Bird-friendly Design and Bird-friendly Glass

It is possible, has always been possible, to design functional, sustainable and attractive buildings that can reasonably be expected to kill few or no birds. Numerous examples already exist, not necessarily designed with birds in mind. These buildings may have many windows, but their screens, latticework, louvers, and other devices outside, or patterns integrated into the glass, warn birds before they collide. Finding glass treatments that can eliminate or greatly reduce bird mortality, while minimally obscuring the glass itself, has been the goal of several researchers, including Martin Rössler, Daniel Klem, and Christine Sheppard. Their work, has focused primarily on the spacing, length, width, opacity, color, and orientation of elements marked on glass, and has shown that patterns covering as little as 7% of the total glass surface can deter most strikes under experimental conditions.

Designing a new structure to be bird-friendly does not require restricting the imagination or adding to the cost of construction. Architects around the globe have created fascinating and important structures that incorporate little or no dangerous glass. In some cases, inspiration has been borne out of functional needs, such as shading in hot climates; in others, from aesthetics. Being bird-friendly usually has been incidental. Now, however, buildings are being designed with birds in mind, and materials designed for this purpose are multiplying.

Bird-friendly design means designing structures and landscapes to minimize features that cause bird mortality and incorporating materials that actively deter collisions with glass. Because we want landscape and habitats that are good for birds and people, making structures with bird-friendly materials provides the ideal outcome.

Bird-friendly materials and design features often overlap in function with materials to control heat and light, security measures, and decorative design details. Bird-friendly building-design strategies also fall into three general categories, although all three could be combined in a single structure. These are:

1. Using minimal glass (Bronx Call Center
   U.S. Mission to the United Nations)
2. Placing glass behind screening, louvers, second skins (de Young Museum, Cooper Union)

3.Using glass with frit, UV and other patterns designed to reduce collisions (Brooklyn Botanic Garden Visitors Center; Student Center at Ryerson University, Toronto; and Cathedral of Christ the Light

What is 'bird-friendly glass'? We often talk about bird-friendly glass when we mean bird-friendly design strategies, or bird-friendly materials. Bird-friendly glass is a subset of bird-friendly materials, and can be used in bird-friendly design, which also includes using features like external screens, louvers and sunshades.

Patterned Glass

Most bird-friendly glass incorporates a visible pattern – integral to the glass or applied later. This can be frit, etch, enamel or other material. The pattern is what *we* notice, but it is the empty spaces in the pattern that is meaningful to the birds. Putting a decal or a sign on glass warns *people* of an invisible barrier, but birds don't understand the concept of glass as either an invisible barrier, or a reflection that appears to be part of the surroundings. People learn the concept when they are very young and also learn a set of cues that alert them where to expect glass. But a single decal on a pane of glass to birds is on obstacle floating in empty space. Birds interpret the elements of a pattern as obstacles and they must decide whether they can fly between them. When they veer away – that's bird-friendly!

Birds can fly through surprisingly small spaces (link to videos?) -- they know how big their wings and bodies are and they can maneuver on the wing. To protect the smallest frequent colliders, like hummingbirds, spacing in any direction should be no greater than 2. However, the elements that make up the pattern don't have to be enormous – birds only need to change course while about ten feet from a glass wall. Good guidelines for element size are at least 1/8" for dot diameter or line width, but larger works better. And there's no need to consider only dots and lines nor just black and white! ABC rates patterned glass and assigns Threat Factors on a relative scale, according to how well a sample deters collisions (see 'about the rating system'). Threat Factors are measured under standard conditions [link to tunnel test'] but a given type of glass may have a different appearance on different façades of the same building – or at different heights on the same façade. Designers should keep this in mind.

SIDEBAR: avian vs human vision

> Humans and other primates have relatively flat faces, with eyes close together. The overlap of visual fields means that humans have good depth perception and a tendency to focus on what is ahead. Most birds have eyes at the sides of their heads, giving them excellent peripheral vision but poor depth perception, often limited to the length of their beaks, presumably to judge potential food items. They may be much less intent on what is in front of them (Martin 2011, 2012) but able to watch for potential predators to the side or behind them. Many species' most acute vision is to the side. Without much 3D vision, birds use a mechanism called "visual flow fields" to judge their speed and rate of progress in flight by the passage of environmental features to their sides (Bhagavatula *et al.* 2011). Collisions with glass may be partly a result of birds expecting open air ahead, combined with relatively poor depth perception.

For patterned glass to do its job, the pattern must be visible to birds most of the time. Birds collide with glass throughout daylight hours – and they start their days before most of us do. For birds flying through what they expect is open sky, possibly intent on what is to the side and behind them, we use patterns to bring their attention to obstacles ahead.

Two aspects of visibility are important. First, as described above, a pattern has to have appropriate dimensions. Ideally, patterns would always be on the outside surface of the glass -- aka 'side one'. Side one is where reflections are – and they can be so strong that they obliterate the view of patterns on inside surfaces. Most retrofit solutions are applied to 'side one' but the glass industry has only recently begun marketing 'side one' glass (see database of bird-friendly materials). The photos above show black and white stripes, on the inside and outside of a piece of window glass. It is not surprising that the external white stripes, which reflect the most light, are very visible. The internal white stripes are relatively visible, even through the reflection. The external black stripes are visible, but don't contrast well with the reflections and the internal black stripes (there are three) are hardly visible at all. Color, dimensions, spacing and other factors can all influence how well birds see and react to patterns.

Bold patterns are more visible than faint ones. Even if a pattern is 'technically visible' it may not show up against a reflection. In these examples, sets of paired lines are laid across the photo of a window showing a strong reflection. The lines grow wider, left to right. In the example on the right, the opacity of the lines is greater than for the example on the left. Narrow lines show up better against the continuous blue sky than against the complex colors of vegetation. Wide lines are always more visible that narrower ones, and lines that are more opaque are always more visible against sky or vegetation. A different color would also affect visibility.

Modern, insulated glass uses highly reflective coatings to conserve energy and block harmful light – one reason that homeowners often notice a problem with collisions after they install replacement windows. To complicate matters, structural glass may consist of two or more glass panes, separated by spaces often filled with argon or other gas. Coatings might be applied to any glass surface, potentially reducing visibility of patterns. For this reason, we restrict the definition of bird-friendly patterned glass to that with visible surface light reflectance of 16% or less (see about the rating system) and we do not test other glass in the tunnel.

Spandrel Glass

Glass with a continuous color, which includes 'spandrel' glass, must be discussed separately. This type of glass can produce reflections that vary from a mirrored surface to one that is almost entirely non-reflective. If the surface is reflective virtually all this category of glass is dangerous to birds. An exception is glass with continuous etch on the outside surface. Even matte glass may be part of an assembly with reflective glass at the outside surface. At this writing, ABC is developing a scale of relative sharpness of images formed on glass, to help evaluate these materials. Glass with an etched surface (gloss measurement <XX) can be considered bird-friendly [if background isn't mirror?}

UV Materials

Avian vision differs from human, but there is also variation in vision among different groups of birds. While some birds see only into the violet range of light, others, including most songbirds (Ödeen and Håstad, 2003, 2013) see into the ultraviolet wavelengths (UVS species). Birds share this ability with insects, fish, reptiles and amphibians – it is we mammals that are unusual in lacking UV vision.

Ultraviolet can be a component of any color (Cuthill *et al*. 2000). Whereas humans see red, yellow, or red + yellow, birds may see red + yellow, but also red + ultra-violet, yellow + ultraviolet, and red + yellow + ultraviolet—colors for which we have no names. Every object absorbs, reflects, and transmits ultraviolet light along with the other wavelengths in the visible spectrum. Several companies now manufacture glass with UV patterns visible to some birds but not to humans. These materials can be useful options, when clarity of view is paramount. However, because many bird taxa that collide frequently with glass, including raptors, pigeons, woodpeckers, and hummingbirds, may not be able to perceive UV patterns, this must be considered carefully. For example, a UV glass might not be advisable for a nature center attracting all types of birds to viewing windows with feeders. Additionally, birds are often active in early morning, when UV light levels are low, and the same is true for days with a low UV index.

There are other ways to make buildings safer. One basic strategy is to simply use less glass. This is especially true for structures like skyscrapers – energy efficiency decreases with more than about 40% glass on a façade, but that is more than enough to provide light and views.

Netting, Screens, Grilles, Shutters, Exterior Shades

There are many ways to combine the benefits of glass with bird-friendly design by incorporating elements that preclude collisions while providing light and views. Some architects have designed decorative façades that wrap entire structures. Decorative grilles are also part of many architectural traditions. Exterior, motorized solar screens and shades are effective at controlling heat and light, increase security, and can be adjusted to maximize view or bird and sun protection at different times. Netting, grilles, and shutters are common elements that can make glass safe for birds on buildings of any

scale. They can be used in retrofit or be an integral part of an original design and can significantly reduce bird mortality.

Before the current age of unopenable windows, screens protected birds in addition to serving their primary purpose of keeping bugs out. Screens are still among the most cost-effective methods for protecting birds, and, if insects are not an issue, nearly invisible netting can often be installed. Screens and netting should be installed at some remove from the window so that the impact of a strike does not carry birds into the glass.

Several companies sell screens that can be attached with suction cups or eye hooks for small areas of glass. Others specialize in much larger installations.

Awnings and Overhangs – not recommended

Overhangs have been frequently recommended to reduce collisions. However, there are many situations in which overhangs do not eliminate reflections and only block glass from the view of birds flying above. They are thus of limited effectiveness as a general strategy.

Overhangs work best when glass is shadowed from all sides. Functional elements such as balconies and balustrades can block the view of glass, protecting birds while providing an amenity for residents.

Angled Glass – not recommended

In a study (Klem et al., 2004) comparing bird collisions with vertical panes of glass to those tilted 20 or 40 de- grees, the angled glass resulted in less mortality. Klem speculated that this was because the glass reflected the ground, not vegetation. Using angled glass has become a common recommendation as a bird-friendly feature. However, while angled glass may be useful in special circumstances, the birds in the study were flying parallel to the ground from nearby feeders, hitting the glass at acute angles, with less force than a perpendicular strike. In most situations, however, birds may approach glass from any angle.

Opaque and Translucent Glass

Opaque, etched, stained, or frosted glass and glass block are excellent options to reduce or eliminate collisions, and many attractive architectural applications exist.

They can be used in retrofits but are more commonly used in new construction. Frosted glass is created by acid etching or sandblasting transparent glass. Frosted areas are translucent, but various finishes are available with differing levels of light transmission. An entire surface can be frosted, or frosted patterns can be applied.

Patterns should conform to the 2 x 4 rule described on page 47. For retrofits, glass also can be frosted by sandblasting on site. Stained glass is typically seen in relatively small areas but can be extremely attractive and is not conducive to collisions. Glass block is versatile, can be used as a design detail or primary construction material, and is also unlikely to cause collisions. Another promising material is photovoltaic glass, which has been used in stained-glass windows and highway noise barriers. This solution is especially interesting, because transparent highway noise barriers can cause collisions, and such barriers are beginning to be installed in the United States.

Window Films

Most patterned window films were initially intended for use inside structures as design elements or for privacy. Now, outside surface applications intended to reduce bird collisions are coming onto the market, and some have proved highly effective and popular. The oldest such product creates an opaque white surface on the out- side of glass that still permits viewing from the inside.
Patterns can be printed on this material, although im- ages of trees and other habitat are not recommended.

A film with a pattern of narrow, horizontal stripes has eliminated collisions at the Philadelphia Zoo Bear Coun- try exhibit for over five years (see photo opposite) and has been similarly successful in other installations when applied to outside surfaces of glass. In these cases, the response has been positive. Another option is to apply vinyl patterns like window film but with the transparent backing removed.

Solutions Applied to Interior Glass

Light colored shades have been recommended as a way to deter collisions. However, when visible, they do not effectively reduce reflections, and reflections may make them completely invisible. Closed blinds have the same problems, but if visible and partly open, they can pro- duce the appearance of a 2 x 4 pattern. If an exterior so- lution is not possible and tape or sticky notes are applied to the inside of windows, be sure to check the windows several times a day to ensure that these materials are visible.