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To cite this version:

Dawn Schuette. Recent acoustic upgrades in Verizon Hall at the Kimmel Performing Arts Center. Acoustics 2012, Apr 2012, Nantes, France. hal-00811088

HAL Id: hal-00811088

https://hal.science/hal-00811088v1

Submitted on 23 Apr 2012

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Recent acoustic upgrades in Verizon Hall at the Kimmel Performing Arts Center

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The Kimmel Performing arts Center in Philadelphia, Pennsylvania, USA opened in late 2001. In 2011, the year of its tenth anniversary, recent acoustic upgrades within Verizon Hall, the 2547-seat concert hall at the heart of the Kimmel Center, were observed to have resulted in positive changes in the room's sound. These changes were particularly observed with regard to: increased projection and presence for the Fred J. Cooper Memorial Organ; enhanced on-stage ensemble hearing conditions; increased full-frequency response for the organ, orchestra, chorus and sound-reinforcement system; and notable improvement in sound level and presence from the stage. The cumulative result is a perception of enhanced reverberation and presence for non-amplified events, and a better sense of balance and clarity for amplified presentations. Final analysis of test data will indicate whether the changes have resulted in an increase in reverberation level or longer reverberation time. This paper presents an overview of the architectural modifications and the resulting acoustic changes.

1 Introduction

Verizon Hall is the largest of the performance spaces at the Kimmel Performing Arts Center. Designed by architect Rafael Viñoly and acousticians from Artec Consultants, the building opened in December 2001. The design of Verizon Hall allows for great acoustic flexibility utilizing reverberation chambers along both sides of the Concert Hall, areas of acoustic drapes and banners within the room and reverberation chambers, and a three-ring adjustable canopy over the stage and front of the audience seating area.

Programming in Verizon Hall varies greatly, and the room must work well for non-amplified events ranging from full symphony orchestra and chorus to individual recitals as well as a full host of amplified presentations.

In early 2009, Threshold Acoustics LLC was engaged by Kimmel Center leadership to embark upon an assessment of the acoustics of Verizon Hall with the goal of identifying any adjustments that might be made to refine the sound in the room.

2 Acoustic Modifications

The assessment process involved detailed acoustic testing within Verizon Hall, listening during a wide range of rehearsals and concerts, including primarily non-amplified symphonic work but also a number of recitals and amplified presentations. Musicians of the Philadelphia Orchestra, members of the Philadelphia Orchestra administration, and members of the Kimmel Center staff were enlisted during this listening period to evaluate various acoustic conditions in the Hall, which provided valuable information to the acoustic evaluations.

During the assessment, various temporary modifications were evaluated to determine the efficacy of their impact to the sound on stage and in the Hall. After subjective and objective evaluations of these changes, final recommendations for modifications were made.

The permanent installation of the following elements was completed during the summers of 2010 and 2011, with the major work occurring the second latter year.

2.1 Stage Visual Screen Fabric

During the course of the acoustic assessment, a detailed review was performed of the fabric that provided a visual screen around the stage platform, behind which, solid concrete walls were installed in a configuration that did not follow the curved wood and fabric screen wall.

The fabric was found to have an open weave but with a thickness to the individual fibers that was of acoustic concern. Insertion loss testing on the original fabric as well as a number of alternates led to the selection of a new fabric for use around the stage area that minimized the high frequency roll off provided by the original material.

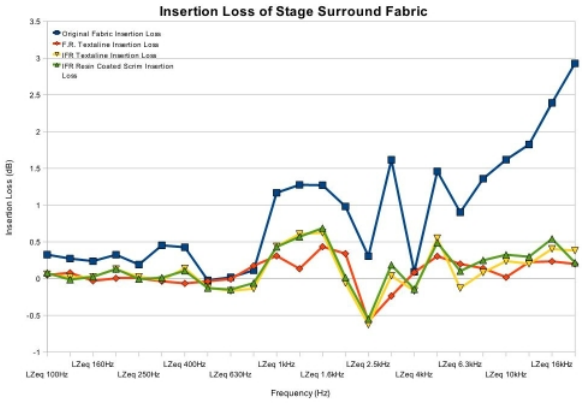

Figure 1: Insertion loss test data

Similar fabric was also replaced below the organ façade as noted in the following section 2.3.

2.2 Organ Chamber

The Fred J. Cooper Memorial Organ was installed in phases after Verizon Hall's completion, with its dedication in May 2006. The instrument is at this time the largest mechanical action concert hall organ in the United States. The organ features 111 stops, including 32 foot (9.75m) wood and metal pipes in its pedal stops to provide great power to the instrument in this large Hall.

During the acoustic assessment of the Hall, it was determined that the top of the organ chamber required improvement to sufficiently resist vibration imposed by the organ but also to limit its movement from the sound of instruments and singers on the stage and choral balcony below. The area of this surface at 75 square meters was sufficient to have a notable acoustic impact.

In the summer of 2010, working above the instrument and the original organ chamber ceiling surface, new steel was installed to support the original ceiling and provide a stiff framework for a new system of honeycomb panels and plywood. These materials were effectively sandwiched on top of the original surface as well as to the new steel framework.

2.3 Stage and Choral Balcony

During the initial acoustic assessment, a system of plywood panels was installed around the stage behind the visual screen wall to determine how modifications to the wall angles would impact sound on the Stage and in the

Hall. The mock-up of these surfaces allowed evaluation by a variety of performance groups and performance conditions (amplified and non-amplified presentations) before final wall surfaces were designed.

In addition to changes in wall geometry behind the stage screen walls, it was determined that a new surface at the sides of the stage would improve on-stage hearing conditions as well as projection of sound into the Hall. New surfaces in these areas of the room were also evaluated during the initial assessment.

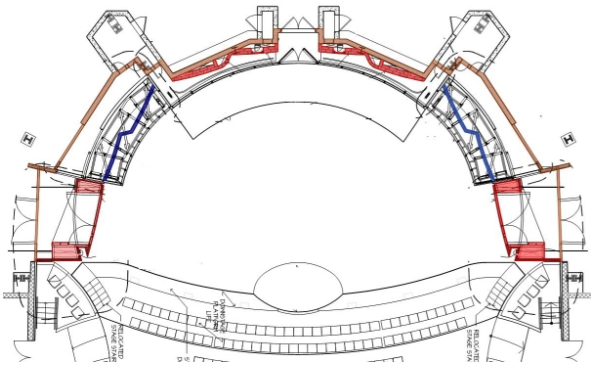

Figure 2: Stage wall diagram – original wall construction is shown in brown and new wall and tower construction in red and blue.

New masonry walls were installed behind the screen in the center upstage area, matching the weight of the original concrete walls in this location for full-frequency support but modifying the geometry slightly. This construction was possible in this area where existing steel framing could carry the weight of the new masonry material.

At the sides of the stage, large moveable seating wagons are in use for almost all performances, and a new system of new walls was installed within these wagons (shown in blue in Figure 2 above) to work in conjunction with the newly shaped upstage wall configuration. As these surfaces had to be installed within moveable wagons, a system of plywood and paper honeycomb was utilized, similar to the new structure above the organ, to provide sufficient stiffness for full-frequency sound reflection but not be so heavy that the mechanism of the wagon movement had to be modified.

Within the front half of the stage, the main stage entry doors were originally located quite far apart, matching the width of the main floor seating area. It was determined that narrowing the room at this location would improve communication on stage but also add presence to sound for the audience, particularly for the strings located within this zone of the stage. The challenge was that this area also had to remain open at times for some of the amplified presentations or other events hosted by the Kimmel Center, so the new construction had to be able to move as well as maintain the clearances required for loading equipment and instruments on and off stage.

New adjustable towers were designed to allow the wall / door area to move inward up to 3.7 meters at each side of the stage, effectively narrowing the stage by 7.2 meters when located in their most on-stage position. The towers carry the weight of the new wood and honeycomb core sandwich panels that provide stiffness for sound reflection in this critical area of the stage but can move on tracks imbedded in the stage floor to maintain the original opening area.

Final work around the stage was performed at the choral balcony to improve hearing conditions for singers located below the organ overhang in the center of the room as well as to improve the organist's ability to hear the instrument from the tracker console at the rear of the choral balcony.

The screen fabric material originally used around the stage was also located at the organ chamber, and this material was replaced at the overhang of the instrument above the choral balcony to match the more open material installed around the stage. New reflective panels within the organ chamber were installed in the overhang to provide reflections across the choral seating area that had previously been lost into the organ chamber.

2.4 Stage Canopy

During the initial acoustic assessment, heights of the stage canopy were evaluated. It was found that the canopy could not be adjusted significantly from its lowest setting without loss of stage communication. However, the low setting preferred by performers created problematic reflection conditions due to a series of vertical sound reflecting panels originally installed at the underside of the three canopy rings. Removal of these vertical panels was evaluated during the initial assessment, and they have not been reinstalled at this time.

Figure 3: Verizon Hall before modifications.

Figure 4: Verizon Hall after modifications.

3 Results of Improvements

The goal of this renovation work was refinement of the acoustic conditions within the room to improve on stage hearing conditions, presence and clarity of sound, and reverberation. Some of these conditions are hard to present in terms of objective measurements. Where data does not clearly illustrate a result, subjective results are noted.

3.1 Presence and Bass Response for Organ

The modification to the top surface of the organ chamber resulted in a marked difference in bass response but also clarity and projection across the entire frequency range of the instrument.

Subjective impressions from the organ builder, those who tune and maintain the instrument, and an organist who knows the instrument well indicated that the organ was able to speak much more clearly into the room after this work was completed. An initial sense of a "muffled" quality was no longer present.

The work on the organ chamber was the only change made in the room in the summer of 2010, and it was fortunate that there was the opportunity to hear the impact of this change alone.

3.2 Presence and Clarity from Stage

Clarity and presence for the audience has been enhanced for all instruments on stage, but most notably for strings, which had not had the same level of support of those instruments located in the upstage areas of the platform. These improvements began as a result of the initial fabric changes on stage but were most pronounced after the new stage wall construction and downstage tower additions in the summer of 2011.

Specific results will be discussed in greater detail during the paper presentation.

3.3 On Stage Hearing Conditions

On stage hearing conditions have been improved with all sections of the orchestra reporting that there is greater transparency and communication among all players.

Impulse responses of sine sweeps measured on stage before and after the architectural modifications show an increase in early reflections within the first 40 to 100 milliseconds, with the greatest improvement occurring in the frequency range of 1000Hz to 8000Hz.

Specific results will be discussed in greater detail during the paper presentation.

3.4 Canopy and Reverberation Chamber Settings

One of the most significant changes associated with the recent modifications has been the ability to adjust the height of the over stage canopy. After the new stage walls were in place, the canopy was raised to allow better access of sound into the reverberation chambers at the sides of the room. The higher canopy has also allowed musicians on stage to better sense reverberation returning to stage without a loss of early communication reflections previously experienced.

With the change in canopy height, adjustments to the reverberation chamber door settings were found to be more effective than originally experienced during the initial acoustic assessment of the Hall, which resulted in the measurement of a slight improvement in reverberation time compared with the previous results.

3.5 Improved Strength and Early Energy

There has been a notable change in the strength of early energy due to the architectural modifications that have been undertaken in Verizon Hall with a resulting subjective improvement in reverberation time in the room.

Initial review of the test data after the modifications show that Early Decay Time (EDT) [1] has improved for most areas of the stage and Hall, with the most notable improvements occurring along the front half of the stage and the main floor seating level. The new walls on stage, most significantly the newly introduced downstage towers, are providing additional early reflections to these areas to achieve this result.

Specific results will be discussed in greater detail during the paper presentation.

4 Conclusion

Subtle architectural adjustments in the construction and orientation of materials within the organ chamber and stage have put polishing touches on the stunningly designed Verizon Hall. The current season is one of evaluation and ongoing listening to determine what, if any, further steps might be required.

Acknowledgments

We would like to acknowledge the help we have received in the course of this work from the Kimmel Center and Philadelphia Orchestra.

References

[1] L. Beranek, *Concert Halls and Opera Houses*, Springer-Verlag, New York (2004)