Sound Insulation in Retrofitted Buildings in Iceland

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ABSTRACT

Many of the older well designed buildings in Iceland are architecturally conserved. In many cases there is limited information available about building methods, the construction in general, and therefore its structural capacity. This makes reconstruction projects more challenging, and requires more investigation (field testing) and more intense cooperation between relevant parties compared to in new building designs.

This presentation will provide a brief overview of the ambitious requirements that are made to retrofitted housing in Iceland. In the design phase, a detailed assessment must be taken into account for many aspects of engineering and aesthetics, along with usability/functionality of the retrofitted building.

The author will describe a few examples from Iceland as a consulting engineer in the field of acoustics and noise control.

Keywords: acoustics, noise, regulation, standards, requirements, retrofitted, insulation, impact, HVAC.

1. INTRODUCTION

Over the last decades, there have been several updates and changes in the regulatory environment regarding acoustics and noise control in Iceland. These updates and changes have put Iceland from being "behind" to being "experienced" regarding requirements and user satisfaction.

Requirements mainly come from three sources, Regulation on Noise, The Building Code, and Sound Classification Standard, ÍST45, having four classes of quality, A, B, C and D. Class C defines minimum requirements for new buildings and renovations of older buildings, which can be a real challenge. The standard defines sets of requirements for different types of buildings, e.g. schools, hospitals, apartments, hotels etc.

2. REQUIREMENTS FOR RETROFITTET BUILDINGS

The requirements made today in buildings in Iceland are defined in the Sound Quality Classification Standard, ÍST45:2016. The groups presented in the standard are as follows:

- Group A. Refers to very good conditions regarding acoustics and noise, resulting in annoyance being very rarely caused by sound or noise.
- Group B. Refers to better acoustics than reference values defined in group C, meant for new buildings. Some users can occasionally become annoyed due to sound and noise.
- Group C. Defines reference values and minimum legislative requirements for new buildings, and for renovated buildings with same requirements applied to as new buildings. It can be expected that around 20% of users can become annoyed by sound and noise.
- Group D. Defines reference values for already built buildings, and retrofitting of older buildings that shall not fulfill group C. This group is not meant to be used for new buildings.

In the building code no. 112/2012, it is mentioned that group D can only be used (as reference values) for minimal changes of a room, and never if the usage of a building is changed. There is a need for more detailed definition of this aspect.

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3. GENERAL CHALLENGES IN ICELAND

3.1 Structural methods

For the last century, concrete has been a large part of building materials used in Iceland. This has resulted in partitions with high sound insulation, except for in elements with windows or doors. This has also made Icelandic people used to robust floors – that is with minimum of the hollow sound or squealing in timber floors.

Due to this, Icelandic people are quite used to high insulation partitions, and that has been reflected in strong requirements in the building code.

The main drawback is that in old buildings, not much is known about how the concrete was reinforced. Therefore, structural designers are not willing to add additional weight to concrete floors.

The structural requirements made by authorities are mainly that the load bearing capacity of the building will not be less after renovation than it was before.

3.2 Reverberation time

Requirements for reverberation time have in the past been few and mild, and did not ensure user satisfaction at all. When buildings were generally built out of concrete, less emphasis was on reverberation time than on sound insulation. Therefore it is common to have challenges in making the reverberation time shorter.

3.3 Architectural conservation

When retrofitting older buildings in Iceland, the odds are quite high that the building is protected in some way or another because of architectural or aesthetical aspects connected to the Icelandic building heritage. This has made changes on ceilings, walls, windows and doors quite complicated, which has influence on many aspects of acoustics and noise control.

3.4 Technical equipment in older buildings

Many buildings are built before there was a demand for technical equipment like today, for example elevators, fire protection systems, HVAC and more. Fulfilling requirements for noise level from this equipment is even more some complicated, often with poor choice of routes or insufficient finishing details for pipes and HVAC.

3.5 Flanking transmission

Some wall partitions are quite poor regarding risk of flanking transmission. Inner layers of facades were often insulated with wood-curl, or simply the airgap alone. This makes a real challenge for fire/smoke and sound transmission between rooms. Also where plastic insulation has been glued between a concrete outer wall and mortar, there is a problem with flanking transmission around 250 Hz.

4. HOTEL BUILDING IN THE CENTER OF REYKJAVIK

4.1 Sound Insulation between floors

Measurements were made of the sound insulation between floors. They revealed that the sound insulation fulfilled requirements, except between the 1st and 2nd floor (between a restaurant and hotel rooms). The concrete floor slab is only 13-14 cm thick, and the measured airborne sound insulation was R’w (C;Ctr) = 50 (-1;-4) dB. The ceiling on the 1st floor is protected and could not be changed in any way. In the search for a solution, most solutions were rejected by the structural designer due to additional weight. The final solution was a 25 mm high density wool (125 kg/m^3) on the floors in the hotel rooms, along with a 12,5 mm gypsum and a douple layer of 12 mm particle board. The total weight of only approx. 30 kg/m^2 fulfilled requirements from the structural designer, and the total height of the additional floor was only 61,5 mm (plus parquet), fulfylling architecural requirements, requirements for wheel chair access and universal design. This gives approx. +10 dB in R‘w, resulting in expected measured values of R‘w > 60 dB. The floor is all connected with elastic connectors, to prevent leakage.

Other methods were used in the bathrooms, due to a risk of water and high humidity. In those rooms, there was placed Instalay 50 underlay with a 40 mm fiber float/slab with ceramic tiles.

The impact noise insulation was measured between the 2nd and 3rd floor. It was measured L‘n,w = 58 dB with floating parquet, and therefore requirements defined in quility class C were fulfilled, according to ÍST45.

It was decided to use solid parquet and Instalay 50 underlay (Instafloor), wich was on of the best underlay found at the time in Iceland.

There was also a problem with airborne sound insulation on the top floor, where the floor was made of a light timber construction. The top floor (6th floor) was not meant to be used, but this type of structure gave transmission problems between rooms on the 5th floor. The airborne sound insulation was obviously low, and mitigation measures were needed to prevent problems. Therefore it was decided to use a triple gypsum layer mounted on timber joists under the timber floor construction. The gypsum had a little gap inside the wall dividing the rooms, to prevent flanking transmission.

This prevented leakage between rooms on the 5th floor and is a good base to work on if later on it will be decided to use the 6th floor also for hotel rooms.

4.2 Sound insulation between rooms

According to requirements from the hotel manager, walls between two adjacent rooms must fulfill R'_w = 58 dB in lightweigt walls.

For that, there was need for walls made of a double stud system, along with wool and triple gypsum on each side, with a total wall thickness of 225 mm. Sound insulation between rooms within each floor is therefore more than between floors. One wall needed to have a certain load bearing capacity, and therefore timber studs were used in one layer instead of aluminium studs. In the connection between the gypsum wall and the mortar on the facade, the mortar was broken with timber to prevent leakage of fire and noise.

Walls between rooms and corridors were not as sound insulating as walls between rooms, but it was quite a challenge to get proper doors between corridor and rooms, whereas the doors were protected by the architectural conservation.

4.3 Pipes between rooms

All pipe routes go between floors above the ceiling in bathrooms and entrances in each room. The ceiling was finished with a double layer of gypsum. The original design proposed all electrical pipes to go in special installation trays, built inside a double layer of gypsum, but in the construction phase, there was no room for such finishing.

Instead, plastic pipes were used. The pipes were covered with a 1“ thick layer of rockwool, covered with Silentfloor Gold parquet-underlay. The pipes were stuffed as possible with rockwool.

The reason for this special solution for finishing is that after the financial crisis, all suppliers sold their inventories of building materials, and since then all material must be preorded with at least 6 weeks notice. This project was on due date – planned to open in the coming month and the solution had to be found with available material.

4.4 Protected stairway – Impact noise and reverberation time

In the stairway, there is a protected marble on the floors and steps that could not be concealed or changed. Therefore it was decided to use pieces of carpets to ensure proper impact noise level from the stairway to adjacent rooms. It would also have a good influence on the reverberation time, as the walls and ceiling are also protected. Therefore there was also a need for sound absorbing paintings and smaller absorption areas, to fulfill the requirement for reverberation time in the stairway.

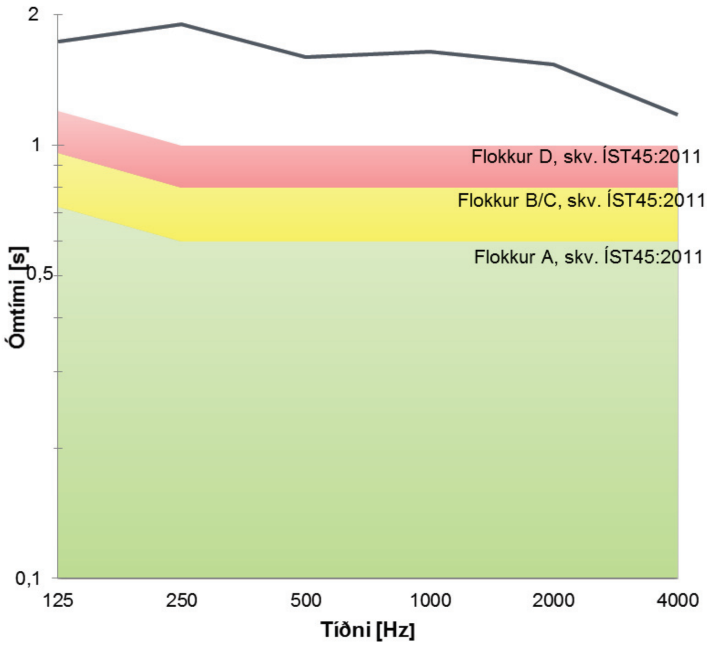

Figure 1 – Measured reverberation time in stairway, and quality classification (ÍST45)

4.5 HVAC, top floor (light structure)

Mitigating measures were needed to prevent annoyance from the HVAC system that was to be placed on the 6th floor (timber structure). All pipes were mounted with elastic mounts and enveloped with appropriate materials, as well as built in with two layers of gypsum.

4.6 Street noise – Party noise

Environmental noise is mostly noise from discotheques/clubs/bars and pedestrians in the street at all hours. To achieve acceptable noise level indoors, windows must fulfill R'_w = 40 dB. Present windows are made of a single layer of glass, approx. R'_w = 19-21 dB (old windows, poor sealing). Since changing the outer facade was unaccepteble (architectural conservation), an inner window was added.

The importance of proper inspection of all windows is very high, regarding heat insulation, tightness and mounting, prior to implementing this type of installation.

5. HOTEL AND A CONCERT HALL IN THE CENTER OF REYKJAVÍK (ONGOING PROJECT)

5.1 Start of design

This is an interesting project that started last winter and is ongoing. The hotel is big and will partly be in an older building, and partly in a new building. This involves different types of concrete slabs and structural solutions. The basement will be of a special use, with lots of water, humidity and pipes. The biggest challenge is an old architecturally conserved concert hall. The concert hall is famous for its looks, but the acoustics are currently quite poor. Above the concert hall there will be some conference rooms and hotel rooms, requiring silence after 22:00 in the evening.

5.2 New solutions

To fulfill all requirements, the architecturally conserved concert hall will be levelled to ground, and rebuilt as a box-in-box concert hall (with “flying walls”). Under many of the thin concrete slabs in the building, there will be used Kinetics Super-Compact Ceiling Hangers, to fulfill strong requirements on sound insulation, with additional floating floors on top of some floor slabs.

Doors into rooms will be especially sound insulating.

5.3 Street noise

Environmental noise is mostly noise from discotheques/clubs/bars and pedestrians in the street at all hours. To gain acceptable noise level indoors, windows must fulfill at least $R'_w = 40$ dB. Present windows are made of a double layer glass, approx. $R'_w = 28$ dB. An inner window will be added, or the glass replaced. Emphasis will be made on the importance of inspection of all windows regarding heat insulation, tightness and mounting, prior to implementing this type of installation.

6. CONCLUSION

Designers often face real challenges in fulfilling sound insulation requirements, when retrofitting older buildings. It would for example be preferable to have guidelines in diagrams, with different requirements depending on the scope of changes and how extensive the reconstruction is (part of a building or the whole building). It would also be good if there were established guidelines on special considerations or possibilities of certain exemptions to make for protected buildings, and areas where it is challenging and/or expensive, or simply impossible to fulfill the requirements.

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