Point-Supported Glazing

Architectural glass that is monolithic, laminated, or insulating has traditionally been supported by capturing the edges of the glass. As architects have expressed their desire to make the walls of buildings more transparent, engineers have developed methods to reduce the amount of framing required to support the glass. In recent years, especially in Europe, it has been increasingly popular to attach the glass to the structure using fittings directly connected through holes in the glass or with fittings through the joints between the glass. These fittings allow improved transparency and offer additional architectural opportunities in the detailing of the bolted connections.

Performance Considerations
One of the complexities of glass structural performance, as opposed to steel or other metals, is glass does not always fracture at the point of maximum stress. Experimental testing has produced a “failure prediction model” which takes into account the random nature of the location of surface damage or flaws that determine the “break origin” of in-service glass. ASTM E1300-16, Standard Practice for Determining Load Resistance of Glass in Buildings, uses this “failure prediction model;” however, it does not address glass with holes and notches. Architects wanting to incorporate a point-supported glass façade or canopy in their design need to seek out engineers who are familiar with the use of glass as a structural material. These specialists have studied the experimental statistical analysis data and the breakage probability theories that form the basis for failure prediction models. They are then able to determine the glass thickness required for the size of glass lites, and the applicable code designated design loads; based on the usage of the glass, and its location on the building. The safety factor issues and the breakage probability calculations necessary when designing a structure using a brittle material like glass must be understood by those designing point-supported structural glass canopies, skylights, guard rails, hand rails and façades.

In addition to glass strength, deflection performance is an important design consideration. If the glass lite deflects laterally by more than half its thickness, large deflection, non-linear plate theory must be used when analyzing the performance of the glass. Finite element analysis is often required to determine the amount of stress and deflection of the monolithic tempered or laminated glass lite. The movement capabilities and limitations of each hardware connection system must be taken into account. Deflection of the glass lite under load causes the relative
distance between the point supports to decrease. Allowance for this motion must be designed into the supporting fittings by using, for example, oversized holes or slotted connections. The designer must limit the glass deflection under load by specifying thicker glass or altering the position or number of supporting points because the increased flexural strength of the glass does not change its stiffness. Accurate values for the interlayer properties are needed for finite element analysis of point-supported laminated glass. These properties are dependent on temperature, interlayer type, and load duration. The effective thickness of laminated glass is less than the actual thickness of the laminated unit and it should be calculated based on the procedure outlined in ASTM E1300.

**Hardware**

Point-supported hardware is supplied by several manufacturers. Typical hardware includes a simple bolt and patch plate system, a simple countersunk bolt, hardware with flexible washers and gaskets within the supporting structure, and hardware with articulated bolts. All of these hardware systems have been successfully used for façade and canopy structures. Hardware manufacturers often do not make recommendations regarding glass thickness, distance from the hole to the glass edge, and maximum distance between point connections. The structural glass must be designed and fabricated properly to be compatible with the specific hardware system specified. The amount of stress in and around the holes in the glass will vary depending upon the location and size of the clamping hardware, and the load and geometry of the glass lite. Glass holes and notches as a minimum (IE structural designs may require more conservative approach to hole and notch locations) shall be designed and fabricated in accordance with the guidelines established in ASTM C1048 Standard Specification for Heat Treated Flat Glass (not everyone agrees that this is always true).

**Applications**

Point-supported glass is used in two distinct applications: vertical glazing and sloped/overhead glazing. Vertical glazing can use monolithic or insulating glass units of tempered glass or heat-treated laminated glass. Sloped glazing and overhead canopies require heat-treated laminated glass. The fundamental difference between sloped/overhead glazing and vertical glazing is that sloped/overhead glazing is subject to a permanent gravity load from its self-weight and, possibly a long-term snow load and/or load from maintenance personnel.

**Vertical Façade Applications**

Vertical façades can be floor-loaded, stacked (floor loaded and stacked kind of mean the same thing) or suspended. The dead load of the glass for high vertical walls can cause lateral buckling of the lites if they are stacked too high. Façade systems above a certain height, as determined by the hardware and glass specifics, will need to be suspended from above.

It is most important that the façade designer has a clear idea of how the whole structure will behave under all imposed loads, including wind, seismic, and blast loading. Because façade designers do not usually have the responsibility for the building structural design, they must be certain that the exterior loads imposed on the structure by the façade can be accommodated (I am not sure how you do this, typically loads are provided to the EOR for the building and he does
Deflection and construction tolerances must be incorporated into the façade design and connections to the building structure. The differential deflection of adjacent structural elements to which the glass is attached should be taken into account to allow for this movement within the perimeter framing of the glass opening and to maintain adequate bite and engagement. Vertical downward deflection of roof trusses due to snow load or other dead loads can transfer undesirable vertical loads to the edges of the glass façade if sufficient edge clearance is not provided in the perimeter design. Downward deflection of the floor supporting the system or upward deflection of roof trusses (especially in high wind areas) may cause disengagement of the glass.

It is very important to assess the safety implications of glass breakage and associated risk of injury from falling glass. Design redundancy must be used to avoid or greatly reduce the possibility of progressive collapse of the point supported system should one element fail.

**Sloped and Overhead Applications**

Glass canopies and roofs are more susceptible to impact from falling objects and thrown objects than vertical glass. Overhead glazing is more likely to fall from the opening when it breaks than is vertical glass. Most building codes require laminated glass for sloped glazing in order to retain the broken glass fragments or heat treated glass with mesh screening beneath the glass to prevent the broken glass from falling on persons below in the event of breakage.

The dead load of the glass is applied permanently and the snow loads may be imposed on the glass for long periods of time, requiring the lower long term strength of glass be used as the design strength, rather than the short term strength used for wind load. Snow drift loading must be included in the calculation as it can often be several times the magnitude of the ground snow load. Flat roofs or canopies may also be susceptible to water ponding if the glass deflection under gravity load is excessive. When designing laminated glass for sloped glazing, the interlayer properties for long duration loading should be used.

**Conclusion**

The reduction or elimination of the visible barrier between the outside and the inside of buildings is a growing desire of architects. This trend means bigger openings in a building and fewer impediments to the outside view. Point-supported glass is one solution to this demand.

The Glass Association of North America (GANA) is publishing this information regarding point supported glass in order to educate glass suppliers and users about some of the design considerations necessary for assuring proper, safe use of this popular means of achieving greater wall transparency. GANA encourages architects, structural engineers, building officials, building owners, glazing contractors, and glass fabricators to become more aware of some of the limitations as well as the benefits of using point supported structural glass.

Consult the GANA website ([www.glasswebsite.com](http://www.glasswebsite.com)) for additional information on glass and glazing applications and links to members providing additional technical resources.
Quick-Reference Guide to Point-Supported Glass

- Do - use tested systems. (The glass and hardware system should be tested to provide data as to its ability to withstand both vertical and horizontal loading as required by the application. Some systems have been tested only for vertical façades and some for both vertical and sloped applications. This information should be provided by the manufacturer to the design engineer for his use in the required structural calculations.)
- Do - use engineers familiar with structural glass design.
- Do - when using overhead laminated glass or glass that support vertical or horizontal loads), design the glass using interlayer and glass properties and long term loading when calculating the glass thickness
- Do - consider consequences if one or more lites should break
- Do - understand the limitations of the system
- Do - involve the glass engineer and glass fabricator early in the design stage
- Do - allow the glass to flex under load, but control the amount of deflection
- Do - recognize the limitations of alignment of heat treated laminated glass, both edges and holes and tolerances in all materials used in the system.
- Do - consult the laminated glass interlayer supplier for interlayer properties for use in calculations

- Don’t - use rigid interior connection systems (Rigid can mean something else in engineering) in exterior applications. Maybe put this in the DO list as allow system to move with temperature, and provide adequate room within or around the system for building movements.
- Don’t - approve engineered systems that you don’t understand

The Glass Association of North America (GANA) has produced this Glass Informational Bulletin solely to provide general information as to identify issues related to point-supported glass applications. The Bulletin does not purport to state that any one particular type point-supported glass process or procedure should be used in all applications or even in any specific application. The user of this Bulletin has the responsibility to ensure the design, engineering and installation guidelines from the system supplier(s) are followed. GANA disclaims any responsibility for any specific results related to the use of this Bulletin, for any errors or omissions contained in the Bulletin, and for any liability for loss or damage of any kind arising out of the use of this Bulletin.

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