



PRE-RESTORATION SUBJECTIVE ACOUSTIC COMFORT IN THE GOAN CHURCH OF NOSSA SENHORA DO PILAR

Menino Allan S. M. Peter Tavares, António P. O. Carvalho¹, S. Rajagopalan² and Satish J. Sharma³

¹Laboratory of Acoustics, Faculty of Engineering, University of Porto, 4200-465 Porto, Portugal

²Department of Physics, Nagpur University, Nagpur – 440 033, India

³Department of Electronics, Nagpur University, Nagpur – 440 033, India

e-mail: allan.wholysound@gmail.com

Abstract

This study at the Church of Nossa Senhora do Pilar, built in 1613 by the Spanish Capuchos Franciscan, investigates the acoustic effect of music on the subjective comfort of a listener in a worship space. The results presented describe the effect of variations in the type of music rendered (in the form of live music from the cello, clarinet and the ensemble) from two music sources sites (the nave and the choir loft, of the church) on the subjective acoustic comfort of listeners in the church of Nossa Senhora do Pilar (a significant Catholic church of Goa, India). The subjective acoustic comfort of the listeners for different music types at the two music sources was measured through the *Acoustic Comfort Impression Index* (ACII). This index for subjective acoustic comfort was derived as a difference between desirable Subjective Acoustic Impressions such as of Intimacy, Envelopment, Reverberance, Loudness, Clarity, Directionality, Balance and undesirable Subjective Acoustic Impressions such as of Echoes and of Background Noise. The derived acoustic comfort impression index also took into account the requisite of reverential awe; intelligibility for sacred speech, music, singing and the sacred silence that characterizes a worship space. Although the sacred music rendered by the ensemble seems to have elicited better scores of Acoustical Comfort Impression Index (ACII) among the listeners, yet there is no significant difference between the means of the listeners acoustical comfort impressions by the ensemble, cello or clarinet ($p = 0.43$). Amongst the two music source locations, although the Acoustical Comfort Impression Index (ACII) seems to favor the choir loft location, the music rendered therein is only 80% significantly more effective than the music rendered from the nave floor location ($p = 0.20$).

1. Introduction

The desire for religious comfort and solace brings a devotee to a worship space. A good acoustic ambience facilitates the experience of subjective comfort in a worship space thus enabling *Active, Conscious and Total Participation* of the devotee in community worship [1]. This study investigates the acoustic effect of music on the subjective comfort of a listener in a worship space to determine as to what type of music would be acoustically preferred in order to make the sacred liturgy in a worship space a genuine celebration of ‘Comfort’ and ‘Solace’. The results presented here describe the effect of music rendered by the cello, clarinet and the ensemble from different source locations (namely, the nave and the choir loft of the church) on the subjective acoustic comfort of listeners. Reverential Awe, Intelligibility and Silence as constituted of subjective acoustic impressions are hypothesized as determinants of ‘comfort’ in a worship space. The net desired effect is named as *Acoustic Comfort Impression* (ACI) and indexed as *Acoustic Comfort Impression Index* (ACII). This study shows an advancement in the comprehension of ACII as compared to what was presented earlier [2].

2. The church of Nossa Senhora do Pilar: the sample church

The Church of Nossa Senhora do Pilar, built in 1613 by the Spanish *Capuchos* Franciscan, lies atop a hillock that rises alongside one of the largest reclaimed khazan lands of Goa. Its small nave has a high plain barrel vaulted ceiling while its diminuted sanctuary’s roof, like the other earlier churches of the konkan [3], is covered with a finely coffered barrel vault. The paintings on wood and canvas which decorate the church were done by local and possibly Chinese artists [4]. The present choir stall at the entrance of the church seems to be a later addition or a renovation of the original. The church has undergone a number of improper interventions causing visual and acoustical damage to the interior worship space of the church [5]. The church is presently in the process of restoration. The church before and during restoration is shown in Figure 1.



Figure 1. Nossa Senhora do Pilar church (Goa, India) during and before restoration.

Some important architectural details of Nossa Senhora do Pilar church are shown in Table 1.

Table 1. Architectural details of Nossa Senhora do Pilar church (Goa, India)

ARCHITECTURAL MEASURES	DESCRIPTION	UNITS	VALUES
Total Floor Area	A_{TOT}	m^2	400
Nave Floor Area	A_{NV}	m^2	130
Maximum Height	H_{MAX}	m	15
Maximum Length	L_{MAX}	m	30
Total Volume	V_{TOT}	m^3	3457
Nave Volume	V_{NV}	m^3	837
Total Average Height	H_{AVG}	m	9
Maximum Nave Width	W_{NV}	m	9
Average Width	W_{AVG}	m	8

The ground floor plan of the church shown in Figure 2 reveals the diminished sanctuary style of the church.

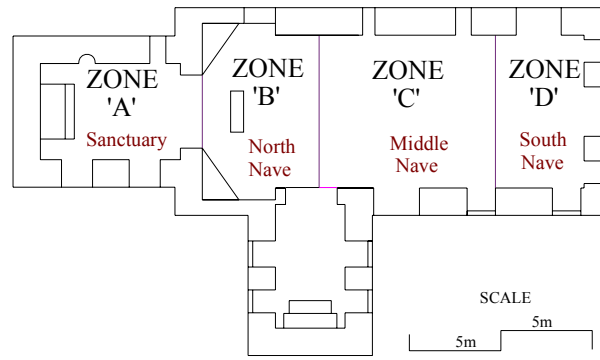


Figure 2. Ground Floor plan with the zones demarcation (Floor plan courtesy: Engr.Thomas D’Costa)

3. Methodology

3.1 Listeners and Music sources

Nineteen trained normal listeners were spatially seated into four seating zones within the church. Two locations in the church were chosen as music sources. The first location, labelled as ‘Music Source A’ (MA) was the floor of the North East nave – sanctuary corner of the church (Ground floor) and the second location, labelled as ‘Music Source B’ (MB) was the floor of the Choir Loft of the church (First floor). The musical instruments that were tested in this church are cello (P), clarinet (Q) and an ensemble of cello, clarinet, violins and guitar (R). The locations of the music sources (MA and MB) and listeners seating for the subjective acoustic tests are shown in Figure 3.

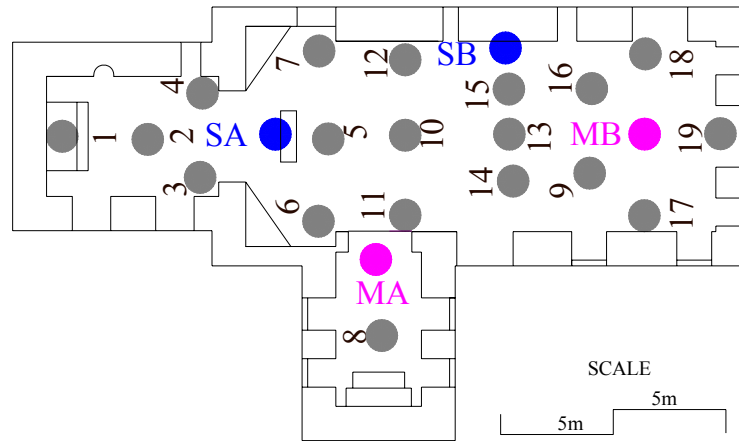


Figure 3. The locations of Listeners and Music Sources in the Nossa Senhora do Pilar church (Goa, India).

The cellist played “Bach’s Suite No. 2”. The clarinet player rendered the tune of the “Motet: Fera Pessima” a traditional Christian Lenten hymn. The ensemble played a Goan devotional classic “Piedade Saibinni in minor and major”.

3.2 Subjective Evaluation method

The acoustic evaluation sheet [6] [7] given to the listeners was interpreted to accommodate parameters of worship. The experience of reverential awe was expressed as an average of the following desirable Subjective Acoustic Impressions (SAI): Subjective Acoustic Impression of Intimacy (SAI_{INT}), Subjective Acoustic Impression of Envelopment (SAI_{ENV}), Subjective Acoustic Impression of Reverberance (SAI_{REV}), Overall Subjective Acoustic Impression (SAI_{OVER}). The quality of Intelligibility of speech, singing and music was judged as an average of the following desirable Subjective Acoustic Impressions (SAI): Subjective Acoustic Impression of Loudness (SAI_{LOUD}), Subjective Acoustic Impression of Clarity (SAI_{CLAR}), Subjective Acoustic Impression of Directionality (SAI_{DIR}), Subjective Acoustic Impression of Balance (SAI_{BAL}). The quality of silence was judged from the following undesirable Subjective Acoustic Impressions (SAI): Subjective Acoustic Impression of Echoes (SAI_{ECHO}) and Subjective Acoustic Impression of Background Noise (SAI_{NOIS}).

3.3 Derivation of Acoustic Comfort Impression Index (ACII)

The Acoustic Comfort Impression Index (ACII) measures the subjective comfort induced by the acoustics inside the worship space. This subjective acoustic comfort enables the necessary disposition to worship. A difference was drawn between the Desired Subjective Acoustic Impressions (DSAI) in worship space and the Undesired Subjective Acoustic Impressions (USAI) in a worship space in order to acoustically comprehend and optimize this ‘Religious Feeling of Comfort and Solace’.

The Desired and Undesired Subjective Acoustic Impressions (DSAI and USAI) were evaluated as averages of the desired eight SAI and the undesired two SAI respectively. The net difference score between the desired and the undesired on a semantic scale of 1-7 was averaged and coded as the *Acoustic Comfort Impression* (ACI) of the worship space.

Finally The *Acoustic Comfort Impression Index* (ACII) at each zone of the worship space was evaluated using equation 1, for different music types: cello (P), clarinet (Q) and ensemble (R) and for different music sources: floor of the nave (MA), and floor of the choir loft (MB).

$$ACII_{0-1} = \frac{ACII_i + ACII_{max}}{\Delta ACII_i} \quad (1)$$

where,

$$\begin{aligned} -1 &\leq ACII_i = \text{calculated value} \leq +1 \\ ACII_{max} &= \text{Maximum value} = 1 \\ \Delta ACII_i &= \text{range value} = 2 \end{aligned}$$

The subjective data was analyzed using *Excel*, *Origin 6.1* and *Origin 8*.

4. Results

The effect of different music source locations (within a church) and the effect of different music types on the subjective acoustical comfort of the listeners is assessed through the results of the ANOVA tests on the means of the populations of *ACII* averaged across 18 listener locations in the church as shown in Table 2.

Table 2. ANOVA tests on means of *ACII* populations in the church

ANOVA TEST ON MEANS OF <i>ACII</i> FOR DIFFERENT MUSIC TYPES AND DIFFERENT MUSIC SOURCES							
TYPE	Data	Mean	SD	SE	N	F value	p value
<i>ACII</i>	P	0.41	0.11	0.03	18	0.85	0.43
	Q	0.45	0.18	0.04	18		
	R	0.48	0.20	0.05	18		
<i>ACII</i>	MA	0.70	0.13	0.03	18	1.69	0.20
	MB	0.75	0.11	0.03	18		

5. Conclusion

Although the sacred music rendered by the ensemble seems to have elicited better scores of *Acoustical Comfort Impression Index (ACII)* among the listeners, yet there is no significant difference between the means of the listeners acoustical comfort impressions by the ensemble, cello or clarinet ($p = 0.43$). Amongst the two music source locations, although the *Acoustical Comfort Impression Index (ACII)* seems to favor the choir loft location, the music rendered therein is only 80% significantly more effective than the music rendered from the nave floor location ($p = 0.20$).

References

- [1] Vatican II, 1963. *Sacrosanctum concilium*, 4 Dec. 1963, article 14, 34.
- [2] M. A. P. S. Tavares, S. Rajagopalan and S. Sharma, 2007. Comparative Acoustical Studies of Two Goan Churches, *Proceedings of the 19th International Congress on Acoustics*, 2007, Madrid, Spain; *J. Revista de Acústica*, 38, 3.
- [3] J. Pereira, 2000. *Baroque India; The Neo-Roman Religious Architecture of South Asia: a global stylistic survey*, Aryan Books International, New Delhi.
- [4] C. J. Costa and S. Mascarenhas, 2009. Ed., *Pilar; a guide book*, Pilar Publications, Pilar.
- [5] R. Gettu, M. Santhanam, A. Menon and R. G. Pillai, 2013. Ed., *Rehabilitation and Restoration of Structures* IIT Madras, Chennai, 335 - 345
- [6] António P. O. Carvalho, 1996. Analysis of subjective acoustic measures and speech intelligibility in Portuguese churches, *Proceedings of 131st Acoustical Society of America meeting*, Indianapolis (USA).
- [7] M. A. P. S. Tavares, 2009. *Acoustical Studies of Worship Spaces*, Ph.D. thesis, Nagpur University, India.