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Physical, mineralogical and mechanical characterization of ready-mixed clay plaster

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Abstract

The use of clay plasters with or without plant fibers (straw, hemp or other) inside buildings is currently showing considerable growth in many countries. Despite this development, there are very few data in the literature on the characteristics of clay plasters. This paper deals with the characterization of five ready-mixed clay plasters from French brickworks using the recent German standard. The work essentially consisted in measuring the flow of fresh clay plasters and their characteristics after hardening (shrinkage, and compressive, flexural and adhesive strength). The characterization of the samples showed that the granular characteristics were practically the same and that the main difference concerned the nature of the clayey minerals they contained: four samples were essentially composed of montmorillonite, chlorite and illite whereas one was only composed of kaolinite. Despite this difference, the flow of fresh clay plasters and their characteristics after hardening (shrinkage, compressive and flexural strength) were very similar and were comparable to the values given by the standard. However, the measurement of the adhesive strength led to two significant problems: the dispersion of the values was very high and the results were markedly different from the values given by the standard. For these reasons, it seems necessary to complete and adapt the procedure for measuring adhesive strength and it could be interesting to develop new tests for the measurement of this important characteristic, either in the laboratory or on building sites.

Keywords

Clay plasters, characterization, earthen construction, standardization, testing method.

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1. Introduction

There is an increasing demand for earthen ecological construction in countries with advanced economies today, especially in European countries like Germany, Italy, France and Great Britain. There are several reasons for this new attraction of earthen building materials in industrialized countries but the most important are certainly the low impact of the materials on the environment and their capacity to regulate the hydrothermal conditions of the indoor climate. Earthen building materials can be used in essentially two different forms: as earthen walls (mainly masonry of earth blocks, rammed earth walls or cob wall) or as clay plasters [1, 2]. The use of clay plasters with or without plant fibers (straw, hemp or other) inside buildings is growing considerably in many countries. This use of earth, often linked with aesthetic considerations, cumulates several advantages: the earth can play its role of humidity controller [3-5] and the clay plasters can be applied to most types of supports for renovation or in the construction of new buildings. However, the development of this new market requires a better framework for the characterization of clay plasters. In Europe, there is no standard for this, except in Germany where a standard has existed for the characterization of ready-mixed clay plaster since August 2013 (DIN 18947) [6]. This standard is strongly based on the standards for conventional plasters (cement or lime-based plasters) (EN 1015 - 1 to 15 series) but some adaptations have been made to take the specificity of earth into account. Furthermore, there are very few references dealing with the characterization of clay plaster in international scientific journals [7-9, 3-5], which shows the need for scientific experiments and publications on this type of material.

This paper reports the characterization of five ready-mixed clay plasters from brickworks in the neighborhood of Toulouse, France. First, the physical and mineralogical characteristics of the five mixtures were studied. Then, the properties of fresh and hardened clay plasters were measured using the procedures proposed in the German standard. This essentially consisted in measuring the flow of fresh clay plasters and their characteristics after hardening (shrinkage, and compressive, flexural and adhesive strength).

2. Materials and methods

2.1 Materials

The five ready-mixed clay plasters under study came from brickworks in the neighborhood of Toulouse in southern France (Fig.1).

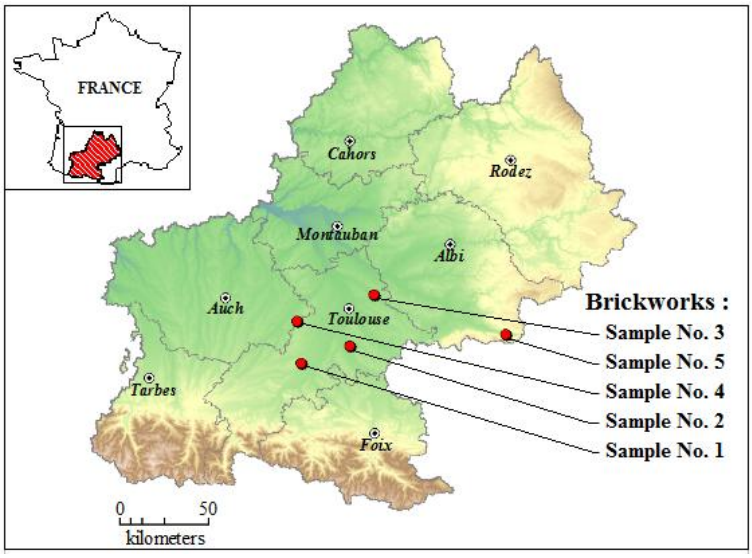

Figure 1: Locations of the various clay pits that provided the samples

These brickworks produce both fired bricks and unfired clay bricks with different compositions, especially regarding the proportions of clay and sand in the mixtures. In response to increasing demand from their customers, some of them propose ready-mixed clay plasters based on a mix of the clayey soil from their pit and sand (from their own pit or purchased in certain cases). Depending on the brickworks, the mixtures studied during this work were ready-mixed or composed of clayey soil from the clay pit of the brickworks and a 0/4 mm siliceous river sand coming from another pit near Toulouse (Table 1).

Table 1: Presentation of the clay plasters (percentage of the dry fraction mass)

Sample	Soil (%)	Sand (%)	Color
1	ready-mixed		tan
2	ready-mixed		ochre
3	33	67	ochre
4	29	71	brown
5	29	71	rust (red)

As shown in Fig. 1, all the brickworks were in the same area except for brickworks 5. The clayey soils of pits 1 to 4 had the same overall characteristics. Field studies and geological maps (not presented here) revealed that these soils were almost entirely silty clay with a few layers of marl and sandy lenses. The colors of these four soils were nearly the same. Clayey soil 5 was different from the other four because pit number 5 was on red clay ground.

2.2 Procedures

2.2.1 Physical and mineralogical characterization of raw materials

The size distribution of the mixtures was analyzed using two techniques: the coarser fraction (>80 µm) was analyzed by wet sieving, and the finer fraction by means of pipette analysis according to standard NF P 94-057 (method based on the measurement of the sedimentation time of solid particles in suspension in a solution of water mixed with sodium hexametaphosphate, which acted as a deflocculating agent) [10].

The crystalline phases were identified using a Siemens D5000 powder X-ray diffractometer equipped with a monochromator using a Ka (λ = 1.789 Å) cobalt anticathode. The specific characterization of the clayey minerals was carried out on oriented aggregates using three preparations: air dried or natural, after glycolation, and after heat treatment at 500°C [11].

2.2.2 Fresh plasters

Determination of the consistence of fresh plaster

This test was carried out on fresh plaster using a flow table according to standard EN 1015-3 [12]. The flow value was measured by the mean diameter of a test sample of fresh plaster that had been placed on the flow table disc by means of a truncated conical mold (60 mm in height with internal diameter of 100 mm at the bottom and 70 mm at the top) and given 15 vertical impacts by raising the flow table and allowing it to fall freely through a given height. The standard proposes no specific change in the procedure to take account of the specificity of clay plaster. The German standard proposes fixing the consistence at 17.5 cm if no other information is given by the producer of the ready-mixed clay plaster. The water content of the fresh clay plaster was measured by drying at 50°C. The wet density of the fresh plaster was measured in a cylindrical container (100 ml), the sample being compacted using the same procedure as that used for the preparation of 40 mm x 40 mm x 160 mm prisms.

Preparation of test plasters

This test was carried out according to standard EN 1015-2 [13]. The mixing procedure in this standard is the same as that used for the preparation of cement-based plasters (EN 196-1 [14]). The German standard suggests a modification in the mixing procedure as follows:

- Place the water in the bowl,
- Add the solid over 30 s with the mixer at low speed,
- Switch the mixer to high speed and continue mixing for an additional 30 s,
- Stop the mixer for 5 minutes,
- Restart the mixer and continue mixing at high speed for 30 s.

For the preparation of the test specimens (40 mm x 40 mm x 160 mm prisms) for the measurement of flexural and compressive strength, the German standard suggests following standard EN 1015-11 part 7.2.2 concerning plasters with hydraulic binders and plasters based on lime/cement in which the mass of lime is not greater than 50% of the total weight of binder [15]. The procedure consists in compacting the plasters using a rammer. Because it appeared simpler, the test specimens were prepared according to the standard used for cement-based plasters (EN 196-1 [13]): the plaster was compacted in the mold in two layers using 60 jolts of the jolting apparatus for each layer.

The German standard suggests removing the test specimens from their molds between 2 and 7 days after casting and then keeping them on a paper laid on a grid at 23°C (± 2°C) and 50% relative humidity (RH) (± 5% RH) until their mass is constant (the mass is considered as constant when the difference between two consecutive measurements 24 h apart is less than 0.2%). During our tests, it was not possible to remove the specimens from their molds between 2 and 7 days after casting because the bottom of the specimens was not dry after this time. So, it was decided to remove the metal plate forming the bottom of the molds and to turn the mold over to accelerate the desiccation of the specimens.

2.2.3 Hardened plasters

Linear shrinkage

The linear shrinkage of the clay plasters during their desiccation in the curing conditions (23°C (± 2°C) and 50% RH (± 5% RH)) was measured on three specimens. For this measurement, the plaster prisms were cast in 40*40*160 mm^3 molds equipped with embedded length measurement studs. The linear shrinkage was evaluated in % as the mean of three values based on the initial measurement. This is a slight variation on the procedure proposed in the German standard, where the linear shrinkage is measured using a caliper.

Flexural and compressive strength

The German standard recommends measuring the mechanical strength of hardened clay plaster specimens following standard EN 1015-11 [15] with slight modifications. The flexural strength was measured on three specimens. For each plaster, six specimens for the compressive strength were thus obtained from the test of flexural strength. For both tests, the duration of the test had to be between 30 and 90 s. The samples were cured for at least 14 days and for the last seven days (at least), they were cured at 23°C (± 2°C) and 50% RH (± 5% RH) until their mass became constant (the mass was considered constant when the difference between two consecutive measurements 24 h apart was less than 0.2%). The mechanical tests were carried out using a hydraulic press with a capacity of 10 kN.

Adhesive strength

The German standard recommends measuring the mechanical strength of hardened clay plaster specimens following standard EN 1015-12 [16]. The adhesive strength was determined as the maximum tensile stress applied by a direct load perpendicular to the surface of the plaster on a substrate. The tensile load was applied by means of a defined pull-head plate glued to the test area of the plaster surface. The adhesive strength was obtained as the quotient between the failure load and the testing surface area.

Concrete panels (530 mm × 220 mm) were used as the substrate. The concrete was mixed using a water to binder ratio of 0.49. The aggregates used were conventional siliceous aggregates (a 0/4 mm sand and a 4/12 mm gravel). The concrete panels were older than 28 days when the plaster was applied. The surface of the substrate was brushed with a wet brush for one hour before applying the plaster. As recommended by the standard, placing of the plaster began as soon as the wet top surface was no longer shiny (visual inspection).
The fresh plaster was applied to the substrate with light impulsion and then leveled using a trowel. Circular test areas 50 mm in diameter were cut through the plaster layer using a ring approximately one hour after the application of the fresh plaster. As was the case for 40 mm x 40 mm x 160 mm plaster prisms, the German standard recommended conserving the specimens for 14 days at 23°C (± 2°C) and 50% RH (± 5% RH). At least 24 hours before the test, pull-heads were glued onto the test areas, with the adhesive positioned in the center.

Standard EN 1015-12 recommends using a testing machine that can apply the tensile load perpendicular to the test area through the pull-head plates. The load should be applied smoothly and at a uniform rate and the standard recommends using a rate that leads to failure after 20 s to 60 s. For this study, a specific tensile strength tester was used that respected the recommendations of the standard (Figure 2).

Figure 2: Tensile strength tester used for adhesive strength test

3. Results

3.1 Physical and mineralogical characterization

Table 2 shows the physical and mineralogical characteristics of the five ready-mixed clay plasters. The granular characteristics were very similar, which was not surprising since most of the mixtures used the same sand in comparable proportions (70%). The main difference between these mixtures concerned the nature of the minerals they contained.

Table 2: Physical and mineralogical characteristics of the ready-mixed clay plaster

Sample		1	2	3	4	5
Granular characteristics	Clay (<2 µm) (%)	8	10	6	10	11
	Silt (2-50 µm) (%)	44	44	51	48	49
	Sand (50-2000 µm) (%)	46	40	39	36	35
	Gravel (2-5 mm) (%)	2	6	4	6	5
Mineralogical characteristics	Clay minerals	Montmorillonite Chlorite Illite				Kaolinite
	Other	Albite Orthose Muscovite Calcite Quartz				Goethite Orthose Muscovite Calcite Quartz

The minerals contained in mixtures 1 to 4 were the same, which, again, is not surprising since the samples came from the same geological area. The clay minerals contained in these samples were montmorillonite, chlorite and illite. In addition to these clayey minerals, the materials contained feldspars, calcite ($CaCO_3$) and quartz (SiO_2). Sample 5, which came from a clay pit farther away, was different: the only clay mineral it contained was kaolinite. Moreover, this sample was rich in iron oxides (goethite (FeO(OH)) and micas (muscovite, easily recognizable in the form of flakes). Like the others, sample 5 contained feldspars (only orthose in this case), quartz and a small amount of calcite (less than 2%).

3.2 Characteristics of fresh plasters

The characteristics of fresh plasters having a consistence of 17.5 cm ± 1.5 cm measured using the flow tests are given in Table 3.

Table 3: Characteristics of fresh plasters (3 specimens, mass percentages)

Sample	1	2	3	4	5
Water content (%)	16.8	20.5	20.2	20.0	18.8
Consistence (cm)	18.5	18.25	16.5	17.5	16
Wet density ($g.cm^{-3}$)	2.1	2.0	2.1	2.10	2.1
Dry density ($g.cm^{-3}$)	1.8	1.7	1.7	1.8	1.7

As was the case for the granular characteristics, the characteristics of fresh plasters were comparable for the five samples. The water content necessary to obtain the right consistence for the five mixtures ranged from 16.8% (mixture 1) to 20.5% (mixture 2). It seems that the difference in the nature of the clay minerals did not have a significant effect on these characteristics, certainly because of the low clay mineral contents of the mixtures.

After casting in 40*40*160 mm^3 molds, specimens were cured in the conditions described in section 2.2.2. After removing the metallic plate that formed the bottom of the molds and turning the molds over, the specimens were kept like this for three more days before complete demolding. The loss of weight and the linear shrinkage of the clay plasters were then measured daily on three specimens of each plaster. The results are presented in Figure 3 and Table 4.

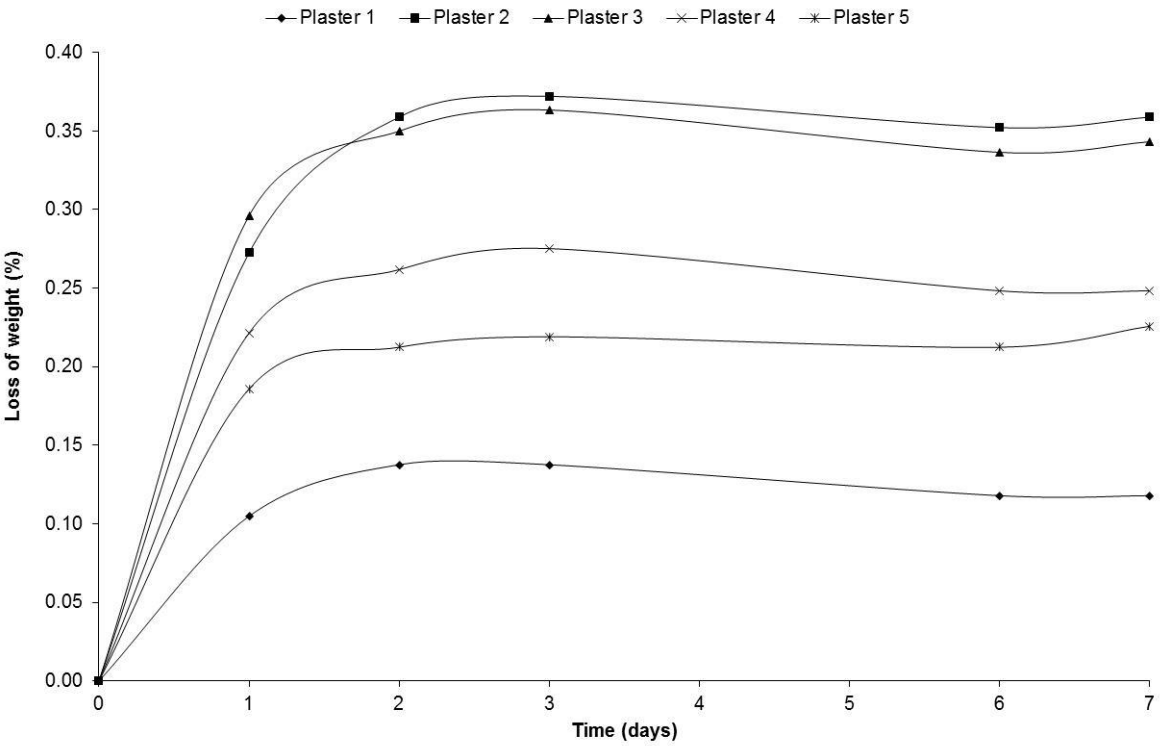

Figure 3: Loss of weight of the fresh plasters after demolding

The loss of weight presented in Figure 3 does not take account of desiccation before sample demolding. Thus, it is not possible to compare the loss of weight of the various plasters. The interest of these results lies essentially in the kinetics of desiccation of the samples: desiccation occurs very fast once the specimens are demolded. After only three days, the weight became stable. In consequence, the minimal duration of conservation of clay plaster recommended in the German standard (14 days) is largely sufficient for the desiccation of the plasters.

Table 4: Shrinkage of fresh plasters

Sample		1	2	3	4	5
Shrinkage (%)	Min	1.5	1.9	1.3	1.8	2.4
	Max	1.6	2.2	1.6	1.9	2.6
	Average	**1.6**	**2.1**	**1.5**	**1.8**	**2.5**
Water content (%)		16.8	20.5	20.2	20.0	18.8

The dispersion of the linear shrinkage among specimens of the same plaster was very low. The linear shrinkage was rather high for each plaster, ranging between 1.5 and 2.5%. The water content of fresh plasters is recalled in Table 4 but it does not explain the differences of shrinkage between the various plasters. No apparent link was found with the loss of weight presented in Figure 2 either. This is not really surprising because the curves of water content do not take the complete drying into account, and the first stages of desiccation are known to have a significant influence on shrinkage. A more remarkable feature is that the differences in mineralogical composition (and especially the nature of the clay minerals) are not consistent with these results. In particular, the linear shrinkage of sample 5, essentially composed of kaolinite, was greater than those of the other samples, which contained montmorillonite, a mineral known to have larger swelling and shrinkage capacities.

The only parameter that seems to be correlated with shrinkage is the total clay content estimated in granular analyses by the mass percentage of particles < 2 µm. This could indicate that, despite the various clay natures observed in the samples, the total clay activity remained similar among the plaster formulations tested.

These linear shrinkages can be compared with the thresholds proposed by the German standard in order to limit cracking of the clay plasters during their desiccation. This standard proposes two limit values: 2% in the general case, but the maximal linear shrinkage could reach 3% in the case of plasters reinforced with fibers and 4% in thin-layer plasters reinforced with fibers.

The linear shrinkage of all the plasters under study was lower than 3% and no cracking was observed on the samples during our experiments (even when the plasters were spread on a substrate in 1-cm-thick layers, during the preparation of the adhesive strength test for example).

3.3 Mechanical properties of hardened plasters

i) Flexural and compressive strength

The flexural and compressive strengths of hardened plasters are given in Table 5. This table also presents the limit values of the two strength categories ("SI" and "SII") of the German standard.

Table 5: Flexural and compressive strengths of hardened plasters

Sample		1	2	3	4	5	Category	
							S I	S II
Flexural strength (MPa)	Min	0.68	0.57	0.47	0.59	0.55	≥ 0.3	≥ 0.7
	Max	0.71	0.64	0.49	0.69	0.59		
	Average	**0.69**	**0.61**	**0.49**	**0.64**	**0.57**		
Compressive strength (MPa)	Min	2.1	1.7	1.2	1.7	1.6	≥ 1.0	≥ 1.5
	Max	2.2	1.9	1.4	1.8	1.8		
	Average	**2.1**	**1.8**	**1.3**	**1.8**	**1.7**		

The dispersion of the results (for the three values for the flexural strength and six values for the compressive strength) was quite low. The results were very similar between the various mixtures, with the exception of mixture 3, for which the strengths were slightly lower. The granular characteristics (Table 2) showed that this mixture contained less clay than the others, which could be an explanation for the lower strength. But the differences in the clay contents presented in Table 2 are very small and may not be representative. The other properties measured on the samples (density, water content, loss of weight and shrinkage during desiccation) were not helpful to explain the relatively low strength of mixture 3 compared to the others. Finally, these results show that, in these cases of study, the nature of the main clay minerals contained in the soil does not seem to influence the strength of the clay plasters: the strengths of mixture 5, rich in kaolinite, were close to those of mixtures rich in illite, montmorillonite and chlorite.

ii) Adhesive strength

The adhesive strength is an important mechanical property for plaster. The procedure used was that described in the German standard (see section 2.2.3).The results obtained using this procedure were highly dispersed. For a given mixture, the values could vary widely, e.g. between 25 and 150 kPa for sample 3. Moreover, the adhesive strength for clay plasters 2 and

5 was close to 0. The results obtained using the standardized procedure are very questionable: the dispersion was very high, and the differences between the various mixtures were not consistent with the other properties measured during this study, which were quite similar. The adhesive strengths were also much lower than the limit values given by the standard.

A modification of the procedure was tested on three samples according to the advice of a specialist in field works with clay plaster: it consisted of dirtying the surface of the concrete panel using a suspension of the clay plaster tested (liquid mixture of earth and water). The clay plaster was applied after the water of this thin layer of clay had been absorbed by the concrete plate. This modification had some significant effects on the results. It strongly increased the adhesive strength measurement in the case of clay plasters for which the adhesive strength was close to 0 using the standardized procedure (sample 2). Moreover, it reduced the dispersion of the results for a given mixture and gave more uniform values for the adhesive strength measured on the various plasters tested. The modified procedure led to average adhesive strength values ranging between 111 and 140 kPa measured on 3 different plasters. These results are more consistent with the overall study, which showed that the various properties of the five clay plasters were very similar. Finally, the average adhesive strengths obtained on the three plasters tested were also more consistent with the limits proposed by the standard. With such a procedure, the three mixtures were classified in the category “S II” as was the case for the flexural and compressive strengths.

Table 6: Adhesive strength of hardened plasters

	Standard procedure					Modified procedure			Category	
Sample	1	2	3	4	5	1	2	4	S I	S II
Adhesive strength values (kPa)	38 42 47 58	2 5 8 8	18 22 32 32 34	25 32 103 110 150	4 5 7 9	74 106 128 169 175 188	98 100 100 125 137	78 79 141 147	≥ 50	≥ 100
Average (kPa)	46	6	28	84	6	140	120	111		

4 Discussion

Very few papers in the literature offer a complete approach to a variety of clay plasters, considering physical, mineralogical and mechanical properties simultaneously. Consequently, the results presented in the previous sections can hardly be compared with other existing research results. However, several points can be discussed in the present case.

First, the links between the shrinkage values obtained in the tests and the other properties measured on the plasters require more comments. Shrinkage was only shown to be correlated with the total clay content during the experimentation. However, this statement cannot be generalized. In reality, shrinkage is quite a complex phenomenon in natural soils. It involves the percentage of clay and the specific surface of the minerals (depending on their nature), together with the cationic content of the water and the drying procedure used (that may cause various suction conditions within the material). Moreover, the real shrinkage observed in the field will be different from that measured in the tests because the support prevents contraction in its immediate vicinity and changes the drying process (different drying kinetics between the two sides of the plaster). In consequence, the values obtained in the tests have to be considered as indicators. They may be useful and quite reliable for a comparison between

various plaster compositions but they are not characteristic values for field application. A field validation, such as verification that no tensile cracks appear on a 15x15 cm plaster sample laid on a wall, should be recommended to validate the compatibility between the selected plaster and its support before final construction work.

One may wonder about the interest of measuring the flexural and compressive strengths in the case of clay plasters. Generally speaking, plasters do not really undergo high mechanical stresses, except in the case of compressible supports such as straw bales. Measuring the flexural tensile strength can be justified, however, by the fact that this mechanical characteristic can play a significant role during cracking of the plasters linked to their shrinkage. It may also be an interesting property in the case of locally poor plaster-support contacts that may cause the plaster to buckle. For the compressive strength, the link with the mechanical stresses undergone during the use of the hardened clay plaster is more difficult to establish. In our opinion, this parameter is mainly recommended by the norm on the basis of conventional practice for fired brick or concrete and does not really correspond to a critical property for clay plasters. Moreover, the testing procedure on nearly cubic samples leads to a strong influence of the lateral confinement generated by the friction between the sample and the press plates. In our opinion, these compressive strength values have to be considered as indicators for comparing various plaster formulations, but not really as characteristic strength values.

Another question concerns the adhesive strength measurements. Our study highlights some weaknesses in the procedure, which is currently insufficiently described and not repeatable enough to determine this characteristic reliably. In particular, our results show that the adhesive strength essentially depends on the type of substrate and on its surface finish. The choice of concrete as substrate is open to discussion: the surface of the concrete can be very different according to its composition, its laying, its cure and many other parameters. Considering the importance of the surface finish on the results, it could be pertinent to choose another type of material with less variability. Further improvement could be made by including the modified procedure used in this paper, in which the substrate is “dirtied” before the application of the plaster, as is commonly done on building sites. This procedure was shown to significantly reduce the dispersion of the results.

A last point relative to adhesive strength measurement is worth discussing. It is not certain that the tensile stress applied by a direct load perpendicular to the substrate is the best to represent the real behavior of hardened plasters in situ. A shear stress test could be more appropriate. The development of such tests is presently in progress at two scales: a laboratory test, using an instrument derived from the Casagrande test, and a test for use on building sites, where samples of plasters (5 cm x 5 cm) are loaded directly on the appropriate substrate [9]. The latter test has two advantages. First, it is very simple and can be implemented on site without any specific skill and, second, it permits the adhesive strength of the clay plaster to be measured on the actual substrate of the building, which is very important because the type and nature of the substrate will considerably influence the value found for the shear strength of the clay plaster, as shown previously.

5 Conclusion

This paper has dealt with the characterization of five ready-mixed clay plasters from French brickworks using the new German standard DIN 18947. This standard, mainly based on those for conventional plasters (cement or lime-based) with some adaptations, constitutes a very

interesting development in an area where there is little uniformity among testing procedures. Our work essentially consisted in measuring the flow of fresh clay plasters and their characteristics after hardening (shrinkage, and compressive, flexural and adhesive strengths).

The characterization of the samples showed that the granular characteristics were quite similar and that the main difference concerned the nature of the clay minerals they contained: four samples contained mainly montmorillonite, chlorite and illite whereas one contained only kaolinite. Despite this difference, the flow of fresh clay plasters and their characteristics after hardening (shrinkage, and compressive and flexural strength) remained quite comparable, and in good accordance with the indicative values given by the standard.

However, some criticisms could be voiced as to whether the testing procedures proposed give representative results. In particular, it must be emphasized that several values derived from the standard have to be considered as indicators, particularly useful for comparing ready-mixed plasters, for instance, but not as characteristic on-site values that could be used in calculation processes.

Concerning shrinkage, the procedure shows a very good repeatability and yields useful information for plaster sensitivity during the drying phase. However, it does not consider the influence of the support, nor the specific drying kinetics that may be encountered in the field. Concerning the compressive strength, its evaluation is not really linked with the real mechanical stresses on plasters, and the testing procedure on nearly cubic samples implies a deviation due to the friction between sample and press plates.

Concerning the adhesive strength, which is an important mechanical characteristic for plasters, the tests carried out in this study using the procedure described in the German standard highlight two significant problems. First, the dispersion of the values can be very high and depends strongly on support type and preparation. It would be interesting to review this testing method with a special focus on the type of support and its surface preparation (see section 4). On the other hand, it could be interesting to analyze the adhesive strength in terms of shear resistance: this type of stress could be more representative of the in-situ behavior than a testing procedure based on a pull-out test. Some alternative testing procedures are currently under development, including simple on-site methods.

It must also be emphasized that this first investigation on usual characteristics would need to be completed by measurements of the hydrothermal properties (including humidity transfer) of the ready-mixed clay plasters. These would certainly yield very interesting results concerning the supposed ability of the plaster to regulate indoor air humidity and improve comfort in closed buildings.

Finally, the use of clay plasters with or without plant fibers will doubtless increase strongly in the coming years. The development of standards for the characterization of these plasters will have to accompany this process, as has been done in Germany. The study presented in this paper, even though limited to five clay plasters, permits us to conclude that the German standard is appropriate on several points but that a few adaptations remain necessary. Some in-situ methods should also be added so as not to penalize craftsmen who work with the earth found on the site and not from ready products. This would be consistent with the development of training, as was recently done in Europe with the LearnWithClay (Leonardo) project, which included a training course in clay plastering and had a credit point system compatible with ECVET (European Credit system for Vocational Education and Training) for

construction skills, and qualifications that are recognized by all participating countries (Bulgaria, France, Germany and United Kingdom) [12].

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