
Transport
for NSW

Noise wall design guideline

Design guideline to improve the
appearance of noise walls in NSW



Acknowledgements

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This document won the Australian Institute of Landscape Architects National Landscape Architecture Award for Research & Communication 2008.

Image — Noise wall on Hunter Expressway

Cover image — Noise wall on M7 Motorway

All images provided by Urban Design Roads and Waterways, sketches by Tim Throsby.



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Foreword

This updated guideline, published as part of the Beyond the Pavement initiative, addresses the issue of noise wall design and its effect on the community, customers and landscape of NSW. TfNSW has a commitment to good infrastructure design, including the element of noise walls along its transport corridors.

There are ways to mitigate noise. Where there is space, distance is the most effective measure. Landform such as mounds and cuttings can reduce noise effectively. Applying architectural treatments to individual properties also has a role to play.

Noise walls are probably the most widely recognised form of noise mitigation. They are particularly useful and effective in urban areas and where space is limited. However they are expensive and, as well as blocking noise, they can block views and be visually obtrusive. Consequently noise walls must be carefully designed.

This document sets down objectives, principles and detailed guidelines that will lead to well designed and cost-effective noise walls. It encourages a design approach that is considerate of the character of the transport corridor, its context and the views to and from it and the interests of the community and travellers. It stresses the importance of maintenance and the need for simple, robust designs. Above all, it leads to a balanced approach to design so that noise walls are not just utilitarian noise reduction measures but also fit sensitively into their context and are attractive elements in their own right.

Increasingly noise walls are opportunities to integrate art into the transport corridor where they can't be enveloped in the landscape, and this document demonstrates some examples.

TfNSW Urban Design Roads and Waterways



Metcalfe St Noise Wall.

1 Introduction

1.1 Purpose of the guideline

This guideline was developed from a research and development project to investigate noise wall design in NSW, Australia and overseas. It forms part of a compendium of detailed guideline documents that support TfNSW's overarching *Beyond the Pavement urban design policy, procedures and design principles, August 2020*.

It is not the intention of this document to encourage or deter the use of noise walls. Its primary purpose is to improve the urban design of noise walls, where they are necessary, by highlighting the main design problems, providing examples of good noise wall outcomes and setting down guidelines to achieve similar outcomes for road users and the community.

Photographs have been included. Some are examples of good noise wall design and some are examples of poor design. Many simply illustrate a point or design principle and should not be seen as a criticism of the noise wall and the efforts of the teams that were responsible.

For quick reference a summary of the design guidelines is presented in 4.11. It is recommended that this summary is read with reference to the rest of the document.

The photographs selected are not representative of the full range of design possibilities. Each site has its own constraints and each design team its own talents. The range of possible outcomes is broad.

The key message of this document is that the right process must be adopted, and the appearance of the wall and its relationship to its context must be adequately considered.

1.2 Who is this document for?

This document will be of assistance to a wide range of people involved in the process of noise wall design including engineers, project managers, architects, landscape architects and contractors, as well as property managers and environmental managers.

It is not intended to be a manual on the acoustic or engineering design of noise walls; its main purpose is to address the aesthetics of noise wall design and their integration into a road corridor. Brief notes on technical aspects are included as an aid for readers with minimal background in acoustic design.

1.2.1 Related policies and practices

The reader is referred to other TfNSW publications which include relevant material:

- ▶ *Beyond the Pavement*, TfNSW 2020: describes the policy, procedures and principles of urban design for roads, streets and maritime projects.
- ▶ Structural Design and Construction of Noise Barriers (Specification R271): sets out the requirements for the material, structural design and construction of noise barriers.

The right process must be adopted, and the appearance of the wall and its relationship to its context must be adequately considered.

1.3 Background

Noise is not a new phenomenon. Cities have always been noisy places and traffic and transport has always been a source of noise. However with growing levels of traffic, expanding economies, higher population density, and higher expectations of quality of life, noise has become an important issue in the development and operation of transport networks. Consequently, noise walls have become a necessary and highly visible component of our cities.

Since the first noise walls were built in California in 1968 there has been a large amount of research carried out all over the world on the science of acoustic barriers. The results, from a purely acoustic viewpoint, appear to be successful and as research turns up new techniques it can be expected that noise protection will become even more efficient. However in terms of the quality of urban design and subsequent aesthetics, the results have been variable.

In general, the standard of design has been less than successful. Nonetheless there are many good examples both in Australia and internationally. These have helped in the development of these guidelines.

1.4 Lessons

Noise walls are one of the most significant visual elements in a highway or rail line and their cost can be a significant proportion of the construction budget.

Many of the first noise walls built were of a variable standard with different design approaches across the State and on occasion within the same corridor. This section sets down some of the lessons learnt from these noise walls in terms of appearance, resistance to weathering and management of vandalism.

The most common lessons are:

Consistency

Noise wall designs can vary frequently along continuous and sometimes relatively short distances with jarring effect.



The images shown above are all from one short stretch of the M4 Motorway at Merrylands in Sydney. The effect of using one or two noise wall designs along the whole corridor would have been more effective from an aesthetic perspective.

Consideration of site character and context

Noise walls can relate poorly, or not at all, to their site.



The design has not considered the site and the road user experience.

Form

The dynamic three-dimensional experience of noise walls can be neglected.



Discontinuous in plan and elevation, this wall does not appear to have been considered as a complete design.

Detailing

Detailing can be poor, especially the details of connections to other roadside elements.



The design of all elements should be considered as a whole composition, rather than separately as in this poor example.

Use of art

May not solve the fundamental problems of design. Works best when an integral part of the noise wall design and where called for.

1.5 What makes a successful noise wall

Several hypotheses have been put forward as to why many noise walls are unsatisfactory, and what can be done to improve matters. One common thought is that noise walls are monotonous, with mile after mile of bland concrete walls, all of roughly the same height, colour and texture. However, there are in fact many repetitive elements along a modern highway — the ribbon of pavement, the safety barriers, the streetlights, the tunnel linings and so on — and we do not necessarily find these monotonous. Indeed the repetition of a simple, strong and consistent form can be visually powerful, even where the basic building block may not in itself be a thing of beauty.

Generally speaking it is the visual strength of the elements moving together in parallel — the wall, the pavement and the barriers — that creates this powerful effect.

One of the reasons for this is that the design rules for high speed roads are such that the geometry of the paved carriageways is inherently visually strong, with coordinated smooth curves both horizontally and vertically.

Indeed where the tops of noise walls run parallel to the road surface they are generally much more visually acceptable than the stepped variety (especially those that are irregularly stepped), irrespective of the details of wall construction.

Where stepping is unavoidable eg. due to topographic conditions, it should be done neatly and thought about as a piece of architecture. Overlapping walls and differentiating wall types can be effective.

Finally, a successful noise wall occurs when equal attention is paid to the front and back of the wall and integrates with the residential environment built form and vegetation.

The following guidelines set down the approach to achieving a successful noise wall.



Eastern Distributor residential side.



Eastern Distributor road user side at Myrtle Street.

2 Acoustic principles of noise wall design in NSW

It is important to note that this section does not intend to describe acoustic engineering principles in detail. Such information is provided in other publications. The purpose is to outline the basic acoustic principles that designers and related professionals need to appreciate.

2.1 Noise principles

The difference between the terms “sound” and “noise” is subjective but generally speaking noise can be seen as unwanted sound.

Noise is measured in decibels (dB) on a logarithmic scale. Thus familiar rules for addition do not apply. Noise is measured using a weighted scale (A weighting) to allow for the human ear’s response to the frequency range involved. Units are indicated as dBA. An increase of 3dBA amounts to a doubling of sound energy level (and conversely a reduction of 3dBA is equivalent to a doubling of distance from the source of the noise). Note however that a 3dBA increase is barely perceptible to the human ear. As a rule of thumb a 10dBA increase corresponds approximately to a doubling of perceived loudness (eg 60dBA sounds twice as loud as 50dBA).

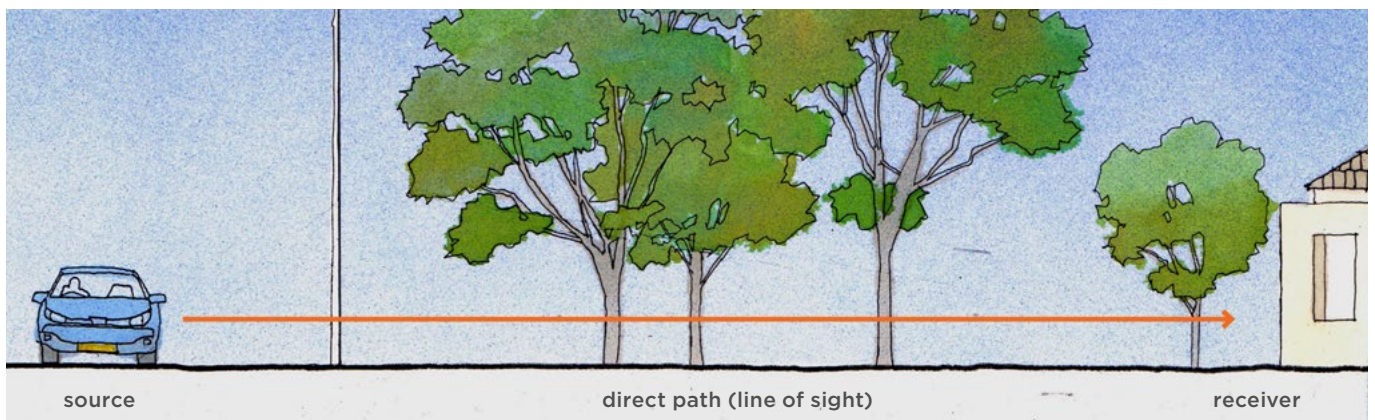
It is useful to consider sound propagation as a series of rays emanating from the source of the sound (although in fact sound travels in waves). Thus the sound will reach a listener either directly (in a straight line) or indirectly by reflection or diffraction.

By introducing a barrier (noise wall) between the noise source and the receiver, the amount of sound reaching the receiver can be significantly reduced (see figure opposite).

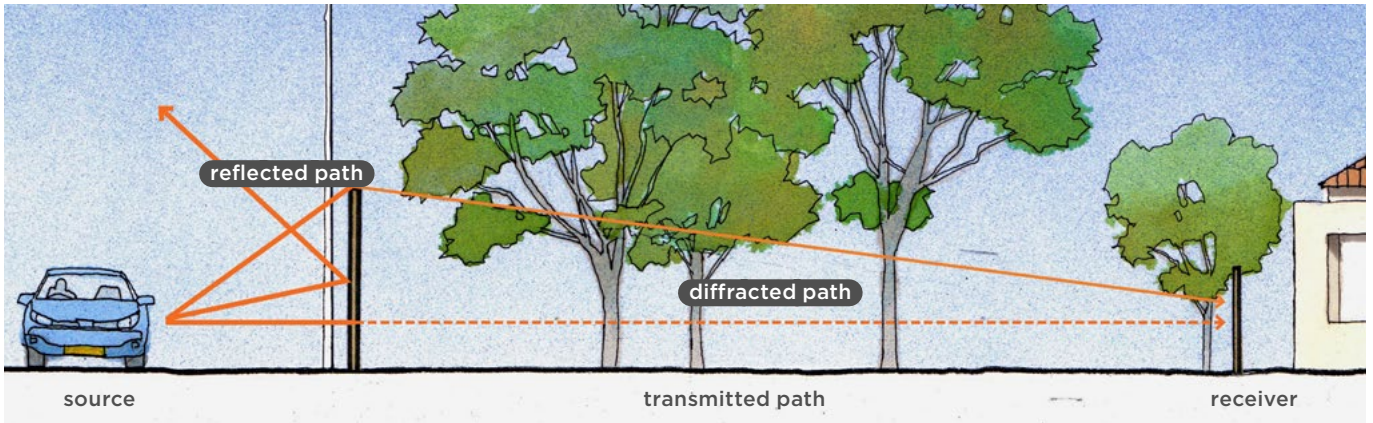
There are other methods of reducing the amount of road noise reaching the listener:

- ▶ Planning can in some instances direct major highways away from residential areas, thereby attenuating the noise by distance, within a noise catchment. However the distances needed to provide reasonable attenuation are so great that this is generally not an option in urban areas where new highways are located within the existing urban fabric.
- ▶ The noise can be reduced at source by quietening the engine, exhaust or auxiliary brake noise or by reducing the level of tyre noise by utilising a quieter road surface.
- ▶ The sound can be attenuated at the receiver by using insulation (double glazing and the like) but outdoor areas will not benefit from building facade treatments.

While all of these methods are undoubtedly important and useful in some situations, they are outside the scope of this study which concentrates solely on the siting and design of noise walls.



Noise follows direct line of sight and diminishes in an inverse square relationship.



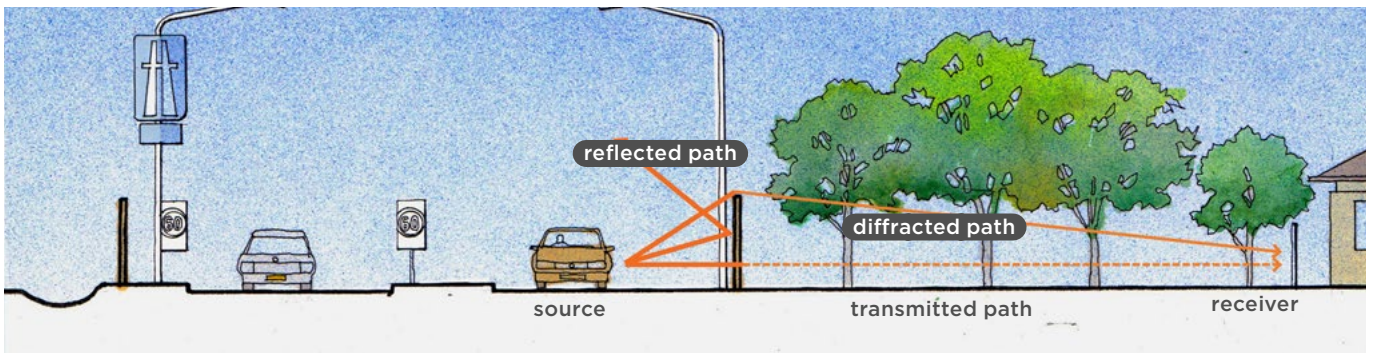
Noise can take a diffracted path over the top of the noise wall.

2.2 Noise barrier location

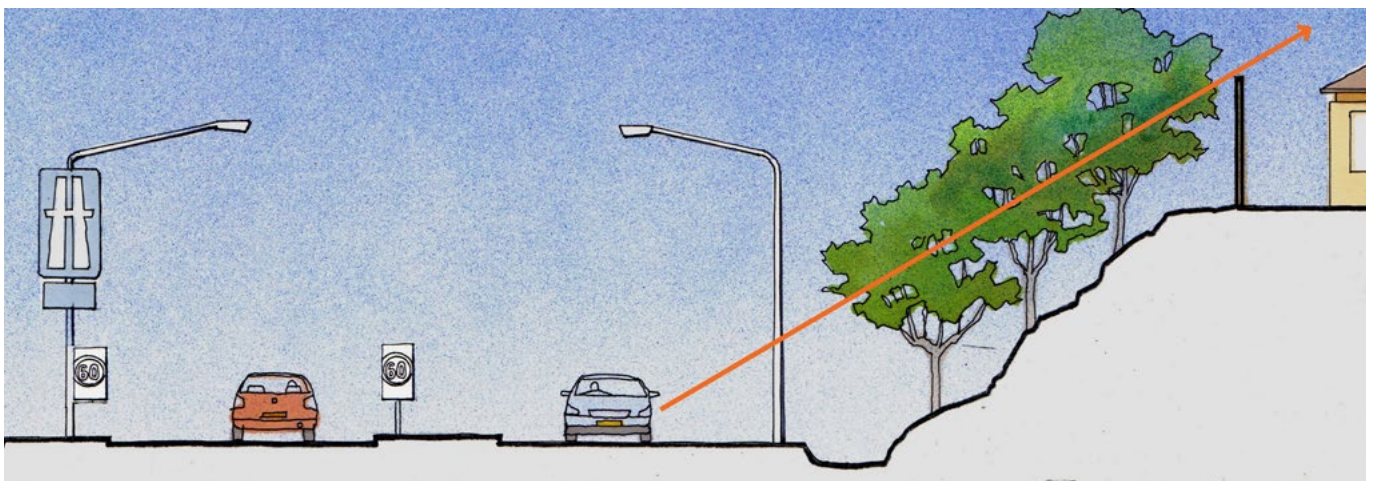
The first general consideration of physical noise reduction by noise walls is where to locate the barrier. In principle it is most effectively located as close to the source of sound (ie the road) as possible, except where the road

is in a cutting when it is better to place the barrier at the top of the cutting where it will have greater effect.

These principles may of course need some compromise where there may be physical constraints or overarching aesthetic objectives to consider.



On level ground the noise barrier located close to source of sound is effective.



In a cutting the noise barrier located at top of a cutting is effective.

2.3 Noise barrier height

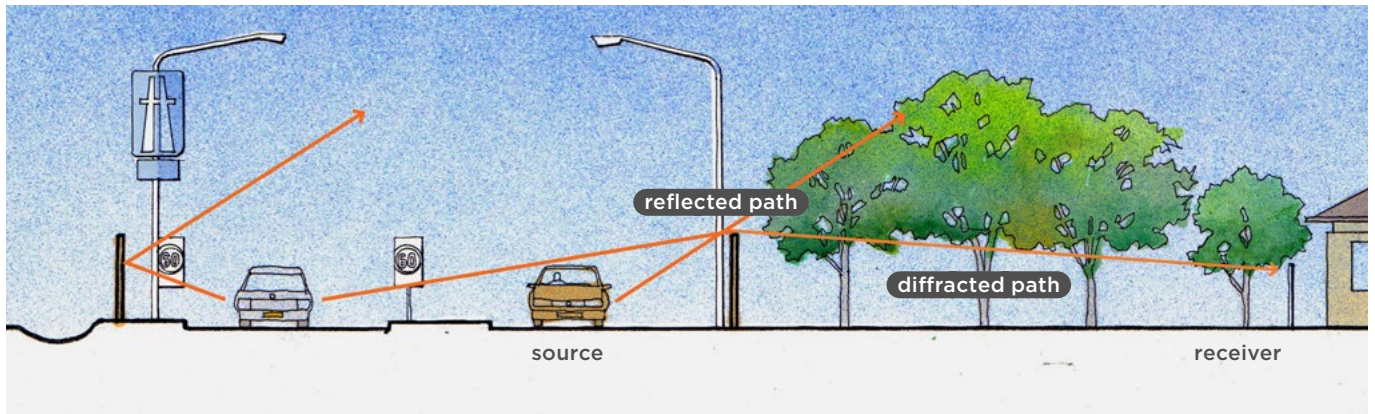
The height of the barrier is also significant — as a general rule a barrier should at least be high enough to dissect the line between a point anywhere 1m above the road surface (on both carriageways) and a point 1.5m above the floor of an adjacent residence.

Two storey residences should also be considered. Noise treatments for new road and upgrade proposals need to be designed in consideration of all affected residences including those in multi-storey buildings where reasonable and feasible.

In general, the higher the barrier, the greater the level of noise reduction. On multi-lane roads the noise from the furthest traffic lanes will not be reduced as much as that from the near lanes of the different path angles.

In theory this problem can be solved by increasing the barrier height but in practice aesthetic and cost issues must be seriously considered before constructing high walls. To understand how high is too high, the character and visual sensitivity of the context needs to be understood. One possible solution is to locate a second barrier in the median strip but again this has economic and aesthetic implications that must be considered.

Where barriers are located opposite each other, an absorptive treatment may be appropriate to reduce the impact of reflected noise. The appropriate vertical alignment of the noise wall should also be considered.



Barriers can reflect noise.

2.4 Noise mounds

Where space is available, noise mounds (which are, in effect, simply barriers) are generally a more attractive solution, either on their own or with a low wall type barrier on top of the mound. This is generally only an option in outer suburban or rural projects where wide corridor widths are possible.



A noise mound is a better urban design solution for road users and residents than a noise wall in most instances.



This carefully scaled and well sculpted and landscaped noise mound adjacent to the City West Link in Sydney not only blocks noise from traffic but allows views of the harbour.

2.5 Continuity

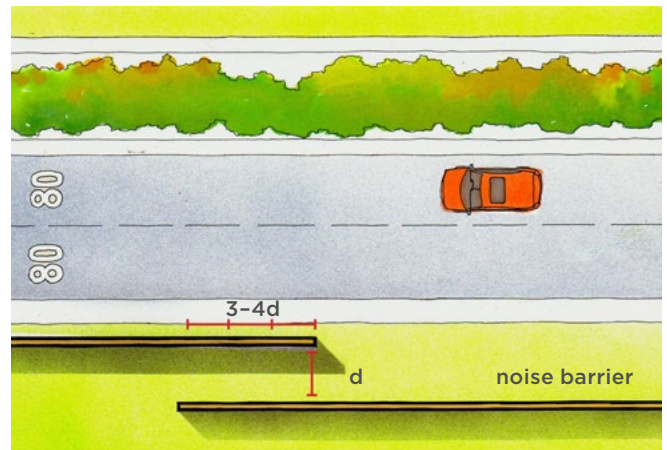
Noise barriers must be continuous to have a mitigating effect. This presents a challenge when providing access, that requires careful design resolution.

To be most effective noise barriers must not only be 'solid' (whether or not they are transparent) but also continuous with no gaps in the vertical or horizontal plane. In practice this is not always possible — for example it is often necessary to break walls to allow access for pedestrians or cyclists, emergency vehicles, or inspection and maintenance access. Overlapping walls is one solution to this problem. The overlap should be at least three to four times the opening width.

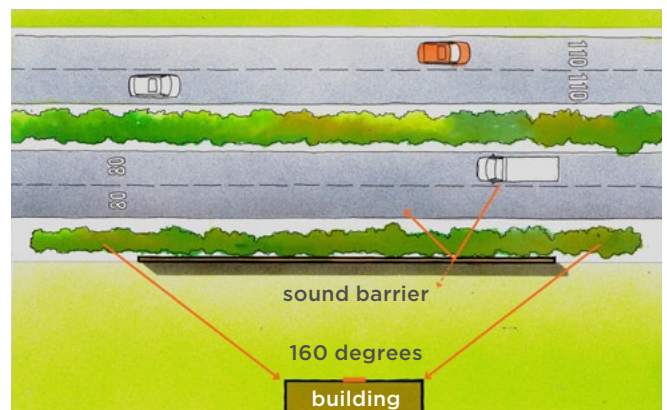
The other factor to be considered is the length of the wall since sound will still travel to the listener unimpeded, albeit from a distance. The generally accepted approach is that the barrier should extend to cover an angle of 160 degrees from the receiver. This assumes a level site, and local constraints must be considered along with desired aesthetic outcomes.

Where there is insufficient space to construct a barrier long enough to provide attenuation, the effect can be enhanced by returning the ends of the walls (see diagram).

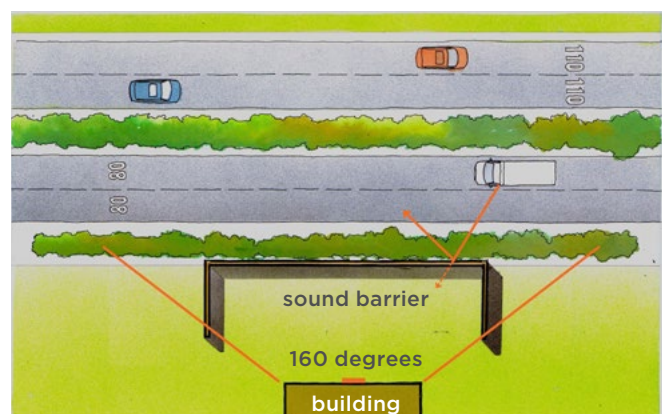
Noise barriers must be continuous to have a mitigating effect. This presents a challenge when providing access, that requires careful design resolution.



Relationship between openings in noise barriers.



Insufficient barrier length.



Sufficient barrier with return.

2.6 Reflected noise

In the previous section, only the direct and diffracted paths were considered. Reflected paths are also significant, particularly with harder barrier materials such as concrete. It is possible to reduce the reflectivity of the surface by applying absorptive materials.

A further consideration is that the angle of sound reflection can be used to direct noise away from the receiver by using tilted walls.

These then are the basic principles behind the design of noise walls. It is interesting to note that where a low to medium performance of the barrier is required (ie less than 10dBA reduction), the material from which the barriers are to be constructed is not of high significance. A general approach is that the Weighted Sound Reduction Index $Rw+ctr$ (previously called the Sound Reduction Class or STC) for the material should be at least 10dBA higher than the noise reduction required. Therefore for noise reduction higher than 10dBA, material selection becomes important.

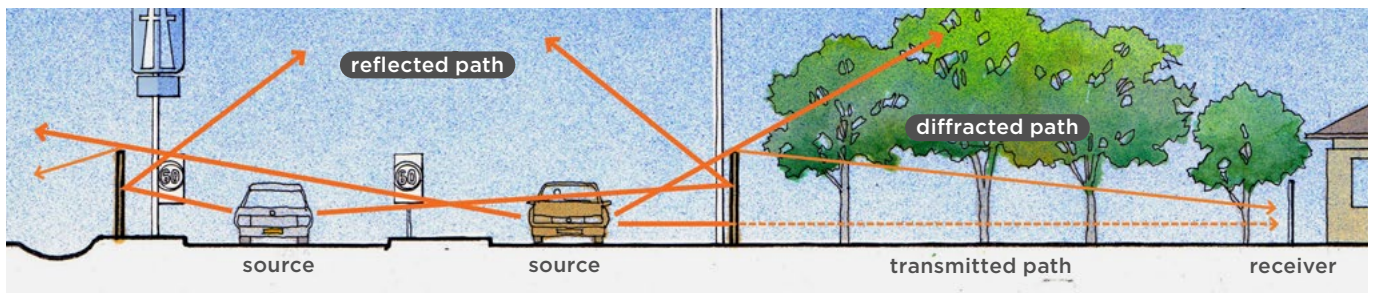
There are several techniques that may be employed to increase the level of sound attenuation, mainly by modifying the form of the top edge of the barrier in elevation or section.

These are generally expensive solutions, unlikely to be cost-effective except in limited applications and have aesthetic implications.

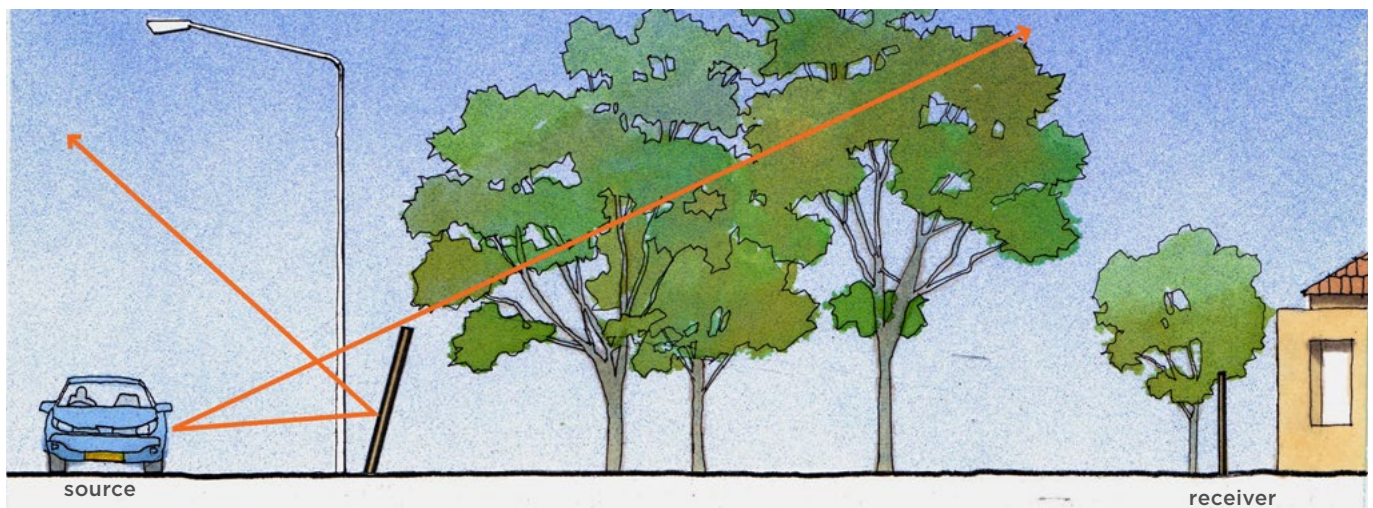
2.7 Vegetation

There is a commonly held belief that vegetation is an effective noise barrier. However, unless there is a substantial width of vegetation the benefit is generally psychological – if you can't see the traffic it reduces the perception of noise – but does not reduce measured noise levels. While this effect alone can be a powerful mitigation tool it cannot be relied upon to reduce measured noise levels. Where there are dense rows of trees they may provide measurable benefit, including reducing noise up to 3 dB(A) after 20 metres, increasing up to 7dB(A) over 120 metres of trees.

TfNSW does not include the benefit of vegetation when designing noise mitigation to meet noise objectives. This is because future changes in land use clearing can prevent long term objectives being met.



Reflective paths can add to noise and need to be considered.

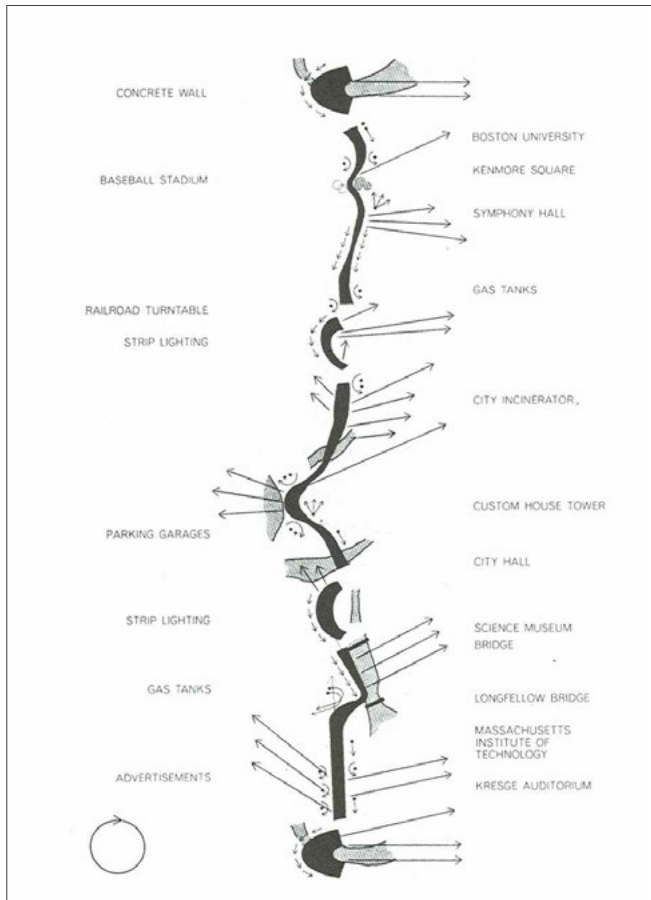


Tilted noise barriers can direct noise away from the receiver.

3 The approach to highway and corridor noise wall design

We need to look at the landscape through which the highway passes and consider the various elements that make up the landscape in order to choreograph the visual experience of travelling along the road. This body of research also applies to rail corridors.

3.1 Imageability



The View From the Road (Kevin Lynch): Noise wall siting and design must recognise the importance of the sequential experience of motion.

The modern urban highway is symbolic of the trade-off between convenience and character. On the one hand, accessibility and connectivity have been vastly improved by constructing freeways but on the other hand, much of the imageability of the city has been lost in the process. In the past people were able to build up a mental map of the familiar landmarks, vistas and spaces which made up their city. This image was generally fine grained and highly detailed and varied according to their mode of transport. At the pedestrian scale not only are the major landmarks of importance – in Sydney views to the Harbour Bridge, the Sydney Tower, the Opera House – but little things also become significant – changes in pavement detail, the type of magazines displayed at the news vendor’s stall, the shop windows and so on. However, with the urban freeway the views of these familiar landmarks are often obscured and the grain becomes much coarser, with little detail or complexity. Noise walls have contributed to this change – not only can they block views of the city and countryside but, can lack local character or meaning.

Whilst not an easy problem to resolve, there are a number of things that can be done to improve this situation. Firstly, we need to look at the landscape through which the highway passes and consider the various elements that make up that landscape – topographical features (hills, mountains, valleys, rivers etc), structures (bridges, towers, distinctive buildings, airports etc) and natural or developed patterns (woodlands, parks, playing fields etc) – in order to choreograph the visual experience of travelling along the road. At a large scale this involves aligning the road to expose the landscape character. At a detail scale opening up views through gaps in the walls, or using transparent barriers.

Secondly, even where there are no obvious landmarks (for example passing through an area of relatively homogeneous landscape) it is possible to create choreography through the careful design of noise walls and other structural and landscape elements. This provides a sense of pace and rhythm which can help to keep drivers alert. The M7 motorway in Sydney is an example of this.



This noise wall on the West Charlestown Bypass has a sea eagle motif that is of significance to the Awabakal Aboriginal community and is part of a broader bird life theme. The eagle is set across concrete panels whose diagonal mouldings are a stylisation of the underground coal seams in the area. This forms a strong architectural composition.



Well designed walls can be a form of art in their own right and do not need further adornment as demonstrated on the M7 Motorway in Sydney.

3.2 Art

In reaction to criticism about the visual appearance of many noise walls efforts have, at times, been made to improve the standard of design by adding art into the equation. However, unless an existing wall is being retrofitted, the very notion that art is an identifiably separate activity to design is a misconception. Unfortunately this belief has often led to art being seen as an optional extra, rather than as an integral component of the design process.

This is a difficult area to discuss since it necessarily involves highly subjective judgements. Furthermore it is hard to define exactly how art and design differ, or where one stops and the other begins. Indeed it is even difficult to define each activity separately with any level of precision. The Concise Oxford English Dictionary suggests that art is a cunning, imitative or imaginative skill applied to design, as in paintings, architecture etc whereas design is a preliminary sketch for picture, plan of building, machine etc. Neither definition is of much help in this context. Design is neither art nor science, but rather combines both activities. As Jones (1970) has pointed out, design is a hybrid activity which depends, for its successful execution, upon a proper blending of art, science and mathematics and is most unlikely to succeed if it is exclusively identified with any one. This goes some way to explaining why efforts to improve the design of noise walls by adding art, or more accurately artwork, have been largely unsuccessful. It is because the artwork has typically been regarded as an applied finish to a wall designed purely on engineering grounds.

In the context of any major construction activity – such as a freeway – the design of the entire corridor must be seen from an urban design perspective as a work of art (or more accurately a piece of design) rather than as an assemblage of separate elements.

In this context nothing should be looked at in isolation. The ribbon of the pavement is just as important to the overall design/artistic vision as the noise walls, bridges, lighting and so on.

That is not to say that artists can not and should not contribute to the design of noise walls. Rather they should be seen as contributors to a total composition, just as urban designers should work with engineers on the design of bridges and similar structures. In successful projects, such as the noise walls along the City West Link, the artist/designer (whilst he has indeed incorporated sculptural elements in the work) has primarily treated the walls as a piece of sculpture in the context of the entire project. The added artwork (the studs, cut-outs etc) contributes to the whole, but it is not the dominant feature. It also has a strong reference to the local context expressed in abstract form.

In summary, art is not a panacea for ugly noise walls, but rather the solution is to approach the problem in a holistic manner.



City West Link: A successful urban design outcome achieved through collaboration between engineers, urban designers and artists.



These precast concrete, full height panels at Sexton Place above the Warringah Expressway in Cammeray have a sculptural design on the front face that is both decorative and helps deter graffiti.

3.3 Who should design noise walls?

This is a relevant place to discuss who should actually be responsible for the design of noise walls. As well as urban designers, other relevant disciplines (such as road design engineering and acoustic engineering) are, of course, also involved in the design process. However, the purpose of this section is to ensure that the urban design aspects of noise walls are a priority.

Noise wall design must, in the first instance, be the outcome of collaboration between a number of players. Secondly good designers are necessary — even the best guidelines in the world do not guarantee good outcomes in the hands of poor designers. Thirdly, the best efforts of top designers can be negated by poor detailing and execution and by design modifications during construction — thus design control must be implemented from start to finish.

Based on these observations it would be appropriate to adopt the following approach:

1. Urban designers with capacity to do noise wall design (usually drawn from architecture and landscape architecture), noise consultants and engineers must all be involved in the siting and design of noise walls.
2. Urban designers should be experienced and selected from the TfNSW shortlist of urban design consultants.
3. The implementation of the noise wall must be monitored closely in terms of appearance and structural aspects.

Engineers are central to the team, especially the acoustic engineers, since a noise wall that doesn't work effectively as an acoustic barrier is fundamentally unacceptable. However compromises may sometimes be necessary to reconcile conflicts between localised noise problems and the greater community good when considering overall design vision, eg views may be more important than noise.

3.4 Theoretical design considerations

From a customer's perspective a road or rail corridor exists in time as well as space. A traveler does not view the corridor at any particular point in time, nor indeed from any one point of observation. Instead the experience is what Simonds (1983) described as a flow of impressions. When in motion, one sees a series of images blending into an expanded visualisation of an object, space or scene. This becomes even more significant when one considers the speed at which the experience occurs. At 40 kilometres per hour detail may still be relevant, but at 110 kilometres per hour what is important to the viewer is an overall impression rather than the detail. Indeed it is highly inappropriate from a safety viewpoint to include detailed elements since these could distract a driver. On the other hand, if the visual experience is overly simplified this may induce monotony. Therefore the whole must be considered as a composition of structures and spaces which relates to the site at a scale able to be safely comprehended in motion.

This is very different to the considerations made when designing a noise wall that will be viewed from an adjacent residence or in the community. Here the view must be considered, more or less, as a static composition with very different visual requirements. What is needed is quality detailing and an attractive composition of wall and landscape that will be seen by residents day in, day out. Similar requirements apply to the noise walls viewed from a pedestrian or cycle path, although here the progression through space — albeit at a much slower speed — is also relevant.

As a result, a given noise wall typically has two sides with radically opposed design requirements and this might well become the basis of a design methodology for noise walls.

The primary design consideration for the appearance of the noise walls should be sculptural — the noise wall as a three-dimensional object in the landscape and as a ribbon in space, where the important factors are scale, proportion and form.



Noise walls provide road users with a visual experience in movement.

Colour, texture, pattern and rhythm become secondary, though still important, considerations for both faces of the wall. Colour and texture are relevant in all cases — the choice of complementary and muted or starkly contrasting colours will have a significant effect on the drivers and residents perceptions of the structure, as will fine or coarse textures. On the traveler face of the wall too much detail is inappropriate but rhythm is important and a system of simple abstract linear patterns can be very effective. These may be drawn from local characteristics or themes (as for example on the Gore Hill Freeway) or from historic or cultural precedents such as local Aboriginal stories. This is meant in an abstract, not literal, manner. Alternatively patterns can be created through simple repetition of natural forms, as for example was used on the Eastern Freeway in Melbourne. Such patterns are inherently harmonious. They can be appreciated in the peripheral visual field of passing traffic at high speed, while at lower speeds there is the opportunity to trace the detail. Furthermore all such patterns can be cost-effective, cast in volume in a variety of textures and colours.

Finally, in many cases the best wall is one that can't be seen; and burying the wall in planting should therefore be a serious consideration.

3.5 Principles for the well designed wall

So what makes a successful noise wall? Primarily a noise wall must reduce noise to the required levels, but its visual qualities are also of much importance. In addition noise walls must be structurally safe, durable and cost-effective.

Good design in the context of a noise wall is basically all about form (the vertical and horizontal alignment) and texture (the materials, design and quality of finish). It is not primarily about colour or pattern, although these factors certainly have a significant role to play in design.

A noise wall that has not been adequately considered as a three-dimensional object that is generally experienced (from the road) at speed is unlikely to be visually acceptable.

Therefore some basic design rules for noise walls are:

3.5.1 A good noise wall design is consistent along the length of a corridor

This does not necessarily mean that all the noise walls should be identical, although in principle there is nothing inherently wrong with this. Consistency can mean several things such as consistency of material, form, colour or detailing. Just as a symphony may have a basic underlying melodic and harmonic structure that breaks into a number of variations, so may the design of noise walls vary whilst still adhering to an overall visual structure. This becomes especially important when the design and construction of a transport corridor is being staged. The urban elements, including the noise walls, should not be designed in bits and pieces. Instead a long term strategy for the entire corridor should be formulated during the earliest stages, particularly where noise walls are being retrofitted as funds become available.



Simple, strong, consistent forms.

3.5.2 Noise walls should relate to their site

This is a difficult concept to explain without considering a discrete piece of design in a particular location with a particular sense of place. Transport infrastructure is often situated in many different areas, each with their own distinct visual, physical and ecological characteristics.

In essence the solution to this problem will inevitably be a compromise between local considerations and considerations that relate to the corridor as a whole. This requires input from experienced urban designers highly skilled in this particular area of work.

This is not a task which can be undertaken by an untrained person. It is crucial that those in charge of the management process are sensitive to design debate and design quality.

3.5.3 A successful noise wall has a considered, elegant form

Unfortunately, many noise walls have discontinuities where the physical constraints become difficult. This is especially the case with noise walls that have been retrofitted. In some instances this occurs as a result of sudden landform changes that cause harsh stepping of the top of the wall, which is visually jarring. This is not to say that noise walls should never contain any stepping, but rather that stepping should be considered in the context of the wall as a sculptural object in space.

A successful noise wall is thought about in its context and formed as part of a whole composition.

3.5.4 Noise walls have two faces with different visual requirements

From the traveler's side it is the overall form and scale that are of central importance with colour, texture, pattern and rhythm being secondary considerations. It is therefore appropriate to decrease the perceived scale of the wall e.g. by breaking down proportions and utilising appropriate planting. From the residents side human scale, detail and landscape are important.

3.5.5 Detail and coordination are very important

It is not enough to produce a standard design for a particular project, nor indeed a series of standardised designs which the contractor is left to construct to the best of their abilities.

The manner in which all elements fit together must be considered in detail for every element at every location before construction commences because each site is different.

This requires the allocation of sufficient resources. Ultimately it depends on the commitment of those in charge of the project and the degree of sympathy they have towards the design vision, and their tenacity in fighting to uphold that vision.



Syd Einfield Drive: A composition of noise wall types designed to address different conditions on the road and residential side but unified and context sensitive.

4 Detailed design guidelines

It should be stated at the outset that in an ideal world, if planning could obviate the need for noise attenuation then this would be vastly preferable for all concerned.

Distance is the obvious solution, but others exist such as using buildings as noise barriers. This, however, would require collaboration with local authorities and the community.

Where noise can be sufficiently attenuated using landforms, it should be. Mounds with attractive landscaping are a preferable alternative to noise walls in many situations.

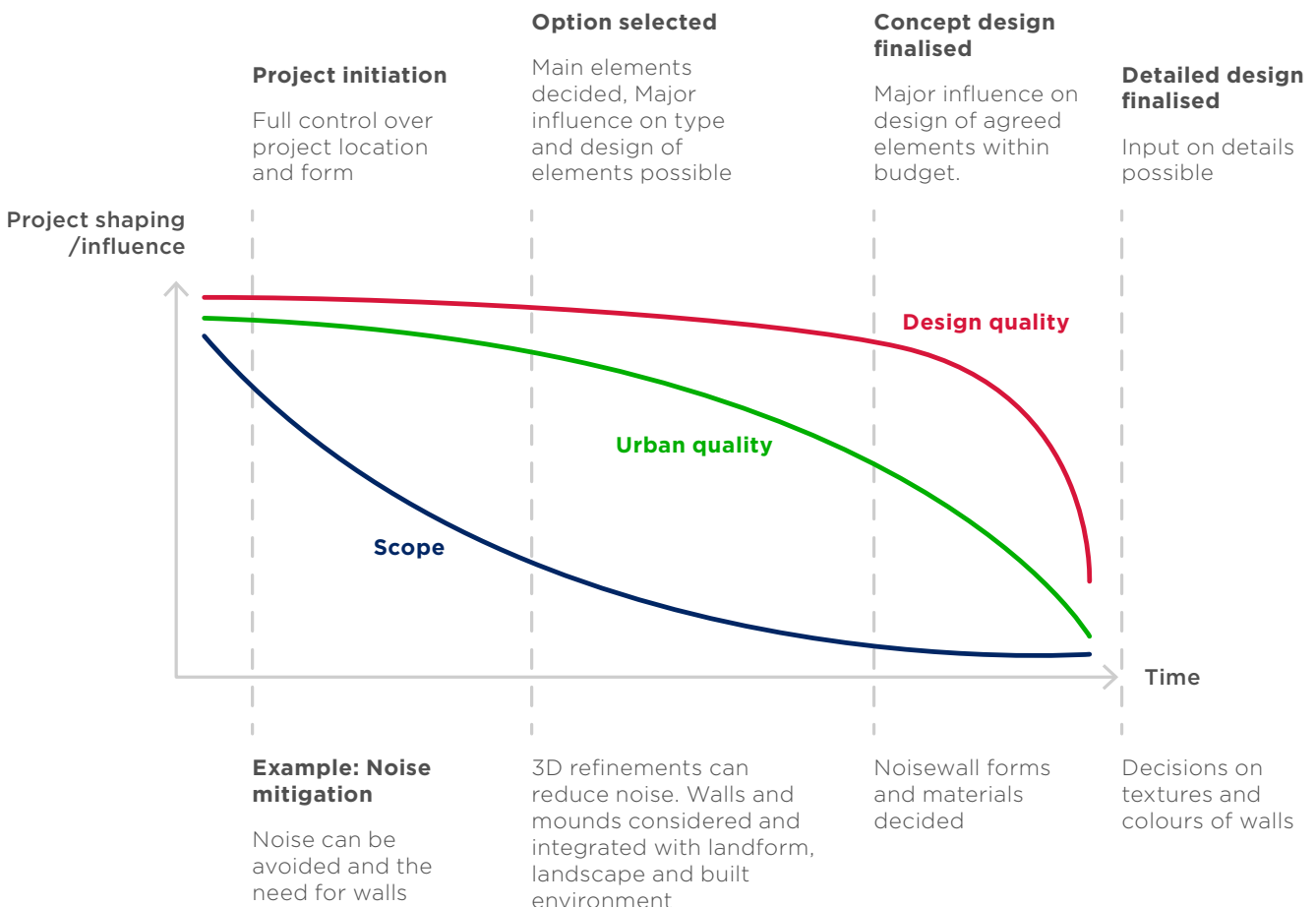
Where noise walls are necessary, their design should be treated as of equal importance to the design of every other part of the corridor – not relegated to a secondary position or delayed until a later stage.

The following section describes the guidelines to be addressed in the design of noise walls. As a quick reference checklist, they are summarised in 4.11.

4.1 Design process

The urban design of infrastructure projects which include noise walls as part of the overall project, should be part of the project management process outlined in *Beyond the Pavement*. However if individual noise walls need to be designed as a project in itself, the stages of design tabled overleaf need to be followed.

The value of early urban design input (Figure from Beyond the Pavement 2020).



Individual noise wall projects

Stage	Involvement*	Considerations
1. Initial scoping	TfNSW Urban Design Roads and Waterways	Funding allocation should be compatible with design objectives of wall
2. Establish noise wall technical requirements	Project Manager Acoustic Engineer Structural Engineer Urban Designer Asset Manager	Noise reduction required Optimum barrier location requirements Optimum barrier height requirements Maintenance requirements Budget
3. Understand context of road corridor and local setting	Urban Designer Road Designer	Built, natural and community setting Other noise walls Views from the road Views to the road Shading and visual obstruction
4. Noise wall urban design objectives, principles and concept design	Urban Designer Acoustic Engineer Asset Manager TfNSW Urban Design Roads and Waterways	Explore alternatives to noise wall Consistency along corridor Consistency with context Unobtrusive/sculptural Opaque/transparent Materials – absorptive or reflective Colour/texture Planting Height and location Drainage Cost Maintenance Emergency Services Access Fire hose access points Other Utilities (eg lighting, sign supports)
5. Detail design and documentation	Project Manager Acoustic Engineer Structural Engineer Urban Designer Asset Manager	Plans Cross-sections Detailed drawings Specifications
6. Finalise design and submit completed design report to Urban Design Roads and Waterways for sign off	Project Manager Urban Designer	
7. Review implementation	Project Manager Urban Designer Urban Design Roads and Waterways	

Note: If noise wall is mounted on a bridge, the TfNSW Bridge Section must be involved in items 1 to 7. *The list of those involved is not intended to exclude all the other people normally involved in road design. Rather it is intended to indicate the major players involved in making decisions regarding the urban design qualities of the noise walls. All other disciplines will clearly be involved at the relevant stages.



Angled clear noise walls with tapered supports, integrated with the road viaduct, where the whole is considered as a three-dimensional composition as on this M7 Motorway viaduct.

4.2 Three-dimensional form

The most important design consideration for noise walls is the three-dimensional form of the walls. They must be considered as sculptural elements rather than simply in cross-section or elevation.

Secondly the form of the walls must take into account the views from and to the transport corridor. These views have different visual objectives. Viewed at speed, detail is less important than when the wall is viewed as a static object (for example, from an adjacent house).

When designing it is important that consideration be given to opening up views of landmarks, special vistas and so on. Not only does this enhance the visual experience, but it also serves to relate the journey experience to its setting and the region generally.

The designs of views to the infrastructure must consider what might be termed district views as well as localised views. District views are views from further away than immediately adjacent to the corridor. Within these the walls can be seen as pieces of sculpture or as visual boundaries (which the walls tend to be at the localised level). It may be appropriate to consider opening up longer views through and across the walls where these views are of significance.

It is tempting to consider noise walls in cross-section as vertical elements: vertical walls are likely to be cheaper, easier to build and easier to maintain than the alternatives such as cantilevers, sloping, angled or curved walls or tunnels.

A slight lean in a wall can make a considerable difference, visually reducing the dominance of the wall and mitigating the boxed in effect.

Walls viewed in the landscape and walls viewed up close in the corridor often require different approaches. The smooth grading and linearity of the road and the more natural and undulating topography of the landscape require different design responses.

4.3 Vertical alignment

The form of the wall should in general follow the grade of the road at the macro scale.

The appearance of the top edge of the wall should be considered. This is one of the strongest visual elements of the wall since it is usually in sharp contrast with its background. It is preferable that the top edge be parallel with the pavement since this will aid in reading the wall as part of a larger architectural composition. Indeed, this may help in acting as a foil to a chaotic background (such as may occur in an urban area). In general, the edge should be smooth. However there are exceptions to this, for example where large panels are used.

Consider carefully the merits of any attempt to increase the visual interest of the wall by creating a complex top edge. Often this technique is unsuccessful and can draw attention to the wall, especially in silhouette.

Steps in the top edge should be very carefully considered; depending on the background they may further emphasise visual dominance or visual confusion. Uneven steps are particularly disruptive, especially steps which go up and down in response to localised conditions. However, minor stepping can give the appearance of a continuous flowing edge if the steps are equalised.

Alternatively, where walls are of significantly different height, consider separating the walls with an overlap between. In some cases the overlap need only be the width of a wall panel.

Choosing to keep a noise wall at a uniform height above ground level can result in unwanted visual effects where the (external) ground level changes frequently. It is visually better to have a slightly higher wall that is a consistent height rather than steps.

Finally, one should consider tapering the walls at the ends on bridges or into landform.



This is a well choreographed noise wall on the Hunter Expressway as part of a sweeping road composition. The form of the wall, with its continuous top edge, follows the road geometry. The tapered end ties the wall into the landscape and avoids an abrupt termination. The overlapped panels, all in the same direction, hide the vertical posts from view and help provide a sense of movement for the motorist.

4.4 Horizontal alignment

In most instances it is best to maintain a parallel relationship with the carriageway or rail line.

However, this is not a hard and fast rule. Curved walls can help to create a special sense of place.

Separating and overlapping walls is an elegant way of dealing with walls of different form, material or height.

The decision to overlap individual panels and recess the support post has several benefits. The post is hidden from view and the panels can be angled so that they follow the grade of the road or topography.

In most instances it is best to maintain a parallel relationship with the carriageway.



This wall is used to create an imageability to the upgrade of the M2 Motorway in Sydney. Over and above the strong vertical and horizontal relationship with the carriageway, the choice of colour punctuates the journey and creates a contrast with vegetation. The form, texture and detailing of aerated concrete panels is exemplary. Such application of colour should be used circumspectly. When using non-neutral, bright colours the permanent view from residents towards the walls must be considered and selected with input from residents; this should include the outward face of the walls or any inward facing walls visible from residential areas.

4.5 Landscape design

In many situations, the best noise wall is one that is screened from the view of both the motorist and the resident.

Therefore one should consider the potential benefits of strategic planting. Planting greatly assists in reducing the dominance of noise walls, whether in front of the wall or behind. In the latter case, tall plantings will break down the dominant effect of

the top of the wall. Keep in mind, however, that since it takes time for plants to mature, the (short-term) appearance of the bare walls must also be considered.

Consider the space available for planting. There are many examples of noise walls where the space between the roadside barrier and the wall is insufficient to create a reasonable planted effect.

Appropriate clear zones need to be complied with and safety barrier deflection zones must not be compromised.

Maintenance access to noise walls must also be considered in the landscape design process.



A short noise wall protecting a primary school on Taren Point Road. Concrete walls with playful colouring and patterns to reflect the school and its pine trees. Small regular steps work well to accommodate the slope and importantly retaining existing trees outside the wall helps set it into the landscape.

4.6 Relationship with adjacent development

Consider the effect the walls will have on the quality of adjacent development, particularly residential development. Walls should not dominate buildings or outdoor spaces. If solar access is seriously compromised, consider using transparent panels or reducing the height of the wall – even at the cost of reducing acoustic effectiveness. In such instances, urban design considerations may well outweigh noise issues.

When using clear panels it is important to consider the privacy of adjacent residents. In some cases a frosted opaque finish may be effective in providing privacy and allowing light.

Security is a critical design consideration. Dead spaces adjacent to pathways should be avoided at all costs so that no hiding spaces are provided for potential attackers. Similarly the layout of noise walls should be designed so that it is not possible for an attacker to force a victim behind a wall, out of sight of the pathway. The design of walls adjacent to residential developments should consider the potential for intruders to be sheltered from view. Walls can be located to avoid providing seclusion or clear panels can be incorporated.



This neatly designed wall with lettering protects Erina Heights Public School from noise and fronts onto landscaped public space with shared path.

4.7 Surfaces

Surface finishes are extremely important. They are perceived as a combination of colour, texture and pattern.

4.7.1 Colour

Colour is particularly important in highway design and can be used to tie a visual composition together even where elements are some distance apart — such as noise walls on opposite sides of a highway — or to link different elements which may not be physically connected, such as an overpass and a noise wall. Colour can also be used to give emphasis to an element by highlighting it. Conversely, an element can be de-emphasised, through the use of a palette of subdued colours.

When making decisions about colour one should consider the background of the wall. Depending on the design of the corridor this may be the sky, urban development or landscape. The colour of a wall can either blend or contrast with its background. As a general rule it is preferable to select a colour for the wall that will harmonise with the backdrop. However, this is not to suggest that walls simply be painted blue against the sky, or green against a landscape since these colours are likely to appear artificial.

In the vast majority of cases the most appropriate colour for noise walls within the Australian landscape is dark grey.

As a general guide walls close to the corridor should be lighter in tone than walls situated within the landscape. Dark tones tend to complement vegetation and are unobtrusive, especially when walls are located on top of cut, whilst lighter tones are less overbearing.

Colours should be chosen carefully rather than selected through a default process. Before finalising colour schemes designers should ensure that the colour is readily available in the event that it is needed for painting over graffiti.

In the vast majority of cases the most appropriate colour for noise walls within the Australian landscape is dark grey.



A system of interlocked concrete noise walls protects two Campbelltown schools at Thomas and Moore Streets and helps define this precinct.

Another consideration is the colour of adjacent structures, especially houses. Where there are several different colour schemes it is usually best to use muted colours.

Avoid using colour in small areas on the highway side of the wall since this will not be read from the driver's perspective.



The walls on Syd Einfeld Drive are designed to protect the park and streets on the residential side and provide a human scale. They have a dark grey recessive colouration. There is great attention given to proportion and articulation of panels and to detail, such as the acrylic portholes.

4.7.2 Pattern and texture

Whilst it is often regarded as a secondary issue, adding patterns or texture to a noise wall can increase visual interest.

In general patterns should be relatively simple so that they can be easily comprehended at speed and they should be selected from a limited palette to avoid visual chaos.

When incorporating pattern/texture consider the context in which it will appear. Source material could be from local or other cultures, or historical periods. For example, Aztec, Chinese or Celtic designs could be drawn upon for inspiration. Note that most attempts to imitate natural materials using concrete are unsuccessful.

Consider using a variety of complementary patterns throughout the entire corridor. Travel speed should be taken into account when selecting a texture or pattern. The faster the speed, the coarser the texture or the larger the pattern needs to be. Coarser/rougher textures will create more shadowing on the surface and will therefore be more readily perceived. Similarly, an embossed pattern should be deep enough to create strong shadow lines.

Optical illusion is a useful way to reduce the apparent height or length of the wall. Horizontal patterns tend to reduce the visual impact of walls by compressing their height. This effect may be of particular use on the residential side of the wall. On the driver's side, strong vertical features at regular intervals can also be used to create an impression that the wall is shorter than it actually is.

Concrete has the greatest potential for textural and pattern use due to its great flexibility. However, other possibilities include stone walls or gabions.



Strong noise wall patterns on a section of the M4 Motorway.

4.8 Materials

It is important to understand the nature of materials, the purpose and where the material can be used including its visual character within a context. Craftsmanship is also critical with the 'devil' often being in the articulation of elements and the execution of building.

In addition to aesthetic considerations, criteria for materials selection for noise walls should include:

- ▶ **Durability.** Consider the design life of the wall. A wall that is expected to last for 25 years or more without reconstruction will need highly durable materials, especially in areas with aggressive climate conditions such as along the coast.
- ▶ **Weathering.** Consider the detailing of the wall. How will the material weather? Is it liable to stain or suffer other deleterious effects?
- ▶ **Vandal proofing.** Ensure that materials are as vandal proof as possible. This generally rules out any lightweight or soft skin materials that can be cut or scratched, such as aluminium sandwich panels or high gloss plastics.
- ▶ **Graffiti.** How will the material react to graffiti and how easily can it be repaired? Consider the use of a rough textured finish to deter graffiti artists. Smooth surfaces are more attractive targets for tagging, but are easier to clean or repaint than textured finishes.
- ▶ **Safety.** Are there any risks inherent in the material?
- ▶ **Fire retardance.** Is the material flammable?

Refer also to TfNSW Specification R271 Structural Design and Construction of Noise Barriers.

4.8.1 Precast concrete

Concrete has great inherent flexibility and is therefore very suitable for noise barriers. It is highly durable, weathers well and is not easily damaged. Whilst it is possible to construct concrete walls in-situ, this is not recommended due to the difficulty of ensuring quality control.

Texture and pattern can be created in precast concrete by a wide variety of means including elastomeric or regular form liners or through sand or water blasted exposed aggregate finishes. Very careful specification and quality control is essential to ensure consistency of finish where blasting is concerned. It is also possible to water wash to expose the aggregate but it is very difficult to maintain consistency over a large run of panels and therefore this is not a favoured method. The disadvantage of normal concrete is its weight which makes it more difficult to fix, particularly in retrofit situations and on existing structures. Further if a patterned panel is damaged some years after initial construction, it may be difficult to replace it (when using panelised or block systems). Careful consideration should therefore be given before any decision is made to use specially designed panels. Either they should only be used in locations where there is a low risk of physical damage or extra panels should be cast at the outset and stored for possible future replacements.

Consider weathering and long term durability when designing patterned and textured concrete. Capping the wall can reduce the deleterious effects of run-off. Where incised patterns or expressed joints feature, use bevelled (rather than flat) edges so that pollutants will not settle on ledges.

Consider the possibility of graffiti. Heavily textured finishes and planting frames deter vandals but are also more difficult to clean and repair. Specialised anti-graffiti coatings can be unsightly and should be selected carefully.

Painted finishes to concrete walls are worth considering since these are easier to repair in the event of graffiti and easier to colour-match. Textured coatings such as Acratex are also an option. Whilst more expensive than paint finishes, they have a longer life and offer greater protection to the substrate. With all coatings, the quality of the substrate is critical to achieving a high quality, durable finish.

Colour can also be added through the use of concrete dyes which has the advantage that it is longer lasting than an applied coating. Whilst it is possible to obtain dyes in a wide range of tints, it is recommended that only muted colours be used. To ensure consistency in colour, tinted concrete should only be considered where panels are being made in a factory.

4.8.2 Masonry

Bricks and blocks are best used on a more domestic scale or where some detail is desired, for example where walls are in close proximity to residences or pedestrian paths. Patterns can be created by utilising the wide range of textures and colours that are available. Some form of pier is usually required to provide the necessary support for the wall. Textured or modular blocks are examples of suitable materials which could be used in particular, but generally limited, locations.



Block walls with architectural elements define entrances to residential areas behind them and produce a domestic scale.

4.8.3 Lightweight aerated concrete panels

Autoclaved aerated lightweight concrete panels have been used extensively throughout the Sydney region. These panels are generally 100 millimetre thick by 600 millimetre high and come in any length up to six metres. They are usually fixed horizontally between universal beams that are fixed into concrete footings. These are effective noise barriers, simple to erect and cost-effective. Unfortunately though, in the past they have often been used in an unsophisticated manner which has resulted in unsightly walls. Efforts to improve the aesthetics of the walls by painting patterns on their faces, has only made the problem worse by drawing attention to them.

It is, however, relatively easy to modify the construction details in such a way as to create walls with high architectural merit. At the City West Link Road an architect worked closely with the supplier and the contractor to produce noise walls of great visual strength. In fact, it was the use of light weight concrete panels that allowed the design to be carried through since other materials (such as precast concrete) are not flexible enough to achieve the desired form within a reasonable budget. Given that the panels are supported between steel columns, the walls can easily be angled vertically or horizontally simply by erecting the supports at an angle.

Note that because lightweight aerated concrete is inherently soft there is a high risk of physical damage to the faces of the panels during both delivery and construction. Damage can be avoided through the use of an applied hard wearing finish coat, which has the added advantage of being easy to clean. Note that whilst autoclaved aerated concrete can be coloured with integral dyes, it is not possible to obtain consistent colours when autoclaving. Therefore colour should only be used as an applied finish. It should be noted the bottom of horizontal panels often drop down and may require concrete plinth or other support. A large gap can allow traffic noise through.

Lightweight autoclaved panel construction has several advantages over conventional precast concrete:

- ▶ The amount of excavation required for footings is much less.
- ▶ Panels are easily replaced if damaged, eg if hit by a vehicle.
- ▶ Panels are fire resistant (useful in bushfire prone areas).
- ▶ Panels are more forgiving in an accident.

4.8.4 Timber

Timber sleepers were one of the earliest materials used for noise walls in Sydney. They have the advantage of being relatively cheap, and simple to construct, and are very flexible since they can easily be modified on site. However they do not have a long design life and are susceptible to fire and, if not treated properly, rot. Furthermore some treated timbers contain arsenic (CCA) and, in the event of a fire, can give off highly toxic fumes. For these reasons sleepers should only be used in exceptional circumstances and never in bushfire prone areas.

Timber has been used in Europe, particularly in sensitive locations where a more friendly approach to noise reduction is required. However such treatment requires great care in the selection and detailing of timber in order to achieve suitable longevity.

In general, timber walls are only suitable in exceptional circumstances and only where fire or vandalism is not a serious risk.

The species of any timber being used should be selected both for its durability and its lack of need for any treatment or coating. From a visual perspective, naturally weathered timber is considered the most suitable finish. Suitable NSW hardwoods include Ironbark, Brush Box and Tallowwood. In addition to life cycle costing it is very important to consider environmental sustainability. For this reason scarce timbers such as Jarrah should never be used.

Plywood panels have been used as an alternative finish to lightweight concrete panels, but with a similar construction technique.

It is important to avoid gaps under or between pieces of timber. Thus tongue and groove or overlapping of timber is necessary. Lapped and capped detailing is generally not recommended.

It is preferable that the timber does not come into contact with the soil, irrespective of the species or any special treatment.



Timber has a domestic scale, and needs to be well articulated in its context.

4.8.5 Transparent panels (acrylic)

Transparent panels have been used extensively in recent years, although their use has been restricted because they are very expensive compared with more conventional alternatives. They should only be considered where views are significant either from the road to particular landmarks or vistas, or where there are views across the road from adjacent buildings. Transparent panels can also be used where a reduction in visual bulk is required, such as on a bridge or wall. Glass panels are subject to vandalism and shattering therefore are to be avoided – acrylic is the preferred material for transparent panels.

Details which must be considered in specifying transparent panels include:

- ▶ All plastics must contain a fire retardant and UV inhibitor.
- ▶ Glare from reflections of the sun or headlights is a potential problem which should be avoided.
- ▶ Transparency will deteriorate through the build up of pollutants. Therefore consider angling panels away from the carriageway to enhance natural cleaning from rain. (There is much less potential for build up on the residential face.)
- ▶ Ensure that the privacy of residential areas is not compromised. Frosting lower sections of transparent walls may be an effective way to allow both privacy and light.

Glass panels are subject to vandalism and shattering therefore are to be avoided – acrylic is the preferred material for transparent panels.



Transparent acrylic panels used on Bonville Bypass on the Pacific Highway allow views from bridges of the landscape.

Residents should be advised when requesting clear noise walls that reflective glare may occur which can be minimised with a matt finish, but the result will be translucent not transparent.

Definitions:

- ▶ **Translucent:** Permitting light to pass through but diffusing it so that persons, objects, etc., on the opposite side are not clearly visible: Frosted window glass is translucent but not transparent.
- ▶ **Opaque:** Not able to be seen through; 'not transparent'.
- ▶ **Absorptive transparent:** Material with sound-absorption properties while also reducing visual impact of solid surface materials by providing views through.

4.8.6 Plastic noise walls

Rotationally moulded plastic (RMP) noise walls have benefits in terms of avoiding the need heavy lifting, and for removal of vegetation when constructing as they can be carefully inserted into a vegetated environment with minimal disturbance, graffiti removal, repeatability of different textures, weight and manoeuvrability. However, there are specific issues that need to be considered in designing this product. It is not possible to achieve a flat surface – the panels need to incorporate a texture or bowing (pillow) effect to provide rigidity and this may not be desirable. The expansion or shrinkage of the plastic due to temperature changes requires a gap between the panels, the details of which may be difficult to control. Maintenance of fixings also need to be considered in terms of the expansion of the material in extremes of temperature.

4.8.7 Metal

Metals are rarely used in noise wall construction for both practical and maintenance reasons. Whilst metals are relatively light in weight (especially sandwich panels) and easy to fix, their high rate of expansion in hot weather necessitates frequent expansion joints which creates a detailing problem to maintain noise attenuation. Lightweight panels (ie with an aluminium cladding) are notoriously easy to damage and are thus readily vandalised. Further the coatings are not easy to repair once graffiti is applied.

The most suitable metal for noise walls is galvanised mild steel but it requires fairly heavy framing and fixing due to the likelihood of distortion during the galvanising process. This is expensive.

Therefore, the use of metals in noise walls is not encouraged except in very limited areas and for very specific design and acoustic reasons.

4.8.8 Bio-barriers

As previously mentioned mounds are the preferred solution to noise problems where space permits. In Europe various treatments have been developed using bio-barriers – walls constructed largely from soft materials such as soil and plants, sometimes with a retaining wall type system. These are unlikely to be suitable in NSW for climatic reasons (there is not enough rainfall on a regular basis to sustain the plants) and should only be considered after sufficient research has been carried out to ascertain their viability.

In extremely limited situations it may be possible to create such a system using automatic irrigation. Such situations would only occur at exceptionally critical locations.

4.8.9 Absorptive surfaces

Proprietary absorptive noise barriers are available, but they tend to be expensive in comparison to standard noise walls. It is unlikely that they would be cost-effective on the majority of road and rail projects and would therefore only be considered in critical situations, where reflected noise must be avoided.

4.8.10 Innovative treatments

As technology develops opportunities will arise for innovative treatments for noise walls. In Switzerland for example an entire length of noise wall has been built from solar panels, angled away from the road surface. This does of course require the appropriate orientation but the treatment fulfils all of the requirements of a noise wall as well as feeding back power. However solar panel walls can be visually obtrusive if not sensitively designed.

4.9 Detail

There has been an apparent tendency, once the form and materials of the noise wall have been selected, to forget the detailing (or at best to leave the detailing to the contractor in the field). Such an approach is unacceptable.

Every joint detail and every fixing must be properly considered by the wall designer and not delegated to a non-designer. As well as visual, these details can have a large effect on acoustic performance with any gaps degrading noise mitigation. Ends and junctions also need to consider acoustic performance.

These details include:

- ▶ **Joints.** Between components, between panels, between different materials, between panels and other elements (barriers, retaining walls etc). Joints may be expressed or concealed, depending on the overall vision and, for example, whether a horizontal or vertical emphasis is sought. It is very important to maintain consistent panel sizes. Where joints are dictated by physical constraints (such as at movement joints in structures) the panel layout should take this into account. Shorter or longer panels should not be used to meet up with such constraints. Amendments to panel sizes should be taken up over a run of panels.
- ▶ **Ends.** Great care must be taken when designing to the ends of noise walls. They may be square turned or faded into the landscape, or alternatively may be deliberately emphasised as a feature. Either way, it is important for every end to be deliberately designed. This applies as well to the return of the wall at intersections.
- ▶ **Junctions.** Where noise walls meet other major features such as bridge abutments and tunnel portals, consider the juxtaposition of materials. Should there be a deliberate contrast or should both materials come from the same palette? Consider how the two elements will meet. Should there be a gap between the two or should there be a smooth transition?
- ▶ **Tops.** Consider the top of the wall very carefully. If possible, it should remain a constant height above the road surface, however this will depend on the physical constraints. Tops should not be wavy, castellated or have extrusions unless specifically required for added noise attenuation, and even then only then when specifically endorsed by TfNSW Urban Design Roads and Waterways Noise Wall Design Panel. Stepping is not a preferred solution and should only be specified where there is no alternative or where the steps are part of a deliberate design concept. Where steps are used in a long run, the top of the wall should, wherever possible, follow the vertical geometry of the corridor and steps should be of equal height. Consider adding copings to walls where weathering and staining may be a problem and where a strong top edge is desirable for visual effect.



Plastic panels are lighter than other materials. Their use can minimise the need for heavy machinery and vegetation removal, but need to be employed circumspectly. These walls on the M5 are a mixture of plastic dark grey panels and yellow aerated concrete panels.

- ▶ **Bases.** Consider surface water run-off. In some instances it will be necessary to allow water to run under the noise barrier. In these cases special detailing will be required to maintain the acoustic barrier.
- ▶ **Signage and street furniture.** Do not forget all of the added components that are necessary for the safe operation of the corridor street lights as well as advisory and other signs. The location of these should, wherever possible, be related to the visual form of the wall. They should not simply be placed according to broad engineering criteria without reference to the designer. The juxtaposition of individual signs should also be considered. Such placement issues should be taken into account during the concept design stage in consultation with appropriate authorities. Safety is a major consideration. Wherever possible, large signage structures and lighting columns should be located behind noise walls. A number of manufacturers are working on developing systems whereby streetlight columns are used as the support for lightweight panelised noise barriers. Such innovations are to be strongly encouraged.
- ▶ **Structure.** Consider the structural requirements of noise walls – particularly the need for the structure to support the walls against wind loads when located on bridges or similar structures. See RTA QA Spec. R271 Structural Design and Construction of Noise Barriers for more details.
- ▶ **Footings.** Where proprietary systems are used, the detail of the footings (boots) must be very carefully considered. In general boots should only be used when not exposed or where they can be hidden by landscaping.

4.9.1 Sample panels

On larger projects full size sample panels should always be constructed prior to the finalising of details. This approach was used extensively and to great effect on the M7 motorway noise walls.

On larger projects full size sample panels should always be constructed prior to finishing of details.

4.10 Maintenance considerations

Noise wall design should aim to minimise maintenance costs. This should be borne in mind when comparing the cost-effectiveness of various options. Irrespective of the materials and finishes selected, ongoing inspections are required to ensure that graffiti is removed promptly (to discourage further graffiti), and to ascertain that structural and acoustic integrity are maintained.

There will be a need for occasional maintenance such as washing or painting) on both faces of any noise wall. Designs must therefore allow for safe and convenient access for maintenance personnel and plant. Similarly, where landscape is a component of the design, access to all planted areas must be provided, without the need to close lanes if this is at all possible. This should be seriously considered in consultation with the road or rail design engineer during the concept design stage.

4.11 Summary of design guidelines

Due to the significant length and height, and their corresponding visual impact on the corridor, the landscape and adjacent residents, noise walls should be designed with thought and consideration and by using the right skills and adopting an integrated approach.

1. Wall composition

Consider noise walls as three-dimensional sculptural objects that have two faces: one seen fleetingly from the road or rail corridor as a continuous linear object and the other viewed from the landscape as a permanent structure and from adjacent or nearby residents.

Walls should be part of an architectural and landscape composition — designed in the context of a precinct and as part of the character and visual experience of a corridor. Excessively long sections of noise wall on both sides of a road should be avoided.

Noise walls should avoid, as far as possible, blocking significant views of the surrounding area both towards and from the corridor. They should be located and designed to avoid over-shadowing properties and also blocking sight lines for surveillance purposes.

2. Height and vertical alignment

Where possible, avoid stepping in the wall. Instead, consider setting the support posts perpendicular to the topography or road grade, or angling the panels either side of the supports. If steps are required, ensure they are small and regular or organised in equal or controlled rhythms. Where sharp stepping is unavoidable then this should be done sharply as part of a strong architectural composition, depending on the topography and local context.

Large changes in height are best accommodated by marginally separating walls from each other and overlapping them. The same should be done for changes in form, and changes in material.

Consider tapering the ends of the wall to either fit the wall into the adjacent landform or to create a wall termination that is not abrupt depending on the context.

Angling noise walls as little as 5 degrees away from the road can have a significantly beneficial effect on the visual experience of using the road.

3. Horizontal alignments

Walls close to the road should be parallel to the road alignment horizontally, as well as vertically. Significant changes in horizontal alignment should be accommodated by separating and overlapping the walls. Long curves or separate sections of straight wall are preferable to angled and sharp changes in direction.

Varying the alignment of the wall at a micro scale to skirt around road structures and road furniture should be avoided. Noise walls should be returned at street corners where necessary for acoustic purposes and be part of a continuous design.

Noise walls adjacent to residences may be located on the property boundary (preferable with just a 300mm offset from the boundary and footings protruding into the public verge space), replacing existing fences. They may otherwise be located in front of the property boundary, preserving the individual fences, but at a distance of at minimum 1m away from the property boundary, depending on wall length, to allow for maintenance. This needs to be done in collaboration with TfNSW asset managers.

Noise wall design along a shared path or footpath should consider the human scale, not appear bulky and incorporate planting where possible.

4. Wall posts and panel articulation

Panel joints should line up and posts should be consistently spaced.

5. Materials and finishes

The mixing of different wall types and materials should be avoided where possible. If required, this should be done architecturally, yet boldly. In general, avoid small sections of different materials. Most materials can be designed to produce a visually acceptable, low maintenance, wall. Each material has its own characteristics which shape the design outcome.

Concrete has great strength and allows flexibility in design. Blocks and bricks have local interest and are more suited to a domestic scale. Lightweight (aerated) concrete is cost-effective when used on a large scale and is also flexible in design terms. Stone is expensive, but adds character and can be effective in highly sensitive scenic or heritage environments. Timber is useful on a domestic scale, away from the road along property boundaries but, whilst unobtrusive, needs consideration with regard to durability, maintenance and fire damage.

Clear walls, which are best done in acrylic, can be expensive but are the only alternative if noise is to be mitigated and views retained. In such cases, glare, privacy and bird deterrence must be considered. Noise walls on road bridges should be transparent to allow views and reduce the visual bulk (minimise the slenderness ratio) of the bridge superstructure. On pedestrian bridges or ramps, noise wall design should consider the privacy of residents potentially overlooked. The top section of a noise wall above say 2.5m from ground level should also be transparent to allow solar access to adjacent residential properties; this also helps to reduce visual bulk.

In general, walls should be painted to reduce maintenance and enable graffiti to be painted over.

6. Colour

As a general rule, natural subdued colours should be used. There can be exceptions to enliven a corridor or signify a location, but the use of brighter colours requires great care and design skill. A natural concrete light grey can complement the road environment, whereas a dark charcoal grey tends to complement the Australian bush. Avoid painted pictures and patterns, these are difficult to maintain and draw attention to the wall.

7. Decoration

Although textures can deter graffiti and add interest, they should be used sparingly. Repetitive abstract patterns are preferable if decoration is called for.


'Art' used solely as an additional adornment should be avoided; instead, artistic input, where called for, should be integrated into the design process.

8. Planting

Planting should be used in most circumstances to complement or screen the wall visually; design will depend on location and climatic conditions. Where it can be done cost-effectively and sustainably, it can be advantageous to communities to vertically 'green' an entire wall from behind, especially along a public open space edge.

9. Maintenance

Durability, access for maintenance and cost-effective design and selection of materials for maintenance all need to be considered from the early stages of design.



Appendix A Case Studies

While this document is illustrated with many case studies throughout, it is worth exploring some examples in more detail, which demonstrate the application of the principles of noise wall design.

The case studies shown cover

- ▶ Applied art to an existing wall design — Burnt Creek Deviation
- ▶ Integrated art and design — Warringah Freeway
- ▶ Residential walls in planting — Hart Drive
- ▶ Rural highway noise walls — Pacific Highway
- ▶ Urban clear walls — M8 Motorway

Burnt Creek Deviation Noise Wall, Balgowlah



Designing and integrating art into urban design elements especially when they enhance Connection to Country and incorporate heritage and cultural contexts will ultimately contribute to the unique and valued social, cultural and physical aspects of a local area.

An integrated art response for noise wall design should demonstrate sensitivity to interfaces with neighbours, recognise, maintain and enrich, the identity of the local neighbourhood, complement the immediate landscape, enhance the journey and create engaging and memorable experiences for commuters.

From time to time existing walls will need to be reviewed in terms of their maintenance and vandalism and this wall was a significant drain on resources. To address this artwork was retrofitted onto the walls creating a 1/2 km long unique canvas.

Location

Burnt Bridge Creek Deviation. A new section of noise wall was constructed along the boundary of Burnt Bridge Creek Deviation (BBCD) in 2016, designed to reduce noise generated from BBCD to the residents located along Serpentine Crescent and Boronia Street, North Balgowlah.

Year constructed

2016

Design intent

The wall was originally designed as a smooth topped, flowing concrete wall enveloped in planting. The planting was not able to be implemented which meant the customer experience was poor and graffiti vandalism was a problem. Several years after completion an Aboriginal design company, Balarinji, was engaged to help develop an artwork for the wall. The selected piece created by the late Jessica Birk is called Shorelines and Storylines.

The designers and artist

Jessica Birk was a Yaegl woman from Sydney's Northern Beaches. She graduated from the College of Fine Arts, UNSW and her work is predominantly themed around her coastal home and cultural links. She was selected through a process involving the local community and worked with the designers at Balarinji to produce this beautiful artwork.



Design concept

The design concept for the mural is 'Shorelines and Storylines'. This design acknowledges and celebrates the connection between land and water within the Balgowlah area, this is documented in the local rock engravings and contemporary stories.

The design focuses on this connection to place. It is a contemporary visual narrative, created in a repeat design which uses colour, symbols, linear designs and pattern to conceptually represent connections between people, place, land and water.

Some of the visual elements represented include; Hibiscus and Wattle Flowers, Fresh and Salt Waterways, Stingrays, Lomandra Grass Seed, Rock Wallaby, Sandstone, Seeds and Gum Leaf and Banksia.



Warringah Freeway Noise Walls, Metcalfe Street and Sexton Place



Noise walls can be intrusive elements in the built environment and their three dimensional form at both the macro and finer grained scale is important. Ensuring a consistent height or smoothly flowing top to the wall and avoiding harsh turns in plan view can help a wall sit more comfortably in the landscape. Integrating planting helps considerably, as can creating something unique and of its place through artistic textures also called bas-relief.

It can help to think of walls as having two faces with differing urban design requirements based upon different customer experiences – the experience of the road user and the experience of the resident or community.

In this case study the residents and community had a strong preference for a landscape outcome with space for trees, shrubs and climbers and a dark green coloured wall. This suited the more permanent nature of their experience. The view from the road considered the linear more fleeting experience of the walls, their relationship to other nearby walls, the character of the corridor and the quality of the architecture seen by millions of people a week. It is important to note that larger patterns and texture will be experienced at speed differently to those at a slower pace, and repetitive patterns will have a life of their own when experienced at speed by the road or corridor user.

Location

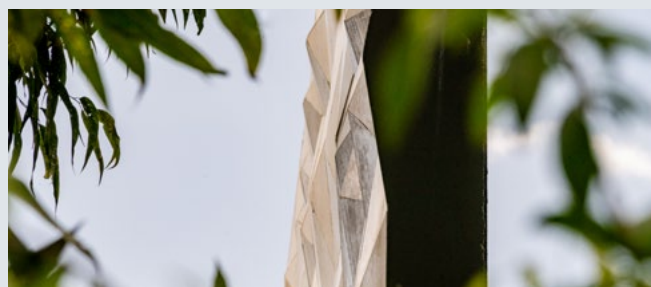
One noise wall on the north side of the Warringah Freeway at Sexton Place, and two overlapping noise walls on the southern side of the freeway at Metcalfe Street, North Sydney.

Year constructed

2013 and 2017

The designers and artists

Sexton Place was design by Richard Goodwin artist and architect. The Metcalfe Street walls were designed by Richard Goodwin and Tract. Urban Design Roads and Waterways provided strategic and detailed urban design input to all walls.



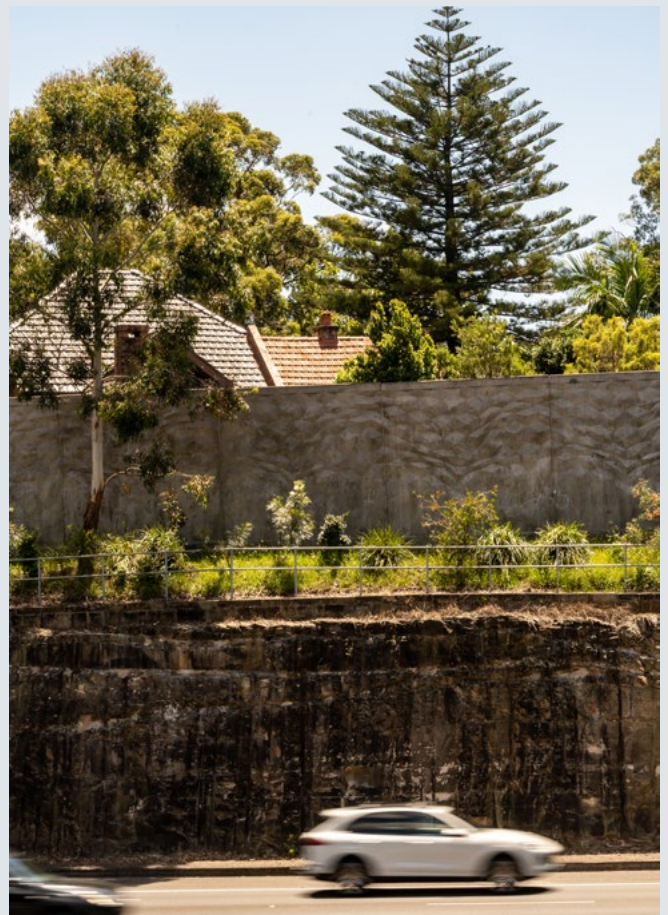


Artist concept

Richard Goodwin, Sydney artist, architect and designer of some of the earliest noise walls in NSW on the Gore Hill Freeway (1992), sought inspiration for these walls from the nearby Walter Burley Griffin designed incinerator at Willoughby and they also bear a relationship to other walls along the motorway also designed by Richard Goodwin in the late 1980's / early 1990's.

Design intent

The walls are solid cast concrete set onto pier foundations and provide highly effective noise mitigation. The texture is restricted to the face of the wall facing the freeway, while the rear of the walls are planted and painted green at the request of residents. The design includes overlapping of the blade walls so therefore avoids the need for stepping or change of direction and each noise wall set at a height to provide sufficient noise amelioration. Both walls have a 100+ year design life, are extremely robust and have created quiet garden enclaves away from the motorway to positive community feedback. Their design also contributes to the visual experience of using the motorway and is context sensitive.



Hart Drive Noise Walls, Wentworthville



Depending on context and space available the solution to a noise issue can be relatively straightforward, yet the Guideline principles still apply. Hart Drive noise wall combines a concrete lower wall and acrylic clear upper wall, a dense area of planting and neat clean lines in terms of alignment and details. It is a good model for similar situations.

Location

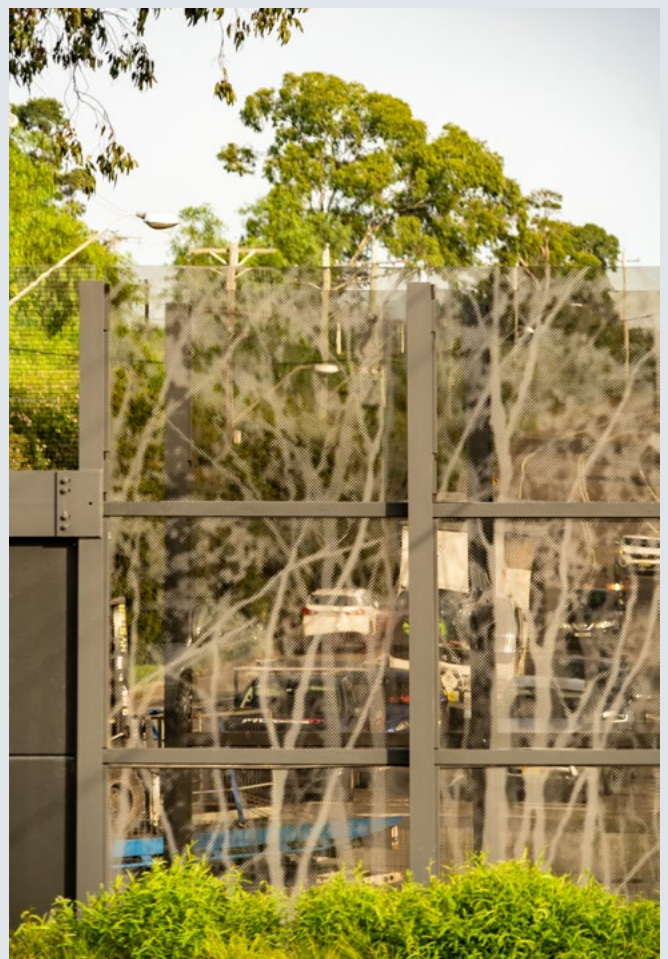
Wentworth Avenue cul-de-sac and Hart Drive, Wentworthville

Year completed

2020

Design intent

The Hart Drive noise wall project adopts a simple design approach combining concrete panels with a section of acrylic at the top to maximise light and reduce visual dominance. The wall alignment reflects the principles of the guideline following the line of the road in plan and with a smooth non stepping top. There is sufficient space for dense native vegetation and with the walls painted a dark charcoal grey they will eventually be lost in the shadows of the vegetation.





Access through the walls is provided by a short overlapping section of acrylic panels. These allow passive surveillance from the surrounding area and individual surveillance ahead. The opportunity for including tree silhouettes was taken and based on photography of Cumberland Plain Woodland native to the area. They create a dynamic visual experience for pedestrians as they approach the two sets of parallel transparent panels and walkway between them. They also help minimise the impact and prevalence of vandalism, however they had to be carefully designed to ensure a legible image. Trial panels demonstrated that two layers of dense tree silhouette became hard to read and the trees were indistinct. A sparser pattern was used in the final outcome.

With these simple features – and space for vegetation – the Hart Drive outcome is a good model for the design of tall walls on busy roads in residential areas.



Pacific Highway Upgrade, Warrell Creek to Nambucca Heads



Imageability considers the qualities of urban elements that provide identity, structure and distinction, such as nodes, edges, and landmarks, to the landscape and our orientation or place within it.

Noise wall location, siting, shape and finish all contribute to a place's imageability. The placing of, and design of, noise walls within a corridor have the ability to trigger and enhance views and vistas for commuters as well as creating memorable and legible places for residents. Imageability can enable a strong sense of Place and legibility for people to build a mental map of their place and enable people to read their places intuitively.

Integrated noise wall design enriches the identity of the corridor, enhances the journey, and creates engaging and memorable experiences for commuters.

Location

The project starts at the existing highway at Allgomera Deviation in the south to provide a bypass of Warrell Creek and Macksville before it ties in to the southern end of the Nambucca Heads to Urunga project, south of the proposed Nambucca Heads interchange.

Year constructed

2016

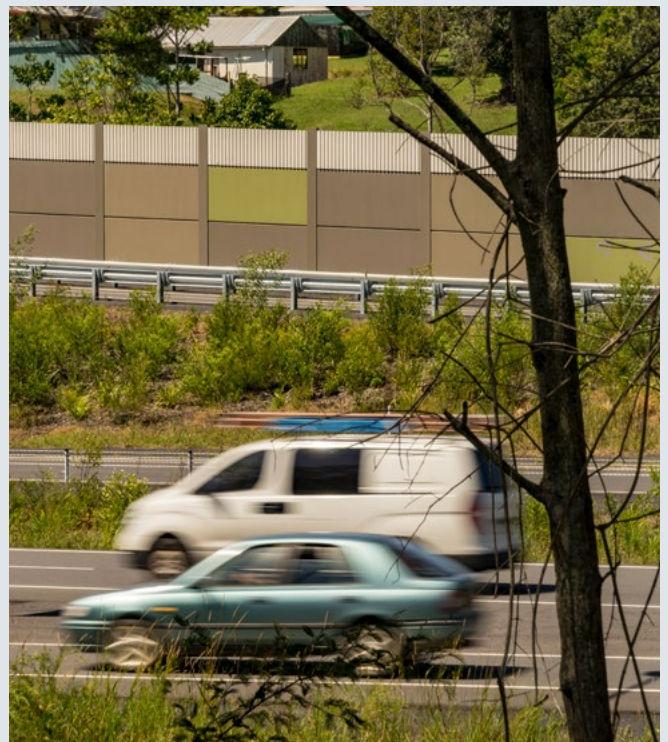


Design intent

Both noise and glare barriers were required on the project in order to mitigate environmental constraints for the road user and local residents. The noise walls provide a high-quality design outcome that makes a positive contribution to the local area and minimises negative impacts of noise, spilled light, overshadowing and visual pollution. The design picks up on the material and forms in the nearby town including the colourations and use of corrugated roofing.

Design concept

The design concept for the noise walls was based on reflecting natural surrounding conditions, responding to the existing character of the place as well as the existing vegetation communities that are present. The result is well-integrated noise walls that enhance the journey and to create an engaging and memorable experience for commuters.



M8 Motorway Noise Walls



Acrylic walls are useful in restricted spaces where good views are needed and overshadowing to be avoided. The principles of the Guideline are applicable in terms of avoiding jarring alignments and keeping a flowing top line. The choice of colour is important and there are a range of options. The recent walls of the M4 East and M8 projects are good examples of the type.

Location

Canterbury

Year completed

2020



Design intent

Simple clear walls allowing light and views and minimising the visual dominance of bridges and retaining walls.

The wall follows the alignment of the motorway in both plan and elevation and is protected by the safety barrier.

The wall design is part of a suite of elements set down in the Westconnex urban design framework. It is intended to help achieve the goals of simple, refined architectural elements suited to the motorway environment but also respecting the character of the areas through which the motorway passes.

Tapered section posts add to the modern clean lines and aesthetic. The spacing between posts is set by the standard width of the acrylic sheet.

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June 2023

TfNSW 23.069 ISBN 978-1-922875-76-1

