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Insulation corkboard for sustainable energy and environmental protection

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Abstract

Cork products for the construction industry have an important contribution and remarkable advantages, namely insulation corkboard (ICB). The production of insulation corkboards uses only superheated steam, using steam generators fed with their own waste obtained in cork grinding and board finishing operations, not introducing any other products that are not exclusively cork. The agglomeration is based on cork resins, being a 100% natural and ecological product. At the end of the period of use, this product may come to be used in identical applications, since some tests showed that after this time the look and the essential properties of this insulation material are unchanged. In the case that this is not possible its grinding is promoted, obtaining a re-granulate which is used for new applications in thermal insulation or to be used as inert in the manufacture of light concrete and mortars. Considering an apparent density average value of 120 kg.m^{-3} and an average value of 90,000 m^3/year for the total ICB production, this corresponds to a CO_2 equivalent (sequestration) of more than 25,500 ton/year and corresponds to the pollution of more than 11,200 cars/year.

Keywords: cork; insulation corkboard; sustainable construction; sustainable materials.

1. Introduction

Cork is a material whose applications have been known since Antiquity. Cork production and utilization is closely related to the maintenance of biodiversity and the reduction of emissions and sequestration of CO_2. Cork oak forests ("*montados*") are a habitat for many plant and animal species, some of them endangered. These are aspects that, in addition to the environmental importance, are also economically very important [1,2].

In the fight against climate change and greenhouse gases, the parameter most commonly used is the ton of CO_2, which has a market value. The protection of selected species costs a huge amount of money. Other services such as the formation of the landscape, soil protection, regulation of hydrological cycle, and other also have a value which is not easy to quantify but clearly perceptible [1].

Sustainable materials are those that are durable and require little maintenance, which can be reused and/or recycled or recovered, among other considerations. The selection of a sustainable material should take into account parameters such as durability, the fact that it must come from a fair production, a reasonable price, the possible rise in value, the fact that it is not contaminant, consumes low energy, has some cultural value, come from abundant and renewable sources and if it can incorporate recycled material [1]. This selection is made in order to aim at projects that reduce environmental impacts and increase social benefits within the limits of economic viability (e.g. in green or sustainable buildings).

There is no single insulation material or solution capable of fulfilling all the requirements with respect to the most crucial properties, like thermal

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conductivity, perforation vulnerability, building site adaptability and cuttability, mechanical strength, fire protection, fume emission, robustness, climate ageing durability, resistance towards freezing/thawing cycles, water resistance, costs and environmental impact [3] but the insulation corkboard (ICB) is one of the most well balanced materials in this field. Several variables have to be considered in the design process and this cannot be focused just on the best environmental material choice, but should also concern the product configuration, its usage context and its end of life scenarios, choosing materials which ensure reduced environmental impact from cradle to gate and also selecting materials which fulfil different needs during the different life cycle phases [4].

Fig. 1. External insulation of the Portugal Pavilion in Expo Shanghai 2010 with ICB.

2. Cork and ICB

The European Union is the largest producer of cork (more than 80%), particularly in the western Mediterranean countries, among which Portugal (greater than 50%) is the world's largest producer processing most of the world's cork. Cork oak forests, namely the "*montados*", usually with 50-150 trees/ha, are extremely well adapted to the regions of southern Europe and northern Africa, preventing desertification and providing habitat to many unique animal and plant species, with a world total area of about 2.3 million ha and an average annual production ranging from 200,000 to 300,000 tons of cork [1,5,6].
ICB, sometimes also called black cork agglomerate due to its colour, is a product made of granules of cork, mainly from the pruned branches of the cork oak, which are expanded (steam-backed) in autoclaves (>300ºC) and agglomerated together by pressure and temperature without any exogenous glue. This material is produced with the lowest quality types of cork but it has very good properties for some applications [7].

Fig. 2. Cork raw material for ICB production.

This material is also of easy or no maintenance or replacement (easily disassembled and collected), and in the sensory field is good in human perception, has low environmental impact, is eco-efficient, is derived from a renewable resource and has no toxicity for human health (bio-compatibility) and can have a lifetime extension (durability), all aspects included in the guidelines for a sustainable product [4].
Insulation corkboard applications are divided in three aspects: thermal insulation, acoustical absorption, vibration insulation for the building and industrial fields. Regarding sustainable energy, ICB is mainly related to thermal insulation, in buildings and cold chambers, and also to vibration insulation with several studies being carried out in this field for application in wind turbines [7].
The future of this material may be related to its association to several cutting edge insulation materials like some of the ones referred in [3].

3. Sustainability and environmental aspects related with ICB

Cork oak forests ("*montados*") are a habitat for many plant and animal species. The "*montado*" is integrated in one of the 34 "*hotspots*" of biodiversity worldwide, featuring a number of species per m^2 even higher than the Amazon rainforest. WWF has identified and quantified geographically Areas of High Conservation Value in the "*montado*", which are locals where values such as biodiversity, but also the carbon storage and regulation of the water cycle are of critical importance. The decrease in the economic viability of the "*montado*", for example as a result of a decreased use of cork products, may lead to a lack of investment in its exploitation and abandonment, with a corresponding loss of biodiversity and environmental benefits and social imbalance, resulting in great loss of sustainability [1,2,3].

In terms of cork products' production and use, it is noted that the production of insulation corkboards uses only superheated steam, using steam generators fed with their own waste (cork powder) obtained in the grinding and finishing operations, not introducing any other products that are not exclusively cork, and the agglomeration is based on cork resins, being a 100% natural and ecological product, which is an advantage very difficult to match by competing materials.

Besides the use of cork powder from the grinding operations of cork raw material and finishing operations of ICB, with a higher heating value ranging from ~4500 to ~7000 kcal/kg (16.7-29.3 MJ/kg) [8], for energy production to be used internally, it is now also being studied the possibility to treat some effluents of the ICB manufacture, as the leaving condensed steam and the ICB cooling waters charged with organic extracted materials from cork, by anaerobic digestion, for the simultaneous recovery of its energetic potential through methane production [6]. There is also the possibility to use a gasification process to produce combustible gases of low to medium heat value that could eventually be used in an electric power plant, having low content of sulphur and chlorine which is advantageous from the environmental point of view [9].

The release of toxic fumes during fire, as e.g. for polyurethane insulation materials [3] with serious health hazard issues, is not a problem when ICB is used, as referred by ICB producers.

The use of cork products is also ecologically very important because a renewable product is used in long life products, promoting the sequestration of CO_2. In addition, the periodic extraction of cork oaks for cork production, produces between 3,5 and 5 times more cork than they would produce if it they were not explored (when the bark is harvested the tree produces rapidly new bark for protection) increasing the fixation of CO_2. Therefore, the consumption of cork products that leads to the exploitation of this material promotes the formation of more cork and thus more CO_2 is sequestered, beyond the fact that such products are long-life products retaining the carbon during their useful life, and sometimes extended, and being "carbon neutral" at the time of decomposition or energy use (burning). Cork oak forests make a sequestration of about 5.7 ton CO_2/ha/year. The 2.3 million ha of cork oak forests worldwide are seen as promoting the retention of about 14.4 million tonnes CO_2/year [1][2].

Significant reductions in emissions of greenhouse gases in the construction sector can be achieved through various measures for energy savings following European Directives, an area where cork derivatives can have a very important role, particularly regarding the thermal performance of buildings, but not only, because about half of the energy consumed by buildings is related to their insulation [1]. Building energy consumption accounts for approximately 40% of global energy demands and the energy requirements for heating and cooling of a building is approximately 60% of the total energy consumed in buildings [10].

Energy efficiency is a reference of a sustainable society and in some extent, these are interdependent concepts. The economic thermal insulation thickness considers the initial cost of the insulation system plus the ongoing value of energy savings over the expected service lifetime of the insulation [10]. For example, considering a functional unit of an insulating material in a lifecycle analysis for 1 m^2 of insulation material, for two thermal resistances R = 1 m^2.K/W and R = 5 m^2.K/W, a difference was obtained between the energy consumed and the energy saved over a period of 50 years, having values, respectively, from -450 MJ to -1335 MJ and from -4050 MJ to -9925 MJ. Using these data we can estimate, for example, for the insulation corkboard, 50 mm thick (common) that has R = 1.25 m^2.K/W, a value for this difference of about -2865 MJ [1].

At the end of the period of use, often imposed by the end of lifetime of the building not the degradation of the material, when it is feasible to remove the entire expanded corkboard pieces, these may come to be used in identical applications, since some sampling and testing of insulation corkboard used in buildings for 30-50 years showed that after this time the look and the essential properties of this insulation are unchanged. For example, in the demolition of the cold chambers of DOCAPESCA (one of the biggest European companies working in the fishing industry) near Lisbon, in Portugal, samples were collected and tests were carried out with ICB obtained from this demolition (after 41 years in use) to verify some characteristics in order to compare these with ICB specifications. The conclusion is that, after several decades of intensive use, ICB shows a thermal behaviour better than the specified limit for ICB in relevant standards and it is a proof of ICB durability [11].

Fig. 3. ICB after more than forty years in use.

In the case that this is not possible (breaking of boards, contamination with other products) its grinding is promoted, obtaining a re-granulate that like the clean/new re-granulate is destined for new applications namely in thermal insulation or to be used as inert in the manufacture of light concrete and mortars, i.e. the expanded cork agglomerate is a completely recyclable product while some competitors are only partially [1].

Fig. 4. Expanded cork re-granulate for several applications.

The main advantage of these procedures is that this material incorporates carbon fixed by the cork tree that remains there during the lifetime of the products, thus increasing the delay of the emission of this carbon back to the atmosphere. Also noteworthy is that if there is no more use after their useful life, cork products can be used in energy production and when incinerated (high calorific value), and the CO_2 produced is equivalent to the material being fixed in the material, what is commonly referred to as being "carbon neutral".

The ICB average carbon content is of 64.6% (w/w). We know that the mass ratio of CO_2/C is 3.664. So, for 1 kg of ICB, carbon corresponds to 0.646 kg and this value corresponds to 2.367 kg of CO_2. The overall annual production of ICB ranges from 80,000-100,000 m^3. Considering an apparent density average value being of 120 $kg.m^{-3}$ and an average value of 90,000 m^3/year for the total ICB production, this last value corresponds to 10,800 ton/year of ICB and on the other hand this corresponds to a CO_2 equivalent of more than 25,500 ton/year. According to the JATO Report, the average CO_2 emissions expected for 2011-2015 is of 130 g/CO_2/km, and considering the average annual mileage equivalent of 17,500 km/year, the ICB annual production corresponds to the pollution of more than about 11,200 cars/year [12].

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