

Right: The transparent metal mesh and its acoustic shelves optimised in order to create the desired early reflection coverage in the Jinan concert hall

The iconic building, with its signature bubbles housing the main performance spaces, includes a 1,600-seat opera house, a 1,500-seat concert hall and a 500-seat multipurpose hall – as well as two impressive sky lobbies on top of the opera house and concert hall.

Updating vineyard style

For the 1,500-seat concert hall it was clear from the outset that architect Paul Andreu was in favor of a surround typology with seats arranged in vineyard terraces around the stage, inserted in an oval plan. Over the last decade, a large number of vineyard halls have emerged around the world. They are unanimously praised for their spatial qualities, offering a high degree of intimacy and good visibility due to the audience enveloping the stage.

There has, however, been some discussion of the acoustic merits and shortcomings of the original vineyard architectural style when compared with shoebox halls with side balconies. It is true that the latter lend themselves more easily to providing early lateral reflections – essential for a rich spatial impression and good musical clarity – than vineyard halls. The acoustic concept for the Jinan Concert Hall was to take the original vineyard paradigm one step further by geometrically sculpting the hall envelope such that useful early reflections to the audience were promoted, while keeping harmful focusing reflections from the oval shape tightly under control. This was eventually achieved via a number of design ideas that emerged from the fruitful collaboration between the architect and Kahle Acoustics.

First, the particular ceiling shape, with its sloping central part and horizontal lateral parts, reintroduced some of the acoustic merits of the shoebox hall. The two linear notches created by the ceiling geometry create early lateral reflections to the parterre and the stage, as if they had come from the upper walls of a shoebox.

The curved bamboo sidewalls of the vineyard terraces were acoustically sculpted with great effort and care using dedicated 3D CAD software to optimize the early lateral reflections to the parterre and back to the musicians on stage. The acoustician's prior experience with curved bamboo walls on another project in China

Grand designs

Combining aspects of different architectural styles presents acoustic challenges, which must be overcome through the innovative use of design and technology

Main: The Jinan concert hall with its vineyard terraces, curved bamboo side walls and a ceiling shape inherited from the shoebox paradigm

Since opening in October 2013, the Jinan Grand Theater has already established itself as one of the prime cultural arts centers in China. On a recent visit the Chinese Prime Minister, Li Keqiang, even declared Jinan to be the second performing arts center in China, after Beijing.

Jinan is the buoyant capital of Shandong province, which is home to 100 million inhabitants. The Jinan Grand Theater is located on the future subway line between the historic city center and the new one currently emerging around the new high-speed Jinan West Railway Station, which connects the major cities of Beijing and Shanghai.



ACOUSTICS

Above: **Detail of the opera hall with an asymmetrical parterre and balconies acting as a light source. The three elements of the ceiling canopy also support the early reflections**

Center: **The three roof shells of the Jinan Grand Theater span a force line to the three towers, creating a highly memorable icon effect standing as China's second performing arts center**

Below: **The foyer of the opera hall gives access to the venue's balconies and to the sky lobby at the top**



Photos: Philippe Ruault

(the Wuxi Opera House, opened in 2012) came in handy, not least in convincing the local policy makers of the qualities of Chinese grown bamboo as a high-quality interior design material. The convex curved separations between the terraces lean forward, creating strong lateral reflections to most audience seats. To deal with disturbing focusing effects, the rear concave parts of the bamboo wall gradually lean backward in order to send those reflections upward, safely above the heads of the audience.

To further deal with the lack of early reflections in the lateral vineyard terraces, 126 acoustic shelf reflectors were integrated behind the acoustically and visually transparent metal mesh lining of the oval walls. All the shelves are linear but in sections they are slightly angled for optimal acoustic coverage. In the lighting scheme chosen by Paul Andreu and his team, these shelf reflectors, in conjunction with the acoustically transparent metal mesh, can create a mesmerizing visual effect.

While it is anticipated that the concert hall will be used for many kinds of music, it was designed and optimized for unamplified symphonic music, surpassing the limitations of some prior vineyard concert halls and integrating acoustic characteristics normally attributed to shoebox concert halls, notably the combination of long reverberation time with high clarity and ample lateral reflections.

Free form shoebox design

For the opera hall, after several design trials with standard theater shapes, an innovative and clear-cut design concept was finally adopted: two freely shaped balconies are suspended, floating within a

shoebox envelope. On the proscenium end, the balconies connect to two enormous architectural columns, framing the view on either side of the proscenium opening. Other than their architectural function, the columns also serve as lighting positions and were acoustically designed to integrate some acoustic reflectors as well as the house loudspeakers.

In the opera hall, early lateral acoustic reflections are created by geometrically sculpting the balcony fronts, as well as down-stand reflectors inside the architectural columns. Further early reflections are provided by three canopy elements floating above the orchestra pit and by large zigzag-shaped reflectors in front of the lighting bridges integrated in the architectural ceiling.

The walls of the shoebox enclosure are clad in purpose-designed GRG-panels, creating acoustic diffusion while maintaining strong specular reflections. Paul Andreu and his team originally envisioned a subtle night-blue color, but after discussion with the Chinese client, a golden or a champagne color was finally agreed on for the opera house. The night-blue color is now featured in the third hall, the multipurpose theater – a welcome change from the world of black box theaters! The walls of the latter space were acoustically designed to create the required degree of lateral early reflections, while avoiding undesired flutter echoes.

The shared entrance hall of the building opens up into three dedicated foyers – one for each performance hall – located within the volume of the corresponding bubble. The foyers of the concert hall and the opera hall are voluminous, at 55,000m³ (1,900,000ft³) each. The finishes of the



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Photo (right): Kahle Acoustics

Above: **The acoustic macro-micro shaping of Wuxi Grand Theater's curved bamboo walls**

foyers were carefully designed and coordinated with the architect. They are lined with thousands of square meters of locally produced acoustic bamboo panels, granting good control of the reverberation to achieve comfortable occupied noise levels. In addition, the sky lobbies on top of the opera and concert halls can be used for music

events, even though they are located within the same volume as the public foyers.

The result is a series of sumptuous foyers, with stunning artistic interventions and pleasant acoustic conditions. ■

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KahleAcoustics

Suzhou Science & Cultural Arts Centre / ECADI / 2007

Wuxi Grand Theatre / PES-Architects + SIADR / 2012

Jinan Grand Theatre / Paul Andreu Architecte + Richez Associés + BIAD / 2013

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