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MATERIAL DISRUPTION: CROSS-LAMINATED TIMBER IN TEXAS

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ABSTRACT: The rise of mass timber construction in the U.S. can be traced to the introduction of one building product: cross-laminated timber, or CLT. Originally developed in Europe, CLT panels have revealed the potential for mid- and high-rise buildings with primary structural systems that are made almost entirely of timber. By combining these panels with glulam beams and columns, this novel approach competes with conventional steel and concrete building systems for structural performance. While many European countries have used CLT products for almost 20 years, the U.S. has been slow to adapt. Early pioneer projects relied on European manufacturers for their panels, and CLT fabrication in North America did not commence until 2011.

As one of the fastest-growing regions in the country, Texas continues to experience a substantial increase in its population. Most of this growth is concentrated in urban areas, and sustainable urban development will need to focus on affordable, healthy environments for living and working while also reducing carbon emissions. However, concrete and steel continue to be the building materials of choice. This paper will present case studies and recent developments in mass timber construction in a part of the world that is not known for its sustainability efforts.

KEYWORDS: Mass Timber, Texas, Cross-Laminated Timber, Multi-Story Timber Construction, International Building Code

1 INTRODUCTION

The rise of mass timber construction in the United States can be traced to the introduction of one particular building product: cross-laminated timber, or CLT. Originally developed in Europe in the 1990s, cross-laminated timber consists of several layers of lumber board that are stacked at right angles to one another and glued face-to-face to form large-format structural panels up to 3 meters (10 feet) wide, 18 meters (60 feet) long, and 30 centimeters (12 inches) thick. This cross-lamination yields exceptionally strong and dimensionally stable products with bi-directional load-bearing capacity, particularly suitable for floors, walls, and roofs in multi-story applications [1].

CLT panels have revealed the potential for residential and commercial mid- and high-rise buildings with primary structural systems that are made almost entirely of timber. By combining these planar panels with glulam beams and columns, this novel approach competes with conventional building systems for structural performance. Most important, building with mass timber takes advantage of one of the most significant benefits of wood: its ability to store, or sequester, significant amounts of atmospheric carbon. Substituting wood for energy- and carbon-intensive materials such as steel and concrete can therefore result in substantial carbon savings over time. Although wood is not necessarily the appropriate choice for all construction applications, there are clear environmental advantages to using it when possible. Contrary to popular belief, using wood does not contribute to deforestation as long it is obtained from responsible sources, making it a truly renewable building material. Each log harvested from a sustainably managed forest and processed into lumber makes room for new trees to grow, with the ability to absorb more carbon dioxide from the atmosphere. That's why well-managed forests can provide more significant climate change mitigation than unmanaged forests while also preserving wildlife habitats, increasing biodiversity, and improving water and soil quality. The widespread deforestation occurring in the tropics is rarely related to harvesting wood for construction but instead is caused by clearing land primarily for agriculture, particularly commodity crops and cattle ranching.

While many European countries have used cross-laminated timber products for almost 20 years, the U.S. has been slow to adapt. Pioneer projects here relied on European manufacturers for their panels. CLT fabrication in North America started in 2011 when Canadian companies Structurlam in British Columbia and Nordic in Quebec began operations. The U.S. trailed its northern neighbor by four years, with DR Johnson in Oregon and SmartLam in Montana starting commercial production in 2015. Since then, International Beams (now SmartLam in Alabama) and Katerra (now Mercer Mass Timber) in Washington have begun production. But in Texas, one of the fastest-growing states in the United States, concrete and steel continue to be the building materials of choice. Although dimensional lumber is used extensively for

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residential and small commercial light wood framing, timber construction has played only a minor role in the state's construction industry. That is partly because trees big enough to supply large-scale commercial production do not grow in much of Texas. Regardless, architects, engineers, developers, and clients today, recognizing the environmental challenges of our times, are looking for new ways to improve the performance of the built environment. As the operational energy consumption of buildings has been vastly reduced, the need to lower their embodied energy becomes more apparent since it makes up a considerable portion of a building's life-cycle energy use. This is where mass timber and its potential for carbon sequestration comes in.

2 EARLY ADOPTERS OF MASS TIMBER

Eager to undertake aspirational building projects, enlightened clients have proven instrumental in teaming with Texas architecture firms to employ these novel technologies.

The architecture firm Lake|Flato of San Antonio has been at the forefront of bringing engineered wood products to the state. In 2018, the firm's rooftop addition to the Museum of Fine Arts in Houston — the Sarah Campbell Blaffer Foundation Center for Conservation — featured the first installation of dowel-laminated timber (DLT) panels in North America. Two more of Lake|Flato's DLT projects, the Hotel Magdalena in Austin and the 13,000-square-meter Soto Building in San Antonio, were completed in 2021.

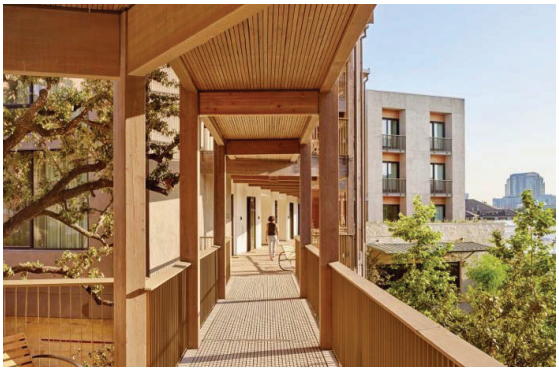

Figure 1: *Hotel Magdalena, Austin, Texas; Architect: Lake|Flato; Engineer: StructureCraft*

The 4,500-square-meter complex of Hotel Magdalena consists of three buildings and is the first mass-timber boutique hotel constructed in North America (Figure 1). The primary structure for the hotel rooms is made of DLT panels, which are supported on light wood frame bearing walls. Exposed exterior DLT walkways connect the rooms and are supported by a glulam substructure. The interior panels are exposed at the ceiling, while the exterior panels are exposed on both sides, floor and ceiling. Other custom mass timber elements include DLT stair and elevator shafts, hanging balconies, hybrid timber-steel staircases, and a stand-alone porte-cochere [2,3]. The 13,000-square-meter Soto Building, a collaboration with BOKA Powell, consists of a glulam post and beam frame supporting dowel-laminated timber floor panels and is the first six-story, mixed-use mass timber building in Texas (Figure 2). Its well-thought-out systems integration strategy features a raised floor plenum with underfloor air distribution. The result not only maximizes flexibility for tenants but also removes the visual impact of suspended air ducts while highlighting the beauty of the exposed structural components [3,4].

Figure 2: *The Soto Building, San Antonio, Texas; Architect: Lake|Flato and BOKA Powell; Engineer: StructureCraft*

In Austin, TB/DS, a joint venture between Thoughtbarn and Delineate Studio, worked with ambitious client Endeavor Real Estate Group to reimagine a turn-of-the-century warehouse aesthetic for a contemporary five-story office building in its eclectic East Side context (Figure 3). Completed in 2019, 901 East Sixth is the first Texas project to use cross-laminated timber as part of a composite structural system. Steel beams and columns with bolted connections provide flexible, column-free spaces with an industrial feel, while mass timber floor decks add warmth and form the finished ceiling. The 12,000-square-meter, five-story hybrid structure went through a yearlong alternate materials and methods approvals process with the city, paving the way for future CLT projects [3, 5].

Figure 3: *901 East Sixth, Austin, Texas; Architect: Thoughtbarn and Delineate Studio; Engineer: Leap Structures*

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3 MASS TIMBER ESTABLISHES A PRESENCE

For the First United Bank branch in Fredericksburg, Gensler's Dallas office completed the state's first full mass timber structure in 2019 (Figure 4). The forward-thinking client wanted a building that not only reflected the bank's strong presence in rural communities but also aligned with their sustainability goals. The 800-square-meter building is also the first mass timber structure in the United States to use CLT panels made from Southern Yellow Pine. Using this species native to Texas, the architects delivered a net-zero energy design with a vernacular yet modern look, showcasing that any building can be a steward for the environment [3, 6].

Figure 4: *First United Bank, Fredericksburg, Texas; Architect: Gensler; Engineer: DCI Engineers*

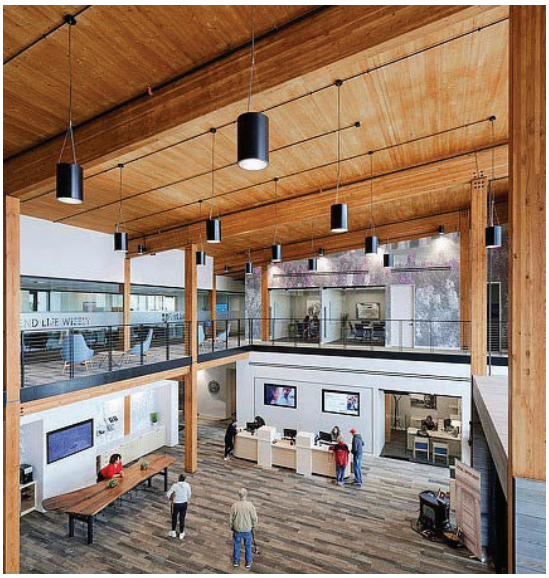

Figure 5: *First United Bank Regional Headquarters, Sherman, Texas; Architect: Gensler; Engineer: DCI Engineers*

Gensler is also behind the company's other mass timber building in Texas: the two-story First United Bank Regional Headquarters in Sherman, which opened in 2021 (Figure 5). The bank commissioned the architects to design the 3,500-square-meter building with the goal of attracting and retaining top talent, uniting its teams in one connected hub, and serving the wider community. The design creates an environment representative of the local area while placing a heavy emphasis on sustainable materials and practices using mass timber construction. In addition to using mass timber, the bank's regional headquarter meets net-zero energy objectives by having the ability to provide the entire building's power requirements with solar panels located on the roof. A collection system also harvests all rainwater runoff from the roof and condensation from the HVAC system to service the site's irrigation. The building fulfills the client's vision for a community-centric location that remains inclusive and sustainable [3, 7].

With Fifth + Tillery in Austin, Gensler recently completed an adaptive reuse project by reimagining a post-industrial site as a vibrant, wellness-focused office complex with indoor/outdoor connections (Figure 6). The repurposing of a large and dark existing warehouse was an opportunity to create a multi-tenant office space with the purpose of attracting creative businesses and talent. The client also wanted the design to minimize the environmental impact and positively contribute to the surrounding neighborhood, resulting in a high-performance building that embraces sustainable practices. Exposed wood, ample daylight, access to fresh air, and the integration of abundant landscaping were key elements of the project's biophilic design strategy. The 17,550-square-meter utilizes a hybrid steel and timber structural system to reduce embodied carbon while also introducing the natural beauty of wood into the spaces. Drilled piers support steel columns that are paired with long-span Douglas Fir glulam beams and a long-span metal deck with concrete topping. Even though this project does not specifically utilize CLT, it demonstrates the viability of using mass timber in the revitalization of existing structures in Texas [3, 8].

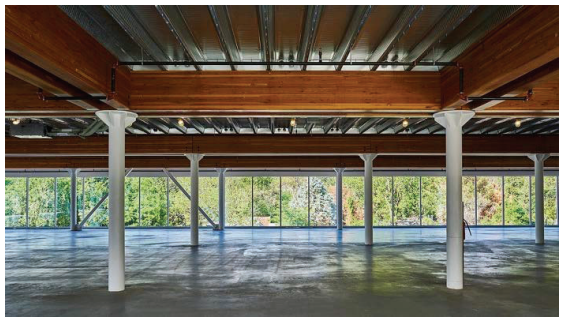

Figure 6*: Fifth + Tillery, Austin, Texas; Architect: Gensler; Engineer: MJ Structures*

Gensler is also collaborating with Duda|Paine Architects on the Offices at Southstone Yards, the first mass-timber office development in the Dallas-Fort Worth Metroplex (Figures 7+8). The seven-story, 22,000-square-meter building will anchor an 18-hectare visionary mixed-use development in Frisco, Texas, with the goal of creating well-located offices that accommodate the requirements

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of future workers. The client is seeking to develop an office environment that caters to the increased expectations of employers and their teams in a post-pandemic world by delivering a dynamic experience that enriches their daily lives and is supported with virtues of wellness, flexibility, and enhanced amenities. With completion expected in the third quarter of 2023, the building is projected to become the largest mass-timber office building in the United States [9].

***Figure 7**: Offices at Southstone Yards, Frisco, Texas; Architect: Gensler and Duda|Paine; Engineer: Thornton Tomasetti and BDD*

***Figure 8**: Offices at Southstone Yards, Frisco, Texas; Architect: Gensler and Duda|Paine; Engineer: Thornton Tomasetti and BDD*

Kirksey Architecture in Houston is leading the way in the higher education sector with several mass timber university projects in East Texas. The three-story, 11,000-square-meter Anderson-Ball Classroom Building is a mass timber structure on the Central Campus of San Jacinto College (Figures 9+10). The structural system is made entirely out of mass timber, except for steel bracing used for lateral support, making it one of the first in the Greater Houston Area. Featuring a glulam post and beam frame, CLT floor plates, and CLT staircase enclosures, it was the nation's largest academic building constructed from mass timber when it opened for the 2022-23 academic year [10].

The firm is also collaborating with American/German architectural practice Barkow Leibinger on a five-story, 165-bed dormitory for Rice University (Figure 11). The 5,200-square-meter Hanszen College New Wing will replace an aging building with the goal of making on-campus living more attractive for upper-level students. The university hopes that the innovative design of the building will benefit the well-being of its inhabitants since early studies show that mass timber buildings can positively affect physical and mental health. In addition, Kirksey Architecture has recently begun working on a four-story, 338-bed dormitory on the Stephen F. Austin State University campus. The scheme is in its early planning stages and will include a new dining hall, welcome center, and an addition, as well as renovation of the school's fine arts facilities [11].

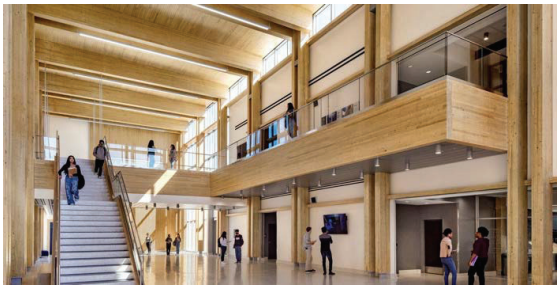

***Figure 9**: Anderson-Ball Classroom Building, San Jacinto College, Pasadena, Texas; Architect: Kirksey; Engineer: Armstrong-Douglass Partners*

***Figure 10**: Anderson-Ball Classroom Building, San Jacinto College, Pasadena, Texas; Architect: Kirksey; Engineer: Armstrong-Douglass Partners*

***Figure 11**: Hanszen College New Wing, Rice University, Houston, Texas; Architect: Kirksey; Engineer: knippershelbig*

All three higher education projects are supported by federal funding from the Mass Timber University Grant Program, a cooperative partnership established by the U.S. Department of Agriculture Forest Service and the U.S. Endowment for Forestry Communities. This

initiative aims to break barriers related to the design and construction of cost-competitive, code-compliant mass timber buildings while showcasing the architectural and commercial viability of these materials in sustainable construction. It also seeks to clearly demonstrate the direct relationship between the use of mass timber products, the health and resilience of American forests, and the potential for economic development in rural communities [12].

Hines, an international real estate developer, is collaborating with architecture firm DLR Group to bring its mass timber concept T3 (timber, transit, and technology) to Austin ((Figures 12+13). Deemed T3 Eastside, the project is poised to redefine the standard for modern, creative office space. The building will feature 8,500 square meters of Class-A office space and 850 square meters of residences, with the goal of inspiring creativity, attracting talent, promoting productivity, and honoring the unique spirit of Austin's Eastside neighborhood [13, 14].

***Figure 12**: T3 Eastside, Austin, Texas; Architect: DLR Group; Engineer: MKA*

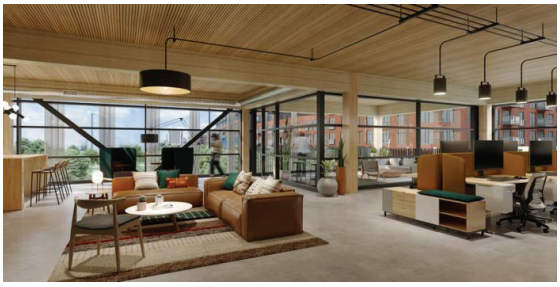

***Figure 13**: T3 Eastside, Austin, Texas; Architect: DLR Group; Engineer: MKA*

Mass timber is also replacing building materials in North American construction methods that have historically relied on concrete.

The Southfield Park 35 warehouse by architecture firm PDMS Group in Dallas uses CLT in place of the concrete tilt-wall panels of a typical industrial warehouse, with the goal of supporting the client's ambition to reduce the environmental impact of their developments (Figure 14). The decision to use CLT over traditional concrete tilt-up construction helped reduce the carbon footprint of the 15,000-square-meter building by more than 45% [3].

Architecture firm DesignTrait recently completed the mixed-use project The Duke in Austin's Webberville neighborhood (Figure 15). The 3,700-square-meter building consists of three stories of light wood framing over a ground floor podium. Instead of a commonly used concrete podium structure, the designers opted for glulam beams and columns with CLT floor slabs to create a more sustainable urban design project [3, 15].

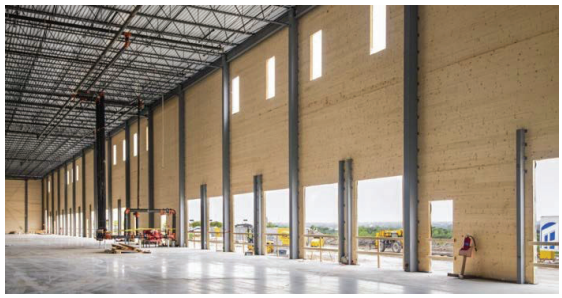

***Figure 14**: Southfield Park 35 warehouse, Dallas, Texas; Architect: PDMS Group; Engineer: Timberlab*

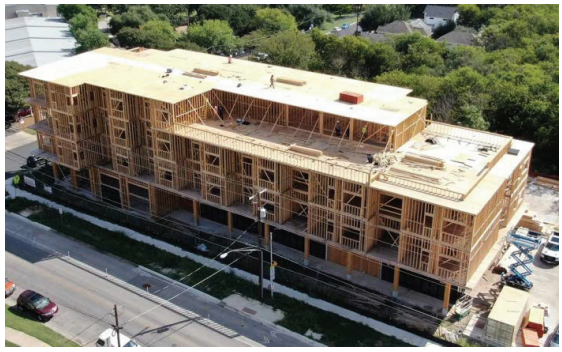

***Figure 15**: The Duke, Austin, Texas; Architect: DesignTrait; Engineer: WGI*

Other significant mass timber projects currently in development or under construction in Texas include the new San Antonio Spurs training facility, designed by architecture firm ZGF and Arup engineering. Twenty 40-meter-long glulam beams will support the roof structure, providing uninterrupted space for basketball training courts (Figure 16). When the 12,300-square-meter building opens in August 2023, it will be the largest practice facility made of mass timber in U.S. professional sports and the largest mass timber construction in Texas [16].

Architecture firm Bohlin Cywinski Jackson is bringing mass timber into the educational realm in Addison, Texas, with the Valdes STEM + Innovation Center for Greenhill School, an independent school serving the greater Dallas community (Figure 17). The 4,800-square-meter project will house flexible classrooms and labs for the school's math and science departments. A modular approach to

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classroom design will ensure spaces can adapt to changing use and technologies over time while creating an open and collaborative environment that empowers students to incorporate STEM learning in all facets of their education. The building will provide opportunities for students to learn about integrated sustainable design through its exposed mass timber structure, daylight autonomy, rainwater harvesting, and visible energy conservation strategies, allowing them to draw connections between their work and the physical environment [17].

***Figure 16**: San Antonio Spurs Training Facility, San Antonio, Texas; Architect: ZGF; Engineer: Arup*

***Figure 17**: Valdes STEM + Innovation Center, Addison, Texas; Architect: Bohlin Cywinski Jackson; Engineer: DBR*

4 REGIONAL PRODUCTION

Many mass timber buildings in Texas have been completed with cross-laminated timber from European suppliers. Despite the disadvantage of long transportation distances and panel sizes limited by the dimensions of international shipping containers, these products have been very cost-competitive, thanks to the manufacturers' high production volumes and significant market shares.

North America's most established CLT production facilities are concentrated in Canada and the northern U.S., which can still present procurement challenges to early adopter projects in more distant states, including Texas. For example, there are no CLT production lines yet in Texas that manufacture for building applications, but several suppliers are in nearby states. SmartLam's Dothan, Alabama, plant, operating since 2018, is the first to offer certified CLT products made of Southern Yellow Pine. Located in Magnolia, Arkansas, Texas CLT gets its raw materials within a 160-kilometer (100-mile) radius of its facility. In addition, the company has plans to set up a second plant in Jasper in East Texas.

Canadian company Structurlam has expanded its operations to Conway, Arkansas, for its first U.S. CLT and glulam plant, which opened in 2021. About 40% of the facility's entire manufacturing output will be solely for Walmart for the first three years. The world's largest retailer has pledged to build its home office campus in Bentonville out of mass timber, and Structurlam will serve as its exclusive supplier.

Illinois-based Sterling has been manufacturing CLT mats for temporary access roads and working platforms in Lufkin, East Texas, since 2019. In 2022, the company received a Wood Innovation Grant from the U.S. Department of Agriculture to accelerate mass timber adoption with standard-format CLT panels. Its cross-laminated timber product line recently received PRG 320 certification, which is required in North America for CLT panels used in structural building applications. With its 700,000-cubic-meter annual production capacity, Sterling is poised to contribute to the mass timber construction market in Texas significantly.

Anyone interested in building with wood in Texas will surely welcome a ramp-up of production capacities. Broader availability of mass timber products throughout the Southern states will facilitate material procurement, reduce transportation costs, and foster healthy competition between manufacturers. Moreover, as the number of built projects made possible through regional production grows, the increased visibility is likely to lead to broader acceptance of timber buildings by the public and rising demand for their construction by future clients.

BUILDING TALLER IN WOOD

Most mass timber buildings completed in Texas have been permitted as Type III and Type IV construction under current applicable building codes. For these construction types, the 2018 International Building Code, or IBC, allows building heights of up to 26 meters (85 feet) with a maximum of five stories for residential and six stories for office occupancy.

While both types are similar in allowable height and the number of stories, there are some notable differences. Unlike Type IV, Type III requires char rate calculations for member sizes to determine residual cross sections for load capacity calculations, which can lead to oversizing of structural members to achieve the necessary fire rating. Exposed steel connections also are not permitted under Type III and require protection. Just these two examples highlight the potential impact of code limitations on architectural expression.

Therefore, it is advisable to engage the local Authority Having Jurisdiction early in the design process since it can serve as a valuable partner in selecting the most appropriate construction type. Mass timber structures taller than 26 meters (85 feet) and exceeding six stories are currently only possible in many parts of Texas if they undergo an Alternative Materials and Methods Request, a provision in the IBC. This gives local building officials the flexibility to address new concepts, innovations, and developments that the current code may not formally recognize yet. Depending on the extent of the request, this can be a lengthy, costly process that might require structural tests as well as fire resistance testing.

In response to the growing interest in tall timber construction, the International Code Council approved a set of proposals in 2019 to allow tall wood buildings as part of the regular code changes cycle. Based on the previous Heavy Timber construction type, which has been renamed Type IV-HT, the 2021 International Building Code (IBC) now includes three new construction types: Types IV-A, IV-B, and IV-C, arranged from the highest fire resistance and safety requirements to the lowest.

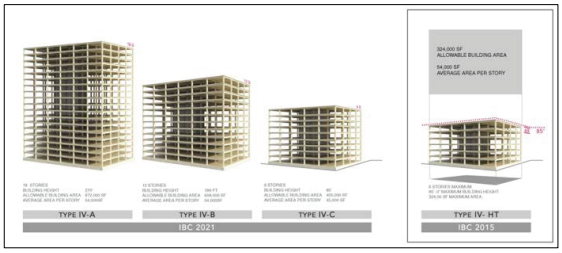

***Figure XX**: IBC new construction types: IV-A, IV-B, and IV-C; courtesy of atelierjones*

For business occupancy, Type IV-A allows buildings with 18 stories up to 82 meters (270 feet) tall with no exposed mass timber components. Type IV-B allows 12 stories up to 55 meters (180 feet) with some exposed mass timber elements, and Type IV-C allows nine stories up to 26 meters (85 feet) with almost all interior mass timber exposed.

Several jurisdictions in Texas have already adopted the tall mass timber provisions of the 2021 IBC, either in their entirety or with local amendments. This includes the cities of Allen, Austin, Bryan, Carrollton, Plano, Grand Prairie, and Fort Worth. In addition, the City of Dallas has incorporated some tall mass timber allowances of the 2021 IBC and the upcoming 2024 IBC [18, 19].

5 CONCLUSIONS

As one of the fastest-growing states in the nation, Texas will continue to experience a substantial increase in its population. Most of this growth will be concentrated in urban areas, and the increasing density of its cities will play a critical role in reducing the state's impact on climate change. Sustainable urban development will need to focus on affordable, healthy living and working environments while reducing carbon emissions.

Building with responsibly sourced timber can decrease the state's reliance on fossil fuels and turn its buildings and cities into carbon sinks rather than sources of CO_2 emissions. With wood deemed unsuitable for dense urban environments for so long, the recent development of engineered wood products and amendments to building codes have allowed its return to the city.

Innovative strategies for structural design and fire protection have enabled the construction of multi-story buildings that satisfy the most stringent standards, offering opportunities for the emergence of a new type of urban architecture. Increasing demand for timber buildings in cities will not only ensure that forests remain sustainably managed but also drive economic development in Texas' rural areas through new jobs from the manufacturing of wood products. Building with mass timber has the potential to positively impact the state's environment, local economies, and building culture.

ACKNOWLEDGEMENT

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REFERENCES

[1] Dangel, Ulrich: Turning Point in Timber Construction – A New Economy. Birkhäuser Basel, 2017.
[2] Lake|Flato, www.lakeflato.com/hospitality/hotel-magdalena
[3] Woodworks Innovation Network, www.woodworksinnovationnetwork.org
[4] Lake|Flato, www.lakeflato.com/developmentcommerical/soto-building
[5] Thoughtbarn, www.thoughtbarn.com/projects/901-east-6th-street/
[6] Gensler, www.gensler.com/projects/first-united-bank
[7] Gensler, www.gensler.com/projects/first-united-bank-sherman-regional-headquarters
[8] Gensler, www.gensler.com/projects/fifth-and-tillery
[9] Crown Holdings, www.crowholdings.com/insights/crow-holdings-development-announces-plans-for-the-offices-at-southstone-yards-a-first-of-its-kind-mass-timber-construction-in-north-texas/
[10] Kirksey Architecture, www.kirksey.com/portfolio/projects/san-jacinto-college,-central-campus-classroom-building
[11] Kirksey Architecture, www.kirksey.com/portfolio/projects/rice-university-hanszen-college-new-wing

https://doi.org/10.52202/069179-0587

[12] Forest Service, U.S. Department of Agriculture, www.fs.usda.gov/news/releases/mass-timber-university-grant-program-projects-support-forest-health-and-vibrant
[13] Hines, www.hines.com/news/hines-announces-next-generation-timber-office-in-austins-eclectic-eastside-neighborhood
[14] T3 Eastside, https://www.t3eastside.com/
[15] WGI, wginc.com/projects/the-duke/
[16] Timberlyne, www.timberlyne.com/gallery/commercial/san-antonio-mass-timber
[17] Bohlin Cywinski Jackson, www.bcj.com/projects/academic/greenhill-school-valdes-stem-innovation-center/
[18] WoodWorks, www.woodworks.org/resources/tall-wood-buildings-in-the-2021-ibc-up-to-18-stories-of-mass-timber/
[19] WoodWorks, www.woodworks.org/resources/status-of-building-code-allowances-for-tall-mass-timber-in-the-ibc/