



## Relative Humidity measured by the wooden stick method in Norwegian concrete Structures with and without surface protection



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### ABSTRACT

The wooden stick method for measurement of relative humidity has been used on several structures in Norway since 1995. Results up to now show that the relative humidity is stable 5 cm from the surface and that ingress of rainwater is a very important source of water in the concrete. In 1998 beams and columns in an office building in Oslo were coated with four different product-systems. Measurements show that the relative humidity 5-cm from the surface decreased significantly during two years time. However, no significant differences were observed between the different products. In 1999 and 2000 columns from a road bridge in Trondheim were impregnated with 3 different types of silane. Results after more than 2 years show reduced relative humidity on the leeward side of all the columns. One of the products reduces the RF% more significantly than the two other products.

**Key words:** concrete structure, relative humidity, wooden stick method, surface protection, coating, silane.

### 1 INTRODUCTION

Measurement of relative humidity in concrete structures by use of wooden sticks has since 1995 been used in several Norwegian concrete structures whereas 2 cases is given here. Results show that the method is very reliable and especially applicable to concrete with high humidity as in structures damaged by Alkali Aggregate Reaction (AAR). Description and documentation of the wooden stick method have been published in Norway and Internationally (1), (2), (3). Correlation tests with two commercial humidity sensors (AHEAD Hygro Temp II and Humi Guard) have shown that wooden sticks still are in good condition and reliable after 5 years use (2). Figure 1 shows the correlation between wooden sticks after 3 years continuous use and AHEAD hygrottemp sensors. Note the acceptable correlation between the two methods.

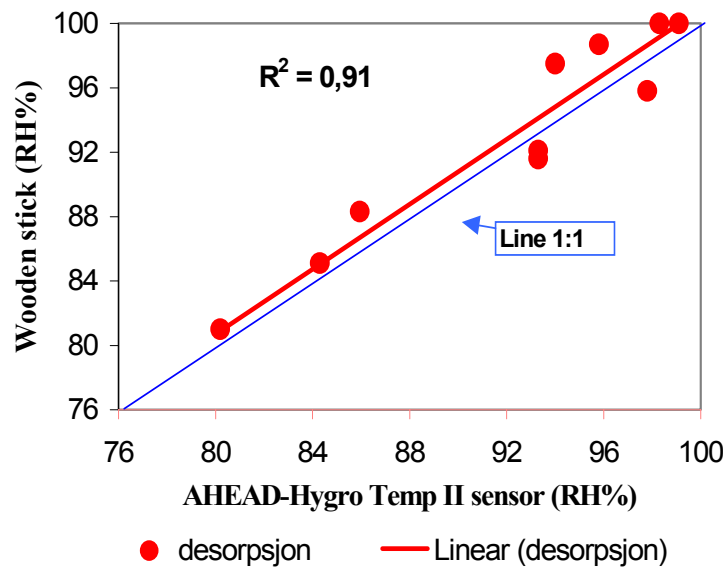


Figure 1 – Correlation between AHEAD hygro temp II sensors and wooden sticks after 3 years continuous use in a bridge.

## 2 CASE 1: ELGESETER BRIDGE, TRONDHEIM

In 1990 deleterious alkali aggregate reaction (AAR), caused by the rock types mylonite, graywacke and argillite, were diagnosed in the bridge. In 1995 an in-situ system for measurement of relative humidity by wooden sticks and expansion of cracks (not described in this paper) was started up as a pilot project. Eight measurement places were mounted in one beam and 4 columns, each with diameter 80 cm. Results up to now show that the relative humidity varies from 100% to 87%, that 5-cm from the surface the relative humidity is stable over time and that rainwater is an important source of water in the concrete (humidity profile)(2). With aim to document humidity in other columns, both on land and in the river, eleven new measurement places were mounted in 1999. Three different types of silanes were also examined on 3 columns. Dynasytan BHN (100% isobutyl-tri-ethoxysilan) was applied by the road directory in July 2000. Masterseal SL 40 (40% organosilan ester in isopropanol) and Wacke Cream C (80% not specified silane type) were applied by the product dealers in September 1999. Results up to now is given in Table 1.

Table 1 - Relative humidity % (average) in columns before and after impregnation with silanes

Note: All the products were applied according to specifications.	Western face of column		Eastern face of column	
	before imp.	after imp.	before imp.	after imp.
Dynasytan BHN (680 dg)	100	100	96	90
Masterseal SL 40 (957 dg)	99	97	95	88
Wacke BS Cream C (957 dg)	98	91	97	83

Note that the relative humidity is more reduced on eastern faces compared to western faces. Results suggest that impregnation with silane is able to lower the concrete's relative humidity and that efficiency on that depends on product types.

### 3 CASE 2: THE NORWEGIAN VERITAS HOUSE, OSLO

With the aim to document the long time performance of surface protection systems and ability to reduce the concrete's relative humidity, experiments were started up in 1998 on the Norwegian Veritas House in Oslo. Here, AAR was diagnosed by micro structural analyses in 1996. Three types of coatings – impregnation were tested, namely Sikagard 550 + 552 (*elastic acrylic dispersion*), Conservado 30 + 40 (*oligomer siloxan/silane*) and Dynasytan BHN (*100% isobutyl-tri-ethoxysilan*). The product dealers applied the surface protections according to own specifications. In addition the owner mounted aluminum cladding on one column. Table 2 gives results of relative humidity from surface protected and unprotected columns/beams after 863 days (4), (5).

Table 2 – Relative humidity (average) 5 cm from the surface before and after protection.

	places	before protection	863 days after	differences
Referances	7	93	94	+1
Aluminium cladding	2	94	80	-14
Conservado 30 + 40	2	97	81	-16
Sikagaard 550 + 552	3	90	79	-11
Dynasytan BHN	2	93	80	-13

Note that all the protected concrete's after 863 days obtain significant lower relative humidity and that only slight differences occur between the systems.

### 4 CONCLUSIONS

It is concluded that the wooden stick method is reliable under field conditions over long time and gives valuable information about the humidity conditions in unprotected and protected concrete structures. Results suggest that surface protection and impregnation with silanes are able to reduce the relative humidity in concrete structures.

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