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May retrofit also include acoustics aspects?

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Abstract

In recent years technology has tried to develop new solutions suitable for extending and improving the life of existing buildings. In Italy, working on the building envelope has turned out to be one of the most common processes to improve buildings' thermal insulation. The aim is generally reached by replacing windows and adding ETICS (External Thermal Insulation Composite System) to the façades. But could these solutions also be a good acoustic insulation enhancement ?

Nevertheless renovation is always a very complicated issue caused by the unavoidable existing limits. In many cases, because of the structural aspects, light solutions should be found to avoid the increase of weight on the existing building, or to limit as much as possible solutions with heavy loads. In order to propose acoustical solutions for facades as well as airbone and impact sound insulation solutions suitable to fit the needs mentioned above, the issues have been investigated in real buildings under renovation, during work, by carrying on acoustical measurements during different steps.

In this study, lightweight solutions have been investigated and optimized, the effect of installations has been even analysed and optimized as well as the effect of suspended ceilings. The contribution to sound insulation and impact noise has been studied. The effects of suspended ceiling under the separating floor have been tested.

Last but not least, in a modular building the facades were coated with 14 cm ETICS of EPS (expanded polystyrene) and with 14 cm ETICS of mineral wool. The sound insulation effect of both systems has been studied and compared.

The research, carried out on real buildings, has shown that lightweight solutions can be useful responses in renovating old buildings and furthermore it is possible to combine thermal and acoustical insulation for optimizing the different solutions.

Keywords: Retrofit; Acoustical insulation; Lightweight solutions; ETICS

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1. Introduction

In order to investigate the possible acoustical contribution given by different solutions in existing buildings, case studies have been carried out in real buildings.

The method followed to analyse the different acoustical contribution was based on site measurements. Having defined, for each case studied, the basic solution (the starting point), measurements have been carried out step by step at each additional solution in order to define the single contribution. The different solutions considered for each case and the results obtained are described. The aim is that of proving the possible acoustical contribution on existing building when the main purpose of the retrofit is based on thermal aspects aimed to save energy.

2. Suspended ceiling

The case study concerns the construction of a suspended plasterboard ceiling in a room of a residential apartment in an existing building. The aim was to increase the airborne sound insulation and to reduce the impact noise level between two different units.

2.1. Building characteristics and the implemented solution

The building, located in the province of Milan, dated back to the Sixties. The building element typologies were typical of the period. The different elements are described in Table 1, and the testing rooms are shown in Fig. 1.

Table 1. Construction typologies under investigation

		Thickness (*cm*)
Floor	plaster	1
	Structure in masonry	16
	Sand and cement screed	6
	Parquet	2
Inner walls	Plaster	1,5
	Hollow bricks	8
	Plaster	1,5
Outer walls	Plaster	1,5
	Semisolid bricks	30
	Plaster	1,5

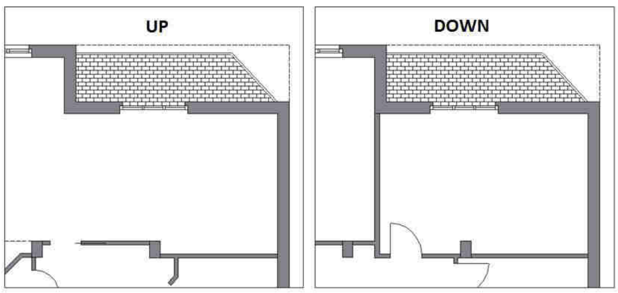

Fig. 1. Rooms under measurement.

In the unit defined "down" in Fig. 1, a single frame plasterboard false ceiling was built close to the floor ceiling. The plenum of 8 cm was partially filled with mineral wool, 4,5 cm thickness (Fig. 2) and the covering board was made with a single gypsum board with high density (thk. 1.25 cm, surface mass 17,5 kg /m2).

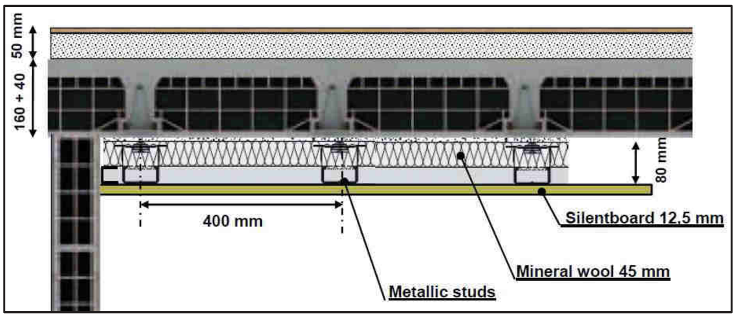

Fig. 2. Single frame plasterboard false ceiling.

2.2. The contribution of a plasterboard false ceiling

Measurements of airborne sound insulation and impact noise level have been performed, in accordance with the Standards [1-2-3], before and after installation. Measurements were repeated at the end of the work. The contribution, given by the plasterboard false ceiling, is shown as a comparison between the pre and post construction. The installation performed has shown an improvement of airborne sound insulation of 6 dB and 17 dB for impact noise. Results are shown in Table 3 and Fig. 3 and Fig. 4.

Table 3. Comparison of results pre and post operam

	Descriptor	Results (dB)
Ante operam	R'w	50
Post operam	R'w	56
Ante operam	L'nw	79
Post operam	L'nw	62

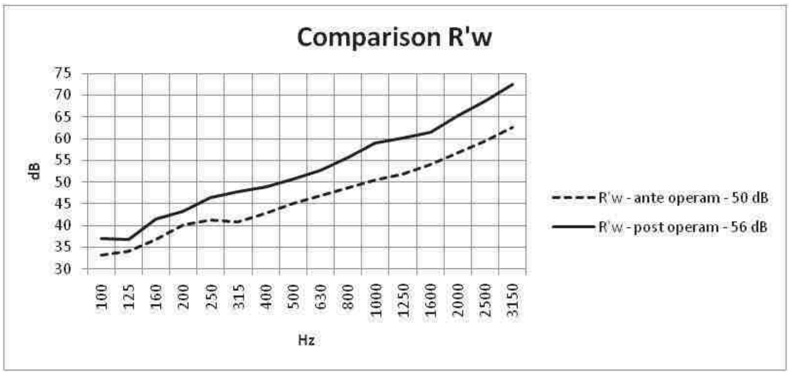

Fig. 3. Airborne sound insulation - Comparison

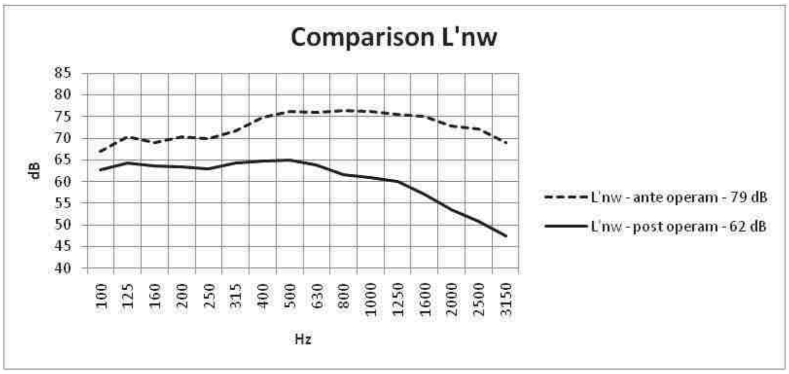

Fig. 4. Impact noise - Comparison

3. External Thermal Insulation Composite Systems (ETICS) on the façades

The façades of the Italian buildings, dating back to the Twentieth century, could be mainly divided in two groups: full or semisolid brick walls, each one very heavy; lightweight brick walls with 55% of holes. In order to evaluate the ETICS contribution, mineral wool or EPS, on both types of existing outer group of walls, a case study has been carried out in a construction site during the work. The testing rooms were in a context of Social Housing, therefore the different units presented the same geometry. The testing rooms were 6: three of them closed with light aggregate concrete blocks, 30 cm and a surface density of 400 Kg/sqm, have been used to simulate full or semisolid bricks; the others with lightweight brick blocks, 30 cm and a surface density of 240 Kg/sqm to simulate lightweight bricks. Windows and French windows have been walled up using the same material as the rest of the façade, see Fig. 5. Each room had a volume of 43 cubic m and a façade surface of 13,4 sqm.

Fig. 5. The samples rooms – different construction steps

3.1. Method followed

For each of the conditions considered, see Fig. 6, and listed in Table 4, the standardized sound insulation index of the façades D2m,nT,w was measured according to the Standard [4] and then, the obtained results, were converted to R'w apparent sound reduction index [5].

The first tests were performed on 6 façades where the blocks were neither coated nor finished. Then, the façades, previously tested, were just covered with 14 cm of high density mineral wool and afterwards with 14 cm of EPS. Measurements were performed on uncoated surfaces, and then coated but unfinished.

Table 4. Test configuration described step by step

light aggregate concrete block	high density uncoated mineral wool	high density coated mineral wool
light aggregate concrete block	uncoated EPS	coated EPS
lightweight brick	high density uncoated mineral wool	high density coated mineral wool
lightweight brick	uncoated EPS	coated EPS

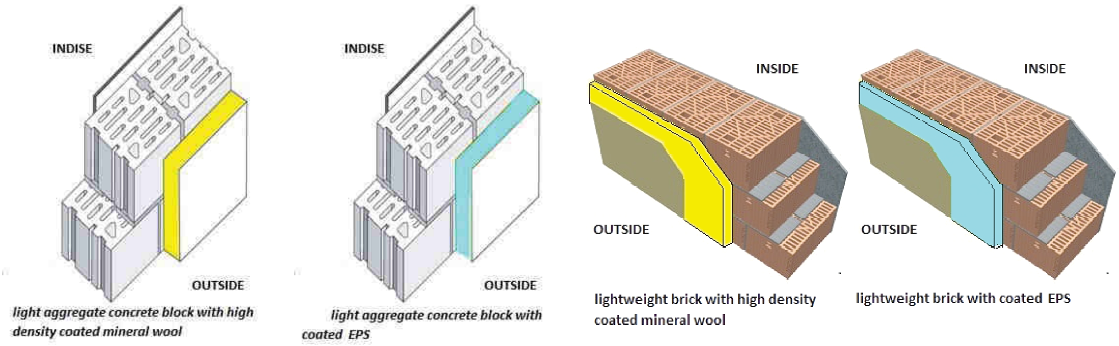

Fig. 6. Specimens investigated

3.2. The contribution of ETICS

The acoustical contribution of ETICS, with a technical approach described above and based on the results obtained with different on-site measurements, is shown in Table 5 and Table 6. The comparison, in third octave band, between the different steps, divided by type of block, is shown in Fig. 7 and Fig. 8. The results have shown that the contribution of ETICS in mineral wool is more significant when combined with lightweight brick (R'w 48 dB) than with light aggregate concrete block (R'w 47 dB). ETICS in mineral wool prevails compared to the contribution of the basic layer . On the contrary with ETICS in EPS, the contribution of the basic layer prevails: lightweight brick (R'w 40 dB); light aggregate concrete block (R'w 43 dB).

Table 5. Results for light aggregate concrete block

	D2m,nT,w	R’w
Basic layer	35 (-1; -4)	35 (-1; -4)
High density uncoated mineral wool	43 (-2; -5)	42 (-1; -5)
High density coated mineral wool	47 (-2; -6)	47 (-2; -6)
Uncoated EPS	42 (-1; -4)	42 (-2; -5)
Coated EPS	43 (-1; -4)	43 (-1; -4)

Table 6. Results for lightweight brick

	D2m,nT,w	R’w
Basic layer	29 (0; 1)	29 (-1; 0)
High density uncoated mineral wool	47 (-2; -5)	46 (-1; -4)
High density coated mineral wool	49 (-2; -5)	48 (-1; -5)
Uncoated EPS	36 (-1; -2)	35 (0; 1)
Coated EPS	40 (-1; -2)	40 (-1; -3)

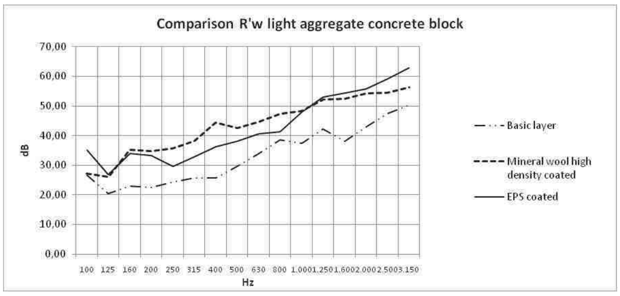

Fig. 7. Light aggregate concrete block – ETICS contributions

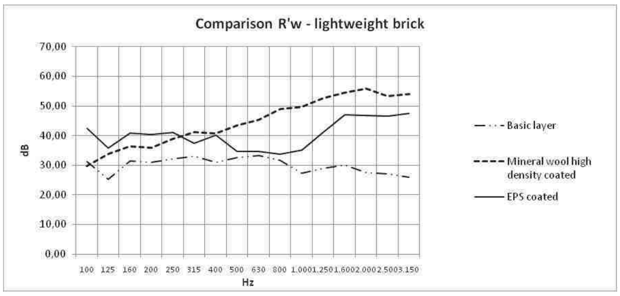

Fig. 8. Lightweight brick block – ETICS contributions

4. Conclusion

The case studies carried out on real building, using a false ceiling, have shown the possibility of increasing the acoustical performance of an inner building component by using lightweight systems. The data shows that, despite the high number of rigid contacts of the false ceiling with the existing ceiling floor and the presence of significant flanking transmission, the intervention brought a significant improvement in the insulation to airborne noise and a very important reduction of the impact noise level. The correct installation, factor of paramount importance, was supervised throughout all the execution of the work.

The measurements performed on real buildings have shown ETICS contributes for the enhancement of sound insulation in the façades. In detail, it has shown that lightweight external walls are more affected by the ETICS than heavy walls. In particular the use of an ETICS mineral wool may increase significantly the sound insulation.

In urban contexts, where city noise is relevant, the use of mineral wool as a building envelope, combined with high performing windows, will increase significantly the acoustical comfort of existing buildings.

The study has shown that retrofit influences acoustics aspects and the improvements in sound insulation are not negligible.

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