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ACOUSTIC BEHAVIOR OF ACTIVE GLAZING FAÇADES WITH CIRCULATING WATER CHAMBER

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Abstract

In recent years, the construction of buildings with extensive glass facades has increased rapidly. The widespread use of glass as facade elements represents a serious challenge for the heating and cooling of these buildings, and also to achieve acoustic comfort in noisy environments.

Active Glazing System can be used in order to avoid these negative effects. This system is based on a double or triple glazing with a circulating water chamber that reduces the solar factor and increases the acoustic insulation.

From the thermal point of view these multilayer active enclosures have been studied and proved to be lightweight and with excellent performance. However, from an acoustic point of view, in general they have been little studied. Therefore the main objective of this paper is to show the results of acoustic insulation of active glazing curtain walls to fulfill the sound insulation values required in the SpanishTechnical Building Code (CTE). This article will explain the process that has been followed to carry out an investigation on the acoustic behavior of active glass facades. For this purpose acoustic behavior and sound intensimetry measurement methods have been used. After obtaining these results, a comparison between active glass panels and traditional curtain walls was made.

Keywords: acoustic behavior active glass facade.

1. INTRODUCTION

A lightweight solution with low specific mass is of particular interest for high acoustic performance in façades. The acoustic performance of curtain walls is primarily a function of the glazing and internal seals to stop air leakage. The sound attenuation capability of curtain walls can be improved by installing sound attenuating infill and by making construction as airtight as possible. Incorporating different thicknesses of glass in an insulated glass unit will also help to mitigate exterior noise. This can be accomplished by increasing the thickness of one of the lites of glass or by incorporating a laminated layer of glass with a noise-reducing interlayer, typically a polyvinyl butyral or PVB.

This article will explain the process that has been carried out for an investigation related to the acoustic behavior of light active curtain walls. For this purpose, sound intensimetry measurement methods have been used.
The main objective of this research is to validate light active curtain walls system with a high degree of acoustic insulation that can be used in any noisy environment. These curtain walls show excellent thermal characteristics, without neglecting important aspects such as the sustainability of materials, industrialization and costs.

The CTE DB-HR Protection against noise [1] establishes the requirements for the façade enclosure according to external noise (noise index L_d days) and the use of the building. According to the simplified option of CTE DB-HR, to assess whether an enclosure meets the requirements of airborne sound insulation, insulation data is taken from both the opaque and glass parts (window). Depending on the percentage of window area, a difference value in levels is obtained, weighted A, in facades in contact with outside air for car noise $D_{2m, nT, Atr}$ (dBA).
Therefore, according to the simplified design option CTE DB-HR, taking into account Values of Airborne Sound Insulation $D_{2m, nT, Atr}$, in dBA between a protected building and the exterior, depending on the daytime noise index Ld (Table 1), the range of insulation can then be calculated for the three types of light multi-layer facades that would be valid in the most unfavorable conditions such as bedrooms and residential and hospital stays. Typical values of Noise Reduction Index R_A for curtain walls, taken from the CTE Catalogue of Constructive Elements [2] and the explanatory report of the BALI project "Building Acoustic for Living" [3] are from 30 to 34 dBA.

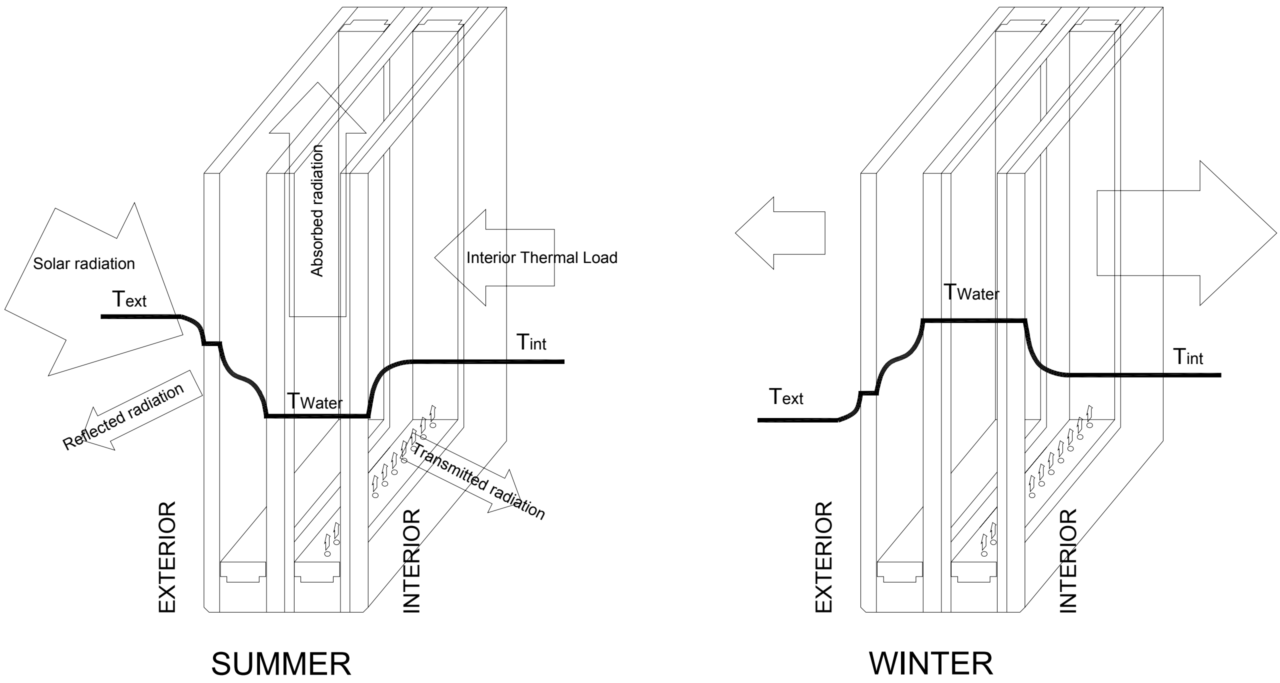
Table 1 – Values of Airborne Sound Insulation $D_{2m, nT, Atr}$ depending on the daytime noise index Ld.

Ld (dBA)	Residential and Hospital Building		Cultural, school, ofice Building	
	Bedrooms	Rooms	Rooms	Classrooms
Ld ≤ 60	30	30	30	30
60 ≤ Ld ≤ 65	32	30	32	30
65 ≤ Ld ≤ 70	37	32	37	32
70 ≤ Ld ≤ 75	42	37	42	37
Ld >75	47	42	47	42

2. DESCRIPTION OF ACTIVE GLASS

The Active Glass system incorporates the movement of a layer of water that blocks the thermal solar radiation and can be used for cooling or heating. The panel consists of three glasses monolithic or laminated, separated by two 16 mm chambers. One of the chambers is filled with water. The connection between the interior of the camera and pipes is done by a special piece that adapts to the separator profile of the glasses. This profile has some perforations specifically designed, based on study and simulation of the flow of water flowing by all straight surfaces of the project. Glass is maintained at constant temperature thanks to water in circulation, so temperate treatment in the case of glasses exposed to strong solar radiation can be avoided. Active Glass systems avoid these two defects on the double glazing with air chamber and low solar factor. An active glazing system is able to manage the energy of the building. Water has the property of being opaque to the infrared radiation, so by using a water layer in circulation, a 60% of the solar radiation energy can be absorbed with transparent glass. Thermal properties of this Active Glass have been well studied. The aim of this paper is to study airborne sound insulation of Active Façades by field measurements.

Figure 1. Description of Active Glazing System.



3. DESCRIPTION OF THE BUILDING

The building selected is the School of Journalism of Castilla La Mancha University, in Cuenca, Spain.
The floor plan of the School of Journalism is rectangular. A 16 meter high lobby receives daylight through the curtain wall facing west. This space contains a staircase along the west wall that leads to the rest of the floors. This entrance lobby of the building is what connects the two corridors serving classrooms on both sides. The lobby and the corridors are separated from the rest of the building by fire separations. The building has a total of sixteen classrooms. Each classroom has large windows facing east or west.
The biggest problems with solar heat gain, which direct sun entry can produce, are experienced with west-curtain wall. In the middle of the morning and afternoon the sun can be low enough in the sky and solar radiation can´t be blocked. The surface of the curtain wall is 150 m2. This wall is made with extruded aluminum frame filled with active glazing with different thicknesses of glass incorporating a laminated layer of glass with a noise-reducing interlayer.
Daytime noise index in building area is $65 \leq Ld \leq 70$, so values of Airborne Sound Insulation $D_{2m,\ nT,\ Atr}$, in façades should be between 32 and 37 dBA.

4. MEASUREMENT METHOD

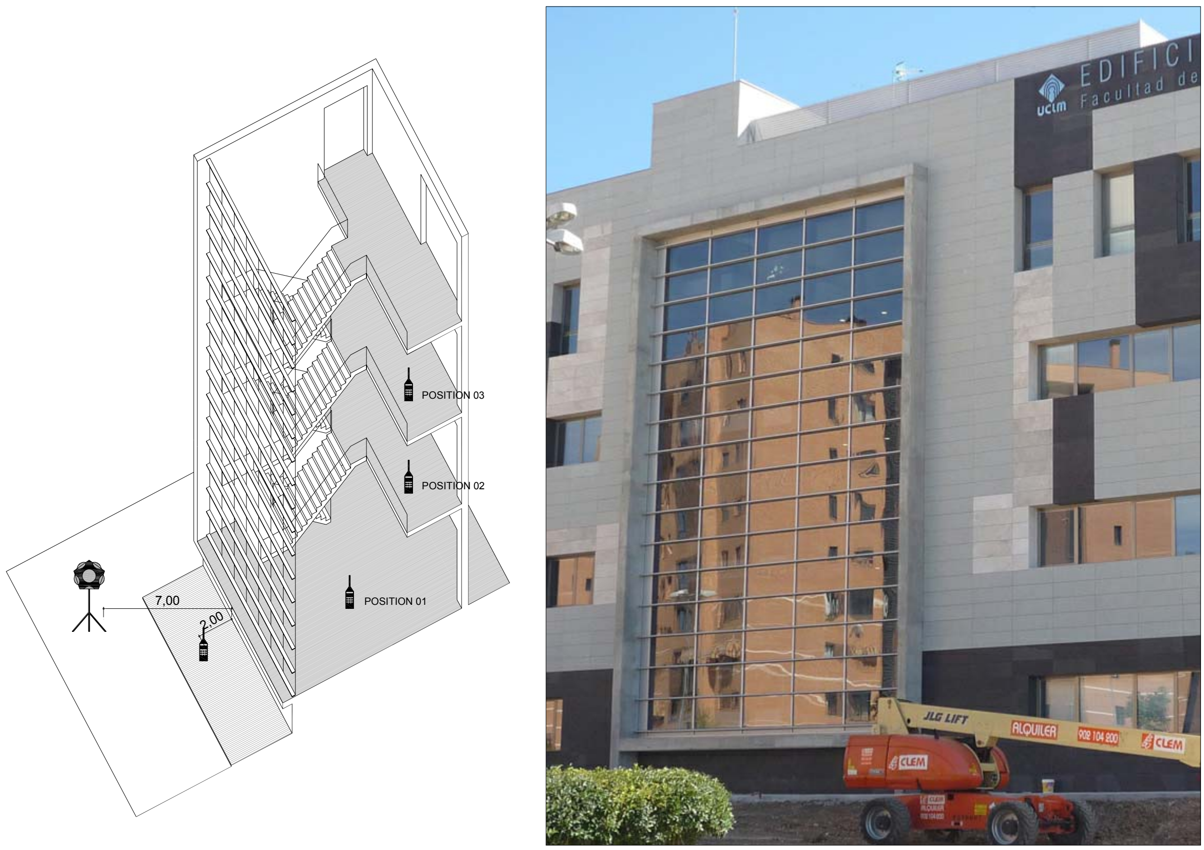
This part of ISO 140 [4] specifies two series of methods (element methods and global methods) for measurement of the airborne sound insulation of facade elements and whole facades, respectively. The element methods aim to estimate the sound reduction index of a facade element, for example a window. The global methods, on the other hand, aim to estimate the outdoor/indoor sound level difference under actual traffic conditions. The most accurate global methods use the actual traffic as sound source. The global road traffic method yields the real reduction of a facade in a given place relative to a position 2 m in front of the facade.

This method is the preferred method when the aim of the measurement is to evaluate the performance of a whole facade, including all flanking paths, in a specified position relative to nearby roads. The result cannot be compared with that of laboratory measurements. The global loudspeaker method yields the sound reduction of a facade relative to a position 2 m in front of the facade. This method is particularly useful when, for different practical reasons, the real noise source cannot be used. The result cannot be compared with that of laboratory measurements. The global loudspeaker method has been used to measure the façade of the building.

The equipment used to measure is Cesva SC310 - BSC001. It is a Class1 digital sound level meter with octave and third octave band filters, reliable and easy to use. SC310 is used for environmental noise measurements, according to DPCM 01/03/91, Law 447, D.LGS 16/03/98, and for evaluating the noise disturb in working places. It is suitable for reverberation time measurement, according to ISO 3382, ISO 354 and ISO 140. It is well adapted for acoustics in buildings.
The source of sound is the AP600. It is comprised of a White and Pink noise generator and a power amplifier. The AP600 has been especially designed to generate the signal to be reproduced by the BP012. The BP012 has 12 loudspeakers mounted on dodecahedral housing. This ensures a complete omni-directional radiation diagram; that is to say, sound is radiated in a spherical distribution, as is required by the standards ISO 140 and ISO 3382.

For airborne sound insulation tests, the Dodecahedral loudspeaker is placed outside at a distance of 7 meters from the façade, as it is showed in Figure 2. The source noise level is then measured a minimum of five times, measuring each time in a different randomly selected location that is at a minimum distance of 1 meter form any wall, floor, ceiling or the speaker.
As per the standard, ISO 140 - 5: 1999 [4], a reverberation test was also carried out. This involved generating a sound at the source and then abruptly stopping the sound. The time taken for the sound level in the room to dissipate is used to calculate the recognized reverberation time for the room being tested. It is the reverberation time of the receiving room that is required. The final part of the test involves measuring the level of background sound. This background level is taken into account when reading the received levels of sound transmission. It is imperative that the background sound pressure level is below a certain level. Background readings were taken in the receiving room.

Figure 2. The lobby and 3 positions of digital sound level meter used for this study.



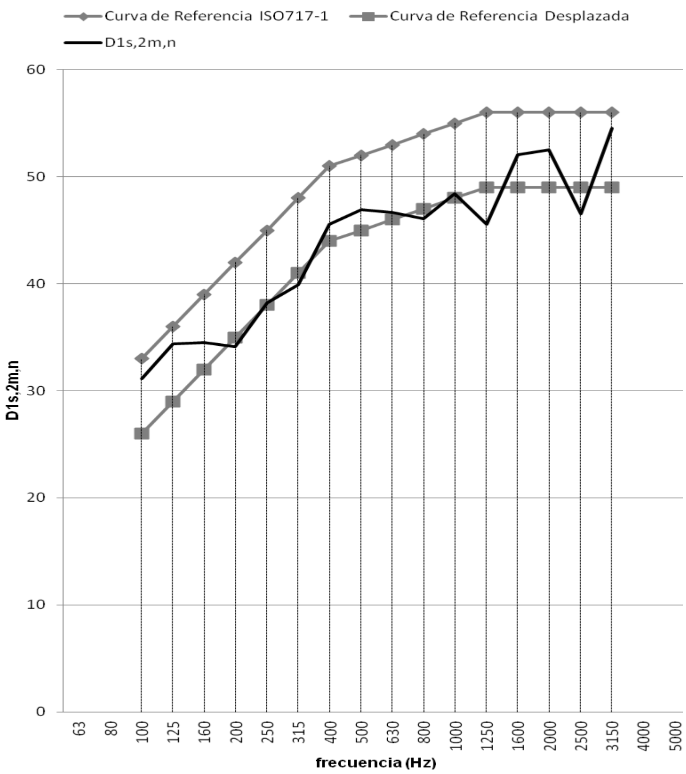
5. RESULTS

Table 2 shows the results for active glass curtain wall analyses of all test measurements in both tabular and graphical forms. The resulting frequency dependent level differences are converted into "a single number characterizing the acoustical performance" using the method given in BS EN ISO 717-1:1997 [5].

Table 2 results of Airborne Sound Insulation for active glass curtain wall in 3 positions.

Position 1. Date: 22/01/2012	
Façade Area: 150´82 m^2	Volume: 1.885´3 m^3

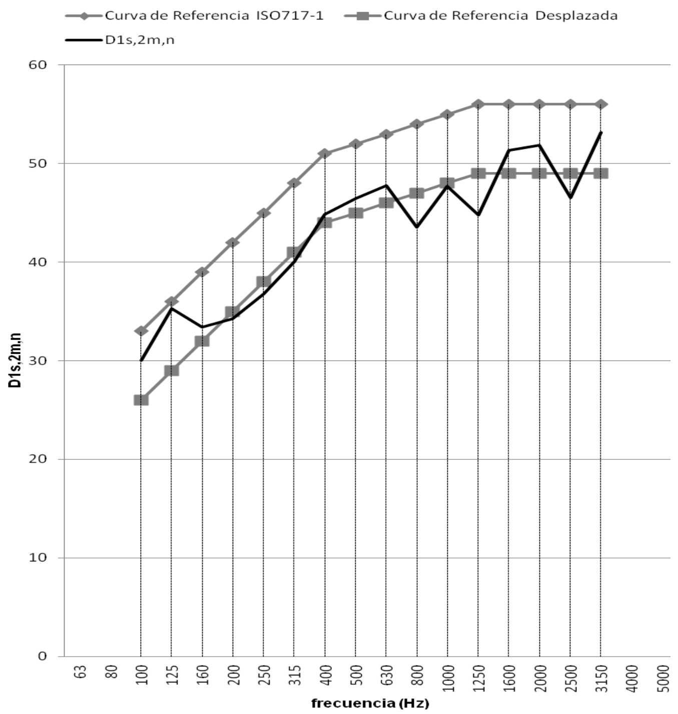
frecuency (Hz)	D1s,2m,n (dB)
100	31,2
125	34,4
160	34,5
200	34,1
250	38,2
315	39,9
400	45,6
500	46,9
630	46,7
800	46,1
1000	48,4
1250	45,6
1600	52,1
2000	52,5
2500	46,5
3150	54,5
4000	
5000	



X_a = -10log∑n = 42,9dB	$D_{1s,2m,n,w}$ = 45 dB
C_{TR} = $X_a - D_{1s,2m,n,w}$ = -2 dB	
$D_{1s,2m,n,w} + C_{TR}$ = 45-2 = **43 dBA**	

Position 2. Date: 22/01/2012
Façade Area: 150´82 m^2 Volume: 1.885´3 m^3

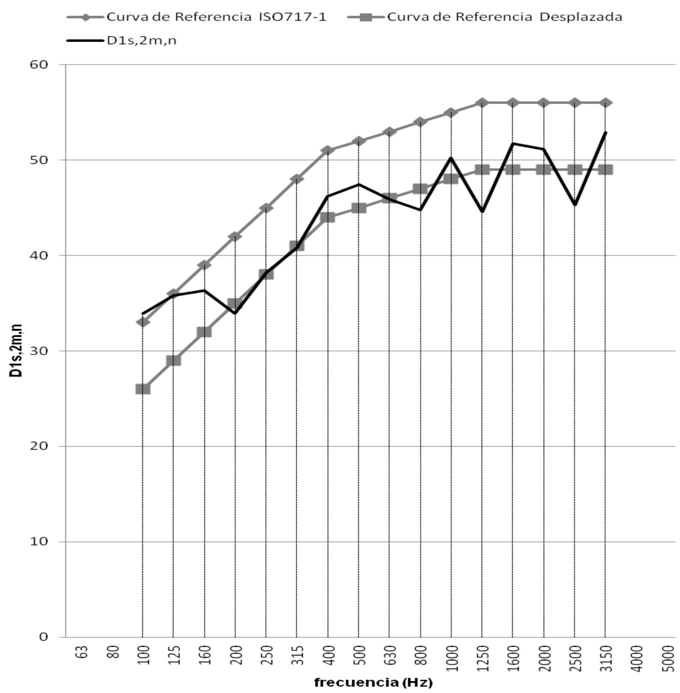
frecuency (Hz)	D1s,2m,n (dB)
100	30,1
125	35,3
160	33,4
200	34,2
250	36,8
315	40,0
400	44,9
500	46,5
630	47,8
800	43,5
1000	47,7
1250	44,8
1600	51,3
2000	51,8
2500	56,5
3150	53,2
4000	
5000	



X_a = -10log∑n = 42,3dB
$D_{1s,2m,n,w}$ = 45 dB
C_{TR} = $X_a - D_{1s,2m,n,w}$ = -3 dB
$D_{1s,2m,n,w} + C_{TR}$ = 45-3 = **42 dBA**

Position 3. Date: 22/01/2012
Façade Area: 150´82 m^2 Volume: 1.885´3 m^3

frecuency (Hz)	D1s,2m,n (dB)
100	34,0
125	35,8
160	36,3
200	33,9
250	38,2
315	40,8
400	46,2
500	47,4
630	45,9
800	44,8
1000	50,2
1250	44,6
1600	51,8
2000	51,2
2500	45,3
3150	52,9
4000	
5000	



X_a = -10log∑n = 43,4dB
$D_{1s,2m,n,w}$ = 45 dB
C_{TR} = $X_a - D_{1s,2m,n,w}$ = -2 dB
$D_{1s,2m,n,w} + C_{TR}$ = 45-2 = **43 dBA**

Using the same method, another measurement is done in a classroom. This façade is composed by 10 m2 of opaque multilayer wall with and 15 m2 of window. The sound level meter was always positioned at least 0.5m away from any room boundary or diffuser and at least 1m from the source. Each measurement position was at least 0.7m away from other positions where practicable and on a different axis.

Table 3 shows the results for traditional façades of classrooms.

Table 3 Results Airborne Sound Insulation in classroom façade.

Classroom. Date: 22/01/2012

Façade Area: 25´42 m^2 Volume: 173´9 m^3

frecuency (Hz)	D1s,2m,n (dB)
100	36,9
125	30,1
160	25,6
200	27,7
250	34,2
315	43,1
400	42,1
500	36,6
630	34,7
800	34,5
1000	35,4
1250	35,8
1600	41,1
2000	42,0
2500	49,1
3150	45,9
4000	
5000	

$X_a = -10\log\sum n$ = 35,3 dB

$C_{TR} = X_a - D_{1s,2m,n,w}$ = -7 dB

$D_{1s,2m,n,w} + C_{TR}$ = 42-7 = **35 dBA**

$D_{1s,2m,n,w}$ = 42 dB

6. DISCUSSION

From the thermal point of view, active glazing enclosures have been studied and proved to be lightweight and with excellent energy savings. This paper shows the results of acoustic insulation of active glazing curtain wall in the School of Journalism of Castilla La Mancha University, in Cuenca, Spain. These results have been compared with traditional façades values in the same building.

Taking into account the results of sound insulation obtained, both systems, traditional façade with more than 50% of window area and active curtain walls could be implemented in most cases in areas where the daytime noise index is 65 < Ld < 70 for dorms and stays (Residential and Hospital) and for rooms and classrooms (Cultural, school, ofice Building).
However, the active glass façade sample can be implemented in areas where the daytime noise index is 70 < Ld <75 for bedrooms and Ld > 75 for stays and classrooms, which means that this enclosure meets the requirements in noisy area.

The results of samples show that this active glass with aluminum frame enclosures have good acoustic performance, surpassing the light façade values in the Catalogue of constructive elements of the CTE [3] (point 4.2.10, 4.2.11 and 4.2.16), with similar thickness and mass or even greater. The Active Glass curtain wall studied in this paper fit insulation requirements in noisy areas. It is shown that such modification of construction of lightweight façades could be an effective method to reduce sound transmission. The improvement in Airborne Sound Insulation is about of 8-10 dBA compared to traditional curtain walls.

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