How salts affect the vapour permeability of old walls? Key differences between the vapour permeability of salty and non-salty masonries.

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Abstract

Moisture is one of the main decay factors affecting old buildings. The movement of moisture is often accompanied by the presence of water-soluble salts which can impact the masonry in several ways. Present paper explores the differences in vapour permeability between salty and non-salty masonries, how salts impact both the moisture retention and free evaporation of moisture. It has been found that electrically charged salt ions hinder the free evaporation of moisture, contributing to the retention of moisture inside the masonry.

Peer-review under the responsibility of the organizing committee of the ICMB23.

Keywords: salty masonry, effect of salts, vapour permeability, breathability, wetting

1. Introduction/Background

The concept of vapour permeability, also known as breathability, the ability of an old damp wall fabric to regulate its moisture content by evaporation is paramount in building conservation. If the free evaporation of moisture is hindered by various moisture barriers [1], these can result in the accumulation of moisture inside the building fabric, long-term damaging old masonry structures.

Old damp walls often contain significant amounts of salts. These can originate from multiple sources: from the ground (rising damp), the building fabric (the mortar, chimney soot) or the surrounding environment (sea spray). Once deposited in the masonry, salts interact with the building fabric in several ways [2], the most common effects being: 1. Hygroscopic effect: salts absorb humidity from the surrounding environment, making the masonry damper [3]; 2. Damage by crystallization: drying salts crystallize and expand in volume, breaking down the masonry, causing significant damages [4-5]. Other effects of salts have also been observed, salts causing non-negligible spontaneous electrical voltages in damp masonry [6].

Present research paper discusses how salts affect the vapour permeability of old masonry structures.

2. Experimental Setup

Two identical old-style new porous bricks have been used in the experiment, one saturated with tap water, the other one with sea water (approx. 3.5% NaCl solution). Both bricks have been thoroughly air-dried until they reached air-dry equilibrium values.

Then, a series of Sensirion SHT-31A microsensors have been embedded into both bricks, measuring temperature and relative humidity (RH) variations on the surface, in depth, and of the surrounding environment. Both platforms have been placed on individual custom scales, allowing to measure ongoing moisture increases and decreases with less than 0.1g precision. All data has been logged at 18 sec intervals by a Tektronix-Keithley DAQ6510 80-channel professional data acquisition system featuring 6½ digit resolution and 0.0025% accuracy. (Figure 1)

Figure 1: Experimental setup

Both bricks have been subject to a cyclic wetting and drying regime by water vapours only, using a smart humidifier, programmed to release vapours for 30-mins (wetting) followed by a 90-min rest period (drying), 24/7.

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 DOI: 10.14293/ICMB230002

3. Discussion / Findings

Figure 2 presents the variation of RH (vertical axis) throughout a 17-day period (horizontal axis). As a result of ongoing wetting-drying cycles, ambient relative humidity (orange band) varies between 63.9 to 95.6% (a 31.7% change). These ambient humidity changes impact the surface and depth of salt-free and salty bricks differently, the data being summarized in Table 1.

Salt-free surfaces (light blue band) mirror ambient humidity changes closely. Their large variation (24.2% RH) indicates that moisture can move in and out of non-salty surfaces easily–these responding quickly to ambient changes, getting wet and drying out quickly. Salty surfaces (light green band) show about 5X less variation (4.6% RH) than identical non-salty surfaces.

The depth of the test bricks shows a similar behaviour. The core of a salty brick (dark green band) has about 5X less variation (2.4% vs 13.1%) than the core of a similar non-salty brick (dark blue band).

This response can be attributed to the presence of electrically charged salt ions on the surface, interfering with both incoming and outgoing vapour movement.

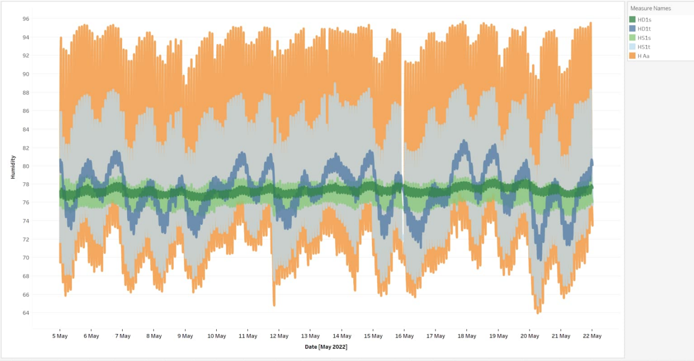

Figure 2: Humidity variations

Relative humidity (%)	Min	Max	Median	Variation	% of 100
Ambient humidity	63.9	95.6	79.8	**31.7**	100.0
Surface (non-salty)	64.8	89.0	76.9	**24.2**	76.3
Surface (salty)	74.5	79.1	76.8	**4.6**	14.5
Depth (non-salty)	69.7	82.8	76.3	**13.1**	41.3
Depth (salty)	76.1	78.5	77.3	**2.4**	7.6

Table 1. Humidity variations summarized: salty vs non-salty bricks

Salts interfere with the *incoming* vapour flow by trapping humidity from the environment – a phenomenon known as hygroscopic action – leading to moisture accumulation. The amount of moisture accumulated in the fabric can be quantified with precision scales by tracking the ongoing weight increase and decrease of each brick. By disconnecting the dehumidifier for a period of 2 weeks, resulting in a more vapour saturated environment, the weight of the non-salty brick has increased by 31.7 grams (about 1.2% of the brick's total weight), while the weight of salty brick has increased by 140.8 grams (a 5.0% increase).

Salts also interfere with the *outgoing* vapour flow, limiting the free evaporation of moisture. After resuming the original wetting-drying regime, the non-salty brick returned to its original weight after 2 days, while the salty brick after 8 days (taking 4x longer).

Based on other measurements performed during the same experiment – not detailed here due to space limitations – the underlying mechanism on how salts trap/interfere with moisture is *electro-chemical* in nature; salts forming an electro-chemical barrier similar to physical moisture barriers (e.g. cement). These findings will be published in a follow-up paper.

Conclusions

From the experimental data we can conclude the following:

- There are significant differences between the vapour permeability of salty and non-salty masonries.
- Salty bricks can accumulate several times more moisture than their non-salty counterparts, leading to significant moisture accumulation inside the fabric.
- The presence of salts reduces the free evaporation of moisture on both the surface and depth, slowing down the recovery or the drying-out of a damp wall fabric.

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