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Application possibilities of hydrophobised ceramic walling in areas with higher risk of floods

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Abstract. The paper deals with possibilities of application of hydrophobised waterproof walling system for construction of building bottom parts (socle walling) in area with higher risk of floods. The paper describes results from the research in the field of hydrophobisation possibilities of ceramic shaped pieces and subsequent development of socle waterproof walling construction.

Introduction

Two basic principles can be applied on building constructions as protection from water and humidity negative effects [1, 2]:

Indirect water-proofing principles – minimisation/reduction of construction moisture load by for instance placement of the object in optimal environment drainage of the adjacent environment to the object, increase of construction surface temperature etc.

Direct water-proofing principles - the prevention of water and humidity inleaks into the construction. In order to obtain required properties water or vapour-proof materials are applied as for instance coating water-proofing application of hydro-concrete (white bath-tub method), injections, penetration and impregnation of surfaces, hydrophobisation of surfaces etc. Also active methods [3, 4, 5] like electro-kinetic one represent further possibilities how to prevent water inleaks into the construction.

The highest load of vertical walled construction by higher moisture is mainly in the construction bottom part. This moisture load of the construction occurs either during the building of the construction and during use of it as well. Coating water-proofing and surface treatment are the only ways how to protect constructions from increased moisture at present [6].

During building works humidity enters into particular constructions especially before roofing of the carcass and before termination of surface treatment. If the construction is not air-proof sealed immediately after its termination in autumn or winter months, then in spring or summer the excess moisture is vaporised again from the constructions. Closing of humidity in constructions results mainly in worsening of thermal and technical properties of the construction and subsequently also mould and fungus formation.

During use of the construction the moisture in construction grows primarily due to damage or failure of the water-proofing. For instance, incorrect application of waterproofing or additional application of penetrations through the water-proofing may be the reason. It is often a serious problem having influence on degradation of the construction depending on moisture load rate.

Hydrophobisation of particular walling members is one of the ways how to protect walling from moisture load. Through the hydrophobisation the walling member absorption abilities are changed and thus the influence of moisture load of the construction is reduced. Chemical hydrophobisation preparations may strongly influence final price of walling members, therefore it is necessary to consider the hydrophobisation rate of particular construction members. Considering the economic and added value points of view the hydrophobisation of shaped piece bottom parts within several

centimetres height appears as the most convenient solution. These shaped pieces can be used for first walling line by which the moisture influence in construction is eliminated in the construction bottom part in carcass period and usage time as well.

Hydrophobic agents

Upon the laboratory experiments, it was found that the best hydrophobisation effects were obtained by application of silicon based preparations. The silicon based preparations are temperature resistant within -50°C to 200°C and they also resist to temperature changes, climatic effects like direct sunlight and weathering. The application of these materials is limited only in case of waters under pressure; here these materials do not obtain required properties.

Hydrophobised coating is formed on material surfaces by intermolecular condensing of low molecular metylsiloxans by actuation of carbon dioxide. The hydrophobisation effect is formed by suitable orientation of silicone molecules to the surface, therefore big amount of short hydrocarbon residues – for instance methyles, ethyles (CH_3-, C_2H_5-) is created. Due to the formation of this macromolecular layer a contact angle is formed by which the capillary elevation is reduced to zero or even capillary depression occurs. Despite of formation of this layer, the vapour permeability and gas permeability properties of building materials are preserved [7].

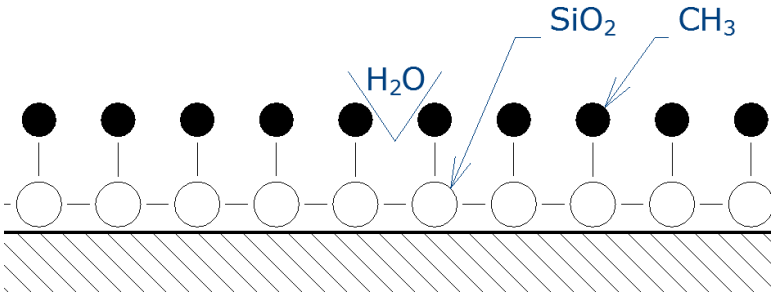

Fig. 1 The orientation of silicone molecules [7]

Testing methodology

Hydrophobisers were applied on ceramic shaped pieces by dipping them in solutions with defined concentrations. The hydrophobisers were diluted to particular concentrations by water and the solutions with application of liquid pigment were prepared in the same way. The dipping was done always for 10 seconds to 70 mm height from shaped piece bottom area. After application of the solutions the samples were stored for one week in laboratory environment to dry the excess moisture off.

Shaped pieces prepared in this way were weighed and put in the plastic box on wooden rack and flooded with water +20 ±2 °C to 50 mm weight from shaped piece bottom edge. In selected time intervals each shaped piece was weighed and from the weighing data the amount of water absorbed in the shaped piece in given time was set. It is mass absorption and by recalculation to shaped piece area it is capillary absorption.

$$A_w = \frac{m_w}{A}$$

A_w – capillary absorption in given time [kg.m^{-2}]
m_w – weight of absorbed water in shaped piece [kg]
A – shaped piece dipped area [m^2]

Test results and evaluation

Resultant values of mass absorptivity and capillary absorptivity are summed in Table 1 and further evaluated in the graphic Fig. 2. To illustrate the hydrophobisation effect also reference absorption and capillary absorption values for not hydrophobised shaped piece are shown here.

Table 1 Overview of obtained absorption values of the specimens

Hydrophobic agents - concentration	Absorption [%]			Capillary absorption [kg.m^{-2}]		
	24 h	144 h	408 h	24 h	144 h	408 h
No hydrophobisation - REF	23.0	29.1	30.3	6.42	8.08	8.45
1 - 1:40	0.4	0.9	1.4	0.11	0.27	0.43
1 - 1:50	0.5	1.8	2.2	0.12	0.39	0.49
1 - 1:60	0.6	1.8	2.3	0.20	0.56	0.73
1 - 1:80	0.9	2.5	3.2	0.26	0.73	0.94
1 - 1:100	1.4	4.3	5.4	0.42	1.28	1.68
2 - 1:20	5.4	17.0	21.0	1.69	5.27	6.55
2 - 1:10	10.6	25.4	26.2	3.30	7.94	8.21
2 - 1:6	13.8	25.4	25.4	4.31	7.93	7.94
3 - 1:10	8.4	23.5	24.8	2.68	7.50	7.92

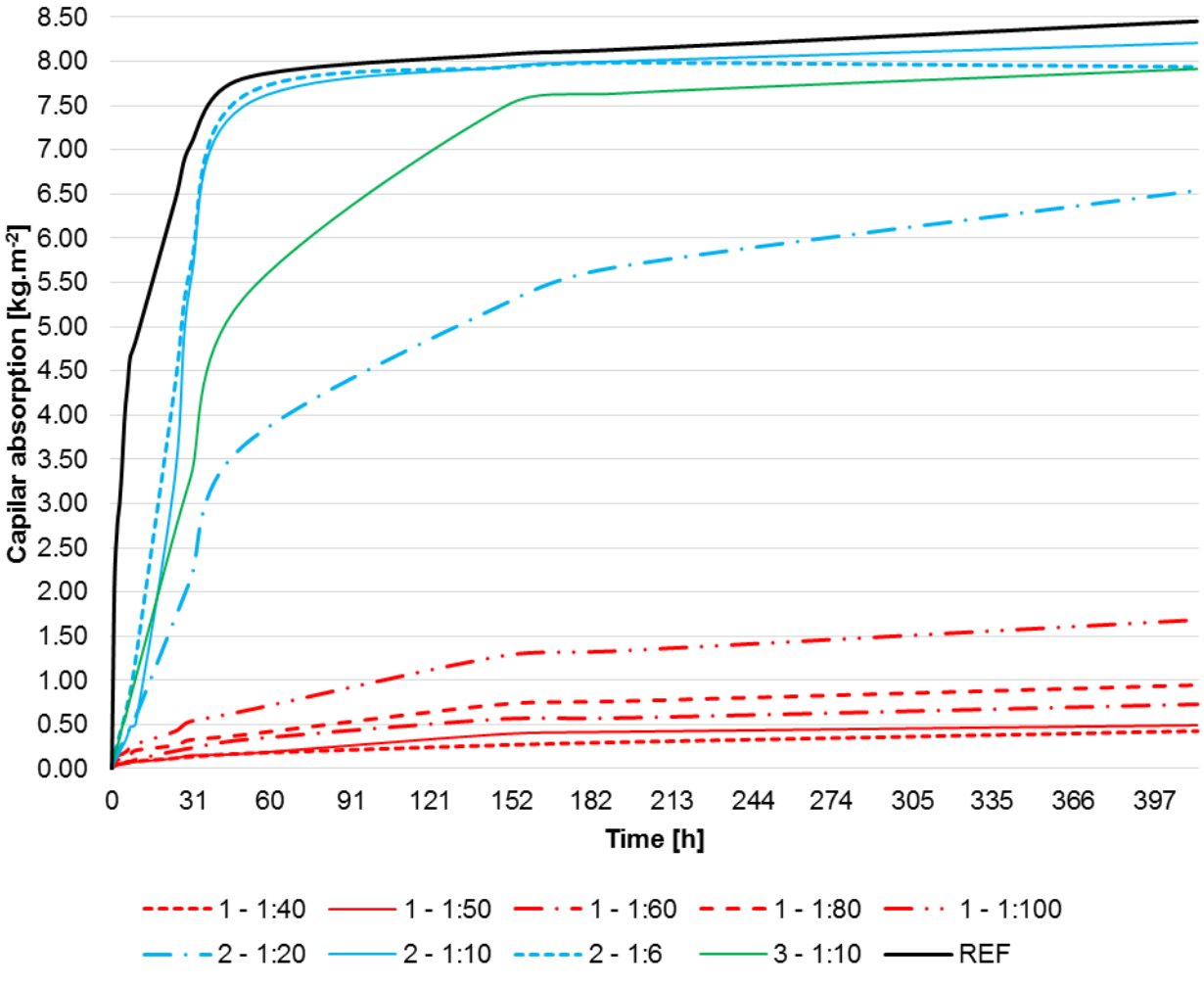

Fig. 2 Absorption in time of test samples

It is clear from the stated values that the most efficient hydrophobisation was obtained using the preparation marked as no. 1. When the application of hydrophobisation preparations no. 2 and 3 were compared with the reference -not hydrophobised shaped piece, certain reduction of absorptivity was noted, however, this hydrophobisation effect was evaluated as insufficient. Liquid pigment was then tested due to hydrophobised part marking. The pigment application was tested with the most efficient variant of the hydrophobisation preparation no. 1 in concentration 1:40. The pigment was applied as additive in the hydrophobisation preparation itself and also by dipping of the shaped piece in pigment-water solution. In case of the application of separate pigment solution, the pigmentation variant and subsequent hydrophobisation was tested and also the hydrophobisation variant with subsequent pigmentation was carried out. In both cases the shaped pieces were dipped in particular solutions with 30s time intervals. The results of mass absorption and capillary absorption with pigment use compared to hydrophobisation preparation no. 1 only are shown in the following Table 2 and graphically evaluated in Fig. 3.

Table 2 Overview of obtained absorption values of the specimens with testing pigmentation

Application method hydrophobic agents and pigment	Absorption [%]			Capillary absorption [kg.m^{-2}]		
	24 h	144 h	408 h	24 h	144 h	408 h
Hydrophobic agents 1 - 1:40	0.4	0.9	1.4	0.11	0.27	0.43
Hydrophobic agents 1 - 1:40 follow pigmentation	0.5	1.2	1.9	0.14	0.38	0.61
Pigmentation follow hydrophobic agents 1 - 1:40	0.8	1.9	2.6	0.24	0.61	0.83
Hydrophobic agents 1 - 1:40 with pigment	1.0	2.6	3.3	0.31	0.80	1.03

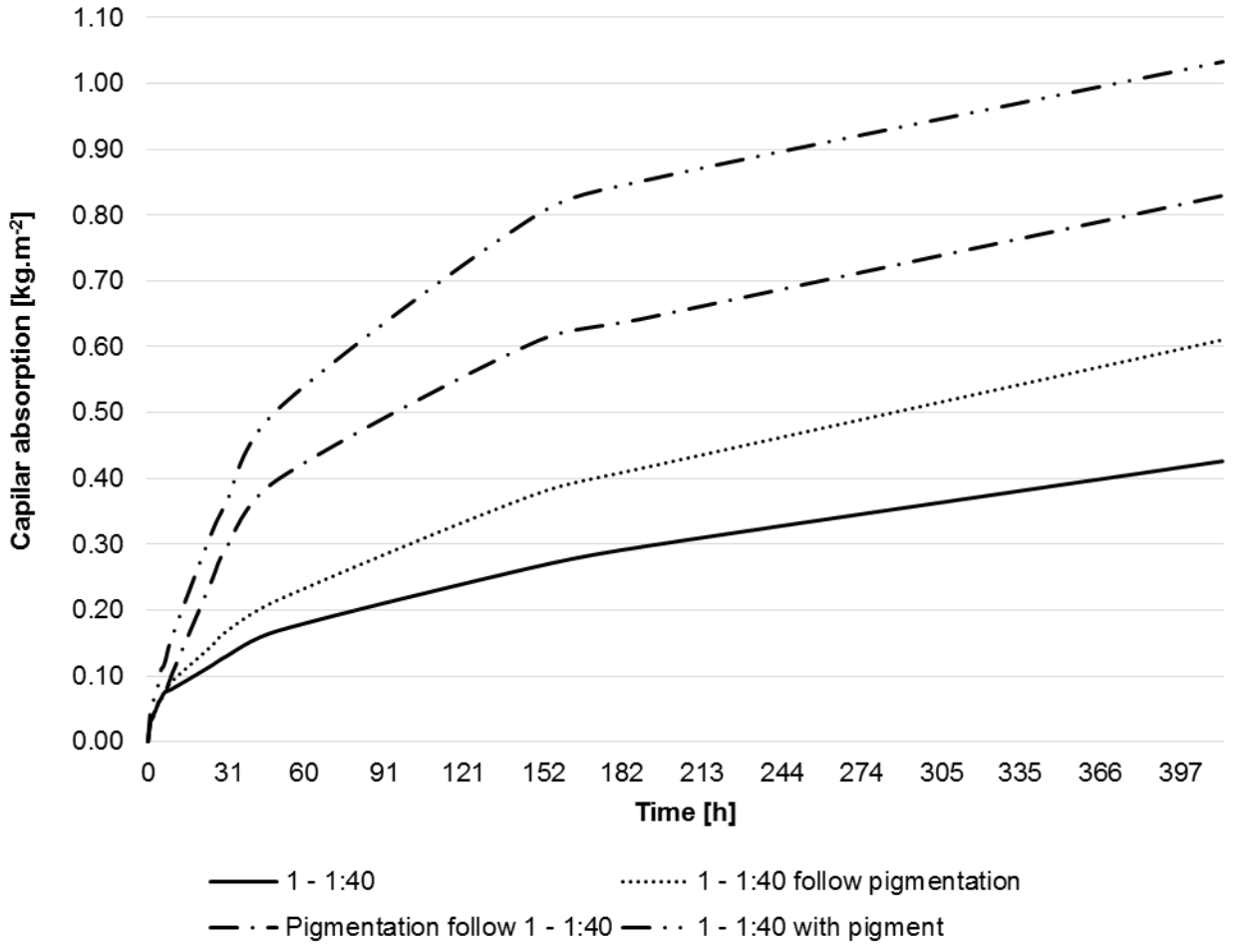

Fig. 3 Absorption in time of test samples with use of pigment

It is evident from the values shown in Table 2 that application of pigments have moderate influence on efficiency of hydrophobisation of shaped pieces. However, the verified values of the mass absorption and capillary absorption are very positive using pigment application compared to values at testing of particular hydrophobisation preparations. The method of ceramic shaped piece hydrophobisation with subsequent pigmentation was confirmed as the most efficient way of marking of the hydrophobised shaped piece. Pigment or pigment particles respectively have influence on penetration of hydrophobisation preparation into the ceramic cullet which reduces the hydrophobisation effect when the pigment is applied simultaneously with hydrophobiser or when pigmentation is made first and hydrophobisation as the second step. At present the reduction of hydrophobisation effect due to pigment application is the subject of thorough research.

Conclusion

During the testing the suitable silicon based hydrophobisation preparation was found. Very effective reduction of walling member absorption was confirmed with all tested concentrations with this preparation even up to the 1:100 concentration. The most efficient was the application of 1:40 concentration. In this concentration as well colour marking of shaped piece hydrophobised part using pigment was also tested. The pigment had not any essential influence on hydrophobisation effect. The method when ceramic walling member was hydrophobised by dipping for 10 seconds in hydrophobisation solution with concentration 1:40 and subsequent 30 second pigmentation in the pigment solution was determined as the most efficient variant.

Compared to not hydrophobised shaped piece which after one day of moisture load obtained capillary absorption 6.42 $kg.m^{-2}$, the capillary absorption of the shaped piece treated in the above described way is lower by more than 0.2 $kg.m^{-2}$ even after two-week long continuous moisture load. Capillary absorption of the treated shaped piece was not higher than 0.7 $kg.m^{-2}$ even after two-week moisture load.

These shaped pieces are assumed as suitable for first walling lines. Due to the hydrophobisation of walling shaped pieces their absorption is reduced, which has also positive impact on humidity capillary attraction. This shaped piece is one of the basic building materials that can serve for development of special walling materials for areas with frequent floods. At present we work on development of further walling members intended for areas with floods and their mutual synergy.

Fig. 4 Hydrophobised ceramic block at concentrations 1:40 and subsequent pigmentation after construction moisture load in time 144 h

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References

[1] Czech standard CSN P 73 0600 Waterproofing of buildings - Basic provisions

[2] Czech standard CSN P 73 0610 Waterproofing of buildings - The rehabilitation of damp masonry and additional protection of buildings against ground moisture and against atmospheric water - Basic provision

[3] Beben, D., Manko, Z. Influence of selected hydrophobic agents on some properties of autoclaving cellular concrete (ACC), Construction and Building Materials, 25, 2011, pp. 282-287

[4] Medeiros, M., Helene, P. Efficacy of surface hydrophobic agents in reducing water and chloride ion penetration in concrete, Mater Struct, 41, 2008, pp. 59–71

[5] Wolff, L., Raupach, M. Hydrophobation of concrete products, Betonwerk und Fertigteil-Technik, 69 (10), 2003, pp. 12–21

[6] Czech standard CSN P 73 0606 Waterproofing of buildings - Continuous sheet water proofing - Basic provisions

[7] Drochytka, R., Plastic substances, Study support, VUT Brno, Brno, 2007