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WATER-PROOFING SOLUTIONS FOR CERAMIC MASONRY

BY

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Abstract. In the worldwide current context of preserving historic buildings, it has been established that moisture is the main cause of degradation. Most of the protected edifices are made of brick masonry, consolidated with lime or cement mortar, and no generally valid solution has been found for the elimination of ascensional moisture, as shown in the literature. A drainage method, extremely often used by the specialists in the restoration of historic buildings, is the injection of some solutions or emulsions into the lower part of the walls, in order to create a water-proof string course. This treatment is a subject widely debated by the scientific community, as no sufficient studies have been carried out to validate the results of these water-proofing systems.

The aim of this paper is to determine, through experimental studies conducted in the laboratory, the influence of water-proofing treatments on ceramic masonry. In the study, small walls from solid masonry bricks, recently manufactured, and old ceramic elements, recovered from demolitions, were made. A part of the manufactured walls was consolidated with lime mortar, and the other part with cement mortar. After determining the level reached by the ascensional humidity, two types of drainage solutions were injected into the masonry: one silane-based and one silicone emulsion. Then, the masonry base wetting was resumed in order to determine the water ascension level after the application of the water-proofing treatment.

The results of the experimental study showed that the ascensional humidity, obtained by injecting the solutions into brick masonry, decreased by about 60%.

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Moreover, the study demonstrated the creation of a water-proof string course over which the water from the capillary action cannot progress.

Thus, both water-proofing solutions scored very good results, reducing ascensional humidity, but the influence of these treatments on buildings, where the degradation mechanisms caused by the presence of moisture are combined with freeze thaw phenomenon, crystallization of soluble salts, and the action of the environmental aggressive factors, remains to be studied.

Keywords: water-proofing; brick masonry; moisture; capillary action; degradation.

1. Introduction

The built cultural heritage includes an impressive number of historic buildings, of a priceless value (Niculiță & Groll, 2007). Frequently, these buildings are not treated accordingly or left prey to degradation. One of the main causes of degradation is the presence of moisture in the building elements. The drainage of the protected buildings is the optimal solution resulting from any cost-benefit analysis (Catalog Rofix), but this type of treatment, although widely used, carries a series of risks, as described in the s literature. The scientific community is concerned with both the lifetime of the water-proofing solutions and the physico-chemical (Klisinska- Kopacz & Tislova, 2012) and mechanical changes (Izaguirre *et al*., 2009) that these treatments have on masonry.

The drainage of historical buildings with chemical barriers such as silicone emulsions (www.sto.ro.), anti-moisture creams (http://www.dryzone.eu), osmotic cements (http://www.hidrotopconstruct.ro/...), or drainage mortars (Catalog Rofix) is an irreversible, less studied in-situ solution that can influence the intrinsic characteristics of materials subject to water-proofing.

In a previously conducted study (Clim *et al*., 2018), a very good behavior of the masonry ceramic elements treated against humidity under water action was determined. The used solutions were a silicone emulsion (Technical chart SikaMur-Injectocream-100) and a silane based anti-humidity cream (http://www.dryzone.eu). The same solutions are used in the present experiment in order to validate the results obtained in the case of the construction elements made from ceramic materials.

2. Research Methodology

The following materials were used in the experimental study:

a) water;

b) two watertight basins;

c) granular material for maintaining moisture in the basin;

d) pressed solid brick, with 230 × 115 × 63 mm dimensions, recently manufactured;

e) solid brick, with 280 × 140 × 70 mm dimensions, retrieved from demolitions, manufactured about 60 years ago;

f) lime and cement mortar, made in the laboratory;

g) silicone-based water-proofing solution - Solution I;

h) silane-based water-proofing solution - Solution II.

6 brick masonry walls were made as follows:

i) 2 new brick and cement mortar small walls – NB+CM I, NB+CM II;

ii) 2 old brick and cement mortar small walls – OB+CM I, NB+CM II;

iii) 2 old brick and lime mortar small walls – OB+LM I, OB+LM II.

Two watertight basins, in which a masonry wall from each series was placed, thus obtaining two series, as follows, Series I – NB+CM I, OB+CM I, OB+LM I, Series II – NB+CM II, OB+CM II, OB+LM II, were manufactured. Then, the granular material was placed in the basins in order to maintain moisture and prevent accelerated water evaporation (Fig. 1). After completion, the masonry walls were left to dry for 14 days.

Fig. 1 – Brick masonry walls.

Stage I

In the first stage, the basins were filled with water, the water level reaching the middle of the first row. After 24 hours, the level reached by the ascensional moisture was measured and recorded. The process was repeated for 16 days, resulting in 8 basin water filling and moisture level checking cycles (Fig. 2).

Fig. 2 – Measuring the ascensional moisture level

Stage II

In the second stage, the masonry walls were perforated horizontally in order to apply the water-proofing treatment. The perforations were made on both sides of the walls, like on a chessboard, at a distance of 10 cm, with a 12 mm diameter and a 12 cm depth.

The first series masonry walls were treated by injection with Solution I (http://www.dryzone.eu), and those from the second series were treated with Solution II (Technical chart SikaMur-Injectocream-100). After injection, the perforations were closed with mortar and the samples were left to dry for 4 days, under laboratory conditions (Fig. 3).

Fig. 3 – Masonry walls treated for water-proofing.

The process of determining ascensional humidity was resumed: the basins were filled with water, the water level reaching up to the middle of the first row. After 24 hours, the level reached by the ascensional moisture was measured and recorded. The process was repeated for 16 days, resulting in 8 basin water filling and moisture level checking cycles.

3. Results

After the experimental study, the following results were obtained:

Stage I:

- The capillary ascension variation in the case of the masonry walls made of new brick masonry and cement mortar (NB + CM) placed in the first series is linear, ranging from 17 cm to 30 cm after 8 cycles (Fig. 4a);
- The capillary ascension in the case of the e masonry walls made of old brick masonry and cement mortar (OB+CM) placed in the first series is linear, varying from 16 cm to 26 cm after 8 cycles (Fig. 5a);
- The capillary ascension, in the case of the walls made of old brick masonry and lime cement (OB+LM) placed in the first series is also linear, ranging from 17 cm to 27 cm after 8 cycles (Fig. 6a);
- The capillary ascension variation in the case of the walls made of new brick masonry and cement mortar (NB + CM) placed in the second series is linear, ranging from 15 cm to 27 cm after 8 cycles (Fig. 4b);
- The capillary ascension variation in the case of the walls made of old brick masonry and cement mortar (OB+CM) placed in the second series is linear, varying from 16 cm to 29 cm, after 8 cycles (Fig. 5b);
- The capillary ascension, in the case of the masonry walls made of old brick masonry and lime cement (OB+LM) placed in the second series is linear, varying from 18 cm to 30 cm after 8 cycles (Fig. 6b).

Stage II:

Following the water-proofing process with solution I, the capillary ascension variation:

- in the case of the masonry walls made of new brick masonry and cement mortar (NB + CM) placed in the first series decreased, varying from 7.5 cm to 11 cm after 8 cycles (Fig. 4a);
- in the case of the masonry walls made of old brick masonry and cement mortar (OB + CM) placed in the first series decreased, varying from 9 cm to 12 cm, after 8 cycles (Fig. 5a);
- in the case of the masonry walls made of old brick masonry and lime mortar (OB + LM) placed in the first series decreased, varying from 10 cm to 12 cm after 8 cycles (Fig. 6a);
- in the case of the masonry walls made of new brick masonry and cement mortar (NB+CM) placed in the first series decreased, varying from 6 cm to 11 cm after 8 cycles (Fig. 4b);

- in the case of the masonry walls made of old brick masonry and cement mortar (OB + CM) placed in the first series decreased, ranging from 7 cm to 12 cm after 8 cycles (Fig. 5b);
- in the case of the masonry walls made of old brick masonry and lime mortar (OB + LM) placed in the first series decreased, ranging from 10 cm to 12 cm after 8 cycles (Fig. 6b).

The purpose of this experimental study is to determine whether the results achieved in the experimental study presented in a previous paper (Clim (Pegescu-Clim) *et al.*, 2018), where the behavior of the masonry ceramic elements under water action has improved significantly after the application of the water-proofing treatment, is also confirmed in the case of the building elements. This aspect has been scientifically proven by the study, resulting in an ascensional humidity decrease of 50,…,60% (Figs. 4,…,6).

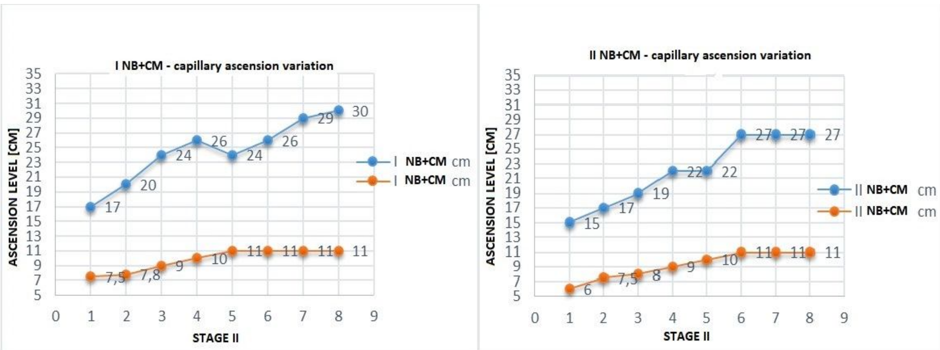

Fig. 4 – Capillary ascension variation I(a), II (b) NB+CM, before and after water-proofing.

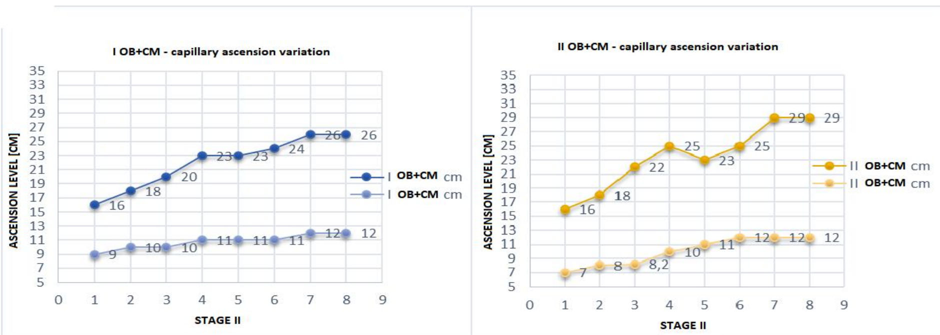

Fig. 5 – Capillary ascension variation I(a), II (b) OB+CM, before and after water-proofing.

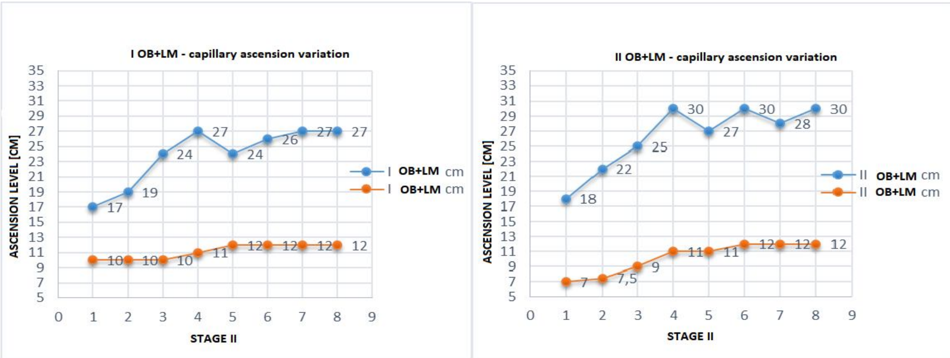

Fig. 6 – Capillary ascension variation I(a), II (b) OB+LM, before and after water-proofing.

4. Discussions and Conclusions

In the experimental study, it was found that if the ceramic masonry elements are more regular and better consolidated with mortar, the level reached by the ascensional humidity is higher.

Regarding the water migration mechanisms, in the case of the masonry walls made of new brick and cement mortar, the moisture level is roughly the same on all faces of the wall, and in the case of masonry made of old ceramic elements, the water has migrated particularly through the mortar layer.

The lime mortar allows water to rise to the highest level, also being the element that retains water inside the walls, as found at the time of carrying out the perforations for water-proofing.

After the water-proofing treatments, the ascensional moisture registered a linear variation in the first 6–7 cycles, after which the variation became constant, a consolidation level being observed. Thus, at the end of the 8 cycles, the moisture level became uniform, remaining below the injection area level.

Thus, both water-proofing solutions achieved very good results, reducing ascensional humidity by 50,…,60%.

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* * * Technical chart SikaMur-Injectocream-100.

SOLUȚII DE HIDROFOBIZARE A ZIDĂRIILOR REALIZATE DIN ELEMENTE CERAMICE

(Rezumat)

În contextual actual al conservării clădirilor istorice, la nivel mondial, s-a stabilit că umiditatea reprezintă principala cauză de degradare. Majoritatea edificiilor protejate sunt realizate din zidărie de cărămidă, solidarizată cu mortar de var sau mortar de ciment, iar pentru eliminarea umidității ascensionale nu s-a descoperit încă o soluție general valabilă, aşa cum este prezentat în literatura de specialitate. O metodă de asanare, extrem de des utilizată de specialiştii în restaurarea clădirilor istorice, este injectarea unor soluții sau emulsii, în partea inferioară a zidurilor, cu scopul de a crea un brâu hidrofob. Acest tratament reprezintă un subiect amplu dezbătut de către comunitatea ştiințifică, întrucât nu s-au realizat suficiente studii, care să valideze rezultatele acestor sisteme de hidrofobizare.

Scopul lucrării este acela de a determina, prin studii experimentale realizate în laborator, influența tratamentelor de hidrofobizare asupra zidăriilor ceramice. În cadrul studiului s-au realizat şpaleți din zidărie de cărămidă plină, fabricată recent şi elemente ceramice vechi, recuperate din demolări. O parte din şpaleții realizați au fost solidarizați cu mortar de var, iar cealaltă parte, cu mortar de ciment. După ce s-a determinat nivelul la care ajunge umiditatea ascensională, în zidării s-au fost injectat două tipuri de soluții de asanare: una pe bază de silan şi o emulsie siliconică. Apoi s-a reluat umezirea bazei şpaleților, pentru determinarea nivelului ascensiunii apei, după aplicarea tratamentului de hidrofobizare.

Rezultatele studiului experimental au arătat că umiditatea ascensională, obținută în urma injectării soluțiilor în zidăria de cărămidă, s-a diminuat cu aproximativ 60 %. De asemenea, studiul a demonstrat crearea unui brâu hidrofob, peste care apa provenită din acțiunea capilară nu poate înainta.

Aşadar, ambele soluții de hidrofobizare au înregistrat rezultate foarte bune, reducând umiditatea ascensională, însă rămâne de studiat influența acestor tratamente asupra clădirilor, unde mecanismele de degradare cauzate de prezența umidității sunt combinate cu gelivitatea, cristalizarea sărurilor solubile şi acțiunea factorilor agresivi din mediul înconjurător.