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Acoustic performance residential buildings (for example Macedonia)

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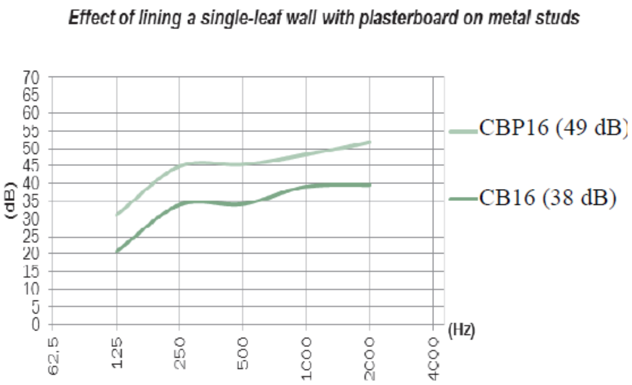
ABSTRACT



The intensity in the building construction, populous areas, traffic congestion and the numerous noise sources, especially in the urban areas, impose the need of adequate materialization of buildings that will ensure an ideally insulated living space. Best confirmation whether the partition walls meet the required value for sound insulation is the field measurement, which reflect the actual situation taking into consideration all of the imperfections of the building process and the flanking transmission of the sound. Field measurements of 18 different types of partition walls in residential buildings in Macedonia were carried out. The results are summarized in the form of conclusions, observations, and recommendations for further research in this area.

Contents

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1. Introduction

The intensity in the building construction, populous areas, traffic congestion and the numerous noise sources, especially in the urban areas, impose the need of adequate materialization of buildings that will ensure an ideally insulated living space [1-4]. The aims and objectives of this paper are: actualization of the need for providing better sound insulation, elaboration of the methods for measuring the sound insulation, solutions for sound insulation problems, as well as determination of the need for adequate legislation. In order to classify the partition elements according to the sound insulation, there are several methods for examining the sound reduction index: laboratory measurement, field measurement and calculation methods [5-7]. Best confirmation whether the partition meets the required value for sound insulation is the field measurement, which reflect the actual situation taking into consideration all of the imperfections of the building process and the flanking transmission of the sound [8, 9]. For the purposes of this study, field measurements of eighteen different types of partition walls in residential buildings in Macedonia were carried out.

2. Overview of the housing stock in Macedonia. The quantity of housing stock

The building industry and the existing housing assets present a good base for further development of the real estate market. There are 697.529 dwellings in the country, according to the 2002 census, with total area of 49.671.709 m^2, see [10]. The largest part of the dwellings, almost 94%, was built after 1945. Table 1 gives evidence that over 70% of the existing dwellings are built after the 70s and they are still in a good condition.

Table 1. Number of dwellings built after the Second World War

Period	Number of dwellings
1945–1960	73.688
1961–1970	136.418
1971–1980	181.969
1981–1990	151.434
1991–2002	118.740
Total	662.249

Approximately 60% of the total dwelling stock in Macedonia is mainly one or two storey single family detached houses. Only 2% are attached or row houses and the remaining 38% are multi-storey flats. In 2012 the number of 6433 new built homes was reached, similar as in the 2006 when the number of new housing output was 6493.

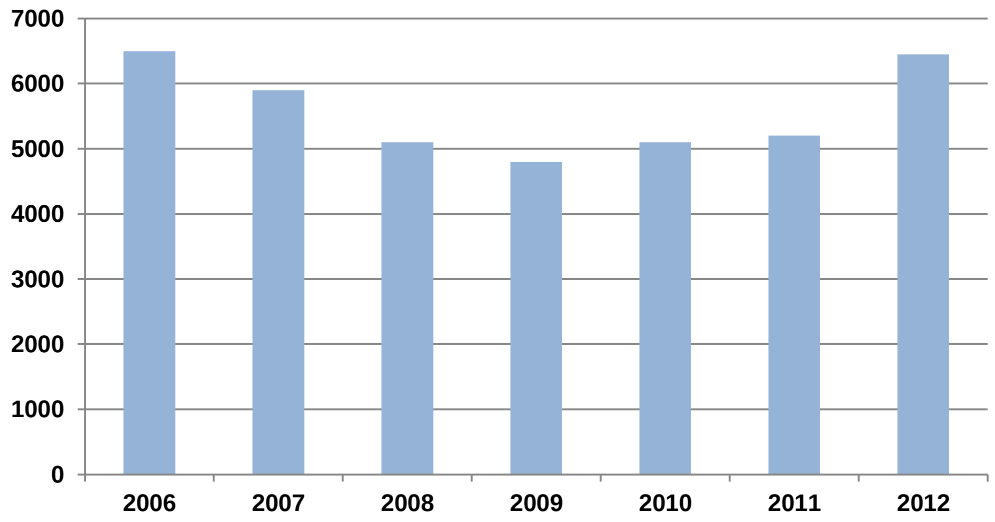


Figure 1. The typical number of new homes built per year in Macedonia Republic

Typical constructions

In the early 1970s, Macedonia survived a radical change from traditional living in single family houses into collective multi-storey family houses. New rigorous seismic regulations and building standards were introduced immediately after the 1963 earthquake. Reinforced concrete skeleton building systems with high quality were mostly used, see [10]. At that time, precast reinforced concrete heavy-panels systems and semi-fabricated light ceramic floors with fine corrugation were introduced. From the acoustics point of view, the use of massive brick wall construction and masonry does not create necessity for significant interventions in terms of noise protection. They beneficially contribute to the acoustic performance of buildings [11, 12]. The new residential buildings in Macedonia are mainly heavy constructions, composed of reinforced concrete skeleton systems with either block or brick walls or solid reinforced concrete walls, see Figure 2. The most common floors nowadays are the solid reinforced concrete slabs, or beam and block (semi – prefabricated) floors, type “Monta”. Lightweight constructions are usually used within the dwellings, as partition walls between rooms in the dwelling, see Figure 3.

Figure 2. New buildings

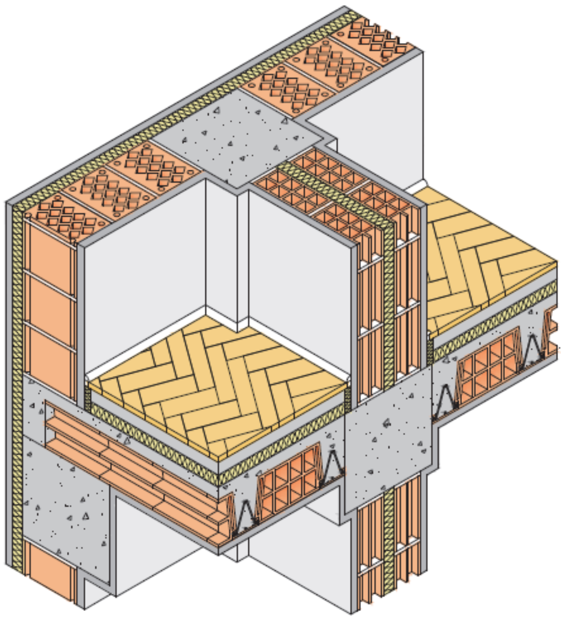


Figure 3. Example of current separating wall and floor construction in Macedonia, see [4]

3. The legislation in building acoustics

Measurements and testing of sound insulation in the dwellings is not mandatory in the Republic of Macedonia. National sound insulation requirements in a form of building code related to the sound insulation existed since 1982, as a regulation in the former SFR Yugoslavia. The code includes minimal requirements for only two types of insulation: horizontal airborne sound insulation and vertical airborne and impact sound insulation, see Table 2. This was contained in the MKS U.J6.201 bylaw, which has been inherited from the old Yugoslav standard JUS.U.J6.201, adopted in 1982 end revised in 1989, see [2]. The abovementioned MKS standard was withdrawn on 30.01.2012. Any adequate replacement of this standard has not been made up to this date. Anyhow, MKS EN ISO 140: Acoustics - Measurement of sound insulation in buildings and of building elements is a common practice currently.

Table 2. Requirements in MKS.U.J6.201 concerning sound insulation

Position in building	parameter	value
Airborne sound insulation between rooms (vertical and horizontal)	R'_w	$\geq 52dB$
Impact sound insulation (vertical)	$L'_{n,w}$	$\leq 60dB$

However, there is experience of utilizing field sound insulation measurements when investigating complaints, on demand of some investors or inhabitants.

Typical errors in design and workmanship

Problem of inadequate sound insulation performance typically arise when the neighbouring apartments are separated by the common massive wall construction with too low mass per unit area [13, 14]. The hollow brick wall, plastered on both sides, with the total mass of around 300 kg/m2 is typically used. In terms of sound insulation, designing of such a construction still represents a typical design error. New contemporary architecture, for example the buildings made of glass and steel, are not usually friendly oriented towards the good acoustics performance of the buildings. The following figures illustrate the typical errors in design, as the example with broken insulation in the Figure 4a, when too many cables and pipes have to cross the floor. The Figure 4b represents one possible solution of the presented problem during the design phase, the raised floor.

a)

b)

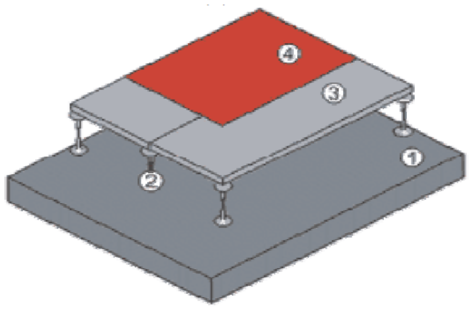


Figure 4. (a) Typical error in workmanship - broken insulation, (b) Possible solution when there are too many cables and pipes (1-reinforced concrete slab, 2-rods, 3-slab, 4-flooring)

Figure 5. Typical error in workmanship – holes for installation services

Some of the most common typical errors in workmanship which diminish the airborne sound insulation are presented in the following figures: holes for installation services on the walls (Figure 5), lack of mortar in vertical joints between the bricks (Figure 6a), or irregular thickness or lack of mortar on the surface layers (Figure 6b).

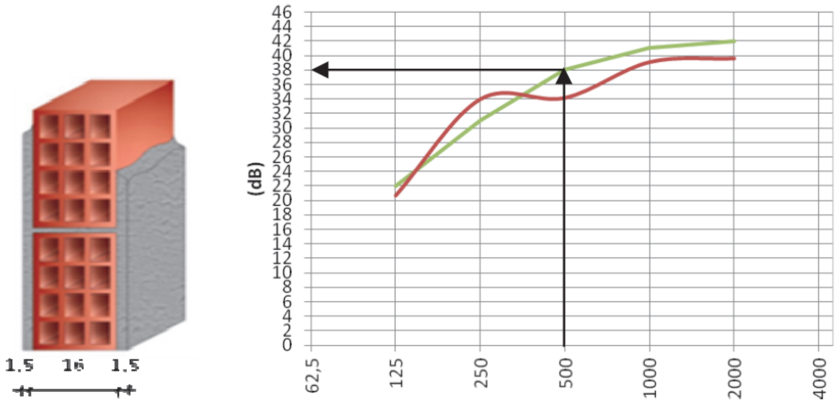
a)

b)

Figure 6. Typical errors in workmanship; (a) irregular mortar layers, (b) vertical joints not filled with mortar

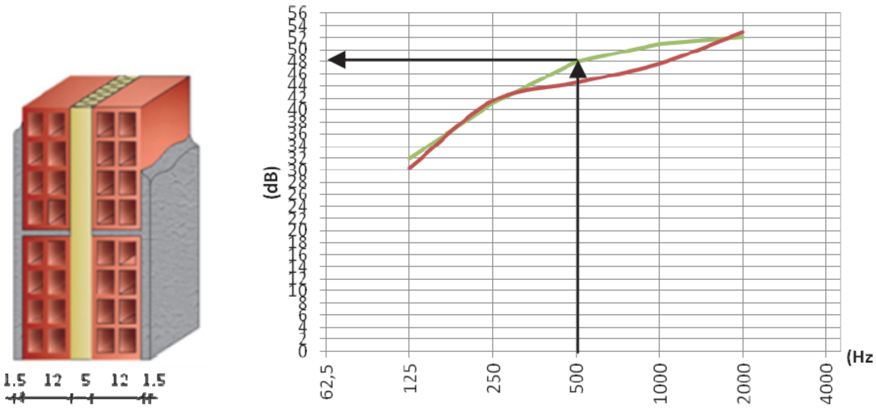
4. Sound insulation: values and graphs

A sound insulation test is usually performed in the frequency range between 100 Hz to 3150 Hz. The corresponding weighted result for airborne or impact sound is presented as a single value. For the purposes of this study, field measurements of 18 different types of separating walls in residential buildings in Macedonia were carried out. The results and comparisons are summarized in the form of conclusions, observations, and recommendations for further research in this area.



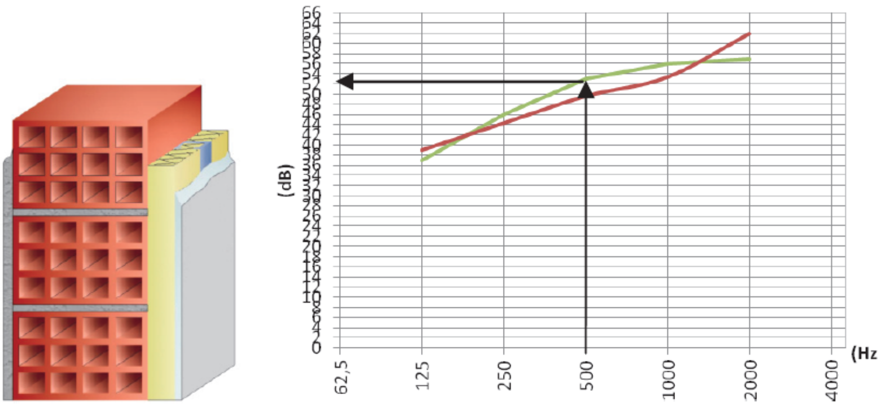
$R_w^r(C;C_{tr})$ = 38(-2;-5)

Figure 7. Airborne sound insulation of a ceramic block wall d = 16 cm



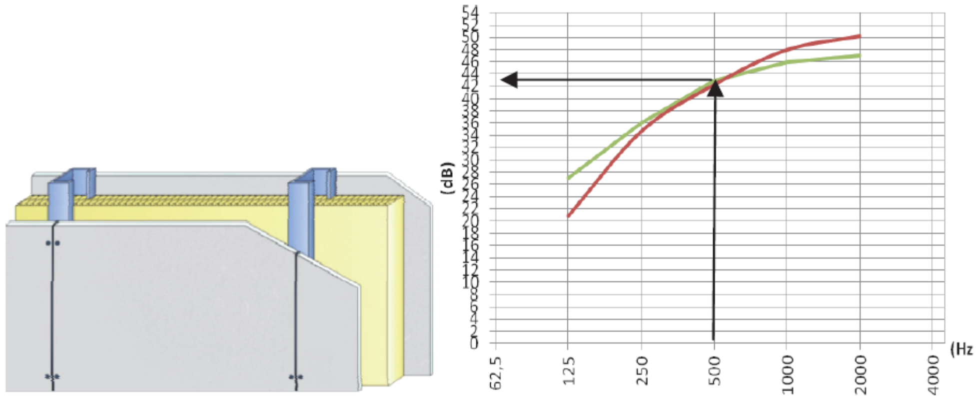
$R_w^r(C;C_{tr})$ = 48 (-2;-6)

Figure 8. Airborne sound insulation of 2x12 cm cellular clay block cavity wall with 5 cm cavity filled with mineral wool and coated on both faces with 1.5 cm mortar



$R_w^r(C; C_{tr})$ = 53 (-1;-4)

Figure 9. Airborne sound insulation of 25 cm cellular clay block, plasterboard on metal studs with 5 cm mineral wool and coated with 1.5 cm mortar on the other side



$R_w^r(C; C_{tr})$ = 43 (-3;-9)

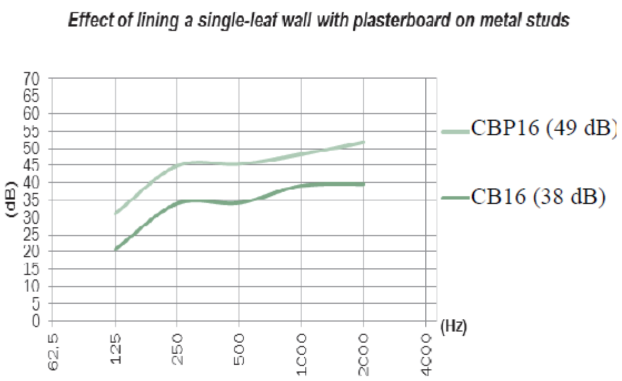
Figure 10. Airborne sound insulation of a partition wall between bedrooms: plasterboards 2x1.25 cm on steel studs, with 7.5 cm mineral wool infilling

The gypsum lightweight partition shows great correspondence in the results, not only for single value sound reduction index, but for each frequency as well, while for the brick hollow walls there are bigger variations, especially for the high frequencies. This is due to the complex nature of the hollow blocks. Only two of the measured partition walls meet the requirements of MKS.U.J6.201 shown in Table 2. This is extremely disappointing, because the examined types of partition elements are the most common ones that can be found in our practice [15-17].

5. Methods of improving sound insulation

There are many ways of improvement the acoustic performance of the existing buildings. That is generally based on the following points: improvement of the impact sound insulation of floors with floating and raised floors; replacement of windows and sealing of leakage between frame and glazing [18-20]. Improvement of airborne sound insulation between dwellings is solved by means of wall linings with plasterboard, see Figures 11a) and 11b). In the case of a ceramic block wall 16 mm thick, the sound insulation increased 11 dB (from 38 to 49 dB). While in the case of ceramic block wall 25 cm thick, the increase in the sound insulation of the wall varied from 46 dB to 53 dB due to the plasterboard lining and layer of mineral wool.

a)



b)

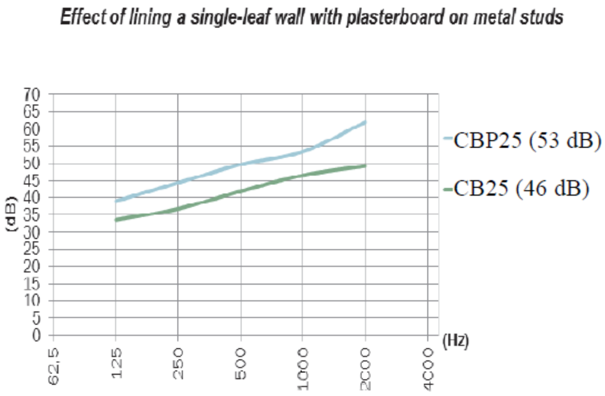


Figure 11. Effect of lining a single-leaf ceramic block wall with plasterboard on metal studs; a) CB wall 16 cm thick, b) CB wall 25 cm thick

6. Conclusions

The gypsum lightweight partition shows great correspondence in the results, not only for single value sound reduction index, but for each frequency as well, while for the brick hollow walls there are bigger variations, especially for the high frequencies. This is due to the complex nature of the hollow blocks. Only two of the measured partition walls meet the standard requirements. This conclusion is extremely unsatisfying, because the examined types of partition elements are the most common ones that can be found in Macedonian practice. Since the current approach of building heavyweight single-leaf separating walls is inadequate in terms of sound insulation, there is a need for changing the design concept, i.e. heavy single leaf partitions should be replaced with lightweight double wall partitions. Publishing an official catalogue with technical features of partition elements which meet the minimum sound insulation requirements, is recommended to facilitate building and design procedures. Furthermore, the current state-of-the-art in building acoustics in Macedonia urges the approval of building regulations which will set airborne and impact sound insulation requirements that each building will have to satisfy. With this approach, the designing of partition elements would be smooth and satisfactory, which will enable the contemporary people to carry out their daily activities without disturbing their comfort due to the unwelcomed sounds from the noisy environment.

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Акустические характеристики зданий в Македонии

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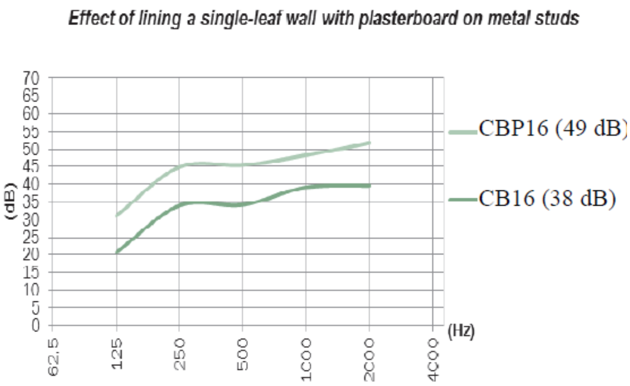
АННОТАЦИЯ



Интенсивное строительство зданий в густонаселенных областях с многочисленными источниками шума определяет необходимость проектирования соответствующей звукоизоляции зданий. Лучшим подтверждением того, соответствуют ли стены зданий требуемым значениям звукоизоляции, является характеристика звукового поля. Характеристики звукового поля отражают реальную ситуацию с учетом несовершенства ограждающих конструкций зданий и характера передачи звука. На основании натурных измерений по 18 различным типам перегородок в жилых зданиях в Македонии были сделаны выводы и сформулированы рекомендации для практического использования, а также для дальнейших исследований в этой области.

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