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Manufacture of Ecological Mortars by Cork and Sawdust Waste Recycling

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Abstract. At present, specialists in all fields increasingly focus their attention on meeting the major objectives of sustainable development represented by the rational use of material and energy resources and the reduction of pollution. In this context, the construction industry is in line with the mentioned objectives through the effort to streamline raw materials and at the same time, to protect the environment by minimizing waste. This paper approaches the study regarding the recycling of waste resulting from various technologies for processing renewable resources, which involves the inexhaustibility of these raw materials. Thus, the paper presents a comparative study of recycled cork and sawdust in the composition of mortar, in order to establish the influence of their use on technical characteristics compared to classical mortar. The research is concluded with the elaboration of the technology for the manufacture of cork granule mortar and saw dust mortar, which are ecological mortars through the reduction of the embodied energy due to the recycling of the aggregates used and which prove to be good thermal and sound insulating materials.

Keywords: recycling, waste, cork, sawdust, building materials, mortar.

INTRODUCTION

The selection of green building materials and products is by far the most controversial task in sustainable construction (Saghafi and Teshnizi, 2011).

Minimizing the use of natural resources and maximizing the recycling potential are important tasks to take into consideration (Thormark, 2006), also an important objective in the management of natural resources is the use of renewable resources. These include cork oak, as well as wood species whose rational use can ensure unlimited raw material resources.

Cork oak grows in protected forests and its exploitation does not involve cutting the tree. Cork bark is harvested every 9-11 years. After harvesting, the bark regenerates over the following years. The tree lives for approximately 200-250 years, reaching a height of about 10-15 m (Naturo-kork, 2013).

From the cork oak (Quercus Suberus), cork is obtained that is used in different fields as products such as:

- expanded cork (black cork) is commonly used as a thermal insulator for floors, facades, framework in the case of ecological houses. It is also used in industry for buffering vibrations (typographic tool foundations, foundation blocks, high speed compressor foundations, jet engine test stand foundations);
- natural cork conglomerate (or cork and recycled rubber conglomerate) is a sound insulator (for buffering impact sound) and a thermal insulator, being used as a support layer under any type of floor;
- high density cork has a wide range of applications, from shoe soles to friction rolls, fittings, anti-vibration support for pumps, compressors, etc.;
- cork rubber is made of a mixture of cork granules and synthetic rubber, being used for low or medium pressure fittings. Its physical properties (flexibility and

compressibility) as well as chemical properties (it is not attacked by solvents, organic oils and fuels) recommend it for the manufacture of industrial fittings and the automobile industry.

- cork/cork-rubber sheets, used for reducing vibrations in electrical transformers;
- thermal and sound insulating products used in construction (Kromston, 2013).

In construction, cork is used as natural cork granules and expanded cork granules. Cork baked sheets are made of pure expanded cork, bonded with an adequate resin. Pressed cork with binders, plain pressed cork or pitch-impregnated cork are more rarely used for insulation (100% Construct, 2013).

The preferred use areas are exterior and interior walls, non-heated rooms, inclined or flat roofs, floors, ceilings, ventilation channels, cork parquet floors. Cork residues are used as filling material for roofs, ceilings and floors (100% Construct, 2013).

Cork accumulates ten times more heat than mineral fiber insulating materials. It is relatively highly insensitive to the influence of humidity. The material is resistant and has a high elasticity. Cork is resistant to insects (except wasps) and fungi (100% Construct, 2013).

The production technology does not affect the product itself, but allows to obtain a material with very good thermal and sound insulating properties, which is antibacterial (it does not allow the development of fungi, mould), antiallergenic, fire resistant and antistatic. In fact, there are two types of cork that are used in the construction industry as thermal insulating materials (Thermal insulating materials, 2013).

Granulated cork (agglomerated cork) is an extremely stable product during stretching and compression, it does not absorb water and does not decay, it is vapor-impermeable and has a low flammability. It can also be supplied as rolls or sheets, depending on the site where it is used (Thermal insulating materials, 2013).

Cork waste resulting from various technological processes can be and is used for the manufacture of products such as expanded cork.

Expanded cork (black cork) is a product obtained from the recycling of cork waste and has the same properties as granulated cork. It is used as thermal or sound insulation for floors, facades, roofs (Thermal insulating materials, 2013).

Cork waste recycling is part of another important objective, that of effective waste management.

Like cork waste, sawdust resulting in very high amounts from various wood processing technologies can be effectively recycled in various fields either as a main material or as an added component part of a newly created material.

Such materials are: laminated chipboards, sawdust briquettes, sawdust boards, wall panels made of sawdust, sand and cement, sawdust mortars.

Like cork, sawdust is a good thermal and sound insulator, which recommends it for the manufacture of thermal and sound insulating materials.

The research on the use of cork and sawdust waste for obtaining ecological mortar fits in this context.

MATERIALS AND METHODS

The materials used as part of the research on the manufacture of ecological mortar are: cement, water, and two aggregate mixtures (a sand and cork granule mixture and a sand and sawdust mixture).

For the experimental part, Portland cement 42.5 and 0-4 mm sand were used, according to the recipes presented in Tab. 1.

The table shows that for the study on the influence of cork granules or sawdust on the physico-mechanical characteristics of plastering mortars, 53% of the sand amount used for standard mortar was replaced by cork granules or sawdust.

Tab. 1

Mortar recipes

Recipe	Cement 42,5 [m^3]	Sand (0-4) [m^3]	Water [m^3]	Cork [m^3]	Sawdust [m^3]
Standard mortar	0.13	0.57	0.3	-	-
Mortar with cork granules	0.13	0.27	0.3	0.3	-
Mortar with sawdust	0.13	0.27	0.3	-	0.3

The method for the production of cork waste mortar and sawdust mortar consists of the following:

- preparation of waste:
  - cork waste was ground so as to obtain a 0-4 mm granularity range;
  - because sawdust contains considerable amounts of water-soluble impurities that delay hydration and hardening of the cement paste, their neutralization is required by physico-chemical treatments. For this reason, sawdust was pretreated by water soaking and washing before mixing, in order to make sure that the auxiliary materials in the sawdust would not affect the hardening of mortar.
- weighing of the materials;
- homogenization of the component materials with the mixer;
- casting of test samples (4x4x16 cm prisms and cubes with a 7 cm side length).

Physico-mechanical, fire behavior and acoustic determinations were performed after 28 days in the cast test samples, stored according to standards during this period.

Experimental determinations regarding the improvement of the impact sound insulation capacity were performed according to the international Standard ISO 140-7, which describes the procedure for measuring sound impact for the establishment of the insulation value in various materials used for flooring (SR EN ISO 140-7, 2005).

The acoustic chain (Fig. 1) used for acoustic measurements is manufactured by the Danish company ”Bruel & Kjaer Sound and Vibration Measurement” and is composed of:

- “PULSE 3560B” sound analzyer;
- “FFT & CPB Analysis 7700” analysis software for PULSE;
- “OmniPower Sound Source 4292” omnidirectional sound source;
- “Power Amplifier 2716” power amplifier;
- “Microphone 4189” microphone (Bruel & Kjaer, 2013).

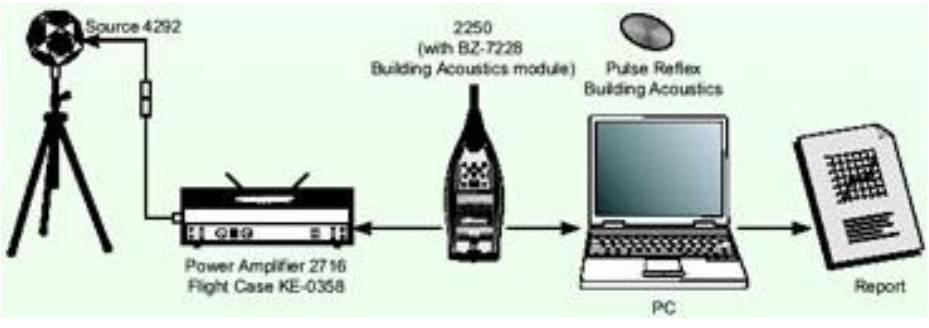

Fig. 1. The acoustic chain (Bruel and Kjaer, 2013)

The impact sound insulation improvement index ΔLw was calculated according to the methodology presented in C125-05 "Norm regarding the design and execution of sound insulation measures and acoustic treatments in buildings " (C 125-05, 2005).

RESULTS AND DISCUSSIONS

The determinations of the physico-mechanical characteristics were performed in 6 test samples according to standards in force, using the equipment of the Building Materials Laboratory of the Faculty of Civil Engineering in Cluj-Napoca.

The following physico-mechanical characteristics were determined: bending and compressive strength, water absorption by capillarity, the impact sound insulation improvement index, and fire behavior.

The results presented are the mean values obtained in the 6 test samples subjected to determinations.

The results obtained regarding compressive strength are shown in Fig. 2.

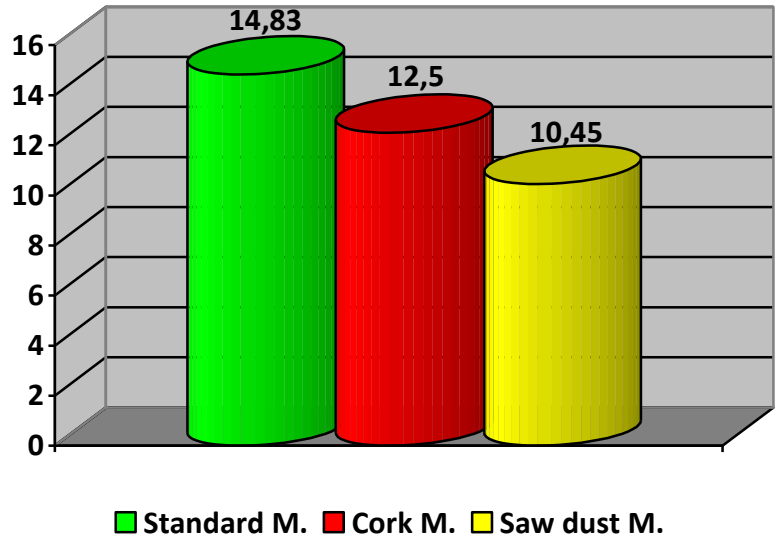

Fig. 2. Compressive strength [N/mm^2]

From Fig. 2 it can be seen that compressive strength decreases in the case of cork granule mortar to 12.5 N/mm^2, which represents a 16% decrease, while in the case of sawdust mortar, values decrease to 10.45 N/mm^2, representing a 30% decrease compared to standard mortar.

However, from the standpoint of plastering mortars, the studied mortars belong to the same class CS IV as standard mortar, while from the point of view of masonry mortars, cork granule mortar belongs to class M12.5 and sawdust mortar to class M10.

Fig. 3 shows a decrease in bending strength, like in the case of compressive strength. The bending strength of cork granule mortar is reduced by 6.2% compared to standard mortar and that of sawdust mortar, by 5.8%.

The higher bending strength of sawdust mortar compared to the bending strength of cork granule mortar can be explained by the water absorbing property of sawdust, which allows a better hydration and hardening of the cement paste.

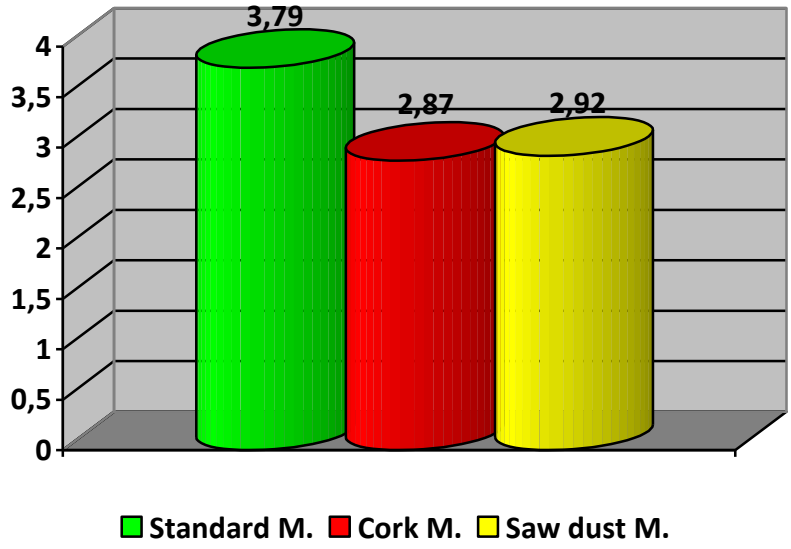

Fig. 3. Bending strength [N/mm^2]

The determination of water absorption by capillarity revealed the following mean coefficients of water absorption due to capillary action: 0.4 Kg/(m^2 x min$^{0.5}$) for cork granule mortar, and 0.71 Kg/(m^2 x min$^{0.5}$) for sawdust mortar compared to standard mortar 0.48 Kg/(m^2 x min$^{0.5}$).

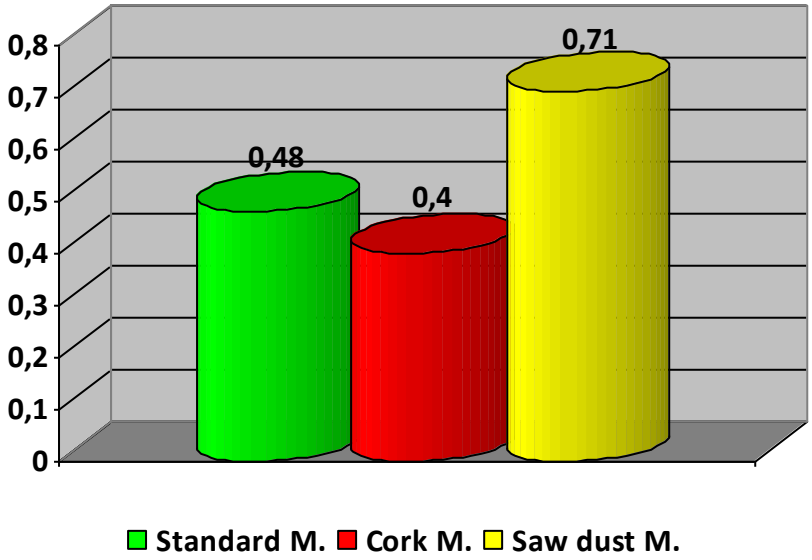

Fig. 4. Water absorption by capillarity [Kg/(m^2 x min$^{0.5}$)]

Thus, from the point of view of water absorption by capillarity, cork granule mortar can be assigned to class W1, while sawdust mortar and standard mortar are categorized as class W0. It can be concluded that from this viewpoint, cork granule mortar is the best.

The explanation for assigning cork granule mortar to class W1 is due to the water non-absorbing property of cork granules. In contrast, in the case of sawdust mortar, due to the water absorbing property of sawdust, the mean water absorption coefficient increases considerably (by 48%) compared to standard mortar.

The impact sound insulation improvement index ΔLw was calculated according to the methodology presented in C125-05 "Norm regarding the design and execution of sound insulation measures and acoustic treatments in buildings ", in relation to the insulation index for 16 cm thick reinforced concrete floors (C 125-05, 2005).

The obtained values are shown in the diagram of Fig. 5.

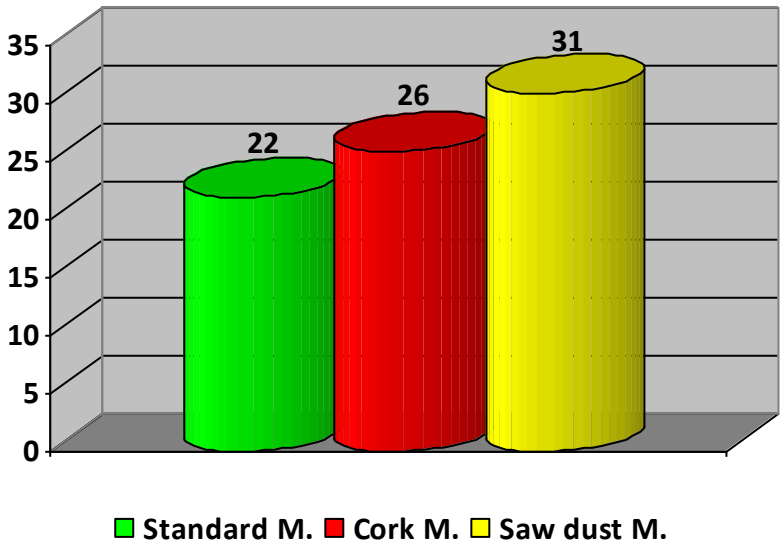

Fig. 5. The impact sound insulation improvement index

The diagram of Fig. 4 evidences a significant increase in the impact sound insulation improvement index compared to the same index for standard mortar:

- the impact sound insulation improvement index of cork granule mortar increases by 18%;
- the impact sound insulation improvement index of sawdust mortar increases by 41%.

From this point of view, sawdust mortar is superior to cork granule mortar.

The analysis of the fire behavior of mortars was performed by exposing a surface of the test samples to the open flame of a gas burner. The action of the flame was maintained continuously throughout the 300 second period of the test (Fig. 6).

Fig. 6. Fire behavior of the mortar

During this time period, there were no significantly different phenomena regarding the fire behavior of the two types of mortars.

Regarding the fire behavior of cork granule mortar as well as sawdust mortar in direct contact with the flame, the following were found:

- in the first phase, in the contact area of the flame with the test sample surface, a strong heating up to incandescence was noted, without the presence of an open flame or smoke emissions;
- in the second phase, after approximately 60 seconds, both the cork granules and the sawdust granules at the surface of the test samples were carbonized;
- by maintaining the flame in the same position for up to 300 seconds, it was seen that burning did not cause distortions of the surface or detachments of the material, on the contrary, the burning and carbonization of cork and sawdust granules was stopped by the previously carbonized layer;
- by placing the hand on the surface opposite to the action of the flame, at the end of the 300 seconds, it was found that the heating of this surface was imperceptible by the human body, which demonstrates that the materials are good thermal insulators.

CONCLUSION

The study led to the manufacture of two new ecological types of mortar: cork granule mortar and sawdust mortar, which involves the recycling of the mentioned waste as aggregates.

The two types of mortar manufactured according to the adopted recipes replace more than 50% of the classical aggregate, sand.

The technology for the manufacture of these mortars does not pose particular problems, being in conformity with the manufacturing technology of classical mortars.

Based on their physico-mechanical characteristics, these are categorized as follows:

- from the point of view of plastering mortars, the studied mortars belong to the same class as standard mortar, CS IV;
- from the point of view of masonry mortars, cork granule mortar is assigned to class M12.5 and sawdust mortar, to class M10.

The comparative study of the two types of mortar shows that sawdust mortar is inferior to cork granule mortar regarding the water absorbing capacity by capillarity.

On the other hand, due to its water absorbing property, sawdust does not allow the rapid drying of mortar, which prevents the appearance of cracks.

A very important characteristic of both types of mortar is the sound and thermal insulation capacity.

Regarding sound insulation, the impact sound insulation improvement index of cork granule mortar increases by 18% compared to that of standard mortar and the impact sound insulation improvement index of sawdust mortar increases by 41% compared to standard mortar.

The experiments regarding the fire behavior of mortars show that they pose no open flame ignition risk and have a high degree of thermal insulation.

The resulting mortars can be successfully used for the improvement of thermal and sound insulation capacity both as plastering mortars and masonry mortars.

REFERENCES

1. 100% Construct, Ecological thermal insulation, simplicity of composition, <http://www.100construct.ro/index.php?section=detalii-articol&id=434&cat_id=76>, last accessed 7 September 2013.
2. Bruel & Kjaer, 2250 & 2270 Based Building Acoustics System, <http://www.bksv.com/products/analysis-software/acoustics/building-acoustics/building acoustics.aspx>, last accessed 7 September 2013.
3. C 125-05. (2005). Norms related to the design and implementation of sound insulation measures and of sound treatments in buildings.
4. Kromston, Cork for insulation, last accessed 7 September 2013, <http://www.kromston.ro/produse/Categories-Tree/35-Pluta-pentru-izolatii>.
5. Naturo-kork, Cork producer and distributor, last accessed 7 September 2013, <http://www.naturo-kork.hu/dopuri.html>.
6. Saghafi, M.D. and Teshnizi, Z.S.H. (2011). Recycling value of building materials in building assessment systems. Energy and Buildings. 43:3181-3188.
7. SR EN ISO 140-7. (2005). Acoustics – Measurements of sound insulation in buildings and of buildings elements – Part 7: Field measurements of impact sound insulation of floors, ASRO.
8. Thermal insulating materials, Cork thermal insulation, last accessed 7 September 2013, <http://www.spatiulconstruit.ro/compendiu/materiale-termoizolante-object_id=23>.
9. Thormark, C. (2006). The effect of material choice on the total energy need and recycling potential of a building. Building and Environment. 41:1019-1026.