HYPERLOOP STATION MIXED DEVELOPMENT STRATEGY: SELECTED OFFSITE CONSTRUCTION CASES

RENDER I

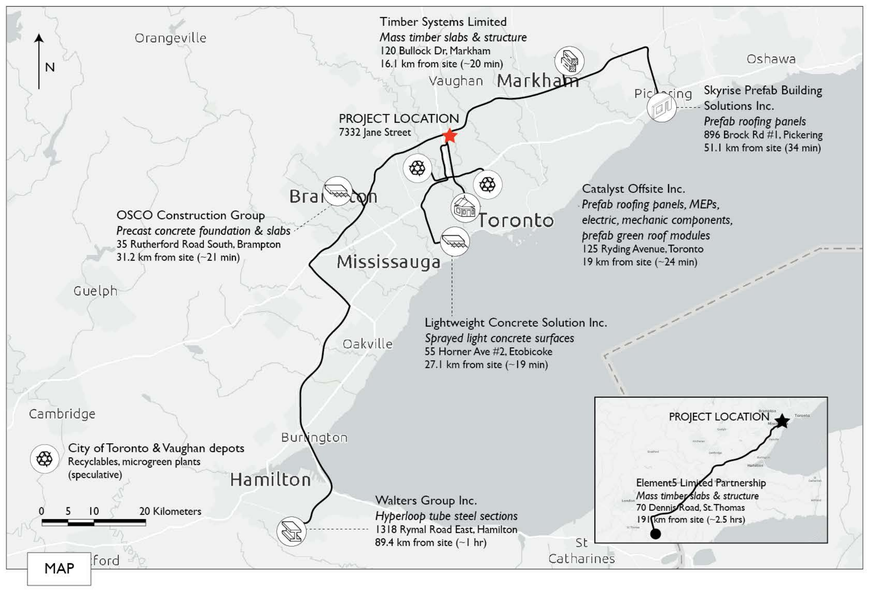
INTRODUCTION

The need for an environmentally regenerative, socially responsible, and economically profitable development is increasingly crucial. Such an instance is the hyperloop station and its nearby city functions to connect the eastern Canada region as one metropolis.

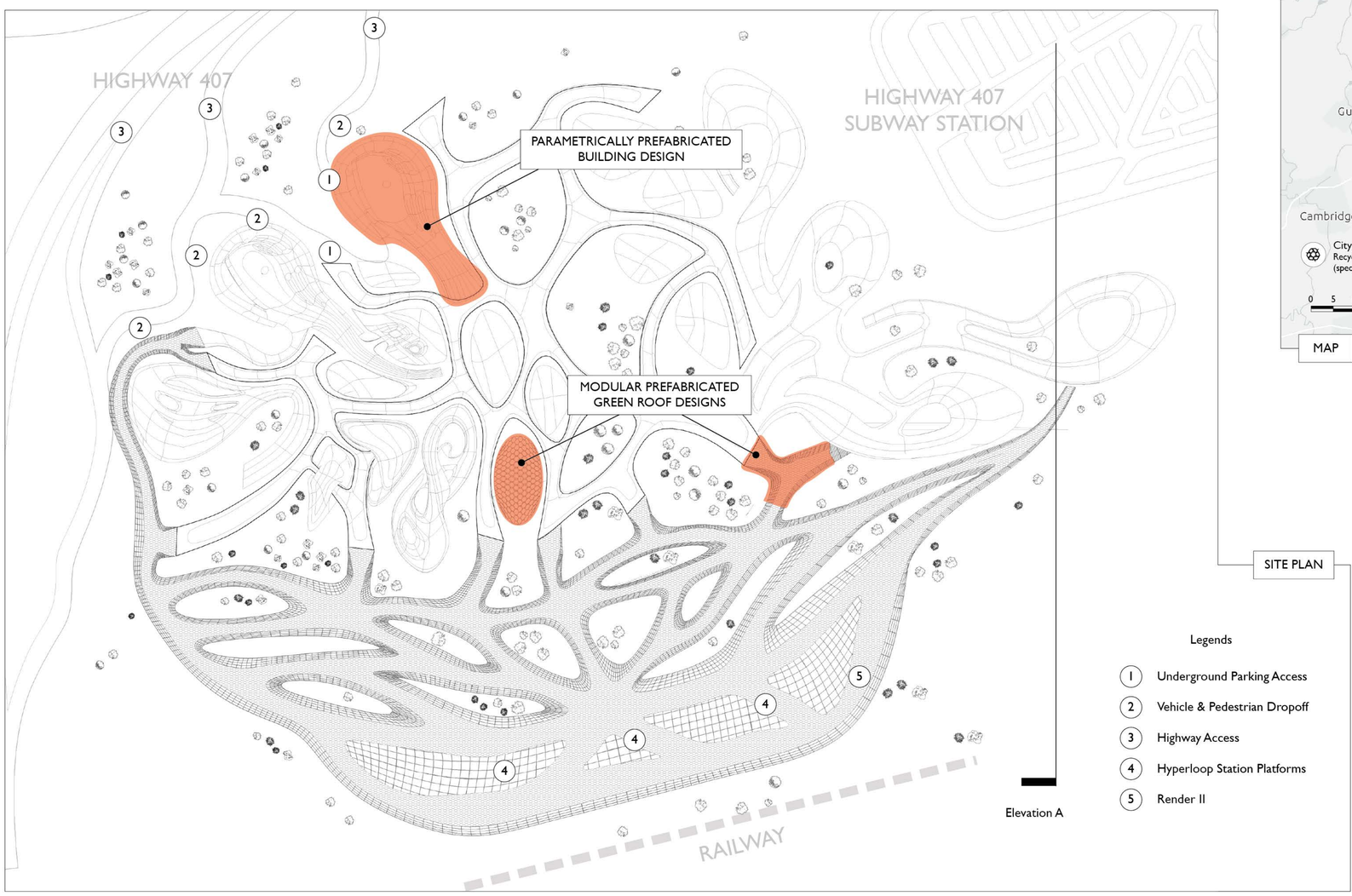
In the first poster, we started by analyzing the expected traffic circulations at the site. We seek to maximize the efficiency of the traffic flows while mimicking the flow of waterways, which crisscross the Greater Toronto Area's existing landscape. It also includes a map showcasing the suppliers and offsite construction locations involved.

The second poster focuses on a building of the station that are being parametrically and/or modularly prefabricated offsite that can be applied to other buildings, while the thrid poster focuses on a method of applying modular offsite prefabricated urban farming modules on the station roofs.

RENDER II



MAP

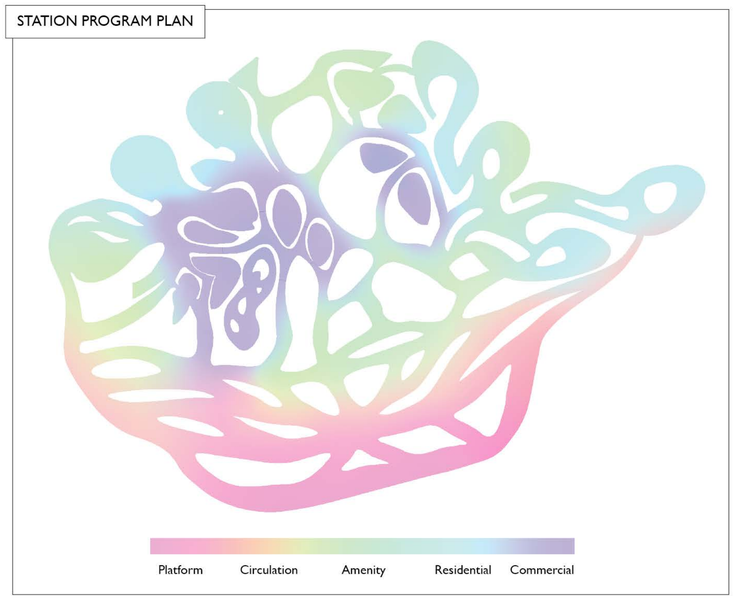


SITE PLAN

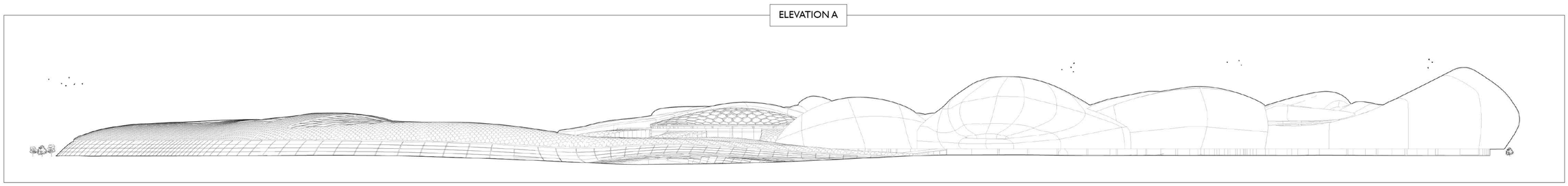
Legends

1. Underground Parking Access
2. Vehicle & Pedestrian Dropoff
3. Highway Access
4. Hyperloop Station Platforms
5. Render II

STATION PROGRAM PLAN



ELEVATION A



PARAMETRICALLY PREFABRICATED BUILDING DESIGN

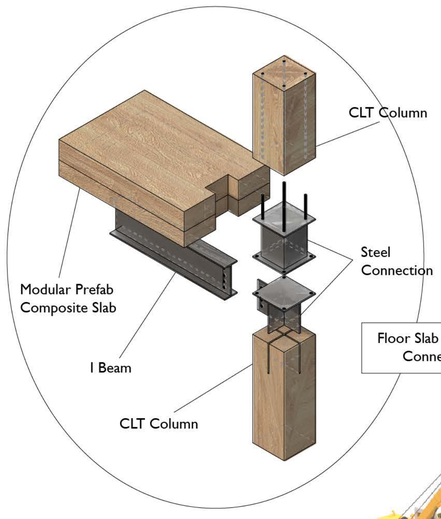
INTRODUCTION

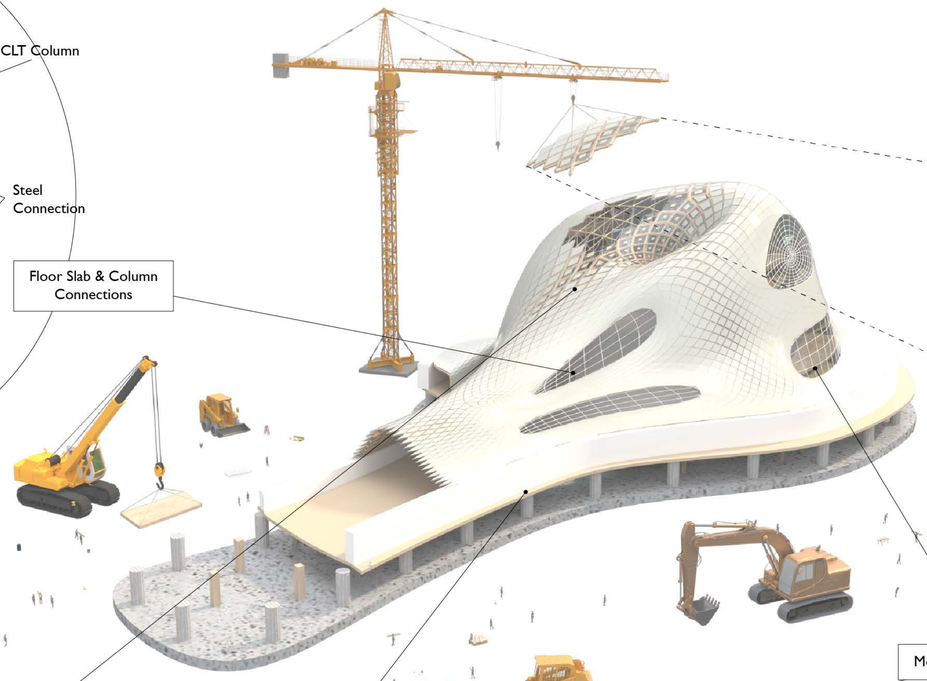
This building is part of the overall mixed development project centered around the hyperloop station. It seeks to improve human comfort & social interactions and to help build and boost a greener local economy through sustainable building design approaches.

The building intends to be a mixed space for public recreational, retail & commercial, and residential functions for the nearby communities and hyperloop passengers.. In order to efficiently produce this complex and dynamic spatial form, this series of drawing showcase how the building utilize offsite prefabrication using parametric and modular approaches.

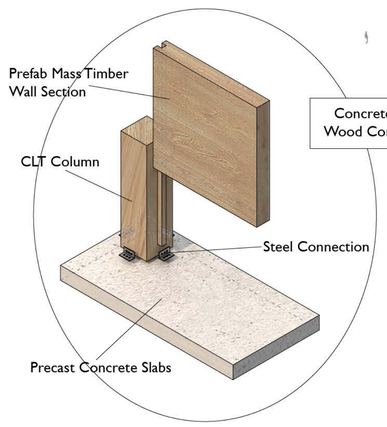
CONSTRUCTION SUMMARY

1. Site survey, ground work and excavation.
2. Complete precast concrete foundations modularly prefabricated and supplied by OSCO Construction Group.
3. Install mass timber slabs and structures modularly prefabricated and supplied by Timber System Ltd. and/or Element5 Limited Partnership.
4. Place composite roof pieces parametrically prefabricated and supplied by Catalyst Offsite and/or Skyrise Prefab (Sto Panels).
5. Complete modular MEP sections prefabricated and supplied by Catalyst Offsite.
6. Install sensors and other mechanisms to give real-time feedback of the full building. Commissioning, etc.



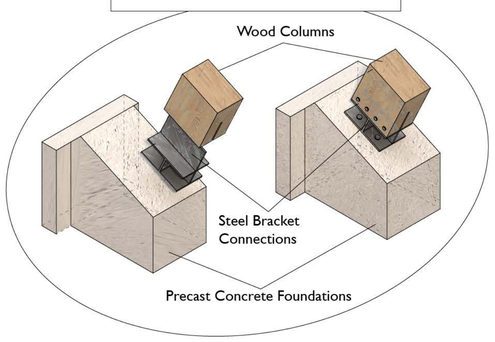


Floor Slab & Column Connections

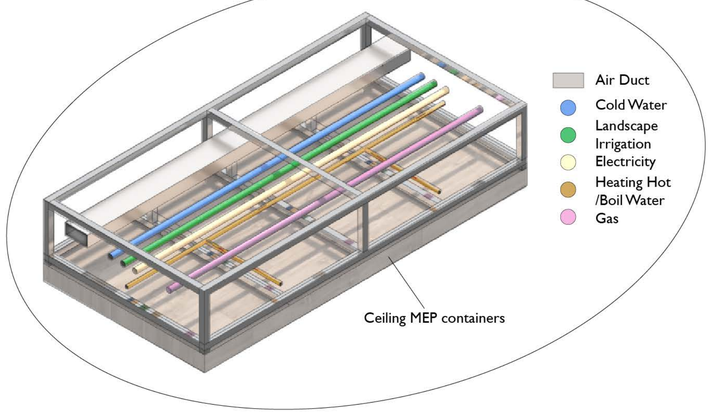


Concrete Slab & Wood Connections

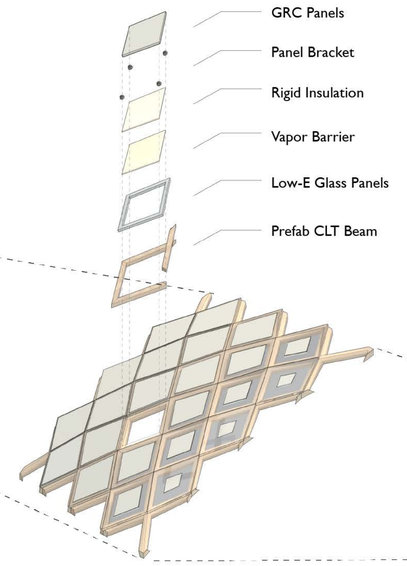
Concrete Foundation & Wood Connections



Modular MEPS Section

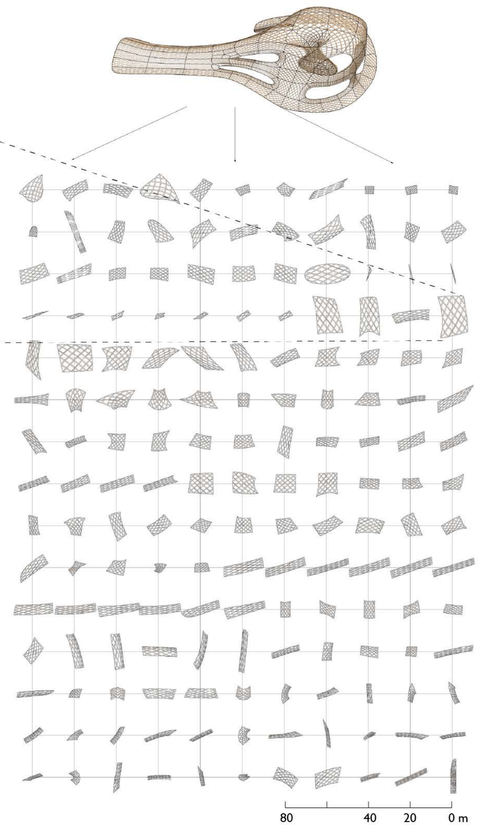


MODUALR STRUCTURE & MEPS INSTALLATIONS



Machine-aided prefabrications can rapidly compute, produce, and numerate various complex physical forms, making complicated forms easily producible that are otherwise impossible or extremely difficult in traditional design approaches.

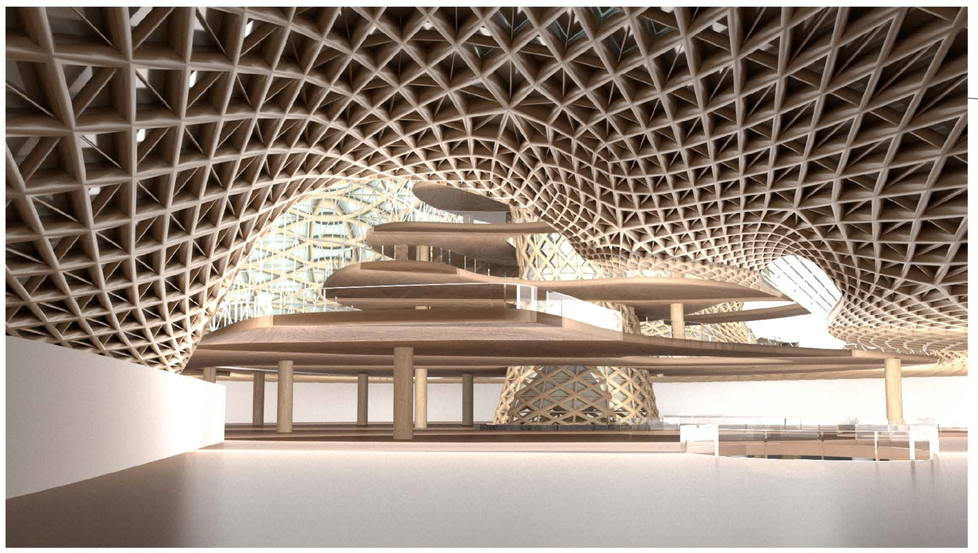
This building's facade is divided into 165 individual transportable pieces manufactured offsite and transported onsite to be assembled by any workers without the need of high-skilled labors. Different layers as demonstrated on the left diagram improve natural thermal comfort for occupants while reducing mechanical heating/cooling needs.



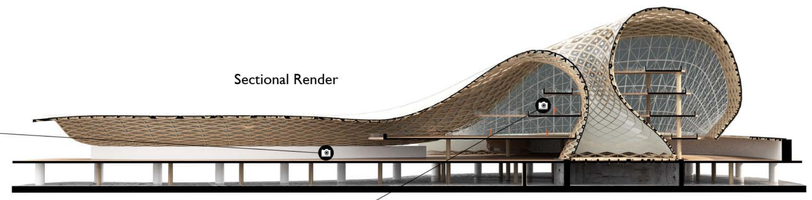
PARAMETRIC ROOF DETAILS & PANELIZATIONS

BUILDING OVERVIEW RENDERS & ILLUSTRATIONS

Rendered Interior View I



Sectional Render

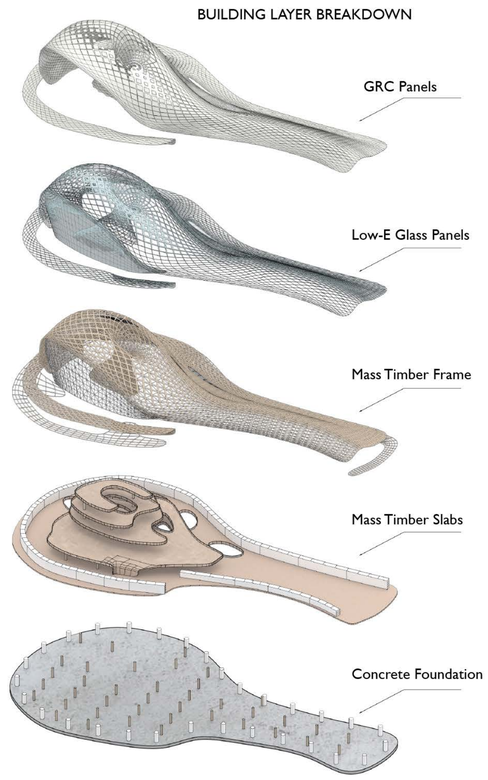


Rendered Interior View II

The building's interior space can be leased to local businesses for public recreational, retail & commercial, and residential functions, thus human comfort and environmental-friendliness is prioritized.

Natural lighting and sustainably harvest local timbers help improve the inhabitants' wellbeing and interior views. 30~40% of building spaces being underground also help insulate the interior spaces passively.

BUILDING LAYER BREAKDOWN



MODULAR PREFABRICATED GREEN ROOF DESIGN USING SALVAGED MATERIALS

INTRODUCTION

As part of the hyperloop station's green roof, this easily-producible hexagon module using salvaged materials such as city recyclables and wood byproducts can be completed by community volunteering efforts. Those modules are then aggregated into composites of transportable insulated roofing prefab portions.

As demonstrated in its simple offsite prefabrication, aggregation for transportation, panelization on any large roofs, and planting of microgreens, this rapidly producible, replaceable, and transportable green roof design produces low-carbon-footprint microgreens, recycles city waste, reduces construction waste, and lowers overall cost in its life cycle as compared to their traditional green roof/urban farm counterparts.

CONSTRUCTION SUMMARY

1. Produce hexagon modules using particle-boards made from wood chips at Catalyst Offsite.
2. Attach modules with building sheets to create transportable composites at Catalyst Offsite.
3. Transport the composite modules to the site, and staple them together onto roof structures.
4. Install sensors and other mechanisms to give real-time feedback about roof conditions.
5. Commissioning to ensure there are no leakages and fix any roofing issues.
6. Volunteers plant microgreens at local communities and secure bottles into modules on site.

OPERATION & MAINTENANCE SUMMARY

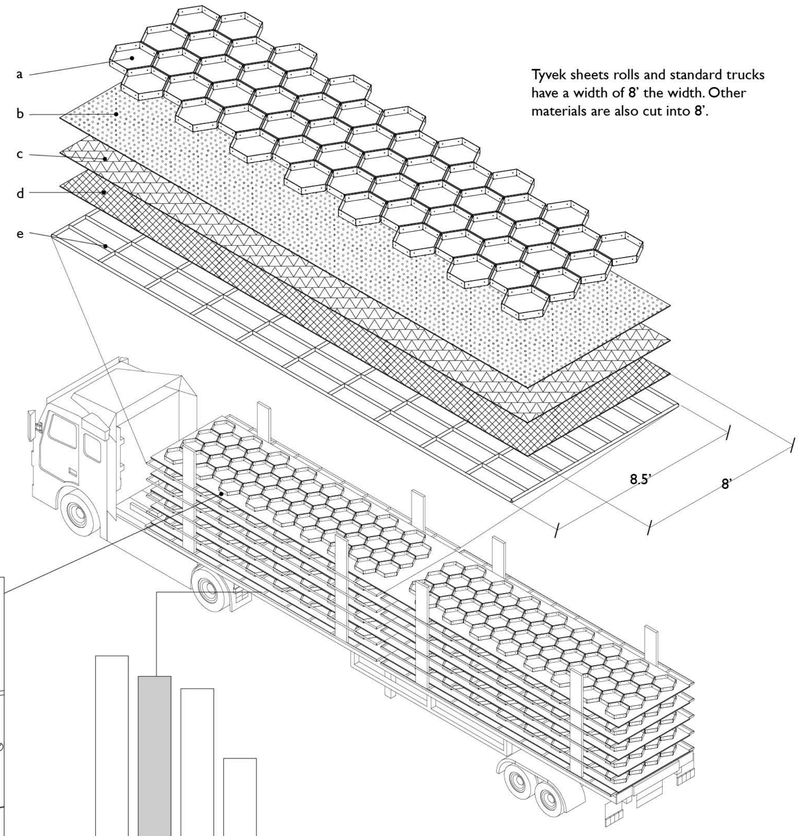
1. Regular check of sensors and fixes of the roof components.
2. Volunteers help detach each bottle to collect microgreens or replace bottles within each hex module.
3. Replacement of hex modules and securing them with meshed wire nets during heavy snowfall or windy seasons.

MODULE AGGREGATION & TRANSPORTATION

Larger composite "modules" are comprised of multiple layers, including rain, air, vapor, and thermal controls.

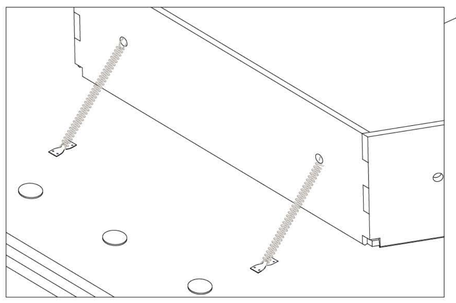
This allows multiple insulation layers alongside farming hexagon modules to be installed on roof structure at once, reducing weather damages on unfinished roofs which were common in traditional green roof approaches.

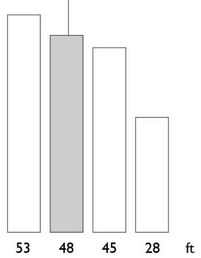
- a Hexagon Modules
- b Filter Fabric
- c Hard Foam Insulation
- d Tyvek Barrier
- e Rack (for ease of assembly through a crane, to be removed once shipment is placed on the roof)



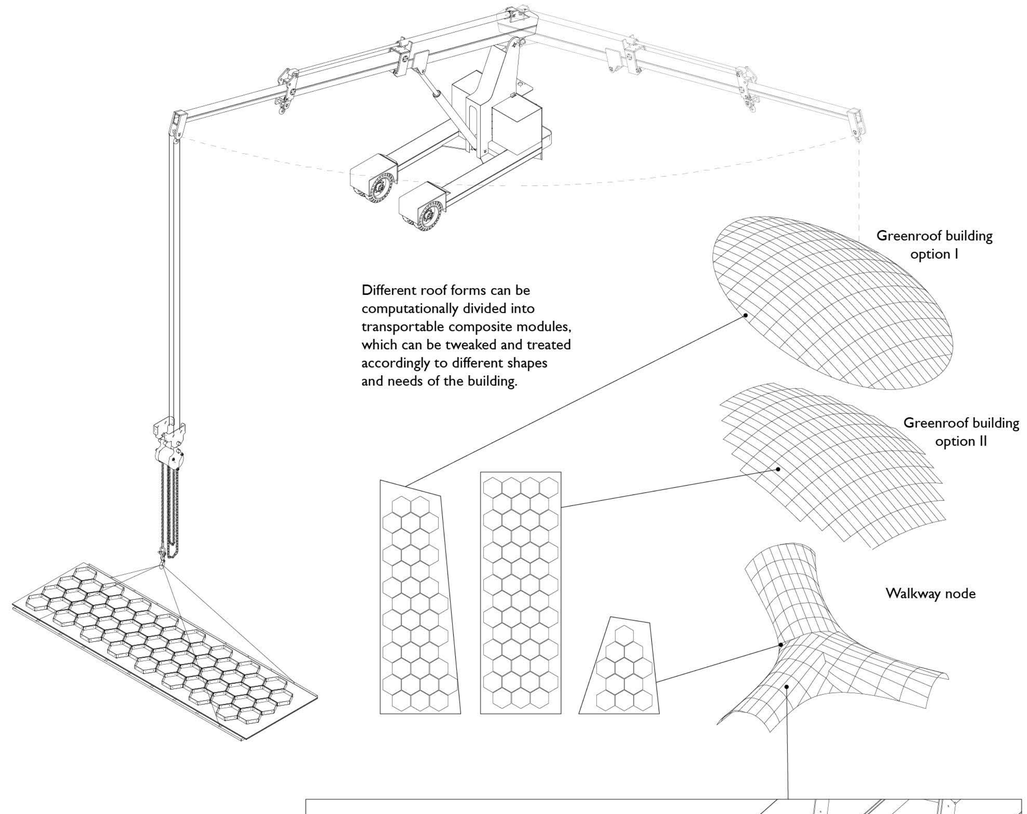
Tyvek sheets rolls and standard trucks have a width of 8' the width. Other materials are also cut into 8'.

Using the same spring suspension system, the hexagon modules can be latched on or off the layered insulations.





Composite modules dimensions based on container trucks' dimension. Can easily adjust module arrangements according to different available truck lengths.



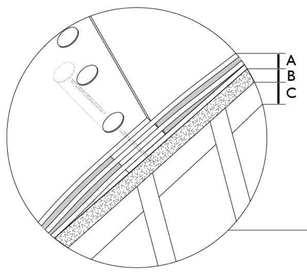
Different roof forms can be computationally divided into transportable composite modules, which can be tweaked and treated accordingly to different shapes and needs of the building.

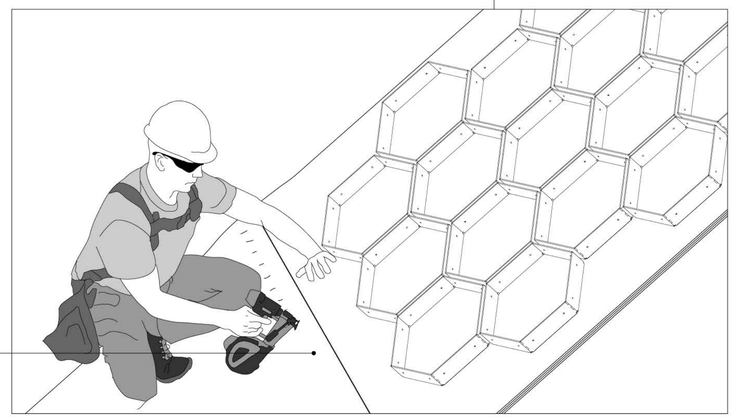
SURFACE PANELIZATION

A. Layered insulated composite modular sheets

B. Roofing panels

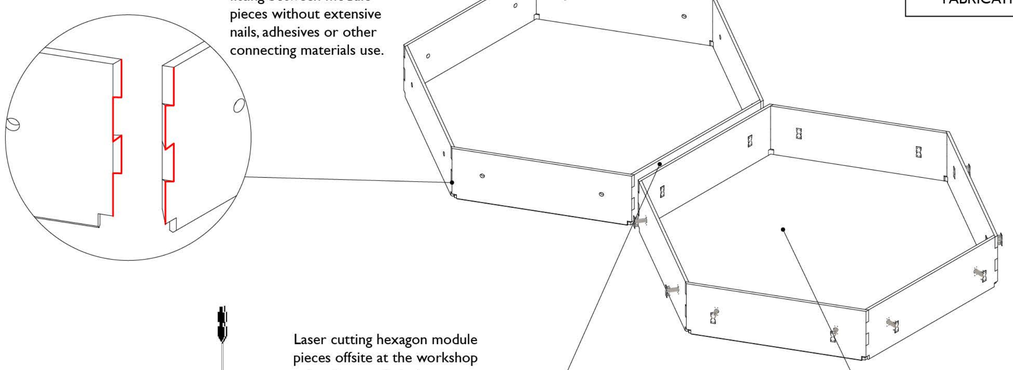
C. Roof structure



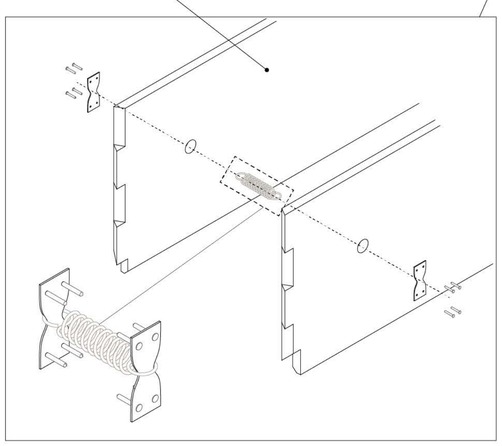


HEXAGON MODULE FABRICATION

Jagged edges for easy fitting between module pieces without extensive nails, adhesives or other connecting materials use.



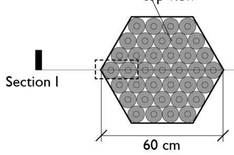
Laser cutting hexagon module pieces offsite at the workshop location can help increase automation and efficiency.



Spring suspension system with easy-to-detach gadgets is used to attach between hexagon modules for easy assembly and detachment.

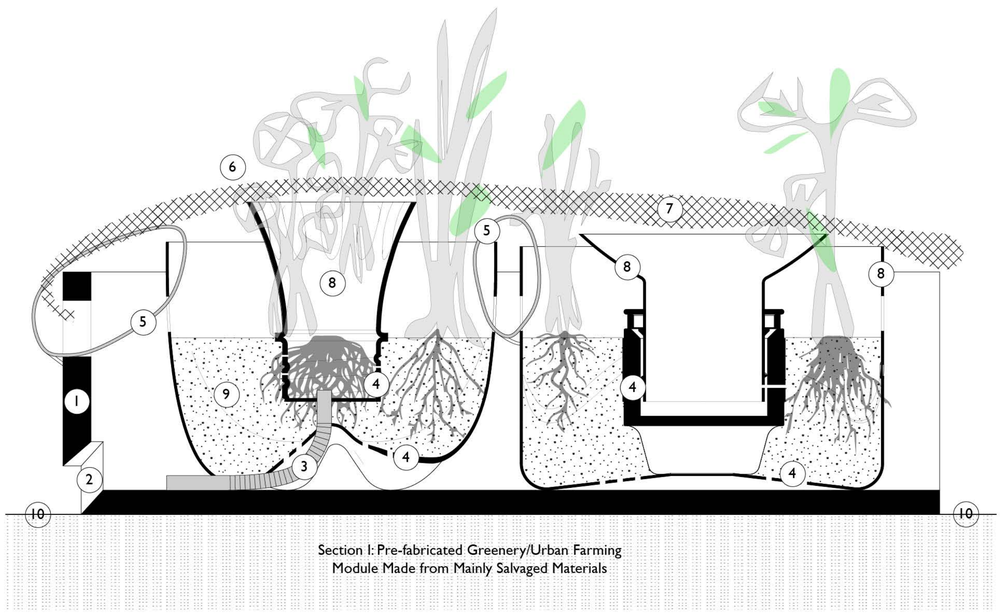
MODULE MICROGREENS PLANTING

Hexagon Module top view



each module recycles 30~80 bottles

In the City of Toronto between 2016 and 2020, plastic bottles and straws remain one of the most disposed wastes, and e-waste such as insulated from phone chargers have drastically increased. Those recyclables can be directly turned into materials for modular urban farming.



Section I: Pre-fabricated Greenery/Urban Farming Module Made from Mainly Salvaged Materials

Legends

1. 0.5 cm particle board module made from waste wood chips and saw dust treated with agents for water and insect insulations & additional root barriers
2. drainage hole in the lowest corner to allow extra water to flow out of
3. recycled plastic straw(s) for additional drainage if needed
4. punctured holes & inverted bottle tops cut off from the same bottles for aeration & drainage
5. recycled insulated electronic wires to connect the bottles and the module
6. microgreens native or adapted to Ontario environments to minimize artificial water & other resource usages
7. meshed nets to keep bottles in place inside the module
8. recycled PET bottles act as root barrier & water storage
9. growth medium
10. roofing membrance & structure

The hyperloop system is a magnetically levitated pod transportation system that rapidly moves people and cargo between cities. Recently, developments in the technology and potential for enormous carbon offsets have raised excitement across the world. This project is a proposed Toronto station to connect with Ottawa, and Montreal, to create an environmentally regenerative, socially responsible, and economically profitable infrastructure network as an integrated regional developmental solution for eastern Canada. The proposed station for this project will be strategically located at the intersection of Highway 407 and 400, next to the existing TTC subways station. The use of precast/prefabricated modular elements will speed up the process of construction, reduce labor, and increase the quality and performance of the final product. Since the structural elements are mass-produced in facilities off-site under controlled environments, it ensures the quality and performance of the structure.

Factors involving the ease of manufacturing, transportation, and assembly were taken into consideration for the design: the geometry of all the precast/prefabricated elements shall be simple for ease of manufacturing; the size of the components is limited to fit in 16m platform trucks; elements are designed in such a way that allows a fast and easy assembly; large components with complex/curved geometry (e.g. curved roof section) consist of smaller elements that can be mass-produced with as least "unique" pieces as possible; the members of the manufacturing partners will actively be involved in the design process to ensure the feasibility production.

Manufacturers will transport structural elements to the site where there is a designated area ready to be deployed, and a "pre-assembly" area where large more complex components will be prepared before they are installed with cranes. For the foundation, driven precast concrete piles will be installed and the main foundation slab will be cast on site. CLT columns, beams, and slabs will be secured, and walls will be installed. This reduces the construction time when compared when regular casted-on-place methods. Composite slab modules will include a semi-installed piping system that can be easily connected after deployment. At this stage, many of the non-structural prefabricated interior components (e.g interior walls, bathrooms, etc.) will be installed in place. For the roof installation beams and joists will be deployed, connected, and secured before installing the glass panels, "pre-assembled" elements with complex geometry, and a green roof system.