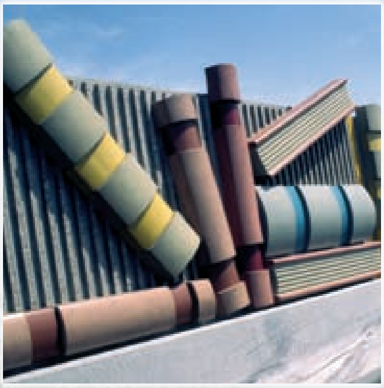
The Concrete Centre™

BRITISH PRECAST

Britpave



Spancrete

Cutting down noise

with precast concrete and masonry barriers

Developments

The noise performance of newly built roads when measured at housing sites must be reduced to a level specified in the Noise Insulation Regulations 1975. This can be achieved by using a barrier or by fitting secondary glazing to the houses. Dramatic increases in road traffic have seen the use of taller and longer noise barriers to meet this requirement. Traditionally noise barriers have been provided only when new roads are built or where major alterations are made to existing roads. However, in 1999 the government introduced a programme to quieten our noisiest roads even where no other works were being undertaken. At these sites, tall barriers are needed to provide real benefits to the local residents.

A European harmonisation programme [2] for noise has required each member state to prepare noise maps of larger towns and cities. Once the maps are completed, each country is required to publish action plans that identify noise standards and set out programmes to reduce levels to these standards.

Unlike many other EU states, the United Kingdom does not have an enforceable limit for road or railway noise in the community, but simply uses the threshold set by the Noise Insulation Regulations to trigger the use of noise barriers.

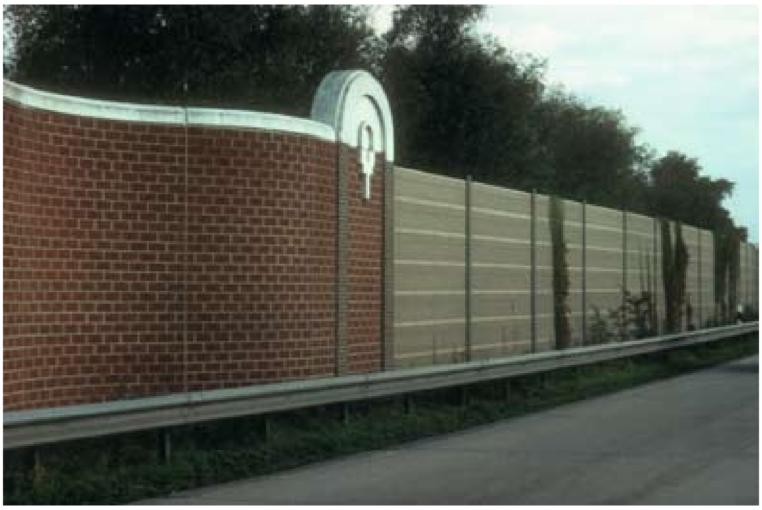
These *de facto* noise limits for transportation sources are significantly higher than the limits in other countries, and once all the action plans are published, the UK government is likely to come under pressure to bring its plan into line with other member states.

Standards for the design of noise barriers have also been harmonised throughout much of Europe. These standards are specifically published for road traffic noise barriers, but apply equally to barriers used in other locations. BS EN 1793 [3] deals with the acoustic performance of barriers and BS EN 1794 [4] sets out the requirements for their non-acoustic properties such as wind and static loading, damage resistance to flying stones, safety in collision, snow clearance loading, resistance to brush fire and reflection of light.

The need for acoustic barriers

Britain is becoming an increasingly noisy country. At the same time its people have expectations of a quieter environment in which to enjoy their lives. Living in noisy places reduces people's enjoyment of their homes and can also seriously affect their health. Research has shown that inhabitants of high noise areas have increased levels of heart disease, high blood pressure and stress [1].

Road traffic is the most widespread source of environmental noise and millions are affected by it. When the M1 motorway was designed, it was to carry just 14,000 vehicles a day, but now it is commonplace for our motorways to carry more than ten times that volume. Parts of the M25 carry up to 200,000 vehicles per day.



The twin pressures of people's demands for quieter environments and the increasing noise from the road system means that the scale of noise barriers used to protect communities is increasing. In turn, this puts pressure on designers to improve the aesthetic design of barriers as well as their effectiveness.

The new century has also seen a revival of railway construction after decades of decline, adding more noise to town and countryside alike. The rapid growth in low-cost air flight has increased airport activity. Barriers are increasingly being used to protect nearby residents from the noise of planes manoeuvring on the ground.

This increase in noise is not just limited to transport infrastructure. Government policy now encourages the building of hypermarkets and other superstores close to the communities that they serve, rather than in out-of-town locations. Ironically this environmentally friendly policy brings noise to those living nearby and acoustic barriers are increasingly being used as a part of these developments.

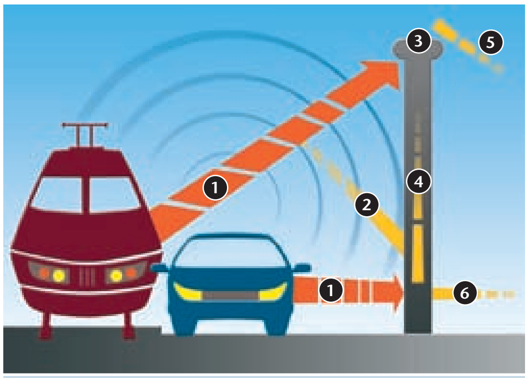
Growing demand for new housing and the need to protect the countryside from development has seen more residential growth in noisy locations. Government policy requires developers to reduce the noise at these sites and environmental barriers are becoming a standard feature around housing sites.

How acoustic barriers work

Sound propagates from a source as expanding pressure waves. Placing a barrier in the direct path between the source and the receiver significantly reduces the sound energy directly reaching the receiver. However, the pressure waves hitting the top of the barrier will be diffracted downwards and some of this sound will still be received. A small amount of the incident sound may also pass through the barrier which needs need to be sufficiently dense and continuous to reduce this directly transmitted sound to an insignificant level compared with the sound diffracted at the top of the barrier. Concrete and masonry are ideal materials for this as their inherent mass will always meet this requirement.

The simplest noise barriers are constructed from solid homogenous materials that reflect the sound waves incident on them. This may not be a problem if there are no noise sensitive receivers on the noisy side of the barrier, but often there may be houses on both sides of a road. Providing a reflective barrier to protect people on one side may increase the noise for people on the other side. Sound absorptive barriers should be used in these cases. These are either made from, or faced with, porous or cellular materials that dissipate the energy in the incident sound waves as they pass through the cavities in the material.

The behaviour of sound emitted by trains and cars



1 Incident sound
2 Reflected sound
3 Barrier
4 Absorbed sound
5 Diffracted sound
6 Transmitted sound

Aspects to be considered when choosing a barrier

When designing a noise barrier there are many acoustic and non-acoustic decisions to be made.

Height and length

The key acoustic considerations are the height and length of the required barrier. The taller the barrier the greater the attenuation that can be achieved. In addition, its length must extend far beyond the area to be protected to avoid its performance being compromised by noise diffracted around the ends of the barrier.

Location

Barrier location is also a vital decision. Optimum performance can be achieved by maximising the difference between the direct line between the source and the receiver and the diffracted path over the top of the barrier. On level ground it is normally desirable to place barriers as close as possible to the noise source, but where roads and railways are in cuttings or embankments, placing the barrier further away at the top of the slope is usually the best solution.

Aesthetics

The optimum position for a barrier can also be its most visible location. With barrier size increasing, it is essential that aesthetic issues are considered at an early stage in design. The design of the barrier must reflect its context and, since barriers are always used in a man-made environment, the use of manufactured materials is generally more appropriate than natural materials. The design team should include a landscape architect who would consider the materials to be used, the colour and shape of the barrier and whether a single design or a pattern that changes along its length would be most appropriate. At the design stage the incorporation of greening solutions such as climbing plants should also be considered.

Durability

Once acoustic and aesthetic parameters have been established, a range of non-acoustic design considerations has to be addressed. Durability is a major concern and road traffic noise barriers are required to last for 40 years without major maintenance [5]. Structural integrity requirements are defined in standards [6] and are particularly important where a porous material, which can absorb water, is incorporated in the barrier. Barriers located close to a road should be designed to suffer only superficial damage when hit by stones and must also resist any dynamic loading during snow clearance. The extent of damage caused by highway verge fires should be minimal. Potential damage due to vandals, vermin and insects such as termites also needs to be considered when selecting materials.

Safety

Safety is a vital design consideration. Where there is a possibility of vehicle impact the barrier should not present a hazard to either the driver or others. A barrier is only considered safe if, when struck by a vehicle, no parts of the barrier would penetrate the vehicle and the vehicle would remain upright. Secondary safety must also be considered and the design should prevent injury to people outside the road corridor due to falling parts from the barrier, particularly where the road is on an overbridge.

Sustainability issues

Increasingly, a holistic approach [7] is taken by designers to environmental issues and the disposal of barrier materials at the end of their life must now be considered. Materials containing chemicals that cannot be recycled or safely disposed of are now avoided.

Types of concrete barriers

There are three types of precast concrete and masonry acoustic barrier – reflective, absorptive and reactive.

Reflective barriers

These work by reflecting noise back towards the source, although it should be realised that this can cause increases in noise on the opposite side of the road or rail track. This can be minimised by sloping the barrier to reflect the noise upwards to pass above any receivers. The performance of a reflective barrier is limited by the diffraction at the top edge. A sub-set of this type of barrier includes a range of modifications to the top edge, such as wide flat tops and multiple vertical edges to reduce the level of diffraction.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Masonry-textured precast barrier.

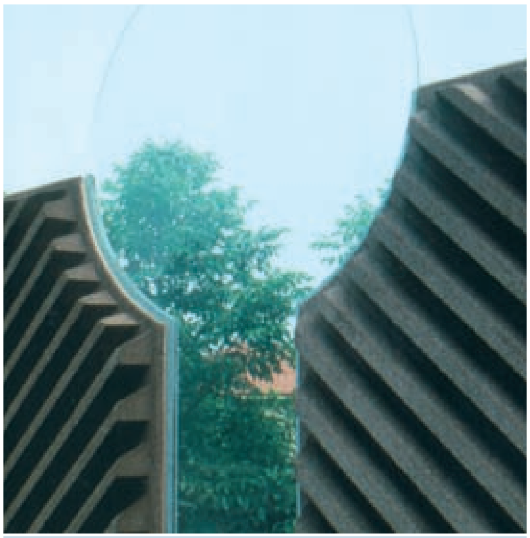
Absorptive barriers

These incorporate a porous element that absorbs noise, for example open-structured concrete using wood fibres or small lightweight cementitious spheres as the aggregate. In a single-sided barrier, this layer forms the surface and is supported by another of solid concrete that prevents sound passing through the barrier and provides structural integrity. The surface is usually quite highly profiled so as to increase its area and provide the maximum sound absorption. In double-sided concrete barriers, absorptive materials, such as mineral wool, can be in an enclosed 'sandwich' layer. The side facing the noise is perforated. Both single-sided and sandwich barriers are precast, in lengths of 4 to 5 m and can be 140 to 190 mm thick with colour incorporated. The panels are usually supported by steel or concrete columns. This type of barrier is particularly useful where there are barriers on both sides of a road, as they prevent the build up of reflected noise.

Profiled wood fibre concrete, an example of an absorptive barrier.

Reactive barriers

These are a specialised form of absorptive barrier that incorporate cavities or resonators designed to attenuate particular noise frequencies. Sound enters these cavities via small holes or slots in the perforated precast concrete blocks and the size of the cavity is tuned to permit phase cancellation at the selected frequency. The range of frequencies for which these resonators are effective can be increased by filling the cavity with sound absorptive materials.



A profiled concrete absorptive barrier with tree-shaped acrylic windows. The granular concrete is highly profiled to maximise the noise absorption.

The sunray motif used at the end of this barrier in Utrecht, The Netherlands, signals that the barrier supports solar panels.

Forms of concrete barriers

Combination barriers

Transparent material can be combined with concrete to provide continuous or intermittent views, to add colour or to allow the passage of light.

Cantilevered and half tunnel barriers

Here the top of the barrier is cantilevered towards or over the road or rail track to minimise the distance between the traffic and the diffracting edge of the barrier. This maximises attenuation without increasing the height of the barrier. In this situation, the scale of the barrier can appear rather oppressive and the top section of the barrier can be a lighter colour or constructed of transparent panels, which will also reduce the shading effect. Half tunnel barriers are an exaggerated cantilevered system where the top of the barrier is extended completely over one carriageway and is supported from the central reserve.

Facing masonry

In urban areas designers may wish to construct barriers from masonry, but reflection of noise can be a problem. In this situation, barriers can be faced with perforated bricks or blocks that give the barrier the appearance of a conventional wall, but allow the sound to pass through and be absorbed by a layer of mineral wool.

Bio barriers

These are barriers that incorporate planting, which softens the appearance of the concrete. Some examples of this type are constructed of dry-stacked hollow concrete blocks that are filled with a planting medium to accommodate suitable plants, which should be provided with irrigation.

Decorative finishes

Concrete barriers can be enhanced by the addition of a variety of decorative finishes. These include photoengraving, colour, and the use of special aggregates to add texture and interest. They can also be tuned into their surroundings by being cast as timber look-alikes. In particular cases white self-cleaning concrete can be used where generous budgets are available.

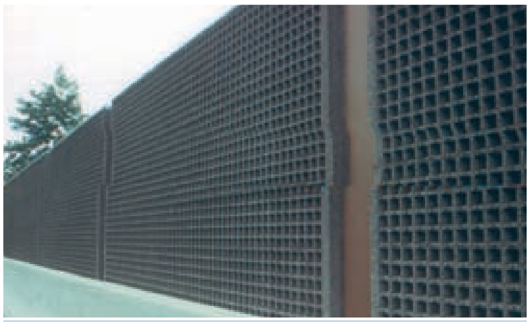
Special shapes

Concrete can be precast in any shape and size required. This includes curved panels and complex support columns. Some precast suppliers also offer glass fibre-reinforced concrete barriers that provide elegant thin and lightweight options in a wide variety of profiles and colours. These are useful for example where dead loads have to be minimised.

Method of construction

Concrete noise barriers can be constructed in a variety of ways, each of which has its advantages. These include posts with precast panels, interlocking panels, wave walls, concrete masonry and dry-stacked bio barriers. Concrete can, of course, provide support to other systems. For example, where a timber acoustic barrier is also required to provide garden fencing, concrete can be used to provide a durable post and foundation system to provide structural strength and protection from water, insects and vermin.

This large concrete barrier that cantilevers over the hard shoulder of the A28 motorway at Zeist in the Netherlands protects the adjacent housing estate from the traffic noise.



For this barrier, open texture concrete is cast in a honeycomb profile to maximise the sound absorption provided by the surface.

Example of a bio barrier that also provides a striking decorative feature.

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Construction of a precast acoustic barrier.

Constructing the wave wall at Gatwick Airport.

The wave wall at Gatwick contains noise and blast from manoeuvring aircraft.

The wave wall at Heathrow – part of the Terminal 5 development.

Benefits of concrete barriers

With inherent properties of strength, durability and versatility, concrete acoustic barriers have many benefits. In most countries, precast concrete is the most commonly used barrier material, providing low cost, low maintenance and effective solutions to unwanted noise. The reasons for this are listed below.

Concrete acoustic barriers:
Are durable, with a design life of at least 40 years
Require minimal maintenance and provide low whole life costs
Can contain traffic on hard shoulder
Can be installed on vertical safety barriers for motorway central reserves
Act as safety barriers on bridges
Are flexible in design – can have any profile, colour or size
Withstand fires and vandalism
Proof against rot, vermin and termites
Have a proven track record in the USA and Continental Europe.
Do not warp, shrink or open up to allow noise through
Can significantly reduce dead weight where this is an issue, such as on bridges, by incorporating glass fibre reinforced concrete
Take up less space than earth mounds
Are made from UK produced materials
Can be designed for installation at a variety of angles – vertical, raked or mixed
Move from being an exposed structure to acting as embankment stabilisers in a continuous ribbon
Match up with bridge parapets in a seamless way
Are plant friendly – they contain no preservatives and need no repeat treatment
Can provide elements of architectural interest

Case studies

Beating the blast at airports

Taxiing aircraft caused high levels of noise at Gatwick's boundary. The source of the noise, jet engines, was located high above the runway and a very tall barrier was required to reduce the noise. Thrust from the engines was also considerable and any barrier would have to withstand significant and regular lateral loading.

Acoustic modelling indicated a requirement for an 11 metre high barrier, the tallest in the country. A striking appearance was adopted using an ingenious, but simple, wave design which made the structure self-supporting. Curved precast concrete panels were used, the mass of which was ideal for dealing with the combination of noise and lateral load, and assisted in the stability of the structure. In all 43 panels each 10 metres long and using four different designs, were erected. Those with the largest amplitude (3 metres) were positioned in areas of aircraft engine blast, i.e. maximum lateral loading.

The units were counter-cast, one above another, in order to minimise the thickness of horizontal joints. Eight 1.4 metre high units make up the 11 metre height of each wall, totalling 344 individual units along the

430 metre length. The units incorporated polystyrene cores to reduce their weight to below 12 tonnes. Consequently this enabled economical 24 tonne flat wagons to transport two units per wagon. When installed the voids were filled with in-situ concrete to protect the reinforcing that was continuous from the piled foundations

White granite coarse aggregate and sparkling sand were used in the precast mix, exposed by grit blasting. Continuity of the 43 individual walls was then achieved by applying mastic sealant to the perimeter of all joints.

The success of this barrier at Gatwick led directly to similar structures being used as part of the new development for the new Terminal 5 at Heathrow Airport.

Opening up a view of the countryside

Along the A2 at Nieuwegein in The Netherlands a barrier has been designed to provide a view of the surrounding countryside, This barrier is a 6 metre high structure running for 600 metres, constructed from uniform 9 metre long panels. If constructed in a straight line the barrier could have intimidated some drivers, so a staggered line was used with transparent panes in the shorter sections, which face the oncoming traffic. When viewed by drivers most of the oncoming view is through the transparent panes allowing them to look out over the countryside beyond the barrier. The staggered design also provides additional rigidity for the structure.

A colourful upgrade

In Charenton-le-Pont, a few kilometres from Paris, a new acoustic barrier has been erected along two 1.5 km sections of the A4 motorway. They replace former reflective barriers that were no longer adequate. The new barrier incorporates wood fibre concrete to increase sound absorption levels. Stackable panels, 5 metres wide and 2 to 3 metres high, are used to create a barrier 6 to 8 metres high. The lower sections have an integrated base, while the upper sections incorporate an anti-diffraction coping. On the traffic side they are coloured in two shades of green to reflect the surrounding hundred year old plane trees, while the other side has been landscaped.

A literary view

In Angouleme, Poitou-Charentes, France the E603 passes through several miles of urban development. Traffic noise is controlled using a simple concrete barrier. To provide visual interest several sections have precast concrete 'book spines' added to the basic barrier panels. These give a sense of place and are a reference to the town's links with the world of literature. The use of coloured concrete provides a durable chip resistant decorative finish adjacent to the carriageway.

Here the noise barrier is integral with the concrete safety barrier, but set back sufficiently so as not to be damaged when vehicles impact with the safety barrier (see tyre marks in the photograph).

Shades of quiet blue

South of Paris, the eastern part of the Francilienne (A104) is flanked by a noise barrier that incorporates a sound absorbent concrete facing and coping. A supporting wall consists of reinforced concrete, topped by a wood fibre concrete coping and faced with sound absorbent panels. The absorbent facing is made from precast elements incorporating wood fibre that each weigh only 26 kg, so aiding transport and construction. A bold blue paint combination adds interest.

Interest is provided for drivers by a view of the countryside through this staggered acoustic barrier in The Netherlands.

Cimbéton

Painted green on the traffic side to match the plane trees, this precast barrier near Paris incorporates sound absorptive concrete and an anti-diffraction coping.

The precast book spines provide a sense of place near a town in central France. The integral concrete safety barrier protects the acoustic barrier from traffic.

Cimbéton

Shades of blue enhance this tall acoustic barrier flanking the A104 south of Paris, which incorporates sound absorbent panels and an anti-diffraction coping.

Further reading

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7 Part 2 of BS EN ISO 1794, see Reference 4.

Websites

Association of Noise Consultants
www.association-of-noise-consultants.co.uk

Institute of Acoustics
www.ioa.org.uk

Noise Abatement Society
www.noiseabatementsociety.com

UK Noise Association
www.ukna.org.uk

World Health Organisation
www.who.int/topics/noise/en/

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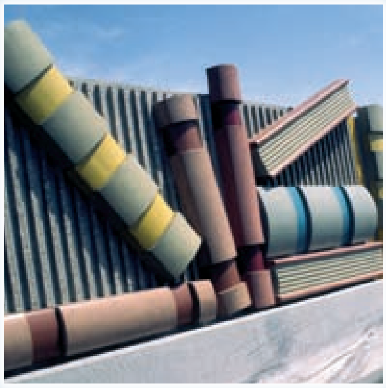

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