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Performance of Plastering Mortars with Regranulated of Expanded Cork

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Extended Abstract

Jury

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1 Introduction

The problems in interior plastering mortars are increasingly common. These problems can be caused by poor ventilation, poor maintenance and inadequate thermal behavior of used materials. Thus, pathologies like humidity stains, cracks and fungi may restrict the performance of mortars.

This situation requires that we find solutions to solve the existing necessities, what can be achieved by reducing the thermal conductivity, improving the durability of plastering mortars. The objective of reducing the thermal conductivity of mortars can be achieved with the replacement of sand by other kind of aggregates, such as regranulated of expanded cork (REC).

The replacement of traditional rock aggregates for other types of aggregates is common in mortars/concrete filling, although it does not happen for plastering mortars. Thus, this study aims to determine the actual impact of such substitution, analyzing the advantages in thermal conductivity and other properties that determine the durability of plasters. To achieve these objectives, the mortars were tested for flexural and compressive strength, for water absorption by capillary action, for water absorption under low pressure, for water absorption by immersion, for drying after immersion, for adhesion of painted mortars, for fungal resistance and finally, the thermal performance. In the fresh mortar, with the purpose of determining the amount of water to be added to each mortar, tests of consistency were also conducted.

In this study, mortars were produced (100% hydraulic lime and 50% hydraulic lime + 50% cement) using various replacement rates (0, 20, 40, 60, 80 and 100%) of sand by REC, at three different particle sizes. However, in the hydraulic lime mortars, the maximum replacement rate was 60%, so as not to penalize too much their mechanical performance.

2 Experimental program

2.1 Materials

In this laboratory work we used fine river sand and REC, provided by Unibetão and Sofalca respectively. Three different sizes of REC were used, in particular, cork powder (R3), with very small particles (<0.250 mm) and two particle sizes above (R1 and R2).

The tests revealed that the aggregate sizes of REC used are quite distinct from the sand, as it is possible to prove through the analysis of the minimum dimensions (D_{min}) and maximum dimensions (D_{max}) of all aggregates (Table 2.1).

Table 2.1 – Minimum and maximum dimensions of the aggregates

	Aggregates			
	Sand	R1	R2	R3
D_{min} [mm]	0,125	1,0	0,500	-
D_{max} [mm]	1,0	4,0	8,0	0,250

By analyzing this table, we can say that the REC, with the exception of cork powder (R3), has a bigger particle size than the sand. There are also some important differences between the regranulated R1 and R2, because the R1 has a particle size less extensive than the R2.

We also used the cement CEM II / BL 32,5 N and hydraulic lime NHL5, both supplied by SECIL.

2.2 Mortars

In total, thirteen different mortars were produced, of which five are of hydraulic lime and the remaining eight are of cement and hydraulic lime. The produced mortars have all the same binder-aggregate volumetric ratio, B/Ag, (1:3, in hydraulic lime mortars and 0,5:0,5:3, in hydraulic and cement mortars), as well as an equal consistency. Besides the difference in binders, there were still used several mixtures of aggregates of way to produce the mortars for the proposed objectives. The relative volume of each aggregate, for each mortar, in the set of aggregates is indicated in Table 2.2 and Table 2.3.

Table 2.2 – Relative volume of each aggregate in hydraulic lime mortars (CH)

Mortar (CH)	% of each aggregate in the set of aggregates			
	Sand	R1	R2	R3
100A	100%	-	-	-
60A+R1	60%	40%	-	-
60A+R2	60%	-	40%	-
40A+R1	40%	60%	-	-
40A+R2	40%	-	60%	-

Table 2.3 - Relative volume of each aggregate in hydraulic lime and cement mortars (CH+C)

Mortar (CH+C)	% of each aggregate in the set of aggregates			
	Sand	R1	R2	R3
100A	100%	-	-	-
60A+R1	60%	40%	-	-
60A+R2	60%	-	40%	-
40A+R1	40%	60%	-	-
40A+R2	40%	-	60%	-
20A+40R1+40R3	20%	40%	-	40%
20A+40R2+40R3	20%	-	40%	40%
30R1+70R3	-	30%	-	70%

In order to produce mortars with equal consistence, tests were performed according to EN 1015-3 (1999). The results of this test are presented in Table 2.4, for the mortars with hydraulic lime, and Table 2.5, for the mortars with hydraulic lime and cement.

Table 2.4 - Consistence and W/B adopted for each hydraulic lime mortar (CH)

	100A	60A+R1	60A+R2	40A+R1	40A+R2
W/B	0,95	0,80	0,83	0,77	0,78
Consistence	63,9%	62,2%	64,5%	64,6%	67,5%

Table 2.5 – Consistence and W/B adopted for each hydraulic lime and cement mortar (CH+C)

	100A	60A+R1	60A+R2	40A+R1	40A+R2	20A+40R1+40R3	20A+40R2+40R3	30A+70R3
W/B	0,79	0,65	0,65	0,62	0,63	0,85	0,94	1,16
Consistence	65,7%	62,4%	63,5%	67,8%	64,8%	63,2%	66,2%	67,1%

With the presented results, it can be noted that in relation to the reference mortar, with the introduction of regranulated R1 and R2 the water required is lower. However, this situation does not occur when using R3 together with R1 or R2. This is due to high water absorption which characterizes the cork powder (R3) or others REC with a small grain size.

3 Experimental results

3.1 Compressive and flexural strength

The compressive and flexural strength tests were performed using the procedure described in EN 1015-11 (1999). These tests aimed to check whether the mortars produced have minimum values of mechanical strength. For this reason, it was considered sufficient to analyze the samples for 14 days instead of the usual 28 days.

The Figure 3.1 presents the test results of compressive strength of mortars produced.

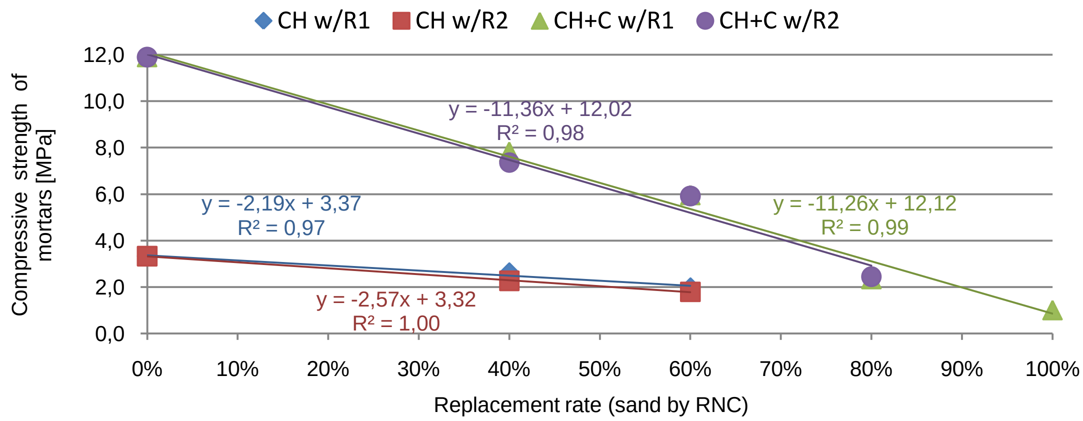


Figure 3.1 – Compressive strength of mortars with REC

With these data, it is observed that with the introduction of REC the compressive strength decrease is approximately linear. It is also clear that in the compressive strength, the performance of mortars with R1 and R2 is similar. It should also be noted that the value considered as the minimum limit (0.4 MPa, according to EN 998-1: 2003) was never crossed.

The Figure 3.2 presents the values of flexural strength of the mortars with REC.

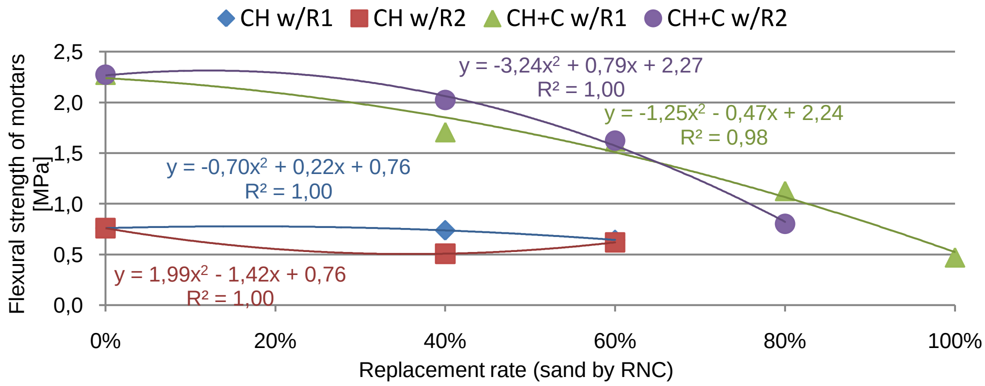


Figure 3.2 – Flexural strength of mortars with REC

On flexural strength, the mortars with REC, don't have a loss of performance as pronounced as in compression. We also identified some important differences between the mortars with R1 and R2. This may be attributed to the microstructure that is created between the binder and aggregates.

3.2 Water absorption by capillary action

The test of water absorption by capillary action was performed according to specification LNEC E 393 (1993). Figures 3.3 and 3.4 present the results of water absorption by capillary action in mortars.

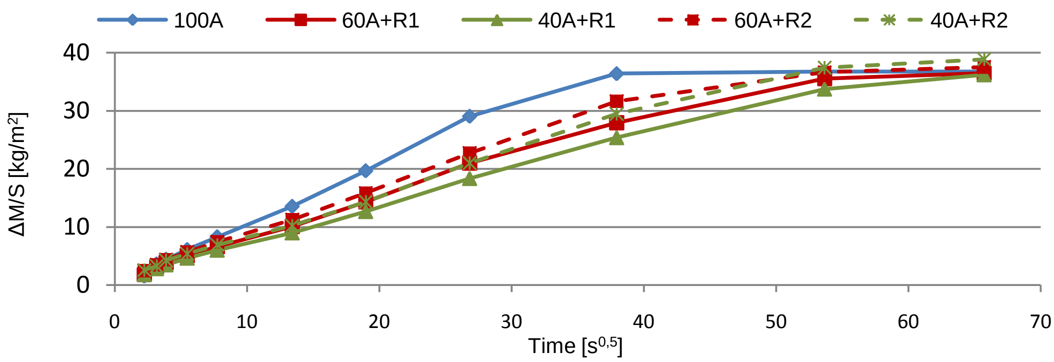


Figure 3.3 – Water absorption by capillary action in hydraulic lime mortars (CH)

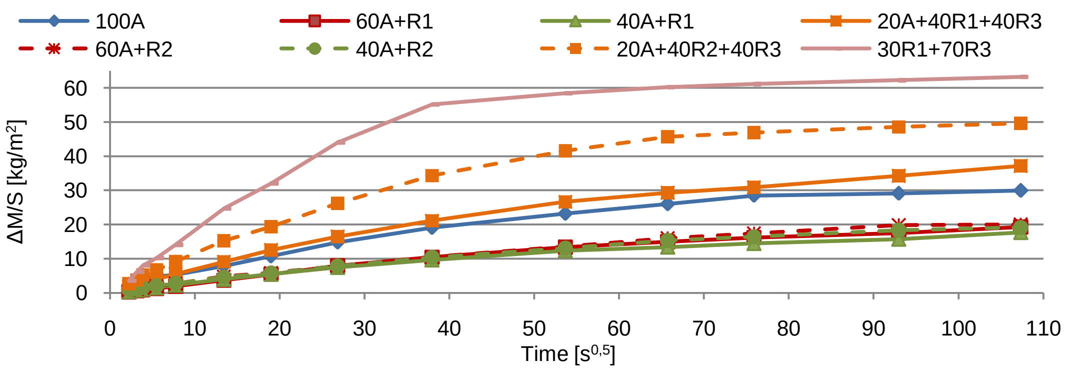


Figure 3.4 - Water absorption by capillary action in hydraulic lime and cement mortars (CH+C)

These results show that in both types of mortar, the initial rate of water absorption by capillarity decreases when replacing sand by (only) R1 or R2. However, when the hydraulic lime and cement mortars has also R3 (cork powder) this effect is opposite and the water absorption increases.

3.3 Water absorption under low pressure

The Figure 3.5 presents the absorption curves of hydraulic lime mortars.

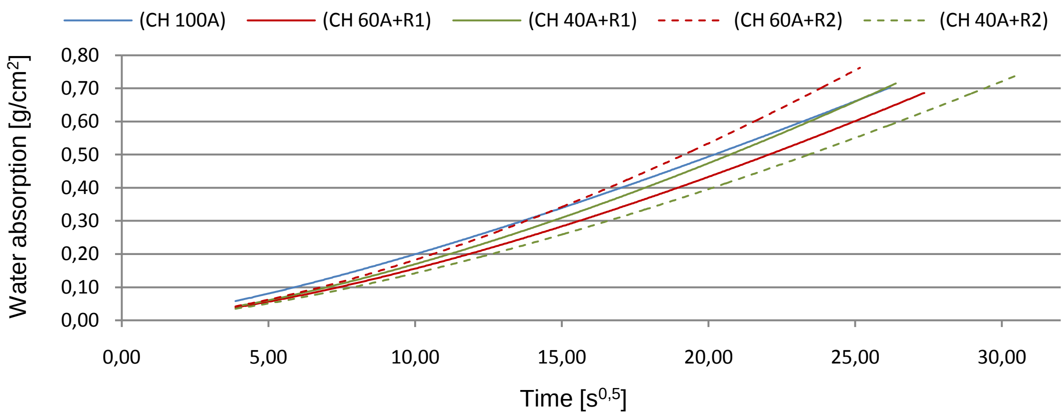


Figure 3.5 – Water absorption in hydraulic lime mortars

By analyzing the previous figure it is concluded that the REC in hydraulic lime mortars does not result in a significant change in the mode of absorption under low pressure.

Figure 3.6 shows the results of hydraulic lime and cement mortars.

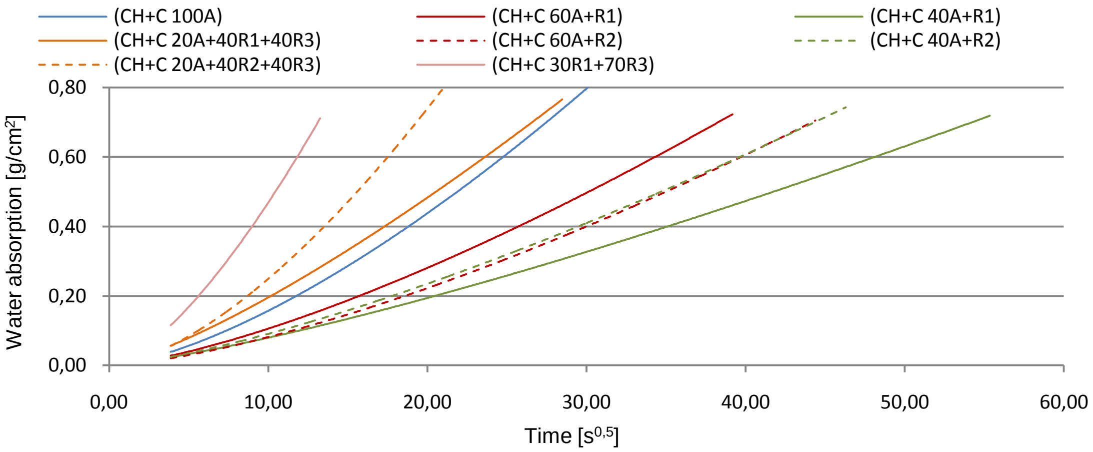


Figure 3.6 – Water absorption in hydraulic lime and cement mortars

In these mortars, the REC causes significant changes in the rate of absorption. And, as happened in the absorption test by capillary action, with the use of R3 absorption increases, while with (only) R1 or R2 absorption decreased significantly.

3.4 Water absorption by immersion

The test of water absorption by immersion was performed according to specification LNEC E 394 (1993). The Figure 3.7 shows the mass of water that mortars absorbed in that test.

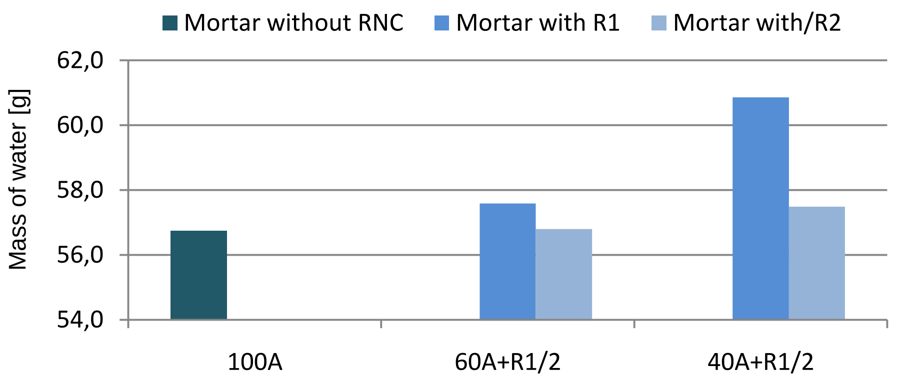


Figure 3.7 – Water absorption by immersion in hydraulic lime mortars (CH)

Analyzing this graph it is observed that hydraulic lime mortars with REC absorb more water than the control mortar, especially in mortars with R1, where water absorption is higher.

The Figure 3.8 has the results for the tests of hydraulic lime mortars.

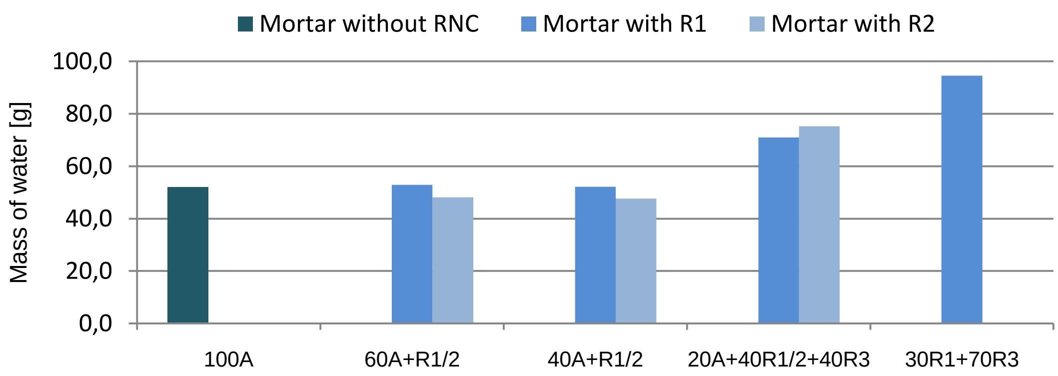


Figure 3.8 – Water absorption by immersion in hydraulic lime and cement mortars (CH+C)

In hydraulic lime and cement mortars, there are only significant changes in the absorption of water by immersion if the mortar has R3 (cork powder).

3.5 Drying after immersion

The results of drying after immersion tests are shown in Figure 3.9 and 3.10.

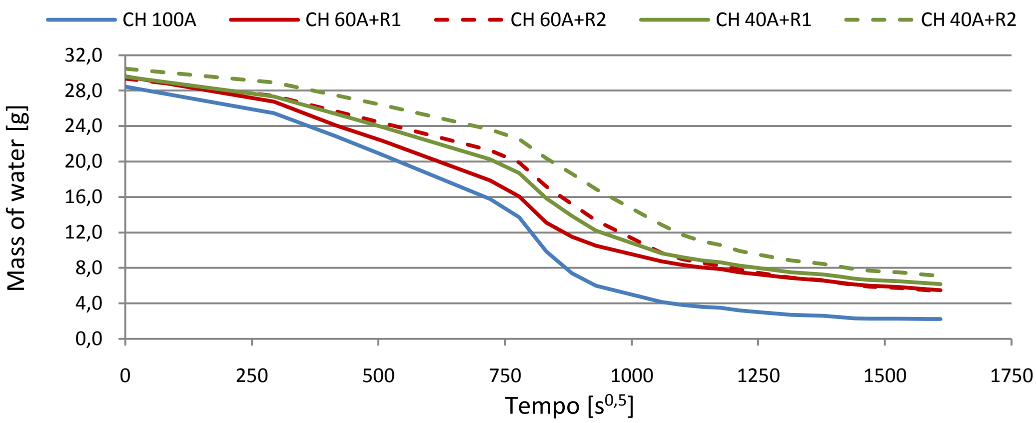


Figure 3.9 - Results of hydraulic lime mortars in the drying tests

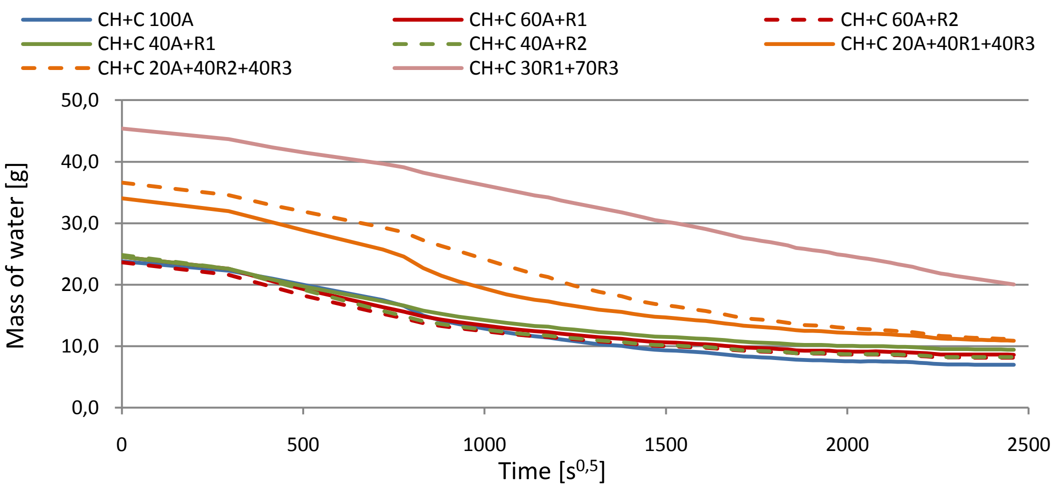


Figure 3.10 - Results of hydraulic lime and cement mortars in the drying tests

These data indicate that the mortars with REC, at the end of the test, present a greater quantity of water than the control mortars.

3.6 Adhesion of painted mortars

The pull-off test in painted mortars was performed according to specification ISO 4624 (2002). Figure 3.11 shows the results of the adhesion in painted hydraulic lime mortars.

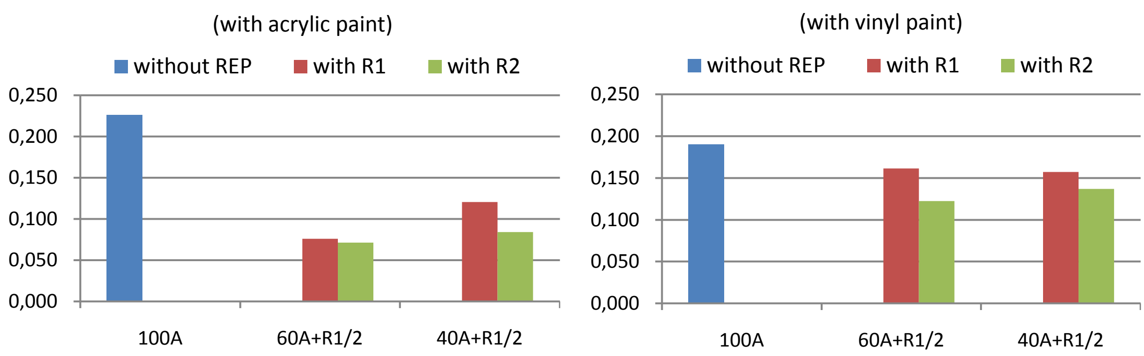
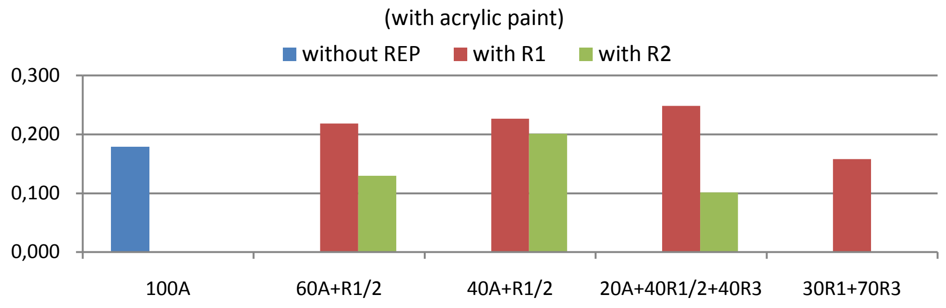


Figure 3.11 – Pull-off strength of the hydraulic lime mortars [MPa]

Analysis of Figure 3.11 shows that the introduction of REC in hydraulic lime mortars reduces the adhesion of the paint in the mortars. This effect is more evident when using R2.

Figure 3.12 shows the results of the adhesion in painted hydraulic lime and cement mortars.



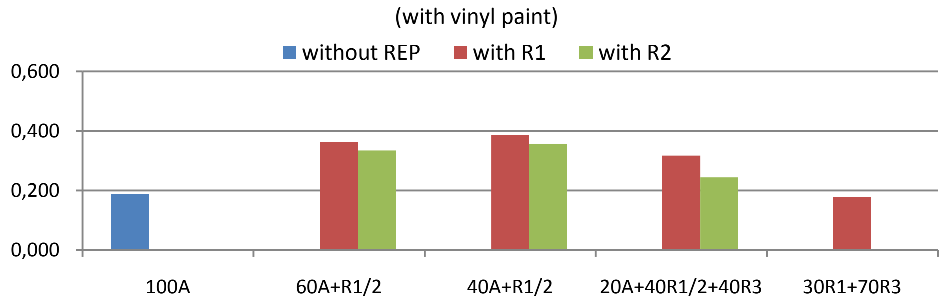


Figure 3.12 - Pull-off strength of the hydraulic lime mortars [MPa]

The adhesion of the coating of paint at mortar is lower when using R2 (compared to R1). We can also see that the pullout strength of hydraulic lime and cement mortars decreases not so strongly. In some samples (with lower replacement rates) there was even an increase in pullout strength.

3.7 Fungal resistance

The fungal resistance test was performed according to ASTM D 5590-00 and ASTM G21-90. The average results of this test are shown in Figure 3.13, for hydraulic lime mortars, and Figure 3.14, for hydraulic lime and cement mortars.

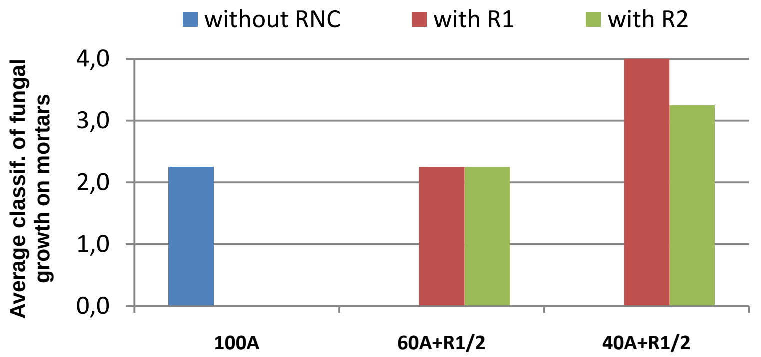


Figure 3.13 – Average classif. of fungal growth on hydraulic lime mortars (CH)

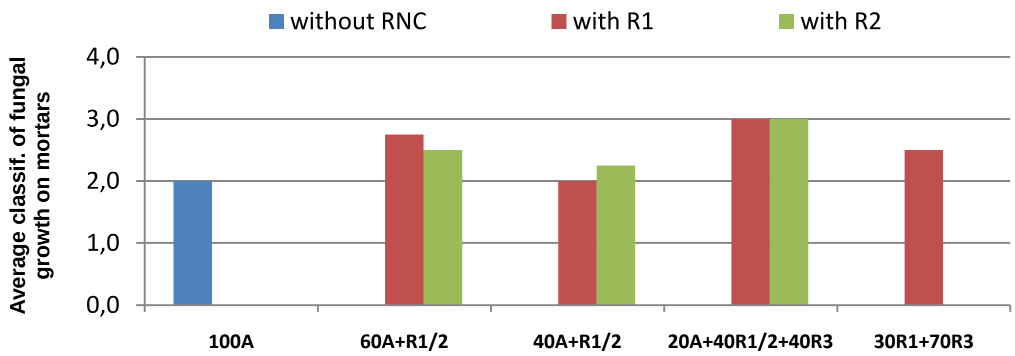


Figure 3.14 – Average classif. of fungal growth on hydraulic lime and cement mortars (CH+C)

In hydraulic lime mortars, with the use of REC there is no clear trend. With the replacement rate of 40%, the growth of fungi at the end of four weeks is similar to control mortar. The same is not repeated with the substitution of 60%, where growth is higher, reaching the maximum level (level 4) according to the classification standard used.

In hydraulic lime and cement mortars, it is seen that the level of fungal growth at the end of four weeks remains to replacement rates of 40%, 60% and 100%. For the replacement rate of 80%, the mortars have higher fungal growth than the control mortars.

3.8 Thermal conductivity

The thermal conductivity test was performed according to EN 12664 (2001) and summary results are presented in Table 3.1.

Table 3.1 – Thermal conductivity of mortars with REC and other construction materials

Materials	Density [kg/m3]	λ [W/m.ºC]
Hydraulic lime mortars (*)	1600	0,800
CH 40A+R1	1195	0,292
CH 40A+R2	1151	0,284
CH+C 40A+R1	1238	0,444
CH+C 40A+R2	1199	0,357
CH+C 20A+40R1+40R3	919	0,221
CH+C 20A+40R2+40R3	846	0,198
CH+C 30R1+70R3	581	0,108
Agglomerate of expanded cork (*)	90 - 140	0,045

(*) – reference values (Santos e Matias, 2006)

These results show that the mortars with REC have a thermal conductivity with low values. It is also concluded that the use of R2 compared with R1, enables better thermal performance.

Finally, the analysis of the values of thermal conductivity shows that the mortars have produced a behavior much more satisfactory than conventional mortars.

4 Conclusions

This study aimed to examine the potential benefits of the use of mortars with REC when compared to traditional mortars, also studying the potential problems of using this type of material. Thus, the following conclusions can be highlighted:

- The mortars with REC have a lower strength, although the minimum requirements are met;
- The layer of plaster with REC is a good support for finishing with paint;
- The use of REC in mortar facilitates the long term absorption of water. However, the mortars with thicker REC particles absorbs water at a rate lower than the sand, while with the thin REC particles absorbs water at a higher speed;
- The existence of REC in the mortars did not cause (necessarily) a worse behavior of these mortars in a situation of colonization by fungi;
- The mortars with REC have a very satisfactory thermal performance. This characteristic can enhance the durability of these materials, as the occurrence of surface condensation can be reduced.

5 References

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