Optical Distortion in Laminated Glass with Heat-Treated Glass Substrates

Laminated glass is a high-performance safety material created by bonding a plastic interlayer between two or more glass panes under heat and pressure in an autoclave. This process results in a durable composite that, if broken, helps retain glass fragments, significantly reducing the risk of injury and property damage. It's commonly used in openings where enhanced safety, security, sound control, UV filtering, or hurricane impact-resistance are required.

Using heat-treated glass (heat-strengthened or fully tempered) in lieu of annealed glass offers several benefits over standard laminated glass since heat-treated glass is stronger than annealed glass. Heat-treated laminated glass provides an opportunity to offer larger window sizes to meet wind load requirements without having to use thicker annealed glass. Heat-treated glass also reduces breakage potential from thermal and bending stresses. Although heat-treated glass does offer potential advantages over annealed glass, heat-treating can also result in properties such as roller wave, bow, warp and kink, which often results in visible distortion, (*see Figure 1*).

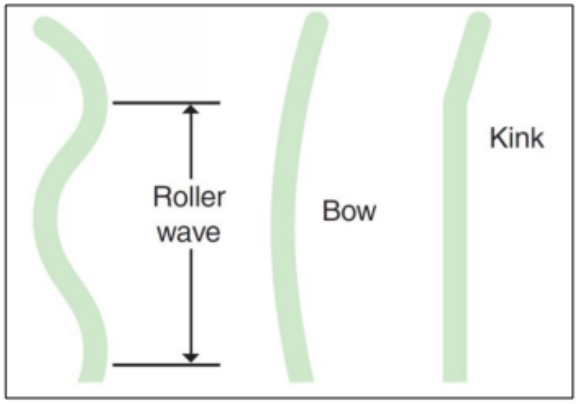

Figure 1 - Heat-treated glass distortion nomenclature

Visible distortion in heat-treated glass when used monolithically or incorporated into insulating glass units is detectible, but seldom aesthetically objectionable. Using heat-treated glass as a substrate when laminating typically results in a great degree of visible distortion due to the lens effect of having the glass surfaces out of phase or non-parallel when bonded together in the laminated glass make-up (*see Figure 2*). This lens effect can result in a magnification of objects when they are viewed through the glass in transmission as well as when viewing reflected images.

Visible distortion is an inherent and expected characteristic of heat-treated glass. This distortion, whether viewed in transmission or reflection, can become more pronounced when observed at angles other than directly perpendicular (90°) to the surface, the more acute or obtuse the viewing angle, the greater the perceived distortion. Standard viewing guidelines per GANA, call for inspection of the glass to be perpendicular to the surface (90°), not at angles.

Because of the above-mentioned distortion concerns, Manko recommends that annealed glass laminates be used in lieu of heat-treated laminates whenever possible, unless heat-treated glass is required to meet extreme conditions (i.e. high wind loads or thermal stress conditions). Annealed glass laminates will lessen distortion but will not completely eliminate distortion.

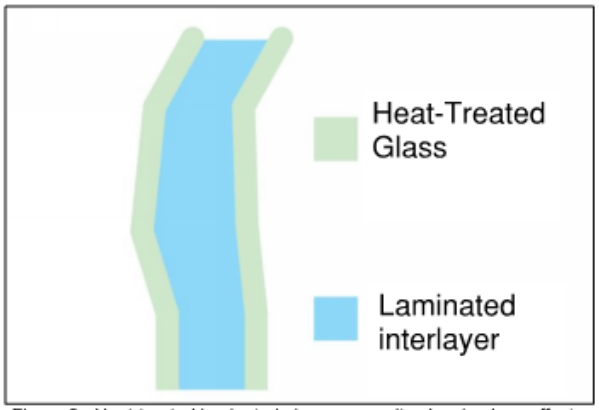

Figure 2 - Heat-treated laminated glass composite showing lens effect

Per the recommendation from ASTM C1172, appendix X1, when heat-treated glass laminates are specified, a full-sized mock-up of the heat-treated laminated glass product is required by the customer so that they can view under typical site conditions and surrounding landscape for evaluation of reflected and optical distortion concerns, approved sign off required.