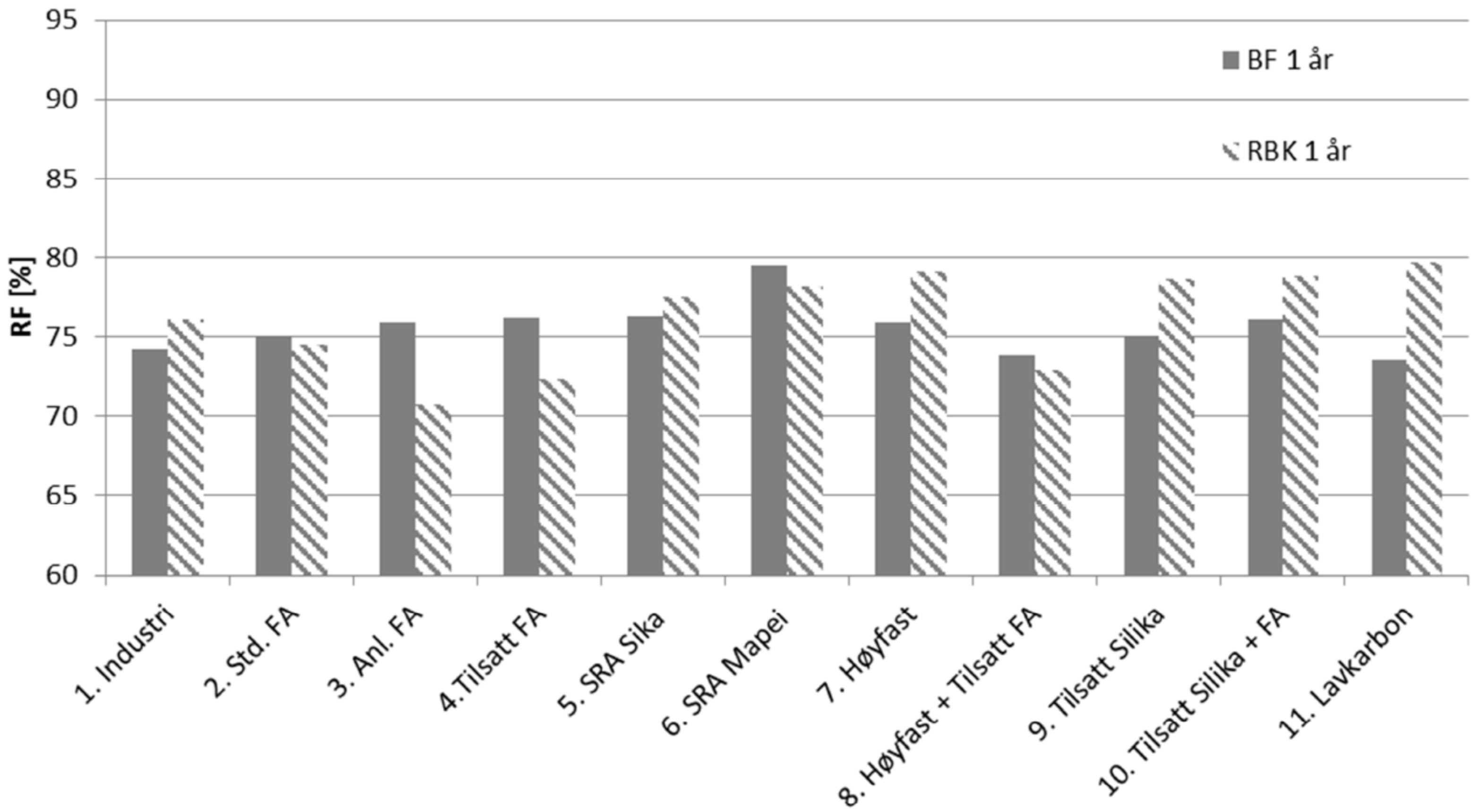
- The target slump was the same in all recipes.

Results with «Byggforsk»

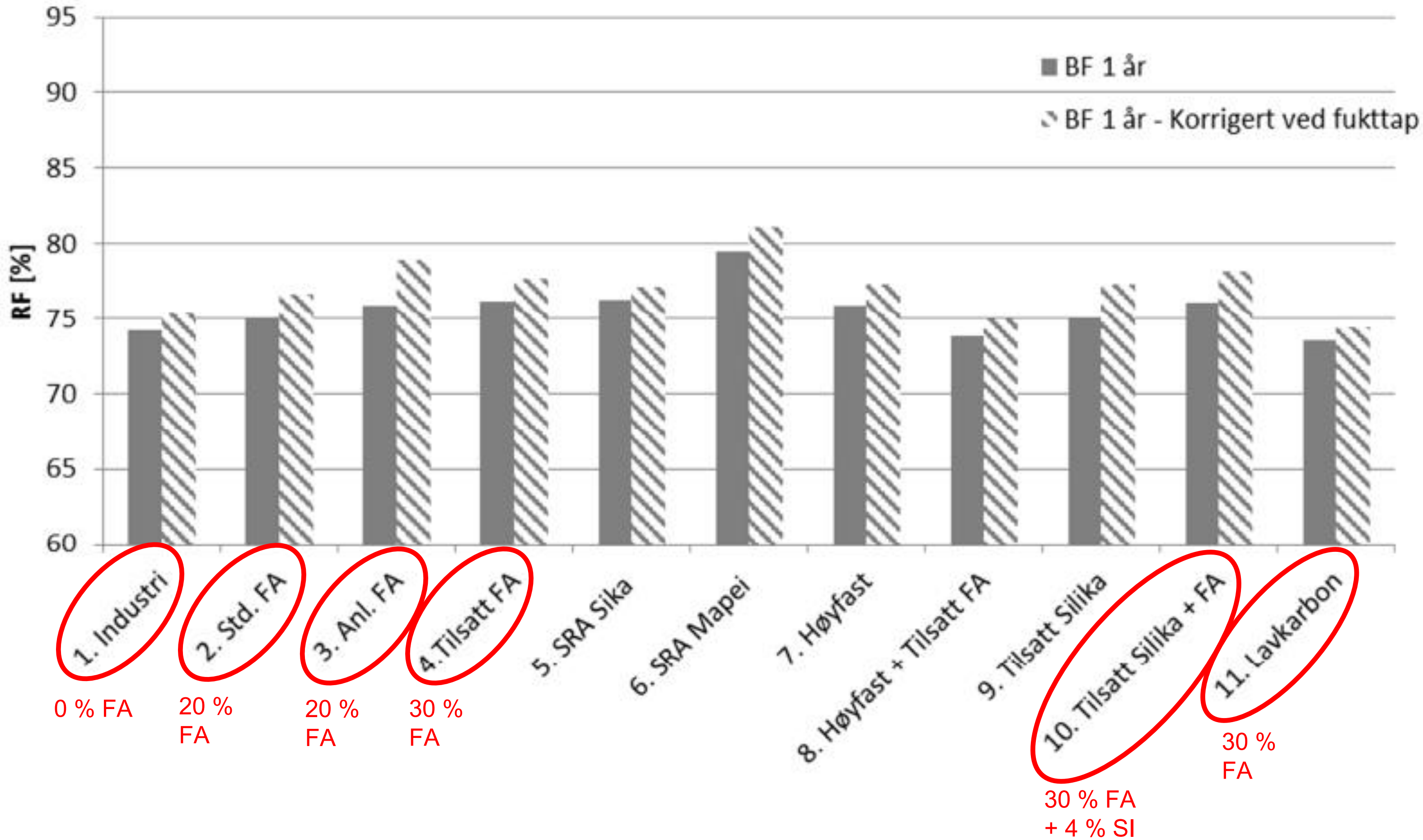


- Each bar is the average of three measurements.

Results with «Byggforsk» and «RBK»

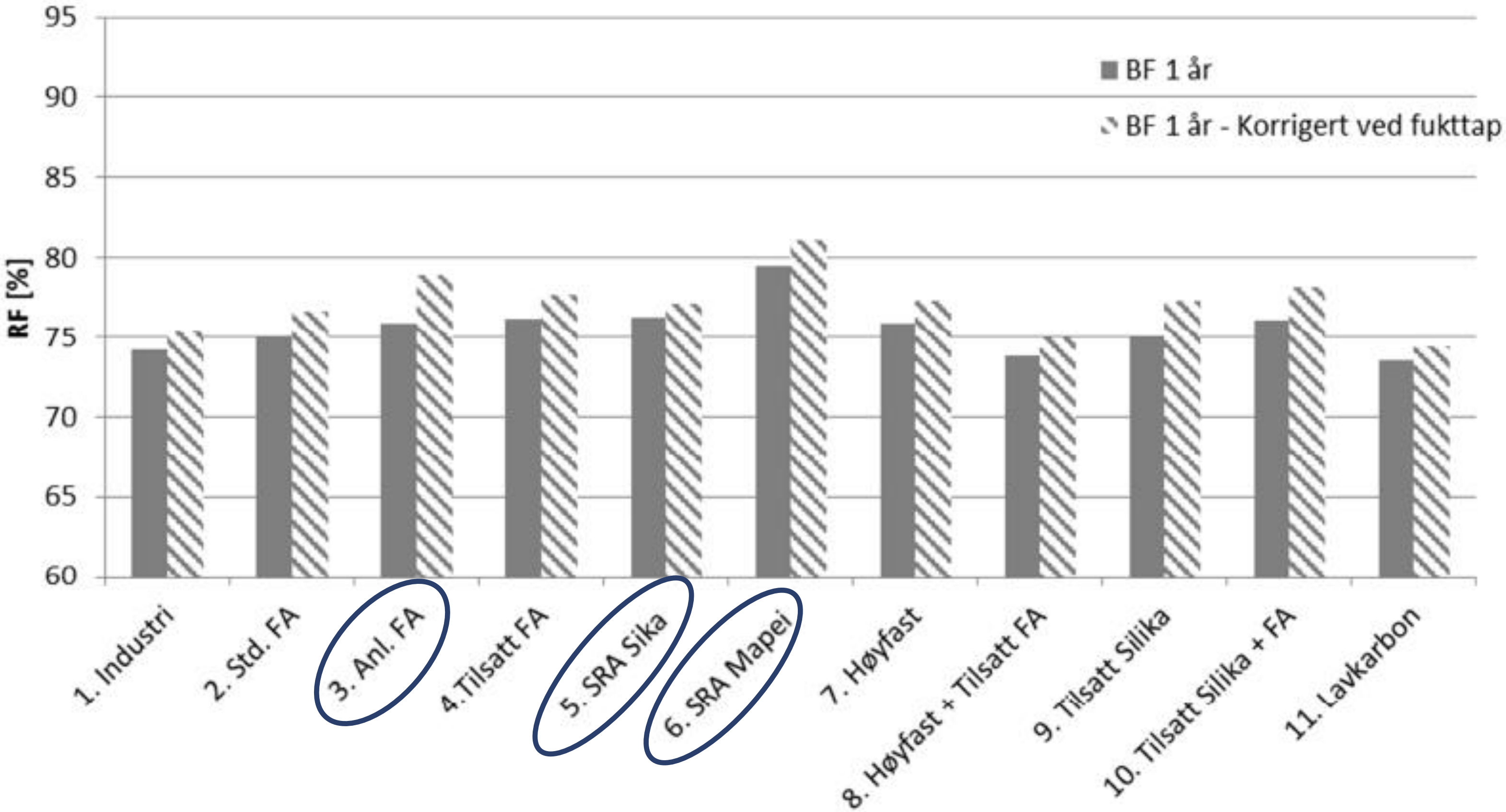


Results with moisture loss



- The samples were weighed in order to correct the RH for the ambient moisture loss using a suitable desoprtion-isoterm and Power's model.

Results with moisture loss



Results with moisture loss

1. The concrete mixes with blended cements and added fly ash have a reduced self-desiccation effect on short term (~3 months).
2. All concrete mixes showed self-desiccation effect after one year, and significant effects after three years.
3. SRA do not affect the self-desiccation significantly on long term.

Fuktmätning i betong

Polygon/AK

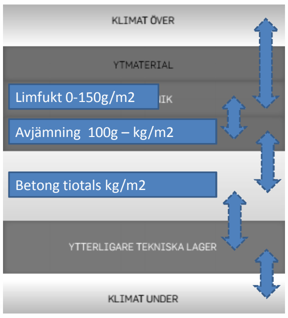
- 20 RBK-auktoriserade (mest HumiGuard i borrhål)
- Diplomerade fuktsakkunniga
- Fuktsäkerhetsansvariga produktion
- Eget analyslab för bl.a. GBR-mätning
- Forcerande torkteknik
- Fuktskadeutredare

Golvsystemet

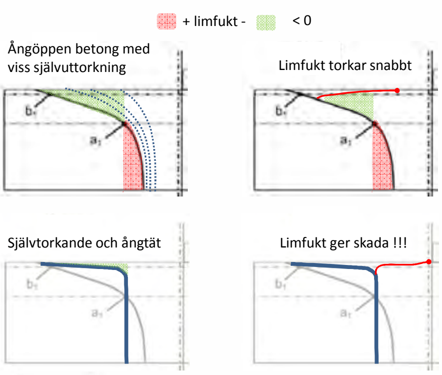
Hela fuktkedjan behöver fungera

Always By Your Side.

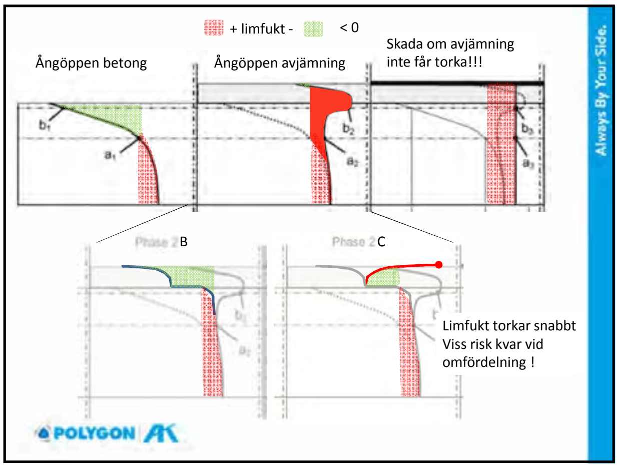
Fukt i systemet

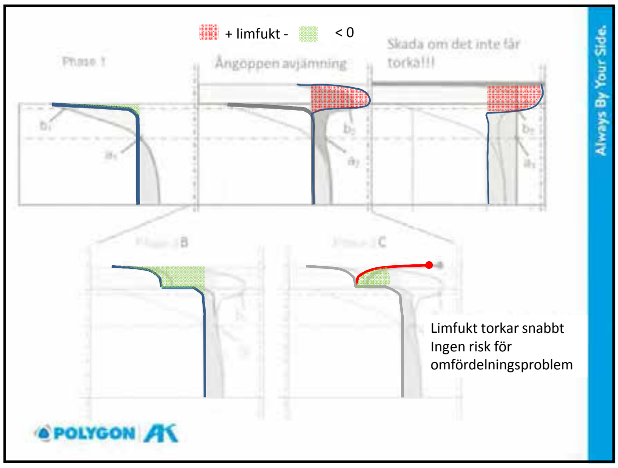


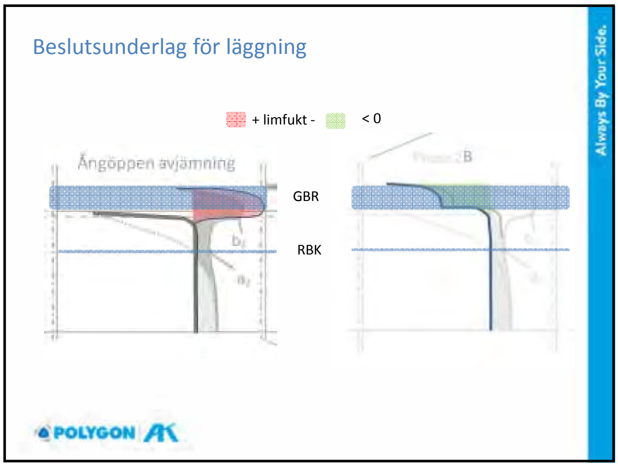
Always By Your Side.



Always By Your Side.


+ limfukt -
< 0
Ångöppen betong
Ångöppen avjämning
Skada om avjämning
inte får torka!!!
B
C
Limfukt torkar snabbt
Viss risk kvar vid
omfördelning !
POLYGON
Always By Your Side.


+ limfukt -
< 0
Ångöppen avjämning
Skada om det inte får
torka!!!
Limfukt torkar snabbt
Ingen risk för
omfördelningsproblem
POLYGON
Always By Your Side.


Beslutsunderlag för läggning
+ limfukt -
< 0
Ångöppen avjämning
GBR
RBK
POLYGON
Always By Your Side.

Bedömningsuderlag RBK + ?

Always By Your Side.

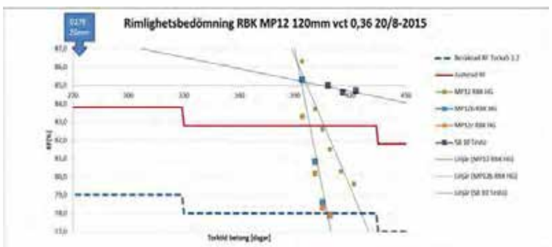
POLYGON AK

Visuell rimlighetsvärdering underlättar!

Always By Your Side.

POLYGON AK

Ibland blir det helt orimligt!



Always By Your Side.

POLYGON AK

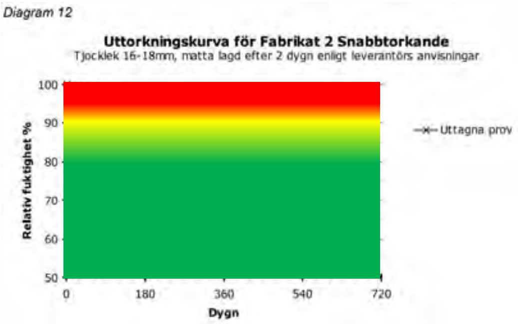
Vi har hittat och hittar "orimliga" mätresultat

Bild: Husbyggaren

POLYGON AK

Always By Your Side.

Har vi rätt fokus? GBR-mätning är lika viktigt!



Baserat på Grantén , 2006, SBUF11680

POLYGON AK

Always By Your Side.

Rekommendationer

- Verifiera självuttorkning
- Mät i avjämning enligt GBR
- Spåra torkmiljön, den behöver styras
- Avjämna tidigt så att det hinner torka
- Trendmät tidigt efter torkstart för att hinna justera vid behov

POLYGON AK

Always By Your Side.

Frågor?

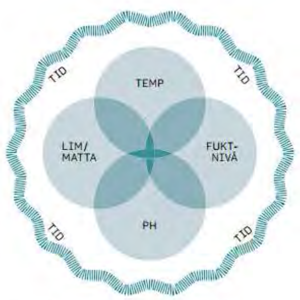
POLYGON AK

Always By Your Side.

POLYGON AK

Always By Your Side.

Golvsystem med låg risk



Figur 2. Avgörande faktorer för alkalisk hydrolys.

Bild: Husbyggaren

POLYGON AK

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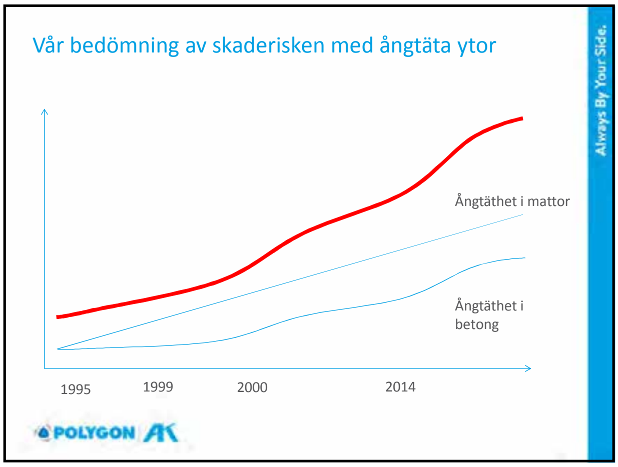
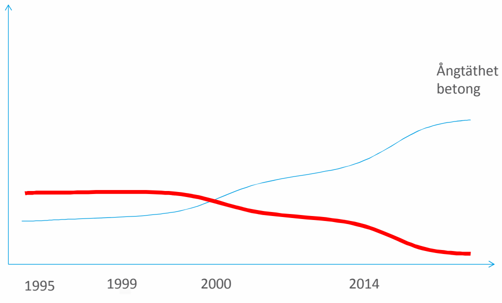
Byggdoktorn
Always By Your Side.
Har du stött på golvskador/golvemissioner i nyproduktion fast det enligt RF-mätning innan mattläggnig inte skulle kunna existera?
42 responses
35,7%
7,1%
19%
31%
nej
ja en gång
ja två gånger
ja tre gånger
Ja flera gånger
Ja men RF-mätning inte genomförd enligt RBK
Ja fast inte RF mätning enligt RBK
Har hittat tre skador det senaste året där husen är byggda de senaste 5
130st tillfrågade skadeutredare, erfarenheter de senaste 5åren
POLYGON


Byggdoktorn
Always By Your Side.
För en specifik skada, när upptäcktes problemet med golvet
36 responses
13.9%
19.4%
33.3%
13.9%
19.4%
innan slutbesiktning
0 till 6 månader efter slutbesiktning
7-12 månader efter slutbeiktning
13-24 månader efter slutbesiktning
25-36 månader efter slutbesiktning
>36 månader efter slutbesiktning
POLYGON


Vår bedömning av skaderisken med ångtäta ytor
Always By Your Side.
Ångtäthet i mattor
Ångtäthet i betong
1995
1999
2000
2014
POLYGON

Vår bedömning av skaderisken med ångöppna ytor



POLYGON AK

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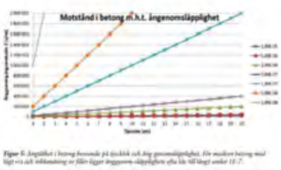
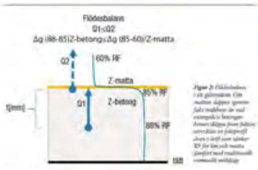
Omfördelning under matta

Täthet matta (s/m)	Flöde [g/mån/m²]	Flöde [g/mån/m²]	Flöde [g/mån/m²]
10 000	3140	2019	897
100 000	314	202	90
500 000	63	40	18
1 000 000	31	20	9
10 000 000	3	2	1





POLYGON AK

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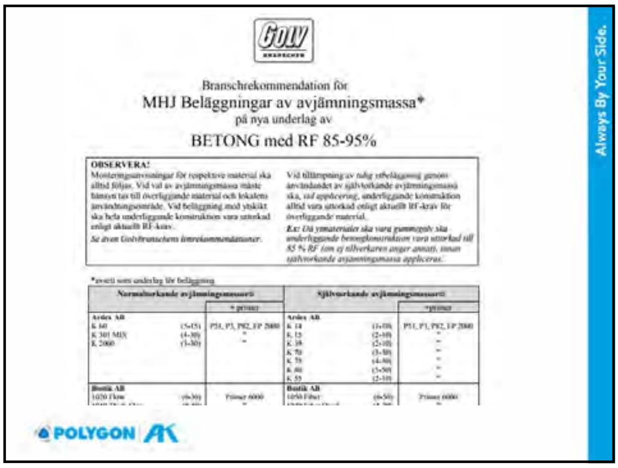
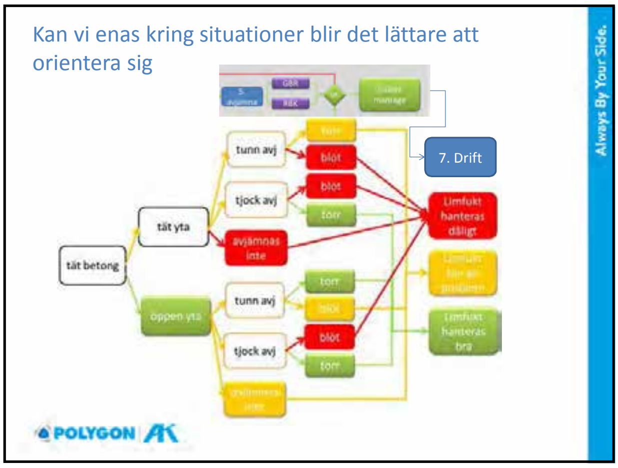
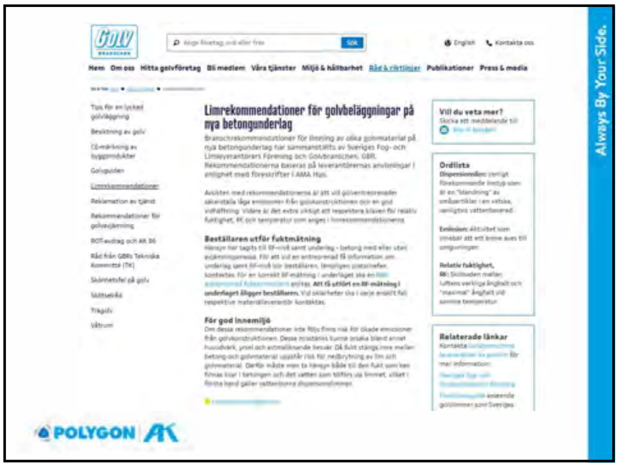
POLYGON AK

Always By Your Side.


Branschrekommendation för
MHJ Beläggningar av avjämningsmassa*
på nya underlag av
BETONG med RF 85-95%
OBSERVERA!
POLYGON
Always By Your Side.


Kan vi enas kring situationer blir det lättare att orientera sig
7. Drift
tunn avj
tjock avj
tät yta
tät betong
blöt
blöt
torr
avjämnas inte
Limfukt hanteras dåligt
öppen yta
tunn avj
tjock avj
torr
blöt
torr
Limfukt hanteras bra
POLYGON
Always By Your Side.


Limrekommendationer för golvbeläggningar på nya betongunderlag
Beställaren utför fuktmätning
För god innemiljö
Vill du veta mer?
Ordlista
Relaterade länkar
POLYGON
Always By Your Side.

Torrhalt och limmängd har betydelse!

Table 2. Adhesives that are used in Norway and Sweden for gluing PVC, linoleum and other floor coverings. The data is according to the specifications of the manufacturers.

Name	Binder[1]	Dry solids content [%]	Density [kg/m³]	Surface covered [m²/l]	Moisture from the adhesive[2] [g/m²]	
Cascoproff Extra 3444	Acrylate/EVA copolymer latex	72	1260	4-6	59	70
Cascoproff 3448	Acrylate copolymer latex	70	1300	3-6	65	100
Cascolin 3449	Acrylate/EVA copolymer latex	74	1400	3-5	73	87
MultiTac MT Golv och vägglim	Latex	71	1270			
Attack golv och vägglim	Latex	71	1270			
Linotack linoleumlim	Vinyl acetate copolymer	75	1380			

1) EVA - Ethylene vinyl acetate polymers.
2) Calculated from the maximum consumption

4 Innehåll (För att lägga till ny grön rad, tabba dig fram från rad med tomma textrutor och klistra in den. Se vidare i anvisningarna.)

Varan består **vid leverans** av följande delar/komponenter och med an

Ingående material/ Komponenter	Ingående ämnen	Vikt % alt g
Kalciumkarbonat		25-40
Etylenvinylacetat sampolymer		[illegible]
Polyakrylsyra		15-20
Vatten		5-15
Hartssyror, estrar med trietylenglykol		[illegible]
Modifierat naturharts		[illegible]

Uppgifter i grönmarkerade fält är krav enligt Kretslopps

Limfukt - hur torr/tjock avjämning?
Torr vid klistring!

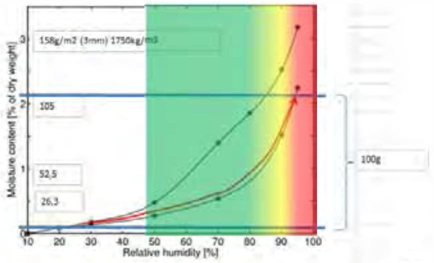


Figure 5 – Sorption isotherm of flooring compound A. Stars are measured values.

Figure

Lim.se
Sveriges fog- och limleverantörers förening

GOLV BRANSCHEN
September 2017

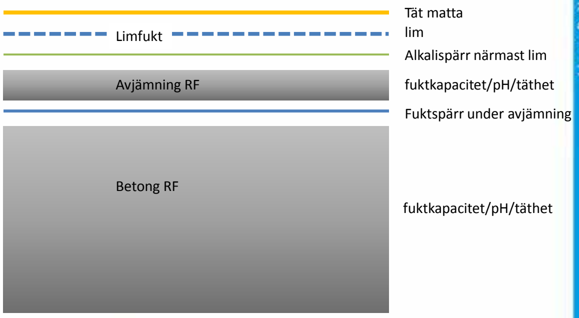
Branschrekommendation för limning av
MFK Beläggning av plastgolv utan PVC
på nya betongunderlag

RF i undergolv	Betong Vct > 0,38 Belagd med lågalkalisk avjämningsmassa ②	Betong Vct < 0,38 Belagd med lågalkalisk avjämningsmassa ①
Över 85 %*	Ardex Ardex AF 180 MS	Ardex Ardex AF 180 MS
Under 85 %	Ardex Ardex AF 180 MS Ardex AF 145	Ardex Ardex AF 180 MS Ardex AF 145
	Bostik Bostik Startac Power (B) Bostik Startac Combi (B)	Bostik Bostik Startac Power (B) Bostik Startac Combi (B)
	Kiilto Floor Plus (B) M1000 Fast (B) Extra (B)	Kiilto Floor Plus (B) M1000 Fast (B) Extra (B)
	Sika ③ CascoProff Universal	Sika ③ CascoProff Universal

① [illegible]
② [illegible]
③ [illegible]

* OBSERVERA att tillåten RF-nivå för övriga ingående produkter i golvkonstruktionen också måste följas (t.ex. för avjämningsmassa och ytskikt).

Placering av spärrar



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Rekommendationer

- Ångöppna golvytor ger stor risksänkning
- Avjämningens uttorkning och tjocklek behöver fuktsäkerhetsprojekteras mht limfuktsmängd
- Det är ofta smart att avjämna tidigt
- Spärrar behöver fuktsäkerhetsprojekteras

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