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ALI QAPU: PERSIAN HISTORICAL MUSIC ROOM

by Hassan Azad

ABSTRACT

The Ali Qapu is a Safavid palace in Isfahan, Iran which was originally designed as a vast portal in the early 17th century and then it turned to a six-story palace with a series of additional architectural elements over a sixty year period to accommodate court functions. Building materials used for the structure of the Ali Qapu are mud and baked brick based on the foundation of the quarried stones. Vaulted ceilings of mud brick are richly decorated with painted, carved stucco and cutout Muqarnas in the sixth floor 'music room'.

This paper introduces the acoustically noticeable architectural elements of the music room of Ali Qapu and discusses their individual effects on the room by making different 3D model configurations and then comparing the results of simulation through the Odeon 9 acoustics computer program. Also some pieces of Iranian traditional music which are expected to be suitably similar to the music of the period of Ali Qapu have been selected for further auralisation related research. The final results provide us with a series of possible discussions revealing the capability of a unique idea of interweaving beauty of architecture and science of acoustics in a hybrid context of form and function.

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ALI QAPU: PERSIAN HISTORICAL MUSIC ROOM

Hassan Azad University of Tehran, University College of Fine Arts, Department of Architecture, http://www.ut.ac.ir/

1 INTRODUCTION

The Ali Qapu is a Safavid palace in Isfahan, Iran which was originally designed as a vast portal in the early 17th century and then it turned to a six-story palace with a series of additional architectural elements over a sixty year period to accommodate court functions[1]. Building materials used for the structure of the Ali Qapu are mud and baked brick based on the foundation of the quarried stones. Vaulted ceilings of mud brick are richly decorated with painted, carved stucco and cutout Muqarnas in the sixth floor 'music room'[2]. As it can be seen in Figure 1 cutouts on the surfaces of the Muqarnas in the shapes of ceramics and glassware have created delicate and fine surfaces which can also meet the acoustical characteristics of a complex and unique Helmholtz cavity absorberdue to their various forms and disparate air volumes behind them.

Figure 1: Cutout Muqarnas, Music Room, sixth floor

During the past decade the use of computer programs such as Odeon, CATT-Acoustics, EASE and Ramsete for the simulation of the acoustics field has become a useful method to predict and also analyze not only the objective acoustics measures but also the subjective qualities of the rooms and enclosures either before or after having them built. Ancient buildings which have had unique acoustical characteristics or have designed to meet music related functions have been the cases of interests for acoustician to be surveyed too. ERATO project (identification Evaluation and Revival of the Acoustical heritage of ancient Theatres and Odea) is one of the most considerable surveys which have exclusively carried out in this area of study. One of the objectives of this project is to study the acoustical properties of ancient theatres and to discuss their 'excellent' acoustics as they generally are described. As a result it is possible for the first time to listen to these historical buildings as they sounded in the past[3].

This paper introduces the acoustically noticeable architectural elements of the music room of Ali Qapu and discusses their individual effects on the room by making different 3D model configurations and then comparing the results of simulation through the Odeon 9 acoustics computer program. Also some pieces of Iranian traditional music which are expected to be suitably similar to the music of the period of Ali Qapu have been selected for further auralisation related research. The final results provide us with a series of possible discussions revealing the capability of a unique idea of interweaving beauty of architecture and science of acoustics in a hybrid context of form and function.

2 PREPARATION FOR SIMULATION

2.1 3D Modeling

The 3D model of Ali Qapu made in different steps through the programs below:
Auto CAD 2009 and Autodesk 3ds Max 2009 regarding to the disparate capability of these programs to make 3D objects and to export files with DXF or 3ds extensions. The architectural drawings and records from which the 3D model was created were collected from the different historic buildings survey projects carried out by Iran Cultural Heritage organization. Figure 2 illustrates an exterior scene of Ali Qapu rendered through 3ds Max program.

Figure 2: Exterior view of 3D model, Music Room

2.2 Architectural Elements Having Acoustical Properties

The fame of Music Room of Ali Qapu is because of its specific and distinct architectural elements having also noticeable acoustical properties, so in order to find out the individual acoustical effects of these details, they were separately pulled out from the Reference model and then the results obtained from the simulation of each configurations compared to either Reference model or to the other ones. The abovementioned configurations of the architectural elements displayed in Figure 3 and Figure 4 are listed as below:
Open windows in Reference model replaced with lattice frames with absorption coefficient of 0.4 in all frequencies in the first configuration. In the second one, cutouts on the surfaces of the Muqarnas covered in order to reveal the effects of the Helmholtz cavity absorbers and finally the role of entire Muqarnas as a diffuser discovered by its omission from the Reference model in the third configuration.

Figure 3: Bottom view, cutouts Muqarnas

The absorption coefficients of the materials acquired from the global material library of Odeon and also available technical documents about the materials which was used in Ali Qapu. The mere reliable in-situ measurement of Ali Qapu has been done by Dr. KH. Molana in collaboration with BHRC (Building and Housing Research Center) that shows the reverberation time in Ali Qapu in the frequency range of 100-3500Hz is approximately constant with the amount of 0.85 s[4].

Figure 4: Interior view

3 SIMULATION

3.1 Preliminary Measures

The imported .dxf models of Ali Qapu into Odeon with no bugs (duplicated or overlapped surfaces) were appeared to have a maximum surface number of 21577 in Reference model and a minimum surface number of 4264 in No Muqarnas model and the room volume measure for corresponding configurations was 847.07 m^3 and 1094.82 m^3 respectively. The simulation carried out with a number of 300000 rays as schematically shown in the Figure 5 and two Omni-directional sources in addition to 10 receivers to maintain an accurate calculation.

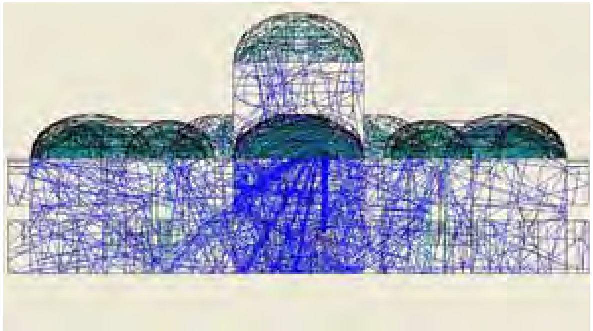

Figure 5: Propagation of rays from source 1

3.2 Objective Measures

The Odeon can make available results for 9 frequency dependent parameters ($EDT_{(S)}$, $T30_{(S)}$, $G_{(dB)}$, $SPL_{(dB)}$, $C80_{(dB)}$, D50, $Ts_{(ms)}$, LF80, $DL2_{(dB)}$) and 3 independent parameters (STI, $SPL(A)_{(dB)}$, $LG80_{(dB)}$) while using multi point response calculation. This paper has dealt with 5 parameters of T30, C80, DL2, STI and G having them analyzed and compared in 4 different configurations.

3.2.1 $T30_{(S)}$

The Figure 6 illustrates that in all configurations of Ali Qapu the reverberation time is considerably low and it ranges from around 1.5s in low frequencies to 0.7s in high ones. There is one notable point that the RT in all configurations except No Muqarnas which declines moderately from low to high frequencies is nearly constant between 125-4000 Hz 1/1 octave frequency bands and it has happened mainly due to the cutouts Muqarnas. All configurations seem to bring about higher RT than Reference model especially Lattice windows configuration which has increased T30 up to 1.47s.

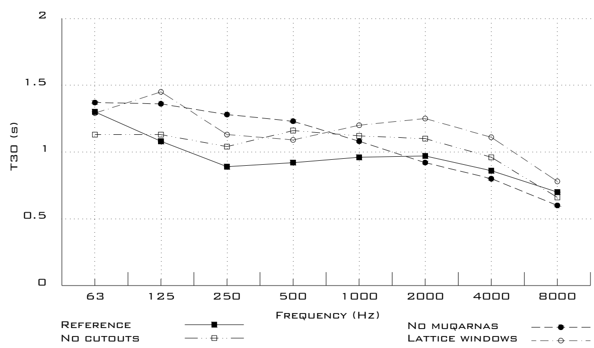

Figure 6: Simulated T30 in 4 different configurations

3.2.2 C80 $_{(dB)}$

As Figure 7 shows clarity is ranged between 0 to 6 dB in most of the configurations with the highest amounts in 125 to 4000 Hz frequency bands occupied by the Reference model. When Muqarnas has no cutouts clarity falls by 2-3 dB in mid frequencies and when other configurations take place it decrease by the average amount of 1 dB. These reductions can be expressed by the diminution in total absorption followed by increase in RT.

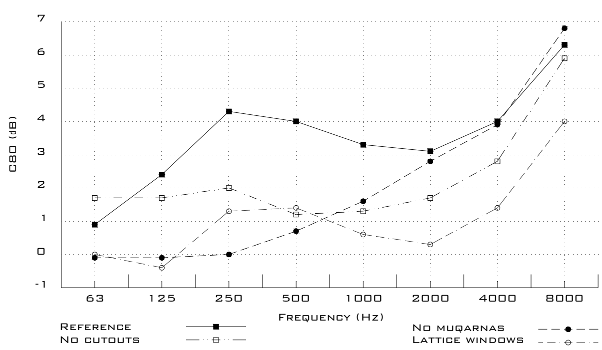

Figure 7: Simulated C80 in 4 different configurations

3.2.3 G (dB)

The range of strength shown in Figure 8 is nearly between 0 to 10 dB which is satisfyingly good in comparison with the amount that is suggested by the Odeon for existing successful concert halls (the strength should not be lower than +3dB). Furthermore, in spite of short distances between source and receivers, the level differences between different receiver positions are rather big and this might be due to the specific architectural spatial organization of Ali Qapu which has created different coupled spaces surrounding the main hall.

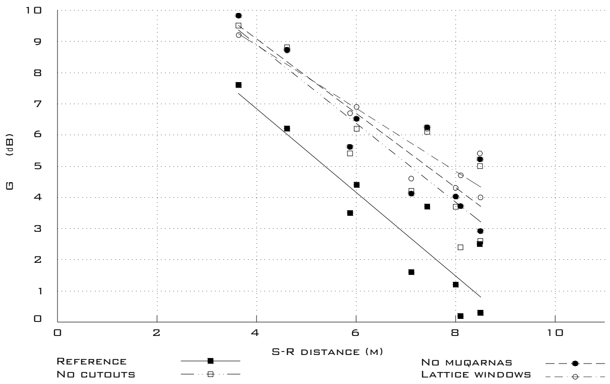

Figure 8: Simulated average strength over the 250-4000Hz frequencies in 4 different configurations

The rate of the level reduction over distance is rather identical in all configurations except Lattice windows. In fact this case has the lowest rate and consequently the lowest effect on G by S-R distance. The average sound decay over distance in Reference model is considerably lower than other configurations. This can confirm that the cutouts Muqarnas have a noticeable role as a diffuser in addition to its key role serving as a cavity absorber.

3.2.4 Average Acoustical Parameters

Table 1 indicates that DL2 is very high and is comparable to free field conditions in all configurations especially in Reference model. It should refer to the form of spatial organization of Ali Qapu and its coupled spaces. As a result of good STI value in all configurations the Ali Qapu could be used as an appropriate place for speech and intimate music rather than orchestral or symphonic music.

Configurations	Acoustical Parameters				
	T30 (s)	C80 (dB)	G (dB)	STI	DL2 (dB)
Reference	0.95	3.93	3.12	0.62	8.03
No Cutouts	1.11	1.55	5.39	0.57	7.50
No Muqarnas	1.13	1.28	5.77	0.58	7.68
Lattice Windows	1.23	0.90	6.07	0.56	6.46

Table 1: Simulated acoustical parameters average over the 250-4000Hz frequencies and S-R distance in 4 different configurations

Though the average T30 is close to each other in No cutouts and No Muqarnas configurations with the amount of 1.1s, in No cutouts configuration in contrary the reverberation time is considerably constant over the 250-4000Hz frequencies and it reveals the special acoustics characteristic of Muqarnas.

4 CONCLUSION

The following results can be derived from the acoustics computer simulations of Ali Qapu:
The reverberation time was nearly low in all configurations. This means that Ali Qapu has been so suitable for intimate music especially Iranian ballad which is a part of Iranian traditional music

performed in that era. It could be informative to be informed that recently there are some genres of Iranian traditional music which are being performed not only in choral but also in orchestral.

In spite of the high proportion of the room volume to the audience between 8 to 10 m^3 per person, the presence of cut-outs Muqarnas brought about low reverberation time to serve the function of the room as a host for speech and intimate music. Finally the maximum amount of C80 and the minimum of G in Reference model discover the diffuser role of the cut-outs Muqarnas.

5 REFERENCES

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