Glass Construction Defects

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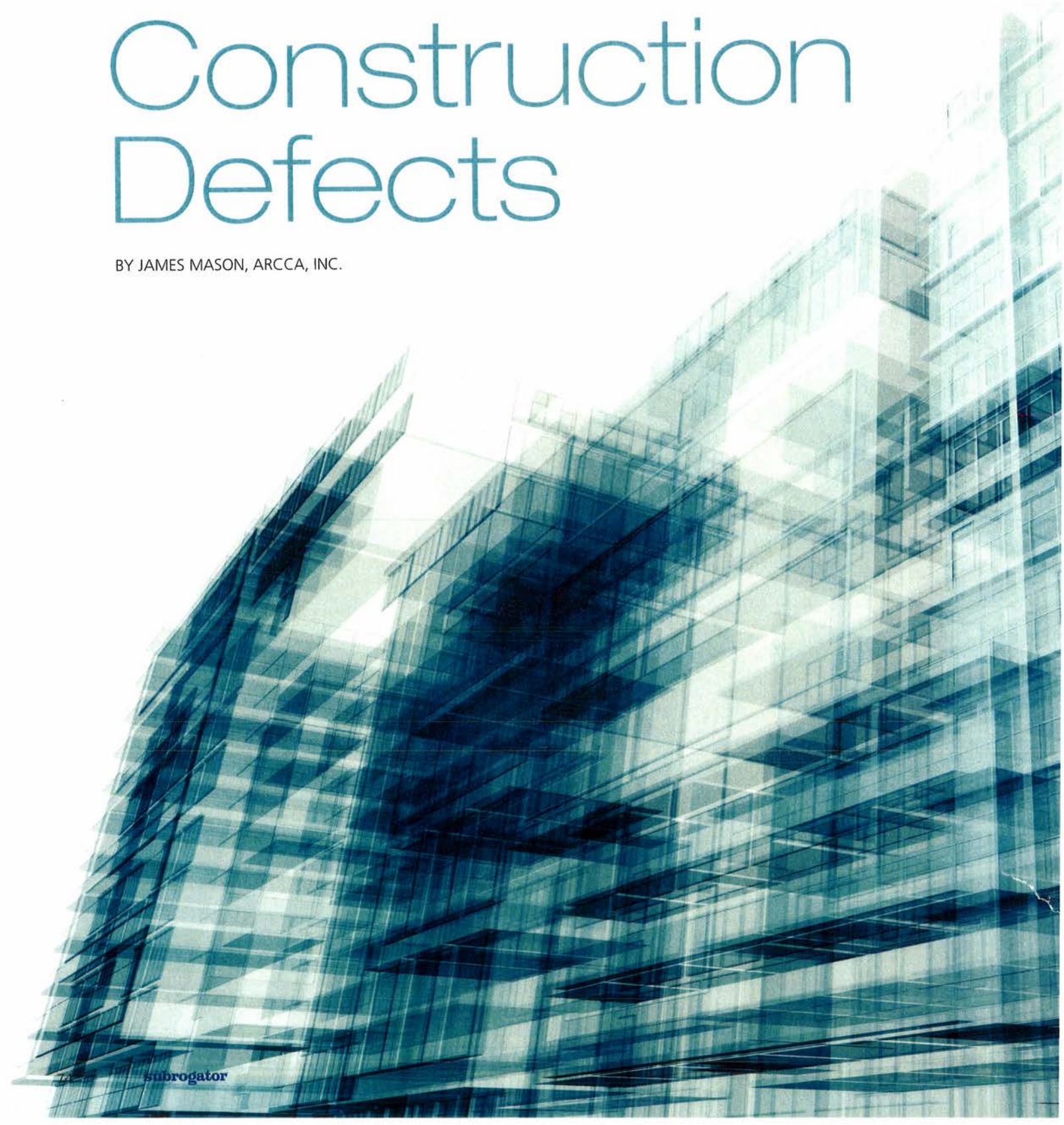
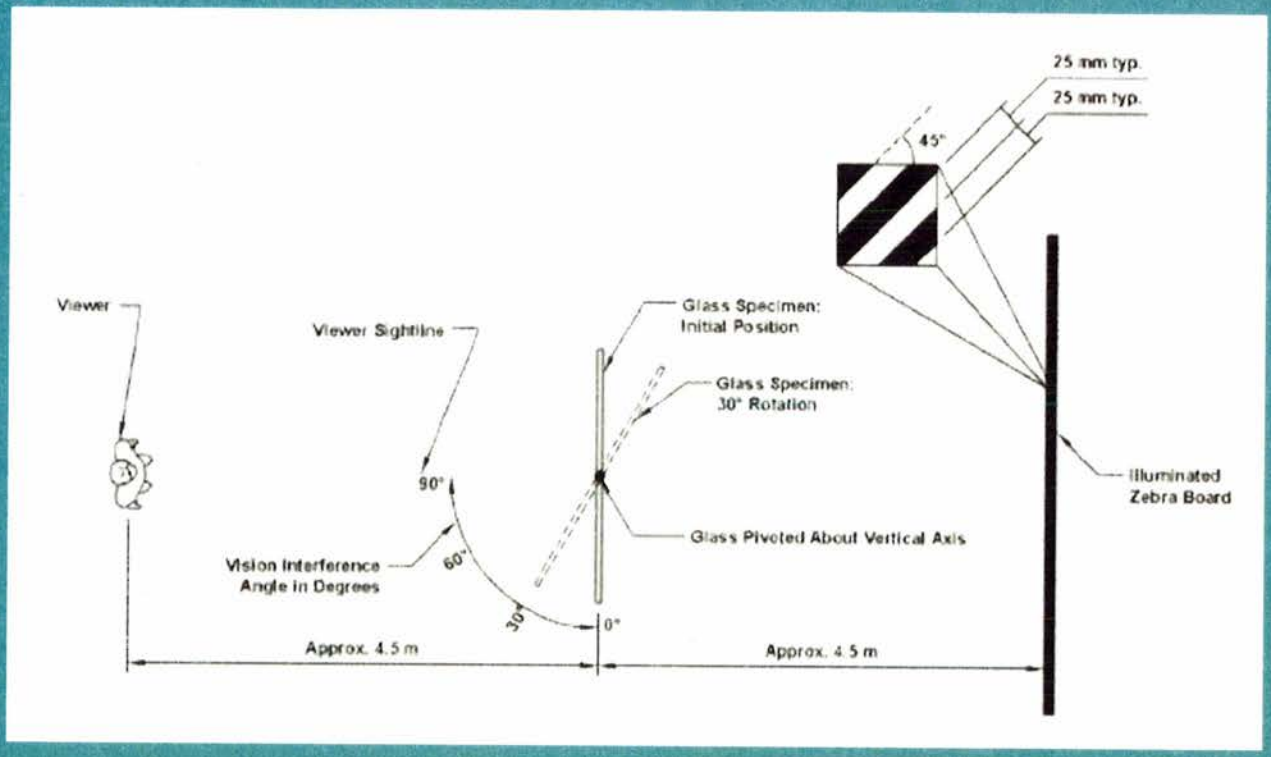


GLASS,

as a material, is often taken for granted. With the advent of Pyrex, safety glass, and laminated glass, we often forget that glass is a brittle ceramic that can be damaged during storage, installation or cleaning.

We forget that glass is inherently imperfect and cannot always be produced without blemishes or irregularities. Finally, we forget that glass must be given special consideration, when compared to other construction materials, when shipped, stored, handled, or installed. This can lead to any number of construction defects involving glass.

First, it should be noted that because glass is inherently imperfect, the quality requirements noted in the "Standard Specification for Flat Glass," (ASTM C1036) are largely based on blemish tolerance levels. That is, a host of different blemishes, such as shell chips, v-chips, distortions, knots, dirt, stones, crush, gaseous inclusions, scratches, rubs, and digs are identified, as well as the allowable levels of tolerance, or allowable size and distribution.



As described in the standard, inspection of glass is performed visually under strict guidelines as illustrated in Figure 2 of ASTM C1036, shown above.

Note that the viewer is to stand approximately 39 inches from the glass and that the light is to be uniform diffuse light. This type of light is specifically NOT direct sunlight. Often times, when a complaint is made of a defect in glass, it is only visible under direct sunlight up close. According to the standard, such a blemish is acceptable, which raises the point that is most often at the center of construction defect cases involving glass. Even though the glass is acceptable according to ASTM C1036, is it acceptable to the complainant? Often times, particularly in high-end, luxury construction, the glass passes ASTM C1036 but is deemed unacceptable by the building owner. Therein lies the battle. Each complaint has to be resolved by the parties involved and resolution may depend on contracts, promises of quality, or the various desires of the parties involved.

So, where do glass blemishes come from? There are several causes.

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MANUFACTURING

Glass can be manufactured with defects. Defects related to the manufacturing are often easily identified. Bloom, exit end scratches, open bottom bubbles, bath stones, tin oxide, top drip and tin pickup can all be traced to the tin bath process used to produce plate glass. Optical distortion of images when viewed through glass is related to variation in the glass thickness and is, of course, related to manufacturing. Changes in thickness as little as 0.00005 inches can cause optical distortions. One type of manufacturing defect that frequently gets mentioned, whether it's relevant or not, is a nickel sulfide (NiS) inclusion.

Toughened safety glass, which is used on balconies, unframed assemblies, structurally loaded glass, or other safety critical applications, is typically tempered to make it stronger and to make it shatter into small pieces that are less likely to lacerate. Think of the side windows on an automobile. This type of glass is actually required by some building codes in the United States for certain applications. Tempering of glass involves heating the glass above its melting temperature. The glass is then rapidly cooled with forced air so that the outside solidifies first, while the inner portion remains liquid-like. Because solidification involves a decrease in volume, this results in the outside surface being left in residual compress and the inner space being left in residual tension. The residual compression on the outside surface resists cracking, making the glass stronger. However, the inside is made

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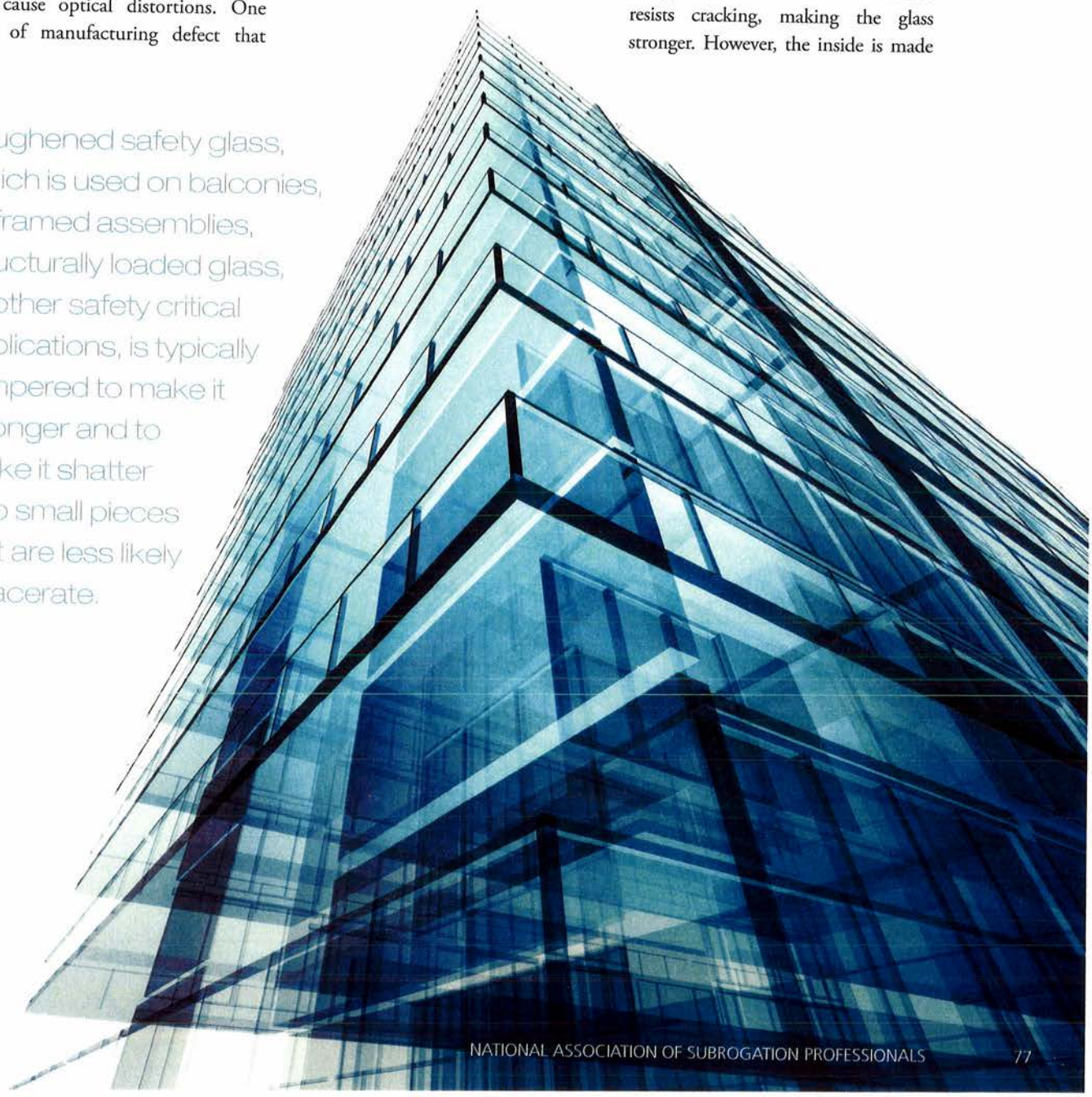
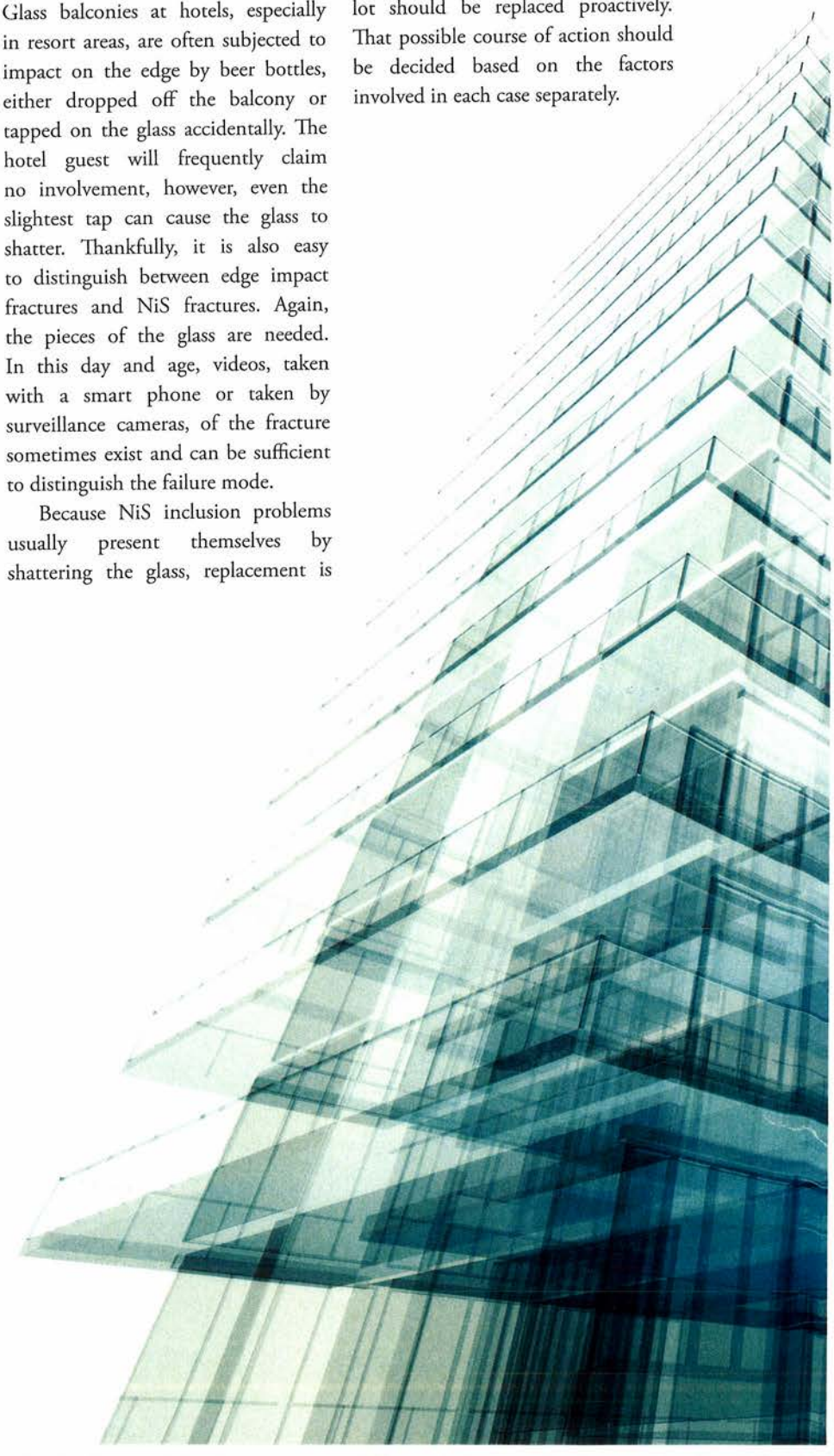


weaker in this process. If any blemishes, inclusions, or stones are in the interior, due to a problem with manufacturing, the glass could be weaker.

The most notable manufacturing defect in tempered glass is Nickel Sulfide (NiS) inclusion. Inclusions are materials that are accidentally introduced into the glass, early in the manufacturing process. Most are harmless; NiS is the exception and then it is only a problem when it is found inside tempered glass. Because the inside of tempered glass is in constant tension, a NiS particle found there is in tension as well. Over time, that particle can crack and the crack in the particle can grow into the glass. At some point, the crack in the glass reaches a critical size and, in engineering terminology, it becomes unstable and grows rapidly. In normal language, the glass panel shatters. This can be quite concerning to someone standing next to the panel at the time. Typically, befuddled witnesses say, "I wasn't doing anything to the glass and it just shattered!" Thankfully, it is easy to identify a NiS fracture if the pieces of the glass are retained.

Manufacturers are well aware of NiS and take great pains to eliminate nickel in the production process. (Sulfur is often used in the manufacturing process.) Alloys that include nickel are shunned and glass furnaces do not use fuels that contain nickel. The problem with NiS inclusions is that any time a seemingly spontaneous fracture occurs, NiS is immediately proposed as the problem, in a knee jerk type reaction. Tempered glass can shatter by other mechanisms. For example, it is very sensitive to shattering due to impact on its edge. Glass balconies at hotels, especially in resort areas, are often subjected to impact on the edge by beer bottles, either dropped off the balcony or tapped on the glass accidentally. The hotel guest will frequently claim no involvement, however, even the slightest tap can cause the glass to shatter. Thankfully, it is also easy to distinguish between edge impact fractures and NiS fractures. Again, the pieces of the glass are needed. In this day and age, videos, taken with a smart phone or taken by surveillance cameras, of the fracture sometimes exist and can be sufficient to distinguish the failure mode.

Because NiS inclusion problems usually present themselves by shattering the glass, replacement is the obvious mitigation. The difficulty comes in determining whether remaining glass panels produced by the same manufacturer or in the same lot should be replaced proactively. That possible course of action should be decided based on the factors involved in each case separately.



INSTALLATION

Although it may be surprising, because glass is often installed with direct exposure to the elements, glass should typically not be stored outdoors before being installed, where it is susceptible to exposure to rain or snow. As some artists will tell you, glass can be etched. In some locations, rain or snow can be acidic and can soak the cardboard in direct contact with glass or can collect in pools on the glass, resulting in etching. One might think the glass is fine because it was intended to be used outdoors; however, it was intended to be installed vertically outdoors, so that it can dry quickly and avoid prolonged exposure to water, and it was intended to be installed without constant contact with wet material, such as packing cardboard or other absorbent materials.

One of the most common installation issues with glass is scratching. While some scratching is allowed under ASTM C1036, as mentioned above it is frequently not tolerated by end users of the glass. Scratching can happen during shipment, so the quality of the glass should be noted upon receipt or at least right before installation, or it can happen after installation. Often, glass is installed prior to the finishing work both on the interior and the exterior of the building. The finishing work can involve all sorts of foreign materials that accidentally adhere to the glass, including wallboard joint compound, stucco, or paint. In some instances, a temporary strippable protective material is applied to the glass to prevent adherence of wallboard joint compound, stucco, or paint. Scratching is commonly not related to the addition of foreign materials to the glass. Rather, it is the removal of such materials that causes the scratching. While glass is a ceramic, its hardness is often less than steel, particularly hardened steel used in tools. Thus, a chipped or dull putty knife can scratch the glass in the hands of an unskilled or untrained worker. On construction sites, it is often thought that scraping paint, etc. off glass is unskilled work, and as a result the unskilled worker scratches the glass causing significant damage. In some

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cases, routine cleaning by contracted window cleaners can cause scratching. Although, this is the exception rather than the rule.

If scratches are the center of the construction defect claim, an inspection following the method outlined in ASTM C1036 should be performed so that it can be determined whether the glass meets or exceed the standard. If it does not meet the standard, mitigation will be either replacement or polishing, as described below. If it does meet the standard, the parties must decide on the course of action.

The mitigation of scratches can be costly. Some experts will only recommend replacement. In recent years, scratch removal by polishing has improved to the point of being a viable option. In this case, the glass is polished with a coarse abrasive material to remove the scratches and is then polished with successively finer abrasive material to make it optically clear. In some cases this is a less costly option. However, it can be very messy and, since scratches are often 0.001 inches deep, or more, it can result in optical distortion. The pros and cons of scratch repair should be discussed thoroughly before choosing it over window replacement.

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AGING

As noted above, glass is often exposed to the elements during its lifetime. Many unusual circumstances can lead to the aging of glass to the point of a failure to perform its many duties. Most notably, double paned, or insulated glass (IG), can have a finite lifetime. The common complaint with IG is fogging of the glass on the inside surfaces, which leads to an obstruction of vision. Technically, this is not a defect in the glass material itself; it is caused by the condensation of chemicals or water on the inside surface, where it is inaccessible for cleaning by the end user. The chemicals can be produced by outgassing from materials inside the cavity between the double panes due to high temperatures generated by direct sunlight, or they can be produced by leaks developed into the cavity between the double panes by aging or degradation of the seal on the panes.

The cavity between double panes in IG is typically sealed in the factory. Sometimes the cavity is vacuumed out, sometimes inert gases are backfilled into the cavity, and other times moisture absorbing materials may be added, out of sight. Then, the cavity is factory sealed to prevent the entrance of moisture or chemicals during shipping, installation, or use. In all cases, these measures are taken to increase the insulating properties of the glass and/or reduce fogging potential. Most manufacturers warrant their glass against an obstruction of vision, like fogging, for a period of time anywhere from five years to a lifetime. And, there are several standards, for example ASTM 2189, specifying testing for determining the fogging potential of IG.

If a complaint of fogging of IG occurs, it is imperative that the manufacturer's warranty be checked first. If the IG is beyond the stated term of the warranty, it will be difficult to prove a defect. If the glass is within the warranty period, an inspection should proceed to determine the chemical makeup of the deposited material causing the fogging and to identify its source, whether that be due to manufacturing defect or leakage. Once that is completed, the responsible parties are often easy to identify. Replacement is the common mitigation.

SUMMARY

Since the beginning of the 20th century, glass has found many uses in construction, from windows, to facades, to load bearing structures. In all applications, construction defects can result from the use of glass. Some of the more common defects have been discussed here, but there are many more. Because of its unique properties, when compared to other construction materials, glass can require special handling and the hiring of uniquely skilled workers. Likewise, in the investigation of a construction defect involving glass, an expert with specific knowledge of glass is required.