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HIGH-TECH

PHILHARMONIE DE PARIS,

THE CHALLENGE FOR PERFECT SOUND

The exterior designed by Jean Nouvel, in Villette park.

32 m
The maximum audience distance from the stage

2,3 seconds
Sound reverberation time

30 500 m³
The acoustic volume

386 million euros
The total cost of the project

This concert hall aims to become the international temple of music: hanging balconies, reflector clouds ... Visit a building outside the norm which will open in January.

By Franck Daninos @fdaninos

HIGH-TECH

Northeast of the capital, near Porte de Pantin, workers and team leaders are pushing the pace to finish the Philharmonie de Paris on time. Eight years after the official launch of the project, a mixture of excitement and stress is palpable throughout the site. This is because the deafening sound of drills, hammers and saws must be replaced in January by the melodies of the greatest French and international musical groups.

It took 60,000 tons of concrete, 9,500 tons of structural and reinforcing steel, 1,000 workers (at the time of peak activity) and 386 million euros to build the new "temple of music" designed by star architect Jean Nouvel. The complex spans 11 levels and 70,000 square meters. The floating and sinuous shape of its exterior surface evokes that of a sound wave. It encompasses a concert hall of a new kind, able to accommodate between 2400 and 3650 spectators. "We finally have a symphony hall of international standing in France," rejoices Laurent Bayle, president of the Philharmonie de Paris. "But the novelty lies mainly in its versatility and therefore its modularity." Symphonic ensembles do indeed represent 60% of the programming. The rest is derived from jazz, world and amplified music, rap and electro-pop. "Our goal is to attract younger audiences and less so the traditional elite, and to build gateways between different patterns of music ownership," underlines Laurent Bayle. That is why the Philharmonie de Paris will also house rooms for conferences and exhibitions as well as educational workshops, a library, two restaurants and eight bars. This building has been a double challenge to both architects and acoustic engineers. How does one offer optimal visual and listening conditions in a symphony hall of such a capacity? How to gather such a variety of musical genres in the same location?

Like any enclosed space, a concert hall confines sound waves and distributes them in a singular fashion, by its volume, geometry and materials, down to the smallest reliefs. It can therefore be seen as an instrument in itself, which is possible to "tune". Acoustic engineers play, on the propagation of waves that travel at the speed of 340 meters per second in the air, losing 6 dB for each doubling of distance. When they encounter a flat and non-absorbent wall, they retain much of their energy and are reflected much like a squash ball bouncing against a wall. We refer to these as "specular" reflections. If these reflections come to the ears of the listeners with a delay of less than 40 milliseconds relative to the direct sound of the instruments of the orchestra, they immediately associate with them, reinforcing the power and clarity of sound perceived . This is what acoustic engineers call the presence of the source.

Studies have shown that our auditory system prefers to receive a significant share of sound reflections laterally rather than in line with the direct sound, each of our ears receiving a different message that the brain then interprets as an impression of sound envelopment. But the "presence of the room" as it is called, must also be nurtured by the delayed reflections (above 40 milliseconds) that, reaching listeners after multiple rebounds, extend the direct sound according to a certain reverberation time (see p. 80). However, the persistence of the sound is pleasant if it decreases softly and evenly. For this purpose, a different kind of reflection is put to use. This reflection occurs when sound waves encounter a relief of a similar size to their wavelength. The energy is then shattered in all directions. These "diffused" reflections promote the mitigation and mixing sounds and thereby allow a progressive decrease. "It's the mixing of sounds produced by these different types of reflections that will give the room its identity," says Geoffroy Vauthier, technical manager and acoustics of the Philharmonie de Paris. "For the acoustic richness of a room is as the light of the setting sun: it fills everything it meets. "

The new Parisian venue was designed to accommodate 2400-3650 spectators in optimal listening conditions and visibility (virtual image).

REVERBERATION

Sabine's Formula

In the early twentieth century, American physicist Wallace Sabine was able to put the architectural properties of a concert hall into a series of equations, in particular, "reverberation time," which refers to the time required for the intensity of a sound to reach a thousandth of its initial value, a decrease of 60 decibels. A duration that lasts much longer than the volume is especially important, and inversely proportional to the area of the room multiplied by an overall absorption coefficient, calculated from each of the materials that provide a contact surface with the sound waves (walls, reflectors, curtains, fans, etc.). The reverberation time of a recording studio is 0.3 seconds, 1.5 seconds at the Opera Bastille, about 10 seconds in a cathedral, and 2.3 seconds at the Philharmonie de Paris.

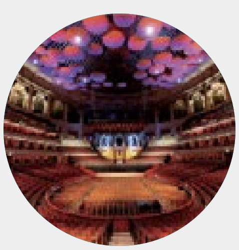
A mix of two existing types of rooms

The geometry of the room plays an important role. To optimize the Philharmonie de Paris, the architect took advantage of the two major existing forms (see p. 80). First let us examine the "Shoebox." Having a rectangular shape and balconies, it is very well suited to symphony orchestras, but not for having larger dimensions. In the other model, "Vineyard," the audience surrounds the orchestra on terraces located at different levels. In the "Egg-shaped" form, the Philharmonie de Paris retains certain characteristics of the "vineyard," but also possesses large hanging balconies projected toward the center of the stage, reducing the maximum distance to 32 meters. This is record for a symphony hall with 2400 seats. But, like in a "shoe box" the nose of each balcony and other surfaces located below produce reflections early and laterally, magnifying the "presence" of the room. The clarity of the sound is accentuated by "cloud" reflectors located under the ceiling. And a platform located above the stage called a "canopy" will, in part, ensure the return of sound to the musicians. Another innovation: the balconies will be affixed to the walls, allowing additional volume to emerge behind the audience where the sound flows freely, favoring late reflections and ample reverberation (2.3 seconds). This, is in addition to the proximity of the orchestra, creates an unprecedented sense of intimacy and sound immersion.

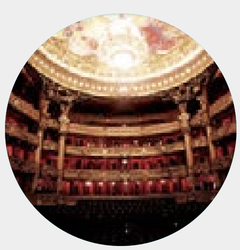
But how does one adapt this symphony configuration to other musical styles such as jazz and amplified music which require, among other things, a shorter reverberation time (about one second)? When it is too large, the direct sound is masked and the musical discourse is rendered unintelligible, resulting in a type of drowned out "brouhaha." To resolve this problem, the designers have thought of a physical and acoustic transformation for the hall. The lower level (ground floor and symphony stage) will be fully mobile thanks to motorized mechanisms. Telescopic bleachers will also be able to retract to clear space for a frontal stage. Part of the audience will be standing, raising the hall's capacity to 3650 spectators. Lastly, removable and absorbent curtains can be used to lower the reverberation time.

TYPES OF ROOMS

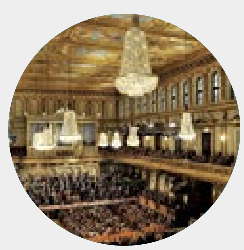
IN SEARCH OF THE OPTIMAL ARCHITECTURE



ARENA Inspired by ancient amphitheaters, arena style rooms, like in the Royal Albert Hall in London, carry voices well, but are not suited to symphony music. In order to blend the sounds and prevent their focus, reflective surfaces must be installed on the ceiling and "break" the concave shape of the walls.

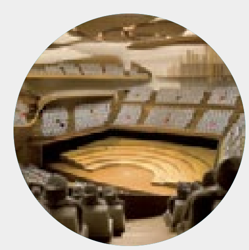


ITALIAN Ideal for theatre and opera, Italian style rooms, like the Garnier Opera in Paris, produce a sound that is too "dry" for large orchestras. It is not projected well because the reverberation time is too short. The visibility of the scene is still excellent except for at the level of the box seats.

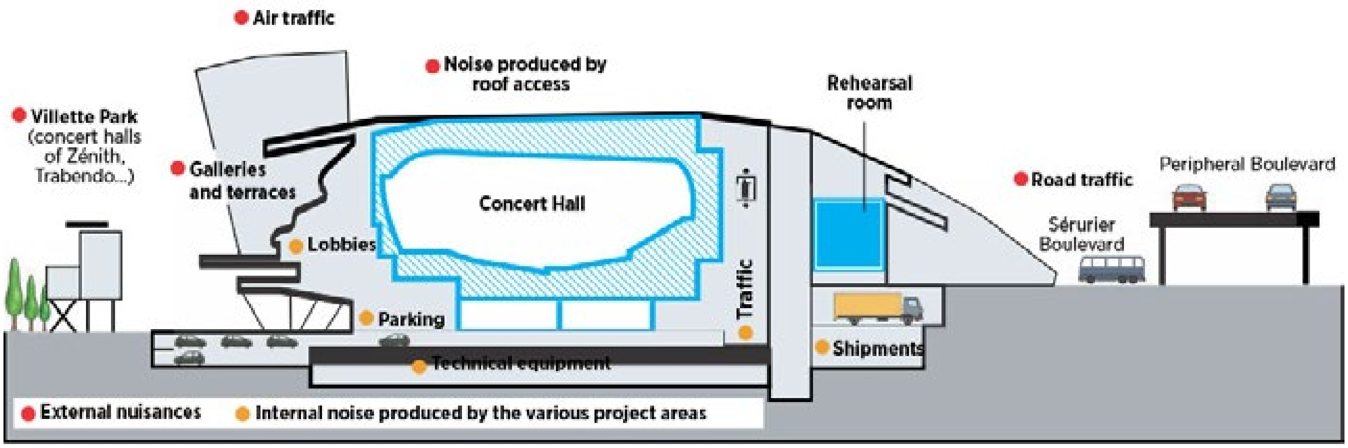


SHOE BOX These rooms, like the Musikverein in Vienna (Austria), are perfectly adapted for classical music. Thanks to reflections created by the side balconies, the sound is clear, strong and enveloping. However, the sound quality is degraded if one wants toincrease the width or length of the room to accommodate more than 2000 people.

VINEYARD The distribution of the audience around the stage allows the admittance of many listeners much like the the Berlin Philharmonic Hall. The direct sound is reinforced by the terraces and the geometry of the ceiling even though it is not always well distributed. However, the reverberation and proximity of the audience are much appreciated.



EGG-SHAPED This type of auditorium chosen by the Philharmonie de Paris will produce a strong sense of visual intimacy and enveloping sound thanks to the balconies being suspended and projected toward the center of the room suspended and projected toward the center of the room. A physical and acoustic transformation of the room will also accommodate a wide variety of musical groups.



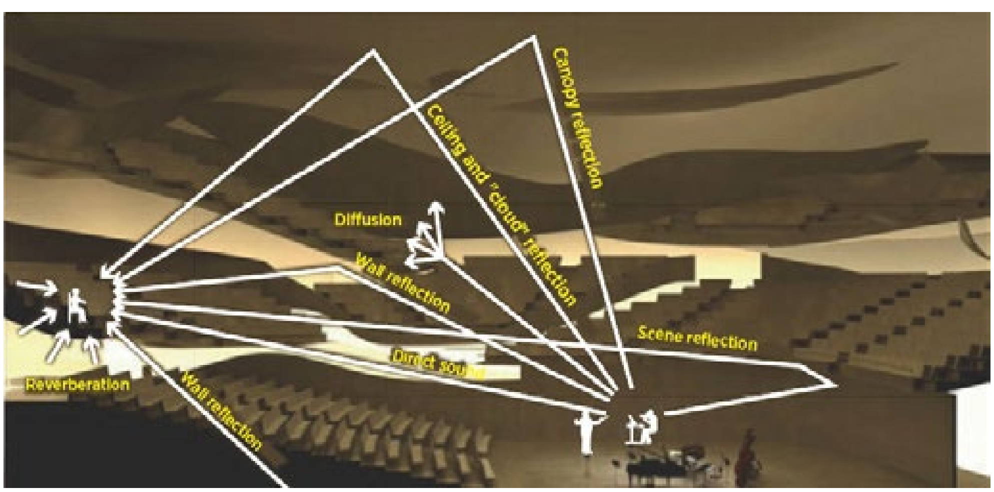
The isolation of the hall from its noisy environment in order to obtain perfect silence, is made possible thanks to the principle of the "box within a box": the room is separated from the rest of the building by being wrapped in a "double skin" (shown in blue).

Achieving the removal of background noise

Another acoustic and architectural challenge, was to isolate the main auditorium from the rehearsal rooms and external noise sources, especially the Zenith concert hall (about 200 meters away) and the neighboring Peripheral boulevard. The concept used was that of a "box within a box" detached from the building's main structure by means of vibration isolators and a double skin. Between the walls of each "skin" there is an air vacuum of 6 to 15 inches that acts like a spring. The "silence quality" must also be flawless. Air from 34 ventilation centers will be pulsed very slowly in ducts fitted with antivibration structures. If the whole system works well, the background noise in the room will never exceed 15 decibels, which is no more than a single leaf rustling.

Before giving the order to begin construction, all architectural acoustics have been tested and validated. For these tests, the distribution and all of the angles of incidence of the sound waves were numerically simulated. It is in this way that the acoustic parameters (reverberation time, sound clarity and force) have been calibrated, and the surface area of the clouds of reflectors was calculated. But the complexity and sheer number of reflections was too large to be entirely calculated by computers, which is why the engineers also used physical models. A 1/10th scale model reproduced the reflective properties of the small contours of the room, right down to the seats and future viewers, who were represented by felt dolls. Several dozens of them were equipped with sensors to determine how the sounds in the model would be perceived at various locations. Like the dimensions of the room, the wavelengths of these sounds were also reduced to one tenth of their actual size.

They correspond to ultrasound waves, which are absorbed more (and therefore further softened) than conventional sound waves in the air. For the physical model to accurately reproduce the absorption of sound at a reduced scale, the chemical composition of the air inside the model was saturated with 98% nitrogen. "The tests have allowed us to identify which echoes remained undetected by computer," explains Geof roy Vauthier. These echoes result from net reflections and delayed reflections beyond 100 milliseconds that are spatially isolated. During the test, some spectators had heard the same sound twice that had shifted, creating the feeling that the sound came from two different places! Diffusing surfaces were added and the angles of certain reflectors were modified to remove all unnecessary echoes. Can it be thus be said, given the the acoustic excellence created by the selected innovations, that the Philharmonie de Paris will be a "perfect concert hall?" "The perfect room does not exist, just as there is no such thing as an perfect voice," retorted Olivier Warusfel from IRCAM. "There are too many subjective factors to count. Only the audience and the musicians will be able to tell if it lives up to its ambitions." The inaugural gala is set to be held on January 14th, performed by the Paris Orchestra.



Sound propagation was modeled and tested using a scale model - reproducing the reflective properties of the room - to determine how it would be perceived by each viewer.