Hitting new lows – specification and deployment of quieter road surfaces

Stephen Chiles (1), George Bell (2), John Bull (3), Richard Jackett (3) and Rob Wareing (2)

(1) Chiles Ltd, 4 Park Terrace, Christchurch
stephen@chiles.co.nz

(2) Altissimo Consulting, 6A Alderson Avenue, Christchurch

(3) Waka Kotahi NZ Transport Agency, 44 Bowen Street, Wellington

ABSTRACT

Strands of research progressing over the last decade have come together to create a framework for practical implementation of quieter road surfaces in New Zealand. Through iterative trials, noise from porous asphalt has been reduced by a combination of smaller aggregate and thicker surface layers. In practice, thickness of porous asphalt surfaces has been found to vary significantly along roads, and this is the primary cause of variations in noise. A magnetic induction method has been identified as a practical and accurate approach for checking surface thickness at discrete points. The development of new corrections for New Zealand road surfaces to be used in noise models has been presented previously. Those corrections are now ratified and include two generic low-noise surface classifications, LN3 and LN5, with corrections of -3 dB and -5 dB respectively. Currently, the classifications can only be met by two specific mix designs / thicknesses that have been adequately tested on different sites and over several years. However, the generic classifications allow robust specification while accommodating further optimisation. All noise mitigation options assessments and any consequent designation conditions / requirements should now refer to high-performance low-noise surfaces only in terms of these LN classifications. As noise is dependent on surface thickness, the porous asphalt specification has been amended so that surfaces with LN classifications must have thickness measured every 20 metres along each traffic lane, with mandatory acceptance criteria and reporting. These quieter porous asphalt surfaces, implemented with strict thickness quality controls, represent significant progress towards better living conditions near highways.

INTRODUCTION

In 2008, Transit New Zealand (a predecessor to Waka Kotahi) published a State Highway Environmental Plan formally recognising harm to health caused by road-traffic noise and setting an objective to reduce exposure to high traffic noise levels from the existing state highway network [1]. Existing road-traffic noise affects hundreds of thousands of people in New Zealand [2] without practicable measures to quickly resolve issues. Therefore, a range of activities have been undertaken to work towards the objective.

A key activity has been to seek noise reductions at source, which for vehicles at highway speeds is controlled by the interaction of the tyre with the road surface. While both parts of this interaction (tyre and road surface) can potentially be altered to reduce noise, this paper relates to work by the road controlling authority with influence only over the surface.

A range of international and some national research has long shown potential noise reductions from different road surface types. However, to achieve sustainable and enduring noise reductions in New Zealand, any solutions need to be practicable, integrated with other engineering requirements and compatible with local factors such as the climate and aggregate supplies. Some possible surface options are constrained by underlying pavement characteristics, some require substantially more material and cost, and some may have reduced lifespans. As such, careful consideration is needed when adopting new potentially lower noise surface types.

An initial proposal was to achieve lower noise surfaces simply by setting an acoustics performance specification and allowing industry to resolve the integration challenges in the most efficient manner. However, consultation responses highlighted substantial knowledge gaps that would prevent contractors from being able to work to such a standard. A collaborative approach was recommended, which led to Waka Kotahi working with contractors, consultants and researchers to understand how existing surfaces perform and to develop and test surfaces to reduce noise [3]. This work is ongoing, but a significant milestone has recently been passed with the publication of standard specifications for implementation of porous asphalt surfaces with consistently reduced noise [4], [5].

A companion paper summarises the development of porous asphalt surface types with reduced noise [6]. This paper describes broader work that has been undertaken to implement these new surfaces in practice on the state highway network. Issues are summarised here and full technical details are separately available in individual reports for different aspects [3].

SURFACE TYPES

Figure 1 shows the approximate proportion of different surface types currently on the state highway network. The majority of the network has chipseal surfaces, which are used because they are cost effective and are compatible with the flexible underlying pavements that comprise much of the network.

Asphaltic mix surfaces are used on around one fifth of the network. This proportion has been steadily increasing over recent years with new expressways and motorways generally having asphaltic mix surfaces. Of the asphaltic mixes, porous asphalt surfaces comprise the majority, equating to just over a tenth of the overall network.

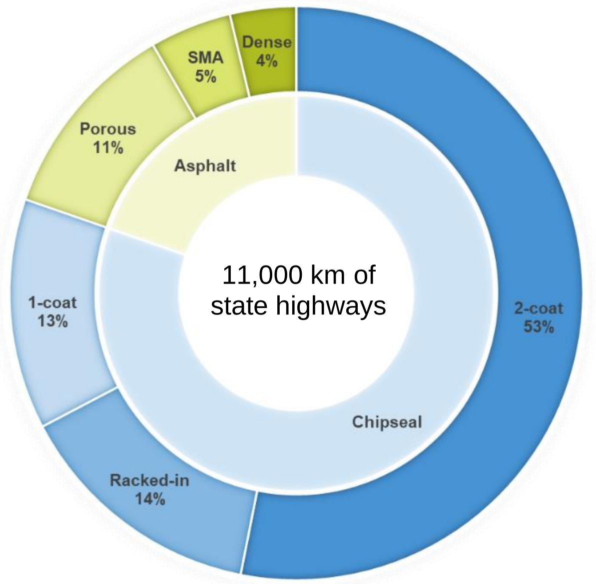

Figure 1. Approximate distribution of road surface types on the New Zealand state highway network (2024)

Acoustically, key features of porous asphalt surfaces are:

- 'negative' texture whereby a relatively flat running surface can be achieved with texture provided by gaps between aggregate particles, and
- interconnected air voids within the surface typically making up approximately 20% of the surface volume.

The tenth of the network with porous asphalt surfaces includes most of the highways with highest traffic volumes and/or passing through areas of highest population density (e.g. Auckland Motorways). As such, effort has been spent on this minority surface type because it has potential to provide a disproportionately large benefit in terms of population noise exposure. It is also a surface type previously used in part because of reduced noise and where further noise reductions appeared attainable from prior research.

Work is ongoing seeking to reduce noise from other surface types, but this paper relates primarily to porous asphalt.

ROAD SURFACE NOISE CORRECTIONS

A prerequisite for evaluation and implementation of any low-noise road surface is to be able to quantify how much it reduces noise. In this instance it has also been necessary to first revisit how existing surfaces perform to provide a reliable baseline comparator.

Close-proximity (CPX) measurements of noise immediately beside a moving tyre [7] have been used extensively and routinely as an invaluable research tool. These measurements allow for the performance along the entire length of road surfaces to be quantified and compared with other surfaces, but differences do not correlate directly to changes in noise experienced by people living nearby.

To evaluate noise at houses, road surface noise corrections are needed that can be applied to predictions, (in New Zealand) using the Calculation of Road Traffic Noise (CRTN) algorithm [8]. With such corrections, noise models can account for a proposed surface type, and benefits of alternative surface types can be evaluated.

For existing road surfaces, Waka Kotahi had previously published surface corrections for twenty-three different types of road surface. It transpired that some of these were inaccurate, and an extensive process has been undertaken with reference to a large CPX database and wayside measurements to essentially recalibrate CRTN for New Zealand road surfaces [9].

The recalibration resulted in a simplified set of corrections with just six types of existing road surfaces as shown in Table 1. The full version of this table [4, Table A1] includes details of how these corrections should apply to other surface types that are not explicitly listed. The method of application for the corrections also changed from previous practice. Values are now applied directly to CRTN outputs, with no prior adjustment to a reference surface, and with no dependence on traffic composition or speed.

Table 1. Road surface noise corrections [4]

Category	Type	Surface correction (dB)
Chipseal	Grade 2 or 3	+6
	Grade 4	+5
	Grade 5 or 6	+4
Asphalt (non-porous)	SMA14	+2
	SMA10	0
Porous asphalt	PA	-1

The corrections in Table 1 now provide a robust baseline when considering new surfaces.

Low-noise surface classifications

New porous asphalt surfaces have been proven to provide noise reductions up to in the order of 4 dB better than typical porous asphalt [6]. While these have been demonstrated to be effective on multiple sites with monitoring over several years, there still appears to be scope for further optimisation/efficiency.

In particular, the new surfaces are thicker (e.g. 40 or 50 mm) than most existing types (e.g. 25 or 30 mm), meaning that more resources and cost are required. Also, the new surfaces use a single aggregate mix envelope, and some have only been tested for surfaces with epoxy modified bitumen. It is likely that with further development, similar acoustic performance may be achieved more efficiently and with fewer constraints on the porous asphalt mix design. This is akin to optimisation that has already occurred whereby the current 50 mm thick surface has been shown to perform as well as previous 70 mm thick 'twin layer' porous asphalt, but using fewer resources and being more practicable to lay and maintain.

Given that the new surfaces are expected to be improved and evolve, it is undesirable to assign unique road surface noise corrections directly to the specific surface types that have currently been tested and developed. Therefore, two generic high-performance low-noise 'LN' porous asphalt surface types shown in Table 2 have been added to the final road surface noise correction table [4, Table A1].

Table 2. Road surface noise corrections, LN types [4]

Category	Type	Surface correction (dB)
Porous asphalt	LN3	-3
	LN5	-5

In the short-term, this framework allows for implementation of the new proven surfaces by classifying them as LN3 or LN5 types. In the medium-term, if more efficient or alternative surfaces are proven they might also be classified as LN3 or LN5 types. Ultimately in the long-term the notation could be extended to even lower noise surfaces.

LN3 AND LN5 SURFACES

LN3 and LN5 surfaces could potentially be specified in terms of an acoustics performance requirement. However, noise measurements at discrete points would be inadequate to control longitudinal variations and CPX measurements are relatively cumbersome. They also do not directly relate to any practical design or construction parameters a contractor might monitor. Therefore, LN3 and LN5 surfaces have been defined by physical parameters of specific surfaces that can be checked directly. (This does not preclude possible future definition of LN3 and LN5 in terms of CPX requirements.)

Specific porous asphalt surfaces have been identified and verified as appropriate for the LN3 and LN5 classifications [6]. These are EPA7 and PA7 mix designations in accordance with the P11 porous asphalt specification [5]. These were pre-existing mix designations in predecessor versions of the specification but had rarely been used on the network. For these mix designations the P11 specification controls most aspects of the surfaces relevant to the noise performance.

Unfortunately, the most critical parameter for noise performance is the surface thickness, which was not previously controlled by P11 beyond an engineering minimum. As a result of this work the issue has been addressed in the current version of P11, which now specifies a thickness measurement method, and for LN surfaces specifies thickness measurement locations and acceptance criteria.

Based on current work and with reference to P11, Table 3 shows the only surfaces currently classified as LN3 and LN5 [4, Table A2].

Table 3. LN surface types [4]

Type	P11 mix designations	Minimum thickness	Mandatory thickness QC
LN3	PA7 EPA7	40 mm	P11
LN5	EPA7	50 mm	P11

Because the LN surface types have mandatory thickness measurement requirements, they cannot apply retrospectively to any existing surfaces where those measurements were not made. Other than the trials for this work there are no existing surfaces that meet these requirements.

THICKNESS MEASUREMENT

As discussed above, surface thickness is a critical parameter for noise performance. Research has shown that current industry practice results in significant variations in thickness along and across a porous asphalt surface, often extending below the specified minimum [10]. While being a simple physical property, road surface thickness is relatively difficult to measure.

Numerous potential approaches to non-destructive thickness measurement have been investigated. It has been found that most robust measurements of thickness (+/- 2 mm) require some action before surfacing in addition to measurements afterwards. Of methods investigated, a laser scan height survey of the entire road before and after surfacing provides the best spatial resolution of thickness across/along a road. However, this is relatively expensive and there are often practical constraints getting a survey prior to surfacing. A practical alternative is to measure thickness at discrete points by using magnetic induction over pre-positioned aluminium discs under the new surface.

Equipment is available to measure thickness by magnetic induction (see Figure 2), making it more practical than traditional manual survey methods. For road surfaces the aluminium discs used are 70 mm diameter and are glued to the underlying pavement immediately prior to surfacing.

Figure 2. Measurement of thickness by magnetic induction

Based on laser height surveys before and after surfacing on a representative project, it has been determined that measuring thickness at discrete points every 20 m along each lane could be used to adequately control the thickness variation and resulting noise performance. On this basis, the new provisions in P11 require thickness measurement of LN surface types by magnetic induction at 20 m spacings in each lane, alternating between left and right wheel paths as shown in Figure 3.

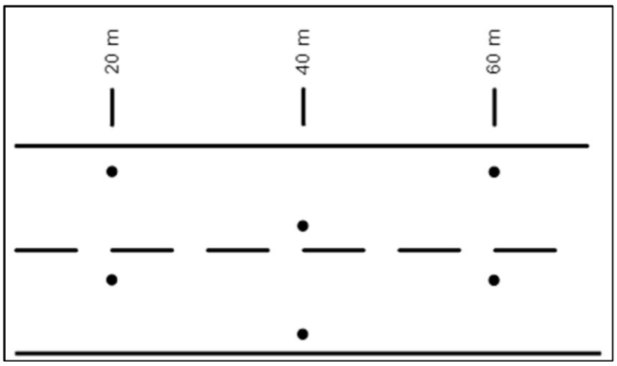

Figure 3. Thickness measurement locations (black dots) alternating between the left and right sides of each lane [5]

The acceptance criteria in P11 is for no more than 25% of thickness measurements, and no more than 4 consecutive measurements, to be below the specified minimum. For an example of current surfacing practice, these criteria would mean that the average thickness would need to be 3 to 4 mm above the specified minimum.

CONCLUSIONS

As a result of numerous strands of research, the following have been achieved:

- Porous asphalt surfaces have been developed and verified with reduced noise,
- New simplified road surface noise corrections have been determined for all surface types to recalibrate the CRTN algorithm for New Zealand,
- Generic LN3 and LN5 high-performance low-noise surface classifications have been introduced, providing certainty of noise performance while allowing for further improvement of surface types, and
- The porous asphalt specification has been updated to include robust thickness controls for LN3 and LN5 surface types.

LN3 and LN5 surfaces should be considered as noise mitigation options, as required and if practicable, on new projects. The LN3 and LN5 notations should be used in all requirements for low-noise surfaces rather than specific mix designs, because this will ensure critical thickness quality controls occur and will allow projects to take advantage of any intervening innovations in low-noise road surfaces.

ACKNOWLEDGMENTS

A large number of people from numerous organisations have contributed to this work for over a decade and all their contributions are acknowledged. At Waka Kotahi, the programme was instigated by Rob Hannaby and later enhanced by Greg Haldane. Particular assistance with pavement engineering expertise has been provided by Dave Alabaster and Grant Bosma.

REFERENCES

[1] Transit New Zealand, “State highway environmental plan: improving environmental sustainability and public health in New Zealand”, June 2008,
[2] Boland, J., “National Land Transport (Road) Noise Map”, 16 May 2019
[3] Waka Kotahi NZ Transport Agency, “Noise and vibration research”, nzta.govt.nz, Accessed: 6 June 2024, Available: https://nzta.govt.nz/roads-and-rail/highways-information-portal/technical-disciplines/environment-and-sustainability-in-our-operations/environmental-technical-areas/noise-and-vibration/noise-and-vibration-research/
[4] Waka Kotahi NZ Transport Agency, “Guide to assessing road-traffic noise”, February 2024
[5] Waka Kotahi NZ Transport Agency, “NZTA P11: 2023 Specification for Open-Graded Porous Asphalt”, January 2024
[6] Jackett, R., Bell, G., Bull, J., Chiles, S. and Wareing, R. “Improving surfaces for quieter roads”, Proc ASNZ 2024
[7] “Acoustics — Measurement of the influence of road surfaces on traffic noise, Part 2: The close-proximity method” International Standards Organisation ISO 11819-2:2017, March 2017
[8] Department of Transport (UK) and Welsh Office “Calculation of Road Traffic Noise”, 1998
[9] Jackett, R. “Road Surface Noise Corrections 2023”, December 2023
[10] Bell, G., “Effects of porous asphalt thickness, ageing, and epoxy, and CPX speed and tyre hardness”, 5 March 2024