Acoustic and Biomedical Engineering

Acoustics of Concert Hall at Academy of Music in Gdańsk, Project and Realization

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This paper describes acoustical properties of concert hall of Academy of Music in Gdańsk, completed in 2007 year. Acoustical consultation with architect as well as building acoustics and room acoustics project are discussed. Results of acoustical measurements at successive stages of works are presented.

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1. Introduction

The concert hall occupies newly–built building situated in the corner between two parts of the existing building. Apart from the concert hall (volume 3500 m^3, 441 seats), the building accommodates rehearsal hall

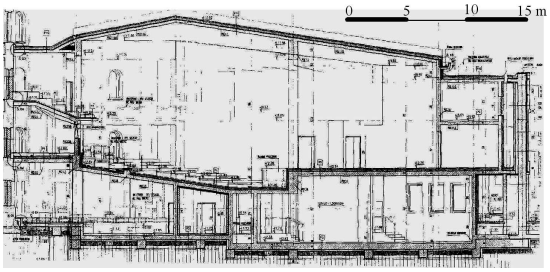

Fig. 1. Vertical section of the building.

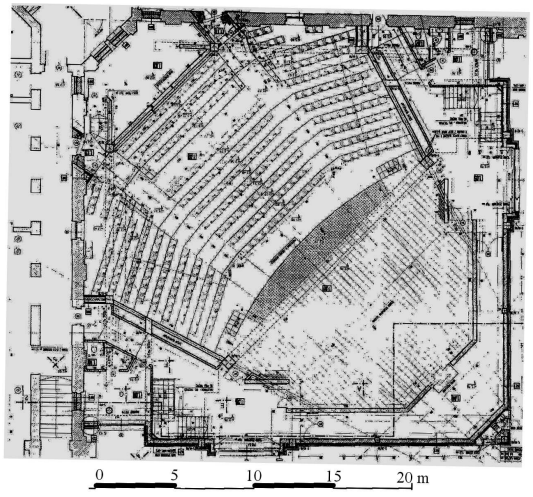

Fig. 2. Horizontal section of the building, concert hall level.

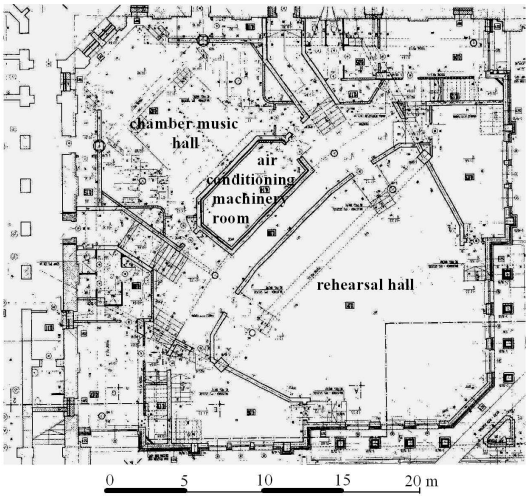

Fig. 3. Horizontal section of the building, rehearsal hall and chamber music hall level.

(800 m^3) and chamber music hall (450 m^3, 71 seats) (Figs. 1–3). Architectural design of the building has been elaborated by Pracownia Projektowa "Sienkiewicz & Filar" from Gdynia, acoustical consultation Andrzej Kulowski and Adam Witkowski.

2. Description of the hall

Numerical data of the hall:

— length incl. stage and balcony:	29 m,
— audience area, stall:	270.6 m^2,
— stage area:	170.4 m^2,
— audience capacity:	441,
— mean width:	21 m,
— audience area, balcony	98.2 m^2,
— volume:	3500 m^3.

Comments to the selected elements of construction and architecture of the building:

(i) Building accommodating the hall is a shell added to an existing building which façade constitutes a back wall of the hall. This is considered a hall's architectural

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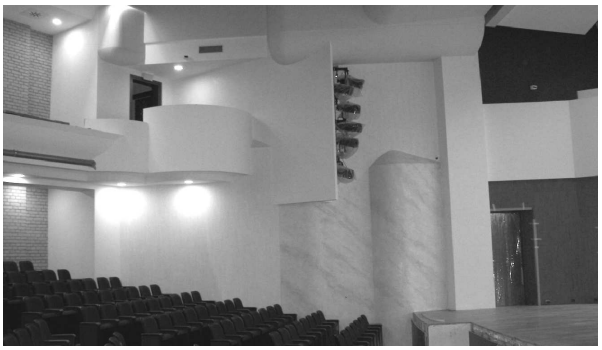

Fig. 4. Sound diffusing elements on side wall and on balustrade of balcony.

Fig. 5. The stage with large group of performers (ca. 160 people).

value, but requires to revise traditional recommendations regarding room acoustics. Due to them, back wall should have geometrically scattered form or should be covered with sound absorbing material. In the case discussed, back wall is a flat, sound reflecting surface. Fortunately, the wall shape prevents creating audible echo. To compensate a lack of sound diffusion from back wall, sound diffusing elements have been situated on side walls and on balcony balustrade (Fig. 4).

(ii) Teaching program of the Academy of Music provides performances of large musical forms (symphonic music, oratorios), staging operatic pieces in reduced set

Fig. 6. Sound diffusing elements on back wall of the stage.

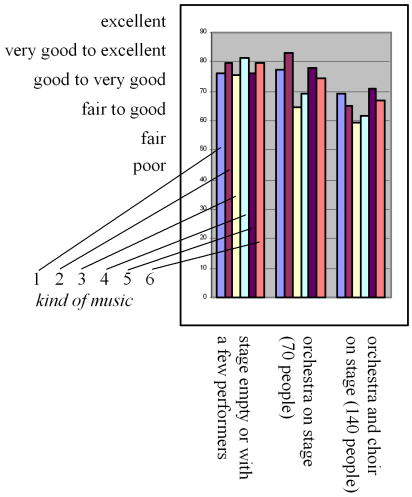

Fig. 7. Acoustical quality of concert hall at Academy of Music in Gdańsk acc. to Beranek method. Kind of music: 1: baroque, 2: classical, 3: romantic, 4: typical orchestra, 5: Wagner opera, 6: Italian opera.

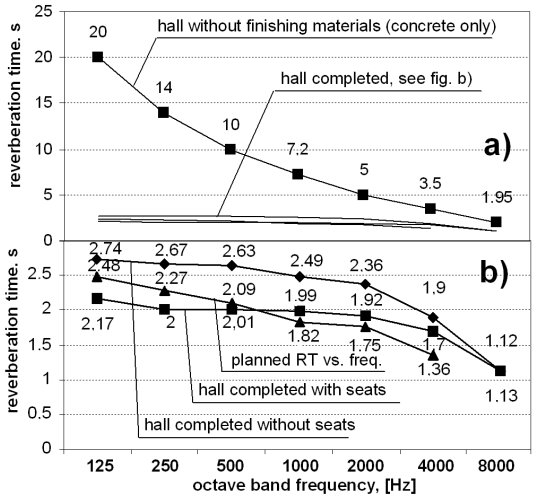

Fig. 8. Reverberation time at successive stages of finishing work (a) influence of finishing materials, (b) influence of seats.

scene and sound recordings of large groups of performers (orchestra + choir). For that reason the hall has very large stage (170.4 m^2, Fig. 5). Its size is comparable to stages of concert halls with audiences 2–3 times larger (e.g. Boston, Symphony Hall: 172 m^2, 1057 seats; London, Barbican Concert Hall: 160 m^2, 1123 seats; Leipzig, Gewandhaus: 181 m^2, 1036 seats) [1].

Special attention has been paid to assuring proper listening conditions on stage. This problem has been considered during suspended ceiling formation above stage. Also, after having performed aural tests with participation of musicians of orchestra of Academy of Music, primary arrangement of stage walls was corrected to improve listening conditions between performers (Fig. 6).

In the hall, stage area amounts *ca.* 50% of audience area (in the large halls mentioned above: ca. 14–18%). Apart from listening condition on stage, such a large number of performers may influence on hall acoustics. Number of performers may change from single persons to ca. 150–170 people, i.e. to a number that amounts a half of audience capacity. Obtained high degree of sound diffusion allows to reduce an influence of performers number on hall acoustics.

Analogous proportions of stage area to audience area can be found in other halls of related size and similar program of use (Table I).

(iii) Because of heritage conservator restrictions referring to Academy of Music building and due to arrangement of rooms in the new building, air conditioning machinery room is situated below the concert hall, between rehearsal hall and chamber music hall (Fig. 3). To separate machinery room from acoustically protected spaces, its construction is thought as "box in the box". Acoustical insulation of walls amounts ca. $R_{A1} \approx 65$–67 dB (concrete 25 cm + mineral wool 5 cm + brick 12 cm).

3. Acoustical measurements

Reverberation time measurements performed at successive stages of finishing works enabled revision of some elements of primary project of hall interior. This gave good compliance of final frequency characteristics of reverberation time with the planned one as well as satisfying acoustical quality of hall (Figs. 7, 8). Impulse parameters (C_{50}, C_{80}) and speech intelligibility parameters of the completed hall (STI, RASTI) are shown in Table II.

TABLE I

Proportions between stage area and audience area in exemplary halls with audience capacity ca. 400–500 seats.

Hall	Year of realization or project	No. of seats	Stage area [m^2]	Audience area [m^2]	Stage area/ audience area
Gdańsk, Akademia Muzyczna	completed in 2007	441	170	369	0.46
Sosnowiec, Zespół Szkół Muzycznych	project, 2008	439	195	371	0.52
Wejherowo, Filharmonia Kaszubska	conception, 2006	360	186	256	0.73
Poznań, Wyższa Szkoła Nauk Human. i Dziennikarstwa	project, 2008	467	250	227	1.10

TABLE II

Acoustical parameters of concert hall at Academy of Music in Gdańsk.

Octave band, [Hz]	C80, [dB]	C50, [dB]	STI/RASTI
500	−1.22	−3.50	0.44/0.43
1000	−0.24	−3.09	("satisfactory"
2000	−0.48	−3.23	speech
4000	–	−3.68	intelligibility,
mean	−0.63	−3.36	[2])
recommendations	symphonic music: 0 [3], $-2 \div +2$ [4], $-3 \div +3$ [5]	speech generally: $-6.4 \div +1$ [6] speech intelligibility grade: $-2 \div +2$: acceptable, $-7 \div -2$: middle [5]	–

4. Concluding remarks

The hall shows good acoustical properties and proper adaptation to scheduled form of use. Due to a teaching program of Academy of Music, specific element of hall's architecture is a stage size. Its area amounts a half of audience area. This might be a reason of listening condition deterioration on stage and influence of performers number on the hall acoustics. Effective way of acoustical conditions improvement both on stage and on audience is increase of sound diffusion.

Halls of similar program of use and similar proportions of stage area to audience area are often commissioned by investors. To avoid deficiencies mentioned above, geometry and finishing materials on ceiling and back wall of stage as well as on side walls of the hall should be thoroughly examined. Proper instrument of compensating acoustical influence of unfavourable proportion between stage area and audience area is sound diffusion.

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