Preserving the Acoustical Legacy of a Modernized Opera House

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Abstract: Following the 1989 Loma Prieta earthquake, a major historic renovation of the San Francisco War Memorial Opera House was undertaken to upgrade the building seismically, overhaul technical and theatrical systems, and restore the building to its original splendor. A primary goal was to maintain the acoustic integrity of this cultural landmark throughout the process of building modernization.

BACKGROUND

The San Francisco War Memorial Opera House is the culmination of a modern city's cultural vision. Built in 1932 during the height of the Great Depression, this performing arts venue embodied the desire by San Franciscans to promote artistic enjoyment while restoring civic pride. The building design was a collaboration by Beaux-Arts architect Arthur Brown Jr. and theatrical designer G. Albert Lansburgh. Providing an appropriate acoustical environment was an important consideration, and records show that both Vern Knudsen and Paul Sabine offered initial design advice; ultimately, the primary consulting role was carried out by Clifford M. Swan, the sole consulting protégé of Wallace Clement Sabine.

Following over 60 years of continual use, and visible damage caused by a major earthquake, a comprehensive restoration and structural upgrade was undertaken partnering both civic and private organizations. With an ambitious construction schedule of only 18 months, the project team and San Francisco Opera and Ballet companies were emphatic about maintaining the acoustic qualities that patrons enjoyed. The primary technical task was to document the existing acoustic environment, and then minimize the effect of formidable changes to the facility and systems.

TECHNICAL BENCHMARKING

A comprehensive series of measurements established a baseline for acoustical performance prior to the renovation. This study would serve as a comparative benchmark to assess the acoustic environment following project completion, if needed. Measurement methodologies included realtime spectral analysis and Time Delay Spectrometry (TDS) to provide detailed information about acoustic energy propagation. Data collection emphasized repeatability, objectivity, and the ability to extract primary room acoustics parameters including reverberation, initial signal delay, clarity, loudness, and energy time arrivals relative to spatial direction. Measurement data were also analyzed at specific locations to assess the impact of visually unobtrusive but potentially significant architectural changes proposed in the auditorium.

DESIGN GOALS

As for most historic renovations, the intent was to be as faithful as possible to restoring original conditions. Strong emphasis was placed on historical accuracy both in terms of materials and aesthetics. This meant that there could be little deviation from the original architecture, and assured that no acoustical enhancements would be undertaken. However, unseen does not necessarily mean unheard. Distinct changes in and around the auditorium had the potential to affect acoustic conditions. These included the following:

Organ Lofts: Because an originally-planned pipe organ was never installed, large areas of open space behind the ornamental grilles on either side of the auditorium had been used as lighting positions, locations for effects loudspeakers, and storage. A longstanding need for additional restrooms was solved by stacking new restrooms inside the loft spaces. Acoustic analysis utilizing TDS comparative frequency response measurements directly in front and behind the decorative grilles verified not only the frequency selectivity of the openings, but also provided insight regarding the effect of introducing massive boundary surfaces within 3 feet of the open grilles. Because the new restrooms would essentially be “in” the auditorium, double wall and floating floor constructions were employed to control plumbing noise.

Dress Circle Shear Walls: A seismic retrofit was the original impetus for the renovation project. Massive shear walls were introduced throughout the building to bolster structural integrity, but were carefully placed to avoid aesthetic
impact. However, concrete shear walls were introduced at the rear of the Dress Circle seating level, placing a new sound-reflective boundary inches from seating. Polar energy time measurements indicated the direction and relative arrival times of sound energy at these locations. Our analysis led to the design and installation of omnidirectional diffusers behind sound-transparent decorative panels to reduce the intensity and level of time-accelerated reflections to nearby listeners.

**Building Systems:** New ventilation systems were implemented to provide greater comfort for both patrons and performers. Existing fan systems were also upgraded. Placement of new mechanical equipment became a challenge, because existing support spaces were at capacity, and unused space was almost non-existent. Locations designated for new equipment were less than optimal for acoustics. A 195-ton evaporative chiller was placed on the roof directly over the center of the auditorium. A specially-constructed structural platform and airspring isolation system were implemented to reduce noise and vibration transmission to the performance space below. A new mechanical room enclosing a sizeable air-handling unit was constructed in the supply air plenum two feet below the orchestra seating. Lighting dimmers powering over 2000 dimmer circuits were housed in an innovative enclosure suspended three levels above the stage. Noise measurements conducted just prior to the building reopening indicated that new systems produced no measurable or subjective increase to overall background sound levels.

**Support Spaces:** The renovation provided the opportunity to upgrade support spaces and enhance technical capabilities. One such enhancement was a new sound production facility located adjacent to the new Dimmer Room above the stage. This suite houses the communications and sound control systems for production support and performance. The centerpiece is the Sound Control Center, the equivalent of a critical listening control room found in modern recording studios. The room size and shape is optimized to be acoustically neutral, even with limitations imposed by existing structure and minimal space for mechanical, electrical, and fire protection systems to structure. Sound-isolating construction surrounds the entire suite to minimize the impact of sound transmitted to the stage below.

**CONSTRUCTION ISSUES**

In addition to a logistically taxing construction schedule, the unfortunate outbreak of a four-alarm fire in the building during construction introduced new challenges. Irreparable fire and smoke damage dictated that all auditorium seating be reupholstered, but modified to meet existing fire code standards. Specifications for acoustical absorption performance were designated for three types of seating, and extensive testing was performed on individual seat components as well as a comparative analysis on multiple banks of seats for before and after conditions.

While reviewing alternative cleaning procedures to remove smoke and soot discoloration to the domed auditorium ceiling, archival documents revealed that the porous plaster material was indeed installed specifically for acoustic performance. Soon after this review, sizeable portions of the ceiling were damaged by inadvertent impact to the support lathing from above, and large pieces of the ceiling were either dislodged or removed. Thus began an elaborate study not only to determine the actual absorption characteristics of the plaster, but to find a similar "recipe" to replace the damaged material. Suitable finishes and corresponding means of application were researched to restore the ceiling to its original color while minimizing the impact on its acoustical performance.

**CONCLUSION**

The San Francisco War Memorial Opera House reopened on September 6, 1997 with a spectacular gala performance by some of the world’s greatest contemporary operatic artists. Preparations for the performance occurred up to the last few hours, allowing little time to assess acoustic conditions beyond comparative background noise measurements. By all accounts, the 75th San Francisco Opera season has been a critical success. Both San Francisco Opera General Director Lotfi Mansouri and Music Director Donald Runnicles have remarked favorably about the quality of the acoustical environment and their inability to perceive any detrimental change.

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