THE ACOUSTIC SCIENCE OF

BOSTON'S SYMPHONY HALLS

Science reveals how Boston got it right (which as it turns out is not about the reverberation time.)

by Nicholas Edwards

RICH MOFFITT

Boston Symphony Hall is universally loved by audiences and musicians. Ever wonder about the history and science behind it?

Charles Follen McKim, the foremost American architect of his time, proposed a concert hall modelled on a Greek theatre for Boston whose model was exhibited in 1894.

The acoustician Wallace Clement Sabine described this form as the "ideal modern auditorium" for music[1]. So confident was McKim in his ideas that a large plaster model was built and exhibited to the public. A commentator noted that "the substitution of an amphitheater for the usual galleries appeared to take everybody by storm." [2]

1 Collected Papers, WC Sabine, Reverberation, Introduction, p4-5.
2 The Life and Times of Charles Follen McKim, Charles Moore, P102 "Naturally he was elated over the opportunity to build a permanent home for one of the world's great orchestras; and he set his heart on designing a concert room after the fashion of a Greek theater. So he made a full set of plans and a model of the interior, which was exhibited in the Public Library in January, 1894.

The First Hall - Boston Music Hall

McKim's Greek Theatre was his proposal for a new concert hall to replace Boston Music Hall.

Boston Music Hall was commissioned in 1852 by the Harvard Musical Association. It followed the European tradition of a flat-floored galleried shoebox concert hall and had well-respected acoustics. It was in this hall that Henry Lee Higginson founded Boston Symphony Orchestra in 1881 and he sustained the orchestra here for nearly twenty years until the new Symphony Hall opened.

Henry Lee Higginson (November 18, 1834 - November 14, 1919) was the founder of the Boston Symphony Orchestra. Portrait by John Singer Sargent, 1903

Despite its undoubted acoustical qualities, Boston Music Hall was "Badly situated, very difficult to access, had dangerous egress, was ill-ventilated, and a fire-trap" [3]. Henry Lee Higginson was aware that his symphony orchestra could not be sustained long-term in Boston Music Hall.

Henry Lee Higginson was a philanthropist banker

3 THE MAKING OF SYMPHONY HALL, Stebbins, p14

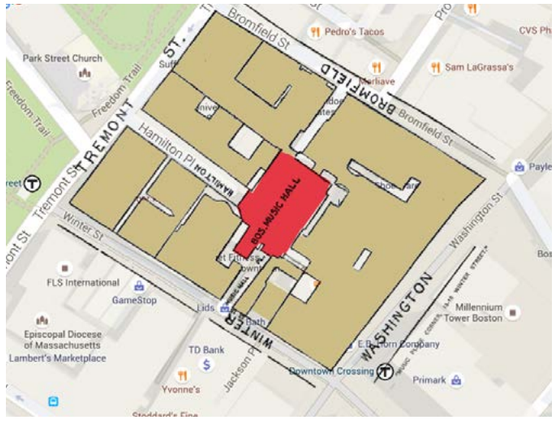
by profession. To secure a performance space for the orchestra, he bought a controlling interest in Boston Music Hall and the first seasons of Boston Symphony Orchestra concerts had taken place in front of the large pipe organ. After the orchestra's third season the organ was removed and this would have greatly changed the acoustics of the hall, increasing the loudness and reverberance. One writer noted "Now an orchestra in the Music Hall really sounds like an orchestra, and not like a weak apology for one.[4]"

This acoustical change while welcomed by the audience would have been challenging for the musicians, reducing their ability to hear one another. A sounding board, derided as "Mr Higginson's Woodshed roof[5] " was installed over the concert platform to improve the acoustics. Although undoubtedly an ugly addition to the hall, the acoustical reflector would have significantly improved the balance of the orchestra, strengthening the sound of the strings much more than it affected the loudness of the brass instruments (as these are more directional). This successful intervention may rightly have given Mr Higginson some confidence in his acoustical judgement.

The Early Plans for Boston Symphony Hall

Higginson had bought land for the new concert hall in 1887 but his plans were delayed by a downturn in

4 Boston Symphony Orchestra AN HISTORICAL SKETCH, M. A. DeWOLFE HOWE P117
5 THE MAKING OF SYMPHONY HALL, Stebbins, p14



Site plan for Boston Symphony Hall.

the economy. However when the City unexpectedly planned a new rapid transit route[6] right through the centre of Boston Music Hall it galvanized Higginson to progress the project some ten years after the land purchase.

Higginson's style was to listen to counsel from informed sources and then take a decision. He would have taken seriously the great conductor Richter's comment that "my first violin tells me we always get the best results in a rectangular hall"[7] .

On restarting the project he instructed his architect that "The Directors feel afraid to try any experiments. While we hanker for the Greek theatre plan we think the risk too great as regards results so we have definitely abandoned the idea. We shall therefore turn to the general plan of our old Music Hall and of the halls in Vienna and Leipzig" [8]. He gave specific instructions to his designers: "Our chief object is a music hall that will hold 2400 or 2500 people. We think our present [Boston] music hall too wide and too short..."[9]

Through these clear directives, Henry Lee Higginson determined the acoustical outcome for Boston Symphony Hall.

6 An Act to provide for rapid transit in Boston and Vicinity 1893.
7 THE LIFE AND TIMES OF CHARLES FOLLEN McKIM, CHARLES MOORE p103
8 THE MAKING OF SYMPHONY HALL, Stebbins, p44
9 THE MAKING OF SYMPHONY HALL, Stebbins, p133

Wallace Clement Sabine (June 13, 1868 – January 10, 1919) was an American physicist who founded the field of architectural acoustics.

Reverberation Time: Is it the Correct Factor?

Higginson brought Wallace Clement Sabine to the project to provide scientific advice on concert hall acoustics. At that time, Sabine was the only person in the world with such scientific knowledge, but his science was limited to that of calculating Reverberation Time. His formula for reverberation time is T=0.16 x "volume divided by area" and that can be rewritten more simply as T=0.16 x "height".

Thus for an RT of 1.8s in a shoebox concert hall, we should expect 11.2m height clear above the audience levels [10] —which is about what we find. The science of Reverberation Time, however, tells us nothing about room shape, length, width or balcony heights—all of which have greater influence on the acoustic experience than the reverberation time.

Boston Symphony Hall audience animation

Acoustician Leo Beranek claims Sabine prevented an "acoustical disaster" [11] from arising in Boston when the building committee instructed the designers to simply enlarge the Leipzig concert hall to increase the seat count from 1560 in Leipzig to 2600 in Boston.

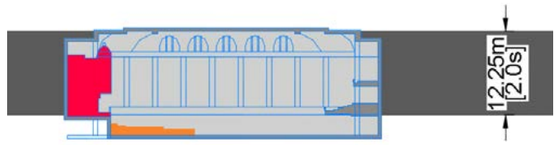
10 The animation explains how, with perfectly-absorbing audience areas folded down on the side walls the upper height of the room with zero absorption provides the reverberant volume.
11 Beranek in THE MAKING OF SYMPHONY HALL, Stebbins, p202

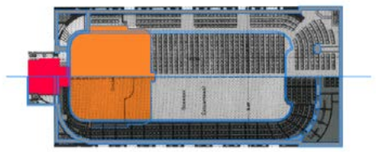
Acoustic computer modeling of Boston Symphony Hall shows that the reason the hall is so treasured has to do with how the early lateral sound is received through our binaural hearing.

Modelling the acoustics of Boston Symphony Hall, looking at sound arriving from both sides of the listener, we see that the width, the height of the side balconies and the rectangular shape ensures it achieves a high level of binaural early lateral sound—in agreement with subjective assessment of this hall's good acoustics.

idibri.com | idibri.uk

Sabine thought this meant that the room height would be increased in proportion. However, this was probably a physicist's misunderstanding of an architecture directive: an architect would increase the plan dimensions but leave the sectional heights unchanged. Higginson certainly did not intend his new hall to be taller than the existing: He wrote to McKim that "I've always thought our hall too high —just so much space to be filled to no purpose"[12] .



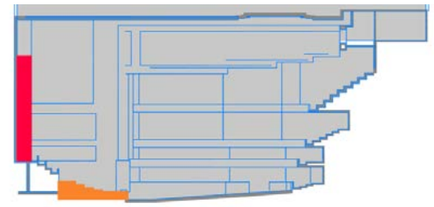


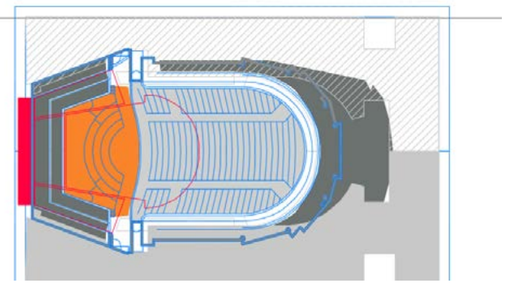
Gewandhaus Concert Hall, Leipzig, Germany

If the room height in the expanded version of Leipzig was to be unchanged, the reverberation time would also be unchanged, and there was no acoustical disaster for Sabine to avert.

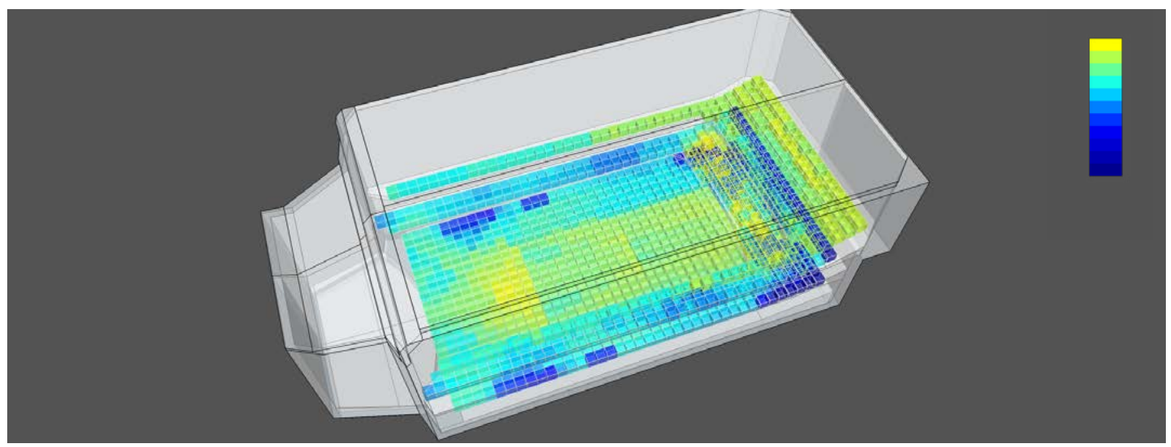
12 THE MAKING OF SYMPHONY HALL, Stebbins, p116

In modern concert hall design, Reverberation Time is far less important than other objective measures such as the strength of the early lateral sound. If a room is designed for strong early lateral sound, the length of the reverberation time is much less critical. We see concert halls, such as the Meyerson Symphony Centre, Dallas where the strong early lateral sound allows a long reverberation time.





The cubic volume of Dallas is more than double the volume of Boston Symphony Hall, while its capacity is about 500 seats fewer. This would have astonished Sabine.



Computer modeling of the acoustic reflections at Boston Symphony Hall

Dynamic experiences. Idibri design.

So if the acoustics of the existing hall are shown objectively to be of high quality, what do we see in McKim and Sabine's favored "Greek Theatre" design? Does it bear out Sabine's description as "a most attractive auditorium"?

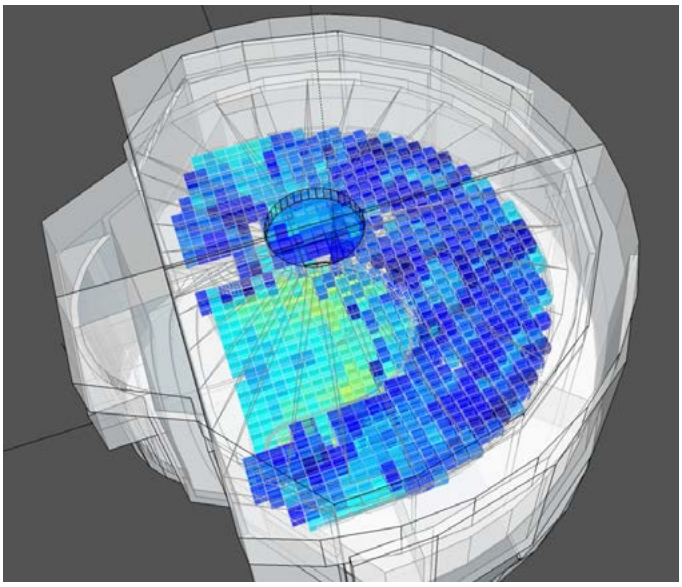
Unfortunately, our modelling shows that this is far from the case.

We see that Boston Symphony Hall was indeed saved from acoustical disaster -- but not by the acoustician. If McKim and Sabine had built their favored Greek theatre form of concert hall with the "correct" reverberation time the hall would not have been acoustically successful and acousticians would have had to look further to find the true secrets of concert hall acoustics.

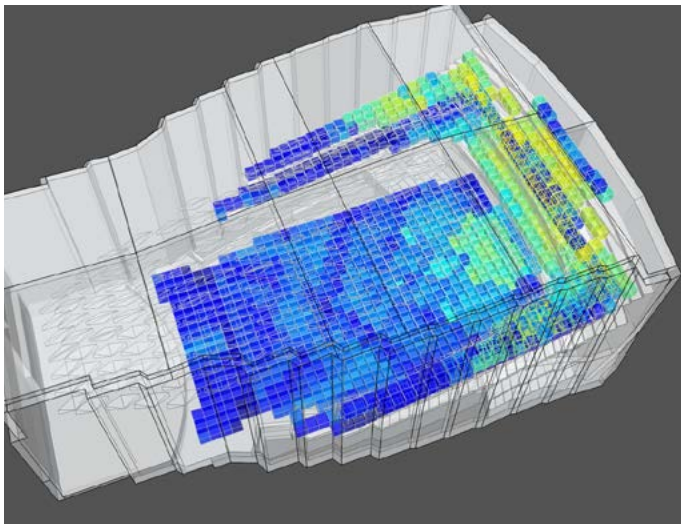
The success of Boston Symphony Hall gave the science of Reverberation Time undue prominence in concert hall design and laid the groundwork for the failure of New York's Philharmonic Hall in 1962. As that hall's acoustician said "..we, Beranek and Johnson, invited Max Abramovitz [the architect] to attend a concert at Boston Symphony Hall at which I emphasized that this was the sound they should expect in New York if the hall was built according to the specifications.[1]"

The popular myth is that Symphony Hall is a triumph of scientific design, but in reality its success comes from its shape and size, not from its reverberation characteristics.

The person we should celebrate as the acoustical hero of Boston Symphony Hall is one Henry Lee Higginson, the philanthropic banker who set the room shaping directives that created the acoustic character of the hall.



Computer modeling of McKim's Greek Theatre concept shows that the acoustic experience in the hall would have been poor because there are not enough early reflections to provide a full binaural experience of the music.



New York Philharmonic Hall had inclined side balconies that placed the side walls in a deep acoustical shadow leading to very low levels of binaural early lateral sound in the main floor seats. It had the same Reverberation Time, but it could never sound like Boston Symphony Hall.

1 ORAL HISTORY INTERVIEW WITH DR. LEO L. BERANEK, Oral History Project; Lincoln Center for the Performing Arts, Inc. INTERVIEWER: SHARON ZANE; LOCATION: CAMBRIDGE, MASSACHUSETTS DATE: 4 OCTOBER 2001, pg 45. Then we, Beranek and Johnson, invited Max Abramovitz and Reginald Allen to attend a concert at Boston Symphony Hall, ... at which I emphasized that this was the sound they should expect in New York if the hall was built according to the specifications I just read.