New Eco-Friendly Gypsum Materials for Civil Construction

Rute Eires [1,a], Aires Camões [1,b], Saíd Jalali [1,c]

[1] Civil Engineering Dept., University of Minho, Campus de Azurém, 4800-058, Guimarães, Portugal

[a]rute@civil.uminho.pt, [b]Aires@civil.uminho.pt, [c]said@civil.uminho.pt

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Abstract. The sustainable world's economic growth and people's life improvement greatly depend on the use of alternative products in the architecture and construction, such as industrial wastes conventionally called "green materials". This paper concerns the development of new composite materials based on gypsum incorporating waste material as granulated cork, a by-product of cork industry and cellulose fibres, waste of paper industry. Such materials are intended to be used as composite boards for non structural elements of construction, such as dry walls and ceiling.

Cork (bark of the plant Quercus Suber L), a substance largely produced in Portugal, is a material whose characteristics are of considerable interest for the construction industry. It is regarded as a strategic material with enormous potential by its reduced density, elasticity, compressibility, waterproof, vibration absorption, thermal and acoustic insulation efficiency [1].

During the first stage of the research the gypsum binder and its properties were studied. Then, composites with mineral additives (added to increase the waterproofing and resistance) were also developed and submitted to tests to determine their physical and mechanical properties. In last stage, reinforced composites using different industrial by-products have been developed.

The paper will present the properties and the manufacture methods used to produce the above mentioned eco-friendly composites that can ease ways for using industrial wastes as new construction materials, with excellent inherent thermal and acoustic properties.

Introduction

The gypsum is a large known material in building construction by the diverse applications, however it is a material with low know how, mainly at research level. The European production of gypsum extracted was 21milions at 1996. The European industry have 220 factories that produce gypsum products and employ, direct or indirectly, more than 400 000 people [2].In Portugal have been produced about 500 000 ton of gypsum for ear since 2000 [3].

The building sector consumes about 95% of total gypsum production. It is calculated that about 80 to 90% of finishing interior work and partition walls in buildings are made through of gypsum products, as the plaster and card gypsum. According to those thermal and acoustical properties, these products contribute significantly for the comfort of million of people. Having an extraordinary resistance to fire, the gypsum products contribute for the buildings security, particularly in public buildings as cinemas [2].

One of biggest deficiencies of gypsum as material construction is the absence to resistance in water presence. Although, actually, this aspect can be partially solved by addictions based on silicones and polymers, as at gypsum card boards. This way, gypsum can be used at humid rooms, but not permits utilization in exterior by the fault of resistance in in long direct contact with water.

The mainly propose of this research work is the development of gypsum boards with bigger mechanical and water resistance. To these boards are also incorporated wastes to turn them more lights and sustainable. The research aims the manufactory of boards for not structural construction

elements, for example, interior and exterior coverings, dry walls and ceiling. For this, it was proceed to the characterization and improvement of gypsum as construction material more water resistant. Being realized a study of preparation and methods of casting and of physical characteristics of the developed materials.

The behaviour improve in relation with water can be achieved, above all, through the reduction of water content in paste, by the addiction of a mineral, that act also as a retarder, and using a casting by pressing instead of the traditional plaster.

To improve the behaviour at flexural tensions, turning the boards more light and with better thermal and acoustical properties it is study the incorporation of wastes or by-products (granulated cork and waste paper at pulp)

Materials and methods

At this research were study four commercial gypsums, existent at our market. Plaster gypsum, for manual and projection application, finishing plaster and escayola gypsum. According to chemical analysis of these gypsums, made in laboratory of University of Minho, it was verified that the manual plaster and escayola gypsum have a bigger purity by the higher calcium sulphate content ($CaSO_4$). For this reason, it was select these plasters as the main materials for the research. In terms of Granulometry it was seen at laboratory tests that the escayola gypsum have a bigger fineness (European Norm, EN 13279-2 (2004)) [4]. At moisture, the plaster gypsum have a moisture of 1,05% and the escayola of 1,32% (Portuguese Norm, NP 319 (1963), [5]. Attended to the water/gypsum relation, it was verified in tests the minimal gypsum essential for hydratation (Portuguese Norm, NP - 318(1963) [6]. The relation of water necessary for a conventional plaster is 0,52 and for a the minimal hydratation is 0,24.

The used granulated cork is a by-product of a Portuguese industry containing diverse parts of cork and different particle sizes. The density is 384.5 kg/m3 and the bulk density is 160.0 kg/m3.

The cellulose fibres or paper pulp was made in the laboratory using waste office paper, triturated in a mix machine and joining the water necessary to the mixture with gypsum.

The absorption tests were realized according to the Portuguese Norm of Gypsum, NP – 762 (1969) [7].

Methodology and results

Incorporation of cellulose and cork on gypsum plasters. It was realized three plasters with a water/gypsum relation of 0,7. One is simple, without any addiction, one with cellulose fibres and other with granulated cork (see figure 1). These samples were tested at compressive and flexural stress and at absorption by immersion in water. It was seen that the cellulose fibres addiction improves a little the flexural resistance and maintain the compressive resistance (see figure 2). At both addictions was verified behaviour more ductile during the mechanical tests. The figure 3 shows a reduction of 15% of water absorption on mixtures developed.

Figure 1 – Gypsum plasters with cellulose fibres and cork

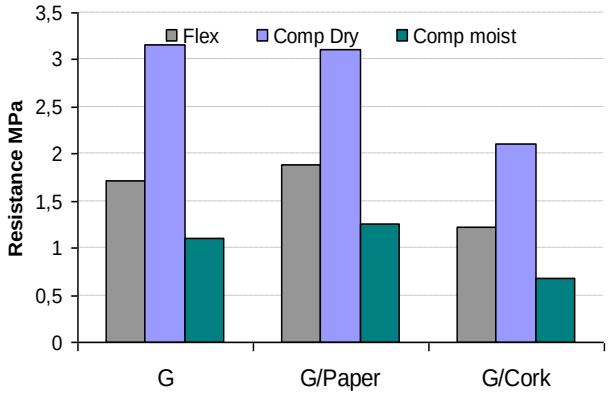


Figure 2 – Compare of gypsum plasters with paper or cork

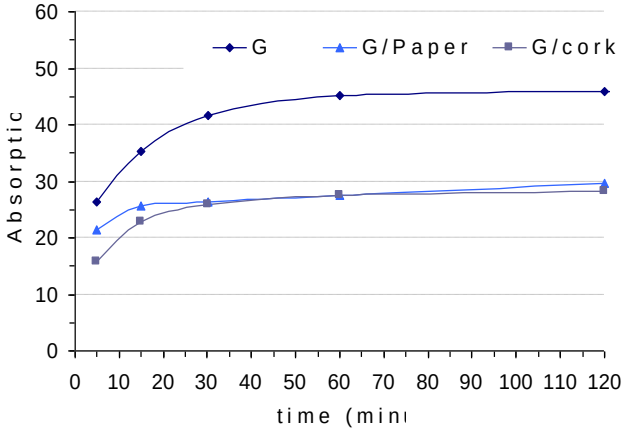


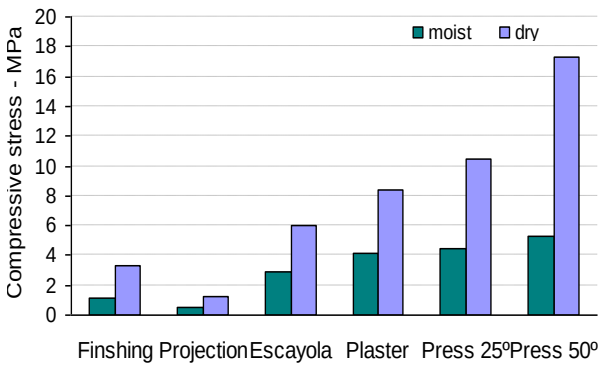
Figure 3 – Absorption of gypsum plasters

Pressed gypsum as method to reduce the water absorption. A system to reduce de water absorption is press de gypsum, reducing also the water of mixture. The minimization of empty spaces enables a reduction of water absorbed percentage by immersion. This way, also the resistances are increased.

It was prepared a mixture of moist consistence of plaster gypsum with just 20% of water, the minimal for hydratation. With manual hydraulic press were produced cylindrical samples under a pressure about 40Psi (275,8 Kpa) (see figure 4). These were made at room temperature (25ºC) and at 50ºC and conditioned at room temperature.

Comparing this pressed gypsum with the plasters of our market at figure 5 shows a considerable increase on the compressive stress at dry samples of pressed gypsum (legend on graphics as Press25º and Press50º), mainly at sample of 50ºC. Since the moist samples obtained of immersion until 2hours have a small increase of resistances.

At the graphic of figure 6 can be seen the differences of absorption between pressed gypsum, plaster and card gypsum board. The decrease of absorption of plaster to pressed gypsum is about 40% and comparing the pressed gypsum with the card gypsum, the pressed maintain the values and the absorption of card gypsum continue to increase. The absorption values were obtained based on Portuguese Norm of gypsum, NP – 762 (1969).



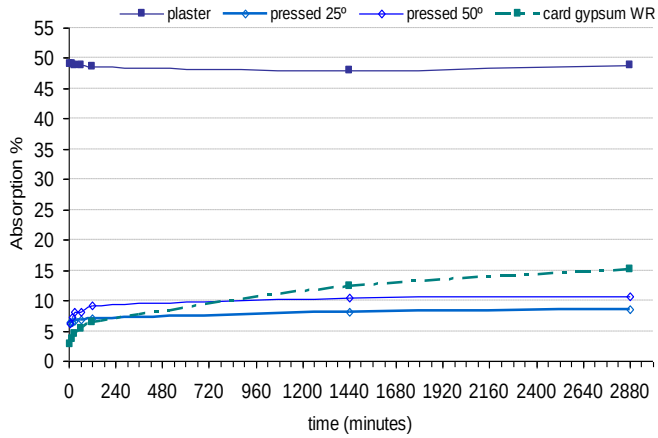


Figure 4 – Compare of plasters /pressed gypsum **Figure 5 – Compare of pressed/plaster/card board gypsums**

Incorporation of cellulose and cork on pressed gypsum boards.

For develop of this boards was necessary, at a first stage, to make boards without any addiction to obtain the better process of manufacture for the boards to achieve the adequate cohesion and finish. These boards was prepared with a metallic mould of 20x20cm^2, filled with the moist mixture of 20% of water and 0,3% of retarder mineral.

Boards were submitted to a pressure of 87,02Psi (600Kpa) and to a decreasing pressure until to 350Kpa for 10 minutes. The boards were removed from the mould at the day after of casting and conditioned at 40ºC for curing and drying. These boards have de designation P0 in the Table 1 and Figure 10.

As the same way, the boards with the granulated cork and/or cellulose fibres or paper pulp was prepared following the same methodology of mix, casting, pressure and conditions of curing. It was prepared four mixtures. Two mixtures introducing granulated cork at 2,5 % and 5 % of gypsum and two mixtures with paper (3 % of gypsum) and cork also at 2,5 % and 5 % of gypsum (see Table 1).

Table 1 – Material Percentages of boards

Board	Cork %	Paper %
P0	X	X
P1a	2,5 of Gypsum	X
P1b	5 of Gypsum	X
P2a	2,5 of Gypsum	3 of gypsum
P2b	5 of Gypsum	3 of gypsum

The next figures shows the final aspect of developed boards and the texture correspondent at near the real scale (see figure 8). Figure 6 show the simple board of pressed gypsum and Figure 7 shows the incorporation of granulated cork and paper at pressed gypsum.

Figure 6 – Board of pressed gypsum

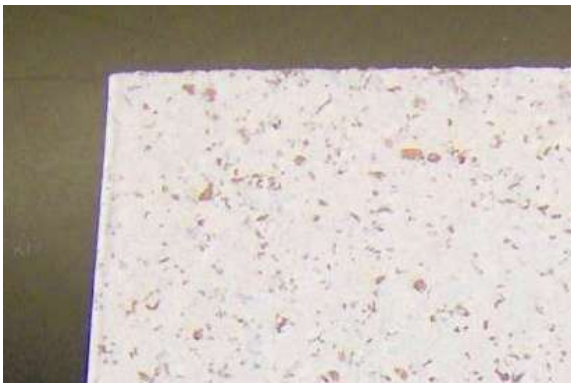


Figure 7 – Board of pressed gypsum with paper and cork

Figure 8 – Board texture of pressed gypsum with paper and cork

These boards were submitted to flexural testes to evaluate the mechanical behaviour. At Figure 10 it was seen that the mixtures decrease around how much more wastes, cork granules or paper fibres, was incorporated. But, the reinforced of paper fibres on the mixture with more percentage of cork reduce in large way the difference of resistances. This happened because the cellulose fibres behaved as a link between cork and gypsum turn the material more compact. The two materials together work as adequate complement turn the boards more ductile at flexural behaviour (see curves at figure 9).

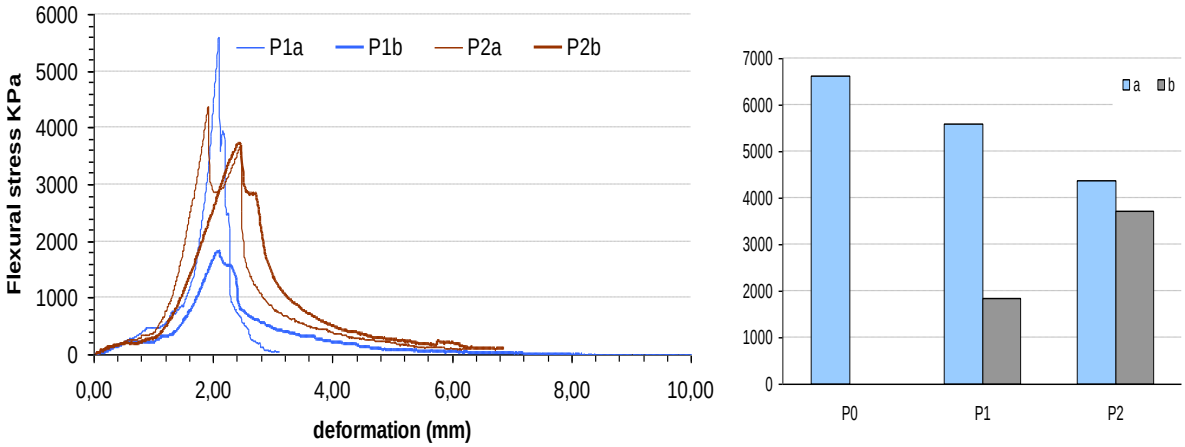


Figure 9 and Figure 10 – Flexural behaviour of pressed gypsum; gypsum/cork and cork/paper

Conclusions

According to the obtained results with the boards it was verified that the incorporation of granulated cork on plaster gypsum and pressed gypsum is possible and can reduce the volumic mass and improve a conventional gypsum board in thermal and acoustical behaviour (properties to be tested with the continuity of the research).

This research work shows that is possible reduce, in large way, the water absorption by immersion, permitting an exterior application of the gypsum boards. Although these water resistances can be improved with the continuity of the research.

The addition of cellulose fibres can improve the flexural behaviour permitting to add a bigger percentage of cork with less reduction on resistances. Furthermore, this addition offers a better cohesion and finish aspect when applied on pressed gypsum boards.

As well, it was verified the possibility of manufactory of not structural construction elements, for example, interior and exterior coverings, dry walls or ceiling. These are new applications for the waste materials mentioned, turn the boards more environment friendly, and a new possibility of use the gypsum in the exterior.

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