ADOBE-BRICKS SURFACE TREATMENT METHODS FOR IMPROVED WATER RESISTANCE

Gabriela CĂLĂTAN[1], *Andreea HEGYI*[2], *Carmen DICO*[3], *Călin MIRCEA*[4]
[1] PhD Stud., NIRD URBAN-INCERC Branch of Cluj-Napoca, gabriela.calatan@incerc-cluj.ro
[2] PhD, NIRD URBAN-INCERC Branch of Cluj-Napoca, andreea.hegyi@incerc-cluj.ro
[3] Eng., NIRD URBAN-INCERC Branch of Cluj-Napoca, carmen.dico@incerc-cluj.ro
[4] Prof., Technical University of Cluj Napoca, Civil Engineering Faculty, calin.mircea@dst.utcluj.ro

ABSTRACT

The main problem with clay-based surfaces is the reduced resistance to water action. Literature does not indicate scientifically validated solutions for surface treatment. However, there are reports that indicate the benefits of impregnating surfaces with animal oils, vegetable oils, petroleum products, etc. The aim of this paper is to identify a solution for treating the surface of earth made bricks, in order to increase the degree of waterproofing and the resistance to water action, using local materials, specific to the western part of Romania. To achieve this, was used a surface treatment based on marble, lime, sand, clay, and water permeation reducing additive. On clay surfaces treated with this material, water vapor permeability and water penetration under wind pressure tests were conducted. The experimental results obtained indicated the optimal composition for the surface treatment material so that it does not crack upon drying, have good adhesion to the substrate, and improve substrate resistance to water action.

Keywords: adobe bricks; water resistance; durability.

REZUMAT

Principala problema a suprafețelor realizate pe bază de argilă este rezistența redusă la acțiunea apei. Literatura de specialitate nu indică soluții validate științific pentru tratarea suprafeței. Există însă raportări care indică beneficiile impregnării suprafețelor cu uleiuri animale, uleiuri vegetale, produse petroliere etc. Scopul acestei lucrări este de a identifica o soluție de tratare a suprafeței caramizilor din pământ în vederea creșterii gradului de impermeabilitate și a rezistenței acestora la acțiunea apei, folosind materiale locale specifice zonei de vest a României. Pentru atingerea acestui scop s-a folosit un tratament de suprafață pe bază de praf de marmură, var, nisip, argilă și aditiv de reducere a permeabilității la apă. Pe suprafețele de argilă tratate cu acest material s-au efectuat teste de permeabilitate la vapori de apă și penetrație a apei sub presiunea vântului. Rezultatele experimentale obținute au indicat compoziția optimă pentru materialul de tratare a suprafeței, astfel încât acesta să nu fisureze la uscare, să aibă o aderență bună la suport și să îmbunătățească rezistența substratului la acțiunea apei.

Cuvinte cheie: cărămizi din argilă nearsă; rezistență la apă; durabilitate.

1. INTRODUCTION

In the context of the global situation, given the intense industrial development in all areas of activity, there is a need of targeting less pollution and less consumption of non-renewable natural resources. In the construction field, it is estimated that only Portland cement production is responsible for about 4% of the total greenhouse gas emissions. (Abdu, 2010; Trevisan and Giglia, 2005; Gualtieri et al., 2006). In this situation, in line with the principles of Finland (2016) and the concept of "circular economy", the use of adobe bricks is a sustainable option for environmental-friendly buildings. However, besides the advantages of this type of building material (Agrawal et al., 2009; Eckel, 1905; Browne, 2009) the main disadvantage is the reduced resistance to water action. Numerous researches have been carried out, in order to increase the resistance of adobe bricks to water action. One method is the application of thermal treatments (burning elements in the furnace) that caused changes in the crystallographic mixture of the material (Klein and Hurlbut, 1985), making it less permeable to water and with less water absorption, without softening in the water (Al-Jadeed and Aziz, 2004; Browne, 2009; Fajobi and Ogunbanjo, 1994). On the other hand, the possibility of using additives in the clay-based mixture was investigated in order to achieve a less water-sensitive clay mass, but keeping the water vapor permeability properties (Norton, 2004; Okunade, 2008; Annovazzi, 2009; Schicker and Gier, 2009). Last but not least, the third type of research has focused on surface treatments, respectively the application of film-forming products that reduce or prevent the penetration of water to the surface of brick. (Schicker and Gier, 2009; Torraca, 1988; Watson, 1986). The literature does not indicate scientifically validated solutions for surface treatment. However, there are some reports that indicate the benefits of impregnating surfaces with animal oils, vegetable oils, petroleum products, etc. Thus, in Africa and South America the painting of the bricks with the juice of the *Euphorbia lacter* plant was used, after drying obtaining a natural rubber (Hamer, 1975). In Peru, a fluid paste made from the juice of the *Opuntia ficus* cactus was used for dyeing, mixed with clay (Gomes and Folque, 1953). In other areas, a solution obtained by boiling strains and leaves of *Musa Paradisiaca* banana, which was used for waterproofing. In Ghana, a solution obtained by boiling and mixing the fruits and seeds of a locust bean, *Ceratonia silicua*, was used also (Marwa, 2011). Bitumen, animal fats, oils and soaps reduce water absorption even with 25% (Tarek and Ghada, R. 2010; Minke 2005; Tripard, 2010; Daddis, 2011). Painting / spraying with solutions based on vegetable oils, tannins, gum arabic or natural resins can also improve water resistance. For experimental research, surface impregnation was performed using six types of solutions: linseed oil, beeswax dissolved in oil, beeswax dissolved in siccative oil, lime paste, hydraulic lime, animal fat. In Morocco, a traditional waterproofing technique is used by plastering with a product made by lime, water, and pigments which subsequently, under the action of friction with a natural stone and olive-based soap, becomes waterproof and glossy by closing the micro-cracks, called Tadelakt (Taylor et al., 2009; Delahousse, 2014; Weismann and Bryce, 2008). In Fig. 1 (Delahousse, 2014) the interior of a bath finished with Tadelakt is shown. Although known from antiquity, this technique has been "forgotten" in the early of '70s, to become of interest again, due to the fact that it is an environmental-friendly waterproofing method.

The aim of this paper is to identify a solution for treating the surface of earth bricks, in order to increase the degree of waterproofing and the resistance to water action, using local materials, specific to the western part of Romania.

Fig. 1. Bathroom finished with Tadelakt (Delahousse, 2014)

2. MATERIALS AND METHODS

The current research is part of a complex program, in which significant data is already available and studied:

– establishing the optimum mix of raw materials for building bricks.
– establishing a mixture of raw materials for making a masonry mortar that makes the connection between earth bricks and that can be used as a mortar for plastering.
– establishing the optimum dosage and mix of the raw materials in order to obtain a treated surface and, therefore, an increased

level of impermeability and its resistance to water action.

The results of these researches were presented in previous papers. To achieve the aim of this current research, three preliminary tests mixes for the surface treatment were established, according to Table 1.

Table 1. *Preliminary tests compositions*

Surface treatment material	A	B	C
Marble powder	30%	20%	10%
Sand 0-1 mm	30%	20%	30%
Clay	30%	50%	50%
Aquastop additive	5%	5%	5%
Lime	5%	5%	5%

In order to determine the desired physical-mechanical parameters, specimens were produced in the following way:

- prism test specimens 40x40x160 mm to determine apparent density, mechanical resistances (compressive strength, R_c and flexural strength, R_f) and axial contractions according to EN 1015-10, EN 1015-11 and STAS 2634.
- prism test specimens 150x150x50 mm of the material for brick making (Călătan and Hegyi, 2014), on which a layer of plaster was applied (Călătan et al., 2014) with a thickness of 10-20 mm and which was subsequently coated with surface treatment material, to determine adhesion to the support by the method of pull-off according to EN 1542, water penetration under compressed wind pressure according to NE 001/96 and water permeability according to EN ISO 7783-2. All the results were then compared to an untreated control surface. The priority criterion in the evaluation of the analyzed treatment surface was the lack of cracks.

3. RESULTS

Laboratory tests and results obtained on the three types of materials selected for the treatment surface are shown in Table 2.

By comparison with previously obtained experimental results, which meant the treatment of the clay surface with six types of solutions: linseed oil, beeswax dissolved in oil, beeswax dissolved in siccative oil, lime paste, hydraulic lime, animal fat (Călătan et al., 2015; Călătan and Hegyi, 2015), the results are shown in Fig. 2 and Fig. 3. Images of the three surface treatments can be seen in Fig. 4.

Table 2. *Result of the laboratory tests performed on the three types of surface treatment material*

Surface treatment material	A	B	C
Apparent density (kg/m^3)	2000	1980	1970
Tensile strength by bending (N/mm^2)	1,1	1,4	1,5
Compression strength (N/mm^2)	2,8	3,2	3,4
Axial contractions (mm/m)	0,8	1,6	1,6
Adhesion to support (N/mm^2)	0,6	0,4	0,4
Water vapor permeability, μ	3,2	2,6	2,4
Water penetration under wind pressure (g/dm^2*zi)	18	30	34
Cracking on drying	generally does not appear	numerous cracks with small opening,	numerous cracks with significant opening,

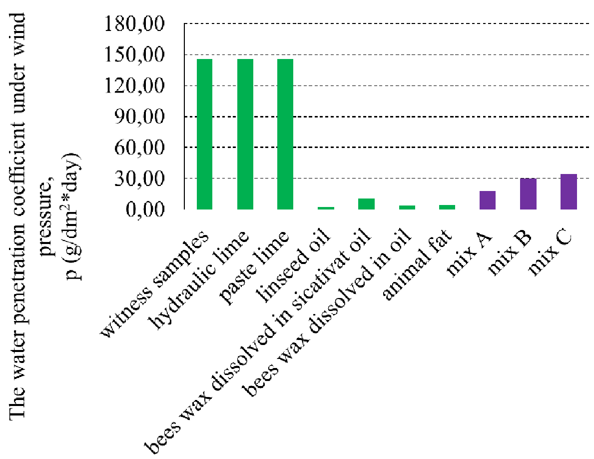

Fig. 2. Water penetration under wind pressure

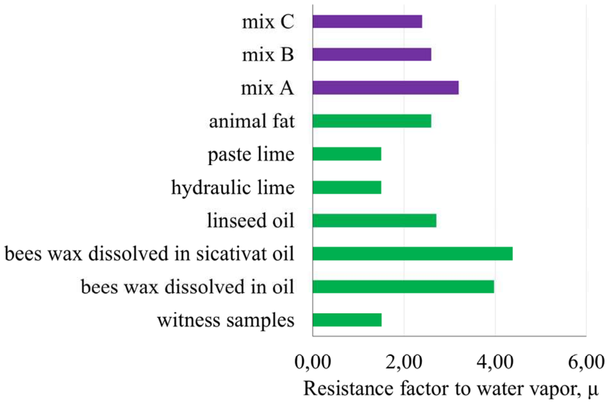

Fig. 3. Variation of the water vapor resistance factor depending on the surface treatment of the specimens

Composite A

Composite B

Composite C

Fig. 4 Images of the three surface treatments

4. CONCLUSIONS

Composition A (30% clay, 30% marble powder, 30% sand, 5% Aquastop additive, 5% lime) did not show any type of cracking. For this composition, the best adhesion to the support, 0.6 N / mm^2 and the lowest drying shrinkage were observed. Compositions B (50% clay, 20% marble powder, 20% sand, 5% Aquastop additive, 5% lime) and C (50% clay, 10% marble powder, 30% sand, 5% Aquastop additive, 5% lime), due to the fact they have a higher clay content, show larger contractions and therefore, cracks and the adhesion decreases.

By comparison with the results obtained for other surface treatments (lime, wax, oil, animal fat), it has been observed that fat-based treatments improve water-impermeability, while lime-based ones allow good water vapor permeability. Composition A may be an effective treatment for the protection of the clay surface, if the surface is not subject to intense water action. Marble dust and sand help to reduce cracks, the Aquastop additive increases water resistance, and the lime is a binder that helps components react one with another, increases mechanical properties over time and improves the durability properties of the material. The Tadelakt type plaster is an excellent support for additional treatments, when needed. For surfaces exposed to the action of water, it is recommended an additional treatment with linseed oil.

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