

Glass Floors and Stairs

Introduction

Glass floors and stair treads are found in both residential and commercial settings, and are growing in popularity because of their aesthetic appeal as well as for the daylighting benefits they bring to a space. While there are manufacturers that provide engineered and tested flooring systems, most glass floor and stair tread projects require the input of a structural engineer to provide load calculations and to provide glazing details. Also, it is recommended that an experienced glazer review the support conditions and waterproofing system if it is an exterior application.

There are many other variables that should also be considered. Some of these are listed below.

Combining Loads

The design of glass floors and stair treads typically calls for load calculations. Those calculations are typically the responsibility of a structural engineer. The load requirements are taken from the applicable building code or, if none, from the American Society of Civil Engineers¹ (ASCE) Standard 7 - *Minimum Design Loads for Buildings and Other Structures*, depending on the jurisdiction. The glass is subject to static uniform loads which may include live, snow, and dead loads, and point loads. These are usually prescribed by the jurisdiction and are particularly necessary when designing floors, stair treads and other special situations.

Careful consideration should be given to unusual loading, or dynamic impact in conditions such as dance floors.

Typically glass floor or stair treads are designed to support the applied loads with any one layer of the glass assembly broken. Glass is by nature a brittle material and surface damage can occur by impact from hard objects, which can greatly reduce the load carrying capacity. Redundancy and suitable safety factors must be used in the design of glass flooring. Glass floors are typically supported on all four sides. Stair treads are typically supported on two sides. The edge support conditions (usually the number of sides, but also other variables) need to be understood in order to determine the load-carrying capabilities of the glass.

ASTM² E2751 *Standard Practice for the Design and Performance of Supported Glass Walkways* contains calculation and testing methods applicable to the design of glass walkways constructed with laminated glass. This standard assists the designer in better understanding the elements related to performance, design, and safe behavior of glass walkways that include interior and exterior walking surfaces constructed and intended for pedestrian use, including floors, ramps, sidewalks, and stair treads.

Choosing the Glazing

Laminated glass products are typically used in floors and stair treads. Laminated glass is defined as two or more pieces of glass bonded together with an interlayer. The glass may be annealed, heat- or chemically-strengthened or fully tempered.

Providing Slip Resistance

Slip resistance of a walking surface is an important safety consideration. The Occupational Safety and Health Administration³ (OSHA) requires a minimum slip resistance, expressed as a static coefficient of friction, of 0.50. ASTM E2751 also notes a minimum static coefficient of friction of 0.5 for walking surfaces under dry conditions. However, special situations such as dance floors, sloped walkways and wet conditions may require a different level of slip resistance. Using a dynamic coefficient of friction that reflects an object in motion is typically more appropriate for these situations.

There are a variety of recognized test methods that measure slip resistance using specific test equipment under dry or wet conditions. Some of these are:

- ASTM E2751 - *Standard Practice for Design and Performance of Supported Laminated Glass Walkways*
- ASTM F609 - *Standard Test Method for Static Slip Resistance of Footwear, Sole, Heel, or Related Materials by Horizontal Pull Slipmeter (HPS)*
- ASTM C1028* - *Test Method for Determining the Static Coefficient of Friction of Ceramic Tile and Other Like Surfaces by the Horizontal Dynamometer Pull-Meter Method*

*Note: ASTM C1028 has been withdrawn since the publication of this document. It is still referenced for historical purposes.

- ANSI/ASSE TR-A1264.3-2007 - *ANSI Technical Report, Using Variable Angle Tribometers (VAT) for Measurement of Slip Resistance of Walkways*
- ANSI A137.1 *Tile Slip Test*
- ANSI A326.3 *Tile Slip Coefficient Test*
- UL 410 *Standard for Safety for Slip Resistance of Floor Surface Materials*

Other industry standards, such as ASTM F1637 *Standard Practice for Safe Walking Surfaces* and ASTM F1646 *Standard Terminology Relating to Safety and Traction for Footwear* address the safety issues of walkway surfaces from a more general point of view.

Processes designed to roughen the top surface of the glass to provide slip resistance include sandblasting, acid-etching, ceramic frit, embossing and others. It is important to note that sandblasting may reduce the strength of the glass by as much as 50%; therefore, glass flooring with surface treatment should be accounted for in the engineering analysis.

Considering Modesty

Modesty becomes an issue when glass floors are found on upper levels and inappropriate lines of sight are created from spaces below. When modesty is a concern, it may be necessary to incorporate acid etch, a ceramic enamel finish, a decorative or translucent interlayer, or glass material to create obscurity.

Testing

Glass floors can be tested for strength according to ASTM E2751 *Standard Practice for Design and Performance of Support Glass Walkways*.

Installation

Any sealant or caulking that is used must be checked for compatibility with the glass flooring. The framing and supports for glass floors comprised of laminated glass must provide drain holes or weep systems to avoid the possibility of water or cleaning fluids building up in the system. Sealants used in a flooring installation should consider the size of the joint, size tolerances of glass, the expansion and contraction of the support system, caulking requirements, moisture management, and other site-specific conditions.

Fire Resistance

Glass floors are not typically fire resistant. Fire-rated glass suppliers offer flooring systems with up to 2-hour fire-resistance ratings for interior and exterior applications. Fire-rated glass floors block radiant and conductive heat and provide a barrier to fire and smoke. The walking surfaces are tempered, laminated glass combined with fire-resistance rated glass, supported by steel fire-resistant structural framing. Fire-rated glass floors are safety impact rated, load bearing, and can be made opaque using decorative frits or sandblasting without affecting the fire rating.

Maintenance

Glass floors should be regularly inspected for damage, as impact from hard objects can crack the upper surface. Any damaged glass should be replaced as soon as possible. Cleaners, polishes and other materials used for the adjacent floor surface maintenance may change the coefficient of friction, or damage the caulk or other sealants, and should be avoided. Contact the manufacturer or fabricator for compatibility testing and cleaning instructions.

Conclusion

Glass floors and stair treads are aesthetically appealing and beneficial as a way of bringing additional light into a space. These systems are used in both commercial and residential spaces and require careful attention to engineering, installation, and pedestrian safety. All parties are alerted to the potential of liability for consequential damages.

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² ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959 United States, Phone: 610.832.9500; Website: www.astm.org

³ Occupational Safety & Health Administration, 200 Constitution Avenue NW, Washington, DC 20210 United States, Phone: 800.321.6742; Website: www.osha.gov

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