SLOPED vs. VERTICAL GLAZING

The Rationale for Clerestory Systems

Alberta Infrastructure

DESIGN & TECHNOLOGY SERIES **02**

The earliest skylights first appeared in Ancient Rome and consisted of an open circular hole at the top of a dome, known as an oculus. Since the Industrial Revolution, advances in glass manufacturing have allowed the widepread production and incorporation of skylights into designs of all types. *Design & Technology Series 02* uses the term *sloped glazing* as a general term to include skylights and larger glass roof installations.

Sloped glazing is used in projects for its dramatic architectural qualities and its ability to introduce natural light into a space. With these benefits come a number of drawbacks:

1. **Complexity:** Sloped glazing and skylight systems are deceptively complicated. Structural loads, thermal movement, air/watertightness and the intersecting joints between glass units must be carefully considered. The face-sealed nature of sloped glazing systems means that the exterior must be diligently maintained in order to prevent sealant failure. The inherent flaw with face-sealed systems is that water will inevitably enter an assembly, requiring drainage channels to divert water away from sensitive building materials.
2. **Thermal Efficiency:** Single and double-paned glazing offers very little resistance to heat gain and loss between the inside and outside of a building. Despite this, they are commonly used in sloped systems for their lightness (vs. triple glazing). Excessive solar heat gain in the summer may make certain spaces very difficult to work in without air conditioning. While heat gain is often desirable during the winter, low sun angles combined with long, cold nights minimize the contribution to passive solar heating. Significant heating may be necessary to maintain a comfortable interior temperature within a particular space. Additional heating and cooling loads may lead to increased energy use, costs and greenhouse gas emissions. The heat lost through sloped glazing, particularly in northern climates, can melt snow on the glass surface, where it can run downward until it strikes a cold surface and freezes. This ice build-up can become a serious structural, envelope, and in some cases, public safety concern.
3. **Moisture:** While a PERSIST assembly *(see Design & Technology Series 01)* provides redundant means of allowing water to escape from the building envelope, sloped glazing systems generally aim to keep water from penetrating their outer surface in the first place. Although the glass may be waterproof, the complex latticework of joints and sealants holding the panes together is not; once water enters the assembly, it is free to work its way into the building interior where it may damage finishes and affect occupant health. In humid spaces, airborne moisture may condense on cold glass surfaces, with similar consequences.
4. **Maintenance and Longevity:** By partially facing upwards, sloped glazing is more exposed to the elements than vertical glazing. Rain, hail, snow loads, dirt, and freeze thaw cycles shorten the lifespan of sloped systems considerably. Frequent inspection and maintenance of joints, sealants and glass is necessary for prevention of problems, and may result in greater tolerance and lifecycle costs when compared to vertical curtain wall assemblies.
5. **Light Intensity:** Direct sunlight can be a pleasant experience, or it can be an unwanted nuisance when its intensity and angle results in distracting brightness and glare. Exterior shading devices are often impractical for sloped surfaces, as they can collect snow, ice, and debris, while interior shades or other control

Daylighting and Renovations:

Where building alterations affect existing sloped glazing assemblies, Technical Services Branch (TSB) recommends:

1. **Early Input:** TSB can provide design and technical advice during project predesign. Risks can be identified and avoided, and options can be presented for study during schematic design.
2. **Clear Design Brief:** Existing sloped glazing should generally be replaced by vertical (clerestory) glazing, however some exceptions may exist (consult TSB). Provide consultant teams with a clear design brief explaining why vertical glazing is to be used, and why sloped systems are not appropriate.
3. **Light Studies:** As consultants migrate to Building Information Modeling (BIM), light studies can be provided that illustrate the implications of replacing sloped with vertical glazing. Basic "proof of concept" shadow studies, or in-depth photometric analysis may be done, based on project complexity.
4. **For More Info:** TSB's *Technical Design Requirements* provide building envelope and window details applicable to clerestory situations (link on next page).

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Before (sloped glass)

After (vertical glass)

Alberta Research Council, Edmonton

Technical Services Branch was consulted to provide input on the replacement of sloped glazing at the ARC building, as the system was at the end of its service life and was experiencing moisture and overheating problems. Additionally, the disciplined geometry of the facade demanded a careful solution that would reflect the design intent of the original architecture.

After considering several options, it was determined that a clerestory approach was the preferred solution. 3D lighting studies demonstrated that lighting levels would be better moderated without degrading the light quality in the space. The new flat roof incorporates properly designed roof drainage, while new vertical glazing prevents water ingress through the curtain wall assembly.

Triple glazed, low-e, gas filled units were specified for the south-facing wall. As a result, summer overheating and winter overcooling of the interior is no longer an issue. The ARC sloped glazing replacement project demonstrates how vertical glazing can successfully replace a skylight system while seamlessly integrating into the design of an existing building.

measures may be difficult to access. Both interior and exterior devices may obscure the skyward views that the glazing is intended to provide.

New Alberta Infrastructure facilities should avoid sloped glazing or skylight assemblies. AI recommends that vertical *clerestory* glazing be used in spaces requiring additional daylighting or special architectural treatment. Installed above eye level and allowing daylight deep into a space, clerestory systems avoid the complications of sloped assemblies while retaining their benefits:

1. **Complexity:** Because the clerestory is installed in a vertical wall (like a conventional window or curtain wall system), there is little risk of ice and water buildup. Avoiding roof penetrations reduces the likelihood of leaks into the building.
2. **Thermal Efficiency:** Curtain wall systems require basic structural consideration, as load paths are vertical (vs. sloped systems whereby loading is typically more complex). For this reason, it is easier to incorporate high-performance triple-glazing in clerestory applications without adversely affecting the structural design of the building or significantly reducing the size of each sealed unit. Vertical glazing can better collect passive heat gain from the low winter sun, and is easier to shade against excessive heat gain during the warm summer months.
3. **Moisture:** Vertical glass allows drainage of exterior moisture by gravity and includes means of directing water out and away from the window. Quality sealed units (e.g. triple-glazed, low-e, gas-filled) discourage condensation from occurring on the window in humid interior environments.
4. **Maintenance and Lifespan:** Since vertical glazing is not subjected to the same loading and exposure as sloped glazing, water and snow have less of an impact on the integrity of the assembly. Curtain wall systems can be well integrated into the air/vapour membrane of a PERSIST envelope that is designed to direct moisture out of the wall assembly. This resilience contributes to the longer lifespan of vertical glazing.
5. **Light Intensity:** Shading devices such as louvres, overhangs or decidious trees can easily be incorporated into the design to modulate interior light levels. Reflective surfaces inside or outside the clerestory can amplify and direct the incident light.
6. **Ventilation** - Installing operable clerestory units can provide free room cooling. Stack effect due to warm/cold air stratification permits cross ventilation (with low air intake, high exhaust locations), thus reducing air conditioning costs and GHG emissions.

In some rare cases, the architectural, historical or social importance of an existing building may warrant the replacement of sloped glazing with a similar design. In these instances, Technical Services Branch should be contacted as early as possible in order to assist in the identification of risks and alternatives, and to provide designers with advice to help minimize adverse consequences.

Information Sourced From:

http://www.infrastructure.alberta.ca/Content/docType486/Production/TechDesignRequirements.pdf

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