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Acoustical design of Shenzhen Concert Hall, Shenzhen China

Keiji Oguchi and Yasuhisa Toyota

Nagata Acoustics Inc., 2130 Sawtelle Blvd., Suite 307A, Los Angeles, CA 90025, USA
oguchi@nagata.co.jp

The Shenzhen Concert Hall complex opened in Shenzhen, China on October 12, 2007. The complex contains the Symphony Hall with 1,576 audience seats, the Theatre Studio with 400 – 580 seats and some rooms for rehearsing. The Symphony Hall has a vineyard configuration with a steep audience block arrangement, termed a “canyon terrace”. At the widest point of the audience seating, the room spans 45m, is 60m long and has a ceiling height of 25 m. Polycarbonate ensemble reflector panels are suspended at the height of approx. 14m above the stage. The acoustical design and characteristics of the Concert Hall are reported.

1 Project overview

In the City of Shenzhen, China, where the city’s status as a Special Economic Zone has been a catalyst of rapid and remarkable growth, the new Shenzhen Concert Hall complex opened on October, 2007.

In 1998, an international competition selection process awarded the Japanese architectural firm of Arata Isozaki Atelier the honor of designing the new Culture Center complex, composed of the concert hall and library. Nagata Acoustics participated on the concert hall project as the acoustical consultant.

The Shenzhen Culture Center is located in Shenzhen City’s central Futian District among other municipal, public-use buildings that include the new city hall. The Cultural Center has a long, 300m. footprint in the north-south direction. A boulevard runs east-west through the center of the site, separating the Cultural Center into north and south halves. The Shenzhen Concert Hall complex occupies the northern half, and the Shenzhen Library, opened 2006, the southern half of the location.

The Shenzhen Concert Hall complex contains the Symphony Hall with 1,576 audience seats, the Theater Studio, a kind of multi-purpose space, with 400 – 580 seats and some rooms for rehearsing.

2 Symphony Hall

2.1 Acoustical design

The study of the room’s shape and dimensions were conducted with ray-tracing based computer simulation, in terms of early reflections, followed by acoustical experiments with a 1/10 physical scale model.

The Symphony Hall has a vineyard configuration that surrounds the stage and a seat count of 1,576. At the widest point of the audience seating, the room spans 45 m. (148 ft), is 60 m. (197 ft) long and has a ceiling height of 25 m. (82 ft). The plan and the sections of the hall are shown in Figure 1, 2 and 3.

In keeping with the basic approach of the vineyard configuration, the hall has terraced blocks of seating areas with large level differences. By inclining front faces of the blocks toward the stage, the faces can effectively provide early reflections to the seats in front of the faces. When viewed from the stage, the blocks of seats give a very dynamic appearance to the hall, called “canyon terrace”.

Above the stage, at a height of approx. 14 m. (46 ft), 30 mm. (1.2 in.) polycarbonate ensemble reflectors are suspended. The underside of these panels is finished with a

layer of matte, metal mesh that renders the panels virtually invisible to the audience. In addition, the stage lighting and sound system equipment are attached to the frames of the sound reflection panels.

The ceiling is constructed of 50mm thick concrete to have sufficient mass effective for high reflectivity of low frequency sound. The surface of ceiling has fine scale micro-shaping to produce a sound scattering at high frequencies. The wall surfaces are reflective, with the exception of the rear wall behind the audience at the very back of the hall. During the 1/10 model testing, this section of wall was discovered to cause a long-path echo if finished reflectively. The inclined walls among the audience seating area are composed of lightweight concrete panels with random-width pieces of timber milled to a triangle profile attached for sound scattering. The stage floor is constructed of 45mm thick “Hinoki” (Japanese cypress) on a wooden structure. The brief of Symphony Hall is summarized in Table 1.

Seating Capacity	1,576
Room Volume	25,000 CM
Surface Area	7,250 SM
Stage Area	210 SM
Finish Materials	
Ceiling	Concrete 50mm
Wall	LC Panel 100mm, Wood rib
Floor	Hinoki 45mm (Stage) Wood flooring on concrete (Audience)
Seats	Upholstered
Miscellaneous	Suspended ensemble reflectors: Polycarbonate panel 30mm thick
Organ	86 stops (Rieger Orgelbau, Austria)

Table 1 Architectural and acoustics data of Symphony Hall

2.2 Acoustical characteristics

Distribution of early reflections

Figure 4 shows the distribution of the early reflections in the hall with the ray-tracing computer simulation.

Room acoustical parameters

Impulse responses were measured at several points in the hall when completed. Some acoustical parameters including those from ISO3382 are derived from the impulse responses.

Figure 5 show the reverberation times (RT60). RT60s at 500Hz are approx. 2.2 sec. (unoccupied) and 2.0 sec. (occupied). RT60s for occupied were estimated from the data measured in the empty hall.

Other room acoustical parameters: EDT, Clarity (C80) and G, averaged over 27 measuring points are shown in Table 2. Figure 6 shows REC curves [1] at 27 points in the audience.

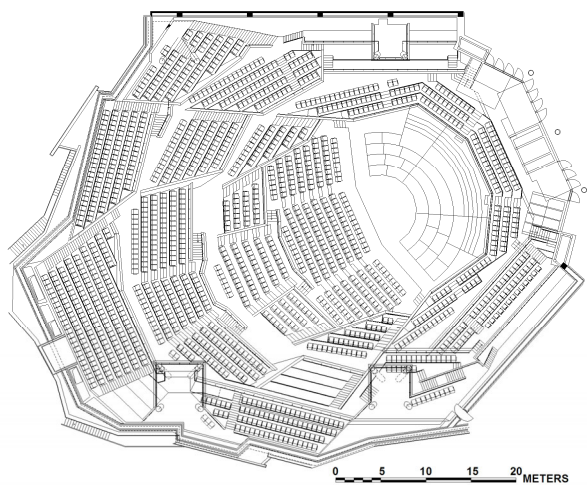


Figure 1 Symphony Hall – Plan –



Photo 1 Symphony Hall – View from top -

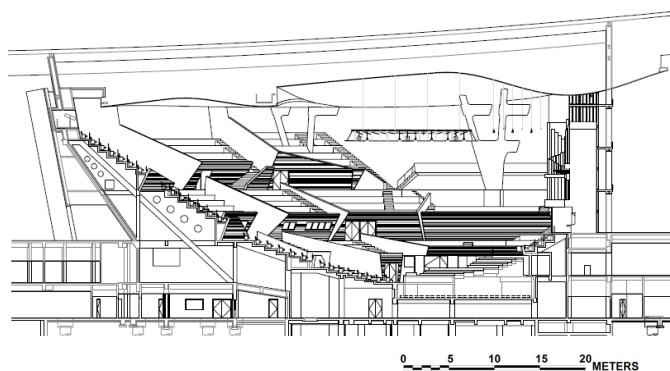


Figure 2 Symphony Hall – Longitudinal section

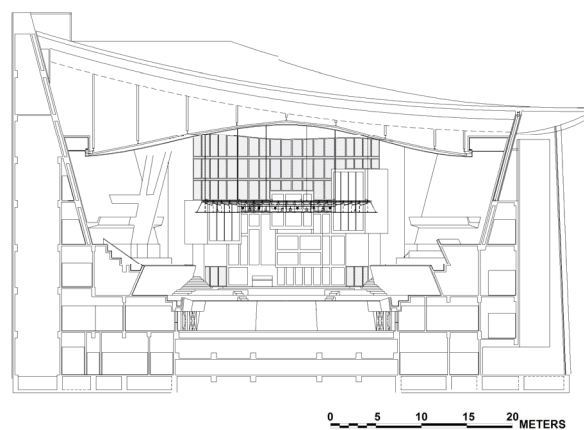


Figure 3 Symphony Hall – Cross section –

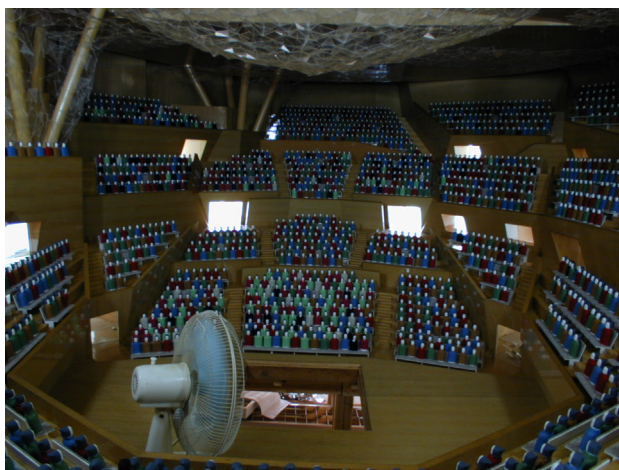


Photo 2 1/10 Scale model of Symphony Hall

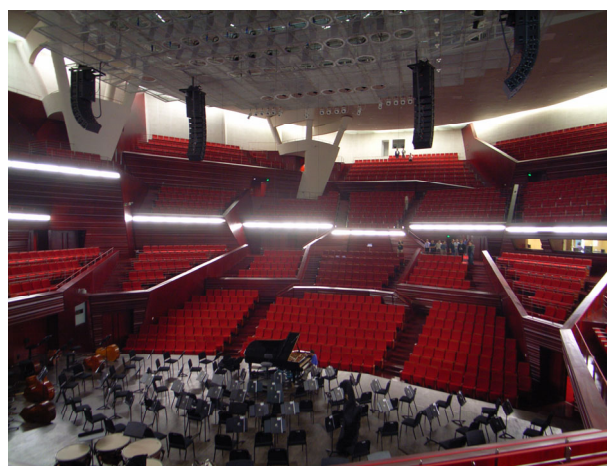


Photo 3 Symphony Hall – View from choir seat

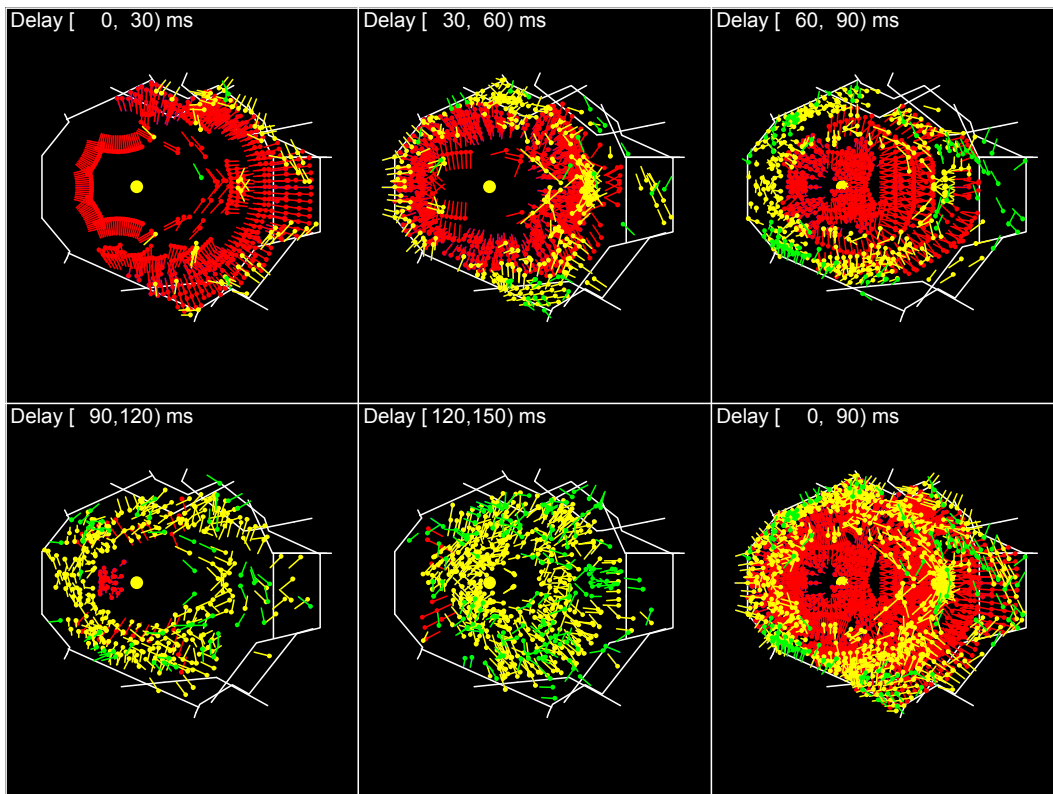


Figure 4 Distribution of early reflection on stage and audience - Ray-tracing computer simulation study -

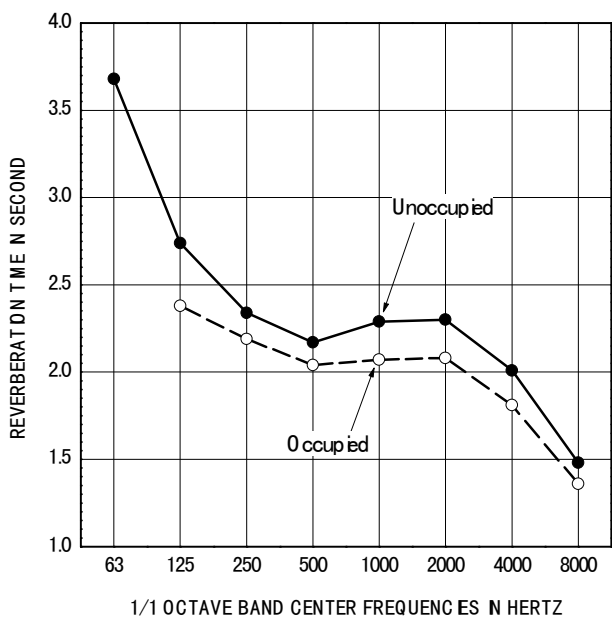


Figure 5 Reverberation time of Symphony Hall

	250Hz	500Hz	1kHz	2kHz	4kHz
EDT [s]	2.2	2.0	2.0	2.1	1.9
C80 [dB]	-0.2	1.0	1.4	0.7	0.7
D50 [%]	39	46	47	43	42
G [dB]	4.2	3.2	3.2	4.1	4.5

Table 2 Room acoustical parameters - Average of 27 measuring points distributed in audience -

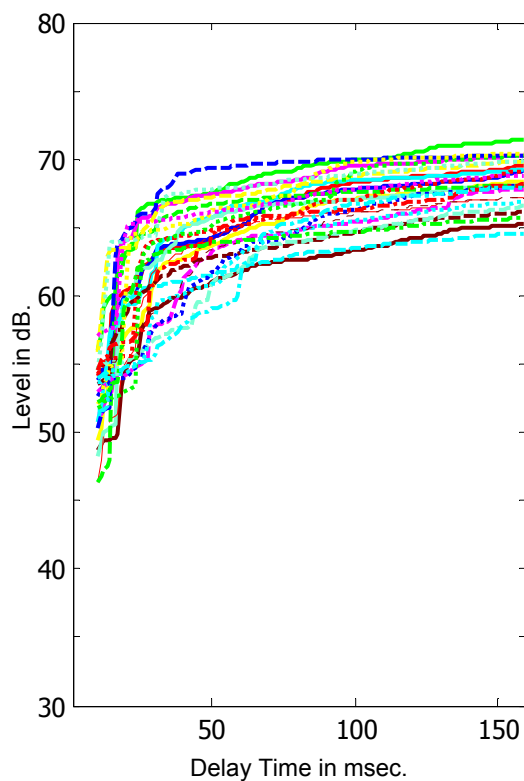


Figure 6 REC Curves in Symphony Hall - 27 measuring points -

Theater Studio

The Theater Studio, has the same type of configuration as Akiyoshidai International Art Village Concert Hall [2], with a flat main floor and two levels of “Flying” configurable seating. The stage floor is comprised of 20 sections that can each be raised independently to create a multitude of stage configurations. Depending on the stage configuration, the Theater Studio accommodates between 400 and 580 audience seats. The plan and the section of the room are shown in Figure 7 and 8. The brief of Theater Studio is summarized in Table 3.

Seating Capacity	400 - 580
Room Volume	6,100 CM
Surface Area	2,250 SM
Stage Area	130 SM (Max.)
Finish Materials	
Ceiling	Gypsum board 12mm x 4
Wall	Gypsum board 12mm x 2, wood veneered
Floor	Hinoki 30mm (Stage) Wood flooring on concrete, Carpet
Seat	Stacking chairs

Table 3 Architectural and acoustics data of Theater Studio

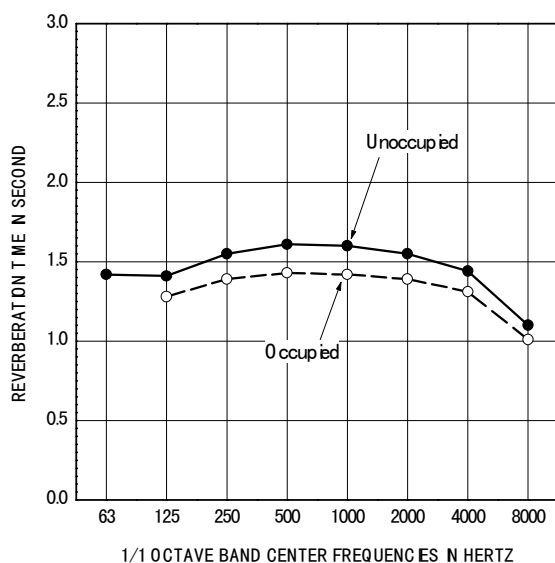


Figure 9 Reverberation time of Theater Studio

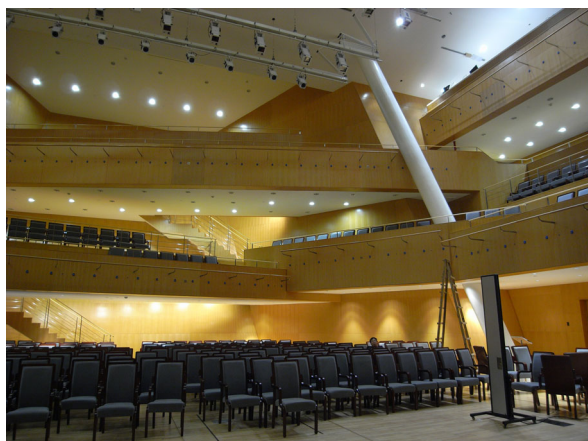


Photo 4 Theater Studio

During the design phase of the project, the planned intention for this space was a recital hall. During the construction phase, the stage mechanisms, stage lighting and a sound system were added and “Theater Studio” became the official name given to the room. Because the basic shape of the room retains its original recital hall dimensions, including a ceiling 14 m. (46 ft) high, the Theater Studio may be used equally successfully for music recitals as for experimental theater performances.

RT60s measured when completed are shown in Figure 9. RT60s at 500 Hz are 1.6 sec (unoccupied) and 1.4 sec (450 occupied).

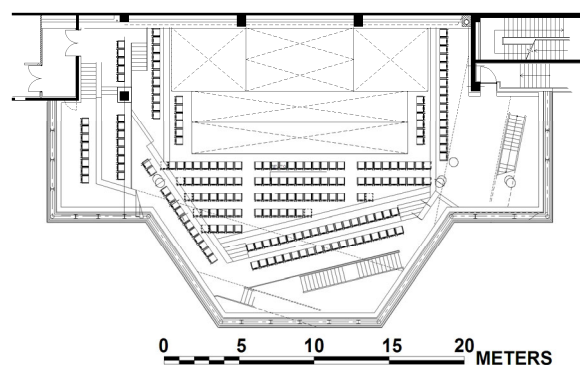


Figure 7 Theater Studio – Plan -

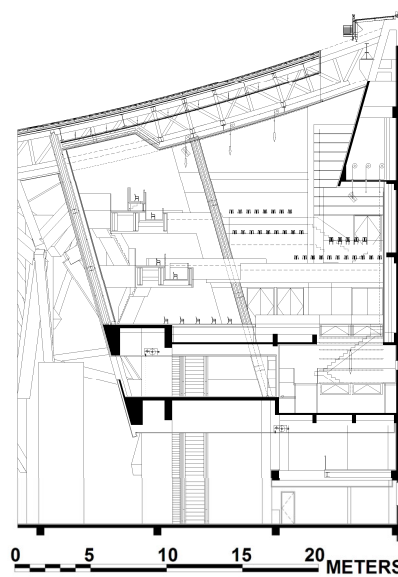
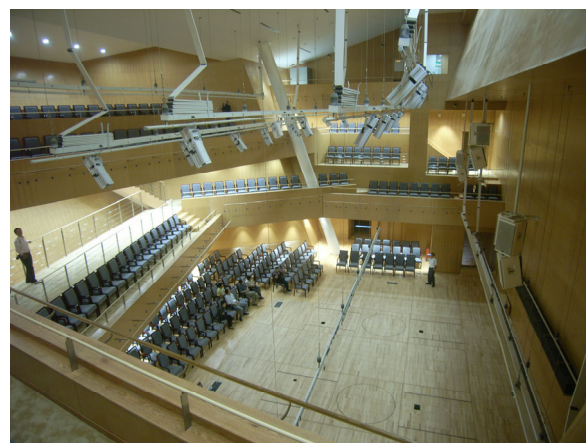


Figure 8 Theater Studio – Section -



3 Opening series at Symphony Hall

On October 12, 2007, the Concert Hall celebrated its opening with Lang Lang performing as concerto soloist at the Symphony Hall. The opening series had taken place during 2007, and concluded with a concert by the Israel Philharmonic Orchestra led by Maestro Zubin Mehta on December 26. During the rehearsals of these concerts, there were the opportunities to listen the acoustics at a number of different seats. Through these rehearsals and the concerts, it was confirmed that the hall sounds with appropriate acoustical intimacy and comfortable loudness, and the acoustical clarity and richness are well balanced. Regarding the acoustics on stage, Lang Lang reported that the hall makes him feel as if he is dancing in mid-air and that it reminds him of the Berlin Philharmonic Hall. And Maestro Zubin Mehta commented “The hall is sounding with warmth. The tone of the violin is beautiful”.

References

- [1] Y. Toyota, K. Oguchi & M. Nagata, “A study on the characteristics of early reflections in concert halls,” Proc. ASA & ASJ 2nd Joint Meeting 1988
- [2] “Akiyoshidai International Art Village Concert Hall”, Halls for Music Performance: Another Two Decades of Experience, 1982-2002, Acoust Soc Am