Health and whole life cost benefits of highways noise barriers

As with any asset on the highways network, it is common sense to allow for realistic maintenance costs when choosing and procuring a noise barrier system. But a short-term approach of focusing on newly installed prices alone creates a false economy and potentially stores up financial hardship for the future.

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The Design Manual for Roads and Bridges (DMRB) document CD 355 covers *'the application of whole-life cost for design and maintenance of highways structures'*. Appendix B gives an example of a lifecycle appraisal for a highways structure stating that a 60-year period is normally required.

Maintenance free?

Few noise barrier systems currently installed on the UK network can be considered maintenance-free and are certainly not designed for a 60-year life. At the very least, any highways noise barrier designer/specifier should be providing a comparative cost appraisal for the lifecycle of the noise barrier that includes for the initial installed cost;

PLUS

- the reinstallation cost;

PLUS

- the clearance and removal cost of the existing degraded system;

PLUS

- any traffic management cost associated with the replacement **each time the barrier needs replacing.**

This is apart from any localised repair work that might be required on an ad hoc basis, not to mention the impact on road traffic flows or journey time reliability each time a replacement is required.

Further guidance

DMRB document GD 304 *Designing health and safety into maintenance* considers the safety benefits of choosing assets with a higher design life. As an example, it states in Table E/A.1 *'choose barrier design life taking into account both working life costs and the safety issues associated with in service maintenance of the system.'*

DMRB document LD 119, *Roadside environmental mitigation and enhancement*, chapter 5: Noise Barrier Design – para 5.9 requires that noise barriers *'have a non-acoustic durability of at least 20 years'*. By the 60th year of its lifecycle, such a noise barrier could be being installed for the fourth time; having required full replacement three times already! Will the specifier take into account the whole life costs associated with all these anticipated replacements?

Following rigorous testing of installed barrier systems, the Transport Research Laboratory published a project report – PPR 490 on the *Acoustic durability of timber noise barriers on England's strategic road network.* The test results suggest that the acoustic performance of timber absorptive barriers degrade in acoustic performance by approximately 7 dB after only five years. Over the same timeframe, single-skin timber reflective barriers to degrade by the order of 4-7 dB but starting from a much lower initial sound insulation level.

When barriers degrade so quickly it becomes essential to financially quantify the effects of durability when choosing between noise barrier systems based on their whole life cost benefits and long-term acoustic performance.

Transport Analysis Guidance (TAG) workbook

The adverse impact of road traffic noise on public health is long appreciated. Being able to quantify in financial terms not only the perceived annoyance but also the long-term damage to health due to traffic noise helps to justify why one particular noise barrier design will benefit the community more than another over its lifecycle.

DEFRA has produced guidance on assessing the impacts of transport-related noise using an 'impact pathway' approach and covering a range of impacts on: *annoyance, sleep disturbance, and health impacts, including heart disease (acute myocardial infraction, or AMI) stress and dementia.* The TAG noise workbook in the WebTAG appraisal analysis provides a way of determining the impact of highway noise on these health aspects and compares the overall (holistic) cost benefit over a 60-year lifecycle of different mitigation measures; such as alternative noise barrier designs.

Noise modelling

To help illustrate how the health and whole-life cost benefits of noise barriers might be compared, a hypothetical road traffic noise model was produced using CadnaA to predict how noise propagates from a dual carriageway towards a nominal 300-house residential scheme. P38

Continued from p36

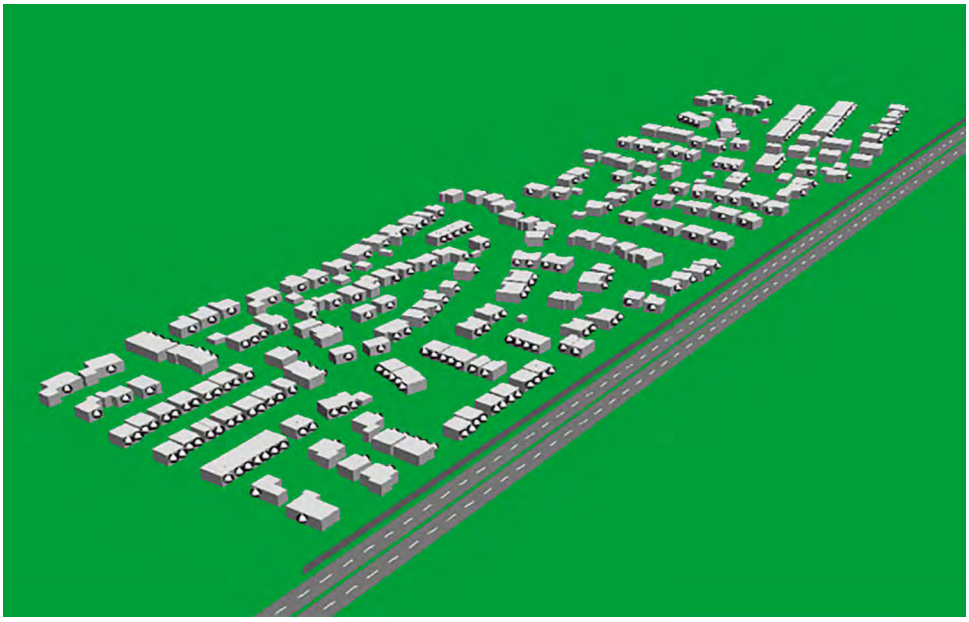
The houses were spread over a 600m length adjacent to one carriageway, each house with a receiver on its most exposed first floor façade. To be generic, the model was assumed flat.

Using Calculation of Road Traffic Noise (CRTN),different barrier design scenarios and types were compared to determine the average noise reductions due to barriers ranging from 600-1000m long and from 2-6m in height. The exercise was then repeated assuming 300 houses on either side of the carriageway for parallel noise barriers of the same dimensions.

Based on the health aspects listed above, the TAG noise workbook in the WebTAGanalysis can determine the financial health benefit of these noise reductions for different barrier heights, lengths and configurations. This financial health benefit is referred to as the net present value (NPV).If TAG assumes that these noise reductions are *maintained* over a 60-year lifecycle, then this *maintenance* will obviously require some barrier types to be replaced a lot more frequently than others.

By selecting different barrier types and material, a detailed cost comparison could then be made, knowing the typical installed costs of each barrier type, the expected number of replacements over a 60-year cycle to maintain performance, the cost of full reinstallation, the clearance and removal cost of the existing degraded system and any traffic management cost associated with the replacement. In so doing, one can obtain a more realistic 60-year whole life cost comparison for different barrier scheme options.

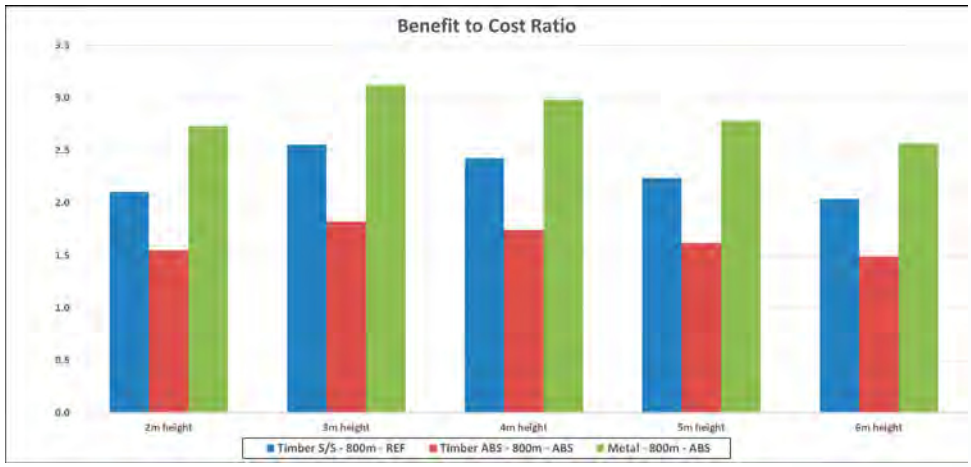
The TAG noise workbook then generates a benefit to cost ratio by dividing the net present value by the whole life cost to determine which option offers the best long-term value to the country both acoustically and in health terms.



Single barrier comparisons

As an example, using the modelled performance of 800m long single barriers, a whole-life cost comparison was be made for a typical single-skinned timber reflective design and a timber absorptive design, which tend to represent lower durability products and a physically and acoustically more durable system such as a metal absorptive barrier design.

CRTN is a blunt instrument and assumes that all the barriers give the same level of attenuation when new, however, when one takes into account the different maintenance expectations for each barrier type and includes for the overall cost of replacements over a 60-year lifecycle to maintain that performance, the benefit to cost ratios may differ enormously.



$$\frac{\text{Net present value (financial health benefit) over a 60-year lifecycle}}{\text{Barrier cost over a 60-year lifecycle}} = \text{benefit to cost ratio}$$

For every barrier height from 2-6m a more durable system such as metal absorptive would normally be expected to give the greatest benefit to cost ratio. For the 3m high barrier design it could be almost double that of the same timber absorptive over 60 years.

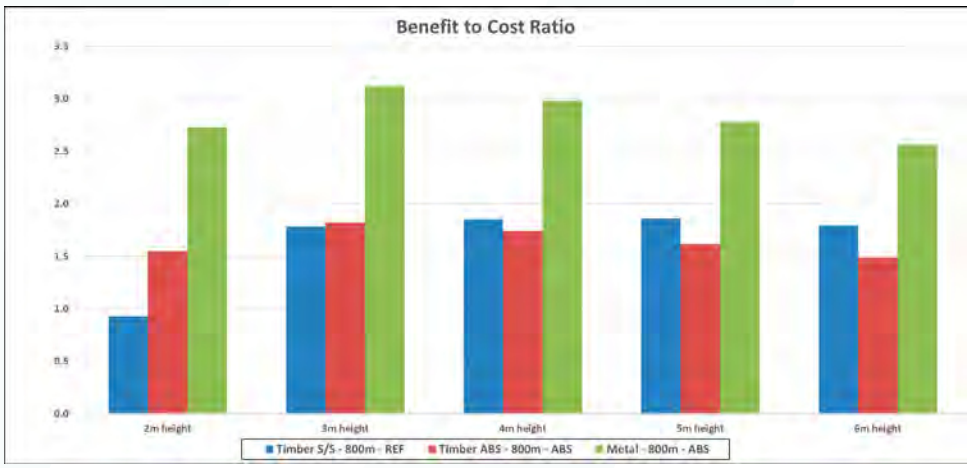
It is also worth noticing that, because of its superior durability, a 6m high metal absorptive system would not only provide twice the acoustic noise reduction of the timber options and protect 60%more properties, it would do so while still maintaining a considerably greater benefit to cost ratio over a 60 year lifecycle than a 3m high timber absorptive system.

Below: Properties benefitting are those where the façade noise level reduced by 3dB or more

Single Barrier	3x800m	3x800m	3x800m	6x800m
Whole life	Timber S/S	Timber	Metal	Metal
Performance Factor	REF	ABS	ABS	ABS
Average Reduction (dB)	**2.6**	**2.6**	**2.6**	**5.3**
Properties benefitting	**174**	**174**	**174**	**277**
Benefit to Cost Ratio	**2.6**	**1.8**	**3.1**	**2.6**

Parallel barrier comparisons

The comparison difference is even more stark for the 800m long parallel barrier scenarios. Here, metal absorptive barrier designs maintain a high benefit to cost ratio from heights of 2-6m whereas less durable timber options, though typically cheaper when first installed, demonstrate in the long run that they represent lower value for money to the country in terms of public health and the acoustic environment.



Again, building a taller, durable barrier system is shown to give a much greater noise attenuation for far more people and a greater overall sustained health benefit than low-cost systems that may be more prone to rapid deterioration.

Parallel Barriers	3x800m	3x800m	3x800m	6x800m
Whole life	Timber S/S	Timber	Metal	Metal
Performance Factor	REF	ABS	ABS	ABS
Average Reduction (dB)	**1.5**	**2.6**	**2.6**	**5.3**
Properties benefitting	**228**	**343**	**343**	**554**
Benefit to Cost Ratio	**1.8**	**1.8**	**3.1**	**2.6**

Things to consider

Scenarios differ and road-to-residential schemes are not normally as uniform as this, however, the principles remain true. There will be different barrier material types that are more durable than others, timber-concrete-based absorptive barriers have been shown to be among the most durable systems both acoustically and structurally.

Realistic assumptions have been made regarding the lifecycle of different barrier types and the costs associated with each complete replacement. So, whether you agree or disagree with some of the values in these comparisons, when you specify, ask yourself:

- How are you determining the whole life cost of a highways noise barrier?
- How are your factoring in for the durability of road traffic noise barriers when you specify them?
- Do you allow for realistic rates for maintenance, replacement, removal and traffic management?
- Rail barriers will require a similar approach – what would be the cost of access each time a barrier needs removing and replacing and are those being considered when pricing for a long-term barrier scheme?