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ScienceDirect

Procedia Engineering 161 (2016) 777 – 782

Procedia Engineering

www.elsevier.com/locate/procedia

World Multidisciplinary Civil Engineering-Architecture-Urban Planning Symposium 2016, WMCAUS 2016

Characteristics of the Pressed Bricks Manufactured by Mechanical Tilery of Silió in Early 20th Century in Valladolid, Spain

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Abstract

Since the second half of the nineteenth century in the city of Valladolid, Spain, facades were built with exposed brick pressed together thin and sunken. This system facilitates the entry of rainwater in the masonry and therefore, its deterioration. However, these facades are in good condition, therefore bricks have been tested to know the characteristics of the ones that influence in the preservation of these facades.

Peer-review under responsibility of the organizing committee of WMCAUS 2016

Keywords: brick; durability; test; conservation; heritage;

Introduction

It is often observed that the facades of historic buildings are damaged by the passage of time, the environment or human action, and studies are carried out on how to intervene to stop the deterioration and preserve the buildings. Pressed brick facades built in the late nineteenth and early twentieth century are generally in a good state of conservation better than other facades built from other materials. It can be important for the conservation of the heritage executed with other materials to know the reasons why such material is so well conserved, without alterations. In the second half of the nineteenth century, the mechanical tilery begun the manufacturing of bricks [1] in large numbers required for the growing demand for the construction of all types of buildings [2]. In the city of Valladolid, the first factory that produced pressed bricks was “La Gran Tejería Mecánica de D. Eloy Silió" [3].

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Peer-review under responsibility of the organizing committee of WMCAUS 2016
doi:10.1016/j.proeng.2016.08.706

One of the first buildings in Valladolid in which pressed bricks were used was the Town Hall, designed by architect Enrique Repullés y Vargas. The facades were built with Spanish blights rig, and in the outer sheet such bricks were used with the system that was called “masonry pressed brick cladding with recocho”.

This tilery produced several brands of bricks with different measures [4]: Borgoña, 0.22 x 0.107 x 0.55 m; España 0.255 x 0.125 x 0.048 m; and Castilla 0.265 x 0.13 x 0.058 m. In the time when pressed brick manufacturing began, it was not common to do tests before using them in the construction, and it was usually sufficient a visual observation and a sound check produced by striking the brick. If it was clear it meant the firing was good. A brochure was located issued by the manufacturer of pressed bricks of the "Gran Tejería Mecánica", where there are the results of the tests carried out by the "Central Laboratory of Military Engineers of Madrid" in 1901 [5]. This article describes the results of studies conducted in 1901 and the studies conducted nowadays at the same factory bricks.

2. Materials, work methodology and the results.

Tests conducted in 1901 were performed at 22 Borgoña Brand bricks of 0.225 x 0.107 x 0.059 m average dimensions. In order to perform the tests, according to the current regulations, 30 bricks of 0.223 x 0.109 x 0.053 m dimensions from the demolitions of a facade have been used (Figure 1).

Fig. 1. Photographs of the two tables of two of the bricks that have been tested.

To better compare the test methods that were used at the beginning of last century with those made today, we are going to compare each current test with each test that was published in the 1901 brochure following the same order in which they appear, and according to the classification of physical, mechanical and chemical tests.

2.1. Physical tests

Observation of the structure. In 1901 this is a visual observation of the so-called fracture of the brick. At present, the procedure of the UNE-EN 771-1 [6] is followed.

Specific weight. In 1901the specific weight was determined by a method called the volumetric procedure. The brick was crushed to powder, the powder was dried in an oven at 110°C, and it was passed through the sieve of 900 meshes per square centimeter. The density was calculated with the Schman hydrometer with benzine. The resulting value was the average of three trials. At present, we have followed the procedure of the UNE-EN 771-1.

Bulk density. In 1901, three bricks were dried in a Frémy oven at 40ºC, then, they were weighed on a precision balance and afterwards the pieces were weighed with hydrostatic balance in the air and submerged in water and the bulk density was calculated. Today, the UNE-EN 772-13 [7] standard is used. Absolute porosity. In 1901, it was the value of the difference between the specific weight and bulk density, divided by the specific weight; this ratio indicates the relation between the pores and the total volume. An average of three tests were made. Currently, this feature of bricks is not among those contemplated in the CE marking. In 1901, this test was used to determine the amount of water absorption: the bricks are dried in a Frémy oven between 30ºC and 40ºC, then placed in tests of distilled water so that the water absorbed reaches half the height of the brick. After 24 hours they are weighed, and then put in the tests again, but this time submerged, and then weighed after 7 and 28 days. Currently the procedure used is that of the UNE-EN 772-21 standard [8]. Resistance to frost. In 1901 the test procedure was as follows: the bricks were dried up,

then saturated and then kept 4 hours at a temperature between -10°C and -15°C, twenty-five times. The serrated faces were covered with a thin layer of cement that make them waterproof. The tests were conducted on three pieces. Currently the test is performed according to the norm UNE 67028 standard [9], with six sample bricks. The results of these tests are listed in following Table 1.

Table 1. Results physical test.

	TESTS DONE IN 1901				TESTS DONE IN 2014			
Brick	Pressed brick				UNE EN 772-1 “piece HD" as a piece of high density baked clay for masonry without coating and "piece with frog"			
Structure observation	Rough fracture with little marked differences. Uniform dark red color. Fine grain. Without hollows and cracks. Some specimens have small caliches				Rough fracture with differences slightly pronounced. Red obscure uniform color. Thin grain. Without cavities or cracks.			
Specific weight	2.74 gr/cm^3				2.55 gr/cm^3			
Bulk density	1.98 gr/cm^3				1.94 gr/cm^3			
Absolute porosity	0.28 (28%)				0.24 (24%)			
Weight of water absorbed in a given time	Submerged time	1 day	7 days	28 days	Submerged time	1 day	7 days	28 days
	water absorbed % in weight	10.5%	11.3%	12.1%	water absorbed % in weight	10.7%	11.3%	11.7%
Frost resistance	brick	Effects of freezing			The result of the tests is: NO FROST			
	$V11_1$	Small cracks			Loss of 0.04% in mass			
	$V11_2$	cracks						
	$V11_3$	small cracks and exfoliation						

2.2. Mechanical tests

The second group of tests are the ones related to the compressive strength of the bricks. The 1901 test method differs from the current one, not only in the size of the samples but also because the specimens were broken after making frost susceptibility testing. Resistance to rupture by compression. In 1901, the tests were carried out by breaking the specimens with a hydraulic press. The five specimens were made by cutting the brick in the shape of a cube and then overlaying two pieces face to face with a thin layer of cement, in this case the specimens had a base of 10.5 x 10.5 cm and a height of 14 cm. Nowadays the tests are made according to the norm UNE-EN 772-1 standard [10]. Ten whole bricks get broken by a press, facings and recesses filled with cement mortar bricks. Resistance to rupture by compression after the frost resistance test. In 1901, brick specimens which suffered no notable changes in the resistance to frost test were subjected to the compression test, in total four of the five samples tested for resistance to frost. This test is not carried out today, but to be able to compare the results the specimens that were subjected to the frost resistance test have been broken using the compression test. The results of these tests are listed in Table 2.

2.3. Chemical tests

The third group of tests are the ones referred to as chemical tests in 1901 which are the tests which most differ from those that are currently done.

Determination of lime and magnesia. In 1901, five bricks were subjected to tests, by immersing them in boiling water for three hours and noting when removing them if there were any cracks or peels, if they do not appear, then it was understood that the bricks did not contain these salts. To compare the results, the specimens have been immersed in boiling water according to the norm UNE-EN 772-7 standard [11], and checked, as in 1901, if cracks or peels have been produced. Determination of soluble salts.

Table 2. Results mechanical test.

	TESTS DONE IN 1901	TESTS DONE IN 2014	
Resistance to rupture by compression	188.48 kg/cm^2	20.31 N/mm^2	199.22 kg/cm^2
Resistance to compression after the resistance to frost	177.15 kg/cm^2	18.66 N/mm^2	183.05 kg/cm^2

The bricks are crushed and the dust is dried to 110 ºC. 25 gr was weighed that was made to boil in distilled water for 1 hour. The residue is required to determinate the content of lime. Efflorescence tests done according to UNE 67029 [12] test on ten bricks. The results have been moved to the Table 3.

Table 3. Results chemical test.

	TESTS DONE IN 1901	TESTS DONE IN 2014
Test for lime and magnesia	the removed bricks had no cracks or peels, which means that they did not contain soluble salts	the removed bricks had no cracks or peels
Determination of soluble salts	Determination of soluble salts % by weight of the residue 2.068	
Efflorescence		Slightly efflorescent

3. Discussion

Many of the required features of brick for load-bearing wall facades, have not changed much over the years, such as compressive strength and durability. While in the CE marking currently require includes the values of, acoustic and thermal insulation, permeability to the passage of water vapour, reaction and fire resistance and moisture expansion, characteristics that were not tested in the beginning of the twentieth century. Regarding the results of physical testing, the appearance and dimensions are similar, they have almost the same density values and the test procedures are similar. The values that have major differences are the absolute porosity, as in the tests held in 1901 this was 0.28, and in the ones carried out today, the result is 0.24, 14% lower. This fact can be explained because the pores of the laid bricks have been obstructed with the bonding mortar, the crystallization of salts in such pores or particle deposited from the environment. Regarding the compressive strength, the obtained values are substantially similar. In Figure 2 the results are shown, being able to appreciate better the little dispersion in them: only 11% difference between the highest and lowest value. If it were the same bricks it could be noted that the compressive strength increases with time. The values of resistance to compression after the frost test are lower in both cases.

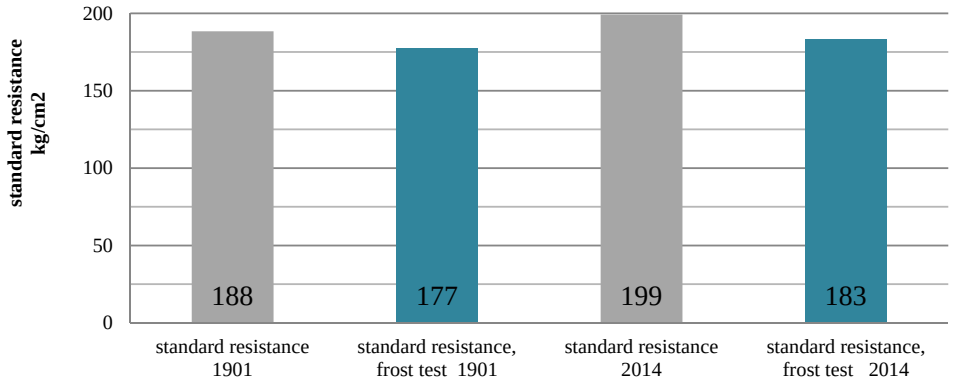
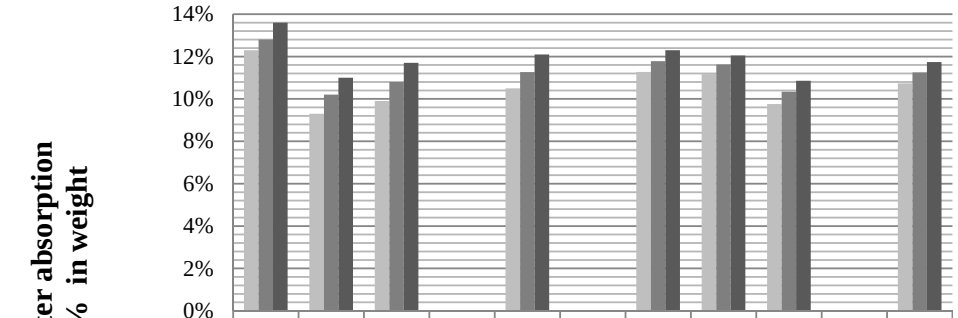


Fig. 2. Results of the tests for resistance to compression.

Regarding specimens that were tested without having been subjected to the freezing test resistance the compression has similar percentages: 6% lower in the case of tests in 1901 and 8% in the tests carried out today. In the current frost resistance test, the brick is subjected to lower temperatures and a greater number of hours, which might explain this difference.



	V1	V2	V3		V1 V2 V3		21	22	23		21 22 23
% absorption 1 day	12,3%	9,3%	9,9%		10,5%		11,3%	11,2%	9,8%		10,7%
% absorption 7 days	12,8%	10,2%	10,8%		11,3%		11,8%	11,6%	10,3%		11,2%
% absorption 28 days	13,6%	11,0%	11,7%		12,1%		12,3%	12,1%	10,9%		11,7%

Fig. 3. Graph with the water absorption in % of the weight of the bricks.

With respect to the absorption and water suction tests, some of the procedures are quite different. We will compare the results of the test in 1901, with those obtained in cold water absorption tests, according to the UNE-EN 772-21 standard for being the most similar test methodology. In the graphic of the Figure 3, on the left is the data obtained from the tests of three bricks in 1901: V1, V2 and V3 and their average values; and right, the water absorption of three bricks from demolition site: bricks 21, 22 and 23, and their average values. The values of absorption of water and the process are similar in the six bricks tested and although there is a dispersion of results among the six specimens, the average values of the tests carried out in 1901 and 2014 are very similar. The durability test, such as the resistance to freezing, provide very similar results: the brick resist frost well; as well as those of efflorescent and soluble salts: the brick may be deemed not efflorescence. In the test carried out in 2014 it should be taken into account that it is possible that the brick dust was mixed with the mortar from the joints.

4. Conclusions

In 1901 they already knew and carried out trials that allowed to know the characteristics that most affect the durability of resistant brick factories: the compressive strength, water absorption, frost resistance or presence of soluble salts. With the results of the tests carried out in 1901 and those made on bricks from demolition in 2014, it was found that they present a proper compression resistance, a very low absorption and resist well to frost and are not efflorescent. Characteristics that make masonry not deteriorate.

The similarity in the results made in 1901 and in 2014 leads to the conclusion that the manufacturer of bricks maintained a constant quality of the pressed brick during years of production. And they have kept these characteristics for a hundred years placed in building. In 1901, two tests were held in successive manner on the same specimens: the resistance to freezing and breakage to compression. Subjecting the same specimens of brick to these two tests is not currently being done even though it seems that it would be appropriate to incorporate this system today, this procedure would set better information about the behavior of the brick on a facade.

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