

NATURE AND LANDSCAPE MANAGEMENT STANDARDS		
SPECIAL MEASURES FOR SPECIES PROTECTION	MEASURES FOR PREVENTION OF BIRD COLLISIONS ON TRANSPARENT AND REFLECTIVE MATERIALS	SPPK E02 007:2022
SERIES E		
<p>Czech title: Opatření v rámci prevence kolizí ptáků s transparentními a reflexními materiály</p> <p>German title: Maßnahmen im Rahmen der Vermeidung von Kollisionen von Vögeln mit transparenten und reflektierenden Materialien</p> <p>The standard contains recommended technical procedures and other measures for securing risky glass panels in building structures in implemented and planned projects against bird collisions.</p> <p>References:</p> <p>Act no. 114/1992 Coll. on Nature and Landscape Protection, as amended</p> <p>Act no. 100/2001 Coll. on Environmental Impact Assessment, as amended</p> <p>Act no. 246/1992 Coll. on Protection of Animals Against Cruelty, as amended.</p> <p>Act no. 183/2006 Coll. on Spatial Planning and Building Rules</p> <p>Act no. 121/2000 Coll. on Copyright, rights related to copyright, and on amendment of certain acts</p> <p>Technical Requirements no. 104/2016, Noise-reducing screens along roads</p> <p>Ballasus H., Hill K., Hüppop O. (2009): Gefahren künstlicher Beleuchtung für ziehende Vögel und Fledermäuse. Ber. Vogelschutz 46: 127 – 157.</p> <p>Barton C. M., Riding S. S., Loss S. R. (2017): Magnitude and correlates of bird collisions at glass bus shelters in an urban landscape. PlosOne, 14 pp.</p> <p>Brown H., et al. (2007): Bird-Safe Building Guidelines. Audubon Society, Inc., New York City, 57 pp.</p> <p>Carley J. R., Klem D. Jr., Lapp A., Bradshaw B., del Rosario H., Hong J. (2016): Bird-Friendly Practices, Glass. City of Toronto, 52 pp.</p> <p>City of Toronto Green Development Standard (2007): Bird-Friendly Development Guidelines. 42 pp.</p> <p>Hrazdilová I. (2019): Ochrana průhledných výplní před kolizí s ptáky. Silnice a železnice 5/2019: 40 – 41.</p> <p>Klem D. Jr (2009): Preventing Bird-Window Collisions. The Wilson Journal of Ornithology 121(2): 314–321.</p>		

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Standard development:

Elaborated for the NCA CR by the Czech Society for Ornithology in 2022.

External examiner:

University of South Bohemia in České Budějovice, Faculty of Science, RNDr. Petr Veselý, Ph.D.

Authorial collective:

Mgr. Lukáš Viktora, Mgr. Gabriela Dobruská, RNDr. Martin Strnad

Illustrations:

Jiří Kaláček

Documentation for the standard development is available in the NCA CR library.

Standard approved on:

RNDr. František Pelc
Director of NLPA CR

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1. Standard purpose and contents

1.1 Standard definition and purpose

The standard “Measures for prevention of bird collisions on transparent and reflective materials” contains rules for preventing bird collisions with risky materials and surfaces and an overview of recommended technical and other measures aimed at securing risky surfaces and preventing bird collisions on both existing and planned structures.

Bird collisions with glass and other materials with similar properties are one of the most frequent anthropogenic causes of bird death and injury.

Glass and other materials with similar properties are increasingly popular in the construction industry thanks to technological advances. The use of these construction materials poses a significant risk for birds flying in both built-up areas and open country.

The supply of construction glass and materials with similar properties (polycarbonate, acrylic glass, Plexiglas) is wide. Fully transparent or, conversely, strongly reflective materials are primarily considered to be highly dangerous. There are a large amount of equally risky options between the two above extremes.

The purpose of the measures is effective prevention of bird collisions with risky surfaces, consisting in modifications to existing risky surfaces using commonly available technical procedures as well as general rules for project planning for new construction, focused on the outer envelopes of buildings, choose of suitable building materials and other aspects. The measures include procedures for planting and modifications of greenery in the immediate surroundings of existing and newly built structures with risky elements.

1.2 Risk factors

Although avian eyesight is much better than human (sharpness, colour definition), birds do not perceive risky glazed surfaces as a barrier. One of the reasons is the active flight velocity at which birds usually move. For smaller species, it is around 30 km/h; excellent flyers commonly move at 90-100 km/h. Another important factor is that the attention of a bird flying in open, or seemingly open, space is not constantly focused in the forward direction. Moreover, the avian sphere of stereoscopic vision is much narrower compared to human vision. Birds will notice a poorly visible obstacle too late or not at all.

1.2.1 Transparent materials

Transparent (see-through, clear) materials are most commonly used as window and door panels, connecting bridges, balcony and terrace railings, noise-reducing screens, street furniture and other applications. They enable views into interiors, which frequently contain objects attractive to birds – greenery, fountains, water reservoirs, and artificial lighting after dark. A particularly risky situation occurs where two

transparent panels on opposite sides, in atria or at corners of buildings make the illusion of an open flight passage (see Annex 1, Transparent/clear panels).

1.2.2 Reflective materials

Reflective materials accurately reflect the environment in front of the panels. The reflective effect is achieved either by pyrolytic glass surface treatment in manufacturing or attaching reflective sheets to the glass surface. These modifications are primarily aimed at stopping light and thermal radiation from the sun into interiors, thus reducing the energy intensity of building operations. These materials are frequently used for building cladding, window panels in non-residential buildings, external lift wells, etc.

They create a fictional image of a space that birds will try to get into. If, for example, greenery is several metres distant from the panels, the bird will crash into the panel at full speed, believing that its destination is still sufficiently distant. Strongly reflective surfaces are thus generally regarded as more dangerous (see Annex 2, Reflective panels).

1.2.3 Lighting

Inappropriately designed artificial lighting radiating into the surrounding area is an equally serious problem for birds that mostly migrate at night. Night-time lighting attracts birds while also seriously disrupting their sense of orientation. Disoriented birds then crash into various obstacles – lit and unlit buildings, wires and other cable or rope structures, aerials, etc. The negative effect of night-time lighting is significantly aggravated by unfavourable weather conditions, most importantly fog, intensive precipitation and strong wind.

1.2.4 Risky surface definition

Risky panels are such that comprise transparent or reflective material with a surface area larger than 2 m², located in direct contact with places of natural concentration of birds. The latter comprise natural elements not screened away by other development (see 1.2.5) up to 100 m from the panel.

1.2.5 Places of natural concentration of birds

Places of natural concentration of birds include primarily:

- continuous greenery with a surface area over 1 ha,
- linear greenery lining watercourses and water bodies,
- tree lines along roads,
- plantings of near-natural gardens with concentrated sources of food for birds,
- watercourses and water bodies,

- mountain saddles.

2. Legal framework

2.1 Act no. 114/1992 Coll.

Act no. 114/1992 Coll. on Nature and Landscape Protection, as amended (the NLPA), defines instruments for prevention of bird collision with risky materials and surfaces at several levels. As part of general protection of animals, natural persons and legal entities are required, among other things, to carry out construction work so as to prevent excessive injury and death of animals that can be prevented with technically and economically available means (Section 5, Para. 3 of NLPA). Excessive refers primarily to deaths that are needless and do not condition the activity (construction work).¹ However, excessive (needless) death of birds occurs very often at places of natural concentration of birds due to the use of inappropriate structure types and building materials. The applicable nature protection authority may pass a decision ordering the entity to use appropriate economically and technically available means if the entity does not do so by itself based on its legal obligation.

If the investor intends to make a serious intervention with its construction project that may affect (inter alia) bird protection interests (in terms of general or special protection), the investor is required to have its intended project assessed in terms of its impact on the protected interest in question in advance and at its own cost (Section 67, Para. 1 of NLPA).² Said assessment is then a mandatory prerequisite for the investor's application (if any) for granting an exemption under the NLPA, or submitted as part of the environmental impact assessment under the Environmental Impact Assessment Act (if it meets the requirements thereof).

If the problematic intended project is located in a Special Protection Area or is outside it but may significantly affect the bird species that are the object of protection of the adjacent Special Protection Area, the project is required to have an assessment of impacts on the status and objects of protection of the SPA. The investor is required to submit such an intended project to the nature protection authority for a position statement whether it may have, by itself or in combination with other plans or projects, significant impact on the objects of protection and integrity of the SPA (Section 45i, Para. 2 of NLPA). If the nature protection authority does not rule out such significant impact, the intended project is subject to an assessment under the Environmental Impact Assessment Act (see below).

Moreover, the NLPA prohibits disturbing, injuring, killing or otherwise interfering with the natural development of individuals of specially protected animal species, including

¹ Vomáčka V. et al. 2017: Zákon o ochraně přírody a krajiny: komentář. 1st ed., Praha: C. H. Beck, p. 67

² In the event of any doubt concerning the extent and seriousness of the intervention, the investor may ask the applicable nature protection authority for a position statement on the seriousness of the intervention.

some birds.³ In cases where such harmful intervention is expected already in the construction phase, the investor is required to obtain an exemption from the prohibited interference with the natural development of specially protected animal species. As part of granting the exemption, if any, the nature protection authority may specify, in the requirements section of its decision or binding position statement, measures to ensure protection of specially protected bird species from colliding with dangerous surfaces.

2.2 Act no. 100/2001 Coll.

Act no. 100/2001 Coll. on Environmental Impact Assessment, as amended (EIA Act). Besides, building structures and materials used are assessed in terms of impacts on bird species in cases where the intended project is subject to environmental impact assessment (whether based on the evaluation of the nature protection authority under Section 45i of NLPA or because it is a project under Annex 1 to EIA Act). Linear structures very often include noise-reducing screens, which are filled with transparent panels in selected sections (to reduce structural loading of above-ground structures, along sections in built-up areas, etc.). The impact of linear (transport) structures is assessed in the overwhelming majority of cases as part of the EIA process under the EIA Act.

2.3 Act no. 246/1992 Coll.

Act no. 246/1992 Coll. on Protection of Animals Against Cruelty, as amended. Particularly serious cases of investor ruthlessness towards bird protection interests, where birds demonstrably die needlessly due to inappropriately chosen structural design or materials, may constitute violations of the Act on Protection of Animals Against Cruelty and associated misdemeanours. Specifically, such action can be classified as causing birds disproportionate suffering (i.e., cruelty to birds under Section 4, Para. 1, item p of the Act) or as killing of animals outside permitted reasons under the Act (Section 5).

2.4 Act no. 183/2006 Coll.

Act no. 183/2006 Coll. on Spatial Planning and Building Rules (Building Act). Most building projects that involve risky surfaces are subject to the Building Act. Appropriate technical design and materials are ideally chosen already at the project planning stage; otherwise, they are typically incorporated at the building permit decision stage (being the administrative act dealing with the specific appearance of the permitted structure), most commonly due to the binding position statement of a nature protection authority or authority applicable to environmental impact assessment).

³Annex 3 to Decree no. 395/1992 Coll., executing some provisions of Czech National Council Act no. 114/1992 Coll. on Nature and Landscape Protection, as amended

2.5 Act no. 121/2000 Coll.

Act no. 121/2000 Coll. on Copyright, rights related to copyright, and on amendment of certain acts (Copyright Act). The Copyright Act protects the owner of the copyright to architectural or urban design work, being the implemented building structure in most cases. Any intervention in the implemented structure that is reflected in its appearance is subject to the consent of the copyright owner in accordance with the Copyright Act. This has to be borne in mind when planning and implementing measures leading to greater safety of risky surfaces of existing structures.

2.6 Technical Requirements 104/2016

Technical Requirements no. 104/2016, Noise-reducing screens along roads (TP 104), approved by the Ministry of Transport, ref. no. 306/2016-120-TN/1, of 24 November 2016, in effect as of 1 December 2016, point 3.7.2 Minimization of barrier effect of noise-reducing screens, specifies the obligation to secure panels made of transparent materials against bird collisions. This obligation is further detailed in point 5.5.2.4 Glass, acrylic glass, polycarbonate, which includes technical descriptions of securing methods.

3. Structure risk assessment

An expert assessment of the structure, the conclusions of which are subsequently implemented in the project documentation, is made by a professionally qualified person in accordance with rules for biological assessment based on an application by the project investor or owner or an administrative authority.

The project assessment is preceded by:

- use of available data on the site (vegetation, watercourses and water bodies, topography, existing and planned surrounding development, presence of protected areas, etc.);
- use of available data on local avifauna (birds.cz database, Species Occurrence Database, etc.);
- basic informative tour of the site;
- ornithological survey on the site in the course of at least 1 calendar year, with a minimum extent during the nesting period and the autumn migration.

The second phase assesses the intended project itself, primarily:

- acquisition of available data on the intended project – project documentation;
- description of the intended project (technical data – orientation, height, shape, segmentation and material composition of façades, dimensions, types and materials of windows and doors, and other characteristics), including planned landscaping (greenery type and distribution, water bodies), expected direct

and indirect impacts on avifauna, including potential risks, possible preventive measures to minimize any negative impacts;

- proposal of the optimal option of the intended project in light of minimizing negative impacts;
- proposal of protective measures at the investor's expense.

3.1 Approximate building risk assessment

The approximate building risk assessment is done using an assessment form, made based on a combination of criteria, including:

- environmental conditions, i.e., immediate and broader building surroundings;
- basic building characteristics and parameters, including materials used for windows and doors and, as the case may be, exterior cladding and other structures (railings, sun and wind screens, etc.).

The assessment attaches adequate scores to each criterion; the resulting score indicates the degree of building risk in terms of bird collisions.

The assessment form can be used for both existing and planned structures, if the assessment author knows the basic structural characteristics and parameters. The structure as a whole may not be risky: the combination of environmental risk factors and risky structures on the building indicates the dangerous building elements and parts (see Annex 3, Assessment table for approximate building risk assessment).

3.2 Approximate noise-reducing screen risk assessment

Risk assessment of noise-reducing screens (NRS) is limited to sections where transparent materials are used as panelling – safety glass, polymethyl methacrylate (PMMA) or polycarbonate (PC). Such sections are typically located on above-ground sections of linear structures due to reduced structural loading, or near residential development blocks.

Transparent sections of NRS are considered high-risk if they:

- cross a watercourse or water body or run parallel to it;
- cross green belts, including tree lines, or run parallel to them;
- run through continuous greenery, including gardens, garden allotments, orchards or plantations located at a distance of less than 100 m from the NRS;
- are located at a distance of less than 50 m from trees or shrubs growing individually, in groups or lines along one or both sides of the NRS.

The material used for the panelling is important for the approximate assessment. Panelling without additional safety elements (see Technical Requirements 104, point 5.5.2.4), should have dimming to at least 30% lower permeability, and must not have reflective surface finish.

Technical Requirements 104 do not apply to NRS that are a common component of housing compound projects located near heavy-traffic roads or other sources of

excessive noise levels. NRS with adhesive individual bird outlines cannot be regarded as secured.

4. Measures for prevention of collisions

4.1 Measures on existing structures

So far the most frequent request has been to secure exposed sections of an existing structure that has been assessed as risky based on repeated finds of dead birds or collision marks.

In this connection, it is necessary to have a written consent from the project design author, as the structure is a complete architectural authorial work subject to the Copyright Act, as well as a written consent of the structure owner, unless the measure is ordered by a public authority based on an administrative decision.

4.1.1 Additional securing of risky surfaces

A common rule applies to any surface finishing of risky panelling: it is always made on the outer, exterior side of the panelling, and on the outer side of NRS facing away from the road.

4.1.1.1 Adhesive coating

Adhesive coating is the most common, technically undemanding and economically favourable form of securing risky panelling on existing structures. Polyvinylchloride (PVC) sheets are the most frequently used. Polymer PVC sheets have longer service life than monomer sheets. Polyester sheets are also used for adhesive coating of smooth surfaces.

The choice of suitable materials is crucial. Durability plays the main role in the selection process: the adhesive coating should last as long as possible, particularly where their installation requires the use of special equipment – lifting platform, catwalk or specialized climbing equipment. Materials with a service life longer than 10 years are available on the market. The minimum durability of adhesive coating should be 5 years or more.

The resilience of the materials used is also important; they should be resilient to weather effects, mechanical and chemical cleaning associated with periodic maintenance of outer surfaces. Certain operating problems that may affect the functionality of the measure occur when erasing graffiti. The sheets partially absorb any applied paint, which remains in the adhesive stickers after cleaning the panels.

It is important to choose material colour combinations that contrast with the risky surface surroundings or background. Combinations of black and orange are recommended, as well as black, white and red. Green adhesive coating has achieved lower effectiveness. The coating colours can be combined.

High safety effectiveness is also achieved using translucent materials that imitate mechanical surface finish (etching, sandblasting).

The visibility of adhesive coating reflecting light at wavelengths of 200-400 nm, which the human eye cannot see, is very low, which is why they are popular for window safety. However, results of tests performed in test tunnels only show limited effectiveness, ranging between 50 and 70%. The lower effectiveness can be attributed to the fact that not all birds are capable of perceiving light at said wavelengths.

UV adhesive coating has limited service life, typically 2 years. They have to be replaced after that. UV adhesive coating is thus successful primarily in areas with a prevalence of songbirds (typically gardens, low density residential development) and easy-to-reach risky surfaces. They are suitable, for example, for single family home windows (aesthetic requirements) and school facilities, which are at the luminosity limit in terms of public health regulations and cannot afford to reduce it further.

The rule for all the above options is that their degree of effectiveness depends on the shape and size of the adhesive stickers and their mutual distances (spacing). From this point of view, the adhesive coating can be divided into spot and linear elements.

4.1.1.1.1 Spot adhesive elements

The design of adhesive elements such as spots, circles or other non-linear elements is practically unlimited. They can be of any graphic shape – patterns, motifs, logos as well as lettering.

The minimum size of the short side or diameter of the element is 5 mm. Another parameter is the spacing between the adhesive elements. It differs depending on the size of the elements: the spacing is 5 mm for elements with the short side or diameter of 5 mm; the maximum spacing for elements with the short side or diameter of 30 mm or more is 100 mm.

The most representative indicator in this sense is the coverage ratio of the risky surface with adhesive elements, which should be at least 25% for elements with the short side or diameter of 5-30 mm, or 15% for elements with the short side or diameter of more than 30 mm.

The coverage ratio in percent is calculated as follows:

Element size 5 – 29 mm:

$$\% = \frac{(D/2)^2 \times 3.14 \times 100}{R^2}$$

D = spot diameter

R = sum of spot diameter and spacing between two spots

see Annex 4, Print and adhesive coating with small spots

Element size 30 mm or more:

$$\% = \frac{(D/2)^2 \times 3.14 \times 100}{R_x \times R_y}$$

D = spot diameter

R_x = sum of spot diameter and horizontal spacing between two spots

R_y = sum of spot diameter and vertical spacing between two spots

see Annex 5, Print and adhesive coating with spots 30 mm or larger

4.1.1.1.2 Linear adhesive elements

In the case of linear adhesive elements, the success is determined by the element thickness, with the minimum thickness being 3 mm for horizontal lines and 5 mm for vertical lines. That said, vertical adhesive elements are typically more effective.

Spacing between linear adhesive elements depends on their orientation and thickness:

- Vertical elements:

- element thickness 5 mm – max. spacing 100 mm

see Annex 6, Vertical print, adhesive coating or mechanical treatment

- Horizontal elements:

- element thickness 3 mm – max. spacing 30 mm

- element thickness 5 mm or more – max. spacing 50 mm

see Annex 7, Horizontal print or adhesive coating

4.1.1.2 Mechanical treatment of panel surface

Used for additional treatment of risky panelling mostly in NRS at present. The treatment is in the vertical direction by sandblasting with exhaust or grinding using a steered mobile device in the field. The parameters are identical to linear adhesive elements are conform to binding Technical Requirements 104.

The surface treatment technique is suitable for all commonly used materials (polymethyl methacrylate (PMMA), polycarbonate (PC) and safety glass) and their service life is comparable to that of the substrate.

4.1.2 Measures in front of identified risky surfaces

If adhesive coating cannot be applied to risky panelling for operating or structural reasons, effective measures can be installed in front of them, particularly where the panelling has a reflective surface finish. Measures in front of risky panelling can have multiple positive effects: the panelling is highlighted, shaded and, in some cases (mesh), the impact is softened if a bird still collides with the building despite the highlighting.

4.1.2.1 External Venetian blinds

If the structure of the building envelope or window frames permits it, external Venetian blinds are a high effective measure; they can be horizontal or vertical. Their dimensions

and spacing are important, and they usually meet the recommended parameters (min. slat thickness 3 mm, max. spacing between slats 100 mm). External roller blinds can perform a similar preventive role. In both cases, the use regime has to be adjusted to the intensity of direct sunshine and the interior operating regime.

4.1.2.2 Hangings outside windows

Smaller areas, primarily on single family homes, can be secured operatively with simple hangings, made of cables or strings with a minimum thickness of 5 mm and max. spacing of 100 mm, suspended on the outside of windows frames and hanging loose along the entire panelling. As necessary, this measure can later be replaced with a permanent safety measure (see Annex 8, Hangings outside panelling).

4.1.2.3 Protective netting

Risky panelling can also be fitted with protective netting tightened in a frame (max. mesh size 20 mm). The netting has to sit tight to the frame along the whole perimeter to prevent smaller birds from entering between the netting and the panel. The tightening of the netting is equally important, as it prevents entangling of wings or feet. Window netting can be permanent or mobile, used in critical migration seasons only (March – May, August – October). Ordinary insect netting, so-called mosquito netting, can be equally effective (see Annex 9, Protective netting outside panelling).

4.1.2.4 Pergolas

If the panelling is risky because of its high reflectiveness, the mirror effect can be partially reduced by installing pergolas, which shade off at least a part of the risky surface.

4.1.3 Interior measures

If transparent panelling is identified as risky, the danger of collision can also be eliminated by interior measures.

Tall potted plants are a great attraction particularly for small songbirds; they can be moved away from the windows to reduce their visibility. Where two transparent panels form a free view through the building, it is advisable to place tall pot plants outside the view axis.

Views into the interior can be reduced with fabric hangings, curtains or interior Venetian blinds that let in enough daylight.

Collisions frequently occur at night time, particularly during migration seasons (spring, autumn). The risk of collisions in non-residential spaces can be reduced by adjusting the interior lighting, primarily by orienting the cone of light on work or walking surfaces only. Adjustments to the lighting operating regime are also effective in minimizing the collision risk (see chapter 5.1.2 Interior lighting).

4.1.4 Adjustments to surroundings

If risky panelling is identified in an existing structure (based on expert or approximate assessment, registered repeated bird deaths or injuries), safety measures can be complemented with adjustments to the surroundings outside the surfaces to discourage birds from approaching them.

4.1.4.1 Greenery adjustments

Greenery adjustments, primarily trees and shrubs, are the easiest to make. Following a positive statement from the authority (if required for the adjustments), trees and shrubs growing near the identified risky surfaces can be reduced and replaced with substitute planting targeted outside the risky parts of the building.

The substitute planting should prefer species with limited production of seeds and fruits attractive for birds, with thin light foliage and trunks without a tendency to form hollows. The planting distribution should be designed so that it guides birds from the building, or its risky parts (canopied and loose green belts). Trees and shrubs in those areas

can be replaced with grass or flower beds, which are only attractive for birds during the growing season.

4.1.4.2 Other adjustments

If the identified risky surfaces are small (only single windows) and are located on the ground floor or first floor level, various types of panels can be installed in front of them (navigation, information, building name, company or advertising panels, etc.).

4.2 Measures on planned structures

Reflecting the recommended rules in project documentation for the structure is crucial for preventing bird collisions. It can efficiently and economically include practically all measures that reduce the collision risk. It can take into account conditions of the structure environment (terrain topography, greenery, watercourses and water bodies, surrounding development, etc.).

4.2.1 Outer building envelope design

The outer building envelope, including roof structural design, is critical for building operating safety in terms of bird collisions. The outer walls are clearly the critical factor.

4.2.1.1 Outer walls

The outer wall structure significantly increases the collision risk if their surface comprises smooth reflective materials, which accurately mirror the building surroundings. The reason for reflective finish of the walls is the effort to reflect maximum sunlight and thermal solar radiation, prevent its penetration into the interior, and thus reduce the energy intensity of the building operation, particularly in summer.

In this connection, it has to be noted that the mirror effect is not only produced by construction glazing, but also polished metal or polished stone cladding. This type of façade most commonly uses flat slabs, but bent glass is increasingly common. If it is necessary notably in order to reduce the energy intensity of the building operation to have the all-glass façade with a reflective finish, the design can use building materials with an uneven surface, which deforms the reflection of the surroundings. The resulting unrealistic image is not attractive for birds. The same effect can be achieved by curving or rounding entire façades (organic façades).

The negative impact of the reflective finish of outer walls can be partially eliminated by slanting the outer walls, if they gradually recede without any overhangs. Thus, the reflective panelling reflects mostly the sky, not so much surrounding greenery (see Annexes 10 a 11, Slanting façades).

The above measures should not be limited to the outer walls only, but include walls of any atria, connecting bridges and other structures (railings, sun and wind screens, etc.).

4.2.1.2 Opening locations and panelling

Excessive collisions can be prevented by the correct choice of numbers, sizes and locations of windows, particularly at building corners. Unobstructed views through building corners attract birds to fly through, particularly in unfavourable weather (strong wind) or in an escape reaction when startled or attacked by a predator. If such window design is indispensable, it is safer if the building corner comprises rounded windows or multiple small windows forming obtuse angles (see Annex 12, Window locations at building corners).

If places of natural concentration of birds (see 1.2.5) are identified in the immediate surroundings of the building (within 100 m), this fact has to be taken into account in the design process, not designing large glazed spaces in direct contact with such places.

4.2.2 Choice of suitable building materials and their modifications

There is no safe glass that would meet requirements for operating functionality and bird safety at the same time without additional modifications. Safety can be achieved by factory modifications or before installation during construction. The purpose of the glass within the structure is critical. The biggest problems are with safety design of glasses conforming to the strictest requirements for both thermal insulation properties and daylight permeability.

- The rule for window panelling is that if materials with reflective surface finish are used, the reflectiveness should not exceed 15%. For highly exposed surfaces with a higher reflectivity requirement, effective measures in front of the panelling have to be provided (Venetian blinds, roller blinds).
- The size (surface area) of windows can also be influenced, as well as thickness of frames of continuous window strips, so that individual windows panes are visibly separated.
- Façade cladding may employ tinted glass with mechanical (sandblasting – surface blasted with silica sand – or milling) or chemical (etching) surface finish, or enamelled glass (paint applied by spraying, coating roller or via screen, followed by firing), which are not reflective but may still perform the thermal insulation function.
- Where daylight penetration into the interior is necessary (e.g., in connecting bridges, entrance areas, partitions, balcony or terrace railings, external lift wells, etc.), transparent construction glass can be coated with print, made by serigraphy or digital printing on the outer side of the glass pane.
- The print parameters should conform to the recommended values, which are identical to recommendations for adhesive coating or mechanical treatment of NRS (see chapter 4.1.1.1.2 Linear adhesive elements). Another alternative is the use of opaque (tinted, non-transparent) glass with grooved surface or glass bricks.
- Sufficient daylight penetration into the interior is also provided by decorative or ornamental glass panes with structure surface or friezes, made by rolling float glass through rollers with the required pattern and can be made of tinted glass. Another option is ornamental glass with inserted wires.

The advantage of these techniques is the possibility to choose the pattern and the service life of the modifications, which is identical to that of the window panelling itself.

If the construction cannot use the above material for objective reasons (particularly in light of reducing the building energy intensity), measures in front of panelling can be used (Venetian blinds, roller blinds, etc.).

4.2.3 Adjustments to surroundings

Planned structures, unless located in blocks or other compact development, usually include landscaping of their immediate surroundings, including smaller areas integrated into buildings with complex floor plans (patios, atria). These may consist, among other things, in ground modifications that may divert or change bird movement into a safe distance from the risky parts of the building by not including elements attractive for birds. Such modifications include, e.g., playgrounds, sports grounds, technical areas (parking, roads and pedestrian paths), areas with gravel or crushed aggregate surface, as well as regularly mown grass on flat ground or, even better, a terrain hump, which shields away views from greenery to the risky parts of the building.

The greenery composition and distribution plays a major role. In their ordinary daily movements (feeding and territorial behaviour, nesting and post-nesting care), birds usually follow trees and shrubs. Planting green belts of trees or shrubs (in rows or loose groups) outside large glazed surfaces can significantly reduce the collision risk.

The same attention has to be paid to planning of all types and sizes of water bodies, which are highly attractive for birds at any time of year, although they may be purely technical in nature (fountains, pools, artificial watercourses, biotope ponds, etc.).

5. Other measures for reducing collisions

5.1 Lighting

Artificial lighting along with transparent and reflective panelling is a fundamental factor increasing the bird collision risk, particularly at night. Inappropriately installed lighting attracts birds and disorients them (see chapter 1.2.3).

5.1.1 Exterior lighting

Exterior lighting can fundamentally influence bird behaviour. It most commonly comprises lighting for all types of roads in the public space and on private land too, as well as lighting for industrial compounds, shopping centres, farms, parking areas, sports grounds and playgrounds. Decorative lighting for heritage buildings, gardens and parks or works of art is very popular. Lighting for large advertising boards is common in recent decades. They are frequently backlit LED panels.

- Light emitted horizontally or from the ground upwards is particularly dangerous for birds. In such cases, the cone of light illuminates the open space over long distances. Mobile spotlights and laser beams, as used during cultural and art performances, are very dangerous and their use should be conditional on approval of an applicable nature protection authority.
- The undesirable effect of light emitted into open space can be eliminated by the lighting fixture design, which directs the light stream only to the place where it is meant to perform its function. It is advisable to install lighting fixtures emitting light from the ground upwards in the opposite direction (see Annex 13, Exterior lighting of areas and façades).
- A solution for pedestrian paths or cycling paths can be regime-altering measures (installation of motion sensors that reduce the lighting to the necessary time and bring electricity savings at the same time).
- Light chromaticity (colour tone, or chromal temperature), which defines the colour tone of light, that is near daylight is stimulating for birds, and such lighting should be used only in justified cases.

5.1.2 Interior lighting

- Lighting for non-residential buildings in particular (office and shopping centres) is often switched on all night, even when not in operation. Light from the interiors penetrates the building surroundings and, particularly during impaired visibility conditions and migration seasons, may disorient birds and cause fatal collisions.
- Therefore, interior lighting for non-residential spaces should only target work and walkable surfaces, and their regime should be adjusted to the business hours. At night, the lights could be controlled by motion sensors or a specially written program. Significant energy savings can be achieved by this at the same time.

6. Measure functionality inspection and maintenance

6.1 Measure functionality inspection

If risky surfaces are identified precisely in a structure, whether based on previous collision record or by a targeted survey, it is possible to make a comparison of the functionality of the measures before and after implementation by subsequent monitoring.

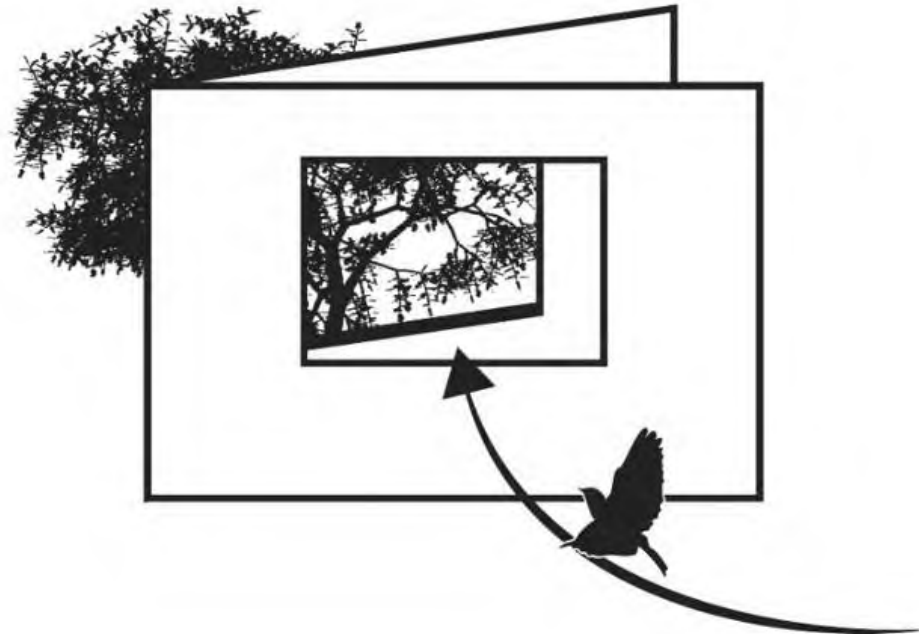
Of course it is also possible to verify the functionality of adopted measures even without knowledge of the initial situation. The monitoring can be done by a professionally qualified person or the building owner (or a person authorized by them) after training by an expert. The monitoring should be done periodically (weekly or monthly as possible) at least over one calendar year, to cover all the important periods (nesting, spring and autumn migration, wintering guests). The main attention of the monitoring is focused on presence of marks on panelling that stick to its surface at the point of contact. Remnants of plumage, blood or droppings are less common. Cadavers of dead birds do not stay for very long under the impact point, and their importance for assessing the measure effectiveness is only secondary.

6.2 Maintenance

Full functionality of all measures requires maintenance, particularly for measures implemented on existing structures. The service life of materials used for adhesive coating or measures in front of panelling is limited; the guaranteed service life specified by the manufacturer or vendor may not match the actual wear on highly exposed surfaces. They can also be damaged intentionally by vandalism. Depending on the structure owner or operator's time or monetary capacities, temporary measures can also be replaced with permanent ones.

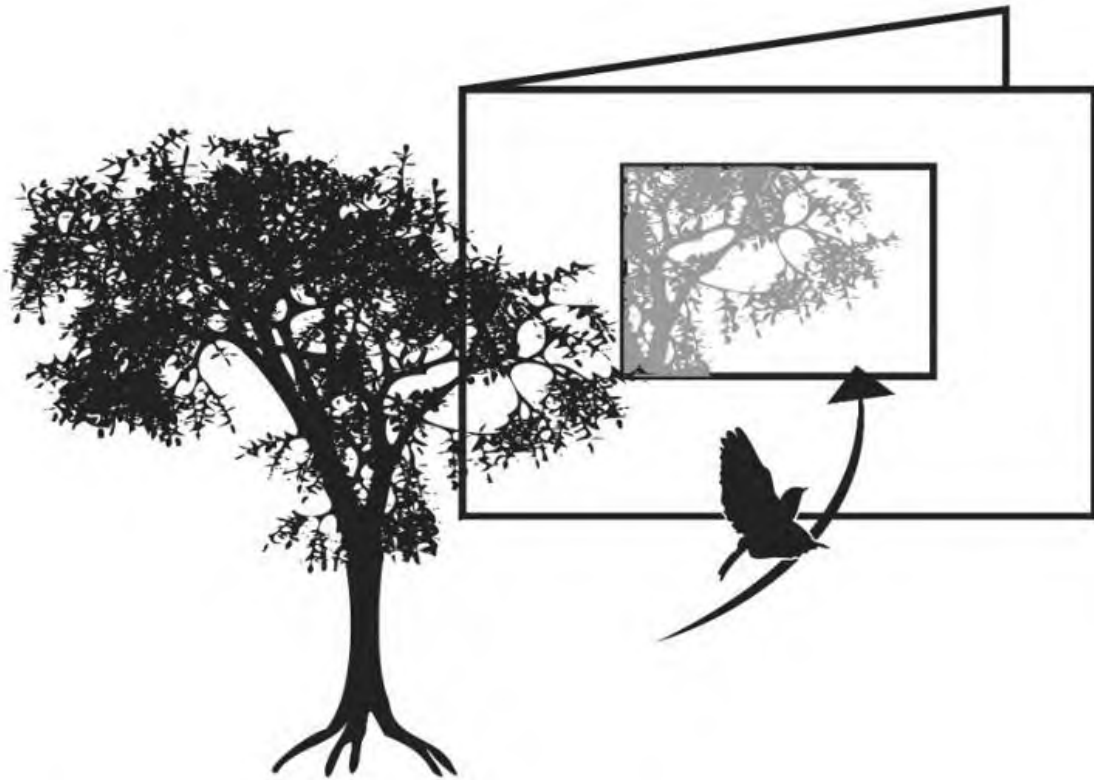
7. Annexes

Annex 1: Transparent/clear panels



Transparent panels permit views into interiors and through buildings. Birds do not perceive them as an obstacle.

Annex 2: Reflective panels



Reflective materials accurately reflect the surroundings in front of them. They thus create a fictional environment that birds will try to get into.

Annex 3: Approximate building risk assessment, assessment table

Building assessment in terms of risk of bird collision with transparent and reflective panels

The assessment table is intended for approximate assessment of riskiness of multi-storey apartment buildings (not single family homes), office, school and healthcare buildings, sports halls, public swimming pools and other types of non-residential buildings. It is intended for approximate assessment of both existing and planned structures. The table can be used in electronic form, which as automated formula settings (available for download from the NCA CR webpage on standards in force: <https://nature.cz/web/cz/platne-standardy>). If you decide to complete its print form in the field, the results then have to be copied into the electronic version.

How to work with the table

Choose the adequate option in sections “1. ENVIRONMENT” and “2. BUILDING” to set the basic score in the column “SCORE”. Afterwards (in the electronic version of the table), section “3. COMBINATIONS OF RISK FACTORS” will automatically reflect the risk factors (marked red) in the total score. There can be multiple combinations; more than one type of environment with increased concentration of birds may be situated near the building, and the building may have more risky structural components.

Row no.	ATTRIBUTE	WEIGHT	SCORE
1. ENVIRONMENT			
1.1 Building position in relation to surrounding development			
1	in continuous dense development	1	
2	at the edge of continuous development	2	
3	outside continuous development	2	
1.2 Surroundings characteristics			
1.2.1 Greenery, watercourses and water bodies			
greenery not screened by other development within 100 m of the building:			
4	garden, park, urban forest (continuous stand larger than 1 ha)	3	
5	garden allotments or summer homes, villa quarter	2	
6	tree lines, bosques perpendicular to building	3	
7	tree lines, bosques parallel to building	1	
8	linear greenery along watercourse or water body	3	
9	greenery in building atria	2	

10	water body or watercourse not screened by other development within 100 m of the building	3	
1.2.2 Surroundings topography:			
11	flat	1	
12	sloping	1	
13	valley bottom	2	
14	mountain saddle	3	
continuous "Environment" score			
no. of risk factors (rows 4, 6, 8, 10, 14)			
2. BUILDING			
2.1 Floor plan			
15	simple, unsegmented (rectangle, square, oval, circle)	1	
16	complex (primarily L, H, E-shaped, etc.)	2	
2.2 Number of aboveground storeys			
17	1	1	
18	1 elevated (above 5 m)	2	
19	2 – 20	2	
20	more than 20	2	
2.3 Façade inclination			
21	vertical	2	
22	slanted (receding from base to top, no overhangs), rounded	1	
2.4 Building segmentation			
23	corridors, lobbies or connecting bridges glazed on both sides	3	
24	atria	2	
2.5 Façade type			
25	masonry	0	
26	polished stone or metal	3	
27	green façade	2	
2.6 Roof			
28	gabled, hipped	0	
	flat:		
29	1. flat	0	
30	2. flat green	2	
31	3. flat with transparent railings	3	
2.7 Share of glazed spaces in total façade surface area			
32	up to 10%	1	
33	11 – 50%	2	
34	more than 50%	3	
2.8 Size of windows			

35	up to 1 m ²	1	
36	1 – 2 m ²	2	
37	more than 2 m ²	3	
2.9 Window type			
38	fully transparent	2	
39	tinted up to 20%	2	
40	tinted over 20%	2	
41	reflective up to 15%	1	
42	reflective over 15%	3	
2.10 Window connections			
43	windows are segmented with vertical pillars or frames more than 1 cm thick	1	
44	windows are not segmented	3	
45	windows make glass corners	3	
2.11 Building lighting			
46	exterior, pointing from ground upwards	2	
47	night interior lighting, permanent	2	
48	night interior lighting, motion sensors	1	
continuous “Building” score			
no. of risk factors (rows 23, 26, 31, 34, 37, 42, 44, 45)			
3. COMBINATIONS OF RISK FACTORS			COMBINATIONS OF RISK FACTORS
risky environments (places of increased concentration of birds): rows 4, 6, 8, 10, 14 risky building structural elements: rows 23, 26, 31, 34, 37, 42, 44, 45 - add 3 points for each combination of both factors.			
Example:	The northern façade with a glazed area share in excess of 50% adjoins a garden larger than 1 ha = 3 points. At the same time, the southern façade with glass with reflective surface finish over 15% is approached by an access road lined with trees = 3 points.		
3.1 Environmental risk factors – recapitulation			
4	garden, park, urban forest (continuous stand larger than 1 ha)		
6	tree lines, bosques perpendicular to building		
8	linear greenery along watercourse or water body		
10	water body or watercourse not screened by other development within 100 m of the building		
14	mountain saddle		
3.2 Building risk elements – recapitulation			

23	corridors, lobbies or connecting bridges glazed on both sides	
26	polished stone or metal	
31	flat roof with transparent railings	
34	more than 50%	
37	more than 2 m ²	
42	glass with reflective surface finish in excess of 15%	
44	windows are not segmented	
45	glass or other transparent materials make transparent corners	
TOTAL SCORE		

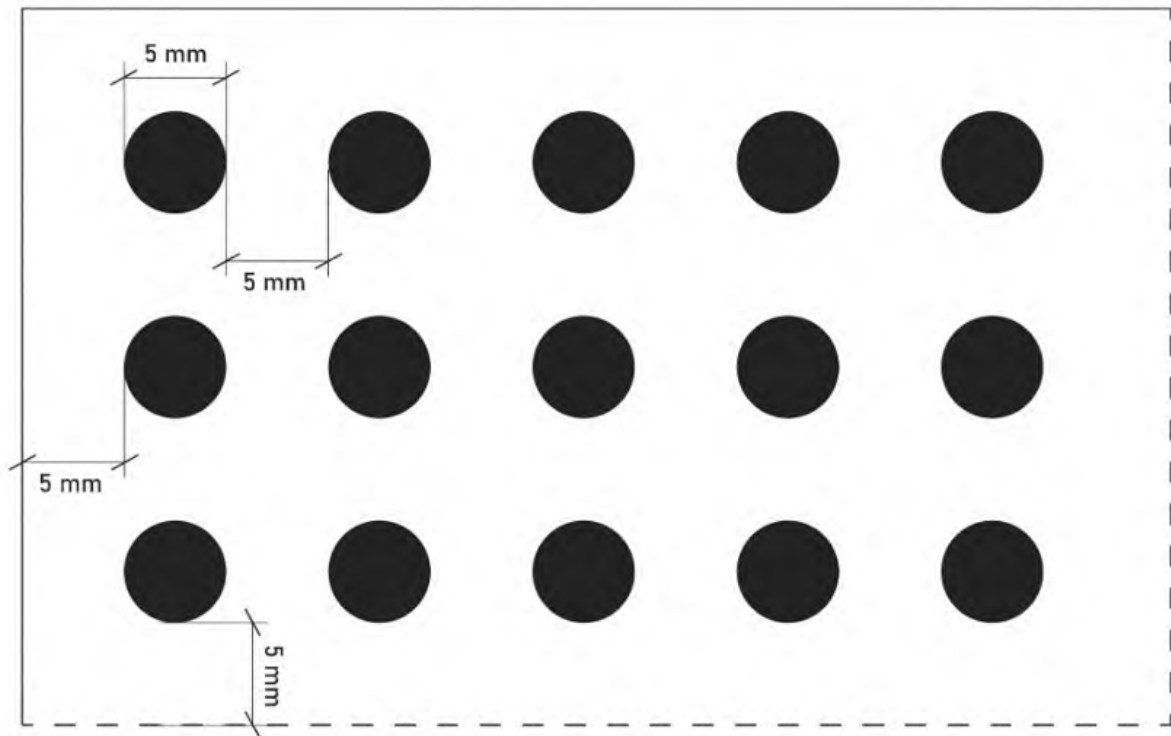
The total score is an expression of the building riskiness in terms of bird collisions with the transparent or reflective surface that exist on the building.

The degree of risk is divided into three categories based on the achieved score ¹⁾:

- low risk (total score up to 20 points),*
- medium risk (25-35 points),*
- high risk (40 points or more)*

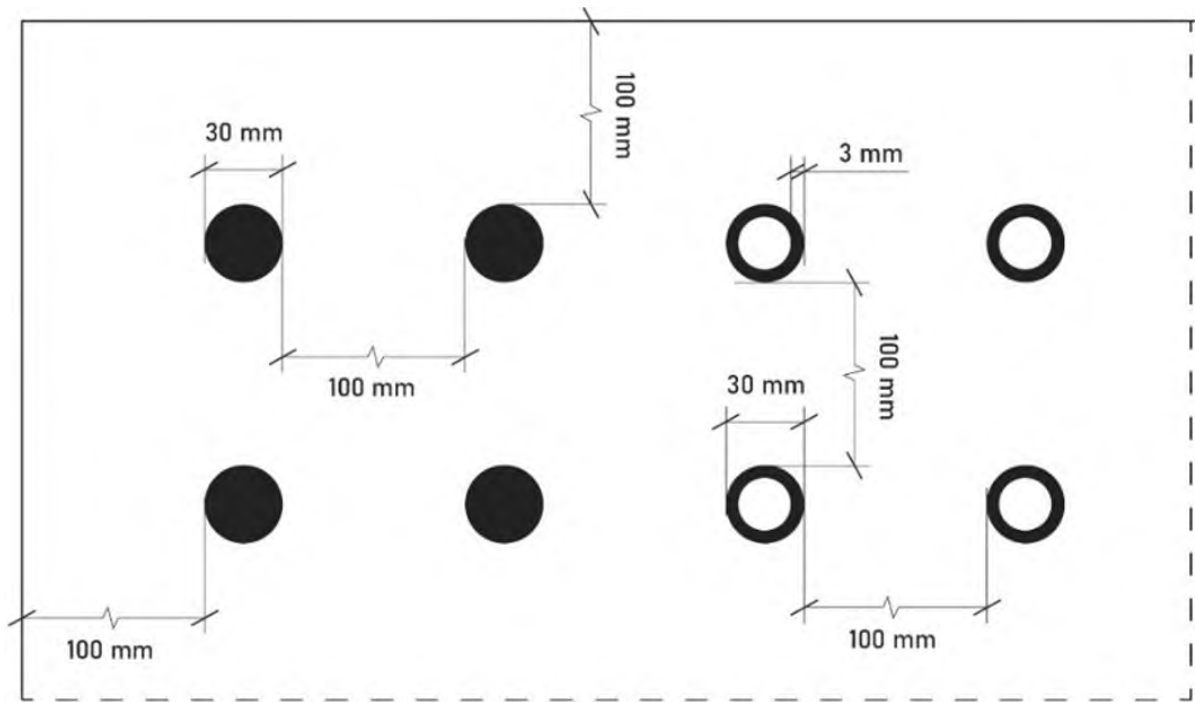
¹⁾ at 21 - 24 points or .36 - 39 points, the building assessment is near the next, higher risk level

Annex 4: Print and adhesive coating with small spots

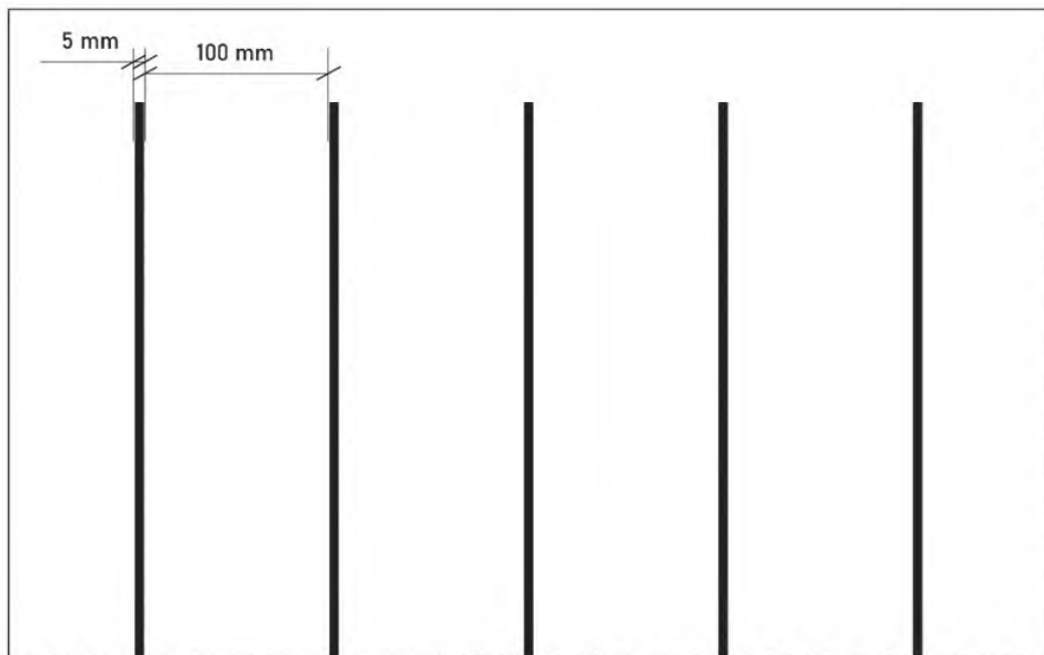


Sizes of elements are identical to their spacing and distances from edges of the secured area.

Annex 5: Print and adhesive coating with spots 30 mm or larger

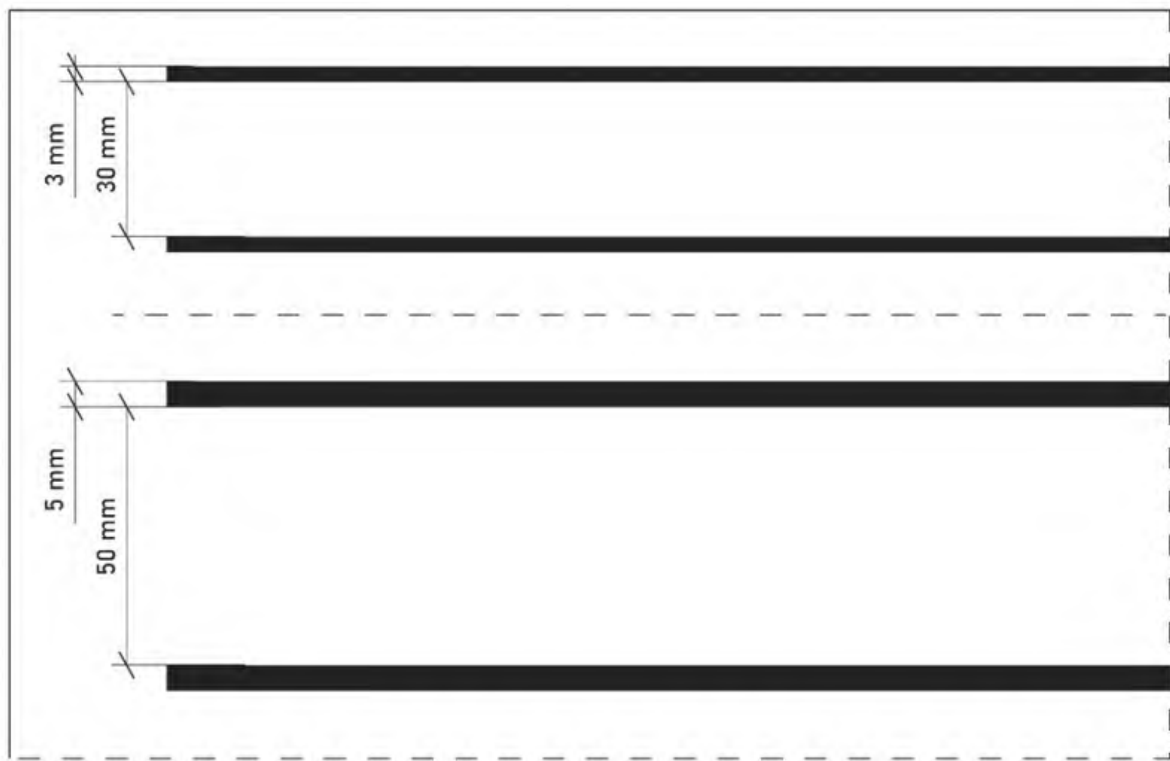


Annex 6: Vertical print, adhesive coating or mechanical treatment



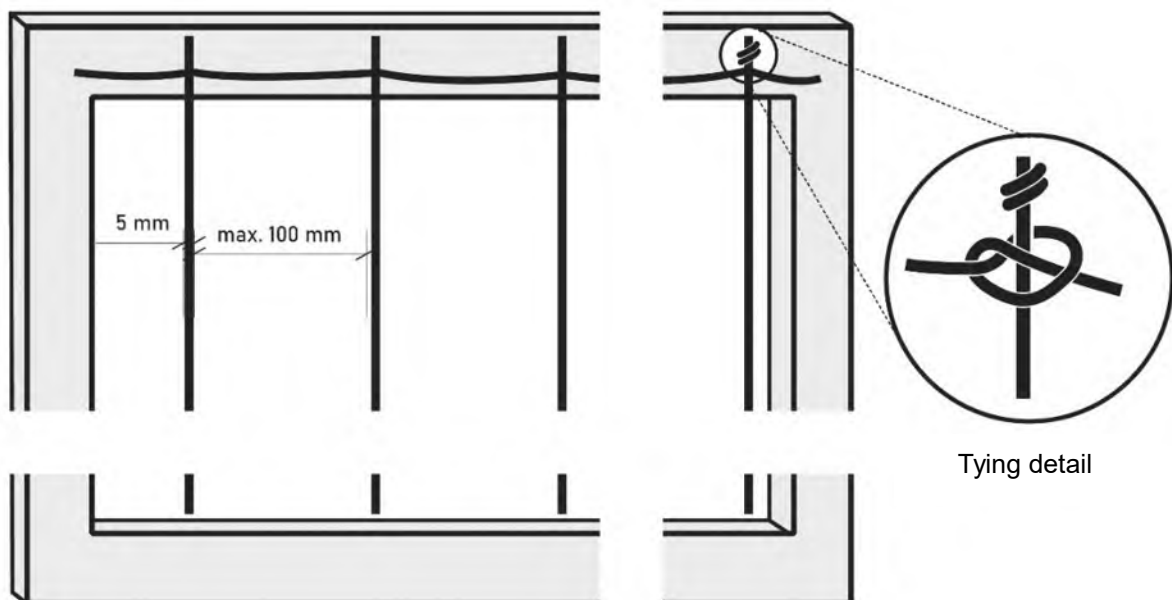
The minimum line thickness for vertical designs is 5 mm, the maximum spacing between lines is 100 mm.

Annex 7: Horizontal print or adhesive coating



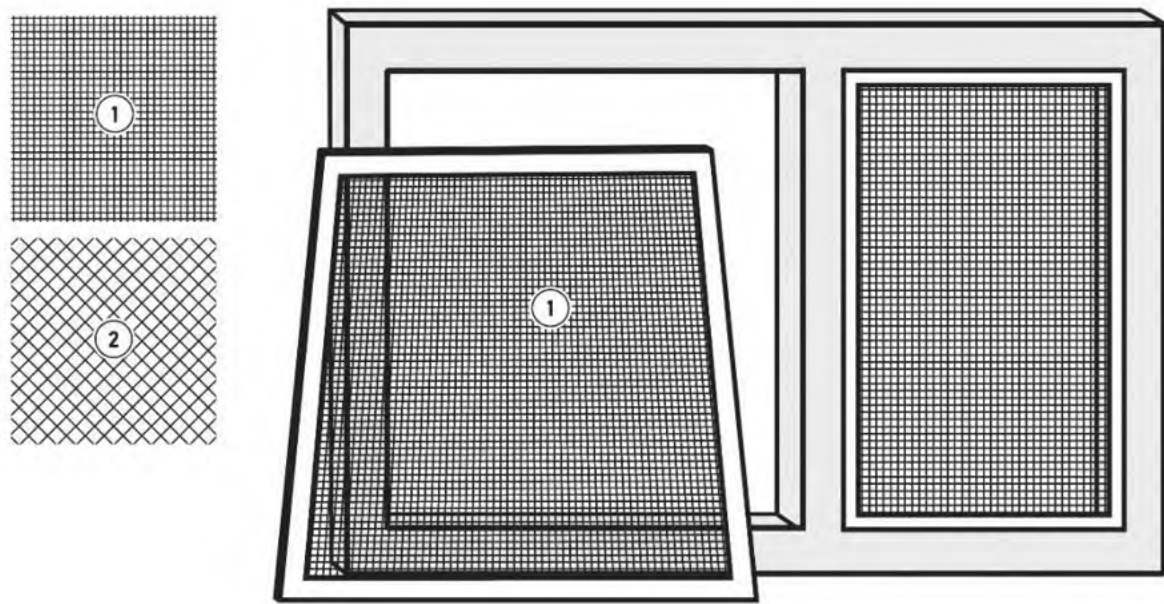
The minimum line thickness for horizontal designs is 3 mm, the maximum spacing between lines is 50 mm.

Annex 8: Hangings outside panelling



The minimum diameter of the material used is 5 mm, the maximum distance between hangings and window edges is 100 mm.

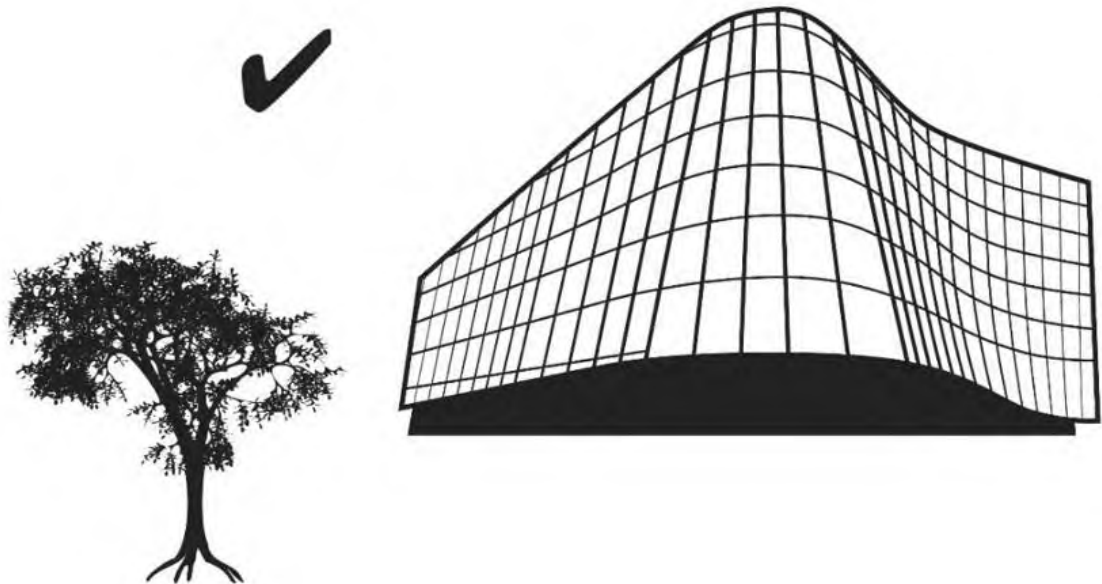
Annex 9: Protective netting outside panelling



1 - mosquito netting

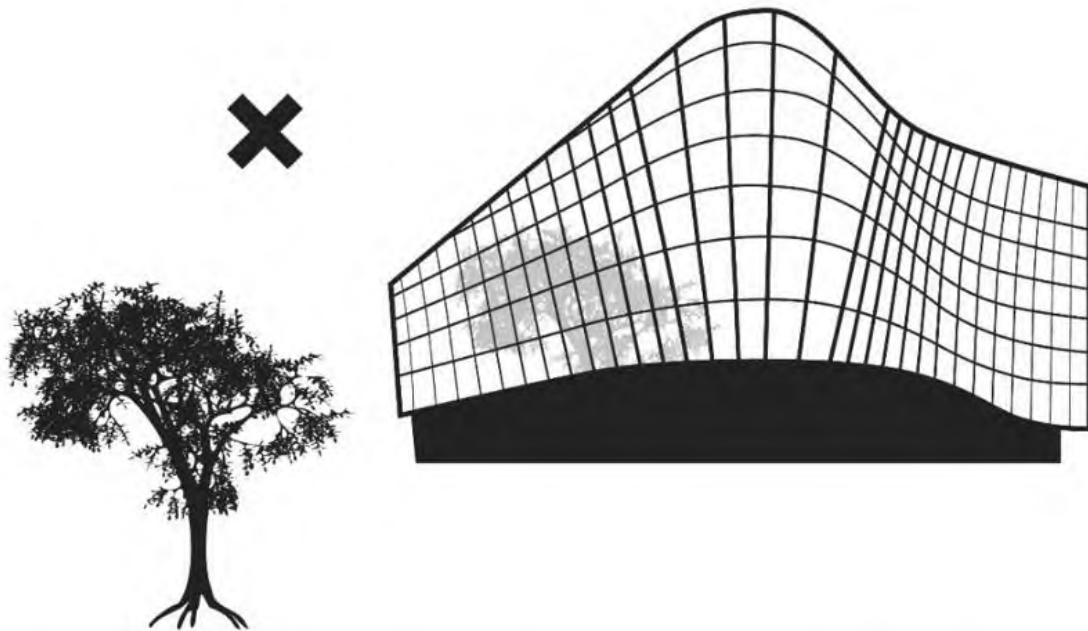
2 - netting with max. mesh size 20 mm

Annex 10: Slanting façades – correct implementation example



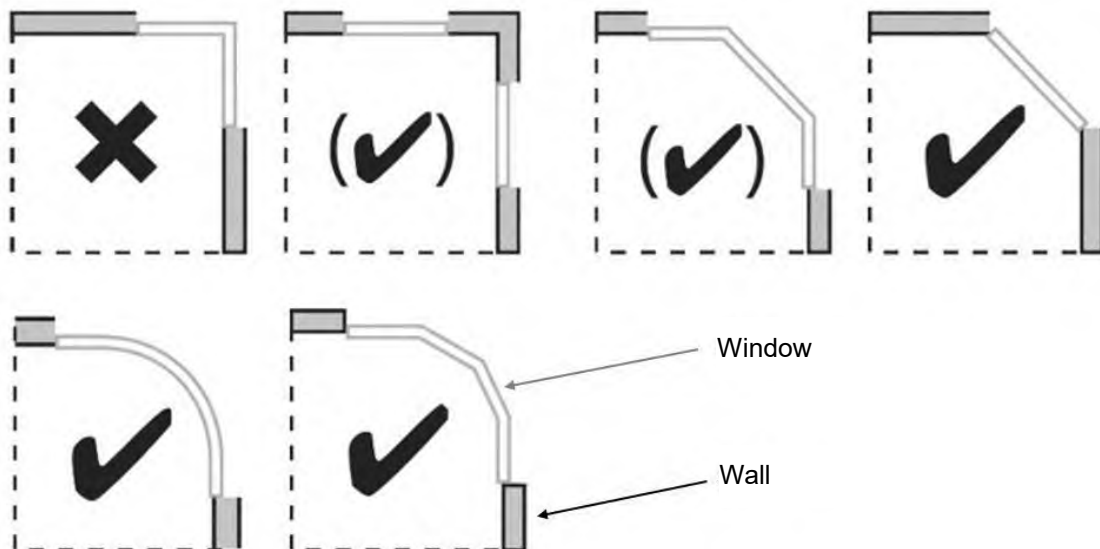
Receding façade does not reflect building surroundings

Annex 11: Slanting façades – incorrect implementation example



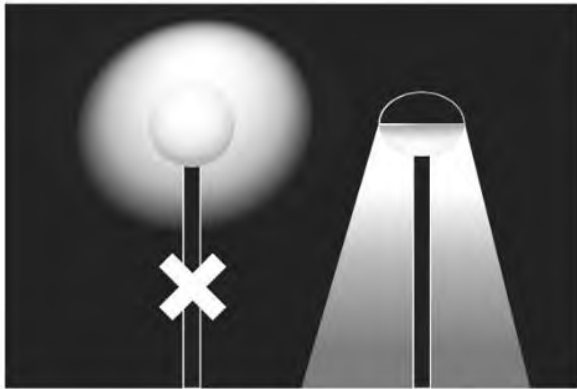
Overhanging façade reflects building surroundings and produces a dangerous virtual image

Annex 12: Window locations at building corners

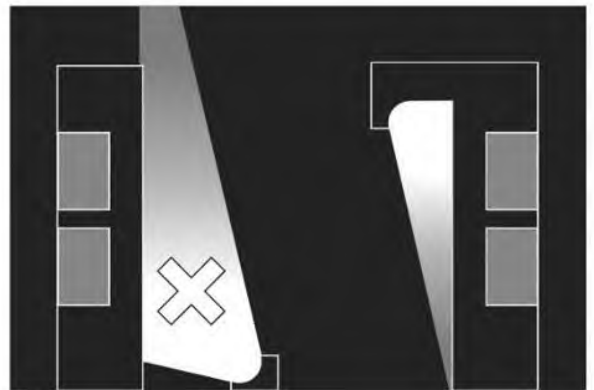


Reflective and, most importantly, transparent window panels should not comprise building corners. If necessary, the corners can be bevelled or rounded.

Annex 13: Exterior lighting of areas and façades All figures show side elevation.



The cone of light always points from the top to the ground and only covers the area for which it is intended.



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Kaplanova 1931/1

148 00 Praha 11

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