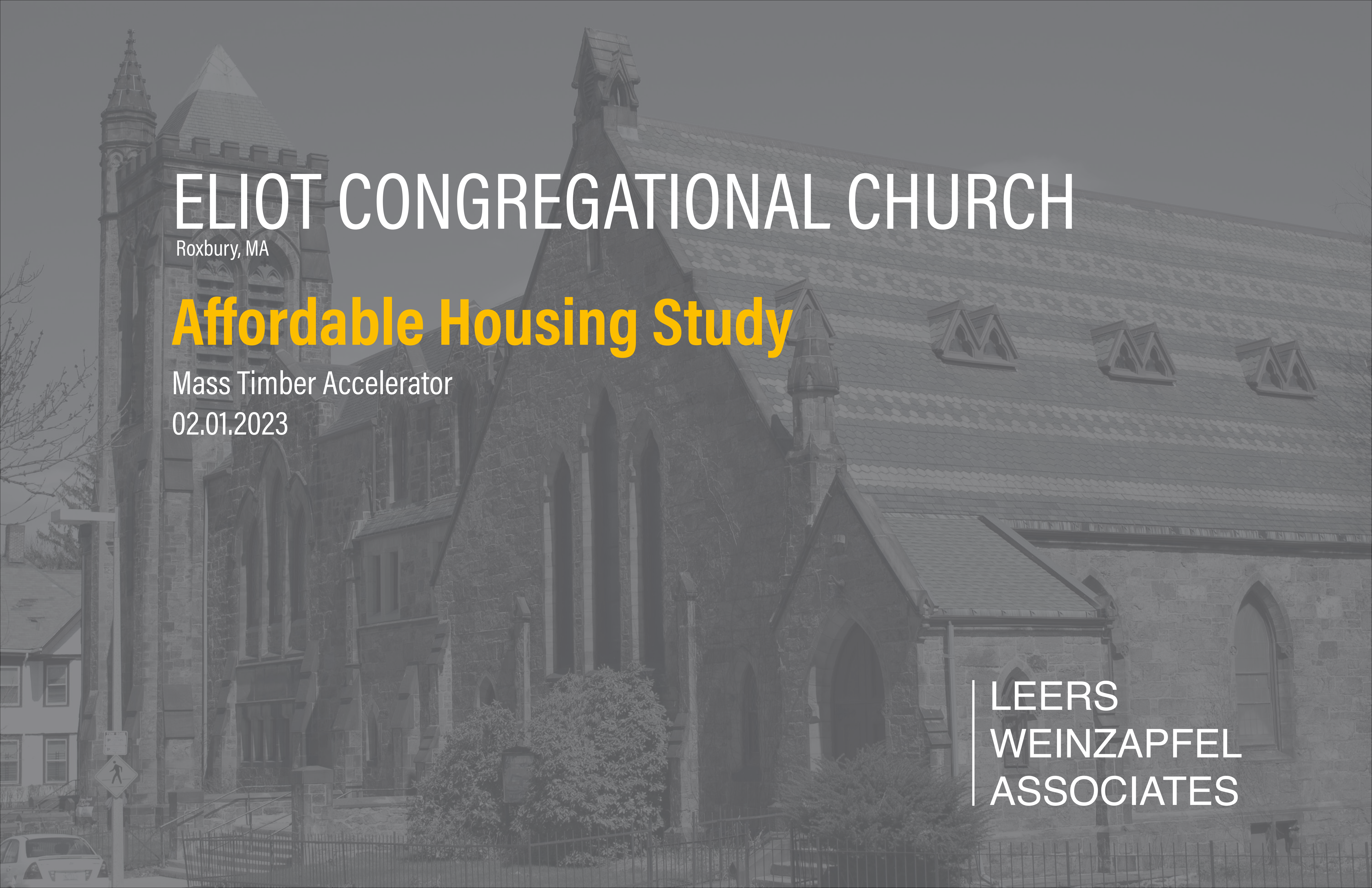

ELIOT CONGREGATIONAL CHURCH

Roxbury, MA

Affordable Housing Study

Mass Timber Accelerator

02.01.2023

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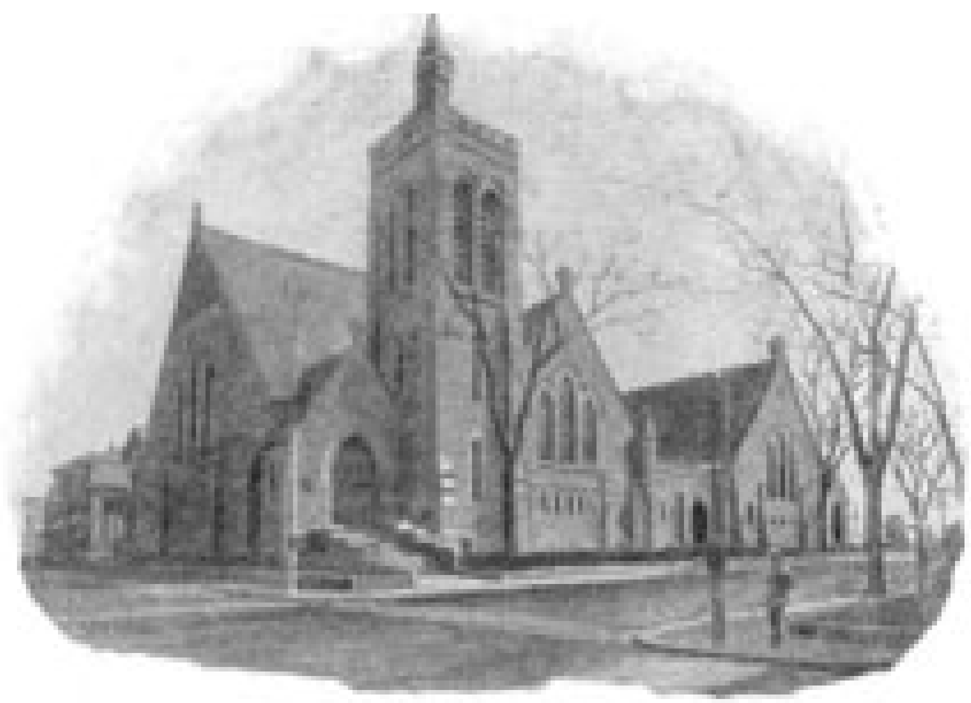


CONTENTS

I. Executive Summary

Housing is the most basic need in our society. Affordable housing even more so for the most under-served residents in our cities and Boston is no exception. Though affordable housing must work within the funding parameters, it does not mean that it has to be a cookie-cutter solution using the least expensive materials, often not well built and below market standards. Rather we should aim to include the latest improvements in sustainability and human well-being for such projects.

Project Description, History, and Team
Affordable housing at Eliot Congregational Church in Roxbury, which is a neighborhood within the city of Boston, MA, will serve the underprivileged inner-city community in Roxbury. In addition to affordable housing units, the large, expansive existing church building can be leveraged to provide community support spaces often necessary but often overlooked with affordable housing; business incubator resource center, after-school activities, and community food pantry, to name a few which many non-profit and faith-based organizations provide. The project is intended to provide a total of twenty-four affordable housing units across an addition and renovation that would work with proposed project source funding common to affordable housing development and includes operational budget for long term viability. Ten percent of the units are planned to be affordable to households making very low income (about $30k per year) while the remaining ninety percent of the units are intended to be affordable to households making about $55 to $70 per year, well within Boston area's low-income thresholds.

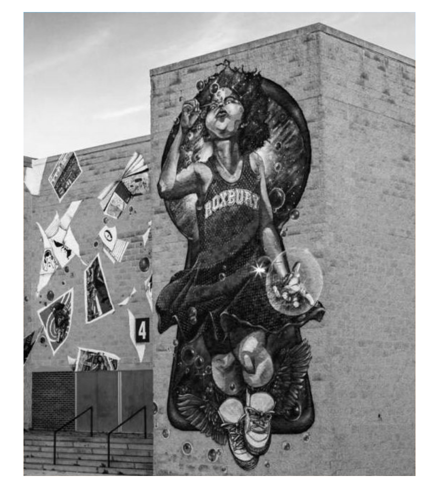
The project will utilize the Church's biggest asset, which is the building itself and the land property on which it sits. The addition will leverage an underused portion of the property, a small site of around 4,500 square feet currently used as a parking lot, and provide a four-story addition with fifteen units, consistent with neighboring triple decker and multi-family residential buildings, providing a good transition from the much larger scale church building on the corner of the property. The renovation portion is intended to be in the current three-story administration wing of the Church where the existing structure and window locations are suitable for conversion to nine housing units. Since the Church is listed on the National Historic Landmark Registry, it quickly proved unfeasible to add units in the main church building as that would have required significant alterations to its exterior. This study focuses particularly on the addition aspect of the project.

Reverend Dr. Evan C. Hines is the Senior Pastor of the Eliot Congregational Church which comprises of a predominantly African American congregation serving the needs of its local community. Rev. Hines has dedicated his life as a minister to helping the people of the Roxbury community, where he grew up, to advocate for their social and economic future. He met Tom Chung, Principal of Leers Weinzapfel Associates (LWA), through Tom's graduate studio in Mass Timber design at Wentworth Institute of Technology where Tom led his students in exploring the potential of mass timber architecture for adaptive reuse and addition to the Eliot Church building and property.

Leers Weinzapfel Associates is a design firm of 30+ architects and designers based in Boston, MA. LWA aims to bring 'responsible design excellence' by focusing on the human experience, sustainability, and craft of building to ensure a solution that is right and appropriate for each project and client's schedule and budget. The LWA team brings extensive experience and leadership in mass timber. Tom understands intimately the interconnected relationships among every entity in the life cycle of mass timber and has an extensive network of connections with the wood industry, which is necessary for exploring the potential of mass timber for affordable housing. This understanding comes from LWA's two large-scale built projects: the Adohi Hall at the University of Arkansas, a student housing project, completed in 2019, which was at the time the largest cross laminated timber building in the US, and the Olver Design Building at UMass Amherst, completed in 2017, which was among the first large scale academic mass timber buildings in the US. Both projects embody the efficiency of mass timber towards a cost-effective layout and construction, that will dictate the approach necessary for this project's housing units. The key is in translating the potential and justifying the cost of mass timber, typically a large-scale building product, into a small affordable housing project.

Project Goals
So why mass timber for affordable housing?

We know that wood is fundamentally sustainable and renewable. As a tree grows, it takes carbon from the atmosphere and stores it, much of it in its trunks and branches which are the source of wood products. In addition, the overall embodied energy or carbon emissions of building with wood from extraction, processing, transportation through construction is much lower than other building materials such as steel or concrete. However, Cross Laminated Timber (CLT), among the most popular mass timber product, is made with highly automated, expensive, large-scale machinery such as CLT presses which are designed to produce large scale mass timber products for buildings in growing urban centers, as well as Computer Numerical Control (CNC) machines which




Google photos showing Roxbury's vibrant community and neighborhood characteristics cut and shape the mass timber products for a plethora of design connections: from simple to very complex joints. But there is a cost to such technology, with investments in CLT factories being in the tens of millions of dollars which ultimately has to be passed down to the customer. While that isn't as a big of a factor in large scale projects that compare with costs for steel and concrete buildings, small affordable housing mass timber projects such as ours must be comparable to light frame wood construction, which is typical for such building types and is among the least expensive structural system.

The goal of the project is to bring all the benefits of mass timber – environmental, experiential, and social to enhance the quality of life for our most underserved residents. This effort will require the experience and expertise of a seasoned mass timber design team to quickly evaluate mass timber options along with light frame wood options to provide the best balance of benefits and cost. It requires knowledge and understanding of the various mass timber suppliers and their respective processes, given that it is very much still an emerging technology with wood species varieties, proprietary lamination dimensions and layups, preferred billet sizes and an array of connections possibilities. The project is intended to incorporate core sustainability principles such as re-use of existing building and new construction with renewable material for structure: wood. Both mass timber and light frame will be used for low embodied carbon and carbon sequestration. Exposure of mass timber elements will be key in limiting additional resources for finishes while providing a space of well-being by taking advantage of wood's inherent biophilic qualities.

Project Approach

The project type and its small size was the primary factor that drove the design team to look very closely at a specific mass timber product, Nail Laminated Timber (NLT), to reduce the cost and carbon footprint even further from already sustainable mass timber products such as Crossed Laminated Timber (CLT). In an effort to afford mass timber for affordable housing, the design team went back to the basic building block, the ubiquitous 2x lumber which is the basis of light-frame wood construction and many mass timber products.

NLT is the closest in relationship to lumber as it is simply either 2x4's or 2x6's, most of which have no further postproduction other than nailing them together into wall, floor, and roof panels without use of expensive machinery. Furthermore, it could be produced nearly anywhere by any contractor with lumber, hand tools, and a worktable. Given the existing site conditions for this project, lumber could simply be brought to site and an adjacent staging area on the property could be used to set up a small tent (for inclement weather if needed) and a worktable to fabricate the NLT panels on site.

Given many similar sized empty lots and old buildings in Roxbury, the city of Boston, and cities throughout the US, the project is intended also to be a prototype that shows a blueprint for neighborhood organizations like Eliot Church, its residents and like-minded developers and their city officials to collaborate and address the issues of affordable housing that exceeds current standards, without necessarily waiting for that "big project" that require large lots and large sums of investment.

Tom S. Chung FAIA, LEED BD+C
Principal, Leers Weinzapfel Associates

Google photo of Eliot Congregational Church in Roxbury, MA

II. BENEFITS / OUTCOMES

1. BUILDING PRACTICES

Design & Construction Strategies
To make best use of NLT, while taking into consideration carbon storage, structural efficiency, design flexibility, and potential to expose the wood for a biophilic effect, NLT was used for all of the floors and roof as well as the inner shear and core walls in a structural grid of 14 to 17 feet wide that would allow for 2x4 and 2x6 lumber, which is much less expensive than 2x8s or 2x10s. These NLT floors and walls would need sheathing on one side to provide continuous structural diaphragm for the floors and lateral shear capacity for the walls. By working within a small span structural grid and containing the sheer structure to the core of the building, this allows for maximum perimeter openings to bring in as much sunlight as needed. This design flexibility which also includes various roof profiles and façade arrangements is advantageous to many different site conditions as we envisioned the project to serve as a prototype for similar small-scale developments on empty lots of similar sizes all around in neighborhoods of the city of Boston as well as other similar urban centers.

Building Code Strategies
The strategy was to maximize the buildable area on this very small lot while keeping in mind the scale of the addition in relation to its context. Preliminary analysis of zoning and context studies resulted in what was essentially an unbuildable lot. With code expert consultation and a creative look at the arrangement of the empty parcels, a strategy was developed that would allow for a credible variance approach, given the community benefits, for a maximum build of fifteen units in a four-story structure of 12,600 gross square feet.

The design team followed the unit size guidelines established by the City of Boston to be eligible for city funding and configure such units within the NLT structural framework that was established. On the ground floor, one of the corner units was eliminated to allow for an open entry area and a common space. Each typical floor above consists of various unit types: two 1-bedrooms, a 2-bedroom, and a studio, to accommodate a wide array of residents, families and single. In addition, the layout consisted of an extremely small and efficient circulation space and shear core with a single stair and elevator. Code allows for a single egress stair in this application and an elevator is not required. But the team wanted to provide equitable access to all, so an elevator was included. The compact hallway maximizes the housing unit areas and keeps the building grossing factor as small as possible, and by having it centrally located in the building, it allows for the perimeter to be freed up for maximizing window area for the bedrooms and living rooms.

2. ANALYSIS

Cost Analysis
Cost parameters ranging from $300 to $325 (number estimated at the project inception in 2020, prior to current pandemic related cost volatility) was the cost per square foot established consistent with city of Boston guidelines for affordable housing. This assumption will be updated when the city of Boston establishes new guidelines.

As mentioned previously, NLT is not a complicated product to make and requires no further postproduction, it doesn't involve expensive machinery, and could be produced almost anywhere. Based on that, the team considered the opportunity of taking advantage of the Church's property which offers a 'back lot' behind the administrative wing where a contractor can set up a workstation for the on-site manufacturing of the NLT panels. Only small construction equipment would be needed to assemble the building, no production waste would be generated, and no storage space would be necessary as the panels would be manufactured 'on-demand.' Additional transportation costs of the material assembled offsite would also be eliminated.

Environmental Considerations / Context
The environmental benefits of all the structural mass timber components in conjunction with typical light frame wood construction and other architectural building assemblies were analyzed by calculating the quantity of carbon storage. Our approach resulted in more than twice the carbon storage for a project consisting of NLT and light-frame construction as compared to the typical all light-frame building approach.

In looking at the surrounding neighborhood, analysis showed an array of vernacular small scale residential typologies of light frame wood structures such as the single family, duplex, and triple-deckers on similar small lot sizes. Given the site conditions and its immediate surroundings, the roof profile was carefully designed. It comprised of a gable and pitch, with the profile of the pitch sloping upwards with its peak towards the taller building, the Church to the right, and a gable which slopes down and has a lower roof profile adjacent to the smaller scale triple-decker neighbor to the left. The window configurations were also carefully selected from an array of options that reinforced the prototypical aspects of this building type.

3. OPPORTUNITIES REALIZED & LESSONS LEARNED

Savings, Monetarily and/or in Structure
Using exposed NLT for the roof and floors has multiple advantages. First the building's overall height would be reduced as the typical plenum spaces required in light-frame construction along with its greater comparable beam depth would be eliminated, and with careful arrangement of light fixtures and sprinklers on the side walls, the ceiling plane would be kept plain and 'clean,' which would also allow for higher-than-typical ceiling heights for the building's residents. Similarly, the NLT walls would be 'clean' and express the warmth of the wood at select areas in each unit which are determined by the locations of the shear walls. There would also be significant cost savings on finishes such as ceiling tiles and gypsum wall boards that would typically be necessary for an all light-frame construction. In addition, reduced overall height of the building would result in savings in material, especially glazing and other exterior enclosure.

Changes in Sustainability Goals or Outlook
We return to the crisis of carbon emissions in our environment today. We've made good strides (especially in Boston and Massachusetts) in recent years in addressing operational carbon with stricter

code requirements and an array of renewable energy such as hydroelectric, geothermal, solar, and wind power for much of our buildings' heating and cooling needs. Now, we must also pay attention to embodied carbon, that is the carbon emissions related to the construction of a building before the building is occupied and in use. We acknowledge that wood is the only renewable building material in the market. Furthermore, statistics show that minority communities are the ones most adversely affected by the impacts of climate change. It's not only sustainable to build with wood, but also equitable and just to use mass timber for housing for the least privileged among us so that they too can thrive and enjoy better housing and not continue to shoulder the burdens of climate change.

Unexpected Opportunities
By implementing a combination approach of using mass timber and light-frame construction, we are capitalizing on the advantages of both construction types while limiting the prohibitions that come with one or the other. For example, mass timber has many benefits such as it allows for the exposure of wood, which has biophilic qualities that promote user well-being in such spaces, promotes faster construction, reduces costs on finishes, and is a sustainable building material. However, mass timber is not the most conducive in having wall cavities to run electric conduit and plumbing, which is where light-frame component of the building comes as an advantage. Light-frame is also more cost-effective than mass timber, so limiting the mass timber only to the shear walls that can be exposed at least on one side as well as the roof/floor elements and using light-frame for all the other partitions maximizes the best qualities of each.

The project is then finished with a charred wood cladding to reduce maintenance and increase the durability of a wood cladding system without having to re-paint every 5-7 years, but one that could take on a different cladding material on other sites as appropriate. In the case of this project in partnership with Eliot Church, the charred wood cladding and its darker, black appearance can be a metaphor for celebrating the history and resilience of the African American congregation and community.

4. NEXT STEPS

We are confident that NLT is the right solution for this project type and scale. We prioritized the embodied energy aspect of this project; material production, in this case wood, from timber harvesting to debarking to cutting the logs into lumber dimensions, often is the base industrial process for the various lumber-based mass timber products like Cross Laminated Timber (CLT), Glue-laminated Timber (GLT), Dowel-laminated Timber (DLT) and Nail-Laminated Timber (NLT). Additional production processes such as wood planning, finger jointing, gluing, and associated post-production machining, all of which have additional costs as well as carbon footprint implications can be eliminated for NLT. And for such a small affordable housing project that must compete in cost to a typical all light-frame wood construction, the challenge will continue in realizing the mass timber element of this project all the way through construction to make sure it is not compromised for another alternative.

We are in the process of actively pursuing additional grants for remaining design phases as well as funding for our development consultant partner to do their work in continuing the project pro-forma and identifying a like-minded developer partner along with community and city engagement as the project develops.

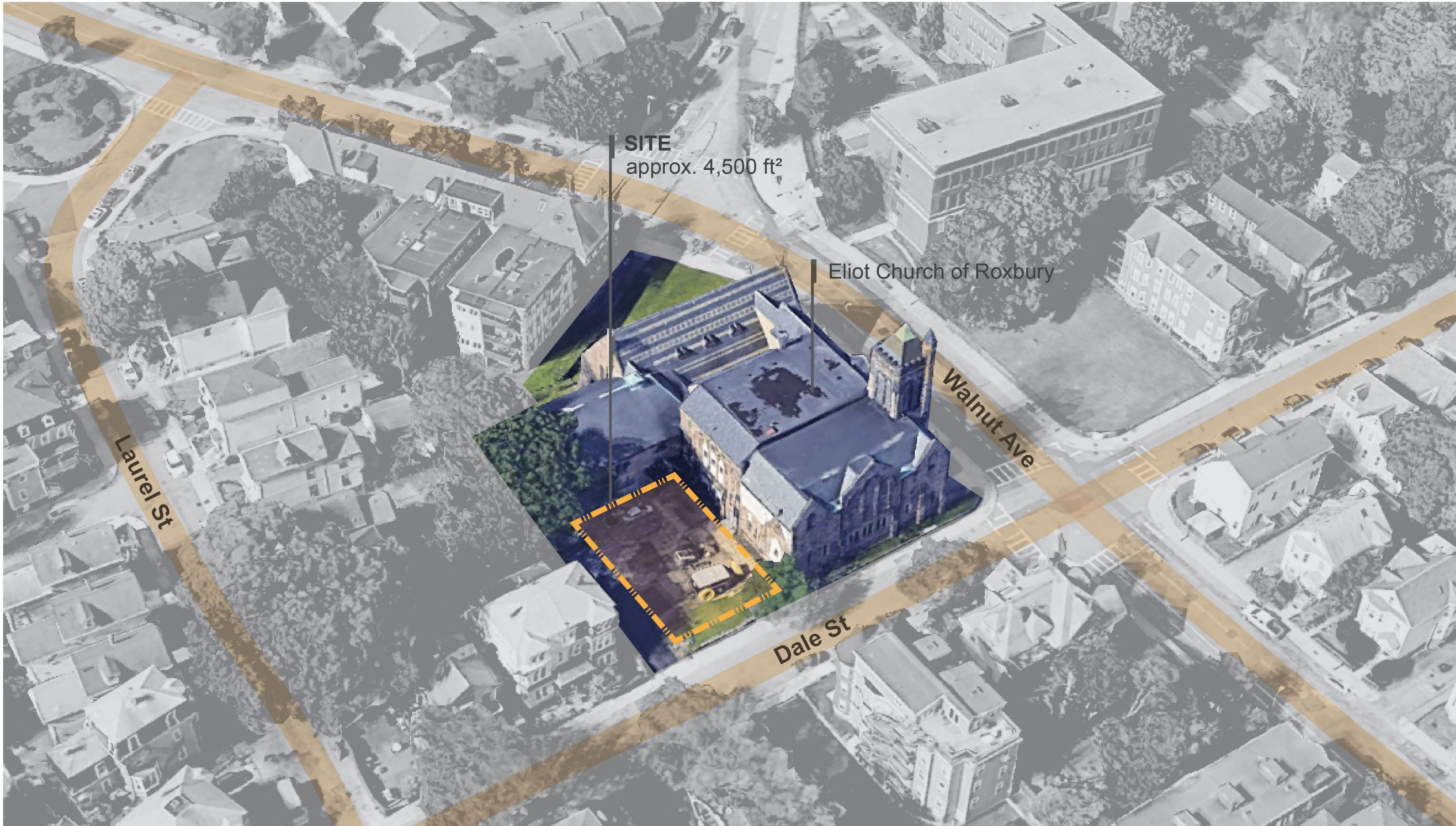
III. PROGRAM IMPACT

Program Evaluation & Impact
We are honored to be selected for the inaugural round of funding by the BPDA Mass Timber Accelerator Grant Program. This enabled us to do the research and develop a credible conceptual design for the project. In addition, it was very helpful being part of a group of awardees to discuss and share information and strategies regarding various types of mass timber products and building types. This program was exactly what was needed to help jump-start Boston's architecture community in taking a serious look into Mass Timber across many project types and will continue to be in need in the coming years as Mass Timber as a new construction type, takes the necessary time to mature in the building construction industry. The seed has been planted as we aim together for a more sustainable – environmental and communal – future together.

Tom S. Chung FAIA, LEED BD+C
Principal, Leers Weinzapfel Associates

SITE OVERVIEW neighborhood site plan showing a 10-minute walking radius from the site

SITE OVERVIEW aerial showing the Church in relation to the available site



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SITE OVERVIEW showing views of the site and elevations of the Church's administrative wing

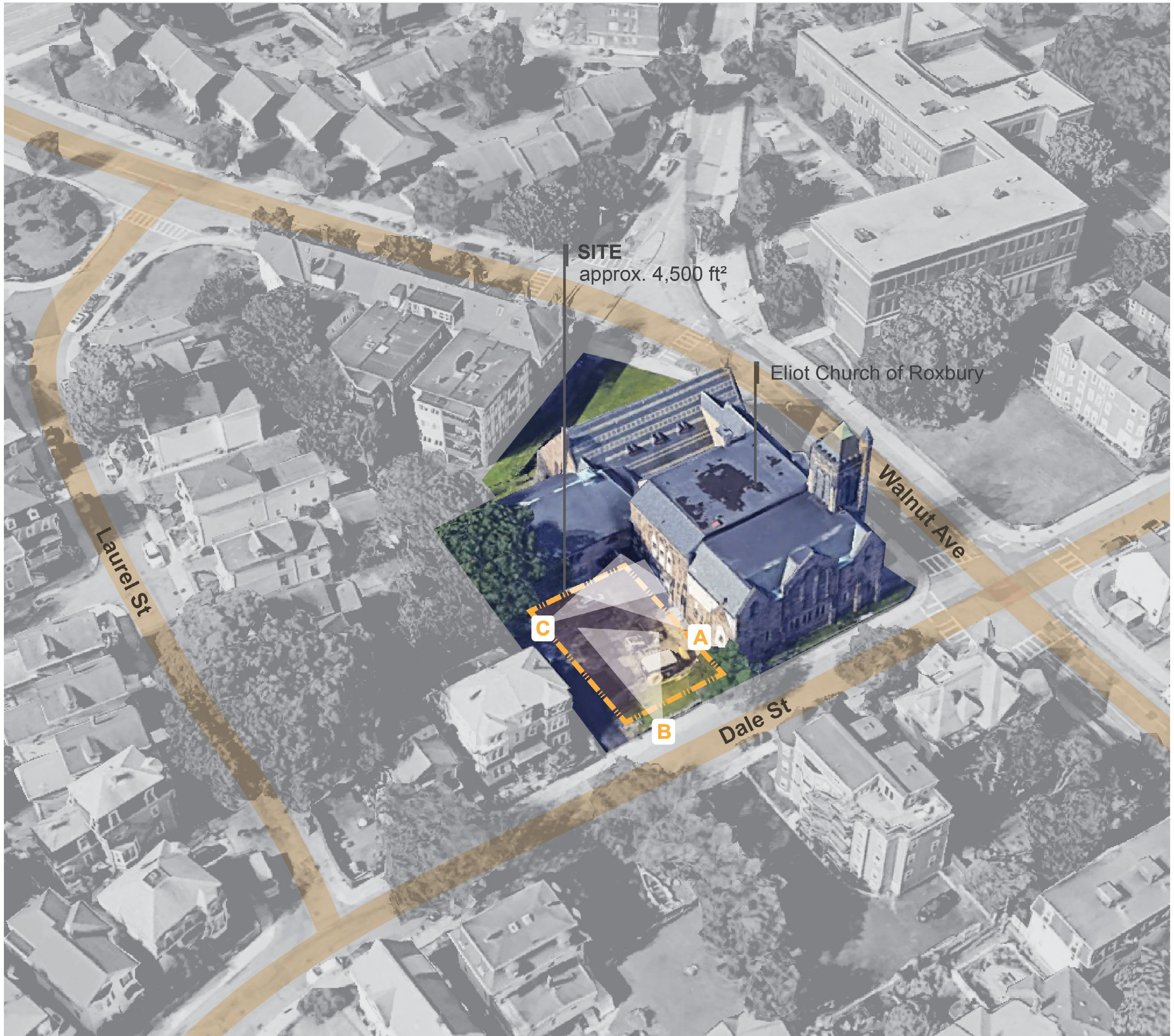

Photo of the site taken by the project team

The Church's administrative wing building shows feasibility for incorporating housing with it's bigger windows and layout.

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0.25 mi radius
5 minute walk
SITE
2-story vernacular
3-story
purpose built housing
other
parks
religious

ZONING PLAN

SITE

Extend the existing lot line (red dashed line) to the church's property line (red solid line) about 15 ft east to allow for maximum buildable area, since given the current lot line, the buildable area is limited to only that shown in the dotted grey square after setbacks are factored in. A zoning variance will be required to extend that lot line.

Setback the building 10ft from the new lot line to allow for an easement.

BUILDING

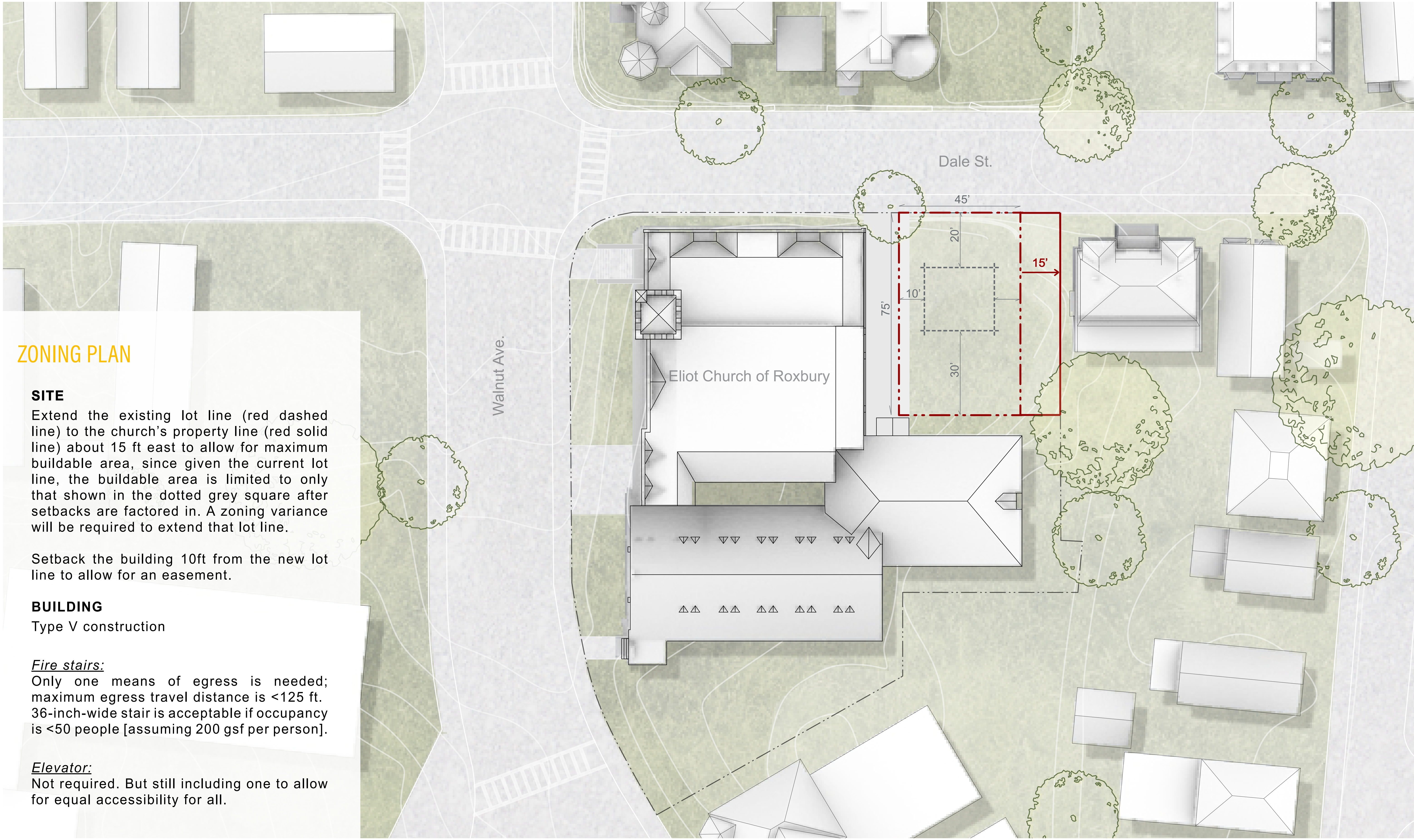
Type V construction

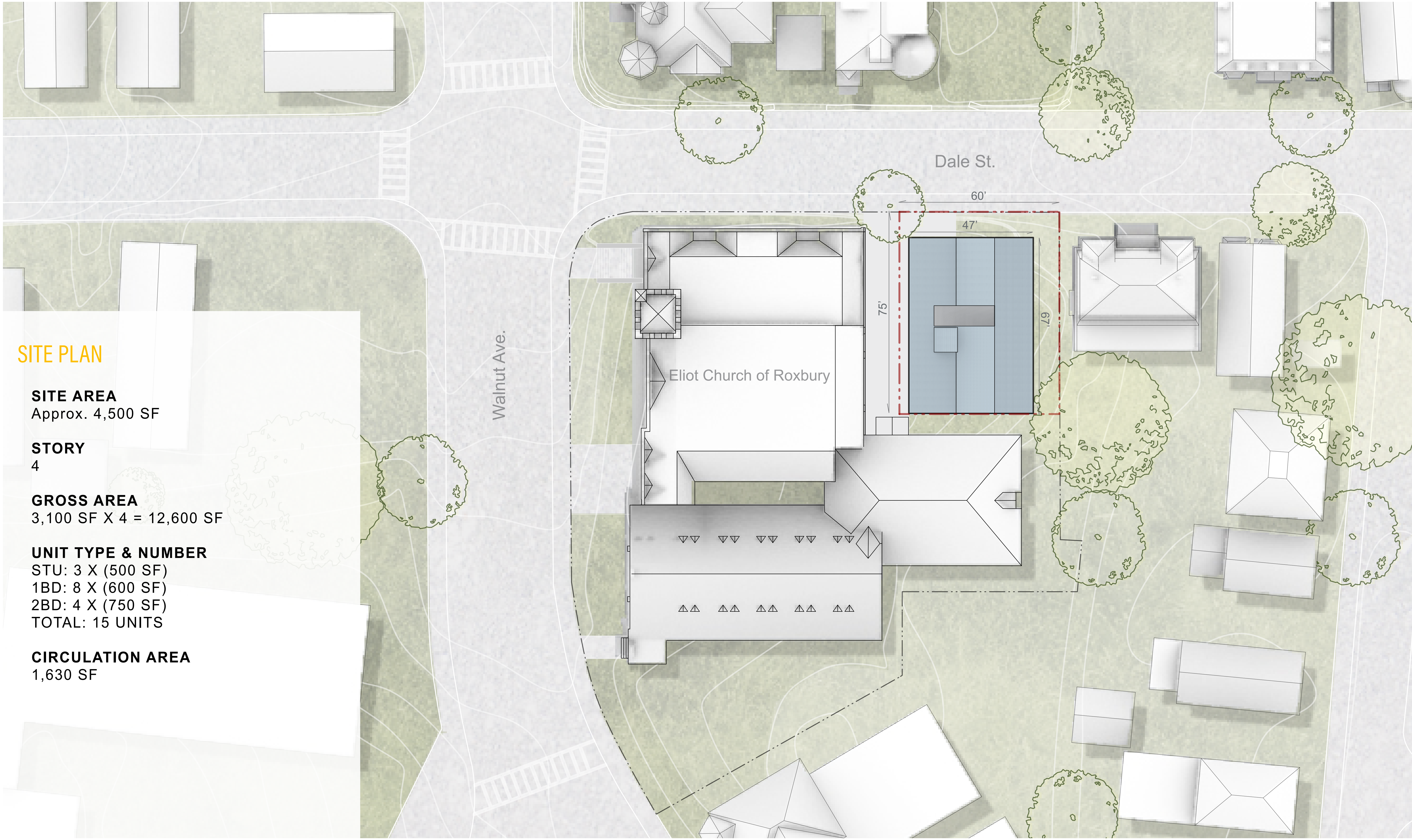
Fire stairs:

Only one means of egress is needed; maximum egress travel distance is <125 ft. 36-inch-wide stair is acceptable if occupancy is <50 people [assuming 200 gsf per person].

Elevator:

Not required. But still including one to allow for equal accessibility for all.





SITE PLAN

SITE AREA
Approx. 4,500 SF

STORY
4

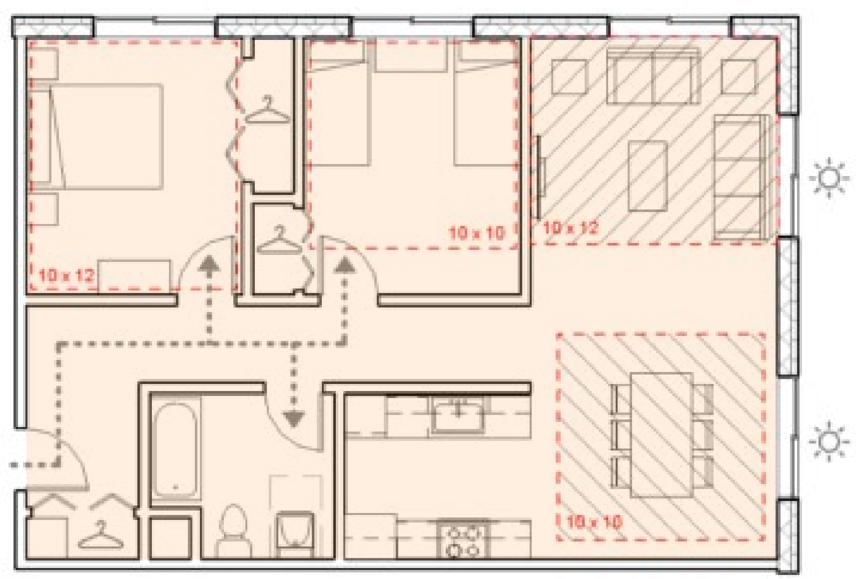
GROSS AREA
3,100 SF X 4 = 12,600 SF

UNIT TYPE & NUMBER
STU: 3 X (500 SF)
1BD: 8 X (600 SF)
2BD: 4 X (750 SF)
TOTAL: 15 UNITS

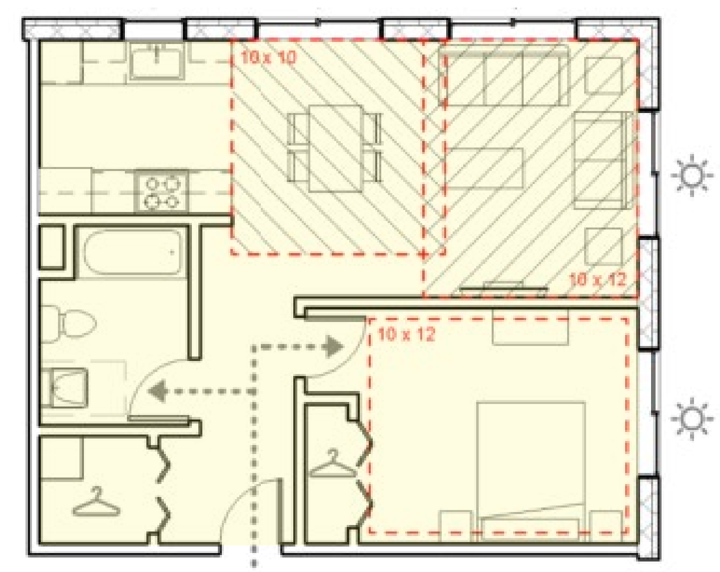
CIRCULATION AREA
1,630 SF

UNIT SIZES & DESIGN STANDARDS

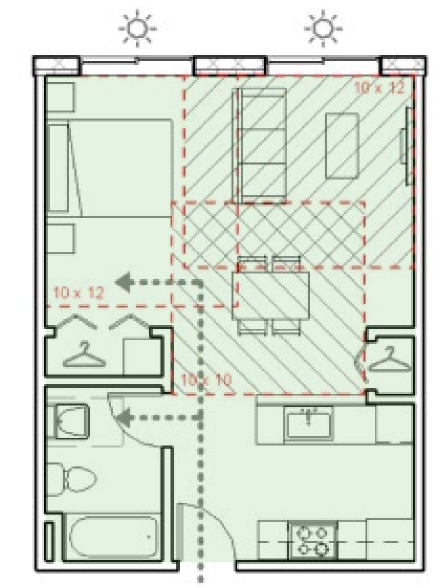
*according to Department of Neighborhood Development (DND) Design Standards 2020



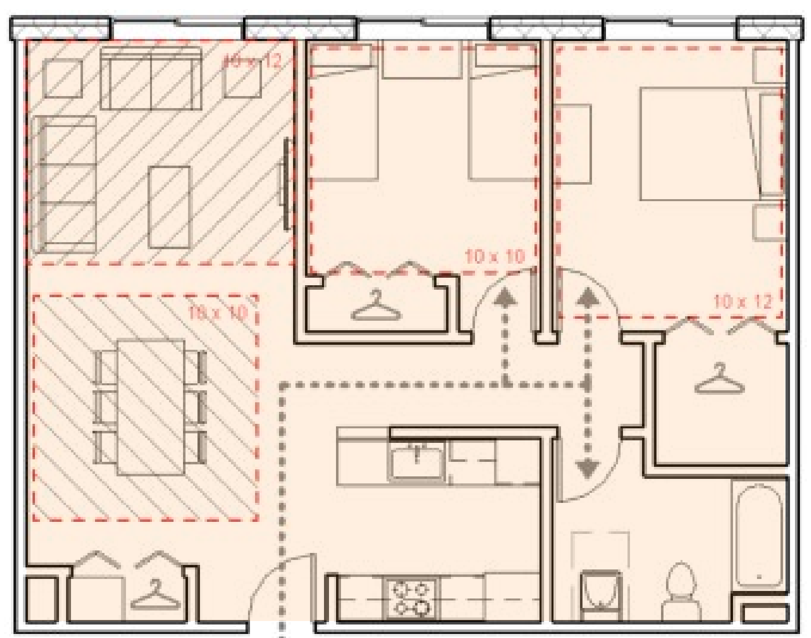
2 bedroom | corner unit



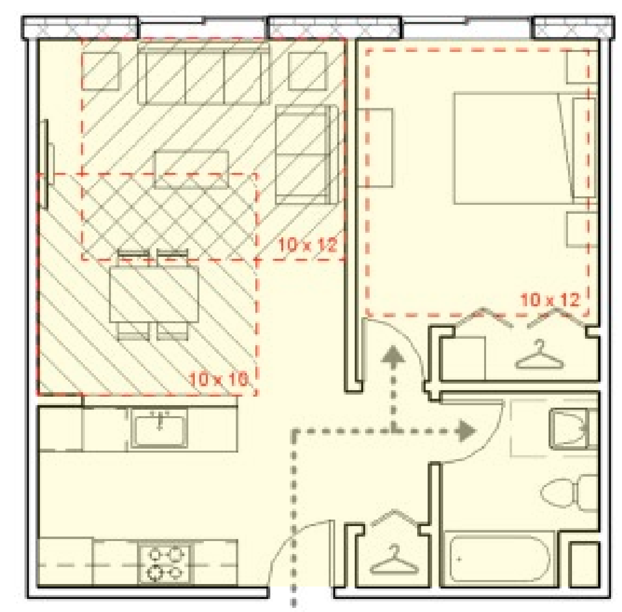
1 bedroom | corner unit



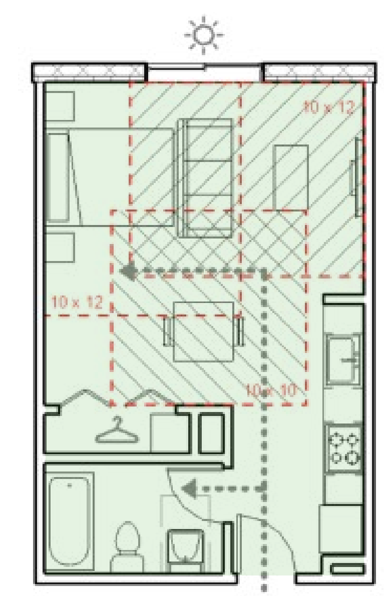
studio | typical unit



2 bedroom | typical unit



1 bedroom | typical unit



studio | typical unit

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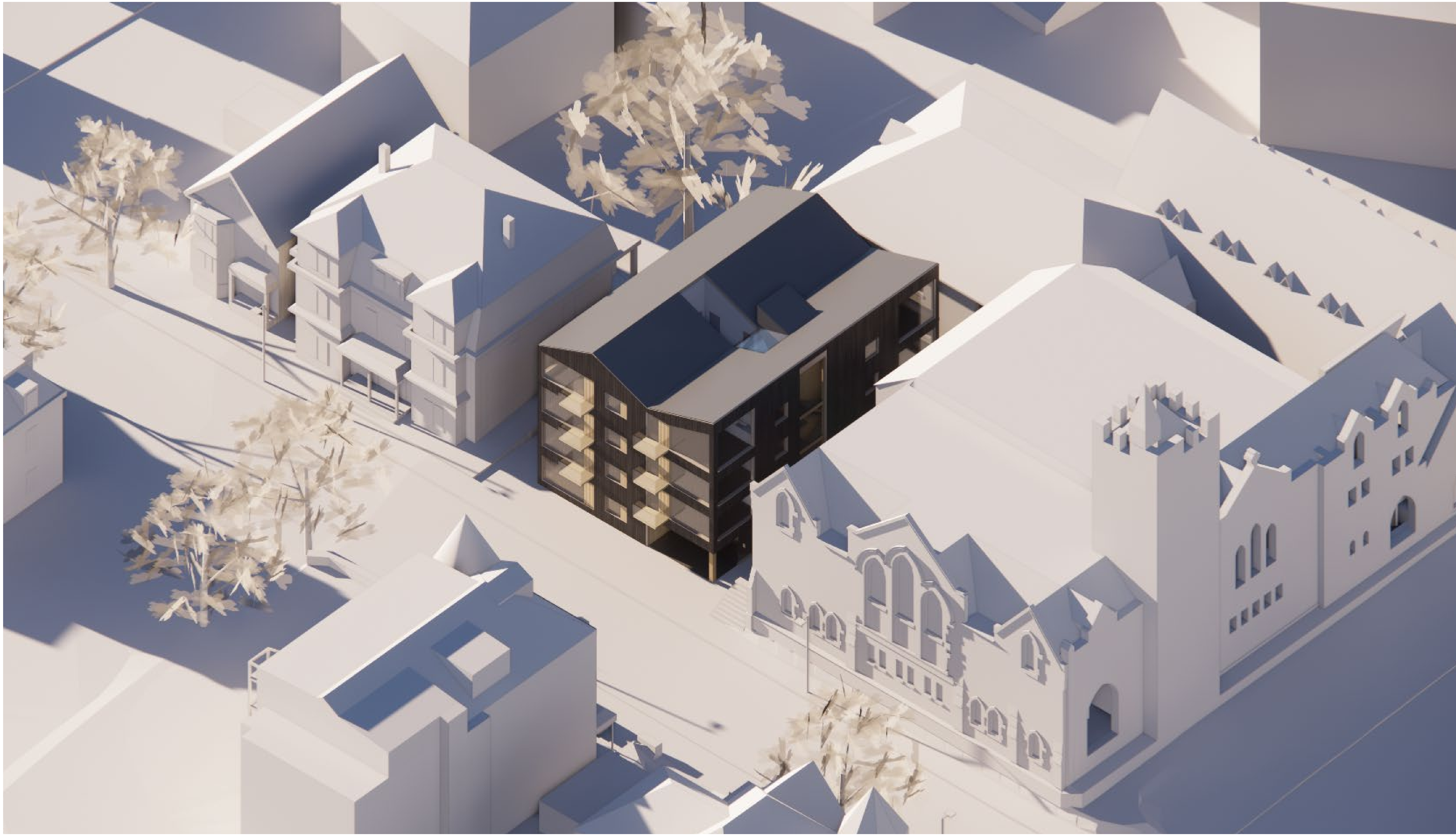
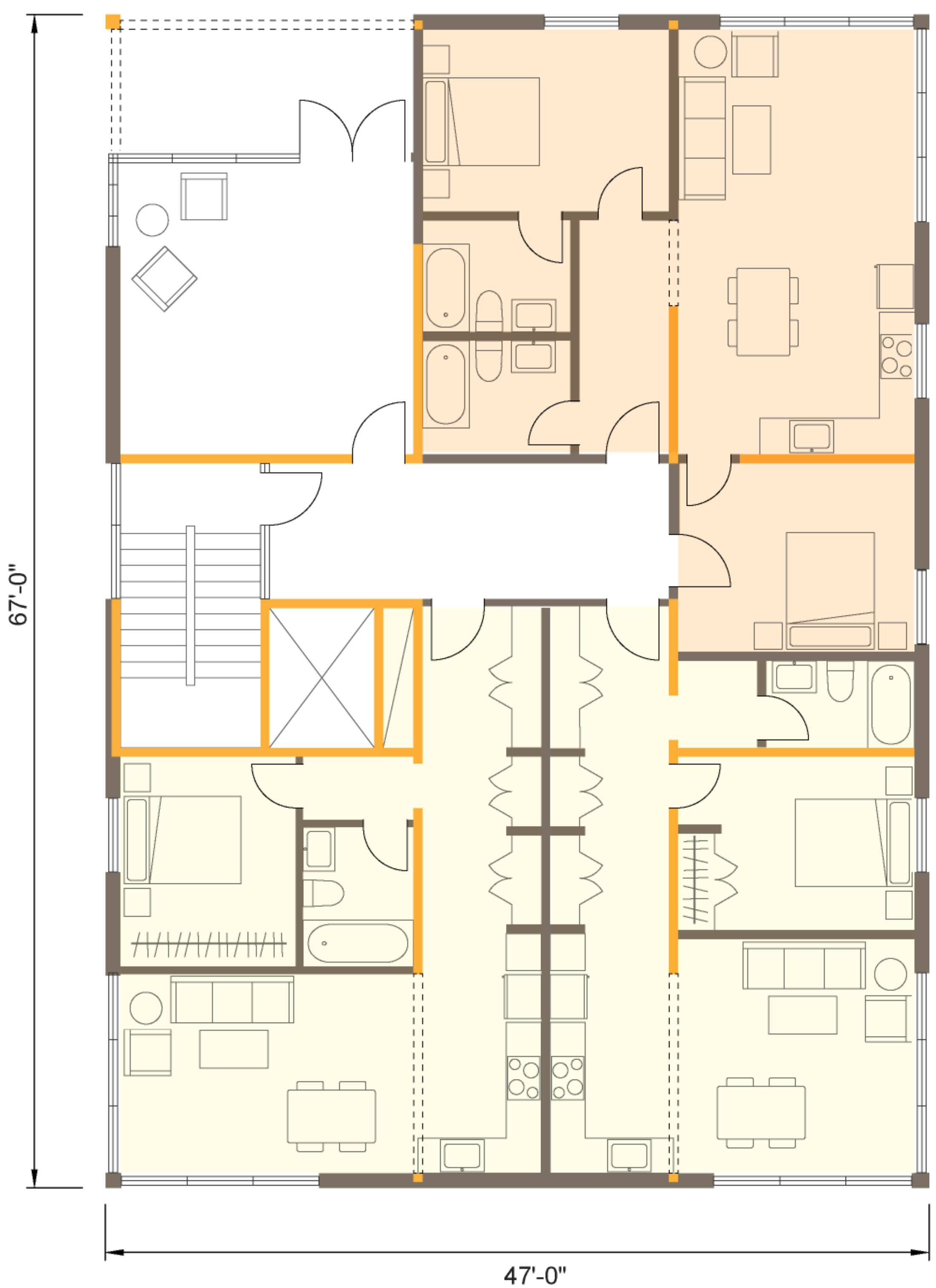
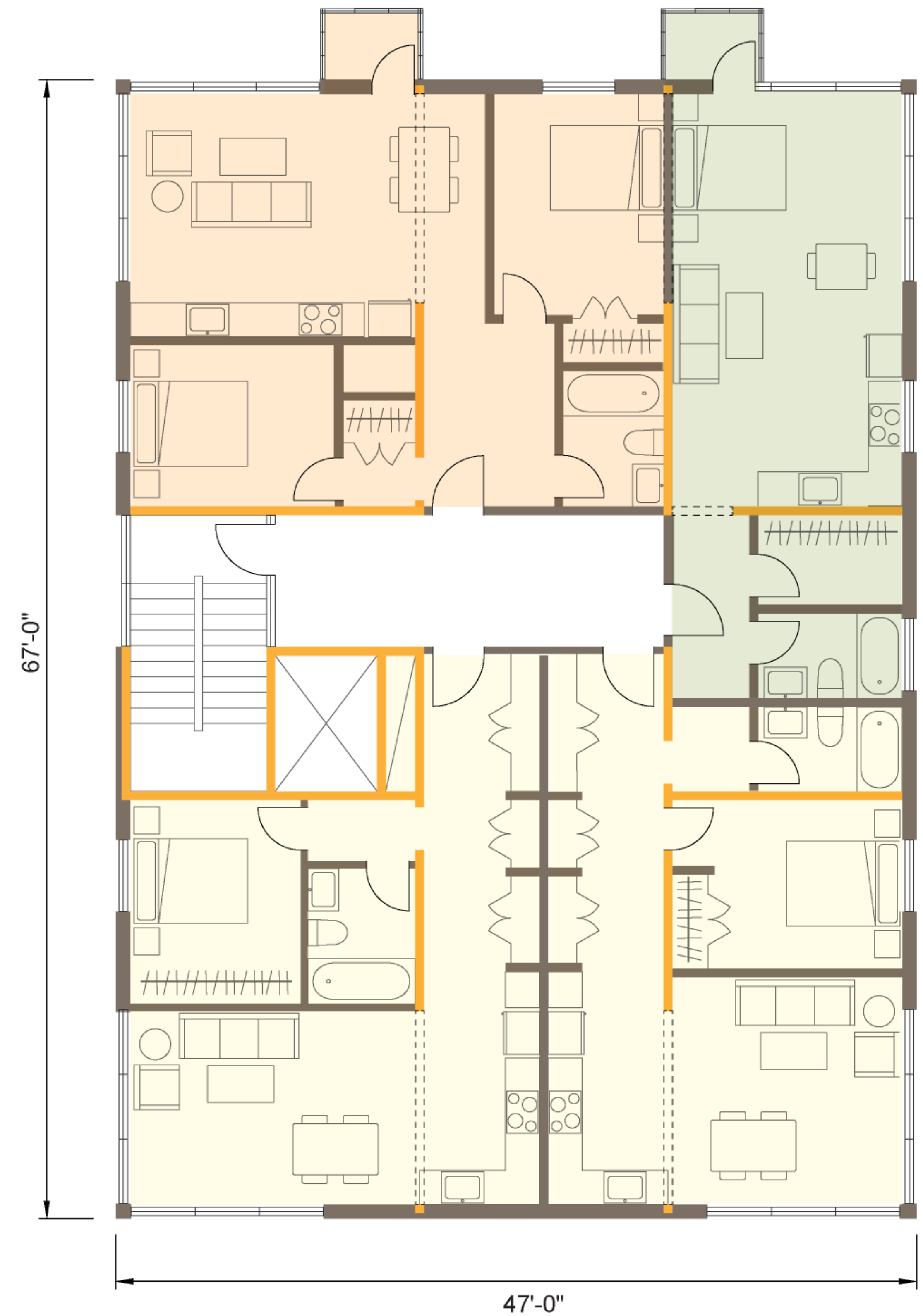
EXTERIOR BIRDSEYE VIEW



FLOOR PLANS showing unit layouts



Ground Floor



Typical Upper Floor

- circulation
- studio
- 1-bedroom
- 2-bedroom

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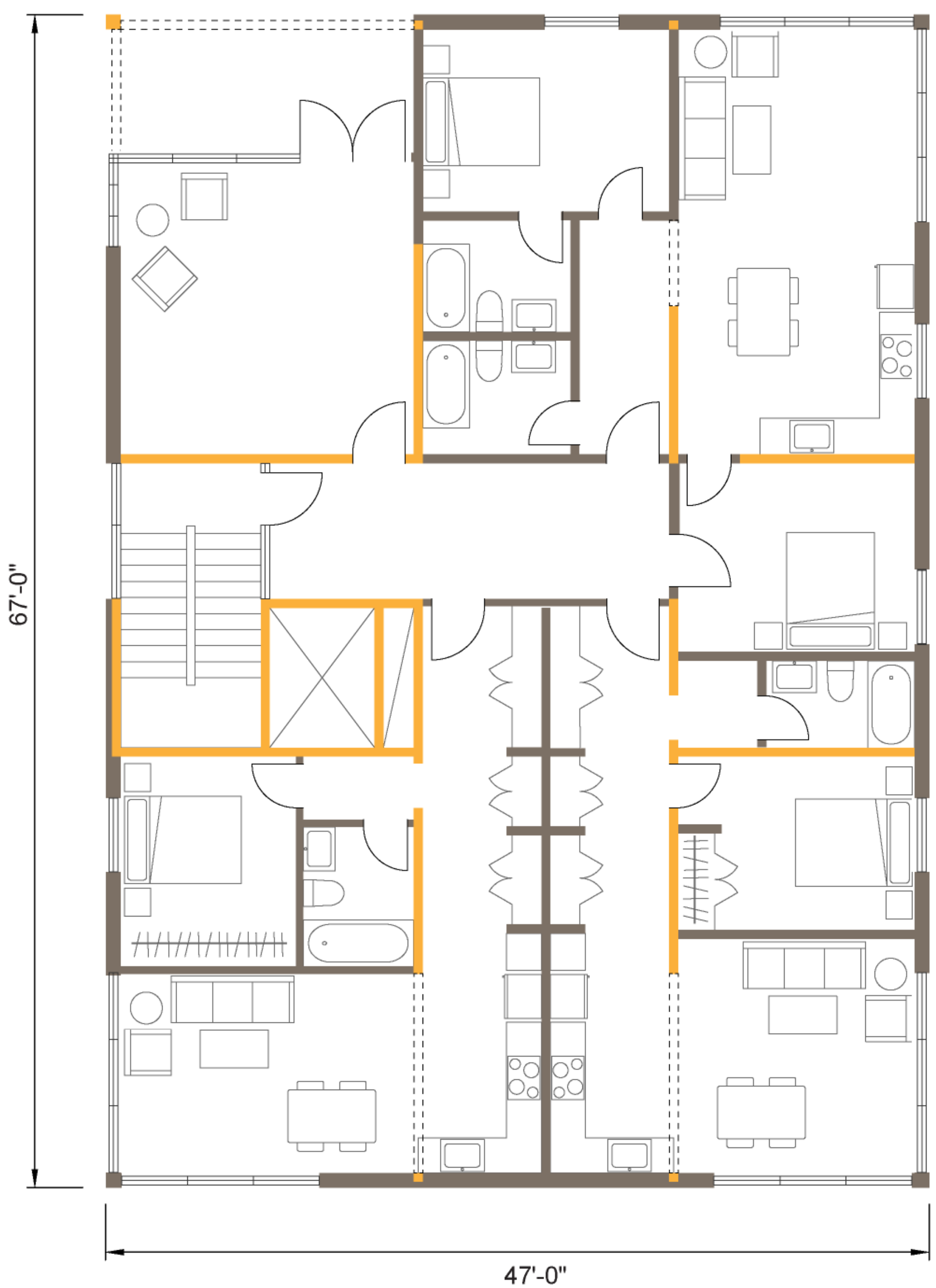
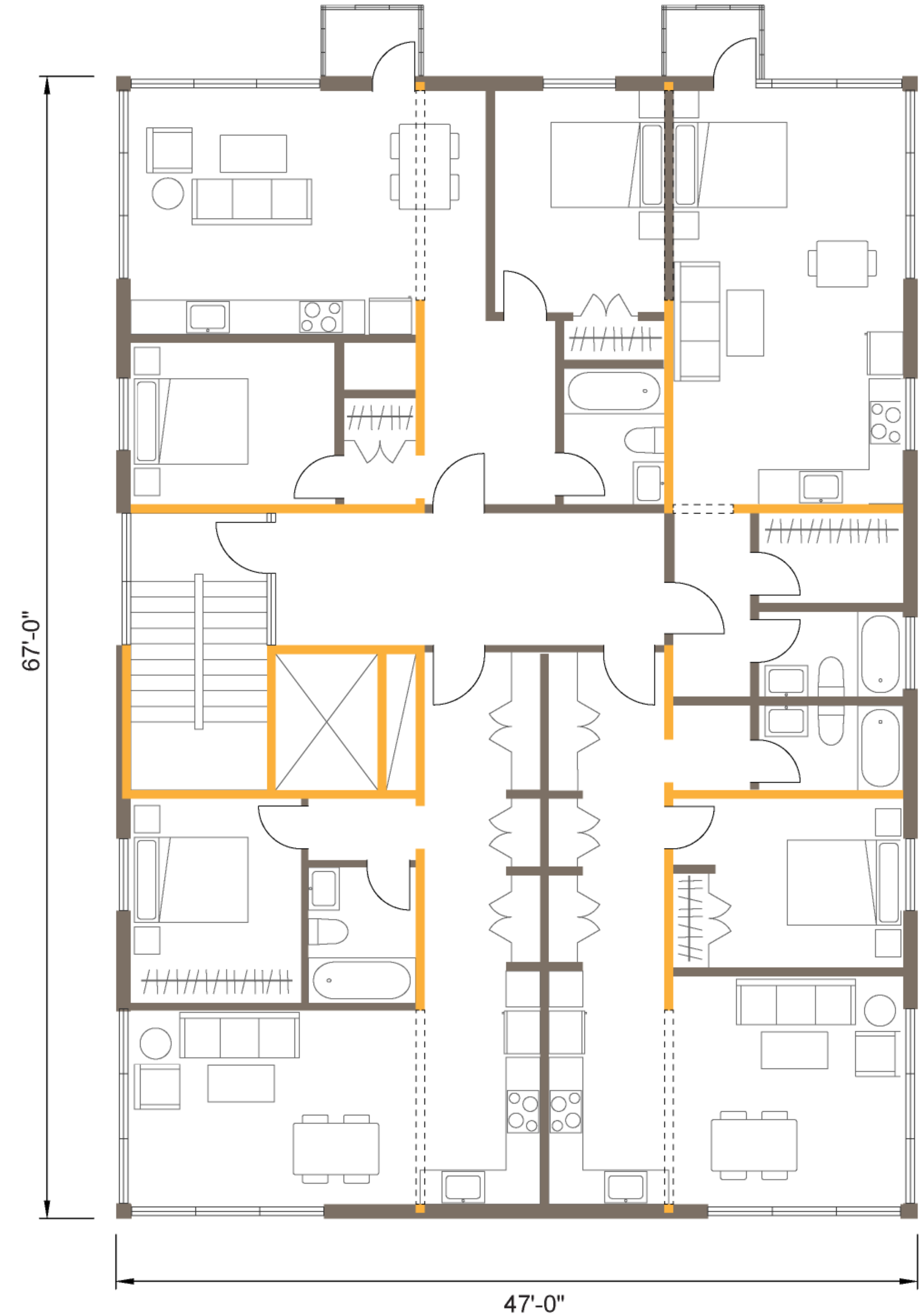
FLOOR PLANS showing shear wall locations



Ground Floor



Typical Upper Floor

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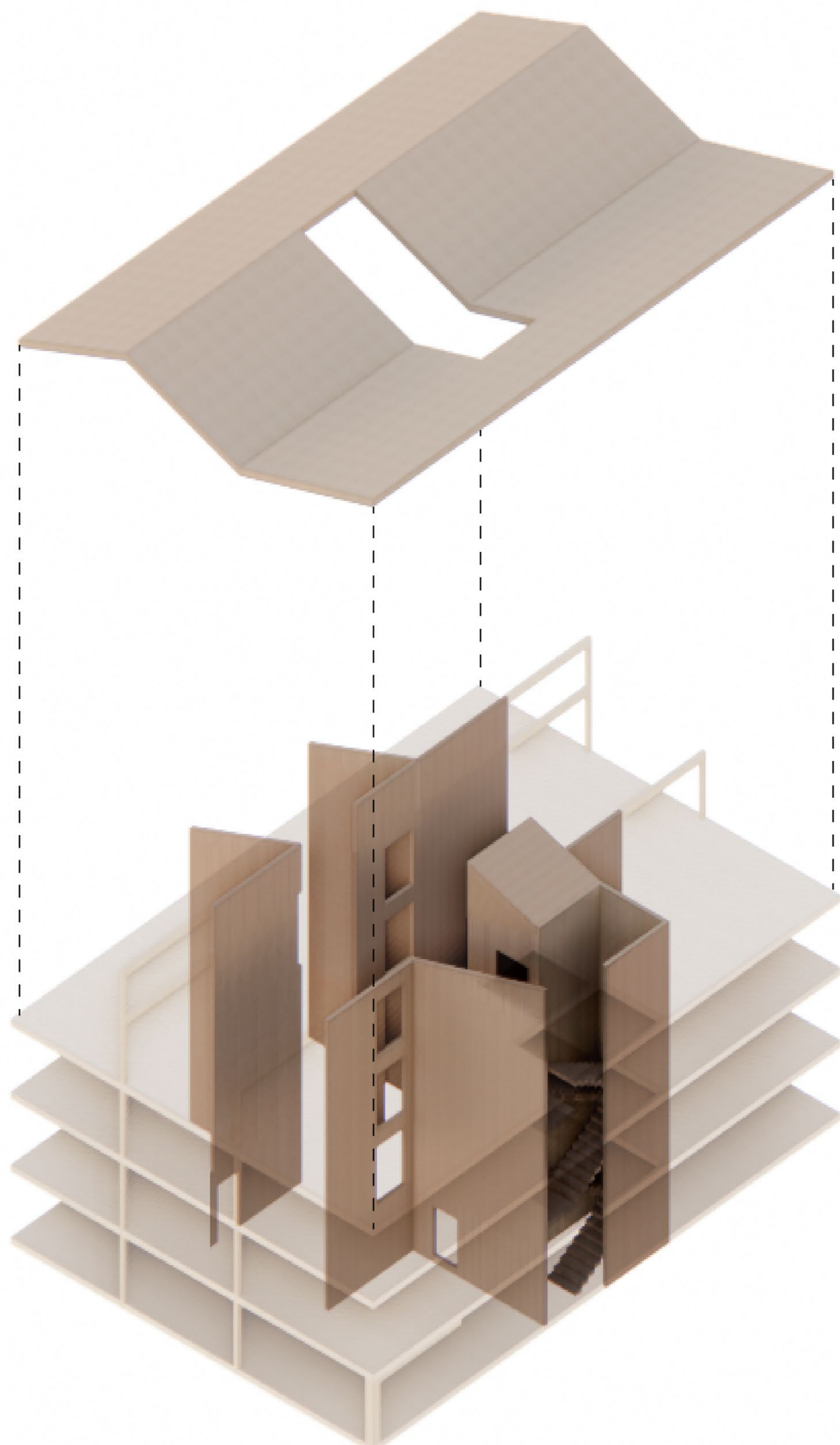
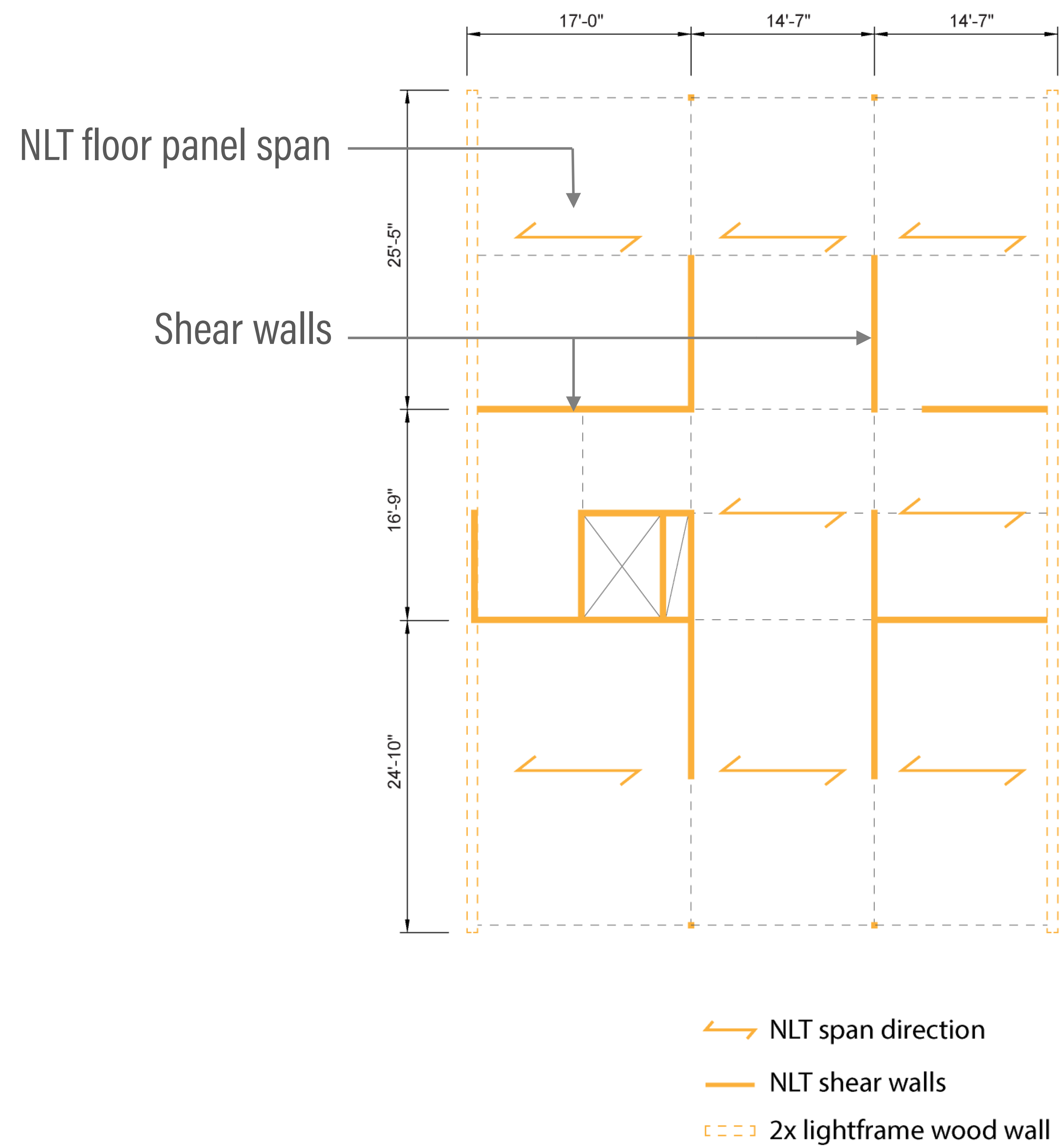
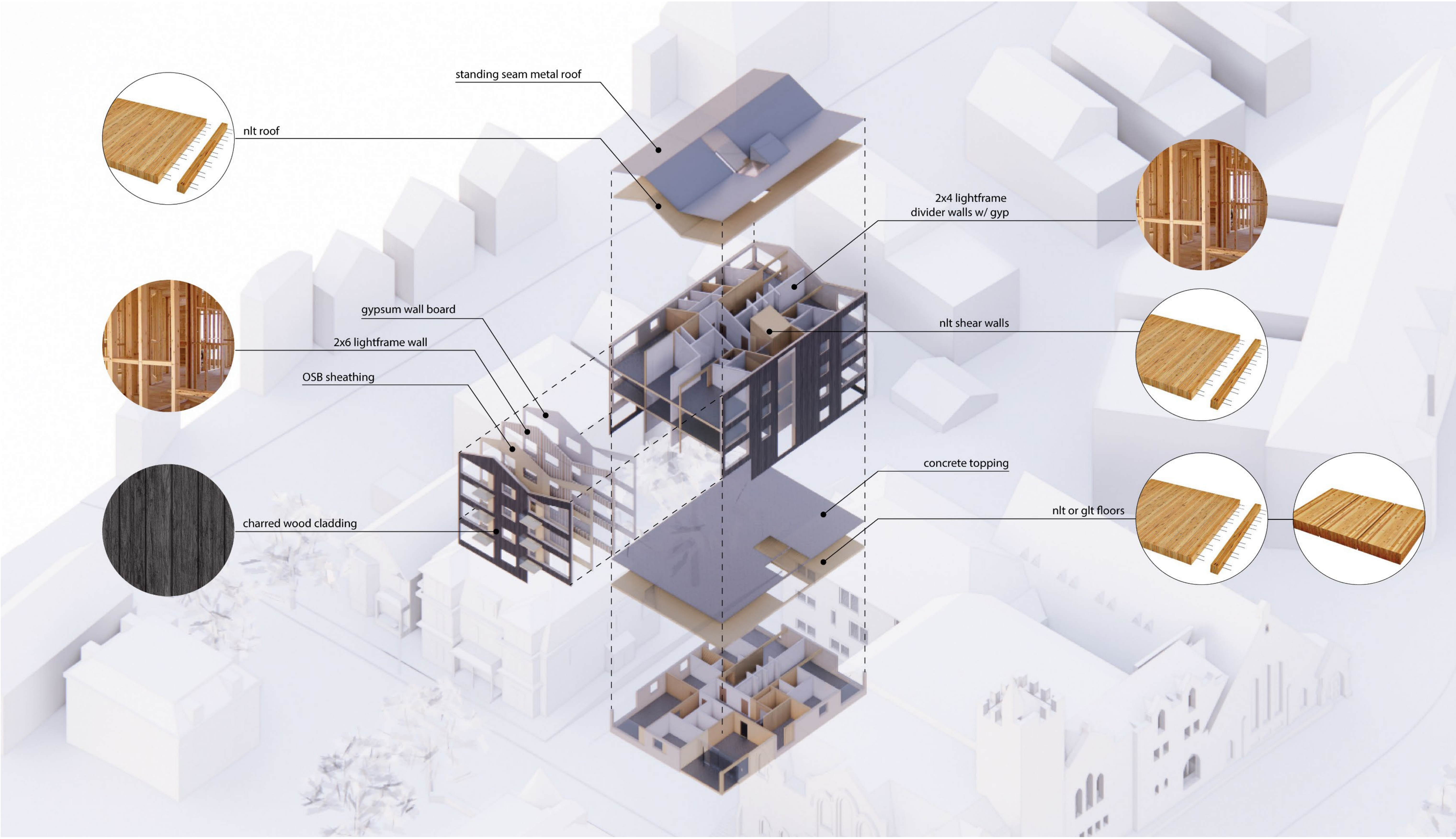
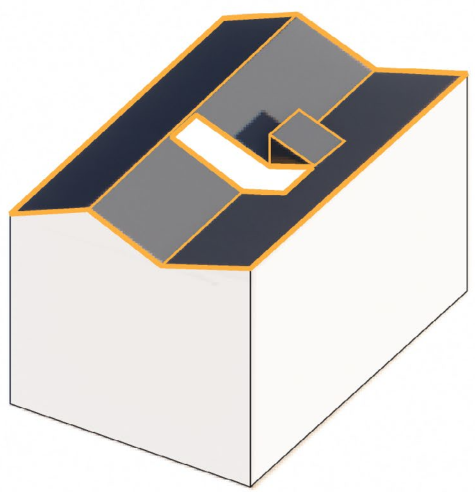
STRUCTURAL AXONOMETRIC showing shear walls, core & floors



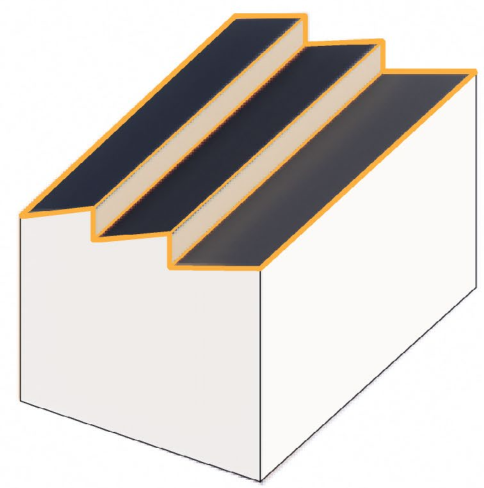



standing seam metal roof
nlt roof
2x4 lightframe
divider walls w/ gyp
gypsum wall board
2x6 lightframe wall
nlt shear walls
OSB sheathing
concrete topping
nlt or glt floors
charred wood cladding

ROOF & ELEVATION PROTOTYPES showing several roof and window configurations that can be combined to meet small urban lot contexts and constraints

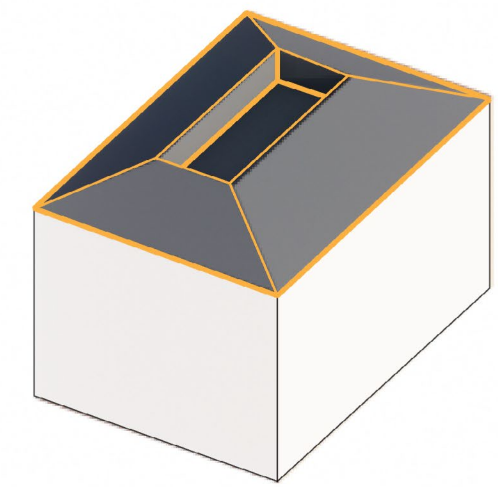


GABLE + PITCH



SAWTOOTH

HIP



SUNKEN HIP

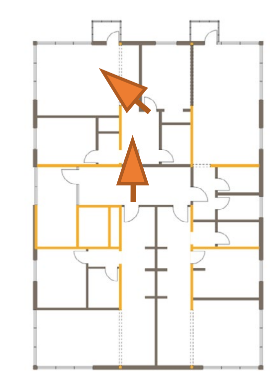
BASE - TYPICAL

LARGE CORNER WINDOWS

CURTAINWALL

STAGGERED

2-BD UNIT ENTRY & LIVING AREA



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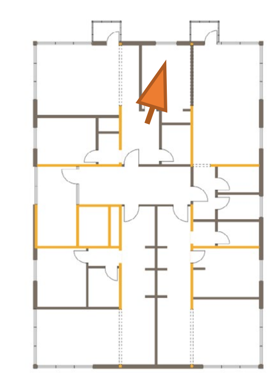
2-BD UNIT BEDROOM



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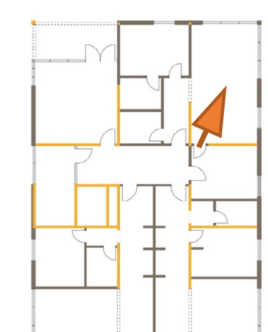
2-BD UNIT GROUND FLOOR LIVING AREA



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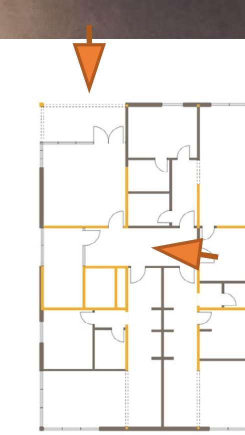
GROUND FLOOR ENTRY & STAIR/ELEVATOR LOBBY



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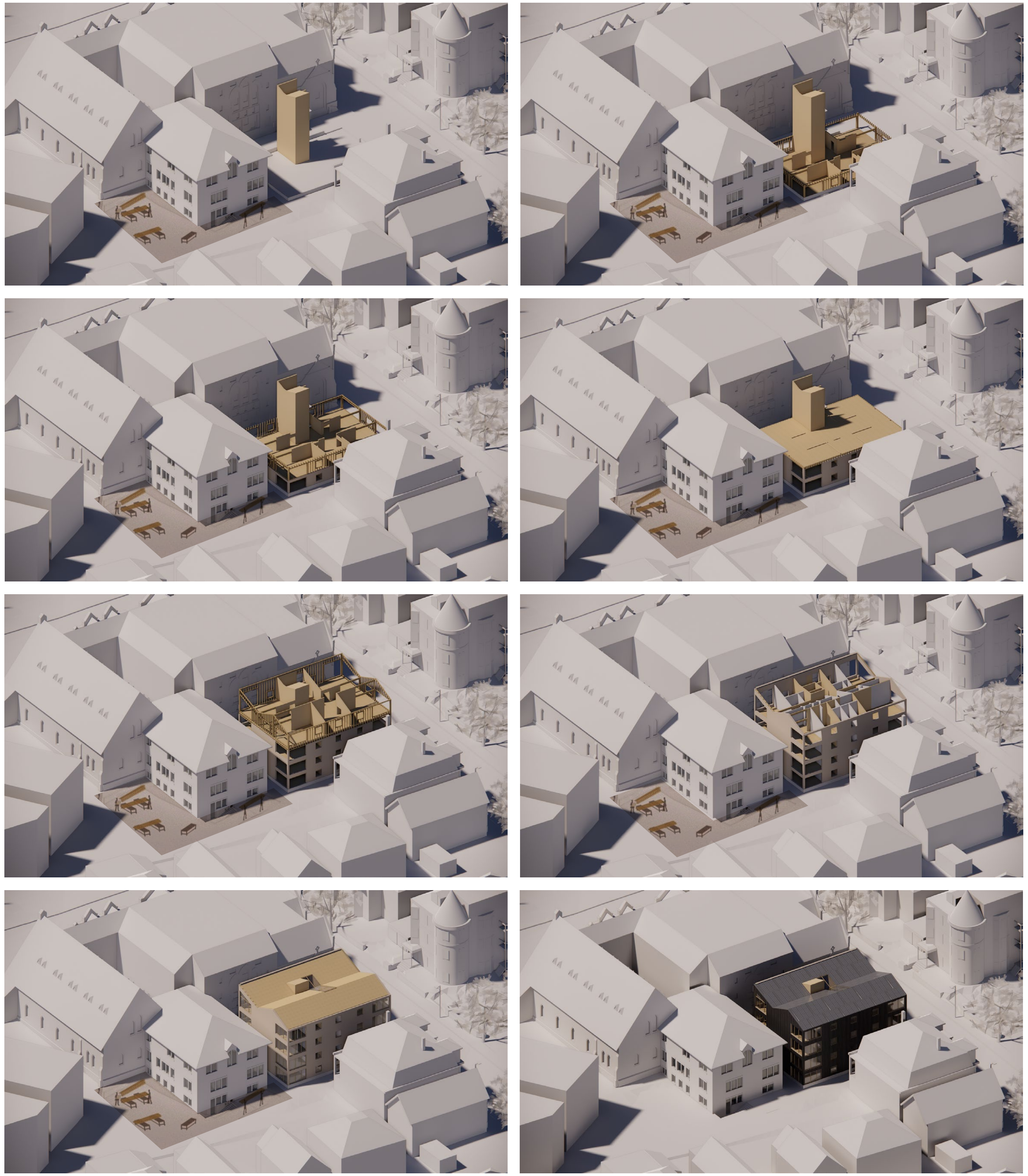
CONSTRUCTION SEQUENCING showing NLT workstation setup

GIF STILLS



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1 of 7

Construction Type

WoodWorks WOOD PRODUCTS COUNCIL

Construction type:	Combination
Displacement factor for structural elements except mass timber:	3.9
Displacement factor for mass timber:	0.71

Compared with other functionally equivalent buildings made of non-wood materials, wood-frame buildings typically generate less embodied GHG emissions during their life cycle. In other words, there are fewer GHG emissions associated with a wood-frame building than other building types. This difference can be quite large and can be taken as a carbon credit for the amount of CO_2 emissions that were avoided (displaced) by choosing wood over other more GHG-intensive materials.

Reference

Light-frame Low-rise or mid-rise	3.9
Post and beam Low-rise or mid-rise	3.9
Mass timber Low-rise, mid-rise or high-rise	0.71
Combination Mass timber/light-frame/post and beam	

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Lumber

bf board feet
lf linear feet
ft³ cubic feet
m³ cubic meters

WoodWorks WOOD PRODUCTS COUNCIL

Lumber

	Unit	Quantity	m³
2x4 (nominal)	bf	5515	8.5
2x6 (nominal)	bf	8384	13.6
2x8 (nominal)	lf	0	0
2x10 (nominal)	bf	0	0
3x3 (nominal)	lf	0	0
4x4 (nominal)	lf	0	0
3x6 (nominal)	lf	0	0
4x6 (nominal)	lf	0	0
Unknown or varied (actual dimensions)	ft³	0	0
Total volume of dimensional lumber			22.1

Lumber Species

	% Total Volume
Spruce-pine-fir	100
Douglas-fir-larch	0
Hemlock-fir	0
Cedar	0
Southern pine	0
Unknown	0

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Mass Timber

ft³ cubic feet
m³ cubic meters

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Structural Composite Lumber

	Unit	Quantity	m³
LVL	ft³	0	0
LSL	ft³	0	0
OSL	ft³	0	0
PSL	ft³	0	0

Structural Laminated Timber

	Unit	Quantity	m³
Glulam	ft³	0	0
NLT	ft³	8097	229.3
CLT	ft³	0	0
Total volume of mass timber products			229.3

Structural Laminated Timber Species

	% Total Volume
Glulam	
Douglas-fir-larch	0
Hemlock-fir	0
Southern pine	0
Spruce-pine	100
Unknown	0
Total (must equal 100%)	100%
NLT	
CLT	

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Panels

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OSB

Thickness in Inches	Unit	Quantity	m³
1/4	ft²	0	0
5/16	ft²	0	0
3/8	ft²	0	0
7/16	ft²	0	0
1/2	ft²	8892	10.5
5/8	ft²	0	0
3/4	ft²	0	0
1 1/8	ft²	0	0
Unknown	ft²	0	0

Plywood

Thickness in Inches	Unit	Quantity	m³
1/4	ft²	0	0
5/16	ft²	0	0
3/8	ft²	0	0
7/16	ft²	0	0
1/2	ft²	0	0
5/8	ft²	0	0
3/4	ft²	17769	31.4
1 1/8	ft²	0	0
Unknown	ft²	0	0

OSB & Plywood by Volume

	Unit	Quantity	m³
OSB	ft³	0	0
Plywood	ft³	0	0
Total volume of panels & sheathing			41.9

Plywood Species

	% Total Volume
Softwood (APA Groups 2-5)	100
Douglas-fir-larch (APA Group 1)	0
Unknown	0
Total (must equal 100%)	100%

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Engineered Wood Products

WoodWorks WOOD PRODUCTS COUNCIL

Engineered I-joist

	Unit	Quantity	m³
I-joist	lf	0	0

Structural Composite Lumber

	Unit	Quantity	m³
LVL	ft³	0	0
LSL	ft³	0	0
OSL	ft³	0	0
PSL	ft³	0	0

Structural Laminated Timber

	Unit	Quantity	m³
Glulam	ft³	300	8.5
Total volume of engineered wood products			8.5

Glulam Species

	% Total Volume
Douglas-fir-larch	0
Hemlock-fir	0
Southern pine	0
Spruce-pine	100
Unknown	0
Total (must equal 100%)	100%

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Decks & Siding

WoodWorks WOOD PRODUCTS COUNCIL

Decking

Thickness in Inches	Unit	Quantity	m³
1	ft²	0	0
1 1/4	ft²	0	0
1 1/2	ft²	0	0
2	ft²	0	0
2 1/2	ft²	0	0
3 1/2	ft²	0	0
Unknown	ft²	0	0
Total volume of decking			0

Decking Species

	% Total Volume
Spruce-pine-fir	100

Siding & Roofing

Thickness in Inches	Unit	Quantity	m³
1/2	ft²	8892	10.5
5/8	ft²	0	0
11/16	ft²	0	0
3/4	ft²	0	0
7/8	ft²	0	0
1	ft²	0	0
1 1/4	ft²	0	0
2	ft²	0	0
Unknown	ft²	0	0
Total volume of siding & roofing			10.5

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Carbon Summary

Results

Volume of wood products used (m³):
312 m³ (11030 ft³) of lumber and sheathing

U.S. and Canadians forests grow this much wood in:
1 minutes

Carbon stored in the wood:
259 metric tons of CO_2

Avoided greenhouse gas emissions:
204 metric tons of CO_2

Total potential carbon benefit:
462 metric tons of CO_2

Equivalent to:

98 cars off the road for a year

Energy to operate **49** homes for a year

NLT + Light-frame

Construction Type

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Construction type:	Light-frame
Displacement factor:	3.9

Compared with other functionally equivalent buildings made of non-wood materials, wood-frame buildings typically generate less embodied GHG emissions during their life cycle. In other words, there are fewer GHG emissions associated with a wood-frame building than other building types. This difference can be quite large and can be taken as a carbon credit for the amount of CO_2 emissions that were avoided (displaced) by choosing wood over other more GHG-intensive materials.

Reference

Light-frame Low-rise or mid-rise	3.9
Post and beam Low-rise or mid-rise	3.9
Mass timber Low-rise, mid-rise or high-rise	0.71
Combination Mass timber/light-frame/post and beam	

Lumber

bf board feet
lf linear feet
ft³ cubic feet
m³ cubic meters

WoodWorks™ WOOD PRODUCTS COUNCIL

Lumber

	Unit	Quantity	m³
2x4 (nominal)	bf	8491	13.1
2x6 (nominal)	bf	8384	13.6
2x8 (nominal)	lf	0	0
2x10 (nominal)	bf	5346	8.7
3x3 (nominal)	lf	0	0
4x4 (nominal)	lf	0	0
3x6 (nominal)	lf	0	0
4x6 (nominal)	lf	0	0
Unknown or varied (actual dimensions)	ft³	0	0
Total volume of dimensional lumber			35.4

Lumber Species

	% Total Volume
Spruce-pine-fir	100
Douglas-fir-larch	0
Hemlock-fir	0
Cedar	0
Southern pine	0
Unknown	0

Panels

WoodWorks™ WOOD PRODUCTS COUNCIL

OSB

Thickness in Inches

	Unit	Quantity	m³
1/4	ft²	0	0
5/16	ft²	0	0
3/8	ft²	0	0
7/16	ft²	0	0
1/2	ft²	13842	16.3
5/8	ft²	0	0
3/4	ft²	0	0
1 1/8	ft²	0	0
Unknown	ft²	0	0

Plywood

Thickness in Inches

	Unit	Quantity	m³
1/4	ft²	0	0
5/16	ft²	0	0
3/8	ft²	0	0
7/16	ft²	0	0
1/2	ft²	0	0
5/8	ft²	0	0
3/4	ft²	12819	22.7
1 1/8	ft²	0	0
Unknown	ft²	0	0

OSB & Plywood by Volume

	Unit	Quantity	m³
OSB	ft³	0	0
Plywood	ft³	0	0
Total volume of panels & sheathing			39

Plywood Species

	% Total Volume
Softwood (APA Groups 2-5)	100
Douglas-fir-larch (APA Group 1)	0
Unknown	0
Total (must equal 100%)	100%

Engineered Wood Products

WoodWorks™ WOOD PRODUCTS COUNCIL

Engineered I-joist

	Unit	Quantity	m³
I-joist	lf	7050	22.6

Structural Composite Lumber

	Unit	Quantity	m³
LVL	ft³	0	0
LSL	ft³	0	0
OSL	ft³	0	0
PSL	ft³	0	0

Structural Laminated Timber

	Unit	Quantity	m³
Glulam	ft³	0	0
Total volume of engineered wood products			22.6

Glulam Species

	% Total Volume
Douglas-fir-larch	0
Hemlock-fir	0
Southern pine	0
Spruce-pine	100
Unknown	0
Total (must equal 100%)	100%

Decks & Siding

WoodWorks™ WOOD PRODUCTS COUNCIL

Decking

Thickness in Inches

	Unit	Quantity	m³
1	ft²	0	0
1 1/4	ft²	0	0
1 1/2	ft²	0	0
2	ft²	0	0
2 1/2	ft²	0	0
3 1/2	ft²	0	0
Unknown	ft²	0	0
Total volume of decking			0

Decking Species

	% Total Volume
Spruce-pine-fir	100
Cedar	0
Southern pine	0
Redwood	0
Ipe	0
Unknown	0
Total (must equal 100%)	100%

Siding & Roofing

Thickness in Inches

	Unit	Quantity	m³
1/2	ft²	8892	10.5
5/8	ft²	0	0
11/16	ft²	0	0
3/4	ft²	0	0
7/8	ft²	0	0
1	ft²	0	0
1 1/4	ft²	0	0
2	ft²	0	0
Unknown	ft²	0	0
Total volume of siding & roofing			10.5

Carbon Summary

Results

Volume of wood products used (m³):
108 m³ (3800 ft³) of lumber and sheathing

U.S. and Canadians forests grow this much wood in:
18 seconds

Carbon stored in the wood:
93 metric tons of CO_2

Avoided greenhouse gas emissions:
184 metric tons of CO_2

Total potential carbon benefit:
277 metric tons of CO_2

Equivalent to:

59 cars off the road for a year

Energy to operate **29** homes for a year

Light-frame only

TOTAL BF of Lumber				
	COMBINATION NLT + LIGHT FRAME		100% LIGHT FRAME	
INTERIOR WALLS	COMBINATION	25315	8491	light frame
EXTERIOR WALLS	2X	9633	8384	light frame
ROOF	NLT	20234.00	5346	2x10
FLOORS	NLT	55613.38	12561	I joist/ 2x10
TOTAL (BF)		**110795**	**34782**	

TOTAL NLT Volume		
INTERIOR WALLS	1650	ft3
EXTERIOR WALLS	126	ft3
ROOF	1686	ft3
FLOORS	4634	ft3
TOTAL:	**8097**	**ft3**

Total Panels				
Floors and Roof	3/4" Plywood			
Floor dims:	67			
	47			
Area per floor	3149 sf			
Total floor area	9447 sf			
Roof area	3372 sf			
Total Area	**12819 sf**			
Exterior Walls	1/2" OSB			
Wall	length	height	Area	
North	47	39	1833	sf
South	47	39	1833	sf
East	67	36	2412	sf
West	67	42	2814	sf
Total Area			**8892**	**sf**
NLT Shear Walls	3/4" Plywood			
Floor	Area			
1	1035			
2	1174.5			
3	1174.5			
4	1566			
Total Area:	**4950 sf**			

EXTERIOR WALLS

2X6 EXTERIOR WALLS
AT 16" STUD SPACING

	FLOOR 1	FLOOR 2	FLOOR 3	FLOOR 4	SUM	
North						
LENGTH	47	47	47	47		
HEIGHT	9	9	9	12		
BF	414	414	414	499		
South						
LENGTH	47	47	47	47		
HEIGHT	9	9	9	12		
BF	414	414	414	499		
West						
LENGTH	67	67	67	67		
HEIGHT	9	9	9	15		
BF	583	583	583	821		
East						
LENGTH	67	67	67	67	551	
HEIGHT	9	9	9	9		
BF	583	583	583	583		
Total BF	1994	1994	1994	2402	**8384**	**bf**
area of ext NLT wall						
length	9		9			
height	9	109	15	154	**263**	**bf**

NLT EXTERIOR WALLS

	FLOOR 1	FLOOR 2	FLOOR 3	FLOOR 4	SUM	X12 = BF
North						
LENGTH	47	47	47	47		
HEIGHT	0	0	0	0		
THICKNESS	0.333333	0.333333	0.333333	0.333333		
VOLUME FT3	0	0	0	0	0	
South						
LENGTH	47	47	47	47		
HEIGHT	0	0	0	0		
THICKNESS	0.333333	0.333333	0.333333	0.333333		
VOLUME FT3	0	0	0	0	0	
West						
LENGTH	9	9	9	9		
HEIGHT	9	9	9	15		
THICKNESS	0.333333	0.333333	0.333333	0.333333		
VOLUME FT3	27	27	27	45	126	
East						
LENGTH	67	67	67	67		
HEIGHT	0	0	0	0		
THICKNESS	0.333333	0.333333	0.333333	0.333333		
VOLUME FT3	0	0	0	0	0	
TOTAL BF					126	**1512**

FLOORS

NLT FLOORS			I Joists or 2x10		
LENGTH	67	ft		67	ft
WIDTH	47	ft		47	ft
THICKNESS	0.5	2x6	16" SPACING		
VOLUME	1574.5	ft3		804	in
ELEVATOR SHAFT				50.25	ft
LENGTH	6.92			2361.75	LF per floor
WIDTH	8.58		**TOTAL:**	**7085.25**	**LF**
THICKNESS	0.5				
VOLUME	29.68	ft3			
VOL PER FLOOR	1544.82	ft3			
VOL TOTAL	**4634.45**	**ft3**			
BF PER FLOOR	18537.79		per floor =	4187	
TOTAL (X3)	**55613.38**	**bf**		**12561**	**bf**

ROOF

	NLT ROOF				2X10 ROOF		
	1 PANEL	2 PANEL	3 PANEL				
WIDTH	16.167	16.75	17.417		AVG WIDTH	16.75	
LENGTH	67	67	67			67	
THICKNESS	0.5	0.5	0.5	2x6	18" SPACING		
VOL	541.58	561.13	583.46				
VOL Total **ft3**	**1686 ft3**						
BF	6499	6733.5	7001.5				
					each plane	1782	
TOTAL BF	**20234 bf**					**5346**	**bf**

INTERIOR WALLS

		NLT INTERIOR WALLS		2X4 INTERIOR WALLS		BF : COMBINATION	BF : 100% 2X WALLS
		FT	IN	FT	IN		
		15	6	9	6		
		8	7	5	5		
		8	7	15	6		
		19		31	4		
		15	6	15	5		
		10	5	14	5		
		19		5	5		
		14	5	14	5		
		9	1	6			
		10	5	9	1		
				11	6		
				9	1		
				13	9		
				7	5		
				14	2		
				14	2		
				15	10		
				10			
				16	4		
subtotal:		127	42 in	232	81		
			3.5 ft		6.75 ft		
LENGTH (1s flr)	115			212.42			327.42
LENGTH (2-4 flrs)		130.5		238.75			369.25
HEIGHT		9					
WIDTH		0.333333333 2x4					
VOLUME (FT3) per floor	345	391.5 at 2,3 flrs					
VOLUME (FT3) Total		**1650.0 ft3**					
BF (1)		4140		1207			1840
BF (2)		4698		1345			2077
BF (3)		4698		1345			2077
BF 4	522	6264		1618			2497
TOTAL (BF)		**19800 bf**		**5515 bf**		**25315 bf**	**8491** bf