# AN EXPERIMENTAL STUDY OF IMPROVING SOUND INSULATION INDEX OF HOLLOW BRICK WALL BY USING WALL LINING PANELS FOR ACOUSTIC SENSITIVE ROOMS IN HOSPITALS

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*Abstract*

*The main construction material between dwelling apartments and hospital rooms in Bulgaria which is not part of the skeleton structure is ceramic hollow bricks. According to National standard the minim sound reduction index between dwellings has to be R'w>53dB for residential buildings and walls between hospitalization rooms R'w>47dB.*

*Most of the brick on the market has maximum sound insulation index calculated and measured is around R'w=46dB which don't meet the regulations.*

*There is different approaches to solve this issue. Same of them include splitting the wall and making double masonry wall, other is to make wall lining with steel studs, mineral wool and gypsum board. They all have their advantages and disadvantages but the focus of this paper will be new type of sound insulation system which can increase significant the performance of the wall with minimum thickness. The experiment study is cared in laboratory and in on site measurements. Results shown great promises for wall lining panels and same conclusions for influence of wall connections.*

## 1. INTRODUCTION

In Bulgaria the walls between apartments for every new building has to be made with minimum thickness of 250mm. Based on architectural plan and civil engineering project wall between apartments are made from rainforest concrete, part of skeleton of building, and ceramic hollow bricks. In the case of rainforest concrete walls the calculated and measured noise insulation index is more than R'w>58dB but in cases where the ceramic hollow brick walls are installed the noise reduction index is less than R'w<49dB. According to national standard the minim apparent sound reduction index between dwellings has to be R'w>53dB and where the requirements are not met the sound insulation has to be increased. In this work, we present same experimental results related with different technics for increasing sound insulation index of hollow brick walls measured in laboratory conditions according to EN ISO 10140-3 [1] and field measurements according to EN ISO 16283-1 [2]. Because every wall and every room has different structure, arrangement of bricks, flanking transmission, all result will be compere only for sound insulation different $\Delta$R'w.

Because of minimum dimensions of rooms the following test will focus only on sound insulation systems from 30 to 80mm, which cannot be achieved with conventional wall lining metal frame. The panels are specially design with combination of high density gypsum fibreboard and absorber material in air gap.

## 2. HOLLOW BRICK NOISE INSULATION

### 2.1. Laboratory measurements

Laboratory measurements are carry out according to EN ISO 10140-3 in test chamber with volume of source room V1= 164 $m^3$ and volume of receiving room V2 = 119 $m^3$. The opening for test walls is with aria of S = 10.92$m^2$.

Tested masonry wall has following materials with their properties:

**Table 1.** Material properties

| Type of material | Parameters | | | | |
|---|---|---|---|---|---|
| | Thick-ness (mm) | Density (kg/m3) | E mo-dule (GPa) | Coeff. of Poisson | Internal loss |
| Hollow bricks | 250 | 625 | 6.85 | 0.12 | 0.02 |
| Gypsum Plaster | 20 | 700 | 1.5 | 0.22 | 0.01 |

**Figure 1.** Typical ceramic hollow brick used in conventional residential buildings and in this experimental study

Detail drawing of masonry wall is shown on figure 2:

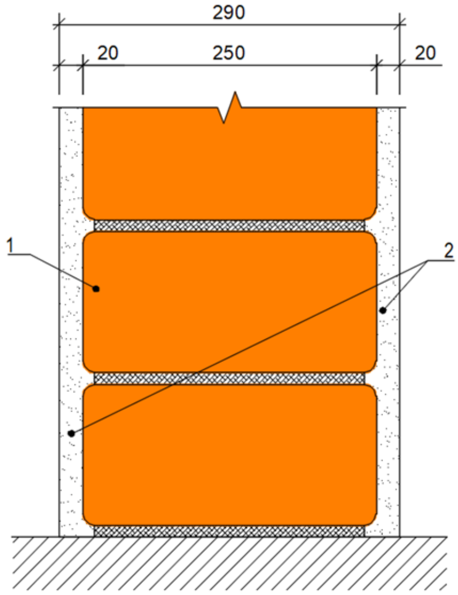


**Figure 2.** Detail of masonry brick (1) wall with gypsum plaster (2).

## 2.2. Field measurements

Field measurements are carried on three different apartments with different wall sizing, room configuration and different reverberation time. Despite that all three has close sound insulation index because of similarity of wall materials.

The figures 3 and 4 the configuration of three apartments are shown.

The measurement follow strictly EN ISO 16283-1 and they are carried.

In all three cases the residents are complaining of intelligibility of speech noise. Because there is no information about the types of hollow bricks and plasters covering the property of walls are not reviewed.

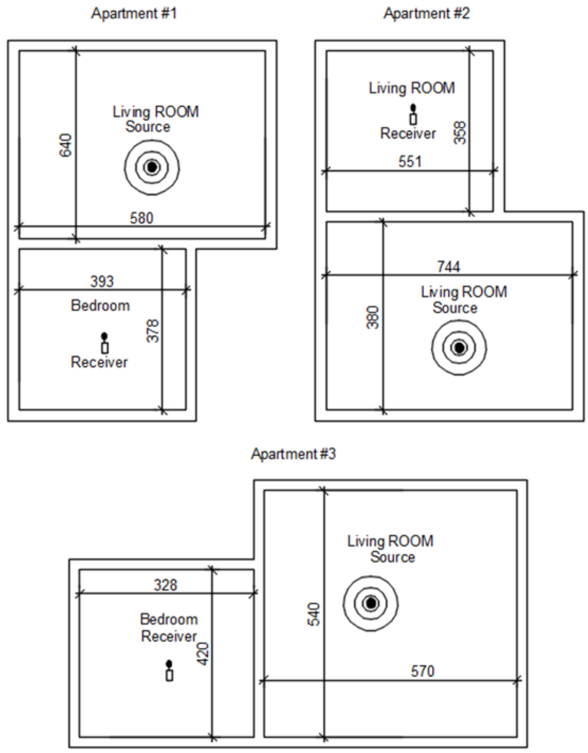


**Figure 3.** Field measurement in:
apartment #1 with high H=2.58m,
apartment #2 with high H=2.45m,
apartment #3 with high H=2.55m

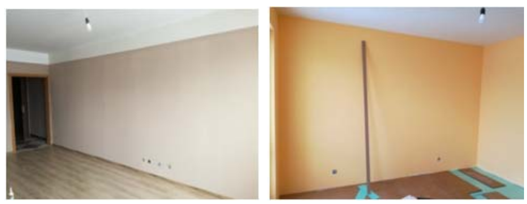

**Figure 4.** Photo of source and receiver room of apartment #1

# 3. WALL LINING PANELS

## 3.1. Laboratory measurements

Four different cases are measured in laboratory conditions in order to choose best wall panel for field measurements. Panels are made from one layer of open cell elastic polyurethane foam, one layer of gypsum fibreboard and finish layer of gypsum plasterboard.

Basically the wall lining panels can be divided into two groups. First group - panels glued to brick wall and second group - panels fix on brick wall with special elastic point connection made of rubber elastomer. Following tables shows system configuration with all materials and type of connections.

**Table 2.** System configurations

| System Name | Thickness of system (mm) | Layers (from wall to room) | Thickness (mm) | Type of connection |
|---|---|---|---|---|
| M1 | 42.5 mm | Air | 0 mm | Glue to wall |
| | | Polyurethane foam | 20 mm | |
| | | Gypsum fiberboard | 10 mm | |
| | | Gypsum Plasterboard | 12.5 mm | |
| M2 | 45 mm | Air | 10 mm | Elastic rubber point connection |
| | | Polyurethane foam | 10 mm | |
| | | Gypsum fiberboard | 12.5 mm | |
| | | Gypsum Plasterboard | 12.5 mm | |
| M3 | 55 mm | Air | 10 mm | Elastic rubber point connection |
| | | Polyurethane foam | 20 mm | |
| | | Gypsum fiberboard | 12.5 mm | |
| | | Gypsum Plasterboard | 12.5 mm | |
| M4 | 85 mm | Air | 10 mm | Elastic rubber point connection |
| | | Polyurethane foam | 50 mm | |
| | | Gypsum fiberboard | 12.5 mm | |
| | | Gypsum Plasterboard | 12.5 mm | |

The goal is to compare two camper the two types of connections and for the second group to compare how different air gaps change sound insulation.

In following figures the details for all four system are presented.

All measurement are carried in same conditions as masonry brick wall.

**Figure 5.** Photo from laboratory with installation of system M2

### 3.2. Field measurements

Field measurements are made only with one type of panels which shown best results – Panel M3.

In all three cases the wall lining panels are placed on side of the source in order to avoid direct flanking transmission from side wall.

Pictures of one of the sites showing installation of panels in progress.

**Figure 6.** Photo

## 4. TEST RESULTS

### 4.1. Laboratory measurements

The measured results of masonry hollow brick wall are shown on "Figure 7"

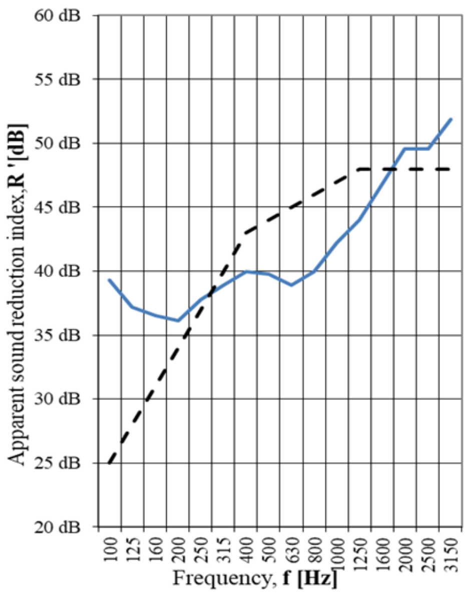


**Figure 7.** Ggraphic of apparent sound reduction index of masonry wall

Results of all group and types of wall lining panels are shown on "Figure 8".

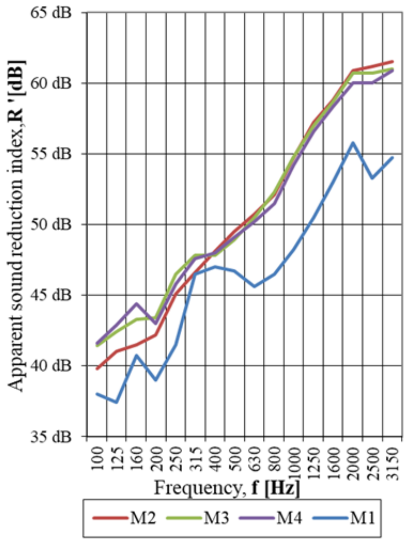


**Figure 8.** Ggraphics of apparent sound reduction index of masonry wall with installed wall panels

The weighted noise reduction index is carried according to EN ISO 717 -1 and the results are shown on "Table 3".

**Table 3.** Laboratory test results

| | Hollow bricks | Hollow bricks + M1 | Hollow bricks + M2 | Hollow bricks + M3 | Hollow bricks + M4 |
|---|---|---|---|---|---|
| **Rw** | 44dB | 49dB | 54dB | 54dB | 54dB |
| **C,Ctr** | -1;-3 | -1;-3 | -1;-4 | -1;-4 | -1;-3 |
| **ΔRw** | - | 5dB | 10dB | 10dB | 10dB |

The following graphic is made to show noise reduction different between hollow brick and every type of wall lining.

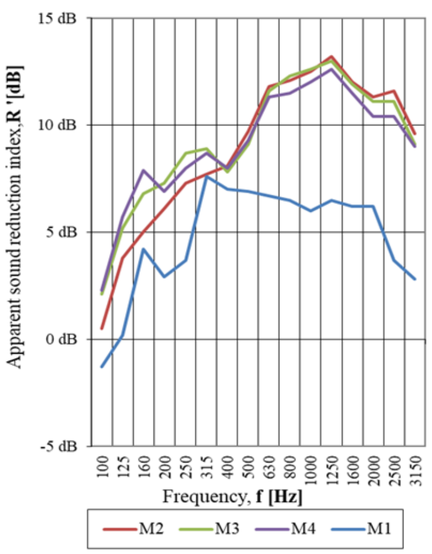


**Figure 9.** Ggraphics of spectral noise insulation improvement

## 4.2. Field measurements

All three cases shown different noise reduction graphs and sound insulation index. The following graphics shows measurement of brick walls before sound insulation and after installation of wall lining panels M3.

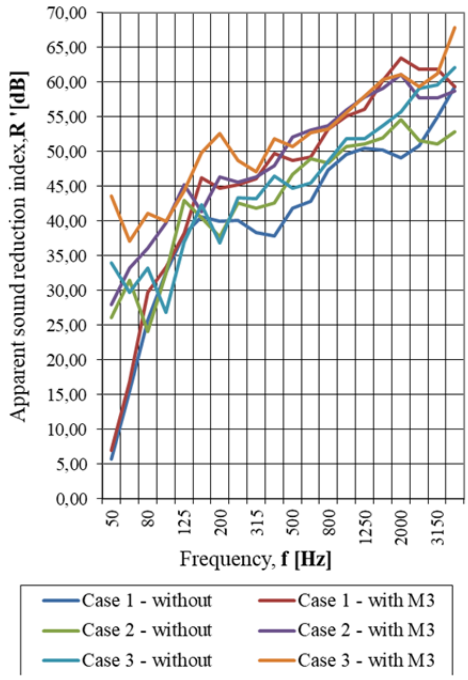


**Figure 10.** Ggraphic of apparent sound reduction index

Results are presented in Table 4, where sound reduction index is carried according to EN ISO 717 -1 [3].

**Table 4.** Field test results

| | Type of wall | R'w | C,Ctr | ΔRw |
|---|---|---|---|---|
| **Case 1** | Hollow brick wall | 47dB | -1;-3 | 7dB |
| | Hollow brick wall + M3 | 54dB | -1;-5 | |
| **Case 2** | Hollow brick wall | 49dB | -1;-3 | 6dB |
| | Hollow brick wall + M3 | 55dB | -1;-4 | |
| **Case 3** | Hollow brick wall | 48dB | 0;-4 | 8dB |
| | Hollow brick wall + M3 | 56dB | -1;-4 | |

## 5. DISCUSSION OF RESULTS

According to laboratory measurement there is big difference between system M1 and other three.

This result shows the how type of conation between the masonry wall and insulation system influent the end result.

Laboratory test also shows that despite the big difference of air gap (40mm) between M2 and M4 the weighed sound level index and in most of the spectrum (from 200Hz to 4000Hz) there is no significant difference. This result can be explain with two models of theoretical expression of transmission loss of double panel by Beranek [4] and Work and London [5]

Laboratory test also shown that the optimum Panel system, considering full spectrum transmission loss is Panel M3, that's why all on side measurement are carried with this system.

On site measurement shown that all brick walls have better performance than this in laboratory this is because in the apartments different bricks are used and the plaster cover is greater. However all three case the requirements are not met and the occupants of the apartments have complains about speech intelligibility from adjacent apartment.

In all three cases the less than laboratory test because of flanking transmission. The weighted noise level difference (ΔRw) is different in every case, but from 200Hz to 4000 Hz the results have good comply. Despite that all measurement are made according EN ISO 16283-1 many factors can explain the difference in noise reduction of frequencies under 200 Hz.

## 6. CONCLUSION

Test results from laboratory measurements show that type of connection have significant influence upon increasing sound insulation index in thick wall systems. The test shows that for the system M1 the minimum requirement from regulation is not met and for the system from M2 to M4 the requirement is met for residential apartments and hospitalisation rooms. The optimal wall system considering thickness and noise reducing efficiency is wall system M3.

On site results shows that the sound insulation index with system M3 are less effective than the results shown is laboratory tests. But despite that the average increasing in sound level index is 7dB and the minimum requirements are met.

Become of laboratory test future work will focus on studding how and witch properties of rubber connection will affect the transmission loss index in order to achieve better results.

## REFERENCES

[1] EN ISO 10140-3:2015

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