Applications of Architectural UHPC in USA building facades

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TAKTL®
ULTRA HIGH PERFORMANCE CONCRETE

Outline

- Introduction
- A|UHPC® classification and properties
- A|UHPC® reference standards, emerging codes, and specifications
- Case example
- Conclusion

Introduction

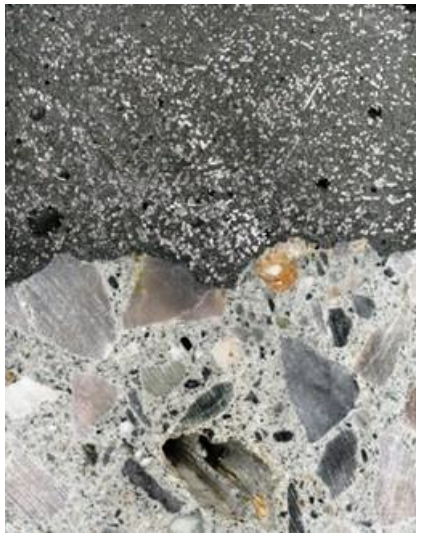
What is UHPC?

"Hydraulic cement-based mixture with a 56-d compressive strength at least equal to 120 MPa (non-metallic fibers) or 150 MPa for metallic fibers"

UHPC properties compared to NC:

- No coarse aggregate (maximized packing).
- Use of silica fume and other pozzolanic materials.
- High % of fiber (steel, AR-glass, PVA, etc.).
- Low water to binder ratios (w/b < 0.30).
- Use of admixture (SP, AC, etc.).

UHPC

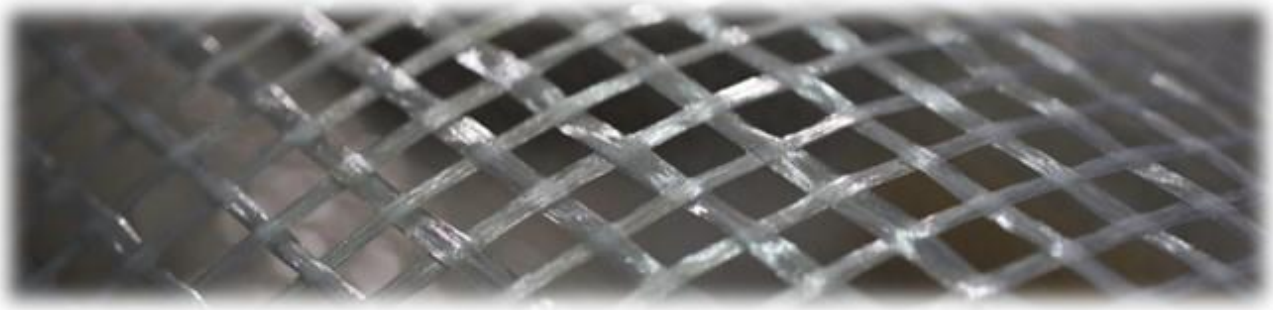


NC

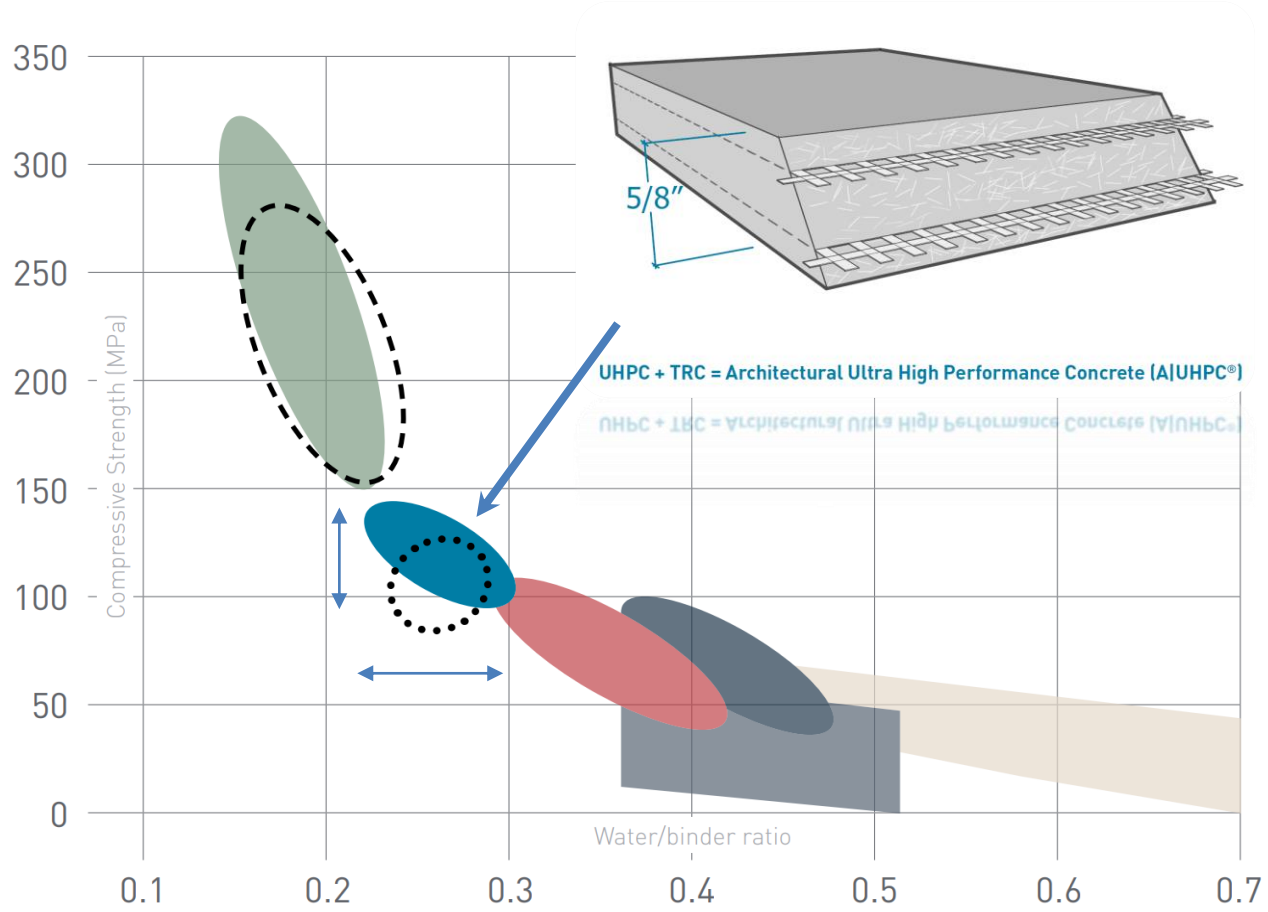
Introduction

Why TRC?

- Allows production of thin and lightweight elements.
- Uses of synthetic fiber mesh (1D, 2D, 3D).
- Solves problem of discrete fiber alignment.
- Increases in anchor capacity.
- Extends deflection and shattering resistance (increased toughness and safety).

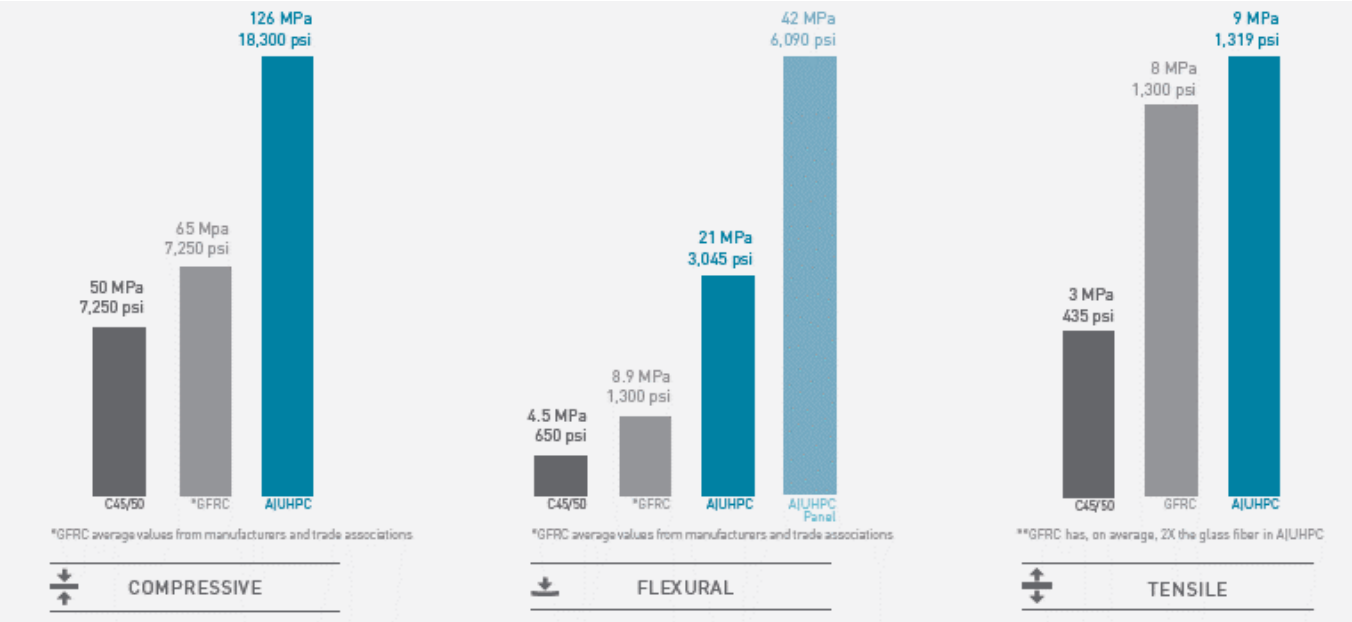


A|UHPC® Definition and classification



- Ultra High Performance Concrete (UHPC) 2000
- A|UHPC® 2010
- High Strength Concrete (HSC) 1985
- Self Compacting Concrete (SCC) 1995
- Light Weight Concrete
- Normal Concrete
- Arch. UHPC PVA fibers (2012)
- Struct. UHPC Steel fibers (1996)

A|UHPC® Properties



ESR-3899 report


ICC-ES Evaluation Report

ESR-3899

Reissued April 2021

This report is subject to renewal April 2022.

www.icc-es.org | (800) 423-6587 | (562) 699-0543 A Subsidiary of the International Code Council®

DIVISION: 07 00 00—THERMAL AND MOISTURE PROTECTION
Section: 07 46 46—Fiber-Cement Siding

REPORT HOLDER:

TAKTL, LLC

EVALUATION SUBJECT:

TAKTL STANDARD AND SELECT ULTRA HIGH PERFORMANCE CONCRETE (UHPC) PANEL SYSTEM

1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2018 and 2012 International Building Code® (IBC)
- 2018 and 2012 International Residential Code® (IRC)

Properties evaluated:

- Physical characteristics
- Weather resistance
- Wind load resistance
- Durability

2.0 USES

The TAKTL Standard and Select UHPC Panel Systems are used as an exterior wall cladding. The TAKTL Panel systems may be installed on buildings of all construction types under the IBC and IRC. The buildings constructed in accordance with the IRC must be installed on exterior walls of buildings of Types I, II, III or IV construction. Installation must comply with Section 4.3 of this report.

The system may also be used for interior applications as part of a Class A interior wall finish.

3.0 DESCRIPTION

3.1 General:

The TAKTL panels are part of a ventilated cavity wall assembly with an open-jointed wall cladding system that includes a drainage plane applied to the exterior sheathing face of the back-up wall. The panels are mounted with either visible fasteners through the face of the panels or with concealed undercut anchors on an extruded aluminum attachment system composed of rails and clips. When used as an exterior wall cladding, the system must be installed over a water-resistive barrier. The TAKTL Panel System is shown in Figure 1.

3.2 Components:

3.2.1 Panels: The TAKTL panels are glass fiber-reinforced, ultra high performance concrete panels manufactured from portland cement, silica fume and fine sands; alkali-resistant glass reinforcing fibers; two layers of alkali-resistant glass mesh; and additives. The panels comply with ASTM C1186 as Type A, Grade IV, fiber-cement sheets; have a flame-spread index of 0 and a smoke-developed index of 0 when tested in accordance with ASTM E84; and are classified as noncombustible when tested in accordance with ASTM E136.

The TAKTL Exterior panels are available in a maximum panel width of 24 inches (610 mm), a minimum and a maximum unstrimmed length of 144 inches (3658 mm). Standard thickness is 3/4-inch (19 mm) nominal, with a maximum base thickness of 3/4-inch (19 mm). The panels are available in a variety of standard colors and various surface textures.

3.2.2 Attachment System: The TAKTL attachment system is for use on interior and exterior installations.

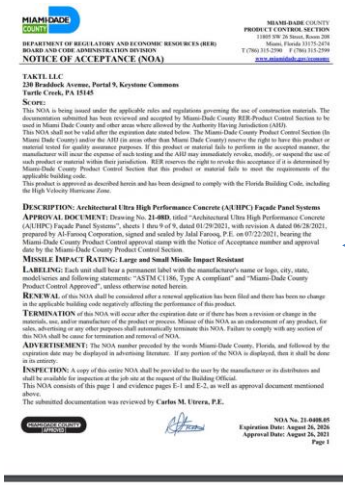
For the concealed attachment system, the TAKTL panels are to be supported by an attachment system consisting of structural rails and clips made of 6005A-T5 extruded aluminum. The rails and clips are 1.18 inches (46 mm) deep, 2.5 inches (63.5 mm) high, and 0.118-inch (3 mm) thick and have a C-shape configuration. The rails are available in various uncut lengths of 12 feet (3.67 m), 16 feet (4.88 m), or 20 feet (6.10 m), and the clips are 2 inches (51 mm) wide. The rail and clip profile is shown in Figure 2. For the visible system, the panels are fastened directly to support framing.

The attachment system may be fastened directly to the back-up wall for close-cladding installation, or to a sub-girt framing system for an increased air gap, using stainless steel fasteners.

Sub-girt framing supporting the TAKTL Panel system must be attached to the structure as designed by a registered design professional to resist the superimposed loads.

For the concealed system, the clips and rails interlock and are secured using bolts and fasteners made of Type 304 stainless steel supplied with the attachment system. TAKTL panels are fastened to the clips with undercut anchors for concealed attachment in accordance with 4.3.2. For the visible system, the panels are fastened directly to the supporting framing with SFS Intec SX3-D12 Torx® self-drilling stainless steel fasteners in accordance with 4.3.3. The fasteners used with the visible system must be designed by registered design professional to

Miami Dade County NOA report


MIAMI-DADE COUNTY
PRODUCT CONTROL SECTION
11805 SW 26 Street, Room 208
Miami, Florida 33175-2474
T (786) 315-2590 F (786) 315-2599
www.miamidade.gov/economy

DEPARTMENT OF REGULATORY AND ECONOMIC RESOURCES (RER)
BOARD AND CODE ADMINISTRATION DIVISION

NOTICE OF ACCEPTANCE (NOA)

TAKTL LLC
230 Braddock Avenue, Portal 9, Keystone Commons
Turtle Creek, PA 15145
Sc ors:

This NOA is being issued under the applicable rules and regulations governing the use of construction materials. The documentation submitted has been reviewed and accepted by Miami-Dade County RER-Product Control Section to be used in Miami Dade County and other areas where allowed by the Authority Having Jurisdiction (AHJ).
This NOA shall not be valid after the expiration date stated below. The Miami-Dade County Product Control Section (In Miami Dade County) and/or the AHJ (in areas other than Miami Dade County) reserve the right to have this product or material tested for quality assurance purposes. If this product or material fails to perform in the accepted manner, the manufacturer will incur the expense of such testing and the AHJ may immediately revoke, modify, or suspend the use of such product or material within their jurisdiction. RER reserves the right to revoke this acceptance if it is determined by Miami-Dade County Product Control Section that this product or material fails to meet the requirements of the applicable building code.
This product is approved as described herein and has been designed to comply with the Florida Building Code, including the High Velocity Hurricane Zone.

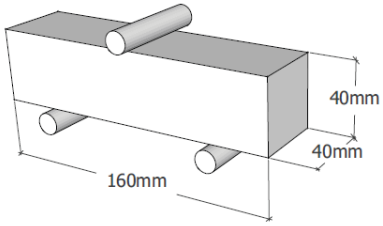
DESCRIPTION: Architectural Ultra High Performance Concrete (A|UHPC) Façade Panel Systems
APPROVAL DOCUMENT: Drawing No. 21-0803, titled "Architectural Ultra High Performance Concrete (A|UHPC) Façade Panel Systems", sheets 1 thru 9 of 9, dated 01/29/2021, with revision A dated 08/28/2021, prepared by Al-Farooq Corporation, signed and sealed by Jalal Farooq, P.E. on 07/22/2021, bearing the Miami-Dade County Product Control approval stamp with the Notice of Acceptance number and approval date by the Miami-Dade County Product Control Section.
MISSILE IMPACT RATING: Large and Small Missile Impact Resistant
LABELING: Each unit shall bear a permanent label with the manufacturer's name or logo, city, state, model/series and following statements: "ASTM C1186, Type A compliant" and "Miami-Dade County Product Control Approved", unless otherwise noted herein.
RENEWAL of this NOA shall be considered after a renewal application has been filed and there has been no change in the applicable building code negatively affecting the performance of this product.
TERMINATION of this NOA will occur after the expiration date or if there has been a revision or change in the materials, use, and/or manufacture of the product or process. Misuse of this NOA as an endorsement of any product, for sales, advertising or any other purposes shall automatically terminate this NOA. Failure to comply with any section of this NOA shall be cause for termination and removal of NOA.
ADVERTISEMENT: The NOA number preceded by the words Miami-Dade County, Florida, and followed by the expiration date may be displayed in advertising literature. If any portion of the NOA is displayed, then it shall be done in its entirety.
INSPECTION: A copy of this entire NOA shall be provided to the user by the manufacturer or its distributors and shall be available for inspection at the job site at the request of the Building Official.
This NOA consists of this page 1 and evidence pages E-1 and E-2, as well as approval document mentioned above.
The submitted documentation was reviewed by Carlos M. Utrera, P.E.

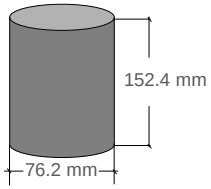
NOA No. 21-0408.05
Expiration Date: August 26, 2026
Approval Date: August 26, 2021
Page 1

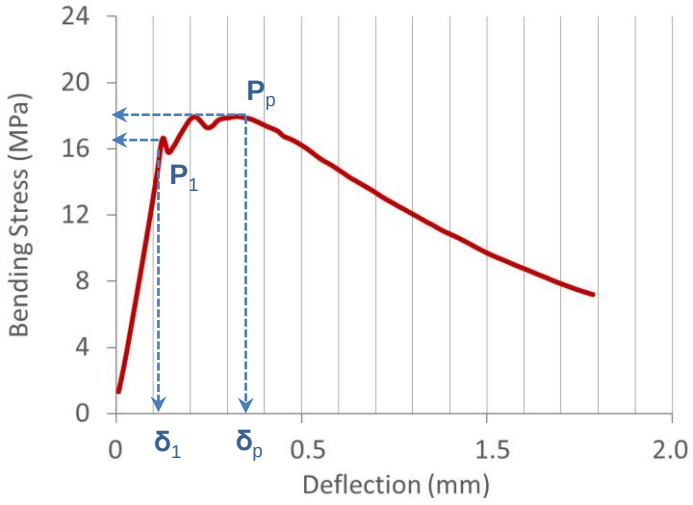
A|UHPC® Code development (IBC)

AC458

Only includes UHPC with fibers
Base UHPC matrix

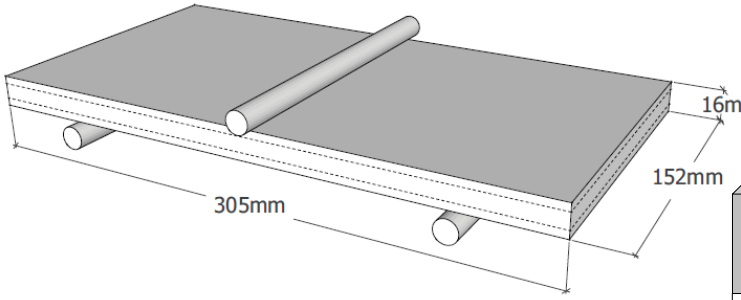


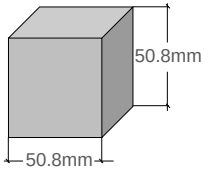


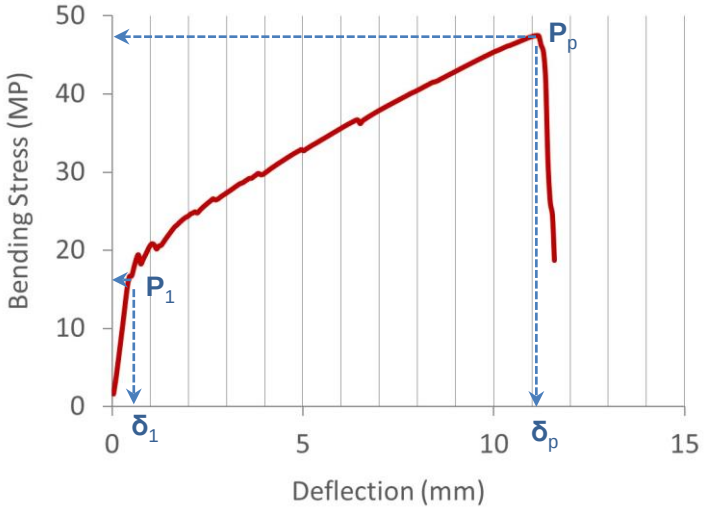


AC493

Includes reinforcing mesh
Tested in form of use





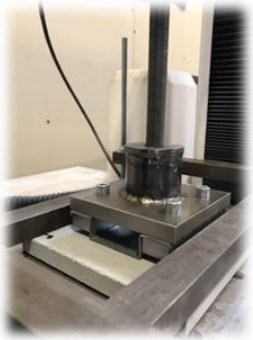


P_1 : First-Peak Load δ_1 : Net Deflection at First-Peak Load P_p : Post cracking Peak-Load δ_p : Net Deflection at Peak-Load

A|UHPC® Code development (IBC)

Panel connections (Fasteners)

329 Broadway, Brooklyn, NY (2019)



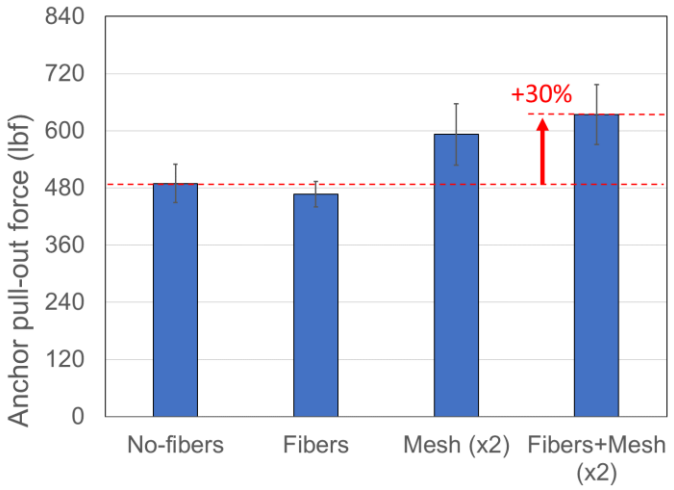
ASTM E488

A|UHPC® Code development (IBC)

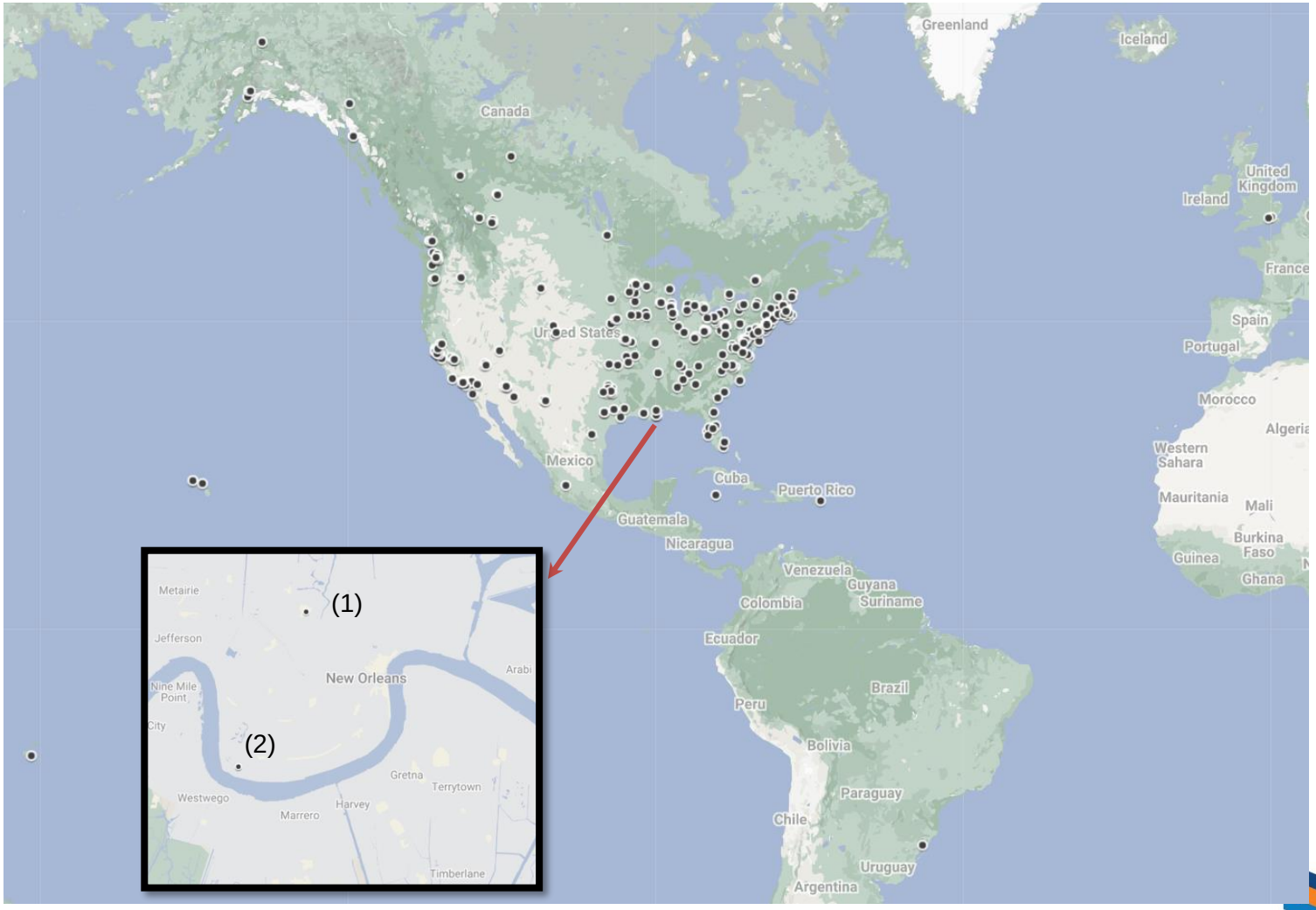
Panel connections (Concealed anchors)

University of Connecticut, STEM Research Center (2022)

ASTM E488



A|UHPC® Projects (>475)



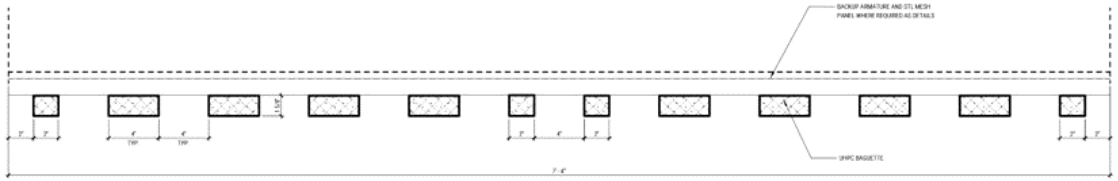
(1) Allie Mae Williams Multi-Service Center, 320 N Carrollton Avenue
(2) Children's Hospital New Orleans Infill Tower, 200 Henry Clay Avenue

CASE Study: 325 Binney St (2023)

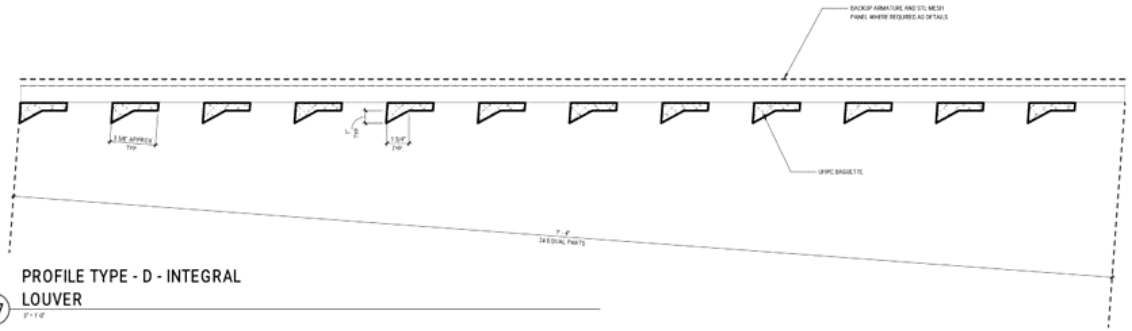
Courtesy of NBBJ Arch.

CASE Study: 325 Binney St

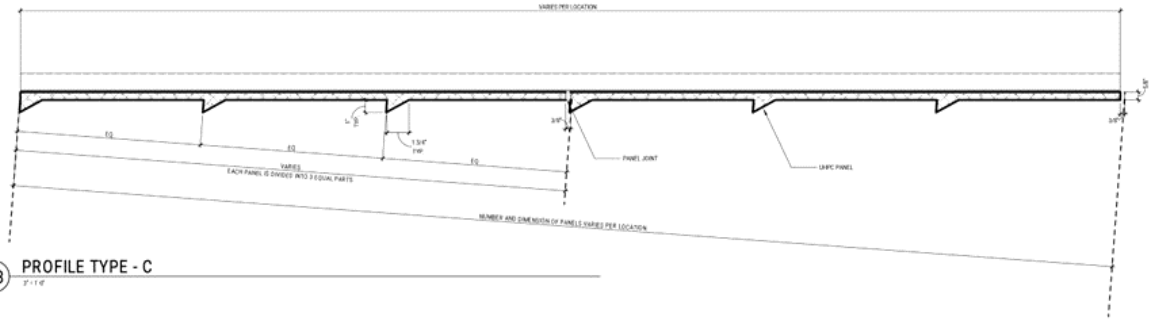
Panel and elements



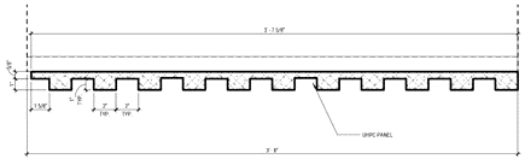
G5 PROFILE TYPE - F - INTEGRAL LOUVER



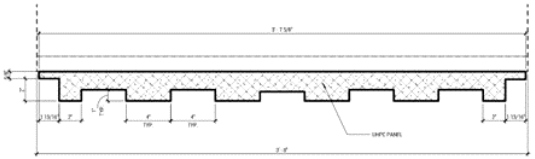
G7 PROFILE TYPE - D - INTEGRAL LOUVER



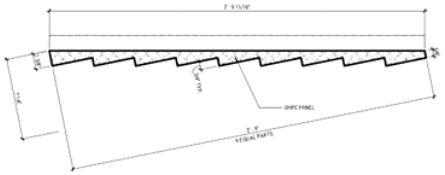
G8 PROFILE TYPE - C



C5 PROFILE TYPE - G



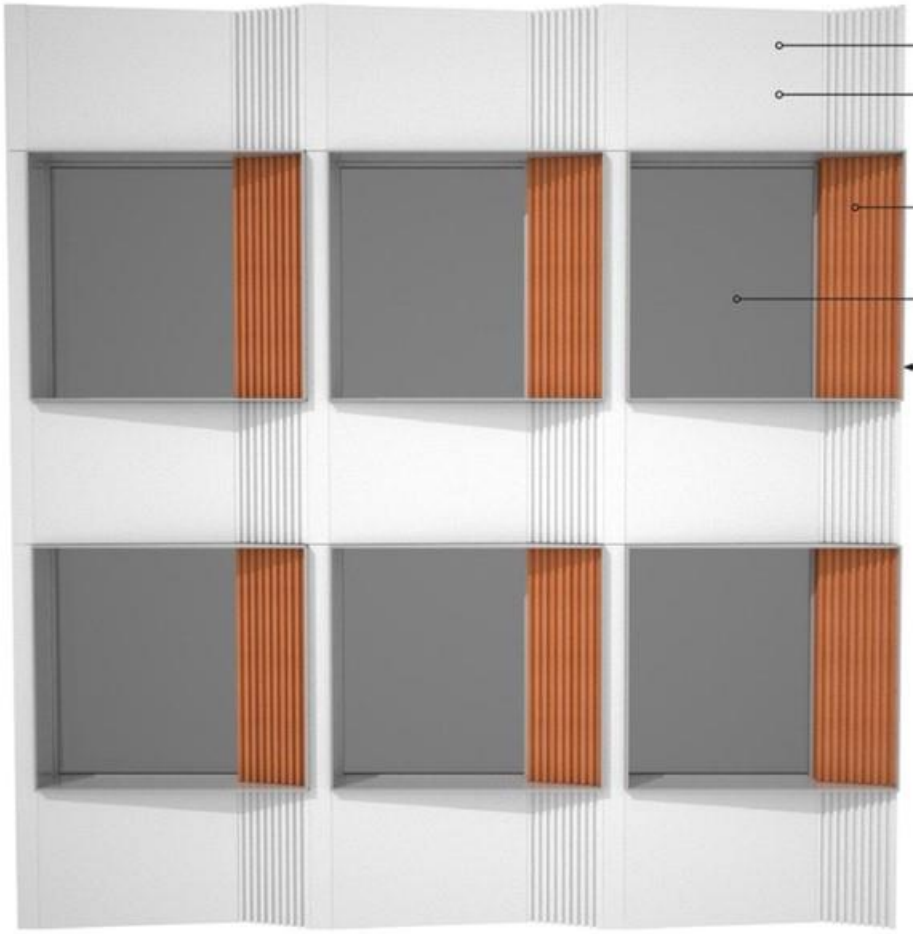
C6 PROFILE TYPE - E

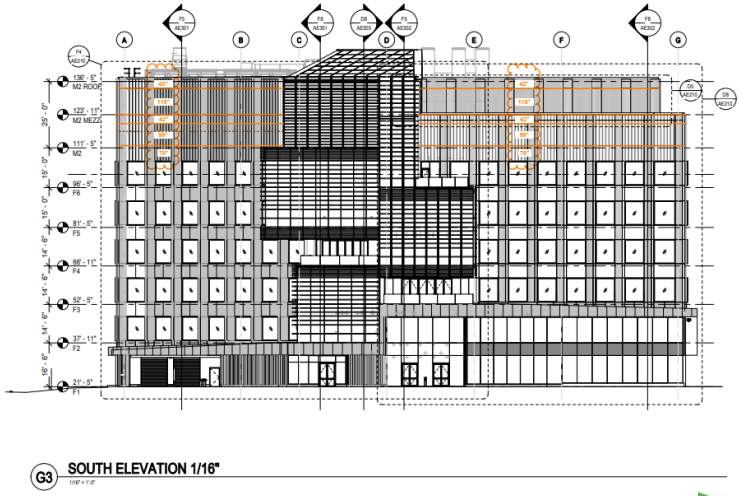


C2 PROFILE TYPE - B

C1 PROFILE TYPE - A

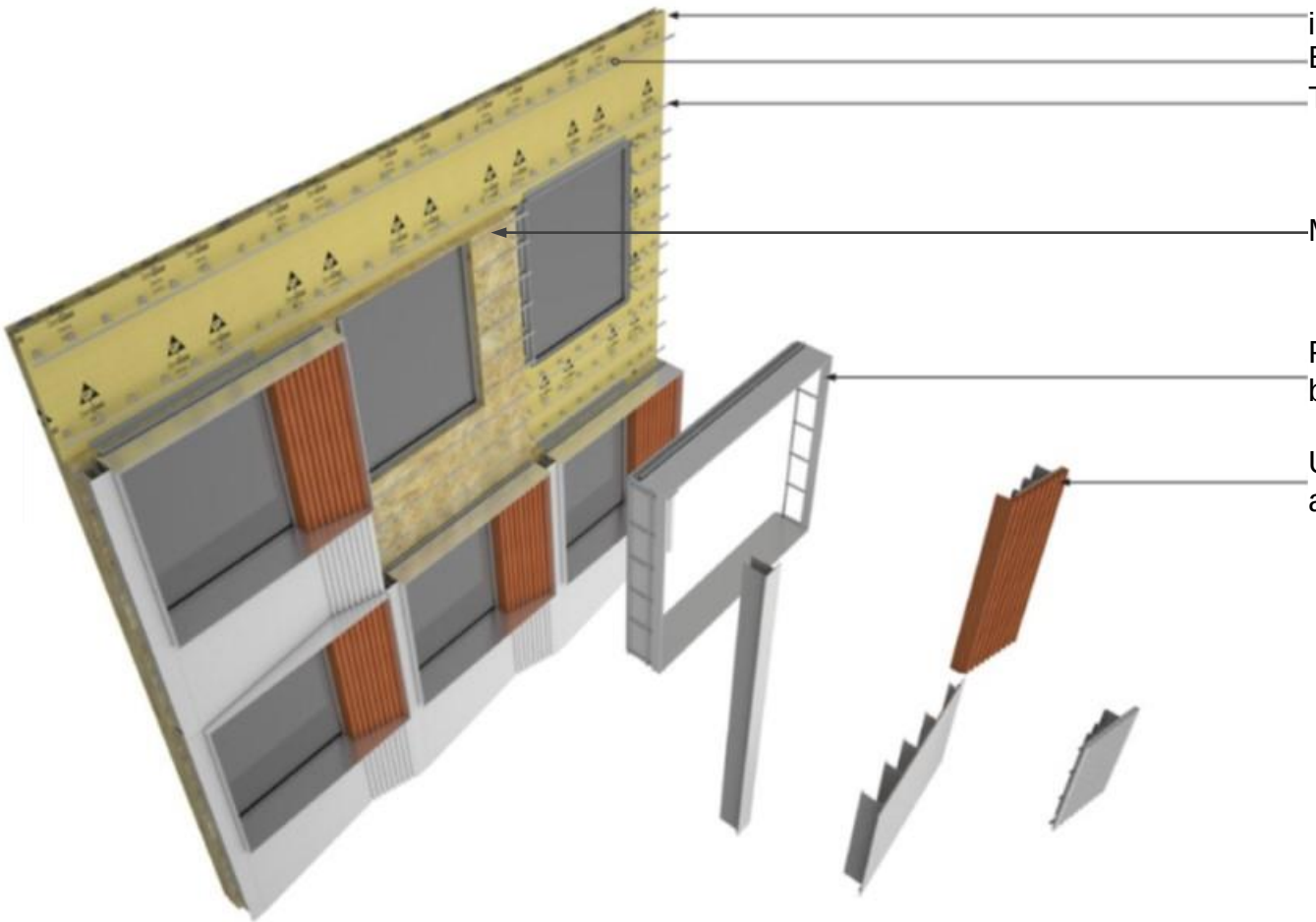
CASE Study: 325 Binney St





Courtesy of STUDIOTJOA

CASE Study: 325 Binney St



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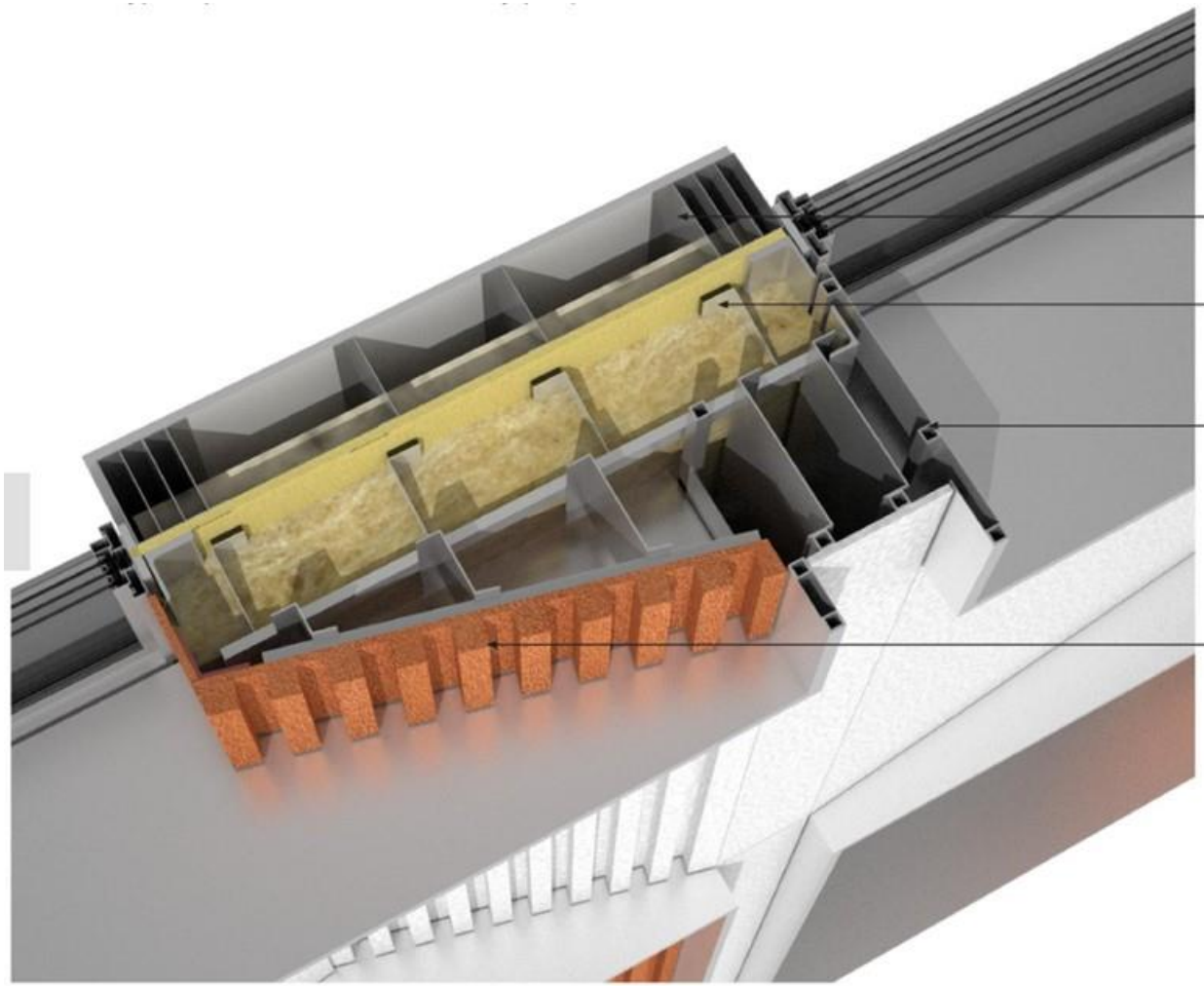
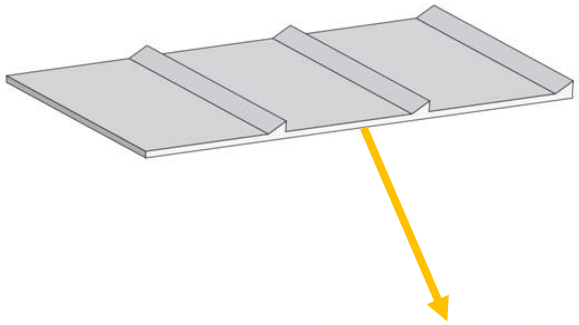
CASE Study: 325 Binney St

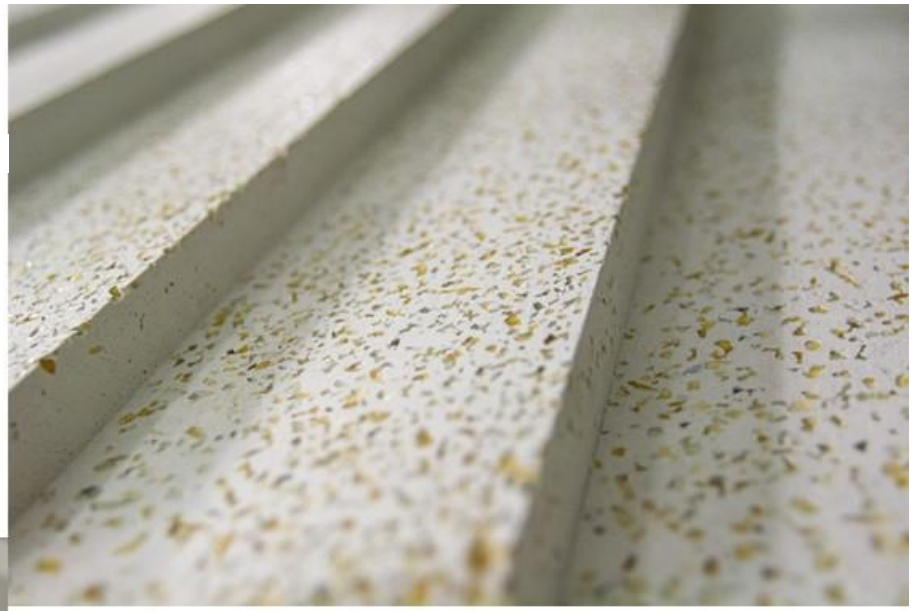


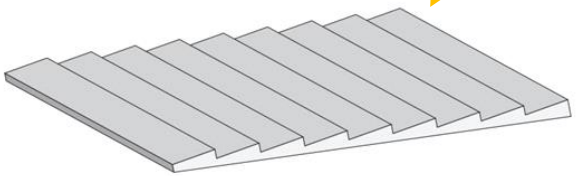
Courtesy of STUDIOTJOA

CASE Study: 325 Binney St

UHPC white tone, Textured Panel (phase aggregates)

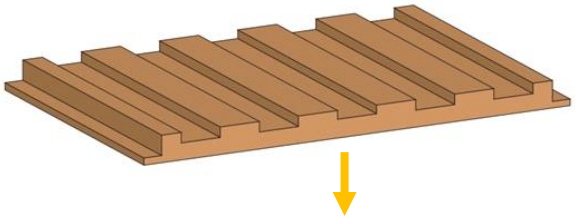


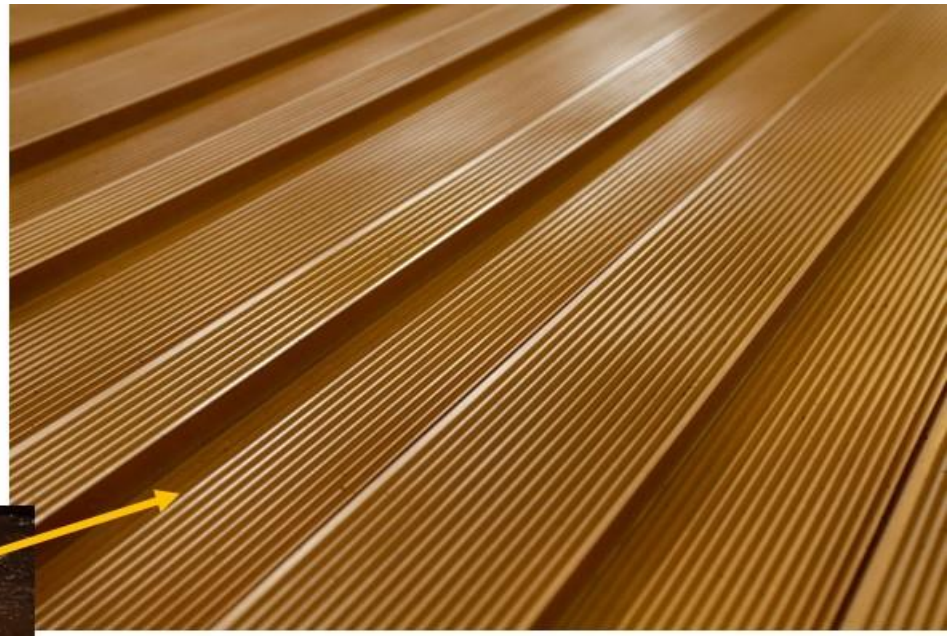




CASE Study: 325 Binney St

UHPC Wood tone, Textured Panel (micro-shadows)





CASE Study: 325 Binney St (Eng.)

5/8" PANEL ANALYSIS: (Corner Zone)

1. Panel RISA Analysis Summary:

Panel Size: 44" Wide

DESCRIPTION: Min. 5/8" Concrete Panel (1 1/2" Max)
MATERIAL: High Performance Concrete

Properties:

$WL := 45 \cdot psf$	(Wind Pressure)
$t := 0.625 \cdot in$	(Nominal Panel Thickness)
$t_d := 0.575\ in$	(Design Panel Thickness - Includes panel tolerance)
$F_u := 3.190 \cdot ksi$	(Modulus of Rupture)
$\tau_u := 0.957 \cdot ksi$	(Shear Stress: 30% of Rupture)
$E := 3685 \cdot ksi$	(Elasticity)
$\rho := 137 \cdot \frac{lbf}{ft^3}$	(Density)
$\Omega := 3$	(Factor of Safety)

Deflection Summary:

$Fastener_{spacing} := 29 \cdot in$ (Fastener Spacing)

$\Delta_{WL\_allow} := min\left(\frac{Fastener_{spacing}}{360}\right)$ $\Delta_{MAX} := 0.0233 \cdot in$

$\Delta_{WL\_allow} = 0.081\ in$ > $\Delta_{MAX} = 0.023\ in$ **Check = "Deflection O.K."**

Bending Stress Summary:

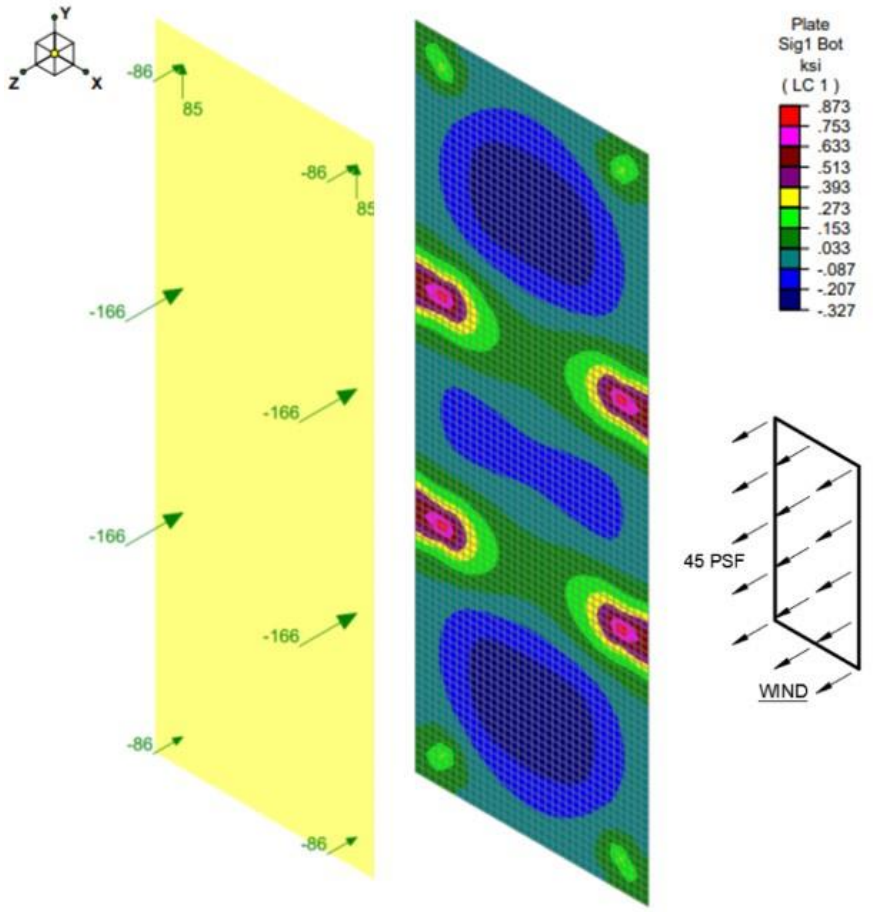
$F_b := \frac{F_u}{\Omega}$ $fb := 0.776 \cdot ksi$

$F_b = 1.06\ ksi$ > $fb = 0.776\ ksi$ **Check = "Stress O.K."**

Shear Stress Summary:

$F_\tau := \frac{\tau_u}{\Omega}$ $fr := 0.195 \cdot ksi$

$F_\tau = 0.319\ ksi$ > $fr = 0.195\ ksi$ **Check = "Stress O.K."**



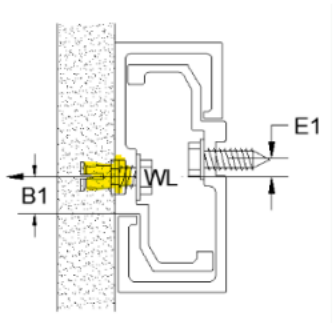
CASE Study: 325 Binney St (Eng.)

CONCRETE PANEL ANCHOR ANALYSIS:

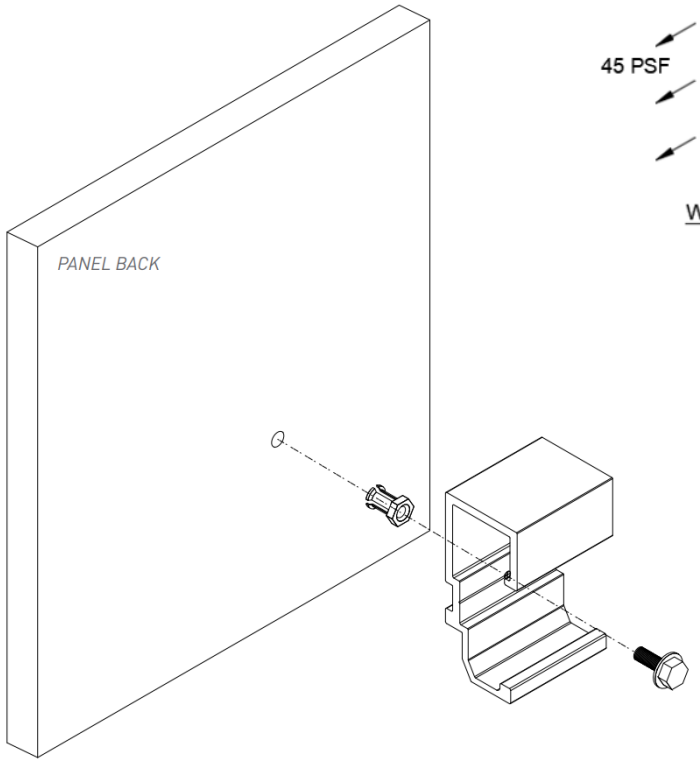
Wind Loading:

$WL := 160 \cdot lbf$ (Max. RISA Center Clip Reaction)

1. 10 mm Anchor Check at Panel Connection Point:



$E_1 := 0.2\ in$ $B_1 := 0.4\ in$



Panel Anchor Allowable Loads:

$\Omega := 4$ (Safety Factor)

$Tension_{ultimate} := 692 \cdot lbf$ (TAKTL Intertek) $Shear_{ultimate} := 1187 \cdot lbf$ (TAKTL Intertek)

$Tension_{allowable} := \frac{Tension_{ultimate}}{\Omega} = 173\ lbf$ $Shear_{allowable} := \frac{Shear_{ultimate}}{\Omega} = 297\ lbf$

Applied Loads wL Anchor:

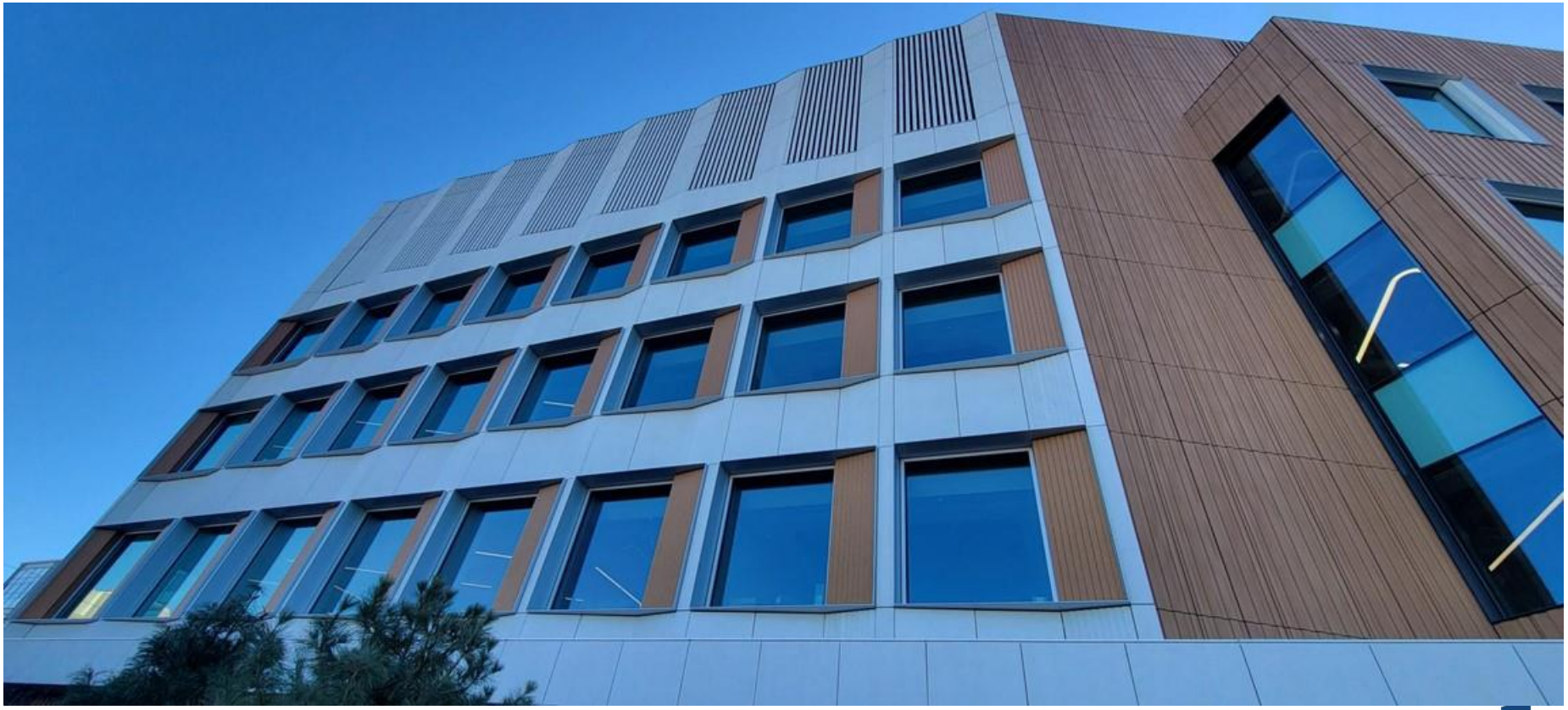
$\delta := 2$ (Double Curvature)

$Tension := WL$

$Tension_{allowable} = 173\ lbf > Tension = 160\ lbf$ **Check = "Keil Anchor O.K."**

CASE Study: 325 Binney St

CASE Study: 325 Binney St

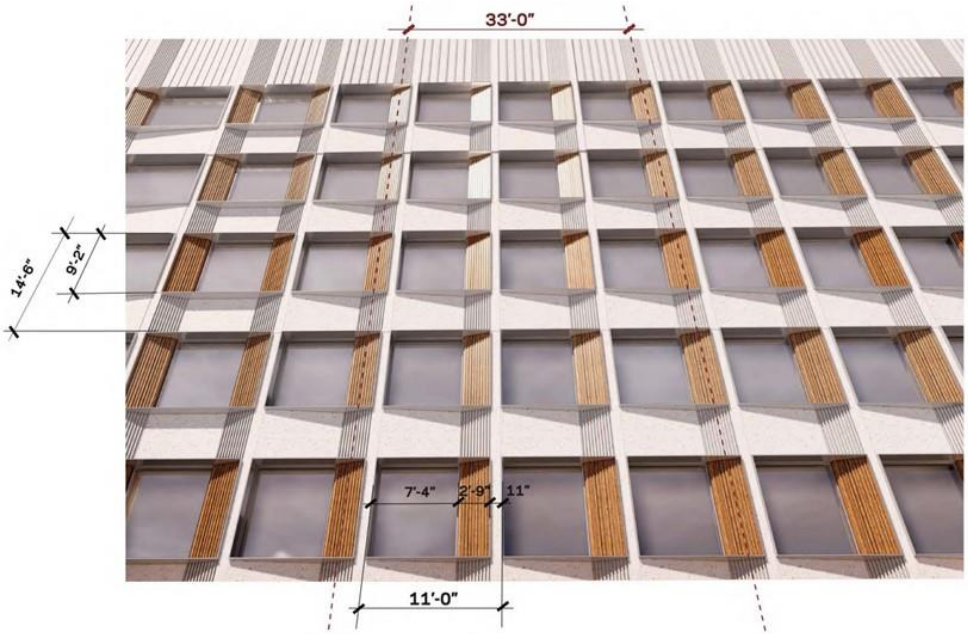


CASE Study: 325 Binney St

CASE Study: 325 Binney St

CASE Study: 325 Binney St

Concept



Realization

Conclusions

- More than 475 successful applications of UHPC and A|UHPC®.
- UHPC is creating the path for long-lasting and resilient building envelopes.
- Still more work needed for continued development of specs, codes and design guidelines (Joint effort from architects, engineers, contractors, manufacturers and regulators).