Health & Safety

The road surface label used as functional contracting to stimulate innovation – A case-study on a motorway project in the Netherlands

Frank Bijleveld[1], Arian de Bondt[1], Harco Kersten[2]
[1]Strukton Civiel, the Netherlands, [2]province of Gelderland, the Netherlands

Abstract

Recently, the road surface label has been initiated in a working group of the United Nations. Similar to consumer goods, such as washing machines, dish washers and tyres, the road surface label provides information about the road regarding the tyre-road noise, the skid resistance, the rolling resistance and the lifespan and categorises them from A to G. The label provides transparency for society and politicians, stimulates innovation, makes the optimisation of tyre-road interaction possible, and it facilitates the interaction and communication with road users and residents. This helps to acknowledge that a road surface is a product that can industrially be developed, designed, built, maintained, removed, and reused and it facilitates the collaboration between tyre manufacturers and road contractors. A functional contracting strategy using the road surface label has been developed in combination with the Most Economically Advantageous Tender (MEAT) method. This strategy has been demonstrated on a motorway project in the Netherlands. The minimum road surface label required by the road agency was EDEE. Contractors that offered a higher label (per label indicator) could receive a fictive discount on their price (up to a maximum of 57%). A porous asphalt has been developed with a lifespan of 15-18 years, a rolling resistance of 7.5-8.0 kg/ton, a noise reduction of 7.8-8.6 dB(A), and a skid resistance of 0.64-0.67 (friction coefficient). Also, various innovative laboratory equipment and in-situ measurements were used to evaluate the asphalt quality. This paper provides a practical method for road agencies to use the road surface label for functional contracting and demonstrates how it stimulates innovation on the four label indicators. Further, the outcomes of this research contribute to a deeper understanding regarding the tyre-road noise, the skid resistance, the rolling resistance and the lifespan.

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1. INTRODUCTION

The road surface label has recently been initiated in a working group of the United Nations [1]. Similar to consumer goods, such as washing machines, dish washers and tyres, the road surface label provides information about the road regarding the tyre-road noise, the skid resistance, the rolling resistance and the lifespan and categorises them from A (good) to G (abysmal). So, labelling of road surfaces is a categorisation of (current and future) requirements and guidelines for road surfaces, similar to the labels for houses and tyres.

The purpose of the labelling of road surfaces is to stimulate progress and innovation for road surfaces. In addition, it provides easier and transparent communication between the client and contractor, and between road authorities and road user/taxpayer and local residents. It also promotes recognition towards society and politics. It helps to make choices between different road surfaces. The road surface label can also be used in the management phase, in determining the replacement time in advance. Moreover, it facilitates the collaboration with tyre manufacturers and other relevant industry partners, resulting in faster innovation cycles (shorter lead times of innovations) and system innovations rather than innovations at the level of individual sectors. Indeed, a tyre can be optimised for a particular type of road surface, but might be less optimised for another type. If these two sectors - the tyre industry and road construction industry - understand each other better, tyre-road interaction can be optimised as a whole. So, it makes the optimisation of the coherence of tyre-road surface really possible.

In this paper, a functional (end-result performance) contracting strategy using the road surface label has been developed in combination with the Most Economically Advantageous Tender (MEAT) procurement method. This strategy has been demonstrated on a motorway project in the Netherlands. The goal of this paper is to demonstrate the use of the road surface label on a actual project in the Netherlands and show how it stimulates innovation.

Section 2 describes the concept of the road surface label in more detail. Next, the procurement strategy to use the road surface label in an actual project has been discussed (section 3). Section 4 describes all results of the case-study on the motorway in the Netherlands, both from a laboratory and an in-situ perspective. Finally, section 5 describes the most important conclusions and recommendations based on this research.

2. THE ROAD SURFACE LABEL

Roads exist to facilitate the mobility of people and goods. Important political and social themes concerning roads include accessibility (and therefore availability), safety, liveability, sustainability, durability and economy. These themes are related to road surface performance indicators as shown in Table 1.
For the safety of a road the skid resistance performance is key, for the liveability (theme) the tyre-road surface noise, and for both sustainability (CO_2) and economy the rolling resistance is very important. For accessibility and availability, the lifespan of the road, both mechanically and functionally, is an important parameter. This lifespan can be further worked out in, for example, resistance to crack formation, resistance to rutting and ravelling. Finally, sustainability can be expressed in an Environmental Cost Indicator of a road surface.

Table 1. Political and societal themes and corresponding road performance indicators

Themes from politics and society	Tyre-road surface performance indicator
Safety	Skid resistance
Liveability	Noise reduction, Rolling resistance
Sustainability	Environmental Cost Indicator
Accessibility, availability	Lifespan
Economy	Rolling resistance, lifespan

The road surface label is based on the labelling of tyres, regulated in Directive 1222/2009/EC of the European Commission. The road surface label complements the tyre label. The road surface label contains the following four performance indicators of which the first three correspond with the three performance indicators on the tyre label, as shown in Figure 1:

- Pavement-tyre noise reduction;
- Wet skid resistance;
- Rolling resistance;
- Lifespan.

The measurement method (1) for the noise reduction is the tyre rolling noise on the pavement, as defined in the environmental noise directive 2015/996/EC, for m=1 (light motor vehicles) and A-weighted over all octave bands i, measured according to ISO 11819-1:1997 Statistical Pass-By method (SPB) with a microphone height of 3 m, (2) for the skid resistance is longitudinal coefficient of friction (COF) between wetted road surface and tyre, determined at 70 km/h using a standardised measurement tyre in a standardised friction tester according to CEN/TS 15901-9:2009 or equivalent, (3) for the rolling resistance the rolling resistance coefficient using the TU Gdansk rolling resistance trailer, and (4) for the lifespan in-situ measurement methods and laboratory tests (EN-12796). More information on these measurement methods are described in the UNECE-resolution [1].

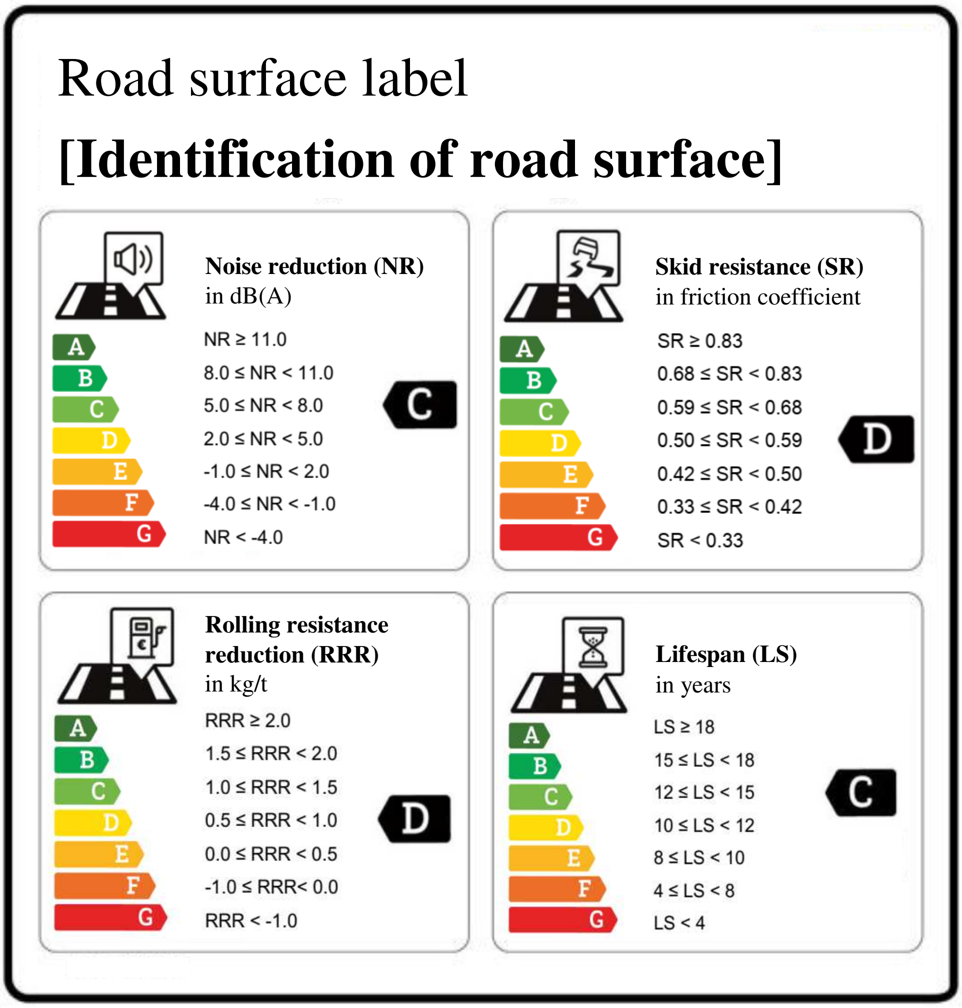

Figure 1: Example of the road surface label

The first three indicators of the road surface label are all indicators of tyre-pavement interactions, and therefore influenced by tyre properties and ambient conditions. Therefore, standard tyres are used as far as feasible to measure these indicators of road surface performance. Where possible, relevant conditions (e.g. temperature or measuring speed) are standardised as well.

At present, there are no European harmonised methods for characterisation of the four pavement performance indicators, but such methods are being developed by the European Committee for Standardization (CEN) Technical Committee 227 Road materials, Working Group 5 pavement surface characteristics. While such harmonised methods are not yet available, the road surface label motivates the use of certain characterisation methods, and boundaries for label classes (A to G inclusive). When harmonised methods become available, they should preferably be adopted to replace the present methods.

The labelling system is intended to be used for specific road surfaces, meaning a road pavement section at a certain location, e.g. road number xxx between kilometre y.y and z.z. This means that, before construction of a specific road surface, e.g. in the tendering phase of a contract, the label classes only can be determined indicatively, either by measurements on one or more already constructed similar surfaces, or by predictive laboratory testing. After construction of the road surface, its label classes can be determined in-situ.

The labelling system is deliberately kept as simple as possible and still tries to stimulate improvement and optimisation (seeking balance between stimulating improvement and clarity / simplicity), similar to the tyre label. Therefore, only one set of scale values is chosen for each of the four considered most essential road surface

performance indicators. For each indicator there exist more than one method to measure or determine a value. The characterisation methods are chosen to match existing regulations and practices as good as possible. Again, these can be replaced in the future by harmonised European standards when these become available.
The boundaries of the label classes are recommended such that F or E are common now, D and C represent current good practice, B is a challenge and A is not attainable at present, but should pose a realistic challenge for the next 5-10 years.
It is recommended that clients not only require the contractor to provide the label classes, but also require the specific values for each of the performance indicators, together with the underlying measurement reports based on reliable and advances laboratory techniques.
The label scales are based on in-situ properties, measured using different concepts for different properties: standardised tyres under standardised conditions (for skid resistance, rolling resistance), representative traffic (for tyre noise reduction), or actual traffic (for lifespan). Laboratory tests on laboratory-made surface specimens may be used to predict in-situ behaviour for purposes of road surface product development. However, “the proof of the pudding is in the eating”, so the in-situ values are decisive. For noise reduction, skid resistance and rolling resistance, i.e. properties that can be determined within a year after construction of a road surface, the label class for innovative products should preferably be based on a set of in-situ sections. For lifespan, this is not practically feasible as the actual performance of the in-situ road surface only shows after many years. By necessity, this label class therefore has to be based on predictive laboratory tests (EN-12697). For measuring in-situ properties of road surfaces, methods are used that can be executed in the run of traffic, to avoid traffic disturbance or unsafe measuring.
It is recognised that e.g. wet skid resistance and tyre-pavement noise are highly dependent on vehicle speed, and that the speed-dependency may differ strongly between pavement types or categories. Nevertheless, for simplicity the label scale is based on only one speed, 80 km/h. Similarly, the label scale is only based on passenger cars, not considering vans, trucks, motorcycles or others. If desired, alternatively a composite value could be based on e.g. 10% trucks and 90% cars.
It is also recognised that road surface characteristics often will change over time. Skid resistance will decrease due to aggregate polishing and tyre-pavement noise may increase as surface texture roughens and sound-absorbing pores get clogged. For noise reduction, skid resistance, and rolling resistance, initial values are used, and the road agency can possibly add requirements that the road surface has a certain label after a specified lifespan, i.e. that the road surface still has a label of EEEE after 10 years.

Road surface labels encourage the optimisation of road surfaces, e.g. for tyre-pavement noise, skid resistance, rolling resistance and lifespan, and help to make choices between different road surfaces. Such improvement of road surface performance will reduce the road-related costs of mobility for society and environment, in reducing fuel consumption, CO_2-emission, accident costs and noise nuisance.
For example, reducing rolling resistance by approximately 10-30 per cent yields fuel savings of 2-6 per cent, and the risk of accidents at good skid resistance is 2-5 times less than with a very poor skid resistance. Silent road surfaces reduce nuisance, noise-related sleep problems, and the need and costs for visually less appealing sound barriers.
Benefits for the whole of Europe have yet to be calculated. For the Netherlands 4% fuel savings yields about 1 Mton CO_2 reduction annually (for national and provincial roads) and approximately €325 million social benefits (for national roads alone). Better skid resistance could save significantly on the annual €8 billion of Dutch traffic accident costs. Lower pavement-tyre noise can save €400 million for raising the present 400 km of noise barriers in the Netherlands [2]. The figures for the Netherlands may be extrapolated to estimate benefits for other countries or regions, and for Europe.
The road surface label can easily be used in the management stage in order to more accurately determine the replacement time in advance and to be able to communicate with society. It encourages road builders to develop products with enhanced rolling resistance, optimum skid resistance, less noise, and an increasing lifespan. Road surface labels stimulate road authorities to tune requirements to specifics situations. Importantly, road surface labels enable the tax payers that finance the road, the road user and local residents to easily appreciate what road surface quality they are getting.
Also, it facilitates the cooperation between the road industry and tyre industry and other relevant partners, resulting in faster innovation cycles (shorter turnaround of new products) and makes the optimisation of tyre-road interaction really possible. Indeed, a tyre can be optimised for a particular type of road surface, but might be less optimised for another type. Alternatively, a road surface can be optimised for a particular type of tyre, but might be less favourable for a different type of tyre. If these two sectors - the tyre industry and road construction industry - understand each other better, tyre-road interaction can be optimised as a whole. Road surface labelling should lead to the recognition of a road as a product that is industrially designed, built and maintained.

The next section describes how this road surface label can be used and applied in an actual procurement in order to stimulate innovation.

3. PROCUREMENT USING THE ROAD SURFACE LABEL

The province of Gelderland has developed and applied a procurement strategy using the road surface label. This strategy has been applied and demonstrated on a motorway project in the Netherlands (A348, km 0.3-2.7). The procurement strategy was the Most Economically Advantageous Tender (MEAT) method, in which not only the price but also quality parameters are used to choose a contactor (that has the best price-quality ratio).

In this procurement strategy, a fictive discount on the price will be given if higher labels items are offered. These road surface labels are besides all traditional requirements on mechanical properties, evenness, etc. Table 2 shows the fictive discount percentages if 1, 2 or 3 label items higher are offered. So, the minimum required label was EDEE and with the label CCBB (or better) the maximum fictive discount of 57% could be achieved. Also, Table 1 shows that there is no added value for a higher noise reduction than label C (because B and A have the same fictive discount).

Table 2. Fictive discount percentages on the price at the procurement

Label indicator	Minimum requirement	Fictive discount 1 label higher	Fictive discount 2 labels higher	Fictive discount 3 labels higher
Noise reduction	D	C: 12%	B: 12%	A: 12%
Wet skid resistance	E	D: 6 %	C: 9 %	B: 9 %
Rolling resistance	E	D: 6 %	C: 9 %	B: 12 %
Lifespan	E	D: 12 %	C: 21 %	B: 24 %

An example: Contractor 1 offers a road surface with label DDDE for 6 million Euro and contractor 2 offers a road surface with label CDBB for 10 million Euro. Contractor 1 receives a discount of 0+6+6+0=12% fictive discount, thus a fictive price of 5.28 million Euro. Contractor 2 receives a discount of 12+6+12+24=54% fictive discount, thus a fictive price of 4.6 million Euro. Because contractor 2 has the lowest fictive price and therefore receives the contract for 10 million Euro, despite contractor 1 was cheaper.
In this way, the road agency (and thus the society) can precisely determine how valuable a higher label item is for a specific project. From these fictive discount percentages, it becomes clear that most value has been given to a longer lifespan (from minimal 8 years to 15 years). In this case, the province of Gelderland had 57% (12+9+12+24) more money available for better quality (label CCBB).
The contract was awarded to Strukton Civiel, that offered a PA8G-Plus (a porous asphalt with a nominal grain size of 8 mm), which is a special fine porous asphalt with a long lifespan and a low rolling resistance, with the road surface label CDBB.

The next section further describes the results of the case-study, in terms of materials and asphalt mixture as well as the results of laboratory tests and in-situ performance.

4. RESULTS CASE-STUDY IN THE NETHERLANDS

4.1 Materials and asphalt mixture

A new porous asphalt mixture (PA8G-Plus) was designed with a long lifespan and a low rolling resistance, with the road surface label CDBB. Therefore, the main design criteria were the following:

- Life span: 15-18 years;
- Rolling resistance: 7.5-8.0 kg/ton;
- Noise reduction: 5-8 dB(A) (noise level of 69.2-72.2 dB(A));
- Skid resistance: 0.50-0.59 (friction coefficient).

Table 3 shows the material composition and Table 4 shows the aggregate gradation of the designed asphalt mixture.

Table 3. Material composition

Material	Composition (m/m%)
Aggregate 4/8	84.4
Sand	2.5
Filler	6.9
Binder drainage inhibitor	0.2
Sealoflex® binder	6.0

Table 4. Asphalt mixture gradation

Sieve size (mm)	Percentage passing sieve
11.2 mm	100.0
8.0 mm	95.1
5.6 mm	48.2
4.0 mm	22.1
2.0 mm	13.8
500 µm	10.4
180 µm	9.3
63 µm	8.0

The main characteristics of the asphalt layer are:

- 40 mm layer thickness;
- 20% air voids;
- Bulk density: 2459 kg/m^3;
- Target density: 1950 kg/m^3.

The characteristics of the binder Sealoflex® 5-90 (PA) are:

- Penetration at 25 °C (0.1 mm): 70-100;
- Softening point (°C): ≥ 85;
- Force-ductility, energy to failure (J/cm^2): 10,0;
- Fraass breaking point (°C): ≤ -18;
- Elastic recovery at 25 °C (%): ≥ 85;
- Viscosity at 135 °C (mPa.s): 1500-2500;
- Viscosity at 185 °C (mPa.s): 200-350;
- Mixing temperature (°C): 175.

The asphalt mixture (PA8G-Plus) has been optimised by using the best Dutch polymer modified bitumen (PmB) available at the moment and by using an optimised filler within narrow specifications regarding its hydrated lime content. Also, a specifically designed compaction procedure has been designed in order to achieve the density and air void content in practice. Furthermore, special sanding equipment is used to prevent aggregate crushing during compaction. Together, this result in a lifespan of 15-18 years without maintenance.

4.2 Determining the road surface label in the laboratory

The designed asphalt mixture was evaluated on its functional design criteria relevant for road users, namely lifespan, skid resistance, noise reduction and rolling resistance.

Lifespan

The most critical failure criterion for this porous asphalt surface layer is ravelling. To evaluate its resistance against ravelling Cantabro-tests were performed according to EN-12697-17. The tests were performed on 6 cores at 5 °C and the mass loss was analyzed after 300 revolutions.

The cores were conditioned in advance according to following procedure:

- 120 hrs at 85 °C;
- In an exicator according to EN 12967-12;
- 48 hrs in a freezer at -20 °C;
- 24 hrs defrosting at 30 °C;
- In an exicator according to EN 12967-12.
- 70 hrs under water at 40 °C;
- 4 hrs in salt water (50 gr salt/liter water) at 5 °C.

The mass loss was evaluated by comparing it to a reference porous mixture (PA 16) from which the in-situ lifespan was known based on actual long-term field performance. The average mass loss of the PA8G-Plus was 160 grams, which was 16.7% mass loss.

The average mass loss of a PA 16 70/100 (6.0% bitumen) was 68% - while the life span in the field has been proved to be 11 years. So, based on these laboratory results and the long-term field performance of the mix optimisations (binder and filler) it is very plausible that the in-situ lifespan of the PA8G-Plus is 15-18 years, according to the mix design.

Skid resistance (wet)

The wet skid resistance was determined using the innovative SR-ITD® (Skid resistance & Smart ravelling & Sophisticated rolling – Interface Testing Device [3]). This is a new laboratory machine previously partly developed in a European research project (SKIDSAFE 7th framework research project). Recently, the device also has been modified to determine the resistance to ravelling and to determine the rolling resistance of a road surface [4].

Using the SR-ITD the friction coefficient was determined. The friction coefficient is the ratio of horizontal force over vertical force, hence its physical dimension is Newton/Newton or dimensionless. Figure 2 shows that the friction coefficient is quite similar to a PA 11.
A standard PA 16, combined with a systematic sanding method, normally has an in-situ wet skid resistance between 0.58 and 0.76 (measured according to CEN/TS 15901-9:2009). So, it is very plausible that the in-situ wet skid resistance of the PA8G-Plus is in this similar range, but at least 0.50-0.59 (-), according to the design criterion.

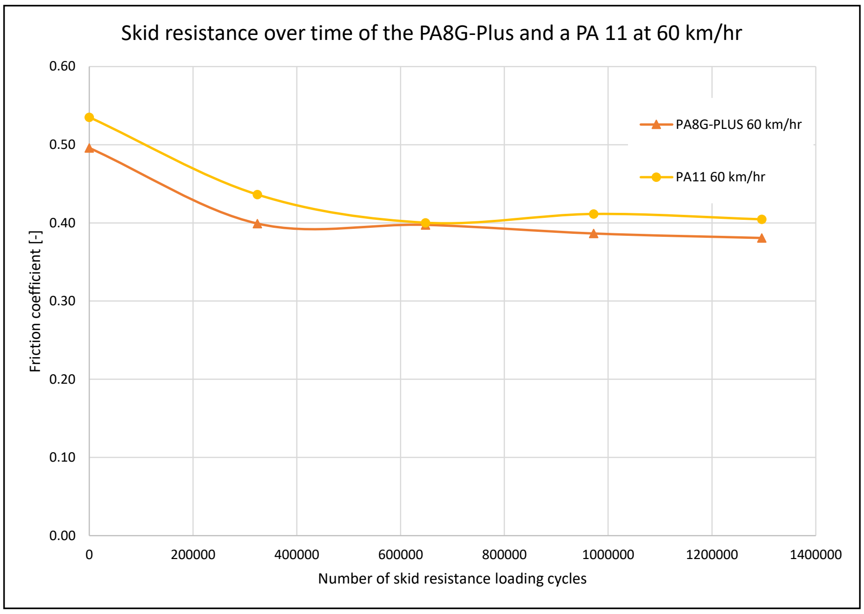

Figure 2: Skid resistance over time in the laboratory

Noise reduction

There were in-situ measurements available (CPX and SPB, according to ISO/DIS 11819-2) of an asphalt mixture with a different binder and filler (although the materials and gradation and thus the void ratio were the same).
The noise reduction of this reference mixture at a measurement speed of 80 km/hr is 6.2 dB(A) (absolute noise level of 70.4 dB(A)). The PA8G-Plus is similar to this reference, however it contains a higher binder modification. The expectation therefore was that the PA8G-Plus performs even a little better than this reference mixture regarding its noise reduction (due to its higher elasticity and lower impedance). Therefore, it is very plausible that the designed noise reduction of 5-8 dB(A) will be reached easily in-situ.

Rolling resistance

The topic of rolling resistance is still in its academic infancy. In the Netherlands, most practical experience is available with the TU Gdansk rolling resistance trailer. The SR-ITD, based on the same measurement principle and validated with the TU Gdansk measurement trailer, was used to determine the laboratory rolling resistance.
The rolling resistance of the PA8G-Plus has been compared to a SMA 11. The texture (Mean Profile Depth) of the PA8G-Plus has been reduced with 10% compared to an SMA 11. In addition, the rolling resistance has been reduced by 30% compared to an SMA 11 – see Figure 3.

The in-situ rolling resistance, based on available historical measurements, determined using the TU Gdansk trailer of the SMA 11 is app. 7.6-7.8 kg/ton directly after construction and is app. 8.0 kg/ton at an older SMA 11. Based on the laboratory experiments (SR-ITD), it is therefore very likely that the in-situ rolling resistance of the PA8G-Plus is lower than 7.5 kg/ton, but at least achieves a rolling resistance of 7.5-8.0 kg/ton, according to the design criterion.

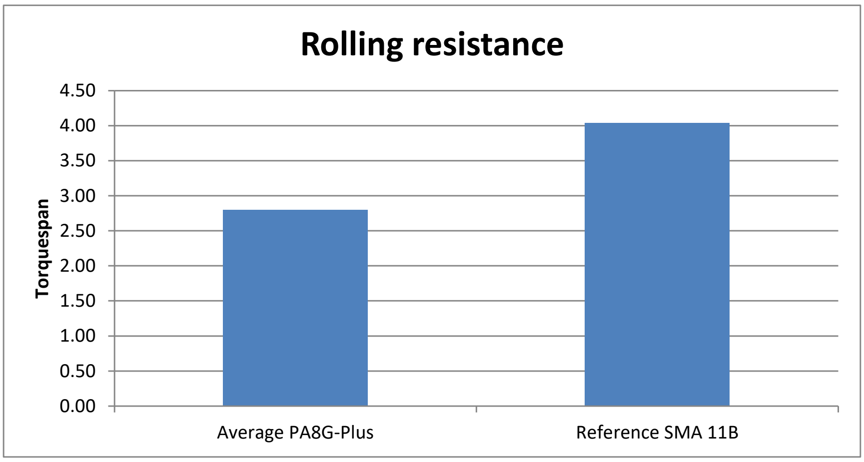

Figure 3: Rolling resistance in the laboratory

These characteristics are the potential asphalt quality. However, these characteristics are only realised when the target density, percentage of air voids and texture will be realized in-situ. It is therefore crucial to also design the compaction process in the laboratory and provide proper instructions to the asphalt team.

4.3 Instructions to the asphalt team

Based on an extensive study [5,6] proper instructions for the asphalt team, and more specifically for the roller operators, are developed. The instructions to the asphalt team are the following, visualised in Figure 4:

- Breakdown roller: 2 roller passes in the temperature window 140-120 °C;
- Sanding at 120 °C using special sanding equipment that has no gravitational force higher than 16 kg/cm1 to prevent crushing of the aggregate (see de Bondt et al. for the development of this special sanding machine);
- Intermediate roller: 2 roller passes in the temperature window 120-100 °C;
- Finish roller: 2 roller passes in the temperature window 100-90 °C.

These instructions and compaction procedure provides more reliability that the target density, percentage of air voids and texture, and with that the potential functional characteristics determined in the laboratory will also be achieved in the field.

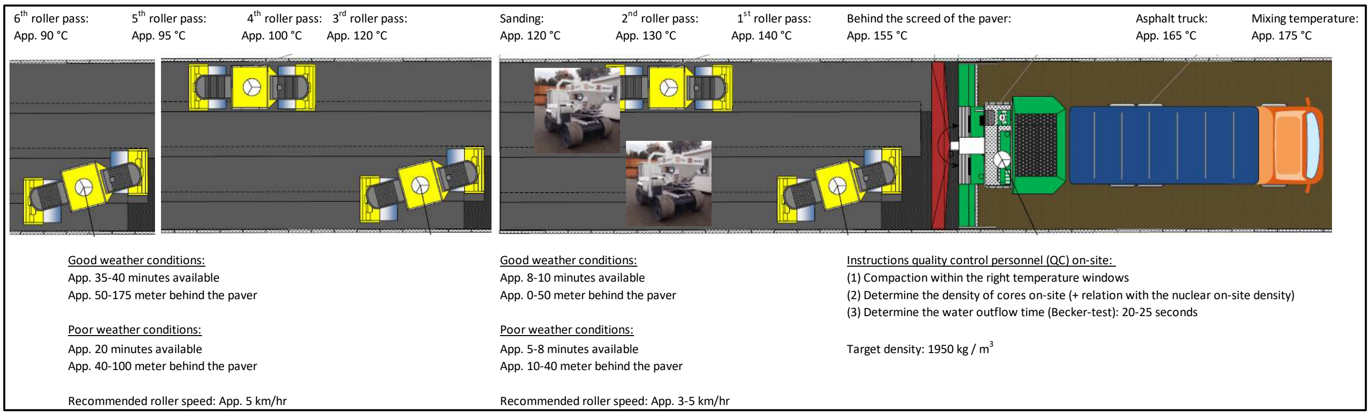

Figure 4: Instructions to the asphalt team

The next section describes the road surface label performance in the field.

4.4 Determining the road surface label in the field

After determining the road surface label in the laboratory, the asphalt mixture has been validated using in-situ measurements to determine the in-situ road surface label. The asphalt mixture (PA8G-Plus) has been constructed on a 2.4 kilometre motorway in the Netherlands (A348 Arnhem, km 0.3-2.7). Figure 5 shows two photos from the on-site construction.

Figure 5: Photos of the construction of the motorway A348 in the Netherlands

After construction, the following performance characteristics were monitored:

- Density and air voids (using asphalt cores drilled from the road);
- Noise reduction (SPB and CPX method according to ISO/DIS 11819-2);
- Skid resistance (Dutch measurement trailer according to CEN/TS 15901-9:2009);
- Rolling resistance (TU Gdansk measurement trailer).

Lifespan: Density and air voids

From the realised construction work, 13 asphalt cores have been drilled and the resulting degrees of compaction, densities and air voids have been measured. The results of these measurements are:

- Degree of compaction: 99.6% (st. dev: 2.0%);
- Density: 1941 kg/m^3 (st. dev: 38 kg/m^3);
- Air voids: 21.1% (st. dev: 1.6%).

Based on these results, the asphalt has been compacted according to the instructions within narrow boundaries.

Skid resistance

The skid resistance of the realised construction work has been determined by using the Dutch measurement trailer (according to CEN/TS 15901-9), which is a compact, robust and versatile measurement system for longitudinal wet skid resistance (Braking Force Coefficient), enabling full-length skid resistance evaluation.

The results of these measurements have been shown in Figure 6. The realised in-situ skid resistance for lane 1 is 0.64 and for lane 2 is 0.67 (at a measuring speed of 70 km/hr). This means that the realised wet skid resistance is better than the design criterion of 0.50-0.59 (friction coefficient).

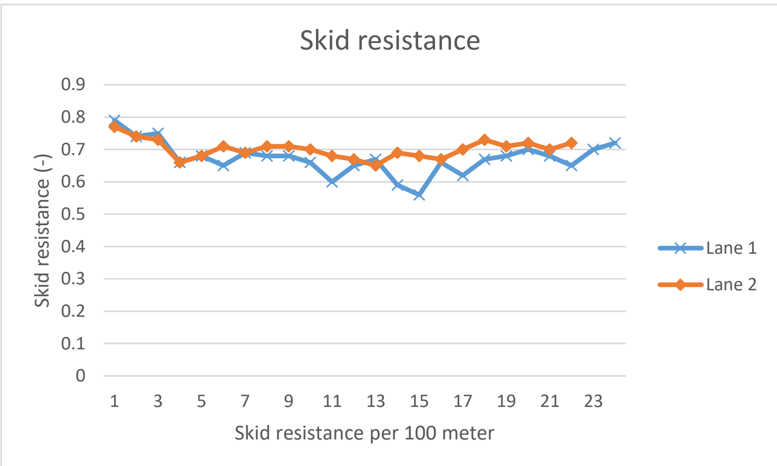

Figure 6: Skid resistance of realized construction work

Noise reduction
The noise reduction of the realised construction work has been determined using both the Statistical Pass-By (SPB)-method and the Close-Proximity (CPX)-method. The measurements were conducted according to ISO 11819-1:1997 Statistical Pass-By method (SPB), but with a microphone height of 3 m, to avoid in-situ measuring problems caused by guard rails. In-situ monitoring of road surfaces were done by means of the CPX method (ISO 11819-2:2017), which were converted to noise reduction values.

The measurements show that the initial noise reduction at a measurement speed of 120 km/hr for light vehicles are the following:

- Lane 1: 7.8 dB(A) – noise level of 74.8 dB(A);
- Lane 2: 8.6 dB(A) – noise level of 74.0 dB(A).

This means that the realised noise reduction is according to the design criterion of 5-8 dB(A).

Rolling resistance
The rolling resistance of the realised construction work has been determined by using the TU Gdansk measurement trailer.
The TU Gdansk rolling resistance in-situ measurement trailer is a three-wheel trailer. The two front wheels are bearing/support wheels and the rear wheel is the measurement wheel. The measuring wheel is attached to the trailer frame by a swivel arm; the angle of the swivel arm provides a measure of the rolling resistance force on the measuring wheel. In recent years, improvements have been made to the trailer to further limit the effects of unwanted variations on the measurement result (in the European ROSANNE research project).
The rolling resistance measurements were conducted with the SRTT (Standard Reference Test Tyre), with a rubber hardness value within the range 62 to 73 at a temperature of 23 °C, the tyre load was 400±40 kg, the measured road surface was dry and free of dirt, and the rolling resistance was determined at 80 km/h.
The measured rolling resistance over the 2.4 km stretch of asphalt was 7.8 kg/ton. This means that the realised rolling resistance is according to the design criterion of 7.5-8.0 kg/ton.

4.4 Results in terms of the road surface label

Based on the in-situ measurements, the road surface label of the PA8G-Plus has been determined. The road surface label of this mixture is CDBB and is shown in Figure 7.

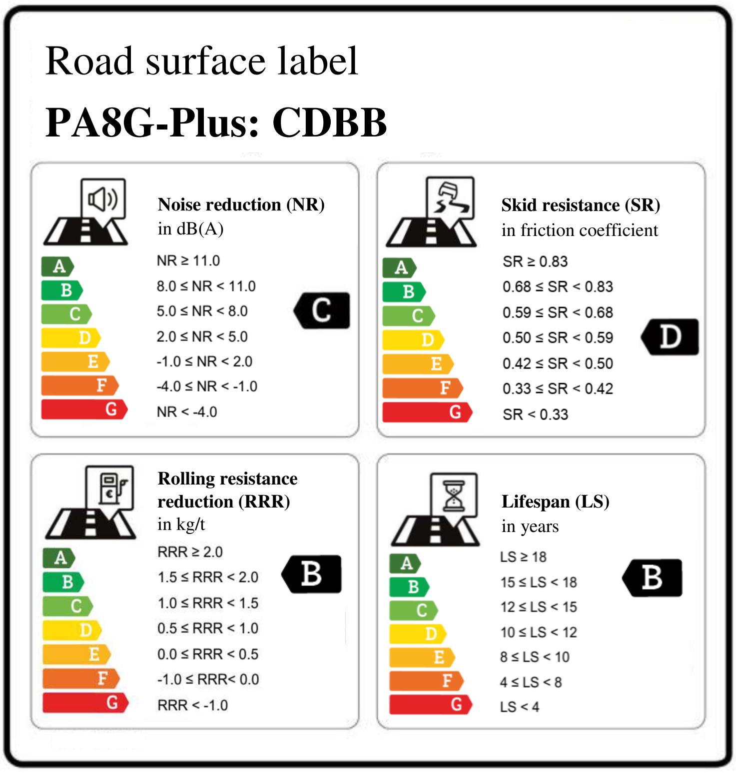

Figure 7: Road surface label of the PA8G-Plus

In conclusion, the minimum requirements of the road agency (province of Gelderland), the offered road surface label of the contractor (Strukton Civiel) and the realised functional performance is shown in Table 5.
From these results, it is apparent that the province 6.2 dB(A) more noise reduction received, 36% better skid resistance, 13% reduced rolling resistance and 7 years more lifespan than the minimal requirements. Further, it is clear that the contractor realised better characteristics, specifically for the noise reduction and skid resistance, than was offered during the procurement phase.
Also, please note that a reduction of 13% of the rolling resistance, over a period of 15 years on a 2.4 km motorway reduces approximately 670.000 litres of fuel and 1500 tonnes of CO_2.

Table 5. Road surface label – minimal requirements, offered by the contractor and realised in-situ

Label-item	Minimum requirement	Offered by the contractor	Realised in-situ
Noise	D: 2-5 dB(A)	C: 5-8 dB(A)	D: 8,2 dB(A)
Skid resistance	E: 0,42-0,50 (-)	D: 0,50-0,59 (-)	C: 0,66 (-)
Rolling resistance	E: 9,0-9,5 kg/ton	B: 7,5-8,0 kg/ton	B: 7,8 kg/ton
Lifespan	E: 8-10 years	B: 15-18 years	-

Measurement of the noise reduction, the wet skid resistance, and the rolling resistance will be conducted on the A348-section every two years for a period of 16 years in order to also determine the degradation over time.
Together, these results demonstrates that the road surface label can be used as functional (end-result performance) contracting to stimulate innovation on road surfaces.

5. CONCLUSIONS AND RECOMMENDATIONS

Recently, the road surface label has been initiated in a working group of the United Nations. This research applied the proposed road surface label, including laboratory and in-situ measurement techniques for the topics skid resistance, noise reduction, rolling resistance and lifespan.
A functional contracting strategy using the road surface label has been developed in combination with the Most Economically Advantageous Tender (MEAT) method. This strategy has been demonstrated on a 2.4 kilometre motorway project in the Netherlands.
The minimum road surface label required by the road agency was EDEE. Contractors that offered a higher label (per label indicator) could receive a fictive discount on their price (up to a maximum of 57%). A porous asphalt, with the label CDBB, has been developed with a lifespan of 15-18 years, a rolling resistance of 7.5-8.0 kg/ton, a noise reduction of 7.8-8.6 dB(A), and a skid resistance of 0.64-0.67 (friction coefficient). Also, various innovative laboratory equipment and in-situ measurements were used to evaluate the asphalt quality.
This paper provides a practical method for road agencies to use the road surface label for functional (end-result performance) contracting and demonstrates how it stimulates innovation on the four label indicators. Further, the outcomes of this research contribute to a deeper understanding regarding the tyre-road noise, the skid resistance, the rolling resistance and the lifespan.

In this paper, the road surface label was mainly used to promote innovation on the road surface. However, the label also provides transparency for society and politicians, makes the optimisation of tyre-road interaction possible, and it facilitates the interaction and communication with road users and residents. This helps to acknowledge that a road surface is a product that can industrially be developed, designed, built, maintained, removed, and reused and it facilitates the collaboration between tyre manufacturers and road contractors. Therefore, in the future the road surface label should also be used for communication to politicians and society.
Further, the road surface label facilitates the cooperation between the road industry and tyre industry and other relevant partners, resulting in faster innovation cycles (shorter turnaround of new products) and makes the optimisation of tyre-road interaction really possible. If these two sectors - the tyre industry and road construction industry - understand each other better, tyre-road interaction can be optimised as a whole. It makes the optimisation of the coherence of tyre-road surface really possible.
The described implementation of the road surface label is a first step on the basis of practical experience and the latest scientific knowledge. It is recommended as a first follow-up step to expand the paradigm of the road surface label and apply it on more projects. In addition, there needs to be further cooperation between tyre suppliers and road constructors in the future so that optimisation can occur between the tyre and the road surface.
Road surface labels are a stepping stone to move forward step by step as a transportation industry. This is a step forward towards professionalisation and industrialisation of the road industry and tyre industry.

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