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Limitations of embedded relative humidity (RH) microsensors in monitoring the moisture content of damp masonries

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Abstract

Accurately measuring the moisture content of damp masonries can be important for research and conservation purposes. Embedding relative humidity (RH) microsensors into the fabric of damp masonries represents an attractive moisture monitoring option due to the wide availability, low cost and accuracy of such sensors. This paper highlights some important limitations of these sensors in embedded under-surface applications which came to light during their prolonged use.

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Keywords: damp masonry, moisture measurement, long-term moisture monitoring, RH moisture sensors, relative-humidity sensors

1. Introduction/Background

To better understand the movement of moisture in old buildings, reliable moisture measurement technologies are an essential part of data collection during the research process. Several moisture measurement methodologies have been developed [1] for both one-off *spot-measurements* (various moisture meters, drilled core sampling etc.) and the *continuous monitoring* of damp masonry structures (moisture sensors) [2]. This latter is particularly important for a better understanding of complex long-term phenomena, allowing the capturing of transient changes and anomalies.

A popular moisture monitoring solution are air-pocket relative humidity (RH) sensors (Figure 1), which are a common monitoring choice due to their high accuracy, low cost and wide availability. Having a small form-factor they can be easily embedded into the masonry for long-term monitoring, measuring the RH of a small air pocket they are enclosed in. Present paper describes some important limitations of RH microsensors in such applications which came to light during their prolonged use.

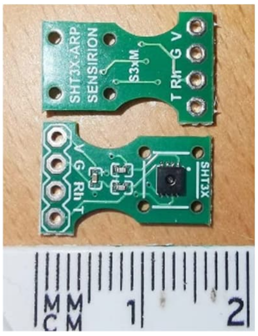

Figure 1: RH microsensor

2. Experimental Setup

The moisture content of an old-style porous brick has been monitored with two different sensor technologies: air-pocket RH sensors embedded in the fabric, and TDR (time-domain-reflectometry) [3-4] microwave sensors capable of directly measuring the volumetric moisture content of the fabric (Figure 2). The moisture content of the surface and surrounding environment has also been monitored via RH sensors.

To track weight gains and losses during the wetting-drying process, the brick has been placed on a custom-built weighing platform with 0.1g resolution.

The brick has been wetted at the start of the experiment, by applying a large cup of tap water at its base (417 ml), then letting it dry out via evaporation, reaching air-dry values after 10 days.

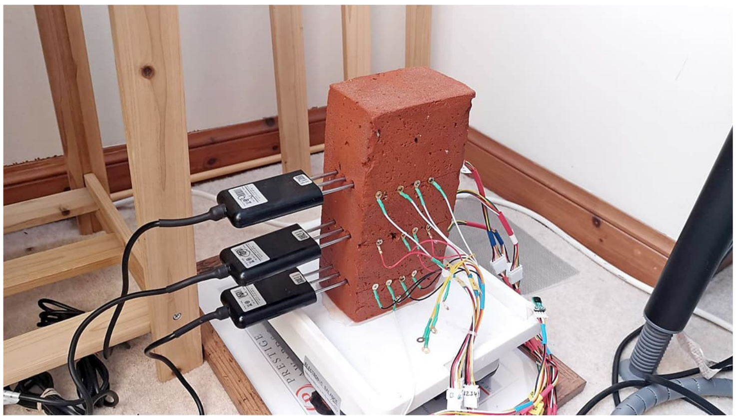
Figure 2: Experimental setup

The data from all sensors has been logged at 5 sec intervals using a Tektronix-Keithley DAQ6510 80-channel professional data acquisition system featuring 6½ digit resolution and 0.0025% accuracy.

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3. Discussion / Findings

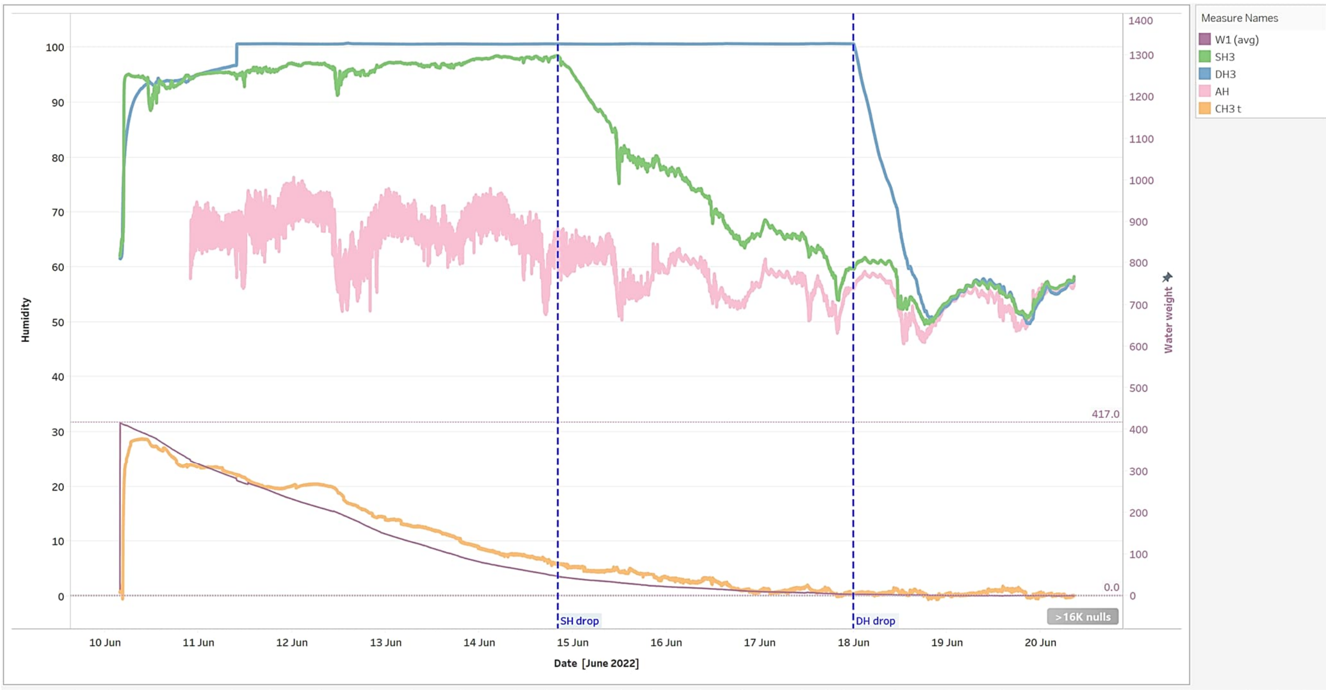

Figure 3: The drying process shown by the various sensors

Figure 3 presents the humidity changes recorded by the various sensors: ambient RH (pink), surface RH (green), depth RH (blue), and depth volumetric (%) moisture content (orange). The rate of actual moisture evaporation or total weight loss of the brick is shown by the purple line. We can draw the following conclusions:

- Surface RH of the brick (green) hovers around 96% for about 5 days then gradually falls to ambient RH.
- Depth RH (blue) reaches 100% shortly after wetting, staying there throughout most of the dehydration.
- Depth microwave humidity sensor (orange) shows a steady decline of the absolute moisture content from 28% to 0%.
- The surface RH sensor first registers a decline after 5 days (first vertical blue line). At this point the microwave sensor indicates a 5.9% absolute (real) moisture content, and 88% of the brick's total moisture content has been lost (417g to 50g) through evaporation.
- The depth RH sensor only starts registering changes after 8 of the 10 days (second vertical blue line). At this point the microwave sensor indicates 0.5% absolute moisture content, and the brick has lost over 99% of its moisture content (417g to 4g). The masonry reached air-dry value *prior* to this point.

4. Conclusions

From the experimental data we can conclude the following:

- RH sensors can reliably measure the vapour content of open spaces – which they have been designed for.
- RH sensors must be used with extreme caution for monitoring the moisture content of damp solid materials under the surface as they can only *measure in an extremely narrow moisture band* (between 0.0 to 0.5% absolute humidity).
- RH sensors become easily saturated and thus unusable if the wall fabric contains even small amounts of liquid moisture. For such application microwave or capacitance sensors are a much better choice, however their larger size can make their installation more difficult.

References

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