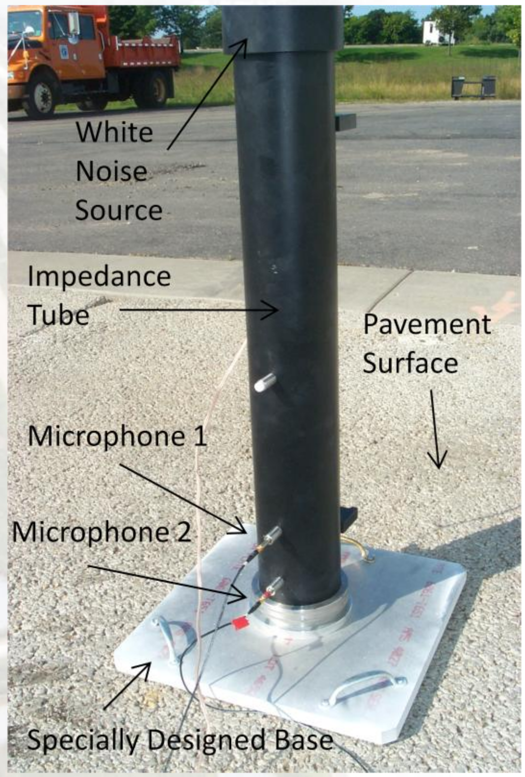
SOUND ABSORPTION COEFFICIENT OF PAVEMENTS – IMPEDANCE TUBE (ASTM E – 1050 MODIFIED FOR IN-SITU TESTING)

General Description



Mn/DOT's BSWA 435 in-situ sound absorption measuring device consists mainly of a rigid impedance tube, capped by a white noise source, supported on a steady base and equipped with two microphones. The tube facilitates insulation from exterior sound source when the white noise source sends signals to the pavement surface. The 11 inch (100 mm) diameter tube accommodates two microphones that are connected to a frequency analyzer. These dimensions of the tube allow an analysis within a range of 20 and 800 Hertz. The separation of the incident noise from the reflected noise is accomplished by the transfer function method.

The sound absorption test is a process that measures the sound absorptiveness of a pavement surface. During the test, the sound analyzed is not generated by the interaction of the rolling tire with pavement surface but by noise source above the impedance tube. On the BSWA 425 device, a white noise source is used. White noise is a random audio signal with a flat power spectral density that contains noise at the same power at all frequencies. During the test, the impedance tube is placed on the pavement surface and a set of sensitive microphones are attached to the pre-installed housing at the lower end of the tube. These microphones are also connected to an analyzer. The noise source sends the incident sound energy (white noise) to the surface and the incident and reflected waves are captured by the two microphones. Software windows the reflected waves and converts the data to the 3rd octave sound absorption coefficient at 315, 400, 500, 750, 1000, 1250 and 1650 Hertz. Thus, the coefficients need to between one and zero where a value of one would mean that all of the sound is being absorbed.

Sound absorption output is generated as a function of frequency as shown in equation 1 (below). Ordinarily, the result is generated in a narrow band but 3rd octave band results are reported. Berengier et al discussed that the sound absorption coefficient (R_p) is expressed as a function of frequency:

$$|R_P(f)|^2 = 1 - \frac{1}{K_r^2}\left|\frac{P_r(f)}{P_d(f)}\right|^2 \qquad (Equation\ 1)$$

Where: K_r is the spreading factor, P_r is the reflected sound energy and P_d is the incident sound energy (3). The output of a sound absorption factor is typically in the form of the sound absorption at the seven frequencies defined earlier. Hence, factor is therefore expressed as a function of frequency.

With this information, the pervious surfaces can thoroughly be analyzed to evaluate acoustical properties. It is also used on other surfaces for an overall evaluation of surface parameters affecting tire – pavement noise. On-going studies are being conducted to find if/how these coefficients correspond to the On-Board Sound Intensity (OBSI) and surface porosities indicated by the Circular Track Texture Meter (CTM).

COLLECTION FREQUENCY

MnROAD plans on collecting information two times a year. Additional tests will be conducted on an as needed basis.

Specifications

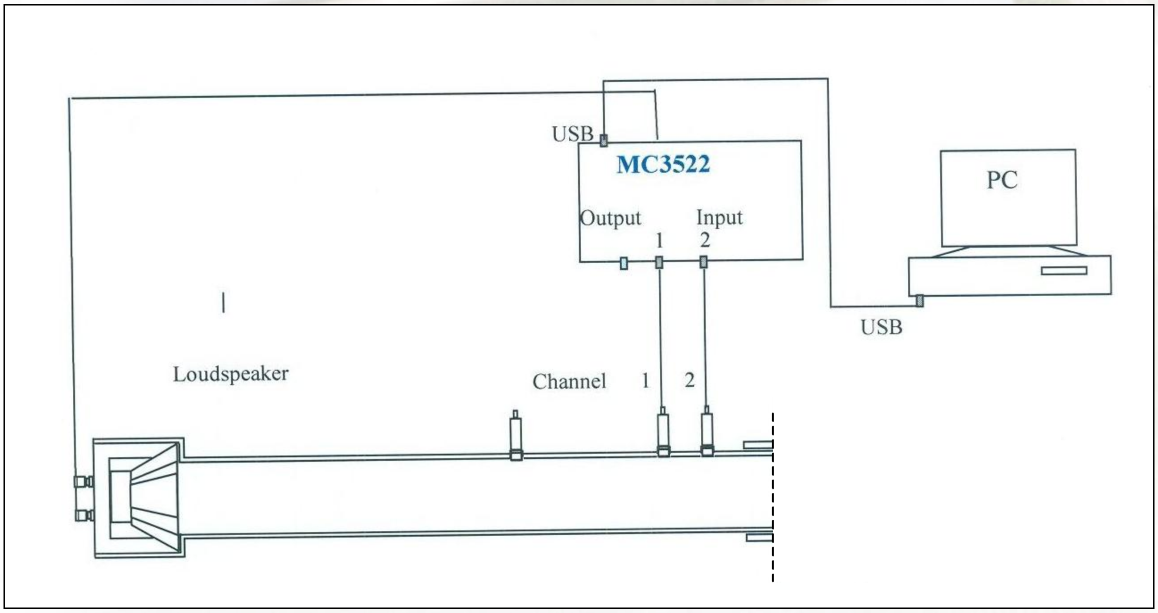
1. ISO 10534-2, "Acoustics – Determination of Sound Absorption Coefficient and Impedance in Impedance Tubes – Part 2: Transfer-Function Method."

2. ASTM E-1050, "Standard Test Method for Impedance and Absorption of Acoustical Materials using a Tube, Two Microphones and a Digital Frequency Analysis System."

3. Berengier, M., et al. Procedure for Measuring the Sound Absorption of Road Surface In-Situ. Euro Noise '98 Conference. Munchen, Germany, 4-7 October 1998.

Field Data Collection Process

Start by unloading equipment and setting it up. Set-up consists of placing base plate on the end of the tube and connecting the wires and microphones as shown below.



Once the set-up is complete and the equipment is running, the sound absorption program can be started (VA-Lab2). Enter general information about the date, the location, which device is being used (MC3522) and calibrate the microphones. Before any measurement can be taken, the atmospheric pressure (Pascal) and the temperature (degrees Celsius) need to be entered into the program. Then use the Transfer Function Method to capture the measurements.

Each measurement consists of four steps:

1. Capture sound for 10 to 15 seconds.
2. Switch the microphone's positions.
3. Capture sound for another 10 to 15 seconds.
4. Save measurements as the test number being conducted (1, 2, 3, etc).

These steps are then repeated for each measurement. Each location needs to have at least two separate measurements to ensure that the results are accurately depicted.

The operator also needs to keep track of the locations of the various tests that are being conducted. Information consists of which cell, station number, lane, wheel-path and any general comments on the pavement condition. This information is collected on a Field Data Sheet and is later transferred to Excel. The cells that being tested get data from at least three different stations and different wheel-paths but the number of total measurements for a cell vary depending on the emphasis of sound absorption for that particular cell.

Data Processing

The data files are saved as .txt files but contain a lot of information that isn't easily extracted from the file. In order to get the necessary information, a more user-friendly program (VA-Lab2) is used to create an Excel file for each test conducted. Then each Excel file has the sound absorption values for the various sound frequencies in an easily accessible manner. So, if 150 tests were completed then 150 Excel files would need to be created.

Next, the Field Data Sheet is transferred to an identical Excel file. Finally, the measurements are broken apart by station, lanes, wheel-paths and cell numbers to get various averages for each tested cell and create graphs with this information.

Limitations

White noise has a flat PSD and is not a true reflection of tire – pavement noise but is sufficient to indicate differences brought about by the pavement surface.

Database Tables

Sound absorption data is stored in the table MNR.DISTRESS_SOUND_ABSORPTION. See the table below for a description of the data.

DATABASE TABLE –SOUND_ABSORPTION

Name	Type	Example	Description
CELL	NUMBER (3.0)	2	MnROAD cell number
STATION	NUMBER (7.1)	116405.5	Station number according to field markers
OFFSET	NUMBER (2.1)	13	Offset from centerline
LANE	VARCHAR(30)	Mainline_Driving	Facility and lane being tested
WHEELPATH	VARCHAR (12)	LWP	Position of test
TRIAL	NUMBER (2.0)	1	Test number at certain location
OPERATOR	VARCHAR(30)	Tim Nelson	Name
DATE	DATE	10/11/2009	Date of test
TIME	TIME	11:15:22	Time of test
TEMPERATURE	NUMBER(2.0)	25	Temperature (degrees Celsius) at test
ATMOSPHERIC PRESSURE	NUMBER(6.0)	101400	Pascal – At time of test
CONDITION	VARCHAR (30)	Sunny	Weather at test
FREQUENCY	NUMBER(4.0)	1250	Sound frequency – Hertz
SOUND ABSORPTION	NUMBER(2.2)	0.24	Decimal percent of sound absorbed
COMMENTS	VARCHAR(30)	Near Core	Comments about test

For more information:

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