Facade Tectonics FORUM HOUSTON

BLOWN AWAY

Designing and Retrofitting Facades for Wind-Borne Debris Protection

SPEAKERS

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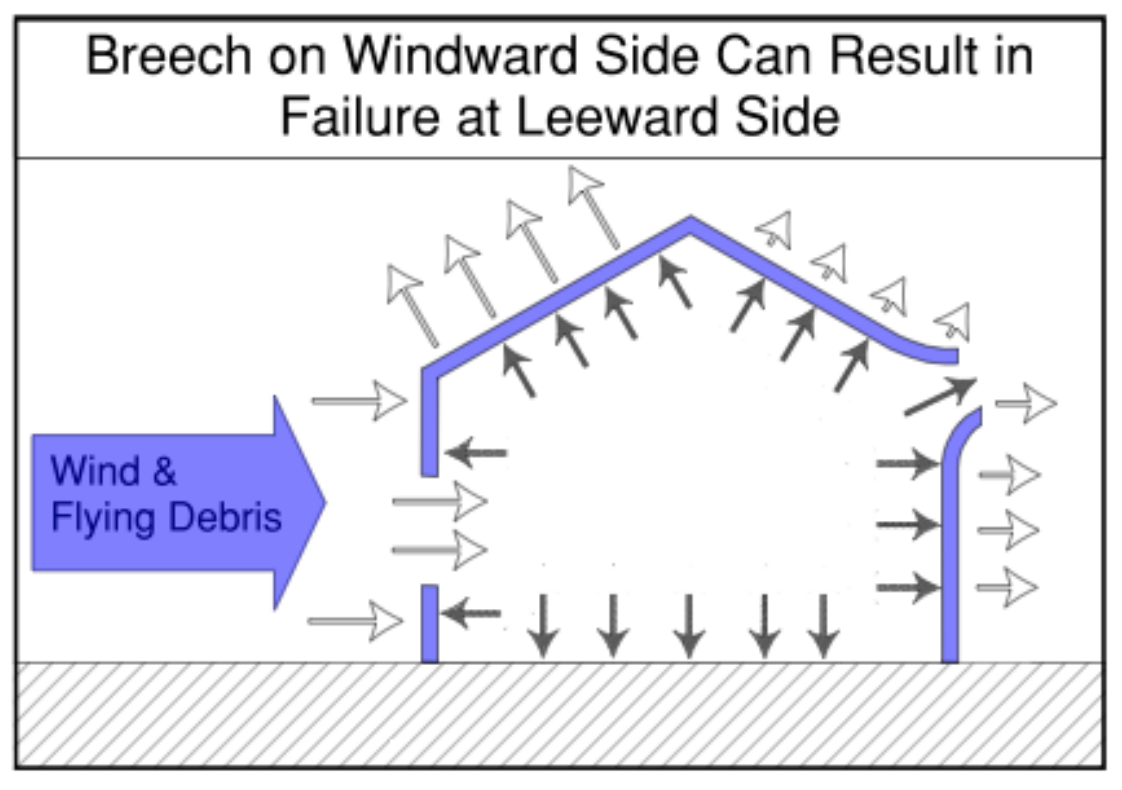
CDC
CURTAINWALL DESIGN CONSULTING™

Impact Resistant Glazing to Meet Code Requirements Along Our Hurricane Coastlines

Risks to the Exterior Building Envelope in a Hurricane



Effects of Windborne Debris were being investigated in Australia and at Texas Tech University in early 1970's

Two Major Hurricanes – Tracy in 1974 & Andrew in 1992:

LESSONS LEARNED

Protect Integrity of Building Envelope;……..when breached**:**

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- Risk of Progressive Structural Failure

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Protect Integrity of Building Envelope;……..when breached**:**

- Risk of Progressive Structural Failure
- Costly Losses & Insurance Claims to Replace Damaged Interior Finish Work

Australian Code

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- Cyclone Tracy; Christmas day 1974
- Darwin Reconstruction Commission (DRC 1975) – All new houses to have glazed openings withstand impact 9lb 2 x 4 @ 45mph
- Technical Record (TR440) followed with similar testing throughout Australia

Florida Code

- Hurricane Andrew; August 24, 1992

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- Hurricane Andrew; August 24, 1992
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- Pass/Fail Criterion: no tear in laminate larger than 3/16” x 5” long

SSTD 12 / ASTM STANDARDS

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- Intense Opposition Initially
  - Geographically Large / Competing Interests
  - Hurricanes Less Severe than South Florida
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SSTD 12 / ASTM STANDARDS

- SSTD 12 Developed by SBCCI as their Test Standard for Impact Resistance
- Intense Opposition Initially
  - Geographically Large / Competing Interests
  - Hurricanes Less Severe than South Florida
  - Impact by Pendulum vs Air Canon
- Because of Deadlock - ASTM Proposed Separate Test Method and Specification and Procedure E1886 & E1996 - Incorporated into IBC


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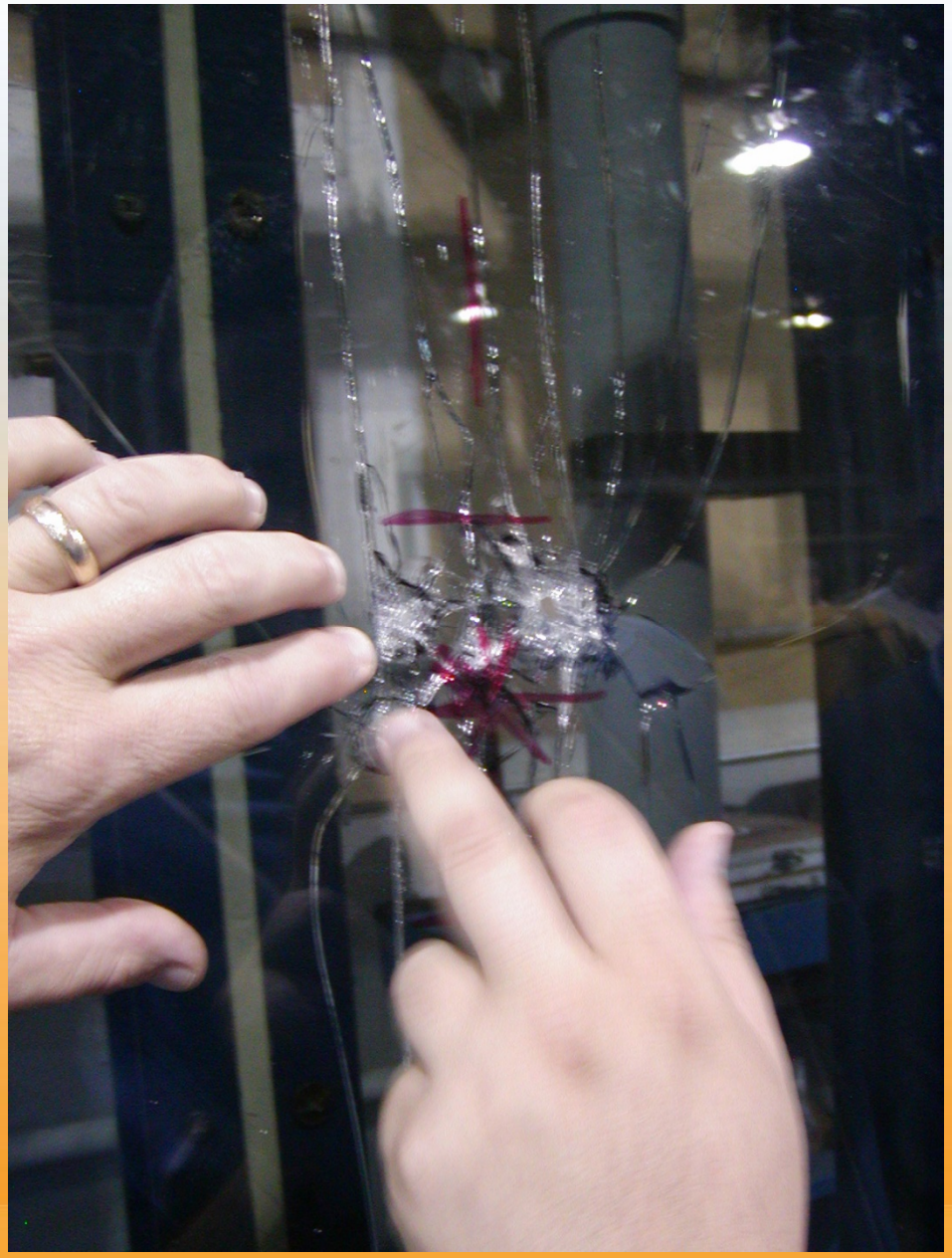
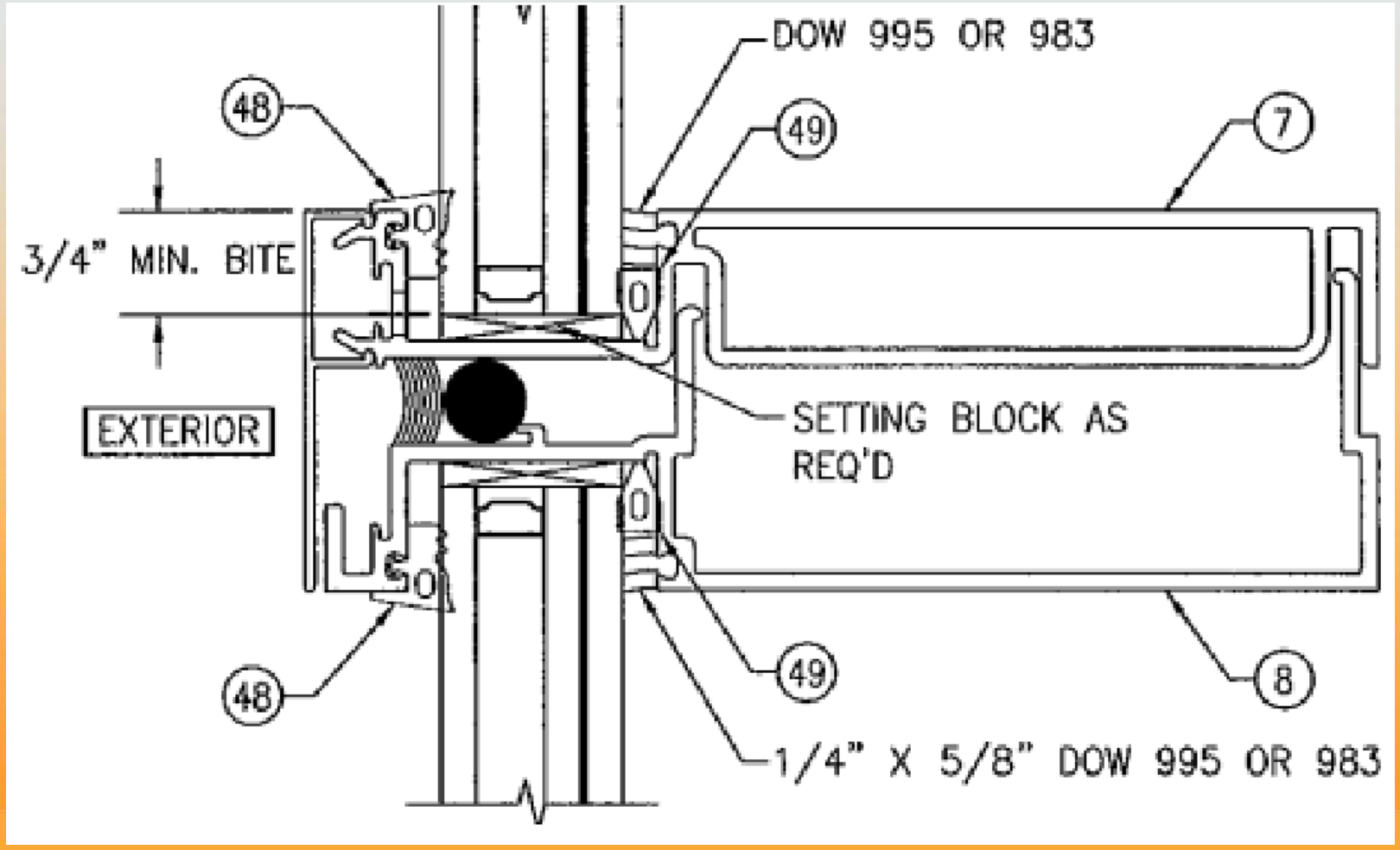
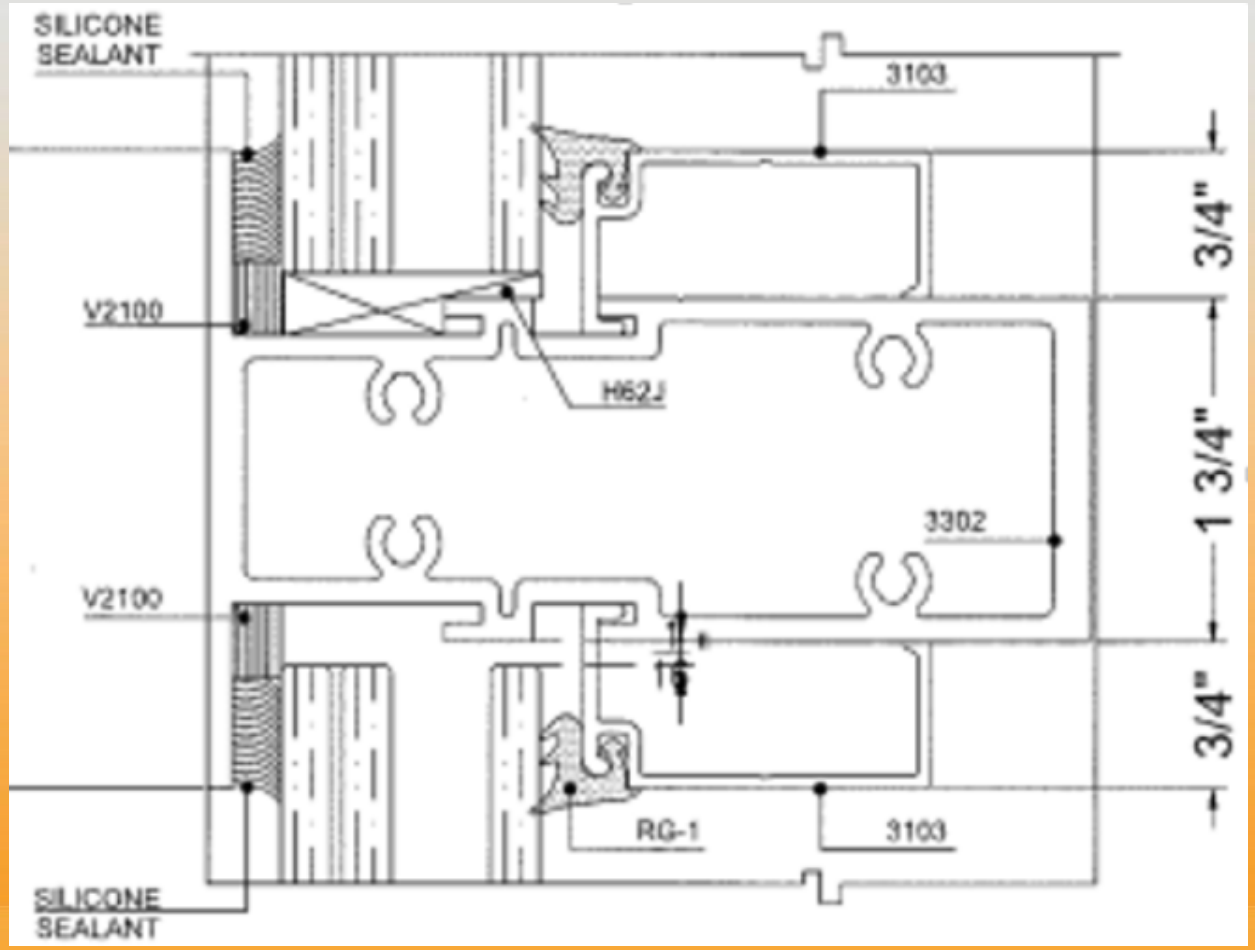
HTL
Laboratory



Typical Glazing Detail



Alternate Detail



Ike – Old Structural Gaskets

Ike – Interior Damage

“At-Risk”, Monolithic Glass Remains Today on Buildings in the Path of Future Hurricanes

Summary

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- Laminated glass required to protect from impact of flying debris and cyclic pressures that follow in a hurricane while keeping the building envelope in tact;

Summary

- Primary goal is to protect the integrity of the building envelope;
- Code Requirements for impact protection of glazed openings in windborne debris regions of hurricane coast lines triggered by Andrew;
- Laminated glass required to protect from impact of flying debris and cyclic pressures that follow in a hurricane while keeping the building envelope in tact;
- Many buildings built prior to current codes remain at risk with monolithic glass and aging gaskets.

Texas Department of Insurance

Windstorm Inspections Program and Adopted Building Specifications

TDI | Texas Windstorm Insurance Association

The Texas Windstorm Insurance Association (TWIA):

- was established in 1971, by the Texas Legislature in response to regional market conditions following Hurricane Celia in August 1970;
- is considered an "insurer of last resort" and not a direct competitor in the voluntary insurance market;
- provides windstorm and hail insurance coverage for qualifying properties in the catastrophe area; and
- is a separate entity from TDI.

TDI | The Windstorm Inspections Program:

- adopts building specifications;
- develops rules and regulations for Appointed Qualified Inspectors (AQIs);
- maintains a list of AQIs
- provides windstorm inspection services using TDI employed inspectors;
- certifies (Form WPI-8) to TWIA on going improvements are insurable against wind and hail losses; and
- evaluates building products for compliance with the adopted building specifications.

TDI | Windstorm Inspection Program

To be eligible for windstorm and hail insurance coverage through TWIA, improvements must:

- be located in the designated catastrophe area;
- be constructed and inspected in accordance with building specifications adopted by TDI; and
- be certified as eligible for coverage by either TDI or by TWIA;

TDI | Designated Catastrophe Areas

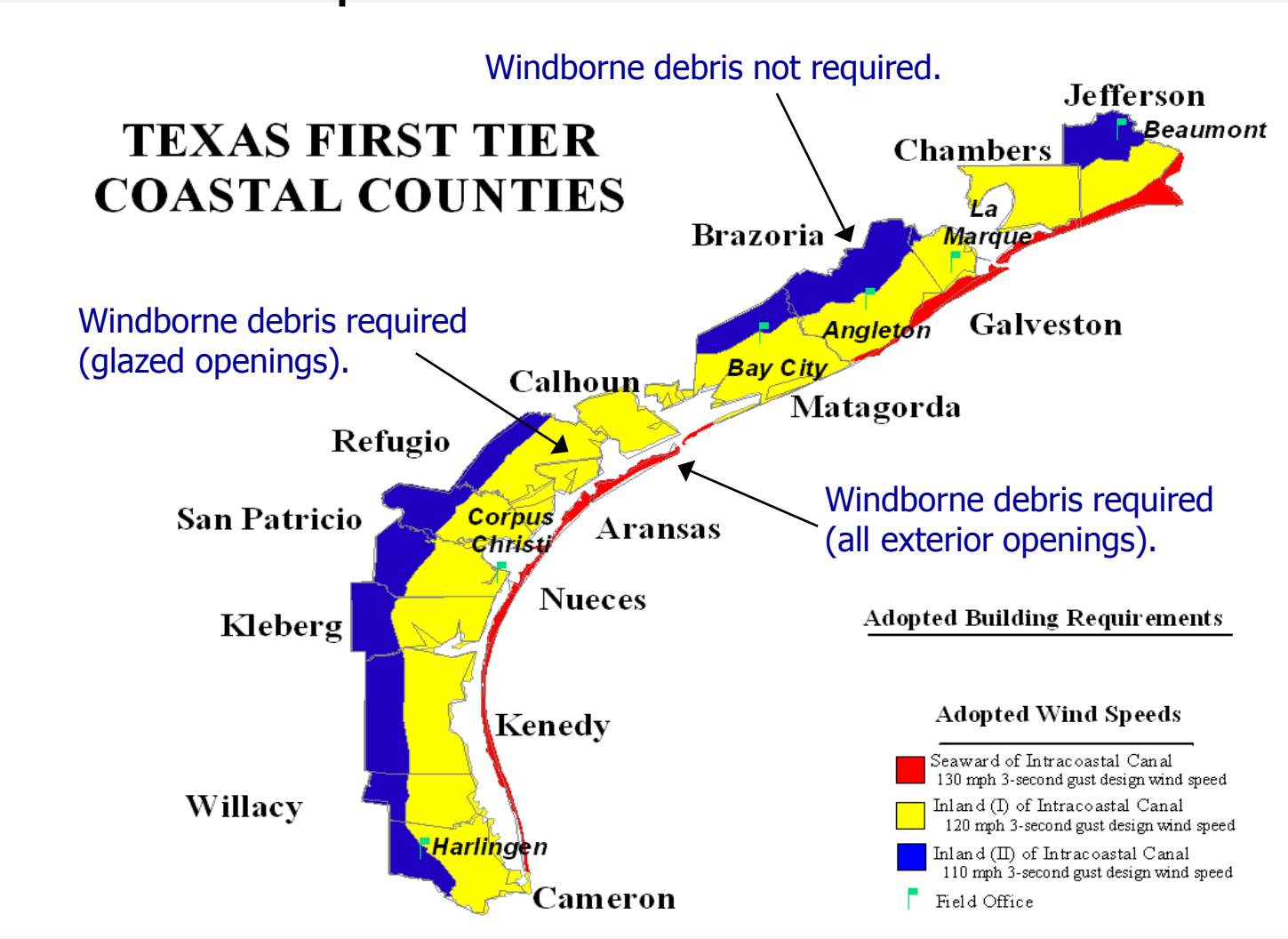
"First Tier" Counties: The following 14 counties immediately adjacent to the Texas Gulf Coast:

Aransas	Brazoria	Calhoun	Cameron
Chambers	Galveston	Jefferson	Kenedy
Kleberg	Matagorda	Nueces	Refugio
San Patricio	Willacy		

Portions of Harris County: Communities east of State Highway 146, Pasadena, Morgan's Point, Shoreacres, Seabrook, and La Porte.

TDI | Designated Catastrophe Area Map

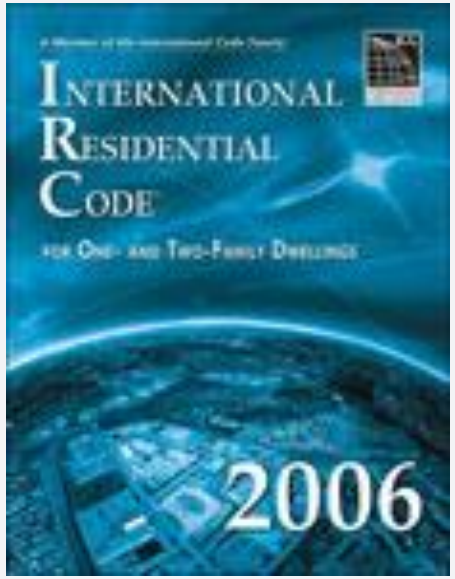
Windborne Debris Requirements



TDI | Adopted Building Specifications

TDI adopted the following International Building Codes on January 1, 2008:

- 2006 International Residential Code (IRC); and
- 2006 International Building Code (IBC).



TDI | Adopted Building Specifications

Texas Revisions

- TDI amendments to the IRC and the IBC.
- Effective January 1, 2008, TDI adopted the following:
  - Texas Revisions to the 2006 IRC; and
  - Texas Revisions to the 2006 IBC.

TDI | Adopted Building Specifications

Wind Speed Requirements:

- TDI specified wind speed requirements for each zone using the wind speed map in the 2006 IBC/IRC and in ASCE 7-05.
- The basic wind speed (3-second gust) for each zone:
    - Inland II – 110 mph
    - Inland I – 120 mph
    - Seaward – 130 mph

Dividing Lines

The designated catastrophe area is divided into three zones; Inland II, Inland I, and Seaward.

- The boundary between Inland II and Inland I are roadways and city limits.
- The boundary between Inland I and Seaward is the Intracoastal Waterway.

TDI | Building Products

- Building products are considered cladding.
- Building products must be inspected to resist wind pressure (component and cladding wind loads).
- Some building products must also be inspected to resist windborne debris.
- When windborne debris protection is required:
  - use an impact resistant building product; or
  - use a non-impact building product and an impact protective system (shutter).

TDI | Building Products

Examples of building products that may resist windborne debris include:

- curtain walls and storefronts;
- windows;
- skylights;
- translucent wall and roof assemblies;
- garage doors, overhead doors;
- Louvers, and roof hatches.

Evaluation Reports, Certifications, and Approvals

Building product performance may be determined by inspection and evaluation reports from:

- ICC Evaluation Service (ES) evaluation reports;
- Uniform Evaluation Services (Uniform ES) reports (part of IAPMO group);
- Miami-Dade County NOA (Notice of Acceptance) reports;
- UL certifications;

Building product performance may be determined by inspection and evaluation reports from: (continued)

- FM approvals;
- ATI Code Compliance Research Reports (CCRR); and
- TDI product evaluation reports.

TDI | Building Products – Test Reports

It is acceptable for an AQI to use a current test report to evaluate the use of a building product. The building product must:

- be tested by an accredited testing agency and the report must be current;
- be tested in accordance with the building specifications adopted by TDI;
- be tested as a complete assembly;
- have an appropriate safety factor applied to the test pressure; and
- be installed in the manner in which it was tested.

TDI | Building Products Test Standards

Miami Dade protocols vs ICC referenced standards:

- The IRC and IBC reference are nationally recognized standards for building product testing.
- Unless specifically limited by the IRC or IBC, TDI recognizes test standards from other organizations such as Miami-Dade County for some building products.

TDI | Building Products Test Standards

Example:

TAS 201, TAS 202, TAS 203 are acceptable Miami-Dade County test protocols for:

- curtain walls and storefronts;
- impact protective systems (shutters);
- garage doors;
- side hinged doors; and
- translucent roof and wall assemblies.

Windows Doors and Skylights – Non-Impact Resistant

Performance requirements

- AAMA/WDMA/CSA 101/I.S.2/A440

As an option, side hinged doors may be tested to:

- ASTM E 330; or
- TAS 202

Windows, Doors, Skylights –Impact Resistant

Performance Requirements

- AAMA/WDMA/CSA 101/I.S.2/A440
- ASTM E 1886, ASTM E1996
- AAMA 506

As an option, side hinged doors may be tested to:

- ASTM E 330 or TAS 202; or
- ASTM E 1886, ASTM E 1996 or TAS-201, TAS-203.

Windows, Doors, Skylights- Impact and Non-Impact Resistant

Performance verification must bear an inspection agency label that:

- identifies the manufacturer;
- includes the performance rating;
- has a logo for the inspection agency (AAMA, WDMA, Keystone, or NAMI); and

Windows, Doors, Skylights- Impact and Non-Impact Resistant

Performance verification must bear an inspection agency label that: (continued)

- includes the following test standards:
  - AAMA/WDMA/CSA 101/I.S.2/A440
  - For impact resistant products, must also include ASTM E 1886, ASTM E 1996, or AAMA 506 and indicate missile level A, C, or D.

Thank you!

SENTECH
ARCHITECTURAL SYSTEMS

Structural Glass Systems Technology

Façade Tectonics | Houston TX
October 10, 2019

Richard Kaire, PE,SE
Lead Engineer

Presentation Outline

- Design Trends
- Impact Resistant Glazing for Jumbo Glass Applications

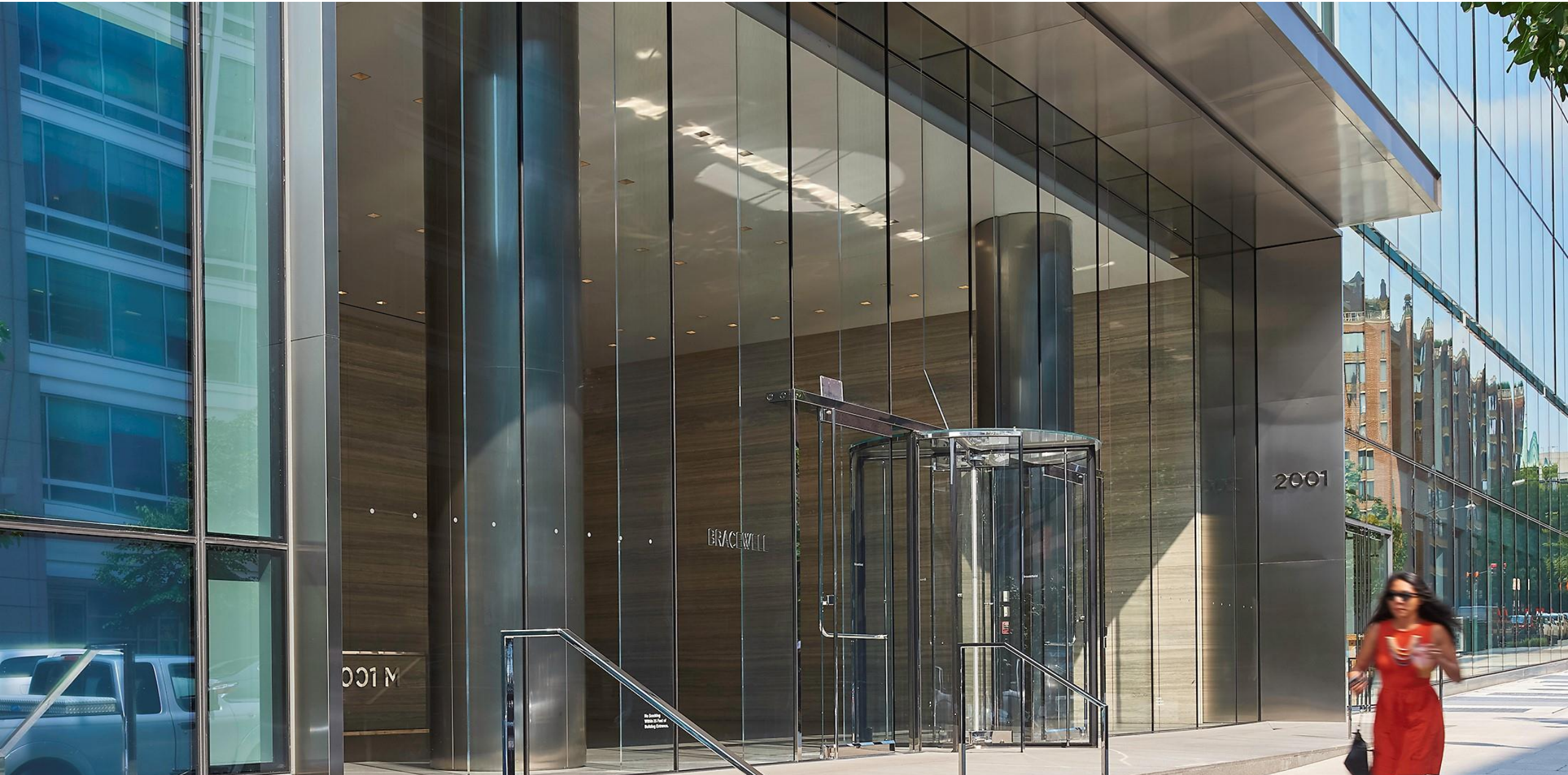
Façade Geometry Trends

- Minimizing the use of horizontal joints
- Use of taller and wider panels
- Use of narrower fins
- Use of clear span glass facades without supports
- Minimizing fitting connections
- Use of hidden fitting connection

Trend 1: Minimizing the use of horizontal joints by using taller panels

- Tall panel solutions have become more cost effective/ large number of players

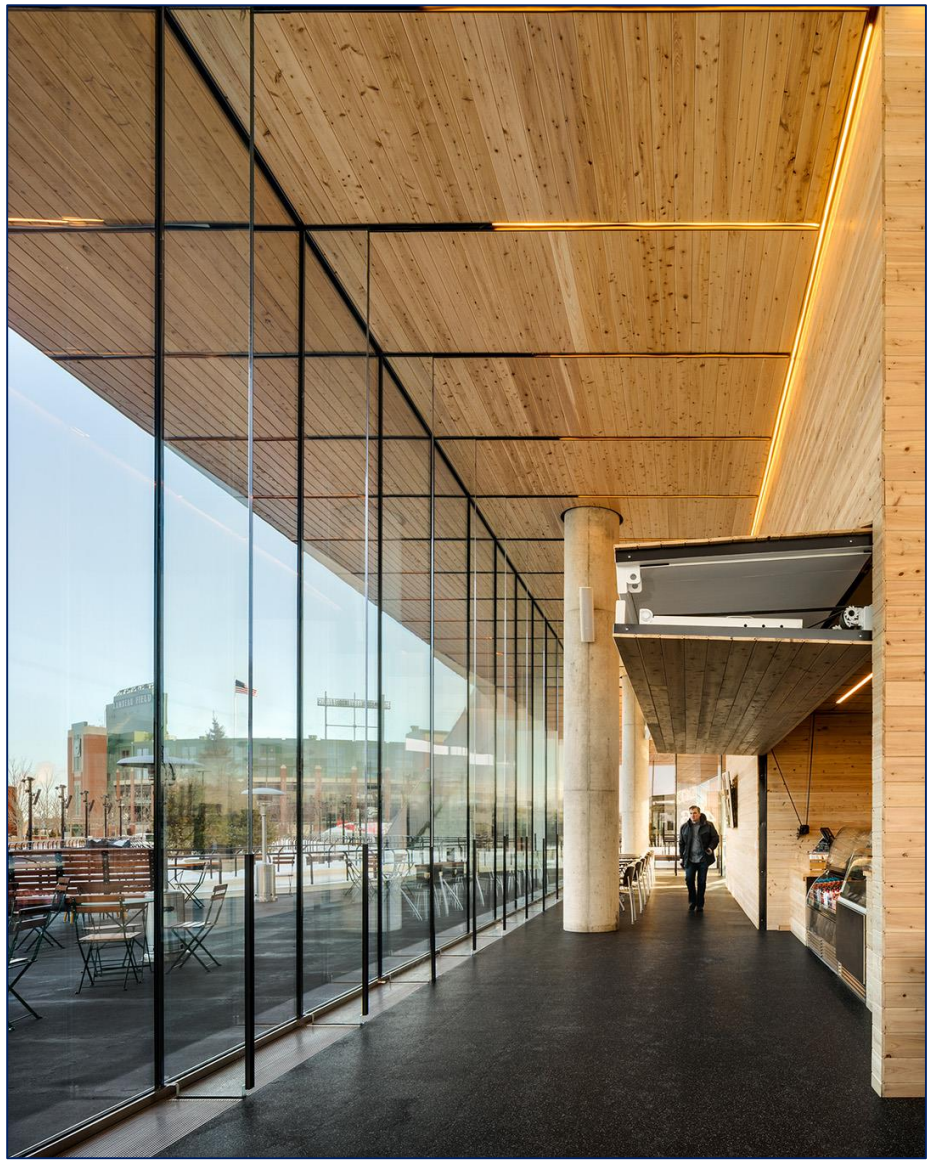
- Glaziers have embraced the use of jumbo glass technology

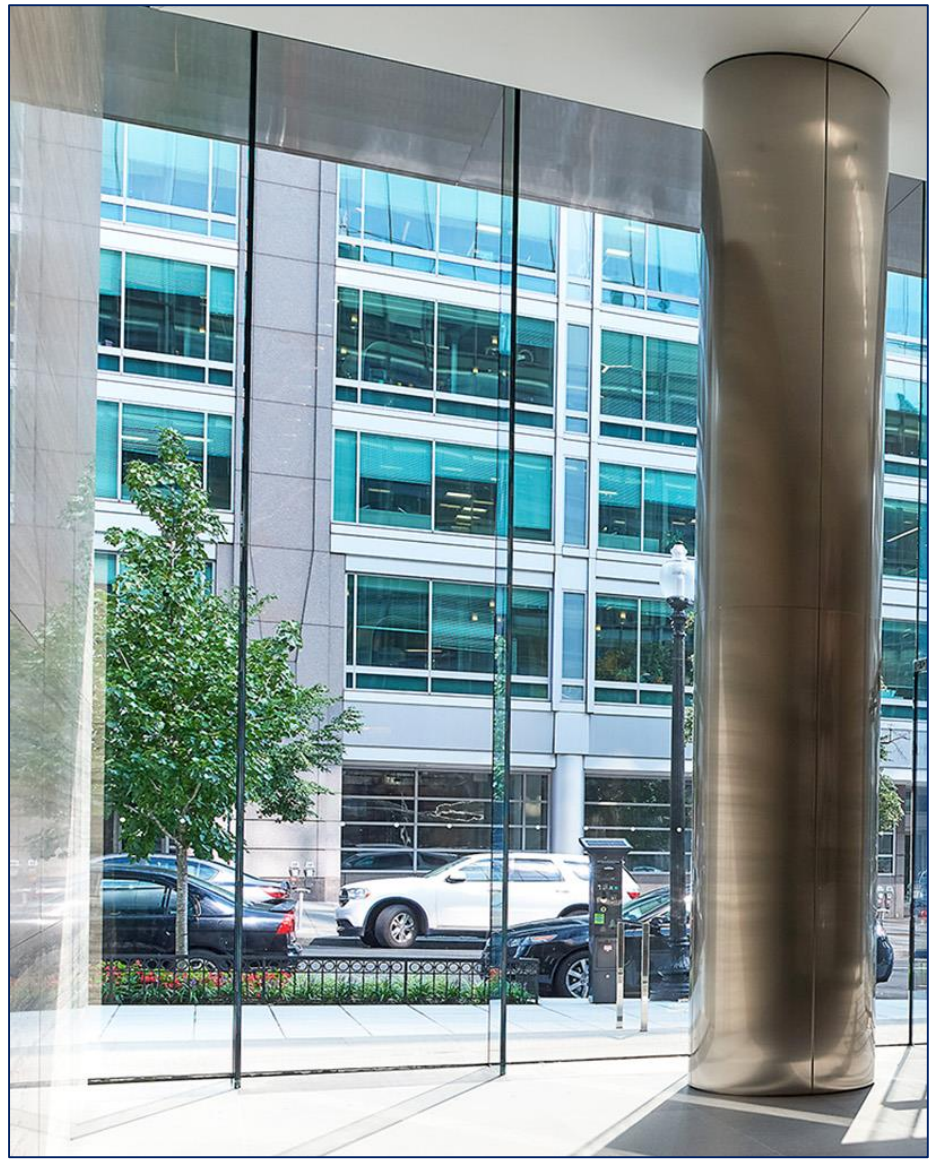


- Technology continues to improve: laminating, insulating, curved panels

Trend 2: Use of single span, taller and narrower fins

- Aspect ratios as high as 25/1





- Fin heights up to 50’

Trend 3: Eliminating Vertical Supports

- Panels manufactured with extremely tight bow tolerances

- Support systems designed to reduce deformation while allowing for movement

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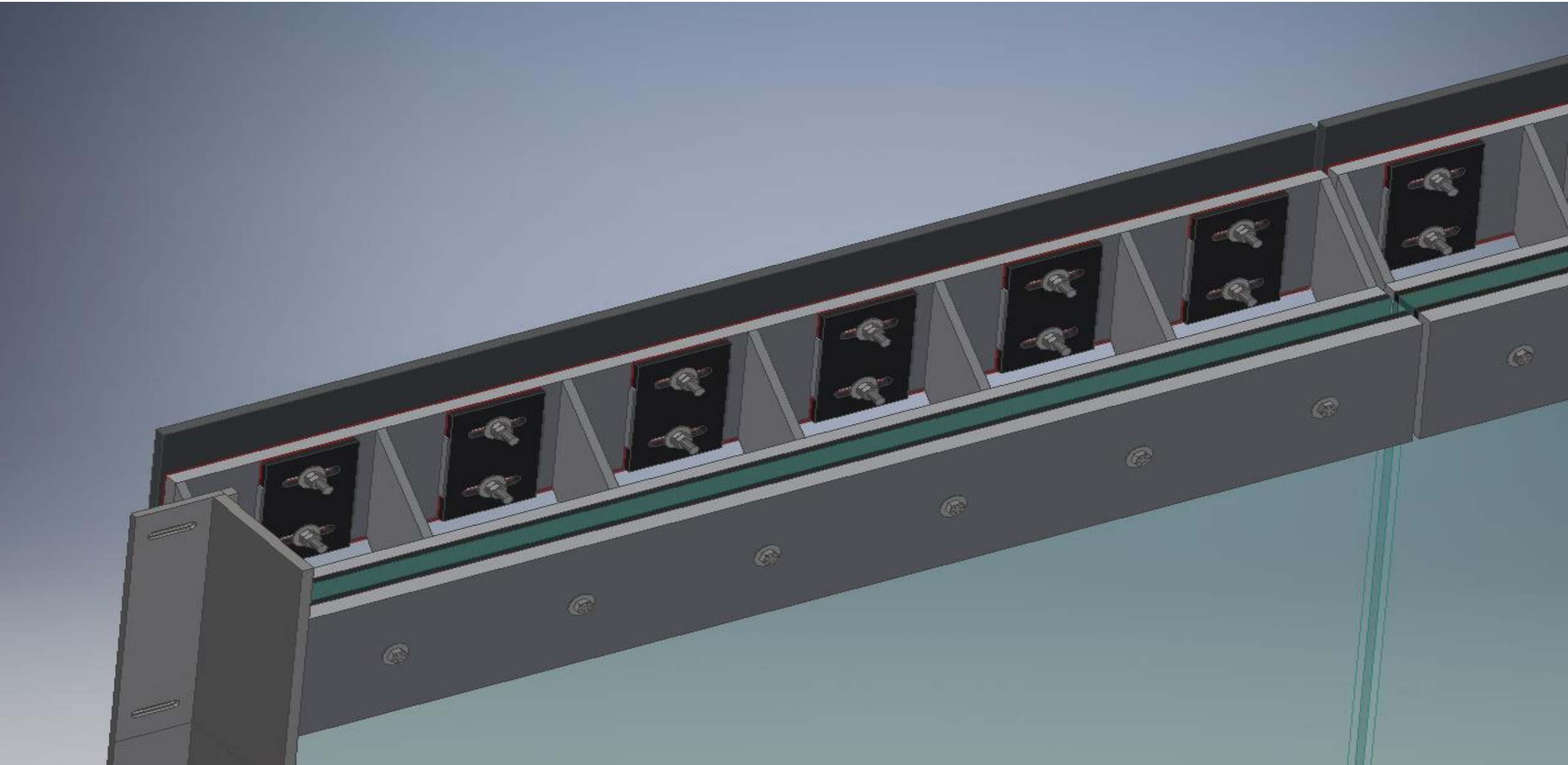
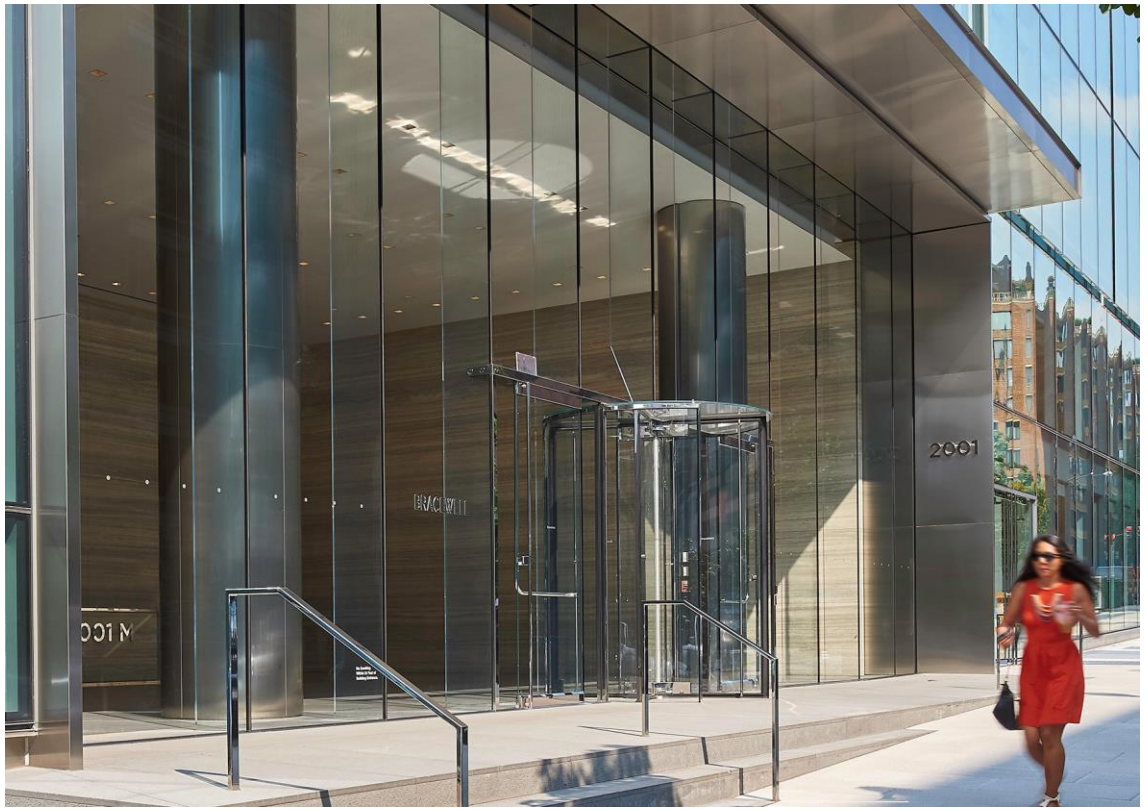
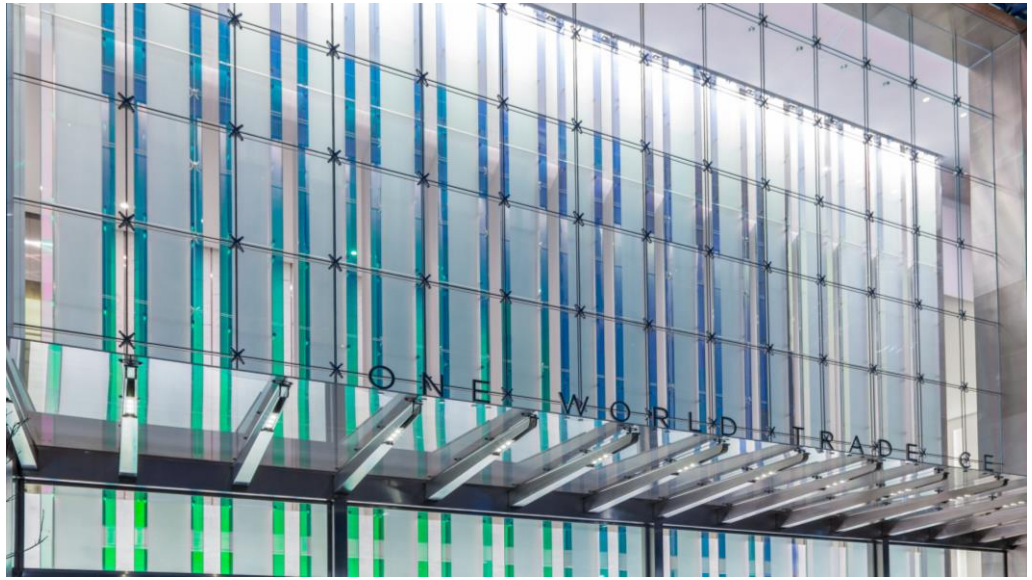


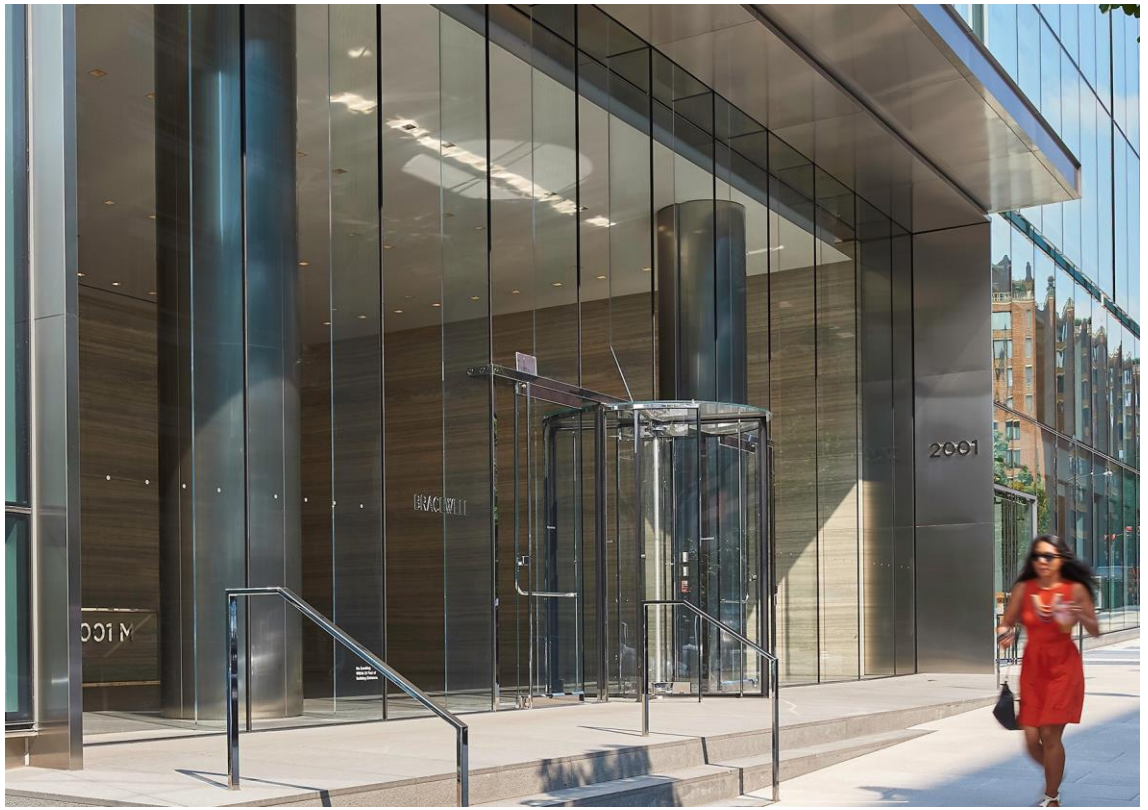
Trend 4: Use of wider panels

- Panels up to 11’ width are frequently used



Trend 5: Increased use of all glass systems

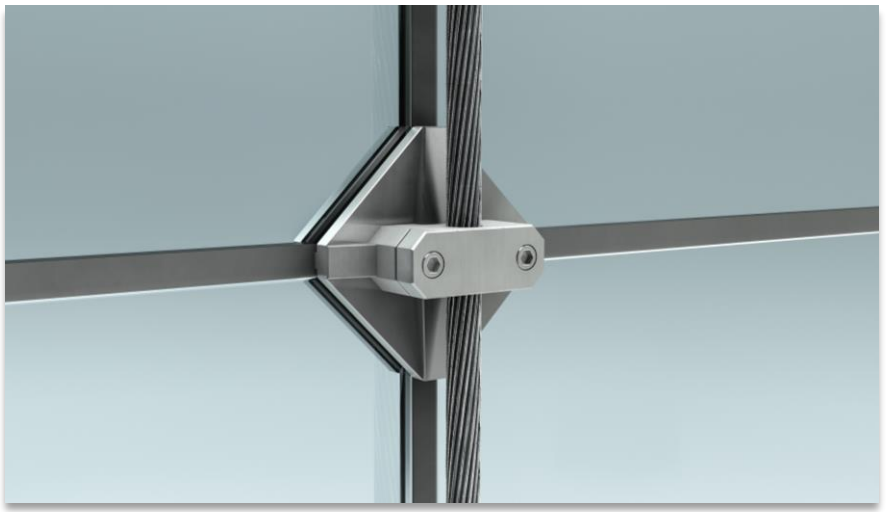




- Advancements in laminating and tempering of fins
- Reduced price of all glass solutions

Trend 6: Increasing transparency by minimizing connections and using hidden connections


OUE



Impact Resistant Glazing

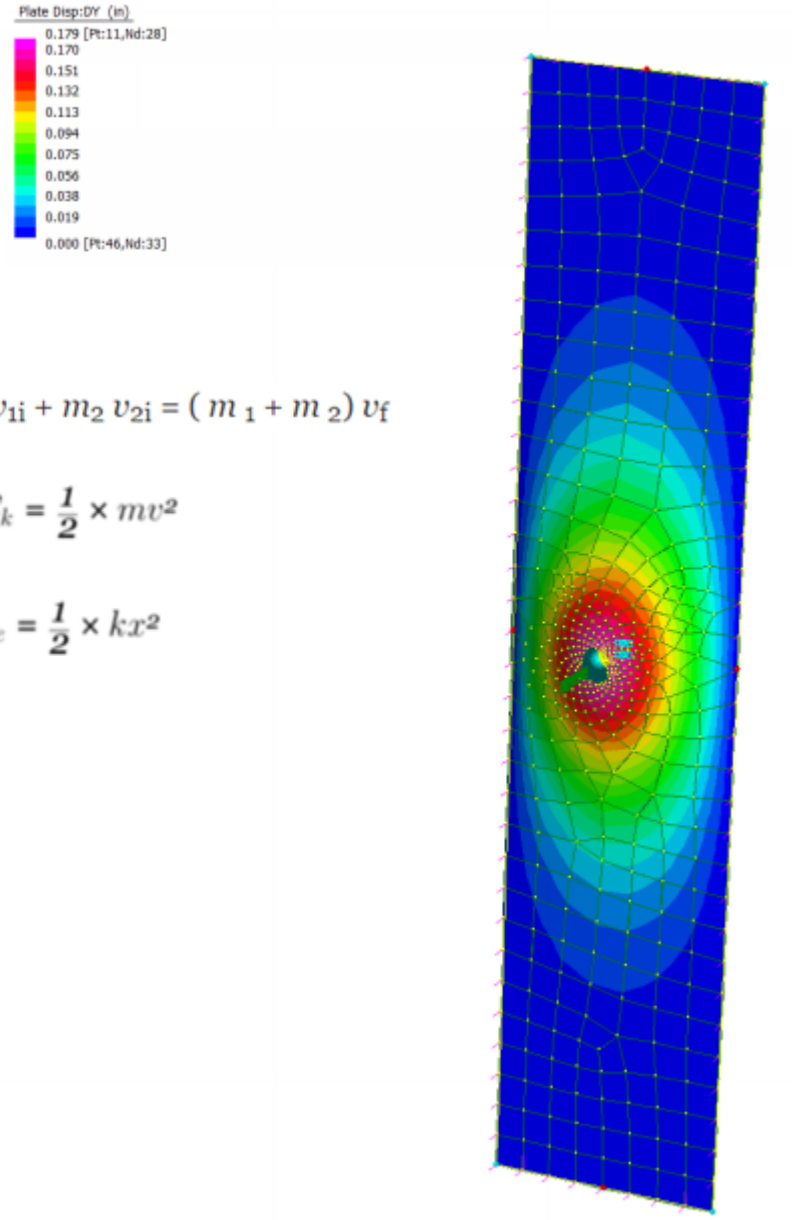
- All the systems presented can be used in impact resistant glazing applications
- Testing expenses are extremely high, a reliable procedure to predict breakage with a high degree of certainty is needed.
- A procedure based on energy methods was developed to predict breakage of thick laminated assemblies.

Analysis Hypothesis

- The projectile impact breaks the outboard glass laminate upon contact
- The inner ply will break if the stress level induced by the glass deformation (on the number 4 surface) upon impact generates stress levels within the inner ply that exceed the material ultimate stress.
- This assumption is consistent with the literature and test result analyses
- Testing being performed to corroborate hypothesis
- Procedure provides designers the ability to predict breakage of inner laminate before testing

Analysis Procedure:

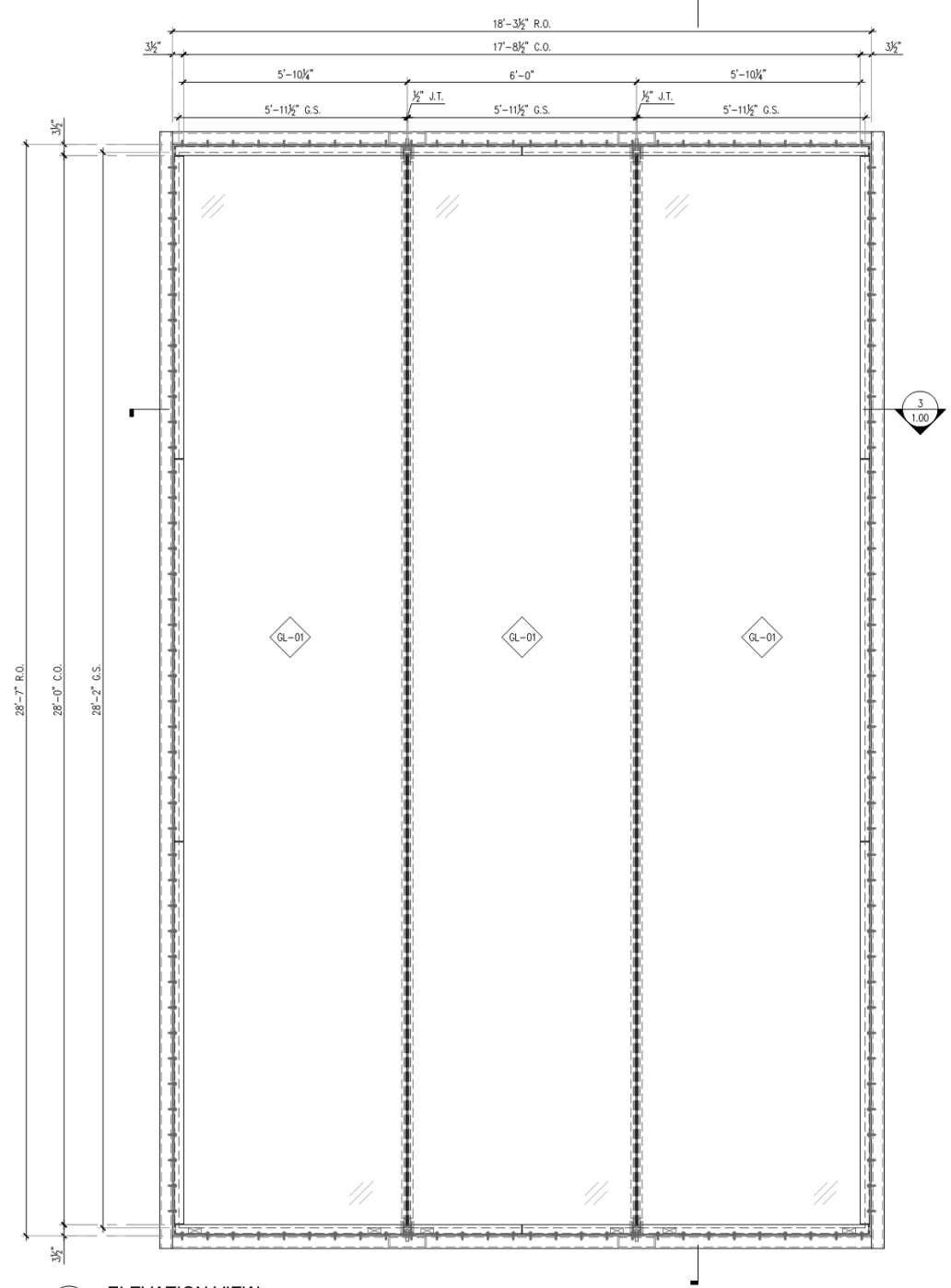
- Enforce a unit load on the panel to determine stiffness and mass participation of panel
- Use the law of conservation of momentum (perfectly inelastic collision) to determine velocity of combined mass (panel and 2x4) after impact.
- Calculate kinetic energy of system
- Determine displacement to convert Kinetic into Potential energy
- Calculate force/stress for above displacement



$$m_1 v_{1i} + m_2 v_{2i} = (m_1 + m_2) v_f$$

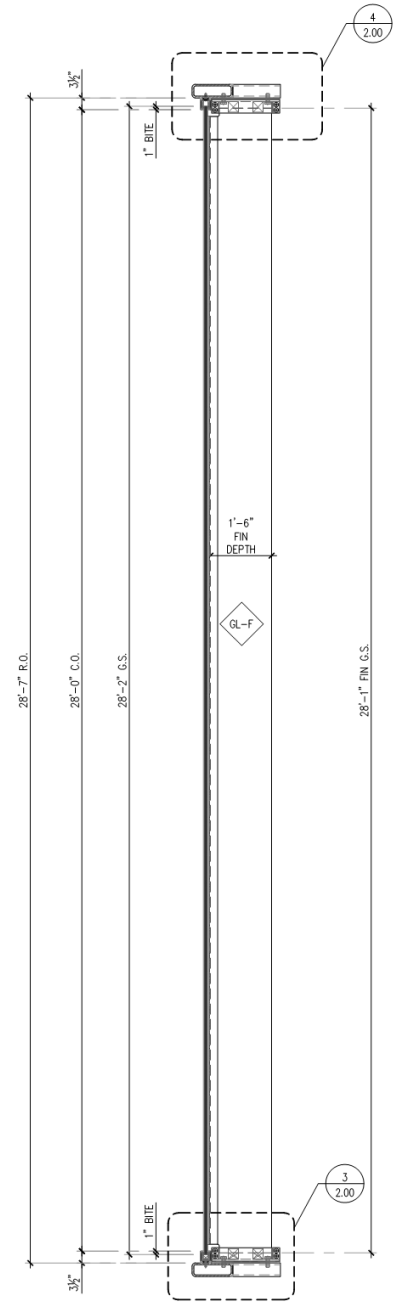
$$E_k = \frac{1}{2} \times mv^2$$

$$E_e = \frac{1}{2} \times kx^2$$



1 ELEVATION VIEW

Scale: 1/2" = 1'-0"



2 SECTION VIEW

Scale: 1/2" = 1'-0"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