

Article

Evaluation of Acoustic Similarities in Two Italian Churches Honored to S. Dominic

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Abstract: This paper compares two acoustical projects, applied to the S. Dominic church of Foligno and Imola, which are subject to a permanent and temporary conversion respectively, to places dedicated for listening to live music. Sets of measurements have been undertaken before the acoustical treatments in order to calibrate the digital model; in Foligno, the measurements have also been performed after the installation of the acoustical features, to check if the aims have been achieved. Between the proposed acoustical projects, only one has been realized in Foligno, with the artistic activity still running inside the auditorium. The challenge to adjust the acoustics of reverberant rooms like churches to host musical venues has been achieved with a good quality of sound perception. In particular, in S. Dominic church of Foligno, the goal has been hit after many digital simulations that calibrated the redirection of the sound towards the sitting areas.

Keywords: acoustics of churches; acoustical measurements; Italian churches

1. Introduction

The demand to attend live musical performance in Italy has increased considerably during the last decades, owed to the deficiency of places dedicated to performing arts. The churches of S. Dominic of Imola and Foligno are two historical buildings having in common the same construction period, geometrical and architectural composition and also the requirement for hosting laic performance, in particular musical and conference venues [1]. What actually discriminates the two, is the consecration, still surviving in the church of Imola and lost for that one in Foligno. As such, this paper keeps in consideration the temporary and permanent transformation as a key feature over these acoustical projects.

It should be observed that this article compares the acoustical studies between two different case studies:

- An acoustical design realized and still existing in S. Dominic of Foligno;
- A proposed acoustical design, that is still a project idea, for S. Dominic of Imola, which has not been undertaken.

Given the similar approach to the concepts, the goal of this paper is to show the importance of the acoustical simulations during the planning design, as the most delicate phase of the project, which highlights the issues that should be solved in order to achieve a good sound perception inside historical buildings. To achieve this goal, measurement techniques and results are critically compared, in line with the project intentions to improve the definition and the sound quality [2].

2. Historical Background

The two churches of S. Dominic are composed of a single nave and both were built during the second half of the 13th century. The construction comprises of an adjacent convent, having vaulted porches. The religious identity has often been changed throughout the centuries and adjusted to the needs at the time. In fact, both the cloisters during the Napoleon invasion of the 19th century were converted to troops' dormitories and barracks for horses [3]. Fortunately, the churches have been left undamaged, and the original and architectural aspect was kept preserved.

Being built during the same period, both churches are characterized by a gothic style, which has been covered by baroque construction elements in S. Dominic of Imola, due to further architectural styles overlapped throughout the centuries, as shown in Figure 1. The church of S. Dominic of Foligno preserves its original style, which is still visible as shown in Figure 2, having a structural shape that is particularly suitable for concerts and theatrical performance.



Figure 1. Church of S. Dominic of Imola.



Figure 2. Church of S. Dominic of Foligno.

3. Geometry and Architectural Organization

Both the churches of S. Dominic have a plan layout of a single nave, surmounted by a barreled vault in Imola and by a gable trussed roof in Foligno [4]. The linearity of the nave, very accentuated in Foligno, is disrupted in Imola by the presence of framed niches at the side walls. The apse is edged for both churches, in the shape of a half decahedron in Imola and half dodecahedron in Foligno. Furthermore, at the east side of the transept of S. Dominic of Imola there is a coupled volume, composed of the chapel of the Rosary, which has a shape of an oval cylinder covered by an elliptical dome in baroque style [5]. Table 1 below summarizes the different features inside the two churches.

Table 1. Architectural characteristics of S. Dominic of Foligno and Imola.

Description	S. Dominic of Foligno	S. Dominic of Imola
Volume (m ³)	Approx. 16,000	Approx. 13,000
Type of roof	Gable truss	Barrelled vault
Material applied on ceiling	Wood	Plaster on bricks
Presence of dome	No	Yes
Type of single nave	Linear	Presence of 3 niches per side
Type of apse	Half dodecahedron	Half decahedron
Coupled volumes	No	Yes

In addition, the finishing materials contribute to character these spaces. In particular, the differences are highlighted as follows:

- *S. Dominic of Foligno.* The exposed gable truss roof is composed of wooden beams; hard reflecting tiles are placed on the floor; the lateral walls have plaster on bricks and the windows are smaller than those inside S. Dominic of Imola.
- *S. Dominic of Imola.* The barreled vault is made of plaster on bricks; hard reflecting tiles are placed on the floor; there are marble columns and marble sheets installed on the lower part of the walls; the glass of the windows cover much of the surface area above each niche; stucco has been applied for decorations.

4. Acoustical Limits

4.1. *S. Dominic of Foligno*

Since the main nave is narrow and long, as shown in Figure 3, the side walls produce strong lateral early reflections, unbalanced between the section close to the transept area (where the reflections are more robust) and the rear part of the nave (where the sound is perceived echoed). The main reason of this acoustical environment is due to the presence of the reflecting apse at the back of the stage. As such, a redirection of sound energy is required in order to be equally distributed along the sitting area. Similarly, a decrease of reverberation and an increase of clarity are necessary to match the criteria of an auditorium.

4.2. *S. Dominic of Imola*

In S. Dominic of Imola, the presence of niches on the side walls of the nave disrupt the perfect linearity as characterized in S. Dominic of Foligno, and hence create a different acoustic effect. The presence of the chapel of Rosary on the east side of the transept behaves as a large resonant box, returning the reflections in an unpleasant delay, as perceived in the nave. Similarly, the presence of a circular dome above the center of the transept creates a focus effect of early reflections that, instead, should be addressed to other directions, specifically towards the nave. The presence of reflecting materials (e.g., marble of columns, tiles on floor, plaster on brick-walls) as finishing surfaces make this volume very reverberant, creating a condition not suitable for listening to classic music. For this reason, the insertion of absorbing materials is required in order to lower the reverberation time and increase the clarity across the sitting areas.

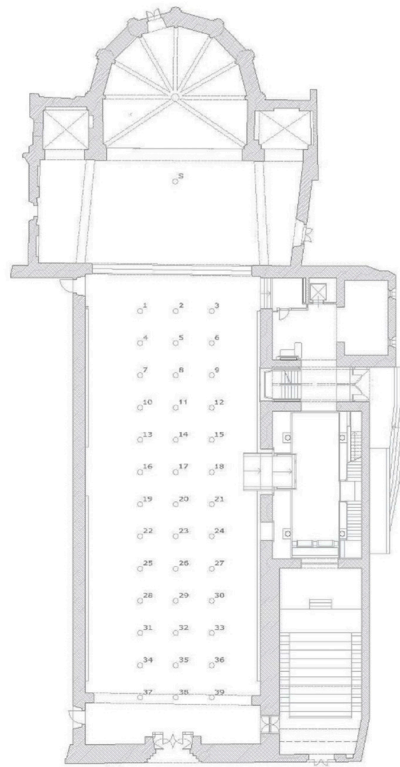


Figure 3. Source and receiver positions inside S. Dominic of Foligno.

5. Acoustical Measurements

5.1. Equipment

In S. Dominic of Foligno the measurements were undertaken during three separate campaigns throughout the decades using different methodologies in accordance with the technology available at the time.

The first measurements were conducted before the refurbishment works in 1986 and then repeated with the same equipment in 1990. They were undertaken by using the following equipment:

- Pistol shot, as the impulsive source;
- Binaural headphones (Sony DRW70C);
- Digital Audio Tape (DAT) (Aiwa St-1), as a recording receiver.

In the laboratory the IRs were transformed digitally in WAV files by using a digital audio board (Multi Wav Digital Pro) and then analysed by using a wave editor (Cooledit 95) in combination with a specific software (MLSSA 10.0C).

A following survey was performed in 1994, made by using the following equipment:

- Omnidirectional loudspeaker (LookLine);
- Binaural dummy head (Sennheiser MKE2002set);
- Personal Computer connected to the LookLine loudspeaker and the receiver.

A Maximum Length Sequence (MLS), produced by a MLSSA board (A2D160), was used as excitation signal, and the RIRs were obtained after the deconvolution of the deterministic sequences in time domain.

The measurements taken after the refurbishment works and with the acoustical treatments applied were completed in 2001 and they had the following equipment:

- Equalised omnidirectional loudspeaker (LookLine);

- Binaural dummy head (Neumann KU-100);
- B-Format microphone (Soundfield MK-V);
- Personal Computer connected to the LookLine loudspeaker and to the two receivers.

In this paper, the reference results as measured values are considered those related to the survey performed in 1994, which resulted very useful in photographing the conditions of the church before any acoustical treatment.

In S. Dominic of Imola the acoustical measurements were undertaken with the following equipment:

- Equalised omnidirectional loudspeaker (LookLine);
- Binaural dummy head (Neumann KU-100);
- B-Format microphone (Soundfield MK-V);
- Personal Computer connected to the LookLine loudspeaker and to the two receivers.

The excitation signal to measure the impulse response (IR) of the room was a 20 s pre-equalized exponential sine sweep (ESS) having a frequency range set between 40 Hz and 20 kHz.

5.2. Source and Receiver Positions

The sound source was located in the presbytery area, simulating the location of a musician playing on the stage. In particular, in S. Dominic of Imola the loudspeaker was not installed along the median axis in order to avoid focal effects owed to the geometry of the circular dome [6], while in S. Dominic of Foligno this problem did not transpire.

The dummy head and the B-Format microphones were moved in 32 and 39 positions across the nave, respectively related to Imola and Foligno, as shown in Figures 3 and 4. In this way it was possible to represent as much as possible all the audience sitting areas [7].

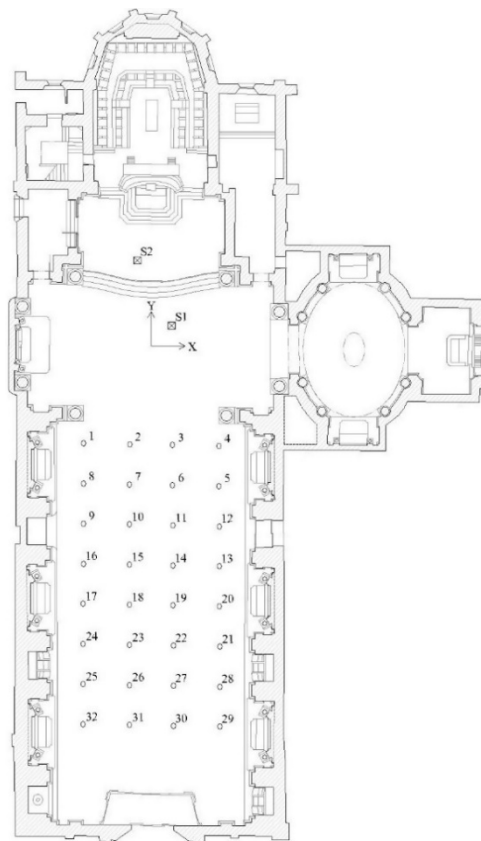


Figure 4. Source and receiver positions inside S. Dominic of Imola.

5.3. Measured Results

The analysis of the measured data shows that S. Dominic church of Imola is more reverberant than S. Dominic of Foligno. Although the volume shape and the volume size are very similar, the main difference between the two churches is the shape of roof and the material of the finish surfaces, which promotes to build-up the emitted sound in a different way [8].

The graphs in Figure 5 are obtained by considering the average values of all the measured points. The monoaural acoustical parameters of the measurements performed in 1994 were calculated from both the binaural channels of the dummy head, as it was used to do in that period (one of the examples is given for La Fenice theatre of Venice) [9]. The same parameters measured after 2001 were obtained from the W channel of the Soundfield microphone.

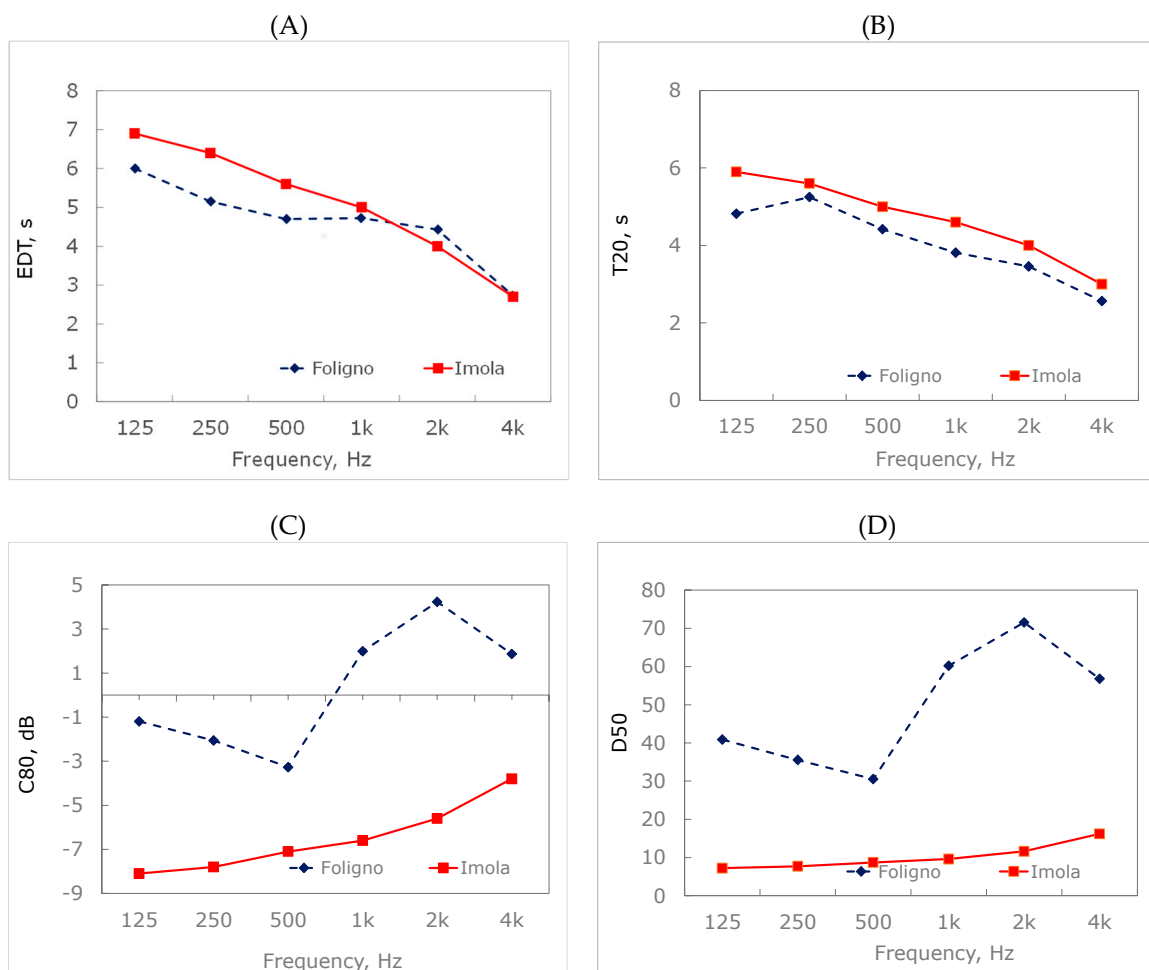


Figure 5. Measured main acoustical parameters. (A) EDT; (B) T₂₀; (C) C₈₀; (D) D₅₀.

5.3.1. EDT

The EDT of both curves have a downward trend, with a difference of almost 1s at low frequencies that becomes null at 4 kHz.

5.3.2. Reverberation Time (T₂₀)

In S. Dominic of Imola the T₂₀ is higher than that found in S. Dominic of Foligno, the with a different of almost 1s for all the frequency bands except at 250 Hz and 4 kHz, having a gap of approximately 0.4s.

5.3.3. Clarity Index (C_{80})

A noticeable difference between the two churches is the C_{80} parameter, showing an upward trend for S. Dominic of Imola and a non-linear trend for Foligno. For S. Dominic of Foligno, the curve shows a downward peak at 500 Hz and an upward peak at 2 kHz. Overall, the results indicate that the clarity index in Foligno is better than in Imola. This is due to the presence of higher surface areas of marble and plaster in Imola, other than the presence of a curved shape of the roof (i.e., barreled vault) and the dome surmounting the center of the transept. The linearity of S. Dominic of Foligno is completely broken in Imola with the presence of the niches along the sides of the nave that diffract the sound waves and redirect the sound more diffusely.

5.3.4. Definition (D_{50})

A similar trend of the clarity index is obtained by the results of the D_{50} , which is more uniform across the frequency bands for Imola and with a downward peak at 500 Hz and an upward peak at 2 kHz for Foligno. The difference between the two curves is not constant but shows a minimum gap of 30 points at 500 Hz and a maximum gap of 60 points at 2 kHz.

Based on the values given in Figure 5, the acoustics of both churches demonstrate that the results of reverberation time are out of target to accomplish the needs of an auditorium. In addition, the intelligibility of sound is very difficult, especially in Imola [10]. The difference in values of the acoustical parameters, comparing the two churches, are given mainly by the geometry and the construction configuration.

As anticipated in Section 4.2, the presence of the chapel of Rosary, inside S. Dominic of Imola, opened laterally to the transept, behaves as a large resonator, returning delayed sound rays after reflecting at the boundary surfaces of the chapel [11]. This issue is not present inside S. Dominic of Foligno, which has no coupled volumes.

A further difference which can be considered is the presence of a dome at the transept level and the barrel-vaulted roof made of plaster on bricks inside S. Dominic of Imola, whereas in Foligno, there is a simple open gable roof in wood. The presence of the dome creates a focus effect, which is unpleasant for musical performance [12]. In a similar way, the disrupting delayed reflections in Foligno are given by the apse. Furthermore, in Foligno, the measurements were undertaken when the church was almost completely empty, without any furniture or seats.

6. Architectural-Acoustic Design

The auditorium of S. Dominic of Foligno was designed to have a capacity of 530 seats. The stage has been designed to be at the center of the transept, equipped with reflecting wooden panels, while the audience areas are arranged mainly along the nave and, for few seats, in the apse. A fire exit has been created on the east side, approximately at the center of the nave length, where the main entrance has been planned, dividing the sitting area of the nave into two blocks: the closest to the stage on ground and the other organized onto sloped stalls. The other functional spaces are allocated outside the church, with a few meeting rooms, a foyer and a 96-seats video room to be included.

A similar organization can be found in S. Dominic of Imola, designed to have a total capacity of 410 seats, planned to be along the nave only [13]. The stage for the orchestra would be at the center of the transept, equipped with an acoustic shell. Two fire exits have been designed between the 2nd and the 3rd niche of the nave, as indicated in Figure 6. A cloakroom and a box office can be allocated beneath the highest seats of the sloped stalls, close to the main entrance. Services and washrooms have been assigned to the western extension of the church, externally to the auditorium.

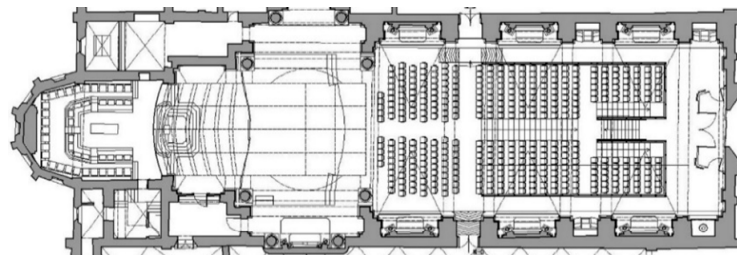


Figure 6. Proposal design of the sitting area in S. Dominic of Imola.

6.1. Stage and Transept Area

6.1.1. S. Diminic of Foligno

Because the single nave of S. Dominic of Foligno can be approximated to a shoe-box room for its pure linearity, as shown in Figure 7, the spreading sound waves generated onto the stage towards the nave hit the side walls producing strong lateral early reflections. The intension of the acoustical project was to equally distribute the early reflections across the space avoiding focal echoes from the apse [14]. As such, one of the first steps of the project design was to redirect the sound energy by the insertion of suspended wooden panels above the orchestra. These reflecting panels, as shown in Figure 8, are equipped with engines, so that both orientation and height can be controlled. The rotation and the height change of the reflecting panels allow to create all types of a desired shell, in accordance with the nature of performance.

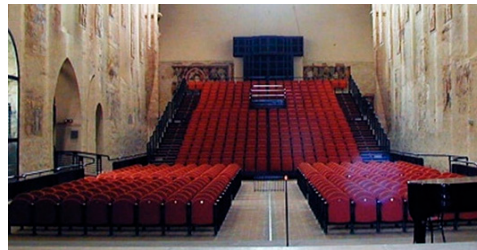


Figure 7. Sitting area in S. Dominic of Foligno.

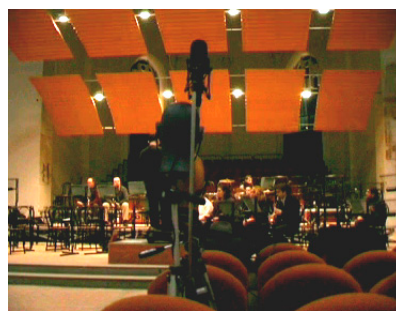


Figure 8. Existing reflectors in S. Dominic of Foligno.

Because another small audience space is allocated into the apse, the installation of heavy curtains at the arched door separating the apse from the presbytery was useful to cancel echoes coming from the apse [15].

6.1.2. S. Diminic of Imola

In a similar way, the acoustic project of S. Dominic of Imola would like to propose a few suggestions in order to upgrade the intelligibility and the sound distribution across the space by lowering the

reverberation. It should be noted that for this project the important condition to be kept in mind is the reversibility of the intervention. The main concepts of the acoustical design are the following:

- A raised stage has the purpose of improving the sight from the audience. It has been proposed to cancel the level difference of the steps of approximately 1.9 m by rising the stage to the level of the altar;
- The light wooden frame of the stage has been introduced in order to work as a resonant box and to improve the booming effect at low frequencies;
- Above the stage, an acoustical shell has the function of cutting off the focal effect created by the circular dome at the center of the presbytery. The shell has been designed to be made of painted wooden panels on the lower part and synthetic transparent glazed sheets on the upper portion. All the panels can be assembled onto a metal frame tensed in a reticular configuration. The geometry of the shell is designed to be free at both sides and closed to the apse in order to reinforce the sound towards the audience, as shown in Figure 9. The dimensions of the shell are 16 m × 10 m in plan, with the sloped curved ceiling going from 3.1 m (above the height of the existing choir) to 10 m, as shown in Figure 9.



Figure 9. Acoustic design of the shell in S. Dominic of Imola: lateral (a) and front (b) elevations.

Other than the aforementioned acoustical strategy adopted for the transept area, the necessity to add some absorbing materials has been planned to make suitable the acoustical parameters for attending live music performance.

A detailed description of the acoustical treatments is given in Section 6.2, with the specific applications to the two cases.

6.2. Acoustical Treatment

The treatment typologies adopted are the following:

- *Plastered panels.* Acoustic panels Class B were used for broadband absorption, to be installed on the walls of the apse and of the transept of both churches;
- *Wooden panels.* They are composed of two layers of plywood (i.e., 5 mm thickness) separated by a 50mm gap filled with batt insulation (i.e., glass wool). The wooden panels have a broadband absorption, mainly spread over the mid frequency bands. This acoustic option has been proposed for the church of Imola;
- *Fabric wrap.* Heavy fabric can be adopted to lower the reverberation. In S. Dominic of Imola the fabric was wrapped around the marble columns in order to reduce the overall reflecting surface area and consequently the sound diffusion for its curved shape [16];
- *Heavy curtains.* The curtains have been proposed in line with the popular feast decorations of churches settled during religious events. As such, the curtains have the purpose of lowering the reverberation by shielding some reflecting surfaces. They are very effective absorbers at mid-high

frequencies. Both churches can take advantage of this treatment [16]. In S. Dominic of Foligno the curtains were inserted at the side walls of the nave, while in S. Dominic of Imola the curtains were used at the separation line of the chapel of Rosary from the main volume, reducing the echoed reflections and for shielding the glass of windows.

7. 3D Modelling and Simulations

The aforementioned acoustical treatments were included in the 3D models, as show in Figures 10 and 11, realized with Ramsete software, which calculates the ray-tracing reflections based on pyramidal (instead of conical) spreading. In addition, source and receiver positions were reproduced at the same location of the real measurements. The simulations have been calculated by applying the acoustical design and all the treatments as discussed already in Section 6.1 and 6.2, in unoccupied conditions. It would not be considered appropriate to simulate occupied conditions because of the Covid 19 pandemic, which requires different (and unpredictable) configurations with different percentage of occupation.

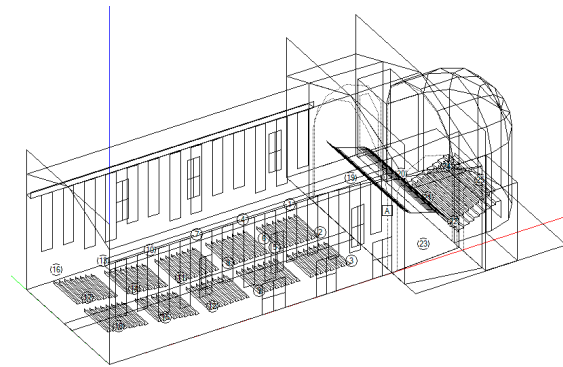


Figure 10. 3D model-S. Dominic of Foligno.

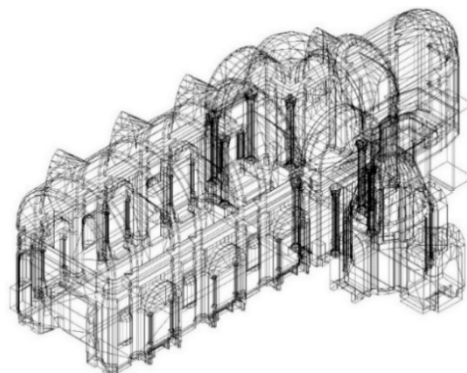


Figure 11. 3D model-S. Dominic of Imola.

7.1. Acoustical Parameters

Because of its permanent desecration, the acoustical treatments as mentioned in Section 6.2 can be adopted for the church of S. Dominic of Foligno by being applied to the measurement configuration related to 1994. In S. Dominic of Imola, instead, the acoustical treatments have been planned to be completely reversible, due to the necessity of daily masses that only allows a temporary conversion to an auditorium [17]. The graphs of Figure 12 show the simulated values based on the model digitally reproduced [18], with the acoustical treatments applied as discussed previously. The graphs in Figure 12 are obtained by considering the average values of all the simulated points.

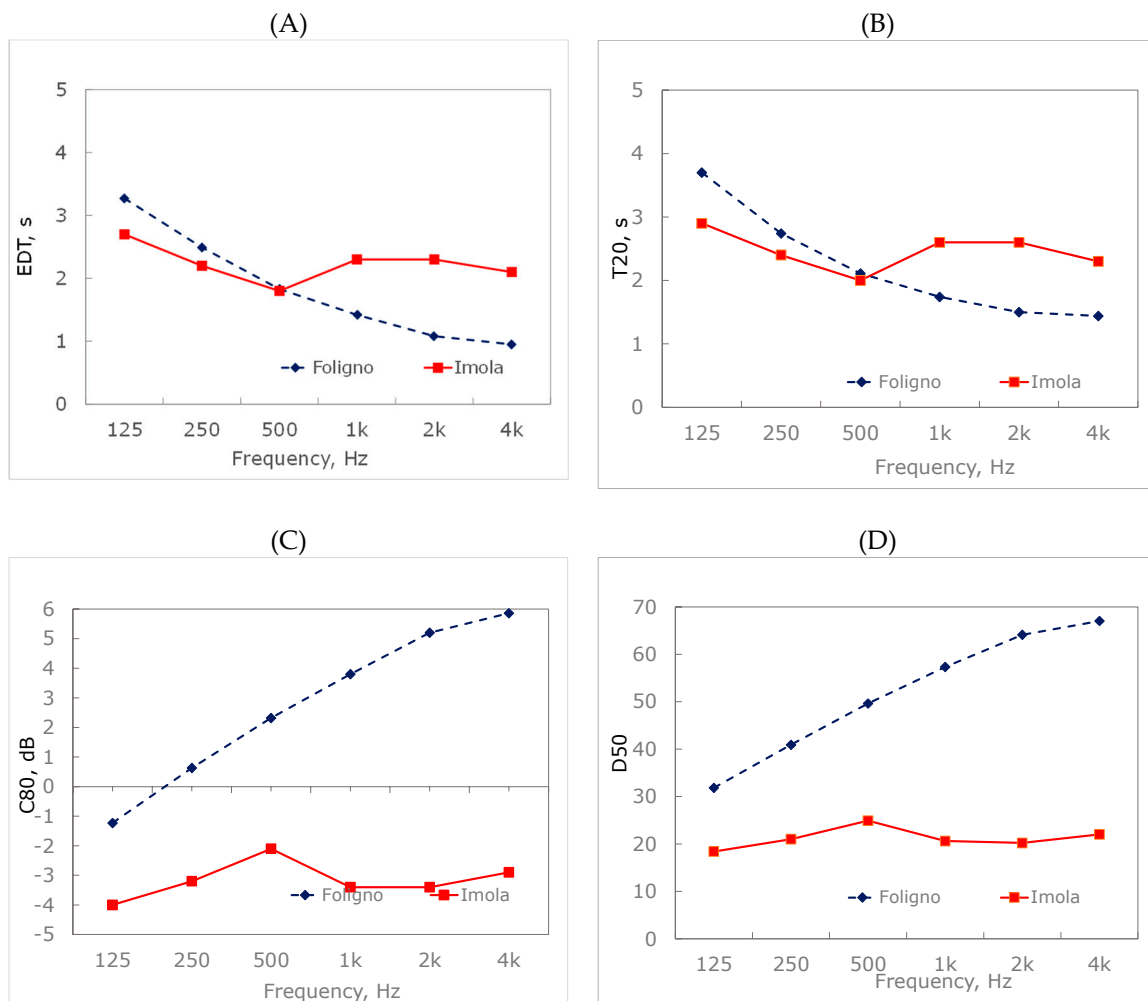


Figure 12. Simulated acoustical parameters. (A) EDT; (B) T₂₀; (C) C₈₀; (D) D₅₀.

7.1.1. EDT

The graph of EDT similarly indicates a reduction in terms of sound energy for both churches. To be precise, the EDT related to S. Dominic of Imola has been reduced of more than 4 s at 125 Hz, with a similar downward peak at 500 Hz reaching a value of 1.8 s. The trend line related to S. Dominic of Foligno is very similar to the results related to the T₂₀, even if in the graph of EDT is shifted 0.4 s downward.

7.1.2. Reverberation Time (T₂₀)

The curves indicate that in both churches the T₂₀ has been reduced considerably. In particular, in Foligno the reverberation time reaches 1.5 s at high frequencies, while at low and mid frequencies it is slightly higher, even if definitively improved overall. In S. Dominic of Imola the T₂₀ has an average value of 2.5 s over all the frequency bands, but the trend line shows a downward peak at 500 Hz equivalent to 2 s.

7.1.3. Clarity Index (C₈₀)

The clarity index C₈₀ has been improved for both churches and now it falls into the range of a good listening to music, even if the dashed blue line reaches a value of 6 dB at 4 kHz. In Foligno the application of the acoustical treatments provoked an adjustment in terms of clarity response, passing from a non-linear trend of the measured values to a linear trend of the simulated values.

In Imola, instead, the curve shows an upward peak at 500 Hz, while the other values are comparable around -3 dB.

7.1.4. Definition (D_{50})

The line of D_{50} related to the church of Foligno is changed from a non-linear to a linear upward trend with a difference of almost 40 points between the beginning and the end of the curve. The values related to S. Dominic of Imola have been improved overall of 10 points approximately over all the frequency bands, with a slight upward peak at 500 Hz.

7.2. Discussions on Simulated Results

The results of Figure 12 above illustrate that the acoustics of a temporary auditorium in Imola is more suitable for sacred musical performances, as initially planned by the project intentions, even if it can be acceptable for other forms of classic music [19]. The acoustical project applied to S. Dominic of Imola does not see a real execution and, therefore, it remains a submitted proposal.

The simulated results related to S. Dominic of Foligno are more suitable for transforming the church to an auditorium, even if further calibrations should be applied in order to balance the acoustical response over all the frequency bands.

8. Realization of the Auditorium S. Dominic of Foligno

Because the desecration of the church was permanently given to S. Dominic of Foligno in 1980 by the local authorities, the simulated results of the acoustical project previously mentioned were developed in order to match the criteria of an auditorium [20], counting on a definitive transformation suitable for musical concerts and congress meetings. As such, the preliminary acoustical studies were finalized with the analysis of all the three measurement campaigns, realized in the following time period:

- In 1986 and 1990, before the refurbishment works;
- In 1994, in unfurnished room conditions;
- In 2001, after the installation of the acoustical treatments.

8.1. Discussion on Further Treatments

After the first study, a second phase of the project took place in order to improve the acoustics inside the auditorium. As such, it has been proposed the insertion of a transparent panel between the transept area and the nave, in order to close the arch separating the two main volumes, as illustrated in yellow in Figure 13 below.

The choice of introducing a panel was adopted to accomplish the necessity of lowering the reverberation time especially at the low frequencies, giving a more regular behavior of the late reflections that, otherwise, would cause a difficult listening to musical performances.

The choice of this type of panel was suggested for two main reasons:

- The insertion of a panel lowers the values of the reverberation time at low frequencies because it splits the big volume in a coupled interconnected space, in line with the principle of volume reduction;
- The free view of the historical space throughout a transparent material has been preferred, in accordance with the principle of transparency, instead of an opaque board, which would reduce the perspective of the stage otherwise.

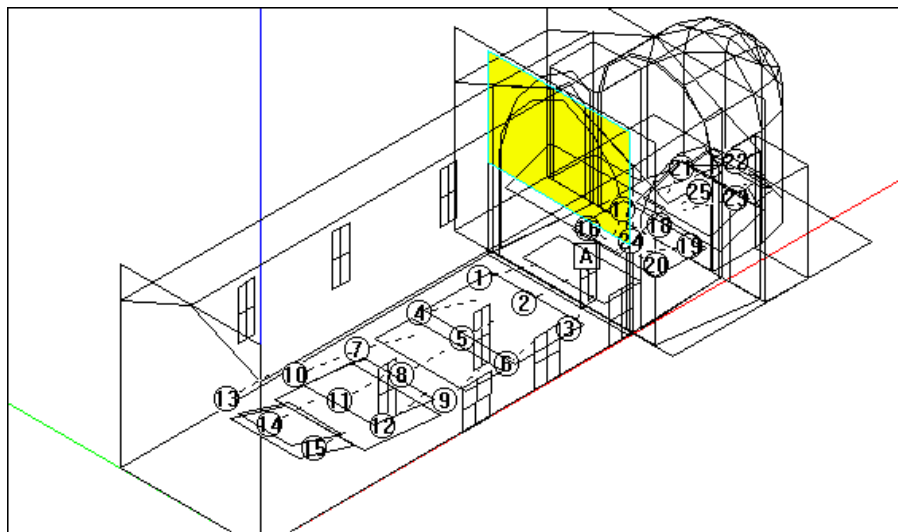


Figure 13. Transparent panel closing the arch dividing the transept area from the nave.

Unfortunately, the suggestion of this type of treatment was never acquired by the committee.

8.2. Final Realisation in S. Dominic of Foligno

After different simulations and after another campaign of measurements performed in 1994, made during the prosecution of the progressing works, the final measurement survey performed in 2001 summarizes the sound perception existing inside the auditorium. Figure 14 outlines the differences of the acoustical parameters obtained with the initial survey (undertaken in 1994) and the final one (in 2001). It should be considered that all the graphs in Figure 14 correspond to the average values of all the measured points.

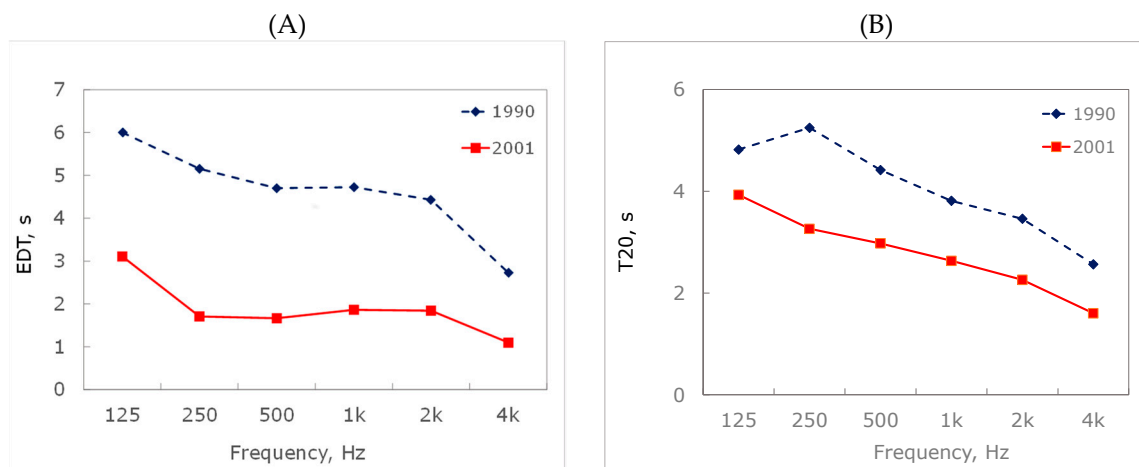


Figure 14. Cont.

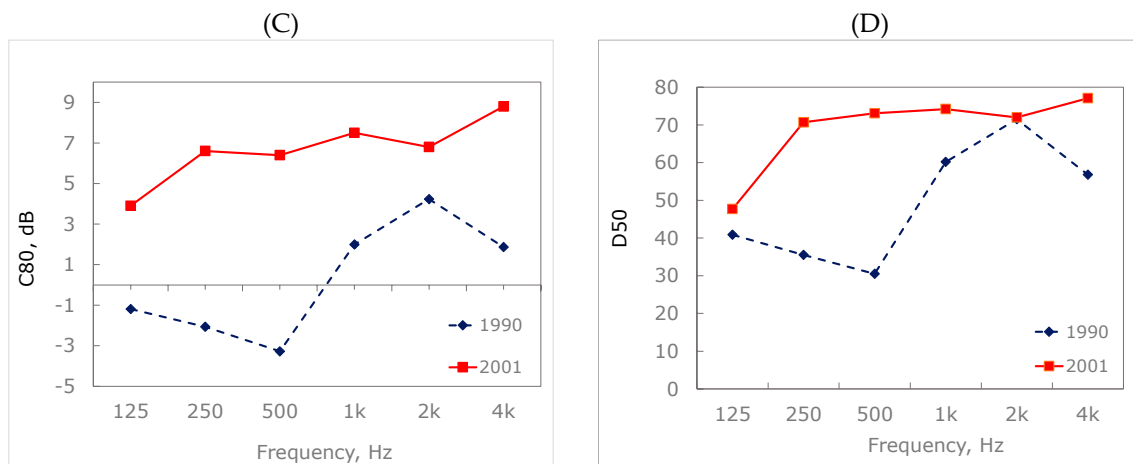


Figure 14. Measured parameters in S. Dominic of Foligno, performed in 2001. (A) EDT; (B) T_{20} ; (C) C_{80} ; (D) D_{50} .

8.2.1. EDT

The EDT dropped considerably, being below 2s over almost all the frequency bands. Since EDT resulted lower than T_{20} , it allows a higher intelligibility, maintaining an important reverberant tail which helps a perception of blended and “live” sound, other than a high level of clarity.

8.2.2. Reverberation Time (T_{20})

It can be seen that the RT (T_{20}) dropped to 2.7s at the central frequency bands, falling into an optimum target range of an auditorium of such volume. Figure 15 indicates the target of the RT achieved by the Auditorium of Foligno, based on the data of room volume.

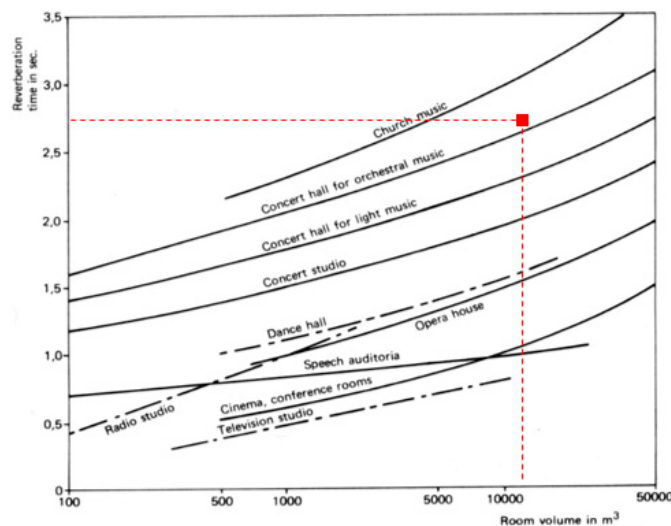


Figure 15. Reverberation Time of S. Dominic of Foligno.

Considering that the auditorium would host mainly classical music and rarely conferences and other types of meetings, the target for a new space for classical music in Foligno has been achieved [21]. The installation of the curtains hung from the top on the lateral walls of the nave and the addition of reflecting panels placed above the orchestra contributed to redirect the early reflections towards the last rows of seats, and to further reduce reverberation time in case of conferences, which otherwise arrived attenuated by the grazing incidence of the long sitting area. Hence, in this way they are more equally distributed [22].

8.2.3. Clarity Index (C_{80})

The clarity index C_{80} increased from negative to positive values, with an upward stepped trend that reaches approximately 9dB at 4 kHz. The plastered panels placed on the back wall (i.e., on the rear side of the audience) cancelled the unpleasant echoes, that before were delayed by the exceeding reflecting surface areas. In addition, drapery and curtains spread on the longitudinal walls of the nave, mainly covering the surface of windows, helped to increase the intelligibility [23].

8.2.4. Definition (D_{50})

Similar to the C_{80} , the D_{50} parameter increased as well, being in a range between 50 and 70.9. These two parameters confirm the high level of intelligibility, which persists even if the reverberation time is fairly high [24].

9. Conclusions

Given its historical background, Italian local authorities have a duty to consider and evaluate the needs of their population. This need causes a rethinking of several dismissed buildings (which include abandoned industrial buildings, barracks, etc.) including some sacred architectural patrimony (e.g., churches and convents). Often, ancient churches represent a potentially perfect room for concerts, both for their history and for the room shape. Although in several cases these churches maintain their original purpose (i.e., worship buildings), they could be temporarily and efficiently used for music performances.

This study reported two example of worship buildings and the acoustic design specifically developed for using these spaces as concert halls. The studies of the two churches were challenged to adapt the acoustical parameters of very reverberant volumes to the criteria required for auditoria.

For S. Dominic of Imola, the current proposal in relation to the acoustical study resulted to be more suitable for sacred music only, because the necessity to combine daily religious obligations with temporary laic venues should be considered at all times. If the aim of the acoustical project would like to pursue an enlarged intelligibility to be adaptable for all styles of classic music the current study requires to be developed furthermore.

Differently for S. Dominic of Foligno, after different measurement campaigns and relative simulations, the installation of the acoustical treatments to the existing building satisfy the residents' desires other than the criteria of the acoustical parameters as intentionally planned to match requirements of both music and speech intelligibility. In this case, the dismissed church has been definitively transformed into an auditorium.

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