Positing Ecology: Mass Material Strategies for Miami-Dade County

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Despite mounting evidence of environmental uncertainty, South Florida communities continue to record steadily increasing growth, with Miami Dade County's [MDC] population expanding by approximately 3.5% between 2014 and 2018.[1] Currently, any concern of building insurance affordability/availability, long-term financial investment risks and health/safety concerns have not significantly altered the short-term future of the construction and real-estate markets.[2] The south Florida community's commitment to urban development is ever present; but the question on the minds of community leaders, policy makers and the general public is, how do we create urban resilience? The architectural profession must address the agenda--how do buildings and policies anticipate an evolving environment and sustain long-term, safe occupation? And what are they made of?

An abundant battery of raw material timber resource, a distributed network of mills, processing plants, and mass timber manufacturing facilities affords an opportunity for the Southeastern United States to focus on implementing wood fibre into the construction ecology. However, a critical hurdle to the successful implementation of mass timber wood products in Florida, and specifically in MDC, is within the policy and permitting process. The required certified product testing by the Florida Administrative Code[3] and the Miami-Dade County Product Approvals and Notice of Acceptance[4] is one of two jurisdictions in the United States implementing the stringent High Velocity Hurricane Zone [HVHZ][5] as an overlay to the Florida Building Code[6]-which must be successfully navigated for project realization.

The focus of this paper engages the question how do we build as a regional inquiry to Southern Florida through a case study on a partnership forged between academics and practice at the University of Miami School of Architecture and Atelier Mey Architects. This collaboration is established with the shared objective of implementing an innovative path to the design and building permitting of cross-laminated timber [CLT] in MDC, specifically the qualitative and quantitative methods required for CLT case study's success. Empirical methodologies used to understand building applications of mass timber products, specifically PRG-320 certified Cross Laminated Timber Panels[7] in Florida is through the design, engineering and submission of drawings to the Miami-Dade building permitting office for review.

[RE] ESTABLISHING NEED, INNOVATION + ECOLOGY

The construction of the first cross-laminated timber [CLT] structure in Miami-Dade County [MDC] sets a new trajectory for South Florida communities in reconfiguring building policies and compliance tracts that posit wood products, specifically mass timber, as a viable building option. The mass timber option builds ecological best practices at the regional, state and community levels. The paper is a case study on the first CLT structure which analyzes the specific qualitative and quantitative methods required for the case study's success. Qualitative examples are the project's commitment to building with regionally sourced and processed mass timber products. Quantitative methods address stringent wind-loading design parameters for hurricane prone areas and adherence to building permitting processes-to include construction inspection compliance specific to High Velocity Hurricane Zones [HVHZ]. Empirical methodologies used to understand building applications of mass timber products, specifically PRG-320 certified Cross Laminated Timber Panels[8] in Florida is through the design, engineering and submission of drawings to the MDC building permitting office for review.

The recent emergence of solid, mass based approaches to wood manufacturing and construction methodology in the United States have expanded the opportunities of renewable, low emergy, and carbon storage in building practices. These grown materials, wood fibre, implemented in their mass form have the capacity to build at a scale that is impossible to accomplish with traditional light wood stick framing techniques. This emerging [arguably emerged in several U.S. regions] building methodology, mass timber, fosters a new ecological dialogue between environment and making within our dense and tall urban environments. Regionally grown renewable resources [wood fibre] can be implemented with new demands and urban agendas, removing a presumed dependency on steel and concrete. Across the U.S., states, counties and Authorities Holding Jurisdiction [AHJ] are including mass timber strategies into their building codes and policies to varying degrees, however, as of 2021 MDC and Broward County have not adopted mass timber, specifically cross-laminated timber [CLT], as an approved building product. In addition to the exclusion from codes, long standing contextual values ingrained in South Floridians serves as a side effect and cultural barrier to the renewable building material. Cultural concerns for wood based structures and assemblies capacity to absorb the climate and environmental pressures common to the region have led to a reticence to advance policies supporting wood buildings and subsequently a lack of innovation and advancement in local building practices.

Hurricane Andrew, which made landfall in 1992, cemented these perceptions, as the most costly storm event in the U.S. at $26.5 billion[9]. The severity and devastation of this storm event was the catalyst governing bodies in MDC and Broward County needed to make significant changes to building codes and policies, from which the HVHZ formalized[10].

One consequence of the adjustments to local building codes was through the complete restriction of wood as a structural [wall] building element within some of the municipalities designated HVHZ. A clear example can be found under Miami Shores– one of thirty-four municipalities comprising Miami-Dade County– building policy Sec. 523.1.-Construction[11]:

> *All buildings and structures shall be constructed of materials approved by and in a manner consistent with the then most current version of the Florida Building Code:*
>
> *(1) Materials. Interior structural walls shall be constructed of stone, wood, steel, brick, or cement or cement products. Construction of all exterior walls and exterior structural elements of a building shall be of stone, brick, tile, cement or cement products with the following exceptions:*
>
> *d. Trusses, joists, and beams. Trusses, joists, and beams may be constructed of metal or wood.*

These building codes, generated over twenty-five years ago, prohibit the use of wood in framed wall conditions while allowing the use of wood elements in the form of trusses, joists and beams,[presumably because it is both tectonically complex and cost-prohibitive to construct these elements in concrete, steel or stone]. Changes to building policies such as Miami Shores Sec.523.1.d have signaled, wood is insufficient for building in HVHZs[12], inculcating three critical issues:

1. A comprehensive shift towards concrete and steel for single family residences through mid-rise buildings,

2. A commitment towards a single process of construction dramatically reducing the skill sets of local building trades

3. A narrowed perspective on construction methods considerably limiting the knowledge base for personnel managing/reviewing construction documents for permit and conducting site inspections.

The constriction of design and construction into a myopic material collection weakens the knowledge set of local designers, contractors, and building authorities. In this perceived static policy environment, the viability of adopting emerging materials and assemblies within existing codes feels foreign and discouraged. It is critical to analyze the impacts of storm events for the advancement of building codes and construction techniques,

Figure 1.Minimally processed Cypress timbers and Palmetto thatch roofs used in the Seminole chickee huts. Image from MacCauley's report (MacCauley 1887) National Anthropological Archives, Smithsonian Institution, Neg. No. 1178-N-8-1.

however, this influence cannot act in isolation. Regional and local municipalities, design professionals and construction industries need to simultaneously advocate for innovation to address the imbalance of energy and carbon implications buildings have on the environment. In summary, the contextual consequences of a local and regional environment should and do influence policy making, but the global building techniques and material science advancements must find a path to implementation at local scales.

[RE]STATING THE ARGUMENT, NARROWING THE AGENDA

Inexplicably, in the years following Hurricane Andrew the population of Miami-Dade County continued to grow, from approximately 1.9 million to 2.7 million people[13]. For the purpose of this paper, the fundamental question of whether or not new structures should be constructed in South Florida's dynamic aquatic environment will be set aside in order to interrogate a more pertinent question; what is an ecologically responsible building process for South Florida communities? One approach, the approach proffered by this paper, defines building resilience as a focused and conscious construction ecology that leverages regionally grown material, regional industry [milling] and regional manufacturing intrinsic with the ability to displace quotidian energy intensive material, industry and manufacturing allegiances. Embedded within this building strategy is an anticipation of dynamic environments and an understanding of resiliency as an anticipated quick recovery, or recoil, not an opposition or overcoming of environmental factors.

Thus, the advancement of policy and governance for buildings should afford the opportunity to utilize renewable materials with carbon sequestering and storage potentials, characteristics imbued in wood. The discipline of architecture should demand responsibility for metropolitan areas, inclusive of Miami, to develop an agenda for architecture and urbanism

Figure 2. The five story Royal Palm Hotel from 1897 along the Miami River constructed by Henry Flager. Aerial view of the Royal Palm Hotel–Miami, Florida. 1920 (circa). State Archives of Florida, Florida Memory. <https://www.floridamemory.com/items/show/39888>, accessed 23 October 2021.

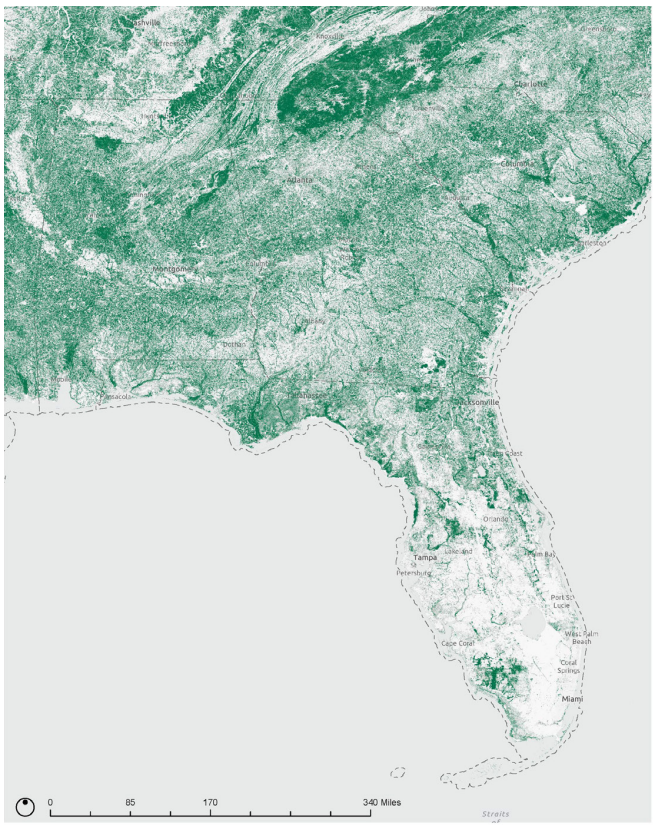

Figure 3. Map of timber lands stretching across Florida indicating an abundance of raw material resources. Map created by University of Miami Littoral Urbanism Lab [LU_Lab].

that is accountable for emergy[14] and carbon; certainly this will require the reinterpretation of policy, materials and processes accepting of novel or emergent approaches. Answering the bell of accountability for littoral cities would require confronting the possibility of a foreshortened existence, questioning how a thirty-five to forty year timetable would change the way we think of and construct buildings.

[RE]CLAIMING WOOD CULTURE: ABBREVIATED HISTORY OF WOOD BUILDING IN MIAMI-DADE COUNTY

Historically, MDC was home to an assortment of structures utilizing wood in the form of debarked logs, heavy timbers (from reclaimed/salvaged and virgin material sources), dimensional lumber products and thatch sheds from a variety of palms. The broad spectrum of material usage, from logs to palm fronds, is directly tied to cultural dispositions that acknowledge the importance of local material resources, structures as temporal and a commitment to regenerative processes of building. The Chickee structures of the Seminole Tribe [Fig 01] used local wood fibre resources to construct shelters able to weather storms, maintenanced or rebuilt as needed. Palmetto thatch roofs existed on five year cycles while minimally processed cypress timbers were utilized for structural elements existing for ten or more years[15]. These native buildings balanced life expectancy, performance and energy/emergy flows. To this day, foundational principles of the Chickee structures are utilized for outdoor pavilions, garden structures and exterior covered seating for restaurants across south Florida.

From the Miami perspective of contemporary buildings, the deployment of wood as structure includes the loosely termed 'vernacular Bahamian' or 'Conch homes', traditional bungalows, Belvedere Bungalows and most impressively the Royal Palm Hotel constructed by the railroad magnate, Henry Flagler. These buildings utilized a range of wood sources, from the native Dade County Pine (Pinus Elliottii Var-Densa) grown in the Pine Rocklands to repurposed wood timbers salvaged from decommissioned ships. The majority of these wood assemblies were based on light frame construction techniques and for better or worse can be traced back to the cultural division related to the contemporary use of wood. The Royal Palm Hotel [Fig 02] was an extremely ambitious timber and stick framed wood project constructed in South Florida in 1897 along the Miami River, standing five stories tall and programmed with 450 guest quarters[16]. Unfortunately the significance of the building was overshadowed by damage suffered by a hurricane in 1926. The building was condemned in 1930 and subsequently razed. These practices wrote the historical perspective of the Royal Palm Hotel as a failed attempt at building with wood.

In the years following the razing of the Royal Palm Hotel, rigorous population growth from the 1930s through the late 1990s drove the need for cost effective housing, which to a certain degree was still serviced by light wood stick framing techniques. For a

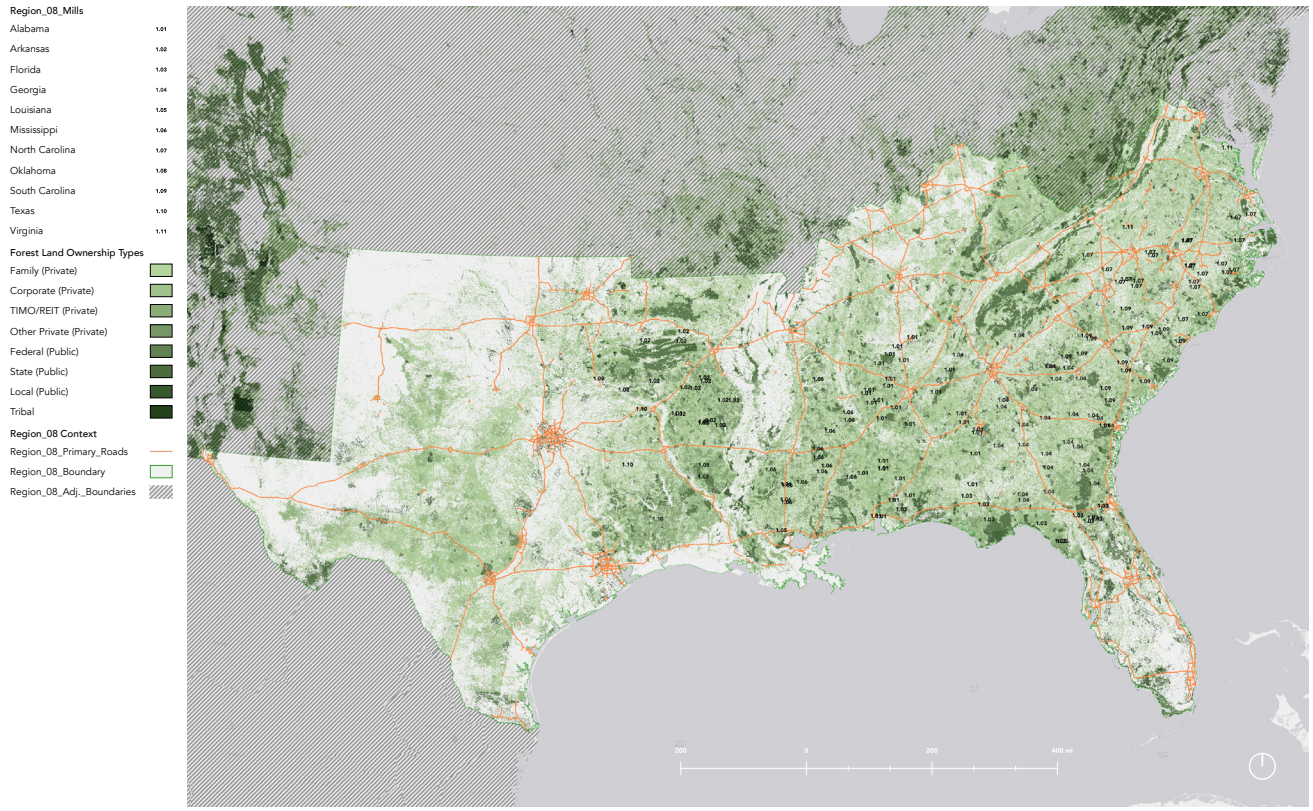

Figure 4. Map of decentralized infrastructure of mills and material processing distributed across Forestry Region Eight. Map created by University of Miami Littoral Urbanism Lab [LU_Lab].

myriad of reasons including a narrowed understanding of wood construction techniques, reactionary building policies, biased governance of construction inspections, pressures to build cost competitively, incompatible building assemblies, and a general lack of building maintenance--the misused utilization of structural wood, light-frame, was mis-managed leading to a skewed public perception of the material performance in general. In turn, issues tied to wood buildings carry both valid concerns and fictional apprehensions brought on by material misuse and cultural misunderstandings. These apprehensions, which were born out of light wood framing systems, are now overlaid onto mass timber and CLT products. Any viable future for solid wood assemblies in MDC will need to acknowledge and dispel the misguided connection between 'stick framing' and 'timber panel or CLT' construction processes by focusing attention on the technical questions detailed by the HVHZ code requirements.

[RE]GIONAL SUPPLY CHAIN

The limited use of wood for building in Southern Florida is in no way a derivative of restrictive access to raw material resources, it is in fact, quite the opposite. The metropolitan area stretching across south Florida has access to an enormous battery of renewable building materials in the form of 208.4 million acres of timber lands[17] within the southeastern U.S. Even more striking is that the state of Florida is approximately 50% forested timber lands[18] reaching as far south as Gainsville, located 350 miles north of Miami. [Fig 03] In support of utilizing southeastern timber resources as building material, U.S. Forestry Region Eight witnessed the expansion of manufacturing and processing infrastructures that offer regional grown, processed and manufactured solid wood products. As of 2021, two CLT manufacturing facilities are in operation and utilizing Southern Yellow Pine [SYP] material to manufacture CLT panels repudiating claims or sourcing issues.[Fig 04] An abundance of raw material resources is evident from region and state levels and the growth of the processing and manufacturing infrastructure allows for regional sourcing of CLT products. These systems of forest to processing through manufacturing are simply under utilized, with eligible forest stands left to be cut and processed each year.

MASS WOOD PERFORMANCE + SPECIFICATIONS, WOOD FRAMES ARE NOT CROSS LAMINATED TIMBER PANELS

Defining the case for mass timber in MDC requires addressing two divergent issues, cultural acceptance for wood buildings and the compatibility of the technical description of building assemblies in conjunction with their performance within the building code. Cultural predispositions are by nature subjective

and establishing them is not within the scope of this paper, however, what must be recognized is their significance in realizing wood buildings. Cultural bias will to some extent remain an unavoidable consequence of a false narrative –solid wood assemblies are equivalent to stick framing– which at times will inject subjectivity into what should otherwise be seen as an objective evaluation of testing and material building performance. In the end, people are still responsible for the decision to accept performative data and to issue building permits, it would be shortsighted to think or practice otherwise. A case study has brought a CLT project to the MDC permitting offices with the request to obtain a building permit for construction, specifically a One-Time Approval (OTA) to qualify CLT for compliance with 2017 FBC-Building Section 2315.1.11.[19] The case study tests the question, can mass timber be constructed in MDC?

The previously stated agendas of culture, place, material resource, environment, and trade knowledge all must be addressed during the design and subsequent construction process for a successful project. However, the municipal review by the MDC building department, required for the construction of any structure, demanded innovation from a larger bureaucratic system. As outlined in the first section of this paper, MDC's existing building code is not immediately structured for the implementation of innovative building materials with code overlay of the HVHZ Section and the embedded Product Approval requirements. While CLT is defined and accepted as a building product in the 2017 FBC, to build with the CLT structural products in MDC, the case study project would have to establish a path of equivalency for all HVHZ code overlays. To establish the path of equivalency and provide documentation of these technicalities, the team drew from their established knowledge networks of individuals within the national organizations like the Woodworks Wood Product Council, the American Plywood Association, and the American Wood Council as well as the product manufacturers SMARTLAM North America and Henkel Adhesives.

Technical questions from the HVHZ code required to obtain a construction permit have been distilled for this publication to the performance of CLT panels in the large missile impact testing FBC-Section 1626.2.4 and wet-dry, wet-dry cyclical testing HVHZ 2315.1.11 f.[20] The project type is a single family residence specifying the use of SMARTLAM NA V3 Grade 3 ply CLT ANSI/APA PRG-320-2019[21] compliant Southern Yellow Pine [SYP][22] dimensional lumber panels. As a baseline definition, standard ANSI/APA PRG-320-2019 compliant CLT panels are defined as prefabricated engineered wood products made of at least three orthogonal layers of graded sawn lumber or structural composite lumber [SCL] that are laminated by gluing with structural adhesives.[23]

LARGE MISSILE IMPACT TESTING

As of April of 2019 the U.S. Forestry Service conducted missile impact testing in accordance with ICC/NSSA-500, the Design and Construction of Storm Shelters. The design team requested the MDC consider the testing reporting and testing procedures as a path of equivalence under [A]104.11 Alternative materials, design and methods of construction and equipment and [A]104.11.2 Tests, for compliance with HVHZ FBC- Section 1626.2.4 large missile impact resistance. The large missile impact testing completed in accordance with ICC/NSSA-500 exceeded the requirements for the HVHZ Section 1621.2.4 Large Missile Impact testing and was ultimately accepted by MDC permitting the results were 'not less than or equivalent of that prescribed in this code in quality, strength, effectiveness, fire resistance, durability and safety' (FBC [A]104.11).

WET-DRY, WET-DRY CYCLE TESTING

Servicing the wet-dry, wet-dry cycle testing required the design team to utilize a path of equivalence in order to satisfy HVHZ codes because at the time of permitting wet-dry, wet-dry cycle testing** as specifically described in the MDC Checklist has not been conducted on ANSI/APA PRG-320-2019 compliant CLT product itself.[The PRG-320-2019 does require a wet-dry testing of the product, but it is not cyclical as required by the MDC Checklist #0475.]

Section 2315.1.11 of the FBC [an excerpt from the HVHZ state code overlay] states all wood-based structural panels, including those made of fiberboard, hardboard and particleboard shall have Product Approval. Product Approval shall be given upon certification by an approved independent testing laboratory that the product:

1. Complies with the applicable standards set forth above.

2. The product complies with the manufacturer's published design properties before and after a wet-dry, wet-dry cycle.

3. The product when tested dry maintains a safety factor of 2:1 and when tested after the cycles specified in Section 2315.1.11(2) above maintains a safety factor of 1.5:1. Testing shall be as specified in the testing protocol.

As with the Large Missile Impact compliance, the CLT panels used for the case study conform to the standard ANSI/APA PRG-320-2019 certification. CLT panels are considered to be a wood-based structural panel laminated by structural adhesives and required to comply with FBC-Building section 2315.1.11. The description of CLT panels as multiple layers of wood laminated by adhesives caused the permitting officials to evaluate the solid wood dimensional lumber as engineered material because it was deemed the structural loads move through the glue line. Subsequently the evaluation of performance data was channeled through Checklist #0475 DURABILITY OF WOOD-BASE STRUCTURAL COMPOSITE LUMBER AND PANELS, initiating the specific wet-dry, wet-dry cycle testing. The intent of the wet-dry, wet-dry cycle testing is to

Figure 5. In process construction photo of the first CLT structure to be permitted and erected in Miami-Dade County. Image by Atelier Mey.

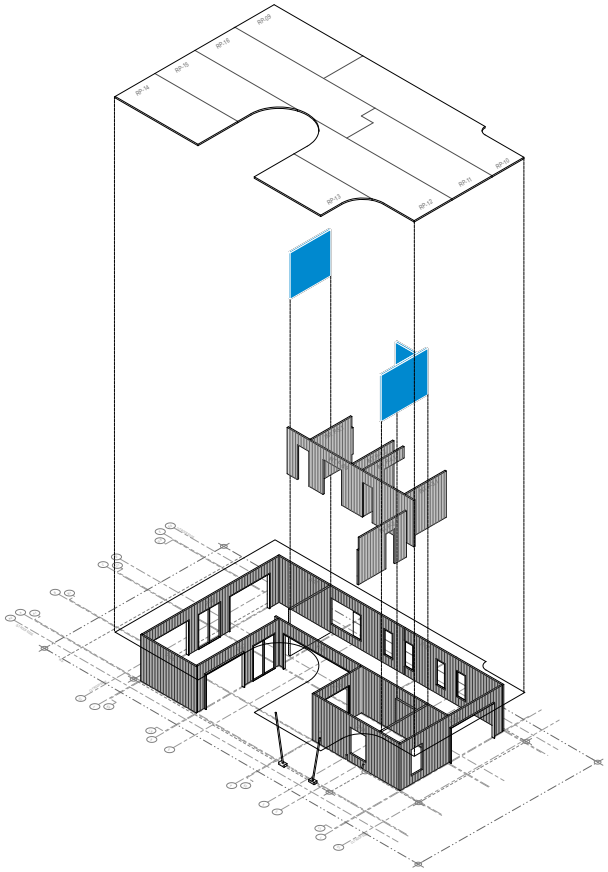

Figure 6. Exploded axon illsutrating the varied wood elements; exterior SYP CLT Wall Panels, interior SYP CLT Wall Panels, interior framed plumbing walls (blue) and SYP CLT Roof Panels. Drawing provided by Atelier Mey.

test the durability of the structural adhesives in conditions that simulate the high humidity levels found in the HVHZ area. From the perspective of the MDC permitting administration the wet-dry, wet-dry cycle testing is proof that the structural integrity of the panels is not severely compromised with the introduction of moisture. Under the provisions of FBC-Building Section 104.11, alternative materials, design and methods of construction and equipment, use of testing by PFS-TECO Oregon Laboratory on Henkel Loctite Adhesives Report withheld for trade confidentiality purposes[24] evaluation of adhesives for structural wood products was accepted for use to obtain the OTA building permit for construction. The required testing as defined by the checklist #4475 suggested a material misuse, as the testing called for performative measurements for a condition that the product is not intended to be used for nor does it align with the products structural behavior. As previously stated, the balance between the objective reading of performance data can be affected by subjective interpretation of material categorization.

In addition to the national requirements of PRG-320-2019, the OTA building permit required every CLT panel delivered to the project site and slated for installation to show product markings/ stamps required by the APA and referenced publication of the CLT's performance tables for inspection. Each panel carried the stamp with the following information, APA, V3 3-alt, PR-L327, Plant # and ANSI/APA PRG-320-2019. The wall and roof panels for the entire case study project were erected in two days on 15th and 16th of June 2021.[Fig 05]

The implications of climate change requires a frontal approach to energetics and the generation, sequestration, storage and release of carbon tied to construction materials and processes for building, in particular for littoral communities. The case study project examines the potentials of the southeastern forest and regional manufacturing as proof of concept that CLT products can follow HVHZ codes and solid wood building techniques can be implemented in MDC charting a path forward for solid wood mass based buildings. Architecture will need to embrace a certain degree of risk in order to lead the way forward with the introduction of novel building techniques, emergent materials, a re-introduction of old materials and new building assemblies. Design teams will need to work hand-in-hand with local building officials, regulatory offices and governance to evolve building codes and policies.

As of 2021, MDC and Broward counties have not adopted CLT into their building codes, however, they have granted a single one-time approval [OTA] building permit for the construction of the county's first mass timber building. The case study project is slated for completion in early 2022 and will stand as an educational tool for local communities as well as regional interests while ongoing efforts push to get solid wood mass based building techniques adopted in current building codes. In Miami, the last territory in the U.S. to restrict the use of mass timber elements and CLT panels, the case study has made significant strides towards the adoption of sustainable architecture practices. As HVHZ codes and mass timber building strategies establish continued alignments, efforts can be focused on developing skilled labor, education of building officials, and shifting the cultural predispositions of wood buildings in Southern Florida.

ENDNOTES

1. United States Census Bureau, Annual Estimates of The Resident Population, Miami Dade County, Florida, accessed October 21,2021 https://data.census.gov/cedsci/table?q=%20Miami-Dade%20County,%20Florida&tid=PEPPOP2019.PEPANNRES.
2. Miami Realtors, South Florida Markets, accessed on October 21, 2021 www.miamirealtors.com/news/south-florida-market-intelligence/miami-broward-jths-detail-statistical-reports/2019/monthly/december.
3. "61G20-3.007 Product Approval by the Commission." Florida Department of Business and Professional Regulation, accessed October 19, 2021. https://www.floridabuilding.org/fbc/Commission/FBC_1219/Product_Approval/61G20-3-007_9.htm.
4. "Product Approval Forms," Miami Dade Regulatory and Economic Resources, accessed October 19, 2021. https://www.miamidade.gov/building/control-forms.asp.
5. "Changes to the Wind Speed Maps and Wind Design-2010 Florida Building Codes," Florida Building Codes, accessed on October 19, 2021 https://www.floridabuilding.org/fbc/wind_2010/flyer_wind_january2012.pdf.
6. "Chapter 16 Structural Design," Section 1616 High-Velocity Hurricane Zones-General, Deflection, Volume Changes and Minimal Load, accessed on October 19, 2021 https://codes.iccsafe.org/content/FBC2017/chapter-16-structural-design#FBC2017_Ch16_Sec1616.
7. APA-The Engineered Wood Association, American National Standard, Standard for Performance-Rated Cross-Laminated Timber, ANSI-APA PRG-320 2019 (Tacoma: APA-The Engineered Wood Association)
8. APA-The Engineered Wood Association, American National Standard, Standard for Performance-Rated Cross-Laminated Timber, ANSI-APA PRG-320 2019 (Tacoma: APA-The Engineered Wood Association)
9. Florida Office of Insurance Regulation, "Office Statement", accessed October 19, 2021 https://www.floir.com/PressReleases/viewmediarelease.aspx?id=1958
10. Simmons, Kevin, Jeffrey Czajkowski and James Done, Economic Effectiveness of Implementing a Statewide Building Code: The Case of Florida, May 2017 https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2963244
11. "Division 7. Quality of Buildings", Section 523.1-Construction, Miami Shores Village, FL, accessed on October 20, 2021. https://library.municode.com/fl/miami_shores_village/codes/code_of_ordinances?nodeId=PTIICOOR_APXAZO_ARTVSURE_DIV7QUBU_S523.1CO
12. Simmons, Kevin, Jeffrey Czajkowski and James Done, Economic Effectiveness of Implementing a Statewide Building Code: The Case of Florida, May 2017 https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2963244
13. United States Census Bureau, Annual Estimates of The Resident Population, Miami Dade County, Florida, accessed October 21,2021 https://www.census.gov/programs-surveys/popest.html
14. Odum, Howard T., Environment, Power and Society,(New York:Wiley Interscience, 197),p. 69.
15. Culture, Who We Are. Seminole Tribe of Florida, Chickee, accessed October 18, 2021 https://www.semtribe.com/stof/culture/chickee
16. Shama, Merle. "The Royal Palm Hotel in Miami." Miami Design Preservation League, 27 May 2020, mdpl.org/archives/2020/04/the-royal-palm-hotel-in-miami. https://mdpl.org/archives/2020/04/the-royal-palm-hotel-in-miami/.
17. Oswalt, S. N., & Smith, W. B. (2014). U.S. Forest Resource Facts and Historical Trends. Washington, D.C., D.C.: U.S. Dept. of Agriculture, Forest Service. https://www.fia.fs.fed.us/library/brochures/docs/2012/ForestFacts_1952-2012_English.pdf.
18. Florida ForestryAssociation, About Florida Forestry, accessed on October 18, 2021. https://www.flforestry.org/about-us/fl-forests-facts/
19. "Chapter 16 Structural Design," Section 2315.1.11 High-Velocity Hurricane Zones-General, Deflection, Volume Changes and Minimal Load, accessed on October 19, 2021 https://codes.iccsafe.org/content/FBC2017/chapter-16-structural-design#FBC2017_Ch16_Sec2315
20. Citation of wet-dry, wet-dry cycle testing_ section 2315.1.11 High-Velocity Hurricane Zone https://www.floridabuilding.org/fbc/thecode/2013_Code_Development/HVHZ/FBCB/Chapter_23_2010.htm
21. Standard for Performance-Rated Cross-Laminated Timber. APA The Engineered Wood Association 6 January. 2020, https://www.apawood.org/ansi-apa-prg-320. ANSA/APA PRG 320-2019
22. Southern Yellow Pine is a general description of Longleaf (pinus palustris), Shortleaf (pinus echinata), Slash (pinus elliottii) and Loblolly (pinus taeda) pine tree species.
23. APA-The Engineered Wood Association, American National Standard, Standard for Performance-Rated Cross-Laminated Timber, ANSI-APA PRG-320 2019 (Tacoma: APA-The Engineered Wood Association) Page 4
24. PFS-TECO Oregon Laboratory Report on Henkel Loctite Adhesive [confidential,unpublished]