STUDY ON WETTING AND DRYING OF CLAY BRICK HAVING SURFACE COATINGS

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ABSTRACT

This study was carried out on 19 brick, of various clay bodies, surface texture and various waterproofing sealers applied to some of the surfaces. The brick were placed in a plastic container such that the body of the brick was encapsulated within the container and only the face was exposed to the exterior. The space between the brick and the container was sealed so that the only path that moisture and/or vapour could enter or leave the encapsulated brick was through the face of the brick.

The brick samples were allowed to dry in an uninsulated and unventilated laboratory with the container open for the spring and until the successive weight changes were minimal. The tests were started in July 2001. Each of the samples was weighed, then submerged in water for a period of 24 hours (24 hr cold water absorption), removed from the water, drained and wiped dry and weighed again. The dry weight and wet weight were taken as the 0% and 100% measurements and used throughout the rest of the tests as the lower and upper moisture limits. The containers were then sealed. The brick were stored in a laboratory and the rate of drying monitored weekly for a period of five months.

After this drying period, the containers were placed at grade outside directly under the eaves of a single storey building, east elevation, located in Burlington, Ontario. This situation simulates a typical brick wall. The samples were exposed to the weather; rain, snow, wind and dry periods. The samples were weighed every month for a period of two years.

The study investigates the following:

- The drying rates of brick in a laboratory
- The moisture content of brick exposed to the elements for a period of two years noting the effect of the seasons
- The difference in rates of wetting and drying of brick with or without waterproofing sealer
- The effect of ceramic coatings and texture on moisture absorption and evaporation from the brick surface

KEYWORDS: vapour diffusion, clay, brick, waterproofing, sealers

INTRODUCTION

Brick walls are designed and built to resist moisture penetration, either as a solid masonry wall or as a masonry rainscreen (drainage) wall system. In both cases, it is anticipated that the brickwork itself will absorb water. This generally is not a problem, as long as the wall itself is correctly designed and constructed so that the water does not reach the interior of the building or moisture sensitive components of the wall assembly. In fact the storage capacity of the brick veneer can be advantageous in the management of water in the wall system.

Brickwork absorbs water during inclement weather and releases the water through capillary movement, vapour diffusion and evaporation during dry weather. The moisture content of the brickwork is therefore in constant flux. As long as the drying potential (capacity to release moisture) exceeds the rate of absorption of moisture, no accumulation of moisture will take place and no problem will occur. However, if the amount of moisture penetrating into the brickwork exceeds the drying potential of the masonry, an accumulation of moisture in the wall system will occur. Excess moisture trapped within the masonry can lead to efflorescence or possible spalling of the masonry itself when subjected to freeze-thaw cycles at the same time.

There are a number of waterproofing sealers available on the market today. These are often touted as the panacea for all moisture problems in a masonry wall. Many of the suppliers claim that even though these waterproofing sealers resist moisture penetration into the masonry, they are breathable and will not inhibit or prevent the loss of moisture back through the brick surface under drying action. In other words, they do not affect the drying potential of the brickwork. This is a very important characteristic of the waterproofing sealer, as sealers, which inhibit the loss of moisture may perhaps lead to accumulation of moisture in the wall system. Reducing the absorption of moisture at the surface is not sufficient if the drying potential of the brickwork is also reduced, since moisture can alternatively enter into the wall system via cracks, interface with other materials and penetrations (windows etc.), at other areas of the wall, or from the exfiltration of air or vapour diffused from the interior. This breathable characteristic claimed by manufacturers is based on tests, which indicate that the sealer does not inhibit vapour diffusion through the treated surface. However, most of the moisture in the masonry is in the form of free water and most of the evaporation (change from free water to vapour) takes places at the surface of the masonry. Although the sealer may not inhibit the diffusion of vapour, it can inhibit the movement of free water to the surface where most of the evaporation takes place, by the effects of wind and sun. Hence, the sealer, although not inhibiting vapour diffusion, can inhibit the drying potential of the masonry. This study investigates the net effect of these waterproofing sealers on the brick when subjected to both wetting and drying.

Traditionally, the colour of the clay brick face was the same as the body of the brick, and the texture was either smooth or matt. The smooth texture of brick is achieved from the mold or die. The matt texture is achieved by removing a thin layer from the surface of smooth brick prior to firing. A large portion of clay brick manufactured today, specifically those brick designated for the residential market, receive a texturing and ceramic slurry coating to the face and headers after extrusion, prior to firing. Although these coatings have been extensively tested for durability of the brick, the behaviour of the coatings with respect to the breathability of the brickwork is unclear. This study looks at the how the coatings affect the drying potential and the net effect of both wetting and drying.

The objective of this study is to determine:

- How the brick behaves in terms of the absorption and release of moisture when exposed to the elements
- How the use of a sealer affects the drying potential of the brick
- How the waterproofing sealer will affect the retained moisture in the brick over a period of time including both wetting and drying, compared with an untreated brick
- How the application of ceramic slurry coating will affect the drying of the brick
- How the ceramic slurry coating will affect the retained moisture in the brick over a period of time including both wetting and drying, compared with an untreated brick

For the matt brick, a variety of clay bodies were used to obtain a range of matt textured brick. For the coated brick, a variety of types of textured brick were used to obtain a range of product. For the waterproofing sealers, all the brick were taken from a single run, Vintage Matt, but a variety of sealers were used. The test procedure was modelled on the principles of ASTM E96 test, but modified to allow for variation of external conditions in the actual environment.

TEST METHODOLOGY

A total of nineteen metric modular size brick were used in the test. Metric modular size brick are 57 mm high x 190 mm long x 90 mm bed depth. Table 1 lists the brick used in the study.

Table 1 - List of brick and waterproofing sealers tested

	Brick Type	Sealer	C*
Matt	Colonial Red Matt		8.1
	Regency Red Matt		8.5
	Copper Matt		8.7
	Sundance Matt		8.3
	Vintage Matt		6.1
Matt & Sealer	Vintage Matt	Sealer No. 1	5.7
	Vintage Matt	Sealer No. 2	5.6
	Vintage Matt	Sealer No. 3	7.1
	Vintage Matt	Sealer No. 4	5.0
	Vintage Matt	Sealer No. 5	6.0
	Vintage Matt	Sealer No. 6	5.6
	Vintage Matt	Sealer No. 7	5.4
	Vintage Matt	Sealer No. 8	5.2
	Vintage Matt	Sealer No. 9	6.0
Coated & Textured	Williamsburg Mk II		7.2
	Antique Copper		6.3
	Georgetown		7.1
	Heritage Brown		7.0
	Williamsburg		6.1

* C = Percentage moisture absorbed after 24 hours submerged in cold water (July 2001)

The brick were prepared by applying caulking to a 25 mm strip of the bedding and header surface, adjacent to the face. This was done to seal the edges and to ensure that any water or vapour transmission takes place through the brick face and does not escape through the adjacent bedding and header surfaces. Plastic containers were obtained, which were large enough to accommodate a single brick in the vertical position (soldier course). A hole was cut into the side of the container, marginally larger than the brick face. The bottom of the container was filled with concrete, up to the level of the bottom of the cut hole. Before the concrete set, a sample brick was positioned in the concrete so that the face of the brick protruded approximately 5 mm from the outside of the container. When the concrete had set, the gap between the brick and the container was sealed using caulking. An airtight plastic cap was used to seal the containers. Figure 1 shows a detail of the brick in the container.

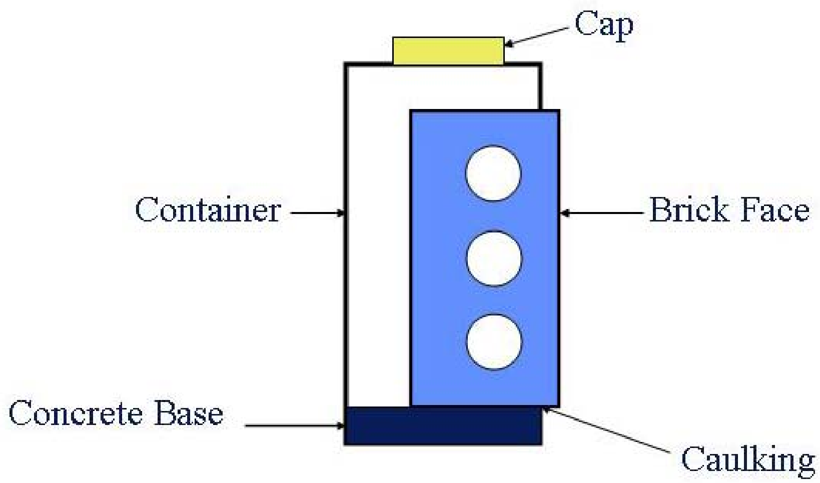

Figure 1 - Sketch of brick in container

The brick samples were allowed to dry in an uninsulated and unventilated laboratory with the container open for the spring and until the weight change was minimal. The test was initiated in July 2001. Each of the samples was weighed, and the open container submerged in water without the cap for a period of 24 hours. The containers were then removed from the water, drained, wiped dry and weighed again. This method was adopted to simulate as close as possible, the 24 hour cold water absorption test taken from the Canadian standard CSA A82.1 Burned Clay Brick. The cold water absorption represents the maximum moisture one would expect brick to absorb in the outdoor field conditions, exposed to the elements. The dry weight and wet weight were taken as the 0% and 100% measurements, respectively, and used as the lower and upper moisture content limits throughout the rest of the testing.

These samples were then capped and left in the uninsulated, unventilated laboratory for five months to dry out. Once capped, the only path available for air or vapour to enter or exit the container was through the face of the brick. The samples were weighed every week during this five month period.

After this drying out period, the containers were taken to a site in Burlington, Ontario, and placed outside, directly under the eaves of a roof, facing east (see Figure 2). This position would simulate the exposure of a typical brick wall on a building under the eaves of a roof. The samples were exposed to the natural weather, rain, snow, wind and dry periods. The samples were weighed every month for a period of two years.

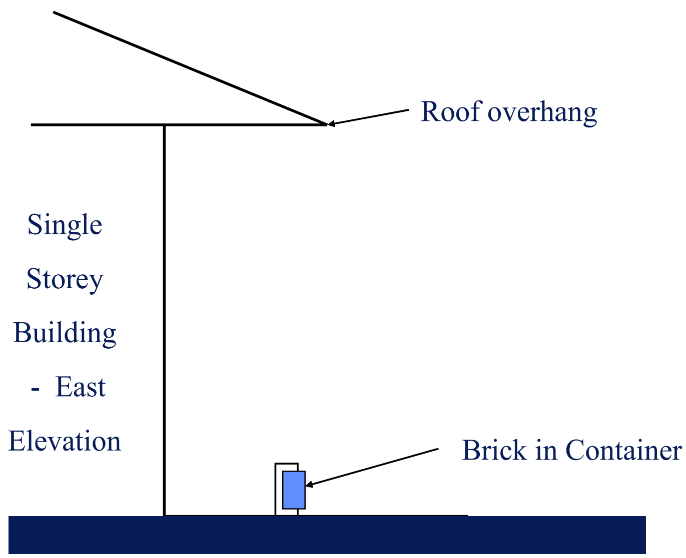

Figure 2 - Position of sample brick placed outside, relative to building

The moisture content of the brick was calculated using the following formula:

$$MC = (Wt - Wd) / (Ww - Wd) \times 100 \qquad \text{Equation 1}$$

Where
MC - % moisture content
Wt - Weight of sample at time t
Wd - Dry weight of sample taken before submergence in water, after drying out for five months in a laboratory
Ww - Saturated weight of sample after 24 hour submergence in water

For purposes of analysis, the brick were divided into the following categories;
Matt - 5 Samples
Matt & Sealer - 9 Samples
Coated - 5 Samples

Table 2 below shows the time frame for the entire study.

Table 2 - Time frame of study

Time period	Stage of study
March 2001	Assembly of test samples
March – July 2001	Drying of test samples in laboratory, prior to test
July 2001	Samples submerged in water for 24 hr. Test initiated
July – Dec 2001	Drying of samples – part of study
Jan 2002 – Dec 2003	Brick samples exposed to elements

DRYING PERIOD

During the drying period, the samples were placed in the laboratory for a period of five months. Figure 3 shows the drying rates of all samples, divided into the categories listed above. This graph shows that the sealer does significantly reduce the rate of drying or drying potential of the brick. In fact, after one week the moisture content of the matt brick were down to 60% of the saturated moisture content, the coated brick were at 66 % and the brick with the waterproofing sealer were at 87 %. The untreated matt textured brick lost three times more moisture (40%) than the brick with the waterproofing sealer (13%).

The moisture content of the various brick types for the ensuing months during the drying period are listed in Table 3. All brick did continue to show loss of moisture, but towards the end of the period, the difference between the different groups started to narrow.

Table 3 - Moisture content of brick during drying period

Month	J	A	S	O	N	D
Matt	100 %	34 %	27 %	21 %	17 %	11 %
Matt & Sealer	100 %	66 %	50 %	41 %	33 %	24 %
Coated	100 %	42 %	33 %	28 %	23 %	18 %

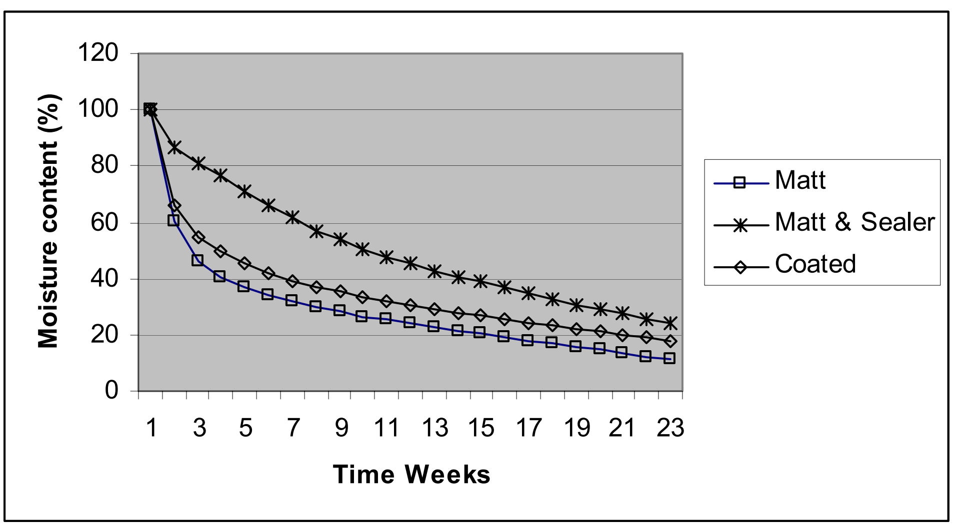

Figure 3 - Drying of the brick

THE SEASONAL EFFECT

During this part of the study, the samples were exposed to the external elements for a period of two years. Figure 4 shows all the brick types combined (as averages) in order to get a seasonal overview of the behaviour of the brick with respect to moisture. Table 4 is a summary of the moisture content for each season. This section of the study followed a five month drying period. Consequently, the moisture content of all the brick samples was initially fairly low, lower than at any time after the brick were placed outside. The moisture content of all brick increased rapidly at about 9% per month and reached a peak in the spring. The highest level of moisture in the brick samples occurs in the spring, while the lowest moisture content was noted in August. For the rest of the year, the moisture content remained fairly constant, around the 40% mark. This trend applied to all the brick, irrespective of whether or not there was a coating or a waterproofing sealer.

Table 4 - Moisture content of brick during various seasons

	Winter *	**Spring**	**Summer**	**Fall**
Matt	43 %	45 %	34 %	46 %
Matt & Sealer	28 %	42 %	27 %	27 %
Coated	56 %	65 %	47 %	57 %
Total	42 %	51 %	36 %	43 %

*Figure includes second year only to eliminate effect of drying period

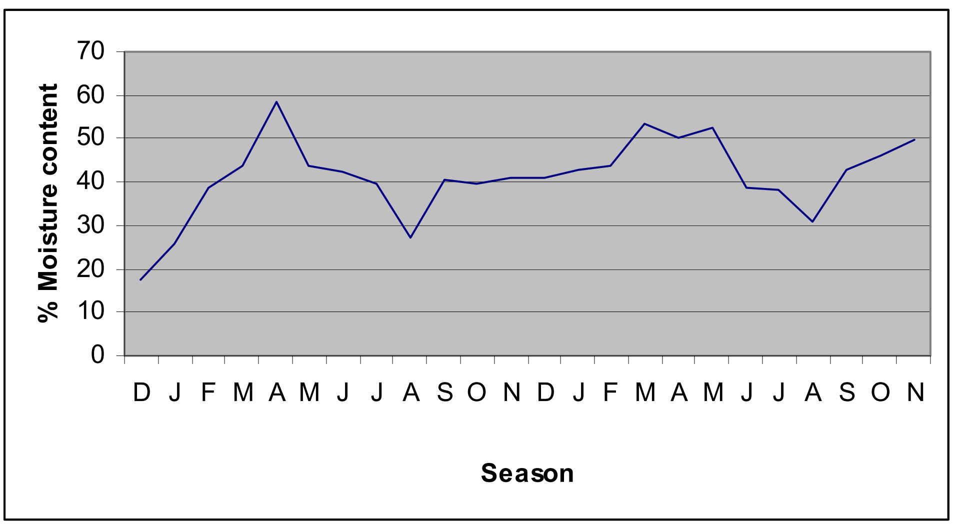

Figure 4 - Drying and wetting pattern over a period of two years.

THE EFFECT OF SURFACE TREATMENT

Figure 5 shows the moisture content of the various brick over a period of two years in the field. Table 5 shows the average and high and low moisture content for each of the sample groups. The samples are grouped as follows, Matt (5 No), Matt & Sealer (9 No) and coated surface (5 No).

Table 5 - Moisture content of brick; average, high and low

	Average 24 months	Average 21 months	High 24 months	Low 21 months
Matt	39 %	42 %	52 %	25 %
Matt & Sealer	32 %	32 %	53 %	22 %
Coated	53 %	56 %	72 %	33 %

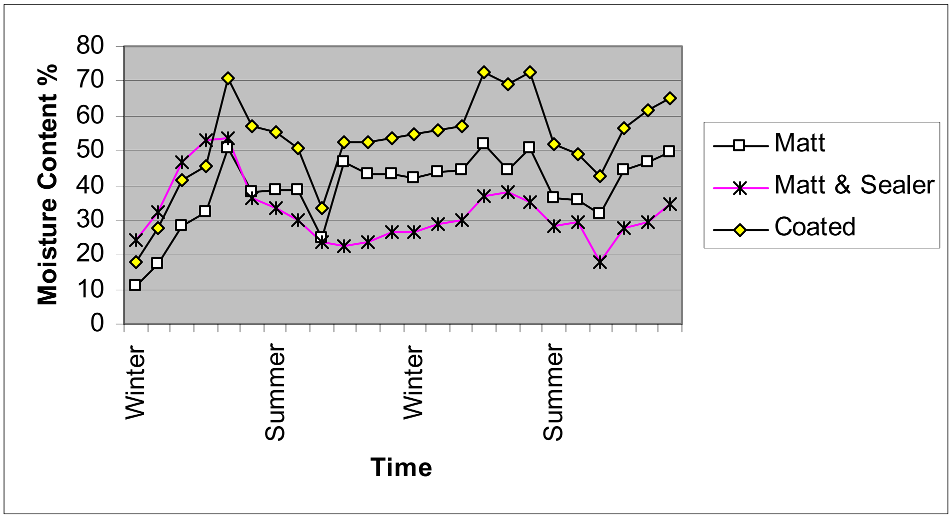

Figure 5 - Moisture content of the various groups over the two year period

The moisture content of all the brick was relatively low at the beginning of this part of the test, resulting from the prior drying period. All the brick absorbed moisture during the winter and early spring for about four to five months until the brick seemed to reach ambient humidity levels. Even the brick with the waterproofing sealer application absorbed moisture at approximately the same rate as the other brick. After the first spring, the moisture content of the brick with the waterproofing sealer became less than the untreated brick and remained consistently lower for the rest of the study.

As expected, the graph shows that the brick reaches the highest moisture content during the late spring months and the lowest in August. It is also evident that although the sealers do reduce the drying potential of the brick, once the brick is exposed continuously to the elements over a period of time, the sealer will maintain the lowest moisture content of the brick. Sealers should still be used with caution. Although on an individual unit, the moisture content of a brick with a waterproofing sealer is likely to be less than that of untreated brick, there is still a likelihood that the moisture can enter the brick at sources other than through the face. Since the drying potential is retarded by the sealer, this moisture will take longer to evaporate from the brick.

The coated brick did have on average approximately 14% more moisture than the matt brick. Coated brick have been used successfully and extensively in North America for decades, hence the above noted difference in moisture content should not be perceived as having a significant effect on the performance of the brick in the wall.

CONCLUSION

The use of waterproofing sealer on the brick surface does reduce the drying potential of the brick. However, when exposed to the elements for a period of time and taking the net effect of both wetting and drying, the moisture content of the brick with the waterproofing sealer appears to be consistently less than untreated matt textured brick.

The moisture content of matt texture brick exposed to the elements for a long period of time, and accounting for the net effect of both wetting and drying, appears to be consistently less that of a coated brick.

The moisture content in brick is expected to be the highest in early spring and lowest in August (for Burlington, Ont.).

The paper deals with vapour permeance of brick. The wetting and drying potential of masonry are to a high degree affected by the characteristics of the mortar joint and the interface between the brick unit and mortar. These results should not be extrapolated to walls.

REFERENCES

1. ASTM E96. Standard Test Methods for Water Vapor Transmission of Materials.
2. CSA A82.1 Burned Clay Brick (Solid Masonry Units Made from Clay or Shale)