FROM SPORTS ARENA TO SANCTUARY: TAMING A TEXAS-SIZED REVERBERATION TIME

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Creating a new home for America's largest church required a facility conversion of unprecedented scale. Over a period of 19 months, Houston's Compaq Center—a sports arena that had been home to the Rockets NBA Basketball team, Aeros hockey team and other Houston sports legends—was transformed into Lakewood Church, a new 16,000–seat worship center for its 47,000 weekly congregants.

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Lakewood's weekly television program is seen in more than 20 million households in the United States and is received by more than 200 million households in more than 100 countries. As one might imagine, there were significant hurdles in converting a sports arena into a house of worship with a major in-house broadcast center—acoustics and noise control being some of the most challenging.

A space that is appropriate for hockey and basketball needs to support hubbub and crowd noise while allowing the sound of sports announcers to ride on top. As you watch a sports event, there are score boards, video feeds, and announcements supporting the live action. In this type of space, speech articulation and the loss of consonants are low on the list of critical functions. If you miss a few words or even an announcer's entire sentence, you still can "get" what is going on. It's a noisy space by nature. For this use, the Compaq Center's existing acoustics were up to the task.

At the other end of the performance spectrum are spaces designed for worship. Here, the goal is to project each nuanced word, both spoken and sung, to every seat in the house so that each member of the congregation has an intimate experience with the message. Worship spaces need to be quiet and acoustically appropriate. Delivering a renovated space that would meet these new criteria was one of the primary challenges in repurposing the sports arena.

The conversion required significant changes to the acoustics within the space along with modifications to make it a much quieter venue. To support both natural-sounding speech and Lakewood's wide-ranging program of musical styles, the first acoustical priority was controlling the low frequency energy in the sanctuary.

As a clear span structure that would hold 16 thousand fans, the arena building was originally designed with a curved roof section that tends to focus sound. Prior to the renovation, non-linearities in the low-frequency response, focusing from the roof deck and end walls, and specific surface reflection paths caused the bass frequencies to build up, making the sound dramatically different from seat to seat and virtually unintelligible in places.

The Arena of the Compaq Center, before it became the Sanctuary of the Lakewood Church (Fig.1), was known among touring companies as a troublesome venue with generally uncontrollable low-frequency performance. From 250 Hz down, the average reverberation time, taken from dozens of measurements throughout the space, clocked in at more than 5 seconds and in some areas more than 10 seconds at frequencies below 150 Hz. This was not a happy place for kick drum and bass guitar, with sound from last week's performance seemingly still rolling around the arena.

The new sanctuary also had a variety of noise and vibration issues. Noise that would have been unnoticed during a basketball or hockey game would be intolerable during a worship service. Increased sound isolation was needed from the concourse (Fig. 2), from the new chiller plant, and from traffic on the freeway just outside the building.

After studying a wide variety of options to tame the long, low-frequency reverberation times, a combination of treatments were employed. Low-frequency absorption was added over the arena's former sky boxes. To reduce low-frequency crawl across the dome structure, the area above the main floor was covered with acoustically absorptive lapendary banners. Suspended from the existing structure, these banners are obstructed from view by acoustically transparent architectural elements below that create the visual ceiling. Control of specific reflection paths from the main clusters was addressed through distributed treatments.

A solution to overcome the narrow-band, low-frequency reverberation time issues via under-seat return air openings germinated from a site visit to work on the heating, ventilating and air conditioning (HVAC) modifications necessary to meet code requirements. While sitting in the stands, light from the exit concourse windows overlooking the adjacent freeway could be seen pouring in through the slots under every seat across the empty arena. (see Fig. 3.) A method to use these slots as a tuned Helmholtz absorber was devised. Creating new slots in the concrete risers at every seat would have been cost prohibitive—but they were already included as a part of the original construction. The slots had been venting return air from the air conditioning systems into the common egress space, a technique that no longer met fire code. While this was still the best philosophical solution to meet return air needs, under-riser plenums would need to be added. The new fire separation scheme for the sanctuary required that a barrier be constructed beneath the arena seating. Nursery spaces and children's classrooms for teaching

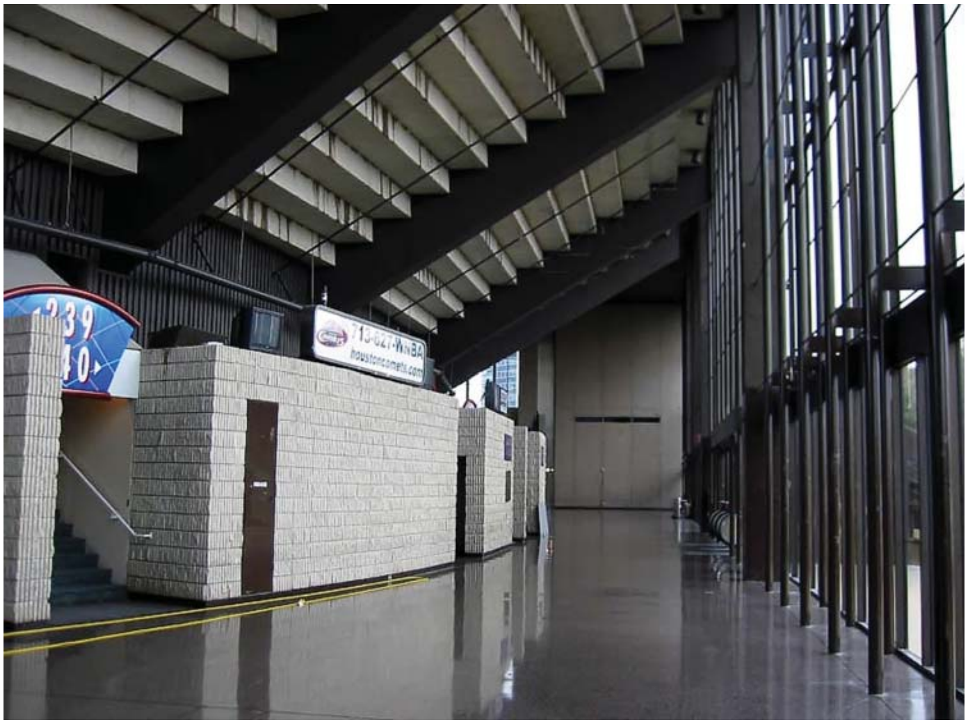

Fig. 2. High background noise levels at the Lobby Level can be traced to the use of hard, reflective surfaces including the terrazzo floor, the glass curtain walls, and the exposed concrete seating structure. Sound isolation was poor at the south side of the Lobby where traffic noise was transmitted through the glass curtain wall. This was the main cause for the high background noise levels.

were being added on the level beneath the bowl, creating a common need for noise control—so the worship service wouldn't disturb them and they wouldn't disturb the worship service. The new barrier was designed to serve triple duty in achieving acoustical separation from the occupied areas below, attenuation of mechanical noise transmitted through the return air path, and (most importantly) low-frequency absorption in the main worship space.

A section typical of the concrete seating risers can be seen in Fig. 4. This shows the location of the slots through the concrete and the relationship to the new plenum feeding the HVAC return air path. Lined with acoustical absorption, the tuning of the slot and plenum combination falls within the range of the problematic low frequency reverberation and provides much needed narrow band absorption. The result can be seen when comparing the average Values After Modifications curve with the Average of Measured Values Before Modification on the graph in Fig. 5. Taken together, the acoustical modifications helped to smooth out the room's response to desirable levels.

Mechanical noise and vibration isolation were other obstacles addressed to insure suitable performance. A new central mechanical plant was designed to serve both the arena and the new five-story structure next door that houses the television production and broadcast center. All the pumps and chillers had to be physically isolated from the building structure using a series of techniques including floating concrete slabs, isolated inertia bases, and vibration isolation mounts on each piece of equipment. The existing air delivery systems were extremely noisy. When this building was used for hockey or basketball, hearing the score through the crowd noise was the only requirement. Now, intelligibility and articulation of speech and music during a worship service are essential. Through geometry, extensions of the existing ductwork, and supplementary attenuation, the background noise levels were reduced to appropriate levels. Overall, the efforts achieved 20 dB of noise reduction in the new sanctuary as part of the renovation.

One of many examples of noise and acoustical issues arising from unique features in the space is the sanctuary's waterfalls. (see Fig. 6.) Lakewood augmented the intimacy of their worship experience with the unprecedented inclusion of waterfalls on either side of the choir area. It's usually not a

Fig. 3. Seating in the Compaq Center consists of upholstered fabric seats and backs that are useful in decreasing midfrequency reverberation times to suitable lengths. Many large ventilation slots are visible in the concrete seating structure and contribute to poor sound isolation between the main bowl and the Lobby Level.

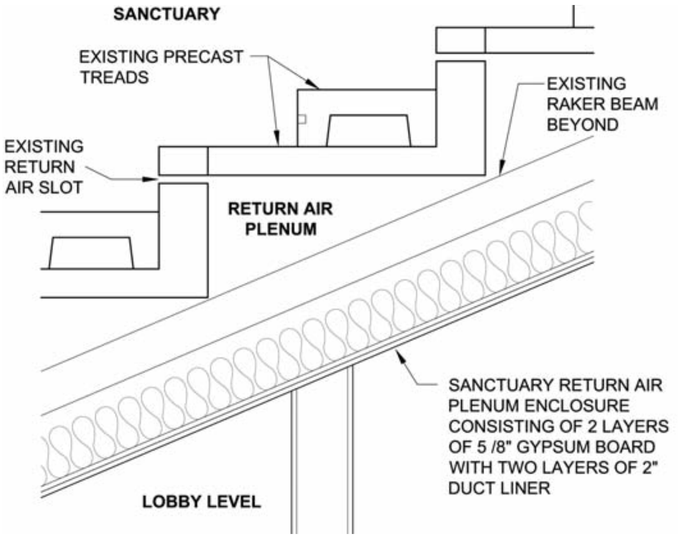

Fig. 4. By using existing return air slots as tuned Helmholtz absorbers, the return air plenum system reduced the low frequency reverberation time of the space. The new plenum also addressed fire separation and sound isolation issues between the sanctuary and occupied lobby levels

good idea to put waterfalls in a building, particularly not right next to a stage. It's not good for the microphones, it affects the sound, its noisy, it introduces moisture and chemicals into the environment, there's a chance that it will leak or that it won't work—but it looks really good.

The waterfalls were one more example of how proper design and coordination can mitigate potentially disruptive issues. The solution was to adjust the water flow rate based on the progression of the service. As people enter the building, the sound of the rushing water is a soothing welcome to the

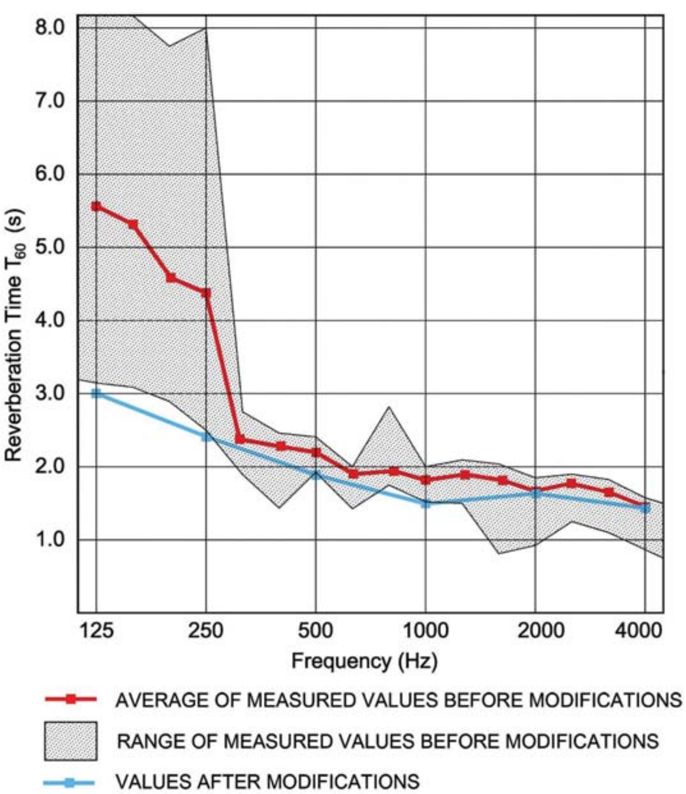

Fig. 5. Reverberation time measurements made in the sanctuary before and after renovations to the space.

congregation, and as the sermon begins, it can be dialed all the way down so that it doesn't interfere with the message.

To make the venue capable of originating the church's television broadcasts, a variety of new control and production spaces were needed. The ministry's media center is located on the fifth floor of a 100,000 sq. ft. addition to the existing complex. The facility includes three audio suites, eight edit suites, a graphic suite, and production control rooms for broadcast video and audio. The audio suites are used during post production and recording of choirs, rhythm tracks, and soloists.

According to Reed Hall, director of audio and technical production and production manager for Joel Osteen Ministries, "The facility now sounds like a well-behaved theater, with live broadcast audio and recording technology that surpasses any major network's late-night TV production. Having produced shows in arenas all across the country, I can say that this is one of the most intimate-sounding there is. The results are stunning, and everyone is very pleased with the room." Hall continues, "Even though this was a 16,000 seat arena, it was our desire for the room to provide an intimate experience for every seat. For the size of the sanctuary I think we have achieved that in part with closeness of the seats to the platform, lighting, and the acoustics, bringing the visual closer with the IMAG (Image Magnification system). Dropping the low frequency reverb times from eleven seconds to three seconds was a big part of that."

The reason that Lakewood Church was successful in making this transition from arena into worship space was their vision in bringing together people who are experts in their individual fields and putting the team into an environment of collaboration. This meant everybody could keep their eye on the end goal and have the time and the back-and-forth necessary to actually develop the solutions required to create an appropriate result. With all of the challenges involved in this project, fundamental teamwork ended up being a necessary ingredient in getting the job done. **AT**

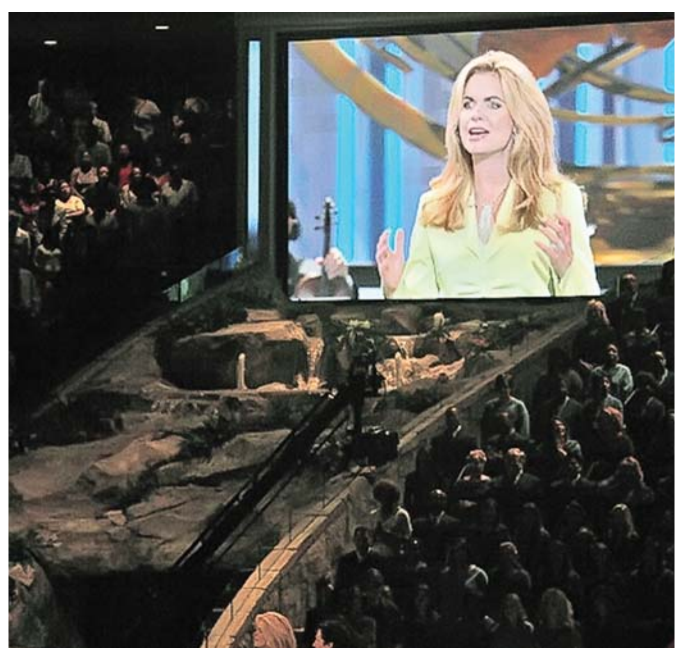

Fig. 6. One of the waterfalls is seen just below the large projection screen. The other waterfall is a mirror image of this one.

Russ Berger is president of Russ Berger Design Group (www.rbdg.com), an acoustical and architectural design firm in Dallas, Texas, that has established itself as one of the industry's premier studio/facility design firms. The recipient of eight TEC awards for acoustics and facility design, Russ has more than 2,500 projects to his credit, including recording, radio and television broadcast studios; facilities for entertainment and media content, audio, film, and post production; technical learning environments for higher education; residential theaters; and corporate production spaces. Projects include NFL Films; National Public Radio, Minnesota Public Radio and more than 70 public radio affiliates; dozens of studio facilities for NBC, ABC and CBS; Sony Music Entertainment; University of Southern California; University of Texas at Dallas ATEC; University of Miami; University of Nevada Las Vegas; Brigham Young University; Lakewood Church; Apple Computer; and the George W. Bush Presidential Library. He has provided studio design for many artists, including Whitney Houston, Michael Bolton, Mariah Carey, Don Henley and Steve Miller, as well as countless recording studios across the United States. His past experience in the studio as musician, engineer and owner gives him unusual insight as a consultant into all aspects and phases of technical facility design.

Russ is a Fellow of the Acoustical Society of America and is past president and chairman of the Long Range Planning Committee of the National Council of Acoustical Consultants. Other memberships include the Audio Engineering Society and the Society of Motion Picture and Television Engineers (SMPTE). Russ is one of the original licensees for performing TEF measurements, and is the 2007 recipient of the prestigious Heyser Award. He has lectured extensively on facilities planning, small room acoustics and studio design, audio electronics and audio monitoring. An advocate for education, Russ has taught graduate-level seminars on studio design and serves on several university advisory boards. He frequently contributes articles to industry journals and trade publications, covering topics on acoustics, architecture, and design.