The noise influence in the school environment

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ABSTRACT: The school building typology at the city of Rio de Janeiro went through a great change in the 80's. At that time, the Rio de Janeiro State's Education Department commissioned the architect Oscar Niemeyer to design a standard building for the elementary schools; and that this design could be used in any sites available to the state. These schools, called CIEPs (an acronym for Public Education Integrated Center) were very criticized for the environmental comfort offered to both students and teachers.
Based on the users' critiques and on the solutions and justifications offered by the architect and by the school's concept creators; we researched the environmental architecture. This researched focused on the main critique to the product: the noise influence in the school environment.
This work's objective is to verify how noise interferes on the children's learning process, on the teachers' vocal health. Based on the results of the intelligibility test applied to students, we propose improvements that do not change the design characteristics and the work of the architect. In our site visits, we observed that the standard architectural model, created to cater any site, is vulnerable to environmental noise level variations, as well as the micro-climate characteristics of the area where the school was build.

Keywords: acoustic comfort; building's technology

1. INTRODUCTION

In the 1980's decade, more precisely in 1985, the first CIEP – Public Education Integrated Center – was inaugurated in the Rio de Janeiro municipality -Brasil. Idealized by anthropologist Darcy Ribeiro, these education centers proliferated during the following years, becoming a symbol of that governmental period.

By the end of the governmental term, 506 school buildings had been built all over the state following this model. The declared intention was to promote a quality improvement in the state's fundamental education. Today, more than twenty years later, the real situation of these schools is very variable. Ninety-seven units stayed under rule of the municipal government, and the full time use proposal (a differential factor when the program was launched) was altered and adapted to the various existing social realities. The buildings' architecture was submitted to the users evaluation, which recognized the positive and negative points of the project from varied points of view. To understand the CIEPs, we must visualize them.[8]

It is a single model building. It's type was repeated in each site where the government of Rio de Janeiro State decided to implant it. Quoting Oscar Niemeyer (architect), the idea of serial construction of schools "*naturally appeared after the use of pre-cast concrete, to make them multipliable, economical and quick to build: in those cases, it is the economy that requests the repetition and the modulation*.".

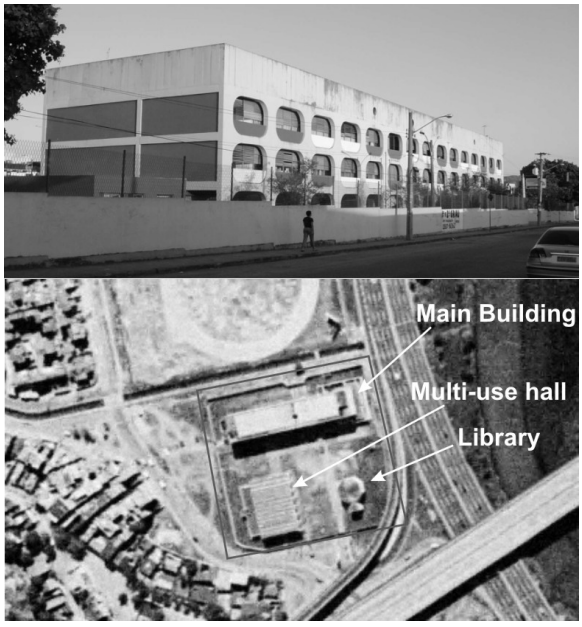

Figure 1: View of the façade and implantation

In Niemeyer's conception, each CIEP is composed of three distinct constructions: the main building, the multi-use hall and the library. The main building has three floors, linked by a central ramp. Located in the ground floor are a lunchroom for 200 people and a kitchen designed to cook breakfast, lunch and snacks for 1000 children. In the other end of the ground floor is the medical center, and between this one and the lunchroom, abroad covered

recreation area. In the two upper floors are located the classrooms, an auditorium, the special classrooms (directed study and other activities), and the administrative sector facilities. In the terrace, there is an area reserved to leisure activities and two water reservoirs.

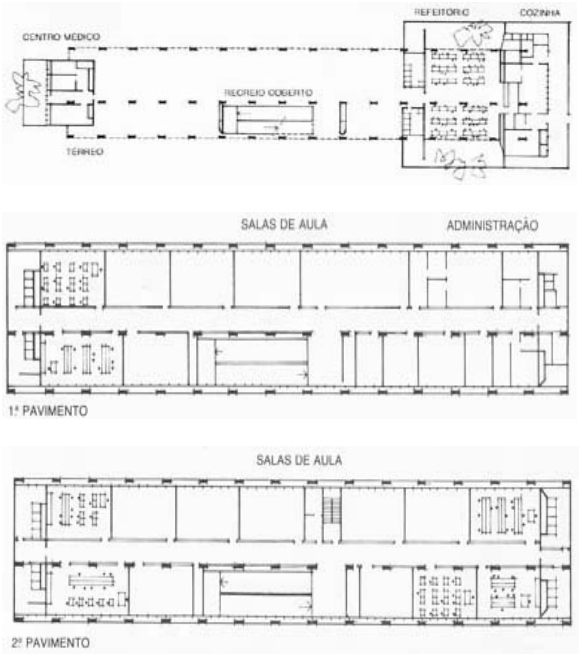

Figure 2: Example of three floors

The multi-use hall is a covered multiple sports court, with rows of seats, changing rooms and deposit for materials.

The third construction is the library, planned to receive the students individually and in supervised groups, being also open to the local community.

For the sites where it was not possible to build the three constructions of the Standard Project, an alternative was elaborated, named compact CIEP, that holds only the main building, the covered multiple sports court being transferred to the terrace, as well as the changing rooms, the library and the water reservoirs.

Figure 3: Example compact CIEP

2. THE BUILDING AND THE ENVIRONMENT

Adopting a single model of school, dissociated of the environmental characteristics of the place where it is to be built lead to failures in the adaptation of the building to the site.

We know that the project of an architectural object must consider the environmental aspects of the place where it will be implanted, and verify in which way they will interfere with the space quality.[6]

We verified in our visits to some of the CIEPs that the architectural model adopted as standard for any region of the state is vulnerable to the variation of the environmental noise level of the site where it was built, as well as to the microclimatic characteristics of the place.

Among the environmental comfort aspects that influence the spatial quality, we concentrated on the acoustics of the school. We could observe in our visits that the sonorous conditions inside the school buildings, among other environmental aspects, disturb the concentration of the students and make the verbal communication between them and the teachers more difficult. .[8]

In some site conditions, as in the CIEP Samuel Wainer, the street day-by-day is inside the school. As it is located between two important streets with intensive traffic, the small retreat of the building in relation to the street allows the outside sounds to arrive inside with intensity higher than the recommended by the World Health Organization. [3][4]

A questionnaire collected by pedagogues Ana Cavaliere and Lígia Coelho and filled by CIEP principals allows identify in the answers the dissatisfaction with the physical environment of these schools respecting the climatic aspect, as well as the sonorous aspect of the buildings.

According to the answers, “The building conceived by the architect Oscar Niemeyer requires a constant maintenance, e not always the number of employees and the budget received contributes to the perfect condition of the physical space, many times harming the school routine. Constant problems such as infiltrations, lack of water, high consume of cleaning material, drafts in the lunch room, problems in the bathrooms, noise in the aluminum shutters are part of our routine (...) Another problem spontaneously cited in the free complementation of the answers was the acoustic of the classrooms, which have half-walls, that is to say, walls that do not reach the ceiling, allowing the flow of sounds between the rooms. The principals refer to that as very harmful to the pedagogic work.” [7]

The model of the windows combines shutters with sliding panes. It favors natural ventilation, and facilitates the entry of external sounds in the building. In the same way, the use of half-walls, allowing crossed ventilation, permits the sound diffraction through the rooms, compromising their privacy, and making the oral comprehension difficult in some moments, requiring higher verbal effort from the teachers [1]. The winds varying throughout the year create, in some seasons, thermal discomfort in classrooms, once the architectural design is based on

crossed ventilation. The air circulation through the shutters in situations of higher wind speed creates an additional noise in the rooms.

Figure 4: classrooms with half-walls

3. THE INTELLIGIBILITY TEST

The intelligibility of speech is related to the capacity of psychological development and balance of man. It is essential to normal communication, and depends on the hearing ability. Nowadays, we live in a world of noises. At home, at school, in the leisure environments noise is present. Its sources are most variable, and we communicate in these environments. The ability to perceive speech in the presence of noise is not an easy task, and depends on some factors as: level and spectrum of speech and noise, distance between interlocutors, psychological conditions, familiarity with the used vocabulary, grammar, language syntax and semantics, beside the environmental context.

To appraise the level of the interference of noise in the students' comprehension we use the intelligibility test. The intelligibility test applied to the classes by means of dictation showed the loss of some syllables by the students. This test allows evaluating if the children have complete comprehension of the sounds emitted in the teaching environment. The loss of some syllables troubles the settlement of disciplines' contents and compromises the learning process.[5]

In November 2004, INMETRO[1] applied speech intelligibility tests to the CIEP Alexandre Carvalho, in the city of Miguel Pereira, Rio de Janeiro state. This analysis was made after a request of the school direction, since it faces problems in account of the high environmental noise level, caused by sources both internal and external to the building.

To set a comparison standard, similar tests were made at a conventional school in the same city, the Escola Estadual Álvaro Alvim.

[1] INMETRO – *Instituto Nacional de Metrologia Normalização e Qualidade Industrial* (National Institute of Metrology, Normalizatin and Industrial Quality)

The students of both schools have similar socioeconomic profile [2]. Beside the intelligibility tests, constructive aspects of the building were analyzed, in order to set the acoustic parameters of the classrooms and, in the case of the CIEP, the acoustic ways through various points of the building.

The experiment used two antagonistic "artificial heads": the hearer and the orator. The hearer records sounds through built-in microphones in the ears, which transmit the sensation of the acoustic environment of the place, allowing discerning the angles and distances of the sonorous sources during the recording. The orator has a built-in speaker, whose sound is directed to the mouth. The target of using an artificial orator is to reproduce a speech directionally similar to the human voice.

Four lists with 20 monosyllabic words each were used in the intelligibility tests, the words randomly repeated at various volumes. The records reproduced during the experiments were made by two professional speakers (one man and one woman) in anechoic chambers to assure that the records were "dry", free from reverberations.

Table 1: Summary table

LIST	NPS dB(A)	Comparison with human voice	% Correctness 5th gd **Álvaro Alvim**	5th gd **CIEP**	2nd gd **CIEP**
1	**75**	Slightly high	**96,0**	**61,3**	**49,6**
2	**80**	High	**-**	**96,4**	**74,2**
3	**70**	Feminine voice (calm)	**92,9**	**57,0**	**56,2**
4	**85**	Very high (effort)	**-**	**85,2**	**66,6**

The reverberation time in the CIEP classrooms is very high- around 1 second – while in the Álvaro Alvim school it is of 0,65 seconds, close to the international norms recommendations for schools.

4 PROPOSED CORRECTIONS

After a detailed observation of the project and approaching specifically its acoustic aspects, even though it interacts with climate, we related the vulnerable points of the building and recommended a few corrections of the sonorous discomfort, with the basic premise of avoiding any aggressive interference with the architecture, in respect to the architect that conceived the building.

4.1 Implantation and sectorization

It is doubtless that many of the acoustic problems to which the CIEPs are subject occur in account of the implantation. The small distance from the sonorous sources, be those external or internal, favors the exposition to the classrooms' noise. The corrections are limited to the change of use of some of the rooms, as for example, in the case of the

compact CIEP, avoiding that the library is placed close to the sports court, and changing the administrative sector when it is in a more favorable location than the classrooms.

4.2 The Classroom

In first place, we suggest an intervention at the windows, keeping the principle of the model so as to not to deprive the characteristics of the façade, but reinforcing the frame's insulating capacity, improving its details and adopting the mobility of the shutter, that in the original project is fixed. In this way, the control of the entrance of sound and wind in the building is achieved. The passage of sound through the shutters may be reduced by means of absorbing materials in the blades and the existing fixed glass may have its width increased.

The half-wall is unacceptable. We know that the sound will diffract, and thus pass from one room to the others. Being so, the easiest solution is to close the openings between the rooms. In those schools where the local microclimate suggests the use of crossed ventilation, the use of half height in the divisor walls with the circulation is tolerable, if an absorbing material is used on the ceilings of both the classes and the circulation.

Figure 5: Example of the classroom with the opening closed

4.3 Sport court and circulations

The CIEPs that have the sports court above the classrooms need treatment against impact noise. The solution may be achieved in the heterogeneous structure supports, with the use of elastic joints or with the damping of impact in the court's pavement.

Analyzing the use of the building, we observed that the alternate playtime causes the classes to leave the rooms one after another, provoking noise in the circulations and interfering with the classes that stay in activity. We cannot ignore that the solution given by the half height walls prevents satisfactory privacy conditions in the rooms. Being so, we reinforce the recommendation of absorbing ceilings in the circulation areas. In the same way, the informative panels and the students' work display panels can be used as absorbing surfaces on the concrete walls.

The pavilion architecture produces long length continuous circulations, and these favor the sound reverberation, part of the problem, that may be corrected with the use of absorbing material in the ceiling.

In spite of the influence of external sounds, this building is hostage of the internal sounds that are reflected by the pre-cast concrete slabs. Anyway, in the plots that keep small distance from the street or from the neighbor buildings, there may be registered levels of noise above the minimal recommendation for schools.

5. CONCLUSION

We understand that the attempts of adjust the building to the dominant climatic conditions of the hotter months through a standard model compromises its the acoustic quality and does not always answer to the thermal necessities of the site.

The need of acoustic correction of the building is urgent, due to the harm to the users health and the damage that the criticism to its architecture has done over all these years.

Aware of the problems reported over the years, and under the pressure of community representative organizations as well as the communication means, the Oscar Niemeyer Foundation allowed an intervention in one CIEP in Rio de Janeiro, in the neighborhood of Campo Grande. As researchers, we wait for the results and hope that the interventions are made in a coherent way, bringing to an end the long period of discomfort to which the users were submitted, honoring an idea defended by Oscar Niemeyer himself that the underprivileged classes do not deserve a second class architecture.

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