Facade sound isolation: a few questions

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Since 2000 it has been compulsory to use European acoustic criteria in France. This means that requirements as formulated in French regulations must be expressed using those European criteria. The applicable regulation pertaining to façade sound isolation with regards to land based transport noise is dated May 30, 1996. Accordingly it had to be revised. This was an opportunity to make improvements on the following points: clarification of the simplified method, coherence with the thermal regulation, and introduction of isolation requirements with regards to air traffic noise. This paper will submit the modifications introduced by the soon to be published regulation.

1 Introduction

Sound isolation with regards to the outside of dwellings, as well as such building types as schools, hospitals, and hotels, are currently determined according to the location of the building with regards to surface transport corridors or airport facilities nearby.

In France, methods used to determine those isolation values are defined in two regulations that are already showing their age:

- The arrest dated May 30, 1996, pertaining to the classification process of surface transportation corridors and to the acoustic isolation of dwellings in the areas affected by noise.
- The article 2 of the arrest dated October 6, 1978, for the noise for airplanes.

Since the 1st of January 2000, the regulations pertaining to the acoustic quality of dwellings are supposed to define the relevant criteria using the European acoustic criteria such as the isolation $D_{nTw}(C;C_{tr})$ or the impact sound level L'_{nTw}. This has been done as far as interior noise is concerned, with the publication of the arrest dated October 28, 1998, which is applicable since the 1st of January 2000. But this is not yet the case for the acoustic isolation of the façades of buildings located in areas affected by the noise from surface transportation corridors or airplanes.

A project of a new regulation is about to be published in order to replace the two fore quoted texts with requirements expressed in terms of the European criteria $D_{nTw}+C_{tr}$ or $D_{nTA,tr}$. This project has been developed by the technical commission of the National Council for Noise under the auspices of the Environment Ministry. It proposes several other improvements as compared to the two former texts:

- Simplify the standard method of determination of the facade sound isolation,
- Determine objective criteria of correction of the isolation values according to the existing protections between the building of interest and the ground transportation corridor,
- Better outline the precise estimation method of sound levels on the facade,
- Regroup within a single regulation the protection of buildings with regards to surface transportation corridors and airplanes,
- Make coherent the thermal regulation and the acoustic regulation when it comes to summer thermal comfort.

The present paper aims to submit the advances of this future regulation as compared to the two regulatory texts currently in force.

2 Simplification of the standard method

The standard method as described in the May 30, 1996, arrest, considers two cases:

- U shaped streets
- Open area

In the case of a building located close to a U shaped street, that is in a rather dense urban environment with nearly continuous buildings on each side of the street, the standard method can only be applied if the building of interest is located in this street and in the alignment of the other existing buildings.

The sound isolation values are solely determined according to the ground transportation corridor category (from the noisiest to the quietest), as illustrated in table 1:

Table 1: Required minimal sound isolation according to the ground transportation corridor category.

Category	Minimal required sound isolation D_{nAT}
1	45 dB(A)
2	42 dB(A)
3	38 dB(A)
4	35 dB(A)
5	30 dB(A)

A correction is proposed by shifting by one isolation class for the lateral facades, and two isolation classes for the rear facades.

Nevertheless, no correction is proposed according to the distance between the street and the building in the case of a building shy of the alignment.

Also, no correction is proposed when dealing with buildings acting as noise barriers in the case of buildings located in another street not far from the noisy street of interest.

Actually, one has to distinguish between the two cases of U shaped streets or open area when determining the category of the ground transportation corridor. For, a U shaped street featuring the same characteristics (flow rate, speed, road covering, etc.) than a similar street in open area, will be noisier due to the presence of buildings on both sides that will generate sound reflections on the buildings.

But once the ground transportation corridor category is determined, one knows the mean sound level at 2 m in front of the building or at a reference point located at a height of

5m and 10m from the edge of the road. Therefore one has no longer any need to distinguish between the cases of U shaped street and open area. One can determine the sound isolation of facades of a building according to:

- The distance between the building and the ground transportation corridor of interest
- The possible presence of shading between the building and the ground transportation corridor
- The exposition of the building to several ground transportation corridors.

3 Correction criteria with shading between the building and the ground transportation corridor

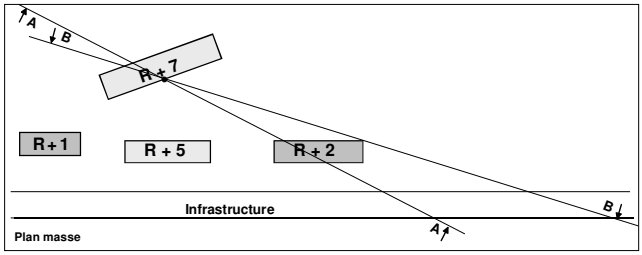
In the May 30, 1996, arrest the correction criteria of the facade sound isolation value in presence of shading between building and ground transportation corridor are very subjective and liable to interpretation.

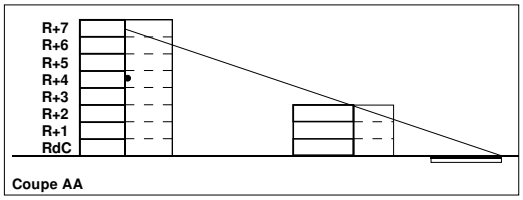
3.1 Protection of the facades of the building of interest by other buildings

For example, for a protected or partially protected facade by buildings, the correction is -3 dB(A) should there be, between the façade of interest and the ground transportation corridor, buildings that are only partially screening the noise. This correction is -6 dB(A) should there be, between the façade of interest and the ground transportation corridor, buildings that are nearly totally screening the noise, only leaving scarce openings for noise propagation.

It is rather hard to find the limit between those two cases. This is the reason for the proposed standard method in the regulation project to submit corrections based on an objective criterion. This criterion is the angle of view under which the ground transportation corridor is seen from the facade of the room of interest of the building under scrutiny.

For each portion of facade, the evaluation of the angle of view α is performed using the masking brought by buildings when looking at a cross section, as displayed by the following example on figure 1:





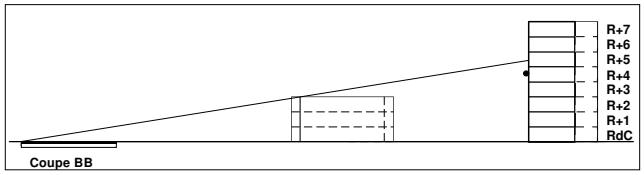


Figure 1: Examples of cross sections on the building R+2: the cross section BB is the one for which the line between the reference point and the upper edge of the building is the lowest. Even in this case there is no direct view of the ground transportation corridor from the observation point located in the middle of the facade of the R+7 at 4th floor.

For this observation point, the building R+1 provides no masking of the ground transportation corridor while buildings R+5 and R+2 are masking this ground transportation corridor.

Consequently, the angles of view from the above observation point are given on figure 2:

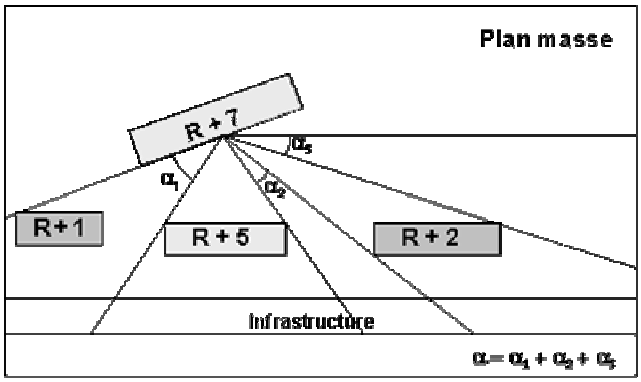


Figure 2: Angle of view α for a point located at 4th floor in the middle of the facade of building R+7

The corrections to be applied to the minimal sound isolation value according to the angle of view are as follows:

Table 2: Corrections to be applied to the minimal sound isolation value according to the angle of view.

Angle of view α	correction
α > 135°	0 dB
110° < α ≤ 135°	- 1 dB
90° < α ≤ 110°	- 2 dB
60° < α ≤ 90°	- 3 dB
30° < α ≤ 60°	- 4 dB
15° < α ≤ 30°	- 5 dB
0° < α ≤ 15°	- 6 dB
α = 0°	- 9 dB

The corrections as defined are more progressive. They vary by steps of 1 dB and no longer by steps of 3 dB. More to the point this notion of view angle takes into account the masking by buildings in both vertical and horizontal cross section, which had not been clearly explicated before. The new standard method is therefore more objective and more precise.

3.2 Protection of the facades of the building of interest by noise barriers or continuous berms along the ground transportation corridor

This new method also points out the corrections to be applied in case of the facades of the building of interest being protected by noise barriers or continuous berms along the ground transportation corridor.

In the May 30, 1996, arrest, one considers part of a facade masked by a noise barrier or a, earth berm by taking into account the height of the barrier (either in the 2 to 4 m range, or greater than 4 m) and the distance between the barrier and the building (either smaller or greater than 150 m). The present regulatory text is not clear at all on what is called a part of facade masked by a building.

In consequence, the project of regulatory text proposes to clarify the situation by introducing the notion of non protected room, lightly protected room, or heavily protected room, with regards to the noise from the surface transportation corridor.

This notion enables the taking into account of real protections brought by the noise barrier to the facades of buildings by examining the situation in cross section as well as to distinguish between the situations from floor to floor.

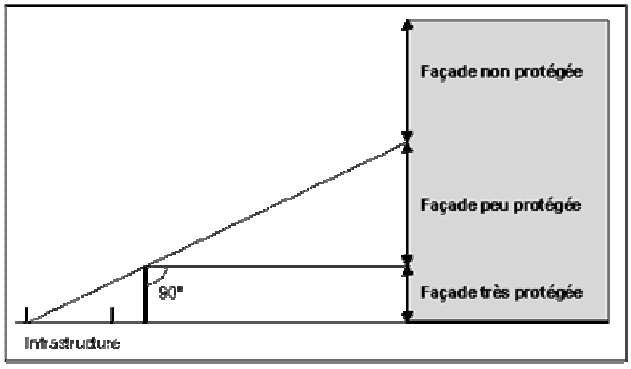


Figure 3: Facade not, lightly, or heavily protected

3.3 Cumulation of the two protections for the facades of the building of interest

When dealing with a noise barrier or a berm along a ground transportation corridor, and buildings possibly acting as noise barriers between the ground transportation corridor and the facade of the building of interest, one cumulates both corrections. However, the global correction is limited to -9 dB.

This cumulation is performed as follows: one determines the corrections to be brought to each part of thee facade due to the presence of the noise barrier on the one hand and due to the presence of buildings on the other hand. One then adds both corrections for each part of facade, as displayed on the following example on figures 4 to 7:

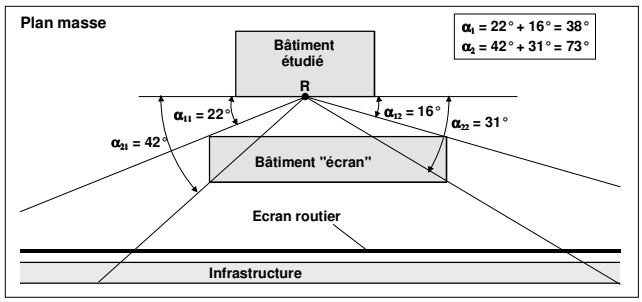


Figure 4: Calculation of the angles of view of the ground transportation corridor from point R located on the facade of the building of interest

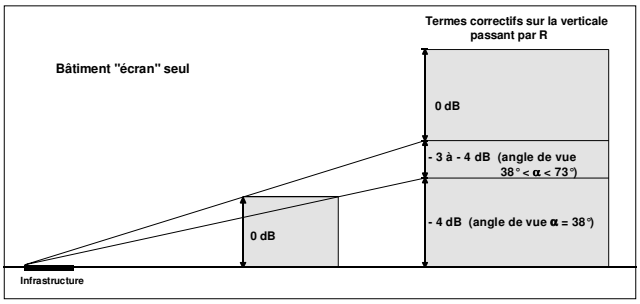


Figure 5: Calculation of the corrections to be brought to the value of the sound isolation due to the presence of the building located between the ground transportation corridor and the building of interest

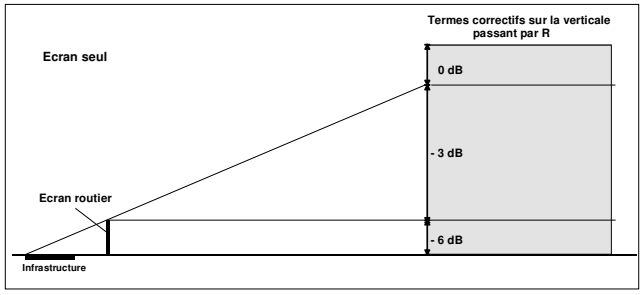


Figure 6: Calculation of the corrections to be brought to the value of the sound isolation due to the presence of a noise barrier along the ground transportation corridor

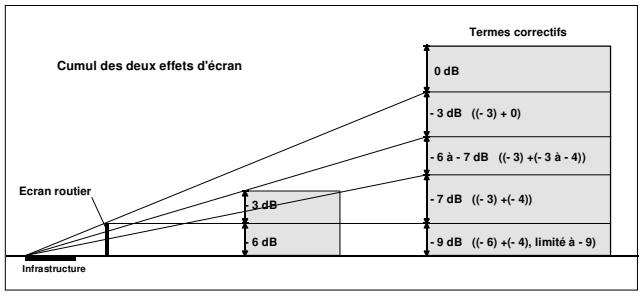


Figure 7: Cumulation of the corrections to be brought to the value of the sound isolation due to the presence of a noise barrier and a building

4 Exposure to several surface transportation corridors

The May 30, 1996, arrest, prescribes to determine the required sound isolation for each facade of the building of interest according to the noise exposure of each of the relevant transportation corridors. Then for each facade the highest of the sound isolation value thus calculated is retained. Should the highest of the sound isolation values be greater by more than 3 dB(A) to other values, it is this value that will be prescribed for the façade under scrutiny. In the opposite case, the prescribed sound isolation value is equal to the highest of the values obtained for each transportation corridor, augmented by 3 dB(A).

In the project of arrest, the calculation of sound isolation values in the case of exposure to several surface transportation corridors has been refined. One compares the values of sound isolation from each corridor by beginning by the lowest values and by successive iterations should there be more than two ground transportation corridors. Each time, the correction from the table below is added to the highest of the two compared values.

Table 3: Corrections to be applied to the highest sound isolation value.

Gap between two values	Correction
0 or 1 dB	+ 3 dB
2 or 3 dB	+ 2 dB
4 to 9 dB	+ 1 dB
> 9 dB	0 dB

Once again, the calculation method is outlined, and the result refined by bringing a correction by steps of 1 dB.

5 Precise estimation of the sound levels on the facade

Article 7 of the May 30, 1996, arrest, points out that the end user can make a precise evaluation of the sound levels on the facade by taking into account the specific urbanistic and topographic data, the location of the building on the site, and if need be the local meteorological conditions. For that, the sound propagation between the transportation corridor and the future building must be studied:

- Either using a sound propagation model
- Or using measurements performed according to French standards NFS31-085 for road transportation corridors and NFS31 088 for rail transportation corridors.

In both cases, this evaluation is performed for each corridor, be it road or rail, by adjusting on the following sound level values at the reference point, defined according to the category of the ground transportation corridor:

Table 4: Sound level value at the reference point according to the category of the ground transportation corridor.

Category	Sound level at the reference point, in day time (in dB(A))	Sound level at the reference point, in night time (in dB(A))
1	83	78
2	79	74
3	73	68
4	68	63
5	63	58

The sound isolation value to be complied with is determined in order for the equivalent sound level to be lower to 35 dB(A) over the day time period (6h-22h) and lower or equal to 30 dB(A) over the night time period (22h-6h) in the kitchens as well as in the main rooms.

The project of arrest has completed those dispositions by stating that:

- Calculations must be performed in accordance with the French standard NFS 31-133
- Sound levels computed or measured at 2 m in front of the facades of the building must be reshifted from the sound levels computed or measured at the point of reference from the values defined in the above table for road transportation corridors as well as for high speed rail lines, and from the values defined in the above table augmented by 3 dB(A) for conventional rail transportation corridors.

This implies that when performing an estimation using a calculation model, acoustical characteristics are defined using whatever data can be collected (sound power level, speed, flow rate, etc…) and are adjusted so as to reshift, using calculations, the sound level at the reference point to the above given value.

When performing an estimation of the sound pressure level on the facade using measurements, one must simultaneously perform measurements at the reference point of each of the transportation corridor of interest as well as at the relevant locations at 2m in front of the facades of the buildings under scrutiny. The measured value at the reference point of each transportation corridor is compared to the corresponding value of the above table (augmented by 3 dB for conventional rail transportation corridors). The computed difference is applied to measured values on the facade of the buildings under scrutiny. When measuring in free field, the measured value at the location of the future building is augmented by 3 dB(A) in order to take into account the reflection on the facade.

6 Protection of buildings with regards to planes

The sound isolation of facades to be complied with for buildings located in areas affected by the noise of airplanes using airports are presently defined by article 2 of the October 6, 1978 arrest according to the noise zone of the airport close to which the building of interest is located.

The opportunity of revising the May 30, 1996 arrest was taken upon to regroup prescriptions regarding the facade

sound isolation for both types of noise (ground and air transportation).

One also had to define a sound isolation value for the fourth zone (known as zone D) that has been defined in the latest Airport Noise Exposure Maps, and that had not yet been followed by any effect due to no sound isolation criteria being defined in the regulations.

More to the point, in order to follow the recommendation by ACNUSA (Autorité de Contrôle des Nuisances Aéroportuaires), the sound isolation values are no longer defined with regards to a pink noise but with regards to a road traffic noise, which means using the.sound isolation criteria $D_{nTA,tr}$. This stems from the fact that noise from a far away plane (several hundred meters) is more heavily tainted in low frequency components and therefore closer to a road traffic noise than to a pink noise. A road traffic noise spectrum is more representative of the noise perceived by a neighbour during the flyover of his building by a plane either landing or taking off.

The required sound isolation is given as follows:

- zone A : $D_{nTA,tr} \geq 45$ dB
- zone B : $D_{nTA,tr} \geq 40$ dB
- zone C : $D_{nTA,tr} \geq 35$ dB
- zone D : $D_{nTA,tr} \geq 32$ dB

The use of this sound isolation criteria $D_{nTA,tr}$ has the advantage of taking into account cases of multi exposition to ground and air noise sources. The minimal sound isolation value is determined from the two values calculated for ground transportation corridors and for air traffic. Those two values are compared, and the following correction is added to the highest of those values:

Table 5: Corrections to be applied to the highest sound isolation value.

Gap between two values	**Correction**
0 or 1 dB	+ 3 dB
2 or 3 dB	+ 2 dB
4 to 9 dB	+ 1 dB
> 9 dB	0 dB

7 Coherence with thermal regulation (RT)

The May 30, 1996, arrest features an article 9 which states that air purity and thermal comfort in warm season must be provided while keeping for dwellings the sound isolation required by the present arrest, which means keeping the noise exposed windows of main rooms and kitchens closed.

Those prescriptions have been taken in the thermal regulation (RT 2005 and later RT 2012). As a consequence they have been removed from the project of the future arrest in order to avoid incoherencies with the evolution of the thermal regulation.

8 Conclusion

The project of regulation was not yet published when this paper was written. Nevertheless, on looking at the improvements brought by this project, its publication is being waited for with great impatience, especially with regards to the following points:

- Coherence of acoustic criteria used in the various aspects of the regulations
- Simplification and optimisation of the standard method enabling to determine the façade sound isolation of buildings.
- Clarification of the precise estimation method for the sound levels on the façade of the building.
- Protection of the buildings with regards to both airplane noise and ground transportation corridors within a same text.
- Suppression of the thermal aspect in the acoustic regulation.

References

[1] ACNUSA, *Annual Report*., Paris (2009)

[2] Arrête du 30 mai 1996 relatif aux modalités de classement des infrastructures de transports terrestres et à l'isolement acoustique des bâtiments d'habitation dans les secteurs affectés par le bruit.

[3] Arrêté du 6 octobre 1978 relatif à l'isolement acoustique des bâtiments d'habitation contre les bruits de l'espace extérieur.