INSTITUTO SUPERIOR TÉCNICO
Universidade Técnica de Lisboa

FACTORY MADE MORTARS FOR OLD BUILDING RENDERS

Francisco Adriano Correia Moreira Gomes

Extended Abstract

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Abstract

The solutions of factory made rendering mortars for replacement of old building renders have been increasing during the last decade. These industrial products offer some advantages that the traditional ones do not, such as: less needs of specialization for the workers; technical assistance by the manufacture; cleaner construction site; certified quality; less waste, etc. However, due to industrial secrecy, the manufactures tendency is to hide some *know-how* information much useful as concerns the composition of the products, their mechanical and physical characteristics and general performance.

In order to improve the knowledge about these products, a survey was carried out in the Portuguese market to identify and characterize, with every information provided, an amount of products specifically made to replace old building renders. It permitted to notice that the solutions offered in the market are in much less number than the ones for current buildings and offer some plurality between them. It is possible to affirm that the hydraulic lime is the main binder but there is also combination of aerial lime with hydraulic lime, cement with aerial lime, or just hydraulic lime. There is also reference to the use of water retaining, hydrofuge and air-entraining agents, synthetic fibers, light-weight aggregates and normal ones with different dimensions and nature, variable quantities of water, as well as mechanical and physical characteristics and use of primer products to improve adhesion, regularization and resistance to salt effect.

After the survey and characterization of products on the basis of the information provided by the manufactures, an experimental campaign was organized in order to characterize four products in dry, fresh and hardened states. It was possible to clearly distinguish the mortars, but also reunite some similarities and suggestions concerning the presence of certain components (as admixtures or light-weight aggregates), information that is much useful to reveal about the general performance of these products. Comparisons were also made, between the results of the experimental campaign and the ones provided by the manufactures and bibliography, in order to evaluate the suitability of these products as replacement mortars for old building renders. It was possible to conclude that some of the studied products have very similar characteristics, and that others have divergent ones.

Key-words:

factory made mortars; replacement mortars; characterization of mortars ;old building renders; aerial lime; hydraulic lime.

1. Introduction

Prior to the introduction of cement, the binder used in mortars for plasters was almost invariably lime [1][2]. Lime mortar offers many advantages over modern cementitious alternatives. Lime mortars are generally less hard and more porous than cement-based mortars; this allows moisture to evaporate through the mortar rather than through the bricks or stones of a building. This prevents a build-up of moisture levels in the wall, which in turn prevents the build-up of harmful soluble salts in the masonry. However, different times and construction places mean different knowledge, methods and constructive materials, so that after the introduction of cement, the practices associated to lime plasterwork were lost through time, while buildings were getting older without appropriate conservation, maintenance or rehabilitation.

Nowadays, any activity of conservation, repair or replacement requires a certain amount of patience, care and appropriate knowledge. As major guidelines to consider: reduce interventions to the minimum; adapt the new to the old; use of compatible materials and techniques; preserve the most and promote reversibility. It is expected for a replacing mortar to protect the walls, not to damage the building visual aspect, be durable and contribute to set durability of the masonry. [3]

One option, is the use of pre-batched products, which have been increasing in Portugal since the beginning of the present decade. In spite of the major offer of these kind of mortars for current buildings, there are already many solutions for rehabilitation purposes. The present extended abstract is focused on products for replacement of old building renders. A survey was carried out in the Portuguese construction materials market with the objective of identifying and characterizing, with all information provided by the manufactures, the solutions specifically conceived for the referred purpose, and then include four of them in a experimental campaign for posterior detailed characterization.

2. Market survey

Twenty three manufactures were contacted, but just nine of them commercialize factory made mortars specifically for replacement of old building renders. Many of them have a recommended primer associated, however the present extended abstract will focus on the main mortars and its possible characterization by the information provided by the manufactures, presented on Technical Sheets or obtained orally.

2.1. General information

The manufactures, the factory made mortars and some of its components and characteristics are presented in the Table 1.

Table 1 - Identified factory made mortars and some of its components and characteristics, information provided by manufactures.

Manufacture	Product	Binder(s)	Admixtures (agents)	Fibers	Aggregate Nature and granulometry	Recommended primer	Type (EN 998-1)	Working principle ([4][5][6], refered by [7])	Water (liters per bag)
BASF	Albaria SP2 (System)	AL, HL and CM	-	-	-	-	R	Salt-accumulating	many diversity
	Albaria Intonaco	HL	-	yes	silica - <2 mm	semi-fluid layer	GP	-	4,5 – 5
Ciarga	ACH	HL	Water retainer*, hydrofuge and air-entrainer*	no	Calcareous* - <1,2 mm*	AE (pre-dosed mortar)	GP	Salt-transporting*	4
Kerakoll	Sanabuild	HL*	-	no*	silica - <2,5 mm	Sanabuild Fondo (impregnant)	R	Salt-transporting*	5,5
Lena	Lena 822	AL and HL	Water retainer*, hydrofuge* and air-entrainer*	no	calcareous and silica - <1,2 mm	Lena 870 (acrylic resin)	R	Salt-transporting*	6,5 – 7
Mapei	Mape-Antique MC	HL	-	yes	<2,4 mm	Mape-Antique Rinzaffo (pre-dosed mortar)	R	-	3,5 - 4
Maxit	Maxit 158	HL		-	<2,5 mm	Not specified	R	Salt-transporting*	5
Secil-Martingança	Reabilita RBA01	AL* and HL*	admixtures to improve workability*	no	calcareous and silica - <3 mm*	-	GP	Salt-transporting*	4,1
Weber	Weber.dry Sane	AL* and CM*	-	-	calcareous and silica	Weber.dry Sane + Ibofon	R	Salt-accumulating	6 – 6,5
	Weber.rev Tradition	AL* and CM*	-	yes	calcareous and silica* - <2 mm	Weber.rev Tradition + Ibofon	R	Salt-transporting*	6 – 7
Tradibau	Medolago	AL* and HL	-	no*	calcareous - <3 mm	Rinzaffo Consolidante Antisale (pre-dosed mortar)	GP	Salt-blocking*	5*

AL: aerial lime; HL: hydraulic lime; CM: cement; R: Renovation mortar; GP: general purpose mortar
* Information obtained orally or via email with the manufacture.

The studied mortars include essentially hydraulic lime in their composition, as expected. However, despite this dominant binder, there are also some products of mixed binders: aerial lime with hydraulic lime and aerial lime with cement.

Like expected, the information about admixtures is not much. There is a tendency for industrial secrecy and to omit the most vital aspects of the product's composition. It is believed that almost every factory made mortar presented in the Table 1 has its own admixtures, however, some manufactures provided information about these components. As informed by these manufactures, water retaining agents are supposed to reduce retraction phenomena, hydrofuge agents to reduce the water permeability in liquid state and air-entraining ones to promote workability in fresh state. In order to perform a better control of the retraction phenomena, some products have also fibers. As concerns the aggregate's nature, it is possible to find calcareous or silicious aggregates, or both in the same product, with particle size under 2 - 3 mm.

The only product that requires application of more than one mortar is Albaria SP2, because it is the most complex system identified, specifically designed to act as a salt-accumulating solution.

The other products, the working principle is not by salt-accumulating (except for Weber.dry Sane), but essentially by salt-transporting (water and vapor permeability) and salt-blocking (water impermeability, but vapor permeability). Almost every product has its primer* product recommended to improve adhesion, regularization and resistance to salt effect (there is also recommendation of finishing products). To refer that the application of this primers may improve different working principles to water and salts, e.g., it is possible that one primer (more resistant, with minor water permeability) may turn a salt-transporting product (main product) into a salt-blocking one (primer and main product). However, the present extended abstract is focused on the main factory made mortars.

Also to notice that the classification, according to EN 998-1:2003 and to the properties and/or use, is variable. There are many products, designed for replacement of old building renders, classified type GP (general purpose), while others are type R (renovation).

The mixing quantity of water varies from product to product. It depends much on the type of binder(s) used and other constituents. The number, maximum and minimum thickness of the layers are also variable (not presented at this extended abstract). Some products, like Reabilita RBA01, Lena 822 and ACH, have also recommended the use of nets to improve its resistance to cracking, at certain circumstances.

2.2. *Mechanical and Physical Characterization*

The main mechanical and physical characteristics identified are presented in Table 2. It is important to notice that sometimes the information provided by the manufactures refers only to the minimum requirements presented at EN 998-1, especially to products considered type R (renovation).

Table 2 – Main Mechanical and Physical characteristics identified.

Manufacture	Product	Mechanical Characteristics				Physical Characteristics				
		Rc [MPa]	Rt [MPa]	Adhesion [MPa] and Fracture Pattern	Elastic Module [MPa]	Bulk density fresh state [Kg/m^3]	Bulk density hardened state [Kg/m^3]	Consistence [%] Fresh state	μ	Capillarity coefficient [Kg/m^2.min^{0,5}]
BASF	Albaria SP2 (System)	from 2,3 to 3,4	-	from 0,1 to 0,3 (A)	-	-	-	-	from 8 to 10	-
	Albaria Intonaco	1,8	-	0,13 (A)	3000	1525	1550	90	10	0,68
Ciarga	ACH	3,5 – 5,0**	2,0**	0,1 (A e B**)	≤ 2500	1650 ± 200	1500 ± 200	55 - 65	< 15	< 0,40
Kerakoll	Sanabuild	≥ 2,5	-	≥ 0,2 (B)	-	1240**	1120	70	< 7	-
Lena	Lena 822	1,5 – 3,5**	≥ 0,2**	0,2 (A)	-	1590	1500	45 - 55**	20**	-
Mapei	Mape-Antique MC	4,0 – 6,0	-	≥ 0,4 (B)	4000 - 6000	1600 - 1800	-	80 - 100	10 - 15	-
Maxit	Maxit 158	≥ 1,5	0,5**	≥ 0,05 (B)	-	1900 ± 150	1550 ± 200	50 – 80	≤ 15	< 0,7
Secil-Martingança	Reabilita RBA01	1,5 – 5,0	-	-	-	-	1400 - 1700	-	≤ 15	-
Weber	Weber.dry Sane	3,0**	2,0**	≥ 0,3 (B)	5500	1400	-	-	≤ 15	<0,05**
	Weber.rev Tradition	2,0**	1,0**	0,2 (B)	≤ 5000	1350	1180	-	10	< 0,1**
Tradibau	Medolago	1,83	1,3	0,3 (B)	2283	-	1550 - 1750	-	< 20	-

Rc – Compressive resistance ; Rt – Flexural resistance ; A – Adhesion fracture ; B – Cohesion fracture ; μ - Water vapour permeability coefficient

* It is possible to notice that primers can be pre-dosed mortars, impregnant products, resins or just semi-fluid layers of the main mortar.
** Information obtained orally or via email with the manufacture.

As concerns the mechanical characteristics, there is tendency for these products to fit in values of compressive resistance between 1.5 and 5.0 MPa. Mape-Antique MC appears to have the highest compressive resistance, as well as elastic module.

There were identified less values of flexural resistance, but they seem to fit between 0,5 and 2,0 MPa. It was also possible to notice that many values of adhesion tension vary between 0,1 and 0,3 MPa, however some products, like Weber.dry Sane and Mape Antique MC, indicate values superior to 0,3 and 0,4 MPa, respectively. The fracture patterns are mostly by cohesion (fracture in the mortar itself), but there is also some cases of adhesion fracture (at the interface between mortar and substrate).

Albaria Intonaco and Tradibau appear to be two of the low mechanical resistance mortars. These products may have less capability to resist (mechanically) to degradation agents than the more resistant ones, but they present values of elastic module much favorable to improve its capability for absorbing deformation (very important issue on mortars to substitute old building plasters) of old masonry.

As concerns the identified information regarding the physical characteristics, and, specifically, the bulk densities at fresh and hardened states, makes sense to refer the mortar Weber.rev Tradition and Sanabuild. These products have, in fact, small values of bulk densities compared with all the other mortars, suggesting, possibly, the use of lightweight aggregates. Its high price (not listened in the presented abstract) suggests the same hypothesis.

There are not many identified values of consistence at fresh state, but they suggest that the minimum values relate to Lena 822 and maximum to Mape-Antique MC and Albaria Intonaco, which appears to be the more fluid products.

The water vapour permeability, quantified by the coefficient "μ", is the most revealed physical characteristic by manufacturers. According to EN 1015-19, the smaller this value, the higher the permeability to water vapour. As regards this coefficient, many manufactures only refer to the minimum requirements presented at EN 998-1 ($\mu<15$). However, products such as Weber.rev Tradition, Albaria Intonaco, Albaria SP2, Mape-Antique MC and Lena 822, present more objective information. To refer that Sanabuild has a maximum value of $\mu = 7$, which may reveal a very favorable permeability to water vapor.

As concerns the identified capillarity coefficient values, the major discrepancy is between Weber products and the other ones. Weber.dry Sane and Weber.rev Tradition present the lowest values of this coefficient, especially the first one. The differences may be related to the use of different hydrofuge admixtures (and different doses), as well as to the porous structure of these mortars.

3. *Experimental Campaign*

3.1. *General aspects*

The developed experimental campaign was carried out at the Construction Laboratory of Civil Engineering Department, Instituto Superior Técnico, in order to study four mortars for replacement of old building renders, selected at the market survey.

A summary of the products main characteristics is presented in Table 3.

Table 3 - Summary of some characteristics of the selected pre-dosed mortars.

Mortar	Type (EN 998-1)	Binder(s)	Admixtures	Fibers	Water * [l/kg$_{dry.mortar}$]$_{Average}$	Consistence [%]	Granulometry [mm]	Rc; Rt [Mpa]	Capillarity coefficient [Kg/m^2.min^{0,5}]	Bulk density [Kg/m^3]
Arg.A	GP	HL	Water retainer, hydrofuge and air-entrainer	No	0,16	55 - 65	<1,2	3,5 – 5,0 ; 2,0	< 0,40	F.S: 1650 ± 200 H.S: 1500 ± 200
Arg.B	GP	AL e HL	-	No	0,14	-	<3,0	1,5 – 5,0 ; -	-	F.S: - H.S: 1400 - 1700
Arg.C	R	AL e HL	Water retainer, hydrofuge and air-entrainer	No	0,23	45 - 55	<1,2	1,5 – 3,5 ; ≥ 0,2	-	F.S: 1590 H.S: 1500
Arg.D	R	AL e CM	.	Yes	0,22	-	<2,0	2,0 ; 1,0	< 0,1	F.S: 1350 H.S: 1180

AL: aerial lime ; HL: hydraulic lime ; CM: cement ; R: Renovation mortar ; GP: general purpose mortar ; F.S: fresh state ; H.S: hardened state ; Rc – Compressive resistance ; Rt – Flexural resistance
*Average quantity of water per kilogram of dry product, used on production of mortars.

Several samples were prepared for characterization at fresh state and molding the test specimens. Two kinds of test specimens were prepared: prismatic ones (16x4x4 mm, produced based at EN 1015-2) and mortar applied as coat layers of ceramic bricks (2 cm). All test specimens cured during 28 days.

All specimens were subjected to cure at laboratory environment (not dry or saturated cure).

3.2. *Performed tests*

The characterization of the dry products was performed by the: determination of particle size distribution, sieve analysis (based on EN 1015-1); determination of apparent density of the dry mixture of product (based on NP EN 1097-3). Through the results obtained with determination of particle size distribution, it was possible to separate what is, by definition, binder(s) and filler from other constituents, through the material retained and passed the sieve of 63 µm.

The fresh state was characterized by the: determination of consistence, flow table (based on EN 1015-3); determination of water retentivity (based on EN 1015-8); determination of bulk density (based on EN 1015-6).

The tests performed at hardened state can be divided in two groups: mechanical characterization tests and physical characterization tests. All the tests were performed for all four mortars and for 28 days of cure.

The mechanical characterization tests performed were the following: determination of flexural and compressive resistance/strength (respectively, over 5 specimens and 6 half-specimens, and both based on EN 1015-11); determination of ultra-sound velocity (over 5 specimens and one "brick"); determination of superficial hardness (over one "brick").

The physical characterization tests performed were the following: evaluation of the drying kinetic (over 2 half-specimens, based on RILEM Test No. II.5); determination of the porosity accessible to water and bulk and real densities (over 2 half-specimens and, respectively, based on RILEM Test No.I.1 e Test No.I.2); evaluation of the carbonated thickness (that will not be discussed at the present extended abstract, due to inconclusive results); determination of the water capillarity absorption (over 1 specimen, based on an adaptation of EN 1015-18); determination of water content at 48 hours (over 1 specimen, based on RILEM Test No.II.1); determination of water absorption under low pressure (over 1 "brick", based on RILEM Test No. II.4).

3.3. Test results

3.3.1. Characterization at dry state

The particle size distribution curve of dry products is represented in Fig. 1, and the predictable particle size distribution of their aggregates (as well as the yellow and fine sand) is presented in Fig. 2.

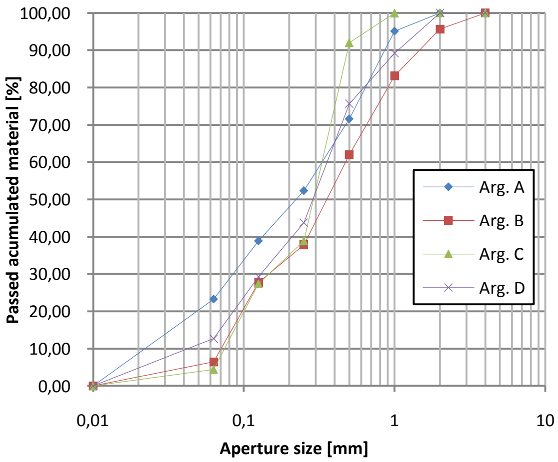


Fig. 1 - Particle size distribution curve of the products.

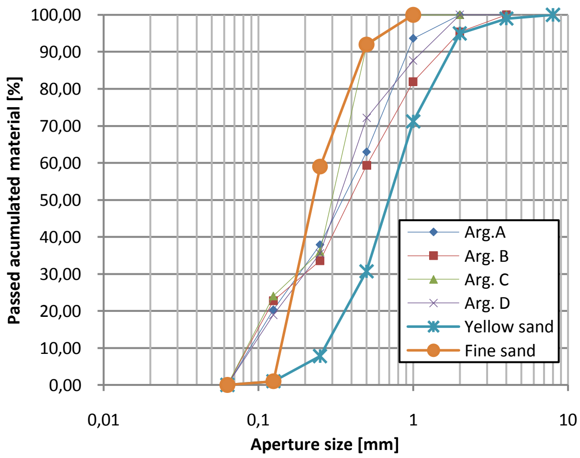


Fig. 2 - Predictable particle size distribution curve of the aggregates, yellow sand and fine sand.

Through the analysis of Fig. 1, it is possible to conclude that Arg.B is the product that has the coarser granulometry and Arg.A detains the highest percentage of fine particles.

Arg.A and Arg.D have very similar curves and can be distinguished mainly due to the higher percentage of fine elements from 0 to 0,4 mm present in Arg.A.

As concerns Arg.C and Arg.B, particle sizes are almost identical from 0 to 0.25 mm, clearly distinguishing above the 0.25 mm, since that, in this range of dimensions, Arg.C is the product that presents the highest values of passed material.

The analysis of the Fig. 2 permits to verify that all the products are composed of aggregates with similar dimensions between 0 and 0.25 mm. Arg.A e Arg.D seems to have intermediate dimensions between Arg.B and Arg.C, and much similar each other.

Fig. 2 includes also the particle size distribution curve of yellow and fine sand, two aggregates frequently used on the production of traditional mortars for renders. The four products studied present intermediate granulometry of aggregates for dimensions superior than 0,25 mm, when compared to the two referred sands.

The maximal dimensions of the aggregates may be in the range between 0,5 and 2,0 mm, in general, compatible with the values obtained from the manufactures.

Fig. 3 presents the mean values of the apparent density of the products, which are variable. However, between Arg.A, Arg.B and Arg.C the difference is not much, since all three fit on the range between 1400 Kg/m^3 e 1500 Kg/m^3. Arg.D presents a clearly inferior apparent density, lower than 1300 Kg/m^3, possible due to the presence of lightweight aggregates in this product, as said before at 2.2.

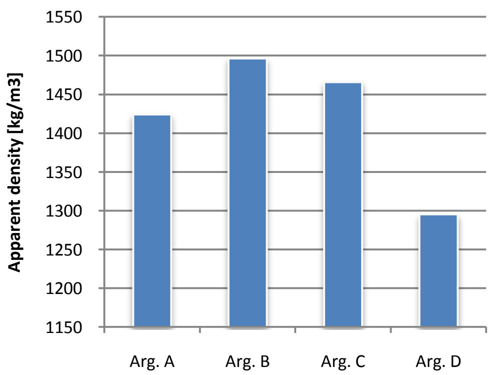


Fig. 3 - Apparent density.

3.3.2. Characterization at fresh state

Table 4 presents the characterization of the products at fresh state performed.

Table 4 - Fresh mortar tests results.

Mortar	Water $[L/Kg_{dry.mortar}]_{Average}$	Flow value [mm]		Water retentivity [%]	Bulk density [Kg/m3]	
		Mean value	Manufacture		Mean value	Manufacture
Arg.A	0,16	130,3	160 ± 5	100,0	1890	1650 ± 200
Arg.B	0,14	151,9	-	98,7	1840	-
Arg.C	0,23	178,2	150 ± 5	99,0	1610	1590
Arg.D	0,22	161,1	-	98,9	1380	1350

The analysis of the flow values shows that the use of water dosage recommended by the manufacturers originates mortars with very different consistencies, with values between 30 and 80%. Arg.C was the most fluid mortar and Arg.A the driest one. However, these two provided different values, when compared to their manufactures. In a intermediate level, appears Arg. B and Arg.D. There is not a good relationship between the obtained flow values and the quantity of water used, Fig. 4. A better, but not too good, relationship is obtained between the flow value and the percentage of fine elements, Fig. 5. The highest flow value was obtained by Arg.C that presents the lowest percentage in fine elements. On the other way, Arg.A, which has more percentage of fine elements, presented the lowest flow value.

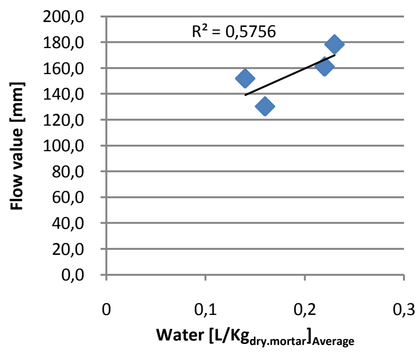


Fig. 4 - Relationship between flow value and quantity of water.

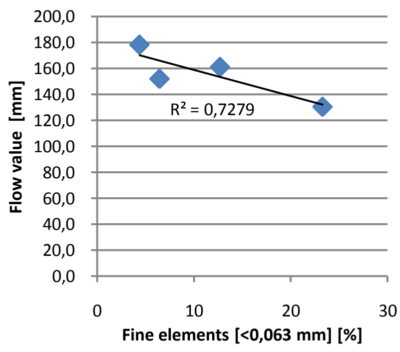


Fig. 5 - Relationship between flow value and fine elements.

As concerns the water retentivity, the results were good, with all values higher than 98%, possibly due to the presence of water retainer admixtures.

Once again, the characterization of the bulk density revealed the lowest value for Arg.D, lower than 1400 Kg/m^3, and Arg.A and Arg.B with very similar results, higher than 1800 Kg/m^3. Arg.C presents an intermediate bulk density. The difference of the bulk density determined on the dry and fresh states for Arg.C, Arg.A and Arg.B, suggest the possible presence of air entraining admixtures in Arg.C (the presence of this kind of admixture was confirmed by the manufacture, as indicated in Table 3).

3.3.3. Characterization at hardened state

Mechanical characterization

The mechanical characteristics of the tested products are presented in Table 5.

Table 5 - Mechanical tests results.

Mortar	Water [L/Kg$_{dry.mortar}$]$_{Average}$	Fine elements [%]	Compression [MPa]		Flexural [MPa]		Ductility	Ultrasounds velocity [m/s]			Rebound	
								Direct test		Indirect test		
			Mean value	Standard deviation	Mean value	Standard deviation		Mean value	Standard deviation		Mean value	Standard deviation
Arg.A	0,16	23,28	5,26	0,15	1,48	0,12	0,28	2570	44	2710	60,1	6,6
Arg.B	0,14	6,46	5,58	0,08	1,66	0,18	0,3	2480	68	2920	54,7	3,3
Arg.C	0,23	4,39	1,28	0,05	0,61	0,03	0,48	1340	33	2380	33,2	4,1
Arg.D	0,22	12,7	1,87	0,2	0,8	0,07	0,42	1600	62	1524	45,1	2,1

The compression, flexural and ultrasounds results reveal characteristics that justify the division of the tested mortars in two main groups: group 1 (Arg.A and Arg.B) and group 2 (Arg.C and Arg.D). The group 1 showed not only the highest values on all mechanical tests, but also a great similarity between Arg.A and Arg.B. Their compressive resistance varies from 5,3 to 5,6 MPa (CSIII), while for those in group 2 these values were lower, varying from 1,3 to 1,9 MPa. Arg.D satisfies the requirement (CSII) for its classification as renovation mortar (EN 998-1), but Arg.C revealed a resistance slightly lower (CSI) to be classified as well. Group 2 mortars showed to have more capability for plastic deformation than the group 1 (especially Arg.C), suggested by its higher ductility, which ends up to be an advantage.

There is an high correlation between compressive resistance and the water ratio used to produce the mortars, Fig. 6. The more resistant ones (Arg.A and Arg.B) were produced with lower water ratios. The analysis of Fig. 7 shows also a great correlation between compressive resistance and ultrasound velocity: the stronger the material, the higher its ultrasound velocity.

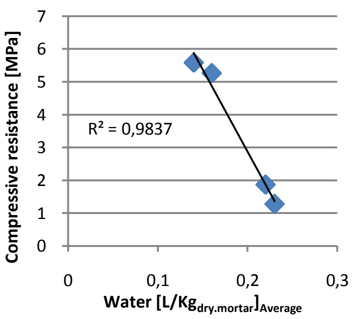


Fig. 6 - Relationship between compressive resistance (28 days) and water ratio.

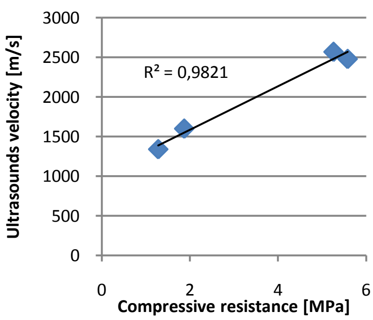


Fig. 7 - Relationship between compressive resistance and ultrasounds velocity (direct test), 28 days.

The results obtained through the indirect test of ultrasounds velocity revealed that its correlation with the direct test ones is, in general, satisfactory, Fig. 8. However, seems that the values of Arg.C did not provide the same correlation as the others. This product provided higher values at the indirect test than the ones obtained at the direct test.

As concerns the superficial strength, it was possible to obtain a good correlation between rebound values and compressive resistance ones, Fig. 9.

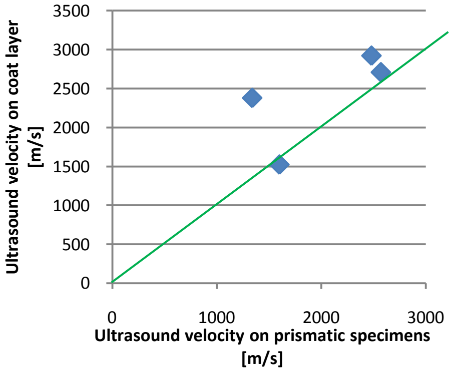


Fig. 8 - Relationship between direct and indirect ultrasounds velocity tests, 28 days.

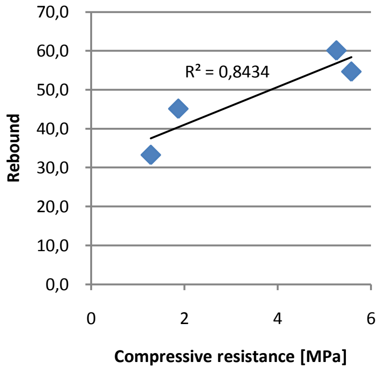


Fig. 9 - Relationship between compressive resistance and superficial strength, 28 days.

All the results of compression and flexural resistance obtained in the aim of the present research did not differ much from the values presented by the manufactures.

Physical characterization

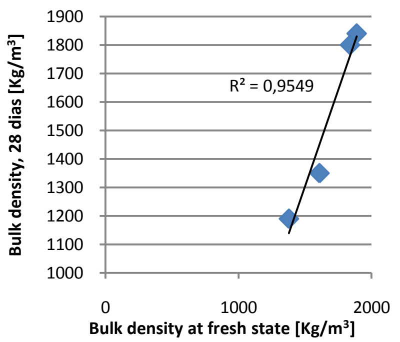
Table 6 presents the mean values and standard deviation of the density, porosity and water content

Table 6 - Bulk and real density, porosity and water content tests results.

Mortar	Bulk density [Kg/m3]		Real density [Kg/m3]		Porosity acessible to water (%)		Water content [%]
	Mean Value	Standard deviation	Mean Value	Standard deviation	Mean Value	Standard deviation	Valor
Arg.A	1840	11	2261	42	18,4	1,0	9,29
Arg.B	1800	9	2169	4	16,9	0,6	8,78
Arg.C	1350	6	1920	2	29,4	0,2	19,89
Arg.D	1190	31	1566	35	23,8	0,3	13,02

Analyzing the Table 6 is possible to verify that Arg.A and Arg.B have very similar characteristics. They present the highest values of both determined densities, as well as the lowest results of porosity and water content after 48 hours of immersion. On the other side, Arg.D appears again with the lowest values of density, which reinforce the hypothesis of having lightweight aggregates in its constitution, and intermediate values of porosity and water content. Arg.C seems to be the most porous product, considering that it presented the highest value of porosity and water content.

It was obtained good correlations between the values of bulk and real densities at hardened state with bulk density at fresh state, respectively, Fig. 10 and Fig. 11.



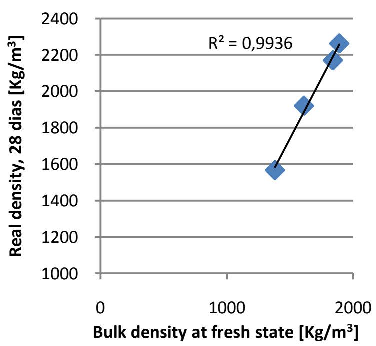


Fig. 10 - Relationship between bulk density (28 days) and bulk density at fresh state.

Fig. 11 - Relationship between real density (28 days) and bulk density at fresh state.

Good correlations between physical and mechanical characteristics were established, e.g., between compression resistance and porosity of the material, as shown in Fig. 12. There is also a very perceptive influence of the quantity of water, used to produce the mortar, and the mortar porosity, Fig. 13, which turns up to influence also its absorption capability at immersion conditions, Fig. 14.

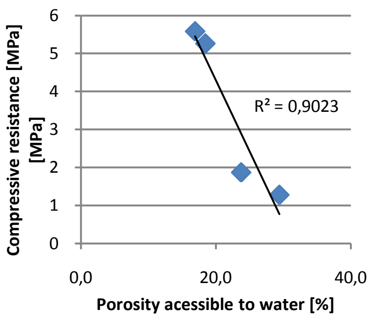


Fig. 12 - Relationship between compressive resistance and porosity, 28 days.

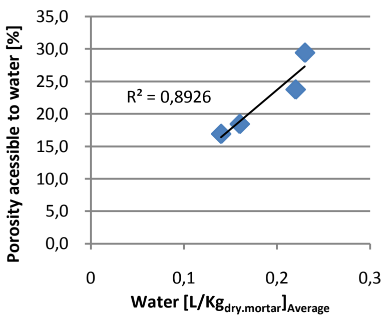


Fig. 13 - Relationship between porosity (28 days) and quantity of water.

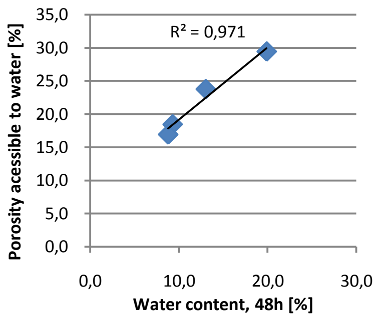


Fig. 14 - Relationship between porosity and water content at 48h (28 days).

According to Fig. 15 and Fig. 16 and Table 7, Arg.D was the mortar that revealed less water absorption, lowest coefficient of water absorption by capillarity (and asymptotic value), and lowest capacity of water absorption under low pressure. These results points the possible presence of a water repellent product (hydrofuge admixture).

Arg.A and Arg.B revealed very similar characteristics of water absorption. These products presented higher capability to absorb water than Arg.D, but lower when compared with Arg.C. This last product reveals to be the most absorbent material studied. Indeed, Arg.C absorbs more quantity of water, by capillarity, maintaining its initial rate of absorption (its capillary coefficient, Table 7), similar to Arg.A and Arg.B, for much more time than the other products, Fig. 15. It is also possible to notice that Arg.C absorbs water under low pressure much faster, Fig. 16.

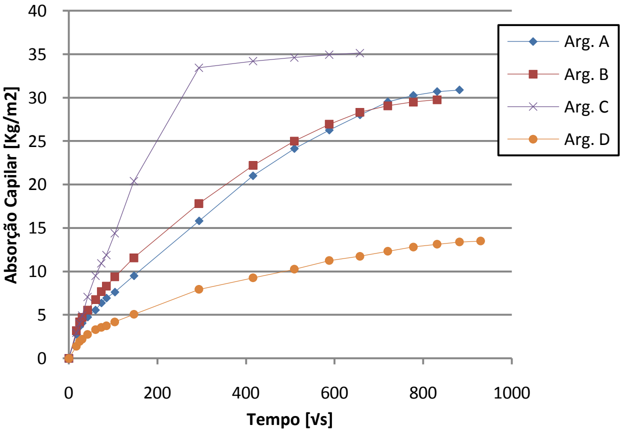


Fig. 15 - Capillary absorption.

Table 7 - Capillary coefficient and asymptotic values.

Mortar	Age	C.C. [Kg/m^2.s^{0,5}]	A.V. [Kg/m^2]
Arg.A	28	0,16	31
Arg.B	28	0,18	30
Arg.C	28	0,17	35
	60	0,17	34
Arg.D	28	0,08	14
	60	0,08	11

C.C. – Capillary coefficient
A.V. – Asymptotic value

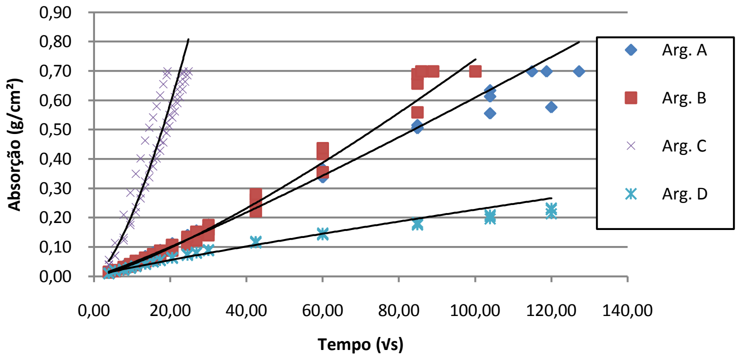


Fig. 16 - Absorption under low pressure.

According to Fig. 17, it is possible to understand that, in general, there are not significant differences related to the drying kinetics of these four products. All mortars have almost stabilized its mass after 30 days and present a good drying behavior, even with the probable presence of hydrofuge admixtures. However, Arg.C and Arg.D reveal capability for a faster drying rate and are able to dry more completely than the others.

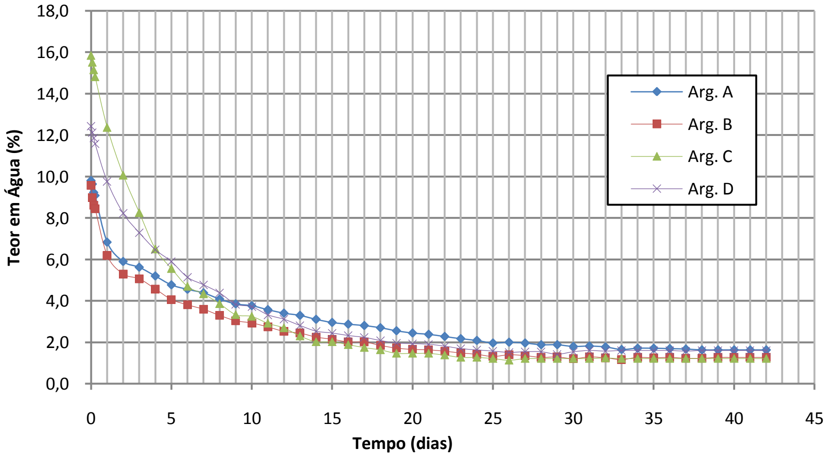


Fig. 17 - Evaporation curve.

4. Conclusions

The present study is intended to be a contribute to improve the knowledge about factory made mortars, specifically designed for replacing old building renders. First, a market survey was carried out on the Portuguese market, with the objective to identify and characterize, a number of specific products for the referred purpose. It was possible to compile a reasonable number of products, made by several known manufactures, and characterize them with the information presented at the technical sheets and/or obtained orally or via email, through contact with the manufactures.

Many characteristics presented at the technical sheets just refer to the minimum requirements of EN 998-1, which is the standard for CE declaration of conformity of rendering and plastering mortars, obligatory for all these products. The survey and identification of eleven products, as well as its main characteristics, permitted to notice that there is a plurality of solutions. There are products with different binders, aggregates, admixtures, compositions, mechanical and physical characteristics, classifications, performances, prices, working principles, application methods, etc.

In order to study some of these products, four of them were selected to be part of an experimental campaign. The study pointed many differences between them, but also some similarities. Arg.A and Arg.B, both GP mortars, revealed very similar mechanical and physical properties. They are the most resistant, rigid, and compact mortars. These products revealed intermediate capacity of water absorption, lower than Arg.C but higher than Arg.D.

Arg.C (renovation mortar) revealed the lowest mechanical resistance, the highest porosity and highest capacity of water absorption, with many similar characteristics to lime mortars. Arg.D presents intermediate mechanical characteristics, but the results have shown more similarities to Arg.C than to Arg.A or Arg.B. The lower values of bulk and real densities indicate that this product might use lightweight aggregates. Its lower capability for water absorption, when compared with the other products, points to the presence of an efficient hydrofuge admixture, however its drying kinetic shows to be much similar to the other mortars. In fact, all products provided very acceptable drying kinetics. Arg.C and Arg.D may also have good capability for absorbing plastic deformations.

The study allowed also the establishment of several correlations between the assessed properties in dry, fresh and hardened states.

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