THE WOODEN CONCERT HALL FOR THE MUSIC FESTIVAL OF EVIAN, 'LA GRANGE AU LAC'

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1. INTRODUCTION

The wooden concert hall, 'La Grange Au Lac', is used annually in May for the International Music Festival of Evian. The site is located inside the private land of Royal Hotel and Evian Mineral Water Co. where one can get a bird's-eye view of the Léman Lake and Geneva. The 15 years old Festival is conducted by Mstislav Rostropovitch and Marta Casals Istomin, the musical programs are mainly made for the classic repertoire, but the pure american Jazz had been invited recently.

The "seasonal" usage and the limited budget(13M FF) guide the architect(Bouchain) and us to image a light-weight, temporary building constructed by wood in Russian style(for Rostro) or a big PVC tent similar to the Alpengala Festivalzelt in Swiss. When the idea of "wooden grain depot" was proposed, people react immediatly, with enthusiasm, that the wooden hall will be automatically good for acoustics, like the musical instruments. Several musicians also had told us about the Music Auditorium totally build by wood in Marlboro College(US). However, from the scientific point of view, a hall in 100% of wood will have both the positive and negative aspects for the acoustic quality of musical performance.

2. WOODEN CONCERT HALL AND VIOLIN'S BODY IN WOOD

It is interesting to analyse the behavior of a wooden envelope for a concert hall. Generally, the wood has a density of 400~800kg/m3; its Young's modulus is 8~13(10^9 N/m²) which higher than those of concret or glass; its internal damping factor(η) for bending(1000Hz) is 0,01~0,04 which higher than the η of concret, brick and glass. From the point of view of external noise insulation, the wood has a small mass per unit area and a higher elasticity, thus a simple wooden envelope is not sound-proofing.

Another important nature for wood is the acoustical-mechanical conversion efficiency(η_{am} =Wrad/Win, where Wrad is the radiated sound power, Win is the mechanical power input). The η_{am} value of wood is 0,024 and higher than those of steel(0,0023) or lead(0,0004)(1). That is one of the reasons why the body of violin is made by wood;it radiates the wondeful sound loudly. However,one question is : Should the concert hall(side walls, floor and ceiling) be built in wood and re-radiate the music sound like a violin's body ? The common experience shows that unless a mechanical contact between the instruments(cello,contrabass,etc) and the wooden floor,only the air-borne music sound energy is not powerful enough to excite the wooden walls strongly. The sound energy retained within the hall is mainly the reflected energy after a frequency "filtering process" effected by the sound transmision and the sound absorption.

Because the light weight of wood and its internal damping,the low frequency absorption is quite important for wood with normal thickness. When the designer(Evian's hall) chooses a a rough,un-polished finishing for wood,then more absorption in higher frequency range will be also inevitable.

Does it exists a magic wood for violin makers and can we imitate it for the concert hall? According many Stradivarious violin investigators,especially the opinion(2) of the Hill's family,published in 1902,the Stradivari's wood materials(e.g., maple,pine produced in Italy) were not magical,even they have the unvivalled tone. During certain years,the remuneration of Stradivari was reltively small,the handsome foreign maple fairly expensive,he had have to use many local woods. A high quality violin is normally made with three important factors : right dimensions and construction; good material(wood); good varnish of the violin. Astonishingly,the experts(Hills,etc) classify the relative importance of these factors as : "1st, Vanish; 2nd,construction and dimensions; 3rd,material(wood)".

The top secret of the vanish kept by the Stradivari's family was highly protected in the history,however,we don't need this vanish for a concert hall. The similarity between a violin and a concert hall in wood is not very impressive.

3.VOLUME,GEOMETRY AND SOUND DIFFUSION

Going back to the Evian's design,the fondamental conceptions were definded as the following :

3.1.Larger volume of the hall
This middle size concert hall has 1156 seats which is adapted for the needs of festival. In order to compensate the inevitable absorption of wooden envelope and to achieve a reverberation time of 1,7 second at middle frequencies,the volume of the hall is controled at 11070m3 or 9,6m3 per seat. This volume is similar to those of Stadt Casino(Basel),Grosser Tonhallesaal(Zurich) or Konserthus(Gothenburg),but with a smaller seating capacity.

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3.2.Geometry of the hall

Since the ground of site is inclined towards the lake,so a ~esonable choice of the geometry of the hall is rectangular. The total length of the inner hall is 41m,the total width of the hall(between two façades) is 21,8m(**Figure 1**).

In order to get efficient early lateral reflections in the stall level,the effective width is reduced to 18,9m by means of two side screens(h=2,0m from the floor) which separate the seating area and the longitudinal circulations. To avoid the flutter echo due to the parallel surfaces,two oblique stage walls of 15° are formed(height is 2,35m). The upper part of the parallel walls in the hall are "diffused" by the side balconies(two rows only) and the large structural reliefs.

The stage has a depth of 11m and a surface of 155m2. If we take a ratio of 1,8m2 per musician,the stage could install 80~90 musicians. The chorus are~ is arranged at higher level (+2,35m) surrounded the orchestra. Its area is 67m2 and it could receive 200 chorists(0,3m2 per person) occasionally.

The acoustic problem is occured on the design of longitudinal section of the hall. Because the preference on architecture and on structure,the roof shape is defined as sawtoothed shape which constitutes the obstacls for the ceiling reflection. To solve this problem,a suspended light-weight ceiling of 420m2 is added under the roof(~900m2). This ceiling is made by the sheets of Alucobond(5,5kg/m2) with low absorption and higher damping factor. In order to avoid the strong specular refle-ction in higher frequencies(harsh sound),this ceiling is designed as a big leaf(**Figure 2**),its reliefs of 10~20cm is formed by the superposition of the sheets(12m2 each).

The height of the "leaf" ceiling is 11m above the stage edge and 9m at the rear part of the stage. This height is not enough for the "spaciousness" of symphony music(we prefered h >15m),but lower ceiling is desirable for the "intimacy" of chamber music or recital. If there was a possibility to equip a mechanical suspending device,the ceiling height can be varied easily.Within the budget of Evian,the height can only be varied by the "alpiniste"(mountaineer) who adjusts the length of metallic cables manually. The compromise was made towards the chamber music hall with the possibility of performing for a large symphony orchestra.

Owning to the consideration of balance between orchestra and chorus(closer to ceiling),many tree trunks of birch are inserted behind the chorus stand for sound absorption.

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Without chorus,these birchs play the rules of sound diffusion and decoration on russian atmosphere. There are six huge Czech chandeliers suspended above the stage,they can more or less diffuse the sound in higher frequencies and provide the luminosity for the musicians.

The side balconies are considered as the large geometrical diffusors.The semi-opened balustrades diffuse and also absorb the high frequency sound. No echo or flutter echo in this hall. **Figure 3** illustrates the impulse responses measured in the finished empty hall,the distribution of the early and late reflections along the time axe corresponding an intimate sound perception.

4.MATERIAL AND ABSORPTION

The large surface of wood panels inside the hall may absorb the low frequency sound excessively. So,the inner panel of the sandwich wooden walls is in smooth particle board of 22mm and 12mm(thickness). The 12mm is decided for the economical reason and for avoid the concentration of resonance(absorption pick). The geometrical irregularity of the stiff frames are required. The absorption coefficients of the ensemble sandwich wall panel is measured in reverberantion chamber(with apparent frame),they are :

Frequency	125Hz	250Hz	500Hz	1000Hz	2000Hz	4000Hz
Alpha	0,14	0,18	0,15	0,17	0,20	0,27

The "leaf" suspended ceiling in Alucobond is also tested in the chamber. The absorption coefficients(in 6 bands) are :

Alpha	0,01	0,02	0,03	0,03	0,04	0,07

The thausand seats are not individual chairs,they are light uphostered benchs,the side and the back of the benchs are in wood. The absorption of the seats is not so high. The values of the reverberation time of the hall are shown as the following :

(second)

Condition	Frequency band(1/1Oct)					
	125Hz	250Hz	500Hz	1000Hz	2000Hz	4000Hz
empty	1,8	1,95	1,9	1,65	1,45	1,25
occupied	1,5	1,55	1,7	1,6	1,4	1,2

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5.SUBJECTIVE ASSESSEMENT

The music sound in this hall is judged by many musicians as "very natural","beautiful and transparent",some musicians fell the sound is quite rich for the Mozartian symphony,but in short of a little bit the liveness for the late romantic symphony.

Regarding the reverberation time of 1,7 seconds,the problem may be occured specially caused by the excessive low frequency sound absorption in this wooden house. The second point of our experience is dealing with the stage height. If we can raise the height more of 2~3m,the richness and the spaciousness of the symphony music might be improved. The third point of our experience is concerning the relation between the hall's volume and the number of the players. For this hall of 11070m3,the sound is very agreeable with 70~80 players. Like one concert where 100 orchestra members plus 200 chorites('La Vie de Tsar' of Glinka),the sound was too loud or "saturated". This phenomenon is occued oftenly in the middle size hall. If the musical program makers can take this physical limitation into account,then some thorny situation could be avoided.

6.NOISE INSULATION

The sound insulation of the wood sandwich(roof and walls) is not perfect,it is about 30dB(A) according to the measuements effected inside and outside the hall by music sound.

Fortunately,the private land around this hall is very quiet. The stable outside Leq is 47dB(A),the nearby passage of the vehicles can be controled during the period of concert or the rhearsal. The only disturbing noise is the song of the birds (50~55dBA) at outside. However,this higher frequency bird's song is easily to isolated by the wooden sandwich panels.

7.REFERENCES

(1)L V ISTVAN,'Interaction of Sound Waves with Solid Structures'/'Noise and Vibration Control Engineering',p277

(2)W H HILL,A F Hill,A E Hill,'ANTONIO STRADIVARI,his life and work(1644~1737),William E Hill & Sons,London,1902

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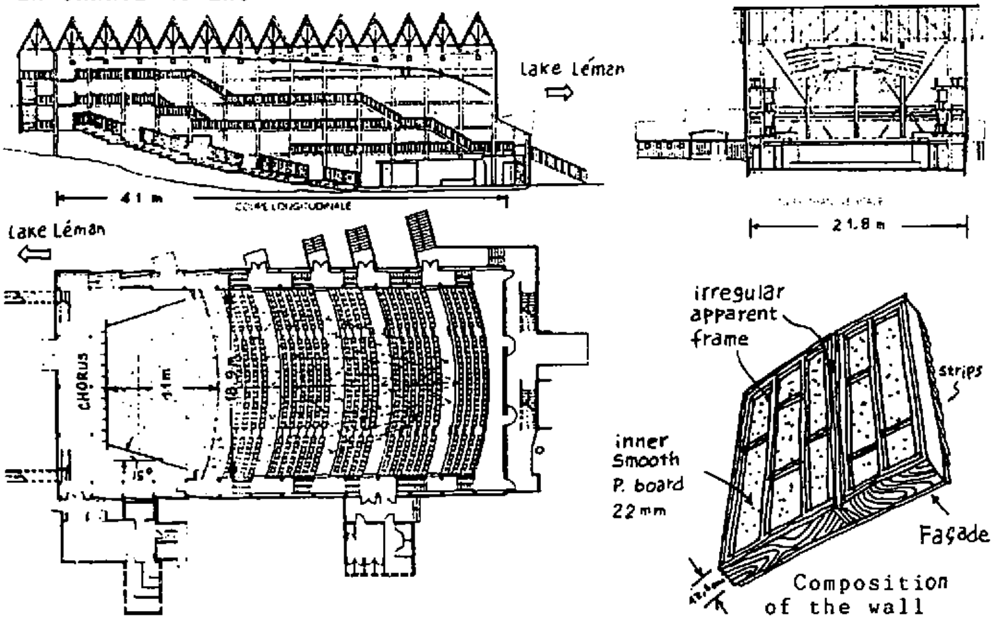

Figure 1. The plan and sections of La Grange au Lac, Evian, France. Volume: 11070m3; capacity: 1156 seats

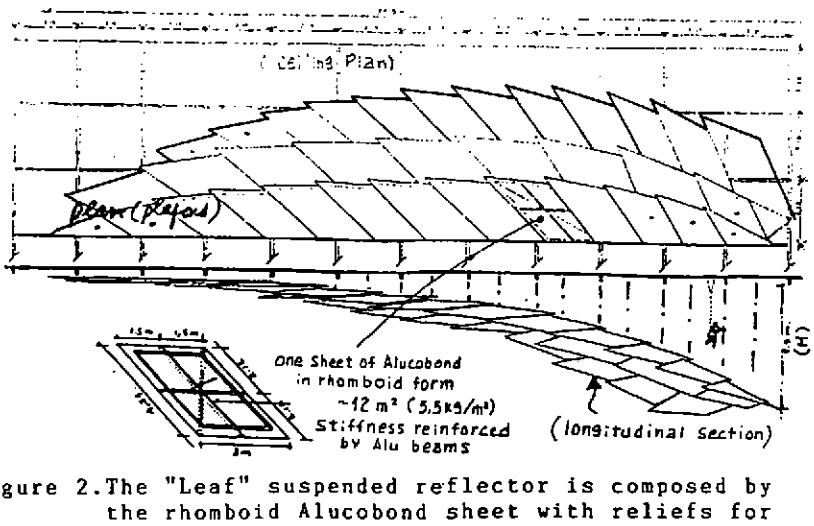

Figure 2. The "Leaf" suspended reflector is composed by the rhomboid Alucobond sheet with reliefs for the sound diffusion (mountaineer adjusts its H)

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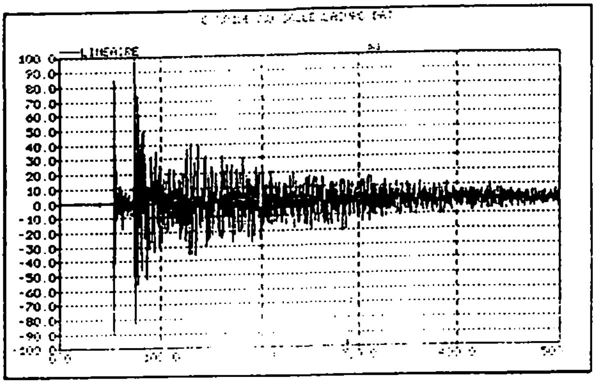
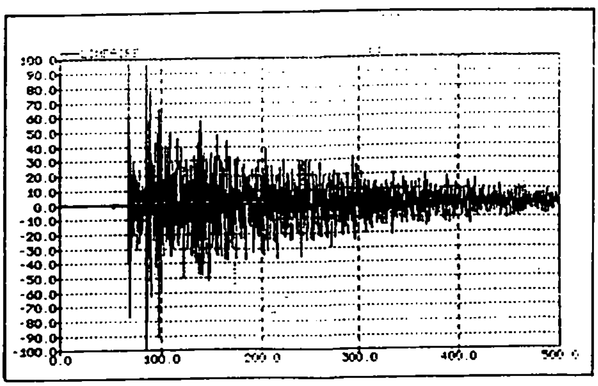
C:\01DB\XU-SALLE\LACVRO.FIL
au centre,rang O,circulation lat.,16,5m du bord
Ordre Séquence = 15 Fréq. d'échantillonnage = 16 kHz
TR auto(*) et EDT sans bruit autres crit. sans bruit
RASTI = ---- STI = ----

Octave Hz	TR60 s	EDT s	C80 dB	D50 %	S/N dB	E1000 dB
125	1.84	1.45	-0.26	38.27	-3.10	-3.8
250	1.91	1.70	-4.64	20.47	-7.17	2.8
500	1.91	1.90	0.50	38.36	-1.71	1.3
1 k	1.83	1.47	1.17	46.98	-0.44	0.0
2 k	1.66	1.43	1.30	48.27	-0.17	2.4
4 k	1.29	1.27	2.33	53.51	1.04	-0.7



(a)Impulse response measured at the center of the hall(empty);Omni-directional source located at the position of conductor/1st Violin



(b)Impulse response measured at the same place as (a),but the source is located at the Oboe position

Figure 3.Impulse response measured at the center