Feb. 29, 2024

By Bill Bahn

of

Hightower Labs

STRUCTURAL GLAZING AND STOMACH ACID

Checking In on Structural Glazing Proliferation

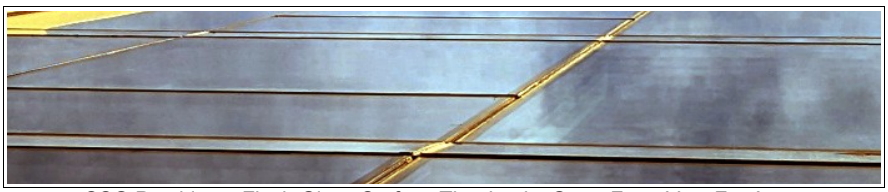
Structural glazing systems have proliferated, extending into spaces where the industry's capacity for quality, safety, design, execution, & oversight are diminished

INTRODUCTION

Structural glazing, the method of adhering sometimes very heavy objects and materials to building exteriors exposed to occasionally intense pressures, is a relatively seasoned process in 2024. Many of the oldest structural glazing applications are still being monitored and proving to retain structural integrity up through today.

What was once a seldom used, meticulously planned means of structural attachment is now relatively commonplace. Even some “high-end” custom residential fenestration manufacturers are now marketing structural glazing concepts in terrifying new ways. Our contention is that wider adoption of this process has expanded its use beyond the industry's capacity to properly analyze and manage it. To preempt misunderstanding, the conclusion of this paper is not *“do not use structural silicone glazing.”* Rather, the conclusions of this paper are 1) much of the structural glazing being applied in 2024 differs materially from the structural glazing applied even two decades ago and 2) much of the industry's oversight of structural glazing applications, even at supposed blue chip marquee institutions, is less rigorous than even two decades ago.

As a proud stakeholder in our right to walk down the street without cartoonishly large objects falling on our heads, there may be some responsibility to share these concerns more widely. Highlighting blind spots in the industry's analysis of this critical life safety (or perilously expensive, if that's more your purview) detail is worth at least the attention afforded by one free article published on a ragtag field testing agency's website.



SSG Provides a Flush Glass Surface That Looks Great From Very Far Away

Web
hightower-labs.com

Phone
312.897.3742

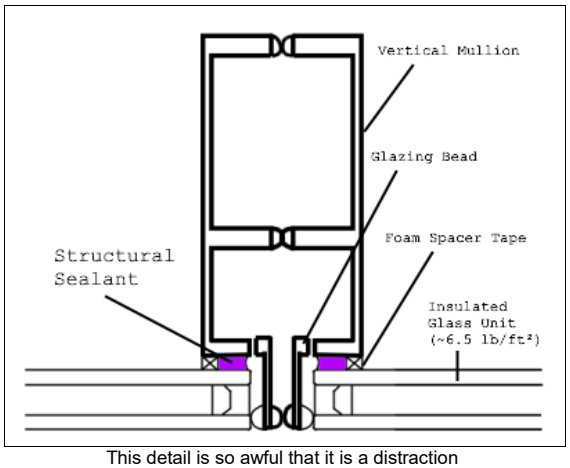
E-mail
service@hightower-labs.com

Fax
no

BRIEF SUMMARY OF STRUCTURAL GLAZING

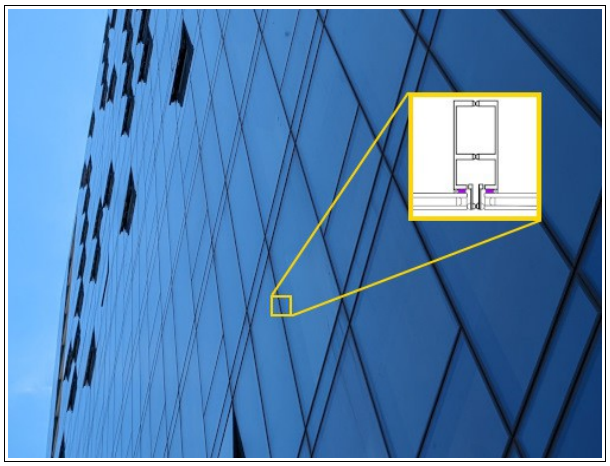
Look it Up!
If you look up at a building and see sheer glass surfaces, you are probably standing under structural glazing!

SSG Systems, or Structural Silicone Glazed Systems, adhere cladding and glazed infills (e.g. metal panels, glass units, sometimes even operable assembly frames) to supporting master frame members via a (typically) thin bead of silicone (tape applications – remember those few months when structural tape was going to overtake silicone? – are omitted from this article for brevity). Four-sided SSG systems typically include no secondary mechanical attachment (e.g. pressure plate) and, consequently, the attachment of that glazing infill to the wall is entirely reliant on the integrity of the silicone bond. Here is an aggressively generic detail of a vertical mullion stack for a structurally glazed system:



This detail is so awful that it is a distraction
We recommend the reader pause for a minute to let any intense reactions subside

On this poorly-drawn (and, in fact, horribly flawed A/W/S) schematic sketch for a four-side SSG unitized system, the structural silicone, highlighted in purple, is the sole means of attaching the glass to the building. If the reader is able to look past the atrocious detailing, they may find this sketch illustrative of the general concept and scale of structural glazing.



The total comprehensive structural silicone bond isn't a monolith (as suggested by that detail's purple blob) – it is comprised of layers of materials and adhesive connections that, together, form the overall structural attachment of the infill to the framing member. The bond between the infill (e.g. glass) and the silicone and the bond between the silicone and the framing member are the two plainly obvious connections forming the overall structural glazing bond. On new envelopes with structurally glazed walls, these are the two most common connections to be routinely scrutinized, modeled, and tested in the assembly.

However, on numerous modern glazed systems, there is a third, equally critical, connection within the overall structural bond that is often overlooked.

References:

ASTM
C 1135
C 1184
C 1392
C 1394
C 1401
D 3359
D 4541
STP 1633
STP 1453
STP 12553S
STP 1286
STP 16291
STP 1069
STP 26793S
STP 1604

AAMA
SSGDG

To reiterate: **this article is not suggesting that all SSG projects are at imminent risk of structural failure.**

Instead, the conclusion here is that a wide swath of projects are oblivious to that risk, rather than quantifying and managing that risk.

Coating Properties
Notes from AAMA 2603/4/5 Specifications

Color Retention
AAMA 2605
10 years, Fade 5ΔE
AAMA 2604
5 years, Fade 5ΔE
AAMA 2603
1 year,"slight fade"

Erosion Resistance
AAMA 2605
10 years, 10% loss
AAMA 2604
5 years, 10% loss
AAMA 2603
not specified

Dry Film Thickness
AAMA 2605
1.2 mils min.
AAMA 2604
1.2 mils min.
AAMA 2603
0.8 mils min.

Salt Spray Test
AAMA 2605
4,000 hrs.
AAMA 2604
3,000 hrs.
AAMA 2603
1,500 hrs.

Warranty
AAMA 2605
10 years
AAMA 2604
5 years
AAMA 2603
1 year

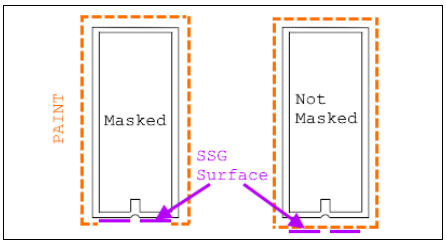
Pull-Off Strength
AAMA 2605
not tested
AAMA 2604
not tested
AAMA 2603
not tested

AAMA 2603
The Contractor's Choice™

The interior mullion coating applicator also becomes, sometimes unwittingly, a critical member of the overall structural glazing process

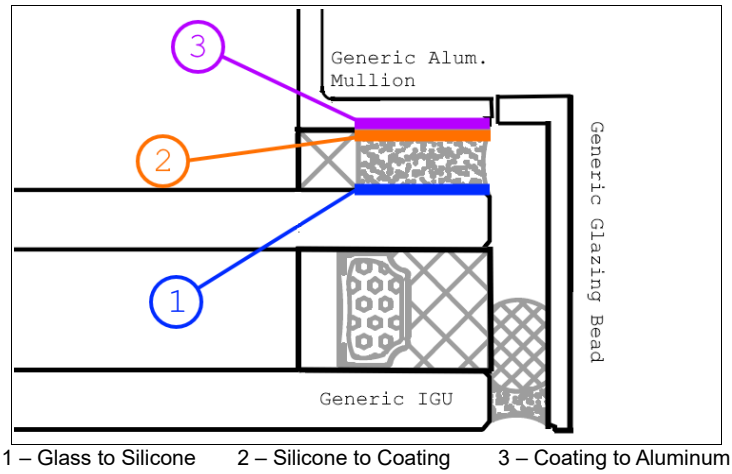
SSG BOND CHAIN COMPLICATIONS

For framing support extrusions (e.g. mullions) comprised of coated aluminum, it is more cost-effective for the applicator to simply coat the entire mullion member – including the structural glazing surface – rather than prepare / mask the bond substrate that forms the structural glazing surface. In these instances, the preparation of the structural glazing surface follows whatever interior finish is selected for that mullion.



Aluminum Mullion Profile Drawings

Consequently, rather than adhere the glass directly to pre-treated (e.g. chemical conversion) aluminum surfaces, manufacturers are frequently introducing an additional material (and connections thereof) into this arrangement. Now, the glass is attached to the aluminum by connections between *four* materials: the glass to silicone, silicone to *coating*, *coating* to aluminum. That is a 50% increase in scope within the overall structural bond.



1 – Glass to Silicone 2 – Silicone to Coating 3 – Coating to Aluminum

In this increasingly common arrangement, the interior coating product is being inserted into the overall structural bond supporting the glass. An applicable and universally comprehensible metaphor would be the overused "weakest link in a chain" analogy; the fenestration manufacturer is introducing a (likely) sparsely-documented and frequently overlooked link into the "chain" that is holding millions of pounds of glass over the nation's sidewalks. It is not unreasonable, in our view, to request assurances and supporting documentation to verify that this additional "link" is on par with the others forming this critical "chain."

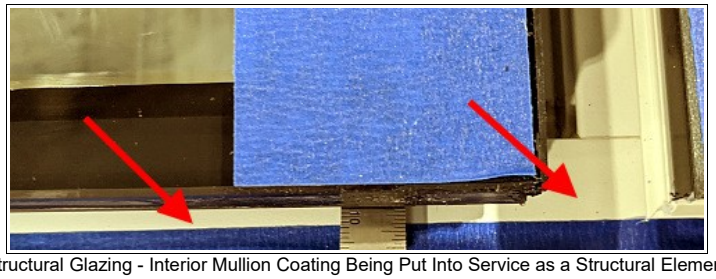
The majority of projects we surveyed suggested the opposite – a total lack of awareness of the interior mullion coating's role in the structural attachment of the glass for the life of the envelope. Instead, the primary focus for interior mullion coating selections typically involve cost, color, and ease of touch-up. The structural integrity of the interior coating is rarely considered by the project team.

Likewise, the typical interior mullion coating product data seems unaware of its own role in the structural attachments of insulated glass, frequently listing recommended applications such as fences, light poles, napkin holders, and, when the manufacturer wants to brag, stadium seats.

Note: there are plenty of interior coatings that will deliver theoretical bond strengths higher than that of structural silicone for an uncertain but probably long time. There are plenty of projects that will utilize this structural design and probably be just fine.

The possibility of this arrangement – where a finish coating forms the bond surface on the aluminum framing member, rather than the chemical conversion surface – is acknowledged in relevant published SSG guidelines such as AAMA SSGDG, ASTM C1401, and sealant manufacturer technical manuals. To varying extents, each of these documents notes the importance of coating material adhesion in the overall structural glazing bond chain. The consistent presumption being that the substrate coating can function in a long term structural application with a performance matching or exceeding that of the silicone, and the responsibility of the design and verification of that presumption is presumed to be by others.

Meanwhile, in practice, the interior mullion finish is typically selected based on color and affordability. Rarely, if ever, is the long-term structural bonding capacity of the interior mullion coating a consideration for its selection.

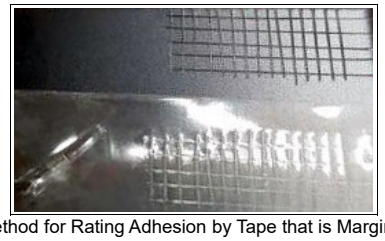


Structural Glazing - Interior Mullion Coating Being Put Into Service as a Structural Element

Buyers of AAMA 2603 paint are typically just gambling that they can get through a 1 year general warranty without the paint boiling off of the frame. Generally, they are not looking for structural longevity.

Because the interior mullion coating is so often a cost-saving VE target, it is natural to consider an inquiry into the interior coating's long term structural bonding capacity outside of industry norms. There exists sparse industry guidance for paying attention to this bond – e.g. some structural sealant manufacturer print reviews and test reports require written acknowledgment of the substrate's suitability as a structurally performing element. This guidance is typically obscured in submittals that often go unread.

Meanwhile, on the interior mullion coating product data submittals, one might find language that explicitly warns *against* use of the product “for any purpose other than that specifically recommended in the technical data sheet.” And “structural glazing” or some other reasonably comparable structural use is not often listed as one of the recommended applications in the technical data of most AAMA 2603 compliant coatings, for example.



ASTM D3359 “Standard Test Method for Rating Adhesion by Tape that is Marginally Better Than Doing Nothing”

The deteriorative potential associated with interior mullion coatings – applicator error, manufacturing defect, etc. – are generally well known and nearly universal for coating products.

However, project stakeholders may evaluate this potential differently when there are structural implications, as opposed to the downside aesthetic risks associated with powder coating a chair at a hot dog stand, for example.

The lack of supporting documentation does not necessarily mean that a mullion coating *will* fail to maintain sufficient structural adhesion for the life of the building envelope. But, for the majority of projects, whether or not the mullion coating will maintain structural adhesion for some duration is not even contemplated. Nevertheless, by introducing a coating material into the critical structural glazing bond surface, the responsible party is also introducing all of the QAQC risks associated with that coating material and its application into the critical structural glazing bond surface.

We also note that there are of course aluminum coatings with adhesive properties in excess of even that of structural silicone. To reiterate – *this paper is not suggesting that all SSG projects are at imminent risk of structural failure*. Instead, the conclusion here is that a wide swath of projects are oblivious to that risk, rather than quantifying and managing that risk. Under those conditions, the uncertainty regarding probability of failure for the structural attachment of a large quantity of glass fenestration is higher than it needs to be.

Sample SSG Question Sequence to Designers:

"Is my building envelope SSG?"

▼

"Are we using the interior mullion coating in a structural glazing capacity"

▼

"What are the structural properties and guarantees of the interior mullion coating?"

INTERMISSION

This article is already longer than I wanted it to be. Based on our industry's appetite for outside design & submittal review services, this article is probably longer than the reader wanted, too. This section is provided as an intermission.

Here are five semi-related ideas and questions for you to contemplate with your favorite B.S. Guru, that one contractor who "really knows his or her stuff," that consultant who would probably wear capes if they were in style again, and/or your social media network:

1. Some SSG systems expose the structural silicone to the rainscreen cavity, a lone raggedy bulb gasket the sole line dampening (but not mitigating) its exposure to the exterior environment and its pollutants, moisture, frost, and thermal cycles. Do you think this arrangement and exposure can impact the long term structural performance of the silicone & associated bonds? If so, do you think manufacturers may some day differentiate themselves by shielding the precious structural silicone behind yet another nearly continuous line of silicone weatherseal? In these latter configurations, the SSG may be less prone to environmental exposure, and maybe fall within the thermal influence of the more stable, conditioned interior environment.

2. Is SSG's reputation as a *necessary* component of an envelope's overall thermal performance overblown?

3. SSG maintenance and re-glaze costs are substantially higher than interior-glazed systems. This is especially notable in the Age of Spontaneous Breakage. This isn't really a question, right? Okay, now it is.

4. QA Checks for Consideration: ASTM D3359, D4541, C1394, C1392, manufacturer's deglazing procedures, etc.

5. Are the aluminum coating structural properties impacted by movement over time? For example, on larger spans, would movement from mullion deflection or thermal expansion/contraction fatigue the coating over time?

WARRANTY

If the reader is not alarmed by the worsening deficiency in structural glazing QAQC oversight outlined herein, owners may be interested to learn that there also exists a growing gap in warranty coverage for the structural performance of their SSG system.

The typical sealant manufacturer's structural glazing warranty is decent (to the limited extent that it at least acknowledges the material's intended function and promises a decent duration – the actual limit of damages and compensation for any failure is constrained to what amounts to a rounding error on the overall glazed envelope scope – some multiple of the sealant material cost only). Conversely, the typical interior mullion coating warranty expressly *excludes* items such as failure due to "sealant/adhesive contact," "structural adhesion," and, sometimes, "any adhesion at all after 30 days" – in general, properties that may be relevant when the coating is utilized as a structural glazing substrate.

Consequently, rather than carry almost-no warranty coverage for the structural system adhering the glass to the building envelope, owners are typically carrying actually-no warranty coverage for the structural system adhering the glass to the building envelope.

And when the coating manufacturer *warranty* explicitly excludes any guarantee of long term adhesion, these exclusions might cloud that same manufacturer's sales team assurances of the coating's long term adhesion.

PQ&A

Preemptive Question & Answer

Q: Why is this structural detail not being closely managed and documented?

A: Innate American aversion to oversight? Commercialization & monopolies within the "Quality Control" space? An industry with an economy the size of Spain built entirely by the lowest bidders?

Q: Powder coat is strong, powder coat is baked on, I have no concerns with using powder coat in a structural glazing application?

A: Okay

Q: If this article were true, where are all the SSG failures?

A: We hope that the entire article is wrong

Bill Bahn
Hightower Labs

About This Article
The intent of this article is to raise awareness of this detail, and encourage assessment of the risks and costs associated with its use.

For brevity, some technical information has been omitted or abridged; concepts herein have been simplified so that even the median developer might be able to understand and act on the information.

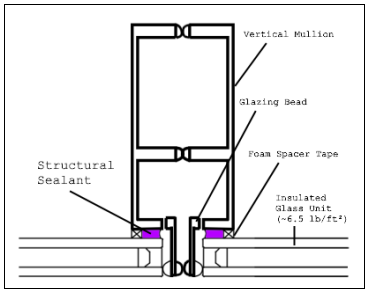
CONCLUSIONS

When the owner buys a structurally glazed system, there is some general understanding of the deliverable, among which is the expectation that the overall SSG bond is properly designed, validated, and guaranteed. If the interior coating forms one third of the overall SSG bond, then it is reasonable to expect that material to be commensurately scrutinized as closely as the bond's other equal portions.

Further, there are large surface areas of structurally glazed walls that have effectively zero warranty coverage.

The hope here is that building stakeholders at all phases of project design, construction, ownership, insurance, loan origination, management, and operation will look more closely at the structural attachment of their envelope systems and contemplate the long term risks. At minimum, building owners and managers can start appreciating the narrow sight lines and over-sized glass spans frequently delivered by structurally glazed systems in the same ways that we enjoy the implied dangers of hastily assembled carnival rides.

We're a small company, so we don't have the resources to lobby trade organizations or code officials, or to sketch details that look any better than this:



Ideally, the larger and more resourced firms and organizations might take a break from Cotton Candy Institutional Work Land and come down to roll around in the murk and help, creating and publishing guidance for QAQC oversight, testing, and long term monitoring of mullion coatings that form the substrate for structural glazing applications.

In the meantime, we can all try to help the projects in our limited circles while continuing to hope that the entire premise of this article is wrong. In closing, here are two selections from an ASTM article published twenty years ago:

"Structural sealant is vulnerable to defective material, design, and workmanship and the result of failure is potentially life-threatening. The author believes that its use should be governed, similar to welding, which can only be performed by registered/certified welders who are trained, tested and carry certification cards" (p. 7)

"Were the British right? Probably not, but we should all be reminded of what can happen if good quality control procedures are not followed. Education is important, but enforcement is critical. Right now, unskilled, unsupervised workers are installing structural sealant around the country. There are plenty of signs that the current system is inadequate. The time for action is now, before someone is hurt or killed." (p. 8)

Baker, M.E., "Structural Glazing Failures – Five Case Studies," *Durability of Building and Construction Sealants and Adhesives, STP 1453*, A.T. Wold, Ed., ASTM International, West Conshohocken, PA, 2004

Note: Data, observations, and conclusions herein apply to U.S. market only. Canadians are stubbornly dragging their atrocious "bypass" window design into the 21st century, but at least the majority of those are captured systems so they get a conditional waiver from the broad yet damning ethical liability of learning the risk identified herein. The point of this footnote is not to enrage every American with civic pride - the point is that the writer's experience is limited to buildings in and this paper applies solely to the United States. For all we know, the rest of the world has SSG sorted and the U.S. construction industry is the only one where cost considerations supersede even code and safety oversight. Just look at how we do makeup air.