Analysis of Noise over the Pavement Trough Anechoic Chamber

Pahola Porras [1], J. Camacho-Tauta [2], O.J. Reyes-Ortiz [3]

(1) nelcy.porras@unimilitar.edu.co
(2) Javier.camacho@unimilitar.edu.co
(3) Oscar.reyes@unimilitar.edu.co

Geotechnical Group, Faculty of Enginering
Nueva Granada Military University, UMNG
Bogotá, Colombia

Analysis of Noise over the Pavement Trough Anechoic Chamber

Keywords:
Anechoic Chamber; Frequency; Noise; Microphone; Pavement.

ABSTRACT

The anechoic chamber is an efficient way to measure the level of noise produced by a traffic loading over a structure of pavement. This kind of chambers are useful to analyze the noise that some processes generate. The geotechnical group of Nueva Granada Military University designed a new prototype of an anechoic chamber that works inside the accelerated pavement testing machine (APT).
This paper describes the designing process in three parts. In the first part, the main mechanical characteristics of the anechoic chamber were defined using SolidWorks. Then, the specifications about position of sensor and data logger were selected to analyze noise from 10 dB up to 90dB. Finally, the last part of the paper deals with preliminary tests conducted in different speeds of the APT with 6 omnidirectional microphones. Results were studied with Smaart V7 software.
To sum up, the anechoic chamber is an effective and reliable machine to analyze the noise due to traffic- pavement structure interaction.

I. INTRODUCTION

The road transit noise could be demarcated by the contact of the wheel cars with the structure pavement [1]. Anechoic chambers has been built over the last years to improve the knowledge about this phenomenon and propose alternatives to reduce the resulting noise [2]. The anechoic chamber consists in a close chamber with absorbent material, which depends on the level of noise that it want to be analyzed [3].

The absorbing textile is a very important detail to take into account as a parameter to isolate the noise source to be measured [4]. As a consequence, different types of porous absorbing materials have been developed [5]. Noise and vibration are variables that usually affect mechanical systems and sometimes are used to diagnostic and monitor a machinery [6]. Usually foam material is used in anechoic chambers to noise pavement analysis [7].

Special sensors are used to measure the level of noise inside of anechoic chambers. For instance, omnidirectional microphones are the greatest to acquire the data [8]. Also, the position of the sensors depend on the kind of pavement on the test [9].

Then, to realize a complete test around a noise a data logger has to be installed. Besides, a special software with integrated measures, analysis and multitasking system should be used [10].

As a consequence, the Nueva Granada Military University wanted to make his own anechoic chamber to installed in the before built accelerated pavement testing machine [11] to also evaluate different structures of pavement flexible and rigid with fatigue studies [12].

II. ANECHOIC CHAMBER DESCRIPTION

To design an anechoic chamber the main variables to take into account are: level of noise to analyze, shape, material, sound and noise.

A. Main variables to evaluate:

1) Noise level to analyze: Noise sources is a result of a pressure that can be measured a different positions. The level of noise that it will be studied is around 20dB up to 90dB with a rolling type around 10Km/h. That speed is produced by the acelerarted pavement test machine (APT), which was aslo building by the geothecnical group at Military University [11,12]. The APT is controlled by a servomotor that was assembled to tyre axis Fig 1. Moreover, the velocity of the servomotor is selected by touch panel screen.

Fig. 1. APT Machine at Military University full view. Source: Authors.

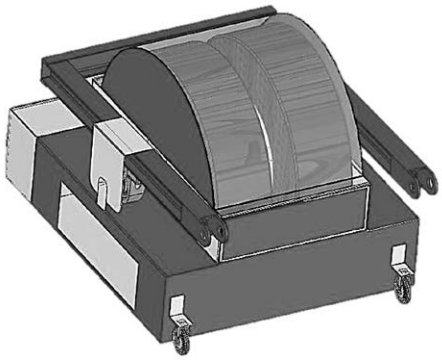
2) Shape : There are a large variety of anechoic chamber form, but as previously mentioned this chamber has to be assembly in the APT machine showed in Fig 2.

Fig. 2. APT Machine at Military University. Source: Authors

Due to determined space in the APT machine, the chamber was designed over the Wheel and assembled with the shaft tire.

The final design was evaluated as simulated by SolidWorks and is described in Fig 3.

Fig. 3. Design Anechoic chamber. Source: Authors



The design contains two sub-assemblies. On the upper side, the tire is covered by a semicircle. No sensor could be installed in this area due to the limited space.

3) Material selection : With the level of noise defined before the sound fiber was selected. The acoustic fiber is a special material that avoids the external noise and also the domes allowed the sound refraction. A Fiber class type dome of 5cm was chosen Fig 4 and Fig 5.

Fig. 4. Absobent acustic foarm. Source: Authors.

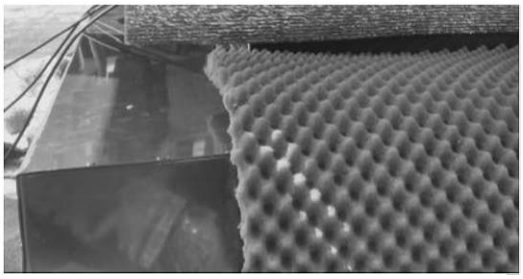
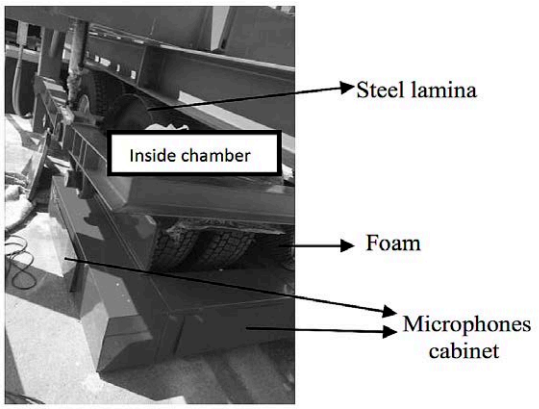


Fig. 5. Material selection. Source: Authors



4) Difference between sound and noise : The central knowledge in acoustic is distinguished between noise and sound as well as the frequency that usually take place. Noise is a no-harmonic vibration, which produces by a different scale of pressures. In contrast, sound is a harmonic vibration that human can ear after 20Kz. That is a very important characteristic to consider when the sensors are selected.

III. INSTRUMENTATION AND DATALOGGER

A. Microphones:

A deep research with the kind of sensors that will going to use was done. Finally, a cardioid omnidirectional microphone was selected DBX RTA-M (Fig 6), which are used with the System Setup Wizard. It is ideal for optimizing the sound quality of even the most difficult of acoustic environments.

Fig. 6. Omnidirectional microphone. Source: Authors

This kind of microphones has a frequency response of 20Hz up to 20000 Hz, impedance of 250, Sensitivity 63dB +/- 3dB, and an operating voltage 9 V.

B. Datalogger:

A PreSonus audiobox was carefully chosen as a datalogger, with capacity of 8 channels that is presented in Fig 7. 5.

Fig. 7. Datalogger of 8 channels. Source: Authors

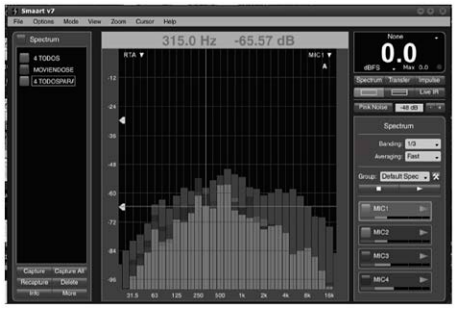
IV. RESULTS

As a result of the design and building of the anechoic chamber the final structure is showed in Fig 7. 6.

Fig. 8. Anechoic chamber installed in APT. Source: Authors

Then a few tests were done with 5 microphones, 2 in each side and 1 on the front of the chamber where the pressure is bigger. First, the noise outside of the chamber was registered such us: hydraulic pump, motor, chain. Second, the APT was moved in different speed from 60 up to 300 rpm. Data are exposed in Fig 9.

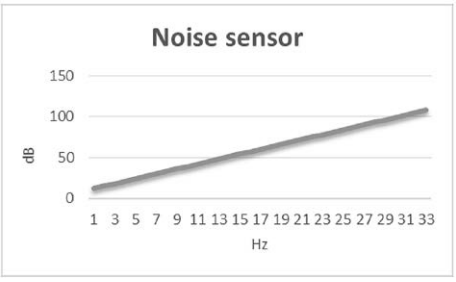
Fig. 9. Data registered by Smaart V7. Source: Authors



On the other hand Smaart V7 is a professional program which use Fourier and other kind of process to export the data as the final user wish in excel sheet.

In Fig 10. The data from sensor 1 positioned in front of the chamber. As it seems on sensor 1 the frequency is directly proportional to the level of Noise.

Fig. 10. Sensor 1 data. Source: Authors



V. CONCLUSION

The anechoic chamber is an effective and reliable machine to analyze the level of noise produce by the contact of tire with the pavement.

The outside noise could be affect the test, even an airplane was flying in the first test and the noise on the data was exhibited.

The used of a professional sensors and datalogger it was a useful tool to analyze the data in a respectable method.

This kind of machine can be advantageous to civil engineers in order to design new roads.

ACKNOWLEDGMENT

The authors would like to thank Nueva Granada Military University and the Vice-Rectory of Research for the economic support with the project IMP-ING-1575.

REFERENCES

[1] R. Ahmed, Y. Yendrew and N. Ahmed, 'Building a Practical Anechoic Chamber for Aero-Acoustic Measurements', AMM, vol. 607, pp. 685- 693, 2014.

[2] R. Sottek and B. Philippen, 'Tire-Road Noise Analysis of On-Road Measurements under Dynamic Driving Conditions', SAE International Journal of Passenger Cars - Mechanical Systems, vol. 5, no. 3, pp. 1116- 1123, 2012.

[3] A. Ongel, E. Kohler, Q. Lu and J. Harvey, 'Comparison of Surface Characteristics and Pavement/Tire Noise of Various Thin Asphalt Overlays', Road Materials and Pavement Design, vol. 9, no. 2, pp. 333- 344, 2008.

[4] 'Reducing tire-road noise', Noise & Vibration Worldwide, vol. 40, no. 4, pp. 26-26, 2009.

[5] Z. Guo and G. Shen, 'Analysis of Tire-Pavement Noise Spectrum of Noise Reduction Dense Asphalt-Rubber Pavement', Advanced Engineering Forum, vol. 5, pp. 345-351, 2012.

[6] F. Tyzzer, Development of a suitable anechoic treatment for the ASD Sonic Fatigue Facility. Wright-Patterson Air Force Base, Ohio: Aeronautical Systems Division, Air Force Systems Command, United States Air Force, 1963.

[7] S. Labate, 'Porous Materials for Noise Control', Noise Control, vol. 2, no. 1, p. 15, 1956.

[8] K. Chung, 'Comparisons of spectral characteristics of wind noise between omnidirectional and directional microphones', The Journal of the Acoustical Society of America, vol. 131, no. 6, p. 4508, 2012.

[9] J. M, A. Flach and A. Zbrowski, 'Control System of a Manipulation Mechanism for Acoustical Measurement in Anechoic Chamber', Solid State Phenomena, vol. 198, pp. 467-472, 2013.

[10] M. Gilchrist, A. Hartman, P. Owende and S. Ward, 'Full Scale Accelerated Testing of Bituminous Road Pavement Mixtures', KEM, vol. 204-205, pp. 443-452, 2001.

[11] Vargas-Fonseca,G.L.;Reyes-Ortiz,O.J.,"Controllerdesig ntohydraulic system of the accelerated pavement testing machine in full scale," Engineering Mechatronics and Automation (CIIMA), 2014 III International Congress of , vol., no., pp.1,5, 22-24 Oct. 2014,doi: 10.1109/CIIMA.2014.6983462

[12] Andres, T.-R.; Pahola, P.; Reyes-Ortiz, O.J., "Automation of a fatigue machine for the load analysis in flexible pavements," Engineering Mechatronics and Automation (CIIMA), 2014 III International Congress of , vol., no., pp.1,4, 22-24 Oct. 2014 doi: 10.1109/CIIMA.2014.6983446