



LIFE project Cool & Low Noise Asphalt: monitoring the acoustic performance of low noise pavements in the city center of Paris

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ABSTRACT

In 2012, the City of Paris launched an experiment on a 200 meters section of the Paris ring road to test low noise pavements and their acoustic and mechanical durability overtime, in a context of heavy road traffic. Bruitparif maintained a permanent noise measurement station to monitor the acoustic efficiency of the pavement over several years. Follow-ups have recently been implemented by Bruitparif in the vicinity of dwellings near major road infrastructures crossing the Ile-de-France territory, such as the A4 and A6 motorways. Today, for ring roads and motorways with traffic speed limits of 70 and 90 km/h respectively, the benefits of using low noise pavements is demonstrated. It is now interesting to study the contribution of low noise pavements in downtown areas with speed limits of 50 km/h or less. As part of the European LIFE “Cool & Low Noise Asphalt” project led by the city of Paris, in which Bruitparif is a partner, three innovative asphalt pavement formulas are being tested to fight noise pollution and global warming on three heavily exposed Parisian sites. Asphalt mixes combine acoustic, thermal, mechanical properties and durability. This article presents the latest results.

1. INTRODUCTION

Reducing noise generated by road traffic in urban areas involves a combination of several actions. Among the possible actions, the laying of low noise pavements appears to be a promising solution to solve the problem at the source. Various evaluations on the subject are carried out in the Ile-de-France, on the Paris ring road and on the A4 and A6 motorways. More recent experimental projects combining acoustic and thermal properties in Paris are also underway. An article on this subject was

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published in 2021 [1]. This document provides new elements concerning the monitoring of acoustic performance one year later.

2. TEST ON THE PARIS RING ROAD

Over the 2010-2011 period, several factors led the City of Paris to test the use of low noise road surfaces on the Paris ring road, in a context of strong constraints linked to the large number of vehicles using this road infrastructure daily (more than 1.2 million vehicles with up to 270,000 vehicles per day in some places).

2.1. Experimental section

As early as 2012, the City of Paris and Bruitparif tested this type of solution on part of the Paris ring road in order to assess its relevance and durability over time from an acoustic and mechanical point of view. The portion chosen for the experiment is a 200 m section located at the Porte de Vincennes. This sector benefited from ADEME funding as part of the treatment of noise hot points. From 25 to 29 June 2012, the City of Paris and the Colas Company applied BBTM 0/6 and BBTM 0/4 type of asphalt on the interior and exterior lanes of the ring road respectively instead of the old pavements that were 3 to 30 years old.

2.2. Noise source evaluation method

Continuous measurements of tyre/road contact noise according to LCPC method n°63 (CPX) have been regularly programmed by the City of Paris in order to monitor the evaluation of the acoustic performance of each traffic lane.

2.3. Noise evaluation method at residential facades

Bruitparif deployed five noise measurement stations to monitor the acoustic efficiency of the products tested. At first station was installed between the lanes (in close proximity to the traffic), three others were installed on the facades of the nearest residential buildings. The fifth station was positioned outside the experimental perimeter of operations as a control station. Real-time access to the results of the noise monitoring system at Porte de Vincennes is available on the Bruitparif data consultation platform via the Bruitparif website: <https://rumeur.bruitparif.fr>. The results of this experiment have also been published and shared with other examples of good practice on the noise abatement actions database available on the LIFE HARMONICA project internet portal online from the end of 2013 [2].

2.4. Initial performance: tyre/road contact noise

The CPX approach allows to characterize the 8 lanes independently for a differentiated follow-up according to the supported traffic (fast lane 1 and slow lane 4). The sound levels were measured at 70 km/h and corrected to a reference temperature of 20°C. To evaluate the gains obtained between the initial situation and the situation after the laying of acoustic pavements, two measurements campaigns were carried out, before (in March 2012) and after in August 2012). Table 1 presents the reductions achieved for each lane since 2012. In 2012, the decrease in sound levels is very important since it varies for BBTM 0/6 from -5.1 dB(A) to -7.8 dB(A) and for BBTM 0/4 from -7.0 dB(A) to -10.1 dB(A). These performances depend to a large extent on the initial conditions of the road surfaces. Also, for substantially identical initial sound levels, the BBTM 0/4 offers better performance.

2.5. Initial performance: noise at residential facades

The first evaluation was carried out three months after the pavement was changed. The noise reduction at the source was on average around - 7.5 dB(A) for the central location results [3]. Such a reduction in noise is quite significant and corresponds to what could be obtained by dividing traffic



by six (all other conditions being equal). On the facades of residential buildings, noise levels have decreased by an average of -2.2 to -4.3 dB(A), depending on the location. The gains obtained correspond to what could be obtained by reducing traffic by 30 to 70%. The buildings that have seen the greatest improvement are those exposed mainly to noise generated by the ring road and located closest to the experimental section. Despite this significant improvement, the situation in terms of noise exposure for residents closest to the ring road remains unsatisfactory. The regular threshold values are still exceeded by 2 to 6 dB(A) for the regulatory night indicators (the French regulatory threshold is 65 dB(A)). The situation is less critical for day time levels since two out of three stations on the front of buildings now record LAeq levels 6h-22h below or very close to the French regulatory threshold of 70 dB(A).

2.6. Performance monitoring: tyre/road contact noise

Table 1 presents the results of evaluations conducted in 2012, 2014 and 2017. The evolution of the two products is comparable, however there is a differentiated evolution according to the traffic lanes and thus according to the supported traffic. For the period 2012 and 2014, the reductions are still significant and vary between -1.6 and -7.5 dB(A). A problem of durability for BBTM 0/4 was quickly noticed with the start of gravel on the surface. For the periods 2014 and 2017, the loss of performance on the fast lane remains of the same order of magnitude with + 1.7 to + 1.8 dB(A) or + 0.6 dB(A) per year. For the other lanes (2, 3 and 4), we note a stabilization of performances with a loss of about + 0.3 to + 0.5 dB(A) on average. Similar experiments carried out in Belgium [4] on other types of pavement surfaces show changes in rolling noise of the order of +0.5 to +2.5 dB per year. The reductions on BBTM 0/4 remain significant with less than -4 dB(A). Deterioration has become widespread throughout the area.

Table 1: Sound levels of side microphones in dB(A) measured at 70 km/h (Ref. 20°C) since 2012.

Lane	Inner ring (BBTM 0/6)			Outer ring (BBTM 0/4)		
	2012	2014	2017	2012	2014	2017
1	-7.8	-6.4	-5.0	-8.3	-7.5	-5.7
2	-5.1	-1.6	-1.6	-7.0	-4.6	-4.3
3	-6.8	-2.2	-1.2	-10.1	-4.3	-4.6
4	-7.8	-3.5	-3.5	-9.5	-4.6	-4.0

2.7. Performance monitoring: noise at the central median

Figure 1 shows the evolution of the average LAeq noise level calculated per year since 2012. This annual approach makes it possible to avoid variations linked to traffic and weather conditions. On the 1st of January 2014, the maximum speed limit on the Paris ring road was decreased from 80 km/h to 70 km/h. This led to a small decrease in average noise levels (around -0.5 dB(A) during day time and -1 dB(A) during night time). To overcome this confounding factor, the assessment of the acoustic performance of pavements was based on data available since January 1st, 2014. The linear regression results correspond to a degradation of + 0.66 dB(A) per year. Experiments conducted in Belgium [4], based on a different measurement method (measurement in passing SPB) and covering other types of pavement, show changes in rolling noise of the order of + 0.4 to + 1.7 dB per year.

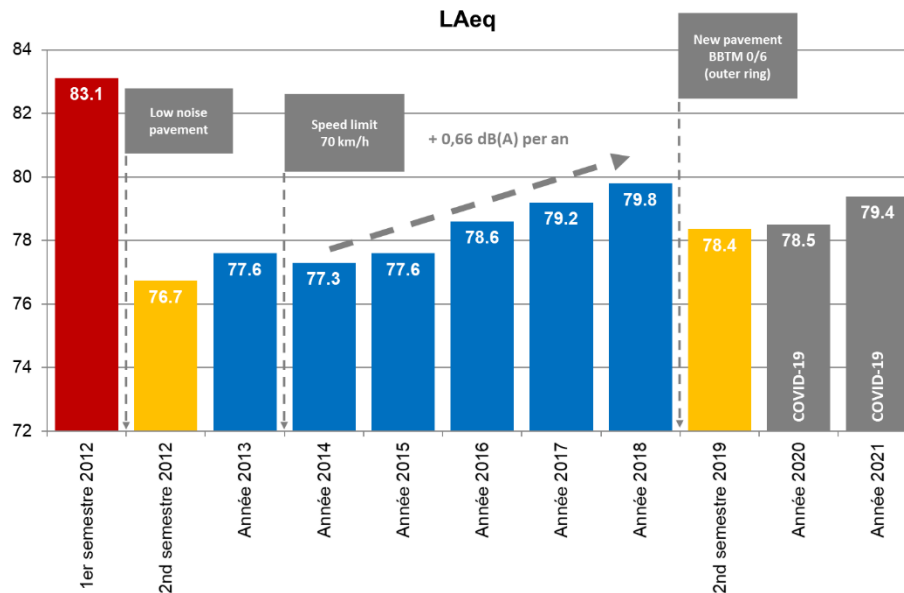


Figure 1: Evolution of the average noise level LAeq calculated per year since 2012.

In June 2019, the BBTM 0/4 placed on the outer ring, mechanically damaged, was replaced by a BBTM 0/6. Today, 50% of pavement used in the Paris ring road is BBTM 0/6. The years 2020 and 2021 were disrupted by the restrictions implemented in the context of the COVID-19 health crisis, significantly modifying the usual road traffic conditions.

3. TEST ON THE MOTORWAYS A4 AND A6

Class 1 noise measurement stations were deployed by Bruitparif on sections of the A4 and A6 motorways where low-noise road surfaces were laid in 2017. Thus, on the A4 motorway, two stations have been installed near the traffic lanes at Charenton-le-Pont, one in each direction of traffic, and one has been set up also in Joinville-le-Pont. On the A6 motorway, two stations have also been set up, in each direction at L'Haÿ-les-Roses. Figure 2 shows the decreases observed since 2017. Three years after installing the low noise pavements, the results are still very positive in terms of the noise reduction efficiency provided by such solutions, with average noise levels reduced from -3.6 to -6.3 dB(A) on average, a reduction equivalent to what could be obtained by a reduction of 57% to 77% in the number of vehicles. A comparison of the reductions obtained since 2017, three years respectively after the installation of the low noise pavements, however indicates a deterioration in their acoustic performance over time, which can be estimated for the moment at +1.0 dB(A) per year [5]. The stations deployed are intended to be maintained for many years in order to document the evolution of the acoustic performance of road surfaces.

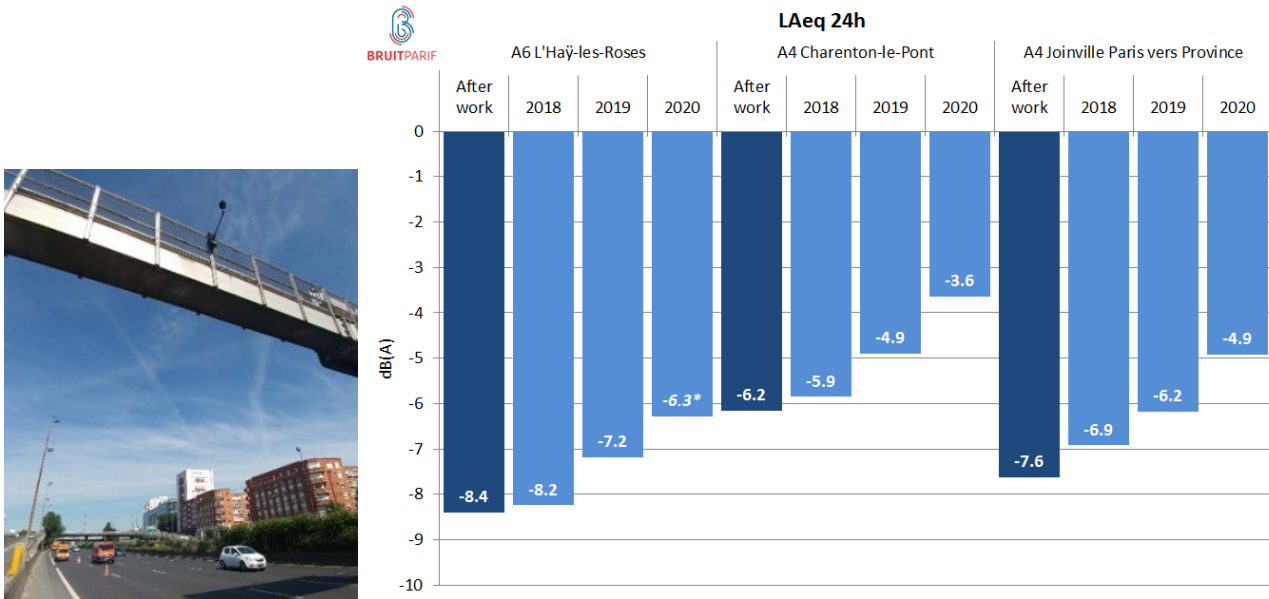


Figure 2: Location of a noise monitoring station (A4) at Joinville-le-Pont (94); evolution before / after road surface replacement; LAeq indicator 24h.

4. LIFE PROJECT: COOL & LOW NOISE ASPHALT

As part of the European LIFE program, the City of Paris, in partnership with Colas, Eurovia and Bruitparif, is testing three innovative pavement surfaces to fight against both noise pollution and global warming [6]. In 2018, three new types of asphalt mix (PUMA, Bbphon+ and SMaphon) gathering both phonic and refreshing properties, while maintaining acceptable durability, were developed [7, 8]. From 2018, 1200 meters of roads are surfaced with new asphalts having acoustic, thermal and mechanical properties. These new formulas are tested on three pilot sites, each 400 meters long, in three Parisian sites heavily exposed to road noise: Frémicourt street, Lecourbe street and Courcelles street. Each site is equipped with various sensors and is coated half with an experimental formula and the other half with the Parisian standard pavement (cf. figure 3).

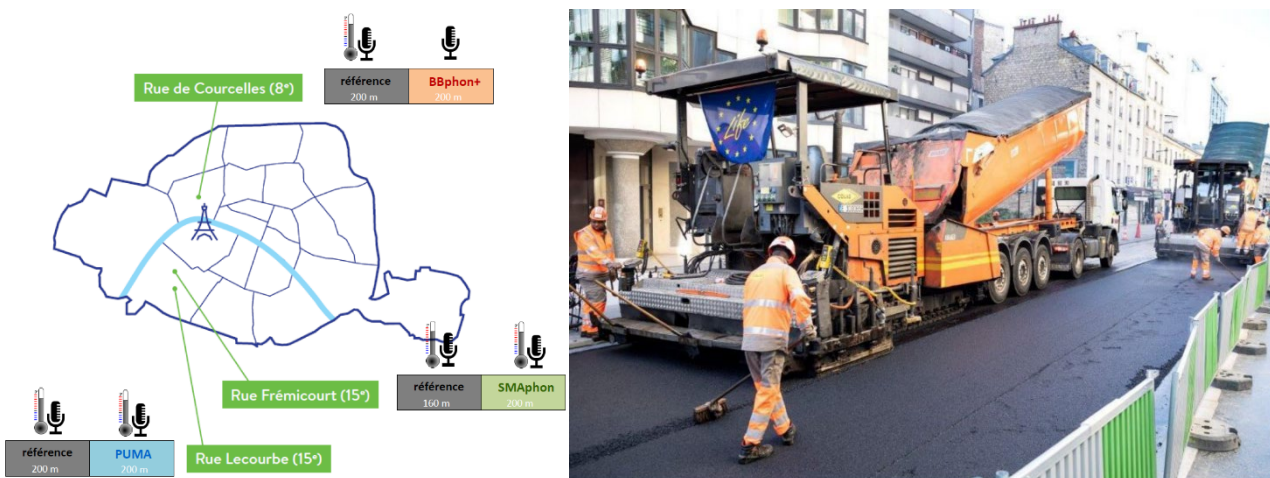


Figure 3: Pilots sites and Frémicourt street with new asphalt mixes, October 2018.

The new types of asphalt mix are tested on road sections of about 200 m and compared to the standard solution deployed by the City of Paris on Parisian roads: ACR 0/10 AC2 and BBMA 0/10. Also, sections of about 200 m of these standard asphalt mix were also laid on the three experimental sites. For the thermal evaluation, a third section keeping the original asphalt is used as a "control" section.

4.1. Monitoring systems

The project objectives in terms of reducing rolling noise compared to standard solutions are achieved. 14 permanent measuring stations have been installed to evaluate the acoustic and thermal performance of the new types of asphalt mix and to compare them to standard solutions: 6 acoustic stations and 8 thermal stations positioned between the roadway and the facade of the buildings. Digital audio recordings on the roadside and continuous ProXimity (CPX) noise measurements, consisting of measuring the noise emitted near a rolling test tire, complete the acoustic evaluation device (cf. figure 4). Measurements of mechanical durability microroughness (skid resistance tester: SRT), macrotexture (mean texture depth: MTD) and in situ survey of small degradations were carried out.



Figure 4: CPX measuring equipment (City of Paris); Acoustic station and thermal station; Frémicourt street 75015 Paris (SMaphon); LA10 indicator (Courcelles street).

On the noise side, the priority objective is to reduce the noise pollution generated by road traffic on urban roads thanks to these new pavements, by reducing the noise emitted by the contact of vehicle tires with the asphalt (rolling noise). On the facade of a building, the reductions in rolling noise are clearly observable during the passage of isolated vehicles at night, when road traffic speeds are relatively higher and the other sources of noise reduced (works, human activity, etc.). Thus, the LA10 22h-6h indicator clearly reflects the reduction associated with rolling noise (cf. figure 4). For the other periods of the day, the acoustic indicators show a reduced or zero benefit.

4.2. Performance compared to standard solutions

The project objectives in terms of reducing rolling noise compared to standard solutions are achieved for the SMaphon and the Bbphon+ (cf. tables 2 and 3). For the PUMA, a reference (ACR 0/10 AC2) not representative of reality did not allow the performance of the new pavement to be assessed before summer 2020. Results for the CPX method are now available for the three new asphalt mixes for years 2020 and 2021. For the facade results, the analysis for the year 2020 corresponds to the period before March 16, a period not impacted by the traffic restrictions associated with the COVID-19 health crisis. For the same reasons, the analysis for the year 2021 corresponds to the period after September 1. Table 4 shows the results for all noise sources combined, not only rolling noise, during the night period. Over the night period, the noise reduction remains significant: around -0.6 dB(A) in 2021.



4.3. Performance compared to the existing pavement

The project objectives in terms of reducing rolling noise compared to standard solutions are almost achieved for the SMAphon and the Bbphon+. Less efficient in terms of noise reduction after installation, the performance of the PUMA seems to be maintained over time (cf. tables 2 and 3).

Table 2: Rolling noise reduction in dB(A) with new asphalt mixes (CPX).

Δ CPX	Compared to reference						Compared to existing					
	2019		2020		2021		2019		2020		2021	
Speed (km/h)	30	50	30	50	30	50	30	50	30	50	30	50
Objective	-	-3.0	-	-2.0	-	-2.0	-	-5.0	-	-3.0	-	-3.0
SMAphon	-2.9	-3.5	-1.8	-2.2	-1.7	-2.1	-3.6	-4.4	-1.8	-2.3	-1.7	-2.0
Bbphon+	-2.3	-3.3	-0.6	-1.5	-0.8	-1.3	-4.2	-4.7	-1.8	-2.4	-1.7	-1.8
PUMA	-	-	0.3	0.3	1.0	1.6	-2.8	-2.1	-2.4	-1.9	-2.1	-1.5

Table 3: Noise reduction in dB(A) with new asphalt mixes (facade all noise sources combined).

Δ LA10 22h-06h Facade	compared to the reference				compared to the existing			
	2018	2019	2020	2021	2018	2019	2020	2021
Objective	-2.0	-1.0	-1.0	-1.0	-3.0	-2.0	-2.0	-2.0
SMAphon	-2.3	-1.8	-1.2	-0.9	-4.3	-3.9	-2.9	-3.3
Bbphon+	-2.8	-2.6	-2.4	-1.4	-3.5	-2.7	-2.1	-2.0
PUMA	-	-	-	2.7	-1.2	-1.1	-1.1	-1.4

Table 4: Noise reduction in dB(A) with new asphalt mixes (facade all noise sources combined).

Δ LAeq 22h-06h (Façade)	2018	2019	2020	2021
SMAphon	-1.3	-1.1	-0.7	-0.6
Bbphon+	-1.4	-1.1	-1.1	-0.5
PUMA	-	-	-	0.9

4.4. Local residents' satisfaction survey

The first results show a significant reduction in noise levels associated with tyre/road contact noise during the night period. However, the ability to distinguish sources of noise by the human ear, can make it possible to feel the benefit provided by the innovative asphalt mixes. A survey of users and residents of pilot sites made it possible to answer this question [6]. In 2019, a survey of users and residents of Frémicourt Street shows that 63% of those questioned noted a reduction in road noise



following the change of road surface. Among them, 67% consider this reduction to be medium or significant. In 2021, a survey of residents of three pilot sites shows that 85% are in favor of extending the solutions to other Parisian sites. These additional qualitative elements in terms of feeling are interesting in the evaluation of the project.

5. CONCLUSIONS

Today, the use of low noise pavement is common on roads with speeds above 70 km/h. The use of these solutions in the city center for speeds below 50 km/h is less usual. For the three contexts studied: A4 and A6 motorways, Paris ring road, and Paris city center roads, early age evaluations of low noise pavements provide very encouraging results in terms of effectiveness in reducing noise exposure of populations living near road infrastructures. The first results in Paris city center roads show a significant reduction in noise levels associated with tire / road contact noise during the night period. A survey of users and residents of Frémicourt Street shows that 63% of those questioned noted a reduction in road noise following the change of road surface. The sustainability of performance over time remains a subject of study. Also, long-term monitoring should be conducted in order to study the durability of acoustic performance and the mechanical qualities of acoustic pavements in a context of dense urban road traffic. For the Paris ring road, ten years after the start of the experiment, sound levels remain below initial levels on the portion of the Paris ring road studied.

6. ACKNOWLEDGEMENTS

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7. REFERENCES

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