

## SUSTAINABLE INSULATION COMPOSITE PLASTERBOARD SOLUTION – ACOUSTIC LABORATORIAL CHARACTERIZATION

José Ávila e Sousa<sup>1</sup>, Dulce Carvalho<sup>2</sup> and Paulo Amado-Mendes<sup>3,4</sup>

1: Grupo Preceram

Travasso, Apt. 31; 3101-901 Pombal, Portugal  
e-mail: avila@preceram.pt, web: www.preceram.pt

2: Gyptec Ibérica

Parque Industrial. Lote 3; 3090-380 Figueira da Foz, Portugal  
e-mail: dulce.carvalho@gyptec.eu, web: www.gyptec.eu

3: CICC, Dep. Civil Engineering, University of Coimbra

Rua Luís Reis Santos; 3030-788 Coimbra, Portugal  
web: www.dec.uc.pt

4: ITeCons

Rua Pedro Hispano, s/n; 3030-289 Coimbra, Portugal  
e-mail: pamendes@itecons.uc.pt web: www.itecons.uc.pt

**Keywords:** Gypsum, plasterboard, expanded insulation corkboard, acoustic performance, refurbishment of existing buildings

**Abstract** *There is a large number of degraded buildings without minimum conditions of habitability. It is urgent to promote their rehabilitation, associated with good performance in terms of insulation, and to invest in comfortable buildings with low energy consumption. In this context, due to its adaptability, ease of application and performance, interior insulation systems are highly recommended as very competitive and efficient solutions. In parallel, we face an increased consumer demand for solving acoustic problems, which often severely affect the quality of life of building occupants.*

*Aiming in contributing to a sustainable solution, Gyptec Ibérica developed, in close collaboration with Amorim Isolamentos, the GYPCORK composite board. This product combines the properties of cork (thermal, acoustic and anti-vibration insulation, high thermal inertia, unlimited durability, dimensional stability and good fire behaviour) with those of gypsum plasterboards (acoustic insulation, low thermal conductivity, moisture regulator, incombustible and effective as fire barriers, durable and impact resistant). The main goal was to achieve a simple to apply, unique panel that could contribute to efficiently address and resolve the above mentioned issues.*

*In this work, we present a summary of the R&D work done in close collaboration with ITeCons, focusing on the acoustic results obtained in an extensive experimental campaign. On the whole project it was possible to show the suitability of GYPCORK composite board for use in hygrothermal and acoustic refurbishment of building walls and ceilings, and a guide of best practices for its implementation was also developed.*

## 1. INTRODUCTION

There is nowadays a clear investment in the renovation and refurbishment of buildings, mainly in urban centres of major cities, often associated with the change of building uses, from residential to hotel purposes.

Besides the need for compliance with the various applicable national regulations, namely regarding thermal and acoustic performances of buildings, there is a growing demand for comfort and energy savings by consumers.

In fact, much of the building renovation that has been done in the last years has been mostly aesthetic and sometimes focused on the thermal characteristics, making use of building materials or building solutions that present no added value to the acoustic performance of dwellings.

The portuguese plasterboard producer Gyptec Ibérica, in collaboration with ITeCons, has been developing and studying different multilayer solutions for sustainable construction and refurbishment, making use of Portuguese products. In the scope of an R&D project, the GYPCORK composite board was developed and extensively tested, as part of a building solution that would improve the thermal and acoustic behaviors of existing masonry walls.

In a large number of buildings constructed in Portugal, in recent decades, lightweight voided slabs with pre-stressed t-beams and ceramic vaults have been extensively adopted. As it is quite well-known and documented through complaints from building users, these constructive solutions exhibit a very poor acoustic behaviour, in terms of airborne noise insulation and, in particular, in terms of impact sound reduction., The main objective of the present work was to develop and validate drywall coating solutions, integrating GYPCORK composite board (Fig. 1), that try to solve efficiently these issues.

## 2. GYPCORK BOARD

Laminate gypsum boards correspond to an excellent building refurbishment product due to their quick, silent and clean application. In fact, when it can be adopted in this type of works, there is very little waste and, after its installation, it only reduces a small amount of living space. Gypsum boards also respond to one of the major needs in today's renovation projects: the increase of thermal and acoustic insulation of existing buildings.



Figure 1: GYPCORK board.

The GYPCORK insulating board is a multilayer (pre-assembled) construction solution, composed by Gyptec laminated plasterboard and expanded cork agglomerate (ICB). In its manufacturing process sustainable by-products are used and the composite board exhibits high thermal e acoustic properties. [1]

## 2.1. Gyptec gypsum plasterboards

Gyptec Ibérica - Gessos Técnicos, S.A. is the only Portuguese company that produces high quality certified gypsum boards with enhanced thermal and acoustic performances.

The company seeks sustainability at all levels, whether economic, social or environmental. With the use of raw materials such as recycled paper and FGD gypsum, a by-product of power plants in Portugal, Gyptec Ibérica avoids the mining of gypsum, thus contributing to the preservation of natural resources. [2]

Gyptec gypsum board is manufactured in accordance with the European Standard EN 520:2004+A1:2009 “Gypsum plasterboards. Definitions, requirements and test methods.” and the composite laminated gypsum board with incorporated thermal and acoustic insulations comply with European Standard EN 13950:2005 “Gypsum plasterboard thermal/acoustic insulation composite panels. Definitions, requirements and test methods.” and EN 14190:2005 “Gypsum plasterboard products from reprocessing. Definitions, requirements and test methods.”. Gyptec Ibérica has implemented and maintains a Quality Management System certified by AENOR - Spanish Association for Standardisation and Certification and exhibits the [N] AENOR Product Certificate.

The main features of the Gyptec gypsum product can be summarised as follows:

- Acoustic insulation;
- Low thermal conductivity;
- Moisture regulator;
- Incombustible and effective fire barrier;
- Durability and impact resistance;
- Versatility and adaptability to all kinds of coatings;
- It is recyclable.

## 2.2. Expanded Cork Agglomerate (ICB – “Insulation Cork Board”)

Cork is the bark of the cork oak (*Quercus Suber L.*), which means that it is a 100% natural plant tissue. It is formed by a honeycomb of microscopic cells filled with a gas similar to the air. A single cubic centimetre of cork includes almost 40 million of cells, arranged perpendicularly to the trunk of the cork oak.

The expanded cork agglomerate (ICB – “Insulation Cork Board”) is a 100% ecological and recyclable product, made from a renewable raw material. It is important to notice that the bark extraction from the cork oak tree is part of its natural and continuous life cycle. In its manufacturing process, only cork granules are used, and when they are subject under pressure to a thermal process, suberin resin is released, which acts as a natural binder [3].

Some of the ICB main features can now be referred:

- Thermal conductivity from 0,036 to 0,040 W/(m.°C);
- It promotes thermal lag;
- Excellent acoustic insulation;
- Excellent fire behaviour, since it does not release toxic gases;
- It is recyclable;
- It is not susceptible to rodent attacks.

### 3. CHARACTERISTICS OF THE COMPOSITE SOLUTION

The GYPCORK boards are manufactured strictly following the criteria defined in European Standard EN 14190:2005 “Gypsum plasterboard products from reprocessing. Definitions, requirements and test methods”. This standard specifies the characteristics and performance of composite panels of laminated plasterboard (subject to European Standard EN 520), through secondary processes.

The processing operation by a secondary process, that generates the new GYPCORK composite board, involves the bonding of the expanded cork agglomerate produced by Amorim Isolamentos, onto the reverse side of the Gyptec laminated plasterboard. Nevertheless, whenever necessary and specific uses are expected for the composite boards, the above mentioned European standard also states the additional technical features that are important for the use and acceptance of the product in the construction industry, as well as the reference test methods. Considering the expected use for GYPCORK composite boards, the applicable requirements include verifying the bending strength, which can be expressed as the bending stress load of the laminated plasterboards used to manufacture the GYPCORK board, and determining their thermal resistance and acoustic insulation properties [1]. Some of the technical characteristics of GYPCORK boards can be referred on Table 1, for two possible configurations.

<i>Characteristic</i>	<i>ICB 13-40</i>	<i>ICB 13-60</i>
Thickness ( $\pm 0,5$ mm)	52,5	72,5
Width (+0/-4 mm)	1200	1200
Length (+0/-5 mm)	2000/ 2400	2000/ 2400
Weight ( $\pm 5\%$ kg/m <sup>2</sup> )	11,1	13,1
Flexural strength, Longitudinal / Transverse (N)>	550 / 210	550 / 210
Thermal resistance (m <sup>2</sup> .K/W)	1,05	1,55

Table 1. Geometrical, mechanical and physical characteristics of GYPCORK boards [4].

### 4. ACOUSTIC PERFORMANCE

As part of the study of multilayer constructive solutions, developed in cooperation with the Research and Technological Development Institute for Construction Sciences (ITeCons), a series of acoustic tests was programmed and performed. The main idea was to understand the contribution of the composite laminated plasterboard with insulation made up of expanded cork agglomerate (ICB), towards a possible solution for refurbishment, renovation and functional improvement of existing buildings.

#### 4.1. Wall application

Two walls were assembled in the laboratory, presenting typologies that reflect the most common construction methods used in Portugal over the past 30 years, and that could be interesting trying to improve. The first wall corresponds to a simple masonry wall with 22cm hollow ceramic bricks and the second solution to a double panel wall using 11cm +15cm ceramic bricks, with no insulation in the air cavity.

These base walls were tested in the horizontal acoustic chambers of ITeCons in order to characterize the standard airborne noise reduction curve and the weighted sound reduction index  $R_w$ , according to standards EN ISO 10140-3 and ISO 717-1.

In a second phase, having in mind the improvement of those reference walls, some coating insulation solutions incorporating GYPCORK boards were applied (Fig. 2) and the refurbished walls were then re-tested in the laboratory acoustic chambers. The best practices usually recommended were followed when applying the prescribed solutions [5].



Figure 2: Application of the GYPCORK board.

The results obtained in the airborne insulation acoustic tests [6] are presented in comparative graphs in Figs. 3 and 4. In both cases, a substantial increase in the airborne noise insulation was achieved after applying the composite GYPCORK solution with 4 cm of expanded cork agglomerate, ICB.

In the case of the simple masonry 22cm brick wall, the airborne reduction index rose from  $R_w = 47$  dB to 56 dB when applying the GYPCORK composite solution. After placing an additional laminated gypsum board, the sound reduction index went up to an interesting value 59 dB. Moreover, the acoustical behaviour of the existing wall was significantly improved along the frequency range, above 125 Hz.

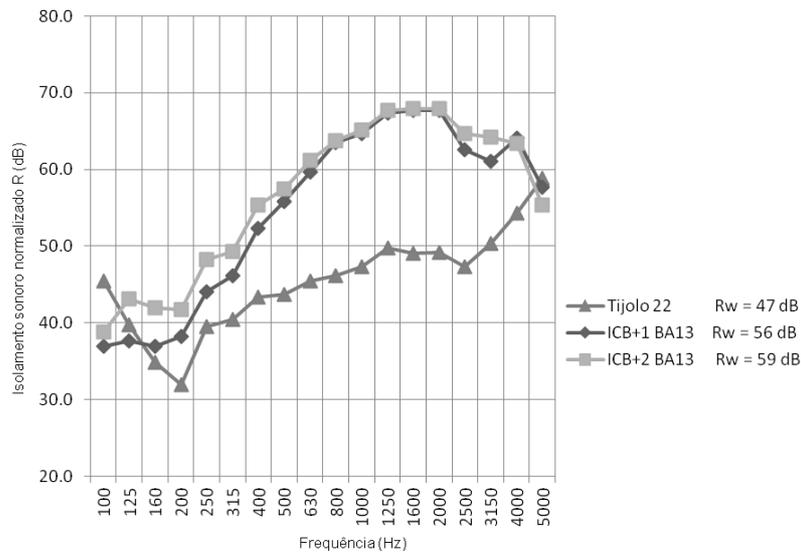


Figure 3: Airborne sound insulation of the reference wall (simple masonry brick wall with 22cm) and acoustical improvements with GYPCORK solutions.

In the second case, with the reference wall the cavity wall (11cm+15cm ceramic bricks), the acoustic gains are quite similar. The airborne sound reduction  $R_w$  index rose from 52 dB to 59 dB, and by placing a second gypsum board, the same index went up to 61 dB.

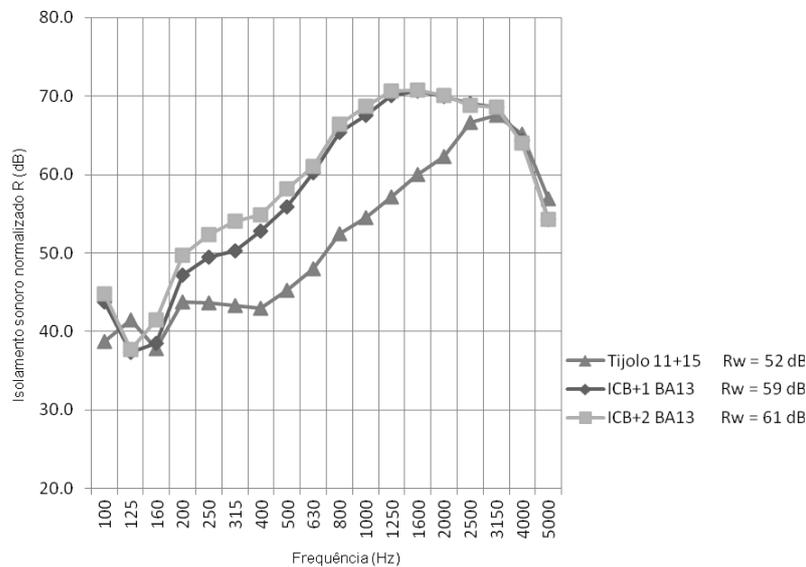


Figure 4: Airborne sound insulation of the reference wall (cavity wall 11cm+15cm ceramic bricks) and acoustical improvements with GYPCORK solutions.

#### 4.2. Ceiling application

Furthermore, the acoustic behaviour of the GYPCORK composite boards was analysed when applied as ceiling insulation reinforcement solutions. The acoustic tests were, in this

case, performed in the vertical acoustic chambers at ITeCons laboratory, in order to evaluate the airborne noise reduction index  $R_w$  and the impact noise insulation index  $L_{n,w}$ .

The reference floor solution was built using a 20 cm lightweight voided slab, composed of pre-stressed T beams, infill ceramic hollow blocks, and a 5 cm compression layer of concrete with wire mesh.

The choice for this type of slab, though it is not a standardized “reference” floor, is intended to be representative of the most common building method used in the last decades in Portuguese residential sector, and which known to be acoustically deficient.

In order to simulate the application of a floor improvement, under this slab a suspended ceiling was built, according to the best practice explained in the Technical Drywall Installation Guide [5].

The laboratory test campaign was very extensive with a wide range of technical solutions being tested. Table 2 and Figs. 5-6 show some of the comparative results obtained using suspended ceilings with gypsum boards and mineral wool, and with GYPCORK [7, 8].

<i>Solution tested</i>	<i>Airborne noise - <math>R_w</math></i>	<i>Impact noise - <math>L_{n,w}</math></i>
Base solution – Lightweight voided slab (ACL323A/13)	45 dB	95 dB
Single gypsum board BA13 with mineral wool (ACL376A/13)	63 dB	64 dB
Two gypsum boards BA13 with mineral wool (ACL378A/13)	67 dB	60 dB
GYPCORK board 13-40 (ACL382A/13)	64 dB	69 dB

Table 2. Lightweight voided slab and ceiling reinforcement. Laboratory acoustic insulation test results.



Figure 5: Airborne noise insulation results with different ceiling solutions: single gypsum board BA13 (ACL376A/13) vs two gypsum boards BA13 (ACL378A/13) vs GYPCORK board (ACL382A/13).

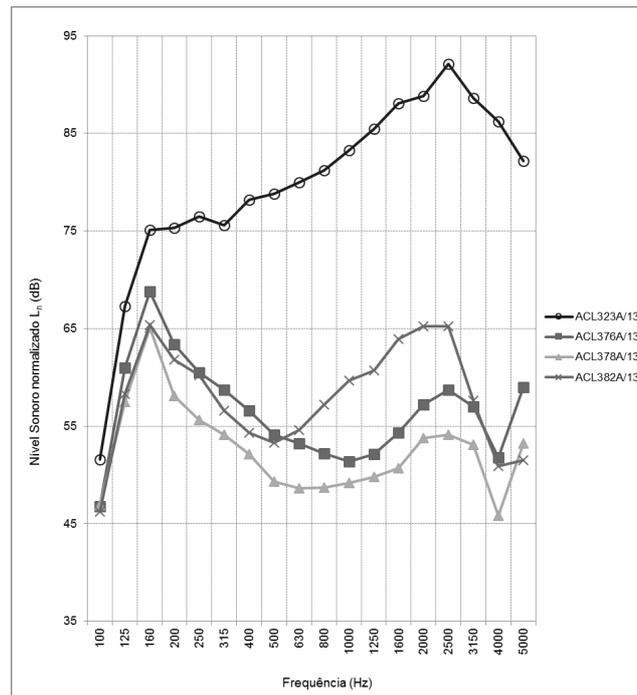


Figure 6: Impact noise level results with different ceiling solutions : single gypsum board BA13 (ACL376A/13) vs two gypsum boards BA13 (ACL378A/13) vs GYPCORK board (ACL382A/13).

From the presented results, it is possible to confirm that the lightweight voided slab, as a base floor solution, is acoustically very deficient, both to airborne and impact noise.

Regarding the airborne noise insulation, there is a clear acoustic improvement in the analysed frequency range, when ceiling insulation is applied to the reference slab solution. The  $R_w$  index increased up to 19 dB, for the tests in which GYPCORK board was used.

For the impact noise levels, it may be observed that suspended ceilings under the slab improve considerably along the tested frequency range, thus revealing a reduction of up to 26 dB, in the case of a ceiling with GYPCORK board.

However, it is worth mentioning that these acoustic results can still be improved under normal circumstances, since the floor compositions tested in laboratory did not have the final floor finishing/coating, which must be applied over the concrete compression layer.

For this reason, a lightweight screed using Argex expanded clay was applied over a resilient under screed produced by Amorim Cork Composites. Table 3 and graphics in Figs. 7-8 illustrate some of the laboratory test results with lightweight screed.

<i>Solution tested</i>	<i>Airborne noise - <math>R_w</math></i>	<i>Impact noise - <math>L_{n,w}</math></i>
Base solution – Lightweight voided slab (ACL323A/13)	45 dB	95 dB
Voided slab and lightweight screed (ACL013A/14)	56 dB	57 dB
Lightweight screed and GYPCORK board (ACL037A/14)	70 dB	43 dB

Table 3. Lightweight voided slab with screed. Laboratory acoustic insulation test results.

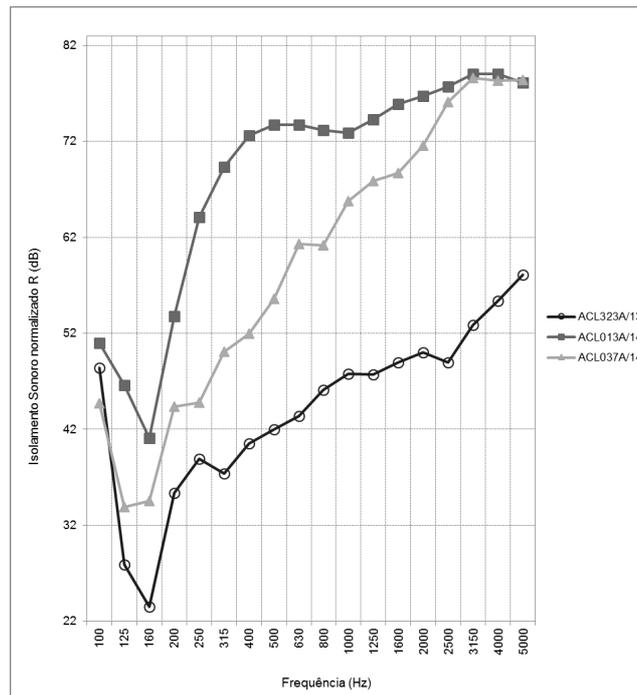


Figure 7: Airborne noise insulation results with voided slab and lightweight screed (ACL013A/14) vs lightweight screed and GYPCORK board (ACL037A/14).

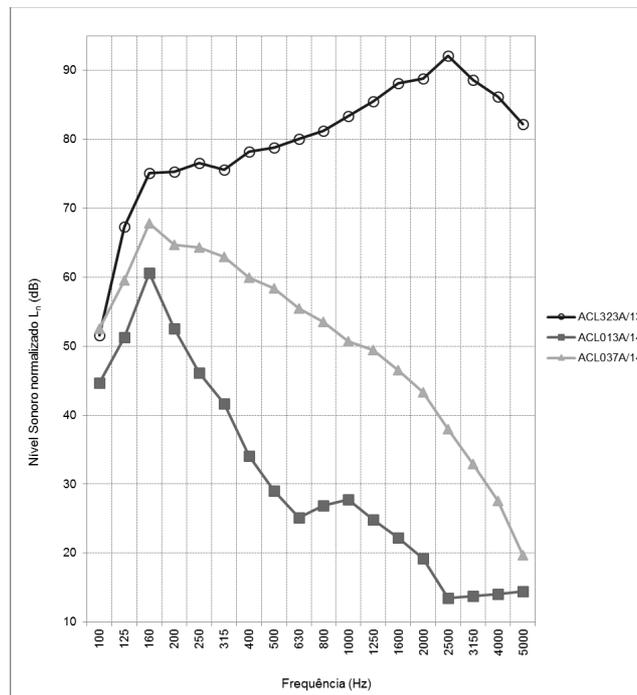


Figure 8: Impact noise level results with voided slab and lightweight screed (ACL013A/14) vs lightweight screed and GYPCORK board (ACL037A/14).

The observed results correspond to major improvements in the acoustic performance of the floor system (in terms of airborne and impact sound), achieving levels that can be considered as very good for any type of usage, namely the residential or commercial ones.

## 5. CONCLUSIONS

In the present work, the acoustic performance of a number of refurbishment solutions (wall coatings and ceilings) incorporating the GYPCORK composite board was analysed, following R&D cooperation work and a set of laboratorial normalized acoustic tests.

The results achieved in the extensive test campaign confirm that GYPCORK is a high value solution that can be used in solving some acoustic deficiencies currently found in Portuguese residential buildings that were built in the last decades.

Furthermore, the joint application of a suspended ceiling using GYPCORK board and lightweight Argex screed resulted in a high standard acoustic comfort level, being a possible specific constructive solution for the upmarket residential and hotel segments.

The main goal has been achieved, by producing a unique composite board that is easily installed, that contributes to better acoustic and hygrothermal conditions and that promotes energy savings.

GYPCORK, containing low level energy products and being produced using strict sustainable criteria, is a major advantage in obtaining credits in green building certification such as the British BREAM, the North American LEED or the Portuguese LiderA.

## REFERENCES

- [1] J. Ávila e Sousa, M. Rocha, D. Carvalho, “Nova placa composta de gesso laminado com isolamento incorporado em aglomerado de cortiça expandida”, in Proceedings of CINCOS’12, 2012.
- [2] “Casos de Excelência de Práticas Ambientais e de Eficiência e Racionalização Energéticas nas Empresas Portuguesas”, AEP, 2011.
- [3] Technical document: Aglomerado de Cortiça Expandida (ICB - Insulation Cork Board), Amorim Isolamentos, SA, s.d.
- [4] Technical Data Sheet Gypcork, Gyptec Ibérica – Gessos Técnicos, SA, 2014.
- [5] Technical Drywall Installation Guide (RCT066/13) [in portuguese], ITeCons, 2013.
- [6] Test reports ACU254, ACU255, ACU260, ACU261, ITeCons, 2011.
- [7] Test reports for samples with reference ACL323A, ACL376A, ACL378A, ACL382A, ITeCons, 2013.
- [8] Test reports for samples with reference ACL013A, ACL035A, ITeCons, 2014.