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ATTEMPTING TO TAYLOR SUIT THE FAÇADE SOUND INSULATION TO THE NEEDS OF THE OCCUPANTS

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In many countries there are regulations governing the sound insulation of the façade of dwellings. This is achieved through either an explicit requirement on the background noise inside the premises or through a façade sound insulation requirement. However the legal requirement does not always fully satisfy the occupants of the dwellings. In some cases they will express annoyance over hearing unwanted external noise (e.g. an emergency vehicle). In some other cases they will complain of not hearing something they can actually see outside! Last, the higher the sound insulation value, and the greater the risk of annoyance inside the dwelling (usually due to the absence of masking noise). This paper looks forward to explain basic legal regulations pertaining to the sound insulation of facades, and possible exemptions (e.g. under tropical climates) as well as possible improvements (e.g. when dealing with labelled construction).

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1. Introduction

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However the legal requirement does not always fully satisfy the occupants of the dwellings. In some cases they will express annoyance over hearing unwanted external noise (e.g. an emergency vehicle nearby). In some other cases they will complain of not hearing something they know as noisy and they can actually see outside (e.g. a plane on the ground near an airport hotel)! Last, the higher the sound insulation value, and the greater the risk of annoyance inside the dwelling due to the absence of masking noise. This paper looks forward to explain basic legal regulations pertaining to the sound insulation of facades, and possible exemptions (e.g. under tropical climates) as well as possible improvements (e.g. when dealing with labelled construction).

2. Basic legal requirements

There are two main methods to state façade sound insulation performances:

- Stating a sound insulation value (e.g. $D_{nTw} + C_{tr}$) of the space under scrutiny with regards to the outside space. The required value is a function of the noise emission of the terrestrial transportation infrastructure and its distance to the building under scrutiny; it also is a function of the noise classification of the area with regards to aircraft activities. This is used, e.g.,

in France [1]. Checking that the target has been achieved usually requires a powerful sound source and patient neighbours if any.
- Stating a background noise level inside the space under scrutiny. This is used, e.g., in the United Kingdom [2]. While this is easier to check by measurement it also requires coordination from other specialties (e.g. mechanical services of the building) in the case one wants to ascertain the actual sound insulation performance of the facade.

Those law texts usually point out that the required acoustic performance must be met while respecting the legal minimum requirements for the ventilation of the premises. Stating exemptions has been done in specific cases, e.g. when natural ventilation is commonly performed, and specific law texts have been drafted for such purpose (e.g. [3] in tropical climates) so as to prevent the systematic use of air conditioning.

For quite some time, one could find law texts pertaining to the thermal issues while others would cover the acoustical aspects. Eventually, complete separation of the matters has been achieved in France but this does not necessarily promote a dialogue between acousticians and HVAC specialists, with the former complaining that they want a given aperture area in the façade and the latter often claiming they have non interest in thermally minded affairs.

3. A few practical problems

While regulations, if applicable, will lead to a minimal sound insulation value, there are a few points that may require specific attention.

3.1 Usual practical problems

To start with, there often are complaints by the inhabitants of a new project:
- They can see something outside that they cannot hear (e.g. people in an airport hotel seeing a plane moving on the apron but not hearing it).
- They feel they are hearing too loudly some external events (e.g. horn from emergency vehicles, the bells or the muezzin calls, etc.)

This often complicates matters as the economics engineer will usually look for the minimal legal requirement. Here is a simple example: a brand new hospital was fitted with a helipad. Based on the predicted air traffic (1 movement per 24h at most) and road traffic around, the sound insulation target of the façade should have simply been 30 dB. Yet, due to the awful din when the helicopter would arrive or leave close to the hospital buildings, a 45 dB target was eventually preferred to limit the noise exposure of the hospital occupants.

3.2 Balance between contributions

In order to feel comfortable inside the premises, proper balance should be achieved between the sound contributions:
- Noise from the outside transmitted through the envelope of the premises
- Noise from mechanical equipment
- Noise transmitted from other spaces of the building..

As a rule, when people are coming to the acoustician inquiring about an improvement of the facade insulation, the acoustician warns them about the importance of those contributions and their masking each other. Most of the time those objections are waived, only to find people being forced into doing something about it later. Effective 1st of July 2017 a new regulation will be effective in France. It will be applicable for thermal rehabilitation of buildings whenever there are requirements on the acoustic insulation of the façade or the constitutive facade elements (windows, air intakes, shutters, roof, etc.), e.g. when the building is located within a defined noisy zone (so called “black point zone” on C chart) or within the annoyance area of an airport. Nevertheless this law text does not point out that those requirements must not undermine the sound insulation between dwellings,

nor does it stress out that a balance between noise contributions from the outside and from the inside of the building must be preserved [4].

3.3 Sustainable development and natural ventilation – New trends

First of all a minimum of ventilation of the premises is needed (and generally required by the regulations in force). This is of course to make sure that a reasonable amount of fresh air is admitted in the premises, so as to limit the introduction of such pollutants as carbon dioxide (from the breathing of people inside) and the emanations from finishing materials inside. This is also for sanitary purposes, in order to prevent mould from appearing in the premises.

In the olden days (when nobody really cared about the façade noise insulation) there simply were large slits under the window frame to allow for such ventilation. On the basis of experience it was estimated that a 22 dB typical $D_{nTw} + C_{tr}$ façade sound insulation was achieved.

Gradually noise attenuators that can be mounted inside or around the window frame have been developed. For some time there even were so called Z attenuators that were proposed (e.g. [5]). They were designed to be included inside the wall and featured interesting sound attenuation performances, but they unfortunately showed a nasty tendency to get obstructed due to air pollution and the eventual replacement of the noise attenuator embedded into the masonry proved to be too much of a difficulty.

Of course, the larger the number of air intakes, the worse the façade sound insulation would be. In order to try and keep a satisfactory façade sound insulation, there is a need to reduce the number of air intakes. It is possible to try and use the thermal inertia of the building to try and limit the needs for fresh air.

One may also consider the use of free cooling for the areas that are normally not occupied during the night. This helps reduce the needs for cooling ventilation in day time and therefore reduce the need for extra openings in the façade. While this is seductive enough, it does introduce a legal technicality: can one actually state a sound insulation objective for day time and a lower value in night time on the grounds that the building is normally not occupied at that time? Consulted on such a matter, a lawyer remarked that while it may sound logical (why try to provide sound insulation to a building that is not occupied?), this would mean regulations would be applied as customized items!

One may also consider double facades to increase the thermal insulation of the building. While this is also quite efficient in increasing the global sound reduction index of the façade, it also introduces a significant risk of creating extra flanking transmissions between spaces [6].

3.4 Structure borne noise

Why speak of structure borne noise here? Several regulations will state facade sound insulation objectives according to the presence of a transportation corridor. What if that transportation corridor generates noise inside the premises due to:

- Vibrations transmitted in the ground and later on radiated in the premises under scrutiny
- Noise radiated from the said transportation corridor and transmitted through the facade of the premises.

In France there are no provisions for solid borne noise. One has to define the sound insulation of the façade as per regulations and eventually adjust it to take into account the balance with the low frequency contents on the grounds of comfort.

3.5 Wind noise

Wind effects have quite a number of effects on the façade. To start with, there can be some serious effects of pressure and de-pressure to such an extent that some glass panes may get loose and fall down. Less dramatically there may appear turbulence around the façade elements. This will result in noise: one may face low ululating sound but also infuriating whistling sound. In both cases it helps to submit a façade sample to a noise generating text in a laboratory fitted with an acoustic wind tunnel to assess the danger and take the relevant precautions [7]. Those will typically entail

the modification of some key dimensions in order to avoid the occurrence of a badly placed resonance frequency, and perhaps the redesigning of such decorative elements as grills and louvers in order to avoid an unsatisfactory incidence angle of the wind onto the element.

3.6 Preserved building facades

When looking forward to preserve a building, one of the first elements that come under scrutiny by the Architect supervisor for preservation of course is the façade as it is one of the first elements to be seen. This often is the start of numerous problems: to start with, most of the time this architect will require the conservation of the existing windows. This introduces a serious air proofing challenge as those old windows are often leaky and the Architect does not want seals on them (actually, there used to be no air intake on such facades, the leaks were sufficient!)! Next, those old frames usually are too weak to be able to bear the weight of modern glazing. To give a rough idea, recently the sound reduction index R_w of an art deco façade in Paris was measured at 18 dB due to the thin simple glass pane and the atrocious leakage around the frames [8]. In order to serve the acoustic and thermal requirements while submitting to the wills of the Architect in charge of preservation, it is then necessary to build a winter garden so as to preserve the appearance of the façade from the outside.

4. Conclusions

The conception of a façade requires that many parameters have to be taken into account (e.g. architectural, structural, thermal, and acoustical), for both design and building phases. A constant exchange between the members of the design team is needed to try and fulfil all requirements.

When space (and budget!) is available, the construction of a winter garden may offer a satisfactory answer for architects and acousticians alike.

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