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THE INFLUENCE OF ROAD CHARACTERISTICS AND TIRES ON VEHICLE NOISE

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***Abstract*—** Frictional noise from the contact between tires and pavement contributes significantly to overall traffic noise. The level depends on the type and condition of tires and pavement. Frictional noise is generally greatest at high speed and during quick braking. In this paper was analyzed the influence of roar characteristics and tire types over the noise produced by the vehicles. There ware made noise measurements with a specific vehicle, in different conditions (on asphalt and concrete roads and with summer and winter tires). The measurements ware made considering Noise Romanian Standard.

***Keywords*—** Asphalt, Concrete, Noise, Pollution, Tire, Vehicle.

I. INTRODUCTION

Objective measurements of sound levels are an indispensable part of any environmental noise protection program. Environmental noise levels vary greatly − noise is often impulsive or contains pure tones. In addition, disturbances from extraneous sources of noise − be it barking dogs, flyovers, or children playing − must be handled one way or another.

Standards and regulations specify which parameters must be measured, and in most cases they also prescribe how to set up measurement equipment and handle various factors such as meteorological conditions. On top of this, certain "good practices" exist. The result of a noise assessment is never simply a figure such as 77dB. It is the value of specific parameters or indicators obtained under known and documented conditions [2].

Road traffic is the most widespread source of noise in all countries and the most prevalent cause of annoyance and interference. Therefore, traffic noise reduction measures have the highest priority. The physical characteristics of the road surface and its surroundings play a large role in determining noise output. Well-maintained, smooth-surfaced roads are less noisy than those with cracked, damaged, and patched surfaces. Expansion joints in bridge decks are especially noisy. Roadside surfaces such as vegetated soil tend to absorb and moderate noise, while reflective surfaces like concrete or asphalt don't have any beneficial function [7].

II. THE NOISE MEASUREMENTS

If a noise source is narrow in one direction and long in the other compared to the distance to the listener, it is called a line source. It can be a single source such as a long pipe carrying a turbulent fluid, or it can be composed of many point sources operating simultaneously, such as a stream of vehicles on a busy road. The sound level spreads out cylindrically, so the sound pressure level is the same at all points at the same distance from the line, and decreases by 3dB per doubling of distance. This holds true until ground and air attenuation noticeably affect the level.

Wind speed increases with altitude, which will bend the path of sound to "focus" it on the downwind side and make a "shadow" on the upwind side of the source [1].

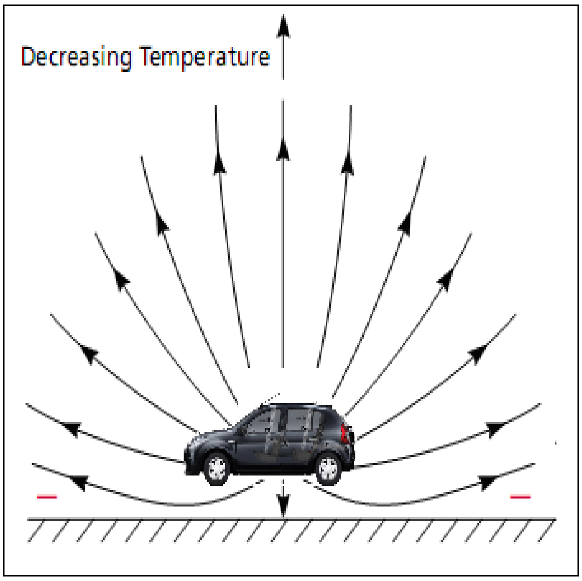

Fig. 1. Noise measurements at lower temperatures.

At short distances, up to 50 meters, the wind has minor influence on the measured sound level. For longer distances, the wind effect becomes appreciably greater. Downwind, the level may increase by a few dB, depending on wind speed. But measuring upwind or side-wind, the level can drop by over 20 dB, depending on wind speed and distance. This is why downwind measurement is preferred − the deviation is smaller and the result is also conservative.

Temperature gradients create effects similar to those of wind gradients, except that they are uniform in all directions from the source. On a sunny day with no wind, temperature decreases with altitude, giving a “shadow” effect for sound. On a clear night, temperature may increase with altitude (temperature inversion), “focusing” sound on the ground surface [1].

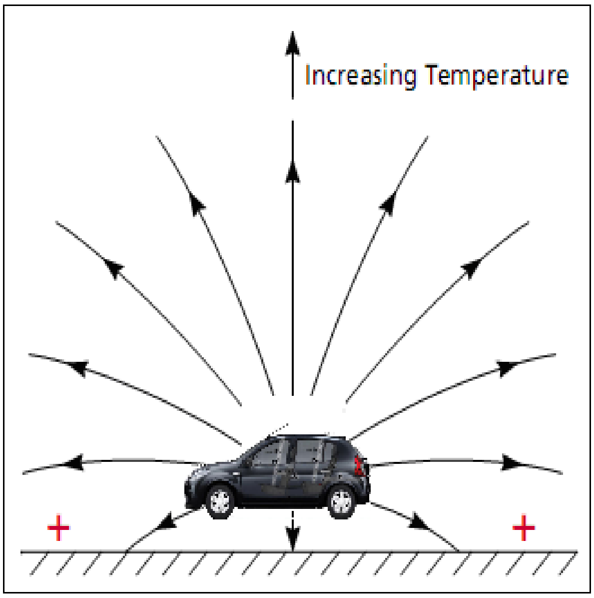

Fig. 2. Noise measurements at higher temperatures.

Noise measurements corresponding to the current regime of traffic flows are regulated by the Romanian STAS 6926/15- 92, as follows [6]:

■ the measurement is made on a straight portion of the road segment, marked as in figure 3;

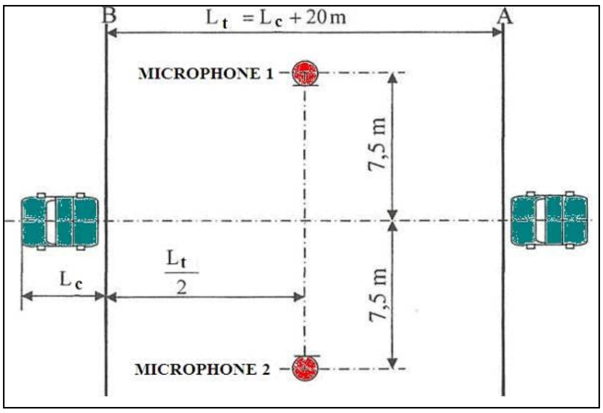

Fig. 3. Vehicle noise measurement scheme.

■ the measurement is made with a unloaded vehicle (without passengers or luggage);

■ the noise recording starts when the vehicle front line passes the starting line and ends when the vehicle front line passes the finish line;

■ the speed at which the measurement is made it will considered the maximum allowable by the traffic laws for the movement of vehicles in cities and should be reached at a distance of at least 50 meters before the start line;

■ during the determination, the vehicle must be driven on the route with constant speed [7];

For figure 3, the parameters have the following meanings:

L_t – The total route length (24.02 meters).

L_c – The car length (Dacia Sandero length is 4,02 meters).

The microphones are placed at a height of 1.30 meters above the road level and at a distance of 7.5 meters from the axis of the vehicle on both sides of the road. For large vehicles with a height greater than 4 meters, microphones are placed at 3.5 meters above the road [3], [6].

We studied the vehicle noise pollution in urban and rural areas, on various kinds of roads and from two types of tires. The annual medium levels of day noise pollution in the residences on the main streets in Brasov, frequently pass over the 70 dB limit. The average sound levels emitted by vehicles traveling at 30-70 km/h in a 12-15 m road (no. vehicles per hour / sound level): 100 v/h (~63dB), 500 v/h (~70dB), 1000 v/h (~73dB), 2000 v/h (~76dB). The vehicle noise was measured with the noise analyzer Bruel&Kjaer 2250 [1].

Fig. 4. Noise measurements layout.

The measurements for this study were made by capturing of noise as the subject vehicle was in the established route, adjacent to the sound meter. The spectral content was used to:

- help confirm that the predominant noise was tire–road noise,
- verify the consistency of measurement, and
- assist in identifying trends with speed and between surface types [4].

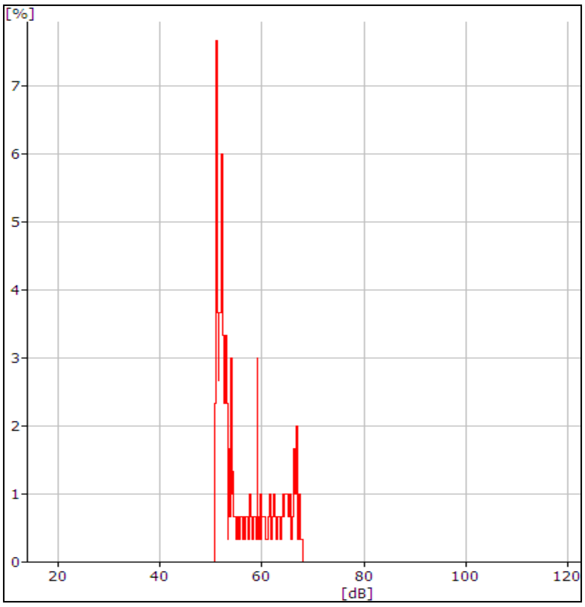

Fig. 5. Noise measurement statistic graphic.

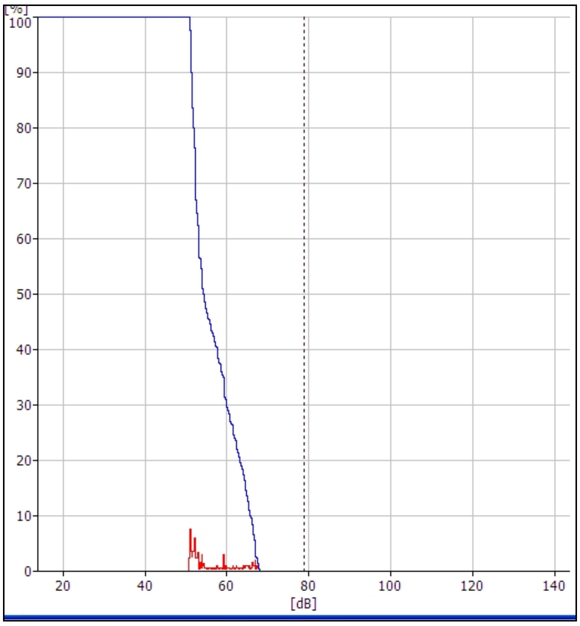

Fig. 6. Noise measurement cumulative graphic.

Measurement of a vehicle in ‘cruise-by’ mode requires that the vehicle is neither accelerating nor decelerating. Taking a sample from the general passing vehicle stream means that driver behavior cannot be controlled directly so an indirect control is used, which is to select test sites that are flat, straight and as far away as possible from intersections. In these situations, drivers should be travelling in the ‘cruise-by’ mode. Measurements were undertaken on roads with posted speed limits of 30, 50 or 70 km/h. Actual on-site traffic speeds at the time of the noise measurements were determined by using a test vehicle driven within the traffic flow passing the site, and repeating this maneuver for several times [5].

For each measurement (2250 project) are reordered several noise parameters and can be obtained a noise measurement statistic graphic.

III. NOISE RECORDED DATA

The table shows the effect different road surfaces and tire type have on noise levels.

TABLE I
NOISE REGISTERED VALUES

Project	L_{Aeq}	L_{Cpeak}	$LA_{F90.0}$	L_{AFmax}	L_{AFmin}	L_{Ceq}
30 a w	57,09	80,4	50,76	63,31	50,24	64,32
50 a w	58,57	80,25	55,27	64,13	54,54	67,93
70 a w	64,88	89,12	55,59	71,02	55,7	68,89
30 c w	59,63	80,09	50,96	63,95	49,6	64,04
50 c w	61,7	89,49	56,6	69,99	53,25	67,48
70 c w	67,35	90,31	57,22	72,98	54,81	69,02
30 a s	56,01	80,00	42,89	62,78	40,94	63,4
50 a s	58,05	83,41	52,28	63,66	51,46	64,52
70 a s	64,15	84,59	56,29	70,27	51,88	68,72
30 c s	59,00	82,99	51,85	63,59	51,22	66,23
50 c s	59,74	84,27	53,86	67,87	50,76	66,54
70 c s	65,34	88,2	55,2	70,85	53,29	68,71

Where:

L_{Aeq}, L_{Ceq} - The equivalent continuous sound level (also called time-average sound level), Lxeq(T), is defined as twenty times the logarithm to base ten of the ratio of a root-mean-square sound pressure during a time interval to the reference sound pressure, sound pressure being obtained with a frequency weighting. The symbols used on the screen of Type 2250 for equivalent continuous sound levels are (for A and C frequency-weighting): L_{Aeq}, L_{Ceq}.

L_{Cpeak} - Peak sound pressure level, is the maximum peak sound level expressed in decibels (dB). The symbols used on the screen of Type 2250 for peak sound levels are (for A and C frequency weighting): L_{Apeak}, L_{Cpeak}.

$L_{AF90.0}$ - The level exceeded for 90% of the measurement time and is used as an indicator of background noise levels. The instantaneous time-weighted sound level is, in other words, updated every Δt second and is expressed in decibels (dB).

L_{AFmax} - The maximum time-weighted sound level is expressed in decibels (dB) and is the maximum sound pressure level (the highest RMS reading a conventional sound level meter gives over a stated period for a given time-weighting)

L_{AFmin} - The minimum time-weighted sound level is expressed in decibels (dB) [1].

30 a s – Noise measurement on asphalt surface, with summer tires, at 30 km/h.

50 c w – Noise measurement on concrete surface, with winter tires, at 70 km/h.

IV. NOISE DATA ANALYSIS

The vehicle is a mobile source of noise pollution. The noise pollution from the vehicles depends on many factors which determine the intensity and the shape of the noise spectrum.

A series of factors depend on vehicles, others are generated by the road construction and by the interaction between the man, vehicle and road. The noise pollution is influenced by the following factors: constructive factors; exploitation factors; road's characteristics; influence factors of the interaction between the man, vehicle and road. Constructive factors – depend on the main constructive characteristics of the engine and transmission, of the suspension, braking, guiding and rolling systems, but also on the construction of the vehicle's body. Exploitation factors – depend especially of the air-fuel ratio, the fuel used, the load, the crankshaft's speed, the thermal regime of the engine and also of the vehicle's speed. Road's characteristics – influence the noise pollution through the constructive particularities: up and down-grades, curves, etc. which determines the speed regime to change. Influence factors of the interaction between the man, vehicle and road – characterizes the interaction between the road material and the tire, but also the driver's style of driving [4].

The noise pollution determined by the road traffic depends also by the road's characteristics. The up or down-grades, and tight curves roads influence the emissions by increasing their intensity to control speed, having a lot of changes in speed, acceleration, braking and high speeds of the engine. The plane roads permit traveling with high speeds and in this case the noise pollution is produced especially by the wheel-road interaction and the air currents produced by the vehicle's movement.

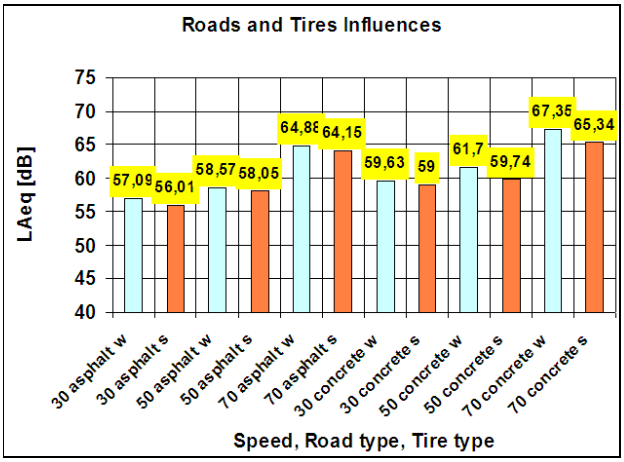

Fig. 7. Road and tired influence over the vehicle noise.

In the figure 7 are presented the values of L_{Aeq} when the vehicle equipped with winter tires is tested on asphalt and concrete, for speed limits of 30, 50 and 70 km/h. It is observed that the noise values required on asphalt surface are with 2 – 3 dB lower than when running on concrete surface. Also, the noise increases for higher vehicle speeds.

Also, in the figure 7 are presented the values of L_{Aeq} when the vehicle equipped with summer tires is tested on asphalt and concrete, for speed limits of 30, 50 and 70 km/h. It is observed that the noise values required on asphalt surface are with 1 – 3 dB lower than when running on concrete surface.

It can be noticed that the noise in case of running with winter tires is with 1 – 2 dB higher than when vehicle is running with summer tires

V. CONCLUSION

The values from the figure 7 can be used to improve the accuracy of noise prediction when using noise models. However, a more important use is to identify the noise improvement that would occur if an existing road surface was to be replaced by a surface with a lesser noise effect.

The road surface type has a significant effect on traffic noise generated. The road surface effect can range up to 3dBA. Also, the in the case of winter tires, used on the dry roads, the noise is bigger with 1 – 2 dB to the case when using summer tires. The influences of different types of roads and tires over the vehicle noise are presented in the next graphic.

It can be observed that the vehicle noise is influenced by the road surface, the cruising speed and by the tires type. Using the winter or intermediate tires in the warm seasons will increase the noise level up to 2 dB(A).

REFERENCES

[1] Bruel&Kjaer, "Hand-held Analyzer 2250 Light", Technical documentation, English BE 1766 –21, Denmark, October 2012.

[2] C. Cofaru, "Pollution legislation in road transportation", Transilvania University of Brasov, 2002.

[3] Directive 2002/49/EC. Available at: http://www.ec.europa.eu/ environment/noise/directive.htm.

[4] V.Dravitzki, I. Kvatch,. "Road surface effects on traffic noise: stage 3 – selected bituminous mixes". Land Transport New Zealand Research Report 326. 40 pp., ISBN 0-478-28738-0 New Zealand, 2007.

[5] G. Pietila, G. Cerrato Jay, E. Frank, "Evaluation of Different Vehicle Noise Reduction Test Methods for Tire Sound Quality Synthesis", 2007 SAE International, ISSN 2007-01-2252.

[6] STAS 6926/15- 92, Noise measuring methods for urban areas.

[7] K. Uzuneanu, "Noise pollution" Didactic and Pedagogic Editor, Bucharest, 2005, ISBN 973-30-1220-3.