# ACOUSTIC INSULATION OF THE NATURAL AIR INTAKES OF THE ECOLE NORMALE SUPÉRIEURE DE CACHAN IN SACLAY


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## ABSTRACT

The construction of the new Ecole Normale Supérieure de Cachan on the Saclay plateau by the Renzo Piano Building Workshop agency required thorough studies on façade sound insulation. In the case of an educational establishment, acoustic insulation from the outside is regulated according to the noise level on the facade due to road traffic.

Rooms of the ENS can be naturally or mechanically ventilated actioning a trap door into the façade and an insufflator automatically according to the weather. Acting so, energy can be saved turning off the insufflator when air can be taken outside without risking discomfort for people.

Due to this automation and the acoustic regulation, we had to develop a solution to provide the necessary acoustic insulation via significant air intakes without providing too much resistance to the air flow.

The approach adopted during the design of the project to develop the selected solution include road modifications to reduce noise levels from road traffic and acoustic treatment solutions for the air inlet. Solutions designed were tested on acoustic laboratory to validate our calculation and to select the most relevant one. Air drop test were also done to verify the influence of each part of the ducted system and ensure the viability of the solution for a correct air flow.

In December 2019 commissioning measurements were performed of the system in use, that will be presented.


## 1. INTRODUCTION

The design of the construction project of the Ecole Normale Supérieure de Cachan in Saclay took place from January 2014 to June 2016 for a project delivered to the client in January 2020. From the response to the competition, the choice of a natural ventilation solution was imposed for the project. This solution implementing significant air intakes in the facade, we had to minimize the environmental impact of the project and optimize the solution of airway treatment.

We therefore present the actions carried out on the overall development plan, the studies and laboratory tests carried out as well as the results of noise insulation measures with respect to the outside space at the end of the work.

## 2. URBAN CONTEXT

The ENS construction project is part of an overall plan to develop a plateau free of any construction on the commune of Saclay (91) in France. This development plan includes the construction of a departmental road (D128) to pass 5 m from the north side of the ENS project. Initially planned as a 2x1 lane road for an Average Annual Daily Traffic (AADT) of 9,000 light vehicles per day, the possibility of modifying the road to 2x2 lanes for an increase in traffic is evoked at the beginning of the studies.

### 2.1 Assessment of the noise level on the project façade

The objective was to present to the planner the acoustic repercussions on the facade of our project according to different scenarios. The two types of roadways were therefore simulated at different distances, 5, 8 and 12m.

We carried out several sound level estimations on the project facade according to different roadway development scenarios. We considered the following traffic data for our calculations, under the CadnaA from Datakustik.

| Road type | AADT | % HGVs | Speed [$km.h^{-1}$] |
|---|---|---|---|
| 2x1 lane | 9000 | 20 | 50 |
| 2x2 lanes | 6750 | 20 | 50 |

**Table 1.** Traffic assumptions for simulations.

Thus, the sound levels calculated on the facade and the corresponding isolation objectives according to the different scenarios were as follows, the objective being to have a contribution of 35 dB(A) from the external environment.

| Scenario | Distance [m] | $L_p$ [dB(A)] | $D_{nTA,tr}$ [dB] |
|---|---|---|---|
| 2x1 way | 3 | 71 | 36 |
| | 8 | 69 | 34 |
| | 12 | 68 | 33 |
| 2x2 ways | 3 | 72 | 37 |
| | 8 | 70 | 35 |

**Table 2.** Calculation results of traffic simulations

Figure (1) shows the sound pressure levels calculated at the front of the project in the form of isophones in 1 dB steps for a 2x1 lane roadway at 12m.

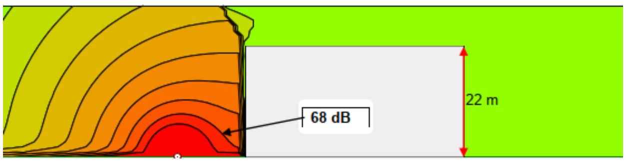



**Figure 1**. Sound pressure level for one double way road at 12 m

### 2.2 Discussions with the Land Developer

In order to limit the impact of traffic on the project and minimize the need for acoustic insulation on the north façade, we engaged discussions with the Land Developer. Based on the simulations carried out, it has been possible to validate a more favorable layout for the project. Thus, a 2x1 lane roadway project with a 5m central solid ground was adopted. In this configuration and using our simulations, we estimate the traffic noise level on the ENS facade at 67 dB(A). In this configuration, a sound insulation from the outside environment $D_{nTA,tr}$ of 32 dB is to be expected, against 35 dB initially at the beginning of the project. A gain of 3 dB was thus achieved by acting solely on the choice of the type of roadway along the project. The other facades of the project retain a $D_{nTA,tr}$ objective of 30 dB.

## 3. DESIGN

With the environmental constraints optimized, we have worked on translating them into technical recommendations for the elements making up the project's façade.

The classrooms can be ventilated in two ways depending on the season and the outdoor climate. In winter, ventilation is of the double flow type via air handling units (Fig. 1). In summer, the air handling units are shut down, trap door are opened in the façade and the rooms are ventilated by an air supply via a concrete duct inside the slab (Fig. 4). A mechanical extraction improves the air flow and ensures a constant minimum flow rate (Fig. 3).

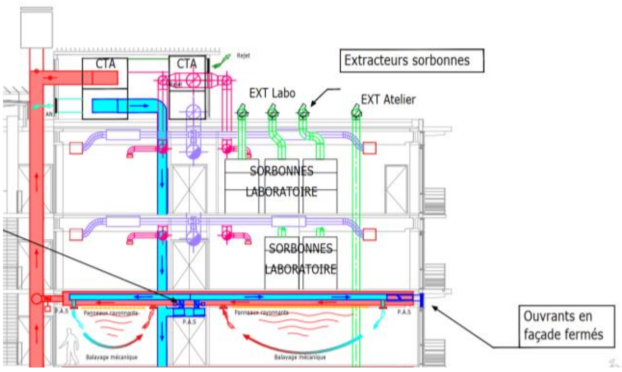



**Figure 2**. Winter - dual-flow ventilation by AHU

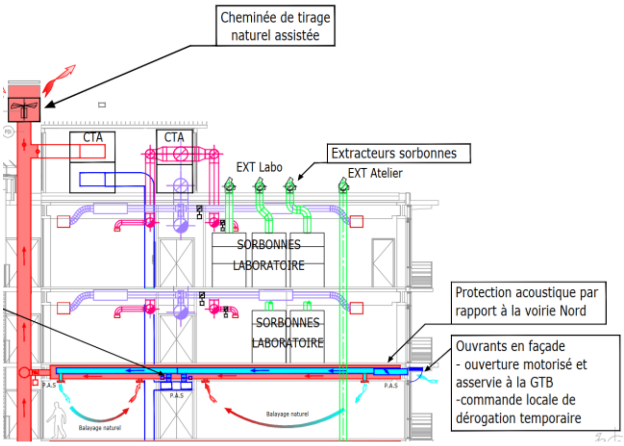



**Figure 3**. Summer - assisted natural ventilation

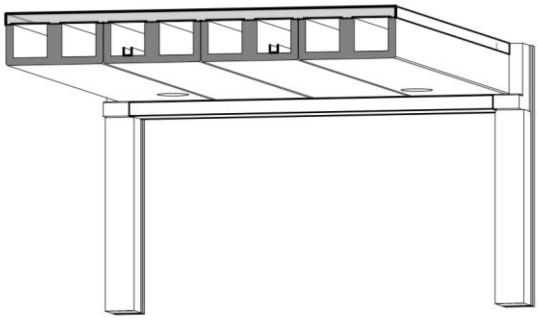


**Figure 4**. Isometric sectional view of the coffered beams

The glass facade and the air inlets are the two elements on which we had recommendations to make.

Using the calculation method of the CSTB 1855 book [1] we estimated that the façade elements should verify the following acoustic performances, according to the final objective.

| Insultation $D_{nTA,tr}$ | Glass facade $R_w + C_{tr}$ | Entrée d'air $D_{ne,w} + C_{tr}$ |
|---|---|---|
| 30 dB | 31 dB | 37 dB |
| 32 dB | 33 dB | 39 dB |

**Table 3.** Component performance according to insulation objective

Since the sound would only pass through the air inlet, the standard insulation of the air inlet would be the final sound insulation. It is thus necessary for us at this stage to determine the performance of the sound trap allowing to ensure an insulation of 37 dB and 39 dB according to the configuration.

By considering the sound penetration in a concrete duct with a square section, 425 mm side and an air diffuser with an internal diameter of 320 mm, we have determined the need to use baffles with a thickness of 200 mm and a length of 1500 mm or 2000 mm depending on the objective.

## 4. LABORATORY TEST

To confirm the design phase and to evaluate others solutions, tests were performed at the CSTB laboratory on five configurations:

- 1. 200 mm diameter cilyndrical silencer
- • 2. A central baffle, 100 mm thick
- • 3. Two baffles, each 100 mm thick
- • 4. A central baffle, 200 mm thick
- • 5. Without any baffle

1

2

3

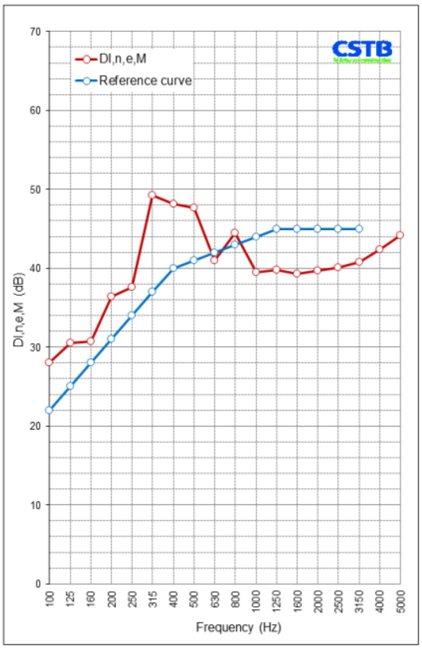
4

The CSTB used an intensimetric method based on ISO 15186-1 to estimate so the $D_{I,ne,M,w}$ due to the configuration of the test prototype[1]and to be sure to evaluate only the sound pressure level through the air duct.

The following table present test results of different configurations

| Test number | $D_{I,ne,M,w} + C_{tr}$ |
|---|---|
| 1 | 35 dB |
| 2 | 36 dB |
| 3 | 41 dB |
| 4 | 39 dB |
| 5 | 30 dB |

For example the result of the fourth test is given in the next figure.




| f | $D_{I,n,e,M}$ |
|---|---|
| 100 | 28,1 |
| 125 | 30,5 |
| 160 | 30,7 |
| 200 | 36,4 |
| 250 | 37,6 |
| 315 | 49,2 |
| 400 | 48,1 |
| 500 | 47,6 |
| 630 | 40,9 |
| 800 | 44,5 |
| 1000 | 39,5 |
| 1250 | 39,8 |
| 1600 | 39,3 |
| 2000 | 39,6 |
| 2500 | 40,1 |
| 3150 | 40,8 |
| 4000 | 42,3 |
| 5000 | 44,1 |
| Hz | dB |

| | |
|---|---|
| $D_{I,ne,M,w}$ | 41 |
| C | -1 |
| $C_{tr}$ | -2 |

| | |
|---|---|
| $D_{I,ne,M,w} + C_{tr}$ = | 39 |

## 5. FINAL TEST

The building has been delivered to the client on January 2020. We performed test on façade to evaluate the final sound insulation.

All test results confirmed the design. We measured sound insulation between 30 and 32 dB for a goal at 30 dB and between 32 and 34 dB in the North Façade where the goal is 32 dB.

## 6. REFERENCES


[1] Cahier 1855: "Comment concevoir une protection satisfaisante contre les bruits extérieurs" *CSTB*, 1983.


[1] Several acoustic test are performed in the lab such as flanking transmission of the slab and impact sound level