# Bouéni middle school

by antoine perrau / 2020-05-31 14:23:39 / France / 9725 / FR


**Primary energy need :**

**90 kWhep/m².an**

**(Calculation method : RTAA DOM 2012 )**

**ENERGY CONSUMPTION**

*Economical building* *Building*

< 50 A

51 à 90 B

91 à 150 C

151 à 230 D

231 à 330 E

331 à 450 F

> 450 G

*Energy-intensive building*

**Building Type** : School, college, university
**Construction Year** : 2019
**Delivery year** : 2019
**Address 1 - street** : CCD6 Bambou Ouest 97604 BOUéNI, France
**Climate zone** : [Aw] Tropical Wet & Dry with dry winter.

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**Net Floor Area** : 5 536 m$^2$ SHON
**Construction/refurbishment cost** : 24 730 000 €
**Number of Pupil** : 900 Pupil

**Cost/m2** : 4467.12 €/m$^2$

## General information

The Bouéni middle school is located on the island of Mayotte. It is subject to major climatic hazards: cyclones, earthquakes, floods and landslides. Our project, winner of a competition, proposed original conceptual and constructive solutions that made it possible to deal with repeated earthquakes and a strong tropical depression during the works and delivery phase. We relied on a construction method in the steel sector, with little impact on the site, in a remarkable environment, studies in a physical wind tunnel which made it possible to optimize the dimensioning of the building for natural ventilation (passive architecture) and for seismic forces and surface rainwater management avoiding the obstruction and / or destruction of networks in the event of heavy rain and earthquakes. The results are up to the ambitions since this bioclimatic building now operational gives full satisfaction to users, after having successfully faced the elements.

### Sustainable development approach of the project owner

### Architectural description

The architectural choice of this project **stems from the concerns of the client** developed in the program and from the visit of the site with its exchanges. Our reflection followed the criteria of choice, without hierarchy:

- Respect of the program, quality of functioning and adaptation to the site
- Overall economy of the project
- Architectural and environmental quality and integration

# A project in line with the program

Our project only deviates occasionally from the program (space optimization). For the rest, the functional units **are grouped into legible and identifiable entities, easily appropriable.**

A functional project: the organization articulated from the central space of the courtyard identified spatially defines **easily usabl**e premises, without creating a closed courtyard.

An evolving project: the technical choice of **load-bearing facade**s frees up the space and allows for **easy evolution of the partitioning**.

A "**mutualizable**" project: the optimization of the premises and spaces was exploited as much as possible and determined the position of the premises and spaces in relation to each other to reach this objective, in particular the multipurpose room, the restaurant, the CDI and the sports facilities.

A **safe project**: the articulation from the courtyard and the judicious layout of the surveillance rooms make this middle school **easy to control and monitor** both inside and outside spaces.

# An economical project with low maintenance

Our project integrates the concern of **constructive simplicity**, guaranteeing a controlled construction cost and easy maintenance. It is composed of simple volumes, covered by large single-slope roofs protecting the facades and respecting the useful surfaces.

The use of **low- or no-maintenance materials** guarantees **an exceptional longevity of most of the exterior structures**.

The adaptation to the ground minimizing the rocky excavations by constructions on piles, parking lots as close as possible to the topography and the privileged use of the flatter zones for the establishment of the courtyard and the stadium optimize **the adaptation to the ground**, in a ground with a marked and constraining slope.

The technical equipment was determined with these concerns of **simplicity, low cost and reduced maintenance**.

# Architectural quality

Quality has been sought through the respect of the previous points.

It stems from the choice of a **soft implantation** in the site, legible functioning, the choice of natural, durable materials, climatic protection, landscaping and the finesse of the details implemented.

The analysis of the context also led us **to take advantage of the exceptional site** offered to us and to allow an optimal exploitation of the views for the non-teaching premises.

We developed an **equatorial architecture**, where the expressiveness of the project stems from architectural elements such as sunbreakers, large roof overhangs, a strong porosity, thin buildings, and an omnipresence of vegetation. This **expression is specific to the climatic and geographical conditions of this territory,** far from a commonplace international architecture.

## Environmental quality

From the start, the philosophy that underpinned our concept was that of **minimal visual and physical impact** on the site. To achieve this, we have organized a project that spreads out in a flexible manner along the contours of the site, optimizing the movement of the earth. This choice was amended and reinforced by the will to preserve the remarkable trees punctuating this site, the two baobabs and the orchard of fruit trees in particular.

The need to ensure optimal ventilation of the premises to ensure thermal comfort also dictated specific morphologies of the building, low thickness of the constructive frame, construction on piles optimizing air circulation, mono-pitch roofs, patios with depression wells, optimizing pressure/depression phenomena, North-South orientations of the building ideal for solar protection and lateral lighting in the classrooms.

Finally, the desire to preserve ecological corridors and good hydraulic transparency led us to build on stilts and to make cuts ensuring the free flow of rainwater on the surface in the existing talwegs, thus limiting the acceleration of runoff and soil erosion so fragile in Mayotte.

## Insertion in the site

At the convergence of the architectural and environmental quality concerns mentioned above, the quality of insertion is thus easily ensured by a minimal impact, a split project, in the slope, in a preserved vegetation. It is a question here of creating a public facility coiled in the slopes and the vegetation, preserving as much as possible the majestic site of the Ile aux Parfums.

The insertion in the site is strongly worked with :

- a staging of the highest volumes in the slope
- a staging of the living terraces, with the play of ramps becoming spaces of evolution complementary to the large spaces of the courtyard
- the conservation of large indigenous trees (baobabs) and domestic trees (mango trees) in order to benefit from shade and to participate in the plenum of inscription in the slope
- simple volumes with roofs following the slope for the tallest (cumulative aerodynamic effect and insertion)
- the vegetal enhancement of the site with, in particular, the creation of forest gardens with indigenous biodiversity (a potential conservation site) forming a setting and continuity with the slope of the great landscape
- soft treatment of rainwater runoff (conservation of small ditches, aerial management of rainwater to remove pollution)

# The architectural image

Mayotte is a young island, and the architectural references for programs of this scale are recent. The materials once used, such as wood and mud brick, which are very interesting in terms of carbon impact and bioclimatic behavior, are currently less used, in favor of a fairly ubiquitous concrete sector as in Reunion Island.

Therefore, we looked for a differentiated and relevant approach for a competent and contemporary architecture in Mayotte. In particular, the use of dry methods allows us to rediscover or renew the immense competence of an emblematic building of the island: the governor's house in Dzaoudzi.

This learned climatic reference designed by Eiffel's engineers has strongly inspired us to search for a differentiated and inventive architectural image. In the green and brown landscape of the xerophilic slopes of Bambo Ouest, the long slope of the buildings is treated with porous materials with a white structure that traps the light and not the heat, behind the wooded masses of the first slopes.

The buildings thus develop an integrated image of competent and bioclimatic institutional architecture. The color effects are defined in a pointillistic way in the manner of the drawings of the bangas on specific elements: sunshades of the volumes of reception and restoration, refrets of the volumes long pan (ochre of the lateritic grounds), doors of the buildings, specific technical aediculae... These elements, as well as the signage that will be designed, provide the domesticity necessary for the social life of the middle school.

# Bioclimatic architecture

It is an obvious fact that is not yet recognized for insertion, but yet very necessary and civic: that of creating equipment whose use minimizes the carbon impact and therefore the consumption of fossil energy. Standard air-conditioning of premises is the plague of tropical and equatorial environments... It is a simplified answer that is not acceptable for the architecture nor for the planet, because it is the architecture that must create the conditions of comfort and avoid or limit the active systems, most of which also pose health problems.

The project is conceived as a climatic machine in the slope, open to the sea breezes and deployed to the weak night breezes. The orientation of the roofs parallel to the slope, the very high porosity of the facades (nearly 50%). The following effects are so many devices combined to irrigate and refresh the interior premises:

- overhangs of the roof
- thermo-acoustic double skin roofing
- tree protection of the "hard" floors and courtyards in particular
- climatic double skin
- ventilated basements (raised)
- thermal draught by associated patios (or even by permanent smoke extraction chimney

- restaurant room).

In addition to the strategy on the site, a thermal zoning is set up in the premises with process like the restoration and its kitchen in order to refine the energy optimization.

# A middle school where life is good

Children are not necessarily prepared to be confined in institutional buildings that can constrain the capacity of students by their poorly designed or poorly adapted aspects. A middle school is a place to live and learn. Also, the beauty of the place (in the sense of the intensity generated by the place) is a condition sine qua non of the quality of life and teaching.

In addition to the comfort generated by the bioclimatic architecture and the generosity of the protected outdoor spaces, we must also mention :

Ø the acoustic partition with the aero-acoustic design of the project (acoustic zoning, orientations, masking effects, etc...)

Ø visual comfort, in terms of daylight

Ø visual comfort with views on the great landscape from the bay or from a wooded courtyard

Ø visual comfort without glare by the north and south orientations of the work space bays

Ø comfort for the body through "soft" courtyards partially treated with synthetic turf

Ø comfort of movement through soft ramps, differentiated inscription of the terraces organized on the site

Ø pedestrian comfort through the protection of soft movements....

**We therefore propose a project of tropical architecture, functional, adapted to a preserved environment that it was essential to protect as much as possible and that can serve as an educational base for the preservation of the Perfume island.**

## If you had to do it again?

We would have used wood instead of metal, which would have further improved the carbon footprint, even if for Mayotte, it is a real change to have been able to go to middle school in the dry sector and not in concrete.

## See more details about this project

Le projet a été étudié sur la base du référentiel HQE, même si aucune certification n'a été faite

## Photo credit

LAB Reunion - Tand'M

# Stakeholders

## Contractor

Name : Rectorat de Mayotte
Contact : Blaise Tricon : blaise.tricon[a]ac-mayotte.fr
http://www.ac-mayotte.fr/

## Construction Manager

Name : LAB Réunion - 2APMR mandataires
Contact : Antoine Perrau ap[a]labreunion.fr
https://labreunion.fr/

## Stakeholders

Function : Designer

Tand'M

Stéphan Aimé

project management

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Function : Structures calculist

GECP & OMNIS

Alexandre Jennant

structural and seismic studies

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Function : Other consultancy agency

INSET

Eric Ottenwelter

Fluid study and BET

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Function : Thermal consultancy agency

LEU Réunion

Simon Chauvat

https://www.leureunion.fr/
Thermal design office, QE, landscape

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Function : Structures calculist

I2M

Jean Marc Bouchut

bet metal structure

---

Function : Other consultancy agency

NATURALISTE DE MAYOTTE

Franck Coudray

Naturalist

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Function : Company

SOGEA TRAVAUX

Claude Petit

external development company

---

Function : Company

SMTPC

Olivier Trassard

masonry structural work

---

Function : Company

SMAC

Virgile Virot

metal structure company - cladding - metal textile

---

Function : Other consultancy agency

Delhome acoustique

bet acoustic studies

Function : Other consultancy agency

MBE

ANtoine Bajeux

bet vrd

Function : Construction Manager

Michel Delafosse

Michel Delafosse

project manager and OPC

## Type of market

Global performance contract

# Energy

## Energy consumption

Primary energy need : 90,00 kWhep/m$^2$.an

Primary energy need for standard building : 330,00 kWhep/m$^2$.an

Calculation method : RTAA DOM 2012

Breakdown for energy consumption : Outdoor lighting: 7,305 kWh Interior lighting: 21,448 kWh Air conditioning: 9556 kWh CMV: 592 kWh Kitchen ventilation: 1082 kWh Elevator: 400kWh Ventilators: 14,990 kWh Hot water: 1000 kWh Restoration: 120,000kWh Miscellaneous: 15,000 kWh

## Real final energy consumption

Final Energy : 27,00 kWhef/m$^2$.an

## More information

Interior lighting expansion of 0.8 Standard building ratio 100 kWh / m²SU / year

# Renewables & systems

## Systems

Heating system :

- No heating system

Hot water system :

- Solar Thermal

Cooling system :

- Water chiller
- Fan coil

Ventilation system :

- Natural ventilation

Renewable systems :

- Solar Thermal

The project of a photovoltaic farm on the roof is under study, it should enable the objective of a positive energy building to be achieved.

## Smart Building

Users' opinion on the Smart Building functions :

# Environment

## Urban environment

Land plot area : 34 443,00 m$^2$

Green space : 19 125,00

From the start, the philosophy behind our concept has been that of **minimal impact,** both visual and physical, on the site. To do this, we have organized a project deploying in a flexible way along the contour lines optimizing the movements of the earth. This choice was amended and reinforced by the desire to preserve the remarkable trees punctuating this site, the two baobabs and the orchard of fruit trees in particular.

The need to ensure optimal ventilation of the premises to ensure thermal comfort has also dictated specific morphologies of the building, low thickness of the constructive framework, construction on stilts optimizing air circulation, single-slope roofs, patios with low pressure wells, optimizing the phenomena of pressure / depression, orientation of the North-South frame ideal for solar protection and side lighting in classrooms.

Finally, the desire to preserve ecological corridors and good hydraulic transparency, led us to build on stilts and to make breaks ensuring the free flow of rainwater on the surface in the existing thalwegs, thus limiting the acceleration of runoff and the erosion of so fragile soils in Mayotte.

## Insertion into the site

At the convergence of the architectural and environmental quality concerns mentioned above, the quality of insertion is thus easily ensured by a minimal impact, a split project, on the slope, in preserved vegetation. It is a question here of making a public facility coiled in the slopes and the vegetation preserving as much as possible a majestic site of the perfume island.

The insertion in the site is worked strongly with in particular:

- a tier in the slope of the highest volumes
- a tiering of living terraces, with sets of ramps becoming spaces for development complementary to the large spaces of the courtyard
- the conservation of large native (baobab) and domestic (mango) trees in order to benefit from shade and participate in the registration plenum on the slope
- simple volumes with roofs following the slope for the highest (cumulative aerodynamic effect and insertion)
- the plant enhancement of the site with in particular the creation of forest gardens in native biodiversity (potentially conservatory site) forming a setting and continuity with the slope of the large landscape
- soft treatment of rainwater flows (conservation of small valleys, decontaminating aerial management of rainwater)

## Products

### Product

COVERIB

ONDULIT

Laurent Pippinato

https://ondulit.com/

Product category : Gros œuvre / Charpente, couverture, étanchéité

Multilayer roofing with high performance: sound insulation (noise impact of rain), high solar reflection power

No specific problem

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SMC2

SMC2

Samuel Guillermard

https://www.smc2-construction.com/

Product category : Gros œuvre / Charpente, couverture, étanchéité

Metallo-textile framework with prestressed PVC type text and tensioning system by mechanical jacks.

Very good feedback, provides sun protection and homogeneous light for sports practice at a very good value for money.

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Crystalis transparent roller shutter

https://www.provelis.com/nouveautes/le-volet-roulant-transparent/

Product category : Second œuvre / Menuiseries extérieures

Transparent roller shutter used in classroom glazing allowing full opening and therefore excellent natural ventilation (maximum porosity).

No specific problem reported.

# Costs

## Construction and exploitation costs

Total cost of the building : 24 730 000 €

# Health and comfort

# Water management

Consumption from water network : 261 573,00 $m^3$

Water Consumption/m2 : 47.25
Water Consumption/Pupil : 290.64
Water tarpaulins have been put in place to collect rainwater to supply the toilets. This device makes it possible to deal with frequent water cuts on the site.

Rainy waters :
On-site rainwater management is managed gently and on the plot. Thus, rainwater delay / infiltration devices have been installed on the site. We thus find, as we can see in the ground plan below, landscape valleys around the buildings and in the lower parts of the plot.

Vegetated valleys are structures that collect and regulate rainwater and runoff by slowing its flow to an outlet. This type of technique is suitable for the management of rainwater for the Bouéni college construction project in Mayotte.
From a technical point of view, the green valleys are structured in this way:

The permeability of a plot is the ability of the land to delay and infiltrate rainwater. Thus, a so-called “permeable” soil will have a greater capacity to manage rainwater on site (greater storage / infiltration volume). A permeable soil is characterized by the nature of its coating. Thus, a concrete surface will be impermeable (coefficient of permeability = 0) unlike a surface with several plant layers (coefficient of permeability = 1).

Permeability
FLOOR COVERING Surface in m² Percentage (%) Coefficient Result
Concrete swept on roadway and access 1,300 / 2.9% / 0.00
Pedestrian swept concrete 2,200 / 5.0% / 0.00
Concrete grass slab 900 / 2.0% / 0.00
Flat stone paving 1,020 / 2.3% / 0.00
Grating 60 / 0.1% / 0.318
High Modulus Asphalt 1,280 / 2.9% / 0.00
Bituminous concrete 6 9,401 / 5.6% / 0.00
Colored bituminous concrete 1720 / 3.9% / 0.00
Concrete stairs 410 / 0.9% / 0.00

BUILDINGS
Overall (Right-of-way built on the ground floor, excluding roof terraces) 3,427 / 7.7% / 0.00
Green roof terrace 823 / 1.9% / 0.3247

PLANT SYSTEMS
SV1 Forest gardens 19 3954 / 3.7% / 1.019 395
SV2 Courtyard Gardens 667 / 1.5% / 1.0667
Planting pit - trees in the yard 15 / 0.0% / 1.015

Project 44 40 710/0% 46%

The plot's waterproofing coefficient is 54%, which is correct.

Drinking water consumption
Consumption item Ratio Area (m²) Daily consumption (liters) Annual consumption (liters)
Flush / 4.5 liters / uses1 200 300,000
Sanitary water (maintenance, hand washing, etc.) 1 liters / day / person 1200 300 000
Catering 4000 liters / day 40001000000
Forest gardens 2 liters / m² / day 193953879014158350
Courtyard gardens 5 liters / m² / day 66733351217275

TOTAL WATER CONSUMPTION: 19,078,025
TOTAL WATER CONSUMPTION: 26,157 m3 / year
WATER CONSUMPTION COST: € 57,806 / year
Assumption: average cost of water in Mayotte: 3.03 € / m3
The project will therefore have a drinking water consumption of 26.157m3 / year.
Note that this applies for the first year of operation because the young plantations must be sufficiently fed to be able to develop sustainably. Ultimately, consumption may be lowered.

## Indoor Air quality

The concept of a building with natural comfort ventilation (only the administrative building is air-conditioned) provides excellent air quality. Simulations in a physical wind tunnel at the Eiffel laboratory in Paris rely on minimum air renewal rates of 15vol / hour ensuring excellent air quality by evacuating pollutants efficiently.

## Comfort

### Health & comfort :

Below is a summary table of the materials used:

**Materials** / **Use** / **Description** / **Proliferation of microorganisms** / **Emissions of VOCs, toxics, allergens, etc.** / **Emissions of fibers and particles** / **Environmental certification** / **Ventilation conditions**

Hot-dip galvanized steel, Frame, Technical room doors, Inert material, Inert material, None, Strongly ventilated, Prestressed PVC, Sun protection

Textile membrane on galvanized steel frame Null

Presence of phthalates

VOC Emissions: None

Strongly ventilated

Aluminum

Transom and spandrel

Composite panels

Nothing

Inert material

Nothing

Strongly ventilated

Polyethylene

Transom and spandrel

Composite panels

Possibility of proliferation of microorganisms if infiltration

Low quantity VOC emissions

Nothing

Not ventilated

Polycarbonate

Vertical berries

Roller shutter

Nothing

VOC emissions

Nothing

Strongly ventilated

Electro galvanized steel sheet

blanket

Nothing

Inert material

Nothing

Strongly ventilated

Mineral wool

Transom and spandrel

Lining partitions and suspended ceilings

Possibility of proliferation of microorganisms if infiltration

Low quantity VOC emissions

Emission of fine particles possible

Obligation to have an FDES

Not ventilated

Saniclip - Comepal

Sanitary separations

Compact laminate

Possibility of proliferation of microorganisms

Low quantity VOC emissions

Emission of fine particles possible

Moderately or heavily ventilated

Plaster

Partitions and lining

Possibility of proliferation of microorganisms if infiltration

Low quantity VOC emissions

Emission of fine particles possible

Moderately ventilated

Concrete

Vertical walls and slabs

nothing

Low quantity VOC emissions (grinding agents, additives, molding agents)

Nothing

Strongly ventilated

Softwood fibers

Roof insulation (thermal and acoustic)

Fiberboards (fibralith)

Possibility of proliferation of microorganisms if infiltration

Low quantity VOC emissions

Emission of fine particles possible

Acermi

NF EN

Not ventilated

Mineral fiber

Ceiling

Ceiling of the kitchen preparation area

Possibility of proliferation of micro-organisms if infiltration, VOC emissions in small quantities, Possible fine particle emissions, Not ventilated, Paint

-

Masonry and plaster walls, Nil, Low quantity VOC emissions, Nil

European eco-label, Moderately ventilated, Earthenware, Protection of walls (housing), Inert material

Inert material, Null, Glue with NaturePlus label, Moderately ventilated, Structured porcelain stoneware, Floor, Kitchen preparation area, Inert material, Inert material, Nil, Glue with NaturePlus label, Moderately ventilated

## Acoustic comfort :

Acoustics :

In this part we will study the acoustic behavior of each room, by determining the indices of attenuation of the walls, the acoustic isolations between rooms and the reverberation time of the rooms.

It should be noted that in the vicinity of the project, no source of external nuisance has been detected.

**Definitions of the acoustic concepts used:**

Sound is a wave of energy that travels through the air more or less quickly. Depending on its intensity, it can make certain bodies vibrate and thus be transmitted through the air as well as through solid elements, such as the walls of a building. Thus, when a sound is emitted outside a room, it can be heard inside it depending on the intensity of the sound, but also depending on the physical properties of the separating walls.

Sound reduction index of a separating wall

The sound reduction index, noted R, allows to characterize the ability of the partition wall to attenuate the transmission of noise. The higher its value, the more the wall attenuates the sound level of noise transmitted.

We will focus here on the sound attenuation index weighted for a pink noise and for a traffic noise.

Acoustic insulation:

The sound insulation of a room is the arithmetic difference in sound pressure levels between the room where the sound is emitted and the room where it is received and is expressed in dB.

We are interested here particularly in the standardized sound insulation weighted DnT,A which corresponds to the sound insulation to airborne sound between two premises, taking into account the reverberation time of the room of reception.

With

- Rw + C is the attenuation index of the separating wall;

- V the volume of the room studied;

- S is the surface of the separating wall common to the transmitting and receiving rooms (room under study and adjacent room);

- a, a corrective coefficient characterizing the decrease of the insulation due to lateral transmissions.

Reverberation time

Reverberation time is defined as the time in seconds that it takes for the sound to become one millionth of its original intensity (60 dB decrease in intensity level). It can be assimilated to the presence of an echo inside a room. This is regulated in educational premises by the decree of 25 April 2003, relating to the limitation of noise in educational premises.

Speech intelligibility

Speech intelligibility is defined as the ability of a monologue or conversation to be understood by a listener located nearby. This depends on the ambient noise level, the absorption of part of the sound spectrum by the walls, acoustic distortions, etc...

Standardized acoustic insulation weighted to airborne sound DnT,A and DnT,A,tr :

The sound insulation levels indicated are expressed in dB from the weighted standardized insulation DnT,W. This notation means that the difference in sound pressure levels measured in octave or third octave bands between two adjacent or overlapping rooms must be corrected for the nominal reverberation time of the receiving room.

Standardized Impact Sound Pressure Levels:

The isolations from impact noise due to walking or solidian excitations by the feet of furniture are expressed as a maximum standardized sound level not to exceed L'nT,w, calculated according to NF EN ISO 717-2, when the standardized impact machine excites the floor considered. This sound level is corrected according to the nominal reverberation time of the measuring room.

In the context of the middle school of BOUENI, this concept takes all its direction in particular for the classrooms, but also for the CDI. The uses being appreciably different, the expected level of acoustic comfort is different:

- in the classrooms, the teacher must be heard by all the students, whatever his position in the room, without encouraging echoes;

- In the CDI, which is not intended for verbal exchange, the acoustic level must be controlled, ensuring that users have a calm working space.

**Acoustic regulations**

The order of April 25, 2003 relating to the limitation of noise in educational establishments.

**Article 2:**

Here is the table of minimum values of standardized sound insulation weighted DnT,A between premises, expressed in decibels:

**ROOM OF EMISSION ROOM OF RECEPTION**

**teaching room, practical activities, administration**

**MEDICAL ROOM, infirmary, low-noise workshop, kitchen, closed assembly room, meeting room, sanitary facilities**

**stairwell**

**horizontal circulation, closed checkroom**

**music room, multipurpose room, sports room**

**catering room**

**Noisy WORKSHOP (as defined in section 8 of this order)**

Teaching room, practical activities, administration, library, CDI, music room, meeting room, teachers' room, low-noise workshop.

Medical room, infirmary.

43 (1)

50

43

40

53

53

55

Multipurpose room.

40

50

43

30

50

50

50

Catering room

40

50 (2)

43

30

50

55

(1) An insulation of 40 dB is allowed in the presence of one or more communication doors. (2) With the exception of a kitchen communicating with the dining room.

**Article 3:**

On the other hand, Article 3 states that the weighted depression level of the standardized impact noise L'n,Tw shall not exceed 60dB. If the shocks are produced in a noisy workshop, a sports hall, the values of weighted pressure level of the noise of standardized shock, L' nT,w, must be lower than 45 dB in the rooms of reception.

**Article 4:**

The value of the standardized sound pressure level LnAT of noise generated in libraries, documentation and information centers, medical premises, infirmaries and rest rooms, music rooms by a building equipment shall not exceed 33 dB(A) if the equipment operates continuously and 38 dB(A) if it operates intermittently. These levels are increased to 38 and 43 dB(A) respectively for all other reception areas

**Article 5:**

**UNOCCUPIED FURNISHED PREMISES**

**AVERAGE REVERBERATION TIME (expressed in seconds)**

Nursery school rest room; nursery school exercise room; nursery school playroom.

Teaching room; music room; study room; hands-on activity room; dining room and multipurpose room with volume 250 $m^3$.

0,4 Tr 0,8 s

Medical or social premises, infirmary; sanitary facilities; administration; foyer; meeting room; library; documentation and information center.

Rooms for teaching, music, study or practical activities with a volume > 250 $m^3$, except noisy workshops (3).

0.6 Tr 1.2 s

Catering room with a volume > 250 $m^3$.

Tr 1.2 s

Multipurpose room with a volume > 250 $m^3$ (1).

0.6 Tr 1.2 s and compulsory special study (2)

Other rooms and corridors accessible to students with a volume > 250 $m^3$.

Tr 1.2 s if 250 $m^3$ < V 512 $m^3$ Tr 0.15 $^3$V s if V > 512 $m^3$

Sports room.

Defined in the decree relating to the limitation of noise in the establishments of leisure and sports taken in application of the article L. 111-11-1 of the code of the construction and the housing.

(1) If the dining room is used as a multipurpose room, the values to be taken into account are those given for the dining room. (2) The particular study is intended to define the acoustic treatment of the room allowing to have a good intelligibility in any point of this one. (3) See article 8.

Note that the Boueni middle school site is not included in a perimeter linked to the airfield noise exposure plan.

**Article 7:**

The value of the weighted standardized sound insulation DnT,A,tr, of the reception premises mentioned in article 2 with regard to the noise of land transport infrastructures is the same as that imposed on residential buildings in articles 5, 6, 7 and 8 of the aforementioned decree of 30 May 1996. It can in no case be less than 30 dB.

### 6.2.3. Acoustic characteristics of the project walls

After having stated the regulatory texts, we will evaluate the characteristics of the project.

The **sound reduction index** of a wall provides a lot of information concerning the acoustic behaviour of a wall, especially its capacity to attenuate the sound levels emitted in an adjacent room. The calculation of its value is necessary to determine the sound insulation of a facade, which may be composed of various constructive elements (walls, windows, doors, ventilation grilles, etc.). Only the sound insulation of a facade has a regulatory character.

The first step is to identify the different building materials used to determine their respective sound reduction values.

*Figure 3: Sectional view of building F*

All the walls and their compositions are marked on the cross-section of building F and their attenuation indices have been evaluated and summarized in the following tables.

We recall that: the higher the loss index RA, the more the wall attenuates the noise emitted in the adjacent premises.

**Facades**

Typology

Curtain wall with aluminum frame + rock wool

Total thickness of the wall

about 100 mm

Number and thickness of plates per facing

3 (sheet metal / polyethylene / sheet metal)

Weight

5,61 kg/m² (5,61 kg/m²)

Surface transmission coefficient

U = 5.6 W/m².K

Rw (C;Ctr)

-

**RA**

**40 dB**

**Partition walls**

Typology

Plasterboards screwed on a galvanized steel frame type Placostil 120/70

Total thickness of the partition

120 mm

Width of the framework

70 mm

Number and thickness of the plates by facing

2 x 13 mm

Weight

42 kg/m2

Insulation

Mineral wool (U = 0,60 W/m².K)

Rw (C;Ctr)

52 (-2;-7) dB

**RA**

**50 dB**

**Slab**

Typology

Raw concrete wall (with coating?)

Total thickness

180_ mm

Weight

432 kg/m² (2400 kg/m³)

Insulation

None

Rw (C;Ctr)

-

**RA**

**58 dB**

Ln,w

77 dB

**Floor**

Typology

COFRADAL 200 Decibel type floor with micro-perforated underside

Total thickness

200 mm

Weight

200 kg/sqm

Insulation

Mineral wool (R = 3,14 m².°C/W)

Rw (C;Ctr)

58 (-2;-8) dB

**RA**

**56 dB**

Ln,w

78 dB

*Note: the values given for COFRADAL 200 correspond to the tests carried out for COFRADAL 200 Decibels with the micro-perforated underside.*

**Roof**

Typology

Roofing sheet COVERIB ep 60/100

Total thickness

60 mm

Weight

8,6 kg/m² (8,6 kg/m²)

Insulation

Mineral wool (R = 0,50 m².K/W)

Rw (C;Ctr)

-

**RA**

**28 dB**

*Note: the announced attenuation index does not take into account the presence of insulation on the underside.*

**6.2.4 Weighted standardized sound insulation, DnTA**

**Educational premises / Educational premises**

Note: the objective is 40dB because of the presence of a communication door

The objective is well respected.

**Administration room / Multi-purpose room**

The objective is well respected.

**Administration room / Administration room**

The objective is well respected.

Note that the noisy rooms (gym, music room) are all located in the G building. There is no room next to the gym and the two music rooms.

The medical room with the social worker's office is isolated in the eastern part of building A.

**6.2.5. Standardized impact sound pressure level, L'n,Tw**

The objectives of weighted acoustic pressure levels of standardized impact noise L'nT,w measured in the various rooms are given in the table below:

**Reception room**

**Objectives of the level of standardized impact noise L'nT,w [dB]**

**College rooms**

60

**Dwellings**

58

For the construction project of the Boueni secondary school, it is planned to install a COFRADAL200 type floor.

**Normalized sound pressure level, LnAT**

The equipment that will be a source of nuisance inside the premises will be

- cassette fan coil units located in the teacher's room and the meeting room

- fan coil unit located in the offices

- Square diffuser in the CDI

- Blower in the laundry/cooking room

- Extractor hood in the kitchen

- Elevators

As a result, the objectives to be respected are listed in the table below:

**Reception area**

**Operation**

**permanent**

**Limited to**

**Operation**

**intermittent operation**

**Limited to**

**NR levels**

**Hall**

38 dB(A)

43 dB(A)

35

**Offices**

38 dB(A)

43 dB(A)

35

**Meeting room**

38 dB(A)

43 dB(A)

35

**CDI / Multipurpose room**

33 dB(A)

38 dB(A)

35

**Classroom**

38 dB(A)

43 dB(A)

35

**Medical rooms**

33 dB(A)

38 dB(A)

35

All these equipments operate continuously and will not exceed 33dB(A). This is specified in the SCC of the relevant lots.

**Reverberation time, Tr**

In order to calculate the reverberation times, it is necessary to determine the absorption coefficients between 125 and 4,000 Hz (frequency of the human voice) of each material developed in the interior walls of the room. These have been compiled in the following table.

**Absorption coefficients**

**Material**

**alpha sabine**

**125 Hz**

**250 Hz**

**500 Hz**

**1000 Hz**

**2000 Hz**

**4000 Hz**

Concrete

0,01

0,01

0,01

0,01

0,01

0,01

Gypsum

-

0,02

0,03

0,03

0,04

0,05

0,04

Closed bays

0,1

0,1

0,1

0,1

0,1

0,1

Open bays

1

1

1

1

1

1

Fibralith 50 mm

0,55 (H)

0,11

0,24

0,66

0,68

0,66

0,76

COFRADAL 200

0,85

-

-

-

-

-

-

As the premises are naturally ventilated all year round, it is interesting to evaluate the reverberation time when the windows are open and when they are closed. When the windows are open, they function as perfect absorbers, and when they are closed, their reflection coefficients correspond to those of a simple glazing.

**REVERBERATION TIME (open windows)**

**Room studied**

**500 Hz**

**1000 Hz**

**2000 Hz**

**Calculated Tr60**

**Tr60 expected**

**Classroom**

50 $m^2$ floor space

175 $m^3$

Equivalent absorption area =

74,11 $m^2$

76,86 $m^2$

76,60 $m^2$

Reverberation time =

0,38 s

0,36 s

0,37 s

0,37 s

**0.4<Tr<0.8**

**Classroom**

75,16 $m^2$

236,06 $m^3$

Equivalent absorption area =

74,11 $m^2$

76,86 $m^2$

76,60 $m^2$

Reverberation time =

0,57 s

0,55 s

0,55 s

0,56 s

**$0.4<Tr<0.8$**

**CDI**

291 $m^2$

1076 $m^3$

Equivalent absorption area =

215,07 $m^2$

187,41 $m^2$

178,56 $m^2$

Reverberation time =

0.80 s

0.92 s

0.96 s

0.90

**$0.6<Tr<1.2$**

**Sports hall**

203 $m^2$

1218 $m^3$

Equivalent absorption area =

205,73 m²

230,19 m²

226,07 m²

Reverberation time =

0.95 s

0.85 s

0.86 s

0.88

**0.6<Tr<1.2**

**REVERBERATION TIME (closed windows)**

**Room studied**

**500 Hz**

**1000 Hz**

**2000 Hz**

Daylight factor : Salles de classe FLJ entre 3,3% et 5,5% - autonomie en éclairage naturel à 300 lux (DA300) supérieure à 80%

## Carbon

### GHG emissions

GHG in use : 47,00 $KgCO_2/m^2$/an

Methodology used :
TEC TEC tool

GHG before use : 823,00 $KgCO_2$ /$m^2$

Building lifetime : 50,00 année(s)

, ie xx in use years : 17.51
The calculation was made on the basis of a tool adapted to overseas departments as part of a study funded by ADEME and AQC.

## Reasons for participating in the competition(s)

The project allows for natural ventilation for comfort and low energy consumption despite high temperatures and humidity. A wind tunnel study allowed an optimization of the use of the dominant winds, either in cross ventilation or with a pressure well. Its implantation parallel to the slope reduced its impact on the site. A thermo-acoustic double skin roof was installed to protect the envelope from solar gain. The use of transparent roller shutters in the classrooms ensures optimal ventilation and light. The building is built to preserve the site and its vista with a steel-clad structure. The following features have also been the object of the greatest care: conservation of native and domestic trees that also allow natural shading, reacute;alization of gardens rich in biodiversity indigène, étagement in the slope of the highest volumes and living terraces.

The resilience of the building is ensured by multiple tools: optimization of the dimensions to allow a natural ventilation and lighting (passive architecture), management of rainwater on the surface (obstructing or destroying the drain in case of seismic or heavy rain), optimization of the load drops to protect the building from seismic altitudes.

## Building candidate in the category

Energie & Climats Chauds

Date Export : 20230503155125