Acoustic Properties of Absorbent Asphalts

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Abstract: Road traffic is one of the greater cause of noise pollution in urban centers; a prolonged exposure to this source of noise disturbs populations subjected to it. In this paper is reported a study on the absorbent coefficients of asphalt. The acoustic measurements are carried out with a impedance tube (tube of Kundt). The sample are measured in three conditions: with dry material (traditional), “wet” asphalt and “dirty” asphalt.

Keywords: Absorption, sound, asphalts, impedance tube.

1. INTRODUCTION

Road traffic is one of the greater cause of noise pollution in urban centers; a prolonged exposure to this source of noise disturbs populations subjected to it. Sound emission of vehicles is due to the operation of engine, to aerodynamic noise of the one emitted by rolling in asphalt to wheel contact. One of possible remedies for reduction of road noise is use of sound-absorbing asphalt, which also has draining functions from road surface exceeding rain water. In fact, some research has shown that in wet conditions risk of accidents is greater than three times compared to when road is dry. At the moment the only tool that seems to allow a significant reduction of noise level, while improving level of safety, is use of porous asphalt (sound-absorbing carpets) that have sound absorption values. Sound-absorbing asphalt are made by mixing aggregates granules with an appropriate diameter with bituminous conglomerate as binder. Absorption effectiveness is due to the diameter of inert materials and thickness of asphalt carpet. Compared to conventional mixtures, draining asphalts have an increase of more than 15% of voids. Furthermore noise generated by rolling of wheels on asphalt in presence of draining asphalt emits components in low frequency area where human ear has lower sensitivity. Bituminous conglomerate is constituted by use of aggregates of different size or by homogeneous quantities. A fundamental parameter for bituminous conglomerate is the percentage of voids after compaction. Percentage of voids to assign to a bituminous conglomerate depends on position that occupies inside of layers that compose pavement and it is important to control phase of compaction to ensure percentage of voids for studying bituminous conglomerate requirements. It synthetically provides properties related to particle size of aggregates, to percentage of binder and to effectiveness of compaction. Noise from rolling essentially depends on vehicle speed and road surface characteristics and conditions (roughness, type of aggregates and granulometry used, deterioration level, sound absorption property), while tire characteristics (size, load, inflation pressure, tire tread design, level of wear), weight of vehicle and its acceleration, have a minor influence. Such noise is mainly caused by impact of tread on surface (“impact noise”), by vibration of compressed air between blocks of tire tread due to the elastic deformation of tire (“air pumping”) and by so-called ” slip and stick ”(tire clinging on aggregates of surface layer of road pavement). Generally, at low speeds, such as those of urban traffic, emissions generated by rolling noise are usually below 1000 Hz, that is in low frequency range; level
on wet noise is higher of about 5-10 dBA. Aerodynamic noise depends on impact of vehicle against air and is a function not only of speed, but also of bodywork profile; it normally covers frequencies between 500 Hz and 3000 Hz and is particularly annoying because it interferes with spoken voice, level of which varies between 45 and 60 dBA. At higher speeds of 50-60 km/h noise contribution of tire rolling significantly increases. For speed above 80 km/h engine noise at maximum power is covered by rolling noise and, when it exceeds 100 km/h, also from aerodynamic one.

2. Sound-Absorbing Asphalt

In recent years technique of sound absorbent pavement has been more and more developing mainly thanks to the use of modified bitumen which have allowed to obtain bituminous mixtures characterized by a honeycomb structure with a high percentage of voids, without, however, penalizing the characteristics of resistance of conglomerate itself. High porosity of surface layer thus realized allows a good drainage of water which, permeating inside mantle of which traffic flows, are conveyed into collection little wells through waterproof slide. To obtain a good sound absorption capacity of mantle it is necessary that the percentage of active voids is at least equal to 20% or more and that aggregates contain a high percentage of stone chippings and a low percentage of sand. Below 10% of voids it is called closed bituminous asphalt (normally used in road pavements). Blends are distinguished by a diversity of products that working on aggregate particle size, as well as on quantity and quality of bitumen; this variety is translated in a response to different requirements (roughness, regularity, impermeability, possibility of small thicknesses use). A series of specimens made with a mixture consisting have been analyzed, with percentages shown by three components: aggregates, binder and voids. Particle size analysis was carried out on a series of fused packaged with a percentage of voids of 16% to 17% and bitumen to 5.3%. For a draining mixture to be applied in a stretch of bypass and it consists in splitting of headstone skeleton composed of a granulometric assortment of this elements: large basalt, small basalt, sand, filler. To carry out this operation is used sifting also said sieving; the test refers to sifts that have standardized sizes and shapes, through a series of sieves. The characteristics of the samples of asphalt used for absorbent measurements are reported in Table I. While the Fig. 1 shows the dimension of samples used.

| Sample | Weight [Kg] | Wet weight [Kg] | Height [m] | Diameter [m] |
|--------|-------------|----------------|------------|--------------|
| A      | 0.990       | 1.010          | 0.061      | 0.099        |
| B      | 0.950       | 0.965          | 0.056      | 0.099        |
| C      | 0.970       | 0.989          | 0.059      | 0.099        |
| D      | 1.000       | 1.022          | 0.065      | 0.099        |

3. Sound Absorption Coefficient Measurements

Sound absorption coefficient at normal incidence was determined according to procedure described in ISO 10534-2 [1, 2, 3, 4]. This method allows to measure acoustic parameters by using small samples that are easy to assemble and disassemble. Measurements were carried out using the tube of Kundt (impedance tube), with the following features: internal diameter of 10 cm (corresponding to a lower limit of 200 Hz, an upper frequency limit of 2,000 Hz), a length of 56 cm and mounts two ¼’’ microphones. The tube of Kundt is composed of a speaker located at one end of the tube, from which is emitted a pink noise. While to the opposite side is placed a termination in which is housed the trial material, on a rigid wall with a circular section of a diameter of 10 cm. The absorption coefficient is
obtained from the combination of the transfer functions measured in the two measuring microphones, placed inside the tube. To limit effects due to irregularities in samples, for each sample four different measurements were performed, every time stirring and inserting the materials in the impedance tube [5, 6, 7]. Resulting absorption coefficient values are the average value of four acquisitions [8, 9, 10, 11]. Fig. 2 shows tube of Kundt for normal sound absorption coefficient measurements.

![Fig. 1. Dimensions of samples used.](image1)

![Fig. 2. Tube of Kundt for the sound absorption coefficient measurements.](image2)

**Measurements with dry material (traditional):** tests of absorption coefficient of sound-absorbing asphalt were performed in a laboratory on a series of specimens with a thickness of 6 cm and a diameter of 10 cm. The value of absorption coefficient at normal incidence was measured, as a function of frequency in 200 Hz - 2000 Hz interval.

**“Wet” asphalt measurements:** Asphalt coefficient of absorption in case of rain varies, voids are obstructed because a percentage of water remains inside occluding pore structure. To check for this condition these conditions have been recreated in laboratory, so as to create a similar situation. Asphalt samples were immersed in a water container for about 20 days, after this period the specimen was extracted from receptacle and measurements of sound absorption coefficient were weighed and later performed with tube of Kundt; Table I reports the value of physic characteristics of the sample after this operations.

**“Dirty” asphalt measurements:** over time road pavement follows a long process of deterioration, but with servicing operation it is possible to maintain sound absorption characteristics. In laboratory
was simulated a condition of sound-absorbing asphalt in decline conditions; therefore it has been rebuilt a layer of dirt on top of specimen in a similar way to what happens in reality due to traffic flow and environment bordering to the road. On specimen has been coated a layer composed of a set of sand, loam, weeds, and once prepared measurements of sound absorption coefficient have been performed. Fig. 3 to Fig. 6 show the values of absorption coefficient measured with the impedance tube. In the three condition as described above

![Absorption Coefficient Measurement](image1)

**Fig. 3.** Sample A, values of absorption coefficient measured

![Absorption Coefficient Measurement](image2)

**Fig. 4.** Sample B, values of absorption coefficient measured

![Absorption Coefficient Measurement](image3)

**Fig. 5.** Sample C, values of absorption coefficient measured
Fig. 6. Sample D, values of absorption coefficient measured

4. Discussion

From measurements carried out it is shown that sound-absorbing asphalt presents good absorption characteristics which vary from 0.6 at low frequencies, to 0.3 at middle frequencies and then subsequently increase to 0.7. This trend is also typical of loose granular materials. For wet asphalt where conditions change, water fills cavities of porous material, reducing sound absorption of absorption coefficients in considered frequencies range [12, 13]. For dirty asphalt in conditions where material characteristics are not the same, due to porosity of material is reduced in its surface because voids are occupied, sound absorption values are reduced enough.

5. Conclusion

From acoustic measurements made with the impedance tube results that sound-absorbing asphalt is a good material, with values of absorption coefficient which considerably vary; at low frequencies values start high and then decrease at medium frequencies. Inclusion of sound-absorbing asphalt layers involves reductions of noise emitted by vehicles in motion and also for vehicles with motor on in a traffic conditions as asphalt can absorb part of noise emitted by vehicle engine in operation.

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