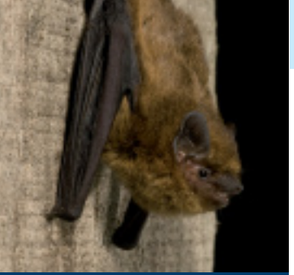
BUILDING

Bat friendly

Over 35 species of bat occur in Europe. A number of these inhabit crevices and spaces such as wall cavities in buildings. However, roosting opportunities for bats are disappearing due to the demolition or renovation of older buildings and a lack of suitable crevices, cracks and openings in new buildings. If the availability of suitable roosting spaces continues to decline, certain species of bat will be driven from the local environment. In this document, we show how safe and attractive roosting opportunities for bats can be incorporated into buildings through good design and construction techniques.

information for home owners, architects and policy officers



Top: Common pipistrelle

Middle: Serotine

Bottom: Pond bat

Introduction

The aim of this brochure is to offer guidance on approaches to the design, construction and renovation of buildings that can be of benefit to bats.

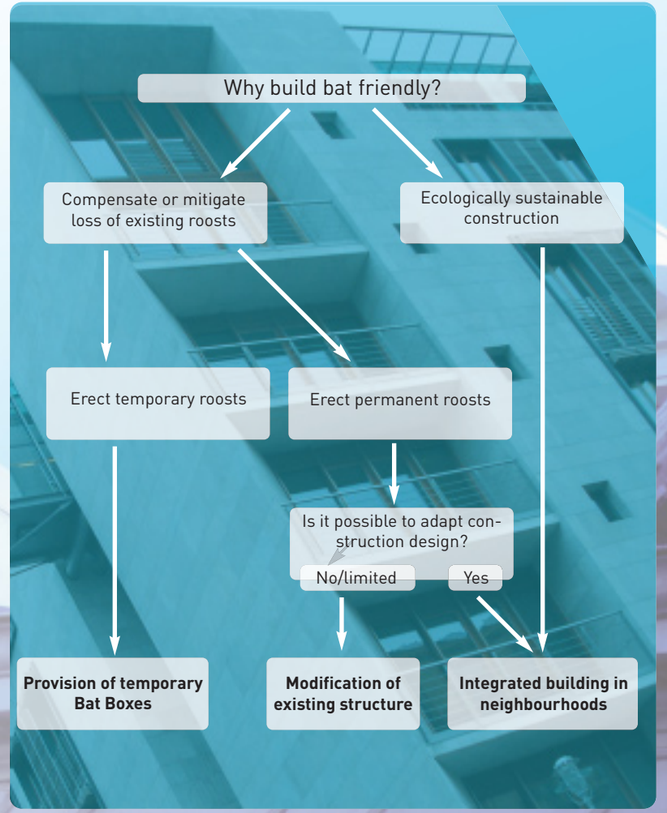
Bats do not build nests, but use existing cracks and crevices, for example in the walls and roofs of buildings. This makes bats vulnerable to changes in existing buildings, and to the ways in which we construct modern buildings. Roosts may be damaged or removed during demolition or renovation. It is partly because of this that in European countries bat roosts are protected by law. Therefore, demolition or renovation may only occur when the loss of a roost is compensated by the provision of new roosting habitat. Usually this happens reactively: when a building is to be demolished, a survey to assess whether bat roosts are present is undertaken. If a bat roost is identified, compensation for the loss of the roost is required.

The requirements of bats can be taken into account in any new construction or during the renovation of an existing building. By building in a more bat-friendly manner, we can offer bats a sustainable network of roosts and this will increase their chances of survival in our ever changing environment. This will provide benefits to bats and also to us as bats have an important function in our urban environment. They capture mosquitoes and other pests and many people enjoy seeing bats hunt above their house or garden.

The location of roost sites can differ widely depending on the species and the time of year. Suitable roost sites can be within the roof spaces of churches, underground buildings or hollow trees, but also within wall cavities, the roofs of houses or other buildings. This document is aimed at the conservation of the bat species that are present for at least part of the year in wall cavities and roof tiling, and other narrow crevices within buildings. These species include the pipistrelles, serotine, parti-coloured bat and brown long eared bat.

Because of their specific legal protection this document does not deal with the restoration of monumental or listed buildings. However, when possible within national and/or European regulations for the conservation of cultural heritage, the basic approach and techniques laid out in this brochure can still be applied.

Building bat friendly: every situation is different There are three options for bat friendly construction. In order of increasing sustainability, these are: external bat provisions, internal bat provisions, or integrated building for bats.
When a bat roost will be destroyed due to demolition or renovation, there is a legal obligation to provide one or more temporary and permanent roosts as compensation. Temporary roosts are to be provided prior to demolition to bridge the time until the new building, which will include the new permanent roosts, is completed. Guidance and examples of temporary roosts are covered in the section "Provision of temporary bat boxes". Permanent roosts are covered in the sections "Including integrated bat roosts post and pre-construction", "Modification of existing structures" and "Integrated building in neighbourhoods".



Provision of temporary bat boxes

Top: Small temporary bat box

Middle: Artificial maternity roost

Bottom: Attaching bat boxes on the corner of a building provides different microclimates

The provision of bat boxes is the simplest way to provide new roosts, and anyone can erect them. It is, however, not the most sustainable method. It is difficult to construct bat boxes in such a way that they will be used as maternity roosts or hibernacula. They are also easy to remove, making them vulnerable to vandalism and thoughtless but harmful activities. However, the provision of bat boxes is the only way to provide temporary roosts between the demolition and construction phases of a development when existing roost sites have been removed.

Small bat boxes (prefab) Small, ready made bat boxes are the most widely available. They are usually made of wood or wood-concrete and are relatively small (150-500 mm wide and 300-500 mm tall). They are commonly flat boxes with 1 to 3 narrow living areas or deeper ones with one internal area. For bats that inhabit crevices in buildings, the flat boxes are the best choice. Common and Nathusius' pipistrelle use these boxes as roosts. Deeper boxes are suitable for brown long-eared bats. Because of their small size and mass and their location on exterior walls, bat boxes do not retain or deflect heat making them unsuitable for hibernation or maternity roosting.

Large, custom made bat boxes The provision of large bat boxes that can function as maternity roosts is a relatively new development and they are not often available in a prefabricated format. There are a number of conditions that are required to enable these bat boxes to function as maternity roosts. Firstly, they must be large enough to allow access to deep roosting crevices for tens to hundreds of bats. The surface area of a large bat box should be 0.7 m^2 or more in order to achieve this. Secondly, they must have a warm, stable internal temperature. Often they are placed on south-west facing walls, so they warm up in the afternoon. This enables the bats inside to raise their body temperatures prior to going out to hunt in the evening. To aid this, heat accumulating or insulating materials are used. To achieve a range of warmth gradients, they often consist of two or more layered compartments.

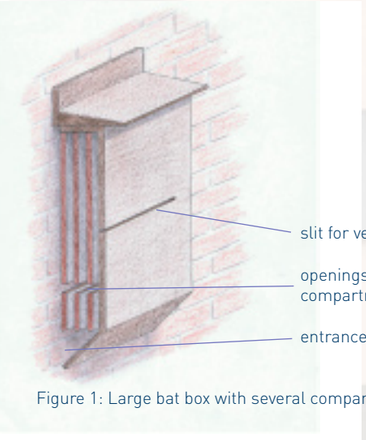


Figure 1: Large bat box with several compartments

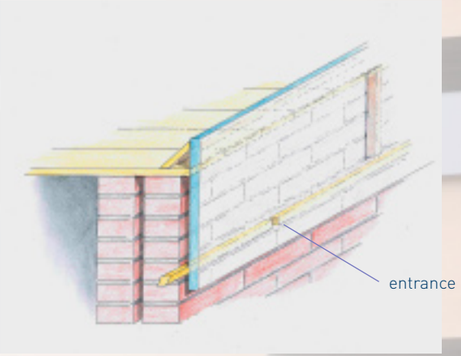


Figure 2. Bargeboard with an entrance for bats

These boxes are usually custom built to match as closely as possible the conditions inside the roost that they are intending to replace.
In existing buildings, when wall paneling, fascias, bargeboards, soffits and other woodwork do not fit to the wall precisely, they can unintentionally provide roost spaces for bats. This makes it possible to adapt or construct wall paneling in such a way that bats can live behind it or to construct bat boxes in such a way that they fit with the style or the shape of the building whilst also serving as wall paneling. For example, a suitable space for bats can be created by attaching wooden paneling to small vertical wooden blocks (1.7-3 cm wide) which have been attached to the wall of a house. This space must then be made accessible to bats by keeping the underside open or by providing entrance slots. It is important to construct this habitat feature in such a way that bat droppings can fall out naturally or to allow droppings to be removed easily. Additionally, double layered fascia board can be provided to allow extra roosting habitat for bats. It is also necessary to ensure that bats cannot reach other spaces in the building where they are not welcome. Of course, it is also important to use timber which has not been treated with toxic materials.

Top: Woodwork often provides sufficient space for bats

Middle: Structure for compensating loss of roosts, with entrance for bats

Bottom: Bat box under a soffit

Common pipistrelle

Multiple roosts Bats are always looking for optimal roosting sites. Throughout the season, they will use several different roost sites. In winter, they hibernate in stable, humid and frost free places. In spring and summer, females group together in warm places with stable temperatures to give birth and raise their young. In other periods, roost conditions are less critical but roosts that heat up in the afternoon and evening are often preferred. During the mating season, males set up a mating roost where they will defend the territory surrounding it and try to lure females.

The thermal capacity of a roost, i.e. the degree to which the sun can warm it up , the capacity to retain this heat and the range of temperature (microclimates) of a roost determine how they are used by bats throughout the year. The temperature requirements of maternity roosts and hibernacula differ but both require a certain range of temperatures and different microclimates. These are found more often in roosts inside a building than in a bat box mounted on the exterior of a building. However, in certain circumstances big boxes on a wall can retain enough heat to function as maternity roosts. Mating roosts and individual roosts of males and females can be provided by small bat boxes within the space behind fascia boards, box soffits or bargeboards.

For maternity roosts and mating roosts, it is preferable that they retain a lot of heat from the sun. These roosts should face south to south west. The provision of several roosts facing in different directions increases the chances of their use by bats. The table (opposite) gives a global overview of the different approaches to bat friendly building and the functions that they provide for bats. However, because this differs between species it is advisable to consult a bat expert for specific advice.

	Heat capacity and buffering	Functionality as roost
Provision of temporary bat boxes		
Small bat boxes	-	m, s
Large, custom made bat boxes	+-	m, s, MM
Adaptation of existing structures		
Woodwork	+-	m, s, MM
Including integrated bat roosts		
Small integrated roosts	+	m, s, MM
Large integrated roosts	++	m, s, MM, h
Bat friendly districts		
Wall cavities	++	m, s, MM, h
Roof woodwork	++	m, s, MM, h
Deeper provisions for bats	++	m, s, MM, h

- = bad; +- = reasonable; + = good; ++ = very good
m = Male roost, s = mating roost, MM = maternity roost, h = hibernacula

Success factors Not every place in a building is suitable for bats. The success of a new roost in a building depends on the range of temperatures that it provides, its dimensions and its accessibility (i.e. the availability of grip at the entrance to the roost site and the location of the entrance).

Temperature The capacities of a box to buffer its interior from exterior temperature fluctuations will determine how and when the bats will use it (refer to section "MULTIPLE ROOSTS").

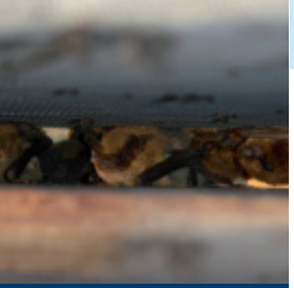
Dimensions For mating roosts or small groups of bats (1-15 animals), bat boxes which are 150-500 mm wide and 300-500 mm tall will be sufficient. Depending on the number of animals, boxes may be suitable as maternity roosts when they are as little as 700-1000 mm wide and 700-1000 mm tall, but, the larger the better.

The depth of a box should be reduced for smaller species, such as the pipistrelles where a depth of 17-20 mm is sufficient. For larger species such as Daubenton bats, parti-coloured bats, serotine and brown long eared bats a depth of 25 – 40 mm is enough. The depth is mostly determined by the number of layers the bats can crawl into. For maternity roosts and hibernacula, boxes consisting of several layers at the depth mentioned above are preferable.

Grip A bat needs a rough surface to grip onto to allow them to crawl in and out of the bat box. Not only the inner walls, but also the space around the entrance should be rough to a distance of 200 mm at least. Wooden boxes can be made suitable by adding grooves of 2 mm deep every 10mm. Also, strong plastic mesh can be added, provided it is securely attached to avoid bats becoming entangled. Wood concrete and brick are usually rough enough to provide grip, but glazed bricks should be avoided as they are too smooth to provide adequate grip.

Entrances To avoid birds adopting the spaces meant for bats, the height of the entrance should not be greater than 17-20 mm for pipistrelles and 20-25 mm for other species. In terms of width of roost entrance, the minimum width is 40 mm although the entrance can be made wider if required. In general, it is best to place the entrance at the bottom of the bat box, to avoid water ingress, and to allow droppings to fall out naturally.

Flight height and space Bats need adequate space to fly in and out of their roosts safely. Place entrances higher than 3 metres above ground level if possible. Prevent structures that allow predators (cats, martens, birds of prey) to perch close to the entrance. Keep the entrance dark, and remove branches or other obstacles that are closer than 2 metres to the entrance as these can prevent the bats from being able to enter and exit the roost



Top: Common pipistrelles in bat box

Bottom: Integrated bat box

Including integrated bat roosts post and pre-construction

Integrated bat roosts Those that want to provide roosting habitat for bats in buildings already designed or built still have an opportunity to include such provisions in the construction. Usually this is in the form of a structure in the wall cavity or outer wall. These spaces are physically isolated from the rest of the building i.e. they are inside the building but offer a space for the bats that is clearly separated from the space occupied by the building's human residents. Because they are included within the fabric of the building, integrated provisions are stable in temperature and therefore more suitable as maternity roosts and hibernacula than bat boxes attached to the exterior of buildings.

Prefabricated integrated bat roosts The simplest option for integrated bat roosts is using the prefabricated constructions that have been commercially available for some time. These are usually wood-concrete or ceramic bat roosts that substitute bricks. These artificial roosts are 200-350 mm wide and 200-600 mm tall. They are large enough to function as mating roosts or summer colonies of up to 20 bats, but generally too small for maternity roosts.

LARGE MATERNITY ROOSTS Maternity roosts must have a stable temperature but also provide a range of microclimates. If a maternity roost is to be built into a cavity wall, a large area will be required. A roost which will provide the conditions required may be constructed by stacking a number of interconnected small prefabricated bat "brick" boxes. Stacking bat boxes vertically provides a larger range of microclimates, and is therefore preferable to combining bat boxes horizontally. Similarly, different microclimates can be provided by combining interconnecting boxes around corners, which will offer different levels of exposure to the sun. In these cases, the south and west side of a building is most suitable.
There are as yet no prefabricated integrated constructions available for maternity roosts and hibernacula. Usually, made to measure boxes are built into the wall, behind the outer wall and in the wall cavity. These custom made walls are generally made from wood. To provide a greater difference in microclimate, they are often made of several layers of compartments (figure 3).

Visible or invisible provisions Dependant on the preferences or motivation of the owner, builder or architect, bat roosts can be designed as a prominent feature or to be nearly invisible. Those that want to advertise their efforts towards nature conservation, can leave the bat roost very visible, or even add a bat figure or some explanatory text. Those who do not can leave only the openings for the bats visible. These in themselves can be used as architectural elements without stressing their function as entrances for bat roosts.

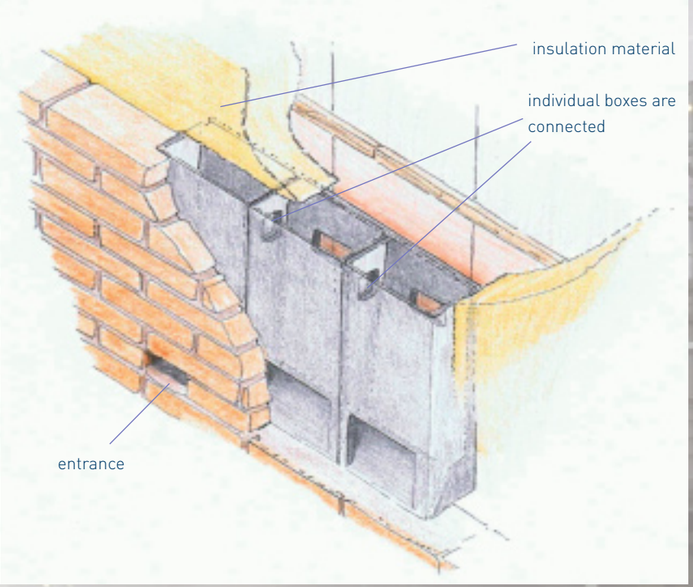
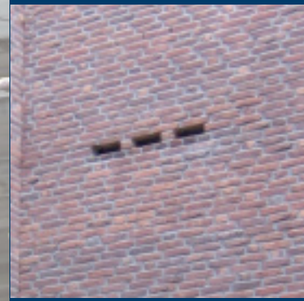


Figure 3. Integrated, connected bat box "bricks"



Integrated bat boxes at the WNF office in Zeist, the Netherlands

Top: Nathusius'pipistrelle

Bottom: Brown long eared bat

Structural design

Conserving insulation When bat roosts are incorporated in the wall cavity (figure 4), there may be less space for insulation although this does not have to be at the expense of its performance as insulation. Wood and wood-concrete bat boxes can provide a certain degree of insulation themselves. However, to avoid a cold bridge, material with a higher insulation value can be placed between the bat box and the inner wall.

Exposure and heat sources Bat roosts within cavity walls are best built into a south- to southwest facing wall. When more than one bat box is to be provided, they can be placed at different locations within and around the building to provide roosting habitat with a variety of micro-climates. This can be achieved by varying exposure to the sun, or by placing the boxes in front of and behind insulating layers in the wall. Another option is building the roost close to an existing artificial heat source, such as a boiler house, chimney, air conditioning ducts or central heating pipes. This of course requires fine tuning and a thorough design overseen by a bat ecologist and an architect.

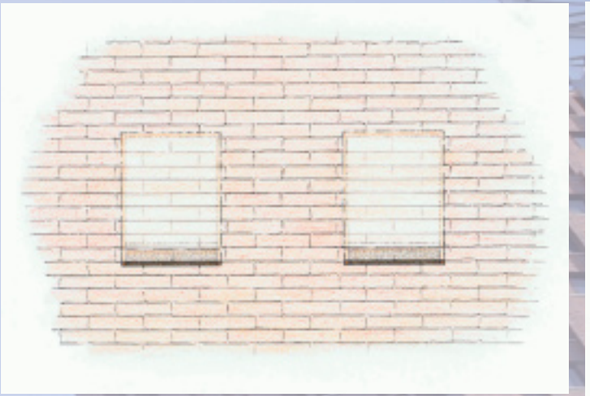


Figure 4. Integrated bat boxes inside brick wall

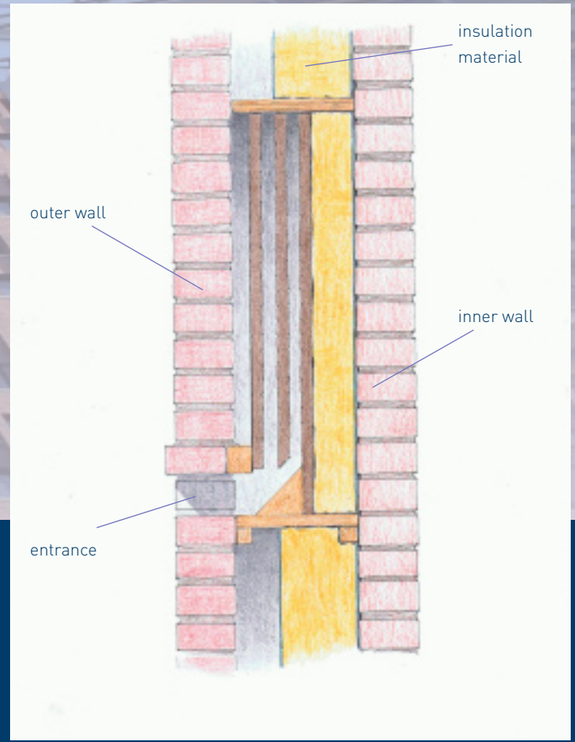
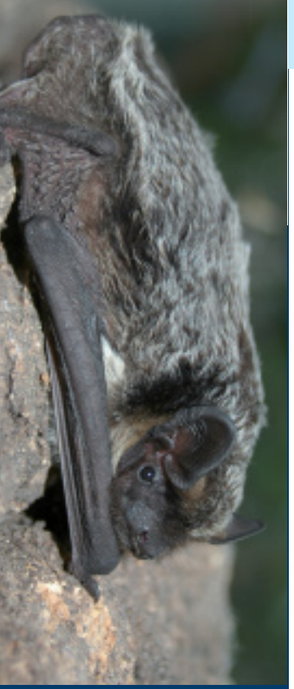


Figure 5. Integrated maternity roost or hibernacula

Prevention of nuisance

The design of bat roosting habitat should aim to prevent nuisance caused by bats to residents living within bat friendly buildings. Solutions for the removal of bat droppings should be designed into any bat boxes which are to be provided. One solution is to make sure the connection between the box and the entrance is diagonal, so the dry droppings will fall out (figure 5). In larger ventilated spaces, such as an open wall cavity, droppings do not usually create a nuisance as they dry quickly and therefore become odourless.

Avoid allowing access for bats into the building itself. A properly designed artificial bat roost will not have connections to the living or working space within a building. Make sure the bat roost entrances are not in close proximity to or above windows or doors. Bats are usually very quiet in the roost, but can sometimes be heard through thin walls. It is advisable, therefore, that living and working spaces are separated from bat roosting habitat by a robust material rather than thin wooden or polymer walls.



Parti-coloured bat

Modification of existing structures

Modification of existing structures From the first moment humans started building housing, bats and other animals have found shelter in those constructions. In walls and roofs, there was always a space where they could roost unnoticed. But because of changing building techniques, this is getting harder and harder for bats. We can provide suitable roosting sites for bats by making the whole wall cavity or roof space accessible. This need not be a complicated process.

Making a cavity wall suitable and accessible Cavity walls are usually 100-120 mm in width in modern buildings. That is wide enough to house both an adequate insulation layer and a roost for bats. A suitable roosting space can be provided for bats within the cavity wall by retaining an area of space at least 30 mm wide between the outer wall and the insulation layer.

Rock wool or fibre glass wool must be covered by a solid rough layer, so bats cannot be injured by it or become entangled in it. The design should allow bat droppings to drop all the way to the floor. Avoid situations where droppings are allowed to build up in a small space. With enough ventilation (which is of course a key purpose of wall cavities), the droppings dry out leaving no smell and causing no damage to the building. Access into the wall cavity can be provided by open joints, open access between the various elements within the wall, open joints between the wall and the eaves or via special "bat bricks".

Making the roof suitable and accessible Bats can also inhabit a number of the spaces within the roof including beneath the roof tiles, the ridge tiles or within the space between the roof covering and the roof lining or membrane. Some species, such as the serotine, even seem to prefer these spaces over other structures. However, in modern buildings with a sloping roof, there are few spaces which provide habitat suitable for roosting.
Making a roof suitable involves adding an additional crevice-shaped entrance which is long and narrow for bats to crawl into. This can be above or under the roof tiles. Create such spaces at several sides of the roof and offer entrances that can be reached easily by bats i.e. the entrance can be at the eaves of the roof, through special edge roof tiles, beneath the bargeboards or box soffit, or at the bottom of the roof, through the fascia. Commercially available bat roof tiles or swift roof tiles can only function as entrances on roofs with an incline of more than 60%. As concrete roof tiles can heat up and cool down very quickly, take care not to place bat roof tiles facing due south.

Provision of segregated roosting habitat It may not always be possible or desirable to make the whole wall cavity or roof suitable or accessible for bats. For example, when current construction or insulation regulations do not allow it, or when inhabitants are not happy with nature-friendly construction. In these cases, parts of the building that are not intensively used or that do not have to com-

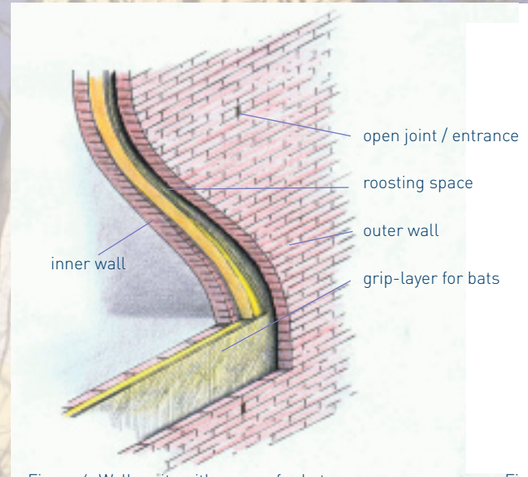


Figure 6. Wall cavity with spaces for bats

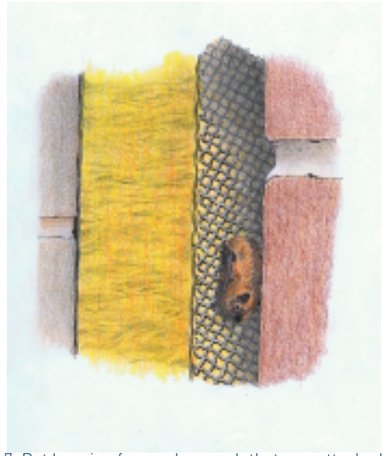
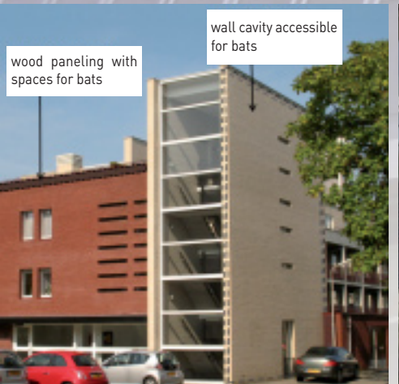


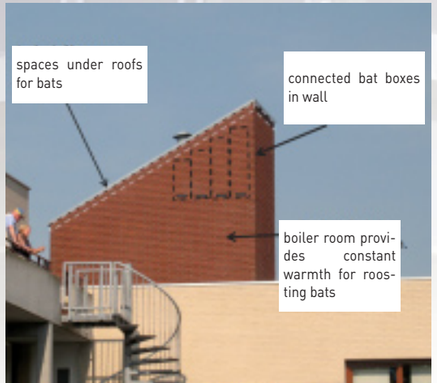
Figure 7. Bat hanging from nylon mesh that was attached to isolation material for that purpose

Deeper provisions for bats
A small number of bat species, such as pipistrelles and serotines, also hibernate in our buildings. Sometimes this may be in a wall cavity or under the roof, but also in spaces deeper in the building. For example in expansion gaps in the concrete parts of the building, or in hollow floors or internal walls with cavities.

ply with the insulation regulations can be used to provide alternative bat roosting habitat instead. For example, false walls can be built to house bat boxes or an extra wall cavity, so that the "real" wall cavity can house the insulation materials. These walls can be made to appear as buttresses or chimneys or can be designed to appear simply decorative. Brick balcony balustrades or ornamental brick roof ridges can hold bat boxes without affecting the performance of the insulation within the building. Additional opportunities for bat friendly construction in office buildings and apartments exist within stairwells, lift shafts and boiler houses.

Examples of provisions for bats that can be integrated during construction





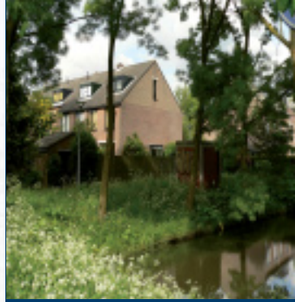
Bat friendly districts

Integrated building in neighbourhoods When building or renovating whole districts, offering only a few roosting opportunities is not sufficient to conserve a healthy bat population. Greater effort is required, and taking bat ecology into account during the planning stage is necessary to achieve this. For example, when a new district or community is built consisting of 70 detached houses, 120 terraced or semi detached houses and 110 properties within an apartment block in addition to a school and a supermarket, one should aim for approximately 35 maternity roosts, 90 mating roosts and 20 large hibernacula. The exact number depends on the conditions at the site and one should consult a bat expert to decide how many roosts to provide. Often, in a district wide approach, initiatives from the council, commercial organisations and private individuals can raise the funding required to provide a number of artificial bat roosts.

In addition to roosts it is useful to create foraging areas and flight paths to link them and roosting sites. Gardens and parks with ponds and native plants can function as foraging areas, connected to the wider habitat via a green infrastructure of sheltered waterways, hedgerows, and botanically rich roadsides. This is not only beneficial for bats, human inhabitants will benefit from the improvement of their surroundings. The key is how these elements are fitted together so that there is adequate connectivity between them.

Lighting is also important. Streetlights can be placed in such a way that there is sufficient light for humans but not too much light to cause disturbance to bats. Larger roads which cross bat flight paths can be designed in such a way that bat mortality is minimized.

Integrated building in a new community requires prior planning, the results of which can only be beneficial. It aids bat conservation and creates leeway with conservation laws when planning neighbouring communities. Bats provide opportunities to experience nature in urban environments, and help keep insects under control. And the landscapes which are necessary for bats, are enjoyed by humans too.



Top: Foraging habitat in the neighbourhood
Middle: Amber LED streetlights as a good alternative for normal streetlights
Bottom: Fauna-overpass

Top: Placing an artificial bat roost

Middle: Swarming common pipistrelles

Bottom: Integrated prefab bat box.

Developing knowledge

Based on our current understanding of bat ecology, this document outlines state of the art design and the best available techniques, methods and developments in the provision of bat habitat within buildings. However our understanding of the roosting requirements of bats is currently still limited. Monitoring the success of newly created roosts is therefore of great importance in improving techniques and practices, and we would welcome any feedback relating to your experience in improving or providing bat roosting habitat in buildings.

Custom design

This document helps the home owner, builder, architect or planning officer in the bat friendly design, construction and renovation of buildings. Successful implementation requires cooperation between bat experts and architects. Would you like to start working in a bat-friendly manner? Then approach one of the organizations involved in the production of this document.

COLOFON

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Text: Erik Korsten, Herman Limpens
m.m.v. Herman Bouman
en Jeroen Reinhold

Fotography: Renée van Assema, Jan van der Bremer, Teddy Dolstra, Theo Douma, Paul van Hoof, René Janssen, Herman Limpens, Erik Korsten, Bernadette van Noort, Jan Pieter Vermeulen, Vivara, Ilco van Woersem

Illustrations: Bram Rijksen

Design: BARD87 ´s-Graveland

Translation: Kerry Rhodes
www.rhodesecology.co.uk
Jasja Dekker
www.jasjadekker.nl

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www.zoogdierverenging.nl
024-7410500

Tauw bv
www.tauw.nl
030- 2824937

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