Why Annealed, Heat Strengthened, and Tempered Glass All Deflect the Same Amount

Deflection

When a solid material like a steel beam has a load applied to it, the load creates a stress in the beam and the beam deflects. The amount of deflection depends on the size and shape of the beam, and the stiffness of the material of which the beam is made, and the amount of load that is applied.

The engineering term for material stiffness is ***modulus of elasticity*** or ***Young's modulus***. Materials with higher modulus numbers are stiffer than materials with lower modulus numbers.

Young's modulus for some typical materials

Carbon Steel	30,000,000 psi
Chromium	36,000,000 psi
Aluminum	10,000,000 psi
Vitro Float Glass	10,600,000 psi

The above numbers indicate that carbon steel is 3 times stiffer than aluminum, and that glass is just slightly stiffer than aluminum. In actual practice, this would mean that if you have two beams of equal size, one of steel and the other of aluminum, the aluminum beam will deflect 3 times further than the steel beam if loaded with the same load.

Tempered or Heat Strengthened Glass

When glass is tempered or heat strengthened, its modulus of elasticity remains unchanged. This means that for the same size and thickness of glass, the deflection for the same applied load will be exactly the same whether the glass is annealed, heat strengthened or tempered.

Even though the deflection is the same, however, a very significant difference does exist. The heat strengthening and tempering processes impart a surface and edge compression envelope around the glass. At the same time, balancing center tension stresses are created in the glass, maintaining equilibrium between outer compression stress and internal tension stress in the final product.

As a result, even though basic material stiffness is unchanged by heat strengthening and tempering, heat strengthened glass is about two times stronger and tempered glass about four times stronger than annealed glass under uniform static loads like wind loading.

This means that for the same size light, same thickness and same applied load, annealed, heat strengthened and tempered glass will each have a different probability of breakage, even though the deflection for each of these glass types will be equal.

Example: a lite of 6mm thick glass, 60" x 72" with an applied wind load of 125 mph (40 psf) will have the following structural characteristics:

GLASS TYPE	*PROBABILITY OF BREAKAGE	MAXIMUM DEFLECTION (INCHES)
Annealed	47 per thousand	0.78
Heat Strengthened	1 per hundred thousand	0.78
Tempered	1 per million	0.78

*Probability of breakage indicates the number of lights that may be expected to break at the initial occurrence of the design wind load. In the U.S., architects generally choose the design probability of breakage for vertical glazing in buildings at 8 per 1000. In this case, then, Vitro would not recommend annealed glass for this application.

Why Annealed, Heat Strengthened, and Tempered Glass All Deflect the Same Amount

HISTORY TABLE		
ITEM	DATE	DESCRIPTION
Original Publication	February 1993	
Revision #1	1/14/2001	Revised & Transferred to TD-113
Revision #2	10/04/2016	Updated to Vitro Logo and format
Revision #3	1/24/2019	Updated to Vitro Logo and format
Revision #4	3/27/2023	Reviewed for accuracy and minor format changes