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Double layered micro-perforated panel as acoustic absorber in mosque

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ABSTRACT – Poor speech intelligibility in large mosque is still a classical problem in many cases to due to lack of consideration for its acoustic performance in the architectural design of the mosque's interior. This paper presents the assessment of indoor acoustics performance of a mosque by using CATT acoustic software. Double layered micro-perforated panel as the acoustic absorber is introduced. It is aimed at discussing the possibility to utilize the micro-perforated panels, which is new for mosque application instead of the typical porous, fibrous absorbers or the conventional Helmholtz resonator. The results show that the micro-perforated panels successfully reduce the reverberation time at low frequencies which can improve the speech intelligibility in a mosque.

1. ACOUSTICS IN MOSQUE

Mosque is an important house of worship for Muslims. As most activities in a mosque deal with speech, good speech intelligibility is thus important to ensure clear voice are delivered to the congregations. Acoustic performance in mosque therefore becomes topics of interest to be studied. The existing studies using simulation include the effect of the wall geometry [1] and roof/ceiling shape [2, 3]. Some studies also conducted on-site measurements for acoustic characterization [4,5]. Discussion on the utilization of the new generation of non-fibrous absorber, namely the micro-perforated panel (MPP) in a mosque is still lacking. As most acoustic problems in mosque are at low frequencies [6], implementation of the MPP absorber is thus more suitable than the fibrous or porous materials which are best at mid to high frequency range. The MPP performance also resembles that of a Helmhotlz resonator. Simulation for the single MPP, however has been presented in [7] and in this paper, investigation is extended to the double micro-perforated panels (DMPP).

2. SIMULATION MODEL

2.1 CATT Geometry Model

Indoor geometry for the simulation model is developed by using CATT acoustic software version 9. The volume of the mosque is chosen to imitate a mosque having a typical large volume of the main hall area as seen in Figure 1. This geometry of mosque, with a unique inclined ceiling is mostly found in Melaka, Malaysia which follows the architecture a traditional Malay house.

Omni directional sound source is placed in front of the mihrab to simulate the speech coming from this area. The main prayer hall is divided into 16 symmetrical areas; with each of the area contains one receiver of 0.5 m to assume the height of ear of a person sitting on the carpeted floor. The absorption coefficient for the materials in the interior including the concrete wall, plaster ceiling, glass window, solid wooden door and thick carpet are extracted from the software data library.

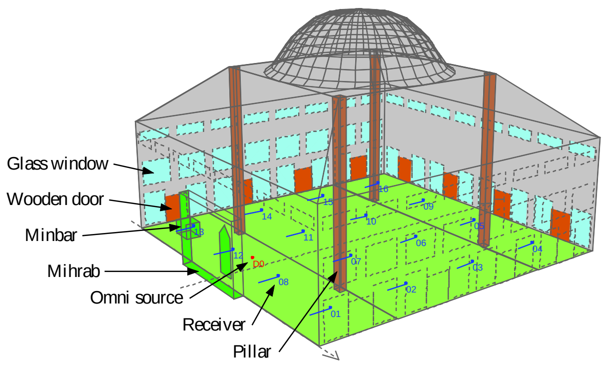


Figure 1 The 3D view of mosque model from CATT.

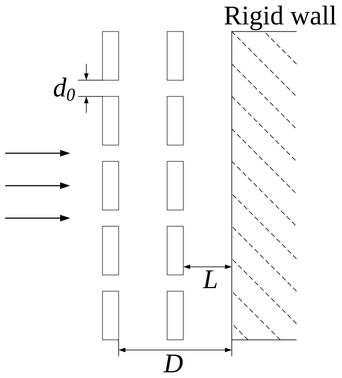
2.2 Double layered micro-perforated panel (DLMPP)

The theory and design of micro-perforated panel (MPP) were pioneered by Dah You Maa in 1975 [8]. MPP are solid panels with holes of less than 1 mm and perforation ratio between 0.5–1 %. The performance of sound absorption for MPP is usually narrow and is mainly at low frequency. The double layered micro-perforated panel (DMPP) is found to be able to widen the frequency band of absorption. Figure 2 shows the diagram of the DMPP system and the analytical simulation of absorption coefficient for different distances between first MPP, *D* and between second MPP, *L* where both distances are from a rigid wall.

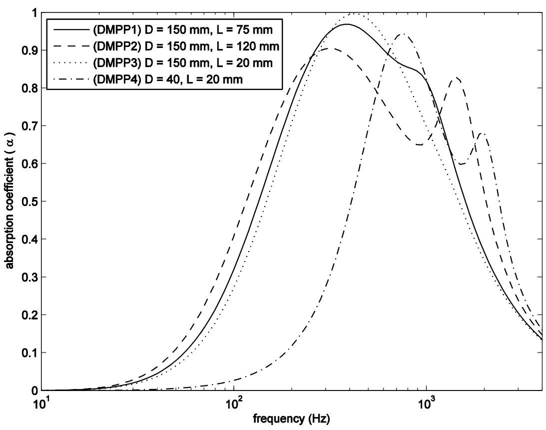
3. REVERBERATION TIME RESULTS

The first simulation is run for the CATT model without MPP installed in the mosque. It is found that the RT reaches 6.47 s at 500 Hz and 4 s at 1 kHz. This is used as the baseline result. The second is by assuming the whole inclined ceiling is covered with DMPP (as seen in Figure 3) with the absorption coefficient of DMPP is as shown in Figure 2(b).

Figure 4 shows the simulation results with DMPP installed on the ceiling. The RT can be seen to reduce to below 3 s at 500 Hz and to below 2.5 s at 1 kHz. The more speech content to the sound, the lower the ideal RT in a room should be. However, by compromising the recitation of Quran as a liturgical music, RT between 2 s to 3 s could still be acceptable [9].



(a)



(b)

Figure 2(a) Schematic diagram of DMPP in front of a rigid wall and (b) absorption coefficient of DMPP.

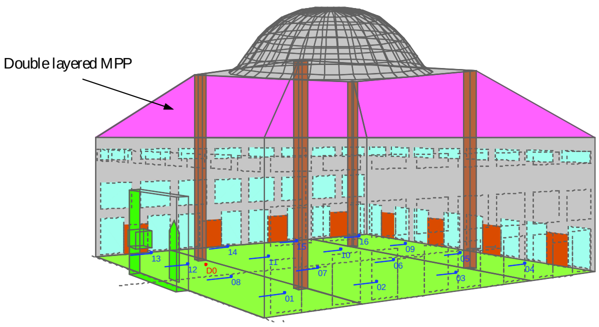


Figure 3 CATT model with DMPP installed on ceiling.

4. CONCLUSIONS

It has been shown from the simulation that use of DMPP in the mosque to improve the acoustic performance is feasible. For the depth of the study in the future, results from real measurement is therefore of interest.

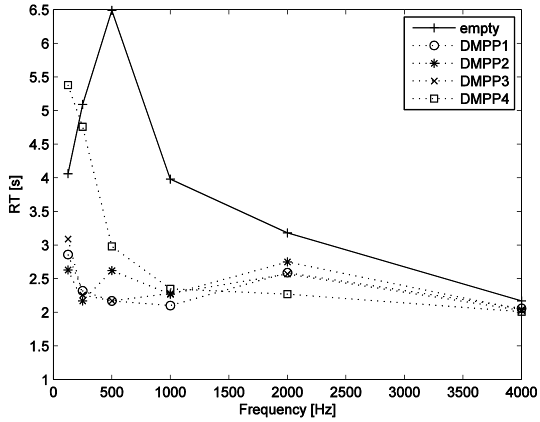


Figure 4 The simulation results of reverberation time.

5. ACKNOWLEDGEMENT

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