Creating Affordable Housing Opportunities with Mass Timber

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Executive Summary

The dire shortage of affordable housing in the United States is unconscionable. The Housing Coalition's 2020 annual report showed that rental rates are out of reach for nearly every worker in the bottom 50% of the national wage distribution (Aurand et al., 2020). With housing at the intersection of so many behaviors — social, financial, racial, political, and cultural — it is a critical problem to solve — the key to a just America. This paper briefly summarizes the history of both affordable housing and multifamily light frame construction, illustrates the challenges with affordable housing today, and presents 340+ Dixwell, a planned mass timber, passive house, affordable housing project in New Haven, Connecticut. The research summarized in this paper compared the 340+ Dixwell project to traditional light frame, illustrating that mass timber is a viable and appropriate solution for addressing affordable housing needs in the United States.

Background

Through a Wood Innovation Grant (WIG) from the USDA Forest Service,[1] research was conducted to analyze the history of multifamily affordable housing in the U.S., tracing the improvements along the way. The research considered the issues facing the creation of affordable housing of an acceptable quality at an acceptable price; the social, economic, and racial conditions facing the industry; and the problems that the acute affordable housing shortage creates.

Throughout most of the United States, low rise buildings for multi-family housing are built from light frame wood, i.e., "stick-built" construction. This technology has been prevalent for about 75 years since the movement to the suburbs began after World War II. Builders have made improvements to the process along the way, such as prefabricated walls and engineered I-joists. However, light frame timber buildings are still limited in the height that can be built. When built on grade, they have a 5-story height limit, and seven stories when built on a two-story podium of concrete.

[1] The work upon which this project is based was funded in whole or in part through a grant awarded by the U.S. Forest Service, Wood Innovations. This article is excerpted from the full final report submitted for the US FOREST SERVICE WOOD INNOVATION GRANT 18-DG-11420004-090. USDA is an equal opportunity provider, employer, and lender.

The study examined mass timber[2] as a possible affordable housing solution, including the opportunity for mass timber, due to its many prefabrication and timber quality benefits, to:

- be used in conjunction with light frame to further improve the delivery of timber buildings up to 5 stories, and
- provide a solution for timber buildings between 6 and 12 stories, instead of steel or concrete, and as a typology that is in great demand.

The study included the research, design, and predevelopment planning of a 70 to 80-unit affordable multi-family housing project, undertaking real design, and engineering, product, cost, and performance analyses.

A History of Affordable Housing in the United States

The first mention of affordable housing in the U.S. was in response to the hardships caused by the Great Depression. The October 1929 stock market crash sent the country reeling toward the worst economic downturn the industrialized era had seen. By 1933, over 13 million people in the country were unemployed and almost half the country's banks had failed (Housing, 2020). This led to widespread homelessness and poverty not only in densely populated regions but also in rural areas.

In 1933, the Public Works Administration (PWA) was established[3] to provide funding for the construction, alteration, or repair of low-income housing. Very few public-private groups qualified for the loans that were offered, so eventually the government took it upon themselves to construct housing projects (Von Hoffman, 2016). This led to 52 new housing projects across the U.S., and the PWA succeeded in creating subsidized and regionally contextual, affordable multifamily homes. However, the PWA proved too costly and slow to have a long-term effect on the nation's dire housing shortage (Vale et al., 2015). In addition, the PWA projects failed to preserve economic or racial diversity in denser communities. In many projects, like the Jane Addams House in Figure 1, which was built for impoverished Italian and Russian Jews, Black Americans were not allowed to apply until maximum capacity in the building could not be reached. Federal policy required that the tenants of a housing development be of the same race as the people of the area in which it was located (Devereux, 1978). While the PWA was able to shed light on the inadequate housing

[2] Mass Timber framing is characterized by the use of large solid wood panels for wall, floor, and roof construction. For further background on mass timber materials and construction techniques, see: Dovetail Partners' report Modern Tall Wood Buildings: Opportunities for Innovation, available at: https://dovetailinc.org/upload/tmp/1588011267.pdf

[3] Around the same time, the National Housing Act (NHA) was passed in 1934, establishing the Federal Housing Administration (FHA). The programs created under the NHA encouraged home ownership and the construction of single-family homes by establishing the mortgage insurance program and federal private deposit insurance, forming the basis for those systems today. Simultaneously, the banks expanded the risk levels in their portfolios by lending to private developers who could build that housing. These programs did not directly address affordable housing needs.

standards across the nation, the program ultimately was unable to build as much affordable housing as planned.

Figure 1. Jane Addams Houses, Chicago (ca. 1938). Built for impoverished Italian and Russian Jews, often Black Americans were not allowed to apply until maximum capacity in the building could not be reached. Courtesy of the Library of Congress & Chicago Housing Authority.

Many of the PWA projects that were completed were criticized for encouraging white flight and displacing minorities. Similar economic exploitation, like access to health care and low-pay jobs, are products of historical discrimination and are deeply intertwined with the lack of affordable housing for the extremely cost burdened that are at highest risk of being homeless. This is evident today in findings that people identifying as Black and Hispanic account for 13% and 18% of the U.S. population respectively, while these identities are 40% and 22% of the population experiencing homelessness (Aurand et al., 2020).

Awareness of the interrelation between housing and healthy living entered the collective consciousness in the early 1900's as building codes called for, even if unmet, more hygienic housing. Mandated air shafts, occupancy limits, and minimum window sizes were an effort to curb the spread of diseases, mostly borne from crowded tenement living in cities and poor housing stock quality elsewhere in the country (Lopez, 2018). Negative health outcomes associated with poor quality housing include exposure to lead poisoning, asthma, and accidental injury. Improved heating, insulation, ventilation, and accessibility components have resulted in decreased rates of hospitalization for both children and adults (Center, 2007).

The National Housing Act (NHA) of 1937 was intended to consolidate the complex housing policy in the U.S. and encourage private construction of housing by facilitating the flow of capital. New York Senator Robert Wagner championed the NHA, also called the Wagner-Steagall Act (WSA), to contribute grants, loans, and funding to local housing authorities and private industry. The policy placed a spending cap on construction cost per unit and considerably increased the rate at which both new and old affordable units were being built and renovated (McDonnell, 1957). However, for every housing unit built, one slum house was mandated to be demolished, based on a fear of affordable housing competing with private, market rate housing development (Madden et al., 2016). States also had to "opt in" to these new federal programs to exempt entities from taxation and allocate eminent domain (Madden et al., 2016). These policies further stigmatized poverty and public housing.

After World War II, the Truman Administration signed the Housing Act of 1949 which funded the clearance of slums to develop new affordable units, and which largely led to the demolition of neighborhoods of color. It is estimated that between 1950 and 1980, one million working class neighborhoods and communities of color were destroyed (Von Hoffman, 2000). Tearing down quality row and townhouses and replacing them with taller towers was often cheaper than making repairs or capital improvements (Von Hoffman, 2000). In some cases, the quality of housing stock became significantly worse (US DOC, 2018).

President Lyndon B. Johnson formed the Department of Housing and Urban Development (HUD) in 1965 to consolidate existing housing related agencies. The Department had a goal to build 26 million new housing units throughout the country in the following decade, with 6 million of them allocated for low- and moderate-income families (Von Hoffman, 2016). Unfortunately, that goal was not reached, and the program was plagued by failures associated with redlining,[4] displacement, and poor construction quality. Following passage of the 1964 Civil Rights Act,[5] legal actions such as *Gautreaux et al. v. the Chicago Housing Authority & HUD* brought the racial segregation of housing projects to light (Rothstein, 2017). After federal attempts to build more public housing failed, HUD implemented Section 236 of the Housing and Urban Development Act. The Fair Housing Act and the Housing and Urban Development Act, both enacted in 1968, followed the more than 150 riots that occurred in the US between 1965 and 1968, the assassination of Martin Luther King, Jr., and the report released by the National Advisory Commission on Civil Disorders (Kerner Commission) that identified the causes of the riots as lack of economic opportunity, failed social service

[4] Redlining is the practice of refusing to offer credit or insurance in a particular community on a discriminatory basis (i.e., because of the race or ethnicity of its residents).

[5] Civil Rights Act Title VIII, known as the Fair Housing Act (FHA), was enacted in 1968 and prohibits discrimination in housing on the basis of race, religion, national origin, sex, familial status, and disability.

programs, police brutality, and racism.[6] The Housing and Urban Development Act of 1968 Section 236 provided private developers with incentives to build more low-income housing (Von Hoffman, 2016). A boom in construction occurred that accelerated the creation of both market rate and affordable housing (Rothstein, 2017). Following the success of the Section 236 program, the Section 515 program of the NHA was expanded to help create rental housing in rural areas (Wiener, 1999).[7] A key point of this period was the Brooke Amendment that capped rent in social housing at 25% of a tenant's income.

In the 1970s, jurisdictions started to change zoning regulations to shut out higher density housing and were hindering progress toward closing the gap for low-income renters in need of housing. These changes, along with several corruption scandals, widespread neighborhood razing, and frequent demolition, resulted in a national housing crisis in the 1970s. In 1973, President Nixon imposed a moratorium on all housing programs due to a growing national criticism of cost, profiteering, and slumlord involvement in federal dealings (Von Hoffman, 2016). In 1974, HUD replaced Section 236 with the Section 8 Housing Program (McCarty, 2005) (see sidebar).

In further efforts to make improvements, HUD created the Low-Income Housing Tax Credit program (LIHTC) in 1986, and it is

HUD and Section 8

The Section 8 program, launched in 1974, supported more rental vouchers and block grants for community housing. Today, Section 8 can be described as two programs which, together serve 3.5 million households annually.

Rental Assistance

The first Section 8 program is the project-based rental assistance. HUD would make rental assistance payments to private, public, or non-profit organizations who were either building new units or rehabilitating old ones. This allowed tenants residing in units to pay 25% (30% as of 2020) of their adjusted income as rent, but the assistance was associated with the unit (not the tenant) so support would end when the tenant moved.

Vouchers

The second Section 8 program, introduced in 1983, provided tenant-based assistance vouchers that stayed with the tenants and attempted to address previous failings by giving low-income families more agency in where to live and how much to spend.

From 1976 to the late-1990s, Section 8 annually produced more units than the 1949 Housing Act or any other federal program, finally demonstrating success in more direct and simple programming compared to preceding federal attempts.

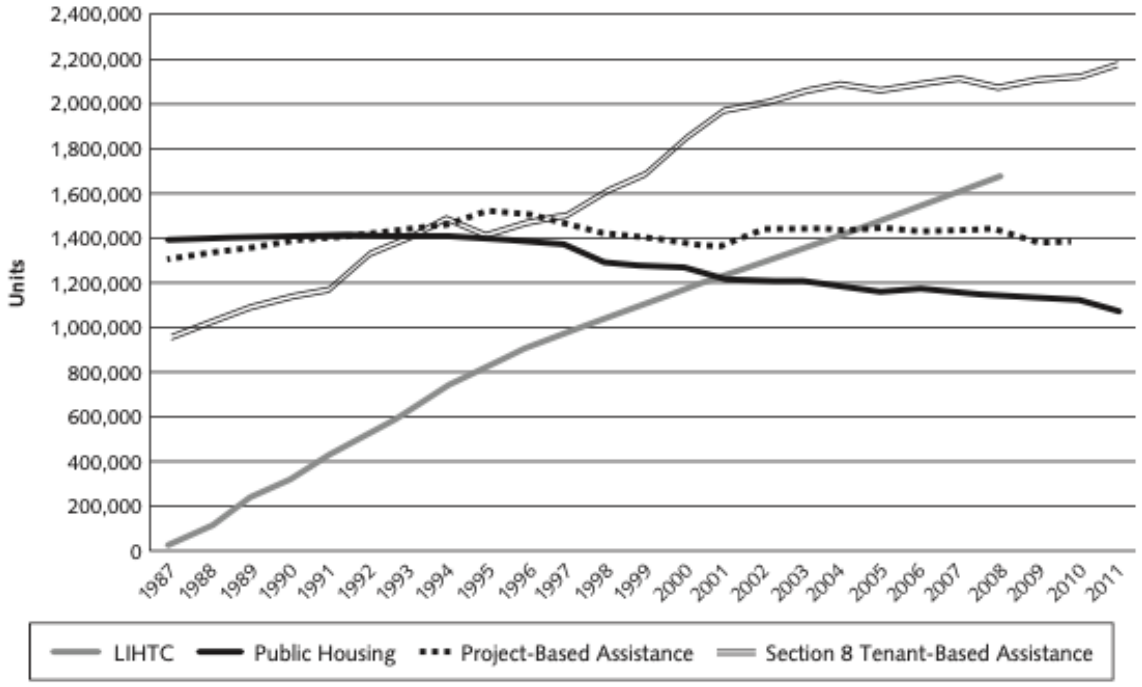
Sources: Von Hoffman, 2000; McCarty, 2005; Cohn Reznick, 2012

[6] For further discussion, Kerner Commission Report – History.com.

[7] Today this program is known as the Rural Housing Service and it collaborates with the Farm Labor Housing Program to operate loan and grant services, developmental housing, and provide housing rehabilitation for any township, village, or smaller city that lacks affordable housing.

the primary public source of funding for low-income housing projects today. As of 2020, this permanent federal program provides over $9 billion in annual tax credits to states to support construction of new units in partnership with private developers or city housing agencies (Cohn Reznick, 2012). The LIHTC program is also the primary resource for elderly, rural, and affordable housing for low income and homeless populations (Cohn Reznick, 2012). The LIHTC has two different financial programs; 9% and 4%.[8] The 9% credits are competitive and there is much higher demand, state by state, than availability of federal financing. The 4% are non-competitive and are primarily for projects seeking financing through tax-exempt private equity bonds.[9] The following figure (Figure 2) shows how the number of units built by both Section 8 and LIHTC have risen while public housing project quantities (the solid black line) have been level or have declined since the 1980s.

Figure 2. Housing Units Provided Annually by LIHTC, Public Housing Projects, Project-Based Assistance (Section 8) and Tenant-Based Assistance (Section 8) from 1987 to 2011. The graph shows twenty-five years of dramatic change in the public-private housing landscape. Excerpt from Nicolas Dagen Bloom's "Public Housing Myths".



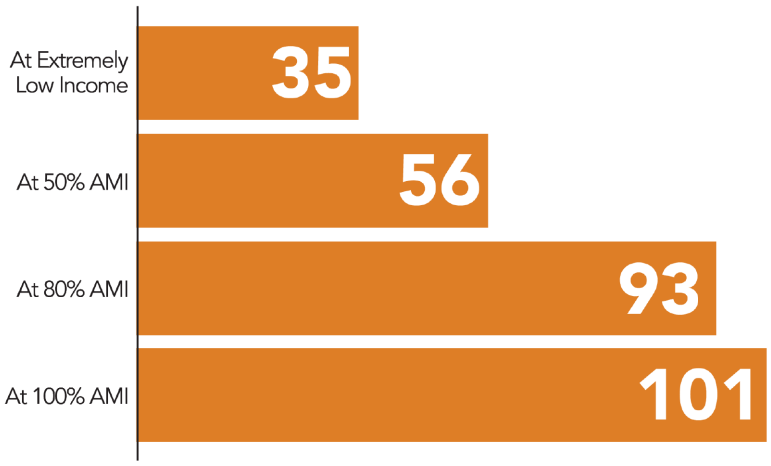
[8] The 9% credit is generally for new construction and delivers up to a 70% subsidy. The 4% credit is for rehabilitation projects utilizing federally tax-exempt bond financing and delivers up to a 30% subsidy. For further discussion, see: An Introduction to Low-Income Housing Tax Credit, Updated 26 January 2021, https://fas.org/sgp/crs/misc/RS22389.pdf

[9] Congressional Research Service and other industry experts have had complaints about these programs for their very prescriptive applications, program complexity, and micromanagement of the development process that are widely believed to increase costs and cause delays (Congressional, 2014).

Affordable Housing Needs in the United States Today

Today, an affordable housing unit in the US is defined as one where the individual or family does not have to spend more than 30% of household income on housing. Households spending more than that are defined as "cost burdened". Eligibility qualifications for affordable housing programs depend on the Area Median Income (AMI) per any given geographic area (JCHS, 2012). Each year, HUD calculates AMIs based on gross income data from the Census. For 2020, the AMI for a family in the United States is $80,320, which means a family that earns $24,096 is earning 30% of AMI and is defined as an "extremely low income" household (Aurand et al., 2020). Research has found that for those households at 30% AMI there are only 35 units available for every 100 that are needed (National, 2018), as shown in Figure 3. [10]

Figure 3. Available Housing Units Per 100 Households with Income Levels that are 30% of Area Median Income (Extremely Low Income), 50% AMI, 80% AMI and 100% AMI. Source: National Low Income Housing's tabulations of 2016 ACS PUMS data



History of Construction Techniques

A brief look at the history of construction techniques in U.S. housing helps in understanding today's approaches for building multifamily units, including affordable housing.

Balloon framing in home construction is known as the first "prefabricated" building system, the prefabrication stemming from the precisely sized pieces of thin wood used for framing (studs), instead of larger cross section and individually prepared timbers. Balloon framing was used for no

[10] As of the beginning of 2020, a quarter (25%) of *all* renters and 71% of extremely low-income renters, were spending more than half of their annual income on housing (Aurand et al., 2020). Currently, there is no US state in which a household earning the local or US federal minimum wage ($7.25/hour) for a full-time (40-hour) work week can afford a two-bedroom rental at the Fair Market Rate (FMR) without paying more than 30% of household income. A minimum wage household can afford a one-bedroom unit at the FMR in 5% of all counties in the country.

taller than 3 story buildings, homes, stores and churches and was the primary method of building these structures from the 1830's until the 1930s.[11]

The increased cost of construction from rapid inflation at the beginning of the 20th century forced designers and builders to innovate multifamily housing layouts. While cities such as New York and Chicago became metropolises of tenements and apartment housing, multifamily housing designs were manifesting as row housing and rental duplexes elsewhere. Regional disasters, like large fires, eventually led to restrictions on wood-framed structures, encouraging new industries and fire-resistant building materials. On the West Coast, pattern books[12] fostered the bungalow style for their multifamily arrangements, courtyard apartments, and the stucco-box/dingbat[13] apartment houses (Fowler et al., 2018).

Balloon framing was eventually replaced by *stick building* or *platform framing*[14] in the 1930s as the shortcomings of balloon frame structures became well known and unacceptable. The term "stick-built" signifies the structure built from sticks (studs) on location. This method employed the now commonly used, mass-produced studs, made from two-by softwood lumber material (nominally 2" thick) as a standard fabrication thickness, with widths in nominal increments of 2" and up. This method was much more structurally sound and made it easier to build taller structures.[15] Residential projects built by stick framing accounted for nearly 65% of the construction that occurred in the 20th Century and stick building was used all over America for all residential building types (Madden et al., 2016). Stick frame is interchangeably known as *light frame*, and this platform building system is the basis for all "framed" buildings from the last half of the 1900's until today. When designed properly, wood framed assemblies have a high strength to weight ratio compared to steel and concrete (Partnership, 2001).

By the 1960's, it became common practice to build wood structures above a "podium" that was one or two stories of concrete or steel. This building type, *podium in conjunction with stick*, is commonly referred to as "5 over 2" or "4 over 1". The goal was to increase the number of allowable floors afforded by the noncombustible lower podium level(s), and the podium approach was approved to build up to 5 timber floors above it, with proper fire rated separations and safety systems which varied by jurisdiction prior to the 2015 International Building Code update (Malone, 2017).

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[11] The studs would run from the sill plate on the bottom of the structure to the top plate at the roof, with intermediate levels nailed along the length to the long stud, where the one or two floors were to go. As nails became mass produced from rolled coils in the early 1900s, they became the standard way of fastening the studs and attachment methodology improved. The technique is known to be named by skilled carpenters observing the comparatively thin framing of St. Mary's Church in Chicago in 1833 and declaring this method of construction to be no more substantial than a balloon, surely to blow over in the next wind (Maass, 1957).

[12] Pattern books and mail-order catalogs of house plans increased access to architectural designs.

[13] Stucco box apartment houses (aka dingbats) were generally 2 to 3 story stucco wood framed buildings containing 4 to 16 units. https://hisour.com/dingbat-building-28980/

[14] Platform framing was a technique to build from floor to floor, in layers or platforms, instead of with the long stud.

[15] Light framing relies on the vertical transfer of the structural loads (the load path) from the roof, through the interior walls of the floors and down to the ground.

The "I-joist" was invented and started to find wide use also in the 1960s, as an efficient, lightweight substitute for two-by's in framing floor and roof systems. In 1990, they were further improved by substituting lighter weight material, oriented strand board (OSB), for the plywood web. Now commonly used, I-joists are approved by code for structural performance, fire resistance, and sound transmission ratings (Liechti et al., 2020). Furthermore, prefab OSB for I-joist or panel-sheathed walls lower costs and reduce the time it takes to construct, compared to conventional two-by dimensional lumber framing.

Further improvements have continued to be made, from various types of engineered materials, to nail guns and other essential improvements in tools, to off-site (prefabricated) framing that can include installation of exterior facades and prewiring. Perhaps the latest evolution is the use of Cross-Laminated Timber (CLT) panels for the floor and roof structure, which is faster, safer for workers to install, and allows the underside ceiling to remain exposed. Despite these innovations and the associated benefits, stick building remains the dominant method for building multifamily apartment buildings, for market or affordable housing, due to the abundant supply and wide distribution of the necessary wood products throughout the country and the ability to complete projects with available semi-skilled labor (Cheung et al., 2005). Because the standardized materials required for stick framing are readily available and this is the least costly way to build, the quality and durability of affordable housing is sometimes diminished.[16] The time is ripe to focus on the next best way to build affordable housing in the quantities demanded to provide decent housing and as a foundation for all other opportunity to spring from.

The 340+ Dixwell Project for New Haven, CT

New Haven, Connecticut, like so many cities big and small in the United States, has a significant shortage of affordable housing. The *340+ Dixwell* project (Figure 4) has been designed and planned to be built largely on land long owned by Beulah Land Development Corporation, the nonprofit housing producing arm of Beulah Heights First Pentecostal Church (Beulah). The project is the result of a vision by Beulah to provide housing for its community, to diminish the impact of poverty and blight, and re-establish the concept of the family community. Beulah selected a team of Spiritos Properties LLC (Spiritos) and Gray Organschi Architecture (GOA) in early 2018, to develop an approximately 70-unit mass timber multifamily rental project, believing that mass timber would provide a durable, energy efficient, healthy, and appealing living experience for the Dixwell Community. The team of Schadler Selnau Architects, an established Connecticut affordable housing and passive house architect, and GOA, a mass timber architect, was selected through a procurement process, to design the project. The original mass timber engineer was KPFF

[16] One note to be aware of is that stick framed buildings are considered quite flammable during their construction phase and are a particularly challenging fire and insurance risk. Fire retardant lumber, fire stops, fire blocking between joists, floor plates, fire resistance rated assemblies, waste management, and security detection including remote sensing, all have allowed light-framing building to continue unabated, sometimes building closer together and more frequently. Despite this, there continues to be fire damage to residential infrastructure during construction. In 2017 alone, 13 fires resulted in damages of $20 million or more, half of which were mid-rise wood frame apartment buildings (Badger, 2018). This product type risk is an ongoing challenge to the industry.

Consulting Engineers, and the MEP engineer was Acorn Consulting Engineers. In early 2019, the New York City-based HELP USA (HELP), a developer of supportive and affordable housing since 1986, and interested in exploring mass timber building, was added to the team as well as structural engineer and East Coast timber engineer Odeh Engineers. The LaRosa Building Group is the construction manager. 340+ Dixwell is a project that has applied for funding through the Connecticut Housing Finance Authority (CHFA), the Connecticut member of the National Coalition of State Housing Agency's (NCSHA) state housing finance authorities.

Figure 4. 340+ Dixwell, view down Orchard Street. Image courtesy of GOA and Schadler Selnau Architects.

The site for *340+ Dixwell* is unique in its prominence, design perspectives, and history. It is located at the apex of major streets, Dixwell Avenue, Munson Street and Orchard Street and comes to a point where those streets essentially intersect, with Shelton Avenue nearby. The Dixwell neighborhood is important in New Haven and Connecticut's history. Traced to the 1820's, Dixwell has been a largely African American community. It was a stop on the Underground Railroad during and after the Civil War. Dixwell Avenue has been a primary route between New Haven and the adjacent towns of Hamden, Mt. Carmel, and Cheshire since the early 19th Century. Shelton Avenue, then known as the New Haven and Centerville Horse Railroad, diverged from the horse-drawn rail tracks on Dixwell Avenue precisely at 340 Dixwell (Figure 5). In 1820, the African American churches of Varick Memorial AME and Dixwell Avenue Congregational (Founded as the Temple Street Church) were both established, the beginning of a long line of Black churches along Dixwell Avenue. This community was only one part of the Black population that was scattered throughout

the City, until European immigration in the late 1800s caused people to group along ethnic identities. A large concentration of Black New Haveners consolidated in lower Dixwell, such that by 1910, Dixwell Avenue was known as the Harlem of New Haven (Yanbo, 2016).

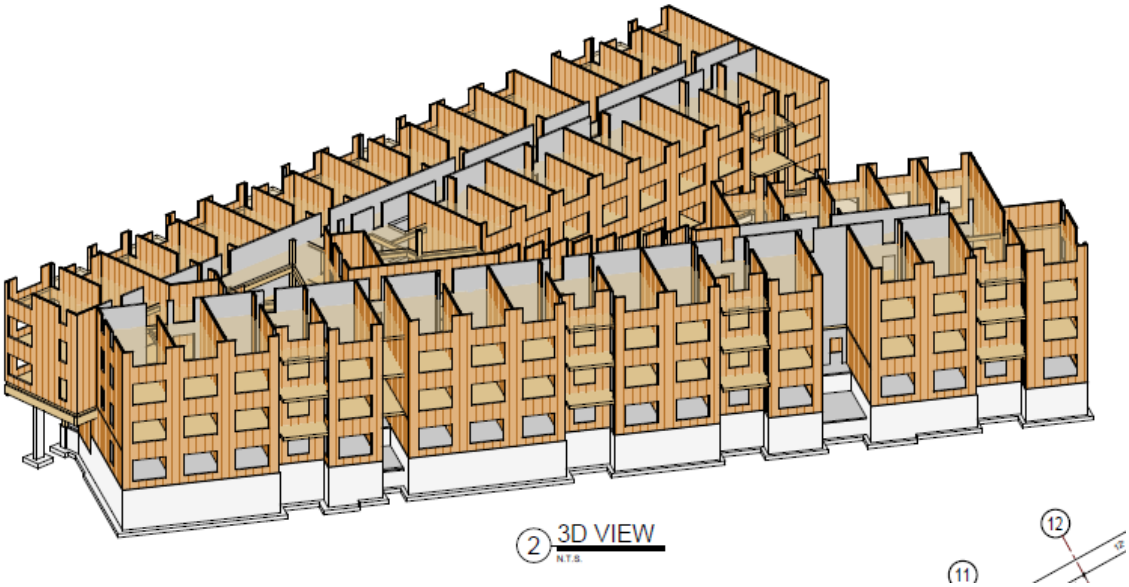
Figure 5. Junction of Dixwell and Shelton Avenues in the late 1800s. Image courtesy of Arnold Dana Collection, New Haven Museum.

Just a quarter mile away was the Winchester Repeating Arms Factory, established in 1870 on the Farmington Canal rail line and providing jobs for many people in the area. To house these workers, many homes were constructed in the surrounding neighborhoods of Dixwell and Newhallville, ranging from tenements to middle-class houses. For several decades, Dixwell was a vibrant neighborhood sustained by manufacturing. Dixwell Avenue was lined with small businesses, while Munson, Orchard, and Shelton housed residences, with stores at the major intersections. From 1911 to 1933, workers from Winchester and other residents would have spent leisure time at the Garden Theater, which occupied 340 Dixwell with Larmer's Drugstore. The Garden Theater closed during the Great Depression, and the period spanning from the 1930's to the 1970's was marked by urban renewal and its failures, taking a toll on the once-thriving street life of Dixwell.

For more than 25 years, 340 Dixwell has laid vacant, facing the same challenges experienced by Black neighborhoods across the country, including absentee landlords, redlining, and lack of investment. The proposed building will serve as an architectural anchor for the neighborhood by providing sustainable, beautifully designed, and durable housing. In addition to the cultural history of the neighborhood, the new development of high-quality housing and commercial space will change the neighborhood's trajectory by demonstrating what is possible to build on underutilized land for and by members of the Dixwell community. With Dixwell being one of the largest and oldest African American communities in Connecticut, the revitalization of 340+ Dixwell is a testament to

the principles and values of the community, being at the forefront in preserving its history and contributing to the historical structure through opening doors to homeownership, job creation opportunities, and fostering economic development.

Figure 6. – 3D view of 340 structure from Orchard Street. Credit: Odeh Engineers



340+ Dixwell Design Details

The Project is two buildings (at 340 and 316 Dixwell) linked through its parking area on Orchard Street (Figure 6). Design objectives are to maximize the number of apartments, in a preferred mix of 1, 2, and 3-bedroom units, provide ground floor commercial retail space for neighborhood businesses, amenity space for tenant use, and parking. Other objectives are to provide outdoor communal space for all tenants and balconies for the 2- and 3-bedroom units to enhance the quality of life through these outdoor opportunities. All of this within the context of a mass timber, passive house design with rooftop solar panels for energy production, to demonstrate how affordable housing can be energy efficient, durable, faster to build, natural, healthy, and respectful of the environment, with largely comparable cost and benefits.[17] The project team established the following design criteria as important to making this affordable housing project meet its objectives, as a way to demonstrate the possibilities for what housing can be.

Design criteria for providing affordable housing with the 340+ Dixwell Project:

1. A mass timber structure, with all its benefits, relative to light frame or carbon producing structural systems

[17] The full project results and reporting include the floor plans, a typical unit plan, schedule comparisons, cost estimates and additional information. These details can be requested by contacting the author of this report.

2. A CLT honeycomb bearing system,[18] to expose a significant number of walls as well as ceilings, minimizing the extent of dropped ceilings
3. Mass timber from the ground up, avoiding the typical one-story concrete or steel podium
4. A passive house design, to be very air and watertight with additional insulation, to reduce heating, ventilation and air conditioning (HVAC) demand and provide energy recovery ventilated (ERV) air to living rooms and bedrooms 24/7, bringing indoor air quality and health benefits
5. Balconies for all the 2-and 3-bedroom units, accessed from the living rooms
6. Outdoor community space for all the residents
7. Ample amenity space for tenant gathering
8. Rooftop solar panels to provide renewable energy and minimize electric grid consumption
9. Efficient stacked layouts for simplified structure, mechanical, electrical, and plumbing systems
10. A regular (12.5') room module to maximize CLT panel production and cost efficiency
11. A 9' to 9'6" floor to ceiling height so that the CLT wall panels can ideally be placed lengthwise to minimize panel quantity and installation time
12. A CLT panel façade, to reduce exterior joints and achieve exterior tightness much easier than with stud walls
13. CLT elevator and stair core walls, possible with only one lift needed if panels are 60' long
14. CLT stairs with skylights above to promote stair use, including the ornamental stair at entry

The following table (Table 1) provides additional project details.

[18] The CLT honeycomb system is commonly used in Europe, in multifamily apartment buildings in England, Germany and France. A glulam column and beam with CLT walls and floors approach is prevalent in the US. Our reasons for choosing the honeycomb method are: a) it provides the opportunity to expose more timber, creating warm, natural, hygroscopic approach, and b) using CLT panels for the exterior wall helps achieve passive house performance easier, in that there are far fewer joints to seal and because CLT panels are considered as "mass walls", carrying a higher R value than framed walls. Further, thermal bridges, another critical feature to avoid in passive house, must be minimized or eliminated, which is easier with a CLT exterior than with light frame walls because the CLT is a solid mass wall.

Table 1. +340 Dixwell Project applicable code and key specifics

Applicable codes	2018 Connecticut State Building Code, 2015 IBC
Construction type	5A
Allowable height	4 stories and 70'
Proposed height	4 stories and 45.5', not including bulkhead
Total parcel area	40,601 sf
Allowable FAR	2.0
Actual FAR	2.06* *Variance approved
Allowable zoning area	81,202
Actual zoning area	83,346
No. units (340 Dixwell)	57
No. units (316 Dixwell)	12
Total no. units	69
Parking spaces required	69
Parking spaces provided	32* *Special exception approved
Bicycle parking required	9
Bicycle parking provided	20
Project gross area	86,806
Typical floor to floors	10'0"
1-bedroom units	26
2-bedroom units	33
3-bedroom units	10
25-30% AMI units	18
50% AMI units	28
60% AMI units	9
Market rate units	14* 20% of the 69 total units
Supportive housing units	14* 20% of the 69 total units

As shown in Table 1, 80% of the units are for renters earning less than 60% AMI, with distribution between 25, 30, 50, and 60% levels. Of those units, 20% will be for supportive housing, for individuals or families experiencing homelessness. A total of 14 units in the building (20%) will be for market renters, the goal being to provide a mixed income building. The rents for the affordable units, including anticipated utilities, in 2023 dollars, which is expected to be the first full occupancy year, vary between $517 for 1-bedroom units and $1,708 for the 3-bedroom units.

Comparison with Light Frame

The majority of low to mid-rise multistory housing in the US is built with light frame construction – typically with a one-story concrete or steel podium to allow commercial use or parking below and to provide the structural column spacing to achieve the spans required for those uses. These methods have been used for many decades and it is known to be the least costly way to build

multifamily housing. While it is far better to build with light frame wood than with higher impact carbon emitting materials like steel and concrete, mass timber provides benefits worth considering as an alternate to light frame.

The benefits that come with using mass timber as an alternative to light frame:

1. Reduced parts and pieces – with mass timber, there are fewer elements to gather and put together
2. Greater height – light frame can only be a maximum of 5 floors over a concrete or steel podium; Mass timber can go to 18 stories with the 2021 adopted code changes
3. Less site impact – mass timber requires fewer deliveries, less traffic, and less trade parking than what is needed with light frame
4. Efficient crew size and mitigated labor challenges – light frame requires 20-30 people compared to 6 or so with mass timber
5. More climate-friendly elevator and stair core walls – these building elements are typically done in concrete or concrete block for light frame and mass timber offers the opportunity to use carbon storing rather than carbon emitting materials for these elements
6. Elimination of waste and clutter – light frame construction includes cutting of lumber, sheathing, etc. on site that all takes space, creates safety concerns and generates waste – these concerns are reduced or eliminated with mass timber
7. Speed – with light frame construction, the walls, shear walls, bearing walls, ceiling joists, connections take longer than placing glulam/CLT panels; and the project needs to wait until the roof is on to start insulation and gypsum due to water infiltration concerns
8. Quality – dimensional lumber is less dimensionally stable
9. Thermal performance – wood studs are thermal breaks in an outer wall that diminish wall R value
10. Safety – fall and trip hazards are greater in light frame construction, and walking on installed joists is a skill
11. Fire risk during construction – dimensional lumber more susceptible
12. Builders risk insurance costs – may be higher with light frame due to construction risks (safety and fire) during placement
13. Durability – light frame structures are subject to more movement and weather impact
14. Natural environment – light frame buildings require covering all wood with artificial surfaces
15. Healthfulness – exposed wood has been shown to reduce asthma and stress, lower heart rate and blood pressure, and improve concentration

Further analysis of the cost comparison between light frame and mass timber is detailed in Figure 7.

Figure 7. Cost comparison – mass timber and light frame multifamily

340+ DIXWELL
MASS TIMBER VS LIGHT FRAME COST COMPARISON

NOTE - GENERAL CONTRACTOR ADD ONS - GC, INSURANCE, BOND, FEE ARE REFLECTED PROPORTIONATELY
NOTE - COST DIFFERENCES IN THE 0% PERCENTAGE COLUMN ARE DUE TO ROUNDING

BUILDING GROSS SF 86,807

CATEGORY	MASS TIMBER (MT) ($)	LIGHT FRAME (LF) ($)	MT PERCENTAGE OF LF (%)
GENERAL REQUIREMENTS	678,927	720,541	-5.78%
SITEWORK	885,870	894,752	0%
FOUNDATION	627,196	633,450	0%
MASONRY	124,375	401,891	-69.05%
METALS	380,692	599,767	-36.53%
WOOD STRUCTURE & PLASTICS	4,592,849	2,384,866	92.58%
THERMAL & MOSITURE	2,390,586	2,108,925	0%
DOORS & WINDOWS	983,251	993,056	0%
FINISHES	1,370,747	1,861,678	73.63%
SPECIALTIES	78,395	79,180	0%
EQUIPMENT	237,577	239,948	0%
FURNISHINGS	308,454	311,529	0%
CONVEYING SYSTEMS	502,332	507,341	0%
FIRE PROTECTION	467,385	472,045	0%
PLUMBING	1,037,884	1,048,232	0%
HVAC	1,546,477	1,561,897	0%
ELECTRICAL	1,631,961	1,648,233	0%
SUBTOTAL	**17,844,958**	**16,467,331**	**108.37%**
CONSTRUCTION PERIOD INTEREST (2 MO)	-80,000		-80,000
NET RENT COLLECTION (2 MO)	-20,000		-20,000
SUBTOTAL COST OFFSET	**-100,000**		**-100,000**
TOTAL COST WITH OFFSET	17,744,958		
COST/SF	**205.57**	**189.70**	**15.87**
OFFSETTING NET REVENUE	-1.15		-1.15
TOTAL COST/SF	**204.42**	**189.70**	**14.72**

Cost differences can be attributed to several factors as detailed below.

1. **General Requirements** – The mass timber (MT) schedule is 14 months, the light frame (LF) is 16 ½. The $41,614 lower price for MT is for shorter superintendent timeframe and a bit for less office trailer, trash removal, and miscellaneous general overheads.
2. **Masonry** – in the LF option, elevator shafts and stair shafts are built from concrete block. The MT uses CLT shafts, resulting in this savings of $277,516. Some work remains in the job for planters and stucco.
3. **Metals** – The LF podium is steel whereas the MT option has glulam framing and CLT walls on level 1, so that the podium steel frame is not required. Also, the light frame building's stairs are steel, for a total $219,175 savings. The MT project still has the level 2 courtyard steel framing and miscellaneous metals.

4. **Wood structure and acoustics** – The pricing differential is for acoustic flooring components as well as for the structural frame. The acoustic floor build-up prices at $9.42 for the four layers between the CLT and the finish flooring. This compares to $2.24 in the LF approach. This $7.18 difference is more than needs to be committed to achieve an acceptable acoustic floor treatment, and we believe a $5/sf less costly solution will eventually be selected.[19]
5. **Finishes** – The three areas where costs are avoided in a MT multifamily project are drywall, ceilings, and paint. The exterior wall remains exposed in the MT so that drywall is saved. The rest of the Project's reduced drywall (interior CLT walls where one side is exposed) is not realized as it is a tradeoff with the metal stud framing for the acoustic and services framed wall that adjoins all CLT walls, for required acoustic treatment. The same goes for the ceiling. While about 50% of the building has exposed CLT ceiling, at the other half, metal framing is needed to support the ceiling where it occurs. Thus, there are no ceiling savings. The total savings here are $490,931.
6. **Construction period interest** – The 2 ½ month shorter construction period saves construction period interest on the construction loan. In our case, that saves $80,000.
7. **Net rent collection** – The 2 ½ month shorter construction yields that much quicker occupancy and $20,000 additional net income as well. This being an affordable housing project, net income is rather meager. A market rate project would show a larger offset.

The light frame, structural to structural, is considerably (approximately $16/sf) less expensive than mass timber, about $24/sf versus $40/sf. The sum of all the adds and deducts for building this mass timber project results in a $14.72 or 7.75% potential cost increase (Figure 7). However, built into this is an expected $5/sf added cost for the acoustic floor treatment in our design that is not necessary. Taking this into account, the differentials are expected to be about $9.42 or 5.12%, which is what we expect the "premium" for building better with mass timber should be. Given the myriad benefits of mass timber residential construction, a mass timber structure should be the next generation for creating healthy, durable, high quality of life housing for all. The character of mass timber erection sets the stage for a much faster and smoother project. It is less reliant on sequence, or on weather. In our 340+ Dixwell passive house project, it makes creating the airtight shell that much quicker and less risky. Less joints, less work, quicker preliminary blower door test[20] – a better all-around result and the way of the future.

[19] The full project report includes a figure (Figure 21) and appendix further detailing floor pricing (see Wood and Plastics and Thermal & Moisture, Appendix 2) and finishes (Appendix 3). These details can be requested by contacting the author of this report.

[20] A blower door includes a fan and mounts into the frame of an exterior door. Energy auditors use blower door tests to help determine a home's airtightness. http://www.energy/gov/energysaver/blower-door-tests

Figure 8. Streetscape rendering, looking north on Dixwell, Gray Organschi, and Schadler Selnau

Conclusion

The current situation of inadequate and underperforming affordable housing in the United States is a critical social, economic, cultural, and political problem. The current situation calls out for achievable, repeatable, affordable, durable, energy efficient, and natural housing solution for those in greatest need, and mass timber can provide that solution. Building mass timber affordable housing can and should be a major contributor to addressing America's overwhelming affordable housing problem.

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