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NEW MUSICAL CLASSROOM WITH HIGH SOUND INSULATION IN AN EXISTING BUILDING AND HIGH SOUND INSULATION IN STUDENT ROOMS

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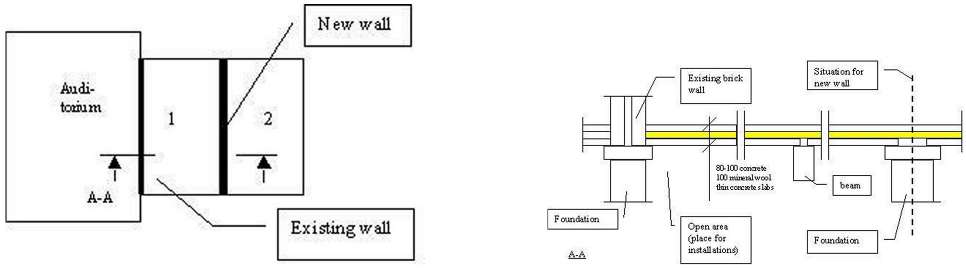
ABSTRACT
In a typical School building near Malmö in Sweden, erected 1970, a new musical classroom was planned 1996. Primarily the aim was to create a musical classroom with high sound insulation, designed to make it possible to carry on teaching without being disturbed during musical lessons, both in a new adjoining classroom (student room) as well as in the current auditorium next-door, and vice versa. In cooperation between the client and the acoustic consultant it was stated that if the sound reduction index exceeds R'_w 60 dB in the completed construction it might be acceptable conditions in current rooms. Therefore, R'_w 60 dB, was settled as a minimum requirement in this particular case. Hence, it was initially necessary to judge whether it was possible to fulfil this requirement without too large and cost consuming modifications in the existing building construction. If this was judged not possible the musical classroom would not have been designed and built. After some initial investigations it was estimated that the requirement will be fulfilled both for the existing wall adjoining the auditorium and for the new wall to be mounted, adjoining the classroom. The main problem was to prevent flanking transmission of the existing floor construction and the interior part of the facade wall. Therefore some minor modifications where made in these parts. Besides this, the existing walls and the ceiling was supplied with additional sound insulation.

1 - INTRODUCTION
In a typical School building near Malmö in Sweden, erected 1970, a new musical classroom was planned 1996. Primarily the aim was to create a musical classroom with high sound insulation, designed to make it possible to carry on teaching without being disturbed during musical lessons, both in a new adjoining classroom (student room) as well as in the current auditorium next-door, and vice versa. In cooperation between the client and the acoustic consultant it was stated that if the sound reduction index exceeds R'_w 60 dB in the completed construction it might be acceptable conditions in current rooms. Therefore, R'_w 60 dB, was settled as a minimum requirement in this particular case. Hence, it was initially necessary to judge whether it was possible to fulfil this requirement without too large and cost consuming modifications in the existing building construction. If this was judged not possible the musical classroom would not have been designed and built.
After some initial investigations it was estimated that the requirement will be fulfilled both for the existing wall adjoining the auditorium and for the new wall to be mounted, adjoining the classroom. The main problem was to prevent flanking transmission of the existing floor construction and the roof construction. Besides this, the existing walls and the ceiling were supplied with additional sound insulation.
The building consists of only one floor plan and hence, only horizontal sound transmission was considered. The lay-out is shown in figure 1 below

2 - EXISTING BUILDING CONSTRUCTIONS
The building in which the new musical classroom was planned is constructed according to the following principles (see also figure 1 below):



(a) **(b)**

Figure 1: Lay out and existing building constructions; 1. new musical classroom; 2. ordinary classroom.

The floor construction which consists of something called ERGE-floor structure, which is typical in many school buildings erected during 1960 and 1970, is built up by thin concrete slabs simply supported on beams. The floor construction is completed by placing 100 mm mineral wool above the thin concrete slabs and then by casting (above the mineral wool) a floating floor construction of 80-100 mm concrete. It is built up according to section A-A in figure 1.
The exterior walls consist of an exterior brick wall. Inside the brick wall there is mineral wool and an interior layer consisting of gypsum board mounted on wooden beams.
The roof construction is made of corrugated sheet plate simply supported on glulam beams. The sheet plate was supplied with mineral wool (thermal insulation) and finally, as roof covering, some sort of hard board.
The separating wall into the current auditorium is built up by two layers of 120 mm masonry walls separated from eachother (airspace 50 mm). Before starting the calculations this wall was measured according to ISO 140-4 [1] and evaluated according to EN ISO 717-1 [2] and the result is presented in figure 2 below.

$$R'_{\mathrm{w}}\,(C, C_{50-3150}, C_{\mathrm{tr}}) = 54\ \ (-1, -3, -7)\ \ \mathrm{dB}$$

One point not to forget was that the new classrooms also have to be acoustically divided in the air flow channels which were placed below the floor structure in the open area below the floor structure.

3 - PHASE 1: REQUIREMENTS

After initial investigations where framework and minor details were studied it was decided to carry on with the project and to state realistic requirements. Requirements which make it possible to create economical acceptable constructions but also enough to ensure that teaching could progress in all rooms without mutual disturbance.
With regard to limitations in the current framework (see clause 4) and with regard to the current building regulation (advisory notes) [3] the following requirements were stated.

Absolute minimum to adjoining rooms

$$R'_{\mathrm{w}} \geq 60\ \mathrm{dB}$$

However, in the calculations the aim was to try to achieve

$$R'_{\mathrm{w}} + C_{50-3150} \geq 60\ \mathrm{dB}$$

Sound level from installations

$$L_{\mathrm{pA}} \leq 30\ \mathrm{dB}$$

There was not any certain requirement stated for the maximum permissible impact sound level. However, there was not allowed to be any impact sound that might cause annoyance in the adjoining room. We will later see how the measures to create enough airborne sound insulation automatically imply that the impact sound level not will cause any problem.

4 - PHASE 2: MEASURES

4.1 - Major difficulties

The major difficulty was to ensure that the flanking transmission through the floor structure would be as small as ever possible. Calculations indicated that this was the dominating flanking path. It was not possible to apply any floating floor construction above the existing floor construction due to low room

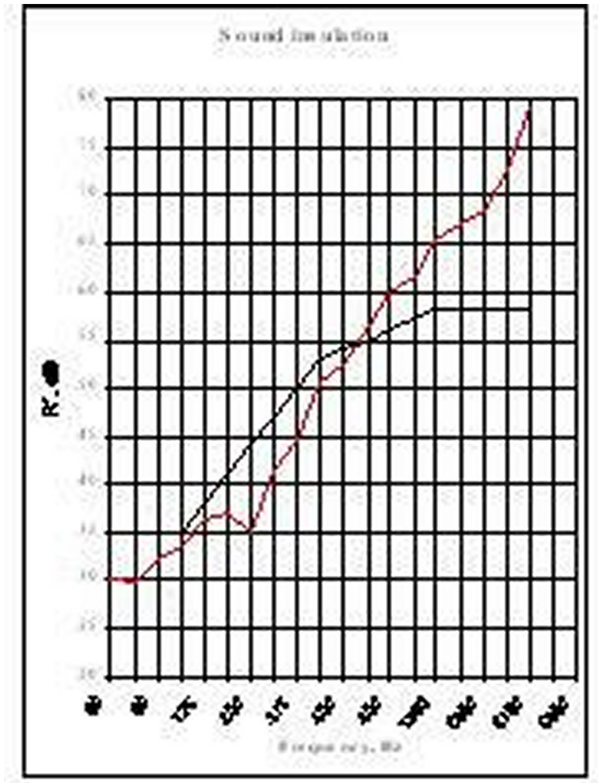


Figure 2: Measurement result from the existing masonry wall without additional sound insulation.

height. Anyway, the acoustical presumptions were good since the floor construction had the advantage that the upper part might be sawn off along the wall lines and in this manner we might create an effective break in the upper part of the floor in the existing structure. However the upper part of the floor is primarily a part of the static construction which create some sort of simply supported continuous plate. This means that if we cut the plate somewhere we might cause alterations in the strain pattern and the static function of the initial construction is changed. These presumptive changes was to be considered before the proposal of measures was presented. Since the plate still was continuous over one support the alterations in the strain pattern in the plate were small enough to ensure the static function of the building construction. Therefore, the upper part of the floor construction could be sawn off both along the current brick wall and along the new wall line between the new ordinary classroom and the new musical classroom.
Along the new wall line there was also some obstacles consisting of columns. These columns became enclosed in the new wall and the upper part of the plate was sawn off according to the figure below.

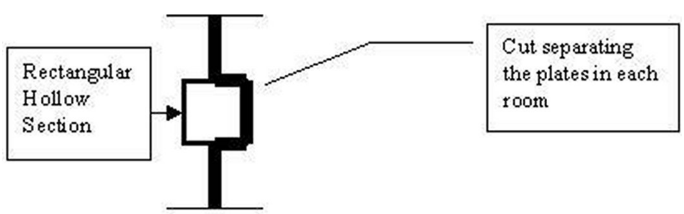


Figure 3: Saw cut when passing a column.

4.2 - New constructions
New wall construction
New separating wall was choosen as a light weight construction consisting of two parts, each part compassing three layers of gypsum board mounted on light weight beams. The air space between the two parts was 250 mm completely filled with mineral wool. The wall was mounted so that the cut was placed between the wall halves.

Supplemented sound insulation of the existing wall

The existing wall was supplied with additional sound insulation according to figure 4 below.

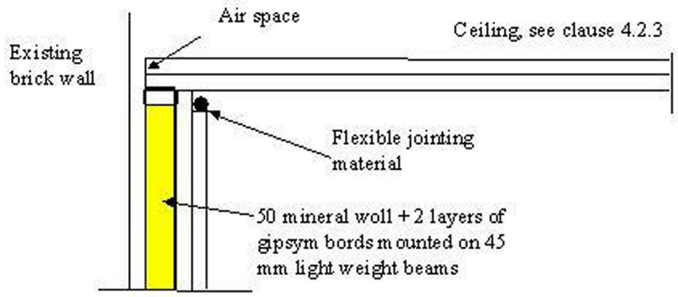


Figure 4: Additional sound insulation of the existing wall and connection against ceiling.

Ceiling and its connection to the new wall

To prevent flanking transmission through the roof construction a ceiling was mounted according to figure 5 below.

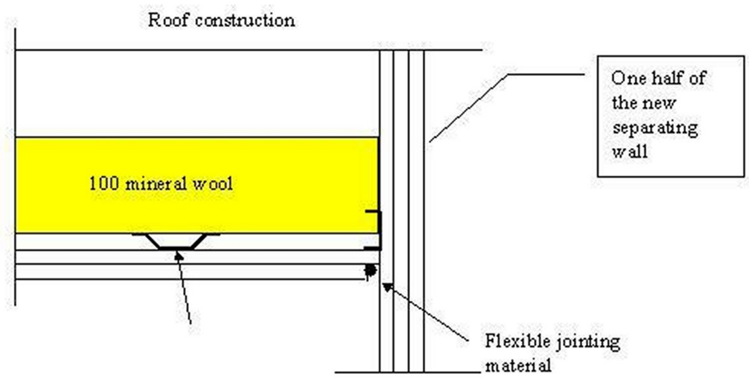


Figure 5: Ceiling and connection against the new wall.

5 - RESULTS

The results are shown in the sound reduction curves below. The left figure shows the results from both walls separating the musical classroom from adjoining rooms. The left chart shows the result for the existing masonry wall supplied with additional sound insulation according to figure 3 and the right chart shows the result for the new light weight wall.

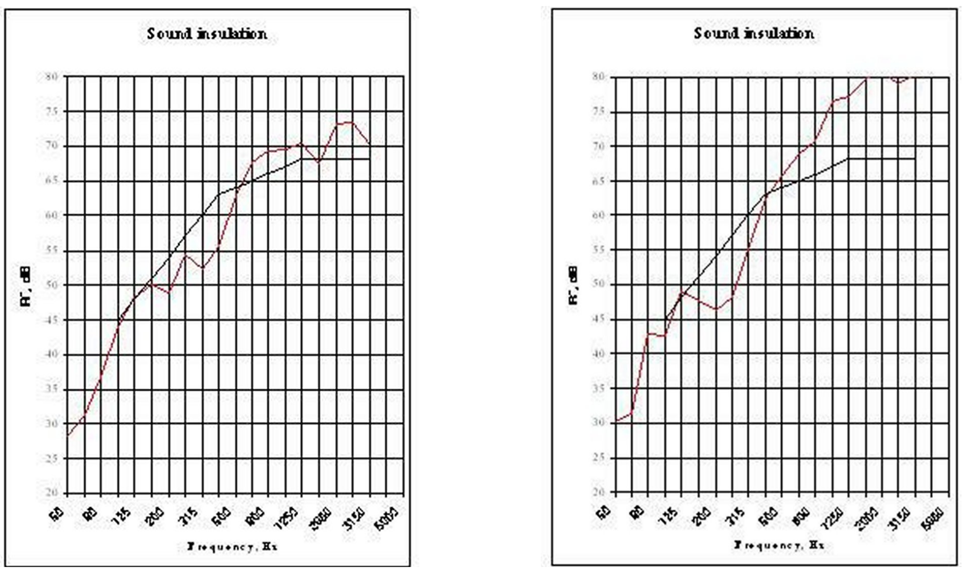
6 - SUMMARY

Besides the important details described in this paper, a lot of other small details have to be considered to achieve sound insulation according to this certain project.

During the building work a lot of care was put into on−site inspection of the construction. The experiencies from this work show that these on-site inspections are absolutely necessary to ensure the quality of the final construction. The importance of the design of small details for the performance of the final construction is normally not very well understood by the building contractor. In this work approximately half of the total time was put into the on-site inspections.

REFERENCES

1. **ISO 140-4**, *Acoustics - Measurements of sound insulation in buildings and of building elements - Part 4: Field measurements of airborne sound insulation between rooms*
2. **EN ISO 717-1**, *Acoustics - Rating of sound insulation in buildings and of building elements - Part 1: Airborne sound insulation*, 1996
3. Att Se Höra och Andas i skolan, Boverket och Arbetarskyddsstyrelsen, only in Swedish, 1996



(a): $R'_{\rm w}\,(C, C_{50-3150}, C_{\rm tr}) =$
64 $(-1, -4, -7)$ dB$R'_{\rm w,8} = 64$ dB

(b): $R'_{\rm w}\,(C, C_{50-3150}, C_{\rm tr}) =$
64 $(-1, -4, -7)$ dB$R'_{\rm w,8} = 63$ dB

Figure 6: Results for the existing masonry wall supplied with additional sound insulation (left) and the new light weight wall (right).