ASPECTS CONCERNING LIGHT WEIGHT CONSTRUCTIONS IN SWEDISH RESIDENTIAL BUILDING WITH HIGH SOUND INSULATION (CLASS B ACCORDING TO SS 02 52 67)"

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ABSTRACT
In Sweden, many new buildings comprising dwellings are today constructed and erected aimed to meet an acoustical comfort better than the minimum standard specified in the building code. Unfortunately, these high acoustical ambitions often result in buildings that precisely meet the minimum requirements, at least for one or a few acoustical parameters. This seem to appear more often when the frame / structure, or parts of it, are made of lightweight materials. This paper will show some examples where the acoustical ambitions and the final result do not agree.

INTRODUCTION
Since 1998 the adaptation terms, specified in ISO 717, $C_{50\text{-}3150}$ for airborne sound insulation and $C_{\text{I},50\text{-}2500}$ for impact sound insulation, have been included in the building code concerning dwellings and in the Swedish classification standard, SS 02 52 67 (2nd edition), "Acoustics – Sound classification of spaces in buildings – dwellings". This means that new housing buildings have been constructed to meet requirements from 50 Hz during the last four years. When the building code was revised the old requirement levels were preserved. However, the extended frequency range automatically results in an increase in sound reduction index and impact sound level index with several dB:s, particularly concerning light weight structures. Nevertheless, the ambition among many building contractors have been to utilize the classification standard SS 02 52 67 to raise the sound insulation, at least one class above the minimum standard. The minimum standard corresponds to class C while one class above corresponds to class B. The standard also includes one superior class A and one class D aimed for certain rebuilding projects. In this paper we show some results, not only results from different light weight constructions aimed for class B, but also heavy concrete constructions. This is to illustrate the difference in planning target and final result depending on frame structure. Unfortunately, the ambition to reach class B and the final result do not always coincide. Fortunately enough, the final sound insulation in dwellings is normally better after the introduction of the sound classification standard (incl. the adaptation terms).

BUILDING CONSTRUCTIONS

The results in this paper are based on some typical categories of housing building constructions. We have analyzed the requirements for each building category and compared those both with expected calculated values (BASTIAN) and measurements in situ when the buildings were completed. We do not describe constructions in detail since the aim of this paper is not to “defame” or recommend certain manufacturer but instead draw some general conclusions concerning different type of constructions, after four years of implementation of the Swedish classification standard. Hopefully, in prolongation some of the different building constructions will be further improved and optimized to meet different requirement classes. In this paper we have picked results from four objects typical for each category. The following constructions, here described in a general manner, are included, see also figure 1:

1. Heavy concrete floor constructions, 250 mm, with lightweight walls. Thin plastic floor covering. (aimed for class B)

2. Concrete construction with 270 mm hollow slabs and 200 mm heavy walls. 15 mm parquet floor mounted on an impact sound reducing upper floor construction (aimed for class B)

3. Lightweight construction with steel frame floor structure. From above: 15 mm parquet on impact sound reducing material – some layers of intermediate materials mounted on a frame structure of C-shaped beams, h=200 mm - two layers of gypsum board 15 mm + 13 mm mounted on an acoustic profile (aimed for class B).

4. Lightweight construction with wood frame floor structure. From above: 15 mm parquet on impact sound reducing material – some layers of intermediate materials mounted on a frame structure of wooden beams, h=220 mm - two layers of gypsum board 13 mm + 13 mm (aimed for class B).

The principle building constructions are shown in figure 1 below. The arrows correspond to the analyzed measurement directions in each case. The walls denoted by capital letters consists of:

A. 2 *13 mm gypsum board / 2*70 mm light weight steel structure (separated) c/c 450 + 140 mm mineral wool / 2*13 mm gypsum board.

B. 15+13 mm gypsum board / 2*70 mm reinforced steel structure (separated) c/c 600 + 140 mm mineral wool / 13+15 mm gypsum board.

C. 200 mm of heavy concrete.

D. 15 mm gypsum board+15 mm wood board / 2* 120 mm (airgap 40 mm) wood structure + 240 mm mineral wool / 15 mm wood board+15 mm gypsum board

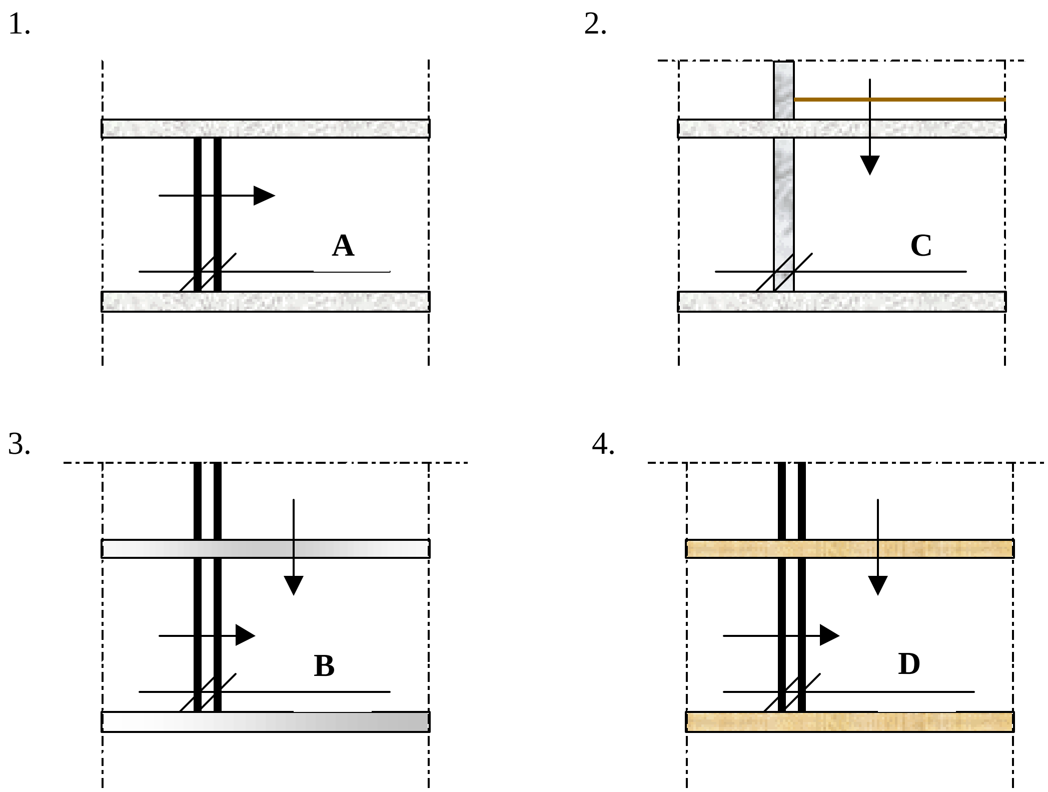


Figure 1. The four typical building construction analyzed in this paper.

RESULTS AND DISCUSSION

Requirements

In all cases above the initial ambition concerning sound insulation between dwellings was the same i.e. to meet the requirement

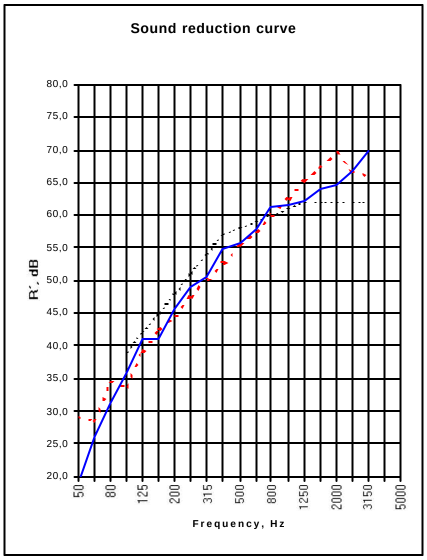
$$R'_{w} + C_{50\text{-}3150} \geq 56 \text{ dB}$$
$$L'_{n,w} \text{ and } L'_{n,w} + C_{I,50\text{-}2500} \leq 54 \text{ dB}$$

which corresponds to the Swedish standard class B.

For the structures number 1 and 2 above we have made both calculations and measurements and compared the results. For the lightweight constructions (3 and 4) it is not yet possible to calculate sound reduction index and impact sound reduction index with the actual computer program, including adaptation terms in the extended frequency range. Therefore only measurement results are presented and discussed in those cases.

Results

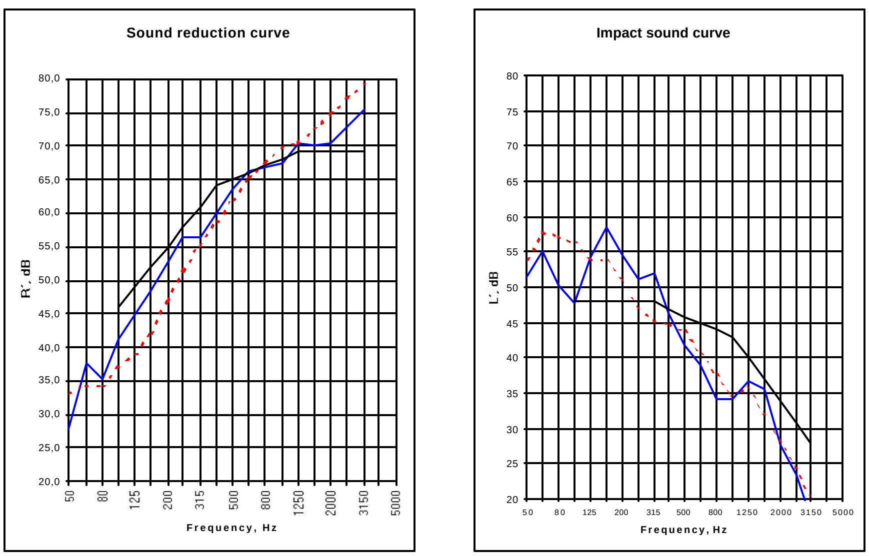
In the figures 2 and 3 below measurement data for the constructions number 1 and 2 are shown. In those cases, where enough input data was included in the computer program database, the calculated single numbers are also presented in the diagrams (dotted lines). The measurements presented here are representative for many objects.



Dotted line – calc value
$R'_w + C_{50\text{-}3150}$ = 55 dB

Unbroken line – measured value
$R'_w + C_{50\text{-}3150}$ = 54 dB

Figure 2. Calculated and measured values for construction number one (horizontal transmission)



Dotted line – calc value
$R'_w + C_{50\text{-}3150}$ = 58 dB

Unbroken.line – measured value
$R'_w + C_{50\text{-}3150}$ = 61 dB

Dotted line – calc value
$L'_{n,w}$ = 45 dB
$L'_{n,w} + C_{I,50\text{-}2500}$ = 49 dB

Unbroken line – measured value
$L'_{n,w}$ = 46 dB
$L'_{n,w} + C_{I,50\text{-}2500}$ = 49 dB

Figure 3. Calculated and measured values for construction number two (vertical transmissions)

In table 1 below some typical results from the four construction categories are put together. In the table airborne sound insulation are presented

Table 1. Some typical values for intended class B constructions.

Construction number	$R'_{w} + C_{50\text{-}3150}$ (dB)		$L'_{n,w}$ (dB)		$L'_{n,w}+C_{I,50\text{-}2500}$ (dB)	
	calculated	measured	calculated	Measured	calculated	Measured
1	55 (h)	54 (h)	-	-	-	-
2	58 (v)	61, 65 (v) 62 (h)	45	46	49	49
3	-	53 (v) 55 (h)	-	55	-	57
4	-	57 (v) 59 (h)	-	55	-	57

The levels above are typical for each type of construction – not just for the cases presented above. According to my opinion there are some important remarks to point out:

1. The first construction category should not be wrong in the completed building since the final sound insulation is predictable and easy to calculate, see also figure 2.

2. Huge difference between various frame structures even though the aim in all cases was to meet class B sound insulation. The best building in this paper is almost a class A building while the worst is a class C building (which corresponds to the minimum requirement in the national building code).

3. Normally the experienced horizontal airborne sound insulation is far better than the experienced vertical impact sound insulation for lightweight constructions. This lead to constructions not optimized according to sound insulation in different directions. A building is never better than the weakest part.

CONCLUSIONS

The design of various frame constructions leads to completely different results in the final building. The best building in the examples in this paper has almost twice as high “sound comfort” (8 dB) as the worst building. However, these differences are normally not known by those who buy the dwellings, since they are all merchandised as “high class sound insulation products”. The cost for rent, or the price (owner flats), is normally high (no big difference between the four cases in this paper) and naturally, there are expectations of an undisturbed life. Unfortunately, the expectations and the real situation might differ in some cases.

Furthermore, there are large differences within certain lightweight buildings in various directions. My experience says that the lightweight ***floor*** structures have to be improved a lot to correspond to the sound insulation in horizontal direction. The largest problem (maybe not very surprising) in the lightweight building technique is the impact sound insulation between dwellings in vertical direction.

Acoustical consultants and manufacturers have to be very careful when designing class B buildings. Caution has to be taken concerning different product data and the effect in the field situation of the adaptation terms, $C_{I,50\text{-}2500}$ and $C_{50\text{-}3150}$. If possible, different constructions should be calculated in advance to avoid uncertain sound insulation estimations. Today it is easier to predict and secure class B for heavy constructions since more product data is available in these cases and their behavior is quite well known by experience. Many of the lightweight constructions on the market today correspond to class C, at least concerning impact sound between dwellings in vertical direction.

Some final remarks:

- As long as input data exist and are correct in computer programs (based on EN 12 354) the calculated and measured value seem to give satisfactory correspondence. Furthermore, a small tendency that the calculated value is underestimating the sound insulation can be traced, or at least, there is normally not any large deviation in the "wrong direction".

- The impact sound level is normally not enough low to meet class B for commercial lightweight constructions. Often the result becomes barely class C (national requirement).

- So far, lightweight constructions will be very complicated and expensive if the intention is to meet class B or better.

- The airborne sound insulation is oversized compared to the impact sound insulation for lightweight constructions (at least horizontal airborne sound compared to vertical impact sound)

- Manufacturers sometimes provide product data that are too optimistic and not rendered to the field situation.

Finally, the use of the Swedish classification standard has ended up with more activity in the field of building acoustics and I am sure that the building technique will be developed further to optimize different building structures to various classes in the standard.

REFERENCES

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