INFLUENŢA ADITIVILOR POLIMERICI ASUPRA PERFORMANŢELOR MORTARELOR DE TENCUIALĂ COLORATE ÎN MASĂ, APLICATE PENTRU SISTEMELE COMPOZITE DE TERMOIZOLARE EXTERIOARĂ

POLYMER ADDITIVES INFLUENCE ON THE COLORED PLASTER MORTARS PERFORMANCE FOR EXTERNAL THERMAL INSULATION COMPOSITE SYSTEMS

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The paper presents the results of the studies performed on the influence of redispersible powders and of the cellulose ethers in mineral plasters applied as the last layer in exterior thermal insulation composite systems. Starting from traditional recipes, using polymeric additives specific for ETICS, there were developed original products in which the polymer additive (redispersible powder) concentration was modified with impact on physical and mechanical characteristics.

The using of the cellulose ether led to obtaining some light compositions (smaller density) and good workability at application.

The using of the redispersible powders has contributed to obtaining some mortars with low water permeability, high water vapour permeability and good support adherence, significant advantages for the products durability.

There have been highlighted the chemical interactions between the redispersible powders and the Ca^{2+} ions released during the cement hydration process. The redispersible powders act as a second binder in the system, thus leading to improved performance.

În prezenta lucrare a fost studiată influenţa pulberilor redispersabile şi a eterilor de celuloză în tencuielile minerale aplicate ca ultim strat în sisteme de izolare termică la exterior. Pornind de la reţete tradiţionale, utilizând aditivi polimerici specifici pentru sistemele ETICS au fost concepute produse originale în care s-a modificat concentraţia de aditiv polimeric (pulbere redispersabilă) cu impact asupra caracteristicilor fizico-mecanice.

Utilizarea eterului de celuloză a condus la obţinerea unor compoziţii uşoare (densitate mai mică) şi lucrabilitate bună la aplicare.

Utilizarea pulberilor redispersabile a contibuit la obţinerea unor mortare cu permeabilitate la apă scăzută, permeabiltate mare la vapori şi aderenţă bună la suport, avantaje semnificative pentru durabilitatea produselor.

Au fost puse în evidenţă interacţiuni chimice între pulberile redispersabile şi ionii de Ca^{2+} eliberaţi la procesul de hidratare a cimentului. Pulberile redispersabile acţionează ca un al 2-lea liant în sistem conducând astfel la performanţe îmbunătăţite.

Keywords: *mortar plasters, polymeric additives, cellulose ether, redispersible powders*

1. Introduction

The exterior thermal insulation composite systems (ETICS) improve the thermal insulation for new as well as for old and renovated buildings. They can be applied on all the self-supporting support (masonry, concrete, plastered facades, and so on). The thermal insulation of the building envelope requires the rational use of materials that prevent the heat transmission from inside to outside (during winter) and from outside to inside (during summer) [1].

A classic exterior thermal insulation composite system ETICS comprises the following components (Fig. 1):

- a specific adhesive for the system and mechanical fixing means specific for the system;
- the thermal insulating board (EPS expanded polystyrene);
- one or more layers of base primer (putty), specific to the system, one of which at least contains a reinforcement;
- a reinforcement, specific for the system;
- a finishing material, which can be a decorative organic or mineral plaster or a film-forming product [2].

In this paper are presented the results of the studies regarding the influence of redispersible powders and cellulose ethers in mineral plaster mortars applied as the last layer of the exterior thermal insulation composite system.

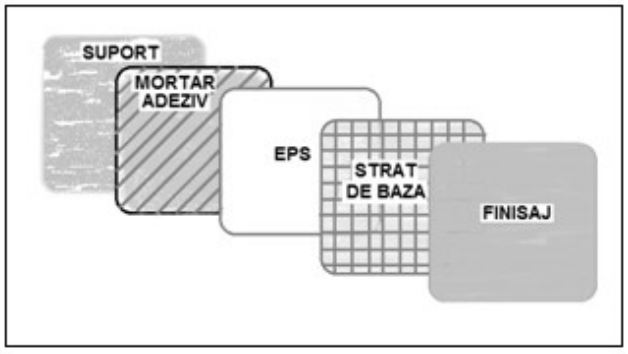

Fig. 1 - ETICS components / Alcătuire sistem ETICS.

Starting from the traditional recipes, but using the specific polymer additives for ETICS systems, three original compositions have been developed in which the polymer (redispersible powder) additive concentration was adjusted, in order to study the impact on the physical and mechanical characteristics [3].

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Table 1

The framework recipe for mineral plaster mortars / *Reţeta cadru pentru mortarele minerale de tencuială*

Materials *Materiale*	*Dosing [%]* *Dozaj [%]*			
	Plaster mortar composition/Code *Compoziţii tencuieli/Cod*			
	M0*	**R 20**	**R 21**	**R 22**
Cement CEM II/B-M (S-LL) 42,5 R *Ciment CEM II/B-M (S-LL) 42,5 R*	15	15	15	15
Hydrated lime *Var hidratat*	5	5	5	5
Sand (0-2 mm) *Nisip (0-2 mm)*	79.5	78.5	78.3	77.8
CULMINAL C 9166	-	0.2	0.2	0.2
VINNAPAS 5043 N	**-**	**1**	**1.2**	**1.5**
BAYFERROX GELB/ORANGE 415 (inorganic pigment) *(pigment anorganic)*	0.5	0.5	0.5	0.5
Water *Apă*	**			

* plaster mortar without additive/*mortar de tencuială fără aditivi*

** in order to obtain a consistency at standard cone of about 8 cm (good workability for application*)/ pentru a obţine o consistenţă la con etalon de cca. 8 cm (lucrabilitate bună pentru aplicare)*

2. Materials and experimental methods for the mineral plaster mortars characterizing

There have been used the following additives, specific for ETICS

- redispersible powder [4] based on a vinyl acetate-ethylene copolymer. Due to the high content of ethylene, this fine resin, flexible, has a minimum film forming temperature (T_g = 0^0C) resulting the reducing of crack formation and a good adhesion to the support (EPS). The vinyl acetate groups, when dispersed in an alkaline solution, react with water (hydrolyze) and acetate ions are obtained which react with the Ca^{2+} ions released during the cement hydration process, thus new compounds being formed [5];
- methyl hydroxyethyl cellulose [6], with a viscosity of 20000 ÷ 30000 mPa.s (2% solution).

The cellulose ether is soluble in water over a wide range of temperatures and behaves as a binder between the aggregate particles. Also, the cellulose ether prevents the formation of particle agglomerations, assuring well homogenized mortars.

The product improves the strength and application properties, the water retention, the workability and the slip resistance. The cellulose ethers are water soluble products used in many industrial applications as a water retention aid agents, thickening agents, protective colloids, suspending agents, binders, and stabilizers [7].

The dosages in which the components have been mixed are shown in Table. 1. The plaster mortars were applied on a support made of expanded polystyrene (density of about 20 kg/m^3) on which was applied base primer containing an embedded fibreglass net (160 g/m^2) and there were conditioned for at least 28 days under normal laboratory conditions.

In order to characterize colored plaster mortars that were used as a final layer in the ETICS composition, it was studied the influence of the polymer dosage on the following physical and mechanical characteristics of plaster mortars: bulk density (fresh mortar), dry bulk density (hardened mortar), compressive strength, liquid water permeability, water-vapour transmission rate (permeability),coefficient of resistance to water vapour diffusion, resistance to penetration, resistance to impact, tensile bond strength (adhesion to support).

3. Results and considerations

In Table 2 are presented the physical and mechanical characteristics for the colored plaster mortar compositions that were studied.

The **plaster mortar apparent density** values both in fresh and in hardened state with additives is lower than apparent density value of the reference plaster mortar, without additives.

It can be observed a **compressive strength** reduction (Figure 2) in comparison with the reference plaster mortar, due to the lower bulk density, and also due to the added cellulose ether that entrains an increased amount of air. Cement mortars which are prepared with without additives are more rigid and for this reason are prone to cracking.

The cellulose ether improves the mortars workability even if it leads to a decrease in the mechanical strengths.

Analyzing the influence of dosage on modified plaster mortar it can be observed an increase in compressive strength for the composition with a 1.5% addition of polymeric additive. The obtained values are according the performance levels of EN 998-1 standard, set for monolayer colored plaster mortars [8].

In comparison with the reference plaster

Table 2

Physical and mechanical characteristics / *Caracteristici fizico-mecanice*

Item no./ Nr. crt.	Characteristics/Caracteristici	Test method/ Metoda de încercare	**Code/Cod M0**	**Code/Cod R 20**	**Code/Cod R 21**	**Code/Cod R 22**
1	Bulk density, kg/m^3 (fresh mortar) / *Densitate mortar, kg/m^3 (stare proaspătă)*	EN 1015-6	2128	1578	1594	1541
2	Dry bulk density, kg/m^3 (hardened mortar) / *Densitate mortar, kg/m^3 (stare întărită)*	EN 1015-10	1949	1427	1358	1341
3	Compressive strength, N/mm^2 Rezistenţa la compresiune, N/mm^2	EN 1015-11	14.8	3.36	2.47	3.93
4	Liquid water permeability, kg/(m^{2}x h^{0,5}) / *Permeabilitatea la apă, kg/(m^{2}x h$^{0.5}$)*	EN 1062-3	2.41	1.46	1.48	0.74
5	Water-vapour transmission rate (permeability), g/(m^{2}x day) *Permeabilitatea la vapori, g/(m^{2}x zi)*	EN ISO 7783-2	223.04	389.10	449.45	273.19
6	Coefficient of resistance to water vapour diffusion (μ) / *Coeficient de rezistenţă permeabilitate la vapori (μ)*	EN ISO 7783-2	22	14	13	18
7	Resistance to penetration, N *Rezistența la penetrare, N*	EN 13498	690	650	635	555
8	Resistance to impact / *Impact* - 500 g (2 J) ball / *bila 500 g (2 J)* - 1000 g (10 J) ball / *bila 1000 g (10 J)*	EN 13497:2004	Imprint, fine cracks, without exfoliation / Imprint with pronounced cracks, exfoliation *Amprentă, fisuri fine, fără exfoliere, Amprentă cu fisuri pronunţate, exfoliere*			
9	Tensile bond strength, kPa / *Aderenţa, kPa*	EN 13494:2003	79*	137*	145*	129*

* cohesive breaking in the expanded polystyrene board (EPS)/ *rupere coezivă în placa de polistiren expandat (EPS)*

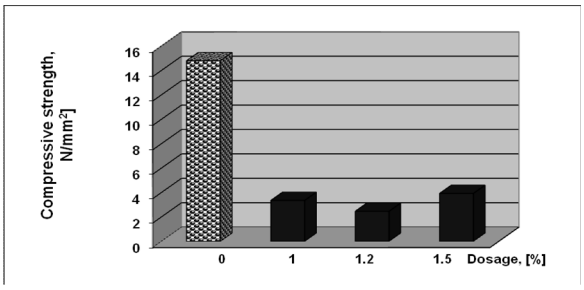

Fig. 2 - Compressive strength depending on the polymer additive dosage / *Rezistenţa la compresiune în funcţie de adaosul de aditiv polimeric.*

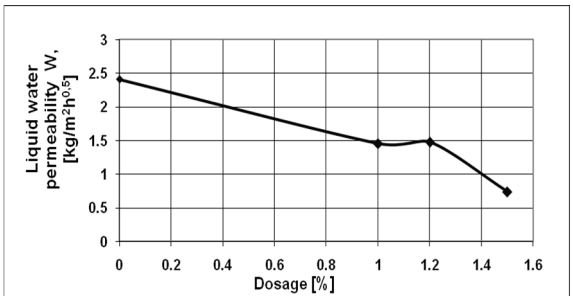

Fig. 3 - Liquid water permeability variation depending on the polymer additive dosage / *Variaţia permeabilităţii la apă în funcţie de concentraţia de aditiv.*

mortar, it can be observed a significant decrease of the liquid water permeability, of about 30%, for an increased concentration (1.5%) of the (redispersible powder) polymer additive. It is emphasized the decrease of the liquid water permeability from 2.41 kg/(m^{2}xh$^{0.5}$), corresponding to the reference plaster mortar M0 (without additives), to 0.74 kg/ (m^{2}xh$^{0.5}$), corresponding to the addition of about 1.5% of polymer additive.

In order to meet the requirement of EN 13499 standard [9] regarding the liquid water permeability of the exterior thermal insulation composite system (ETICS) surface, the liquid water permeability value have to be below 0.5 kg / (m^2 x h$^{0.5}$).

The **water-vapour transmission rate (permeability)** value of the finishing material in an ETICS system, according the EN 13499 standard have to be higher than 20 g/(m^2 x day). All the tested compositions fulfill this requirement.

Analyzing the water-vapour transmission rate (permeability), it is noticed the optimum value for the addition of 1.2% of polymer additive.

The resistance to penetration (Figure 6a and 6b) values are according the corresponding level (PE500) [9] for all the tested plaster mortar compositions.

It can be observed a slight decrease of the resistance to penetration value, corresponding to the additive concentration increasing, with a maximal value at a dosage of 1%, but all compositions meet the level requirement.

The tested compositions **resistance to impact** values are according the level I2 [9] because at the impact with a metal ball having 10 J shock energy (drop height 1020 mm), damaged are appearing and the finishing material is exfoliating.

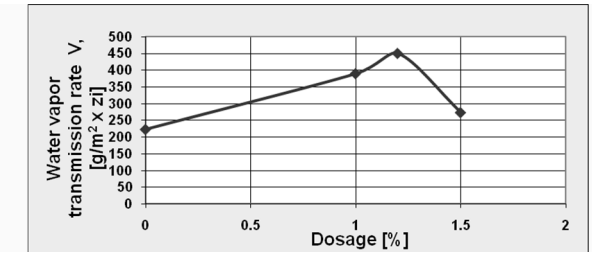

Fig. 4 - Water-vapour transmission rate (permeability) variation depending on the polymer additive dosage / *Variaţia permeabilităţii la vapori de apă în funcţie de adaosul de aditiv polimeric.*

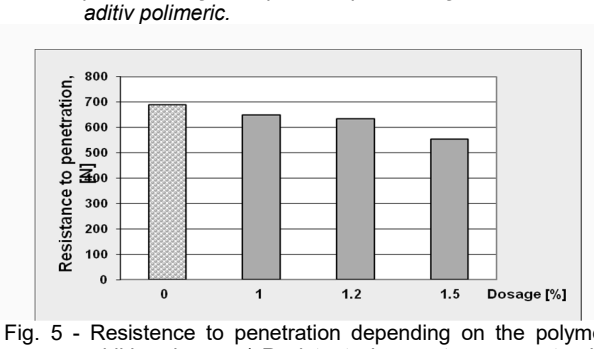

Fig. 5 - Resistence to penetration depending on the polymer additive dosage / *Rezistenţa la penetrare a mortarelor în funcţie de adaosul de aditiv polimeric* .

a b

Fig. 6 - Resistance to penetration test / *Încercarea la penetrare*: a - testing apparatus / *dispozitiv*, b -detail / *detaliu.*

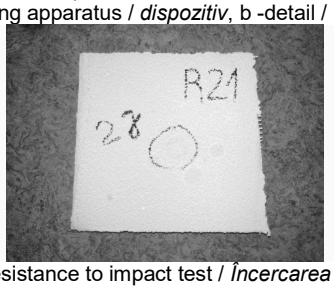

Fig. 7 - Resistance to impact test / *Încercarea la impact.*

The tensile bond strength value has to be higher than 80 kPa, according to the EN 13499 standard [9], and all the tested compositions meet this requirement. It can be observed a tensile bond strength maximum value of 145 kPa for a dosage of 1.5% polymer additive, significantly higher than the value for the reference plaster mortar (without additives) which does not have a proper bond on the expanded polystyrene (EPS) board.

Figure 8 presents the tensile bond strength on the expanded polystyrene board depending on the added additive dosage.

The addition of redispersible powders improves the tensile bond strength of mineral binders to fine supports, which are difficult to cover [10].

Only a certain quantity of redispersible powders and a suitable selection of the polymer

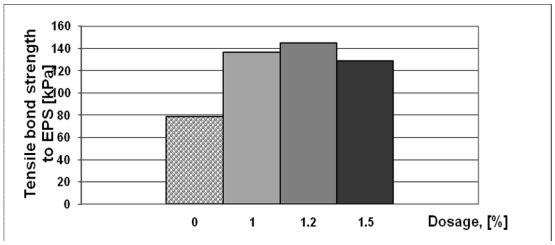

Fig. 8 - Tensile bond strength to expanded polystyrene board (EPS) / *Aderenţa la placa suport de polistiren expandat (EPS).*

can ensure a proper tensile bond strength to the support and at the same time, the flexibility of the base layer.

4. Conclusions

This paper highlights the performances of colored plaster mortar applied in exterior insulation composite systems (ETICS), depending on the addition of polymer additives.

As a result of the determined physical and mechanical characteristics and the study of the tested products performances, with different dosages of polymer additives were found the following:

- the use of the cellulose ether entrains a larger amount of air, which leads to a lower density of the coloured plaster mortars (both in fresh and in the hardened state); also, it is improved the mortar workability, therefore the application on the support is easier;
- the use of redispersible powders has the following advantages: the decrease of liquid water permeability, the increase of water-vapour transmission rate (permeability) and a significant increase of the tensile bond strength (adhesion to the support).

The composition recipes, the aggregates sorts which were used, the type and dosage (concentration) of used additives, allow the achievement of efficient dosed products which fulfil the requirements for their designed intended use.

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