INTERNSHIP RESEARCH PROGRAM

Mass Timber

2024

MVE
+RESEARCH

INTRODUCTION

MASTER PLAN

INTRODUCTION

MASTER PLAN

01 Phase 1 Research

- Overview
- Logistics
- Products
- Structure
- Precedents
- Seismic
- Envelope
- Code

02 Phase 2 Analysis

- Context
- Transportation
- Site Plan
- Environmental Analysis

03 Phase 3 Design

- Introduction
- Massing
- Program
- Documentation
- Environmental Design
- Materials
- Views

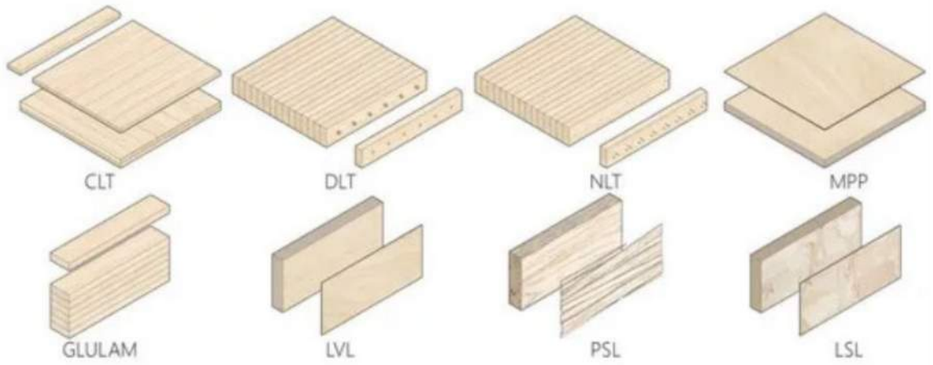
OVERVIEW

MASS TIMBER

Mas Timber is an emerging construction material that is renewable and more sustainable compared to conventional steel and concrete, and opens up more design opportunities for structural innovation and biophilic design.

MASS TIMBER EXAMPLE

TYPES OF MASS TIMBER



Source: mdpi.com

WHY MASS TIMBER?

Renewable Material

50% carbon contained in wood dry mass

Design for Deconstruction

Structural Innovation

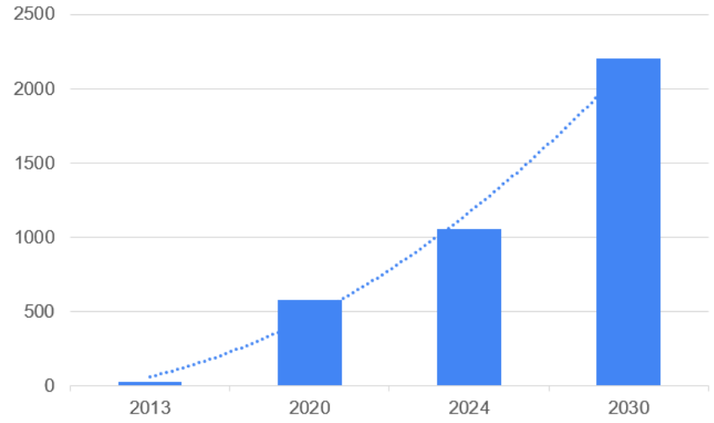
Volvo centre, Gothenberg, Sweden, designed by Henning Larsen - Biophilic Design

OVERVIEW

U.S. MARKET

Mass Timber, especially CLT and Glulam, is a quickly growing construction sector in the U.S., and with the continuing momentum and government support through climate & economy driven policies, the trend is projected to continue for the coming decade.

GROWTH IN U.S. MASS TIMBER



- Mass Timber design is gaining quick momentum as it increased to 26 to about 1000 structures between 20 years.

- Considering the number of buildings that are still in design as of June 2024, in 2030, there will be about 2000 mass timber buildings in the U.S.

GOV. SUPPORT THROUGH POLICY

Community Wood Energy and Wood Innovations

1. Wood Innovations Grant Program
: Each award $300,000, but may consider increasing up to $500,000

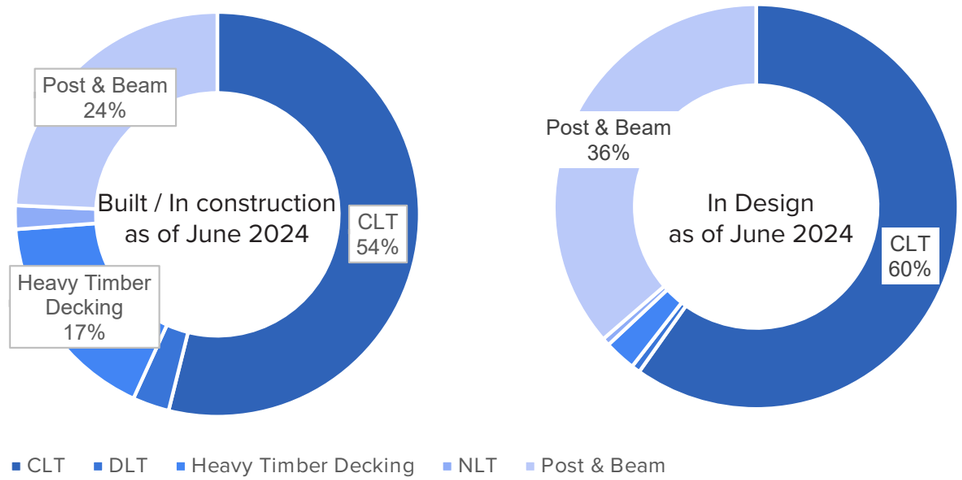
Community Wood Energy and Wood Innovations

2. Community Wood Grant Program
: max of $1 million to pay for up to 35% of total capital costs

3. Mass Timber Federal Buildings Act (April 2024)
:Oregon U.S. Senator Jeff Merkley & U.S. Senator James Risch's bipartisan bill

4. Oregon Mass Timber Coalition wins ***41.4 million grant*** from U.S. Department of Commerce in 2022

MASS TIMBER STRUCTURE TYPE



Post & Beam Construction (Glulam)

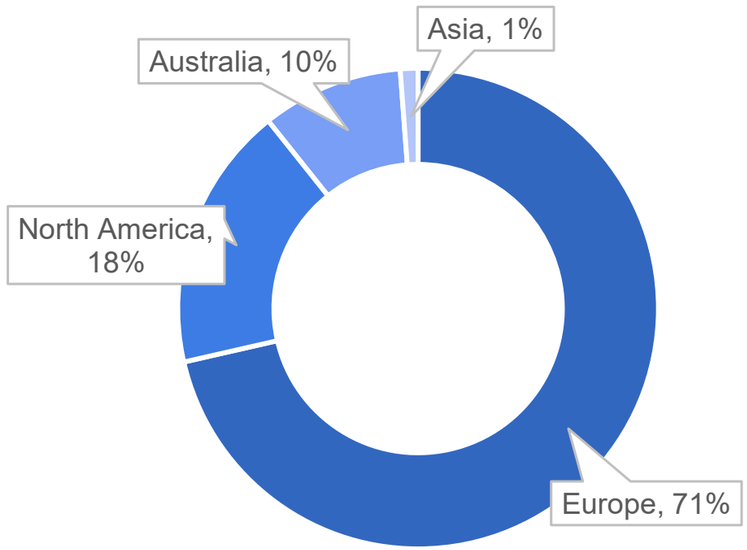
CLT Construction

OVERVIEW

GLOBAL MARKET

Mass timber tower is more advanced and widely built in Europe, and pure mass timber building is more popular compared to the hybrid structures. The trend also indicates mass timber tower design is influencing the residential sector the most.

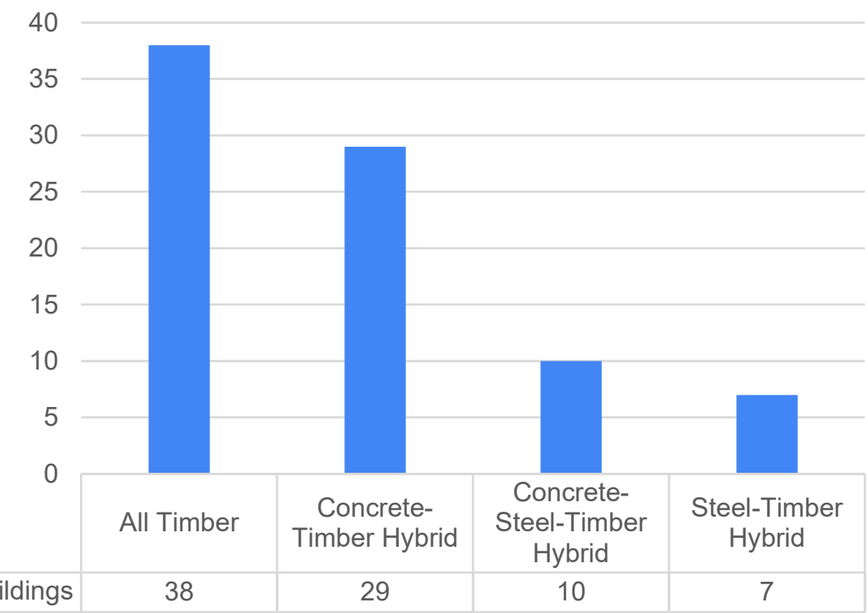
GEOGRAPHICAL DISTRIBUTION OF MASS TIMBER BLDG



Region	# of Buildings
Europe	60
North America	15
Australia	8
Asia	1

GLOBAL TALL MASS TIMBER BLDG BY FUNCTION

STRUCTURAL TYPE



OVERVIEW

EUROPE

Europe continues to be a major force in global mass timber market and is expected to be so until 2031 while New Zealand and Australia continues to play a significant role in the overall market as well.

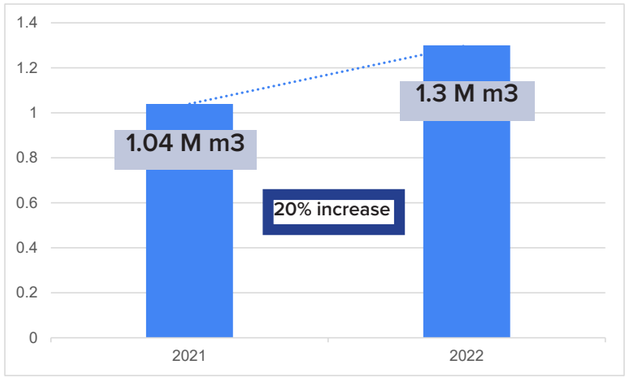
EUROPE IN MASS TIMBER INDUSTRY

1. Europe held the **highest market share** in terms of revenue
2. In 2021, accounting for **more than half** of the global mass timber construction market revenue
3. Likely to dominate the market by **2031**

PRICE COMPARISON

NORTH AMERICA: 20-25 USD per cubic feet
EUROPE: 13-15 USD per cubic feet

CENTRAL EUROPE
(Austria, Germany, Italy, Switzerland and Czechia)



XLam

TOP 8 CLT MANUFACTURERS WORLDWIDE

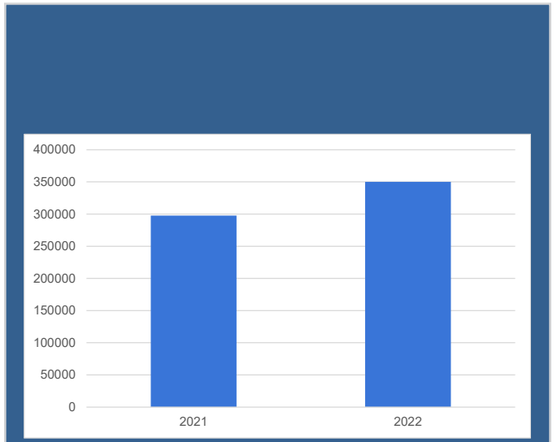
1. KLH Massivholz GmbH (Austria)
2. Binderholz (Austria)
3. Pfeifer
4. Mayr-Melnhof Holz (Austria)
5. Hasslacher (Austria)
6. XLam (Australia & New Zealand)
7. Schilliger Holz (Switzerland)

OVERVIEW

NORTH AMERICA

North America has significantly improved in production capability and also production has increased 15% over a year, but still the overall production is less than a third of Central Europe's mass timber production and the increase in production is not unique to North America.

MASS TIMBER

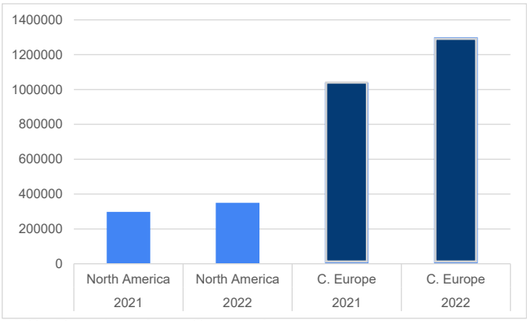


- 15% Increase from 2021 to 2022 (300,000 - 350,000 m3)

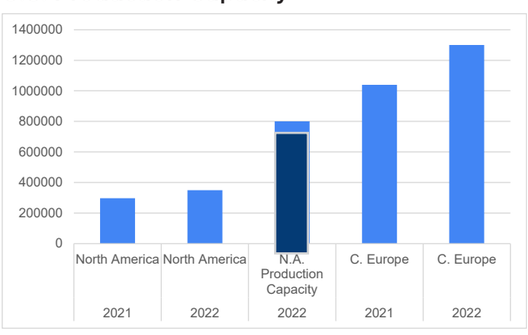
- Significant increase, but the total production is approx. 1/3 of Central Europe's production

- Production Capacity is 800,000, only less than 30% of the Central Europe's production rate.

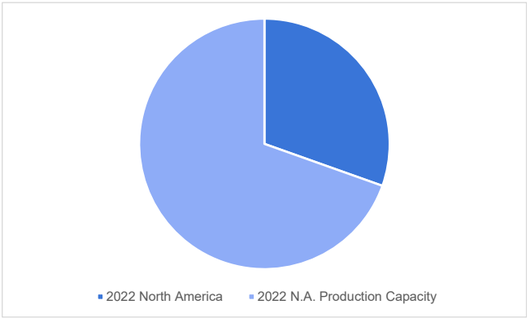
U.S. & Central Europe



U.S. Production Capacity



U.S. Production vs Capacity



OVERVIEW

CALIFORNIA

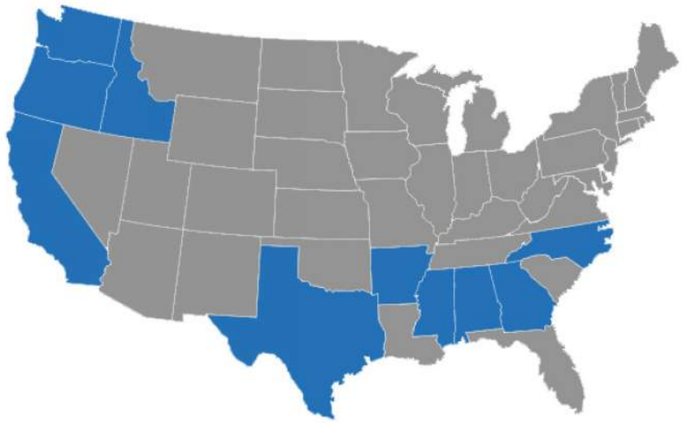
California is one of the biggest lumber producing states, which also includes major softwood species for CLT and Glulam, but the current CLT manufacturers are located outside of California mainly in Oregon and Washington.

OPPORTUNITY IN CALIFORNIA

1. California has four species of tree that meet the minimum of **0.35** specific gravity requirements for CLT production: **Lodgepole pine (0.38), Ponderosa Pine (0.39), Douglas Fir (0.45) & White fir (0.37)**

2. Many of the species used for glulam is harvested in CA: **Douglas fir larch (Douglas fir), Hem-fir (California red fir, white fir), Spruce pine fir (lodgepole pine), Softwood species (Douglas fir, lodgepole pine, ponderosa pine, sugar pine)**

California Forest Aerial



U.S. Top Lumber Producing States

POSSIBLE REUSE OF REDWOOD

1. Rate of Consumption > Rate of Growth	2. Slow growth trees for increased stability
3. 20C aging bldg stocks	4. Naturally durable & Appearance

CHALLENGES IN CALIFORNIA

MERCER mass timber

DR JOHNSON WOOD INNOVATIONS

FRERES ENGINEERED WOOD

Absence of CLT manufacturing plants in CA.

Closest: OR, WA, & AZ

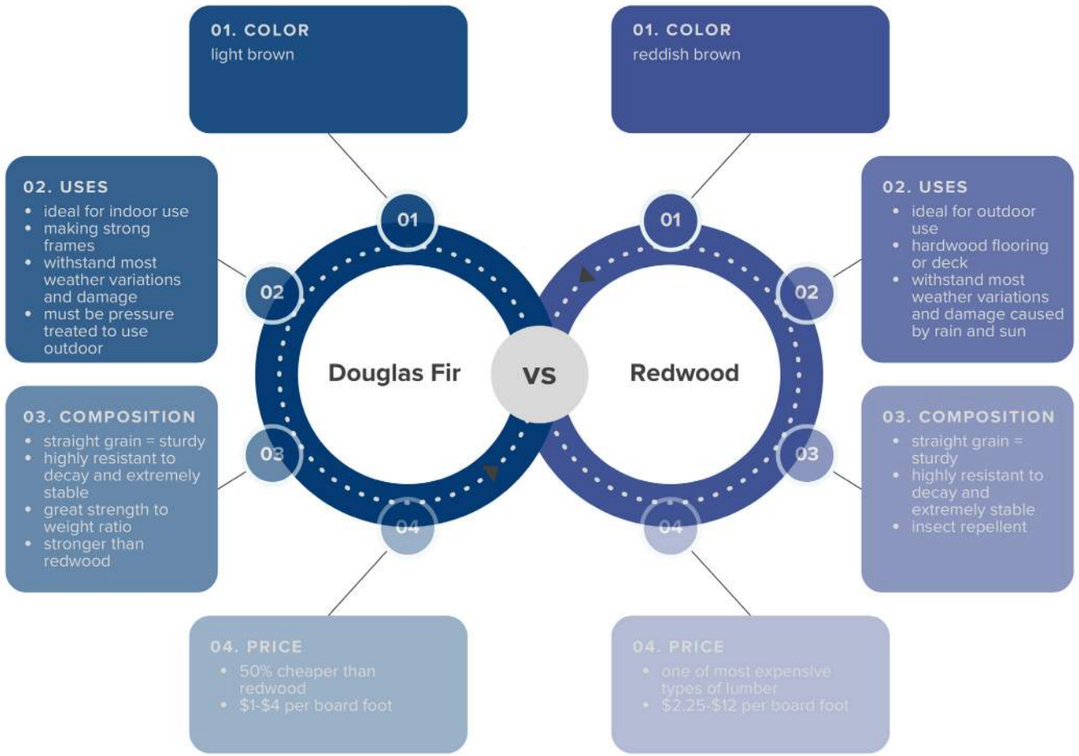
OVERVIEW

WOOD SPECIES

	Modulus of Elasticity (Mpa)	Specific Gravity	Durability	Screw/Nail holding (NLT)	Gluing (CLT)	Notes
Southern Yellow Pine (U.S)	12,100-13,700	0.51-0.59	Slightly	xxxxx	xxxx	• $: Widely available **modest price** • Sust.: Not concerned • Dist.: SE U.S.
Eastern White Pine (U.S)	8,500	0.35	Slightly	xx	xxxx	• $: Widely avail. for construction (**moderate**) • Sust.: Least concerted • Dist.: Eastern North America (also widely grown on plantations throughout its natural range)
Western white Pines (U.S)	57,000-67,000	0.35-0.40	Slightly	xx	xxxx	• $: **Moderate-high** • Sustainability: Not concerned • Dist.: Mountainous regions of **western North America**
Scots Pine (EU)	10,000	0.43	Slightly	N/A	N/A	
Radiata Pine	10,200	N/A	Not Durable	N/A	N/A	
Caribbean Pine	15,400	N/A	Moderately	N/A	N/A	
Hem-Fir (U.S)	10,300-12,100	0.37-0.45	Slightly Durable	xxx-xxxx	xxx-xxxx	• Price: **Moderate** • Sustainability: Not concerned • Location: **Pacific NW**
Douglas Fir (U.S)	10,300-13,400	0.46-0.50	Moderately	xxxx	xxx	• Price: **Modest**, but reclaimed or old growth can be expensive • Sustainability: Not concerned • Dist.: **Western North America**
Douglas Fir (U.K)	10,500	0.44	Slightly	N/A	N/A	
Douglas Fir (EU)	16,800	0.54	Slightly	N/A	N/A	
Western Larch (U.S)	12,900	0.52	Slightly	xxxx	xxx	• Price: **Moderate** • Sustainability: Not concerned • Location: **Northwestern America**
European Larch (EU)	11,800	0.60	Slightly	N/A	N/A	
S-P-F South (US)	65,000-74,000	0.35-043	Not Durable	xx-xxx	xxx-xxxx	• **Spruce, Pine & Fir shares similar mechanical properties and are often used interchangeably** during construction. • Engelmann and Sitka spruces and Lodgepole pine from the West, along with Balsam fir, Jack pine, Red pine and several species of spruce from the US Northeast • Dist.: U.S.(mostly NE)
Whitewood (EU)	10,200	0.38	Slightly	N/A	N/A	
Sitka Spruce (UK)	8,100	0.34	Not Durable	N/A	N/A	
Cedar (US) (**Red Cedar** &Port Orford)	72,00-11,700	0.32-0.44	Durable	xx	xx-xxxx	• Price: **Inexpensive - Moderate** • Sustainability: Not concerned (Port Orford is considered vulnerable species) • Dist. : **Pacific Northwest**
California Redwood	7,600-9,200	0.35-0.40	Durable	xx	xxxx	• Price: **Upper Price Range** • Sustainability: **Endangered Species** • Location: **Oregon - Central California**
Bald Cypress	9,900	0.46	Durable	xxxx	xxx	• Price: **Mid-range** • Sustainability: Not concerned • Location: Southeastern U.S.

OVERVIEW

DOUGLAS FIR + REDWOOD



Douglas-fir

Redwood

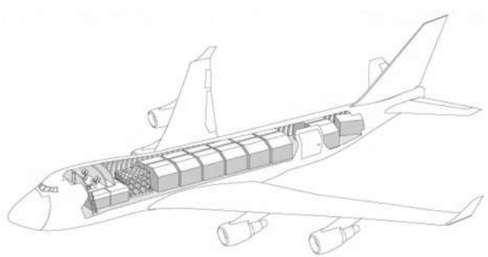
LOGISTICS

TRANSPORTATION

Cargo transported via air, sea, or land freight

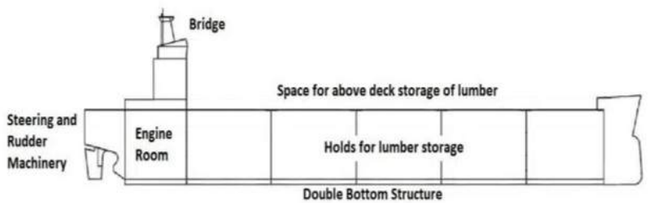
AIR FREIGHT

- offers fast transit time
- more expensive



SEA FREIGHT

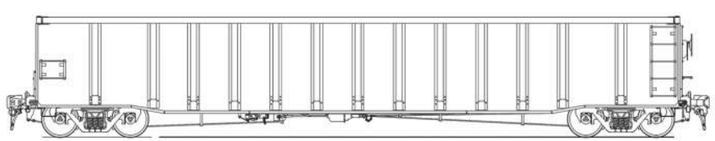
- slow transit time
- more cost effective for bulk shipments



Profile View of a Standard Lumber Carrier Vessel

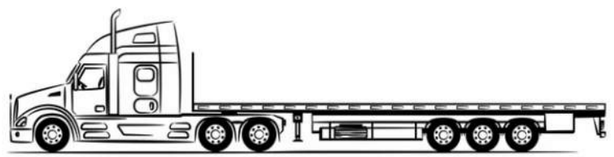
LAND FREIGHT

- more cost effective for bulk shipments



LAND FREIGHT

- doesn't carry as much lumber



ADDITIONAL FEES

International Shipping

Permits

Fuel

Supply and Demand

Quantity

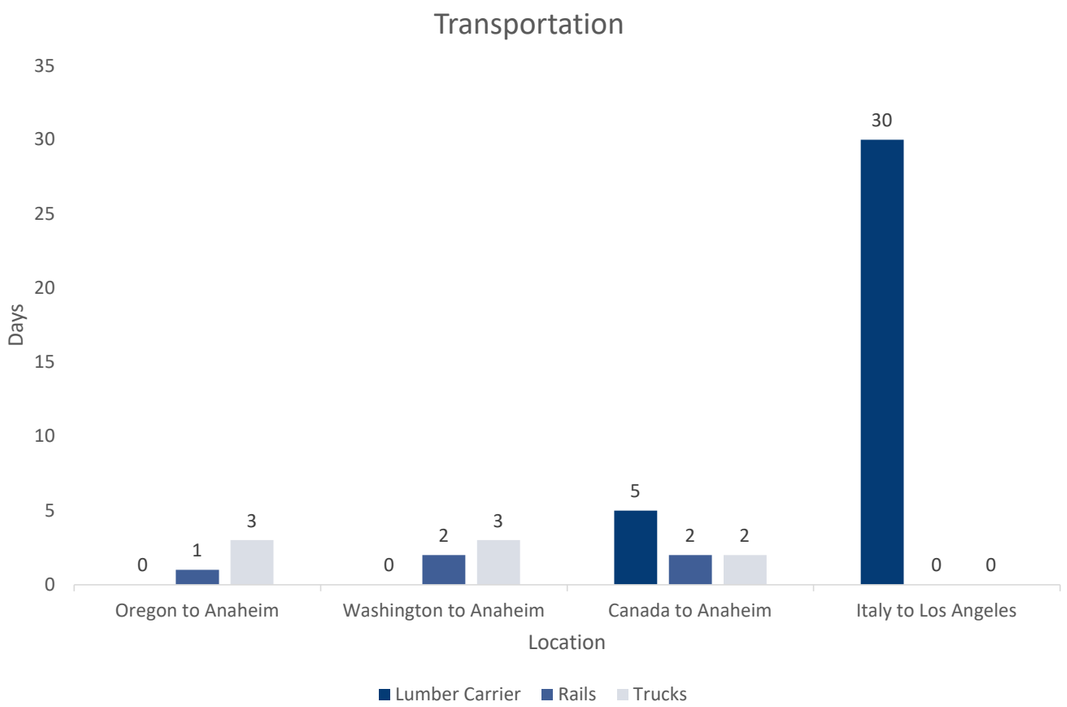
LOGISTICS

TRANSPORTATION

	CARGO AIRCRAFTS	LUMBER CARRIERS	RAILS	TRUCKS
VOLUME		Panamax Bulk Carrier: 60,000 - 99,999 dwt over 786’ in length	Center beam rail car: 200,000 lbs 73’ x 9’-10” x 15’-6” 1 rail car = 4 trucks	48” flatbed truck: 45,500 - 53,000 lbs (1/4 of rail car)
LOAD		cranes and bulldozers are required loading and unloading could take up to 48 hours	forklift used to load and unload experienced operator can load in less than an hour	forklift used to load and unload
COST		20’ container: $1,200 - $2,500 40’ container: $2,500 - $4,000	lower cost per ton mile than truck	driver shortage have caused higher prices
GHG	emits 500 grams per metric ton per kilometer	emits 10-40 grams of CO_2 per kilometer	4 times more fuel efficient than trucks	less fuel efficient than trains
DELAY	delay: weather, congestion at port	delay: weather, congestion at port	delay: weather, technical problems, infrastructure issue	delay: weather, construction, traffic

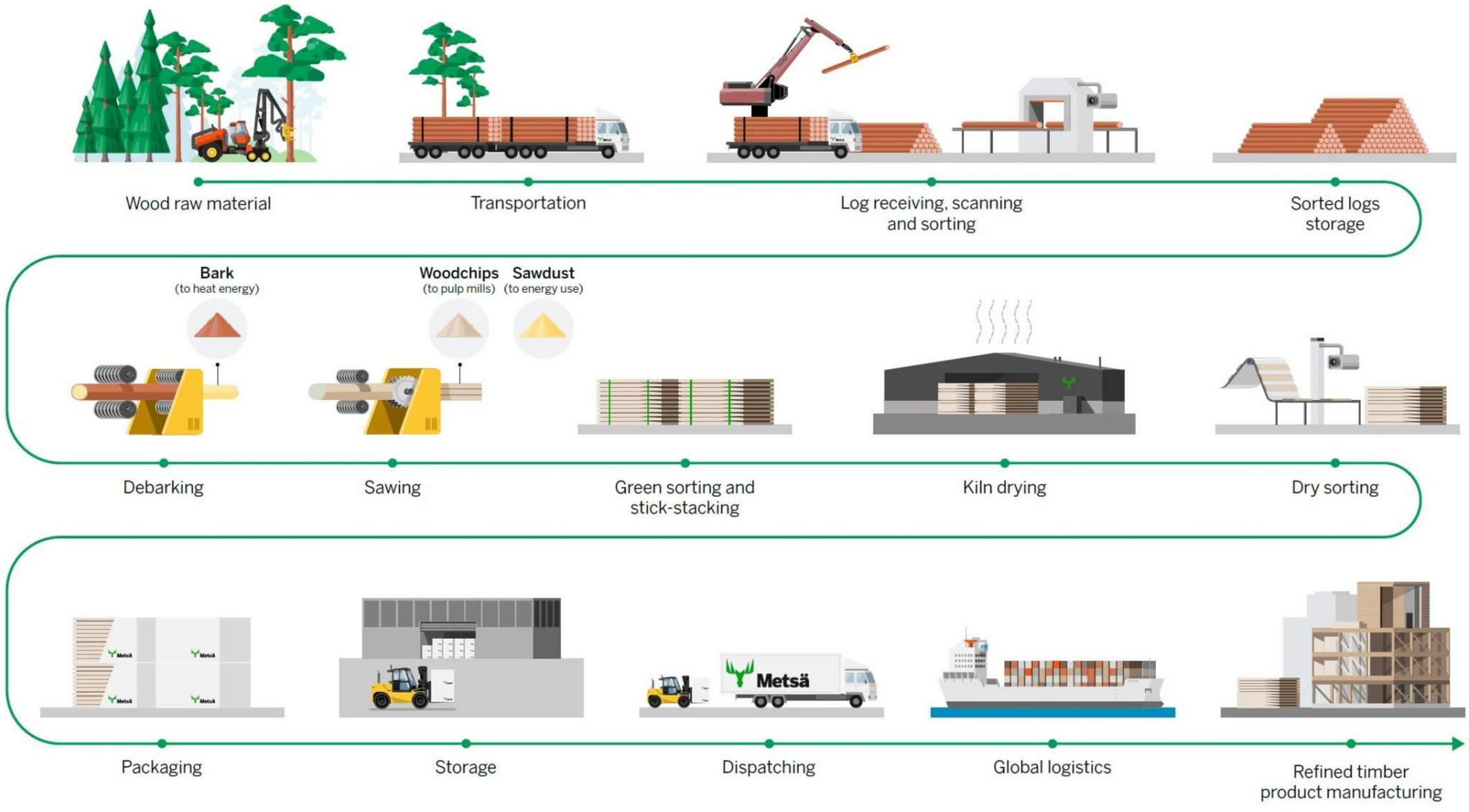
LOGISTICS

TRANSPORTATION



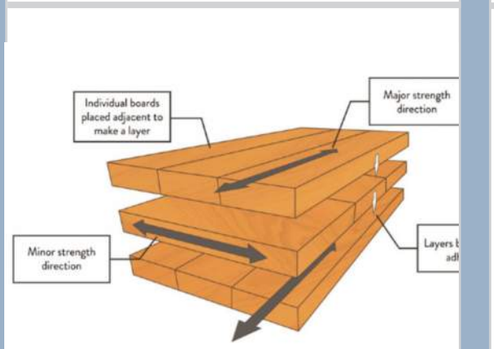
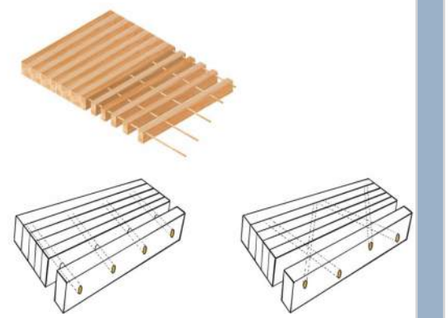
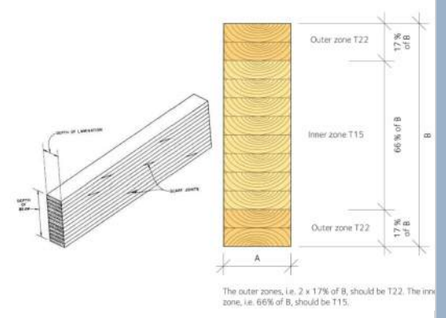
LOGISTICS

LIFE CYCLE



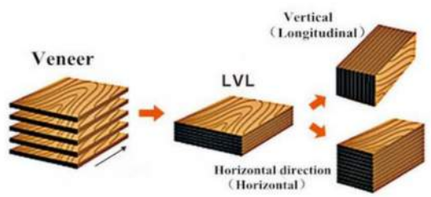
STRUCTURE

PRODUCTS

TYPE	CLT	NLT	DLT	GLULAM
DIAGRAM				
USES	floors, roofs, walls, shear walls & diaphragms, cores & shafts	floors and roofs; can be used for walls/ shafts	floors, roofs, walls	beams, columns, floor joists, trusses, supporting arches, uprights, lintels, bridges, shafts
SIZE	MAX 20’ x 65’ THICKNESS: 3 (4 1/8”), 5 (6 7/8”), 7-ply (9 5/8”), or 9-ply (12 3/8”)	MAX 26’ span THICKNESS: 4”-12”	MAX 14’ x 60’ THICKNESS: 4”-12”	MAX: 100’+ COLUMNS: 60’ North America: 2’ x 40’
BENEFITS & LIMITATIONS	BENEFITS - Two-way span properties -Strength is comparable to concrete - 5x lighter LIMITATIONS - Manufacturing & transportation limits on panel size - Reliance on grid for structural efficiency	BENEFITS - Relative ease of fabrication LIMITATIONS - One-way span: requires support from beam or other structure - Requires significant # of nails - labor intensive - Can’t be CNC’ed - less shear strength than CLT	BENEFITS: - No adhesives - Stronger one-way span than CLT - Lower manufacturing cost -Can house acoustic strips LIMITATIONS: - More common in Europe - Limited info on structural capacity & versatility than CLT	BENEFITS: - Versatile/customizable form - Higher strength to weight ratio than steel - Knots can be strategically scattered to reduce impact on strength LIMITATIONS: - Greater spans require significant increase in depth

STRUCTURE

PRODUCTS

TYPE	LVL	LSL	PSL	MPP
DIAGRAM				
USES	I-joists, beams, headers, trusses, columns	headers, beams, tall wall studs, window framing	long-span beams, columns, large headers	beams, columns, walls, floors, diaphragms
SIZE	MAX 4’ x 80’(60’-vertically) THICKNESS: 1 3/4”” - 11 1/2”	MAX 8’ x 64’ THICKNESS: 1.75” - 4”	MAX 1.5” x 66’ THICKNESS: 3” - 7”	MAX: 12’ x 60’ North America: 1” - 24”
BENEFITS & LIMITATIONS	BENEFITS - Uniformity - High strength to weight ratio than reg lumber - Resists shrinkage and warping LIMITATIONS - Limited width/depth & span - Prone to layer separation - Used in concealed spaces	BENEFITS - Uniformity - Waste reduction and no limitation to specific species - Comparable char rate LIMITATIONS - Lower strength and stiffness properties than LVL	BENEFITS: - LVL or plywood waste can be used - Comparable fire performance - Less prone to shrinking, warping, splitting LIMITATIONS: - No common production standard or design values	BENEFITS: - More than 2x stronger than CLT - Two-way span potential if cross-laminated - Lower volume and cost than CLT - Versatility in function & manufacturing. process. LIMITATIONS: - Greater spans require significant increase in depth

STRUCTURE

GENERAL

PANELIZED

POST & BEAM

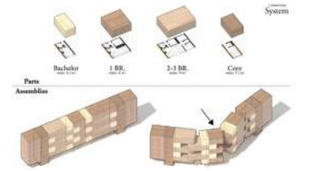
3D MODULE

ALL TIMBER

CHARACTERISTICS & OPTIONS

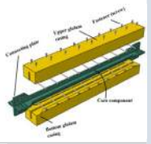
ALL TIMBER

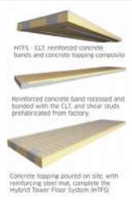
- Lighter structure (25% of concrete) & typically post and beam framing
- Modularity
- Optimization of embodied carbon
- Concealed connections, wood-to-wood connections
- Explore solutions for pushing floor spans



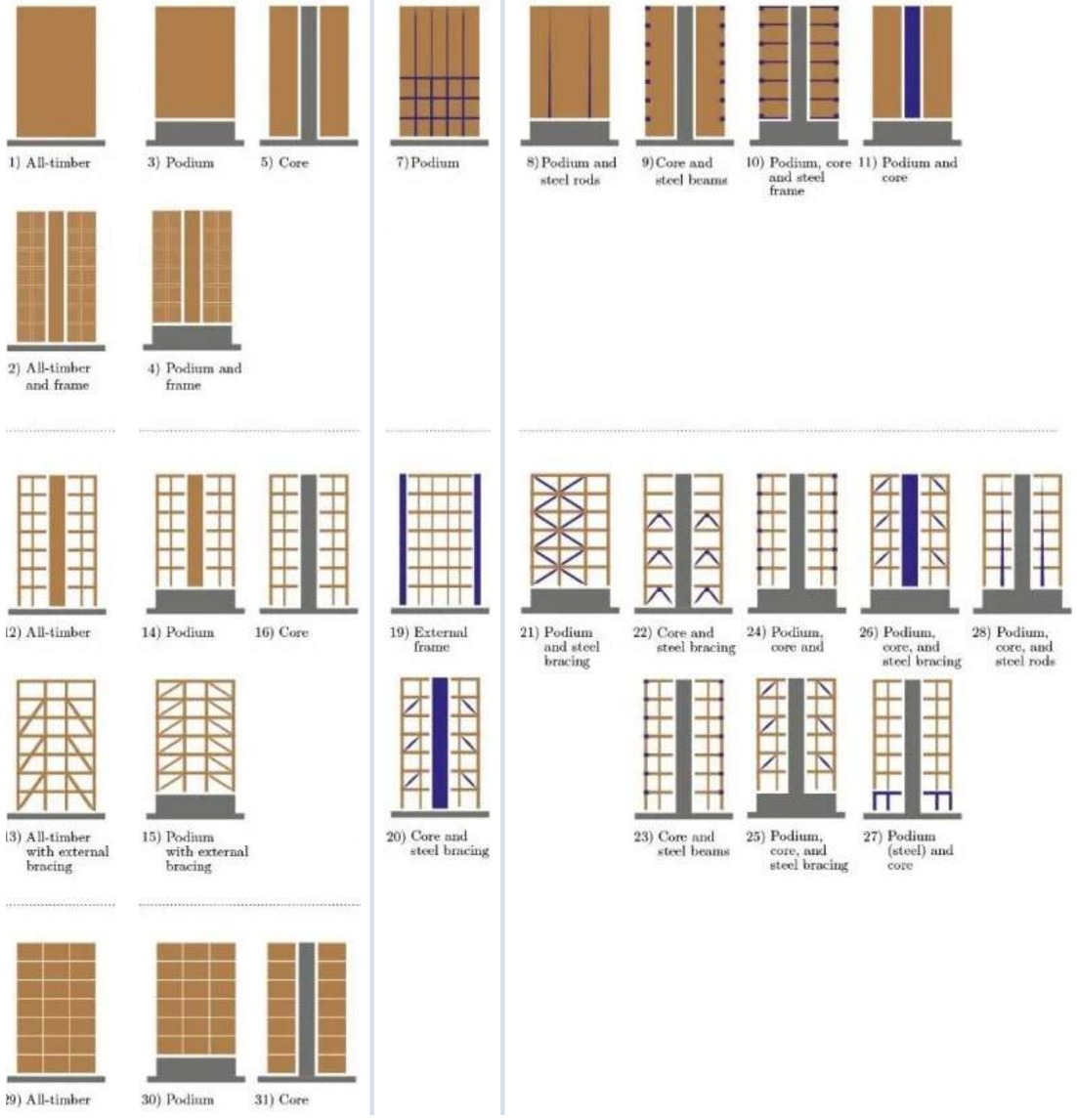
HYBRID

- Post and beam construction & platform construction
- CLT/MPP rocking shear walls
- -Timber buckling restrained braces (TBRBs)
- Concrete cores and/or platform, timber beams, columns, floors
- HTFS: hybrid timber floor system (post-tensioned) allows for 40’ span





TIMBER-CONCRETE TIMBER-STEEL HYBRID



STRUCTURE

ALL TIMBER

TAMEDIA OFFICE BUILDING

1 - STRUCTURE

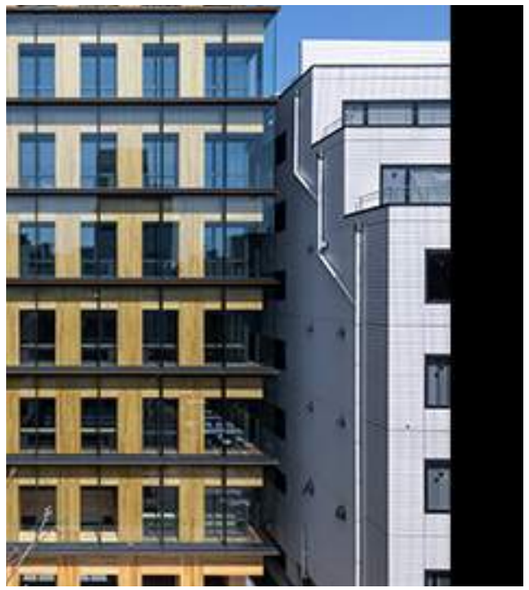
- Post and beam, 7-story rigid frame
- 3 part beam span: two smaller beams at each end, larger beam between

2 - FIRE

- Didn't meet local fire codes, structural members were over-dimensioned to increase fire rating

3 - ASSEMBLY

- Kit of 1,400 parts, including columns
- First 3D-modeled posts & beam digitally fabricated using a CNC mill.



PORT PLUS BY OBAYASHI

1 - STRUCTURE

- Post and beam/Panelized hybrid
- One-way rigid-framed structure with CLT shear walls
- LVL columns & beams

2 - FIRE

3 - ASSEMBLY

- Rigid cross joint system sandwiching plywood panel with column and beam and threading drift pins

FARMHOUSE BY PRECHT

1 - STRUCTURE

- Modular
- Prefabricated A-frame housing modules made from CLT

2 - FIRE

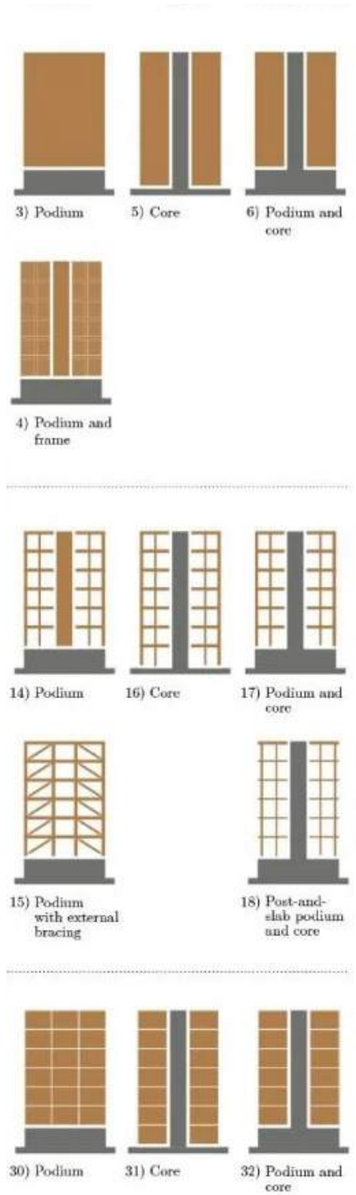
- conceptual, unbuilt, no fire proofing information

3 - ASSEMBLY

- Modules would be prefabricated or constructed on site--simple A frame.

STRUCTURE

TIMBER + CONCRETE



MJOSTARNET

1 - STRUCTURE

- Post and beam
- The main load bearing consists of large-scale glulam trusses
- Top heavy for wind resistance

2 - FIRE

- Steel plate/dowel connections embedded deep into timber
- Facade heat/pressure treated with fire resistant

-Polyurea treatment on glulam

3 - ASSEMBLY

- Prefabrication
- Six stage assembly, 4 to 5 floors at a time.

HAUT

1 - STRUCTURE

- Post and beam/Panelized hybrid
- 1 concrete core, 2 CLT load bearing walls
- Timber-concrete composite floor panels

2 - FIRE

- Built without the presence of building code
- all wood were fire rated or fire treated

3 - ASSEMBLY

- Prefabricated wood elements assembled on-site

BROCK COMMONS

1 - STRUCTURE

- CLT floors point-supported on glulam columns
- concrete foundation and 2 concrete cores

2 - FIRE

- structure fully encapsulated in layers of gypsum for 2-hour rating

3 - ASSEMBLY

- Prefabrication
- 70 day assembly

STRUCTURE

TIMBER + STEEL

SOUTHWEST LIBRARY BY P&W

1 - STRUCTURE
- Post and beam/Panelized hybrid
- DLT (dowel laminated timber) for roof
- Steel & timber braced frames creates a unique hybrid lateral force resisting system

2 - ASSEMBLY

- Prefabrication & shortened construction time (a few weeks)

FARM HOUSE BY PRECHT

1 - STRUCTURE

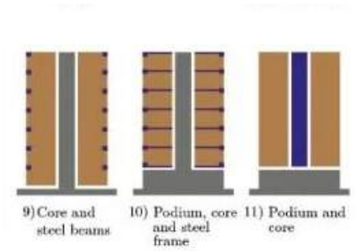
- Post and truss
- Wood space frame constructed from peeler cores, a waste product from the plywood industry.

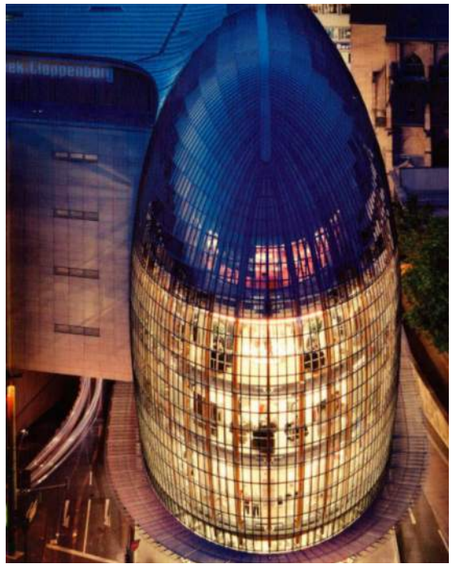
2 - ASSEMBLY

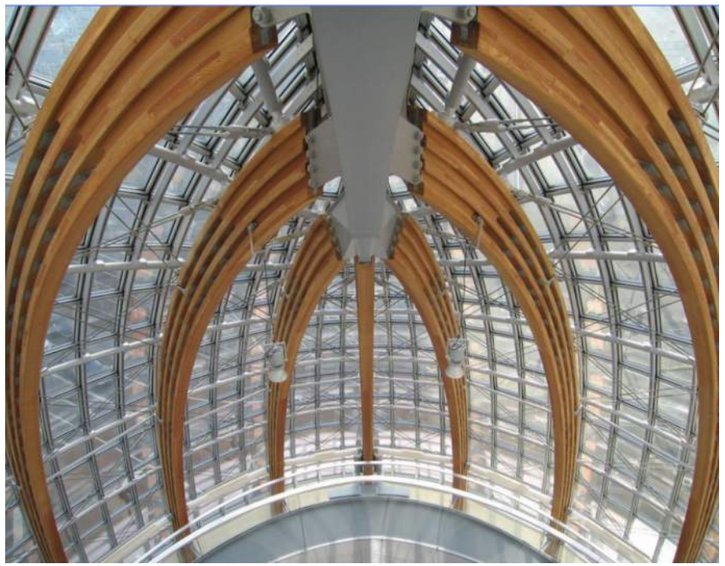
- Light steel framing
- Custom cast connector nodes

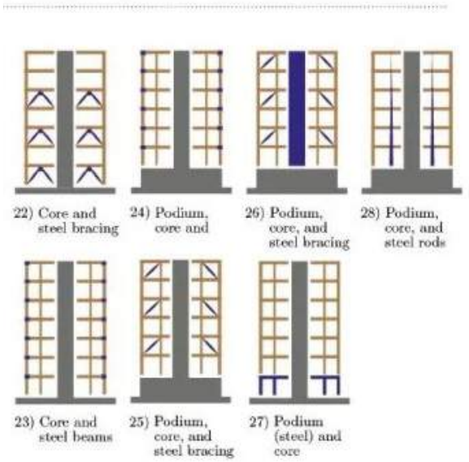
STRUCTURE

TIMBER + STEEL + CONCRETE



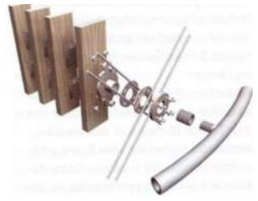


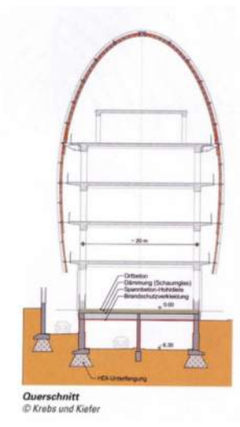


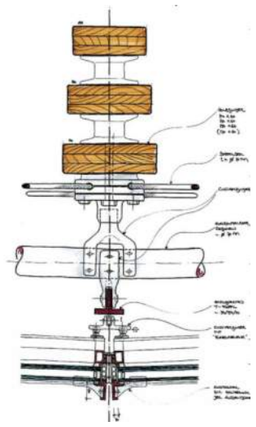


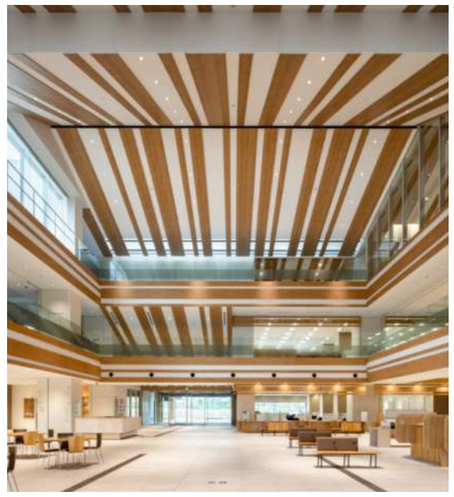
- Glass dome facade supported by 66 glulam arches suspended from primary concrete structure

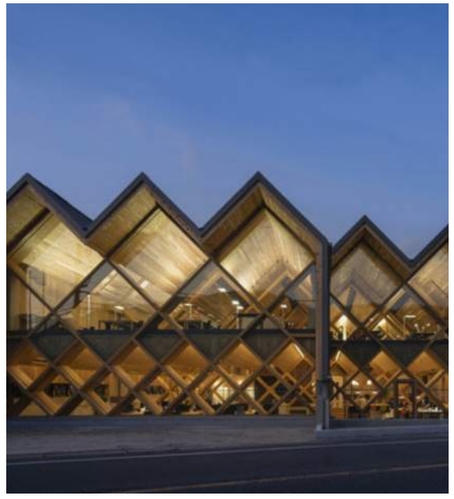
- arches joined via steel substructure

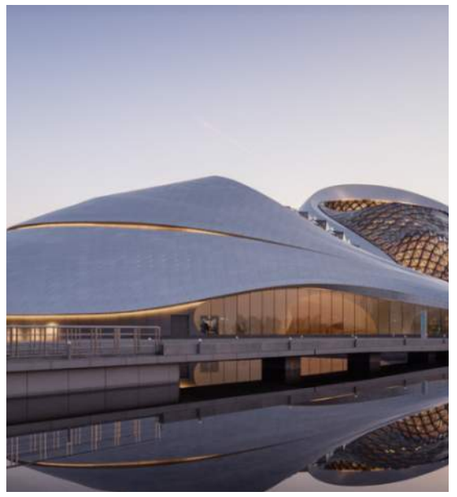


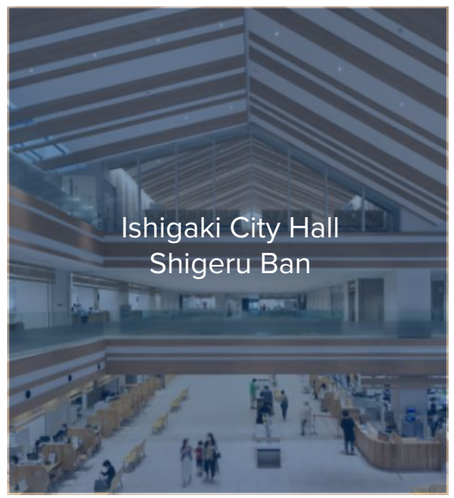


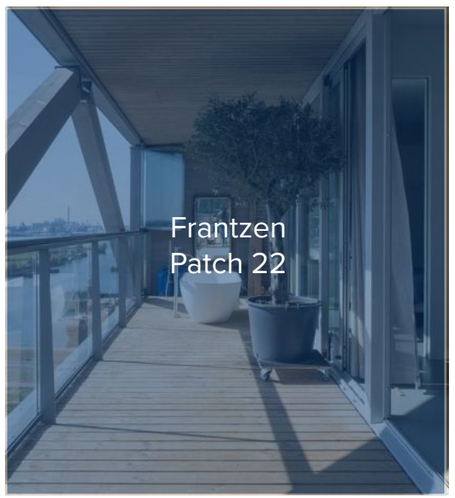


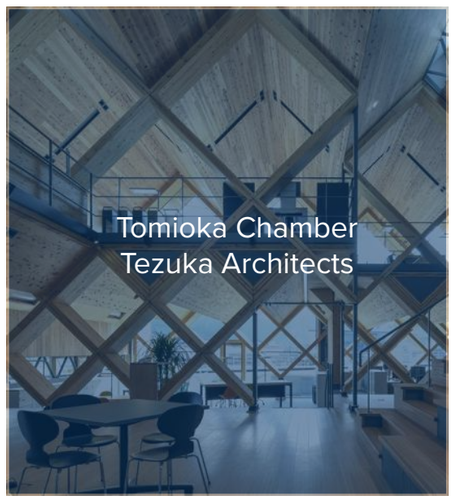




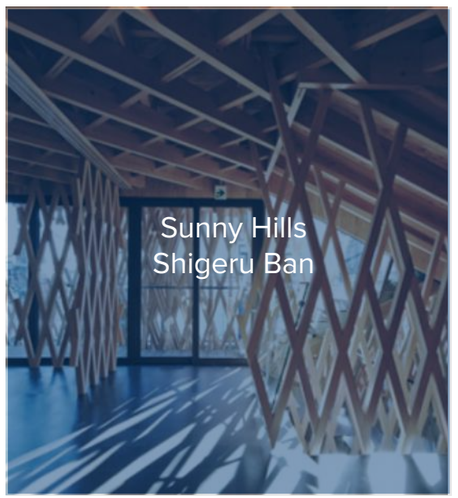


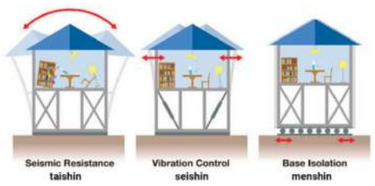
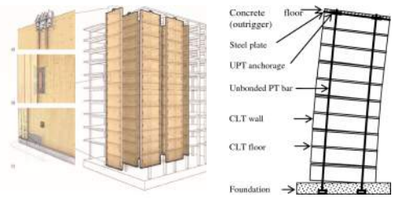
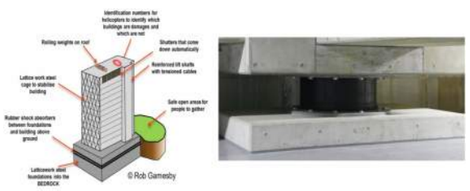
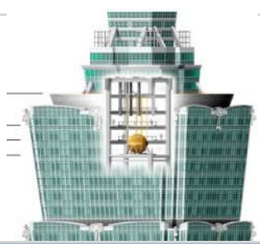

Ishigaki City Hall
Shigeru Ban


Frantzen
Patch 22


Tomioka Chamber
Tezuka Architects


Harbin Opera House
MAD Architects


Sunny Hills
Shigeru Ban

TYPES	HOW	ILLUSTRATION
Seismic Isolation Bearings	- Allow buildings to move horizontally during earthquake, reducing the stress on structure and minimizing damage	
Quake Resistant Checkerboard Wall System	- Interlocking nature of the blocks can enhance lateral stability - Distribute seismic forces more evenly throughout the wall	
Rocking Shear Walls	- 9-ply CLT panels connected with steel plates and post-tensioned steel cables - Unlike fixed shear walls, this system “rocks” under extreme lateral loads and returns to original position when load is removed	
Shock Absorber	- Blocks of rubber about 12-20 inch thick to resist motions of earthquakes (high-rise) - Whenever building columns come down to foundation, they sit on rubber pads	
Damper	- Control floor vibrations and building displacement - Dampers on second levels to top - Filled with liquid instead of air damping walls	

PRECEDENTS

TAKEAWAYS

RESEARCH TAKEAWAYS FOR BUILDING A MASS TIMBER TOWER:

- Tall buildings are more repetitive in structure, greater need for speed in construction (ideal for prefabrication)

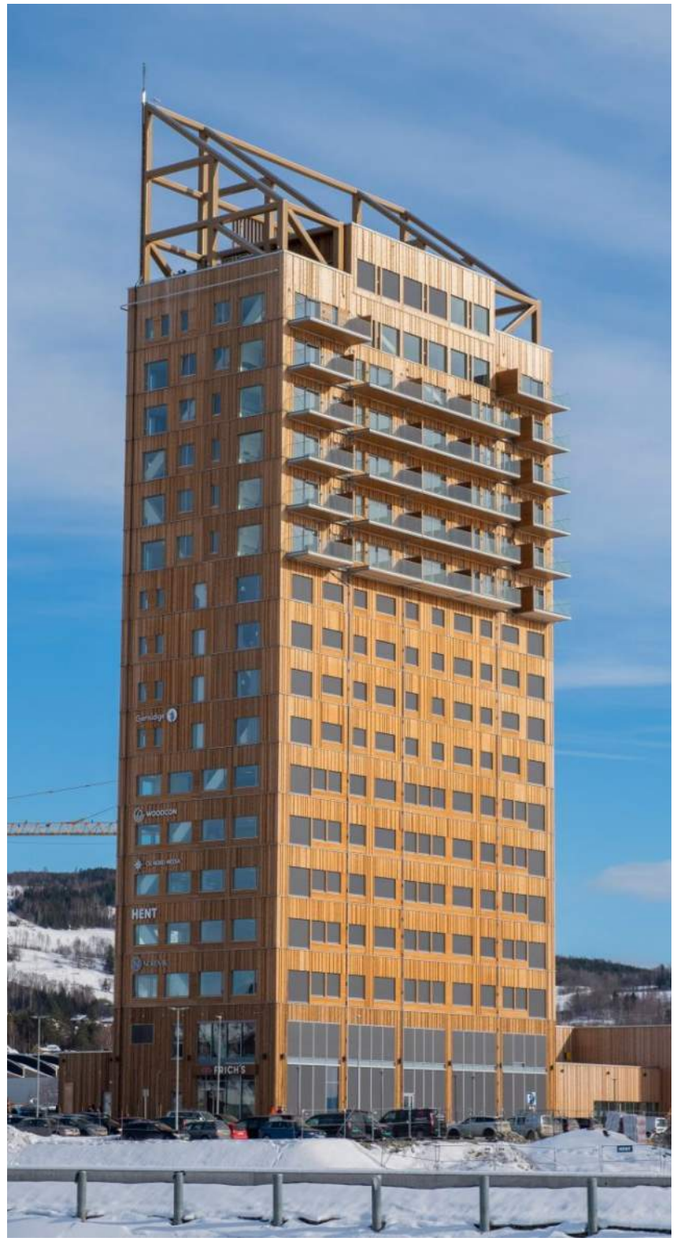
- Hybrid systems can be used to account for mass timber limitations

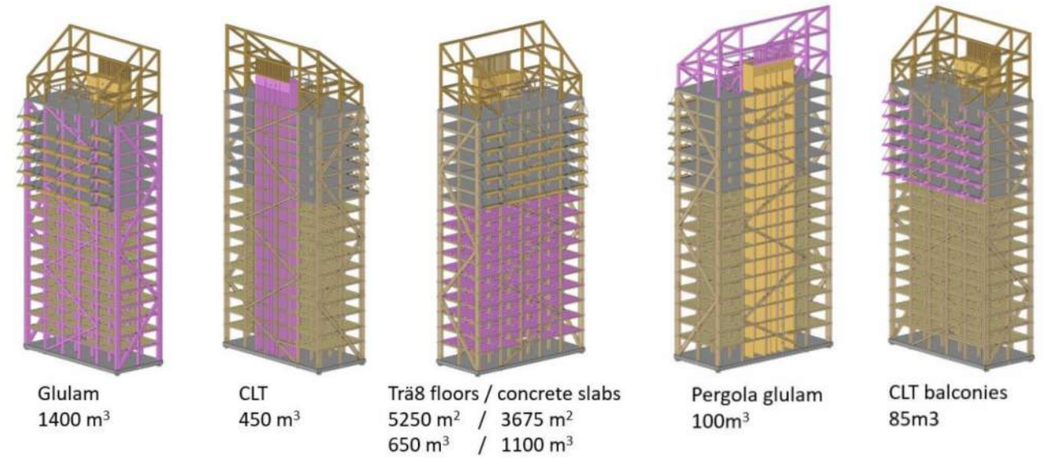
- Encapsulated structure for higher fire rating

- Potential for exterior diagrid system made of timber?

PRECEDENTS

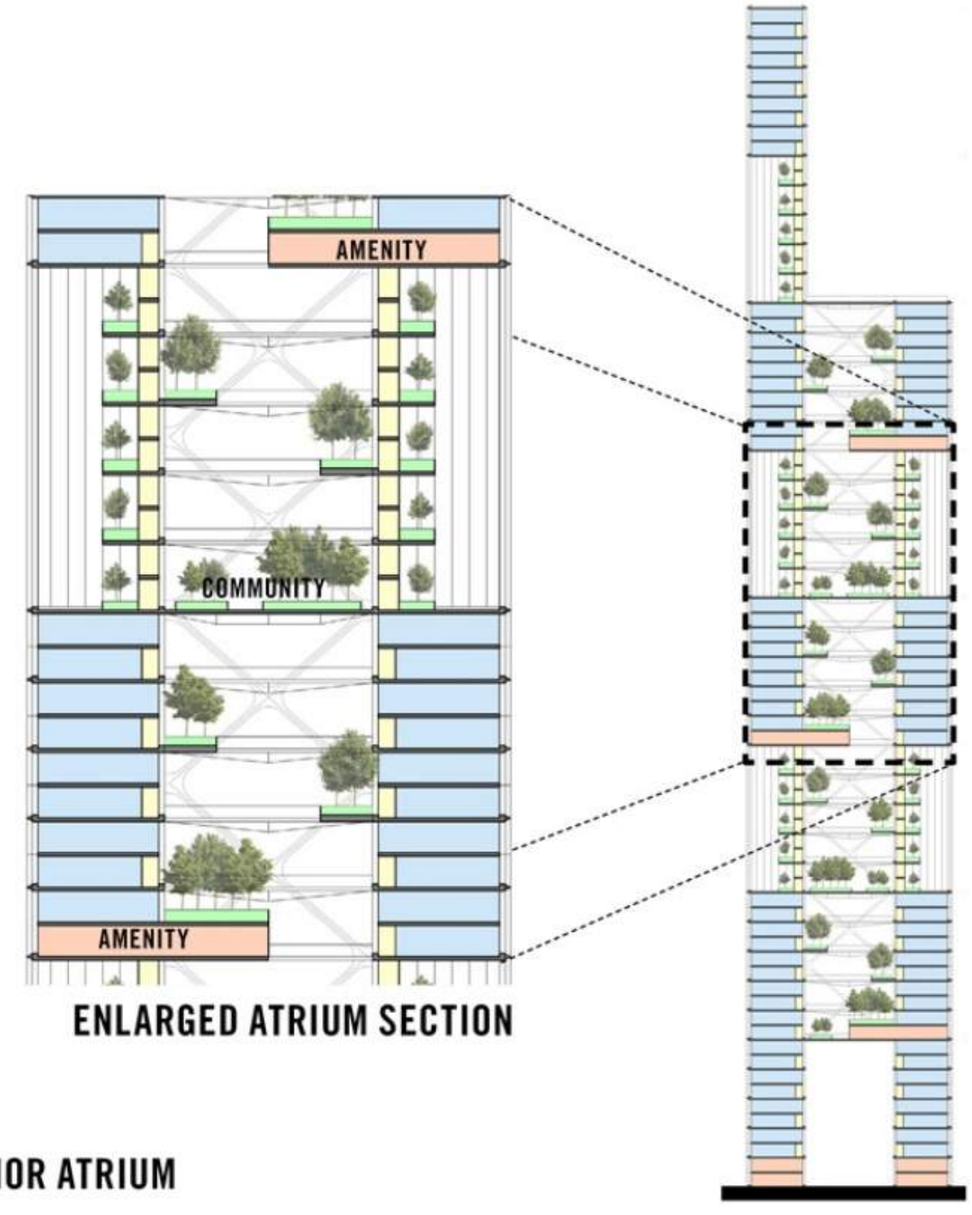
MJOSTARNET BY VOLL ARKITEKTER





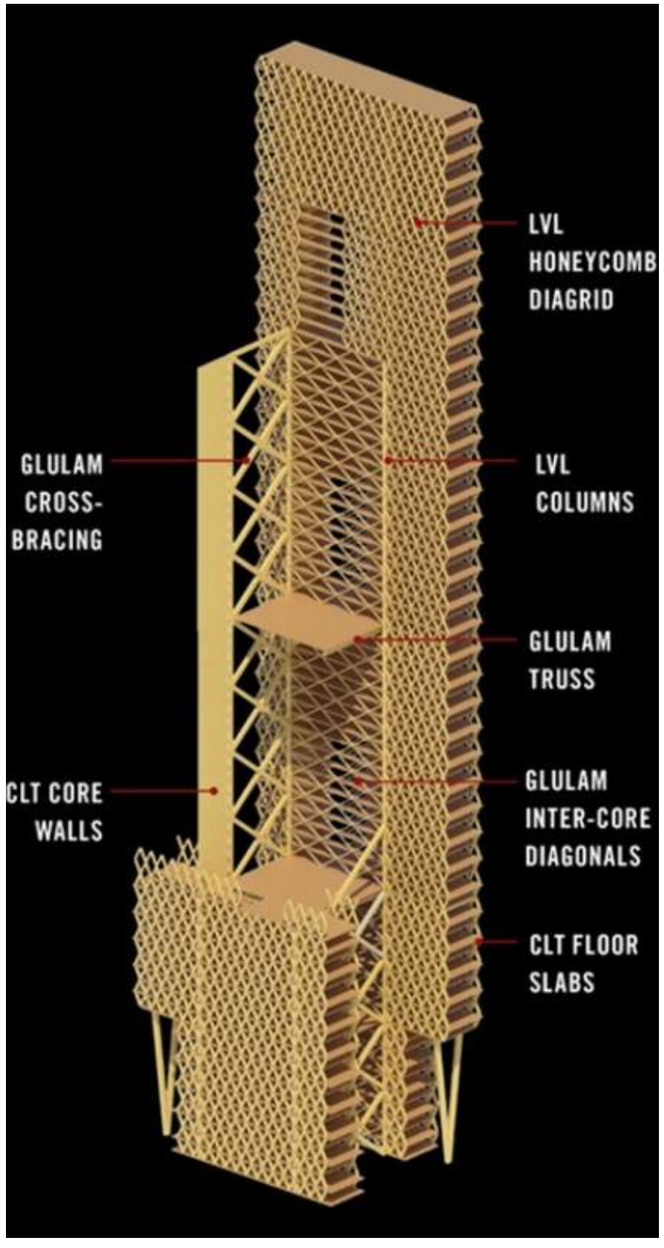
PRECEDENTS

RIVER BEECH TOWER BY PERKINS + WILL



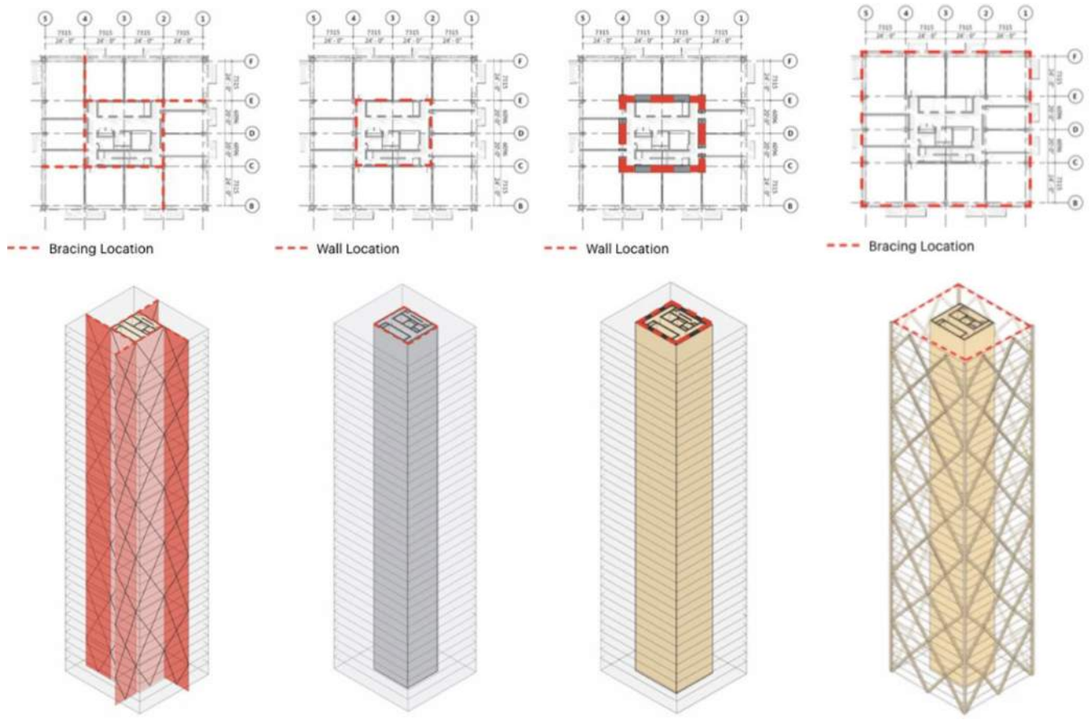
ENLARGED ATRIUM SECTION

INTERIOR ATRIUM



PRECEDENTS

PROTO-MODEL X BY SIDEWALK LABS



PRECEDENTS

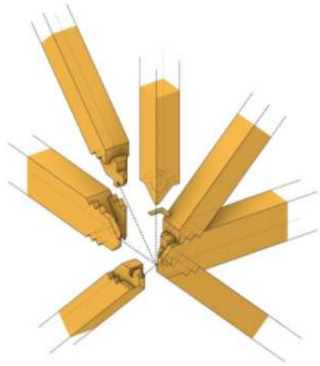
WOOD-TO-WOOD

TAMEDIA OFFICE - SHIGERU BAN

- Matador wooden construction kit: uses wooden rods to connect the components into a stable structure

- Oval shape: Torsionally rigid connection

- Materiality of Wood: Glued thick plates and dowels made of beech plywood inside the connection points, providing improved transverse strength due to its multi-directional graining



UNIVERSITY OF KANSAS - SCHOOL OF ARCH. & DESIGN

- 50,000 sq ft mass timber cube structure
- Tight-fit dowels and notched glulams to create all wood structure
- Columns and beams run diagonally without steel plates or fasteners

THERMAL CAPABILITY:

- U Factor: .16

- Inherent insulative properties of wood and an extremely air tight seal formed by high quality dry glazed gaskets

- Both engineered hardwood and softwood

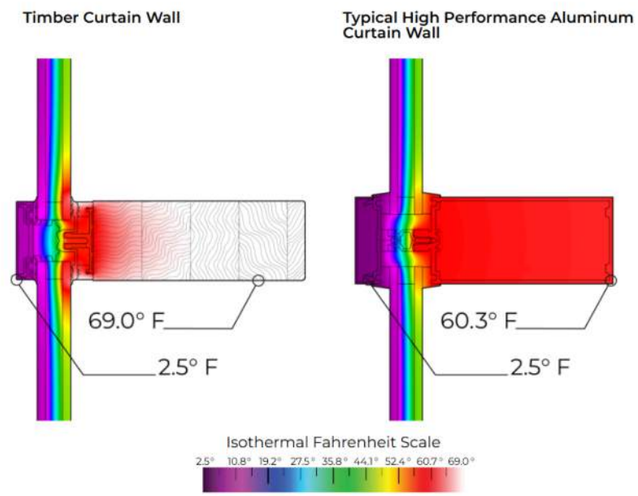
MATERIAL:

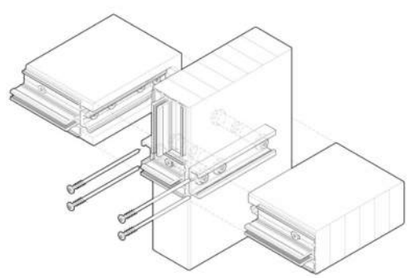
- Glulam curtain walls can be load bearing (capable of long spans and supporting roof)

- Exterior of frame can be capped with aluminium or wood

ASSEMBLY:

- Can be assembled modularly instead of stick-built dry glazed system (no sealant) easier to de-construct and recycle without sealant





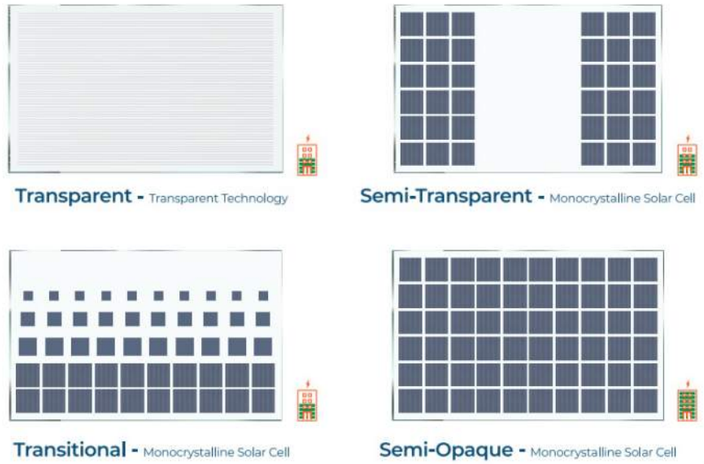
SOLAR GLASS:

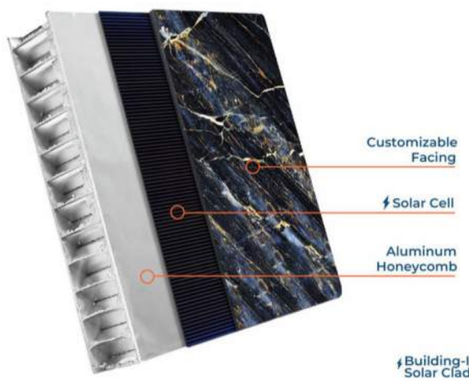
- solar cells sandwiched between glass panels in double-layered or triple-layered IGUs
- concealed wiring, easy access for maintenance
- can be opaque, semi-opaque, or transparent (impacts efficiency)
- power range: 7-18 W/sf
- customizable solar cell pattern

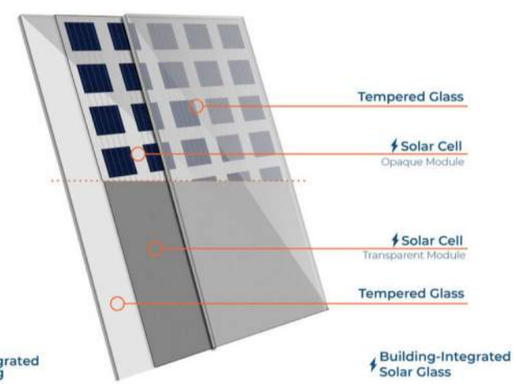
SOLAR FACADE PANELS:

- layered panels with embedded solar cell layer and concealed wiring
- rainscreen, unitized, or prefab system installation
- customizable facing material

Both are adaptable to typical glazing or rainscreen systems







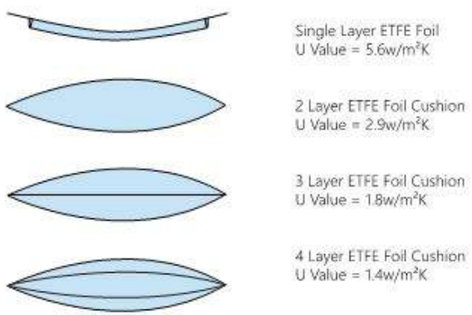
ENVELOPE

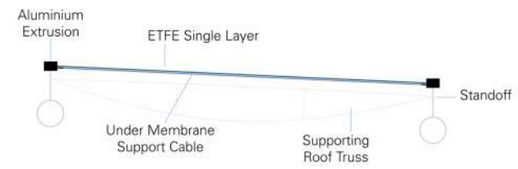
ETFE

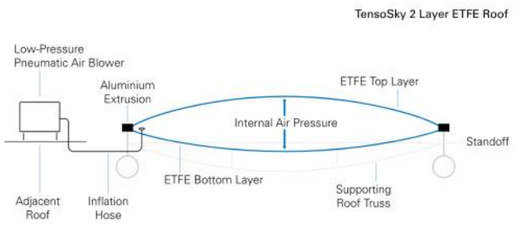
MATERIAL:
- Ethylene Tetra Fluoro Ethylene
- extruded as thin films (foils)

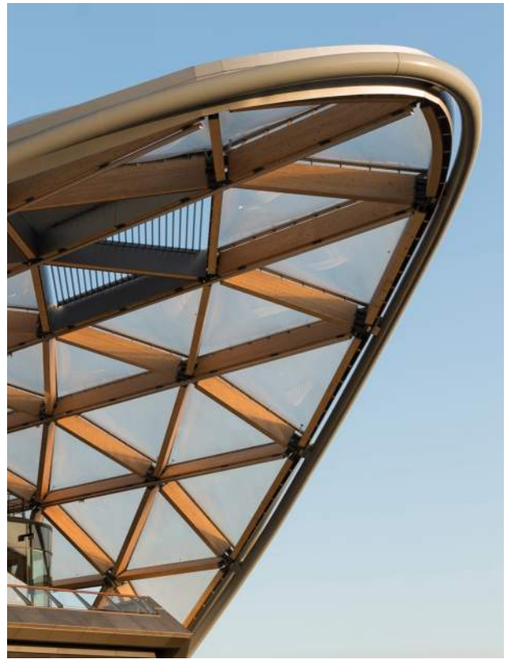
THERMAL CAPABILITY:
- single layer of ETFE has U value of 5.6
- multi-layer cushion offer better insulation, U value of 1.4
- can apply frit or tint to reduce solar gain while maintaining translucency

ASSEMBLY:
- single layer membrane is supported by cable system
- multi-layer cushions supported in an extruded aluminium frame supported by main building frame
- cushions kept continually pressurized by inflation unit connected to AHU to provide structural stability and insulation
- minimal energy consumption, only used to maintain pressure not generate airflow









RELEVANT CODES

California Building Code 2022

California Energy Code 2022

California Fire Code 2022

California Plumbing Code 2022

Fair Housing Act / ANSI A117.1

CALGreen Building Code 2022

FIRE RESISTANCE

TABLE 601

FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
	A	B	A	B	A	B	A	B	C	HT	A	B
Primary structural frame[f] (see Section 202)	3[a, b]	2[a, b, c]	1[b, c]	0[c]	1[b, c]	0	3[a]	2[a]	2[a]	HT	1[b, c]	0
Bearing walls												
Exterior[e, f]	3	2	1	0	2	2	3	2	2	2	1	0
Interior	3[a]	2[a]	1	0	1	0	3	2	2	1/HT[g]	1	0
Nonbearing walls and partitions Exterior	See Table 705.5											
Nonbearing walls and partitions Interior[d]	0	0	0	0	0	0	0	0	0	See Section 2304.11.2	0	0
Floor construction and associated secondary structural members (see Section 202)	2	2	1	0	1	0	2	2	2	HT	1	0
Roof construction and associated secondary structural members (see Section 202)	$1^1/_2$[b]	1[b,c]	1[b,c]	0[c]	1[b,c]	0	$1^1/_2$	1	1	HT	1[b,c]	0

For SI: 1 foot = 304.8 mm.

ALLOWABLE HEIGHT

TABLE 504.3 2022 CBC

									A	B	C		
R-1[h]	NS[d]	UL	160	65	55	65	55	65	65	65	65	50	40
	S13D	60	60	60	60	60	60	60	60	60	60	50	40
	S13R	60	60	60	55	60	55	60	60	60	60	60	60
	S (without area increase)	UL	180	85	75	85	75	270	180	85	85	70	60
	S (with area increase)	UL	160	65	55	65	55	250	160	65	65	50	40
R-2[h]	NS[d]	UL	160	65	55	65	55	65	65	65	65	50	40
	S13R	60	60	60	55	60	55	60	60	60	60	50	40
	S (without area increase)	UL	180	85	75	85	75	270	180	85	85	70	60
	S (with area increase)	UL	160	65	55	65	55	250	160	65	65	60 [j]	40
R-2.1[h]	NS[d]	UL	160	65	55	65	55	65	NP	NP	NP	50	40
	S13D	60	60	60	55	60	55	60	NP	NP	NP	50	40
	S13R	60	60	60	55	60	55	60	NP	NP	NP	50	40
	S	UL	160	65	55	65	55	270	NP	NP	NP	50	40
R-2.2[h]	NS[d]	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP
	S (without area increase)	UL	180	85	NP	85	NP	270	180	85	85	70	NP
	S (with area increase)	UL	160	65	NP	65	NP	250	160	65	65	60 [i]	NP
R-3, R-3.1[h]	NS[d]	UL	160	65	55	65	55	65	65	65	65	50	40
	S13D	60	60	60	60	60	60	60	60	60	60	50	40
	S13R	60	60	60	55	60	55	60	60	60	60	60	60
	S	UL	160	65	55	65	55	270	180	85	65	70	60

OCCUPANCY GROUP

PERFORMANCE GROUP	USE AND OCCUPANCY CLASSIFICATIONS FOR SPECIFIC BUILDINGS OR FACILITIES
I	Buildings and facilities that represent a low hazard to human life in the event of failure, including, but not limited to: 1. Agricultural facilities. 2. Certain temporary facilities. 3. Minor storage facilities.
II	All buildings and facilities except those listed in Performance Groups I, III and IV.
III	Buildings and facilities that represent a substantial hazard to human life in the event of failure, including, but not limited to: 1. Buildings and facilities where more than 300 people congregate in one area. 2. Buildings and facilities with elementary school, secondary school or day care facilities with a capacity greater than 250. 3. Buildings and facilities with a capacity greater than 500 for colleges or adult education facilities. 4. Health-care facilities with a capacity of 50 or more residents but not having surgery or emergency treatment facilities. 5. Jails and detention facilities. 6. Any other occupancy with an occupant load greater than 5,000. 7. Power-generating facilities, water treatment for potable water, wastewater treatment facilities and other public utilities facilities not included in Performance Group IV. 8. Buildings and facilities not included in Performance Group IV containing sufficient quantities of highly toxic gas or explosive materials capable of causing acutely hazardous conditions that do not extend beyond property boundaries.
IV	Buildings and facilities designated as essential facilities, including, but not limited to: 1. Hospitals and other health-care facilities having surgery or emergency treatment facilities. 2. Fire, rescue and police stations and emergency vehicle garages. 3. Designated earthquake, hurricane or other emergency shelters. 4. Designated emergency preparedness, communication, and operation centers and other facilities required for emergency response. 5. Power-generating stations and other utilities required as emergency backup facilities for Performance Group IV buildings or facilities. 6. Buildings and facilities containing highly toxic gas or explosive materials capable of causing acutely hazardous conditions beyond the property boundaries. 7. Aviation control towers, air traffic control centers and emergency aircraft hangars. 8. Buildings and facilities having critical national defense functions. 9. Water treatment facilities required to maintain water pressure for fire suppression. 10. Ancillary structures (including, but not limited to, communication towers, fuel storage tanks or other structures housing or supporting water or other fire suppression material or equipment) required for operation of Performance Group IV structures during an emergency.

ALLOWABLE FLOOR AREA

[BE] TABLE 1004.5

MAXIMUM FLOOR AREA ALLOWANCES PER OCCUPANT

FUNCTION OF SPACE	OCCUPANT LOAD FACTOR[a]
Accessory storage areas, mechanical equipment room	300 gross
Agricultural building	300 gross
Aircraft hangars	500 gross
Airport terminal	
Baggage claim	20 gross
Baggage handling	300 gross
Concourse	100 gross
Waiting areas	15 gross
Assembly	
Gaming floors (keno, slots, etc.)	11 gross
Exhibit gallery and museum	30 net
Assembly with fixed seats	See Section 1004.6
Assembly without fixed seats	
Concentrated (chairs only—not fixed)	7 net
Standing space	5 net
Unconcentrated (tables and chairs)	15 net
Bowling centers, allow 5 persons for each lane including 15 feet of runway, and for additional areas	7 net
Business areas	150 gross
Concentrated business use areas	See Section 1004.8
Courtrooms—other than fixed seating areas	40 net

OCVIBE ZONING

NET DENSITY:	50 DU / ACRES
CONSTRUCTION TYPE:	TYPE I-A, TYPE III-A AND TYPE V-A
SPRINKLERS:	NFPA 13

ZONING INFO

APPLICABLE ZONING IS ARENA DISTRICT AND TRANSIT DISTRICT.

	REQUIRED	PROPOSED
DENSITY	45 DU/AC MIN	50 DU/AC
NO. OF UNITS	50 MIN	327
STRUCTURAL HEIGHT	UNLIMITED	TWO 4-STORY BUILDINGS BLDG 1 HEIGHT: 55'-11" BLDG 2 HEIGHT: 56'-5" ONE 5-STORY BUILDING BLDG 3 HEIGHT: 63'-7"
UNIT FLOOR AREA	1 BR: 650 S.F. 2 BR: 825 S.F. 3 BR: 1,000 S.F.	1 BR: 698 S.F. - 700 S.F. 2 BR: 825 S.F. - 994 S.F. 3 BR: 1,095 S.F.
MAX. SITE COVERAGE	75% MAX	56.4%
MINIMUM SETBACK	RIVER ROAD: 10' S SANDERSON AVE: 9' 9' OF UP TO 30% OF STREET FRONTAGE INTERIOR PL: 0'	15'-8" 4'-9" 10'-0" (SOUTHERN EDGE)
PERMITTED ENCROACHMENT	RIVER ROAD: NONE S SANDERSON AVE: PATIOS - 7' RESIDENTIAL BUILDINGS - 3' INTERIOR PL: -	NONE PATIOS - 7' RESIDENTIAL BUILDINGS - 3' NONE
LANDSCAPE AREA	RIVER ROAD: SUBJECT TO CHAPTER 18.46 LANDSCAPING AND SCREENING S SANDERSON AVE: THE AREA BETWEEN RESIDENTIAL PATIOS AND THE SIDEWALKS SHALL BE FULLY LANDSCAPED INTERIOR PL: IN COMPLIANCE WITH CALIFORNIA BUILDING AND FIRE CODES	TOTAL: 48,066 S.F. POOL: 2,125 S.F. (POOL IS NOT A PART OF LANDSCAPE AREA)
LANDSCAPE COVERAGE	-	16.6%
PRIVATE STORAGE	100 C.F. / UNIT (327 UNITS = 32,700 S.F.) 100 C.F. / UNIT	100 C.F. / UNIT (327 UNITS = 32,700 S.F.) 100 C.F. / UNIT

NOTE: THE PROJECT COMPLIANCE CHAPTER 18.46 FOR REQUIRED LANDSCAPE

FIRE RESISTANCE REQUIREMENT

TABLE 707.3.10 California Fire Code

The fire barriers, fire walls, horizontal assemblies or combinations thereof separating a single occupancy into different fire areas shall have a fire-resistance rating of not less than that indicated in Table 707.3.10. The fire barriers, fire walls, horizontal assemblies or combinations thereof separating fire areas of mixed occupancies shall have a fire-resistance rating of not less than the highest value indicated in Table 707.3.10 for the occupancies under consideration.

TABLE 707.3.10
FIRE-RESISTANCE-RATING REQUIREMENTS FOR FIRE BARRIERS, FIRE WALLS OR HORIZONTAL ASSEMBLIES BETWEEN FIRE AREAS

OCCUPANCY GROUP	FIRE-RESISTANCE RATING (hours)
H-1, H-2	4
F-1, H-3, S-1	3
A, B, E, F-2, H-4, H-5, I, *L*, M, R, S-2	2
U	1

MINIMUM STRUCTURAL FRAMING

TABLE 2304.11
MINIMUM DIMENSIONS OF HEAVY TIMBER STRUCTURAL MEMBERS

		MINIMUM NOMINAL SOLID SAWN SIZE		MINIMUM GLUED-LAMINATED NET SIZE		MINIMUM STRUCTURAL COMPOSITE LUMBER NET SIZE	
SUPPORTING	**HEAVY TIMBER STRUCTURAL ELEMENTS**	**Width, inch**	**Depth, inch**	**Width, inch**	**Depth, inch**	**Width, inch**	**Depth, inch**
Floor loads only or combined floor and roof loads	Columns; Framed sawn or glued-laminated timber arches that spring from the floor line; Framed timber trusses	8	8	$6\frac{3}{4}$	$8\frac{1}{4}$	7	$7\frac{1}{2}$
	Wood beams and girders	6	10	5	$10\frac{1}{2}$	$5\frac{1}{4}$	$9\frac{1}{2}$
Roof loads only	Columns (roof and ceiling loads); Lower half of: wood-frame or glued-laminated arches that spring from the floor line or from grade	6	8	5	$8\frac{1}{4}$	$5\frac{1}{4}$	$7\frac{1}{2}$
	Upper half of: wood-frame or glued-laminated arches that spring from the floor line or from grade	6	6	5	6	$5\frac{1}{4}$	$5\frac{1}{2}$
	Framed timber trusses and other roof framing;[a] Framed or glued-laminated arches that spring from the top of walls or wall abutments	4[b]	6	3[b]	$6\frac{7}{8}$	$3\frac{1}{2}$[b]	$5\frac{1}{2}$

For SI: 1 inch = 25.4 mm.

EGRESS DISTANCE

TABLE 1017.2

EXIT ACCESS TRAVEL DISTANCE[a]

OCCUPANCY	WITHOUT SPRINKLER SYSTEM (feet)	WITH SPRINKLER SYSTEM (feet)
A, E, F-1, M, R, S-1	200[e]	250[b]
R-2.1	Not Permitted	250[b]
B	200	300[c]
F-2, S-2, U	300	400[c]
H-1	Not Permitted	75[d]
H-2	Not Permitted	100[d]
H-3	Not Permitted	150[d]
H-4	Not Permitted	175[d]
H-5	Not Permitted	200[c]
I-2, *I-2.1*, I-3[f]	Not Permitted	200[c]
I-4	150	200[c]
L	*Not Permitted*	*200[c]*

For SI: 1 foot = 304.8 mm.

EXIT REQUIREMENT

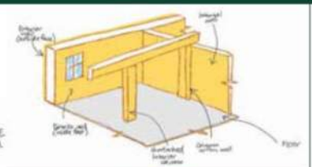
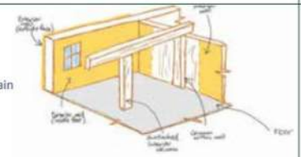
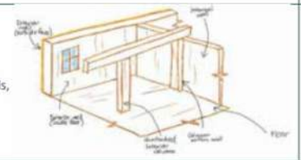
TABLE 1006.3.3

MINIMUM NUMBER OF EXITS OR ACCESS TO EXITS PER STORY

OCCUPANT LOAD PER STORY	MINIMUM NUMBER OF EXITS OR ACCESS TO EXITS FROM STORY
1—500	2
501—1,000	3
More than 1,000	4

CODE ILLUSTRATED

CODE ILLUSTRATED

Construction Type	# Stories	Max Height	Mass Timber	Primary Frame Fire Rating
IV-A	18	250 - 270'	**Fully Protected** PROTECTED NON-COMBUSTIBLE NOT LESS THAN 1 HR. 	3 hour (2 hour floors)
IV-B	12	180'	**Partially Exposed** (20% of ceilings allowed to remain exposed) 	2 hour
IV-C	9	85'	**Fully Exposed** (Except outside of external walls, shafts and concealed spaces) 	2 hour

INTRODUCTION

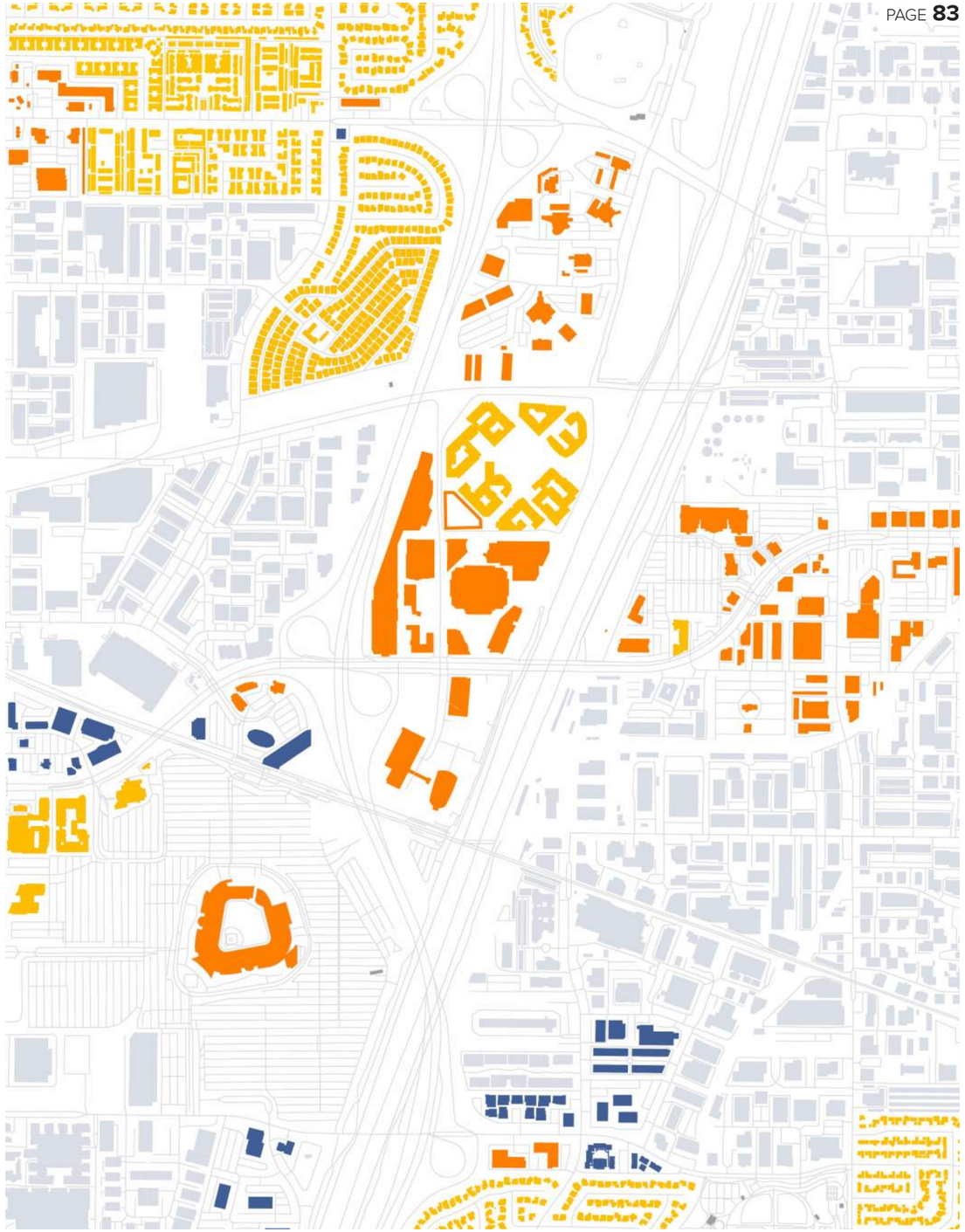
MASTER PLAN

CONTEXT

OC VIBE + SITE

SITE ANALYSIS

SURROUNDING PROGRAM



LEGEND

- OFFICE
- COMMERCIAL
- RESIDENTIAL
- LIGHT INDUSTRIAL

SITE ANALYSIS

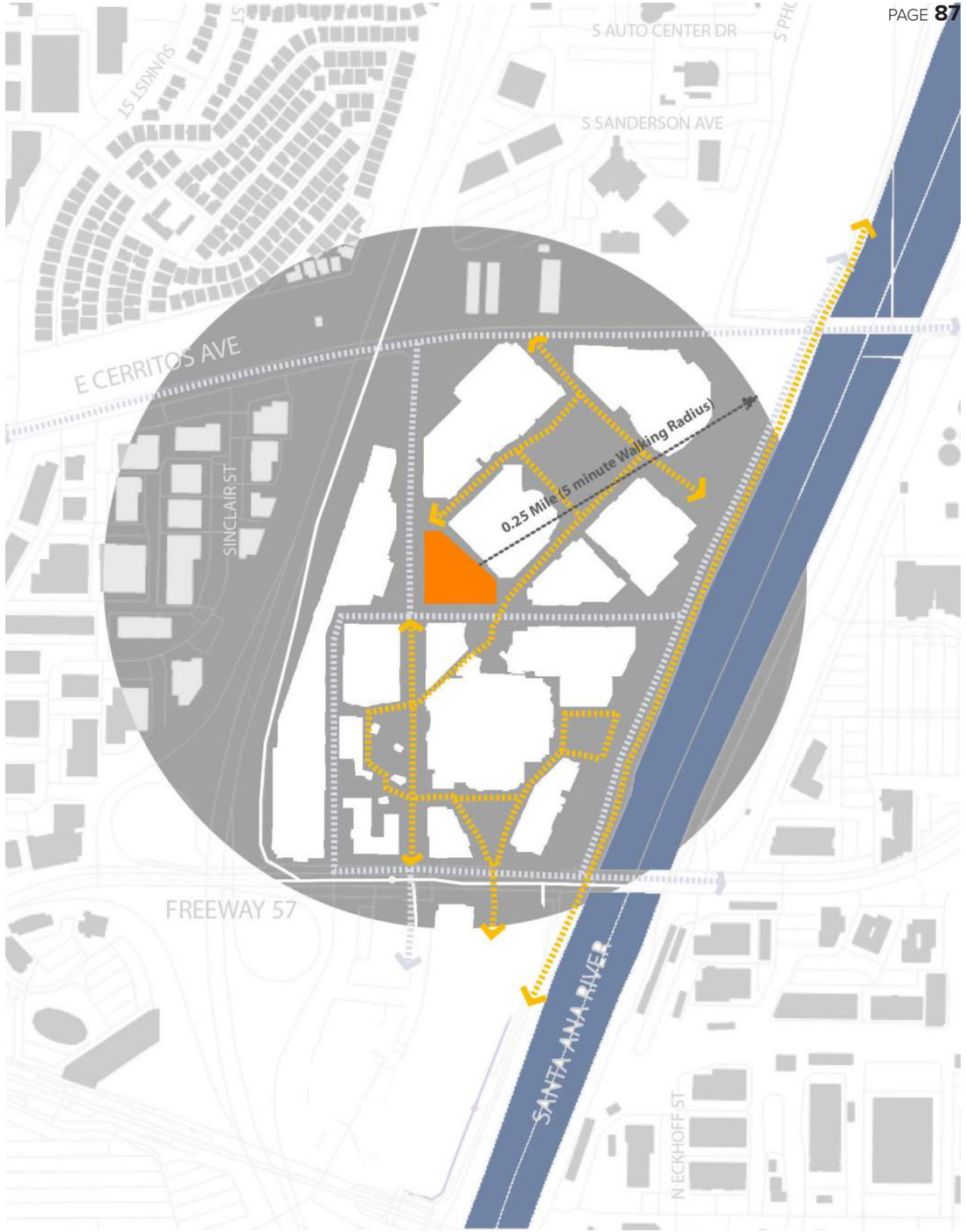
TRANSPORTATION

LEGEND

- RIVER
- SITE
- BUS STOPS

SITE ANALYSIS

CIRCULATION + SITE

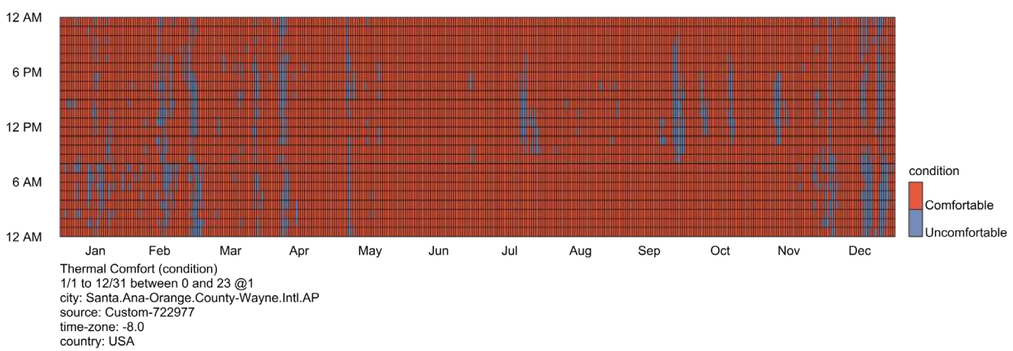


LEGEND

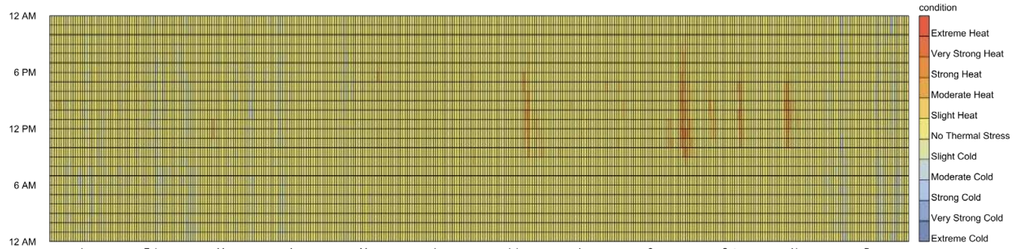
- RIVER
- SITE
- PEDESTRIAN
- VEHICLE

ENVIRONMENT

THERMAL COMFORT STUDY



Thermal Comfort (condition)
1/1 to 12/31 between 0 and 23 @1
city: Santa.Ana-Orange.County-Wayne.Intl.AP
source: Custom-722977
time-zone: -8.0
country: USA



Thermal Condition Eleven Point (condition)
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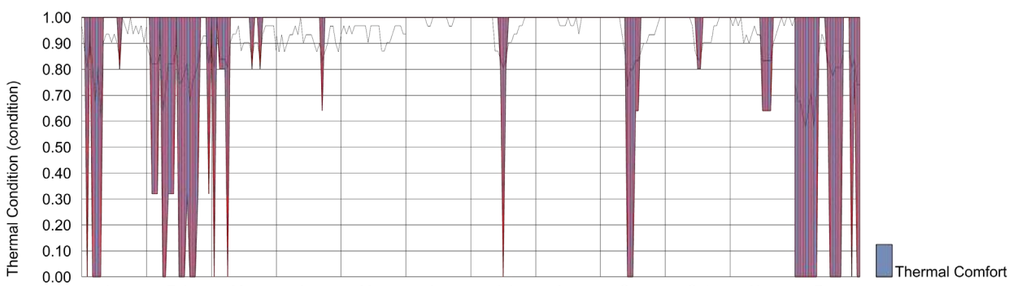
source: Custom-722977
time-zone: -8.0
country: USA



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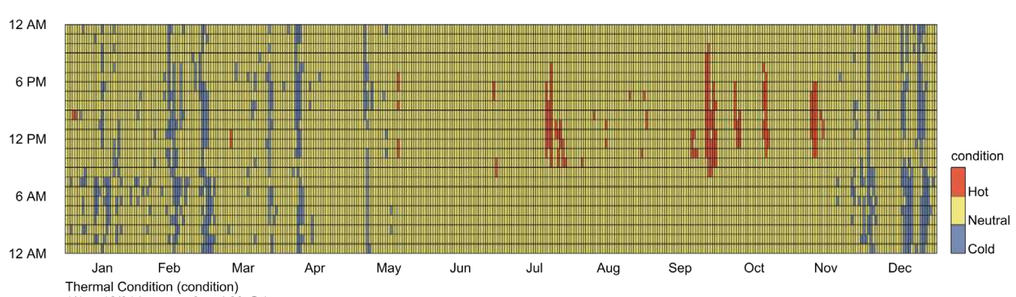
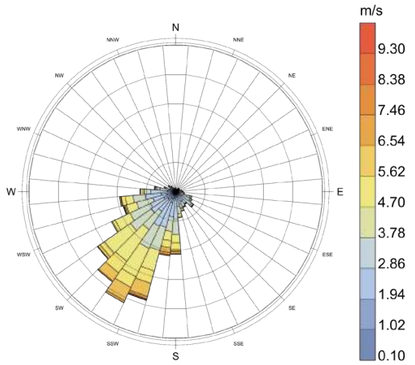


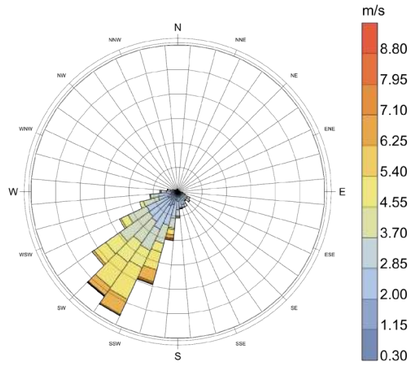
Thermal Condition (condition)
1/1 to 12/31 between 0 and 23 @1
city: Santa.Ana-Orange.County-Wayne.Intl.AP
source: Custom-722977
time-zone: -8.0
country: USA

ENVIRONMENT

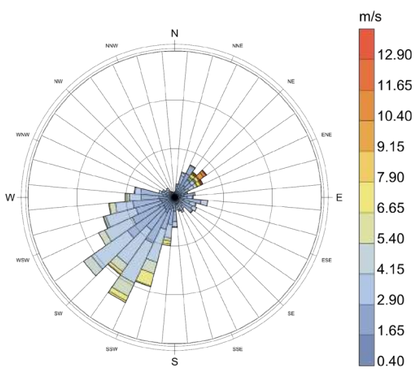
WIND STUDY



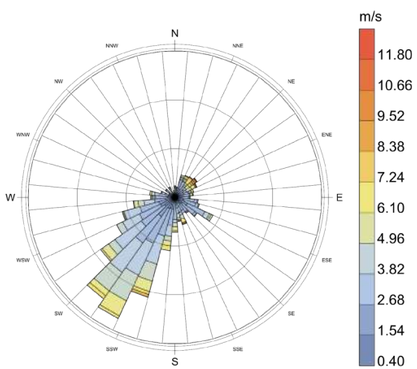
Wind Speed (m/s)
city: Santa.Ana-Orange.County-Wayne.Intl.AP
source: Custom-722977
time-zone: -8.0
country: USA
period: 3/21 to 6/21 between 1 and 23 @1
Calm for 16.83% of the time = 360 hours.
Each closed polyline shows frequency of 2.8% = 50 hours.



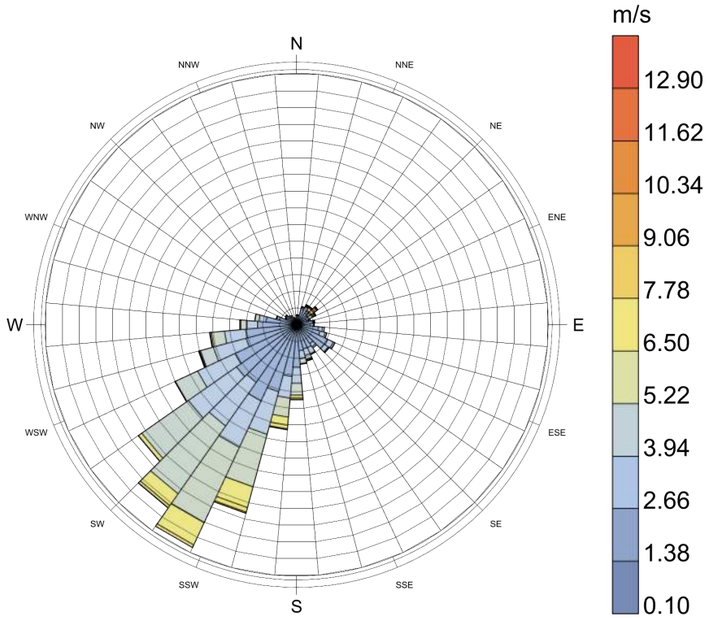
Wind Speed (m/s)
city: Santa.Ana-Orange.County-Wayne.Intl.AP
source: Custom-722977
time-zone: -8.0
country: USA
period: 6/21 to 9/21 between 1 and 23 @1
Calm for 19.59% of the time = 419 hours.
Each closed polyline shows frequency of 2.9% = 50 hours.



Wind Speed (m/s)
city: Santa.Ana-Orange.County-Wayne.Intl.AP
source: Custom-722977
time-zone: -8.0
country: USA
period: 9/21 to 12/21 between 1 and 23 @1
Calm for 38.23% of the time = 809 hours.
Each closed polyline shows frequency of 3.8% = 50 hours.



Wind Speed (m/s)
city: Santa.Ana-Orange.County-Wayne.Intl.AP
source: Custom-722977
time-zone: -8.0
country: USA
period: 12/21 to 3/21 between 1 and 23 @1
Calm for 40.18% of the time = 841 hours.
Each closed polyline shows frequency of 4.0% = 50 hours.



Wind Speed (m/s)
city: Santa.Ana-Orange.County-Wayne.Intl.AP
source: Custom-722977
time-zone: -8.0
country: USA
period: 1/1 to 12/31 between 1 and 23 @1
Calm for 28.52% of the time = 2394 hours.
Each closed polyline shows frequency of 0.8% = 50 hours.

ENVIRONMENT

SHADOW STUDY

	10:40am	12:40am	3:40pm	6:40pm
summer june 20, 2024				
equinox sept 22, 2024				
winter dec 21. 2024				

INTRODUCTION

MASTER PLAN

01 Phase 1 Research

- Overview
- Logistics
- Products
- Structure
- Precedents
- Seismic
- Envelope
- Code

02 Phase 2 Analysis

- Context
- Transportation
- Site Plan
- Environmental Analysis

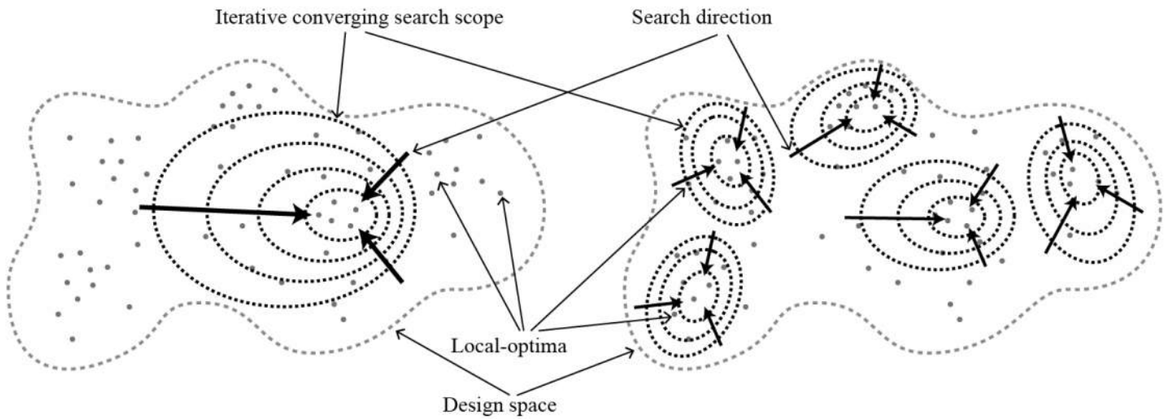
03 Phase 3 Design

- Introduction
- Massing
- Program
- Documentation
- Environmental Design
- Materials
- Views


PARKING STRUCTURE
57 FREEWAY
PARKING STRUCTURE
ARTIC
OFFICE/ FOOD HALL
RESTAURANT
CONCERT HALL
URBAN PARK
THE PASEO
HOTEL
SOUTH PLAZA
HONDA CENTER
RESIDENTIAL (4)
RESIDENTIAL (5)
MEADOW PARK
HOTEL
KATELLA
PARKING STRUCTURE
RESIDENTIAL (1)
NEIGHBORHOOD PARK
RIVER ROAD
RESIDENTIAL (2)
RESIDENTIAL (3)
CERRITOS

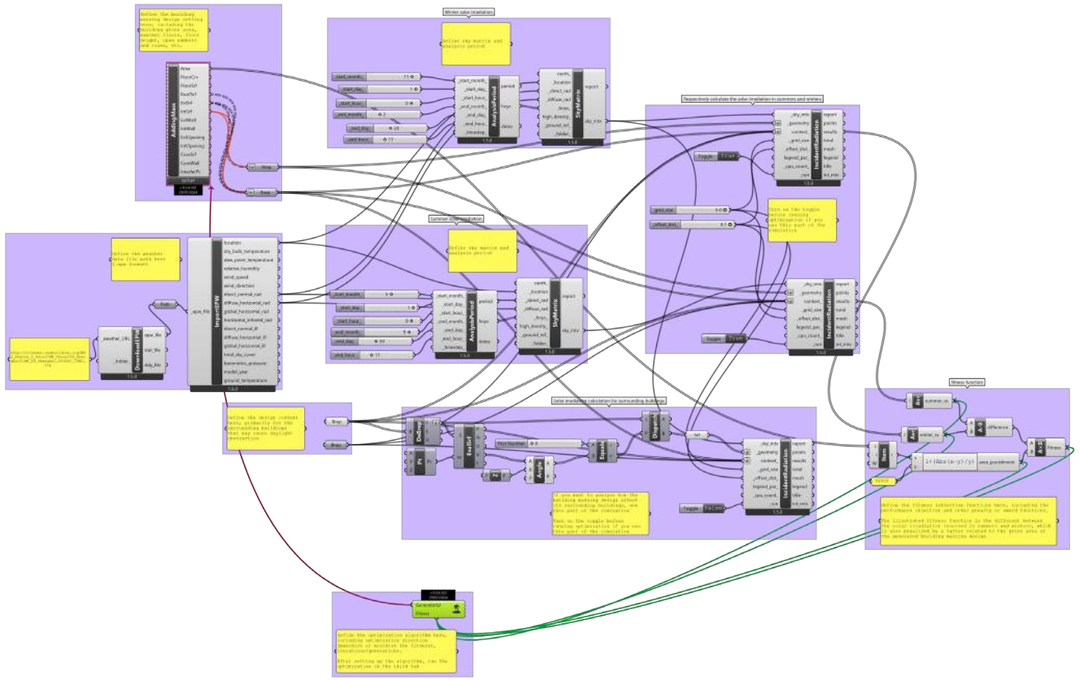
MASSING

SCRIPT



MASSING

SCRIPT

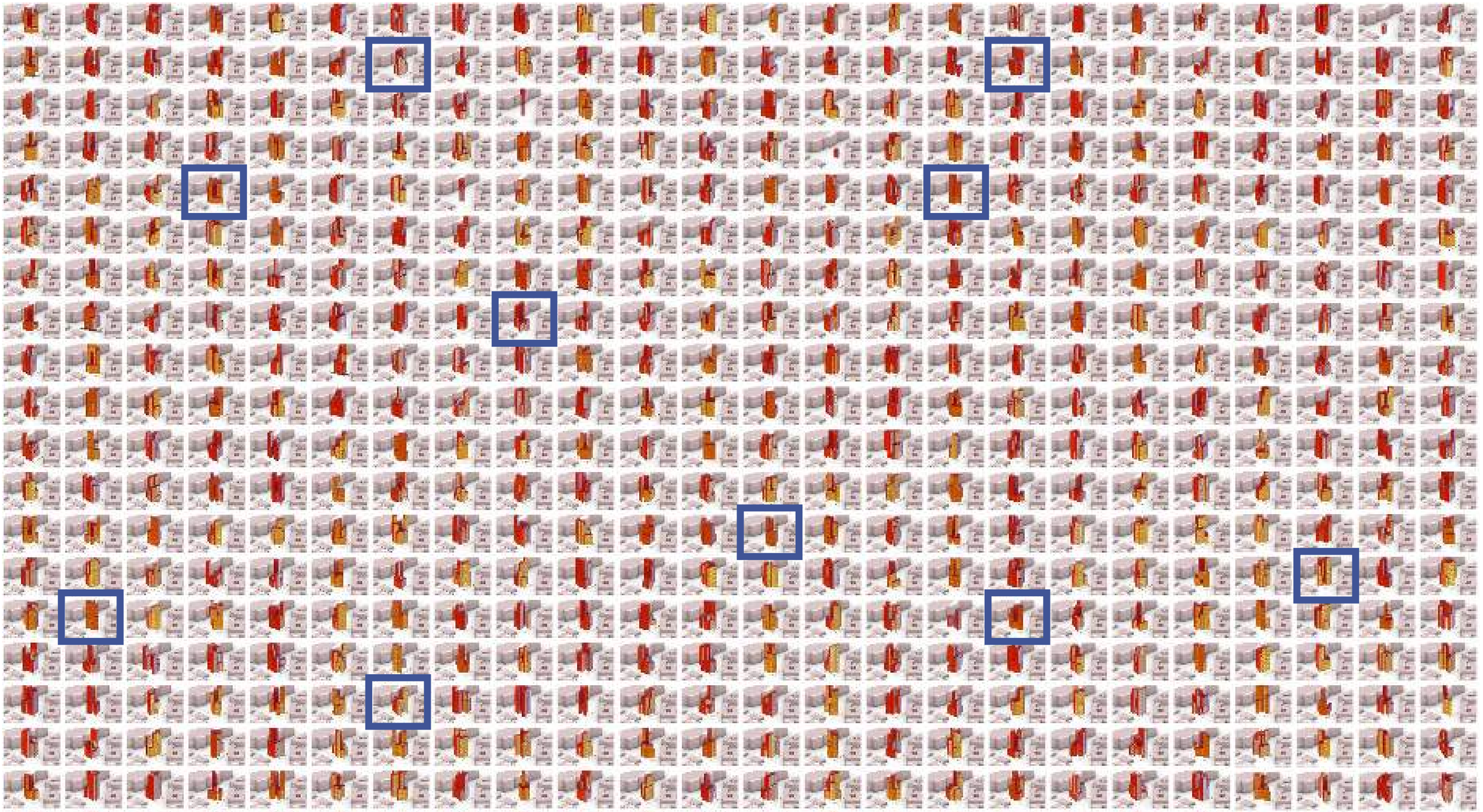


MASSING

SCRIPT RESULTS

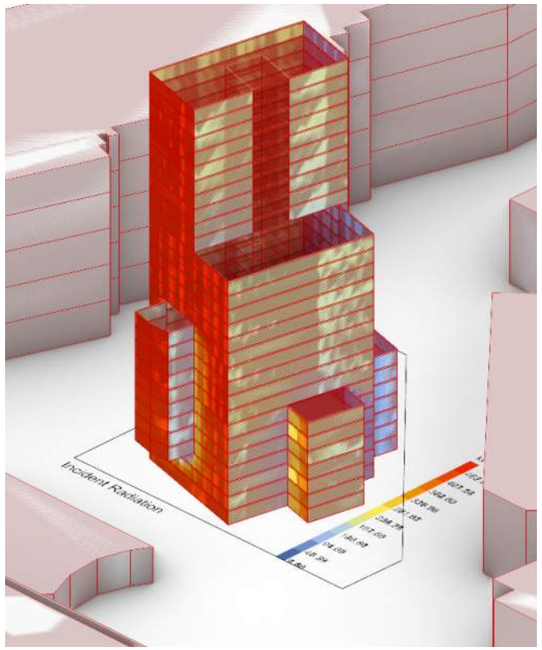
MASSING

SCRIPT SELECTION

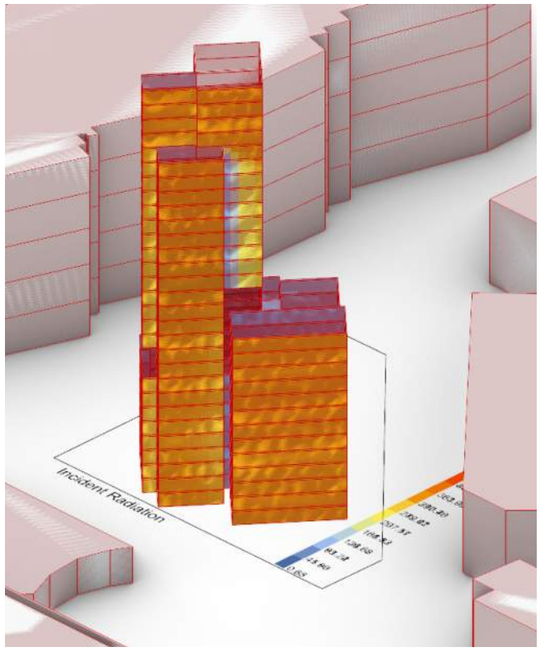


MASSING

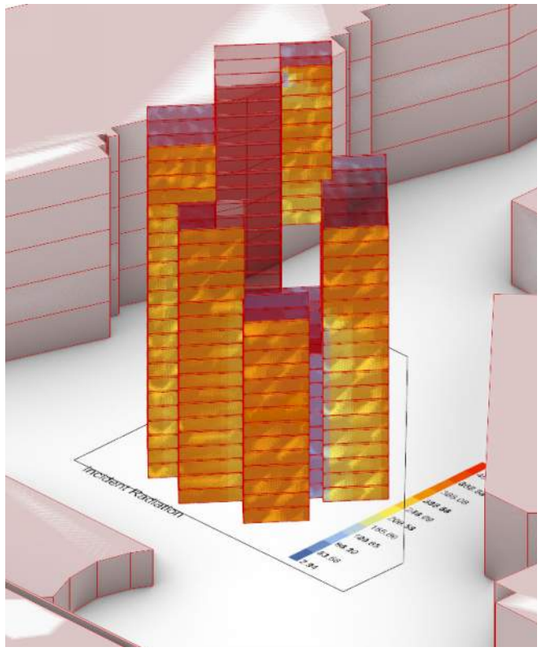
ANALYSIS



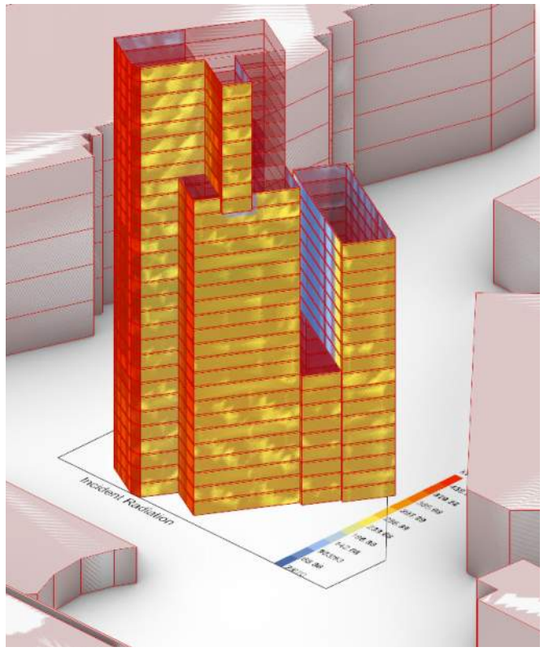
ELIMINATE SMALLER MASSES



ORIENTATION ENSURES NOT A LOT OF DIRECT SUNLIGHT



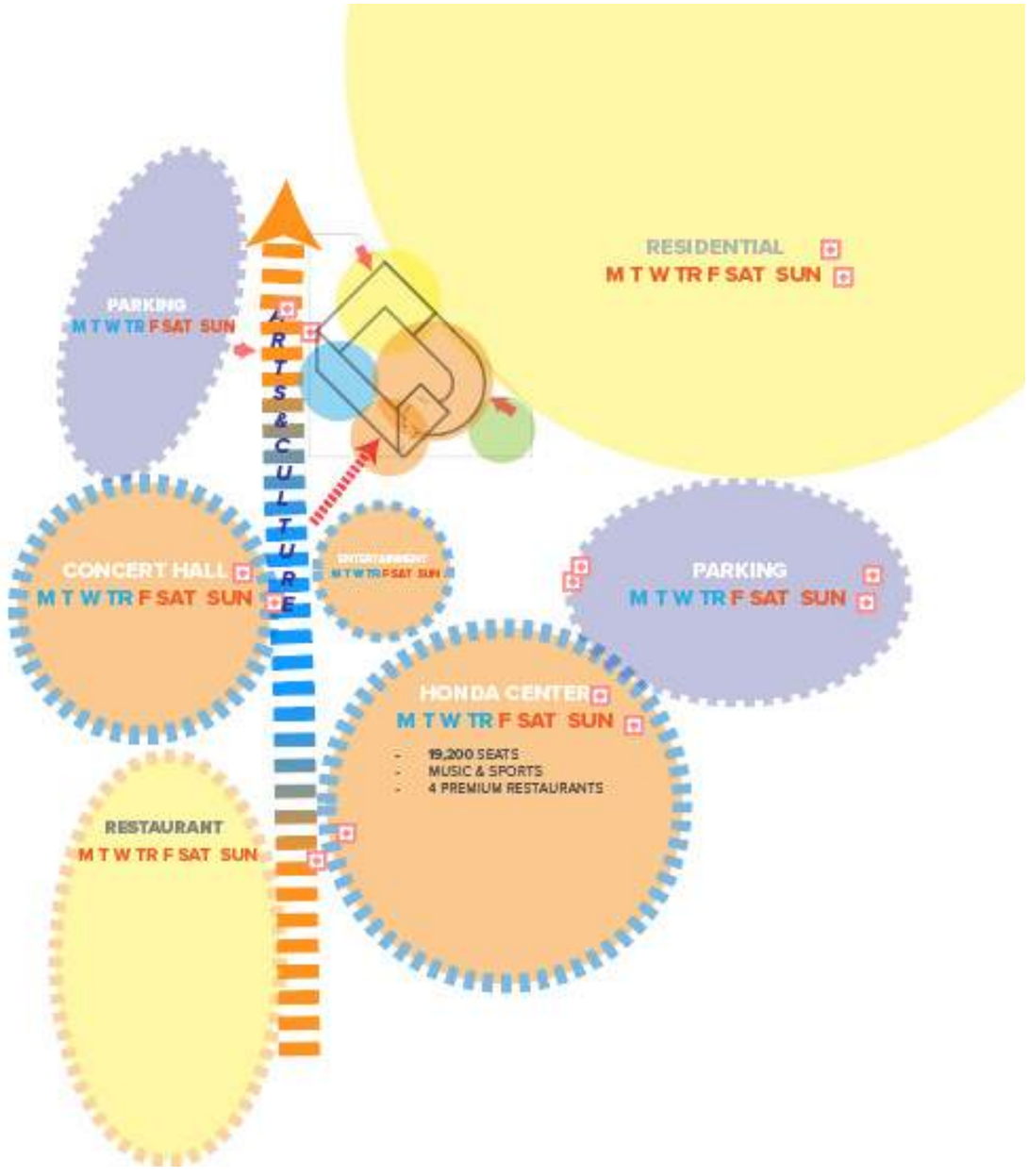
MASSES BREAK DOWN TO PROVIDE MANY VIEWS

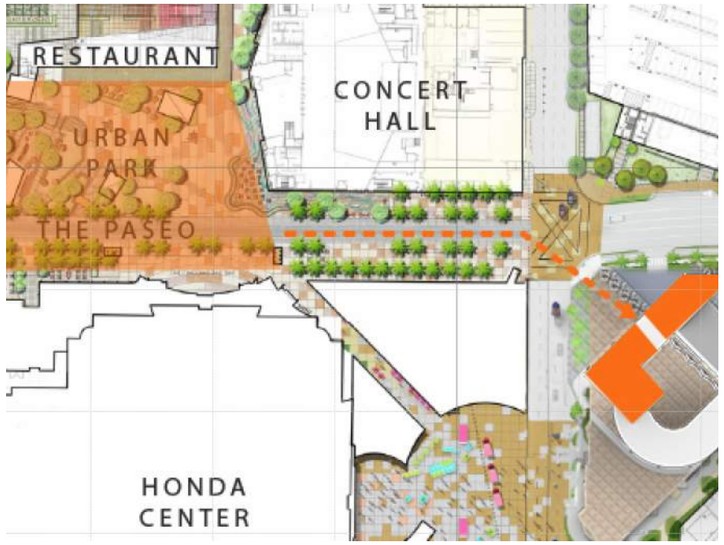


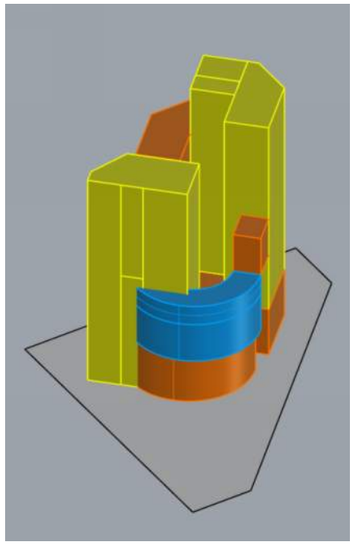
VOIDS BECOME ROOM FOR OUTDOOR TERRACES AND COURTYARDS

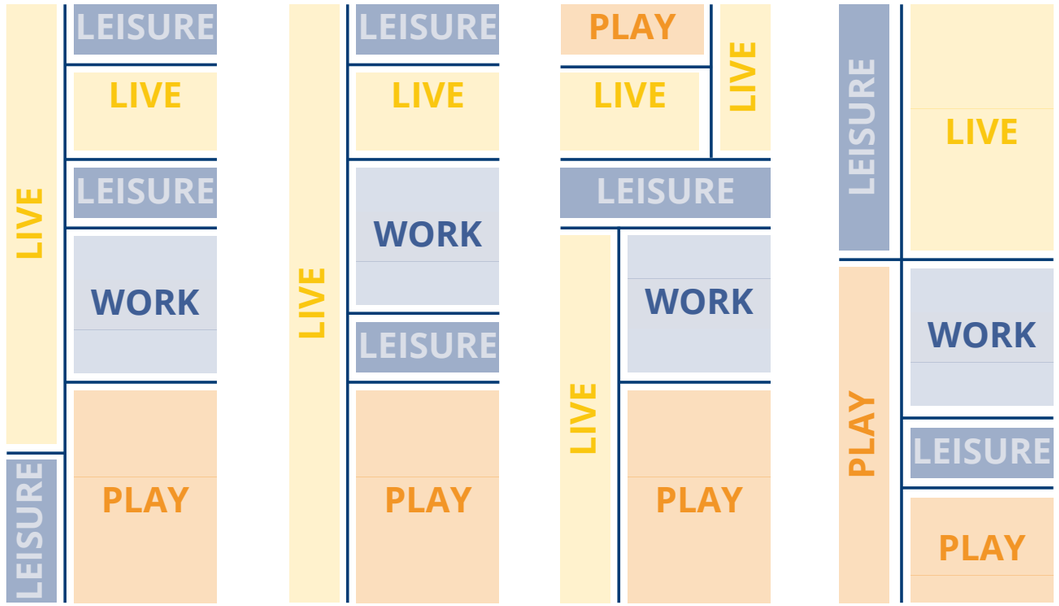
MASSING

PLANNING








LIVE
LEISURE
LIVE
LEISURE
WORK
PLAY
LEISURE
LIVE
LEISURE
WORK
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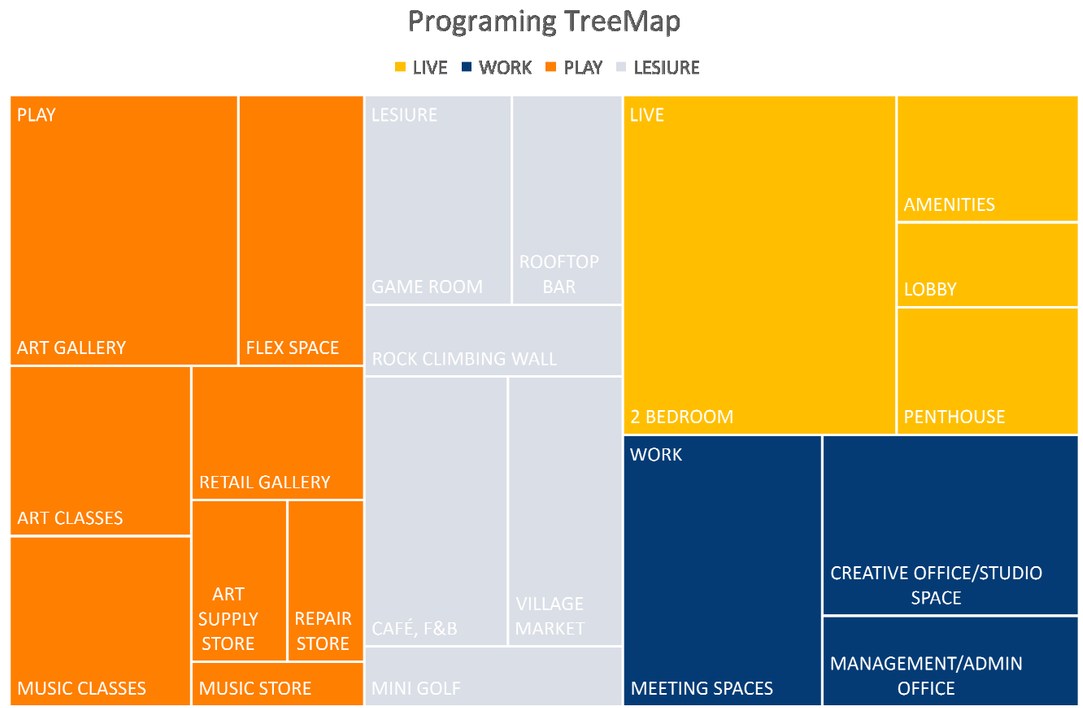
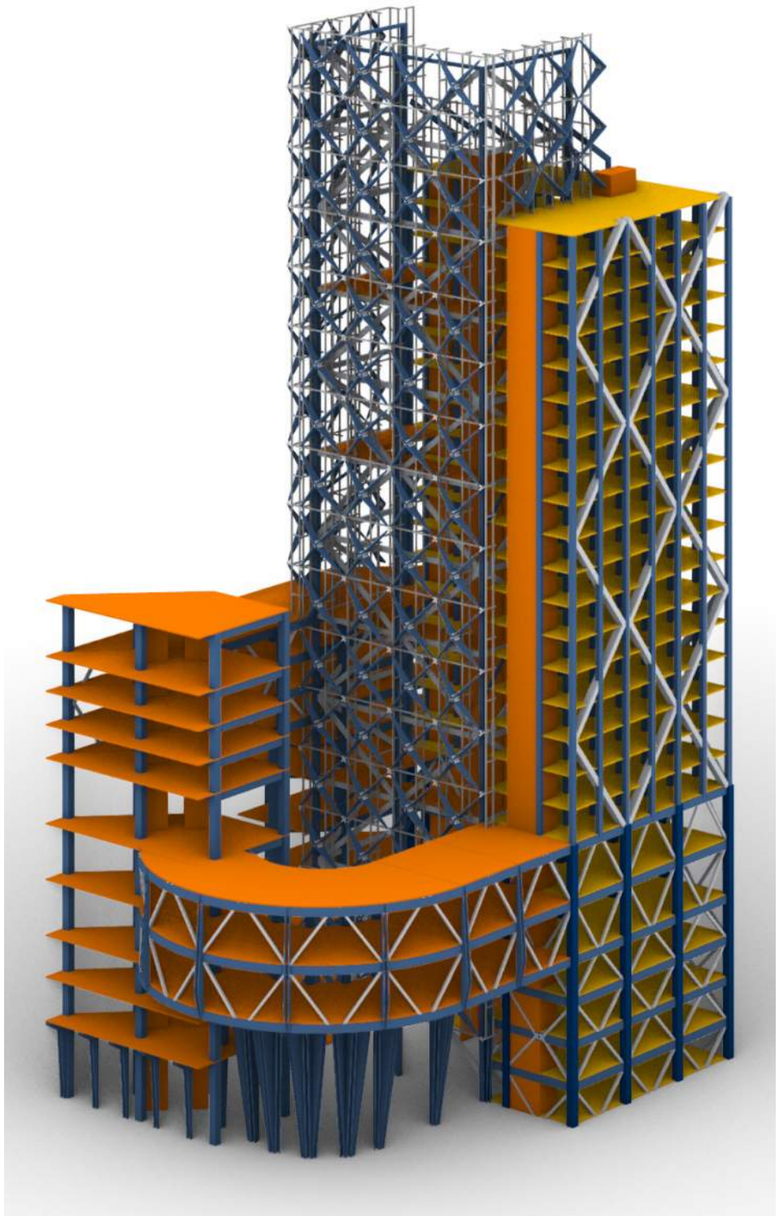
PLAY


Programing TreeMap
LIVE
WORK
PLAY
LESIURE
PLAY
ART GALLERY
FLEX SPACE
ART CLASSES
RETAIL GALLERY
ART SUPPLY STORE
REPAIR STORE
MUSIC CLASSES
MUSIC STORE
LESIURE
GAME ROOM
ROOFTOP BAR
ROCK CLIMBING WALL
CAFÉ, F&B
VILLAGE MARKET
MINI GOLF
LIVE
2 BEDROOM
AMENITIES
LOBBY
PENTHOUSE
WORK
MEETING SPACES
CREATIVE OFFICE/STUDIO SPACE
MANAGEMENT/ADMIN OFFICE

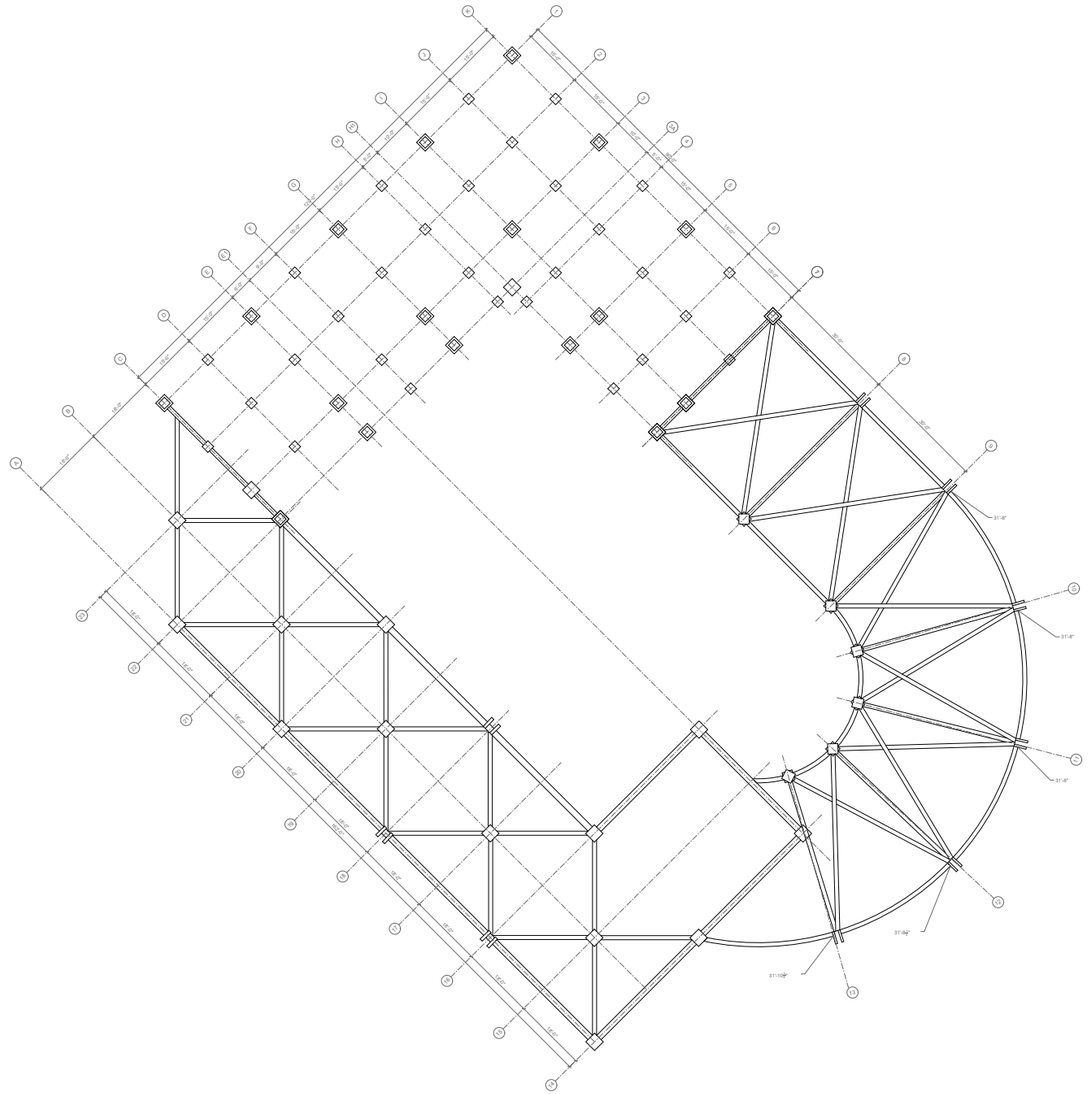
DOCUMENTATION

STRUCTURAL OVERVIEW



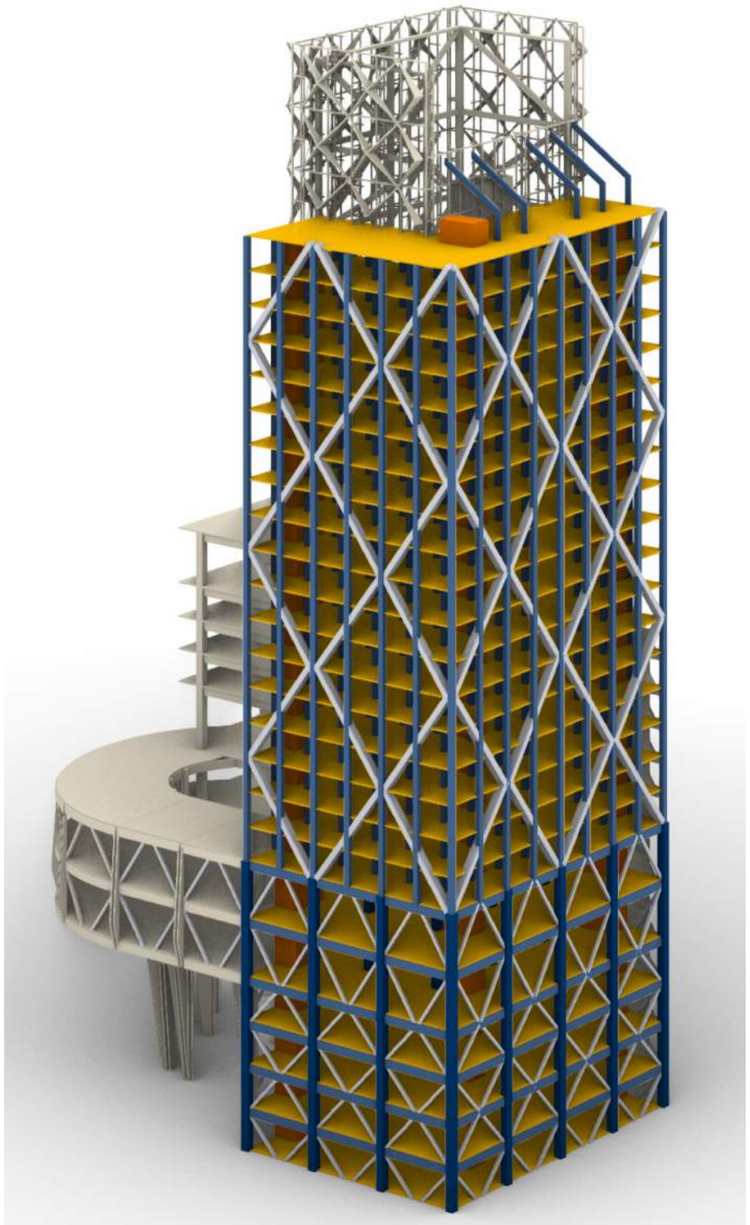
LEGEND

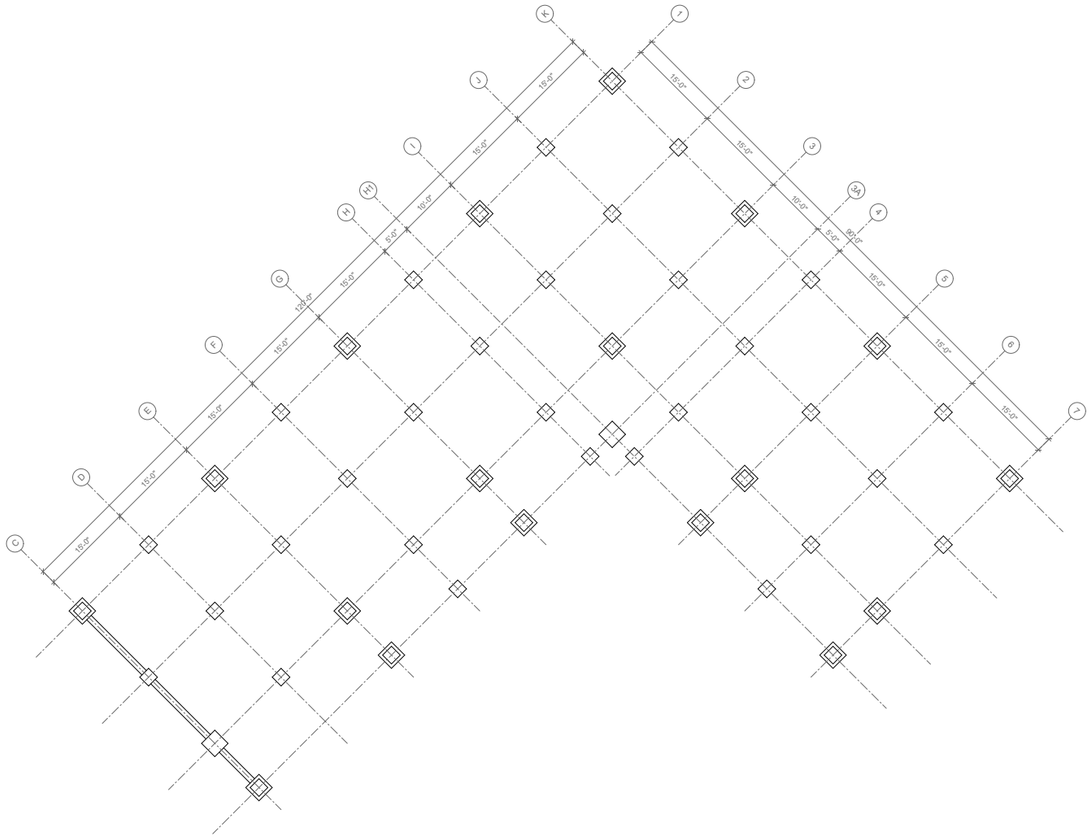
- CLT
- MPP
- GLULAM
- TYPE IA GLULAM
- GLULAM-STEEL BRACING



DOCUMENTATION

RESIDENTIAL STRUCTURE



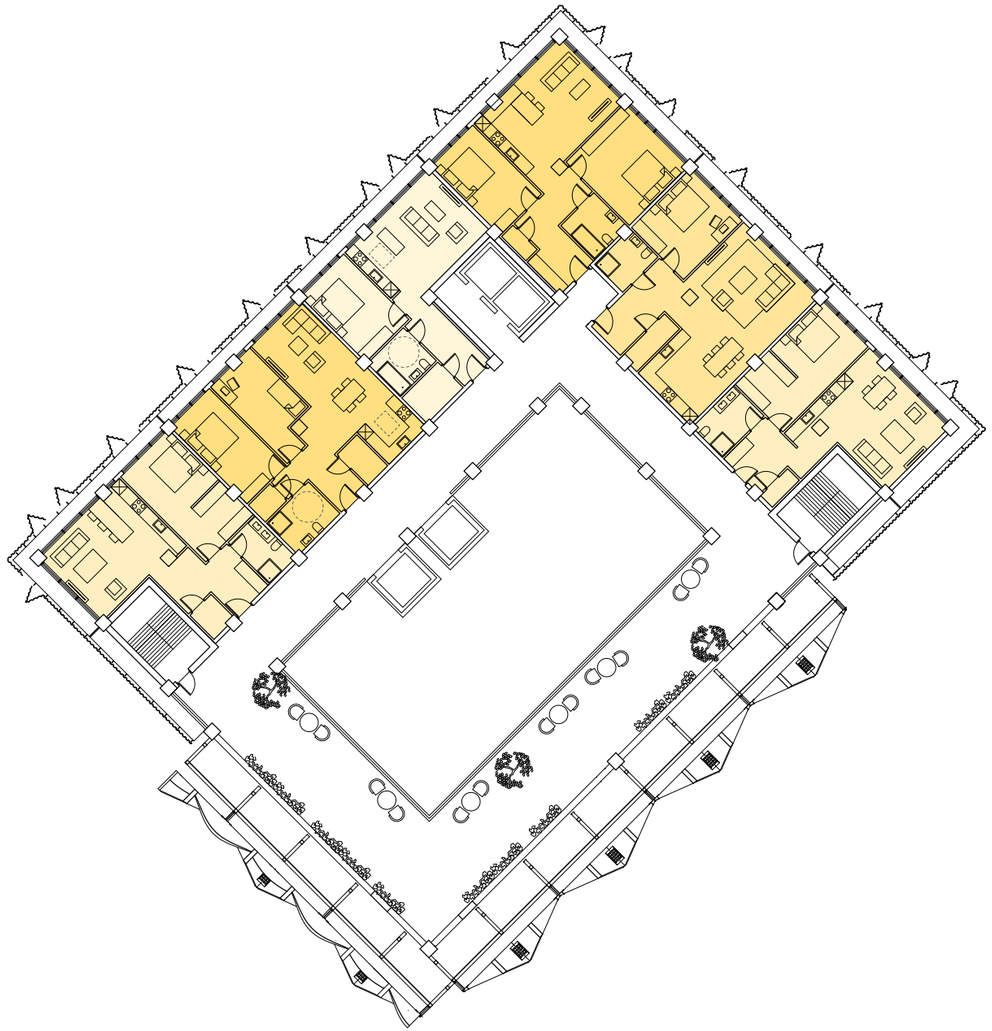


LEGEND

- CLT
- MPP
- GLULAM
- TYPE IA GLULAM
- GLULAM-STEEL BRACING

DOCUMENTATION

RESIDENTIAL TYP. FLOOR PLANS

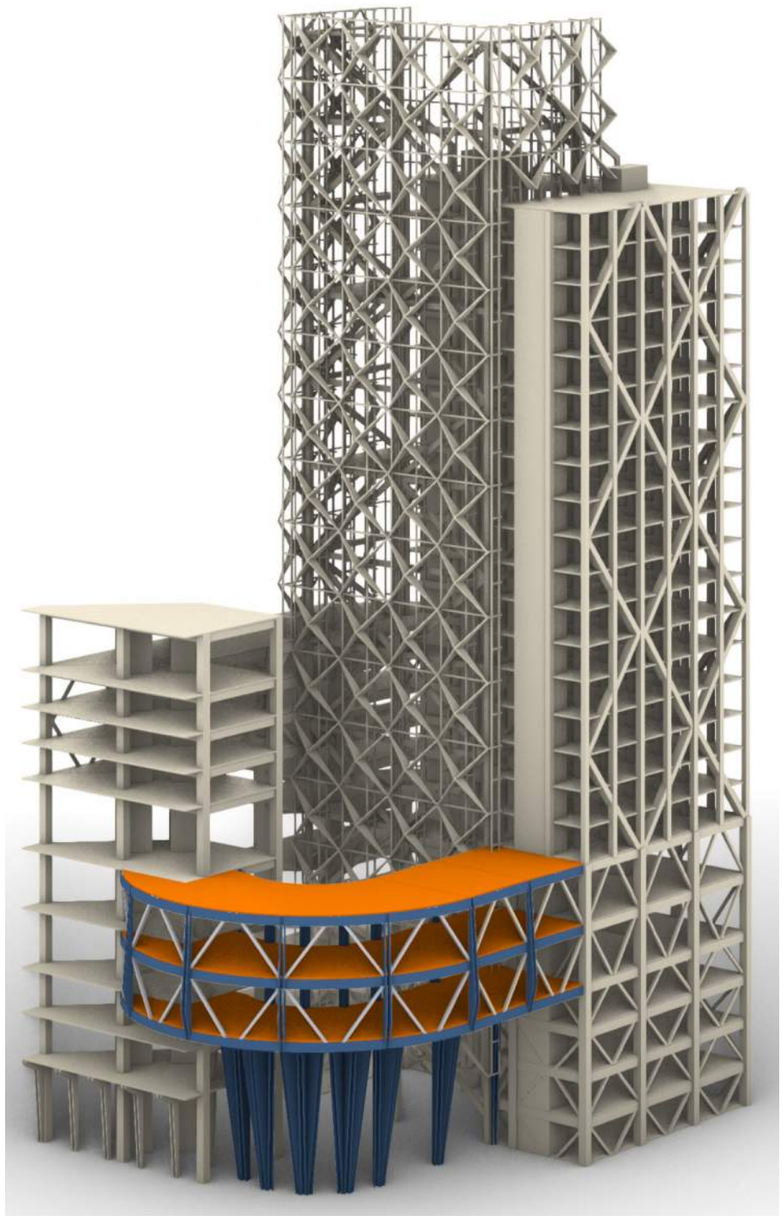


TYP. 6 UNITS FLOOR PLAN
1 BEDROOM, 2 BEDROOM
600-900 SQFT

TYP. 4 UNITS FLOOR PLAN
2 BEDROOM, 3 BEDROOM
1100-1300 SQFT

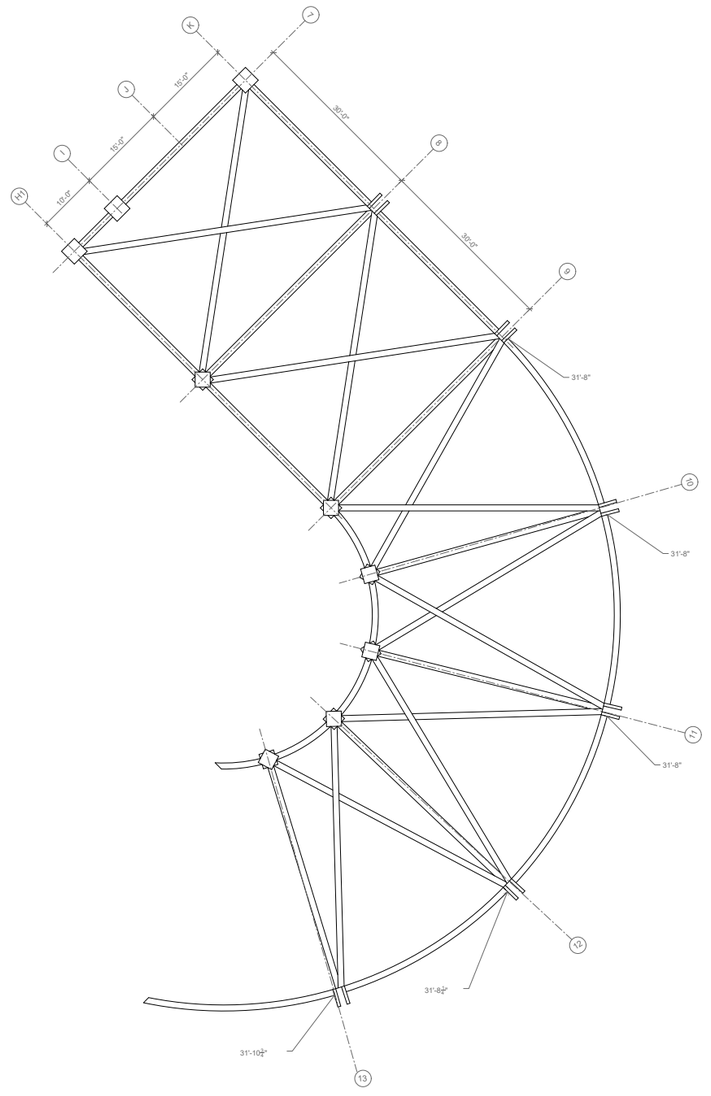
DOCUMENTATION

U-SHAPE STRUCTURE



LEGEND

- CLT
- MPP
- GLULAM
- TYPE IA GLULAM
- GLULAM-STEEL BRACING

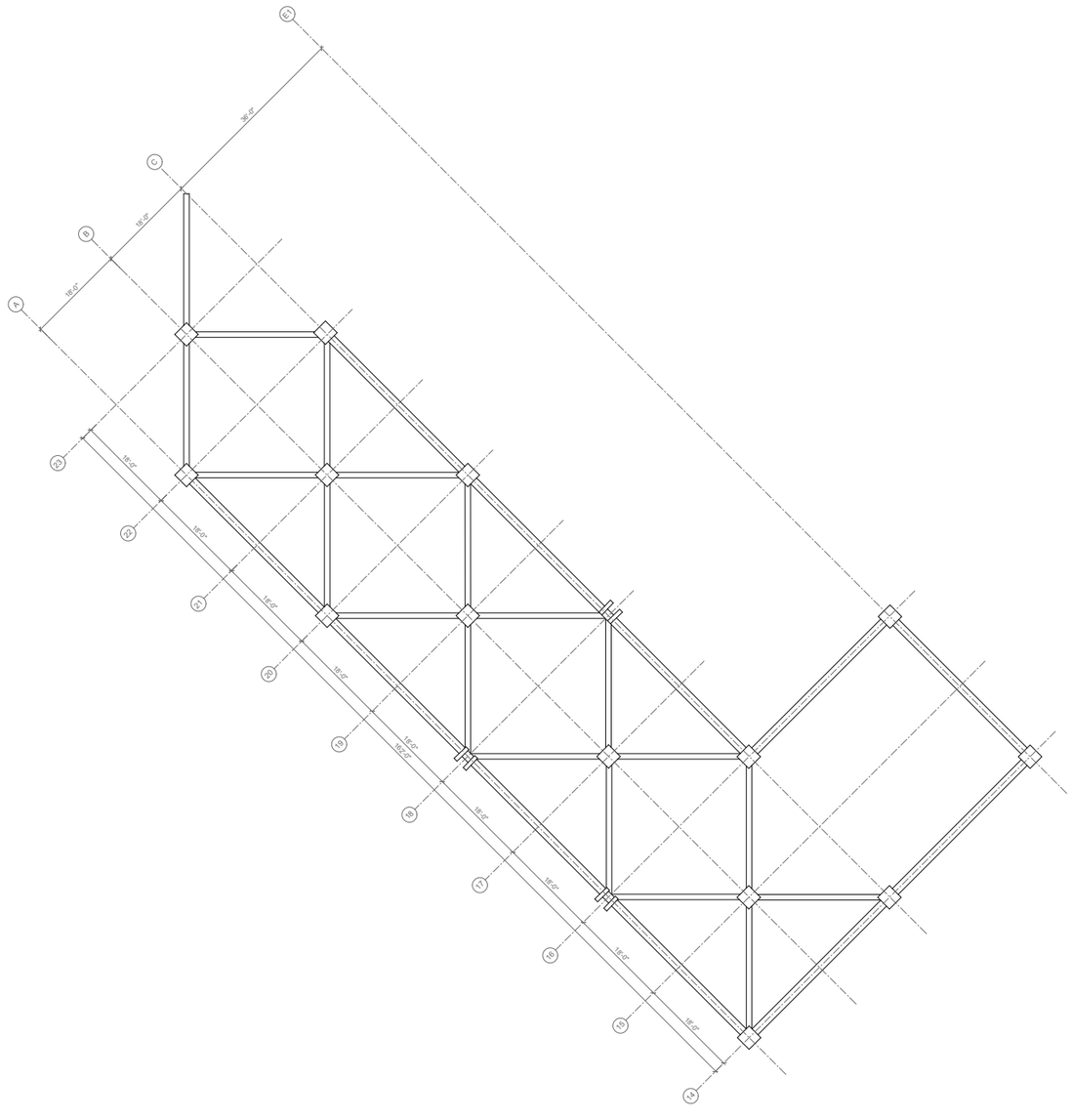


DOCUMENTATION

OFFICE + BRIDGE + GALLERY STRUCTURE

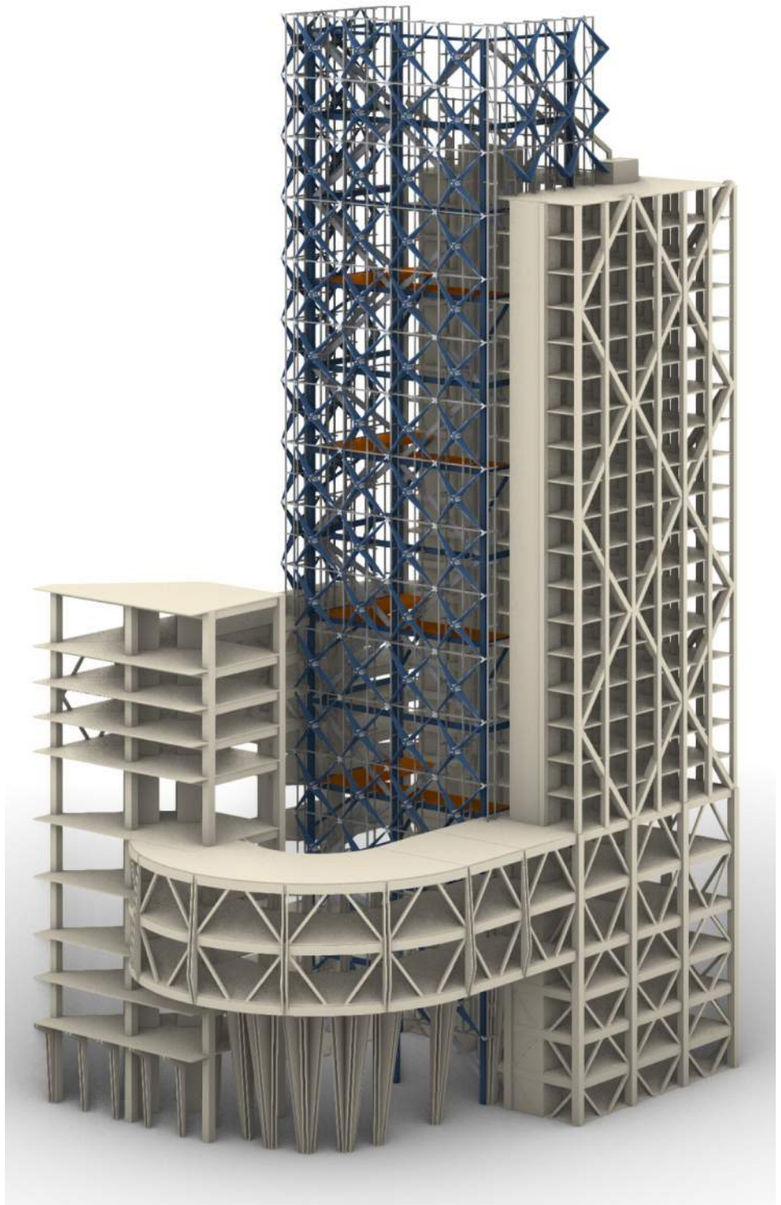
LEGEND

- CLT
- MPP
- GLULAM
- TYPE IA GLULAM
- GLULAM-STEEL BRACING



DOCUMENTATION

ATRIUM

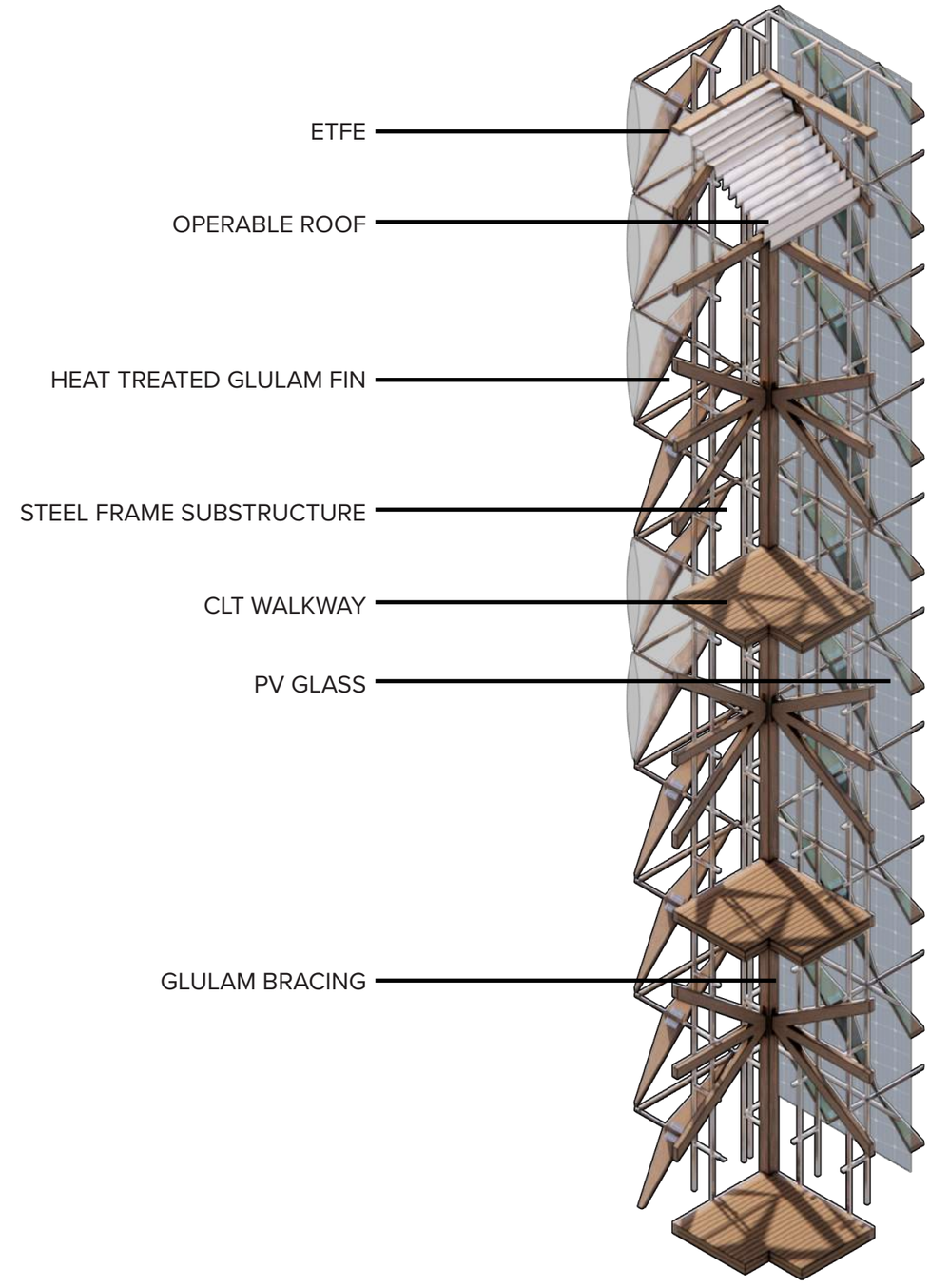


LEGEND

- CLT
- MPP
- GLULAM
- TYPE IA GLULAM
- GLULAM-STEEL BRACING

MATERIALS

FINAL STUDY



MATERIALS

APPLICATION STUDY

①

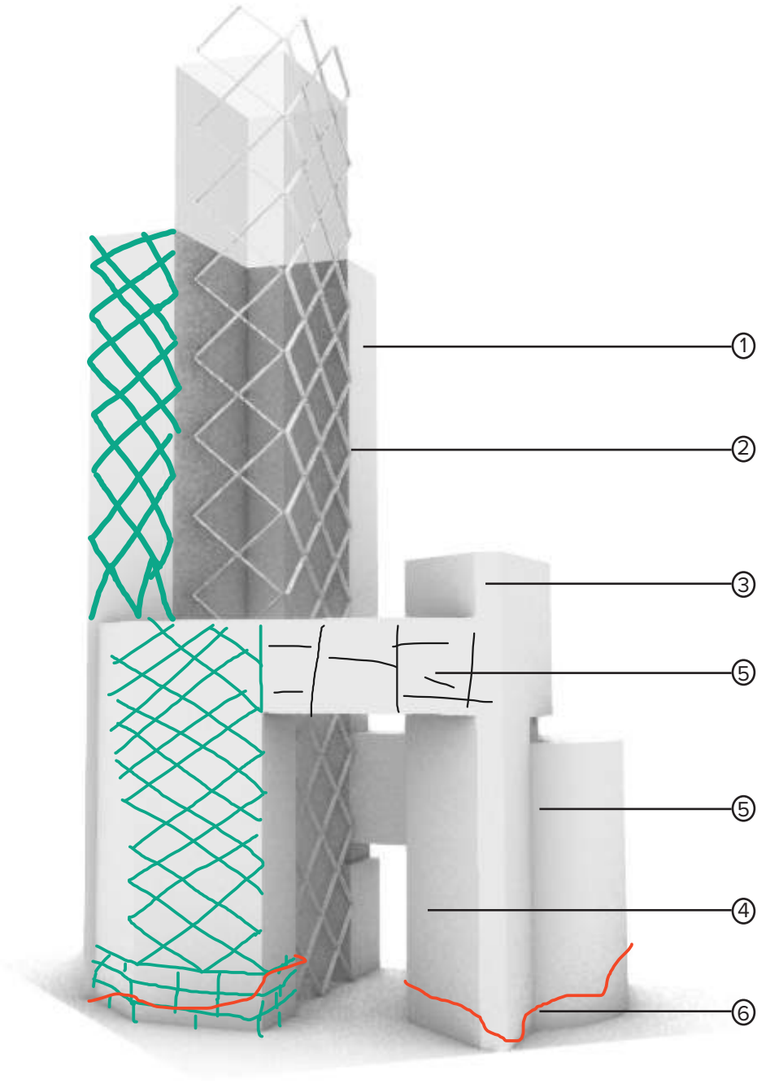
②

③

④

⑤

⑥



INITIAL MATERIAL STUDY

MATERIALS

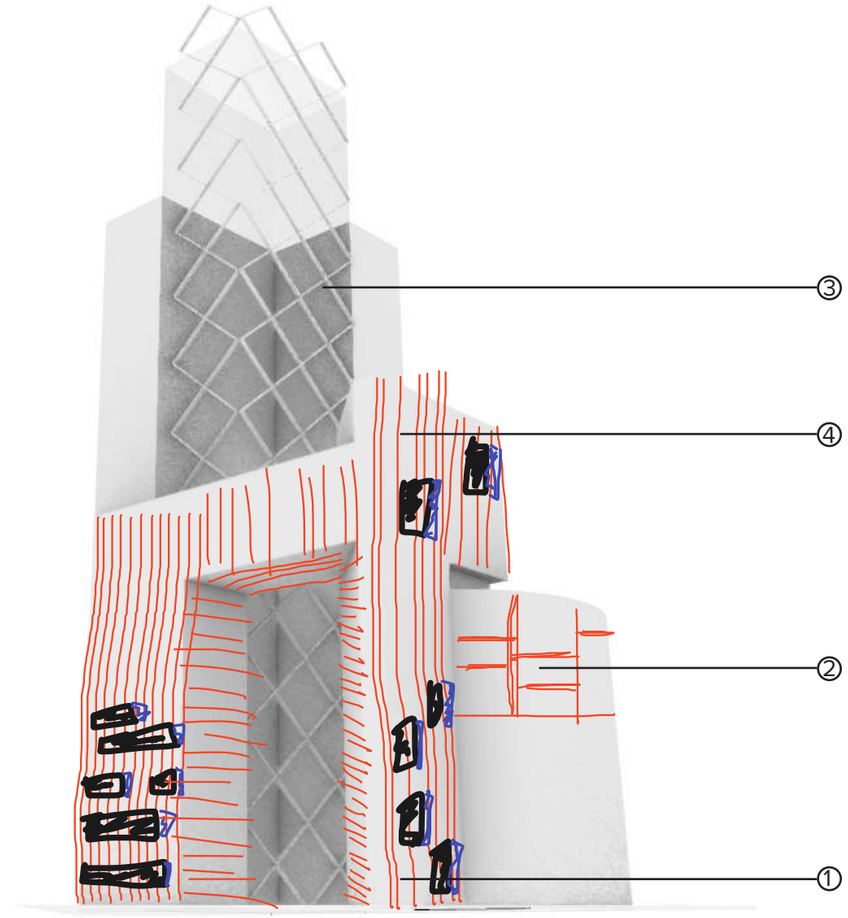
APPLICATION STUDY

① METAL MESH

② TIMBER CURTAIN WALL

③ WOOD BATTEN

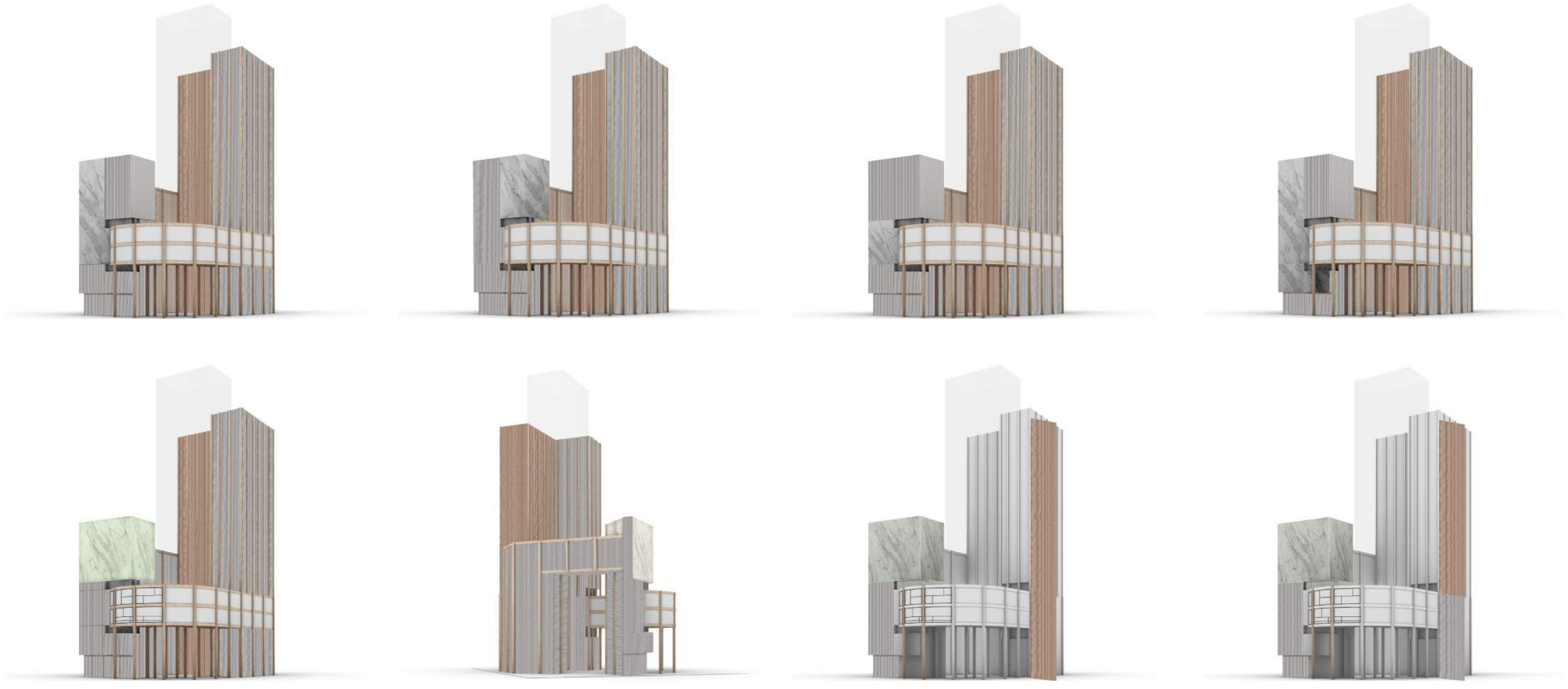
④ SEMI-OPAQUE MARBLE



FINAL MATERIAL STUDY

MATERIALS

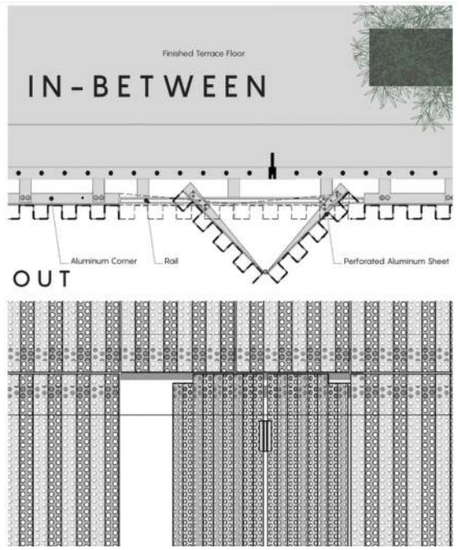
APPLICATION STUDY

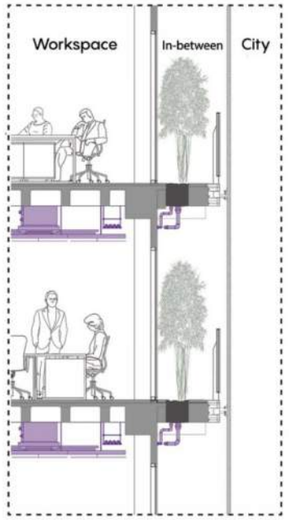


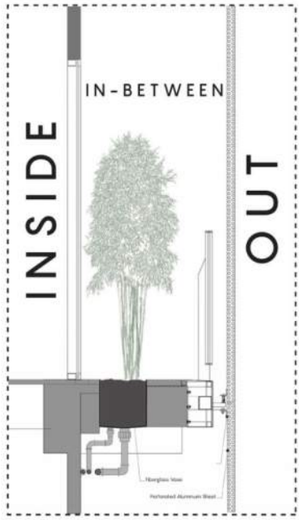
MATERIAL BRAINSTORMING

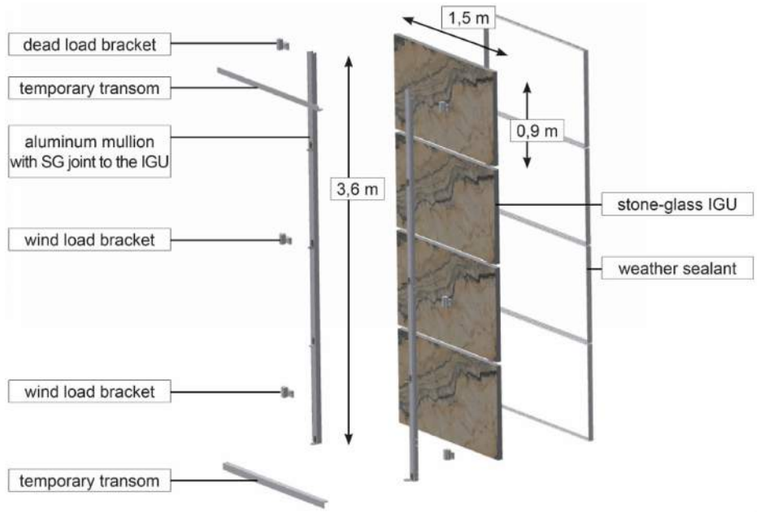
DOCUMENTATION

CONNECTION DETAILS - MESH + STONE







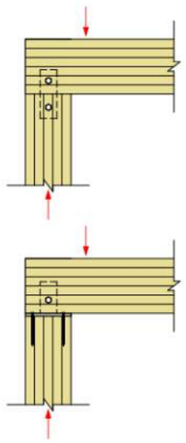


DOCUMENTATION

CONNECTION DETAILS - TIMBER CURTAIN WALL

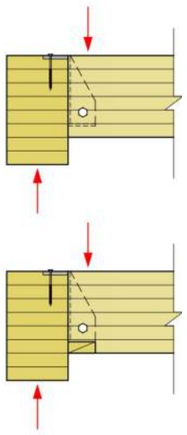
9-2.

Beam Bears on Column with Knife Plate



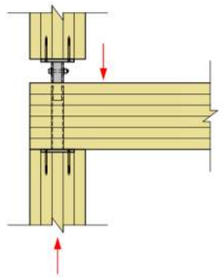
8-4.

Beam Bears on Concealed Steel Bearing Plate with Knife Plate



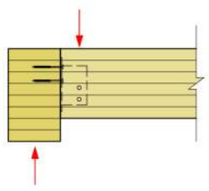
9-10.

Column and Beam Bear on Column at Standoff



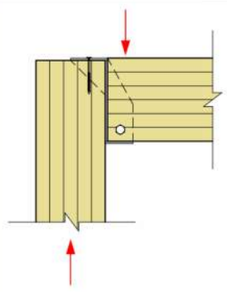
8-7.

Beam Connected to Girder with Concealed Face-Mounted Knife Plate Connector



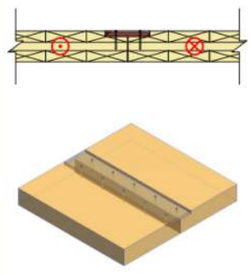
9-11.

Beam Bears on Steel Bearing Seat with Knife Plates on Column



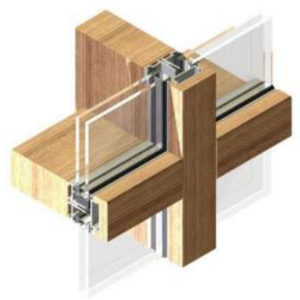
1-1.

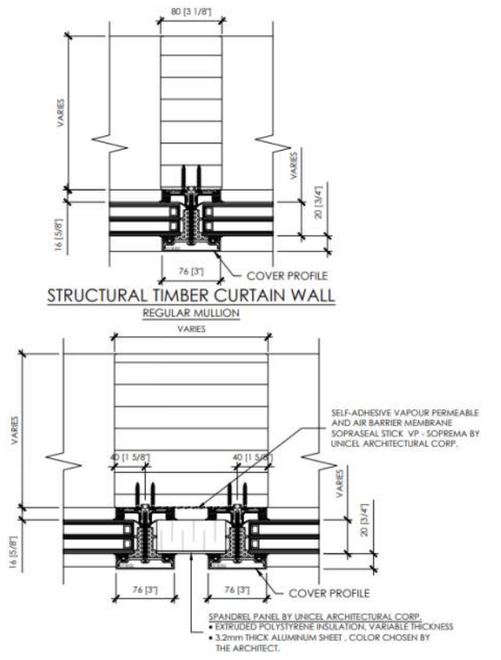
Panels Connect with Single Surface Spline

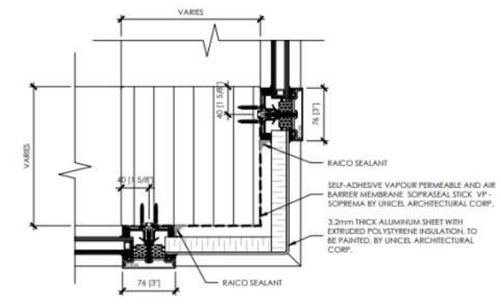


Strap Ties →

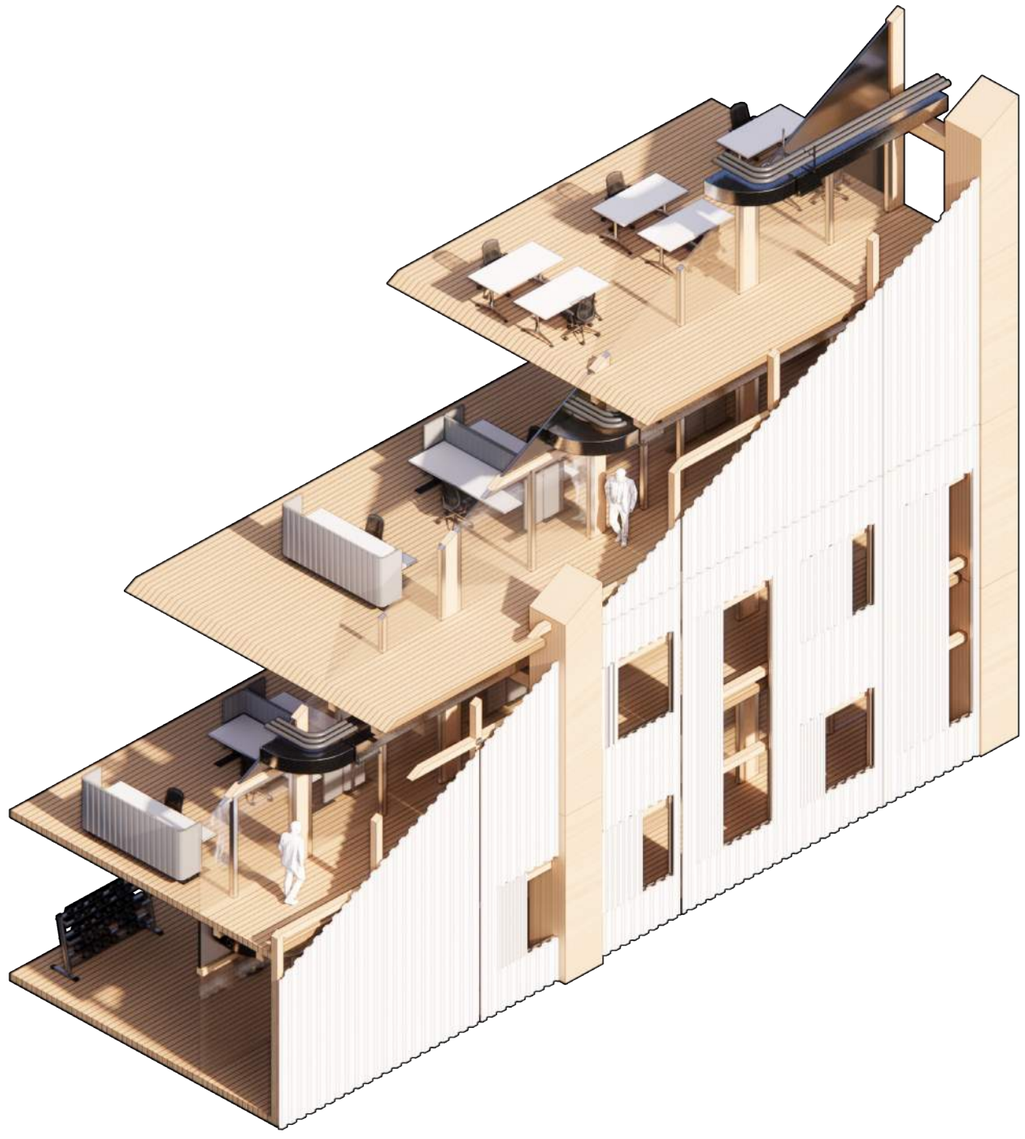
Beam Hangers





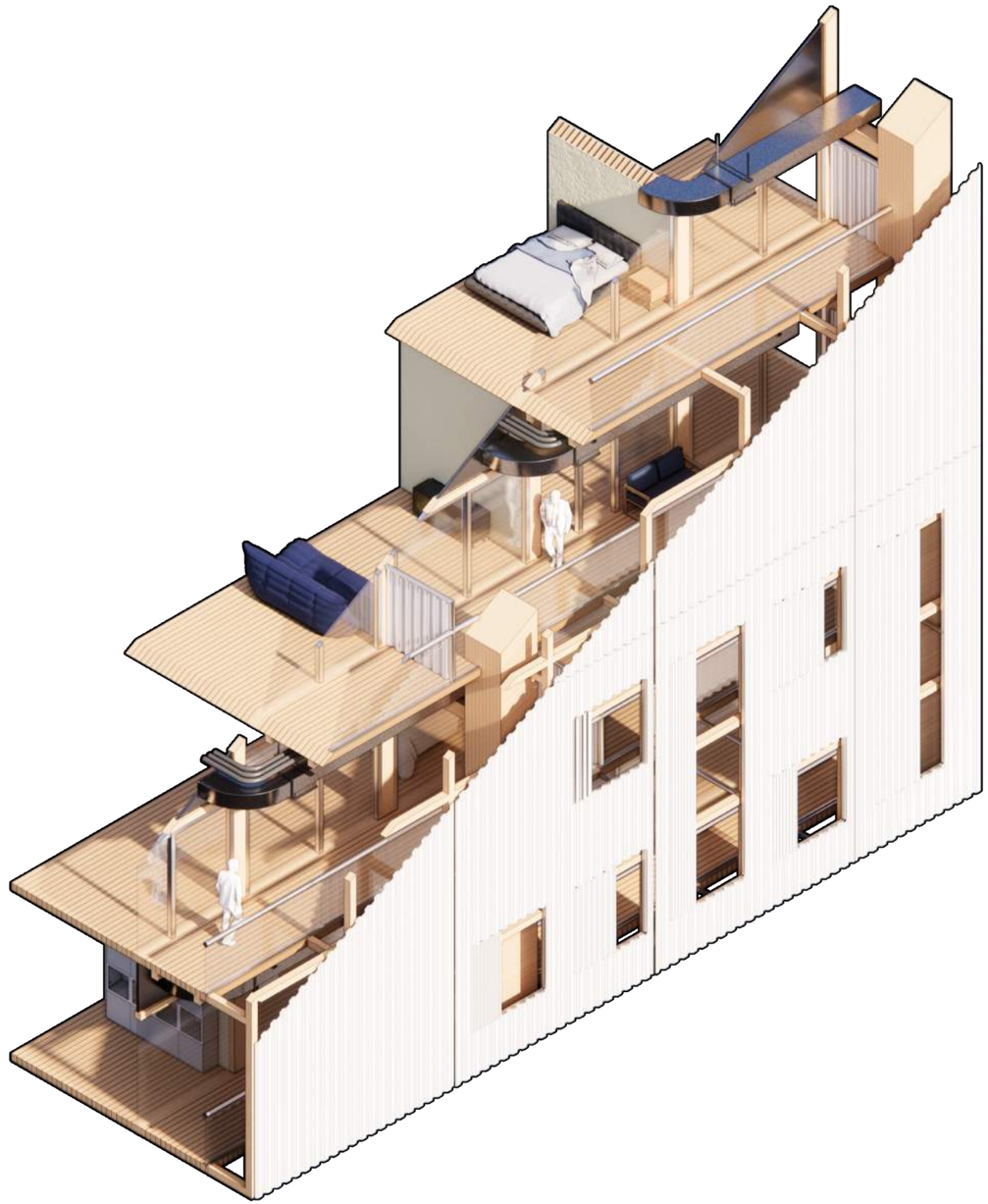


SECTION DETAIL



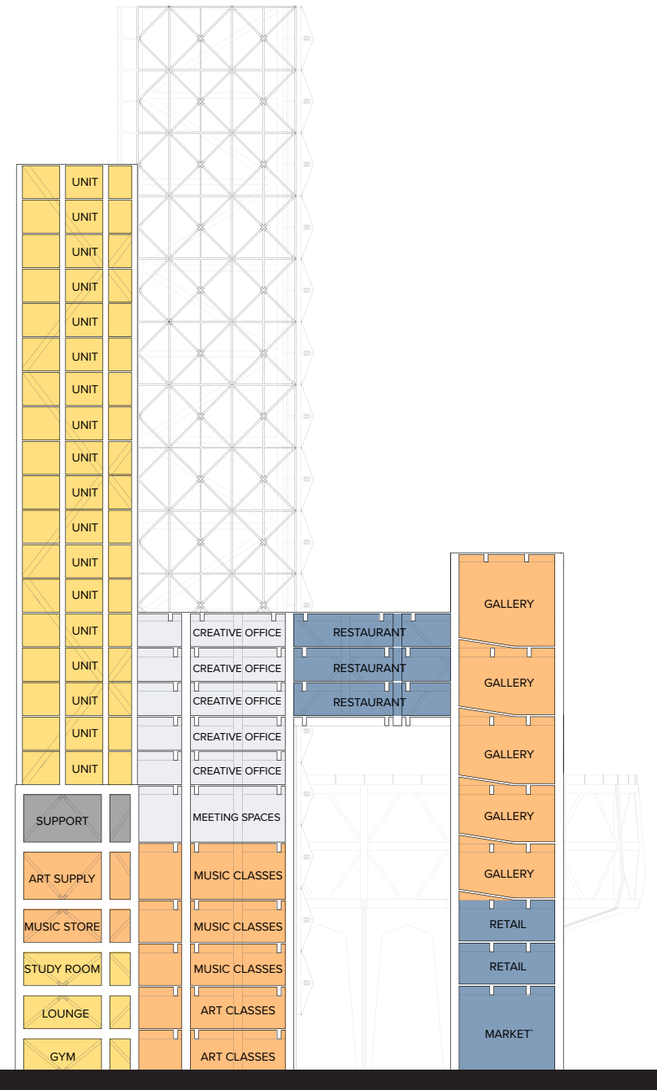
DOCUMENTATION

RESIDENTIAL CHUNK SECTION



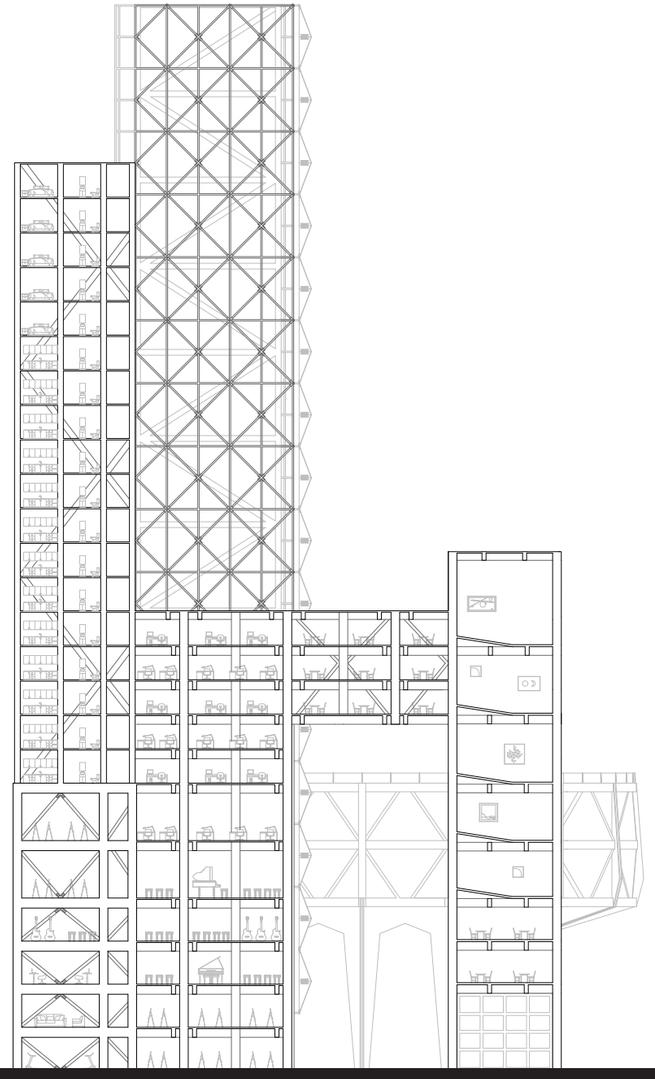
DOCUMENTATION

SECTION - PROGRAMMATIC



DOCUMENTATION

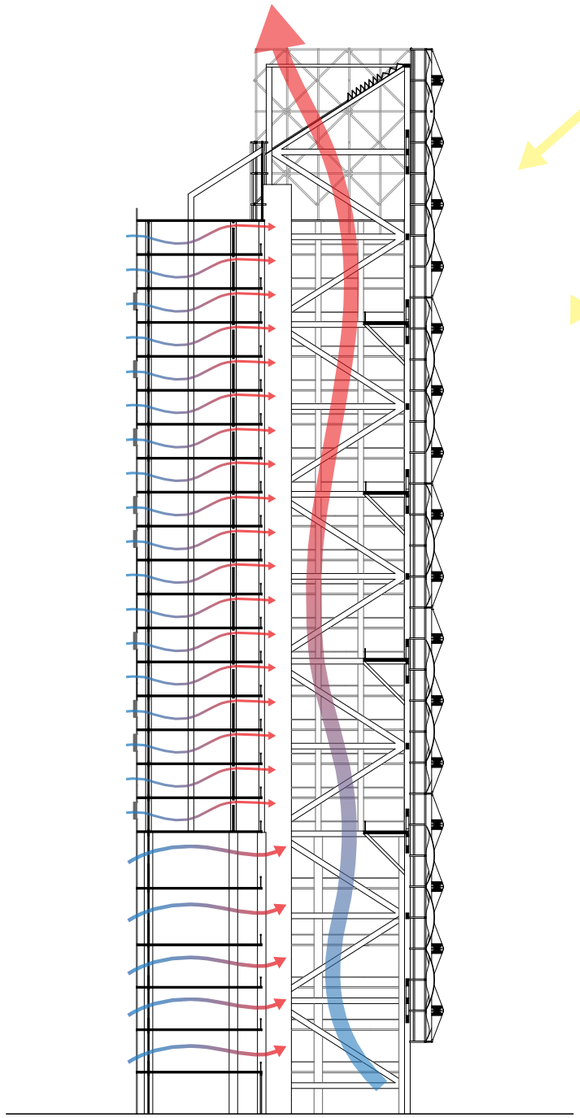
SECTION



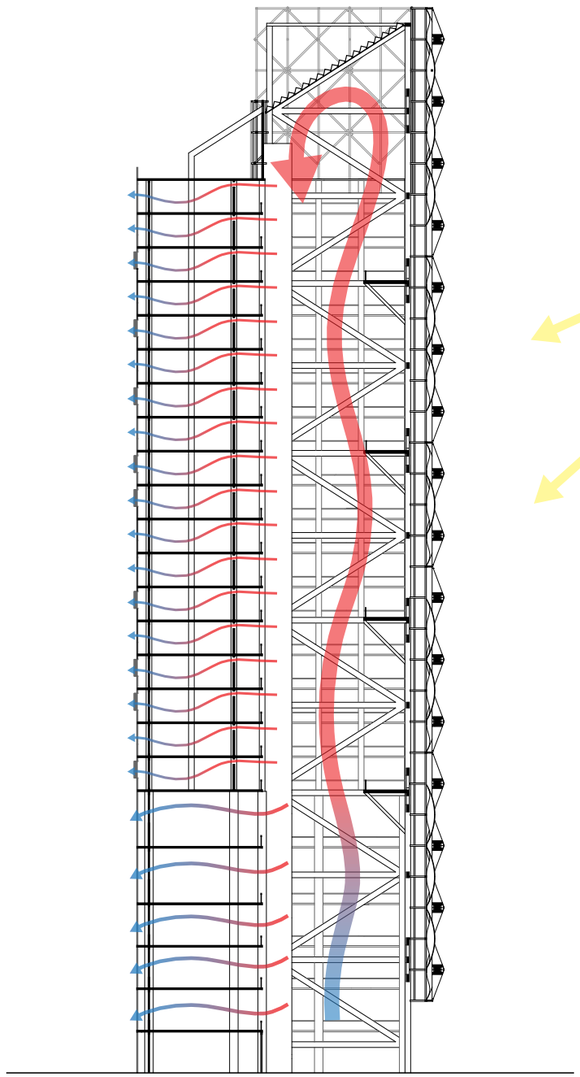
ENVIRONMENT

VENTILATION + PASSIVE COOLING

SUMMER



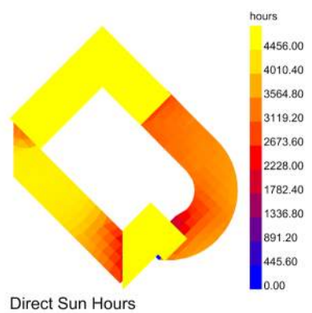
WINTER

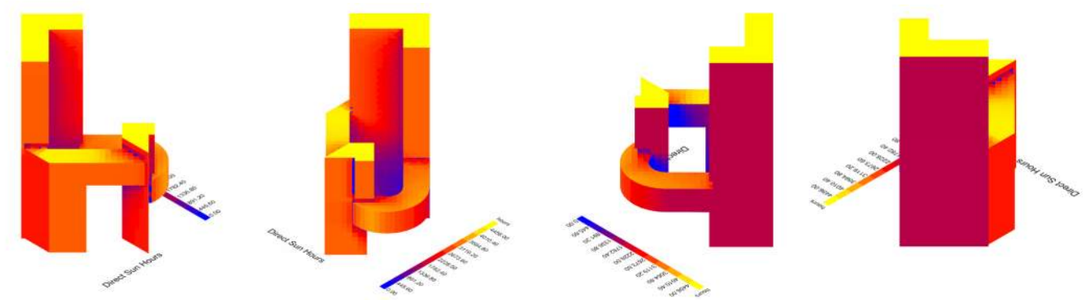


ENVIRONMENT

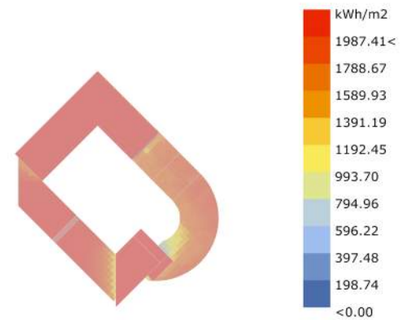
RADIATION - DIRECT SOLAR GAIN

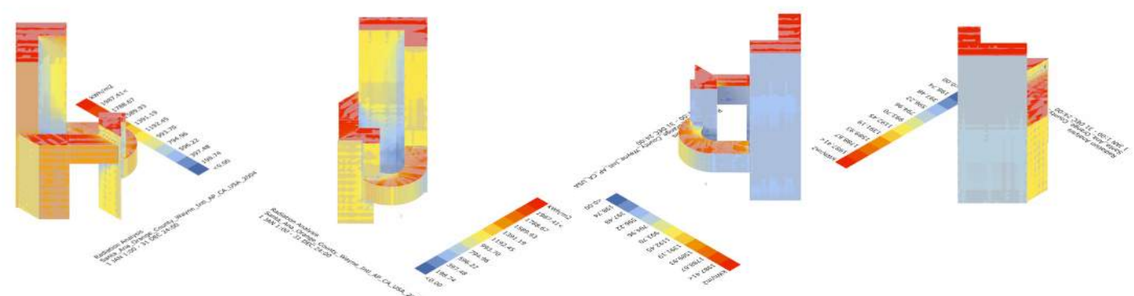
Direct Sun Hour





Solar Radiation



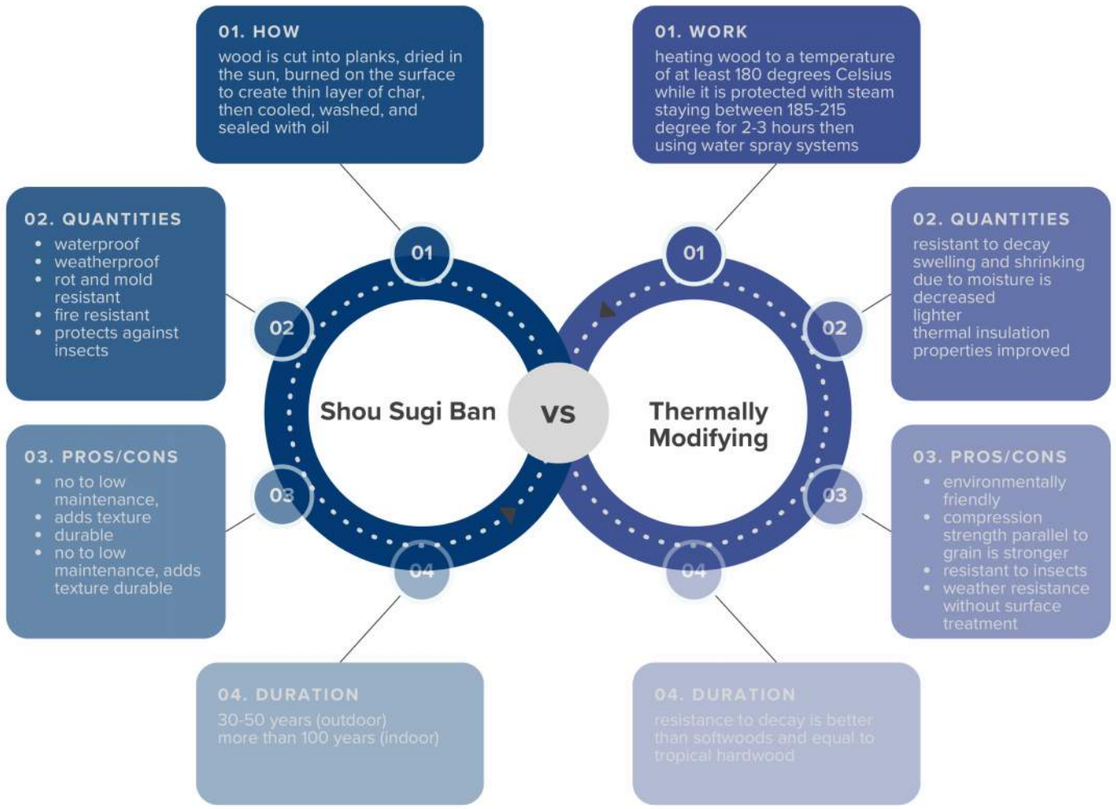


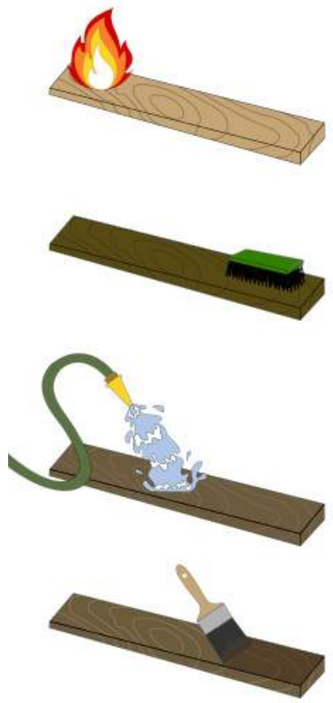
ENVIRONMENT

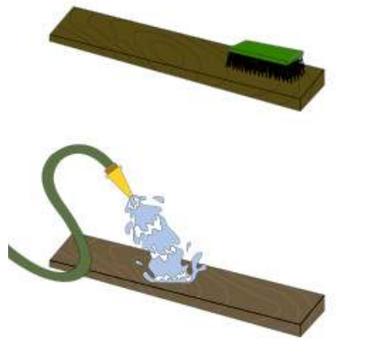
REUSE

ENVIRONMENT

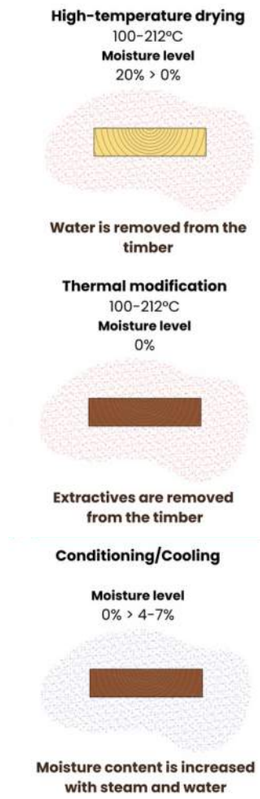
RE-PURPOSE

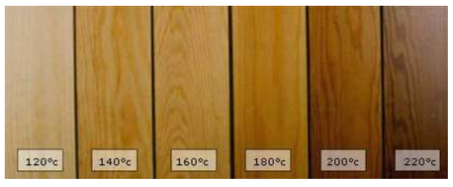






SHOU SUGI BAN

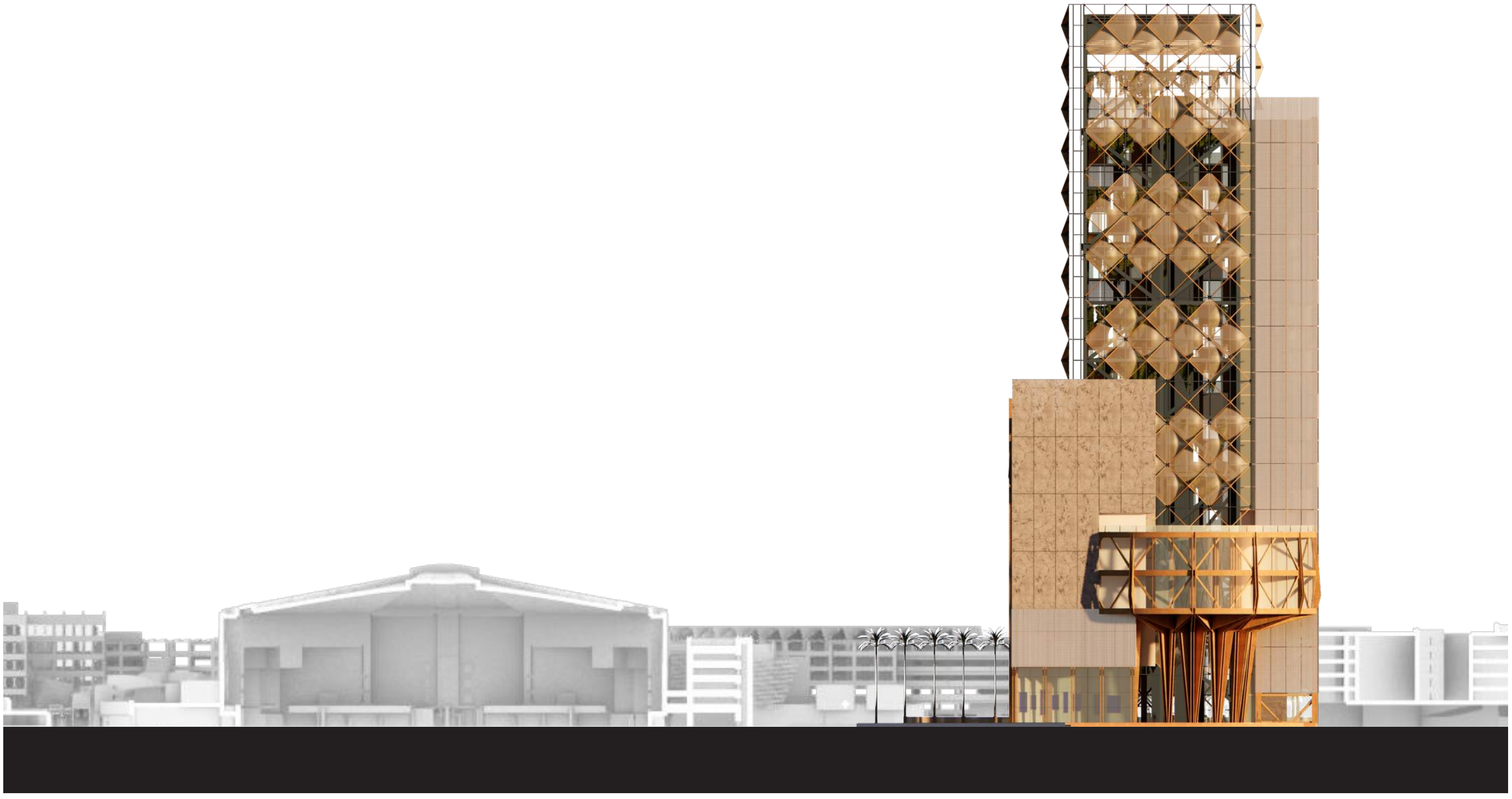




THERMALLY MODIFYING

VIEWS

NORTHWEST ELEVATION



VIEWS

NORTHEAST ELEVATION

VIEWS

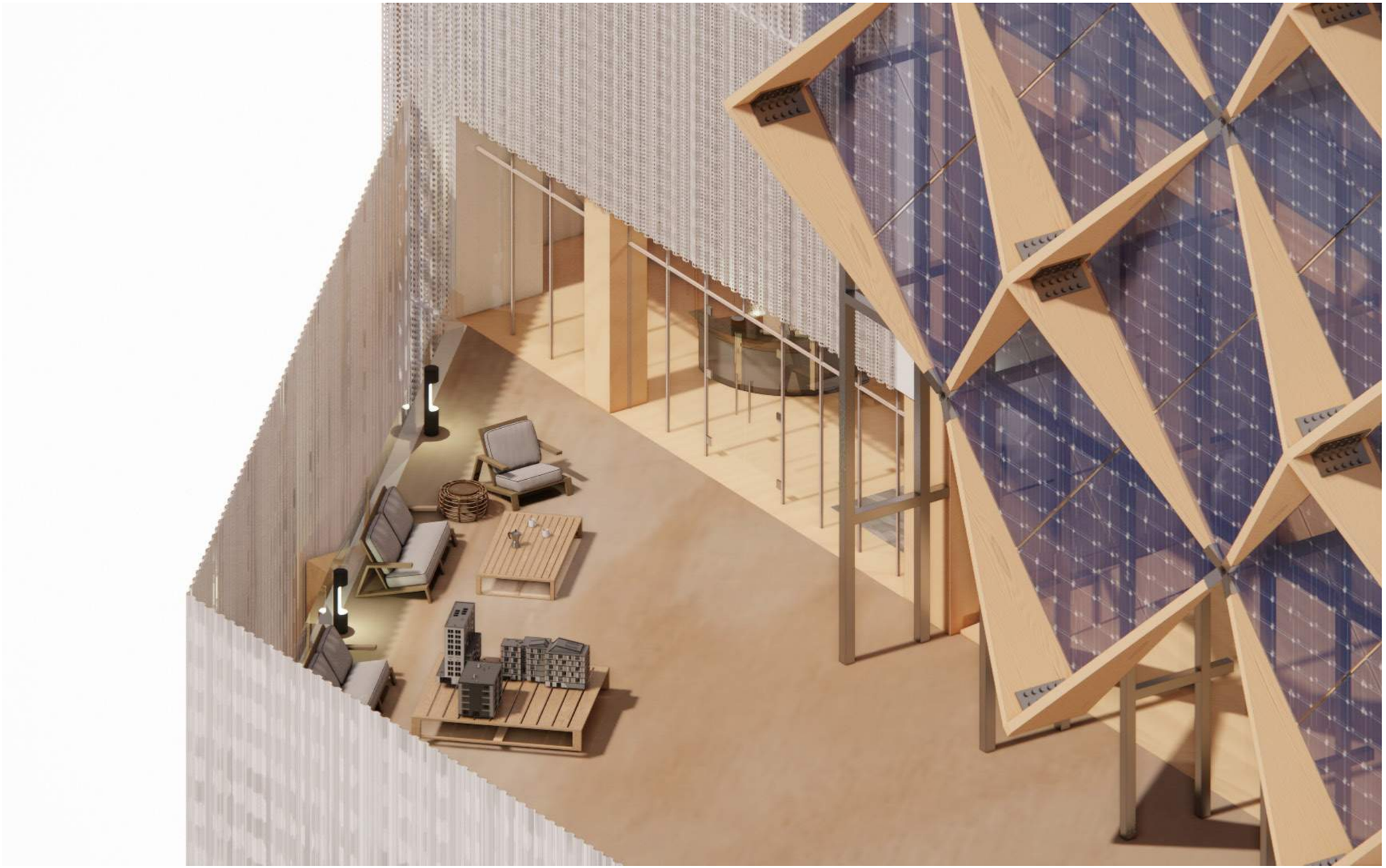
SOUTHEAST ELEVATION

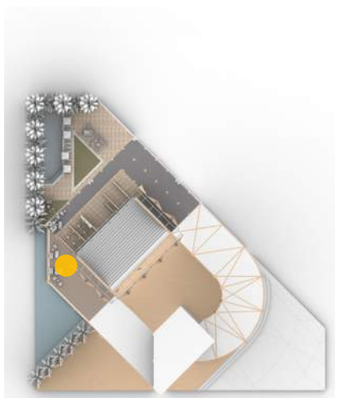
VIEWS

SOUTHWEST ELEVATION

VIEWS

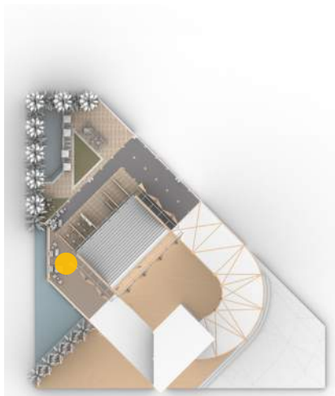
OFFICE + BRIDGE





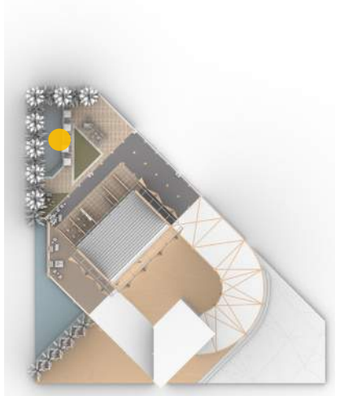
VIEWS

OFFICE + BRIDGE



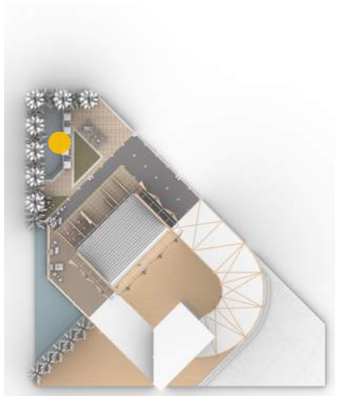
VIEWS

POOL + AMENITY



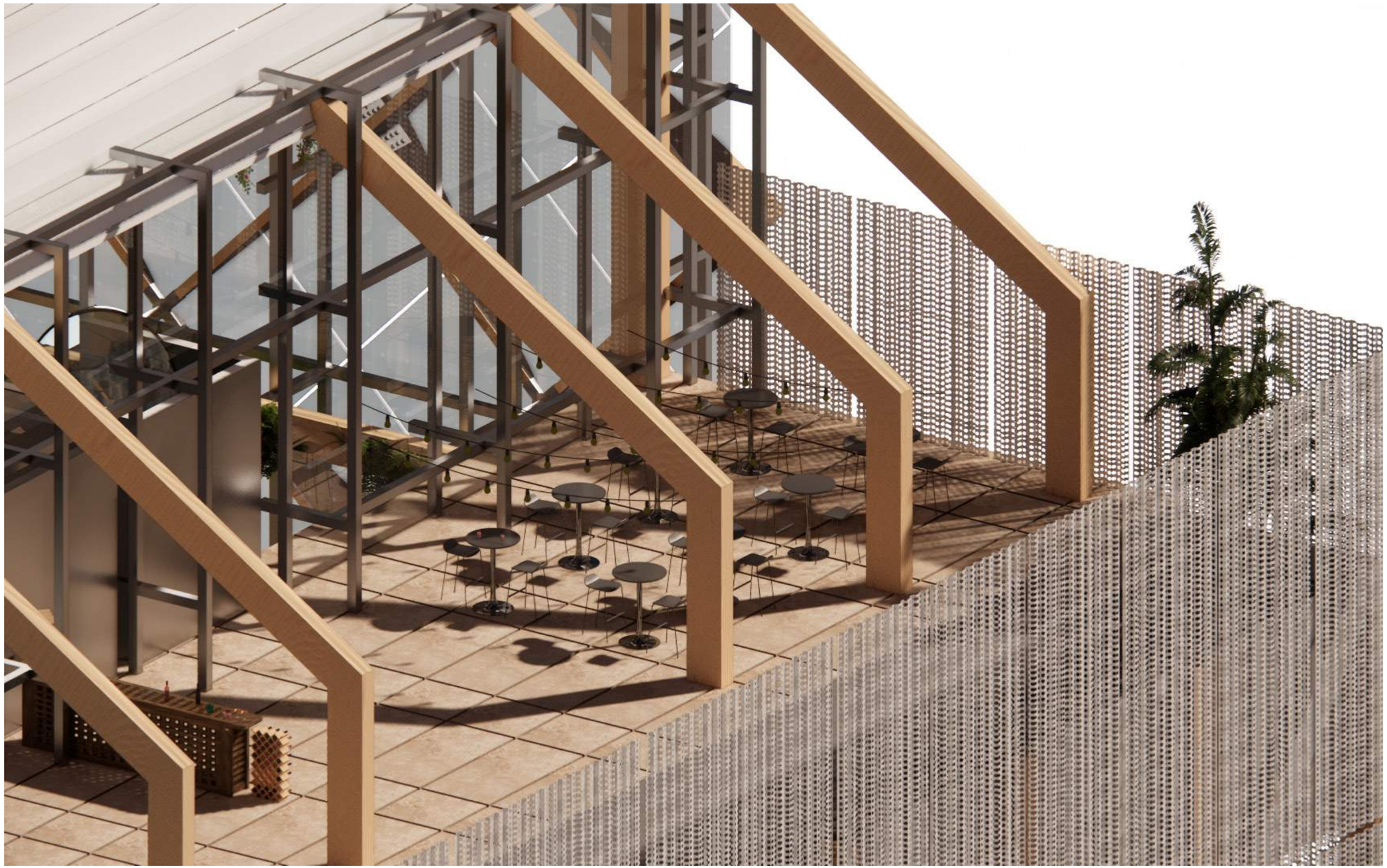
VIEWS

POOL + AMENITY



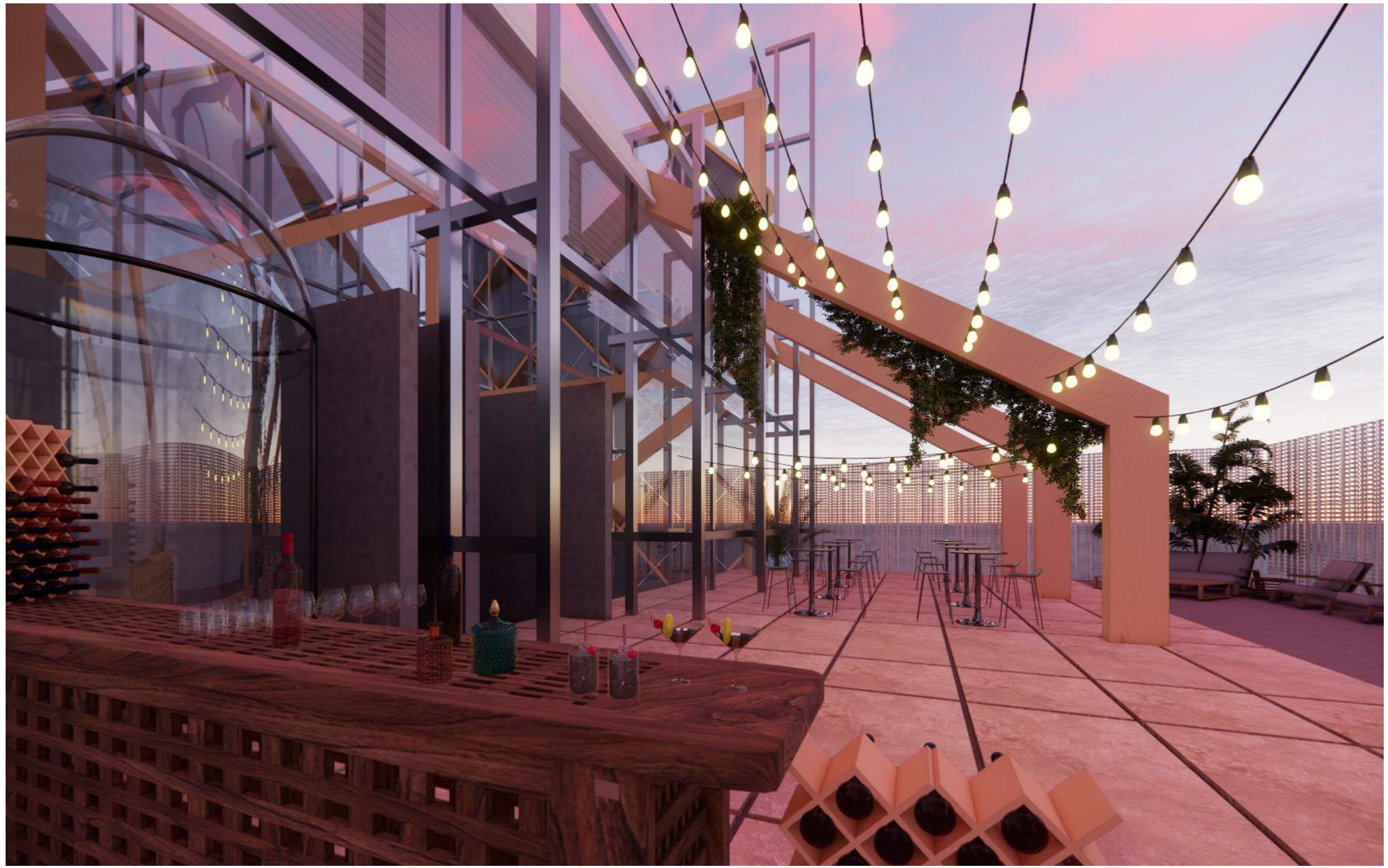
VIEWS

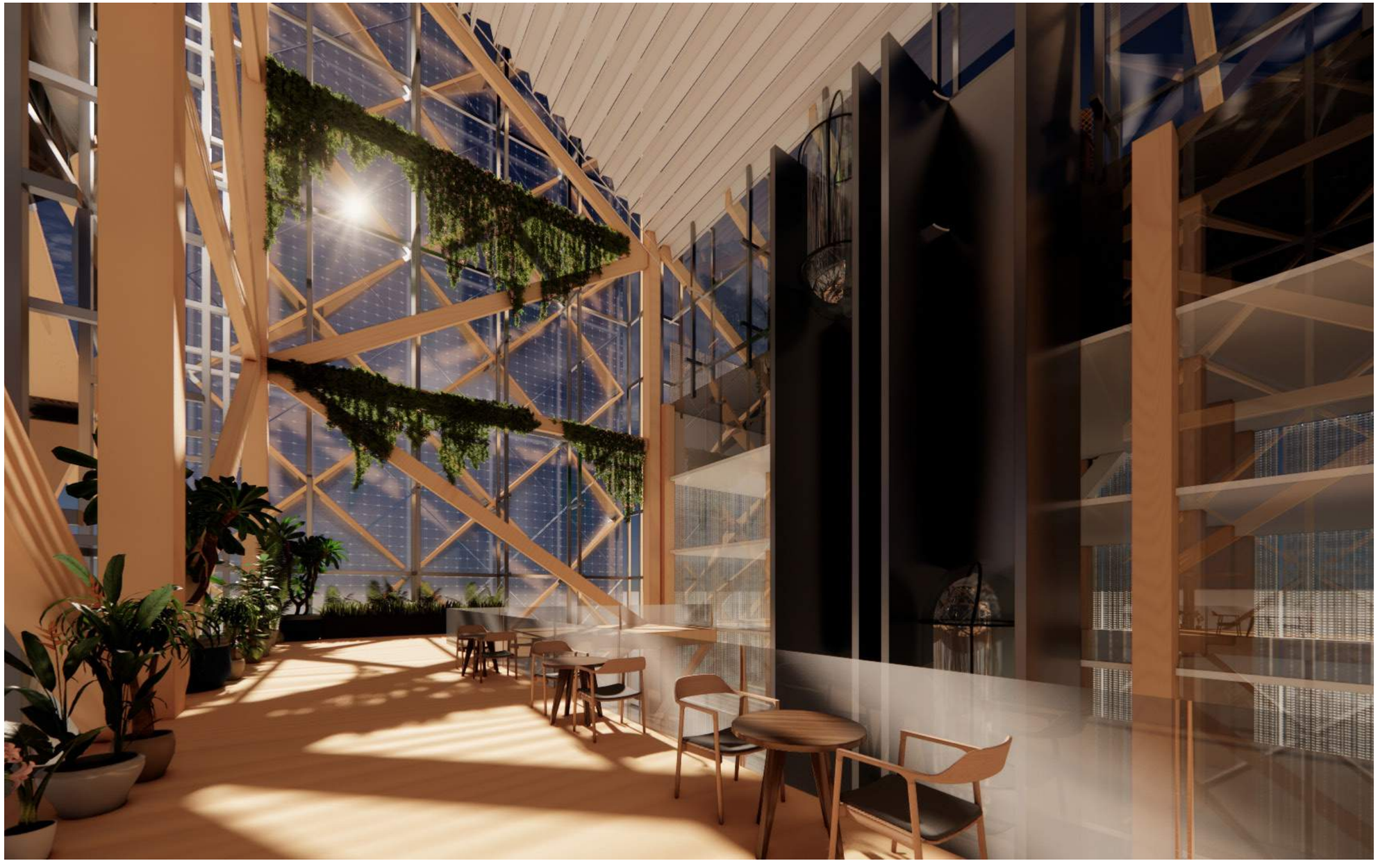
ROOF TOP BAR



VIEWS

ROOF TOP BAR





VIEWS

AXONOMETRIC

VIEWS

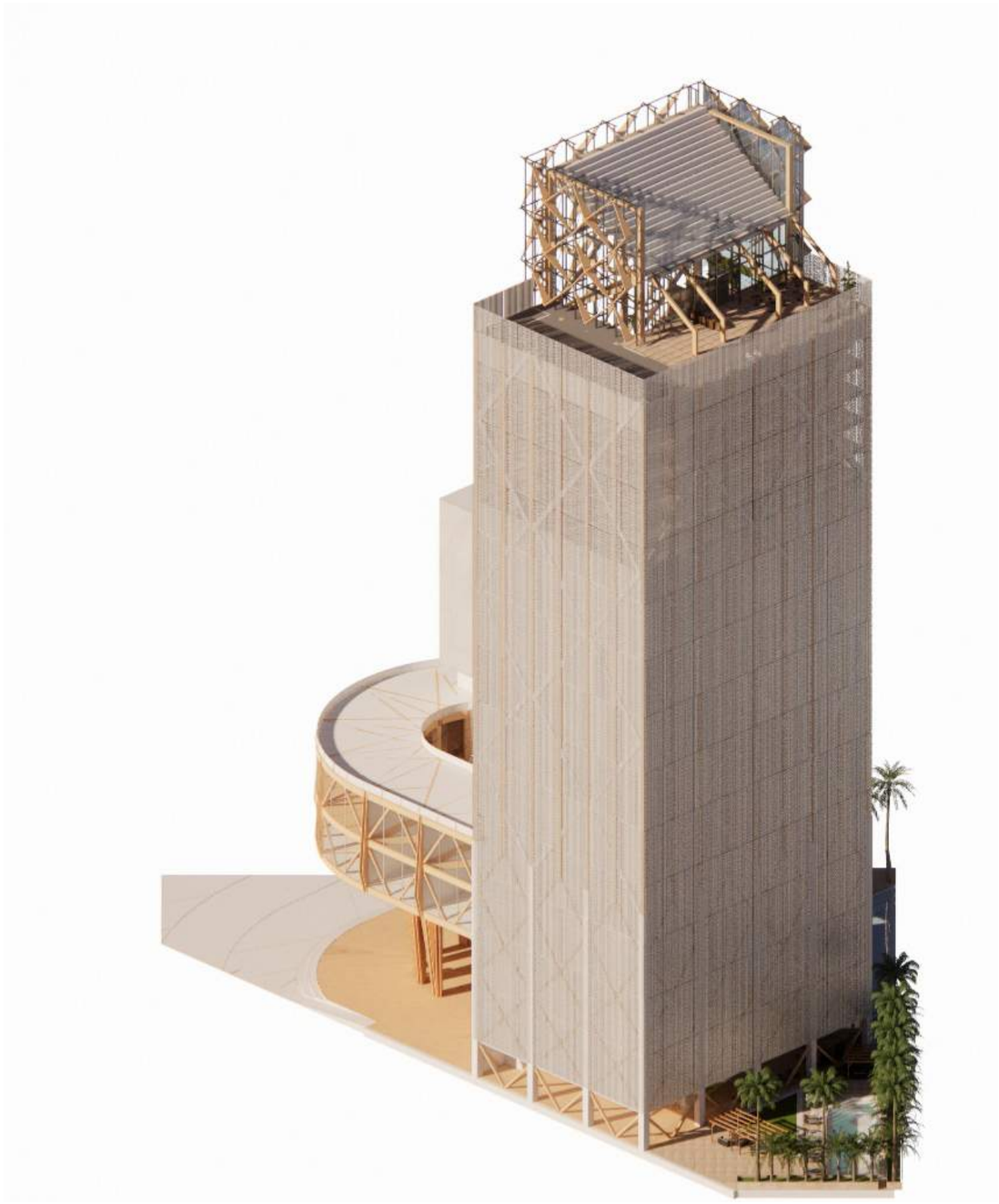
AXONOMETRIC

VIEWS

AXONOMETRIC

VIEWS

AXONOMETRIC



VIEWS

EXTERIOR PERSPECTIVE

INTERNSHIP RESEARCH PROGRAM

MASS TIMBER

2024

Leadership	Matthew Mclarand, AIA Kap Malik, FAIA Mark Kim, AIA
Mentors	Kap Malik, FAIA Joe McClyde Asmaa Abu Assaf Ana Loza Paul Kim Abhishek Vaidya
Interns	Yeji Kwon Erin Chen Samuel Lee Sarah Zureiqat Zachary Kuderna
Firmwide Support	Linda Moreno Katrina Gorgy

MVE
+RESEARCH