Bird-Friendly Building with Glass and Light

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Impressum

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Preface

We´re on the way! In 2008, when we made the first edition of this publication available and sent it to many architects and all the local Swiss building authorities, we had no idea what we would set off. This booklet was translated into Spanish and Italian, and in the meantime France, Germany and Luxembourg have published their own versions.
Our guidelines met with much goodwill in the building trade and enquiries into bird-friendly building solutions have markedly increased since then. Happily, many of our recommendations have been taken up and new ideas have been implemented. Progressive councils have begun to check building applications for bird-friendliness, and here and there, have requested improvements. Increasingly the media have written on this subject and highlighted the many victims – victims, which with better planning could have been avoided. The glazing industry is going to great lengths to develop products which will significantly reduce the rate of collisions. And in research and development too, new advances are being made.
This provides us with more than enough reasons to update our booklet. We have taken the opportunity to include new examples and developments, to expand others and to update our recommendations to the newest standards.
Despite clear progress we have to conclude that there is still a long way to go. Daily, buildings are erected where a bird-lover can only ask "how can anyone do that?" It remains our goal to reduce unnecessary bird hazards and, at the same time, to protect builders, glazing manufacturers, architects and planners from criticism. In addition we want to promote the development of more aesthetic solutions, showing the way to the future. We are working on it. Keep supporting us!

Dr. Lukas Jenni
Director, Swiss Ornithological Institute Sempach

L. Jenni

Hundreds of coal tits died on just this building in Basel, Autumn 2006. Feathers and traces of collisions are lasting reminders of the many dramas on our windows.

Surface collision victims collected in one migration season from skyscrapers in Toronto´s downtown financial district.

Introduction

Birds – our nearest Neighbours

We share living space with birds. Central European housing developments with green spaces frequently accommodate 30 or more bird species. It is up to us to protect them from unnecessary dangers.

The kingfisher is an endangered species, but one which is common in housing developments. Many are killed through hitting glass whilst flying at speed low over the ground.

Birds have lived on our planet for 150 million years. In contrast, humans have only been around for 160 000 years. Since the development of agriculture, we often live in close proximity to them. And in the last few hundred years more and more bird species have become adapted to civilisation. For example, the ubiquitous blackbird used to be a shy forest bird. Its adaption to urban living is, however, playing with fire: advantages such as a favourable microclimate and a rich supply of food are in stark contrast to the considerable dangers posed by traffic, glass bottles and the density of cats. In contrast, the species which have not managed to adapt are threatened by increasing urbanisation and are suffering habitat loss. Thus we have a responsibility, at the very least for those species which have adapted to live with us, to provide suitable living space. As part of that, we need to protect them from unnecessary man made dangers. Otherwise we will pay for it with the loss of birdsong and with it, some of our quality of life.

Birds and people today share the same living space. Around 400 pairs of birds from 40 different species live in this location in central Switzerland - and this on an area of around one square kilometre. The territory of the 15 most common species are here indicated with coloured dots (red: pied wagtail, black redstart and house sparrow; light blue: tits, nuthatches and finches; yellow: thrushes and warblers).

How does a Bird perceive its Environment?

Do we see the world as it really is? Or do birds have a different view? In either case, birds have a few noteworthy abilities that people don´t have.

Birds are very visual creatures. Their eyes are highly developed and are vital for their survival. In most bird species they are set in the sides of the head. This gives them a «wide-angle», in some species even a 360°, view, which enables them to recognise approaching enemies and potential mates or rivals. The disadvantage is a comparatively small area of view is covered by both eyes: stereoscopic vision and with it, spacial perception, are therefore limited. The two eyes often undertake different tasks concurrently: one is focussed on a worm, while the other surveys the surroundings. The resolution is phenomenal: whilst we can just about process 20 pictures per second, a bird can manage around 180. Notable differences are also seen in colour recognition: birds differentiate green tones better than we are able to. And in addition, birds have a fourth colour channel that enables them to see in the UV-A range. The buzzard is struck by the mouse’s urine trace and can accurately estimate whether an attack is likely to be successful. However, despite the excellent optical abilities of birds in their natural environment, glass is invisible to them. Although much is known about the sensory abilities of the eye, many questions remain unanswered, such as the effects of optical triggers in the brain. To imagine you are a bird and to understand how it comprehends its environment and interprets signals is only possible at a rudimentary level. For example, it is not satisfactorily explained whether birds are repelled by UV images on a glass plate, or in fact attracted to them. That requires extensive testing in order to develop effective anti-collision solutions (see page 46).

For most birds, like the blue tit here, the eyes are positioned on the sides of the head. This allows an almost 360 degree view. But the consequence is less stereoscopic vision.

The eyes of the common snipe each cover an angle of view greater than 180 degrees. Thus the bird has a small amount of stereoscopic vision both front and back.

Many birds, like this great tit, are accustomed to fly through dense branches. Even tiny ´holes´ are regarded by them as flight paths.

Palm Area Rule:
As a rule, the size of the palm of the hand can be used to estimate if an opening is big enough for a bird to fly through.

Three Phenomena and their Consequences

Until recently, birds could move unhindered in the air. Obstacles were always visible and the birds could skilfully avoid them. But evolution has not equipped them with the ability to see glass walls. There are three particular phenomena which lead to collisions with glass.

Transparency

The most well known cause of glass collisions is its transparency. The bird sees the tree, the sky or an attractive landscape through the glass and flies straight for it, colliding with the pane of glass in the process. The danger is increased with increasing transparency and size of the glazed area.

Trees, an attractive habitat, free space to fly in and a plate of transparent glass in between: this is the danger for birds.

Reflectivity

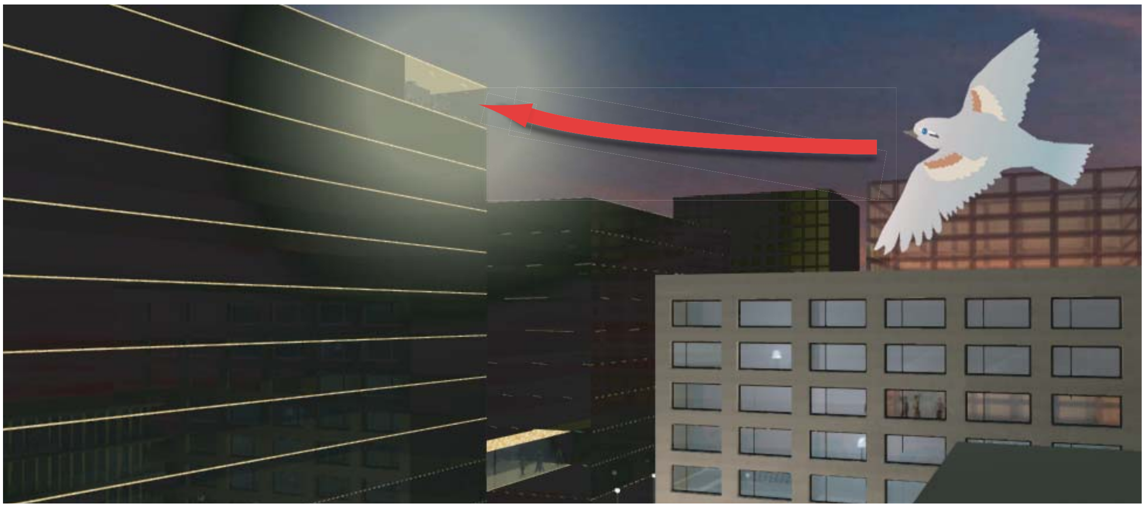
The second phenomenon is reflectivity. The type of glazed surface, the light and the environment behind the glass all determine how strongly and how clearly the surroundings are reflected. If a park environment is reflected, the bird is deceived into thinking it sees a pleasant environment. It flies directly towards it, without realising that this is only a reflection. Reflective surfaces placed in the landscape have the same effect.

Sun-protection glass and many other types of glass have a high reflectivity index. The stronger the reflection and the more attractive the environment reflected, the greater the number of collisions.

Source of Danger: Light

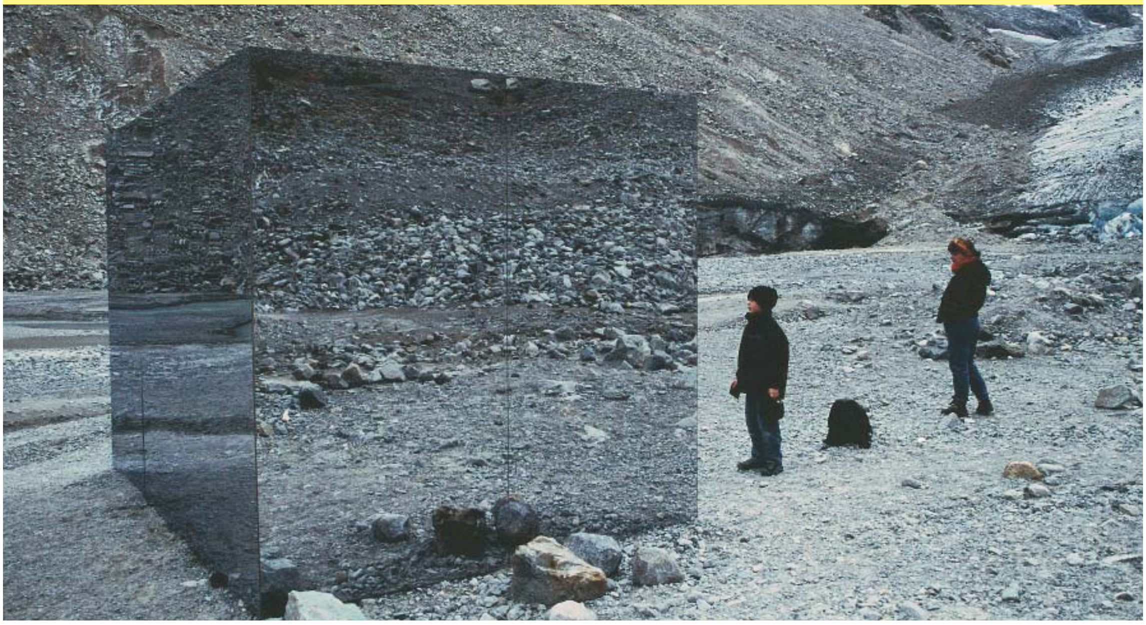
In central Europe, less well known – but still a major issue – for nocturnal migratory birds is the false guidance provided by artificial lighting. Often, birds are attracted to the light, become disoriented and lose their route, or indeed, collide with obstacles. This danger is increased in poor weather and fog. It is known to occur at lighthouses, gas and oil platforms (gas flaring), skyscrapers, lighted buildings on alpine passes, lampposts and other exposed structures. The current trend for more high-rise buildings increases this danger.

Strong lighting is also a disaster for other animal species, in particular insects, and there is controversy over the potential negative influence on our own health from night lighting, as the exchange of the important hormone Melatonin is reduced. Melatonin promotes sleep, regulates physical health and the immune system and triggers hormone production in humans, animals and plants.



Internal lighting in a building: lights which shine strongly upwards, e.g. lighthouses, etc. confuse migratory birds flying at night, particularly in fog or bad weather. They are attracted to the light and collide with the building or the light source. The taller the building, the greater the danger.

Essentially, collision dangers are everywhere.



The danger of collisions with glass is practically everywhere. This highly reflective «Monolith» was installed by an artist at the base of the Morteratsch Glacier in the Graubunden Alps, 2,100 meters above sea level. Although the surroundings look inhospitable, even here there are traces of bird collisions on the mirrored surfaces.

Glass as a Hazard for Birds

*Overview of the hazards in a modern development: **1** Bicycle stand in transparent material; **2** Reflective façades (glass, metal, etc.); **3** Trees in front of reflective façades; **4** Attractive green spaces in front of reflective façades; **5** Transparent noise barriers with ineffective black silhouettes; **6** Glazed entrance to the underground parking; **7** Transparent aerial walkway; **8** Reflective façades; **9** Garden sculptures made of reflective or transparent material; **10** Transparent corners; **11** Winter garden; **12** Glass balcony walls; **13** Transparent corners; **14** Plants behind transparent surfaces.* *For information on how to make this development bird-friendly, see page 15.*

Transparency

Where are the danger zones? The most obvious and well known hazards are those which are often known from childhood: for example, the windbreak on the house corner, or the glazed corridor between two school buildings.

Positions of windows on corners.

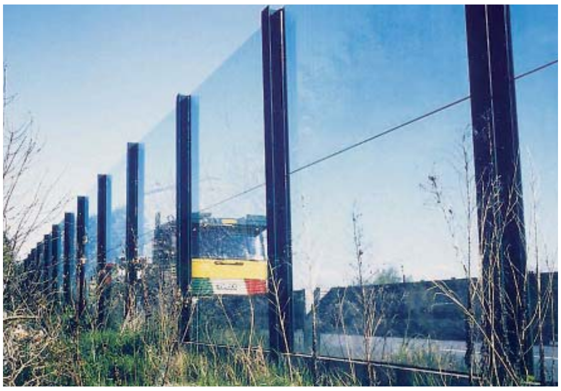
There are countless situations where surfaces, which permit a view of the environment behind them, become a problem for birds. Glazed house corners, wind and noise barriers, corridors, conservatories, etc. are some of the danger zones. The dangers are increased in confined spaces (for example, a glass wall between two large buildings) or dead ends. For the same reasons internal courtyards, particularly landscaped ones are also problematic. With thoughtful planning many of these problems can be eliminated, or at least greatly reduced, in advance. Windows which will later provide a view should not be placed on corners. Bevelled corners, however, are not a problem as long as the bordering walls are visible (see diagrams left). Transparency on balcony walls, corners of conservatories, glazed walkways, acoustic insulation barriers, etc, should be avoided wherever possible, or clearly marked from the beginning. Or an alternative material, such as ribbed, corrugated, matt, sanded, etched, coloured, laser marked or printed glass should be used.

Transparent corner construction

Completely glazed waiting room

Wind barrier with virtually useless bird of prey markings

Wind- and noise barrier between buildings



Transparent noise barriers

Glazed footbridge

Glazed balcony walls and noise barriers

This block of flats contains many transparent glazed balcony balustrades and barriers


Glazed retro-fitted extension to a train station concourse


Valley station of a mountain cable car, glazed on three sides: birds fleeing late snowfall fly into the building and hit the windows - usually from the inside.


Transparent bicycle shelter


The practically invisible plexiglass walls on this shopping trolley shelter are dangerous


Glazed stairwell


Transparent corridor

Reception building for a large industrial company. The optical conjunction of the interior and exterior spaces is extremely dangerous for birds. Just as perilous are buildings by water or in green spaces, when reflective façades integrate into the environment.

A cosy space in the outdoors. The hedges contribute to the corridor-effect created by the panes of glass. The raptor silhouettes on the glass show that the problem is recognized. But they certainly will not resolve it.

➤ **Markings e.g. on glass doors – at least those at eye level – are also helpful for the visually impaired!**

➤ **Raptor silhouettes have not had the desired effect (see page 15).**

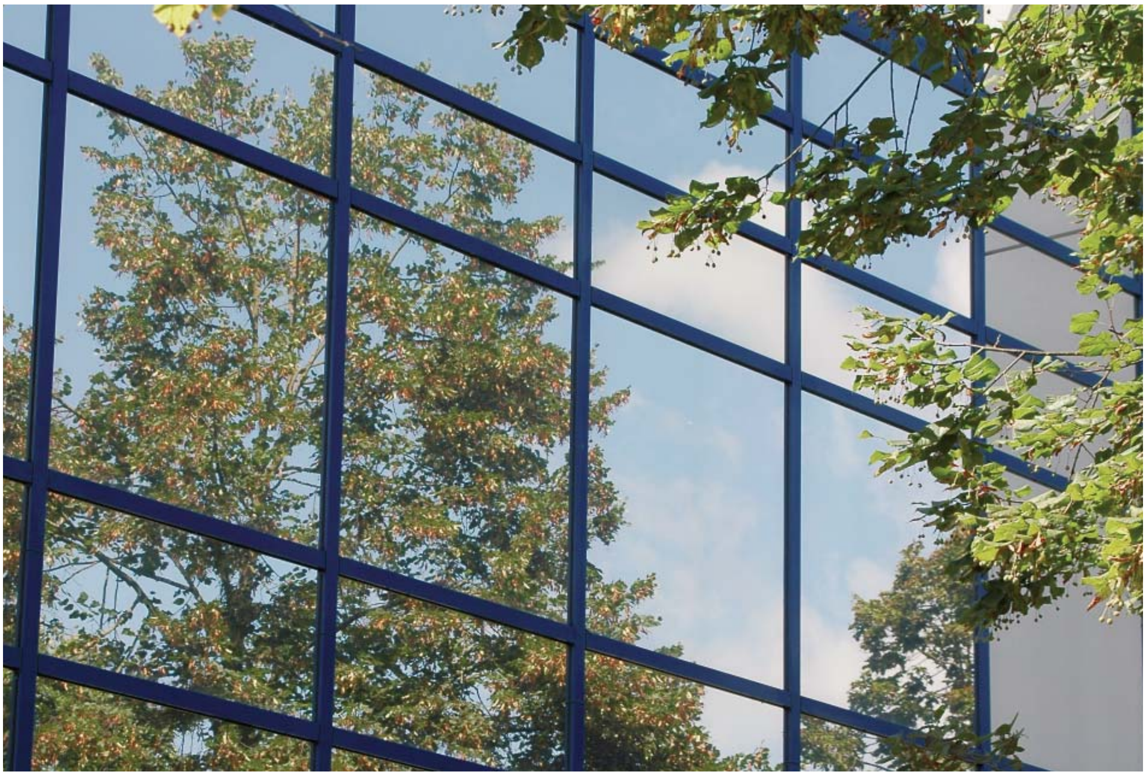
Reflectivity

Reflections of the environment are created as part of the architectural design. In addition, strong reflections minimize sunlight ingress. However reflectivity is just as dangerous for birds as transparency.

It is easy to see why reflections confuse birds. The degree of external reflection of glass panes and the design of the surrounding environment are of great importance. Strongly reflective sun protection glass panels are therefore particularly dangerous. Reflectivity, even at moderate levels, such as on normal window panes poses a danger, particularly when the room behind is dark. In recent years triple glazing has become industry standard: it saves energy and is pleasing to the eye. However, its construction makes it more reflective than standard glazing, which is why the danger for birds is accentuated.

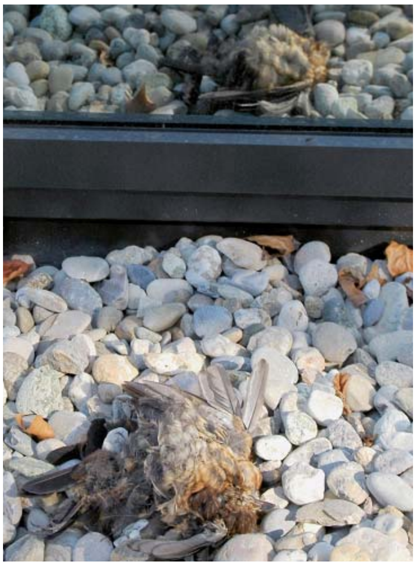
A uniformly coloured sky is the principle danger for aerial hunters, such as raptors, swifts and swallows. Overall, however, trees and shrubs in the nearby surroundings are much more problematic, because they attract more birds of more species. It is therefore important to pay special attention to reflective surfaces when designing the environment (see page 36). This also applies to strongly reflective metal surfaces.

Reflectivity depends on a number of factors such as, for example, the lighting in the interior space behind. The same glass produces stronger reflections with increasing darkness of the background.



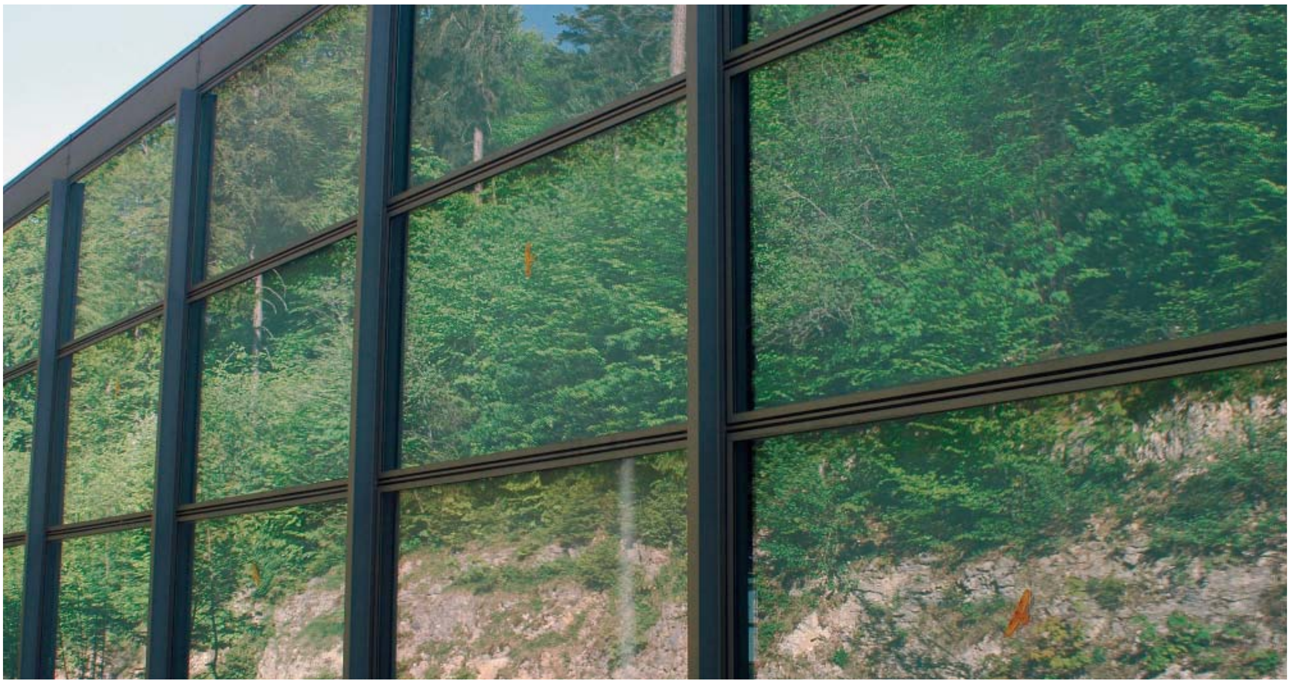
Sun protection glass produces high quality reflections of the environment as a result of its high reflectivity index. The danger is particularly great where it reflects trees or natural landscapes.

On this bank, the Departement for the Preservation of Historical Heritage imposed conditions. A strongly reflective glass façade should highlight the neighbouring church…



…an idea that has already claimed many victims (here a young blackbird).

This association between old and new may be pleasing from an aesthetic point of view, but from the birds perspective it should never have been permitted.



A sports hall: one wall runs parallel to a forest border. There is no pressing need to have such highly reflective glass on this west-facing façade.

Large façades, strongly reflective glass, in the middle of a landscaped environment – a death-trap, which, from the financial cost alone, cannot be rectified.

A new school building with a wide, two story glass façade. Because of the highly reflective glass there were continual collisions. The coloured silhouettes were created by the pupils and the biology teacher in an act of desperation. The collision hazard was reduced, but the issue is neither pleasingly nor effectively resolved.

➤ **No reflective façades next to trees or in landscapes that are atrractive for birds!**

Bird Friendly Solutions

This picture shows which methods can be used to minimise bird hazards (comparison page 8). ***1*** *Bicycle stand in semi-transparent material;* ***2*** *Glass with highly effective patterns;* ***3*** *Reduction of transparent corners;* ***4*** *Modified landscape (no attractive green spaces and trees close to potential hazards);* ***5*** *Noise barriers: surface patterns or semi-transparent material;* ***6*** *Underground parking entrance: surface patterns or semi-transparent material;* ***7*** *Aerial walkway: reduction of transparency, e.g. through design elements in the construction;* ***8*** *Living Walls (façade covered with living plants);* ***9*** *Garden sculptures made of non-transparent material;* ***10*** *Non transparent building corners;* ***11*** *Winter gardens and* ***12*** *Glazed balcony balustrades: surface patterns or semi-transparent material, e.g. patterned glass;* ***13*** *Non-transparent balcony corners (screens, blinds, curtains, etc);* ***14*** *Plants placed only behind semi-transparent surfaces.*

Reducing Transparency

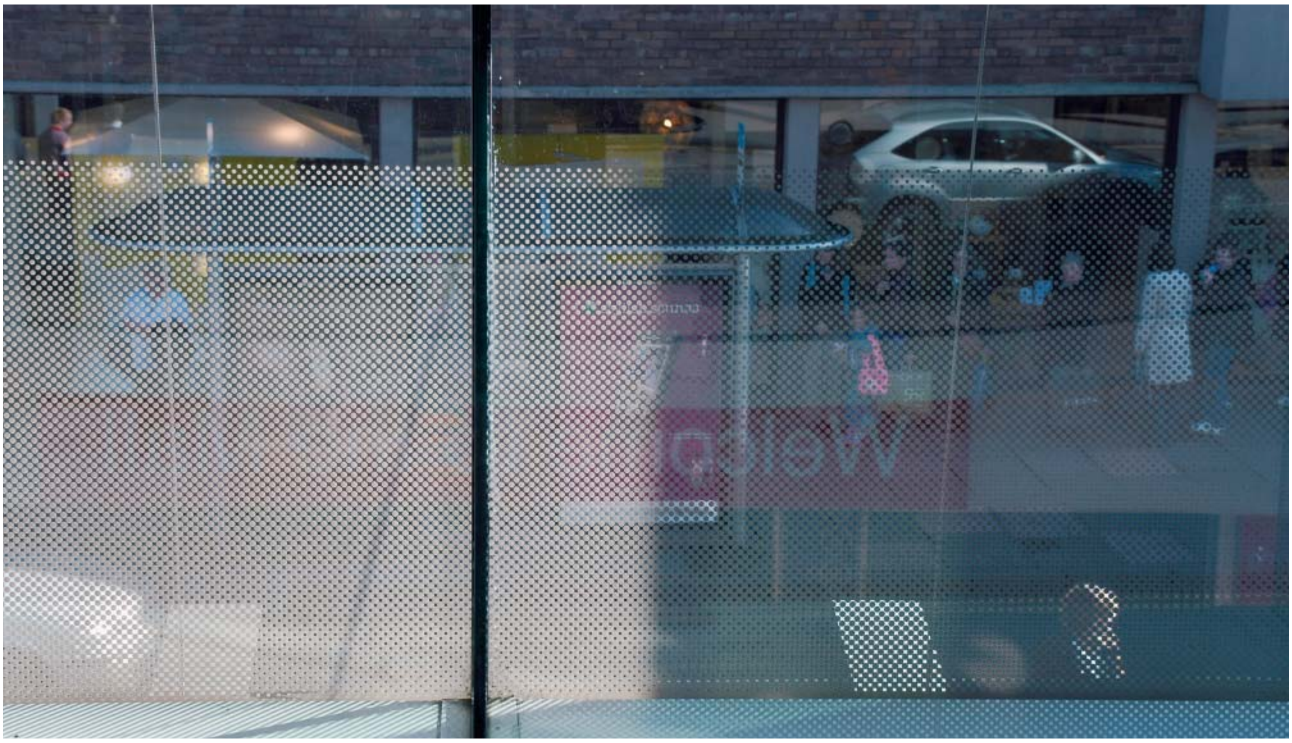
If transparent surfaces on exposed areas cannot be avoided, then it is essential that the through visibility is reduced. The use of semi-transparent material or extensive surface marking is the most effective method. This is true not only for glass but also for other transparent materials, such as polycarbonate.

Black Silhouettes are ineffective

Up front: despite the fact that these silhouettes are regrettably still available in the shops this is no proof of their effectiveness. They are not recognised as predators by birds. In addition, they do not provide sufficient contrast to a dark background. Often, traces of bird collisions are found right next to the stickers. Therefore we strongly advise against using them.

Dots, Grids and Lines

To prevent collisions effectively, transparent surfaces must be made visible to birds. Many new products are now available that promise protection from UV rays with patterns which are largely invisible to human eyes. So far there has been no evidence of sufficient effectiveness. Therefore, we cannot recommend UV-Protection Glass. Thus we have to accept a reduction in transparency will also affect our view. In brief, there are two options: patterns over the whole surface (for example, stripes or dots) or alternative materials, such as opaque,



Patterns have different effects depending on the lighting. This shop window is covered with a very dense dot pattern. Whilst the right-hand section in shade is semi-transparent, and some things can be seen, the left-hand side is much more diffuse. The grid does not need to be this dense in order to provide effective collision prevention.

light-permeable material, e.g. frosted glass. The effectiveness of the patterns is related to percentage coverage, contrast and the reflectivity of the glass. Technically, there are many ways to make effective patterns. If you want to use marked glass, we advise having the glass screen printed during manufacture. Glazing manufacturers often offer a variety of patterns and colours "off the shelf". Lamination, which is very durable, permits two different patterns to be featured in the glass.

Recommendations

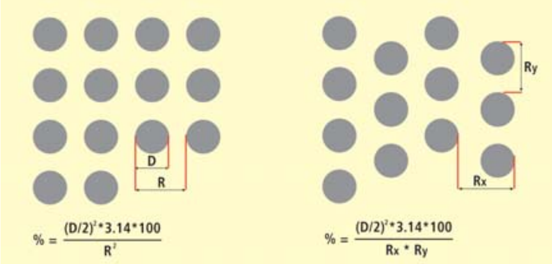
Clear borders and strongly contrasting lines are the most effective patterns. In tests, red and orange patterns are markedly more effective than the same patterns in blue, green or yellow tones. Vertical lines have slightly better results than horizontal ones. Markings placed on the outside surfaces are more effective because they break up reflections. Generally, we recommend using tested patterns and, at least on large projects, obtaining specialist advice. Even small changes to the pattern can bring large changes in effect. In working spaces Local Regulations and recommendations for workplace design should be followed.
Rules for linear patterns: the line must always have a minimum diameter of 3mm (horizontal lines) or 5mm (vertical lines). To be on the safe side, coverage should be a minimum of 15 %. Try to ensure maximum contrast in all lighting, so that the coverage can be minimised.
Dot grids should provide at least 25% coverage. Only if the dot diameter exceeds 30 mm can the coverage be reduced to 15 %. Ideally, the dots should not be too small (minimum Ø 5 mm). Dot grids should also be high contrast compared to the background.

➤ **Wherever possible, place markings on the external surface!**

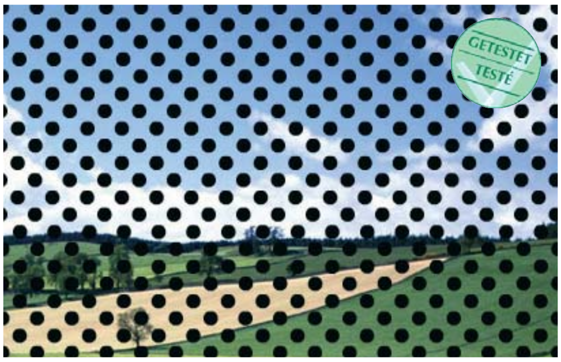
Nuisance – or Accent?

The human eye accustoms itself to many things. Initially a patterned surface can be distracting, but through clever pattern selection and lighting, one can very quickly become accustomed to it. Also, residents often feel the need for privacy, e.g. on balconies, so that complete transparency is unwanted. And: when the reason for the markings is explained, often acceptance follows.
Freeing the imagination provides the chance to turn the glazed surfaces into a decorative element, or even advertising.

➤ Dot grid: coverage: min 25 % for small dots, min 15 % for dots Ø ≥ 30 mm.



Calculation of the coverage afforded with a dot grid



Dot pattern with 27 % coverage, Ø 7,5 mm.

➤ Horizontal lines: min 3mm diameter with 3cm spacing, min 5mm diameter with 5cm spacing. Vertical lines: min 5mm width, max spacing 10cm. Requirements: good contrast to background, otherwise wider lines are required.

Classic example of vertical lines: noise barriers along a traffic artery.

Linear patterns are established prevention. Crystal coloured film contrasts well against most backgrounds.

Variations on a theme are permitted! Small breaks reduce the severity of vertical lines.

It is not necessary to make the lines strictly vertical!

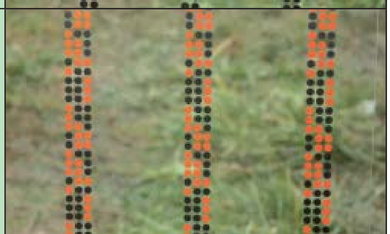
Horizontal black lines, 2 mm in diameter and with a 28 mm interval had very good Flight Tunnel test results – against all expectations. Where it is important to have the best possible visibility, in front of light backgrounds, this is an acceptable compromise. We would, however, recommend that the lines are at least 3 mm wide.

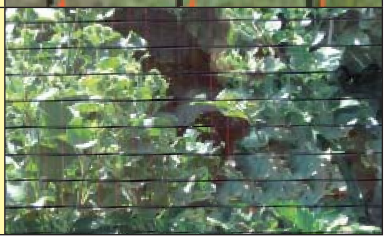
Pattern testing in Flight Tunnels

Martin Rössler has been performing standardised flight tunnel tests (ONR 191040, see Page 47) since 2006 at the biology station Hohenau-Ringelsdorf (Austria). These tests are accepted as the most comprehensive and methodologically sound empirical safety tests on the effectiveness of patterns on glass. 30 of the 38 patterns tested are listed below. 2.4 % approaches means that given a choice only 2.4 % of the birds flew towards the patterned glass panel but 97.6 % flew towards the unmarked control glass panel.

From many years of experience and through discussion with international experts 3 categories of effectiveness have been defined:

Category	Effectiveness of the Pattern/Marking	% of approaches to the test panel
A	Highly effective – "Bird Safety Glass"	Less than 10
B	Suitable in some circumstances	10–20
C	Unsuitable	20–45

Nr.	Approaches	Description	Illustration
1	2.4 %	**Dots black-orange R2** Coverage: 9 % Vertical rows, printed, black and orange Dot Ø: 8 mm Spacing between lines: 10 cm	
2	2.5 %	**Dots black RX** Coverage: 27 % Diagonal dot grid, printed, black Dot Ø: 7.5 mm Diagonal space between centre of dots: 12.7 mm	
3	3.9 %	**8.4v // orange vertical** Coverage: 7.4 % Vertical stripes, printed, orange Line width: 6 mm Spacing between lines: 8.4 cm	
4	5.2 %	**Dots black R2** Coverage: 9 % Vertical rows, printed, black dots Dot Ø: 8 mm Spacing between lines: 10 cm	
5	5.6 %	**Dots Black-Orange R3** Coverage: 12 % Vertical rows, printed, black and orange Dot Ø: 8 mm Spacing between lines: 10 cm	
6	5.8 %	**10v // 5 orange Duplicolor** Coverage: 4.8 % Vertical stripes (enamel spray Duplicolor Platinum, RAL 2009 traffic orange, three coats) Line width: 5 mm	

Nr.	Approaches	Description	Illustration
7	5.9 %	**Glass Decoration 25** Coverage: 25 % Lines of irregular width with irregular edges (adhesive film Oracle Etched Glass Cal 8510, matt, translucent) Line width: 15-40 mm Interval between line edges: max. 11 cm	
8	6.2 %	**Glass Decoration 50** Coverage: 50 % Lines of irregular width with irregular edges (adhesive film Oracle Etched Glass Cal 8510, matt, translucent) Line width: 10-80 mm Spacing between lines: max 6.5 cm	
9	7.1 %	**2.8h // black filament in Plexiglas** Coverage: 6.7 % Plexiglas ® Soundstop with embedded horizontal black polyamide threads Thread diameter: 2 mm Interval between rows: 28 mm	
10	9.1 %	**1.3v // 13 white** Coverage: 50 % Vertical stripes, printed, white Line width: 13 mm Spacing between lines: 13 mm	
11	9.4 %	**10v // 5 red Duplicolor** Coverage: 4.8 % Vertical stripes (enamel spray Duplicolor Platinum, RAL 3020 traffic red, three coats) Line width: 5 mm Spacing between lines: 10 cm	
12	9.9 %	**10v white barred lines, double sided** Coverage: ca 5.3 % On each side, vertical discontinuous lines on the front and back. Adhesive film glossy white (Orajet 3621). Line structure: small horizontal bars, diameter 2.5 mm Line width: 20 mm Interval between rows: 10 cm	
13	10.1 %	**Bars black-orange** Coverage: 7.5 % Pairs of vertical stripes of changing diameter (2.5-5 mm), printed, black and orange, (interval between pairs of lines: 7.5 mm) Spacing between lines: 10.5 cm	
14	10.7 %	**2.8h // 2 black Film/Glass** Coverage: 6.7 % Horizontal stripes (glossy black adhesive film) Thickness: 2 mm Interval between rows: 28 mm On Float Glass	

Nr.	Approaches	Description	Illustration
15	11.1 %	**10v // 5 glossy blue Adhesive** Coverage: 4.8 % Vertical stripes (blue adhesive film Avery 741) Line width: 5 mm Spacing between lines: 10 cm	
16	11.5 %	**2.8h // 2 Black** Printed Film/Plexiglas Coverage: 6.7 % Horizontal lines, black Line width: 2 mm Spacing between lines: 2.8 cm Roller printing on laminate film. Plexiglas, strength 1.5cm, printed surface of the film adheres to Plexiglas	
17	12.5 % (2007) 12.8 % (2008)	**10v // 20 white Tesa** Coverage: 16.7 % Vertical stripes (white tape) Line width: 20 mm Spacing between lines: 10 cm	
18	12.9 %	**10v // 5 black Tesa** Coverage: 4.8 % Vertical stripes (black tape) Line width: 5 mm Spacing between lines: 10 cm	
19	13.3 %	**10v // 5 matt yellow Film** Coverage: 4.8 % Vertical stripes (yellow tape Avery 500, matt) Line width: 5 mm Spacing between lines: 10 cm	
20	14.8 %	**10v // 5 white Tesa** Coverage: 4.8 % Vertical stripes (white tape) Line width: 5 mm Spacing between lines: 10 cm	
21	14.8 %	**Dots, white film** Coverage: 6.3 % Circles (white stickers), Ø 18 mm in grid format Distance between circle centres: 8.2 cm	
22	15.1 %	**10v // 20 black-white Tesa** Coverage: 16.7 % Double vertical stripe, tape, 10 mm black, 10 mm white Spacing between lines: 10 cm	

Nr.	Approaches	Description	Illustration
23	15.9 %	**10v // 20 white barred lines** Single-sided Coverage: ca. 5.3 % Vertical discontinuous lines. Adhesive film glossy white (Orajet 3621) Line structure small horizontal bars, diameter 2.5 mm, bar spacing 5 mm Line width: 20 mm Spacing between lines: 10 cm	
24	18.3 %	**15v // 20 white Tesa** Coverage: 11.8 % Vertical stripes (white tape) Line width: 20 mm Spacing between lines: 15 cm	
25	21.5 %	**Stripes, fine, blue** Coverage: ca. 25 % Fine blue horizontal lines on plastic material between double glazing Line thickness 1–2 mm, spacing 2–3 mm	
26	22.1 %	**10h // 20 Tesa** Coverage: 16.7 % Horizontal stripes (white tape) Line width: 20 mm Spacing between lines: 10 cm	
27	24.1 %	**10v // 5 green Duplicolor** Coverage: 4.8 % Vertical stripes (enamel spray Duplicolor Platinum, green, three coats) Line width: 5 mm Spacing between lines: 10 cm	
28	25.0 %	**2.8v // 2 black printed Film on Plexiglas** Coverage: 6.7 % Vertical lines, black Line width 2 mm Spacing between lines: 2.8 cm Roller printing on laminate film. Plexiglas, strength 1.5 cm, printed surface of the film adheres to Plexiglas	
29	35.3 %	**Plexi smoke** Coverage: 0 % Unpatterned, tinted Plexiglas Soundstop® Smoky Brown, darkened, strength 15 mm	
30	37.2 %	**ORNILUX Mikado Neutralux 1.1** (EP2/Ornilux Mikado 4mm 16 EP3/VSG N33 8 mm, 0.76 mm) Double glazing with special coating in the middle, which according to the manufacturer absorbs and reflects UV radiation.	

The sky is the limit...

Let your imagination take flight! The following examples give an idea of how varied bird friendly measures can be. For architects there are few limits to creativity.

Company logo printed on an office building.

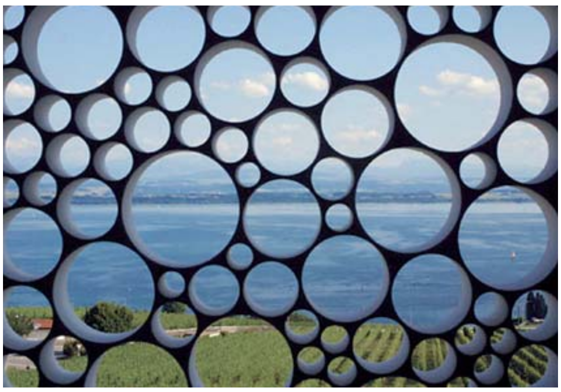
Privacy for guests - and advertising at the same time.

Unfortunately, the Palm Area Rule has not been observed on the unique design on this riding centre.

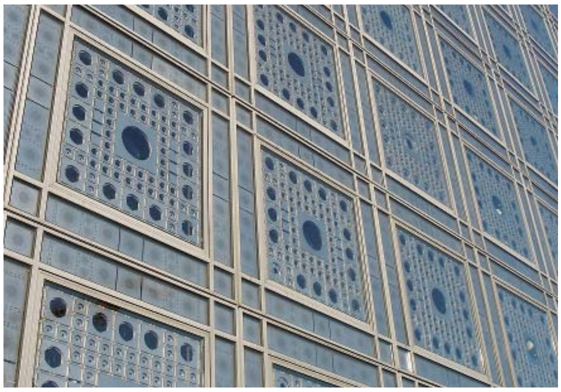
The decoration on the Rainforest House in the Schoenbrunn Zoo also protects the tropical birds inside from collisions.

The collision risk has been considerably reduced through the artistic design on this façade.

The black grid design on this corridor is an interpretation of the Mollier-Diagram.

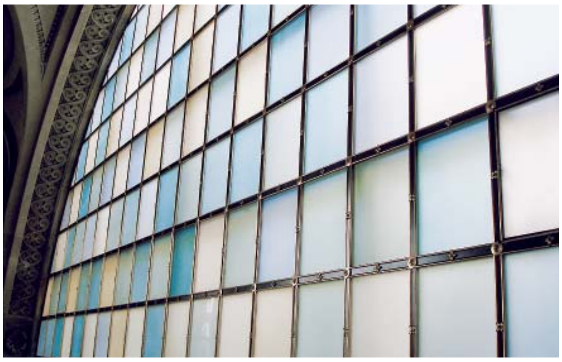


Playful staging of the view – and effective bird protection at the same time (erected in front of the glass).



This façade on the Institut du Monde Arabe brings an oriental touch to Paris.


Noise barriers: effective despite the botanical design.


Using art on a building opens unlimited possibilities.


Pedestrian viaduct with two different, but in both cases effective, solutions.


The screen printed pattern guarantees privacy for the terrace users and enhances the 3D structure of the building.


This printed pattern is placed between the panes of double glazing, which is why the reflections remain.


Highly visible leaf patterns on the panes of glass in this corridor between blocks of flats.


Historic motif, laminated into the noise barrier. Regrettably, the neighbouring barriers are transparent.


Highly effective, even when perhaps not in the spirit of the designers original vision.

Alternative Materials and Construction Methods

Semi-transparent Surface and Glass Bricks

Semi-transparent glass surfaces, semi-transparent walls and glass bricks are building components which do not pose any danger to birds. Depending on the material used, a good amount of light and an interesting light- and shadow-play can be created. Today, double glazing with capillary inlays is available, which directs light deep into the room, but still offers very good sun and glare protection.

Light dispersing double glazing in double shelled U-profile glass makes use of daylight and significantly reduces heat loss. It provides even lighting for the whole room.

Glass bricks are very bird friendly and, from a bird conservation point of view, can be used without reservation.

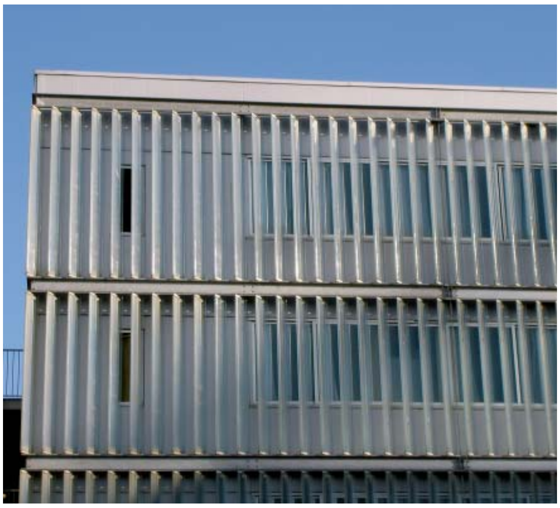
Cycle shelter with semi-transparent side walls. The curved transparent roof should not be a problem.

Semi-transparent balcony glazing, here made of moulded glass, is no danger for birds.

Semi-transparent balcony balustrades look fresh and create privacy.

Suspended and Embedded Screens, Louvres, Brise Soleil and Blinds

Adjustable or fixed sunshades on the outside of a building don´t just provide protection from overheating. Depending on the type and the installation, one side effect is protection from bird collisions. Double glazing with embedded vertical blinds lets diffuse light into the interior and is also bird friendly. Even horizontal blinds will make the glass hazard visible to birds. Effectiveness is still strongly dependent on surface reflectivity and the position of the blinds. Brises Soleil also reduce light emissions upwards at night.



Louvres and vertical or horizontal blinds shade and structure the façade. If they are installed as densely as in this example, the remaining danger is minimal.

Embedded blinds. When in use, even if set at an angle, they provide a degree of protection.

These horizontally movable blinds protect from overheating and avert bird collisions.

Double Glazing with embedded wooden blinds provides a lovely atmosphere.

The Torre Agbar in Barcelona, completely enclosed in Brises Soleil.

Track blinds can be fully adjusted to manage lighting requirements.

Coloured Glass

Coloured glass alone does not offer complete protection, though admittedly, there is insufficient data in this area. What is uncontested is that collisions occur even on highly coloured glass if the surface is strongly reflective. Low reflective surfaces in strong colours, as in our examples can, however, be extremely bird friendly.

This strongly coloured, low reflective glass and the opaque corners make this building bird friendly.

Because the glass panes used here are semi-transparent, of small surface area and low reflectivity: birds can see them clearly.

These new developments are quite distinctive!

Innovative Police Headquarters: poses virtually no problems for birds.

This footbridge in Coinbra, Portugal, brings colour into the landscape.

Angled Surfaces and Skylights

Steeply angled glazed surfaces or even whole roofs of glass are generally no problem from the point of view of bird protection. The roofed plaza in front of Berns' main train station (see picture below), which is very large, floats several metres above the ground, and was thought to be a risk for birds that take off vertically, so glass with a dot grid pattern was installed during construction.

Skylights are generally no problem for birds.

The triangular construction creates a lattice effect.

In general, such large glass ceilings are unproblematic. There is a slight risk posed by the edges, as they have a steeper gradient. Thanks to a point grid pattern over the whole surface, which also provides some glare protection, this danger has been removed.

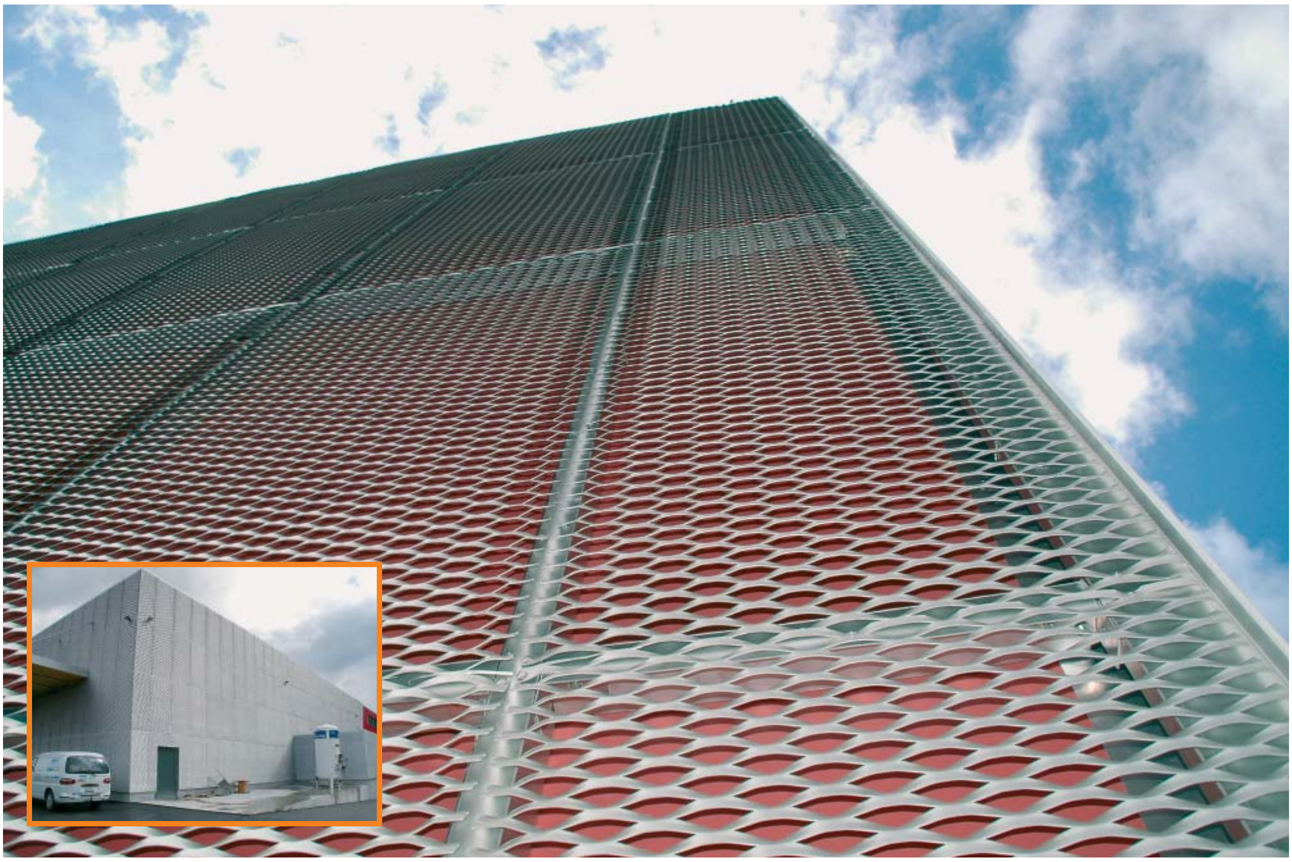
Façades and Buildings constructed from Metal

Building elements constructed of metal or wire mesh are recognised by birds as a barrier. Therefore, these façades are generally not a danger for them. Strongly reflective metal surfaces are, however, an exception. Tests show that these are just as dangerous as similar glass façades. If smaller birds, such as sparrows, should not be able to penetrate the surface, the mesh apertures should not exceed 2 cm. For pigeons, it should not exceed 6cm.

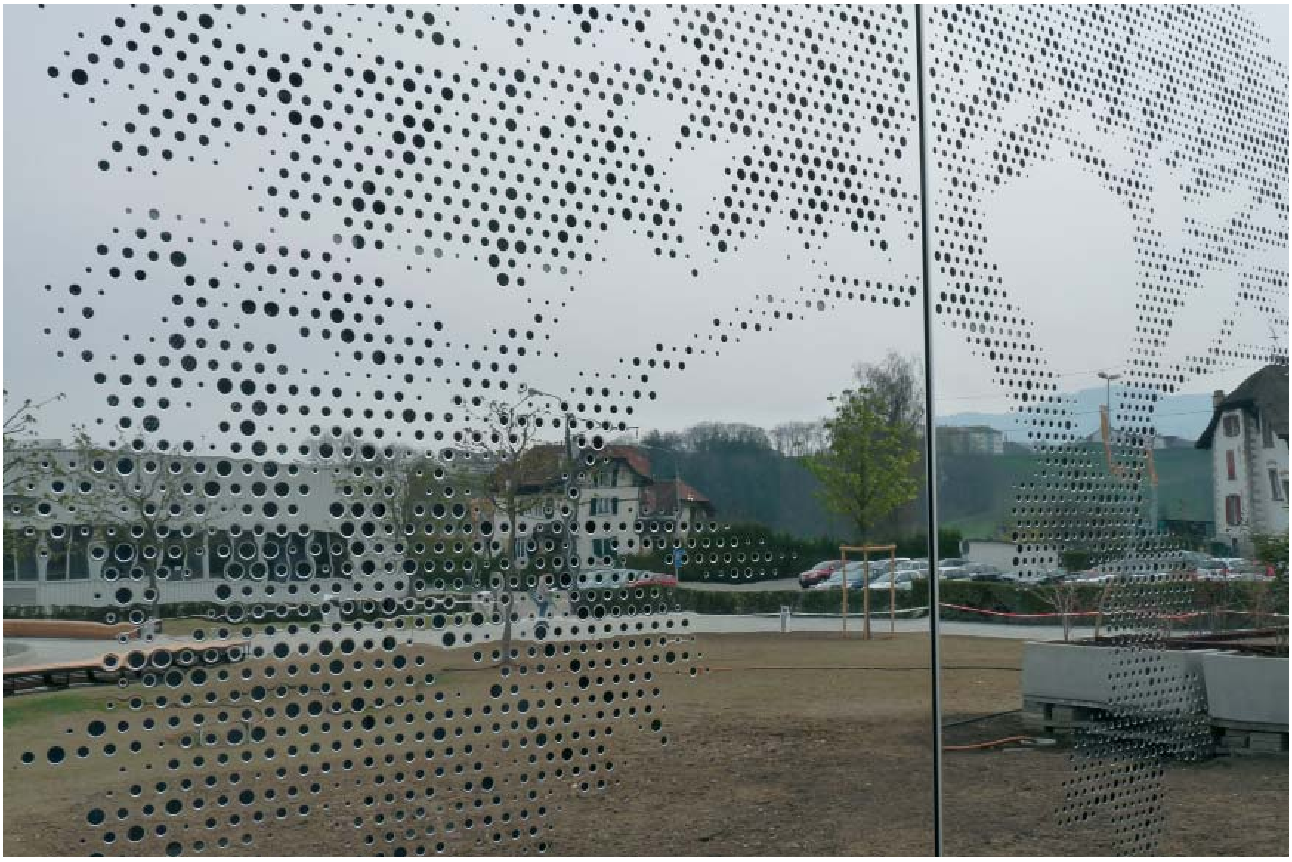
Metal façade erected in front of the building façade

Wire mesh: light-transmissive, economic, bird friendly

➤ **Maximum mesh aperture, so that small birds cannot penetrate the façade: 2 cm (6 cm for pigeons).**



Alternative exterior facing: this factory façade is largely covered in expanded metal and is harmless for birds. With a maximum aperture of 2 cm there is also no danger that birds will penetrate the façade.



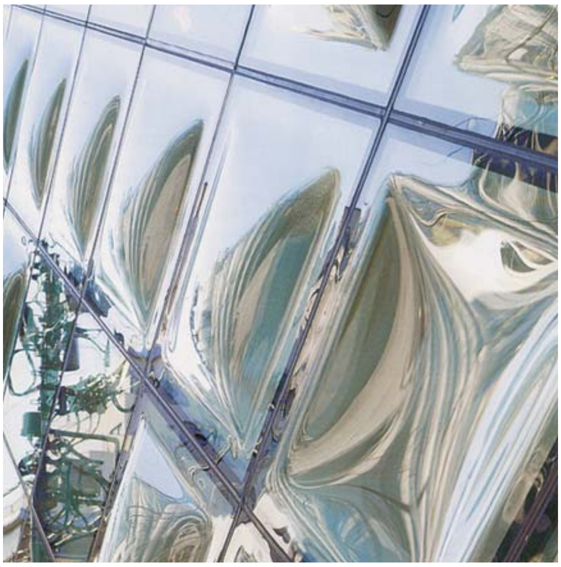
In principle, this façade of strongly reflective metal panels is dangerous for birds. The danger has been reduced through the ornamental holes. There are, however, large spaces of unperforated metal, which remain a collision hazard.

Although this warehouse is almost completely covered in reflective metal, the intense warping makes it harmless for birds.

Contoured surfaces

Strongly contoured or curved glass or metal surfaces should pose only a mild danger even when they are highly reflective, because the reflected image is distorted and often almost unrecognisable. But there is still too little research in this area to be certain.

The reflected Poplars are hardly recognisable on the cylindrical section of this building.



Such curved glass tiles are pretty reflective...

...but as the reflections are broken up the surroundings are hardly recognisable.

Solar Panels on Façades

Solar panels are fashionable right now and further developments, such as the installation of solar modules on balcony balustrades, are on the horizon. Already a wide range of products of varying quality are available. We have not yet observed any problems with birds. But here, too, if there is any doubt about bird-friendliness, we suggest avoiding highly reflective panels – this will also benefit residents and passers-by.

This idiosyncratic hall has a solar roof, which also forms part of the façade. The angled windows below reflect the ground, but whether this is bird friendly is not definitely clear.

Innovative architecture with solar panels mounted on the façade. The solar panels are reflective, but the embedded lines delineate the structure and therefore they are not a bird hazard.

Reducing Reflectivity

Reducing dangerous reflections is a particular challenge because variable light conditions affect reflectivity. Glass with a low coefficient of reflection is a step in the right direction.

To reduce the dangers of reflectivity we recommend only installing glass with an external coefficient of reflectivity of 15 % or less. Increasingly popular, triple glazing often exceeds this value, but triple glazing with a coefficient of reflectivity of 13 % is already available. Such glazing is not completely safe, but for particularly large surfaces, it is an economically attractive and acceptable solution which does not reduce visibility. Light and warmth can be adjusted through clever shade and air conditioning systems. Through night ventilation and heat recovery, etc, overheating in summer can efficiently and economically be reduced. If glare protection glass is unavoidable on a south facing façade, then the reflection can be minimised with a point grid pattern (see page 48).

When installing low reflectivity glass, it is necessary to check that the reduction of reflectivity does not create a new danger in the form of increased transparency. Therefore, glazed corners and other transparent constructions should be minimised through appropriate layout and interior design. The remaining potential flight corridors should be marked as described on page 15.

➤ **External coefficient of reflection: as low as possible, maximum 15 %**

Thanks to low reflection glass it is possible to see into this school building. Only exceptionally would a bird try to fly into this, for it unattractive, building. The saplings will barely be reflected when they are taller.

Integrated shading system in a glass façade. The reflectivity is not completely removed and is increased through the angle of view. Despite this, thanks to the light coloured materials used, the reflection levels are tolerable.

Mounting an external insect screen (window on the right) massively reduces the reflectivity.

Light coloured curtains mounted close to the window reduce reflectivity: the difference is striking.

Sun protection glass in a company reception building. The blinds in the upper storey markedly reduce the reflectivity of the panes.

A solution which has already been frequently commended is adhesive fabrics for windows. If required, they can be removed or re-placed without leaving marks.

These vertical blinds transmit soft light and provide privacy from passers-by. Thread, or fringe, curtains have a similar effect.

Fine textiles laminated into the glass reduces external reflectivity, functions internally as glare protection, but still permits the occupants a view outside (inner is black).

Retro-fitting Protective Measures

With experience, bird hazards can be recognised in the planning stages. If the opportunity to install protective measures during construction is missed, they often have to be added later – an expensive extra.

It is also true of bird safety on buildings that prevention is better than cure – preventative measures integrated up front are often more durable, cheaper and aesthetically more pleasing to than improvised corrections. Therefore we strongly recommend considering collision protection measures in the planning stages.
When retrofitting preventative measures, it is important that the hazard is assessed. Installing a blind won't reduce collisions on if the problem is high reflectivity, whereas with low reflective glass it will help a lot. In general, externally mounted solutions such as those described on page 17 can be retro-fitted using adhesive film. It is important to use high quality, long lasting products. Also advertising media, such as blow-ups and printed panels are effective.
Instant solutions include large or open weave nets, large cloths, thick nylon strings or plastic strips.

Transparent flat blinds are more effective than curtains, because they are always closed. However, they only work on glass with a low reflectivity index.

Printed sheets can be used to cover entire façades with effective advertising. Most are perforated with small holes and so permit an external view.

So called blow-ups are guaranteed attention catchers and are therefore also interesting for advertisers.

A good and cheap solution in this case: vertically tensioned nylon threads.

➤ **Patterns such as those described on page 17 can be retro-fitted (for example, on film).**

Operational Solutions

Operational solutions alone cannot eliminate bird collisions. But with well-chosen measures the dangers can, at least, be temporarily or selectively reduced, often without cost. In particular, in skyscrapers and commercial buildings it is important that the blinds are closed at night, or preferably at the end of the working day, and at the weekend. This is has the additional advantage of saving energy. For buildings with a high rate of bird collisions keeping the blinds closed during the day – preferably horizontal - is a good solution. An intelligent system can be installed to do this automatically. Large plants should be placed away from windows, as they can also lure birds to destruction. And one last, as yet unmentioned solution: the dirtier the windows are the easier they are for birds to see. So: clean your windows less – particularly in migration periods in spring and autumn.

Offices in use at night: where possible, close the blinds (bottom) or use lights which are focused on the workspace (middle). The illumination shown on the top floor should be avoided.

Pot plants do not belong directly behind transparent surfaces, but should be placed further back. Excessive greenery in conservatories and winter gardens is also a danger.

This is exemplary: the blinds are closed automatically at the weekend and at the end of the working day.

Environmental Design

The number and species of birds in the surroundings can be greatly influenced by the design of the environment. The type of trees and shrubs selected and where these are located are deciding factors. And as is often the case: less is more.

The landscape around a building is an important consideration. For us, there are two possibilities:
1. The building is erected in a natural environment (or one which is afterwards landscaped to look natural) and the building itself is as bird friendly as possible
2. The building is created from large expanses of glass, which – for whatever reasons – cannot be made bird friendly. In this case at the very least, it should be ensured that the surroundings are as unattractive for birds as possible. That is:

- As few trees as possible
- As few berry carrying bushes and shrubs as possible
- As few bird feeders as possible and no rubbish
- As few pools and small ponds as possible

Summary: No reflective glass cubes in green spaces and no transparent, unmarked noise barriers in green belts.
When it is really impossible to do without trees, they should be planted in front of non-reflective parts of the building. Also in the interests of bird safety small, unroofed, open courtyards should not have trees.

Extremely problematic: a very natural environment with hedges – and with it, as much transparent glass as possible.

This planting is poor: some trees stand directly in front of sections of the building with highly reflective glass. Hundreds of coal tits died in just one autumn. This obstacle in the landscape, which stands across a migration route, blocks onward flight. The trees´ reflections seem to show the only way through.

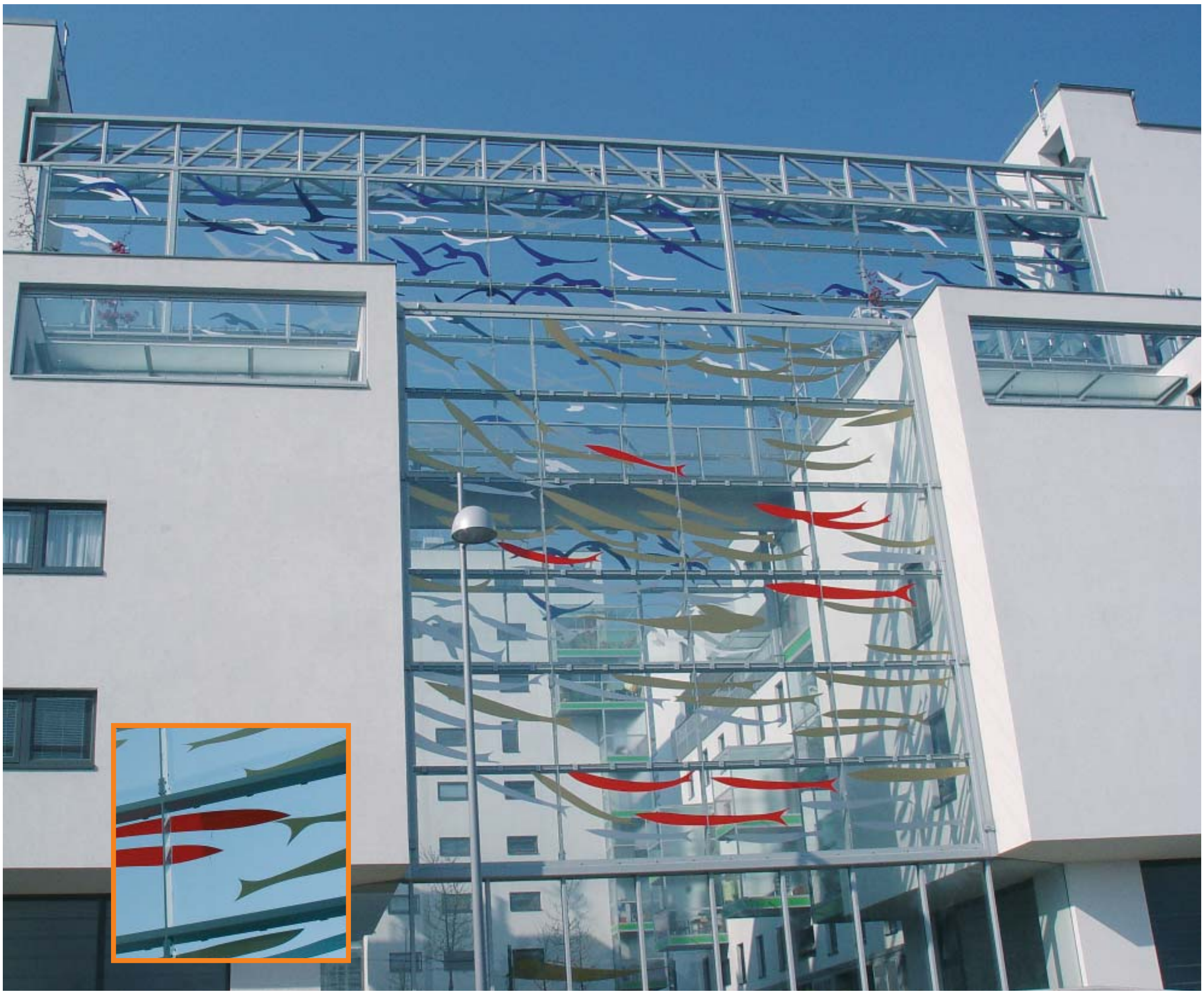
Case Studies

Contemporary Solutions

The following examples, from buildings constructed or renovated in recent years, should provide encouragement and motivation to find similar or, if possible better, solutions. Imitation and trend setting are desired.

Implementation

Innovative solutions can be found for both transparent and for reflective glass surfaces, which may improve the value of your property and make it stand out. After all, everyone can do transparent walls...
The solutions presented here use materials which are noteworthy because of their durability. Where possible the patterns are printed during production and are applied externally and/or on both sides.
The Viennese Environmental Department, the Swiss Ornithological Institute or the Nature Conservation Agency were consulted on the development of most of these examples in the planning phase, or at least, their recommendations or information leaflets were consulted. The above institutions are pleased to help on special projects (subject to capacity).

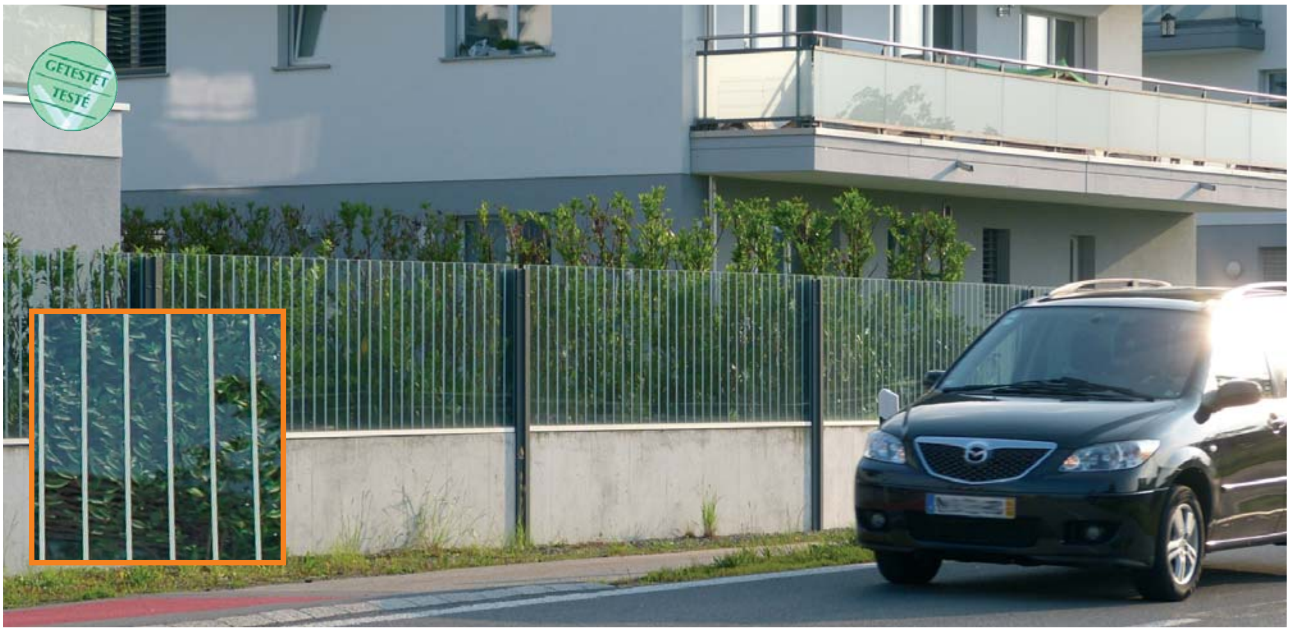


When a large glass surface can't be avoided: Why not include an interesting, or innovative, solution? This example isn't perfect, though, as large areas remain unmarked and thus the Palm Area Rule is not satisfied.

This noise barrier in Theodor-Koerner-Hof in Vienna was erected in 2007 to protect noise plagued residents and to increase their quality of life. It is a model example of bird protection, because the proposed structures were first tested in a flight tunnel, with very convincing results.

Details of the above wall. The pattern - columns of 2 cm wide stripes with 10 cm spacing between columns - is printed on both sides of the glass and in some places on the reverse is somewhat more liberally applied, which increases the 3-D effect on approach.

New housing developments can also incorporate noise barriers with discreet stripes.



In Switzerland, due to a new law on noise protection, countless kilometres of noise protection walls have been erected in recent years. On transparent sections such stripes are an established standard for bird protection.

Bus shelters, small noise protection barriers, wind barriers and balcony balustrades, etc. can also be easily retrofitted with vertical or horizontal stripes. This shelter in Munich was constructed with printed stripes.

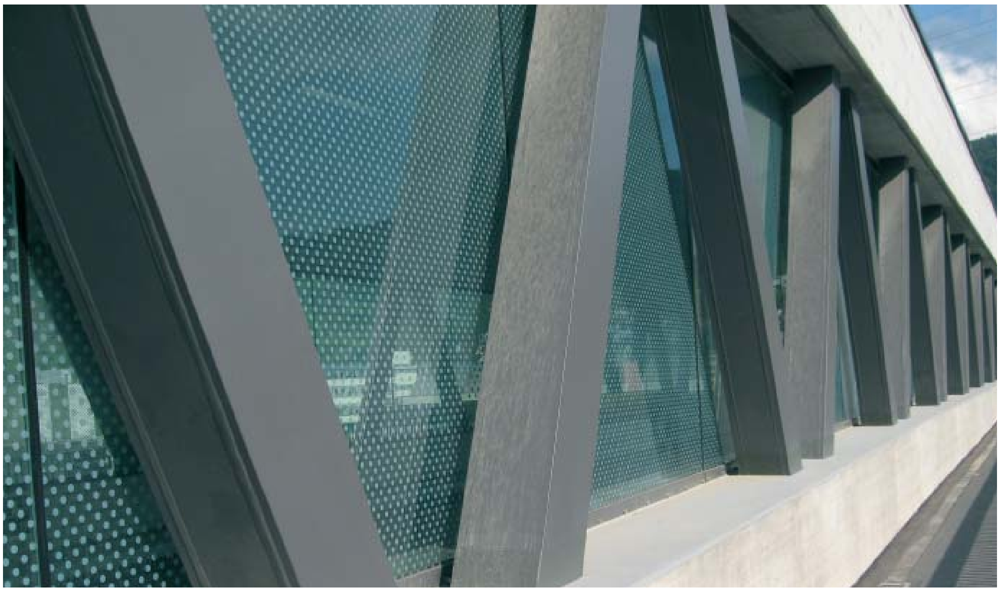
An adventurous solution from Basel. This shelter is covered with white lines of differing thickness.

On this bus stop in Zurich some of the glass panels are printed with the location name. Discreet, but effective, protection.

New standards for train station shelters in Switzerland. Ground level markings are omitted, as through visibility is obstructed by the seating.

This tram stop has been decorated with a black dot pattern. Visibility is not compromised; the pattern is unobtrusive.

On this type of bicycle shelter the vertical walls are particularly problematic. Here, they have been patterned with the company logo.



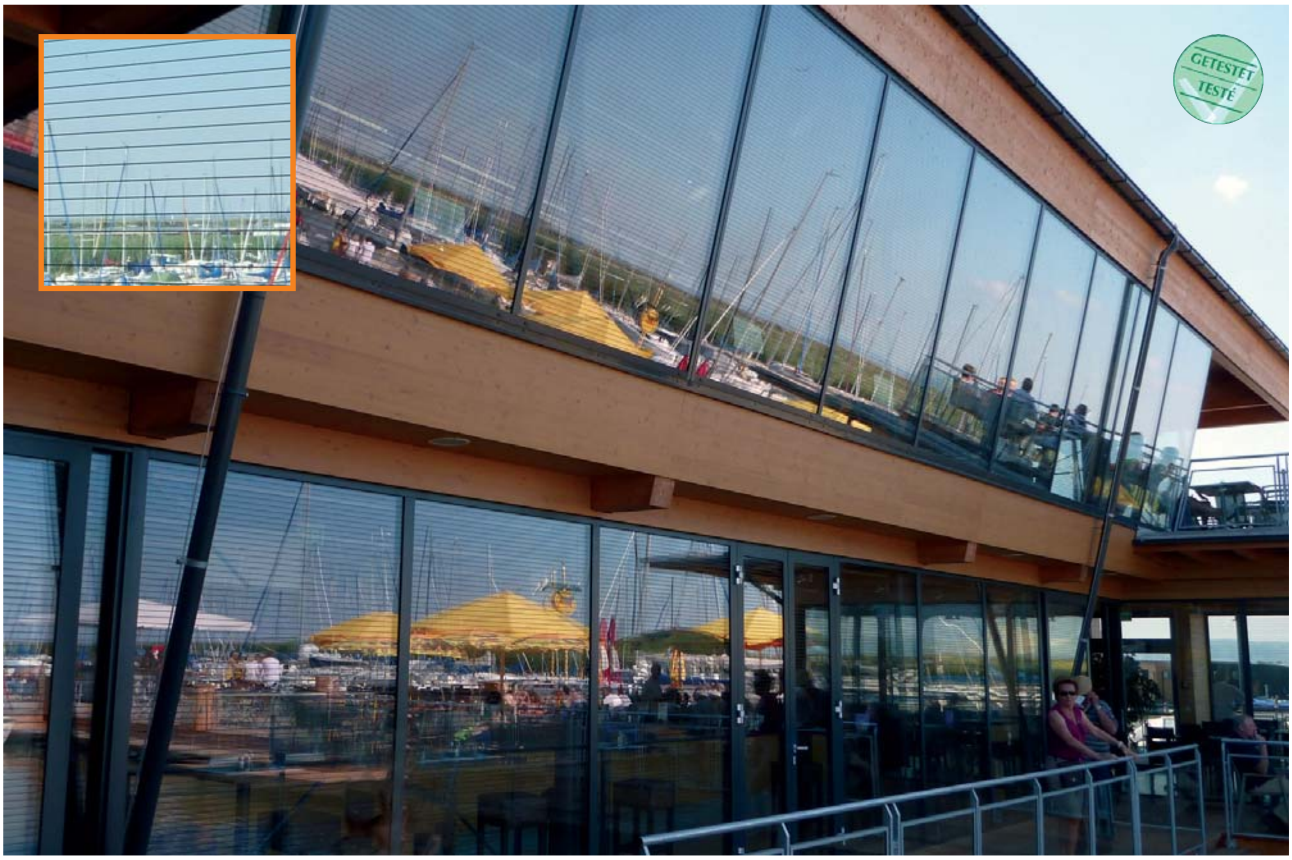
New bridge for a motorway access road: the panels have been decorated with a relatively large pattern of white dots.

Innovative design to make a highly reflective window visible on the Department for Foreign Affairs, Berlin-Tegel.

The printed design on this bicycle garage reduces bird collisions. Attaching it to the outside surface of the glass has broken up the reflectivity and its effectiveness.

Bridges stand across the flight paths of water birds. Semi-transparent arcs are etched into the balustrade. The decor is elegant and dynamic, and for bird in flight the design resembles chain mail, and therefore should be clearly visible.

This entrance hall at the Rietberg Museum in Zurich, named «Emerald», is located in the middle of a park. It has been created – not least for the protection of the birds – out of printed glass and coloured emerald green. A real jewel!



The window panes on this lakeside restaurant in the Nationalpark Neusiedler See have been printed with regular thin black lines (see page 17).

The view from the restaurant is not compromised by the fine lines of the bird safety glass. And the pattern ensures that guests are spared from seeing dead birds.

This housing development displays many elements which, from the viewpoint of bird conservation are to be welcomed. The only downside is the transparent panes of glass that some flat owners on the upper floors have installed for wind protection.

Current Research

Despite the size of the problem, until now there has been very little research on birds and glass. There has been little awareness and less money. In recent years, however, a lot of new findings have been made.

Research in America and Canada

It is mainly thanks to Daniel Klem, an American researcher, that the enormous size of the problem has been realised. In his study, begun at the end of the 1980s, he showed that per year and per building on average there are 1-10 collisions. Thus there are annually between 100 Million and 1 Billion victims in America alone. In further research he showed that many birds do not survive a collision, even if they are able to fly off afterwards; most die later from internal injuries. In addition, he made a series of studies of the efficacy of various prevention systems and discovered that surface coverage is important and that vertical markings are better than horizontal ones. Due to the mass collisions, which particularly affect the east coast cities every autumn, the phenomenon of nocturnal collisions with skyscrapers is relatively well studied. In recent years several cities have published guidelines for bird friendly building (see page 56).

Tests in Flight Tunnels

Field tests are very complex and time consuming, and it is difficult to know how many samples to make in order to have replicable results. The alternative is flight tunnel testing. Here, patterns can be tested under controlled circumstances paying attention to bird safety and with acceptable costs; filming allows for later analysis. Ideally, testing would be performed in a flight tunnel and in the field. As yet, the most comprehensive set of standardised tests made to compare various patterns were started in 2006 at the Biology Station in Hohenau-Ringelsdorf in Austria. At this collecting station there is, in summer and autumn, a wide range of wild birds available. The birds are released after one test flight. Martin Rössler and Wolfgang Laube have developed a revolvable tunnel, the panes of which provide symmetrical lighting. In 2011 the testing was broadened to include: 1) visibility without reflection (ONR-Test), 2) Introduction of reflections in front of natural, light backgrounds (comparison to free stan-

Flight tunnel at the Biological Station Hohenau-Ringelsdorf in Austria. The tunnel is mounted on a pivot, so that it can be oriented according to the position of the sun. At the end of the tunnel are two panels: one with markings and one without (see inset picture). A net prevents the bird colliding with the panes of glass.

A series of patterned panels tested in the Hohenau-Ringelsdorf flight tunnel.

ding panels) and 3) in front of dark backgrounds (comparison with windows into interior rooms).

ONR-Testing method

The method of testing used in the flight tunnel is named after the technical regulation ONR 191040, which regulates the testing of marked panels in Austria. It defines when free standing glazing and transparent glass constructions can be called <Bird Safety Glass>. Reflectivity is not covered in this regulation.

Testing Principles:

1) Birds fly from darkness to light towards two parallel panes
2) Selection test: birds decide between flying towards the panes marked with the pattern to be tested and an unmarked control pane. Ineffective patterns: random approach - 50 % fly to marked and 50% to unmarked panes. Increasing effectiveness is marked by decreasing flight approaches to the marked pane.
3) Lighting on the panes; natural sunlight directed through mirrors to the front side of the pane, symmetrical lighting in the tunnel
4) Constant angle to the sun: adjustment of entire apparatus through a pivot or bogey.
5) Natural background: homogenous vegetation, sky, dark tunnel limits visibility to the test panes
6) Control pane: float glass 4 mm
7) Constant flight approach angle of 90°, no reflection on the panes
8) Bird safety: net, 40 cm before the panes (0.1 seconds before collision)
9) Birds' adaption to light levels: natural light (daylight)
10) Documentation: video recording

Interpretation of the Results

The results of the experiments in the flight tunnels need to be carefully interpreted. Flight approaches of 50 : 50 cannot be interpreted simply as 50 % <effective>. In fact, it means the opposite. The patterned panel is ineffective because the birds do not differentiate between it and the control panel, approaching both panels equally frequently. Quantified declarations on a product that it prevents 50 %, 70 %, or more, collisions are misleading: comparable to the suggestion that a particular brand of suntan lotion can reduce the amount of skin cancer developed by a specific percent. Responsible information on sun protection cream, for example, states when correctly applied what percentage of UV rays still penetrate the skin, how much can be prevented, which products provide high protection and which low protection. Likewise, it is only possible to create categories of a range of effectiveness for glass. From this system, only glass which has 10 % or fewer approaches during testing can be categorised as <highly effective> or <Bird Safety Glass> under the ONR-191040 regulations.

Tests with Reflectivity

Prints and patterns placed on the inner side of the pane, so on the non-bird facing side, can be obscured by reflections. To test whether this effect can be so strong that the marking is rendered ineffective the flight tunnel was modified. In these tests, light fell directly on the panes and by varying the darkness of the background differing levels of reflectivity could be created. The first results show:

- Reflectivity in general reduces the effectiveness of markings, independent of whether these are mounted on the front or the back of the panes.
- Light backgrounds reduce the effects of reflectivi ty.
- Darker backgrounds (e.g. façades) show clear differences. That is, markings "behind" the glass are much less effective.

The Spiderweb Effect – a false lead?

Hopes were raised around the Millennium, when a publication recommended using UV-absorbers to mark glazed panels. It is known that birds avoid spiders' webs, which are thought to contain UV absorbing substances. These are visible for birds but not for humans. That many bird species can see in the UVA range is also uncontested, however it is unclear whether, in collision situations, this UVA information is passed to the brain areas which are used for making flight manoeuvres.
Since then disappointment has set in. Yes, there are various products on the market, but the manufacturers have failed to provide any evidence for their effectiveness. Therefore, based on current knowledge, we advise in general against installing these products.

Alternative Approaches using Sun Protection Glass

More successful is a special technique, whereby sun protection glass is marked on the outside of the exterior face with (when viewed from the outside) faint stripes. The arrangement of matt and highly reflective stripes gives additional contrast; from the inside the view is only marginally affected. These panels have been tested by the Swiss Ornithological Institute over a period of 1½ years on a sports hall. Panels of glass with and without the matt stripes were installed alternately on one side of the building. During this time at least 34 birds flew towards the unmarked panels, whereas only 4 approached the marked panels. Because it has not been possible to test this pattern in the flight tunnel, it is not yet possible to give a final recommendation.

The Swiss Ornithological Institute tested the matt striped panels on this sports hall, described on the previous page. Marked and unmarked panels were installed alternately on the wall facing the forest edge. From the outside the specially marked stripes have a blurring effect and together with the unmarked areas demonstrate high contrast. From the inside the stripes are much less distracting. This product could be used when highly reflective sun protection glass is absolutely essential.

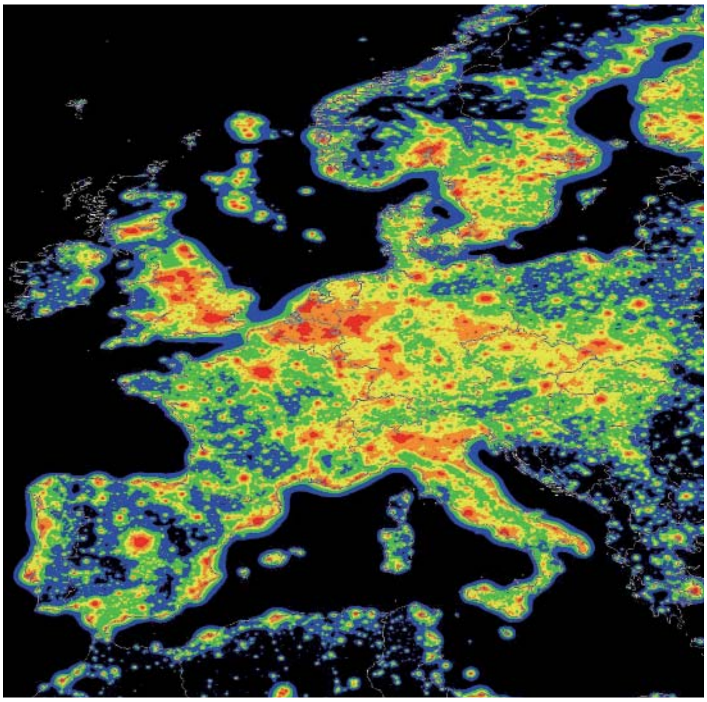
One of the patterns found in the flight tunnel testing to be highly effective is already on offer «off the shelf»; so the printed pattern does not need to be applied to the glass afterwards.

Light as Hazard for Birds and Insects

Like Moths to a Flame...

Birds are attracted to light when flying at low altitudes at night. Many migratory birds lose their orientation when flying in fog and are drawn to urban light islands. Some birds die of stress, many collide with lighted buildings or other obstructions.

Those who fly at night over Europe can see a sea of light below. As long as the night is clear, most migratory birds are not disturbed by it, they can orient themselves using the stars and geographical guidelines. Their difficulties begin when they fly into areas of thick fog or cloud. If, at the same time, they see lights shining up into the sky, their orientation can be affected. They can, for example, be drawn to the city as if bewitched and fly around directionless, often for hours. Some, as a result of stress and exhaustion, fall dead from the sky, others are attracted more and more strongly to lighted buildings, floodlights, or navigation lights, lose all orientation or collide with such structures. This phenomenon is particularly familiar on skyscrapers and TV Towers in North America, on lighthouses and on oil platforms where gas is flared off. The worldwide boom in skyscraper construction and the increasingly extravagant use of light makes it certain that such situations will increasingly be seen elsewhere. There are already similar cases in Europe from nocturnally lit buildings and cliff faces on mountain passes or on the northern edges of the Alps when thick fog prevents the birds from flying on.
The main problem with light smog is not in fact the light source, but strong upward emissions. A lot of energy is squandered and the desired effect is not achie-



The nocturnal picture from space shows how highly illuminated our continent is, in particular, in densely populated central Europe.

As pretty as it looks: nocturnal light emissions, as shown here in foggy conditions along the Savoy Alps, can be disastrous for migrating birds. In addition, along the edge of the Alps the topography forces the birds to converge into flocks, similar to the situation at the coast.

ved because the light is not focused, or not focused enough, on the area where it is required. In addition to the usual light sources, in recent years lasers and searchlights have become fashionable. These are mainly used for advertising and art installations. Show and projection laser light installations, which consist of closely packed class 3 and 4 lasers shining into the open sky, can cause burns on eyes and skin if they are intercepted by an organism. Some cities and towns therefore, have started to ban such searchlight and laser installations.

The Effect on Birds

There are individual well documented examples to demonstrate that searchlights have confused birds. In Germany it is known that 2000 cranes made an emergency landing on a castle ruin, drawn there by the floodlights. Many birds flew into the walls and died. The Swiss Ornithological Institute has been able to demonstrate through experiment that searchlights cause strong fear responses, clear, long lasting changes of flight direction and reduction in flight speed in night flying birds. Sleep and resting behaviour disturbance is also recorded for cranes and geese.

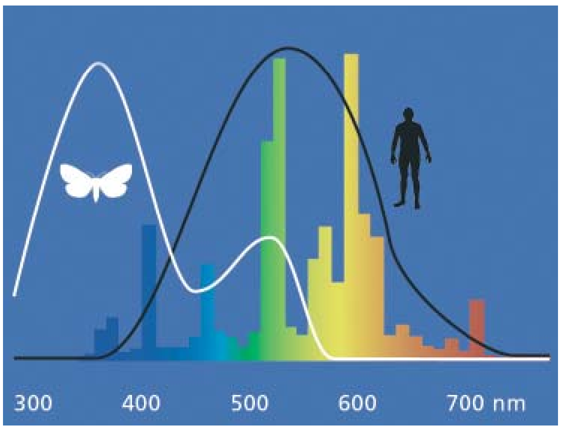
Skybeamer: a concentrated beam of light, hundreds of metres high.

Mass fatalities in Insects

Our external lighting is also a huge problem for insects. From the more than 4000 butterfly species in Europe, not less than 85 % are nocturnal. Light hazards, habitat changes and the effects of pesticides have brought not only many moth species but also other insect species to the edge of extinction. But insects have an important role to play, for example, as pollinators and as a link in the food chain. Annual insect deaths due to street lighting are estimated at 150 billion (150 000 000 000 000) insects in Germany alone.

Together with scent, the light of the moon and stars plays an extremely important role in navigation for nocturnal insects and often determines important phases of their development. The most important wavelengths are those in the UV and shortwave regions (violet, blue, green). Insects which navigate by light are known to be drawn to lamps and fly dizzyingly round the source. If the insect does not die from flying into the light, but settles on a lit surface they are often killed by predators, stepped on or driven over. If the lamp cover is open they burn to death on the hot light.

Moths, like this small elephant hawk-moth, suffer enormous losses.

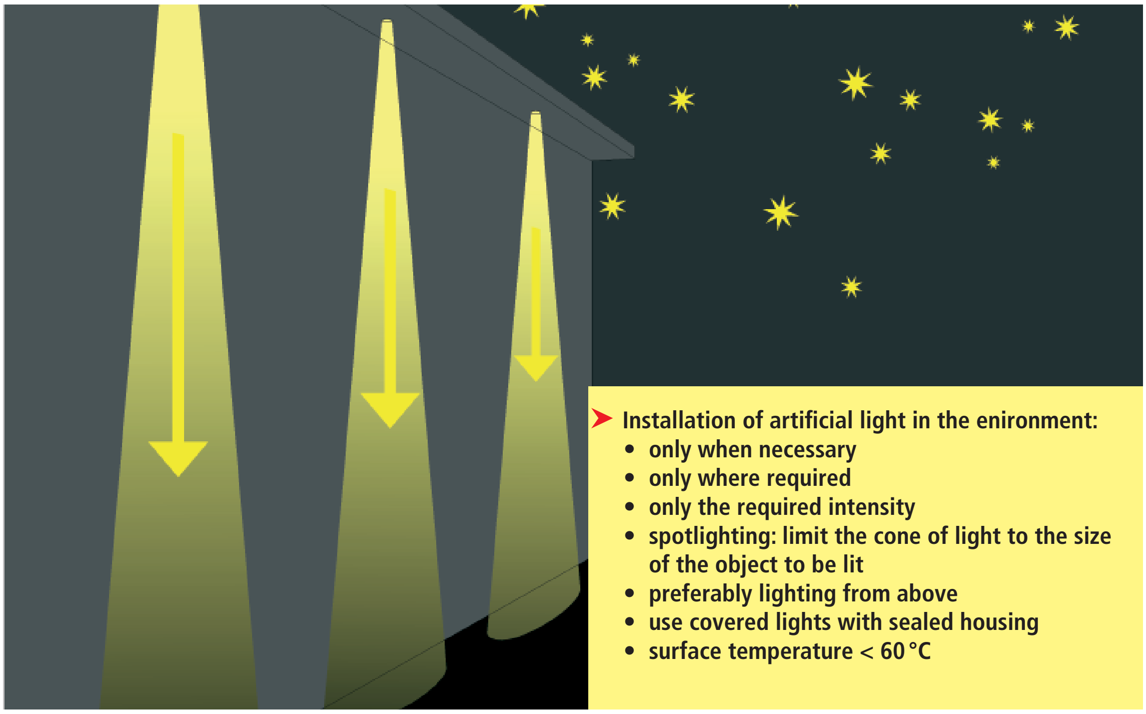


The spectrum of a fluorescent lamp (coloured columns) lies mainly in the visible range for humans (black line). The spectral sensitivity of nocturnal moths is concentrated more to the left (white line), in the UV range.

Animal Friendly Solutions

Technical Solutions

The main problem with light smog is the horizontal emission of light. From the economic standpoint, too, horizontal and upward lighting should be minimised. The goal must be to concentrate the light onto the objects and areas where it is required.

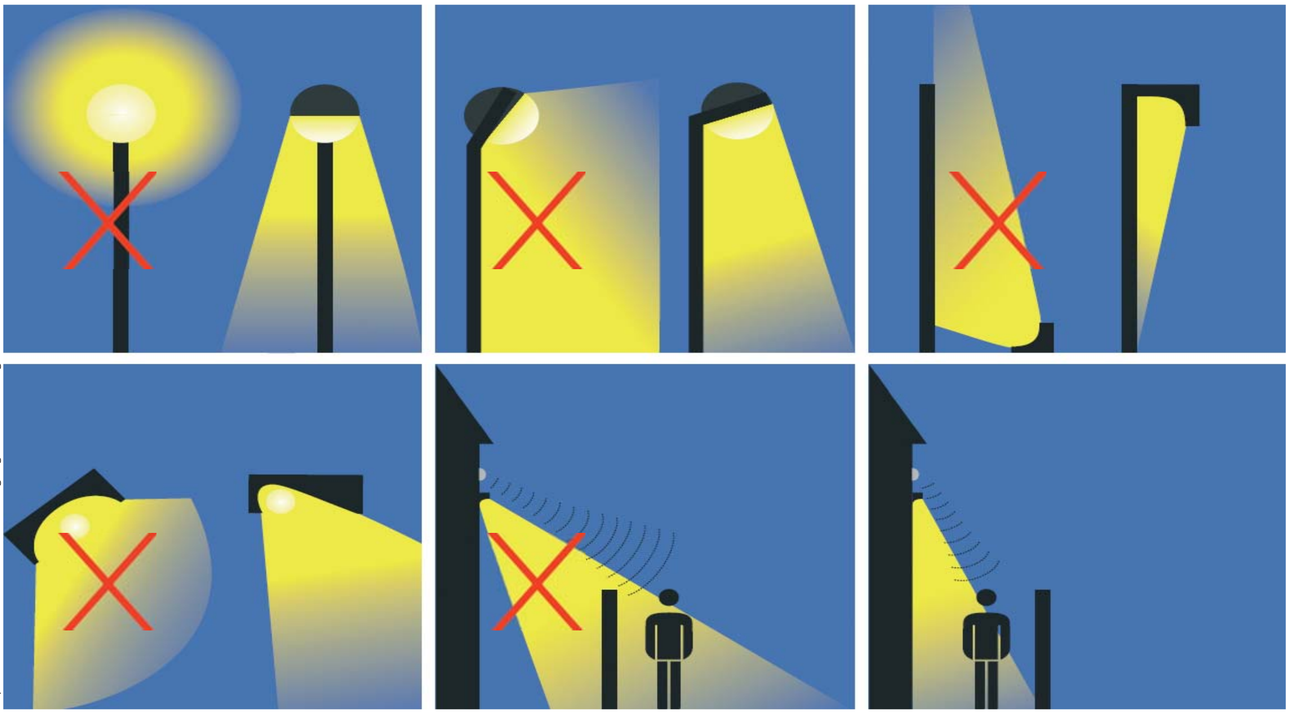


Desirable: directional lighting from above onto the surface to be lit.

Lighting

Horizontal light rays have the greatest effect over distance and thus the largest effect on insects and birds. It takes the longest route through the atmosphere and is thus the most scattered, resulting in additional serious encroachment on nocturnal skywatching. "Full Cut-Off Lights", which are proven not to emit any horizontal light, are recommended on environmental grounds. Because the height of the light masts are reduced extra lights are required to cover the same area, but glare and diffused light are further reduced. Correct installation is essential to ensure that the reflectors are set optimally and that the lights covers are planar to prevent horizontal light emission.
Certificates for environmentally friendly lighting are awarded by the International Dark Sky Association (IDA). The light colour is mainly determined by the bulbs used. High pressure mercury vapour lamps are particularly attractive to insects because the light contains a high percentage of UV rays. From 2015 they will no longer be for sale due to an European Union Regulation. Already they are often replaced by insect-friendlier yellow high pressure sodium vapour lamps, which are also more energy efficient. Metal halide lamps are often used when white light is required for aesthetic reasons; their attractiveness to insects is dependent on the UV spectrum of the light.
Because they are energy efficient and unattractive for insects, low pressure mercury vapour lamps are particularly recommended. However, the monotone yellow light and poor colour representation restrict their use.
Recently light emitting diodes (LED) lights have been offered for external lighting. LED lights with in warmer shades of white light (2700-3000 Kelvin) seem to be

Modern LED spotlights focus light on the required area, for example, a pedestrian crossing.



The examples on the right are always the preferred option: downward facing lights, focused where the light is effective and required. Integrating illumination with a motion detector is also sensible.

particularly unattractive to insects. LED technology is developing very quickly; at present expectations are high for these energy efficient lights, but first we need more experience.

Because LEDs have multiple, dot-like light sources, it is particularly important to minimise glare. High quality, well covered lights are especially important when installing LED lighting. LEDs are easily controllable: using dimming and motion sensors it is possible to save energy and at the same time, reduce light pollution. However, it is important that the energy savings are not lost through the installation of more lights.

Finally it is important to note that blue shaded lighting in residential areas can also be problematic for humans. They set our bodies to <wake mode> and can lead to sleep disorders.

A pedestrian and cycle path, furnished with the newest lighting solutions and fitted with motion sensors. Only when a cyclist goes by is the low level lighting activated.

Operational Solutions

Operational solutions are even more important for light than for glass. A well thought out concept can do a lot for nature.

Lights off! or Darkness in Critical Situations

Operational solutions alone cannot eliminate bird collisions due to light smog. But with well chosen measures the dangers can be minimised or at least temporarily eliminated. An extreme example is the Jungfraujoch, an Alpine pass at 3,471 metres above sea level in Switzerland. There, switching off the searchlight which illuminated the Sphinx Observatory on foggy nights has proven itself. Since this simple measure was introduced uncountable birds have been saved from death.

In central Europe the main migrations take place from the middle of February to the middle of May and from August until the middle of November. For these periods we recommend precautionary measures, particularly for topographically exposed buildings, for example, along the coast or on mountain passes, or for areas where it is already known that there are frequent nocturnal collisions. In particular, lights should be turned off between ten o'clock in the evening and sunrise. Where this is not possible, only well focussed light sources should be used, blinds should be closed or other measures to minimise light pollution should be put in place. Extensively lit interior spaces should be avoided.

Less exposed buildings should install motion detectors in reception areas and corridors and dimmers, or systems to automatically turn off lights, after working hours finish. The effectiveness of the installation, lighting and reflectivity should be checked regularly. Air safety lights on tall buildings should be fitted with flashing lights (minimum interval 3 seconds), instead of blinking or rotating lights and in particular instead of fixed floodlights or red lights.

The Swiss Ornithological Institute is currently working on an early warning system. This system should primarily assist in timely shutting down wind turbines on sensitive migration nights. A similar system is conceivable in the mid-term for exposed buildings.

Illuminated advertising should also be environmentally friendly or turned off during critical times. On the Post-Tower in Bonn, Germany, many of the lights are either turned off or screened during the main migratory period (right). The effect is that each year several hundred fewer birds become stranded on this building.

Key Points

➤ Bird collisions on glass surfaces occur due to transparency, reflectivity or nocturnal lighting.

➤ Collisions happen almost everywhere and on every type of building, but they can largely be prevented. Our recommendations are also appropriate for other transparent or highly reflective materials.

➤ It is strongly recommended that the problem is considered in the planning stages and that specialists are consulted on complex projects.

➤ Where retrofitting is required:
- first, analyse the problem
- look for suitable, long-term solutions
- raptor silhouettes are passé

➤ Reduce transparency through:
- appropriate construction
- selecting semi-transparent materials
- using interior desingn elements

➤ Reduce reflectivity through:
- selecting glass with a reflectivity of less than 15 %
- installing insect screens
- dispensing with mirrors in the outdoors

➤ Patterns to reduce transparency and reflectivity should:
- cover the entire surface (remember the Palm Area Rule)
- be attached to the external face of the glass
- preferably be a tested pattern
- provide a good contrast to the background
- have the following dimensions:
  - Vertical lines: minimum 5 mm wide with a maximum interval of 10 cm
  - Horizontal lines: minimum 3mm wide with a maximum interval of 3 cm or minimum 5mm wide with a maximum interval of 5 cm
  - Spot patterns: minimum coverage of 25 % for spots with minimum 5 mm Ø or 15 % coverage for spots < 30 mm Ø.

➤ Reduce the attractiveness through:
- placing plants away from glazed areas
- appropriate, un-wooded environment, particularly where strongly reflective glass is used

➤ Reduce light smog through
- only installing artificial light where it is necessary
- minimising the intensity and duration of illumination
- using shielded lights and closed light housings
- preventing horizontal light emissions
- ensuring the surface temperature does not exceed 60°C
- limiting lighting to the surface area of the object to be illuminating, preferably illuminate from above
- automated system control in buildings
- installing motion sensors
- banning lasers and advertising searchlights
- using insect-friendly lighting, with minimal short wave and UV light emissions
- installing low pressure sodium lighting in sensitive environments, otherwise high pressure sodium lamps or warm white LED lights

Bibliography

Glass

The most recent publications on the subject of bird safety and glass can be found on www.vogelglas.info under "Bibliography". The following is a selection of the most important publications:

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Buer, F. & M. Regner (2002): Mit «Spinnennetz-Effekt» und UV-Absorbern gegen den Vogeltod an transparenten und spiegelnden Scheiben. Vogel und Umwelt 13: 31–41.

City of Toronto Green Development Standard (2007): Bird-friendly development guidelines. 42 S.

Haupt, H. (2011): Auf dem Weg zu einem neuen Mythos? Warum UV-Glas zur Vermeidung von Vogelschlag noch nicht empfohlen werden kann. Ber. Vogelschutz 47/48: 143–160.

Klem, D. (1989): Bird-Window Collisions. Wilson Bull. 101: 606–620.

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Klem, D. (1990b): Collisions between birds and windows: Mortality and prevention. J. Field Ornithol. 61: 120–128.

Rössler, M. (2005): Vermeidung von Vogelanprall an Glasflächen. Weitere Experimente mit 9 Markierungstypen im unbeleuchteten Versuchstunnel. Wiener Umweltanwaltschaft. 26 S.

Rössler, M., W. Laube & P. Weihs (2007): Vermeidung von Vogelanprall an Glasflächen. Experimentelle Untersuchungen zur Wirksamkeit von Glas-Markierungen unter natürlichen Lichtbedingungen im Flugtunnel II. Wiener Umweltanwaltschaft, Wien. 56 S.

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Rössler, M. (2011): Vogelanprall an Glasflächen - Ornilux Mikado. Prüfung im Flugtunnel II der Biologischen Station Hohenau - Ringelsdorf. Wiener Umweltanwaltschaft, Wien. 28 S.

Schmid, H. & A. Sierro (2000): Untersuchungen zur Verhütung von Vogelkollisionen an transparenten Lärmschutzwänden. Natur und Landschaft 75: 426–430.

Sheppard, C. (2011): Bird-Friendly Building Design. American Bird Conservancy. The Plains, VA. 60 S.

Veltri, C. J. & D. Jr. Klem (2005): Comparison of fatal bird injuries from collisions with towers and windows. J. Field Ornithol. 76: 127–133.

Light

Ballasus, H., K. Hill & O. Hüppop (2009): Gefahren künstlicher Beleuchtung für ziehende Vögel und Fledermäuse. Ber. Vogelschutz 46: 127–157.

Eisenbeis, G. & K. Eick (2011): Studie zur Anziehung nachtaktiver Insekten an die Strassenbeleuchtung unter Einbeziehung von LEDs. Natur und Landschaft 86: 298–306.

Forschungsgesellschaft Landschaftsentwicklung Landbau e.V. (2007): Licht im Freiraum. Bonn. 100 S.

Herrmann, C., H. Baier & T. Bosecke (2006): Flackernde Lichtspiele am nächtlichen Himmel. Auswirkungen von Himmelsstrahlern (Skybeamer) auf Natur und Landschaft und Hinweise auf die Rechtslage. Naturschutz und Landschaftsplanung 38: 115–119.

Hotz, T. & F. Bontadina (2007): Allgemeine ökologische Auswirkungen künstlicher Beleuchtung. Unpublizierter Bericht von SWILD als Grundlage für Grün Stadt Zürich und Amt für Städtebau Zürich. 78 S.

Huemer, P., H. Kühtreiber & G. Tarmann (2010): Anlockwirkung moderner Leuchtmittel auf nachtaktive Insekten. Ergebnisse einer Feldstudie in Tirol. Tiroler Landesumweltanwaltschaft & Tiroler Landesmuseen Betriebsgesellschaft, Innsbruck. 33 S.

Klaus, G., B. Kägi, R.L. Kobler, K. Maus & A. Righetti (2005): Empfehlungen zur Vermeidung von Lichtemissionen. Vollzug Umwelt. Bundesamt für Umwelt, Wald und Landschaft. Bern. 37 S.

Products

New products are always being developed. We try to keep a current list on www.vogelglas.info. The following is a small list of well known manufacturers, whose products appear in this brochure:

Self Adhesive Textiles:
www.creationbaumann.com

Silverstar BirdProtect - glass products:
www.glastroesch.ch; www.glastroesch.de

4Bird printed glass:
www.eckelt.at/de/produkte/sicherheit/4bird/index.aspx

All forms of special glass and glazing:
www.okalux.de

SEFAR Architectural solutions (glass with textiles):
www.sefar.com

Ornilux-Special glass:
www.ornilux.de

Scotchcal films for external use:
www.solutions.3mschweiz.ch; www.solutions.3mdeutschland.de

Information about Bird Collisions and Light Smog

Glass

www.abcbirds.org
www.birdsandbuildings.org/info.html (dort gute Übersicht über amerikanische und kanadische «Guidelines»)
www.flap.org
www.sfplanning.org
www.vogelglas.info
www.wua-wien.at

Light

www.bafu.admin.ch/publikationen
www.darksky.org
www.helldunkel.ch
www.hellenot.org
www.lichtverschmutzung.de
www.nycaudubon.org

Contact Addresses for Specialist Advice

The following organisations offer specialist advice, according to the availability of resources. You will need to provide building plans, visualisations and/or pictures of existing buildings (including the surroundings). Glazing should be clearly marked on all plans.

United Kingdom

xxxxxxx

Tel.: 069 / 4201050, E-Mail: .uk

Deutschland

Hessen:
Staatliche Vogelschutzwarte für Hessen, Rheinland-Pfalz und Saarland, Steinauer Strasse 44, 60386 Frankfurt am Main
Tel.: 069 / 4201050, E-Mail: info@vswffm.de

Österreich

Wiener Umweltanwaltschaft, Muthgasse 62, 1190 Wien, Tel. (+43 1) 379 79, post@wua.wien.gv.at

Schweiz

Schweizerische Vogelwarte, Seerose 1, 6204 Sempach, Tel. 041 462 97 00, E-Mail: glas@vogelwarte.ch

Schweizer Vogelschutz SVS/BirdLife Schweiz, Postfach, Wiedingstr. 78, 8036 Zürich, Tel. 044 457 70 20, E-Mail: glas@birdlife.ch

Luxemburg

natur&ëmwelt/ Lëtzebuerger /Natur-a Vulleschutzliga a.s.b.I., 5, route de Luxembourg, L-1899 Kockelscheuer, tél. (+352) 29 04 04 - 1, fax: (+352) 29 05 04, secretariat.commun@luxnatur.lu

Websites of Related Organisations

www.aspas-nature.org
www.bfn.de
www.birdlife.ch
www.darksky.ch
www.lipu.it
www.naturemwelt.lu
www.ornitologia.org
www.seo.org
www.tbb.ch
www.vogelschutzwarten.de
www.vogelwarte.ch
www.wua-wien.at

vogelwarte.ch