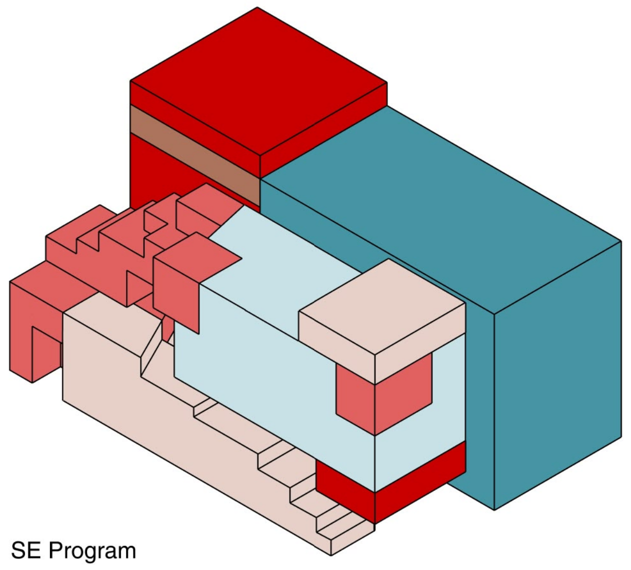
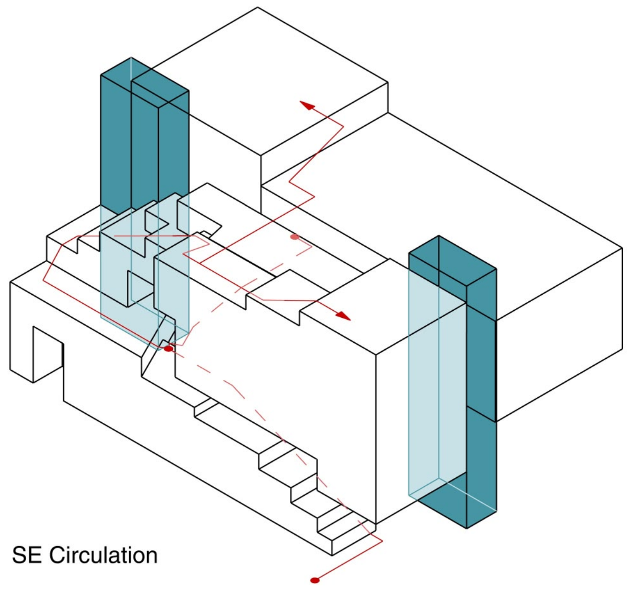
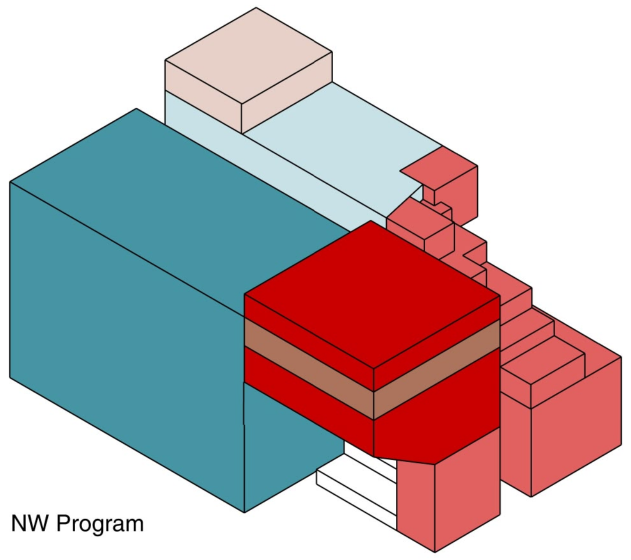
Brief Overview



SE Program

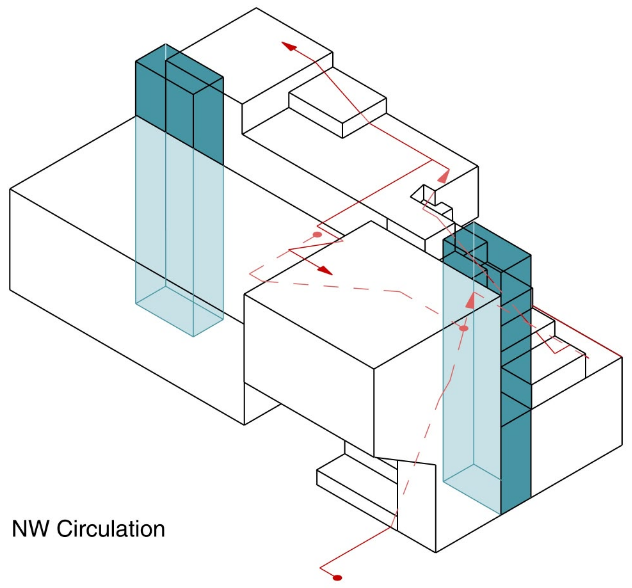


SE Circulation



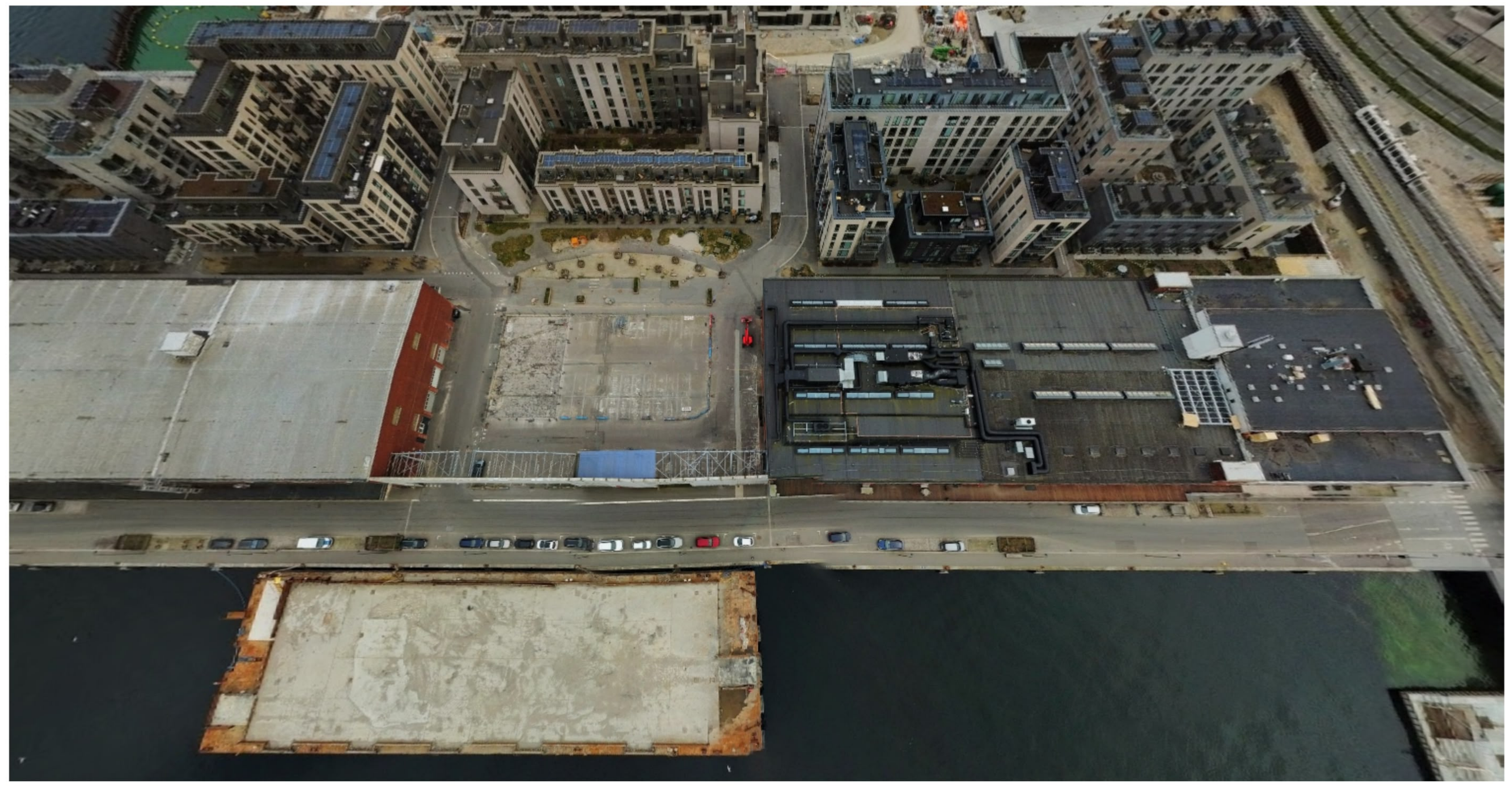
NW Program

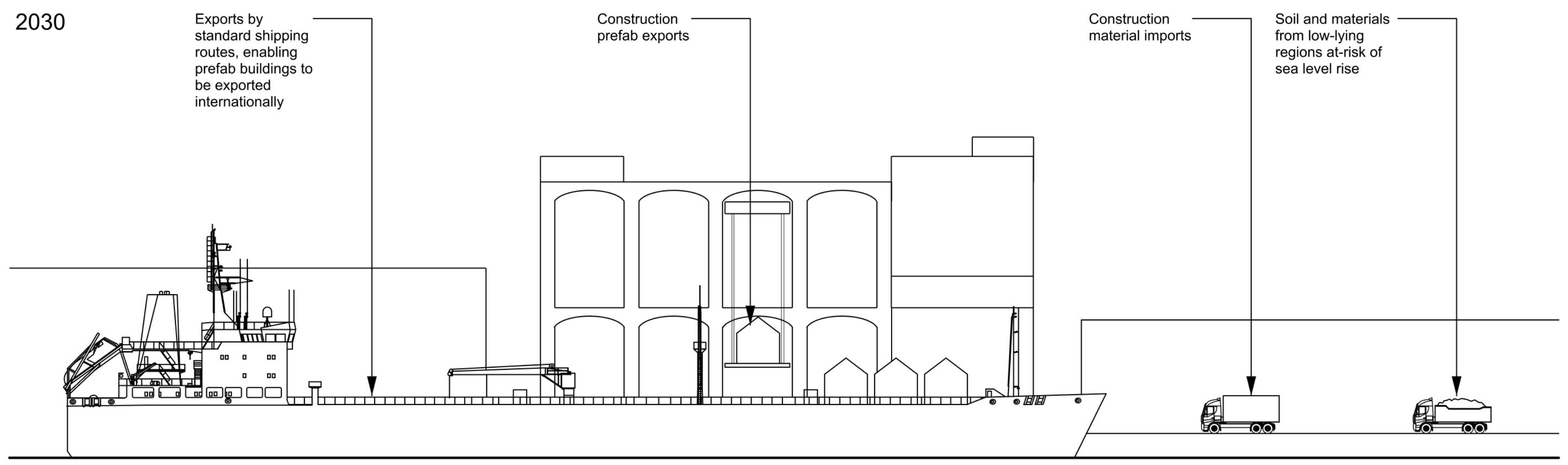
- Educational
- Communal/Gathering
- Factory
- Officespace
- Utility/Storage
- Administration

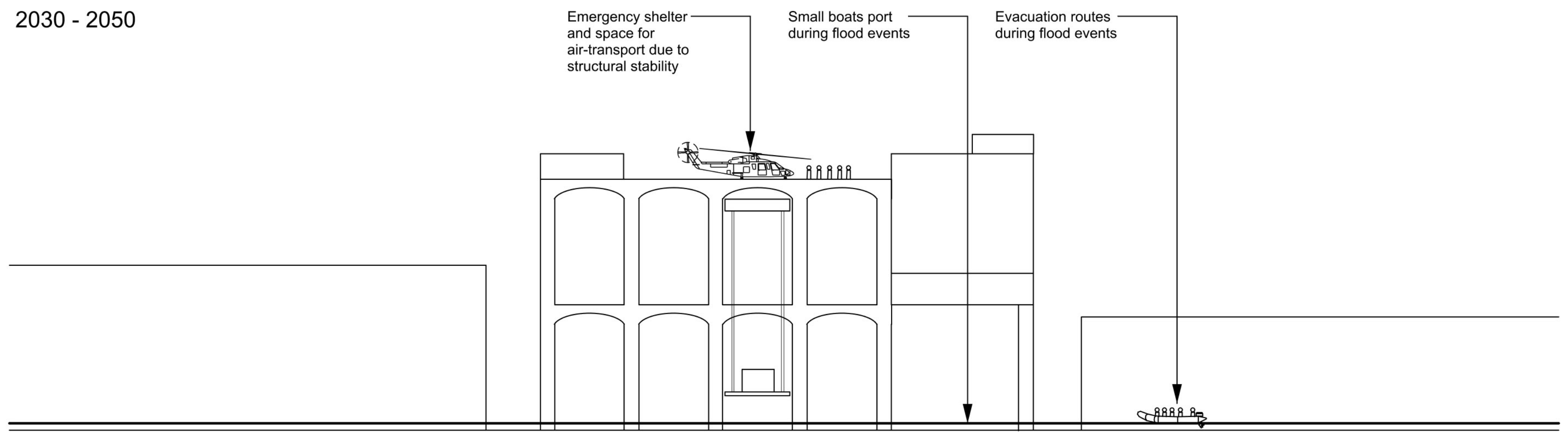


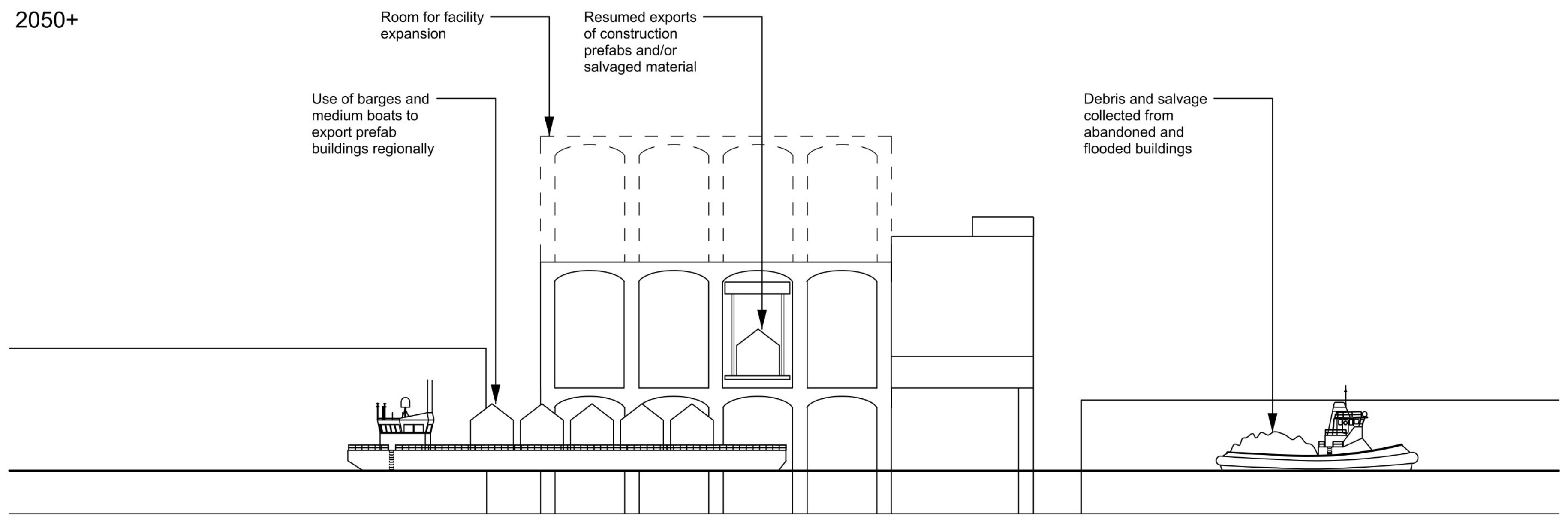
NW Circulation

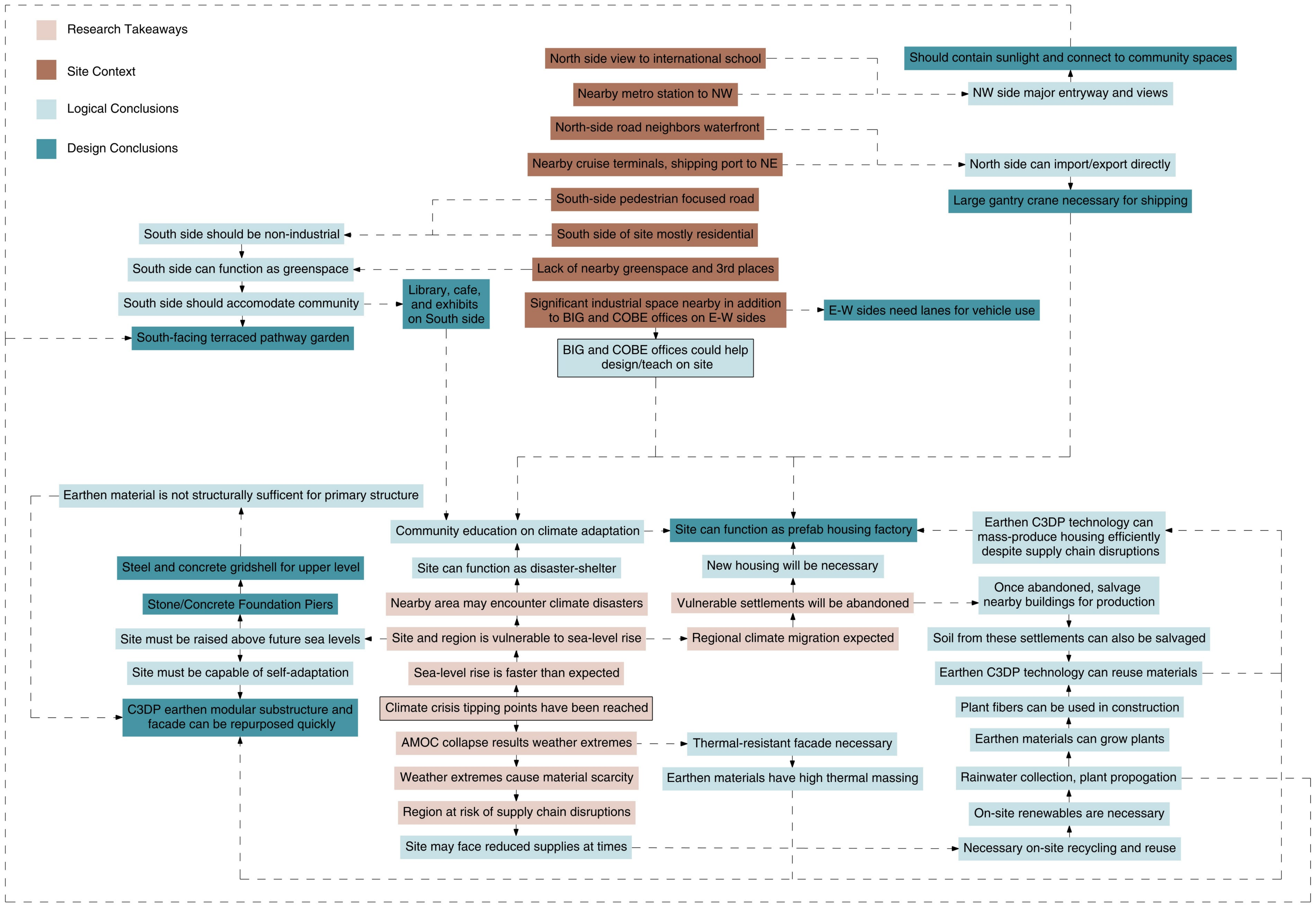
- Primary Circulation Path
- Hidden Primary Circulation Path
- Egress Core
- Hidden Egress Core





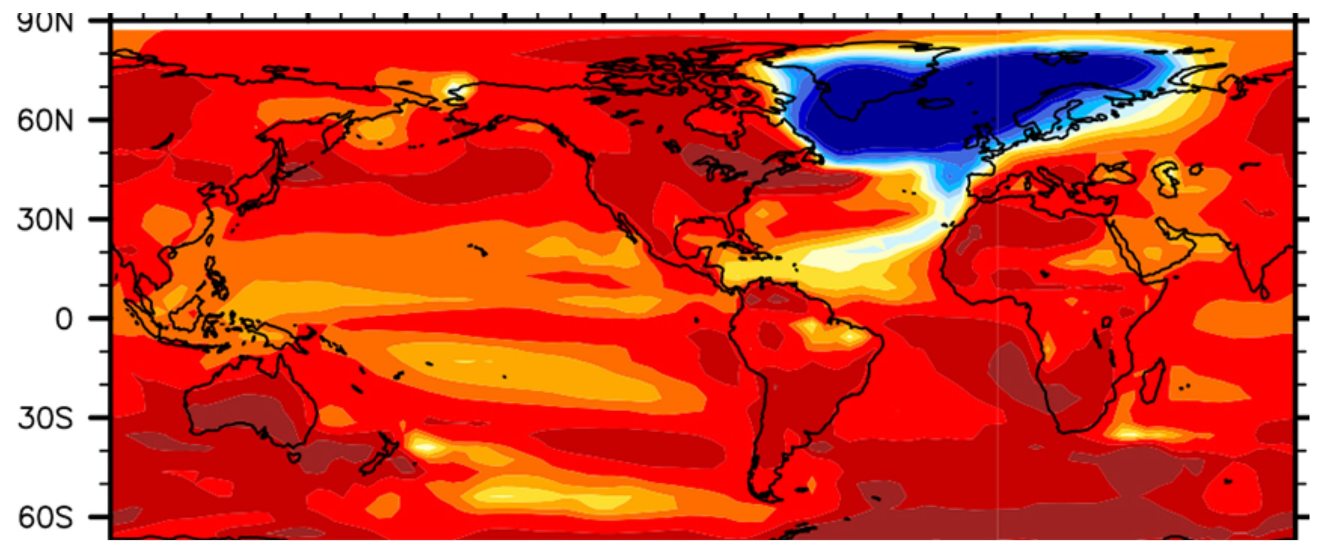






Key Climate Crisis Effects:

AMOC Collapse



Cooling scenaria for AMOC collapse - https://news.wisc.edu/abrupt-climate-change-could-follow-collapse-of-earths-oceanic-conveyor-belt/

The Atlantic Meridian Overturning Current (AMOC) is currently in the process of a total or partial collapse due to the climate crisis. The warm current from the South Atlantic will not reach the North Sea, and the region will cool by more than 3C despite climate change making the global temperature hotter. This will eventually result in cooler winters and warmer summers for the site, with extreme weather events being more commonplace. It is estimated that AMOC will have partially collapsed around 2050.

https://amocscenarios.org/?lat=55.75&lon=12.5&model=cc_RCP45&is_amoc_on=false&is_delta=true&metric=temp_2m_djf

Sea Level Rise

4.4m storm surge map of Copenhagen - https://cphpost.dk/2025-02-20/general/copenhagen-under-water-2/

The vast majority of sea level rise estimates were recently revealed to be far lower than the actual data suggests due to innacurate measurement in current sea levels. New studies estimate that sea level rise will exponentially rise by around 10m by 2100. This will flood the majority of Copenhagen and cause a regional crisis of food and housing. Storm surges and coastal erosion will additionally pose threats to the region.

https://www.newscientist.com/article/2517993-sea-levels-around-the-world-are-much-higher-than-we-thought/

Supply Chain Disruption/Evacuation

Climate change of 4C will effectively dismantle global trade and reduce global GPP by up to 40%, we are currently at 1.5C without any efficient mitigation, with exponential tipping points increasing the rate of global warming above preindustrial averages. The most likely scenarios predict massive disruptions in business as usual, which includes access to many goods in Copenhagen. Supply chain shocks would encourage the region to create a more circular economic model. Climate pressures will result in the need for flood evacuation centers.

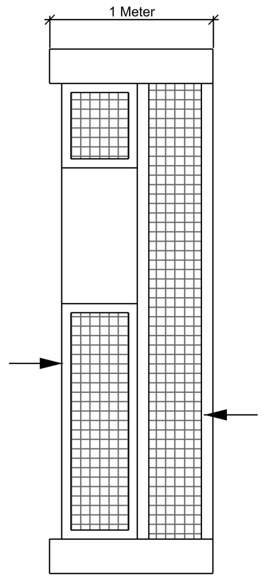
https://iopscience.iop.org/article/10.1088/1748-9326/adbd58

Biodiversity Loss

The site is on a raised seabed, with very little vegetation. There is heavy fishing and maritime disruptions to the local ecosystem, compounding the current biodiversity crisis due to climate change and human interference. This incentiveses the site to provide space for plants and nonhumans as an incentive for local engagement with the environment. Urban geography provides a similar niche to natural cliff ecosystems, if buildings choose to accomodate nonhuman life on their facades.

Adaptation Responses:

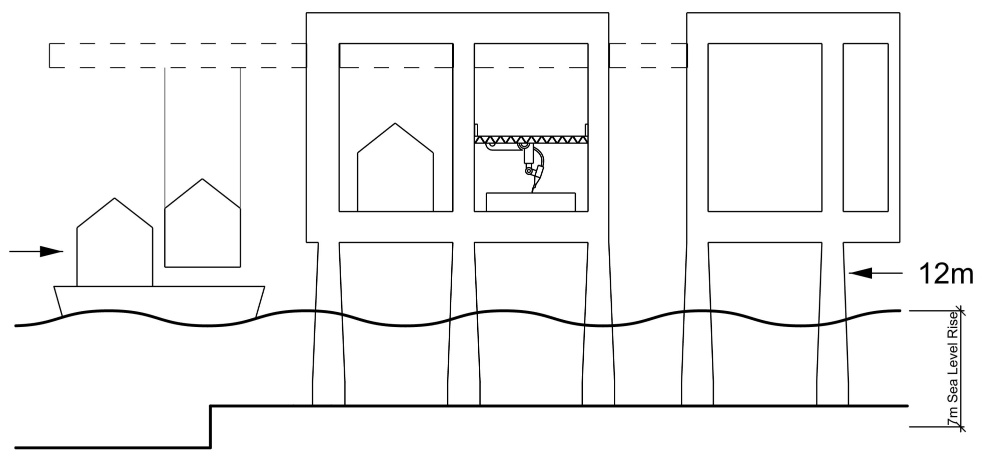
Climate Resilient Facade



Using earthen construction 3d-printed panels made on-site, the building will create a thermal envelope which can adapt to the rapidly changing weather. The use of thermal massing, strategic openings, and vegetation will stabilize the microclimate of the site and enable changes in response to cold and heat extremes. Glazing and openings will be reduced in order to accomodate temperature extremes.

Raised Site

Prefab Construction Exports



The building will be protected from imminent sea level rise through the use of stone columns on the ground level, which will raise the site 10m above the 4m site. Access to the site will be maintained through key evacuation routes located at the corners, providing a safe haven for residents in the area during storm surge events.

In response the the predicted regional housing crisis caused by climate migration, the site will export C3DP buildings and parts via the use of internal construction bays and a crane-gantry system which can load ships and barges from the site itself. These buildings can also provide experimental solutions in the short term, working with the local architectural firms and universities to provide testing space for sustainable construction and climate adaptation knowledge.

Circular Economy/Room for Adaptation

The structure will accomodate additional growth as a result of additional accomidation being necessary for longterm operation of the facility and evacuation requirements. This means the structure must be reinforced with earthen mixtures and standardized to provide reliable stability. Standard high-strength structural bays will provide enough room and support for additional space and material. These materials will be extracted from flood zones in the surrounding area and incorporated into exports for reuse. When the site becomes an island, it will function to salvage and repurpose abandoned buildings in the area.

Planting/Rainwater Harvesting

The facade will improve the aesthetics, microclimate, and resilience of the building through external and internal planting on and within the earthen C3DP mixture. This will reduce rainwater runoff and create an ecosystem which can partially offset and supply residents during an extended flood event as well as being reused for the earthen facade. The soil used for this will be collected from lowlying at-risk zones to 'save' this soil from sea level rise and erosion. Additionally, such planting will improve the structural preformance, fire mitigation, and educational impact of the site.

Earthen C3DP Technology:

Summary

On-site 3d printing, commonly referred to as C3DP, is a developing technology which attempts to construct a building on site with large 3d printersrs. Clay, earthen, cob, and natural mixtures can be used without significant carbon sequestration. With further research, development, and investment into C3DP, construction costs can be significantly reduced compared to traditional construction, as well as being more sustainable. If commercial mixtures used clay or earthen materials instead of concrete, costs would be significantly lower than conventional timber frame construction with an economy of scale.

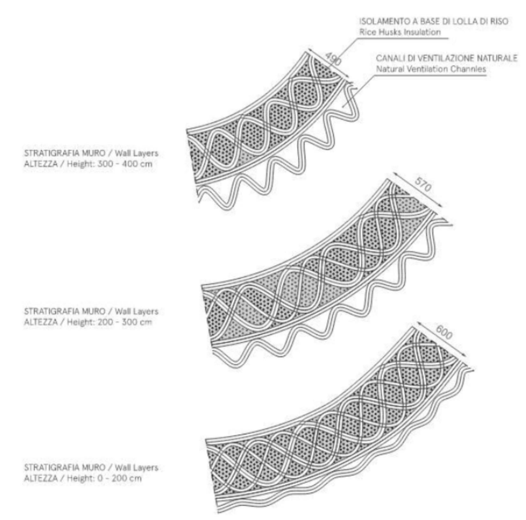
3D printing process reduces labor costs by roughly 60%.

Economic analysis of offsite and onsite 3D construction printing techniques for low-rise buildings

Mixtures composed with around 30% sub-soil, 15% silica sand, 15% straw, 18% water, and 22% clay have been proven structurally effective and cost efficient, attaining 11.04 MPa of compressive strength, embodied carbon of about 0.05239 kgCO2eq/kg with a selling price of 0.137€/kg.

Sustainable mixes for 3D printing of earth-based constructions

TECLA Case Study



TECLA was a 2016 experimental project designed by Mario Cucinella Architects using WASP's C3DP system in Ravenna. This prototype construction used natural materials in a fully 3d printed construction via the use of multiple 3d printers operating at once. It took 200 hours of printing, 350 layers of 12 mm, 150 km of extrusion, and 60 cubic meters of natural materials for an average consumption of less than 6 kW. This project was designed with the assistance of multiple organizations as a proof of concept for sustainable earthen 3d printed construction.

Sustainable mixes for 3D printing of earth-based constructions

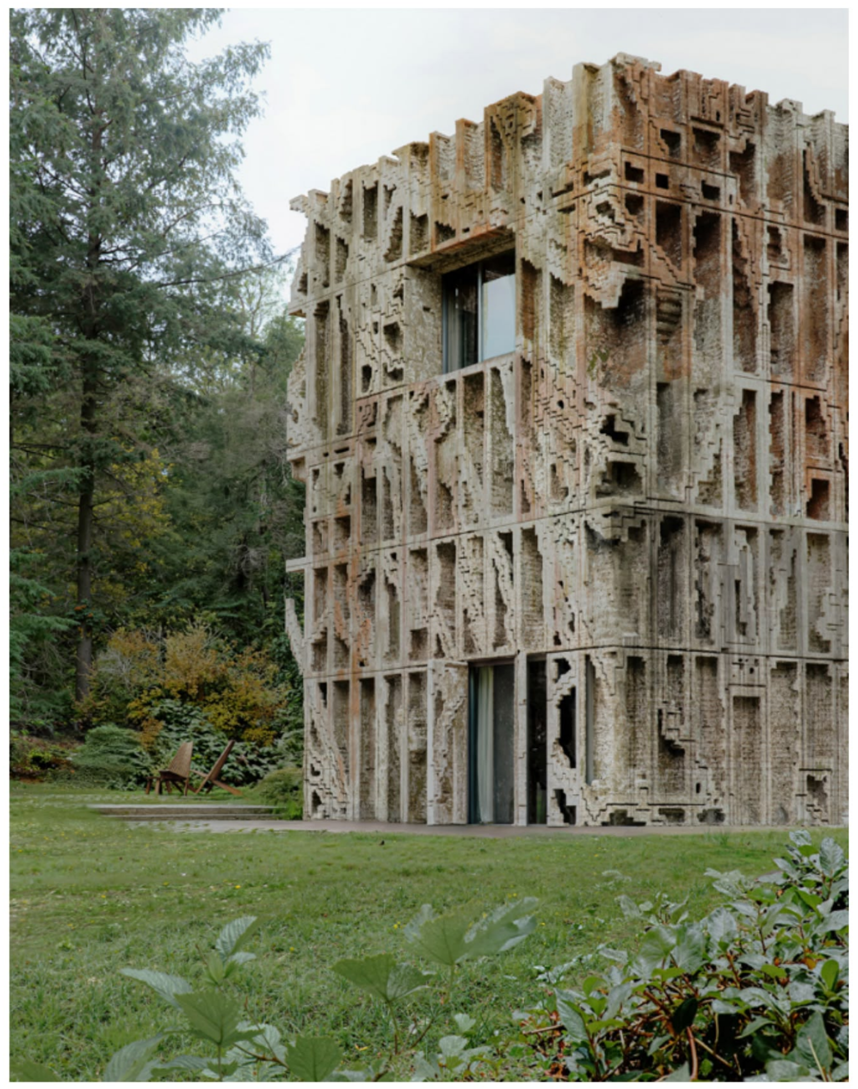
DESIGN DEVELOPMENT

Urban Cliff Microclimate

Theory which compares the condtitions of a cliff ecosystem to that of urban facades, where nonhumans take up space in the niches of each typology. Most buildings attempt to neutralize space for these ecosystems, which reduces the biodiversity and health of urban environments. Despite this, the opportunities to activate facades as an ecological niche for urban centers remains, and could improve urban conditions for both humans and ecosystems by creating new inhabitable spaces.

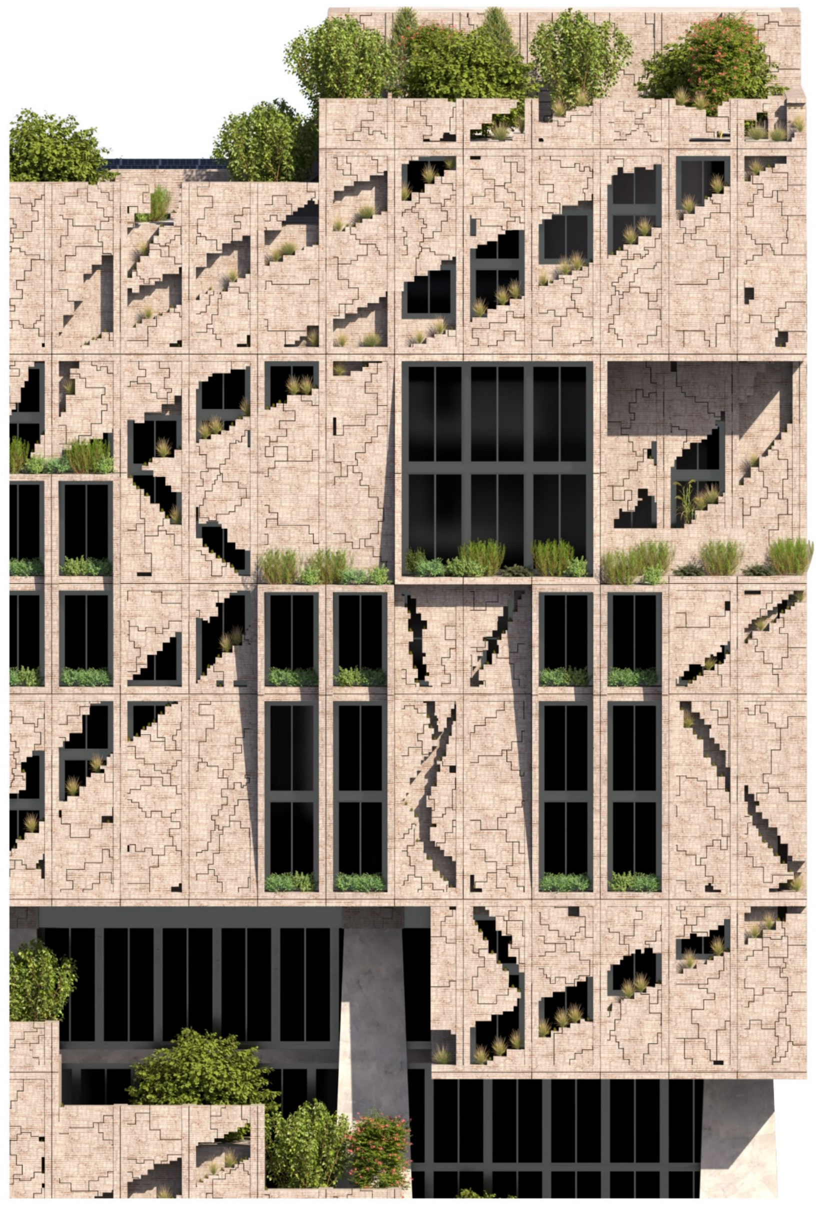
Tùr House Case Study

Designed by Barry Wark, the Tùr house posits that buildings can incorperate changes over time without resisting the forces of nature. The C3DP facade of the building is designed with modular panels to show its weathering rather than resisting it, to collect moisture and organic matter through a complex and ornate facade.



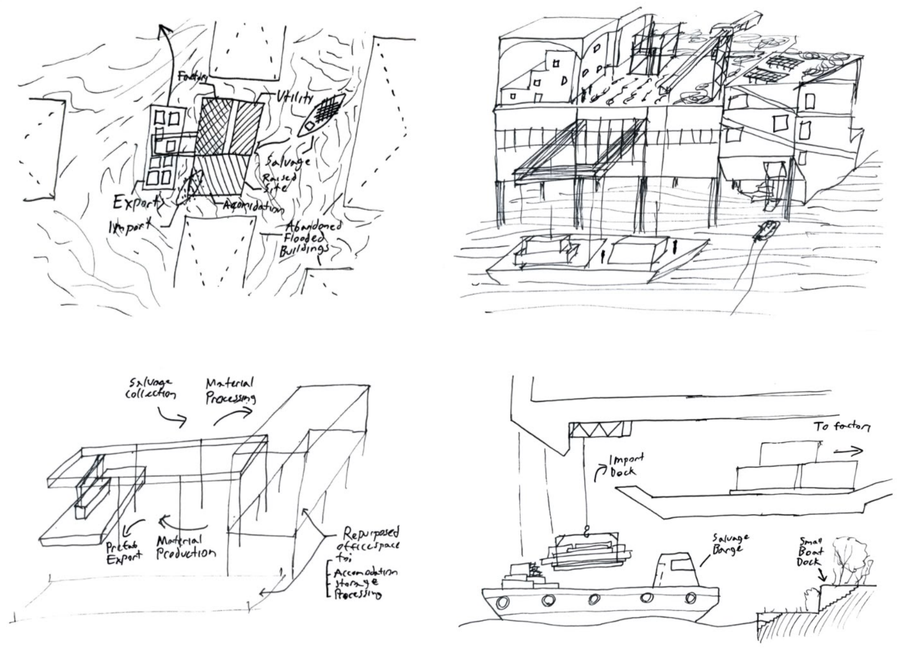
Urban Cliff via C3DP Facade

The facade is constructed out of earthen C3DP panels which provide both thermal massing and soil for plant propogation. To slow down erosion and keep moisture near these plants, the facade panels contain erosion paths which also double as perforations for window placement. Additional sub-pathways were included for ease of maintenence, runoff flows, and aesthetic effect. The facade frame is extruded out in places which require more light, and the drainage channels are designed to flow around these pockets.

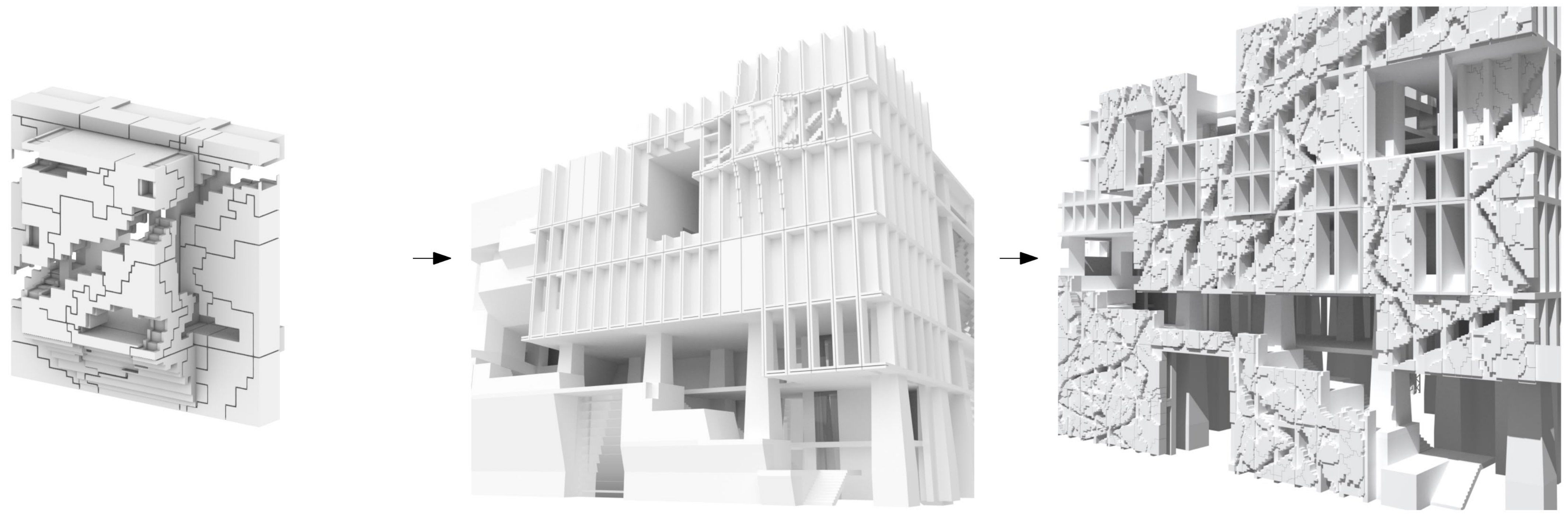


Concept Sketches

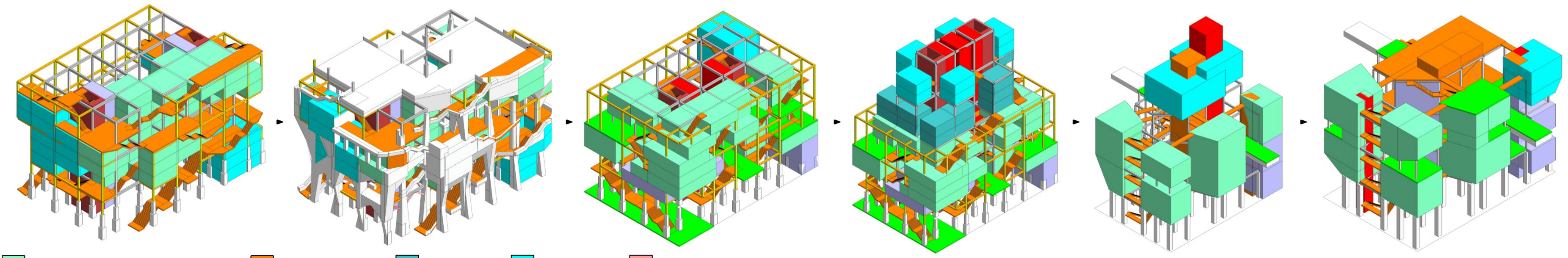
Early sketches describing how the building would continue to function after sea levels rise. The building would serve as a central export/import node for salvage and/or factory of repurposed prefab buildings.



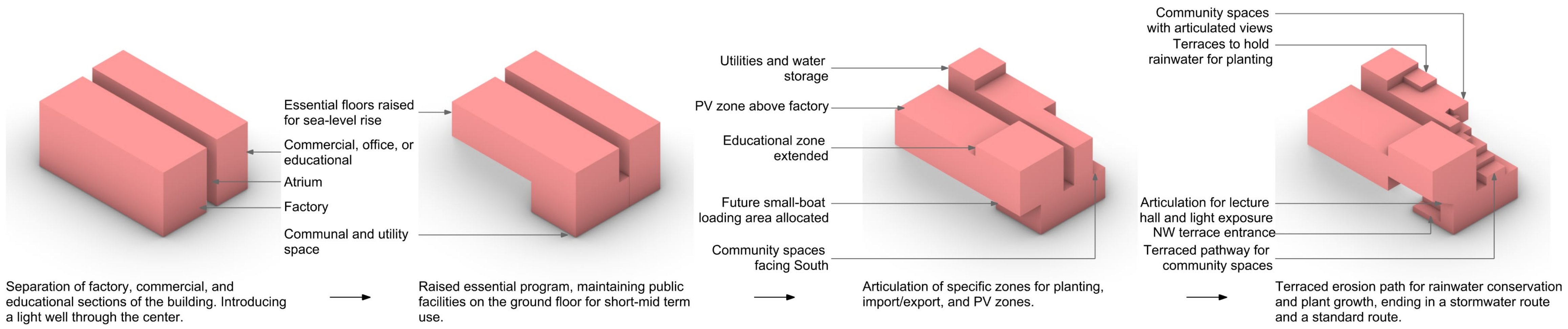
Facade Iterations



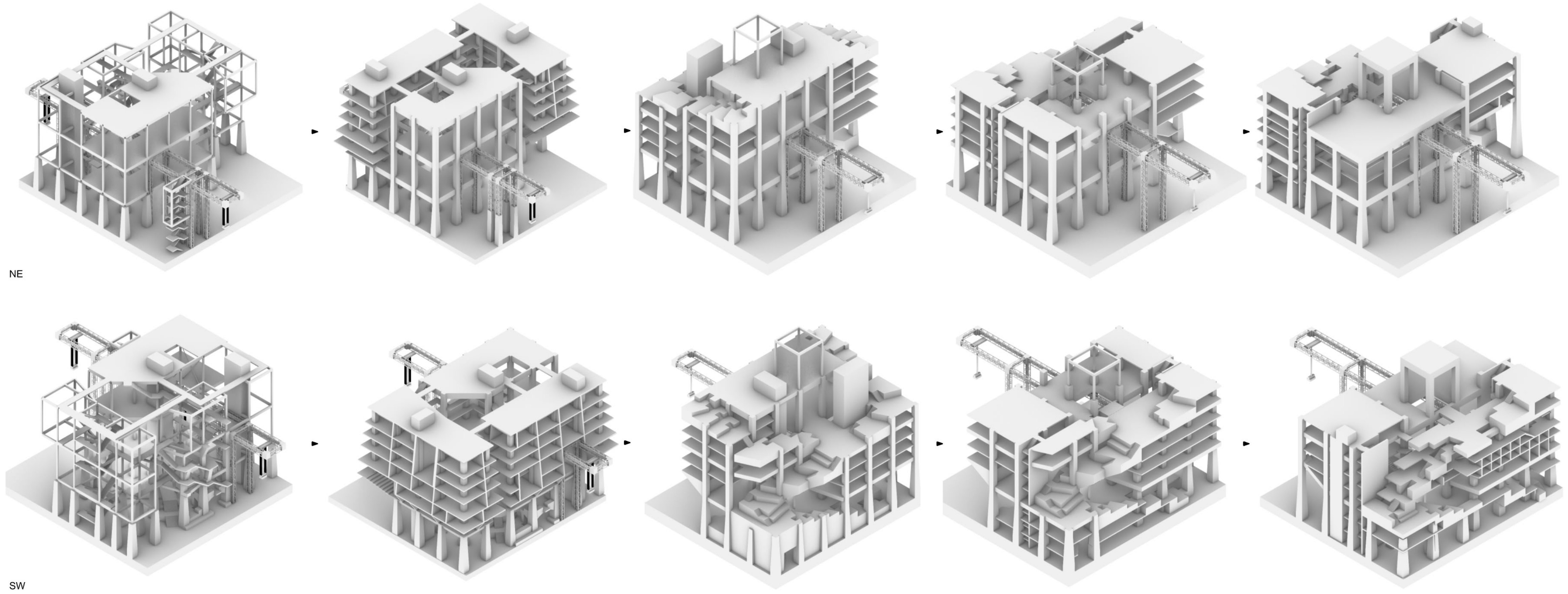
Program Iterations

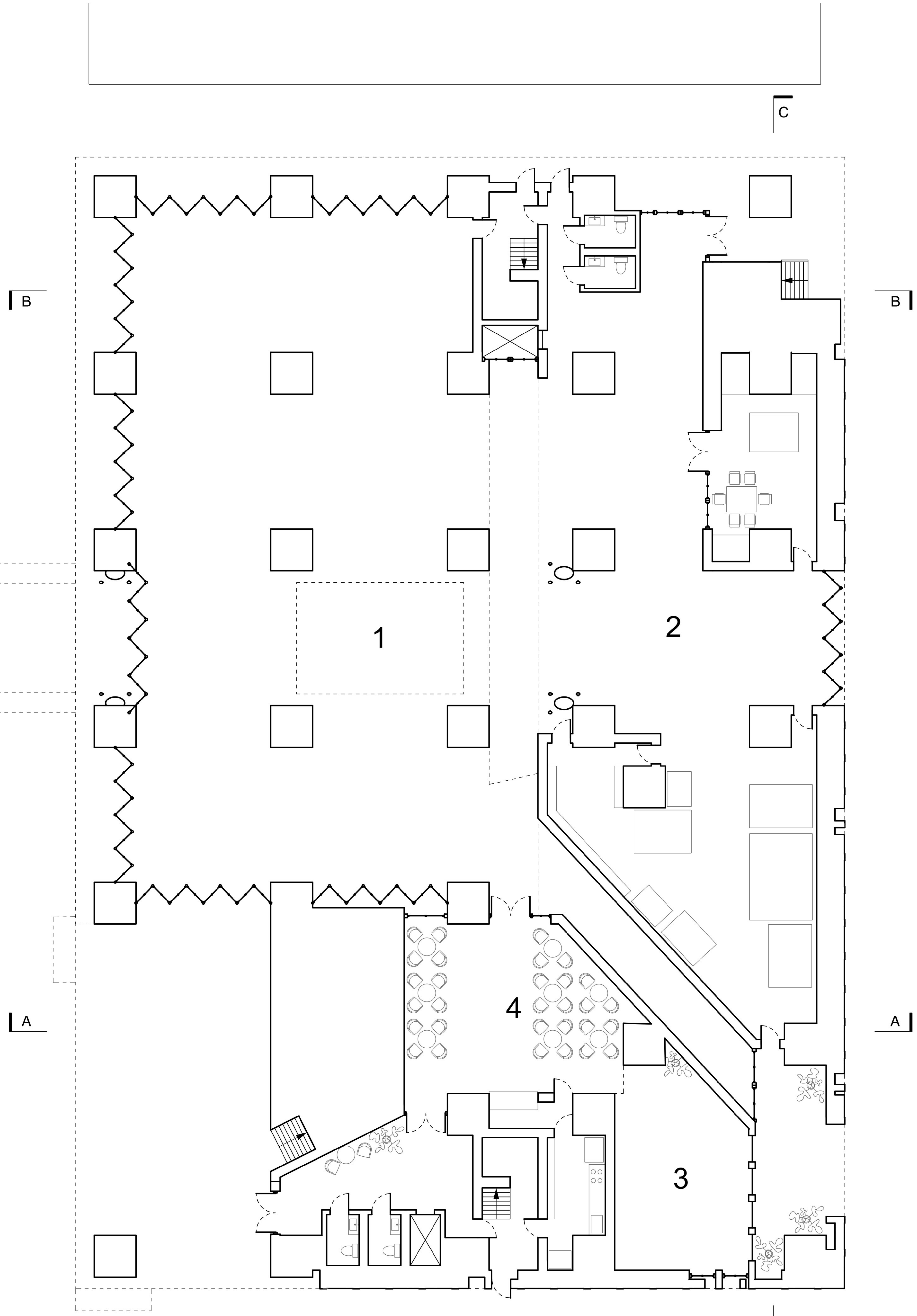


Massing Explanation



Model Iterations

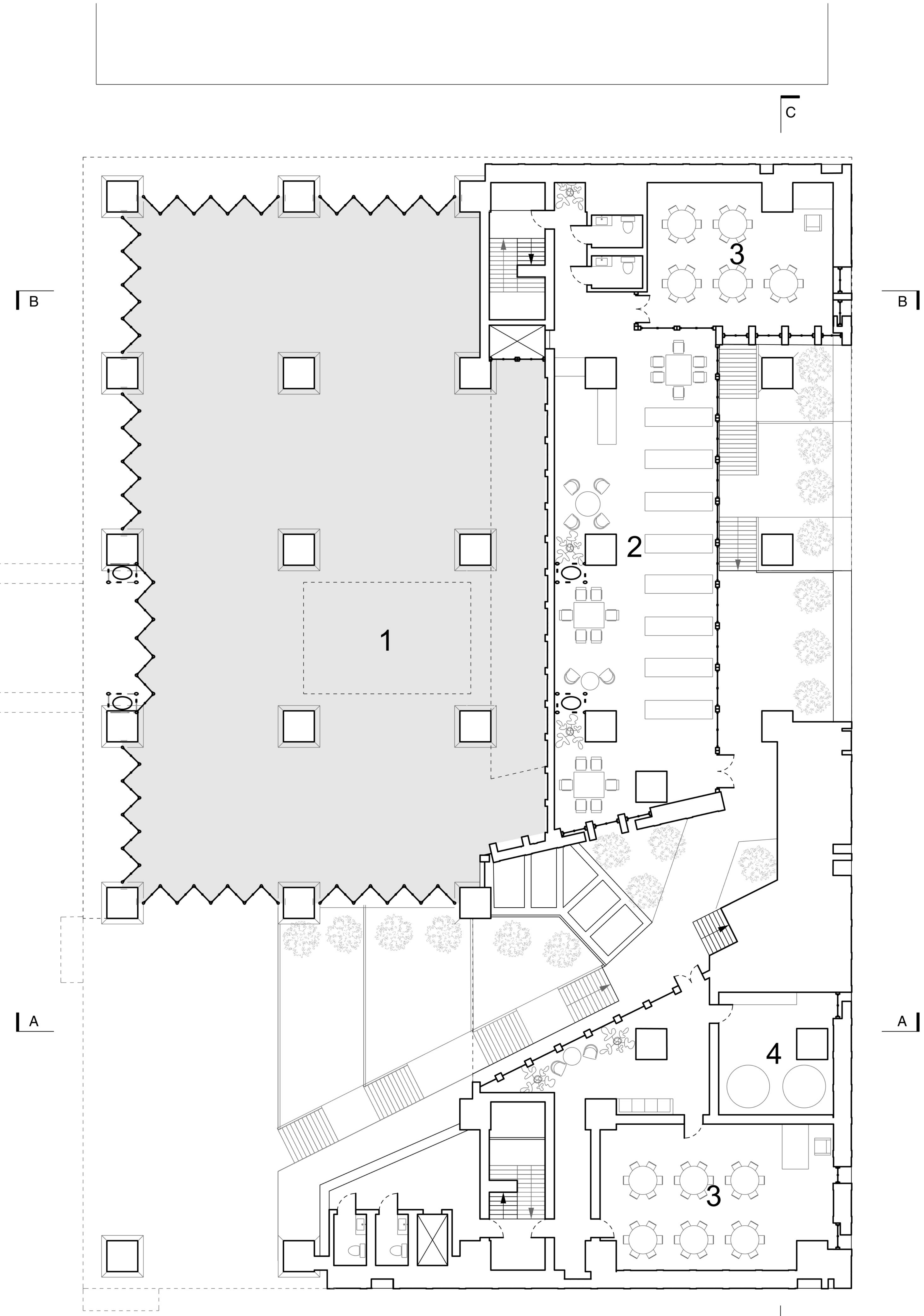




Ground Floor

Scale - 1:200

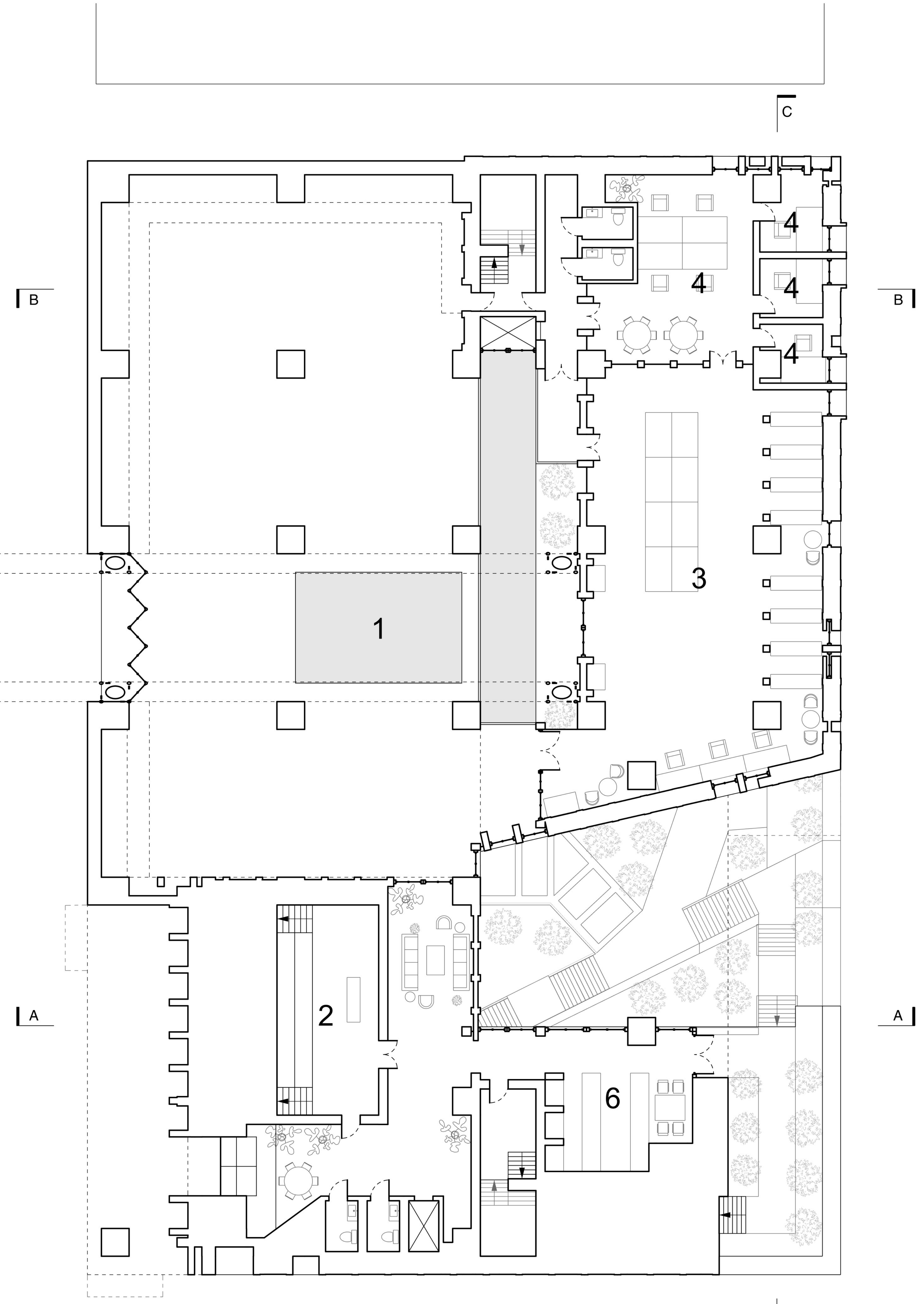
1 - Factory
2 - Storage
3 - Exhibit
4 - Cafe
5 - Bathroom



2nd Floor

Scale - 1:200

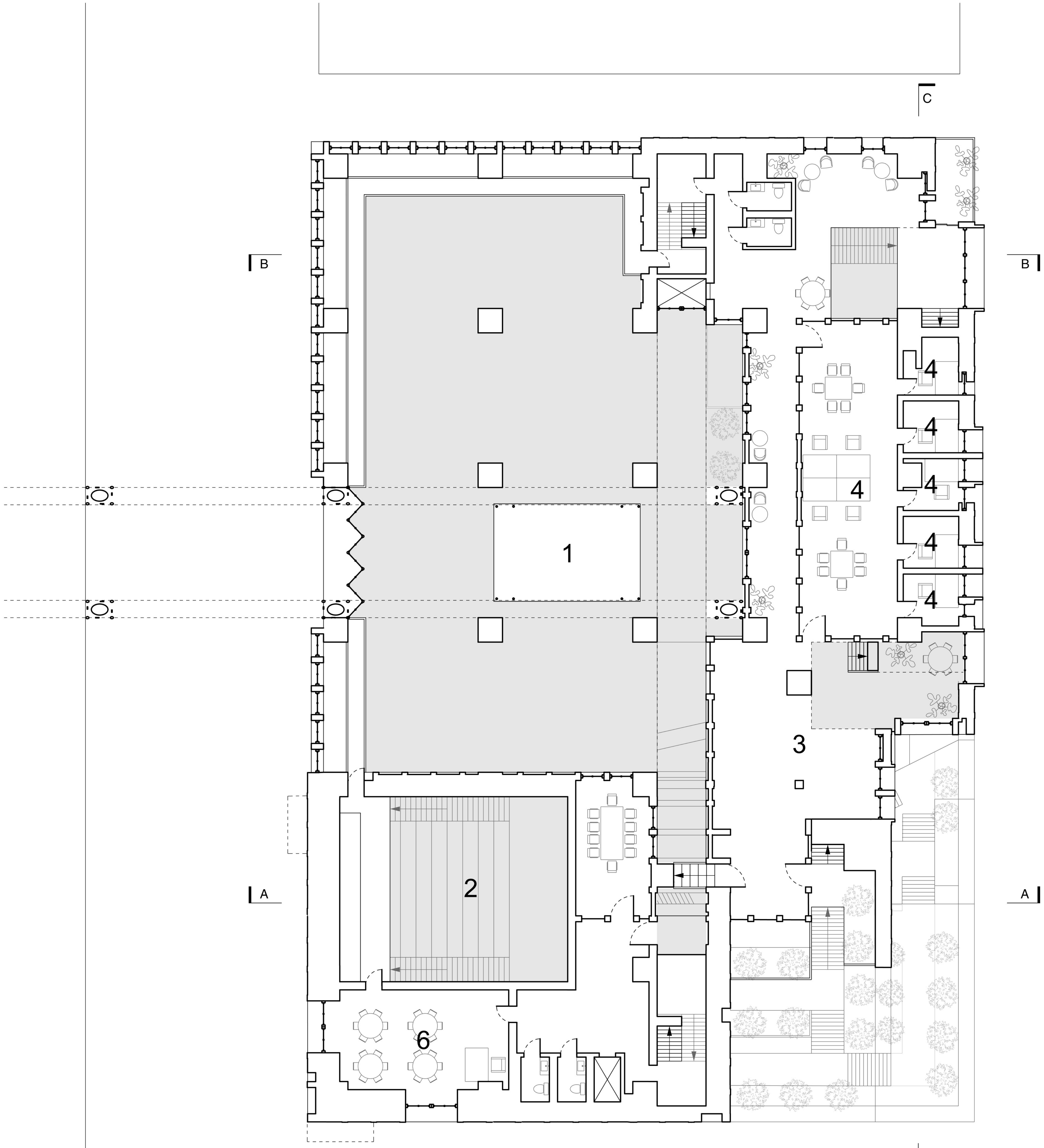
1 - Factory
2 - Library
3 - Public Classroom
4 - Utility
5 - Bathroom



3rd Floor

Scale - 1:200

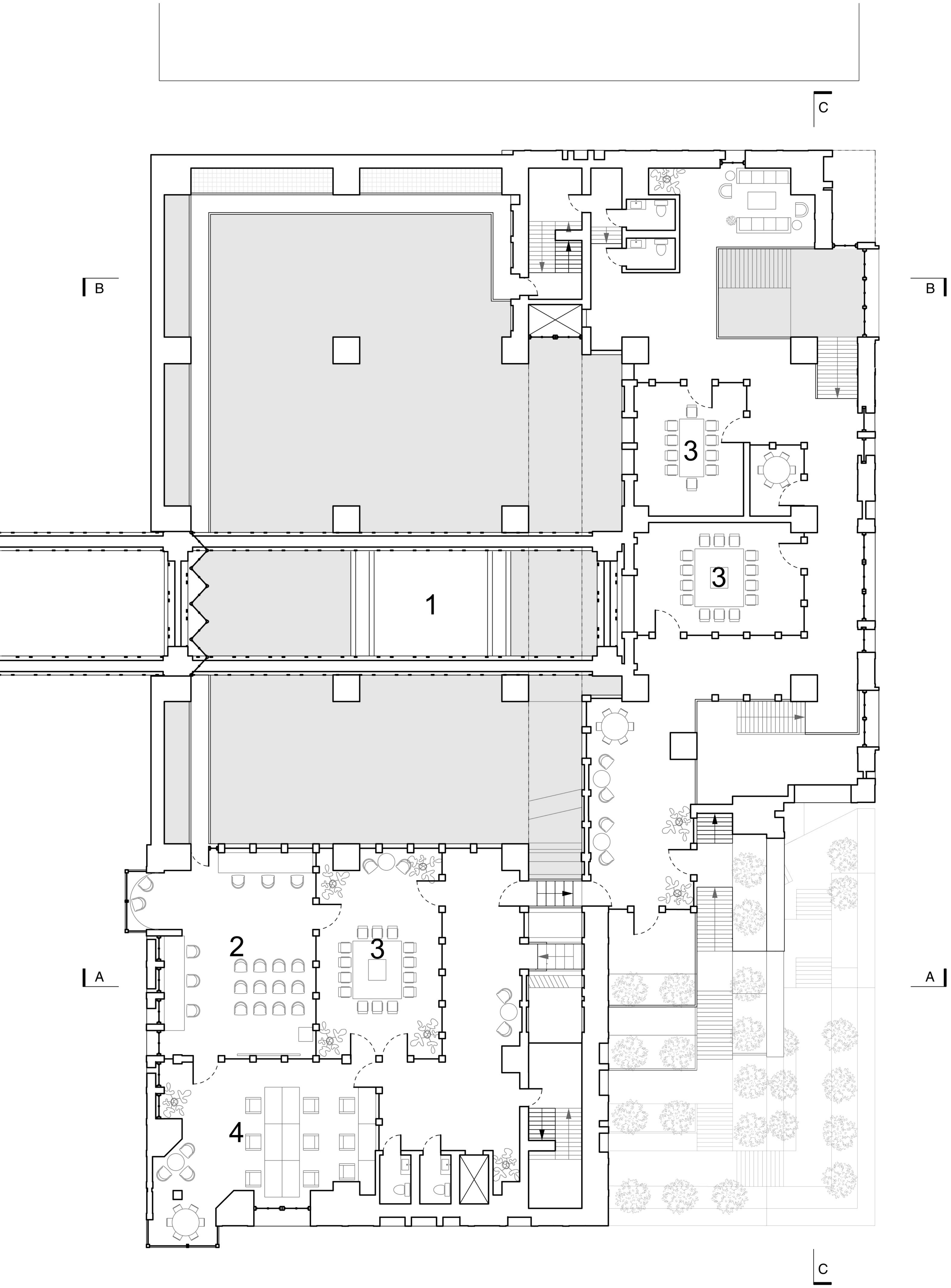
1 - Factory
2 - Lecture Hall
3 - Laboratory
4 - Office
5 - Bathroom
6 - Gardening Workshop



5th Floor

Scale - 1:200

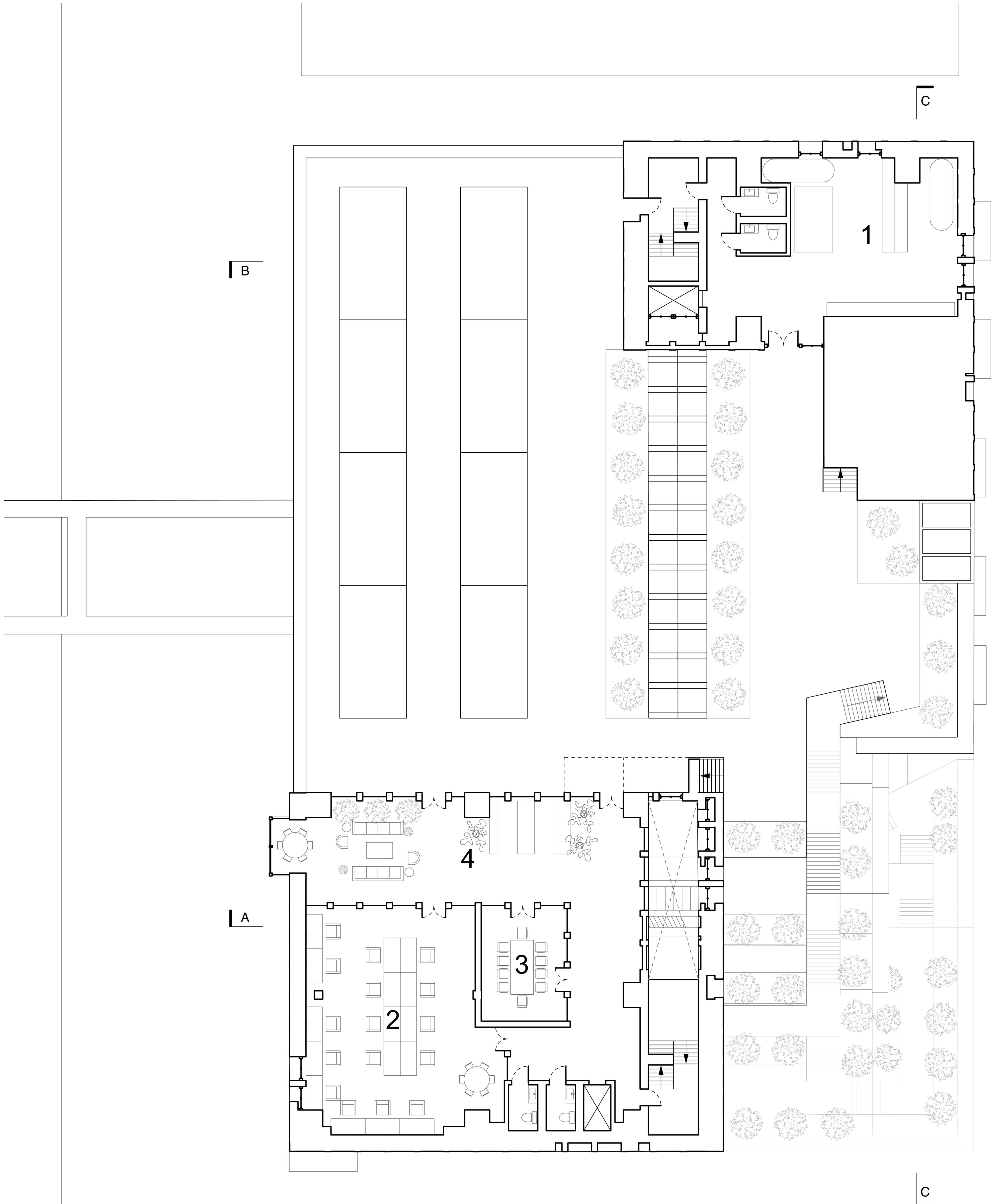
1 - Factory
2 - Lecture Hall
3 - Multipurpose
4 - Office
5 - Bathroom
6 - Classroom



6th Floor

Scale - 1:200

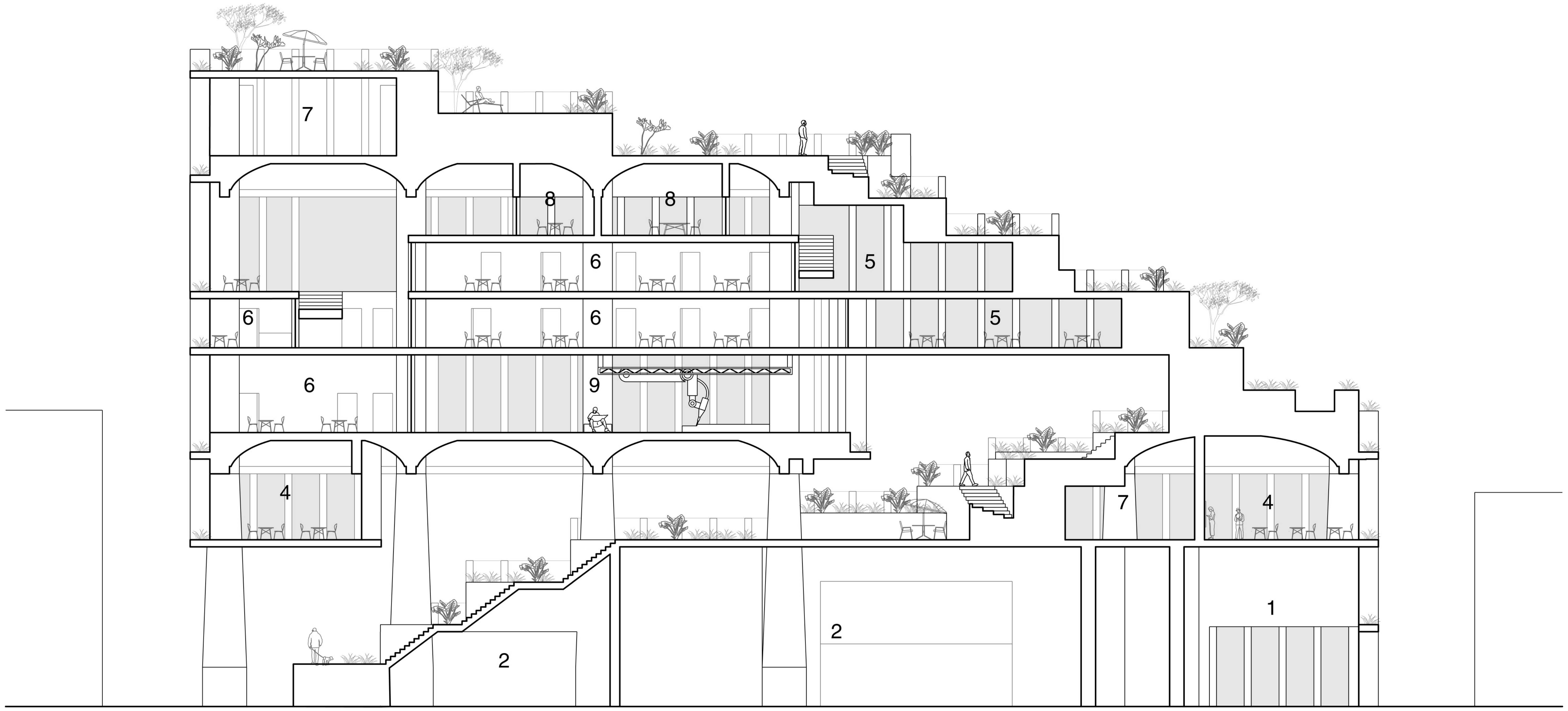
1 - Factory
2 - Factory Administration
3 - Conference
4 - Office
5 - Bathroom



7th Floor

Scale - 1:200

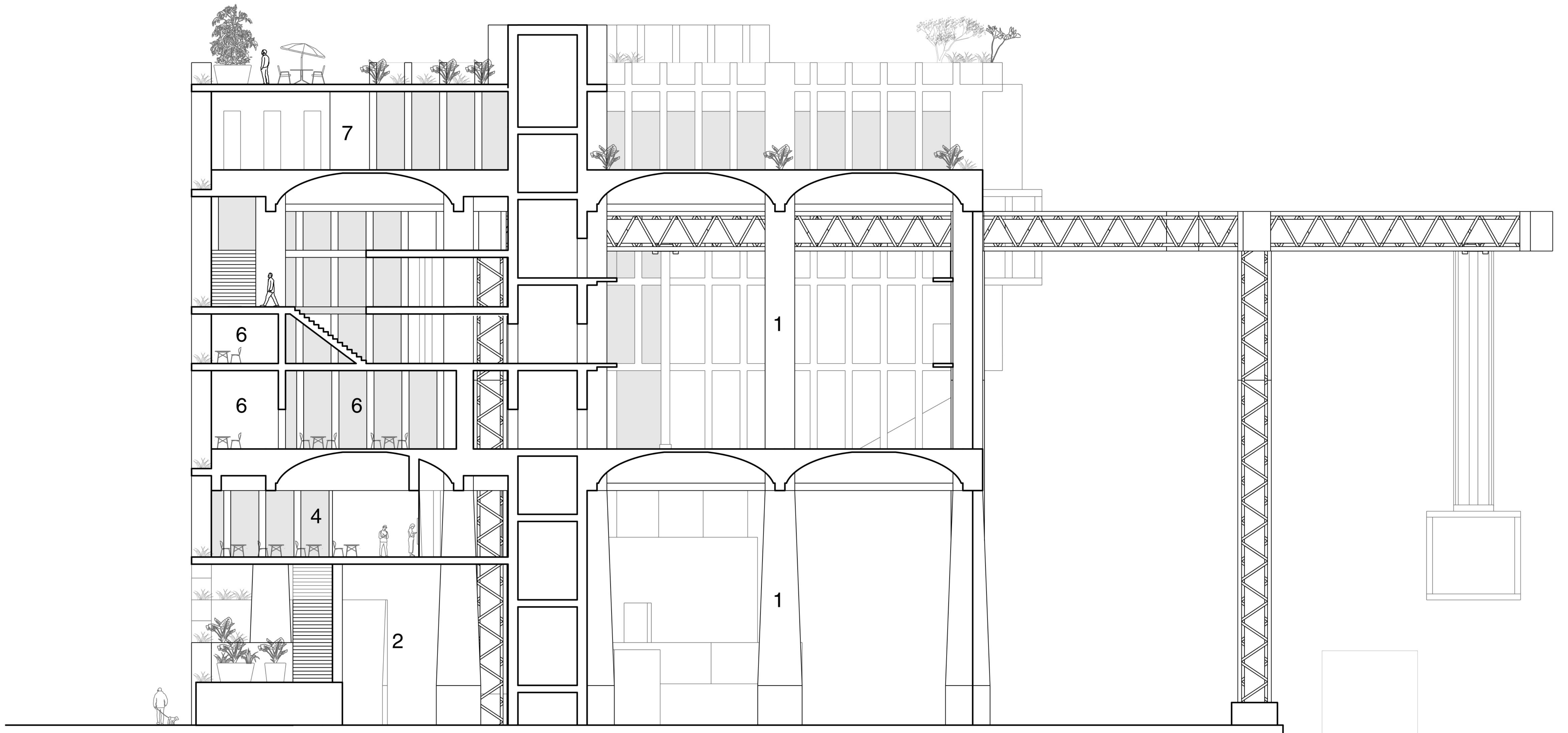
1 - Machine and Storage
2 - Classroom
3 - Conference
4 - Multipurpose
5 - Bathroom



Section C

Scale - 1:200

1 - Exhibit
2 - Storage
3 - Conference
4 - Classroom
5 - Multipurpose
6 - Office
7 - Utility/Machine
8 - Conference
9 - Laboratory

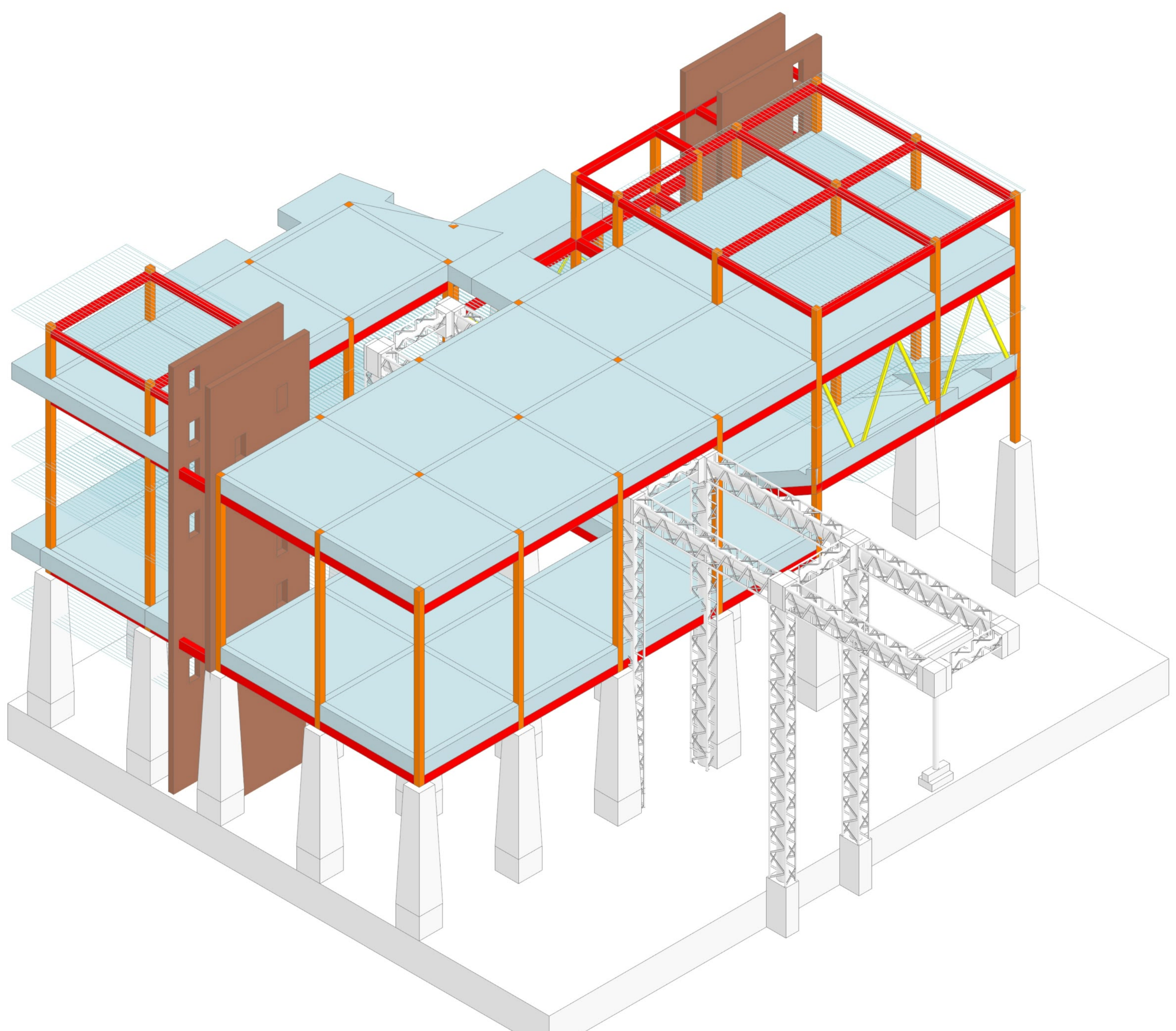


Section B

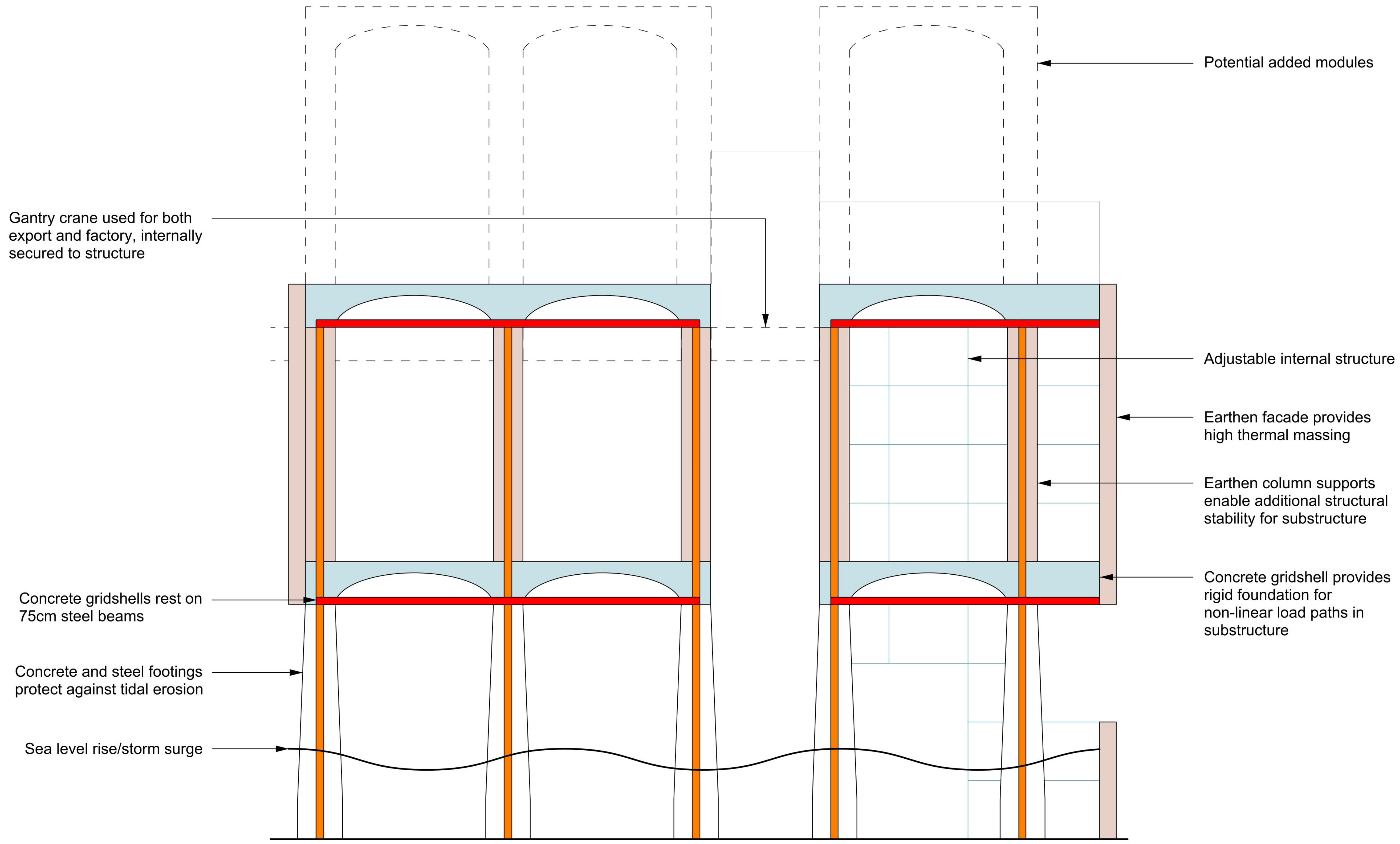
Scale - 1:200

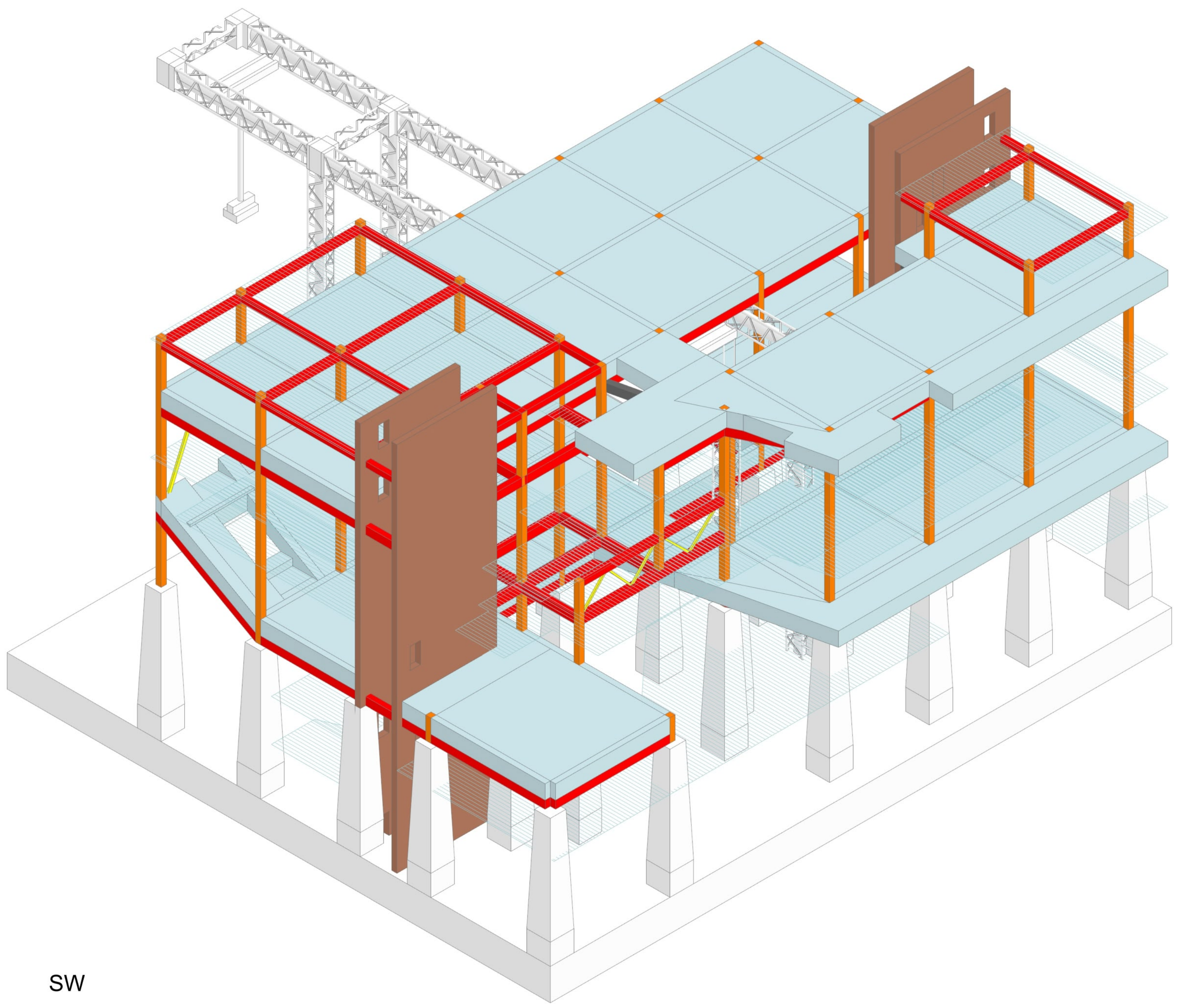
1 - Factory
2 - Storage
3 - Conference
4 - Classroom
5 - Multipurpose
6 - Office
7 - Utility/Machine
8 - Conference

Structural Strategy



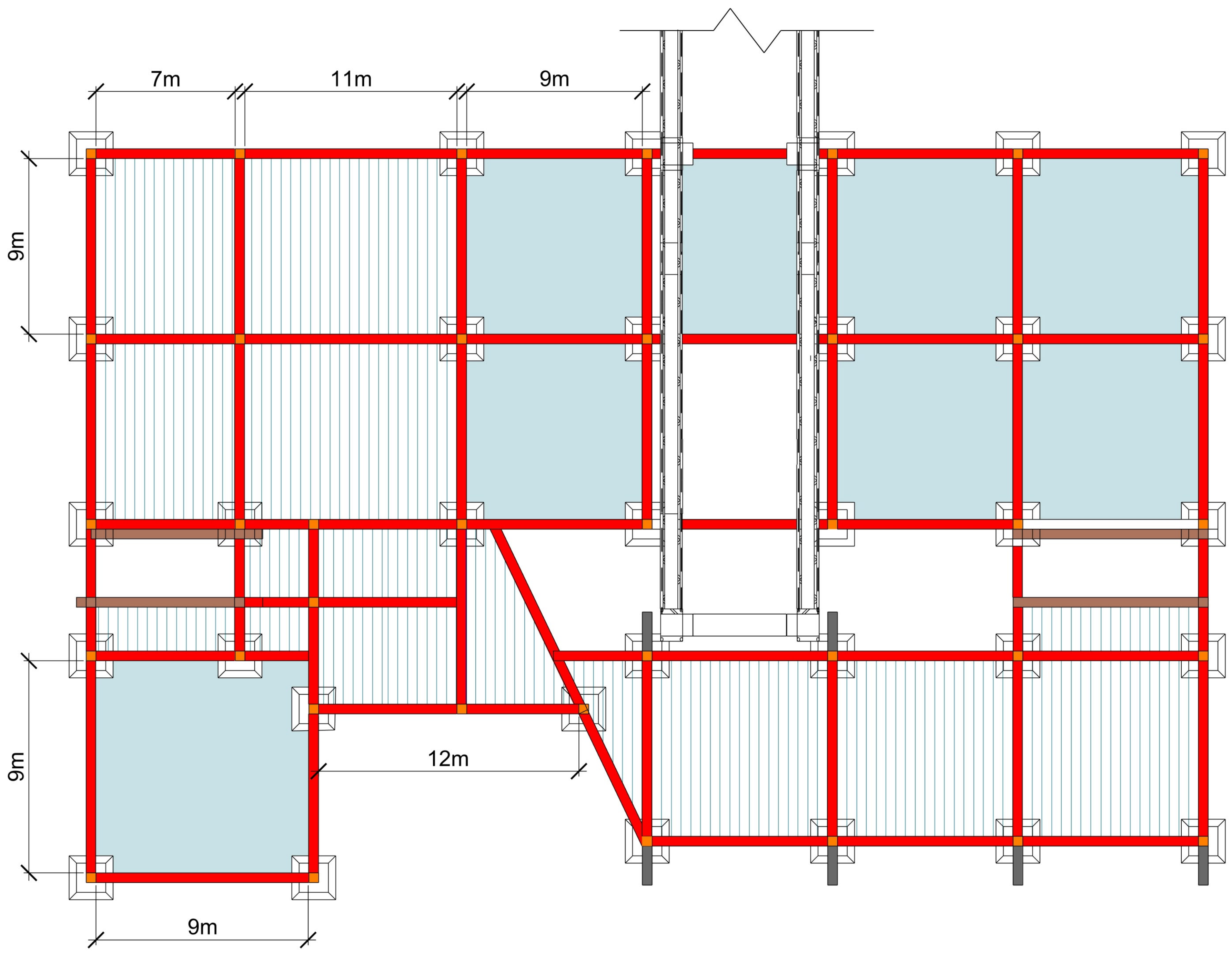
NE





SW

- Concrete Footing
- 75cm Steel Beam
- 50cm Steel Column
- 50cm Steel Cantilever
- Reinforced Concrete Fire Wall
- C3DP Panels
- Reinforced Concrete Gridshell Only
- Internal Light Wood Framing Subfloors



Material and Environmental Strategy

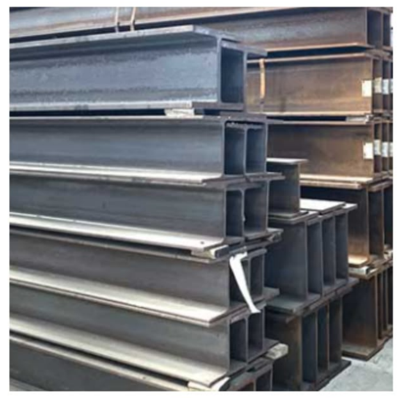
Compiled Statistics:

Net Material Cost - £5,819,428
Net Material Quantity - 13.673,000 kg
Net Embodied Carbon - 1,882,429 kgCO_2

Costs, embodied carbon, and mass are all an investment in future adaptability. Materials are extracted in order to be repurposed, plants are grown on site for construction and sustainment, steel is recycled from existing buildings at-risk. The initial carbon investment is offset by the carbon savings of adaptable and circular economy prefab buildings and internal alterations, with room for growth.

C3DP Earthen Mixture

Specifications - 11.04 MPa compressive / 1.26 MPa flexural
Application - Facade, Internal Structure
Cost - 0.137 £/kg / £726,548 Net
Quantity - 3120 m^3 / 1700kg/m^3 / 5,304,000 kg Net
Embodied Carbon - 0.05239 kg$CO_2$$m^3$ / 277,876 kgCO_2 Net

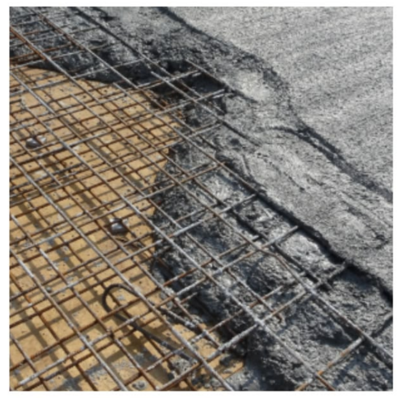


Reclaimed Structural Steel

Specifications - 250 MPa compressive / 235 Pa flexural
Application - Primary Structure
Cost - 2.40 £/kg / £1,130,400 Net
Quantity - 60 m^3 / 7850kg/m^3 / 471,000 kg Net
Embodied Carbon - 1.74 kg$CO_2$$m^3$ / 819,540 kgCO_2 Net

Light Wood Framing

Specifications - 20 MPa compressive / 18 MPa flexural
Application - Internal Structure, Floors
Cost - 1.40 £/kg / £364,000 Net
Quantity - 500 m^3 / 520kg/m^3 / 260,000 kg Net
Embodied Carbon - 0.0875 kg$CO_2$$m^3$ / 22,750 kgCO_2 Net



Reinforced Concrete

Specifications - 30 MPa compressive / 4 MPa flexural
Application - Gridshell Primary Floor Structure
Cost - 130 £/m^3 / £443,300 Net
Quantity - 1300m^3 / 600kg/m^3 / 780,000 kg Net
Embodied Carbon - 0.91 kg$CO_2$$m^3$ / 709,800 kgCO_2 Net

Structural Basalt

Specifications - 200 MPa compressive / 8 MPa flexural
Application - Foundation Pilons
Cost - 0.50 £/kg / £3,429,000 Net
Quantity - 2540 m^3 / 2700kg/m^3 / 6,858,000 kg Net
Embodied Carbon - 0.00765 kg$CO_2$$m^3$ / 52,463 kgCO_2 Net