THE AUTOMATION OF SOUND ABSORPTION COEFFICIENT MEASUREMENT

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ABSTRACT

By manual method, the sound absorption coefficient measurement should be done by utilizing many type of equipment such as: measuring amplifier, level recorder, band-pass filter, protactor, etc. However it caused inefficient and need longer time in processing measurement data, therefore the automation system of sound absorption coefficient has been realized. An acoustical real time analyzer type B&K 2144 has been used to record the decay of sound pressure level, thus the processing data is driven by computer software program. By using this developed measurement system, the configuration of equipment which is used in measurement system is becoming more simplified, moreover the time process which is required for sound absorption coefficient measurement can be reduced significantly.

Keywords*: sound absorption coefficient, automation measurement system*

1. INTRODUCTION

Whenever a sound wave meets a surface, some small amount of its energy is lost. The absorption of a surface is a function of many parameters, including its effective roughness, its porosity, its flexibility, and in some cases its resonant properties. The efficiency of an absorbing surface is expressed as a number between 0 and 1, called absorption coefficient. 0 represents no absorption, i.e. perfect reflection, which is never encountered in practice, and 1 represents perfect absorption [1].

The sound absorption coefficient of material can be measured in the reverberation room. A pink noise which is generated from noise generator is turned on long enough to get a steady state condition of sound pressure level in the room. When the sound source is turned off, the sound pressure level will decrease, thus the sound absorption are obtained by measuring the time rate of decay of the sound energy density in an approved reverberation room with and without the object under test present in the reverberation room, and then the sound absorption coefficient (α) is computed by dividing the specimen sound absorption by the specimen area. Previously the sound absorption coefficient was measured manually, where this method should utilizes many types of equipment, i.e. measuring amplifier, band pass filter and level recorder. The reverberation time was determined by analyzing the time rate decay of the sound pressure level which is found from level recorder chart. The measurement is done sequentially at each frequency of interest in 1/3 octave which is selected by using band pass filter. Therefore this method is very inefficient and takes longer time for the measurement process. Using the developed measurement system, the measurement process of sound absorption coefficient can be made simplified. It uses acoustic noise analyzer to record the decay of the sound pressure level and then the software program was built to calculate the sound absorption coefficient at each frequency interest, so that when the user click the "*Proceed*" button, the numerical values of sound absorption coefficient result and the graph of sound absorption versus frequency can be immediately displayed on PC monitor.

2. SOUND ABSORPTION MEASUREMENT

The absorption coefficient of a material indicates the proportion of sound absorbed by the material relative to the total incident sound. The measurement of sound absorption is conducted in the reverberation room. Standard procedure for sound absorption coefficient measurement is presented in ISO 354-1985: *measurement of sound absorption in a reverberation room* [2]. The sound absorption coefficients are obtained by measuring the time rate of decay of the sound energy density in an approved reverberation room (reverberation time) with and without a patch of the sound absorbing material under test laid on the floor [3]. The equivalent sound absorption area *A*, in square metres, of the test specimen, shall be calculated using the Equation (1):

$$A = 55.3\frac{V}{c}\left[\frac{1}{T_2} - \frac{1}{T_1}\right] \quad (1)$$

where:
c = velocity of sound in the air (m/s)
V = volume in m^3 of the empty reverberation room
T_1 = reverberation time in seconds of the empty reverberation room
T_2 = reverberation time in seconds of the reverberation room containing a test specimen

For temperatures in the range 15 to 30 ºC, the velocity of the sound in the air, c, in m/s, can be calculated from the Equation (2):

$$c = 331 \square 0.6\,t \quad (2)$$

where t is the air temperature in degree Celsius.

The sound absorption coefficient α of a plane absorber shall be calculated using the Equation (3):

$$\alpha = \frac{A}{S} \quad (3)$$

where:
A = the equivalent sound absorption area, in square metres, calculated in equation .
S = the area, in square metres, of the test specimen
The test specimen shall have an area between 10 and 12 m^2 and rectangular shape with a ratio of width to length between 0.7 and 1.

3. MEASUREMENT SYSTEM

3.1 Manual Method

The configurations of the manual method of sound absorption coefficient measurement system consist of equipment such as band-pass filter, measuring amplifier, level recorder, pink noise source, omnidirectional speaker and amplifier. Because of the ambient noise level is relatively high therefore, the sound source has to be loud enough [4]. A pink noise which is used as sound source is amplified by power amplifier. It is turned on long enough to get a steady state condition of sound pressure level in the room. When the sound source is turned off, the sound pressure level will decrease to the lower level. The microphone will detects the sound pressure level then amplified by pre amplifier and finally the sound level will be measured by measuring amplifier. The measurement is done step by step at each frequency of interest in 1/3 octave which is selected by using a band pass filter. The decaying of sound pressure level is recorded and printed out by the paper sheet of level recorder, thus the reverberation time can be determined by analyzing the time rate decay of the sound pressure level which is found from level recorder chart. This procedure is used both, i.e. with and without the object under test present in the reverberation room. The measured reverberation time then computed manually in a *Microsoft Excel*™ to obtain the sound absorption coefficient (α).

3.2 Automatic Method

Fig. 1 shows the configuration of developed sound absorption coefficient measurement system. By this developed measurement system, the utilization of band-pass filter, measuring amplifier and level recorder are replaced with an acoustical real time analyzer. Where the decay of sound level in the frequency range of 100 Hz to 5000 Hz is measured simultaneously by acoustical real time analyzer and then all data are saved in the enable memory file, furthermore the data can be transferred to a PC for data processing. This capability is used to determine the reverberation time [5]. Fig. 2 shows the flowchart of computer software program to drive the automation of sound absorption measurement system.

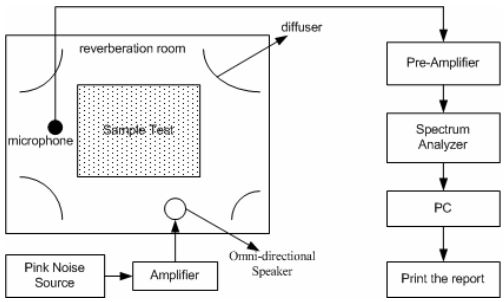

Fig. 1. The Configuration of developed measurement system

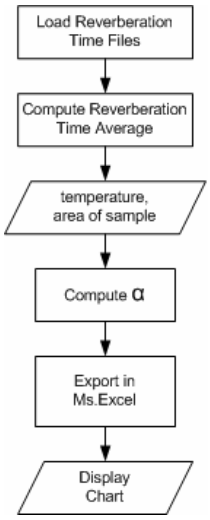

Fig. 2. Flowchart of the computer software program

4. RESULT & DISCUSSION

4.1 Result

The main graphical user interface of the software program for sound absorption measurement can be seen in Fig. 3. Before doing the measurement, the user should entry all parameter regarding to test specimen data such as name, type, dimension of test specimen and environmental condition. The measurements of reverberation time were done in 4 measurement points and each measurement point was repeated 3 times. So that the total files for each frequency measurement are 24 files, i.e. 12 files for empty room and 12 files for room containing test specimen. All data are saved in the memory file of acoustical real time analyzer type B&K 2144, thus the data is transferred to the disk. After opening the software program of reverberation measurement [5], then the reverberation time data from disk are introduced to the program. When the "*Proceed"* button is clicked, it means all data will be computed by the program to obtain the sound absorption coefficient of each frequency measured

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and to draw a graph of sound absorption coefficient versus frequency. Finally, the complete measurement report in Ms. Excel can be generated by clicking the button of "*Report"*. Fig. 4 shows the complete measurement results of sound absorption coefficient of a material test.

4.2 Discussion

By conventional method the measurement of reverberation time and its analysis is done manually at each frequency of interest in 1/3 octave, therefore it spends a lot of time for the measurement process, where for the sound absorption measurement in the reverberation room is required 4 measurement points at different position and each measurement is repeated 3 times. Based on our investigation the process time which is required to measure one set of material is 8 hours.

On the other hand by using the developed measurement system, the reverberation time measurement can be done simultaneously at all frequency of interest in 1/3 octave. The reverberation time data is automatically computed by the software program to obtain the sound absorption coefficient. Therefore, by the same measurement object, the effective time which is required to measure one set of material is only 45 minutes. Moreover, by this developed measurement system, the utilization of band-pass filter, measuring amplifier and level recorder can be replaced only with one equipment i.e. the acoustical real time analyzer type B&K 2144. Due to that, the measurements become more practice. But the measurement is not fully automated because the data should be transferred from analyzer to the PC using floppy disk medium. In the further development, the data from analyzer gathered by PC using GPIB interface.

Fig. 4. Generated measurement report

5. CONCLUSIONS

a. The sound absorption measurement by manual method should utilize a lot of equipment, therefore this method is much unpracticed and need longer time for measurement process, i.e. to measure one specimen of sample should spend about 8 hours.
b. By using the developed method the sound absorption measurement can be done more practice, where the calculation, and the format of measurement report can be done automatically by the software program, hence the process time of measurement became shorter, i.e. only need 45 minutes for the same sample.
c. Moreover, by this developed measurement system, the utilization of band-pass filter, measuring amplifier and level recorder can be replaced only with one equipment i.e. the acoustical real time analyzer type B&K 2144 so that, the sound absorption measurement by using this method became more simplified.
d. Nevertheless, the measurement is not fully automated through the utilization of floppy disk for data transfer but in the further development the data transferred through GPIB interfaces thus creating fully automated measurement system.

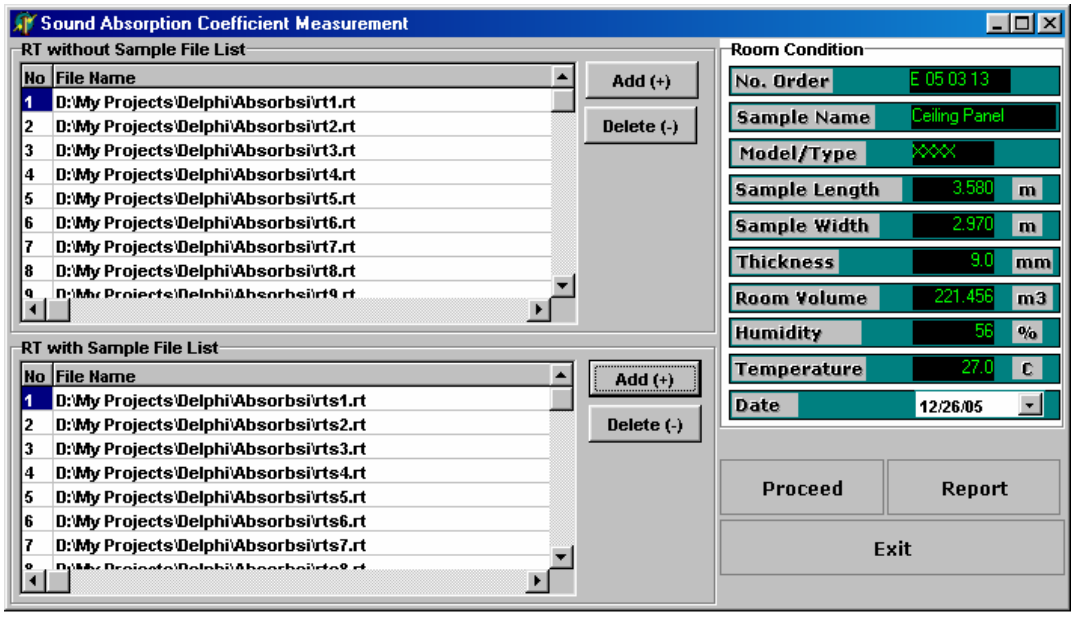

Fig. 3. The performance of the graphical user interface

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