INSTITUT DES ROUTES, DES RUES ET DES INFRASTRUCTURES POUR LA MOBILITÉ

# SUMMARY OF THE TECHNICAL GUIDE

# ROLLING NOISE

GUIDE

September 2024

# OBJECTIVE OF THE GUIDE

According to a recent report by the World Health Organization (WHO), transport noise is the second environmental nuisance affecting health after air pollution. In France as well as in Europe, all studies, Parliamentary reports and surveys clearly show that the exposure and annoyance of populations in relation to environmental noise, are mainly caused by road traffic.

The tyre-road contact noise, or rolling noise, is the most important source of noise emitted by road traffic under most traffic conditions. Road surfacing, which play an important role in the emission of rolling noise, can contribute through their optimization to a better noise environment and to the reduction of nuisances. Thus, in its recent analysis of the noise reduction policy, the French General Council for the Environment and Sustainable Development (CGEDD) mentions among its main recommendations, that of encouraging the labelling and promotion of low-noise surfacing materials.

Even if the acoustic characteristics of road surfacing are not currently the subject of any regulatory requirement, they are indirectly involved in the dimensioning of protections against noise within the framework of the application of the French Noise Law of 1992, as well as in the production of strategic noise maps according to the 2002/49/EC Directive on noise. In this context, low-noise surfacing materials can be used as a means of road noise reduction as such or as a complement to other means. It is therefore important to predict, evaluate or compare their effectiveness throughout their lifetime.

A survey conducted in 2014 by IDRRIM via the National Group on Pavement Surface Characteristics (GNCDS) revealed that road specifiers (road authorities, road managers, etc.) were poorly informed about low-noise surfacing materials and their performance, and that very few of them introduced acoustic performance criteria into their contracts.

IDRRIM therefore undertook to write this technical guide on *"Rolling noise"*, to fill this gap by addressing the stakeholders of road construction, namely. road manufacturers, project managers, contracting authorities, managers of road networks, engineers in technical services or design offices in charge of noise issues. It is organized in seven chapters which present the state of knowledge and practices, and provide concrete examples and recommendations.

This summary highlights the main findings and recommendations of the guide.

More detailed information can be found in the various chapters of the guide to which the summary refers.

# ROAD SURFACING THAT LIMIT ROLLING NOISE

**Chapter 1 details the physical mechanisms of generation and propagation of road noise. Chapter 5 provides an overview of the different types of low-noise surfacing materials, their characteristics and performances.**

Two characteristics of pavement surfaces influence rolling noise:

- texture;
- communicating voids.

Road surfacing **texture** (megatexture and macrotexture) has an effect on vibration:

- megatexture irregularity (wavelengths between 50 mm and 500 mm) promotes vibration of the tyre carcass;
- the vibrations of the tyre tread are directly related to the maximum size of the aggregates (D). For the same family of materials, the higher the D, the greater the vibrations.

A *"negative"* macrotexture (hollow as shown in Figure 1) limits the vibrations of the tyre.

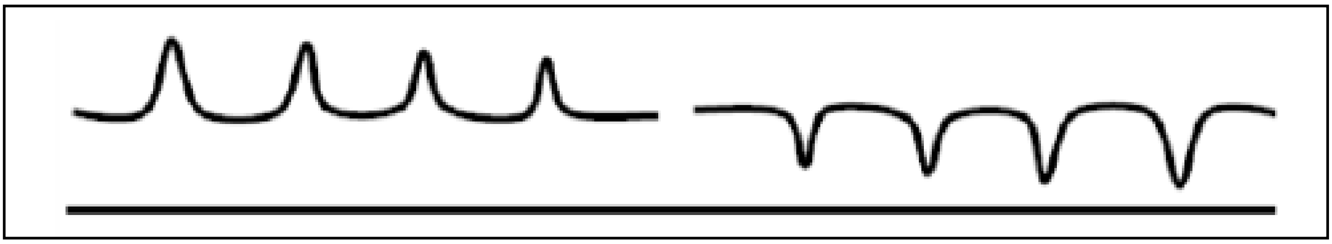

Figure 1: Diagram of a positive (left) and negative (right) macrotexture profile.

Macrotexture also plays a role in creating air cavities between the tyre and the road surfacing, and thus influences the phenomenon of air pumping.

In addition, the sound emission generated during rolling is attenuated by the presence of communicating voids inside the road surfacing (its open porosity). Indeed, these voids reduce considerably the phenomenon of air pumping. They also produce some sound absorption inside the wearing course layer, which reduces the horn effect (a sound amplification phenomenon due to the geometry at the rear of a tyre) and more generally attenuates the sound during its propagation above the road surface.

To date, the so-called low-noise surfacing materials mainly used correspond to thin or even very thin asphalt concrete layers with a high void content, composed of small aggregates (0/4 or 0/6) and binders with reinforced properties to compensate for their mechanical fragility (induced by their high porosity) compared to conventional asphalt. A more detailed description of the different products, their characteristics and properties is provided in Chapter 5 of the guide.

Table 1: Comparative performances of different techniques
(in green the low-noise surfacing materials, *a glossary can be found at the end of the section*)

| Techniques | Aggregate size | Class/Type | Layer Tickness (cm) | Rolling noise reduction relative to a dense asphalt (BBSG 0/10) |
|---|---|---|---|---|
| BBDr | 0/6 | Class 1 | 3 à 4 | + to ++ |
| | | Class 2 | | ++ |
| | 0/10 | Class 1 | 4 à 5 | + to ++ |
| | | Class 2 | | |
| BBTM | 0/4 | | 2 à 3 | ++ |
| | 0/8 | | | - to + |
| | 0/6 | Class 1 | | + to ++ |
| | | Class 2 | | ++ |
| | 0/10 | Class 1 | | - - to - |
| | | Class 2 | | + to ++ |
| BBM | 0/4 | all types | 3 à 5 | + to ++ |
| | 0/6 | | | + |
| | 0/10 | | | - to + |
| BBUM | 0/4 | | 1 à 2 | + |
| | 0/6 | | | + |
| | 0/8 | | | - to + |
| | 0/10 | | | - - to - |
| SMA | 0/4 | | 2 à 8 | - to + |
| | 0/8 | | | |
| | 0/10 | | | - - to - |

Ratings: '- -': low '-': medium '+': high '++': very high

A database compiling the acoustic performance measurements of a large number of road surfacing was created in the 1990s. It is managed and regularly updated by Cerema Est. The measurements listed are carried out according to the standards in force: measurements of pass-by noise (SPB method) and close proximity noise (CPX method). The database contains in 2018 approximately 1,200 measurements using the pass-by method. It also collects measurements with the CPX method but the data are still too few to be properly exploited.

The exploitation of this database makes it possible to classify the road surfacing according to their noise properties and to collect data of evolution of noise levels according to their age. It can be used to set performance levels in low-noise surfacing materials contracts.

Figure 2 presents an extraction of the database for pavements of all ages (0 to 15 years) evaluated by pass-by measurements at the reference speed $V_{ref}$ = 90 km/h. The noise level at other speeds V can be approximated by the relation:

$$L(V_{ref}) + 30 \log_{10}(V/V_{ref})$$

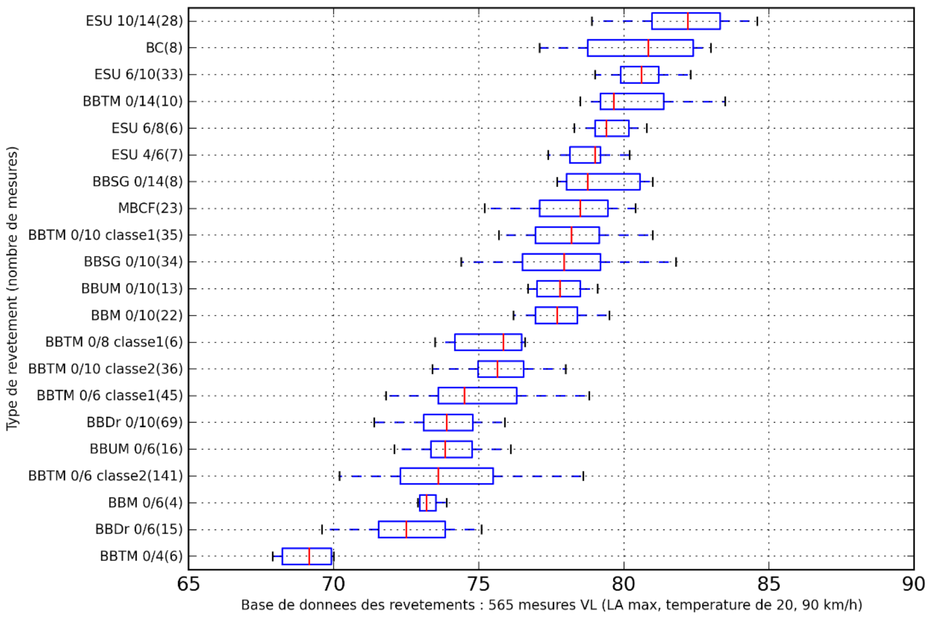


Figure 2: Road surfacing acoustic database: 565 SPB measurements (light vehicles) as of June 30, 2018 ($L_{Amax}$, temperature 20°C, speed 90 km/h). Roas surfacing from 0 to 15 years (*a glossary can be found at the end of the section*)

Low-noise surfacing materials are often also effective on other surface characteristics such as skid resistance or surface drainability. They can also provide an aesthetic benefit due to the homogeneity of their texture. Maintenance conditions in areas with high winter serviceability require special adaptation.

## GLOSSARY

| *French* | | *English* |
|---|---|---|
| **BBDr** : | Béton Bitumineux Drainant . . . . . . . . . | Porous Asphalt Concrete |
| **BBM** : | Béton Bitumineux Mince . . . . . . . . . . . | Thin Layer Asphalt Concrete |
| **BBSG** : | Béton Bitumineux Semi-Grenu . . . . . . . | Asphalt Concrete |
| **BBTM** : | Béton Bitumineux Très Mince . . . . . . . | Very Thin layer Asphalt Concrete |
| **BBUM** : | Béton Bitumineux Ultra Mince . . . . . . . | Ultra-Thin layer Asphalt Concrete |
| **BC** : | Béton de Ciment . . . . . . . . . . . . . . . | Cement Concrete |
| **ESU** : | Enduit Superficiel d’Usure . . . . . . . . . | Surface Dressing/Chip Seal |
| **MBCF** : | Matériau Bitumineux Coulé à Froid. . . . . | Cold Surfacing Bituminous Mixture |
| **SMA** : | Stone Mastic Asphalt . . . . . . . . . . . . | Stone Mastic Asphalt |

# METHODS FOR MEASURING ROLLING NOISE

**Chapter 4 describes in detail the different methods for measuring rolling noise, their use, reliability, advantages and disadvantages.**

Currently, measurements are carried out voluntarily by companies, road owners or road managers.

Two measurement methods exist:

- The pass-by measurement (*"SPB"*) which consists in measuring on the road side with a fixed system, the maximum sound level during the passage of vehicles, in general within a traffic. This method has been standardized and practiced for a long time but is subject to numerous restrictions that make it not very applicable.
- The close proximity measurement (*"CPX"*) which consists in measuring, with a system onboard a test vehicle, the noise emitted in the vicinity of a rolling tire. This method is more recent and has only been standardized since 2017. It has been of a growing interest recently because of its great flexibility of application.

These methods are not equivalent, the measured sound levels are significantly different and their correlation is not yet clearly established. However, they are complementary. Their field of application is specified in Table 2.

Table 2: Comparative areas of use of rolling noise measurement methods

| | PASS-BY MEASUREMENT (SPB, CPB) | CLOSE PROXIMITY MEASUREMENT (CPX) |
|---|---|---|
| **Recommended field of application** | • Accurate assessment of the acoustic benefit of a road surfacing in the environment;<br>• Possible complement to a CPX measurement to refine a diagnostic. | • *"Before-and-after"* comparisons of road surfacing performance at the source;<br>• Verification of compliance with a given specification (see Chapter 4.3.2);<br>• Measurement of homogeneity and monitoring of the evolution of the performance of a road surfacing or network over time;<br>• Qualification of a new road surfacing. |
| **Advantages** | • Allows the evaluation of traffic noise and the effect of the road surfacing for any category of vehicles;<br>• Allows to estimate a level of exposure at façades by using a prediction model;<br>• The method has been practiced and standardized for many years and has resulted in large databases of road noise (see Figure 2). | • Fast and repeatable measurement;<br>• Method allowing to survey a large linear area;<br>• Takes into account the homogeneity/heterogeneity of a road surfacing;<br>• It is well adapted to the characterization of the acoustic quality of road surfacing;<br>• It becomes widespread in Europe. |
| **Limits** | • Low applicability: many site restrictions especially in urban areas;<br>• Point measurement that assesses a spot location (problem of representativeness of the whole section);<br>• Cumbersome to implement. | • Measure not very correlative to the exposure of the resident;<br>• Measure not very representative of real traffic;<br>• More recent method, little hindsight, limited data base to date;<br>• Reproducibility still poorly controlled. |

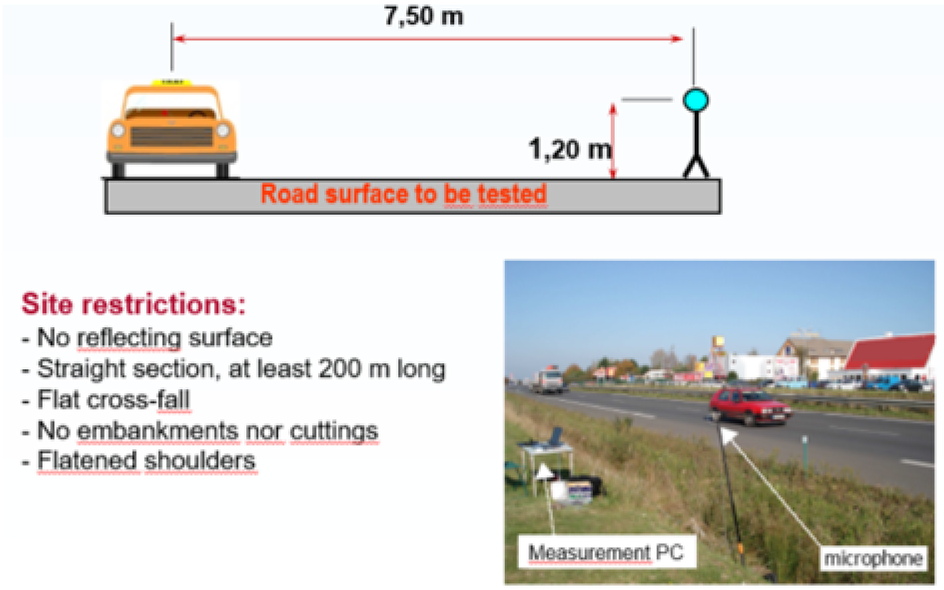


Figure 3: Pass-by measurement of rolling noise (SPB) (source Cerema-Ifsttar)

Figure 4: Cerema CPX measurement trailer (Strasbourg laboratory)

The CPX standardized method recommends the use of a specific reference test tyre (called *"SRTT"*) which allows the harmonized comparison of the acoustic performance of road surfacing. In France, only one device meets this requirement in 2020 (Cerema trailer) and studies are performed within IDRRIM to correlate the current measurement systems (about ten test vehicles) with this reference.

It should be noted that when renewing a road surfacing, some road owners choose to evaluate the acoustic benefits by measuring the average noise level of the traffic before and after the work at a fixed point. This method, if carried out directly at façade of exposed dwellings, has the advantage of characterising the exposure of local residents as well as possible and of being consistent with the application of the regulations. However, as this method is not a measurement of rolling noise, it is difficult to translate the impact of a road surfacing change. In fact, the measurement at façade is global, only representative of a specific site, it integrates the contributions of various sound sources (sometimes other than the road to be characterized) and the specificity of the propagation conditions between the source (the road) and the receiver (the façade).

# REGULATORY CALCULATION MODELS FOR ROAD NOISE PREDICTION

**Chapter 2 details the current regulations on road noise. These are based on predictive noise calculations that take into account the properties of the road surfacing as explained in chapter 3.**

The model used in France is the *"NMPB 2008"* method. It is used for the application of the national legislation on noise from ground transport infrastructures, for various impact studies and it was used until December 31, 2018 for the application of the 2002/49/EC *"noise"* directive. Since this date, the model specified in the directive 2015/996/EC, known as the *"CNOSSOS-EU"* model, must be used for the production of strategic noise maps (SNM).

These models are intended for use by acoustic consultants, competent government departments or managers of ground transport infrastructures. They can be used to evaluate the impact of a change of road surfacing. The road surfacing has a significant influence on the sound power calculated by either of these models.

The emission part of the NMPB, described in a SETRA guide, provides a prediction method for road noise that distinguishes three categories of surfacing materials performances. The categories were defined from a statistical analysis of the database on the acoustic performance of road surfacing, managed by the Strasbourg laboratory (Cerema Est).

The three classes have been defined in relation to rolling noise levels measured by the SPB method at 90 km/h:

- Class R1 for *"low noise"* surfacing materials with an average of less than 76 dB(A);
- Class R2 for *"intermediate"* surfacing materials with an average above 76 dB(A) but less than 79 dB(A);
- Class R3 for *"noisy"* surfacing materials with an average of more than 79 dB(A).

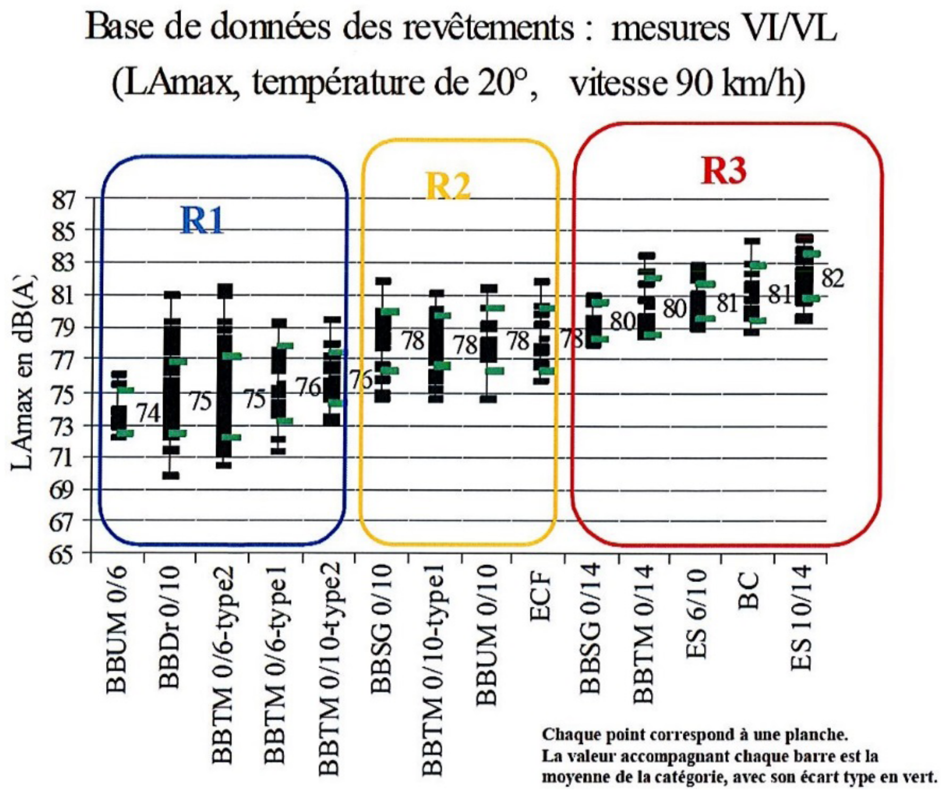


Figure 5: Classification of road surfacing into 3 categories of acoustic performance

The European model *"CNOSSOS EU"* is defined on the basis of reference conditions, including a virtual road surfacing of given acoustic performance. The acoustic effect of a given road surfacing is calculated by applying corrective coefficients with respect to these reference conditions.

These correction coefficients are tabulated from Dutch measurement data for different types of road surfacing which do not correspond to the pavements used in France. Nevertheless, a work has been carried out by Cerema to define these coefficients on the basis of the R1, R2 and R3 road surfacing classes used in the NMPB.

# DURABILITY OF THE PERFORMANCE OF LOW-NOISE SURFACING MATERIALS

**Chapter 6 lists the degradation mechanisms specific to low noise road surfacing, reviews feedback experience from France and abroad, and provides several concrete examples of monitoring ageing in acoustic performance.**

Low-noise surfacing materials generally have a high content of communicating voids, which is a source of fragility and can lead to a reduced service life, particularly in winter conditions, if care is not taken to use high-performance constituents (modified binders), to elaborate an appropriate mix-design and to apply it with great care. They must be laid on a base course in good conditions, waterproof, possibly with the addition of a binding layer.

Like other products with low resistance to tangential and shear forces, low-noise surfacing materials should not be used on junctions, roundabouts, curves with a plane small radius or parking areas. They must also be applied on high quality substrates.

Experience shows that with these precautions, low-noise asphalt mixes have mechanical durability close to that of conventional asphalt mixes.

The mechanisms that lead to a degradation of acoustic performance in addition to the usual ageing phenomena of asphalt mixes are detailed in the guide (post-compaction, stripping or feathering, clogging).

Feedback from experience shows a trend of loss of acoustic performance over about ten years, of the order of 0.5 to 1 dB(A) per year on average. However, individual behavior of certain sections may vary around this trend.

In most cases, the acoustic performance of low-noise road surfacing materials deteriorates over time, but without reaching the noise levels obtained with conventional asphalt of the same age.

# HOW ROAD OWNERS CAN TAKE NOISE INTO ACCOUNT

**Chapter 7 presents how road owners can integrate the noise issue into their technical policy, when drafting works contracts. It also provides examples of specifications in France and abroad and expected developments.**

The choice of a solution is the result of a compromise in which the client must conciliate several constraints: the acoustic performance of the road surfacing, its mechanical performance and the durability of these two performances.

The specification of mechanical performance is unavoidable and has been well managed for many years. The specification of acoustic performances and a fortiori of their durability is on the other hand experimental and not widely shared. The lack of regulatory or normative references, the difficulty of verifying the requirements by a reliable method and the measures to be taken in case of non-fulfillment of requirements are the main explanations given to justify the absence of acoustic requirements in the contracts.

In practice, there are two distinct approaches to specifying acoustic performance in a contract: product specification (e.g. based on R1, R2, R3 categories) or specification of a performance level. The respective advantages and disadvantages are summarized in Table 3.

For the purpose of a noise performance contract, it is recommended to specify a quantifiable target in A-weighted dB expressed as an absolute rolling noise level. An alternative is to specify a noise difference in A-weighted dB relative to an initial situation, but this requires an evaluation of the initial situation before construction and ultimately comes down as to specifying an absolute noise level.

In all cases, the sound level requirement must be accompanied by a tolerance to account for the repeatability and reproducibility of the measurement methods.

Of the two methods (SPB and CPX), it is preferable to express a rolling sound level requirement according to the CPX measurement, as this is about to be the most widely used method. This is a consequence of its ease of application and its ability to characterize an entire road section.

Nevertheless, due to the low number of CPX measurements in the Cerema Est database, it is still difficult to define reference values to be specified with this method. Some values are proposed in Table 3. During this current transition period, these values remain indicative.

In order to feed the database with CPX measurements and to consolidate the proposed reference values, the contractors are encouraged to integrate rolling noise measurements with this method in their calls for tenders.

Table 3: Advantages and disadvantages of the different approaches

| | REQUIREMENT OF A PERFORMANCE LEVEL | | | REQUIREMENT OF A ROAD SURFACING TYPE |
|---|---|---|---|---|
| | REQUIREMENT OF ROLLING NOISE REDUCTION BEFORE/AFTER WORK | REQUIREMENT OF ABSOLUTE ROLLING NOISE LEVEL | | |
| | | SPB | CPX | |
| **GUIDANCE VALUES** | 4 to 6 dB(A) at the same speed with either SPB or CPX method, compared to an initial measured level | 72 to 75 dB(A) at $V_{ref}$ = 90 km/h with SPB method<br>*For another speed V, the following approximation can be used:* $L(V) = L(V_{ref}) + 30 \log_{10}(V/V_{ref})$ | 92 to 95 dB(A) at $V_{ref}$ = 80 km/h with CPX method | BBTM 0/6 class 2 according to EN 13108-2 |
| **ADVANTAGES** | • Relative acoustic requirement easier to specify;<br>• Relative acoustical requirement that is easier to communicate;<br>• May allow comparison of multiple noise reduction solutions. | • Genuine acoustic requirement;<br>• Existence of a database VI providing reference values;<br>• No need for initial measurement before work. | • True acoustic requirement;<br>• In the long term, when the CPX method will be operational, will allow a true comparison of the road surfacing between them;<br>• No need for initial measurement before work. | • Standardized mechanical characteristic;<br>• Easy to draft;<br>• No need for measurements. |
| **DISADVANTAGES** | • Requires specification of other characteristics (mechanical and durability);<br>• Requires initial measurements and requires to repeat them in same conditions after construction (same team, same equipment, same speed, etc). In the end, it is necessary to set an absolute level;<br>• Difficulty in setting a realistic and ambitious noise reduction;<br>• The value of the noise reduction is specific to the construction site and the method used, it is not transferable to another contract. | • Requires specification of other characteristics (mechanical and durability);<br>• Measurement method is often impossible to apply in urban areas;<br>• This criterion is not easy to communicate to the general public. | • Requires specification of other characteristics (mechanical and durability);<br>• Currently, lack of CPX data in the rolling noise database;<br>• This criterion is not easy to communicate to the general public. | • No guarantee of acoustic performance;<br>• Does not stimulate innovation;<br>• This criterion is not easy to communicate to the general public. |
| **RECOMMENDATIONS** | This approach ultimately comes down as to specifying an absolute noise level (next column). | **Preferred approach** (preferably with CPX method). Specification to be accompanied by a tolerance to take into account the repeatability and reproducibility of the measurement methods. | | This type of requirement is not recommended. |

IDRRIM

INSTITUT DES ROUTES, DES RUES ET DES INFRASTRUCTURES POUR LA MOBILITÉ

9, rue de Berri - 75008 Paris - Tél : +33 1 44 13 32 99
www.idrrim.com - idrrim@idrrim.com
@IDRRIM
Association loi 1901

Tracer ensemble les voies durables de la mobilité