A higher aim for wood

A higher aim for wood is all about exploring new solutions for an old material.

Using wood to create a type of building so far exclusively constructed with concrete and steel, it tries to explore the limits of what can be achieved with new wooden materials and technologies.
The main objective is to achieve a high building using wood as its load bearing system.
Recently built projects trying the exact same thing most often ending up being dark, massive structures. So another aim has been to create a construction allowing a high degree of transparency and a feeling of connection to the outside, where the wood structure itself can be exposed , seen and touched.

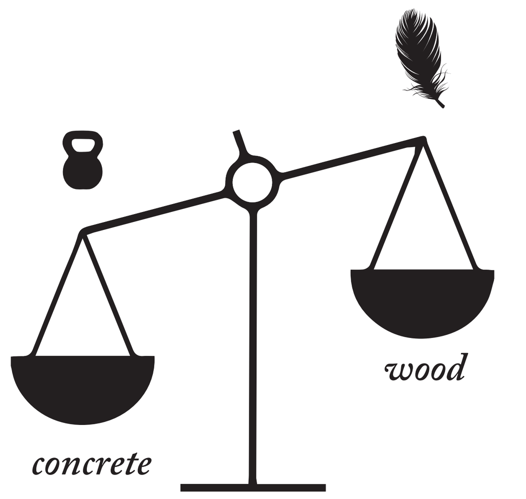
Wood has been used for millennia, to build everything from fences to churches. But there are areas where it has been seen as impossible to use. For about a hundred years, buildings have been growing ever higher. This ascension in height was possible largely thanks to new materials and improvements, using concrete and steel to aspire for scraping the skies. With their high capacity to handle a multitude of shapes and loads, it has become the standard for any building larger than the common villa.

But wood is on its way back to the scene of more complex building, for several reasons. The insight that our environment is fragile is about to change the way we build. Going for greener options means changing polluting materials to carbon positive ones, and perhaps most of all trying to create more efficient processes in which to erect our buildings. Modern wood materials give possibilities for both, making wood buildings a viable option.

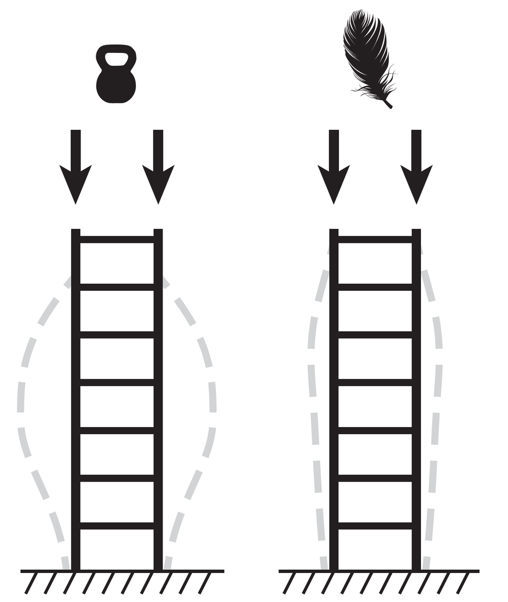
Where concrete emits carbon dioxide in a harmful way, wood can be argued to do the opposite. Replanting to make up for each tree used in constructing not only creates a source that will grow back to be used again, it embeds carbon dioxide in the process. Using engineered wood products such as CNC milled CLT also creates possibilities for quick assemblies and prefabrication of elements, without losing the option of creating a varied set of parts as each piece can be milled differently.

Wood construction

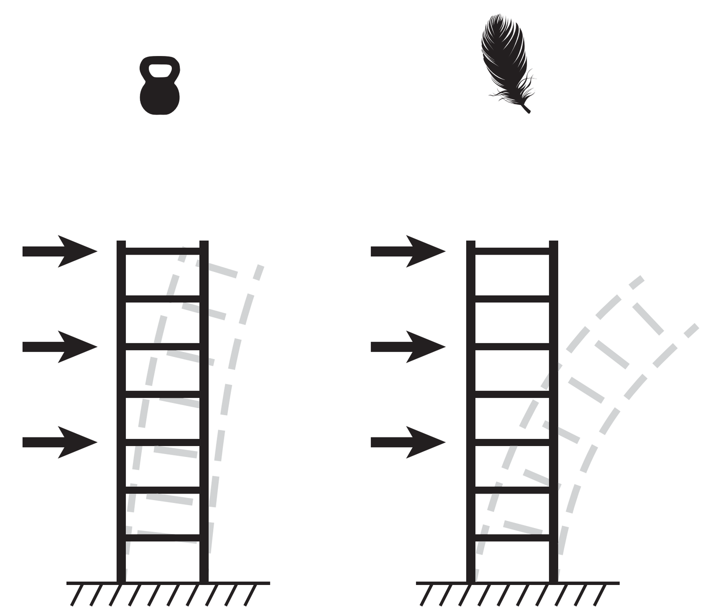
When trying to build high in wood, there are a few things that differ from the usual high building made primarily of concrete. Although the same norms apply, the materials have highly different characteristics for carrying and transferring loads, as well as for fire resistance, moisture, energy efficiency and a whole array of other issues. I have focused on two of these issues, that can be seen as the most pressing to solve for this kind of structure. Load carrying is the primal concern, explained on this page. The other is fire safety and fire protection, which is discussed later.



Wood as a material is very light. With most woods having a density around 600 kg/m3 and concrete 2500 kg/m3, the characteristics for building with wood will be apparently different.



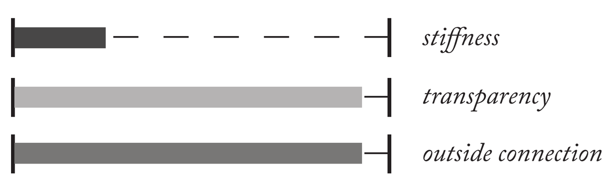
A heavy building (of concrete) has to cope with strong vertical loads resulting from the high building mass. Wood buildings being lighter while still having good compression strength have less problems with handling those forces.

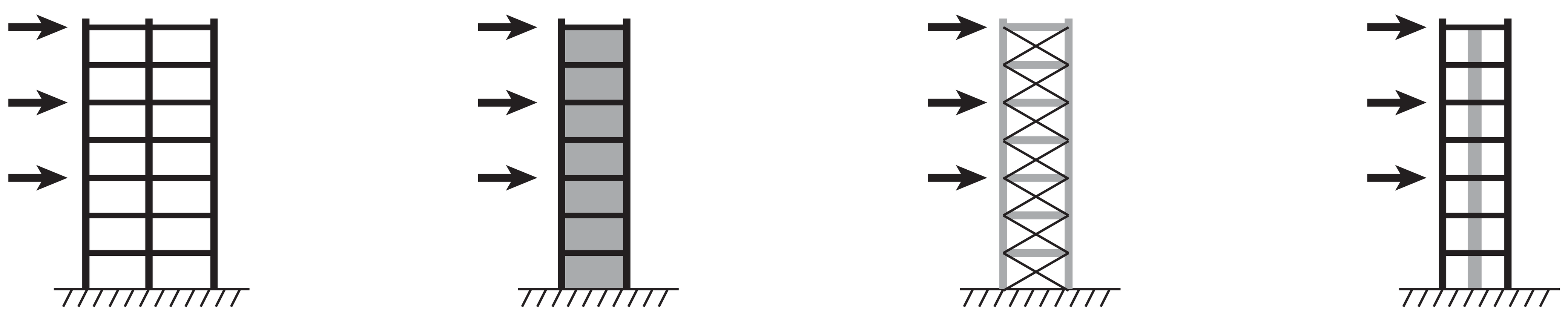


Horizontal loads (such as wind) are a minor concern when using concrete because of its heaviness and structural stiffness making it easier to carry shear loads in the slabs.
For wood however, horizontal loads is the major concern. Being light constructions hard to stiffen, this is the major problem any high building in wood has to solve.

Horizontal stability

As horizontal stability is what really makes or breaks a design in wood, it's worth a more thorough presentation. There are 4 major ways in which to create the needed horizontal stability. To see how each can perform in terms of the thesis objectives, an indicative bar graph shows how each method performs in order of: stiffness (capacity to transport the necessary loads), transparency as well as the contact to the outside (which is an indication of how deep the cross section is, and the ability to have views of the outside).





There are different ways to handle these horizontal loads and create enough stiffness in the construction. One is to broaden the building which simply allows the force transfer longer time to reach the ground.

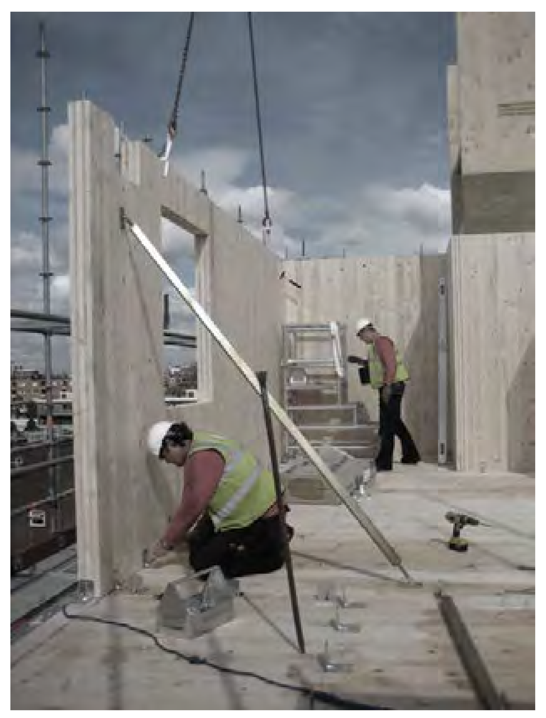
In order to create pathways for the horizontal forces to reach the ground, one effective way is to use diaphragm action by

Another way to stiffen the building is to create a super structure on its sides, acting as crossbracing with the maximum width the building can allow.

Any high building needs a solid core, which also helps considerably managing the wind loads (in concrete buildings this alone is often enough)

Cross Laminated Timber, engineered wood products and ease of fabrication

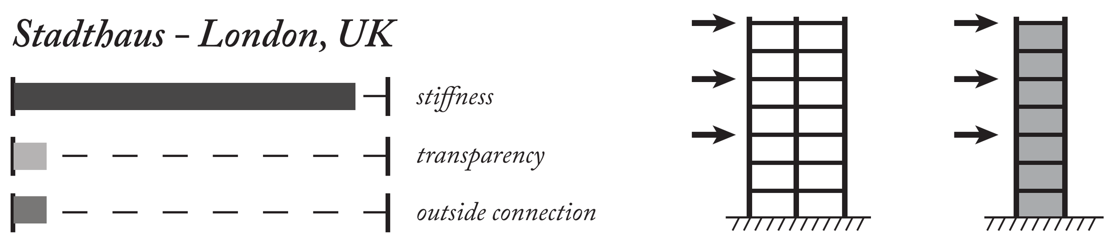
Cross laminated timber (CLT) is a product using regular wood boards glued together in layers stacked crosswise with strong adhesives. Different thicknesses can be achieved depending on board dimensions and number of layers. A minimum of 3 layers is needed for stability. There is no limit to the size of the final CLT panels, in either thickness, height or width, but usually they don't grow thicker than 7 layers and 3x8 m pieces. CLT is often combined with the use of CNC cutters to create prefabricated elements ready for assembly on site.



3 ways of making it - reference projects

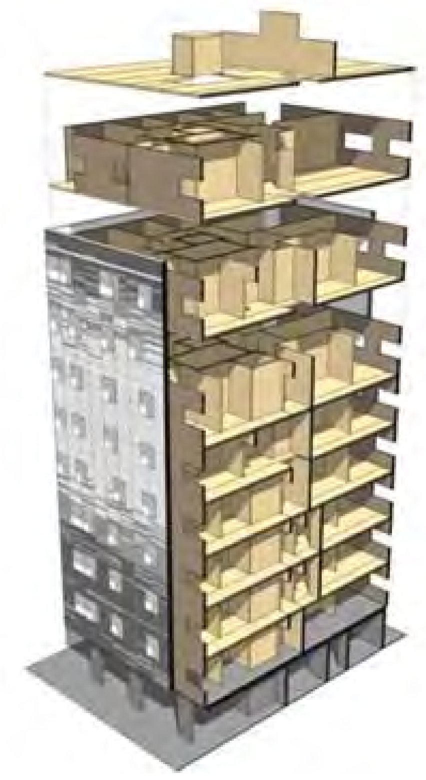
So far, there are very few built projects that can be regarded as being tall. However, there are many under way, being constructed or just about to start. In Sweden, Växjö has had a prominent place in spearheading the development, so far having built an 8 storey residential building using cross laminated timber as the basis for the structure. Here follows 3 projects using different ways of handling the issue of horizontal forces.

Stadthaus - London, UK

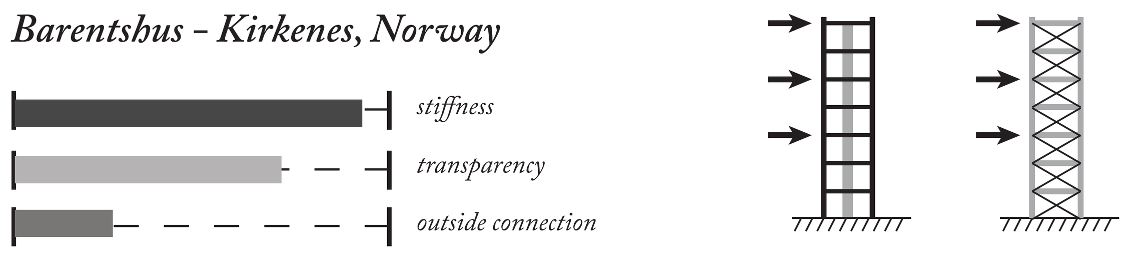


Presently the tallest residential timber building in the world with its 9 storeys. It consists of 29 apartments and is designed by Waugh Thistleton architects in London.
It uses a cross laminated structural system by the austrian wood engineering firm KLH. The CLT form a cellular structure of platform framed, load bearing timber walls, with timber cores, stairs and slabs aswell. Each panel is prefabricated with cutouts for windows, doors and other openings. This made an assembly time of 9 weeks possible on site for the structure.

The wide cellular structure of CLT creates the necessary stiffness, but it takes away any notion of transparency or lightness . In addition, it covers all its interior surfaces with plaster to handle fire regulations. As a project making its way to actually being built, its inspiring, but it lacks many of the qualities that a wood building can have.



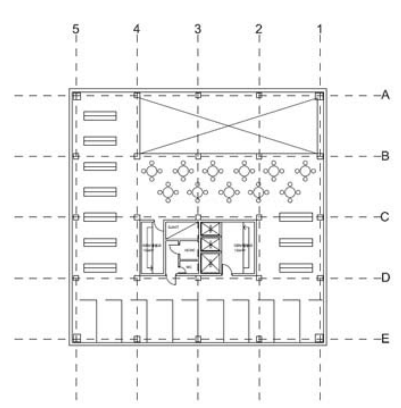
Barentshus - Kirkenes, Norway



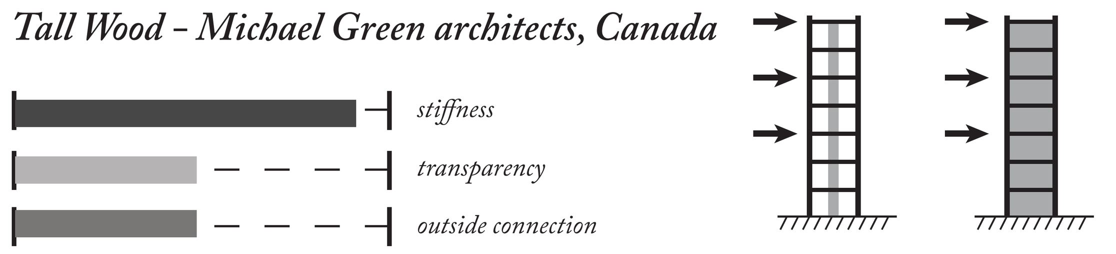
Kirkenes in northern Norway is about to build a cultural centre focusing on the northernmost areas of Europe and the culture of northern Norway, Sweden, Finland and Russia. Arhcitect is Reiulf Ramstad.

The design takes it values from what can be perceived as typically scandinavian: cleanness, transparency and use of natural materials.

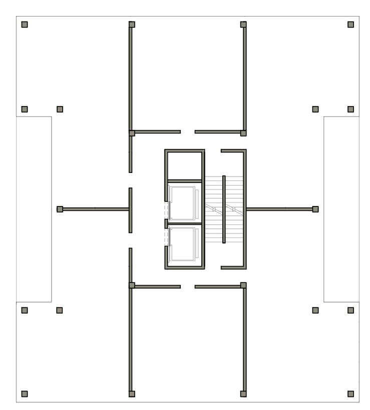
When finished, the building will stand 20 storeys tall (80 m). To build such a high building with a relatively small footprint (at least compared with other wooden structures), it relies on a super structure working as cross bracing fitted to the column/beam-based construction. Using the maximum width of the construction and stiffening without the need for interior diaphragm walls (except a few to carry the loads from the super structure to the core for greater stability), the result is a building with a high degree of transparency. However, its section becomes fairly deep, making it score lower when it comes to the outside connection.

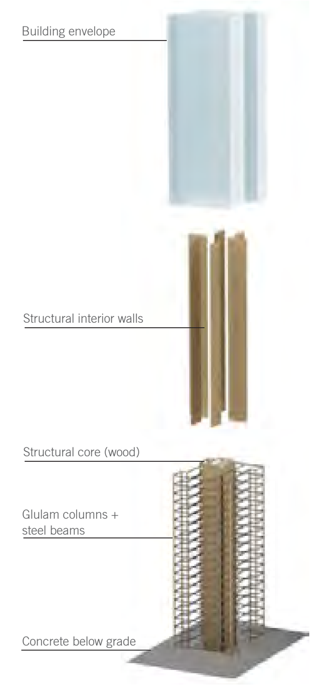


Tall Wood - Michael Green architects, Canada



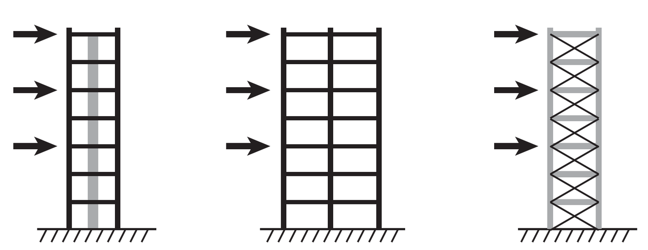
The canadian architect Michael Green has a strong compassion for wood. Along with the office bearing his name, he has created a thouroughly studied option for buildign high in wood. Coming from Vancouver, it focuses especially on how the province of British Columbia can become the new world leader in this realm. Writing a whole manifesto with thoughts about everything from common misconceptions about wood to details about joints, it also presents a possible design of a 20-storey building. Much like the Stadthaus in London, it focuses on using shear walls, but here in a column/beam system instead of being the structure.
Despite the limiting shear walls, this design creates large spaces with a fairly good contact with the outside. On the other hand, transparency is lost.

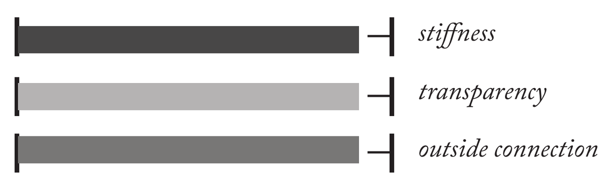




Conclusion

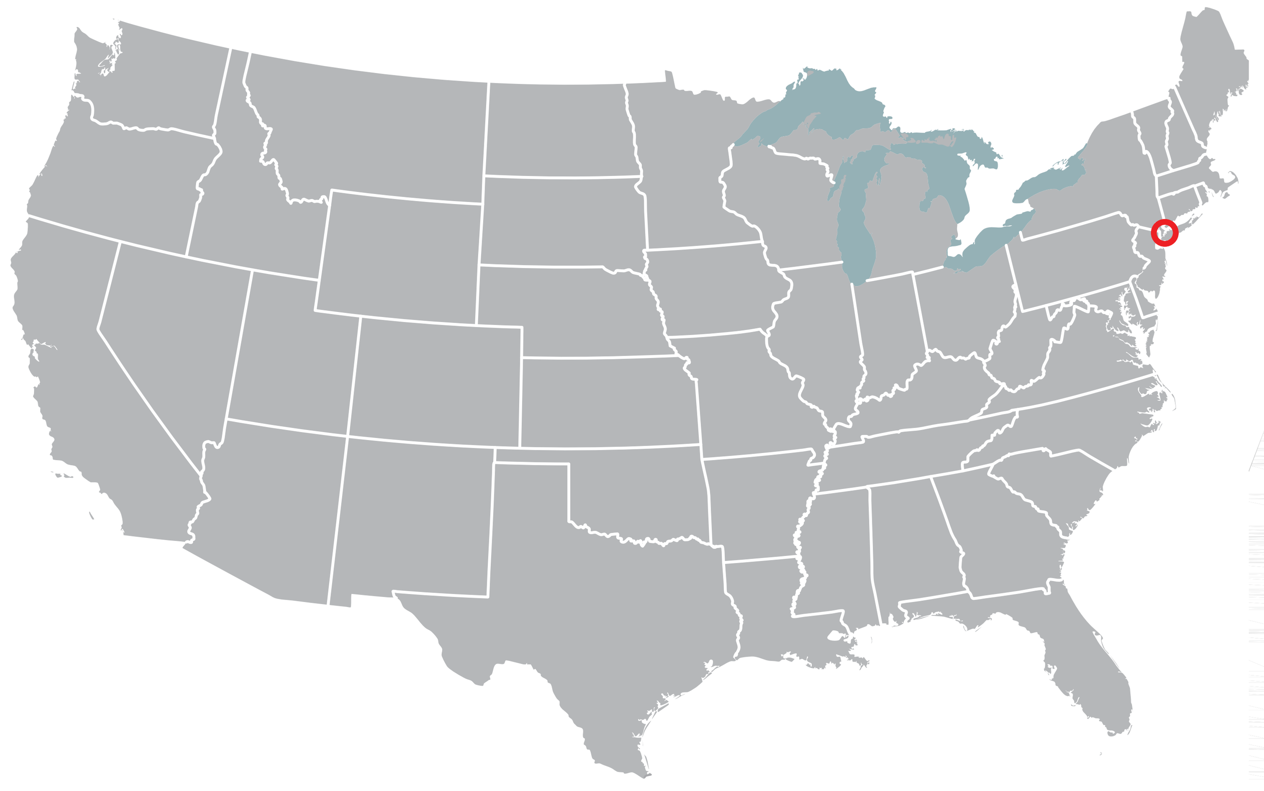
Striving for a maximum amount of transparency and a shallow depth for good outside connection, the most efficient and inspiring solution to create the necessary stiffness seems to be to use a super structure. This frees up the plan inside, where in a column/beam system only a few load transporting shear walls would be necessary. However, too shallow a building would not give the sufficient width for the superstructure to be effective enough. The solution chosen is to widen the building in a 90-degree angle, creating shallow sections but a long path for the super structure to carry loads and stiffening the building. In this way all sought parameters can be fulfilled to a high extend.





Program and site

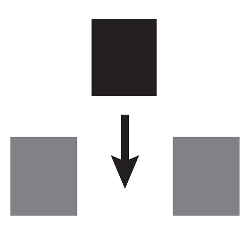
To get a context in which to realize the building, the program for a student competition in USA titled "Timber in the city" has been used. It calls for a high wood building able to house about 200 apartments as well as wood workshops, digital workshops and a bike shop. The site for the project is in Red Hook in south Brooklyn, NY.



Red Hook is a part of Brooklyn that's just beginning to realize its new potential. As the city of New York grows larger, parts of the city yet considered remote are suddenly becoming central. Red Hook is just such a part. Traditionally a part of Brooklyn dominated by shipping and storage for the large harbor, its presently populated by low income groups in houses with a generally poor standard. Many areas have vacant lots and the buildings are generally low. As the land gets more lucrative, the question is how Red Hook can transform to keep both its current tenants and invite the denser city at the same time.

The site itself lies in close vicinity to a large IKEA store, giving the area a steady stream of visitors from other parts of the city. A free-of-charge ferry frequents shoppers and everyone else to and from Battery Park on Manhattan. Other efficient communications lies farther away, with the nearest subway station 2 km away. However, a bike route heavily used by commuters pass right by the site. Neighbouring the west side of the site is a communal gardening patch with an alley of tall trees, but the nearest park for recreation lies far away.

What Red Hook needs to start becoming its futures self is above all a higher density, with social gathering spaces. The site becomes an attractor point for the vicinity, making the new wood building an icon for Red Hooks change for a better future.

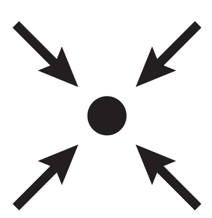


Density

Red Hook generally has a low density with older small and low housing. Many plots are disused. As the neighbourhood becomes increasingly urban, a higher density is needed.

Icon

In order for Red Hook to become a place on the map drawing peoples attention, an eye-catching and adventurous project might be just what is needed. As a counterpart to other eye-catchers in the vicinity, such as the Statue of Liberty which can be seen from the site.



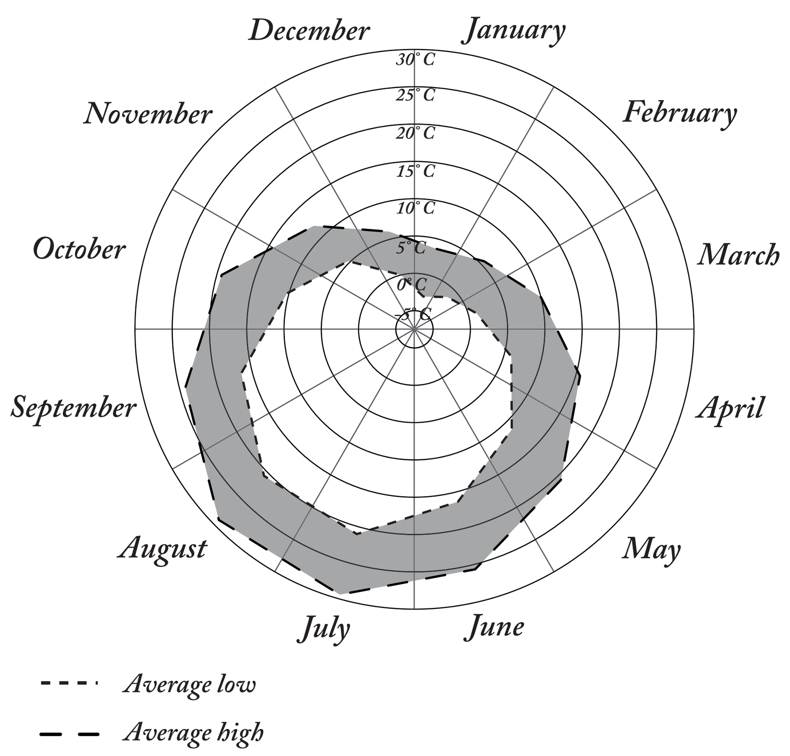
Attractor point

In order for Red Hook to realize its potential and start its rejuvenation, a focusing point is important. The site for the competition lies strategically in order to create such a venue.

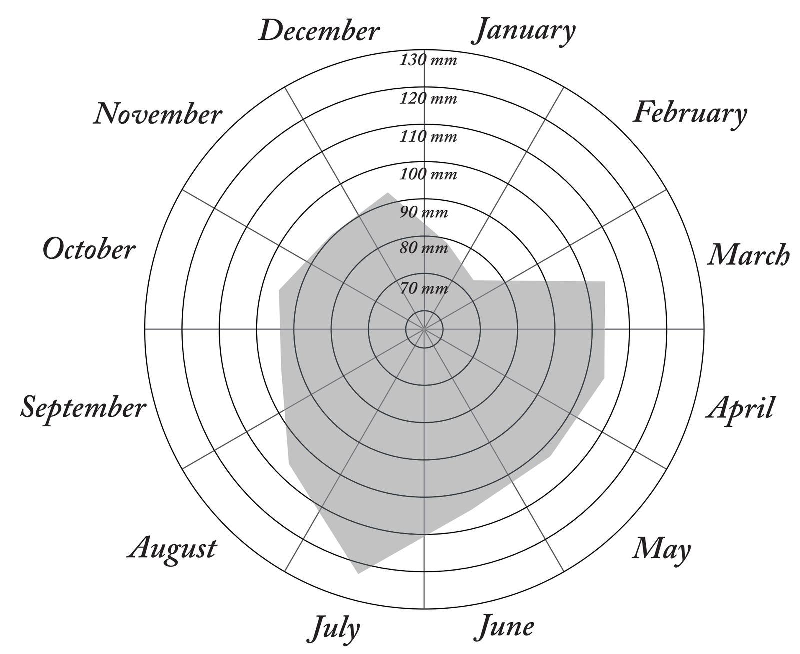
Social gathering and recreation

Red Hook lacks places for social gathering and interaction. Apart from a sport fields (baseball, basket), there is a lack of parks and social recreational space in the vicinity. This makes it important to create spaces where citizens can meet each other and share their life, especially as the city becomes denser.

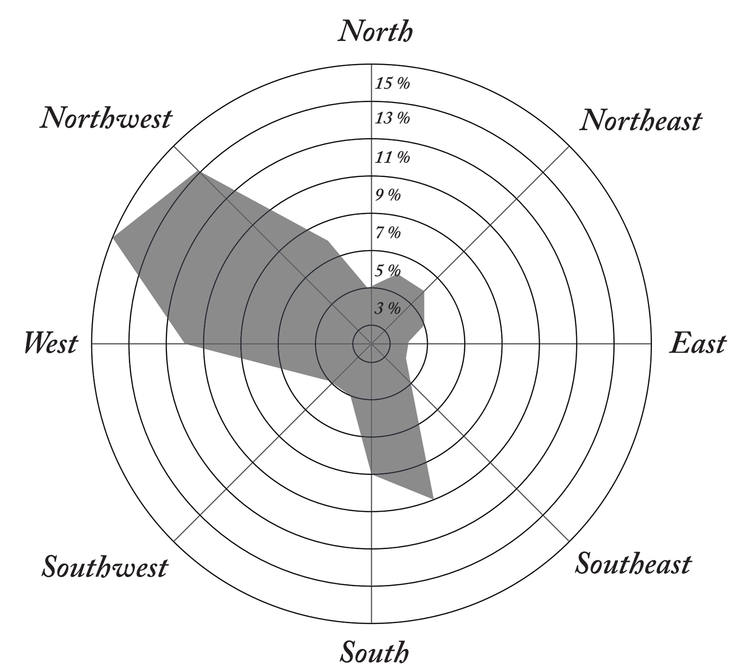
Average temperatures



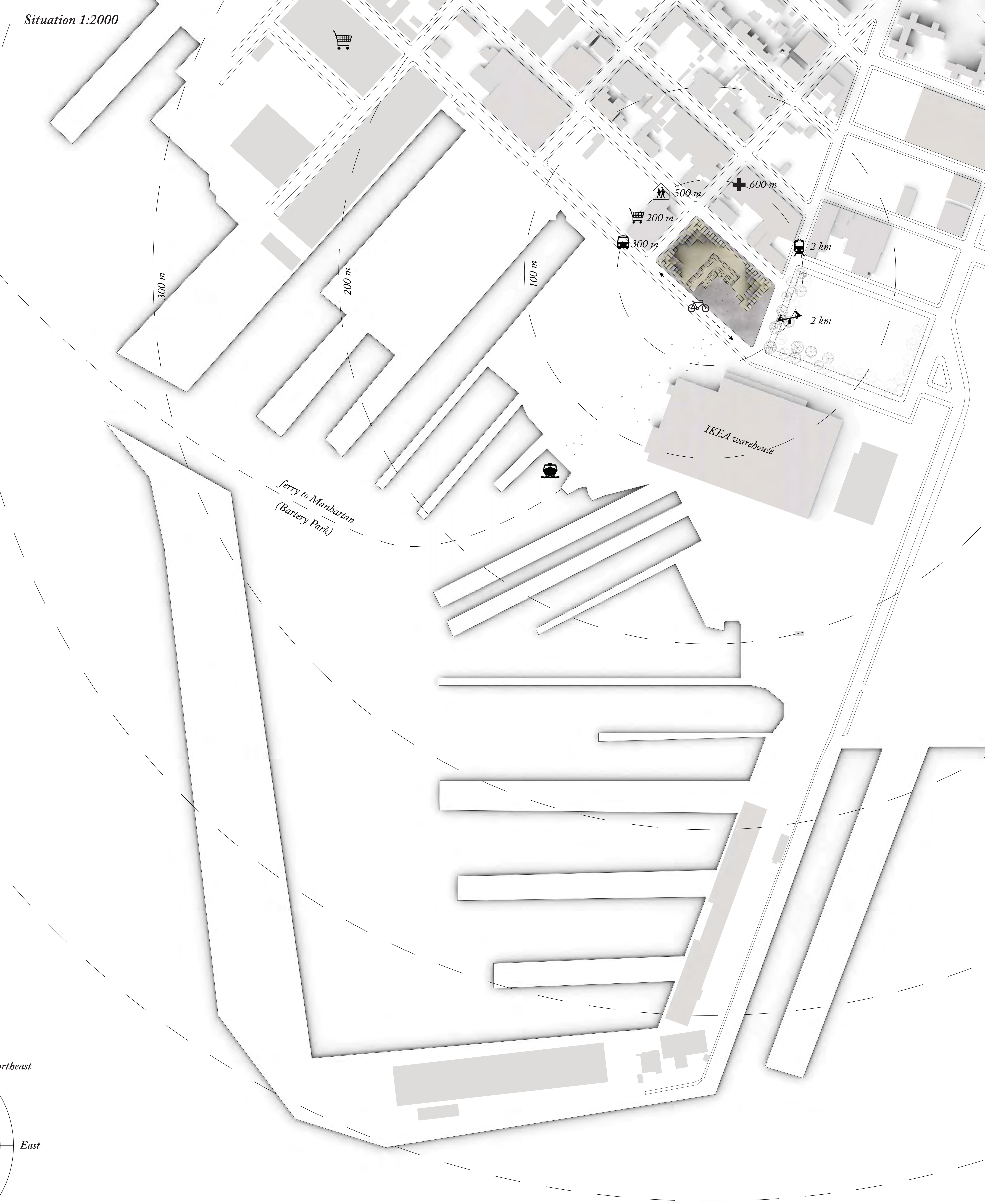
Average precipitation



Wind directions

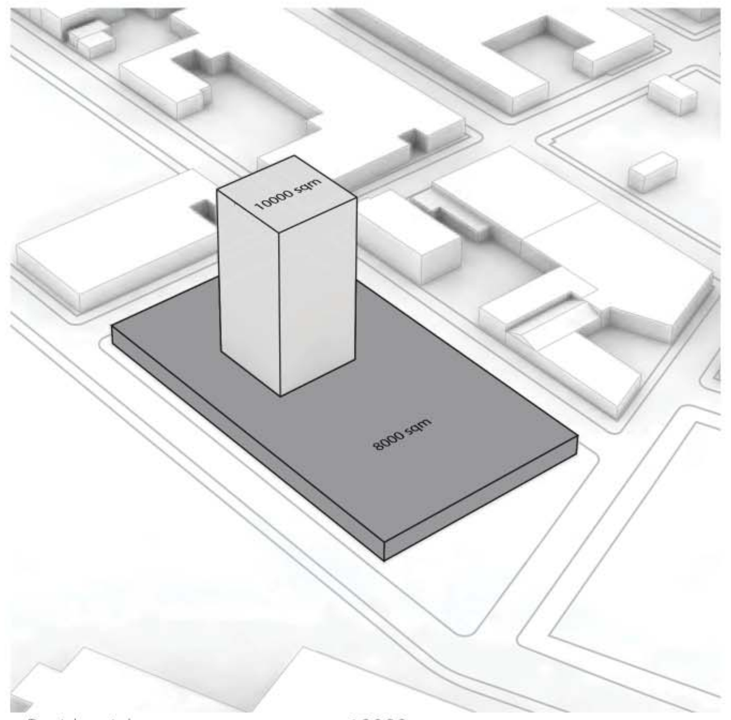


Situation 1:2000



Design

Program and site

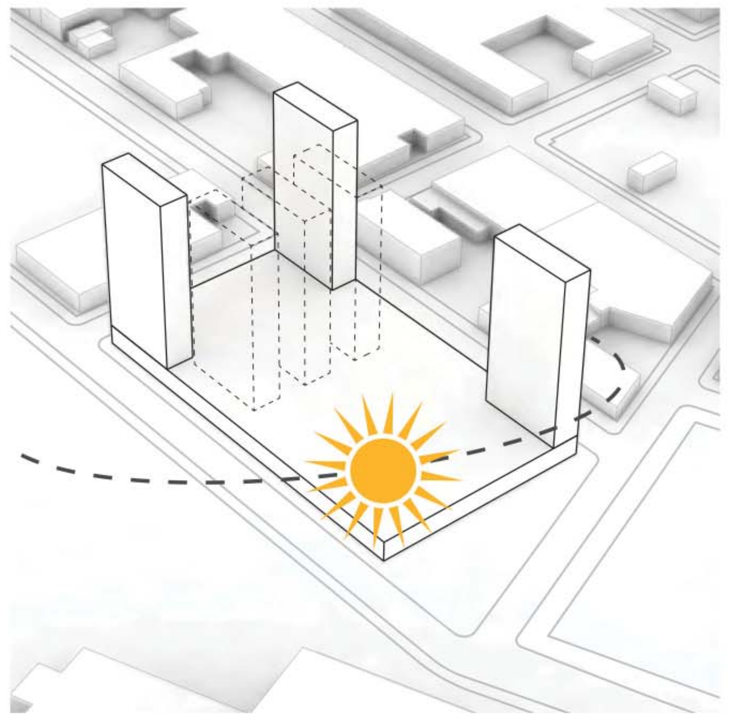


Residential 10000 sqm
Production, Retail 8000 sqm

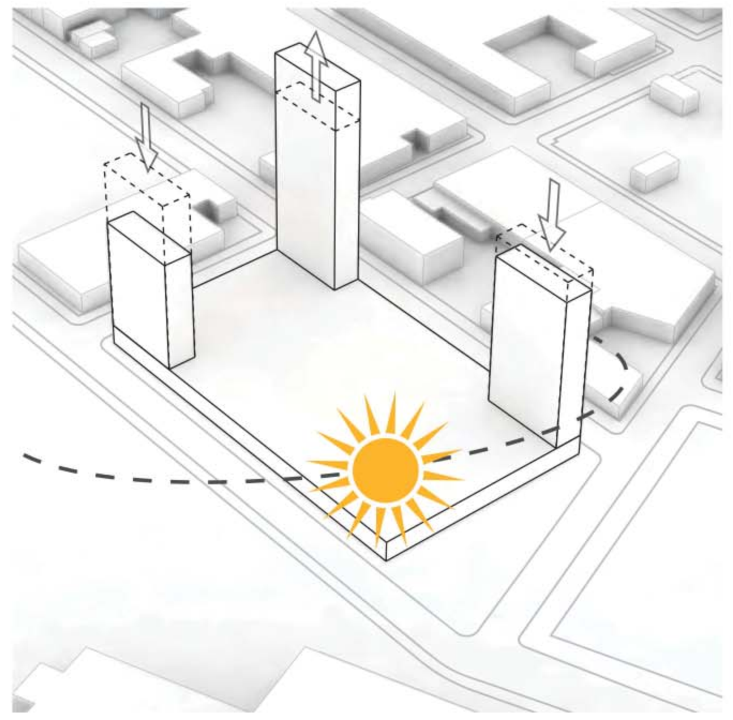
200 apartments, 4 sizes from 30 sqm to 90 sqm.

Production areas for wood manufacturing and digital fabrication, aswell as a bike shop and a café.

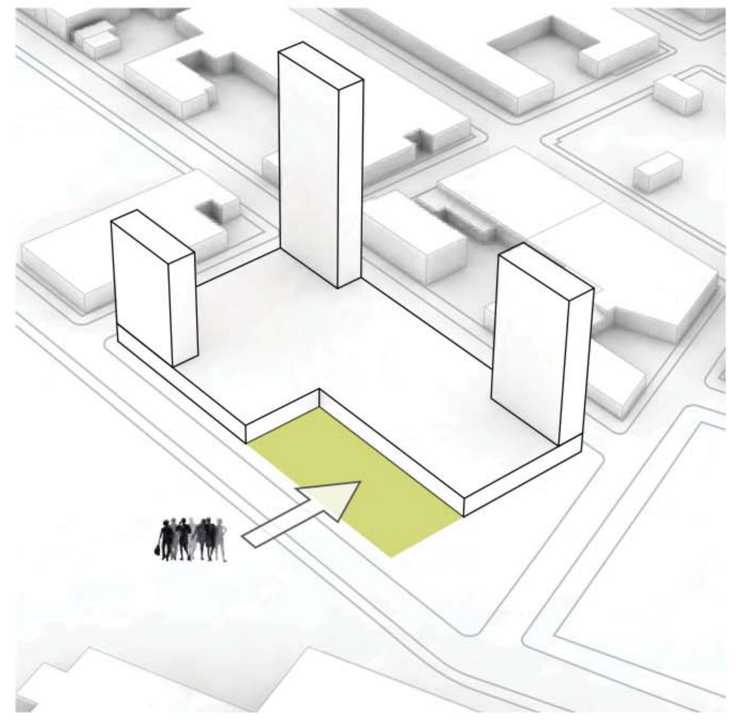
The towering block for the apartments is split up in 3 segments to create slender segments. This gives the apartments better light conditions aswell as views.



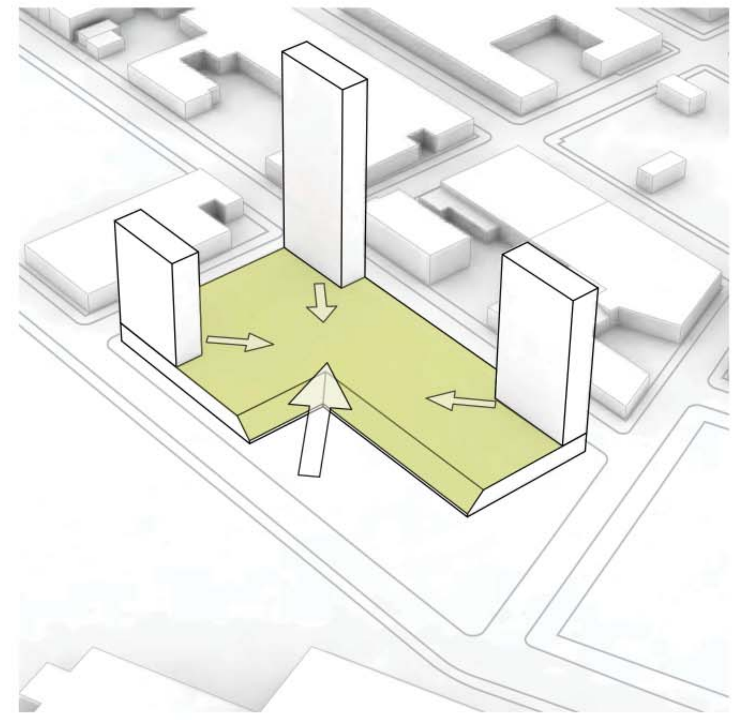
The segments are moved to the corners for maximum sun exposure.



Each tower gets a height that maximizes the sun exposure, aswell as creating interesting volumes with a more iconic presence.

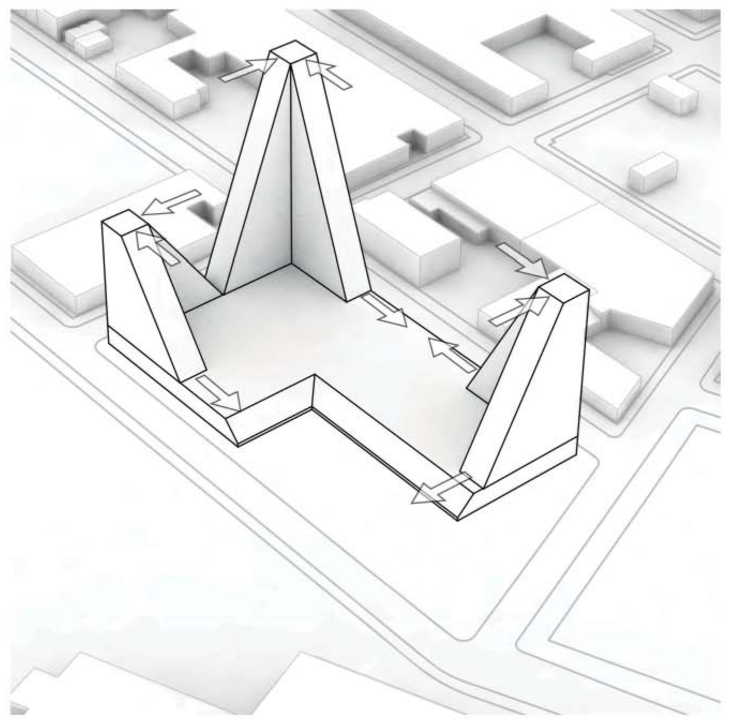


A cut is introduced in the bottom slab to create a social gathering zone in form of a public plaza where the bike shop, a cafe and showrooms for the manufacturing lines the plaza in the cut.

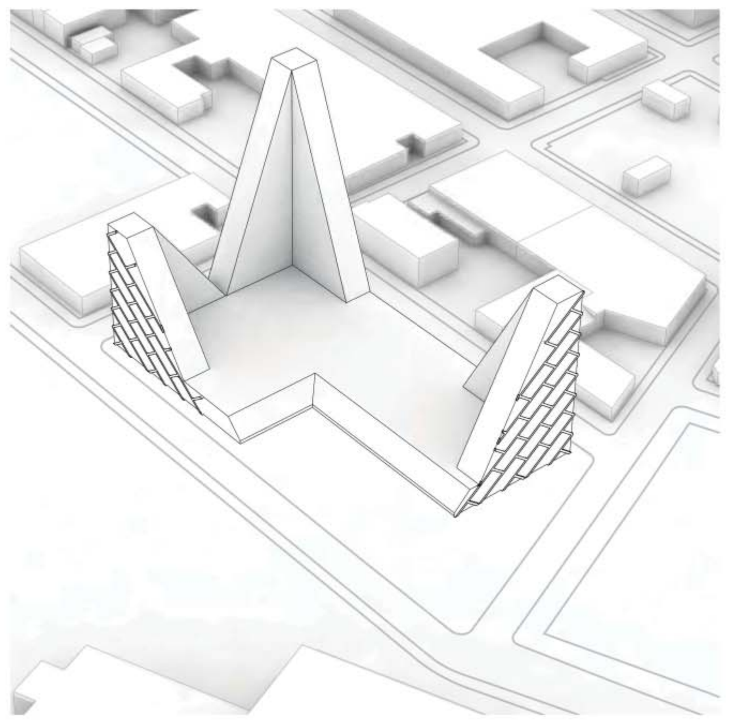


The space between the towers on the bottom slab becomes a garden for the residents aswell as the public.

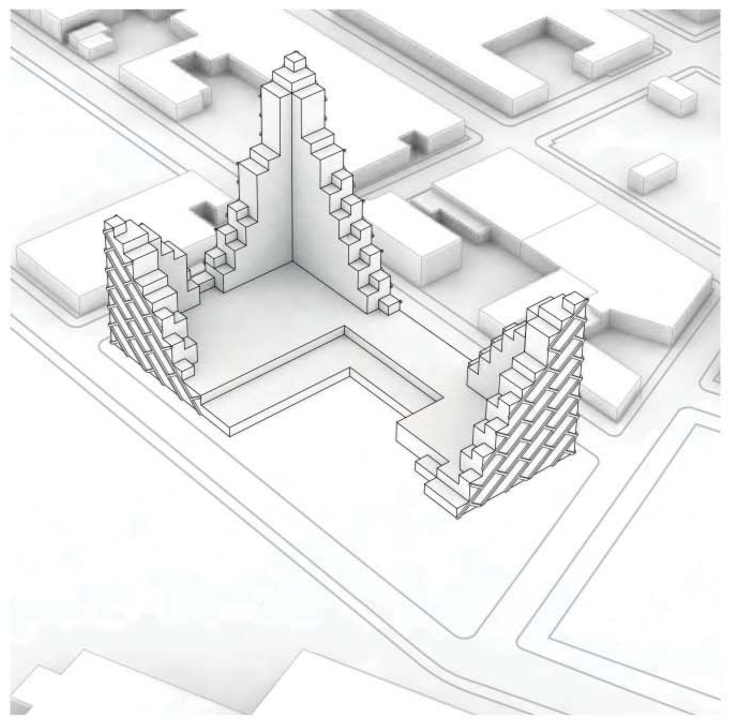
Managing a high, yet transparent building



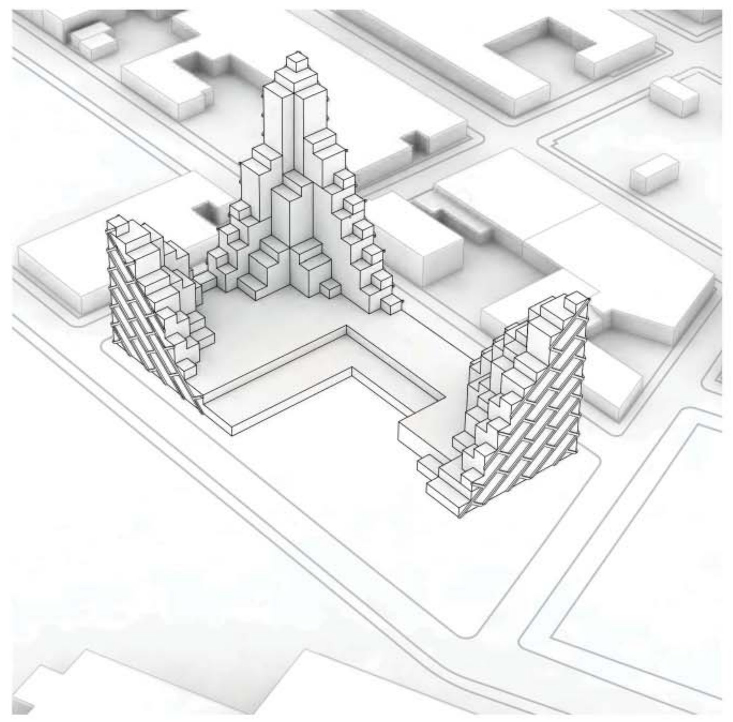
To take care of the horizontal forces, each tower is widened.



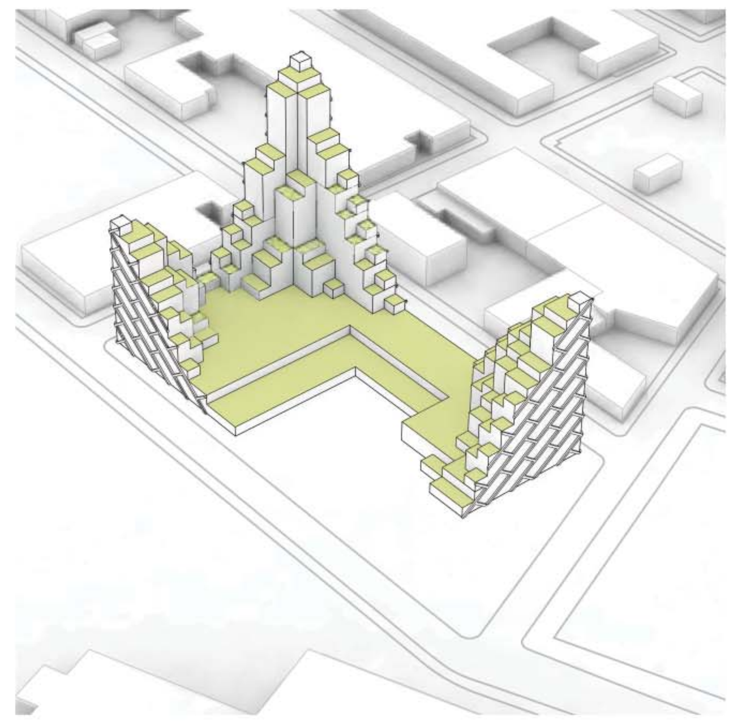
A crossed superstructure is added to the facade, stiffening each tower to help transfer the horizontal loads to the base.



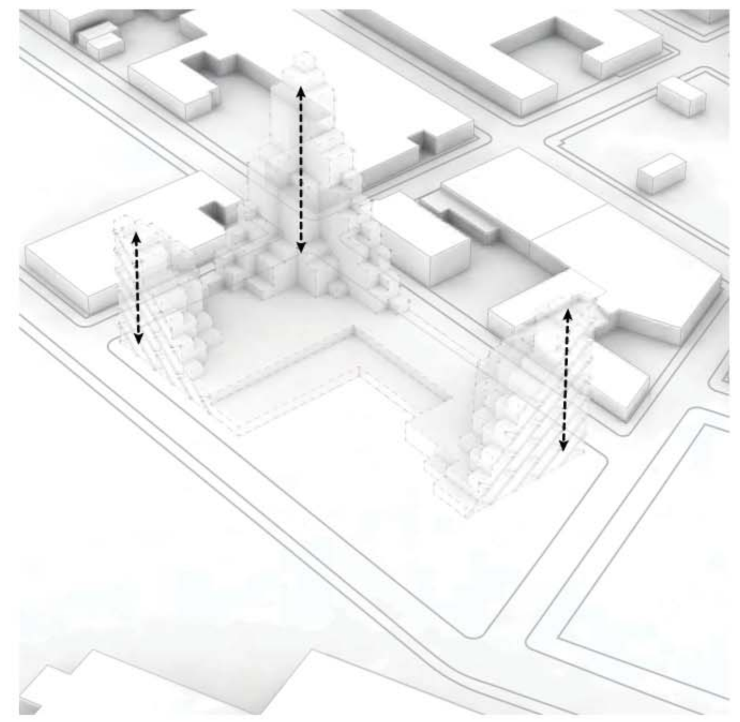
Using a 4x4 m grid of columns and beams, a rational buildup creates a terraced look.



To further help stabilize the towers and fulfill the program needs taken away by introducing the plaza, each tower gets an extra layer och thickness in the base.

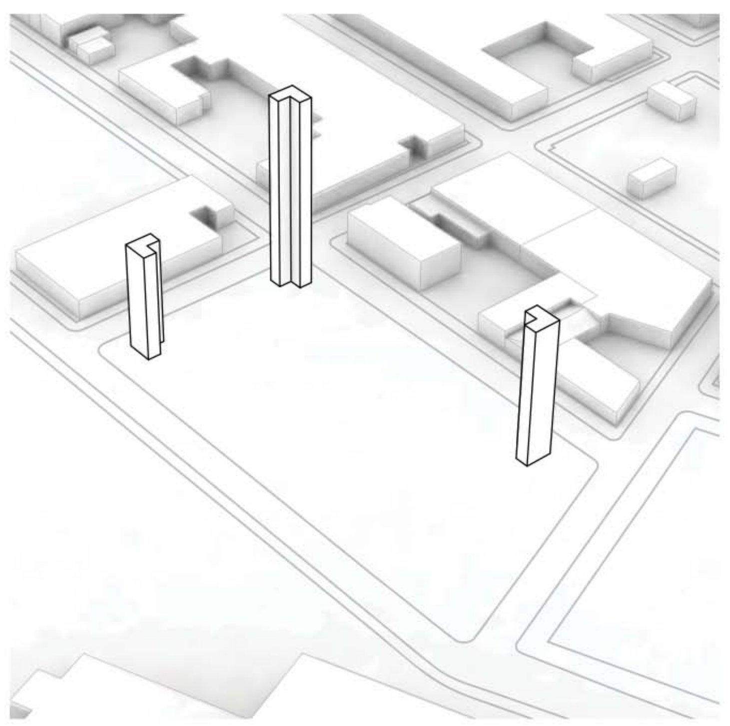


The terraced shape allows for individual terrace gardens for most apartments.

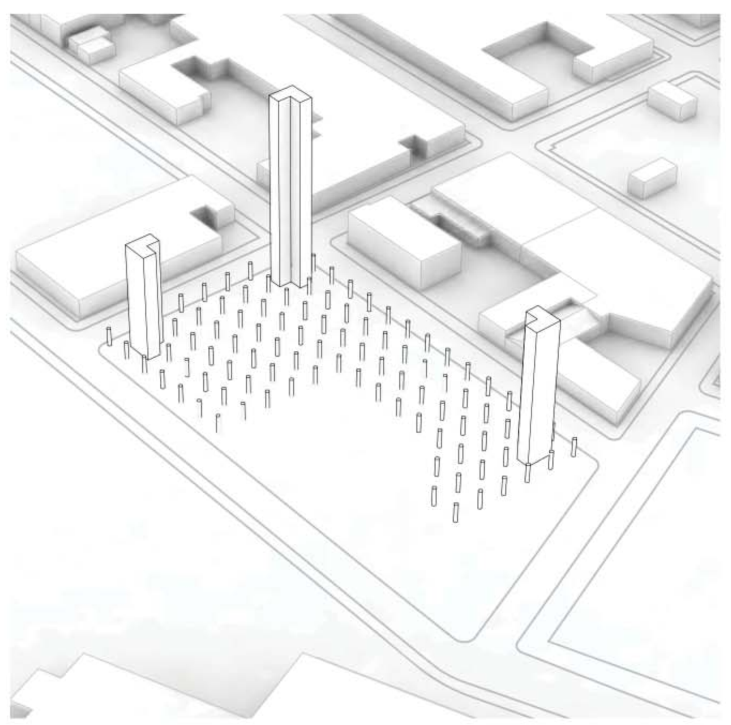


Vertical communication is handled primarily in each tower core with elevators and stairs. Additionally, emergency stair cases are added in the wings where needed.

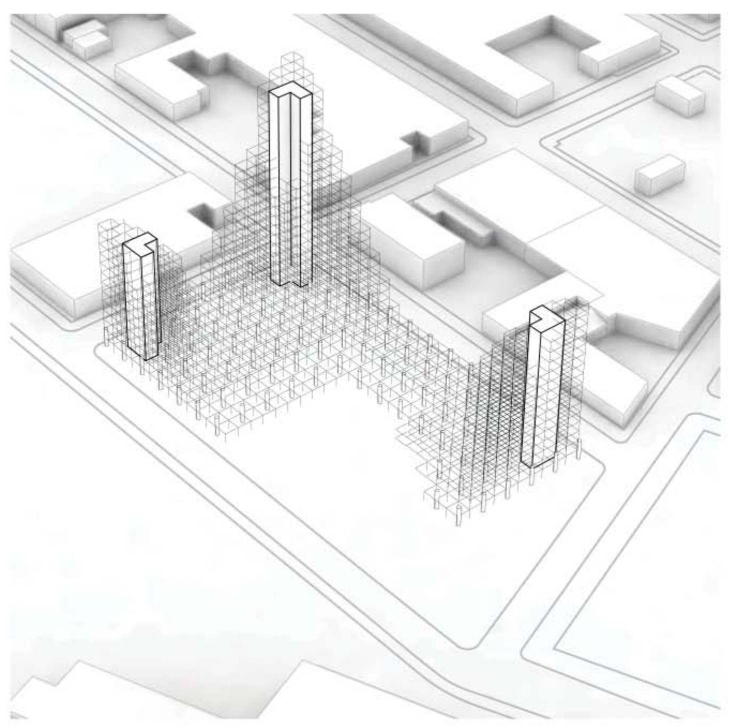
Structural layers



The 3 tower cores are the basis of the structure, made from thick CLT panels. These also create a fire safe compartment.

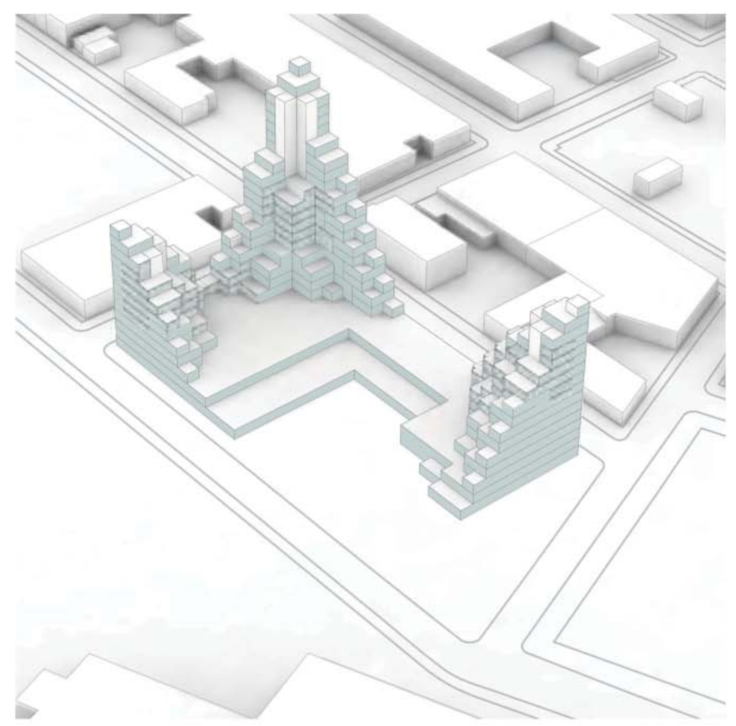


To achieve larger spans and account for the risk of industrial accidents on the loadbearing structure, the bottom floor is realized with interior concrete columns.

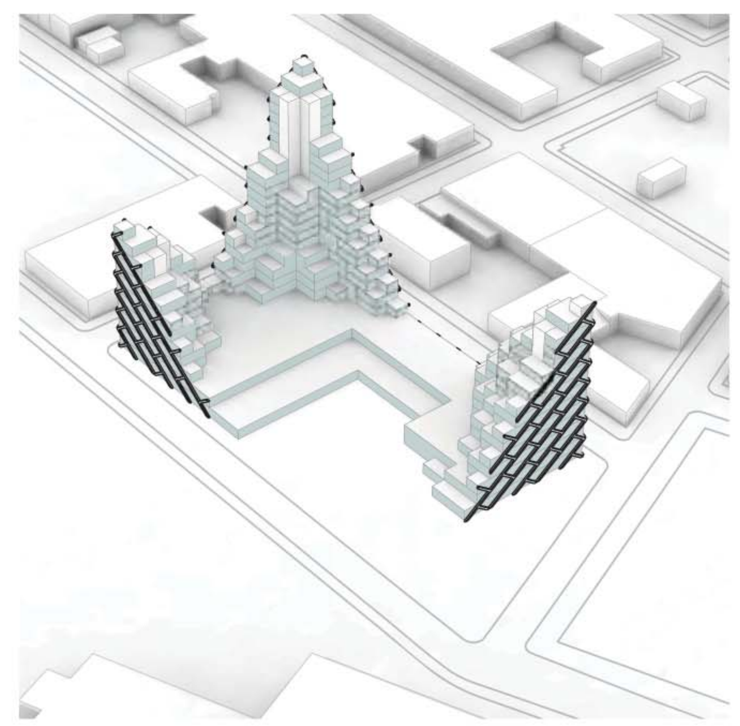


The main system is a column/beam structure of glue laminated wood. Each column typically span a height of 3 floors (12 m), and the beams are sized after a plan spacing of 4x4 m.

4x4 m slabs of prefabricated CLT topped with a thin concrete layer are added. Terrace slabs have a slightly different buildup with a higher percentage of concrete topping to handle the added moisture loads. Interior walls are also made of prefabricated CLT panels.



The volumes are encased in structural glazing, for maximum transparency.



A superstructure made from glue laminated wood, working as a crossbracing fastened to the column/beam structure helps creating the necessary stiffness. A few interior walls connecting this superstructure to the cores are structural, creating pathways for shear forces. The rest of the plan is free to be rearranged from a structural view.

Plan level 5

1:200

Apartments

The 3 towers are made up of 12, 15, and 22 floors respectively. Over these floors, there are four sizes of apartments combining to a total of 200 individual residences. Each size has a common design, based on a number of units in the 4x4 m grid structure. There are:

Studios: 2 units or 30 sqm (with balcony)

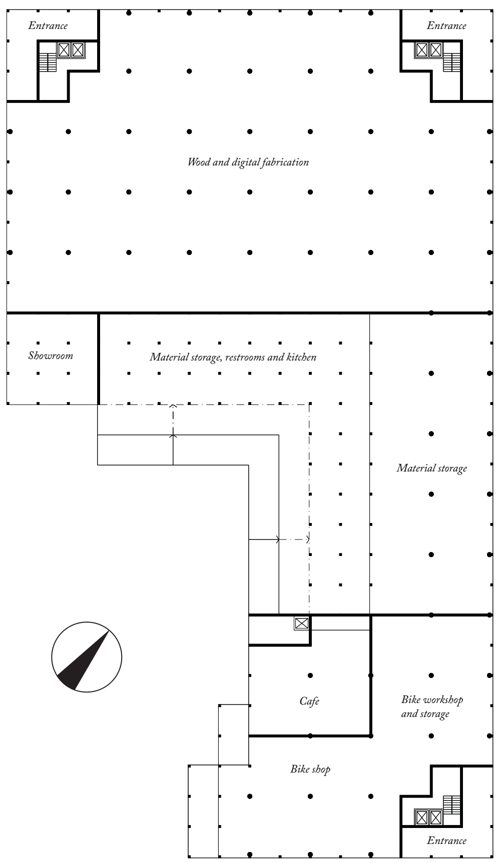
1 Bedroom (1BD): 4 units or 60 sqm (most with private terrace)

2 Bedrooms (2BD): 5 units or 80 sqm (private garden terrace)

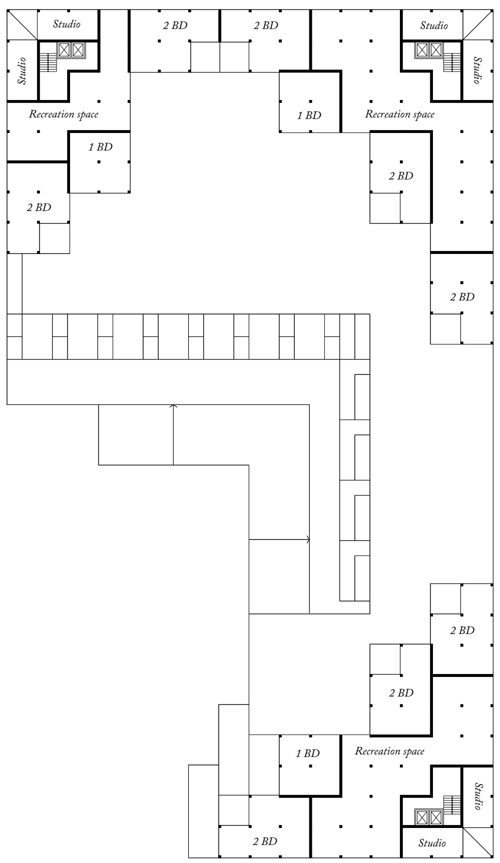
3 Bedrooms (3 BD): 6 units or 95 sqm (private garden terrace)

Except for using the ground floor as workshop space, the towers also houses offices for the manufacturing section (as specified in the program). These offices share the same vertical communications as the residents, primarily using the cores for transport.

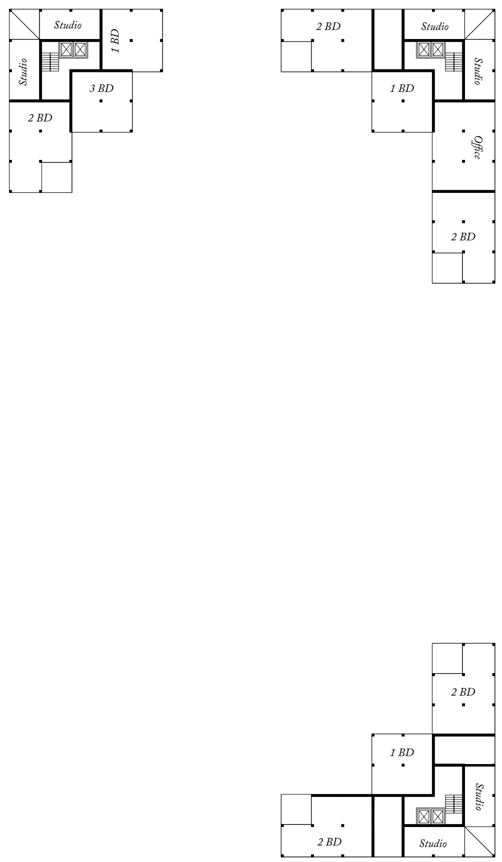
Ground level
1:500



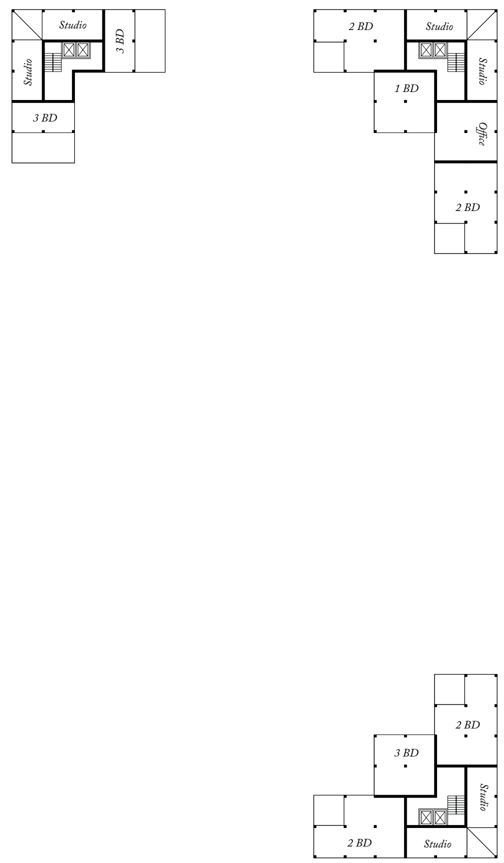
Level 2
1:500



Level 7
1:500



Level 10
1:500



South Facade

1:200

Cross Section

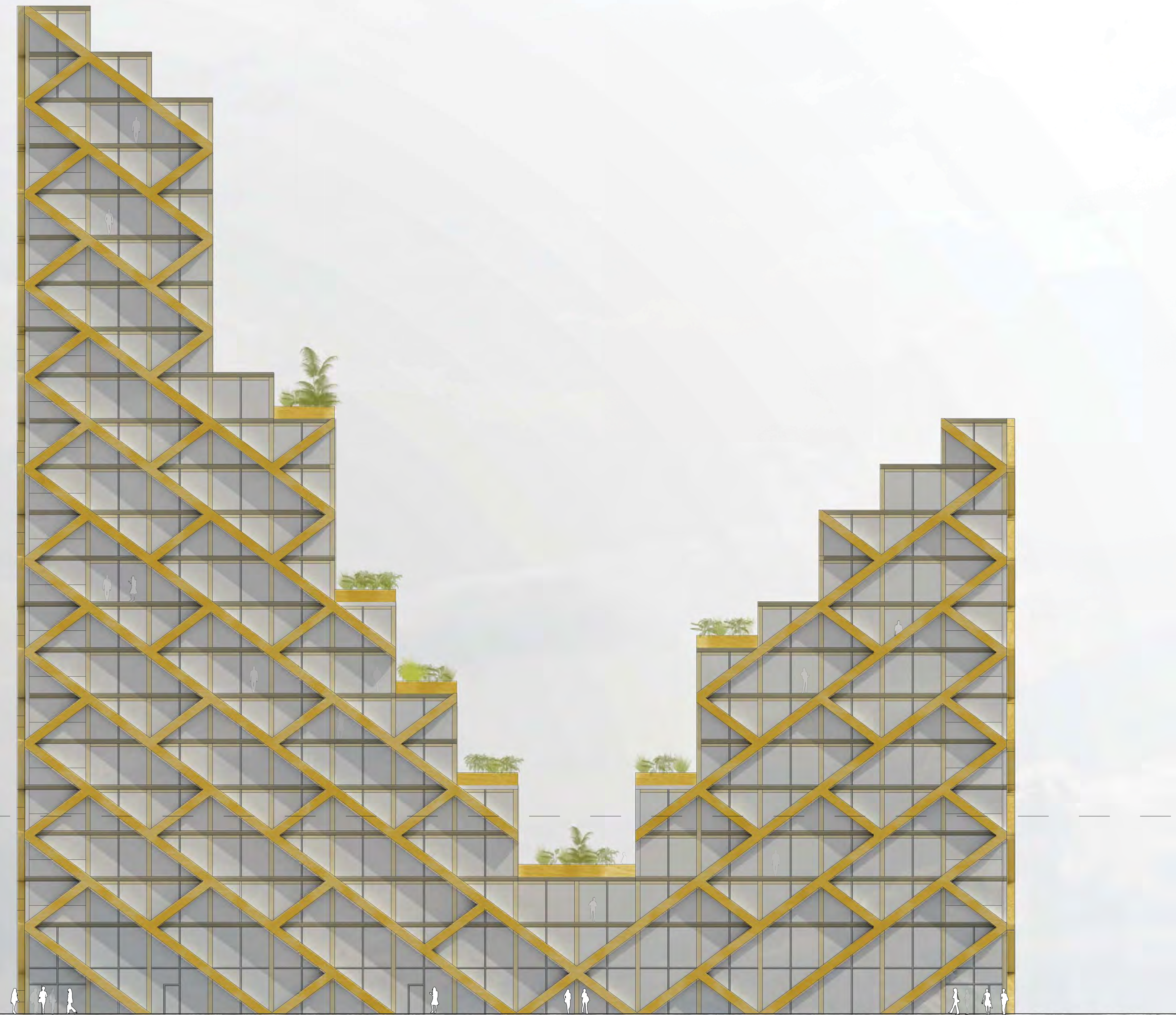
1:200

0 10 20 m

West Facade

1:200

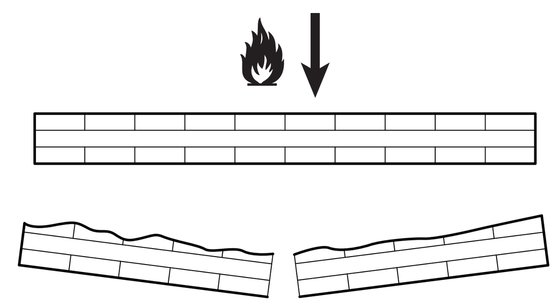
0 10 20 m



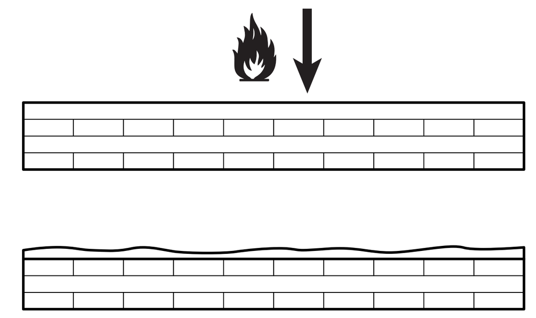
Fire protection and fire escape

When building in wood, fire is one of the major issues that has to be solved. Considered a highly combustible material, wood generally have characteristics that is unsuitable for fire protection. This usually means that all wood surfaces have to use some kind of sacrificial layer, most often gypsum boards, to prevent the fire reaching to the wooden load bearing parts, which would cause a failure and risk the construction of the building. For example, a building such as the Stadthaus in London (mentioned on the introduction page) gives no feeling of being made of wood when one is inside as all surfaces are covered..

There are ways, however, to expose the wooden structure and still keep a sufficient rate of fire protection. Using CLT and Glulam, both wood products made of massive members, the thickness of the material means a charring zone can be formed before the structure fails if the wooden member is sized to accord for it.



If the charring depth is too shallow, the wood construction might break before it stabilizes.



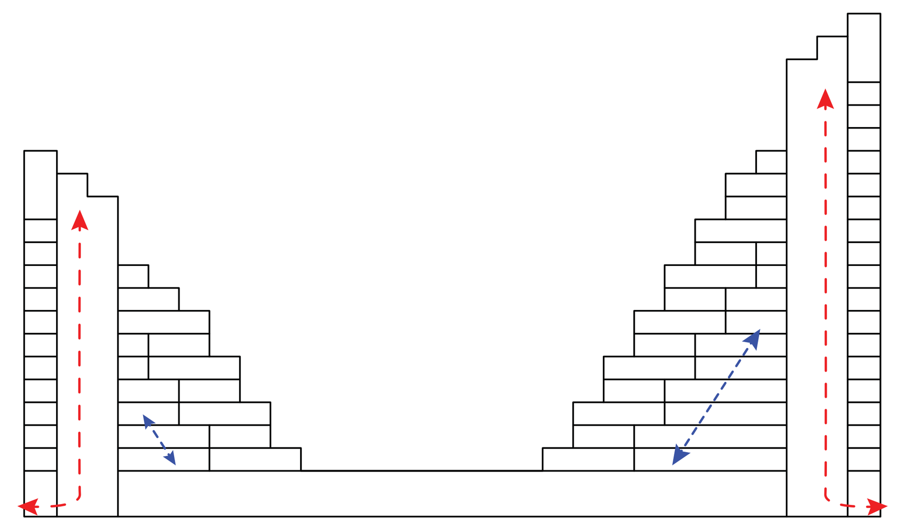
But with a sufficient thickness, the charring encapsulates and protects the important parts. It will not completely halt the fire, but reduces its rate drastically.

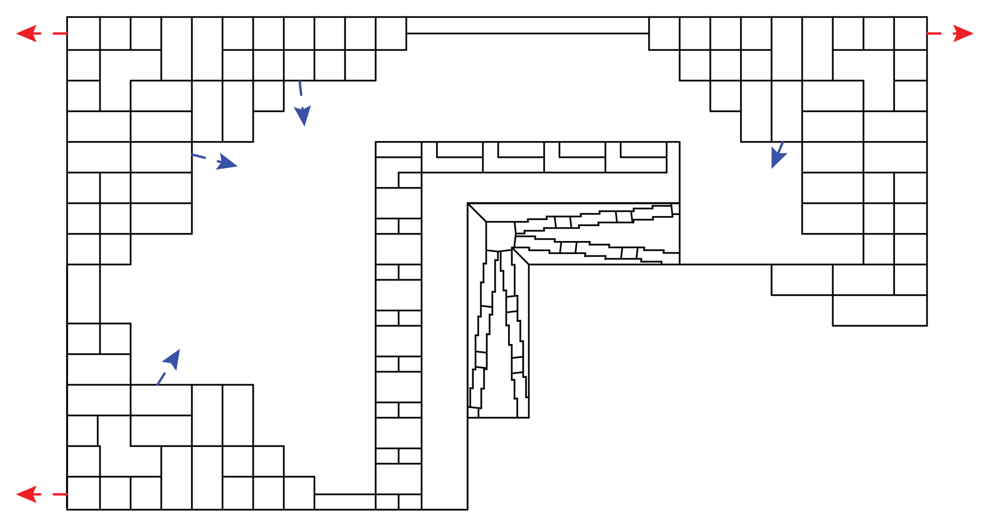
Accordingly, all load carrying members are sized to withstand fire for the time sufficient to evacuate the premises. All slabs have a concrete topping, to help reduce the needed thickness of the CLT, which is also good from a structural point of view. The cores are acting as the major fire escape zone, being able to completely seal off and equipped with mechanical fire ventilation.

Charred CLT.

Fire escape routes

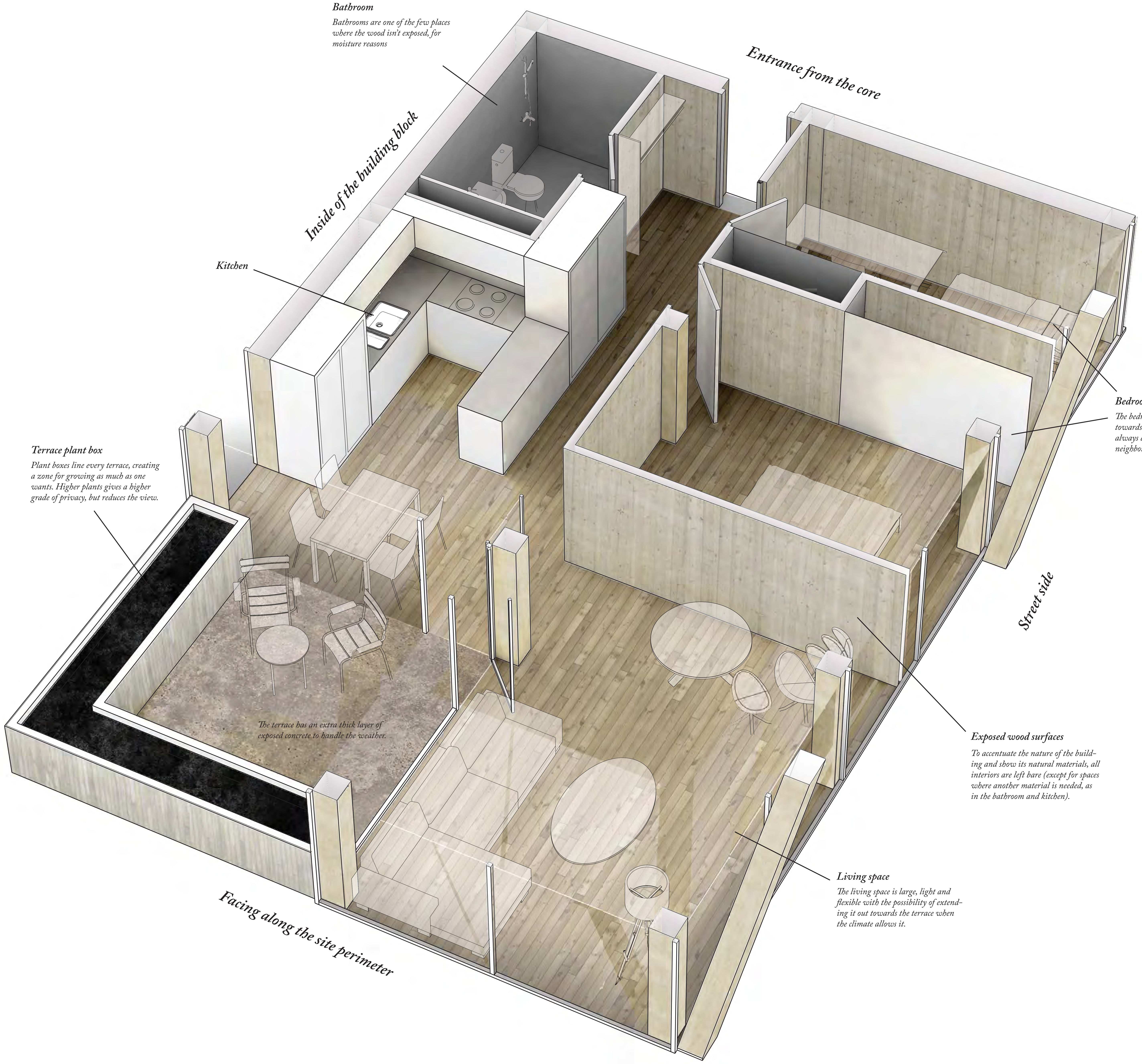
There are two ways to exit the building in case of fire. The main one is to use the core and exit through the normal entrances to the towers (red). The other is to use the extra emergency stair cases leading out into the garden plateau (blue).

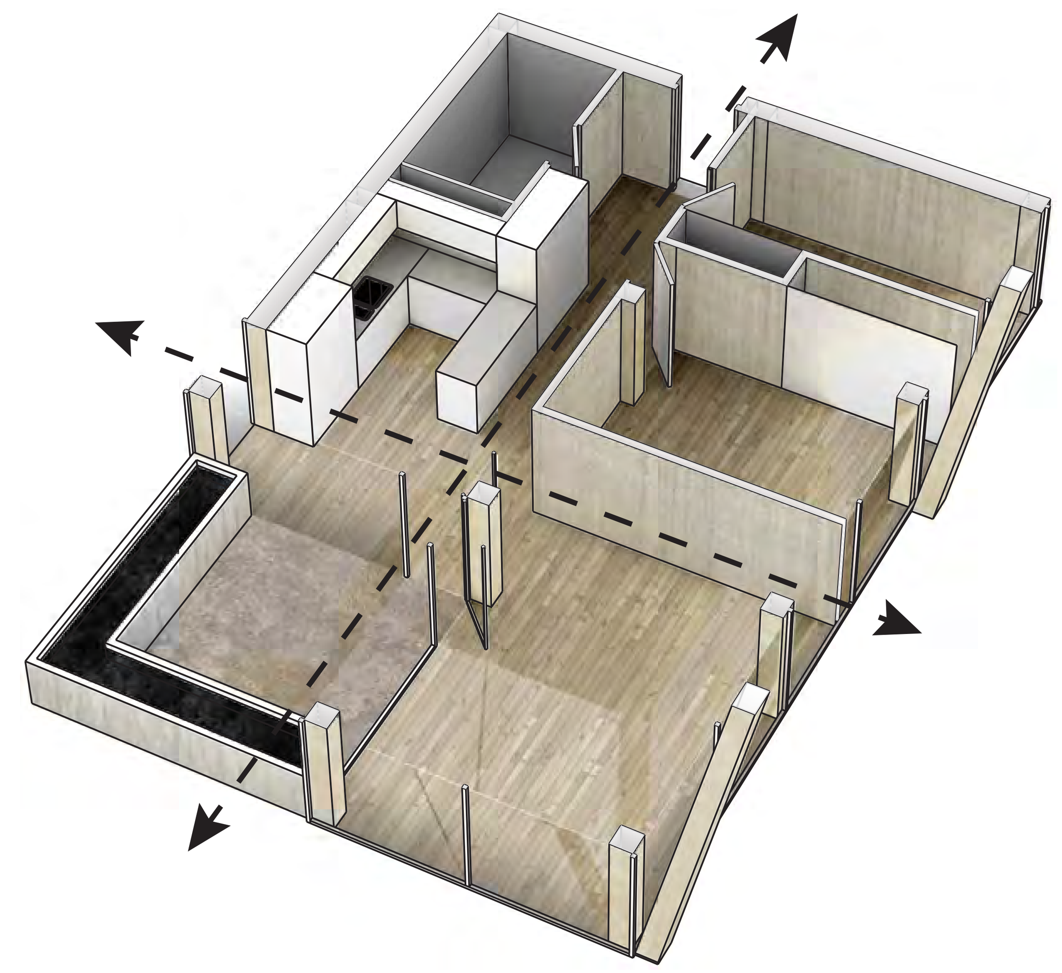




Typical apartment - 2 BD

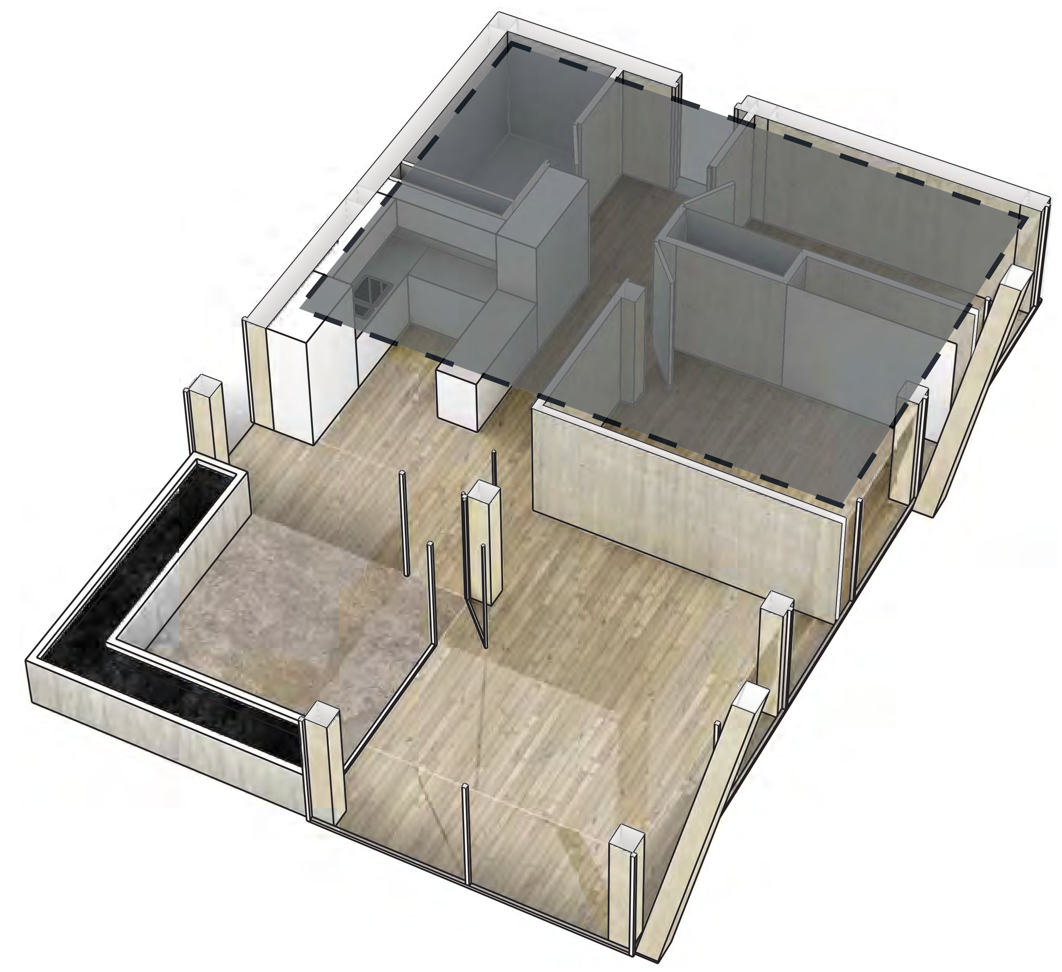
5 units - 80 sqm
with terrace





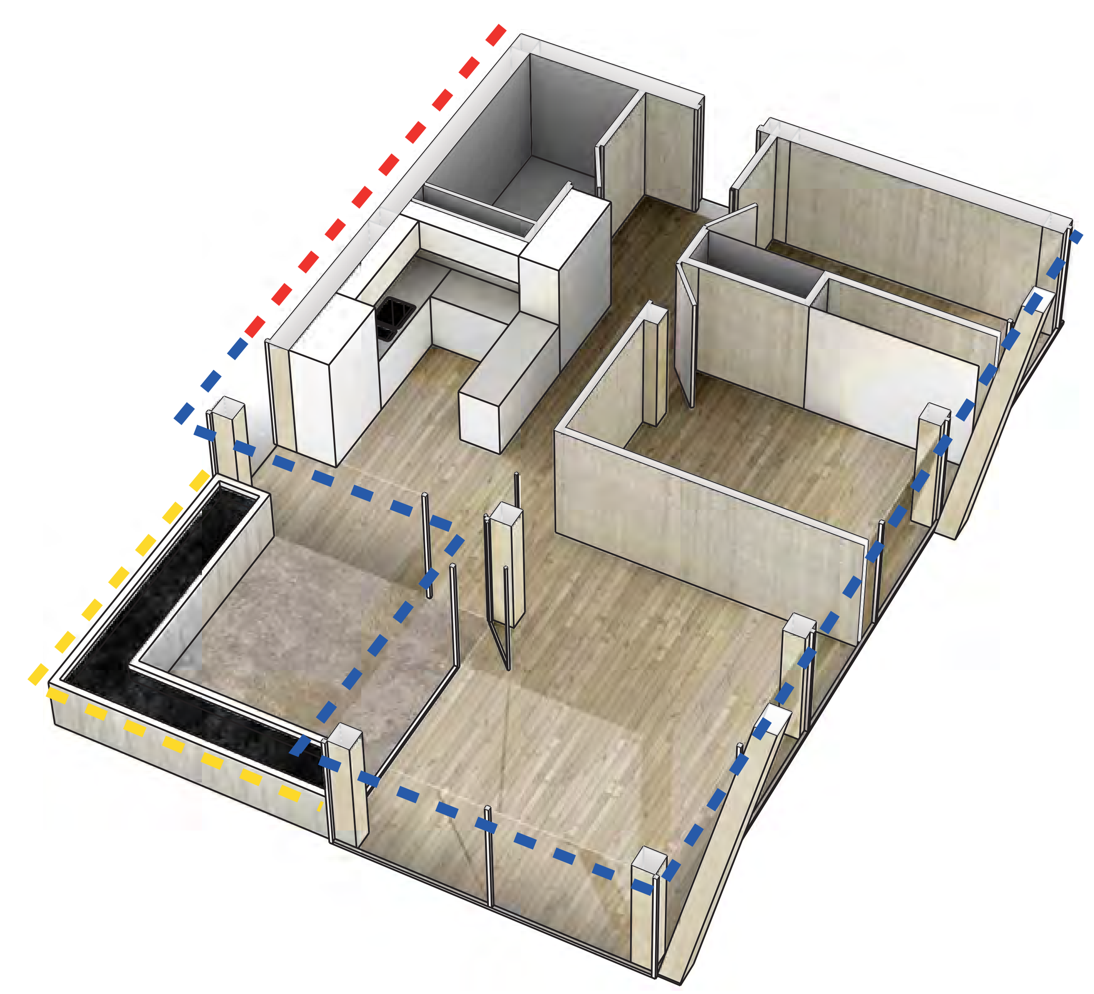
Views

The apartment is based on two axis, creating sight lines and a sense of openness. The unbroken line of view from the entrance to the terrace makes even the darker spaces have a contact with the exterior. Having sightlines both to the streetside and the inside of the block, the other axis defines the contact with the exterior.



Private/open

The apartments are created with a more private and a more public zone. The first half of the apartment can be seen as private, containing bedrooms, bathroom and kitchen. Then comes the eating zone, living room and terrace. These have an immediate connection, where the terrace in warmer weather becomes an extended part of the space.

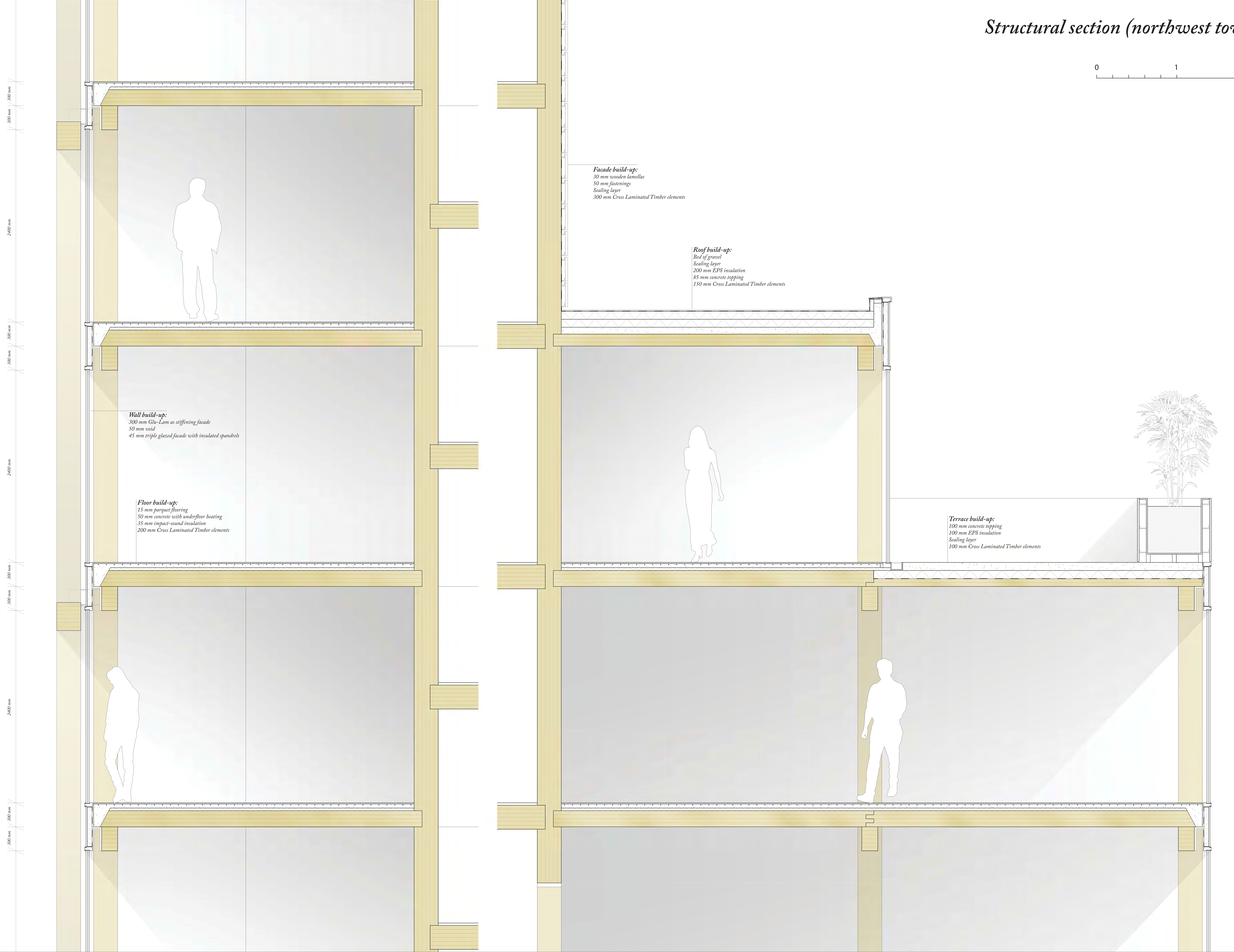


Transparency

The construction allows a totally transparent apartment envelope without any need for closed walls. However, to create a space with a high comfort level and a choice of seclusion, away from neighbours living in close vicinity, one wall extends into the "inside" of the site perimeter. The terrace plant box can serve as an extra layer of seclusion, depending on the plants grown.

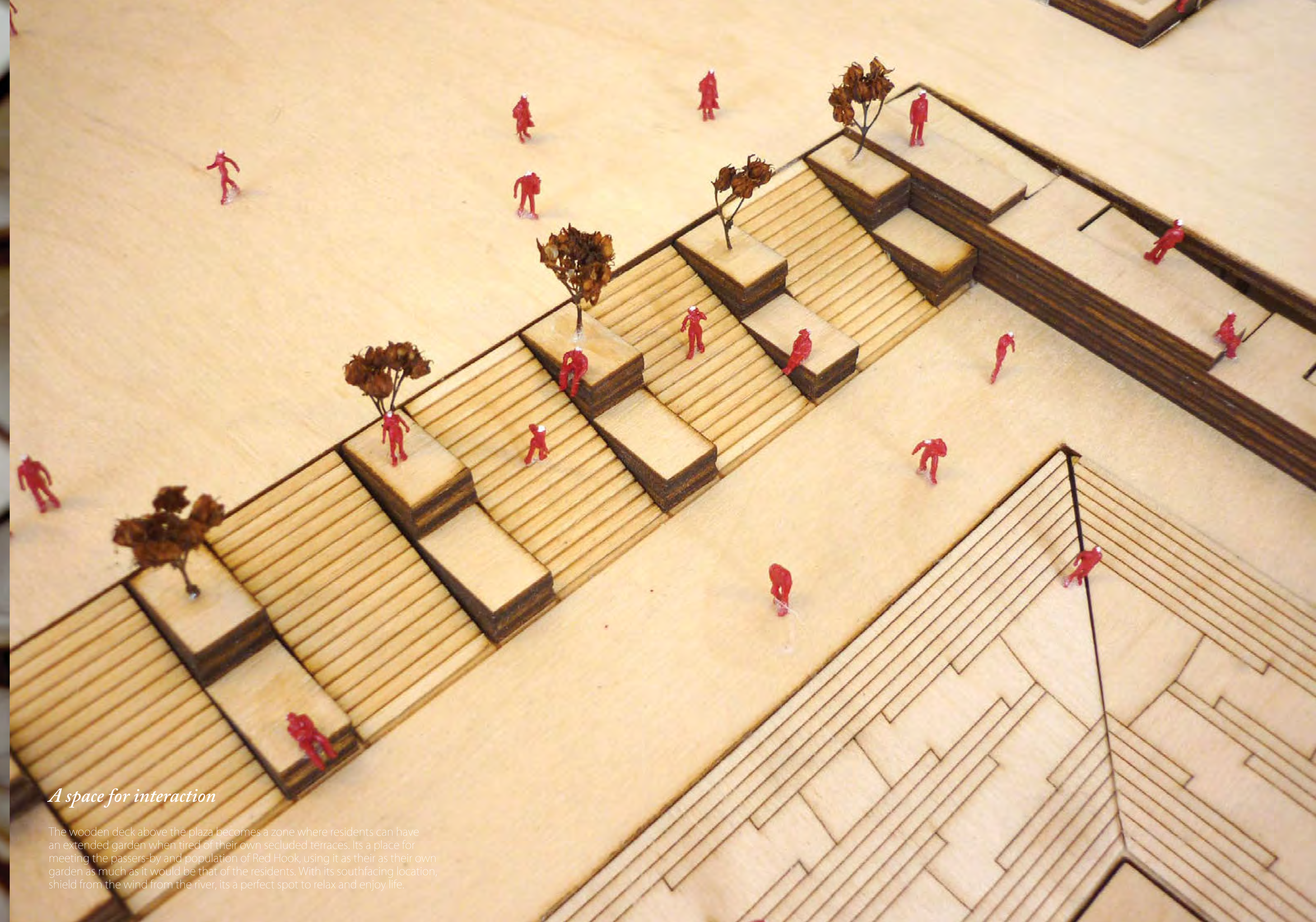
Structural section (northwest tower)

1:20



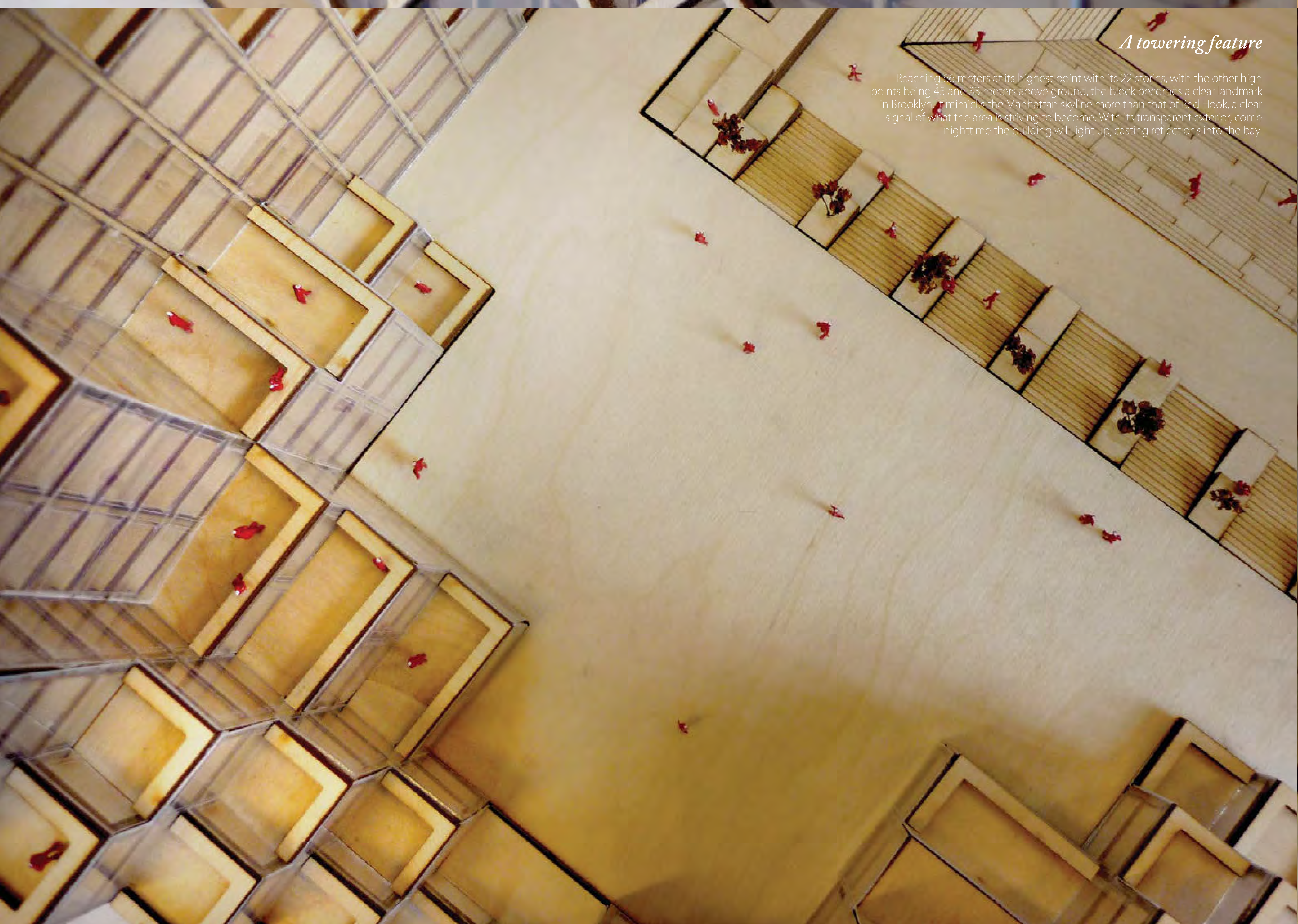
Contrasting in– and outside

From the outside, the block is seen with the characteristic shape of the superstructure on steep facades, making it a clearly defined volume in the urban fabric. A dense, high structure that could just aswell be on Manhattan. Once inside, the warm terracing landscape with its wooden decks and flower boxes stands in stark contrast to the colder, sharper outside.



A space for interaction

The wooden deck above the plaza becomes a zone where residents can have an extended garden when tired of their own secluded terraces. Its a place for meeting the passers-by and population of Red Hook, using it as their as their own garden as much as it would be that of the residents. With its southfacing location, shield from the wind from the river, its a perfect spot to relax and enjoy life.



A towering feature

Reaching 66 meters at its highest point with its 22 stories, with the other high points being 45 and 33 meters above ground, the block becomes a clear landmark in Brooklyn. It mimicks the Manhattan skyline more than that of Red Hook, a clear signal of what the area is striving to become. With its transparent exterior, come nighttime the building will light up, casting reflections into the bay.

A flexible construction

Even though the program for the building contains lots of interior walls, the structure itself can make do with only a few. This opens up for a highly flexible and transparent plan, creating possibilities for a high degree of contact within and outside of the building.