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VALUATION OF THE ACOUSTIC ENVIRONMENT BY THE DOUBLE SKIN FAÇADE FOR POSTGRADUATE CLASSROOM OF THE NATIONAL AUTONOMOUS UNIVERSITY OF MEXICO

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ABSTRACT

The recent building for classrooms of postgraduate studies of the UNAM (2013), exceeds the international standard acoustic comfort of (35dBA), investigating it was determined that the noise entering through the façade that gives to the Insurgentes avenue does not isolate the enough noise. On the other hand, the university legislation does not allow to alter the original facades because it belongs to the cultural heritage of UNESCO-UN, to solve this problem, it was initially brainstormed, in the end two alternatives were proposed. 1°an Insulation Barrier (IB), located at the edge of the property that divide the vehicular stream and the architectural complex; 2° a Double Skin Façade (DSF), with photovoltaic glass 2 meters from the original façade, without laterals that close it. To simulate the SPL that isolates the IB, and those will have been between the original façade and the DSF, The LimA predictor program was used, the microphones values obtained in the first proposal were placed two meters from the original façade, this test was carried out in two different heights from IB, the results were that does not reduce enough, with maximum values of 5 dBA and the interior SPL is 38 dBA or greater. The second proposal, was made in two different DSF heights, the acoustics insulation values obtained by microphones that were placed onside that space are in the range of 11 to 18 dBA, based on these results the SPL inside the classroom are in the range of 28 to 35 dBA, so now it meets acoustic comfort. Analyzing the values obtained with the simulator, we can say that they are probable. Additionally, consider in the urban landscape sustainable building with DSF.

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1. INTRODUCTION

The National Autonomous University National of Mexico (UNAM), has the title from of being the university of the nation, is located south of Mexico City (CdMx), has a total area of 730 Hectares, that is more than what some measure cities in Europe and even what they measure some of smallest countries, such as Vatican City 44 hectares, Monaco 202 hectares. Initially successful the architectural design of the spaces and buildings of the UNAM, has hardly changed in the last 60 years; it is practically design and built just as was when he campus of the University City (CU) was created (1952). This decision was reinforced when the UNESCO-UN in 2007, it grated the CU campus of UNAM the title of Heritage of Humanity, as the architectural design remains intact. The most recent classroom designs and built, do not meet the functional needs demanded by the deep changes that the environment surrounding the campus has suffered, and the intense growth of the population that uses of the space of the CU campus, it is estimated that in the 2018-2019 school year there will be more than 35,000 students. This large population requires mobility within the campus, which has caused a substantial increase in vehicular traffic and consequently high noise generation.

To illustrate the difficulties that arise when continuing with the original architectural design, a study is presented in the architectural complex of the Postgraduate Unit (UP) of the UNAM, due to its semicircular design it has all kinds of solar orientations, natural ventilation, exhibitions internal noise (roads), the architectural complex was built in year 2013. It shows a survey to teachers and students, of the acoustic evaluation of the classroom, by the noise generated by the vehicular passage of the road near the complex. The study focuses on two architectural solutions to the acoustic problem of comfort, considering that the classroom are enclosures where an excellent transmission must be achieved oral. Possible solutions are presented whose application will depend on the decision not to alter the obligations to maintain the title of cultural Heritage of Humanity.

Due to the above, the proposed solutions for this work are studied with the help of the software Predictor LimA Software [1], and emphasis is placed on the results obtained, so the approach is experimental and the simulation.

2. NOISE AS A POLLUTANT

Noise in urban and suburban localities is a constant pollution factor, becoming currently a serious problem to human health, with physiological, psychological, economic and social effects. Studies conducted in different countries have shown that 80% of noise pollution is caused by vehicular traffic in cities, due to the functional maldistribution of territory and dispersed urban development, this has led to the creation of an extensive network of streets and avenues, which connect the different areas of the city trough which different means of transport circulate in a constant and uninterrupted way [2], this often causes the lack of Interior Acoustic Comfort (IAC).

To achieve IAC, the architectural design is divided into two general aspects: a) controlling sound field generated outside to interfere minimally with internal sound field (sound insulation), and b) controlling the sound field inside the enclosure (sound absorption). The specific technical characteristics of these two aspects are defined according to the type of enclosure in question.

3. CASE STUDY

3.1 Ubication

The UP is located within CU of the UNAM, is made up if series of 11 concrete building, which from a semicircle around a square, see figures 1 & 2, buildings B, D, F, H, and J (external bodies), intended for academic activities, including: Basement, ground floor, three levels and roof. Building B, adjoins Insurgentes Avenue, figure2, due to vehicular traffic complaints have been presented by students and teachers about noise levels. A survey of perception carried out [3], yielded the following results: 48.4% of the students state that the environmental noise within this architectural complex is a problem; 59.3% think that the traffic noise affects mainly the academic activities that are carried out inside the classroom; 64,8% consider that Building B is the one with the most problems of all; 42,2% declare that generated by vehicular traffic annoys users; finally, 56.1% said that the main source of noise from Insurgentes Avenue.

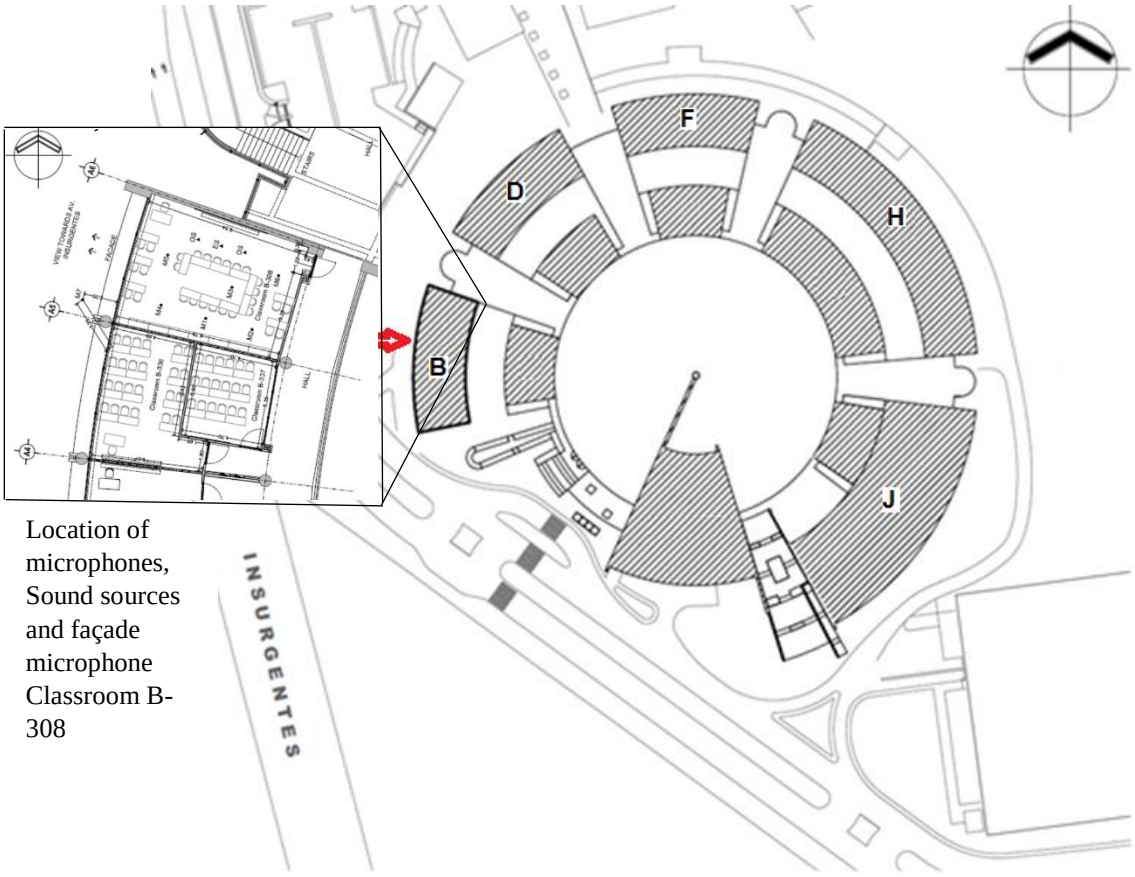


Figure 1. Location of the UP-UNAM. The red arrow points to building B, where the classrooms are located and Insurgentes Avenue

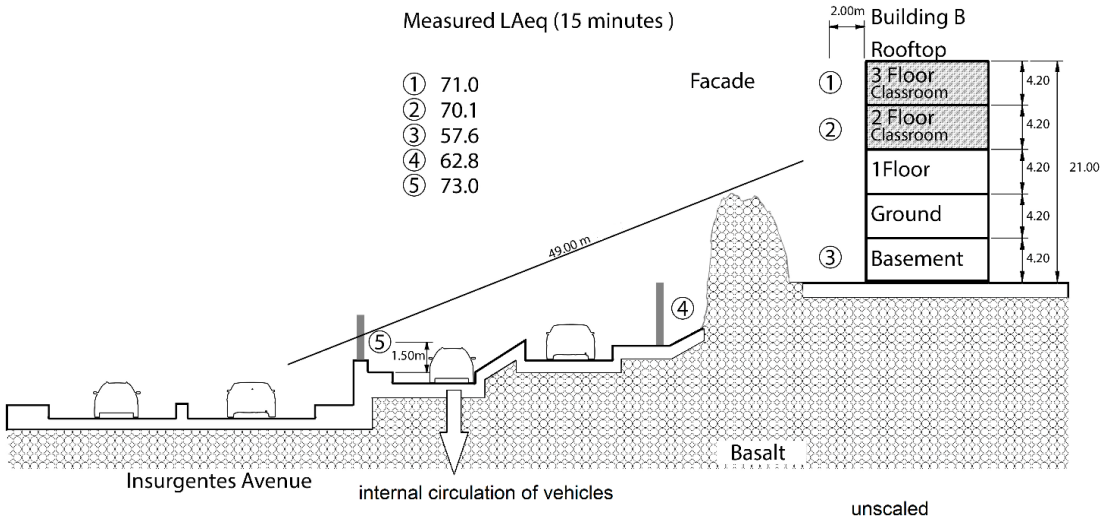


Figure 2. Side view of the location of Building B measuring points of outside noise and distance to Insurgentes Avenue

Figure 3. Position of the microphone for measuring the SPL of vehicular noise outside the classroom, 2 m front of the façade.

The recorded *LAeq* were measured *In Situ*, see figure 2 & 3, with a B&K sound level meter type 2270 and microphones type 4189.

3.2 Architectural description of the classrooms

- Concrete structure, mud tile floor.
- West façade wall, towards Insurgentes Avenue: prefabricated concrete as final finish, cement-sand block wall with alveoli, windows with aluminum frame with glass for lighting, ventilation with sliding window that does not seal.
- Fake ceiling of drywall.
- Drywall dividing walls.
- East wall, with window fixed and sliding window that does not seal, access door of metallic sheet that does not seal, with polystyrene core with glass of 50 x 50cm.

- The volume in the classrooms is from 156 to 205 m^3.
- The RT to the interior is in the range of 1.5 to 1.9 sec.

4. REFERENCE VALUES

The specialized literature, regarding acoustic comfort inside the classroom, has focused mainly on the Reverberation Time (RT) and the level Background Noise (BN). The values used as reference in this work are those of ANSI table 1, they are also the objective values of this investigation.

Standard	Maximum background noise	Maximum RT in seconds, in frequency bands of 500, 1000 and 2000 Hz.	Volume m^3
ANSI/ASA S12.60-2010/PART 1 (USA)	35 dBA	0.6	< 283

Table 1. Reference values that were used in this work

For the interior conditioning of the classrooms and adjust the acoustic performance index (RT, EDT, D50, STI, %ALC), as necessary, we are working the proposal, what is sought in this work is that the SPL of the BN does not exceed what is indicated in the standard.

5. SOLUTION

5.1 Proposals

After studying the problem and brainstorm possible solutions, we concentrated on two proposals to reduce the effect of external noise, without affecting the original façade and having an BN acoustic comfort.

5.2 Proposal No.1

Place an Insulating Barrier (IB), see figure 4, at the boundary of the UNAM and the Insurgentes Avenue, it is proposed that it be a metallic structure with transparent polycarbonate sheets without color of 12 mm thickness, with a height of M-1 of 11 and 15 m.

Advantages of the IB

- The acoustic insulation that will provide the IB, will reduce the noise coming from the outside to the inside of the classroom, without compromising its ventilation.
- Does not affect the original façade.
- It could become a solution adopted in other buildings of the UNAM that will face a similar situation.
- It would add an aesthetic value to the outside, the IB can be designed based on different types of polycarbonate sheets, colors and textures.

Disadvantages

- Partially or totally limits the view of passers-by towards the Insurgentes avenue.
- Relatively high cost.
- Little experience in its design and construction.
- Low acoustic insulation.

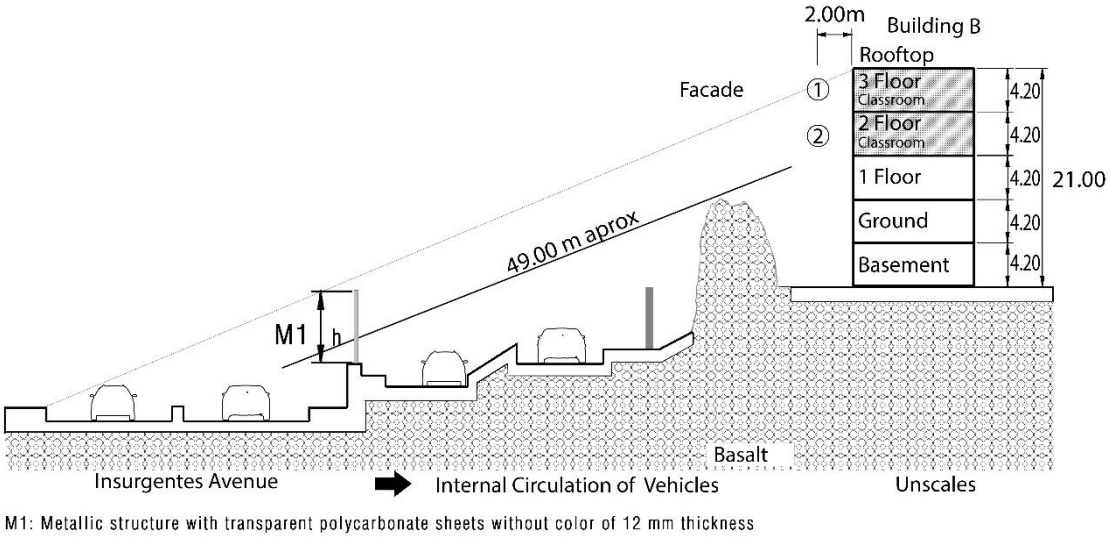


Figure 4. Insulation proposal with IB

In the specialized literature, it recommends that the constructions be at a minimum horizontal distance without barrier of 61 meters from the IB [4], in our case the distance from IB to the façade is 37 m.

5.3 Proposal No. 2

Place a Double Skin Façade, DSF-THIAPIS (Thermal Hydraulic, Insulation Acoustic, Photovoltaic, Insulation Solar), see figures 5, 6, 7 a metallic structure is proposed at 2.0 m, in front of the façade of building B, which faces to Insurgentes avenue, on which photovoltaic glasses will be placed, supporting these on tubes through which water will flow cool them [5].

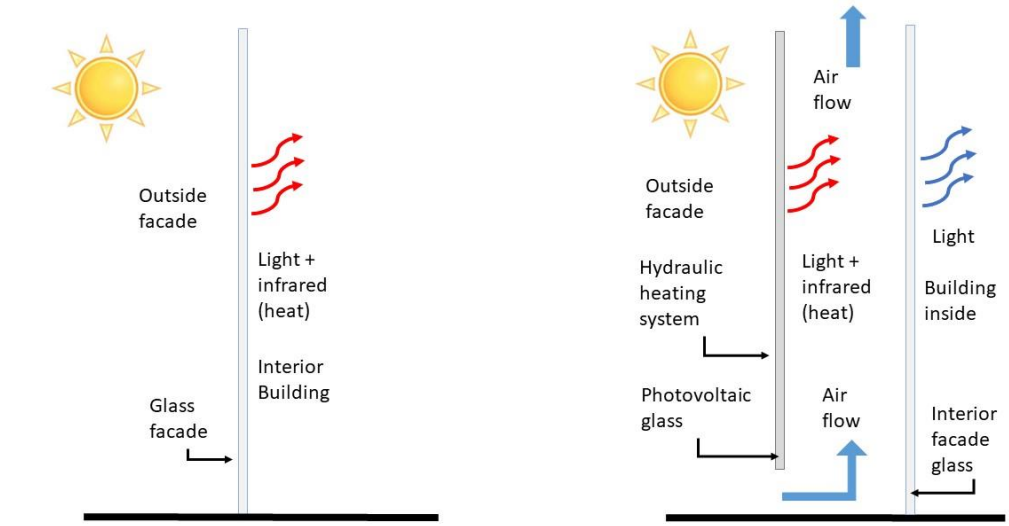
The double skin facades have been proposed in others works, it is mentioned that it can be used as an acoustic isolation solution without giving more information; they are emphasized as a thermal insulation solution. The proposal of this work is to use it, moreover, as a system for photovoltaic electricity generation, water heating and solar radiation isolation.

Advantages of DSF-THIAPIS

- IT will work as a noise reduction system [6], obtaining acoustic comfort inside the classroom.
- Provide a certain percentage of direct solar radiation isolation.
- It will allow to continue with passive ventilation in the classrooms.
- Generation of photovoltaic electric power.
- Water heating in the pipes.
- Add esthetics value to the exterior; The façade can be designed based on the type of structure, pipes, appearance and color of the photovoltaic glasses.
- Sustainable design.

Disadvantages

- Partially limits the view towards the Insurgentes avenue.
- The initial investment of the DSF-THIAPIS
- Possible intervention in the original facade



a) System of a Single Skin Façade (SSF)

b) System a Double Skin Facade (DSF -THIAPIS)

Figures 5a) – Current Single Skin Façade (SSF); 5b) – Proposed of the Double Skin Façade (DSF-THIAPIS)

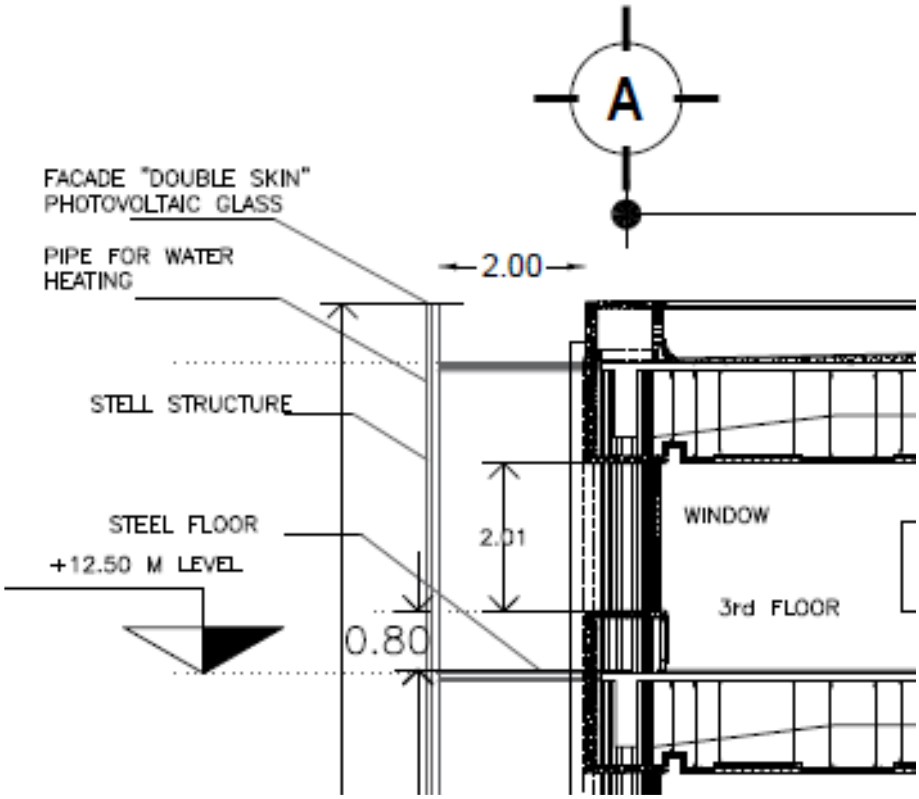


Figure 6. Proposed location of the DSF-THIAPIS

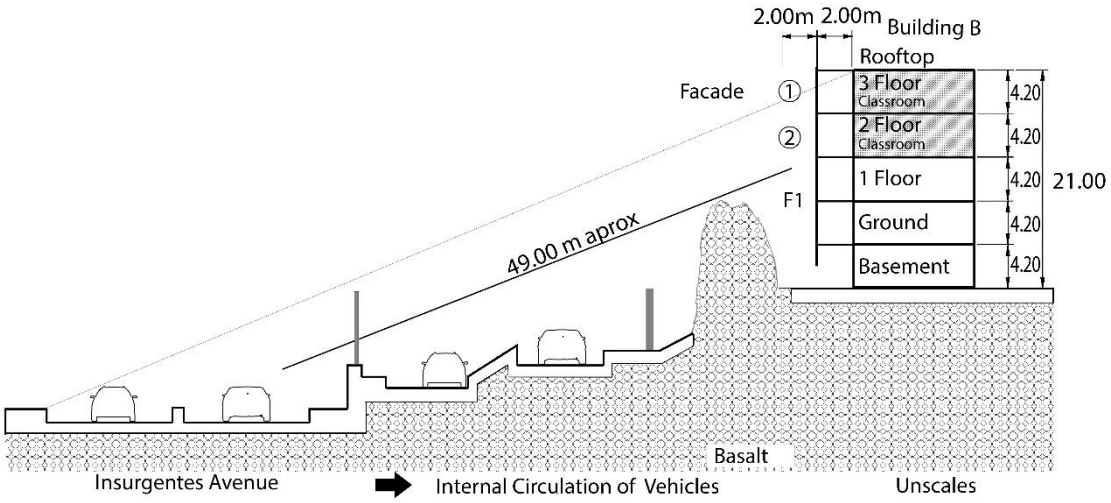


Figure 7. Proposal of the DSF-THIAPIS in building B

5.4 Simulation

In order to have more elements to decide which of the two proposals of isolation mentioned is the one of great merit, for the short and long term, it was decided to incorporate in this work, a computational modeling of the noise generated by the vehicle that transit in Insurgentes avenue. This action has a double objective.

1. The computer model [1] will simulate the efficiency of each of two proposals.

2. Prospective data may be obtained that will allow us to evaluate the efficiency of the proposal in the future; this prospective analysis is of great importance due to the accelerated vehicular growth in the CdMx.

The model was worked considering measurements of the SPL with duration of one hour, from the place of the issuer (Insurgentes av.), as well as in the same receiving places, it was measured in different positions at the vehicular traffic level in front of the B building. To develop the computational model, the software for calculating environmental noise and mapping is used [1]

6. RESULTS

In the two proposals using [1] an array of microphones was considered, one for each square meter, this requires computer equipment that will work eight hours in the calculation for each proposal. The results are in (dB), with weighting A, the average equivalent measurement (L_{eq}) for one hour.

The 1st proposal was considered at two heights, 11 and 15 m, to observed the effects of IB isolation.

Building B Level	Without IB the microphones at 2 m from the façade	Simulated value		SPL of BN inside of classroom, with 11 m wall	SPL of BN inside of classroom, with 15 m wall
		Height of the IB 11m, the microphones at 2 m of the façade	Height of the IB 15m, the microphones at 2 m of the façade		
2°	67	63	62	40	39
3°	67	64	62	43	42

Table 2. SPL two meters from the façade without IB, SPL to meters from the façade with IB and NN inside the classroom with IB

In the 2nd proposal DSF-THIAPIS, is a 2 m from the façade of building B, this is very separate due to the problem of location of the microphones (1 for each square meter), this is so that the microphones are at the center of the space between the two facades. The DS in the lower part reaches two meters above the finished floor level, on the sides it reaches the building boundary, the upper part will be placed in two positions.

Building B Level and height of the DSF	SPL outside to 2 m from the SSF	Simulated value			SPL inside classrooms on the edge of the DSF	SPL inside classrooms between the Edge and the center of the DSF	SPL inside classrooms at the center of the DSF
		Edge of the DSF	Between center and the edge of the DSF	Center of the DSF			
2nd floor, DSF at 1 m above building B	68	56	52	50	32	28	26
3rd floor, DSF at 1 m above building B	69	56	54	53	34	32	31
2nd floor, DSF at 1 m below the height of building B	68	56	53	51	32	29	27
3°rd floor, DSF at 1 m below the height of building B	69	58	56	56	35	31	32

Table 3. SPL outside, SPL between the space of two facades and SPL inside the classrooms.

7. CONCLUSIONS

- With IB it is not possible to obtain the values considered as acoustic comfort, see table 2.

- With the DSF.THIAPIS if acoustic comfort can be achieved inside the classrooms, see table 3.

8. LOOKING TO THE FUTURE

The architectural designs must be sustainable, so that the buildings are increasingly self-sufficient, that fulfill their function, considering the acoustic comfort of the users and increasing the aesthetic value

9. REFERENCIAS

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