ABSTRACT
The acoustical quality of dwellings in Spain was guaranteed up to now with the compliance of the building regulation NBE-CA88. This regulation established laboratory requirements for each construction element depending on its use (for example 45 dBA in the case of separating or partition walls). However, the new Spanish Building Regulation (CTE DB-HR, last draft version [1]) will consider the whole building as a product itself (performance-based-regulation). In situ measurements could be performed to verify that the building complies with the acoustic quality requirements; the acoustic requirements are stronger: 50 dBA for in-situ separating or partition walls.

With the goal of meeting the new sound insulation requirements, LABEIN in collaboration with CSTB is working on the optimization of ceramic brick double walls with peripheral resilient layers, to be used to separate dwellings. Different alternatives of materials to use as resilient layers are being studied. In addition, the effects of other characteristics directly related to brick double walls (such as the type of brick, the brick thickness, the cavity thickness, the type of absorbent material placed in the cavity, etc.) on the acoustic performance are also investigated.

INTRODUCTION
As a result of the mentioned regulation changes, analyses from databases of the acoustic behaviour of the materials were performed, and the following conclusion was reached: it is necessary to work on the improvement of the acoustic performance of products of construction for the fulfillment of the CTE requirements. The improvement is necessary for a large number of building elements; masonry walls being among them.

Following these observations, the Spanish Association of bricks manufacturers HISPALYT started a line of investigation in 2003 with the object of developing constructive solutions with high acoustic performance. The solutions to be developed should not be associated to an increase of costs, nor an overload to the structures of the buildings, and should conserve other inherent qualities of ceramic brick constructions, such as the security against invaders, the thermal inertia of the walls, or the absence of acoustic problems associated to piping systems for different equipments [2]. The result has been the development of a new constructive systems in Spain named SILENSIS [3], with high sound insulation performance.

Among the elements developed in SILENSIS, the ceramic double walls built with an absorbing material in their cavity and resilient layers along their periphery (figure 1) are included. These ceramic double walls have been analyzed in laboratory and satisfactory results have been obtained in terms of acoustic performance: global index RA between 54 and 63 dBA [3] has been reached (the differences with respect to the regular double walls in Spain, without resilient layers, is about 10 - 15 dBA). In view of the good results, this double brick wall system was implemented in real buildings, and in situ sound insulations between 50 and 56 dBA were measured [3]. These values fulfill the established CTE requirements.
The following part of the investigation is focussed on the optimization of these walls. To this end, the IETcc Institute Eduardo Torroja of the Construction, CSTB and HISPALYT are collaborating with LABEIN in a series of research projects described in the present paper. This research work is under development at the moment, so that more results will definitely be presented during ICA 2007 meeting.

OPTIMIZATION OF CERAMIC BRICK DOUBLE WALLS STUDY

Once the validity of ceramic brick double walls with peripheral resilient layers for the fulfilment of the new requirements has been proven, its optimization on the basis of the specific necessities of sound insulation, space and thickness, economic aspects, etc. has been considered of interest.

Since these double walls are new building elements in Spain, not much information about their behaviour is available. In this study, their behaviour considering different products to be used as resilient layers is being analyzed (Phase I), and as well as other aspects related to brick double walls: such as the influence of type and thickness of brick wall, the cavity thickness, the type of absorbent material placed in the cavity, etc... are being evaluated (Phase II).

PHASE I: ALTERNATIVE MATERIALS TO USE AS RESILIENT LAYERS

The resilient layers used with the purpose of reducing sound transmission associated to the flanking path in double walls can be constituted by different materials. It is the case with experiences carried out in several European countries, like France and Belgium, where the use of rubber layers for ceramic partitions is common [4]. Also other materials as some types of cork have been proven successfully.

Up to now, two types of products have been used in Spain as resilient layer: elastified polystyrene (EEPS) and rubber. The results obtained with EEPS have been quite good, whereas those obtained with rubber have not been very satisfactory.

With the purpose of being able to offer new alternatives as resilient layers, some products have been selected. This selection has been made considering some criteria: existing materials in the market that display favourable acoustic benefits, usability, accessibility, affordability, etc. Finally three products have been considered of interest. They present different composition: ethafoam, cork, and a mix of polyethylene and rubber (figure 2). The EEPS is also included in this investigation, since much information relative to the behaviour of this material in double brick wall system is available; this material constitutes the reference material of this work.
The main parameter that can provide information about the validity of a resilient material to be used along the wall periphery is the dynamic stiffness ($s'$). CSTB laboratory has performed the dynamic stiffness measurements following the European Standard ISO 9052-1 [5]. The Standard recommends a loading mass of 8 kg; however, since this mass does not represent at all the mass of a brick wall resting on the resilient layer (from 50 to 150 kg/m² for pieces manufactured in Spain), two other loading masses were considered. The 8 kg loading mass was applied to a 20x20 cm² sample, while the 21 and 51 kg loading mass to a 6x20 cm² sample.

The measurement results are presented in Table I. The selected resilient layers have a nominal thickness of 10 mm. An example of the experimental setup is shown in Figure 3.

![Figure 3.-Experimental setup to measure the dynamic stiffness](image)

Table I.- Averaged dynamic stiffness results ($s'$, MN/m³)

<table>
<thead>
<tr>
<th>Material</th>
<th>Loading mass 8 kg 20x20 cm² sample</th>
<th>Loading mass 21 kg 6x20 cm² sample</th>
<th>Loading mass 51 kg 6x20 cm² sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethafoam</td>
<td>28.36</td>
<td>88.25</td>
<td>59.78</td>
</tr>
<tr>
<td>Polyethylene and rubber</td>
<td>95.62</td>
<td>100.84</td>
<td>61.81</td>
</tr>
<tr>
<td>Cork</td>
<td>56.67</td>
<td>754.82</td>
<td>1589.53</td>
</tr>
<tr>
<td>EEPS</td>
<td>27.06</td>
<td>68.4</td>
<td>69.49</td>
</tr>
</tbody>
</table>

All the considered materials present suitable dynamic stiffness except for the cork which is too stiff under the 21 and 51 kg loading mass. This material could be more resilient if it was combined with some rubber. The ethafoam material presents good dynamic stiffness; however, the experimental setup is not quite stable due to an important decrease in thickness.
decrease in thickness is probably not acceptable for using this resilient layer along brick walls periphery. Therefore, both the cork and the ethafoam material were eliminated from possible resilient layers to be used along brick walls periphery. The product composed of a mix of polyethylene and rubber, as well as the EEPS material were then selected for further investigation, without stopping the search for other possible resilient layers.

Other characteristics of these two selected resilient layers are being evaluated: the decrease in thickness under load (CSTB), the durability (IETcc), and the fire resistance (IETcc), etc...

The acoustic performance measured in laboratory for constructed double brick walls with these new products as resilient is being studied, with the purpose of evaluating their behaviour. Tests of sound insulation following the European ISO 140-3: 1995 [6] are being performed, and the influence of the resilient material is being evaluated measuring the velocity difference between the two brick leaves composing the double wall.

**PHASE II: THEORETICAL STUDY OF DIFFERENT CERAMIC BRICK DOUBLE WALLS**

To investigate the influence of other elements of the double ceramic brick walls, sound transmission prediction is being performed. It should be noted that brick wall behaviour (in terms of acoustics and vibration) is quite complex. The acoustic prediction of hollow elements (such as brick) is still under development in Europe, and so this complicated case of double brick walls.

An approach using the acoustics prediction software CASC [7] is being investigated. This software allows to calculate sound transmission through multilayered systems from the material characteristics of the different layers. Due to the complexity of brick wall modelling, the project has been divided into two different parts: first, a preliminary investigation to validate the prediction approach, and then, if the first part is successful, the evaluation of the acoustic performance for a large number of double brick walls.

**CONCLUSIONS**

The work described in this paper is being developed at the moment, so more results will be presented and discussed during ICA 2007 meeting.

**References:**

[3] [www.silensis.es](http://www.silensis.es)