JOURNAL OF APPLIED ENGINEERING SCIENCES
ISSN: 2247-3769 / e-ISSN: 2284-7197
sciendo
VOL. 13(26), ISSUE 2/2023
ART.NO. 382 pp. 253-258

INFLUENCE OF SPEED BRAKERS ON TRAFFIC GENERATED NOISE LEVELS

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Received: 05.09.2023 / Accepted: 12.09.2023 / Revised: 13.09.2023/ Available online: 15.12.2023

DOI: 10.2478/jaes-2023-0032

KEY WORDS: Traffic threshold, Speed breakers, Traffic noise, Noise pollution

ABSTRACT:

This paper aims to study the on-going problem of traffic generated noise pollution, focusing on the influence of speed breakers on specific areas of the noise spectrum. We studied different types of speed breakers around the metropolitan area of Cluj-Napoca, measuring a sound spectrum from 20 Hz to 20 kHz. Speed breakers have an extensive use all over the world as safety measures near parks, schools, residential areas, but the question to answer is whether they also contribute to the increase in noise pollution and to what measure this contribution is. The study considers the different types of speed breakers used in the metropolitan area and the degree of usage the speed breakers have.

1. INTRODUCTION

Ambiental noise is a prime factor of discomfort in our everyday life, and longer exposure to high noise can be a causing factor of serious health problems such as cardiovascular diseases and more according to the World Health Organisation (Iliescu, 2015).

Road traffic is one of the main noise generating factors in the urban environment, affecting the health and well-being of millions of people across Europe (EEA Report, 2020); it is a growing problem in any developing urban areas such as Cluj-Napoca, an on-growing city with an increasing demographic. Between the known effects of health risks due to high noise levels are hearing impairment, hypertension, ischemic heart diseases, sleep disturbance and low school performance (Passchier, 2000).

This paper is part of a series of papers (Marusceac 2018a, Marusceac, 2019b, Marusceac, 2022c) investigating the impact different factors that can influence the traffic generated noise have, to improve the quality of life (Beca, 2013, Iliescu, 2015. Road traffic noise pollution is generated primary from the power unit in case of fuel vehicles, and through the interaction between the pavement and the tyre (Del Pizzo, 2021).

Speed breakers or traffic thresholds, as they are known, are a safety feature that uses vertical deflection to slow vehicles in traffic and are installed as prefabricated elements made of plastic/rubber compound or they are made of poured asphalt. One study conducted showed that the major contribution fo the noise level comes from deceleration, braking and acceleration while passing the speed hump (Wewalwala, 2011).

Another study was conducted to asses the impact of speed humps with respect to traffic flow (Haroon, 2022). The issue of speed cushions that do not extend over the entire road width and the behaviour of the drivers was addressed (Pau, 2002). Such aggressive behaviour was proven to increase the noise levels by an additional 5 dBA (Janusevicius, 2015).

As speed humps were primary designed to improve the quality of life in residential areas, by lowering the speed of the vehicles, another study makes an overview of the effect of road humps on traffic noise in improving residential well-being (Bachok, 2017).

The effect of speed humps on noise and air pollution was investigated in a recent study revealing that both light and heavy vehicles have an impact on the sulphur dioxide level (AlKheder, 2023).

A corelation between the speed of the vehicle and the noise level was made. Also, it was observed that an increase in the height of the speed hump leads to a decrease in the speed, but an increase in the noise level (Gamlath, 2023).

Actual European standards stipulate that the average noise level limit is 50 dBA during the day and 40 dBA during the night, measured at 3m from the external dwelling wall (EEA Report, 2020). As seen in the results of this study, those values are not respected most of the time, even in residential areas where traffic values are lower.

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2. CASE STUDY

2.1 Materials and methods

The noise measurements were conducted using a NTI Minilyzer ML1 professional spectral sound analyser. This type of device was chosen to analyse the full spectrum of noise levels from 20 Hz to 20 kHz, because different parts of the spectrum require different solutions when it comes to reducing noise levels.

Two types of speed breakers were studied based on the material used as follows: plastic-rubber compound prefabricated thresholds, Figures 2, 3 and 4 and asphalt thresholds, Figures 5 and 6.

For each type we chose different locations throughout the city with different degradation levels to see to what extent the degradation of the speed breaker elements can influence traffic generated noise levels. In Figure 1 each location where measurements were made are shown; blue colour represents the plastic/rubber threshold with different degradation levels, the red colour represents the asphalt thresholds, also with different degradation levels and in yellow an asphalt speed hump is represented, which is a longer version of the standard speed breaker that seems to have less mechanical impact on the vehicles.



Figure 1. Map of the studied locations

For plastic-rubber 3 locations were chosen, the first in a good technical condition, Figure 2, the second with medium visible degradations, Figure 3 and the third, highly degraded and covering only a part of the roadside, Figure 4.



Figure 2. Plastic Threshold in good technical condition, Actorului street, Cluj-Napoca



Figure 3. Plastic threshold with medium visible degradation, albac street, Cluj-Napoca



Figure 4. Highly degraded plastic threshold, Grigore Alexandrescu Street, Cluj-Napoca

For asphalt thresholds, Figure 5 represents the good condition, Figure 6 a threshold with medium visible degradations and Figure 7 highly degraded asphalt threshold. The speed hump is shown in Figure 8.



Figure 5. Asphalt threshold in good condition, Eugen Ionesco Street, Cluj-Napoca



Figure 6. Asphalt threshold with some visible degradation, Venus Street, Cluj-Napoca



Figure 7. Highly degraded asphalt threshold, Baldei Street, Cluj-Napoca



Figure 8. Asphalt speed hump, Fabricii de zahar Street, Cluj-Napoca

2.2 Measurements

In each of the investigated locations, a comprehensive data collection approach was employed, involving the acquisition of a total of 10 distinct measurements. These measurements were meticulously conducted to capture pertinent data regarding both peak noise levels and average noise values.

Measurements were meticulously taken at a standardized distance of 1 meter from the edge of the road, all at the same fixed elevation, with particular attention paid to capturing the required data as closely as possible to the precise moment when a vehicle's wheel made contact with the speed breaker threshold. Furthermore, average values derived from all ten readings at each location.

To establish a reliable baseline for comparison, reference control values, indicated in orange, were obtained under identical traffic conditions and on the same road surface in close proximity. These reference measurements were collected in areas where the presence of a speed breaker did not exert any influence on noise levels, ensuring a consistent and accurate basis for analysis.

2.3 Results

Figures 9 through 14 provide a comprehensive overview of the complete noise spectrum across three distinct categories of speed breakers: plastic thresholds, asphalt thresholds, and asphalt speed humps. Within these figures, the noise spectrum is vividly illustrated through envelope representations, showcasing both the maximum and average noise values. This detailed visual analysis allows for a comprehensive understanding of how these different types of speed breakers impact noise levels across a wide frequency range.

The provided graphs display 1/3 octave measurements spanning the frequency range of 20 Hz to 20,000 Hz, represented logarithmically on the horizontal axis, with noise values in dBA depicted on the vertical scale.

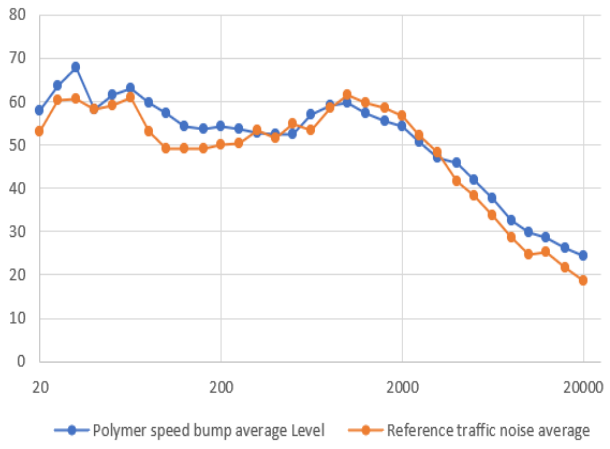


Figure 9. Average noise levels for plastic thresholds

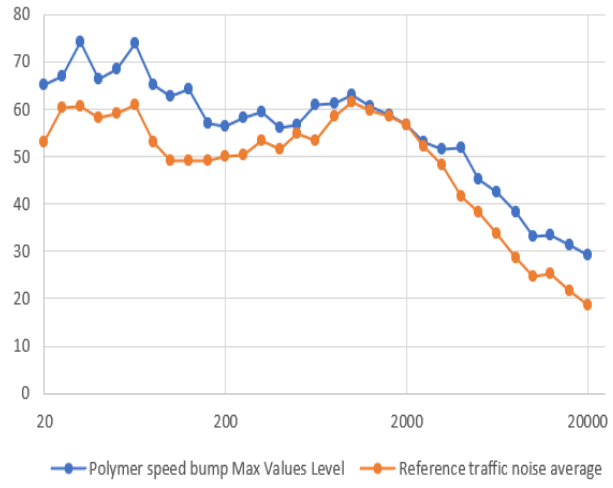


Figure 10. Envelope of maximum values for plastic thresholds

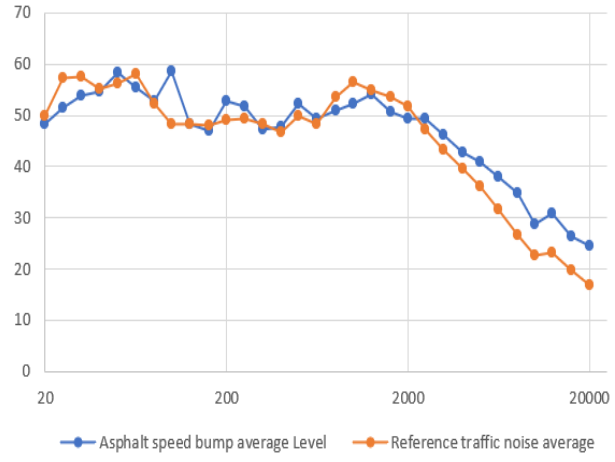


Figure 11. Average noise levels for asphalt thresholds

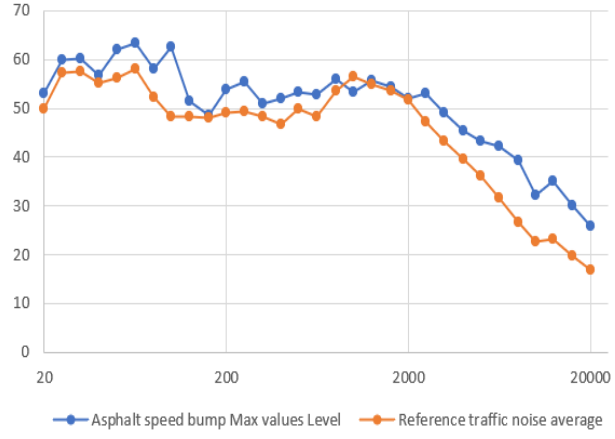


Figure 12. Envelope of maximum values for plastic thresholds

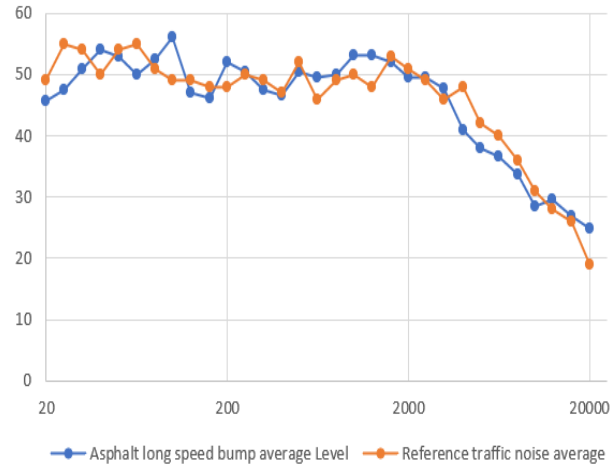


Figure 13. Asphalt speed hump average noise levels

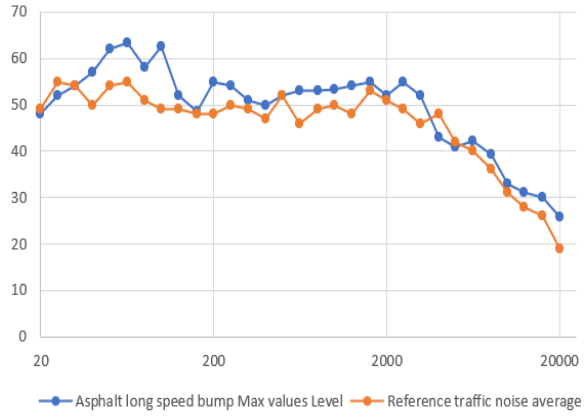


Figure 14. Envelope of maximum levels for asphalt speed humps

As evident from the graphical representations presented above, these speed breakers exert a notable influence on the noise levels generated by passing traffic. Notably, this impact is most pronounced within the lower frequency range, typically spanning from 50 to 100 Hz, with some discernible effects extending into the higher frequency bands of the acoustic spectrum.

The most significant challenge arises within the lower frequency segment of the spectrum, where noise emanates primarily from the interaction between the vehicle's wheels and the speed breaker threshold. Here, we observe a substantial increase of up to 10 decibels (dBA) above reference noise levels, signifying a substantial disruption in acoustic comfort within the area.

Interestingly, among the three types of speed breakers investigated, plastic thresholds exhibited the most substantial influence on noise levels, thereby providing the least favourable acoustic environment in the vicinity. Conversely, the speed hump, specifically the elongated version reminiscent of the classic asphalt speed barrier, demonstrated the lowest noise values. This can be attributed to the structural geometry of the speed hump, which effectively mitigates the mechanical impact, resulting in a comparatively minimal noise increase across the entire analysed frequency spectrum.

At the uppermost end of the spectrum, we observe a relatively modest increase in noise levels. This is primarily attributed to variations in road surface roughness, transitioning from standard asphalt to plastic or painted asphalt. Additionally, the vibration of vehicle components in response to the speed breaker/wheel contact contributes to this observed increase in noise levels.

Upon scrutinizing the noise spectrums for average measured values, a discernible pattern emerges, as depicted in Figure 15. In the mid-frequency range, spanning from 160 Hz to 4 kHz, the average noise levels exhibit a remarkable similarity, demonstrating minimal deviation when compared to the reference traffic noise levels. This suggests that within this frequency band, there is no significant increase in noise levels attributable to the presence of speed breakers, thus preserving a relatively consistent acoustic environment.

However, a distinctive disparity becomes evident when examining the lower frequency spectrum. In this regard, plastic

thresholds reveal a noteworthy surge in noise levels at 31.5 Hz, accompanied by another pronounced peak at 63 Hz. These observations highlight the substantial acoustic impact posed by plastic thresholds within the lower frequency range.

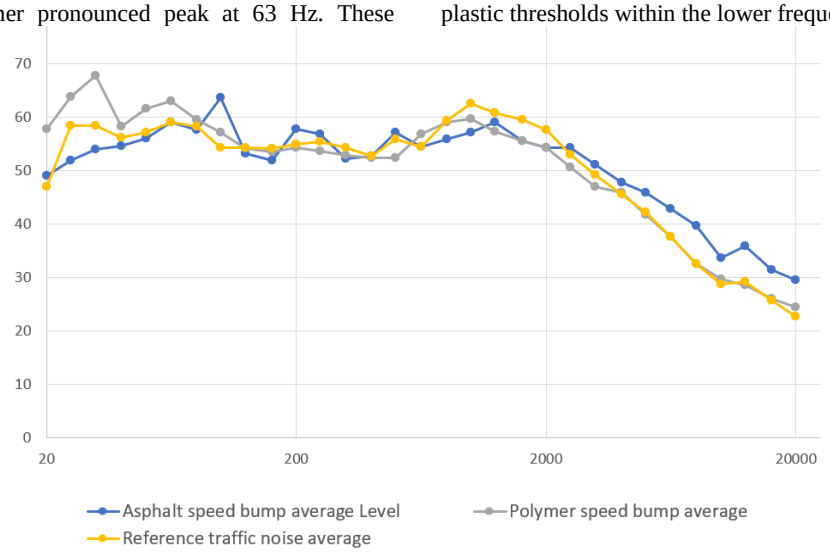


Figure 15. Comparative average noise levels for plastic and short asphalt thresholds

Conversely, at the opposite end of the frequency spectrum, asphalt speed bumps emerge as the most significant contributors to noise pollution. They notably elevate noise levels by an average of 5 decibels from 5 kHz to 20 kHz, signifying their substantial influence on higher frequency noise generation.

In summary, this analysis underscores that the impact of speed breakers on noise levels is not uniform across the entire frequency spectrum. While mid-range frequencies exhibit minimal changes, the lower spectrum experiences a pronounced increase in noise with plastic thresholds, and the upper spectrum is notably affected by asphalt speed bumps, contributing to a nuanced understanding of how different speed breaker types of influence noise profiles.

When examining the maximum recorded noise levels across all three studied speed thresholds, a distinct pattern emerges, with plastic speed bumps exerting the most significant impact on noise levels across most of the frequency spectrum, as clearly illustrated in Figure 16.

Interestingly, it's only within the higher frequency spectrum that we observe a convergence of noise levels, with all three types of speed thresholds displaying similar characteristics. However, as we delve into the lower frequency range, notably between 20-40 Hz and 50-63 Hz, a substantial divergence in noise levels becomes apparent. Here, there is a discernible difference of approximately 10-12 decibels, primarily attributable to the noise generated by vehicle-wheeler interactions, especially the impact noise. Beyond the 125 Hz threshold, the noise level curves for all three types of speed thresholds appear to align, exhibiting a similar pattern. This observation highlights that while plastic speed bumps prominently affect noise levels across most of the spectrum, asphalt speed bumps stand out with pronounced differences in noise levels within specific frequency bands due to their impact-induced noise characteristics.

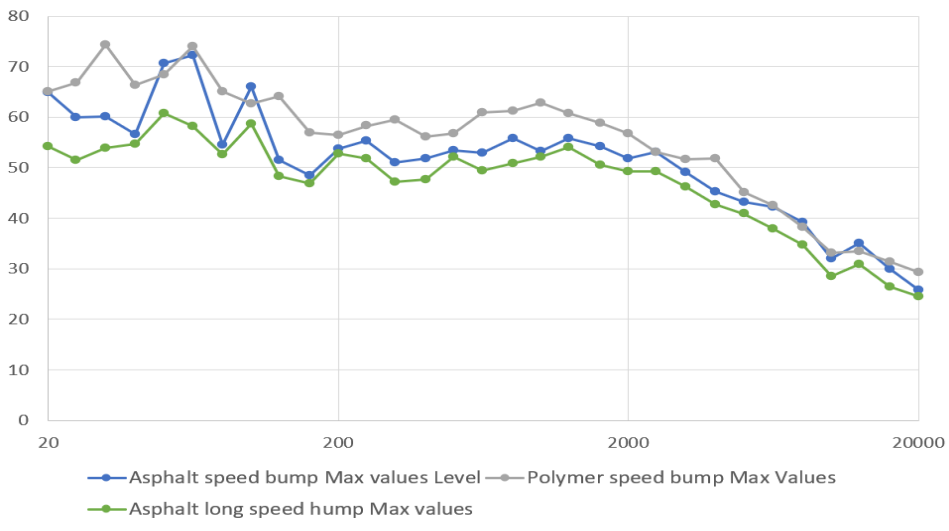


Figure 16. Comparative maximum noise levels for plastic and both types of asphalt thresholds

3. CONCLUSIONS

The primary takeaway from our investigation is the undeniable influence that speed breakers wield over the levels of noise pollution generated by road traffic. This influence is multifaceted and contingent on various factors, including the type of speed breaker employed, the materials used in their construction, the state of degradation of these threshold components, as well as the specific characteristics of the traffic and the speed at which vehicles traverse them.

Our findings have highlighted peak noise values that exhibit a substantial deviation of nearly 20 decibels above the recommended noise level limit for residential areas. This significant increase in noise pollution undoubtedly has profound ramifications for the quality of life and the overall health and well-being of the affected citizens.

Plastic and rubber-based speed thresholds, while cost-effective and relatively easy to install and maintain, do have their drawbacks. One such drawback is their propensity to significantly elevate noise levels and their susceptibility to a shorter lifespan due to wear and tear.

In contrast, asphalt speed breakers emerge as the most efficacious solution of all speed barrier types. Moreover, our analysis suggests that, counterintuitively, longer asphalt speed breakers tend to exert a lesser impact on both vehicles and noise levels. This underscores the importance of considering the materials and structural geometry in the context of vehicle-induced noise, a topic that we plan to explore and present comprehensively in our forthcoming research.

At the upper end of the frequency spectrum, for maximum measured noise levels, an intriguing observation emerges. Regardless of the specific type of speed threshold—be it plastic, asphalt, or any other material—there is a notable convergence in noise characteristics. This convergence implies that at higher frequencies, the influence of speed thresholds on noise levels tends to be relatively uniform.

In practical terms, this finding suggests that noise variations related to speed breakers become less pronounced as we ascend the frequency scale. This uniformity at higher frequencies can be attributed to several factors, including the inherent vibrational properties of the vehicle components and the interaction dynamics between the wheels and the road surface, which tend to exhibit similar behaviour regardless of the type of speed threshold encountered.

Understanding this convergence at higher frequencies is essential for effectively assessing and managing noise pollution in areas where speed thresholds are deployed, as it highlights a potential limitation in the scope of noise mitigation strategies focused solely on addressing higher frequency noise components.

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