

THINK DEEP

Idiosyncraticity in underground architecture,
as an extension of our urban fabric.

Hanlin Stuer

Delft University of Technology | Faculty of Architecture Urbanism and Building Sciences -
MSc Architecture

21/05/2024

contents

Fascination	5	Going under in the 21 st century	56
Introduction	8	Location & site analysis	58
Research plan	12	SWOT analysis	76
Methods	16	Design proposal	78
Theoretical framework	17	Chapter Building	80
Chapter Theory	18	Form	82
Going under	19	Light	84
Shelter, yield, dispose	20	Accessibility	87
The Minnesota Experimental City	23	Way finding	87
Ecopolis	24	Underground as an urban resource i	89
Underground resource model	25	Underground as an urban resource ii	90
Machine or human?	26	Vertical + horizontal	91
Site choice	28	Activating the underground	93
London city vision	39	Blurring boundaries	102
Farringdon area vision	34	Liveable underground	114
Conclusion	37	Harnessing new characteristics	126
Chapter City	40	Architectural language	134
Policy building and urban planning	42	Reflection	160
Governance and legal challenges	43	Bibliography	166
Investment and development	44	Appendix A	168
Cross-disciplinary collaboration	45		
La ville intérieure	46		
Cities without grounds	47		
Marunouchi - master planning the underground	48		
Underground development opportunities	49		

*Ghostly prints of red ochre dust;
Coins engraved with characters from Greek mythologies;
Sarcophagi cradling important ancestors;
Long tunnels created in order to access the valuable
resources which would power the world;
Time capsules left behind by a kid seeking to communicate
with future beings they can only imagine;
Water, waste, energy, information, cars, trains, rats, and
people running through a labyrinth of tubes...
People gathering to talk about forbidden ideologies;
People dancing to non-conforming music;
People moving prohibited goods;
People sheltering from unbearable heat and deadly enemies;
People read about the devil and its demons hiding under
their feet;
People watch movies about the scariness of the dark and
unknown underground;
Gamers slaying dragons in caves and monsters deep inside
earth's crust. Then store their loot in the safety of bunkers...*

What connects all these artifacts of our history and elements
of our daily life is the underground.

For humanity, the underground has always sheltered what is
precious, yielded what is valuable, and allowed us to dispose
of what is harmful¹.

¹Macfarlane, Underworld, p. 4-8

Architecture started in a cave... in a way that was the start and bizarrely it could be the end. It could be the final chapter of architecture as we know it, back to the cave.”²

²Cave Bureau, Manifesto

The message they try to convey is that architects should return to the root of the questions at hand and not assume the answer to a client’s needs is always a building (above ground). There is a quality to the underground and what it can represent that should be embraced. The underground elicits different associations in different cultures, both positive and negative³. For some, it is home and for others it is where evil resides. Admittedly, in popular culture, it has mainly suffered from negative connotations⁴.

³Macfarlane, *Underworld*

⁴Endicott, Johnston, and Lin, *Underground Cities*.

My fascination with this subject stems from a sense of dissatisfaction with the unequal development of underground spaces compared to their above-ground counterparts. The former are often relegated to purely engineering-focused projects, while the latter are gradually shifting from a competition of towering heights to prioritizing human well-being in urban landscapes.

I envision a city that harmoniously integrates both above and below ground elements. In which the ground floor serves as a dynamic nexus, establishing vertical links between the upper and lower realms, as well as facilitating multi-tiered horizontal connectivity among buildings and locales.

My thesis project delves into potential strategies for transitioning existing high-density urban areas towards these envisioned fluid cities of the future. The speculative aspect of my project further drives me to ground it in thorough research and to design compelling architectural solutions.



introduction

In contemporary history, the urban underground has been mainly exploited to relief the dense cities of above ground pressure. Such transport oriented developments allow the unhindered flow of people, goods, and services through tunnels and tubes under the city⁵ which greatly benefit the urban liveability from a mobility point of view. One could say, it has been used by us to dispose of that which we consider undesirable above ground to facilitate further growth of the densifying city.

Exploring what the underground has to offer is the answer to many problems in cities that are associated with their growth⁶, such as increased land prices, congestion, administrative deficiencies, and neighbourhood deterioration⁷. Developing the underground can result in better public transport networks, reduced noise, relief of above ground pressure, and more green space left intact above ground⁸.



Fig. 1 - Terrence Zhang, Shanghai Suhe MixC World seen from above.

The Shanghai Suhe MixC World is an underground shopping center. By developing the underground space it leaves the above ground space free to become a riverside public park.

Cities are projected to continue to grow due to lack of rural opportunities⁹, and more than 60% of the world population is predicted to be living in cities by 2030¹⁰; it is thus important to consider design of the underground as an integral part of the city of the future.

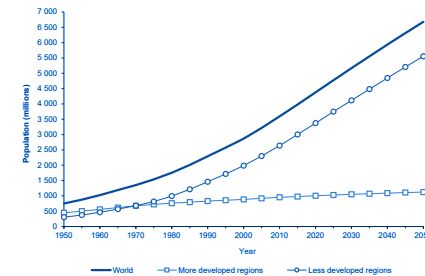


Fig. 2 - Estimated and projected urban population of the world, the more developed regions and the less developed regions, 1950-2050

United Nations, 'World Urbanization Prospects The 2018 Revision'.

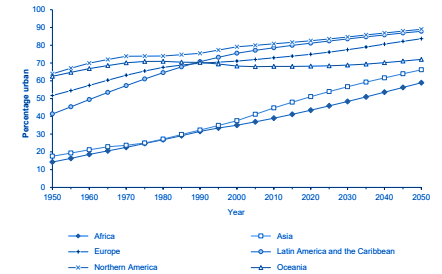


Fig. 3 - Percentage of population residing in urban areas by geographical region, 1950-2050

United Nations, 'World Urbanization Prospects The 2018 Revision'.

In the past decade, a lot of research has been conducted into new methods of planning, construction, and governance of underground developments. Nevertheless, one major issue is often mentioned but not tackled¹¹: how to make these new spaces more liveable and people-centred. That, is the "key to getting this largely untapped resource accepted as a natural extension of the city"¹².

- Reserved routes for new tunnels
- Reserved for future UG spaces
- Existing tunnels and UG spaces
- Reserved for future use (not designated)
- Rock surface less than 10 metres from ground level

Fig. 4 - Helsinki City Planning Department, Extract of the Helsinki Underground (UG) Master Plan.

Helsinki led the way in the development of legally binding underground master plans. This allows control over underground space allocation and data gathering.



⁵Endicott, Johnston, and Lin, Underground Cities.

⁶Endicott, Johnston, and Lin; Admiraal and Cornaro, Underground Spaces Unveiled; Golany and Ojima, Geo-Space Urban Design.

⁷Golany and Ojima, Geo-Space Urban Design.

⁸Admiraal and Cornaro, Underground Spaces Unveiled.

⁹Architecture and technology.

¹⁰United Nations, 'World Urbanization Prospects The 2018 Revision'.

¹¹Endicott, Johnston, and Lin, Underground Cities; Admiraal and Cornaro, Underground Spaces Unveiled; Golany and Ojima, Geo-Space Urban Design.

¹²Endicott, Johnston, and Lin, Underground Cities.

This graduation project strives to explore the vast resource all cities have - underground space. To understand how we can design, plan, construct, govern, and use underground space to create the city we need and live in the city we want. Further research into the symbiotic relationship between the under- and above-ground, their characteristics, and how they can complement each other is important to find out how they can provide what the citizens need. The project aims to create an idiosyncratic architectural language that will allow people to “think deep” and reconsider the use of underground space by incorporating it into the city’s fabric.

Idiosyncrasies are “a distinctive or peculiar feature or characteristic of a place or thing.”

– Oxford Languages¹³.

Can, ultimately, the case be made for leaving behind the culture of mono-development and a defensive stance of spatial relief in favor of a preemptive stance of spatial densification? Putting it differently, the main research question ensues as:

How can underground spaces be designed to respond to the public’s needs and create a new idiosyncratic visions for the future city?

The thesis will approach this question focusing on the architectural and urban design point of view and relating to usage and human experience. Thus the well developed juridical and development aspects will only be touched upon shortly to support the context of the project, but will not be researched extensively.

In a recent conversation with a civil engineer who works for the public transportation authority in Florida, I brought up my thesis topic which elicited this response “Architecture? Underground? What is the point? Architecture stops underground level, the only thing we need underground is engineering. Leave that to us, engineers, ha ha, what are you even going to design underground?”.

¹³<https://www.oed.com/>

research plan

To formulate an answer to the main research question subsequent research is devised around three main topics and a fourth reflective topic.

The first topic “Theory” will critically examine the historical progression of the utilization and understanding of the underground. This examination will involve a comparative analysis of various historical and contemporary uses of the underground, as well as utopian visions that have attempted to forecast its future. The objective of this chapter is to understand the factors that have led to the perceived disconnection of the underground from the urban environment. An in-depth exploration of the challenges currently faced by London and Farringdon, along with their future plans, will provide insights into how the underground can help address the needs of the site.

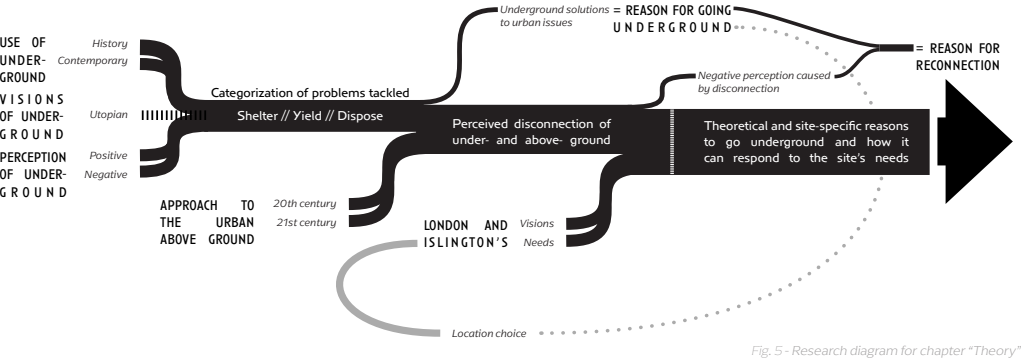


Fig. 5 - Research diagram for chapter "Theory"

The second topic “City” will further explore how the resource which is the underground can function as a symbiotic part of the urban fabric. This exploration will involve an investigation into the various disciplines necessary for optimizing the use of the underground, and consequently, the key stakeholders involved in its development. Case studies of the underground’s utilization as a resource and its integration into a three-

dimensional urban landscape will be conducted. The insights gained from these studies will be converted into diverse strategies for densifying and intervening in various urban underground situations, which will also guide the choice of the project site. The accumulated knowledge will also enhance the site analysis, facilitating the identification of potential opportunities of the site and the stakeholders in the area.

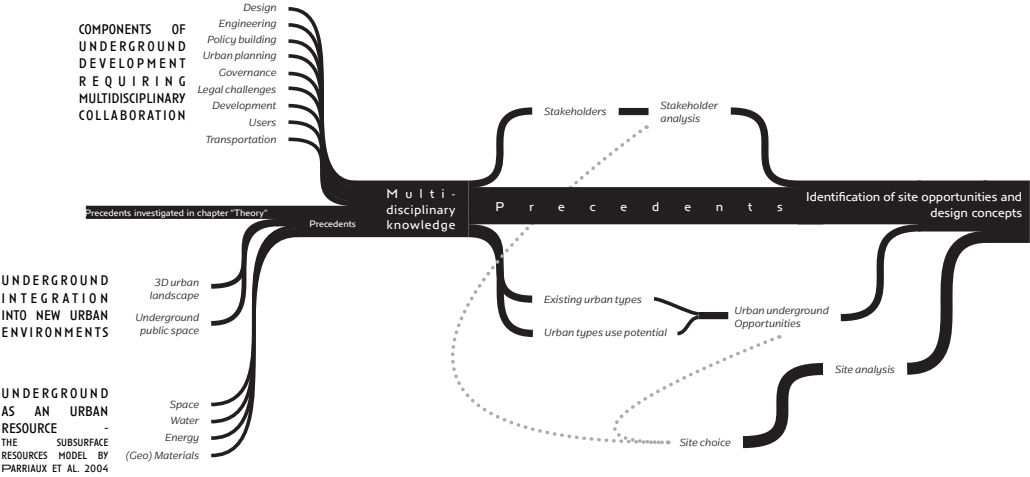


Fig. 6 - Research diagram for chapter "City"

The third topic “Building” primarily concentrates on three aspects. Firstly, it examines case studies related to underground developments, the fluid transition between underground and aboveground spaces, and multi-level public realms. Secondly, it investigates the quality of (semi-)interior public spaces. Lastly, the outcomes of these investigations lead to a determination of the spatial qualities and requirements, which are then further scrutinized to explore various potential solutions. These components contribute to the design of the idiosyncratic architecture that characterizes this new dimension of our urban environment.

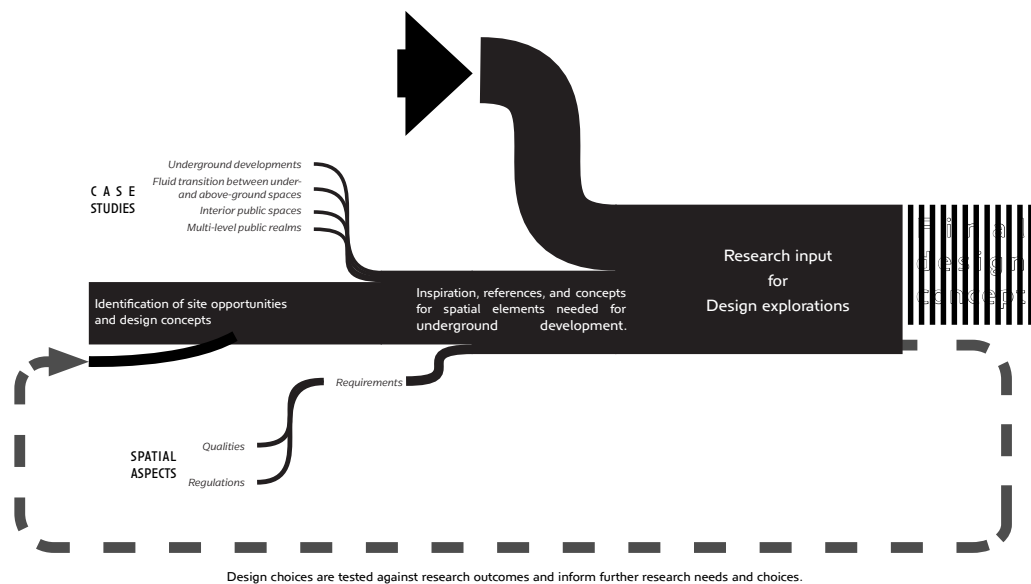


Fig. 7 - Research diagram for chapter "Building"

The fourth reflective topic pertains to the "human(e)" dimension. This overarching topic considers the human experience aspect of architecture and urban design. This topic is in constant consideration during the research and design process as it is the translation of theory into design.

It is crucial also to consider the ethical consequences that can arise during the research and design phases of subterranean developments. As societies become increasingly hierarchical, amplified by the unidirectional verticality of urban environments, it is essential to evaluate the advantages and the possible disadvantages of underground space development. This evaluation should consider its effects on various populations, particularly those who are disadvantaged, as well as its impact on the urban ecology of the surrounding areas. This is because subterranean interventions can possibly have a lasting impact extending beyond multiple generations, necessitating responsible decision-making.

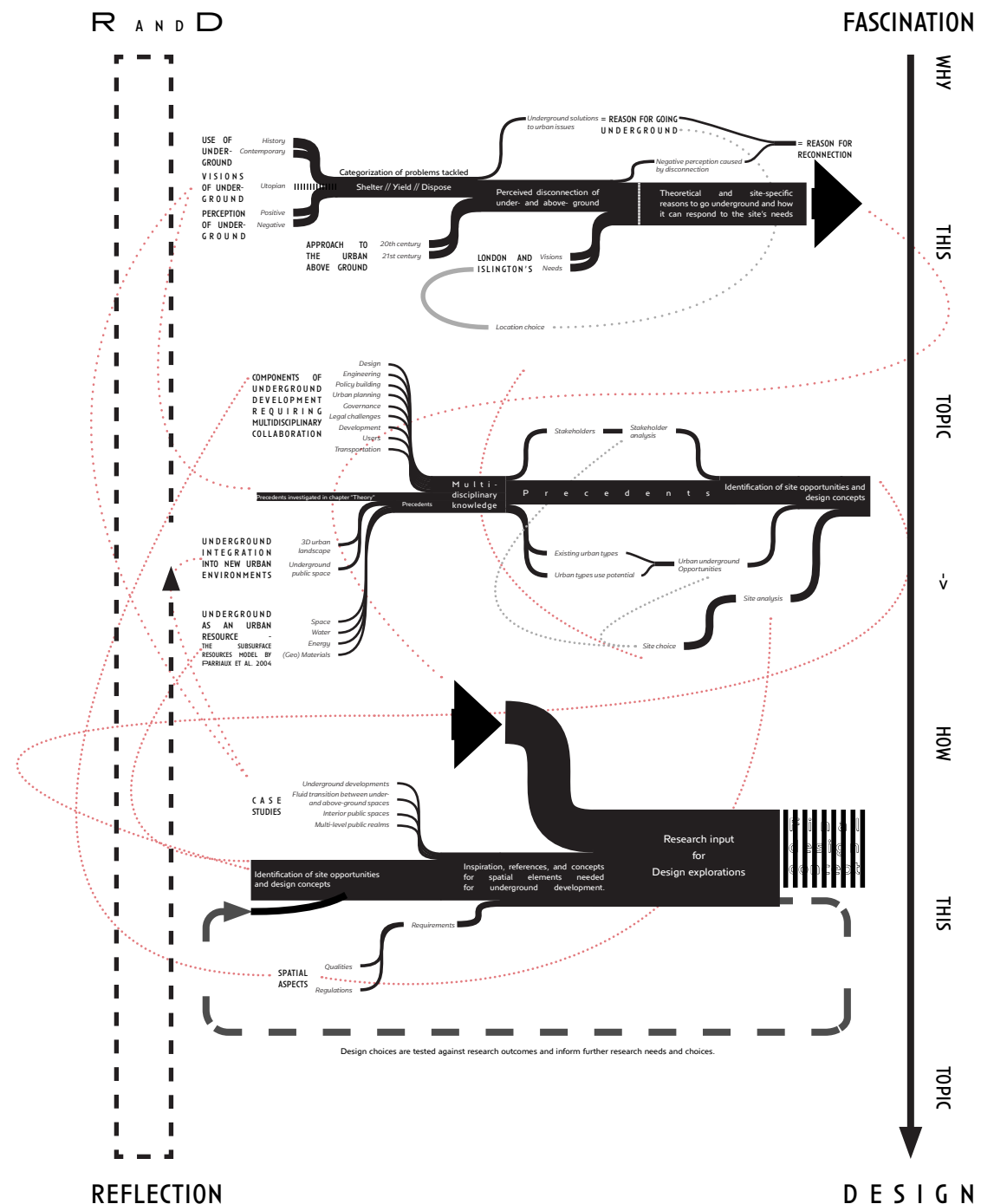


Fig. 8 - Research diagram complete

See appendix A for larger version of the Diagram.

methods

The research is conducted using three tools: literature, precedents (small case studies and reference gathering), and research by design. Each of the three main topics make use of a combination of these tools. “Theory” mainly consists of literature study but also includes precedent research. The “City” chapter mainly focuses on precedent research, which is informed by literature and results in certain researched design concepts. Finally the chapter “Building” mainly consists of translating precedent research into design research concepts.

Literature

The annotated bibliography is divided into main literature and literature about theory, city, and building. The main literature sources were used (with a few other supporting sources) to produce the research plan. Main literature sources will also further guide the research and design phase. Other literature is focused on more detailed information which will help to answer the sub-questions relating to each of the three main topics.

Precedents, cases, and field visits

Built examples, utopian concepts, and modern theories will be researched. This will help to understand different approaches, uses, and cultural perceptions of underground spaces. Many can be found in the main literature sources and internet research. Others were also be found during field trips to the Architecture Biennale in Venice, a visit to Milan, and a site visit in London.

Research by design

To ultimately work towards an architectural expression of the research an overarching method is used: research by design. Where possible, the research will be translated into drawings or little designs forming a catalogue of information. These analyses, concepts, and designs of the chosen location will be done parallel to the research.

theoretical framework

For clarity it is necessary to define key terms used to describe excavated spaces. According to the Swiss academic civil engineer Loretta von der Tann, a possible definition for “underground” or “subsurface” structures is:

Structures and volumes can be considered “underground” when changing the structure or accessing the volume would require removal of or drilling into – natural or altered – ground.¹⁴

In this research “underground” space will be used to describe all relevant spaces according to the broad definition given by von der Tann. However, the goal of the design involves the design of spaces in a fluid ground floor realm in which there is no spatial distinction between what is considered underground or above ground. In these cases all spaces under street-level will also be referred to as underground.

The project focuses on the densification of urban underground spaces. Urban areas or cities are difficult to define, different countries have different lower limits above which an area is labeled urban (ranging from 200.000 - 50.000 inhabitants)¹⁵. This thesis considers areas with high population density in comparison to the national average as urban. These places are often in need of further densification and struggle with the lack of available space.

It is also important to acknowledge the technical complexities associated with subterranean construction. Nonetheless, existing literature indicates a progressive trend in technological advancements, suggesting that the development of underground spaces could soon parallel that of above-ground areas. This projection into future possibilities serves as the impetus for this speculative and conceptual academic endeavor.

¹⁴ Von Der Tann et al., ‘From Urban Underground Space (UUS) to Sustainable Underground Urbanism (SUU)’.

¹⁵ United Nations, ‘World Urbanization Prospects The 2018 Revision’.

chapter “theory”

THEORY

As mentioned before, this topic aims to compare historical and contemporary uses to current approaches to urban design to understand the factors that have led to the perceived disconnection of the underground from the urban environment.

The use of underground space has undergone many changes after we left the caves. It has been used to store water, food, prisoners, unwanted people, the devil, to escape authority, to seek safety, and much more.

The chapter will start with a general understanding of the history of underground space usage and its more contemporary applications. The goals of underground development will be compared to the goals of above ground urban developments to establish where the current approach to underground development might be lacking.

After addressing the reason to further develop urban underground spaces and how new urban underground spaces can be developed, existing visions for London and Farringdon station area will be analysed. This will provide information on the current view for the future and what the problems and opportunities are that need to be addressed. A general SWOT analysis can be made of the project location relating to underground development.

By analysing local plans, more location based approach to underground potential can be explored providing more specificity to further design explorations.

going under

THEORY

Going underground seems to be a counter intuitive action to most. In the recent past the underground has mostly been used to dispose of things we wish to shield away from the public’s eye. Such as sewers and waste channels, transportation tunnels for (smuggling) people, goods, energy, and information¹⁶.

If one looks further into the past, nature was the first to find its way through the underground. Caverns, rivers, faults, volcanoes, roots, and fungi networks have found their way through the ground below our feet without us noticing and created their own ecosystem¹⁷. Afterwards our ancestors found its way into the subterranean world as well. Caves were used for sheltering, storage, and the keeping of memories in the form of burial of the deceased or in the form of art on the walls.

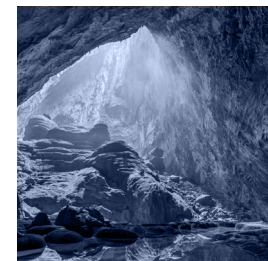


Fig. 9 - Ryan Deboodt, Son Doong cave in Vietnam, world's largest cave with its own ecosystem.



Fig. 10 - Viewing Malta, Malta's Hypogeum underground burial site, main chamber.

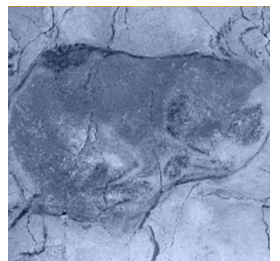


Fig. 11 - A. Held/J.P. Ziolo, Cave painting of bison in Altamira cave, c. 15000 BCE.

Macfarlane concluded that the same three categories of underground use types recur throughout history in different cultures. These are “to SHELTER what is precious, to YIELD what is valuable, and to DISPOSE of what is harmful”¹⁸. Examples are the sheltering of our deceased, our treasures; the yielding of minerals; and the disposal of waste, such as nuclear waste.

¹⁶Macfarlane, Underland.

¹⁷Macfarlane, Underland.

¹⁸Macfarlane, Underland.

shelter, yield, dispose

In our urban environments one can recognise the same types of uses of the underground: shelter, yield, and dispose. Nevertheless, a critical review of how the underground is used is needed. Are these projects in urban areas making optimal use of what the underground has to offer? Or are they mainly used to dispose of that which is unwanted above ground? How can we further diversify the use of the underground in urban areas to create more attractive underground areas for the city of the future?

The use of the underground has for the most part been utilitarian. Within the urban context it has mainly been viewed as an opportunity for spatial relief¹⁹ and the disposal of activities which were undesired above the ground. Such as sewers (fig.12, 13) which had bad odors and were a highway for diseases. Underground transportation was a way to relieve the above ground of congestion (fig.20,21). The sentiment of the underground being an unpleasant place where society stores what they don't have the space for or don't want above ground is also reflective of a general negative perception of underground spaces. The association of underground spaces in the past with darkness, mythical monsters²⁰, or even the devil has also transferred into popular culture. Zombies, video game monsters, horror movies all too often involve an underground space from which these undesirables spawn.

However, this sentiment is not echoed by all people. Some also saw the opportunities the underground has to offer for our urban areas. Athelstan Spilhaus and Guy Rottier both explored, in their own way, how the underground could be developed into an integral part of our urban environments: the Minnesota Experimental City and Ecopolis. Aurèle Parriaux saw the underground as a valuable urban resource² and created a model to determine its intrinsic values.

¹⁹Admiraal and Cornaro, *Underground Spaces Unveiled*.

²⁰Macfarlane, *Underland*.

²¹Li and Parriaux, 'URBAN SUSTAINABLE UNDERGROUND RESOURCES MANAGEMENT: THE DEEP CITY CONCEPT'.

THEORY



Sewers:

Disposal of waste in urban environments in order to keep the above ground clean and prevent the spread of diseases.

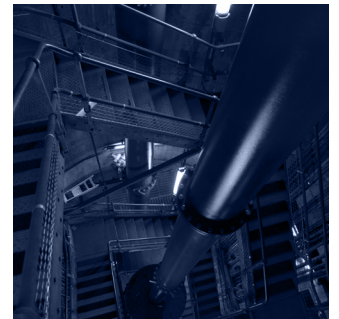
Fig. 12 - Adam Powell, A Fig. 13 - Jose Sarmento
junction in London's King's Matos, A tunnel in
Scholars' Pond Sewer, London's super sewer.



Wells:

Yielding of ground water.

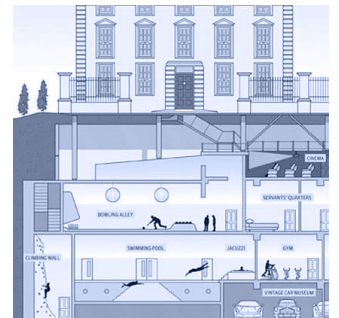
Fig. 14 - Tatsiana Volskaya, Fig. 15 - New civil engineer,
An old well in the Thames water ring main.
Moroccan desert.



Cellars/Basements:

Shelter valuable goods for safe keeping. Yielding the benefits of underground climate. Disposing of functions not needed above ground to save space.

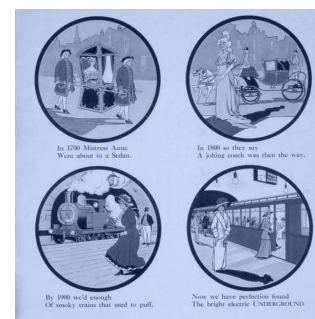
Fig. 16 - De Agostini, Fig. 17 - Ben Hasler,
Château de Meursault London Iceberg houses,
wine cellar.



Mines:

Yielding geo-materials from different depths.

Fig. 18 - Paul Deakin, Rock Fig. 19 - Joe Raedle, open-
bolting in the Boulby pit copper mine in New
potash mine, Mexico.

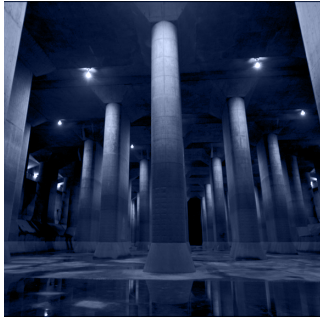


Underground transportation:

Yielding the space that is available underground for fast urban travel. Disposing of machines, noise, and odor (in the beginning) which was unwanted above ground.

Fig. 20 - Unknown, Fig. 21 - Crossrail Ltd.,
Milestones of progress, Crossrail tunneling,
1913





Water storage:

Disposing of stormwater which poses a threat to urban agglomerations. Sheltering water which is transported over a long distance.

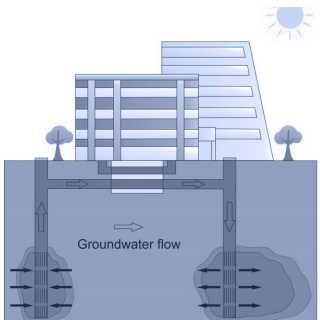
Fig. 22 - Dddecò, The Fig. 23 - Getty Images, water storage tank of the Sultanahmet basilica cistern.



Bunkers:

Sheltering people using the physical qualities of the underground.

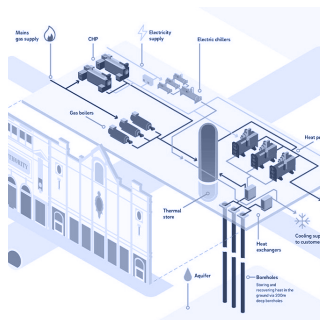
Fig. 24 - Tim Van de Velde, Fig. 25 - Associated Press, Concrete bunker in the People sheltering at Aldvrych Station.



Heat (energy) source:

Sheltering heat gathered on the above ground. Yielding heat produced by the underground heat gradient.

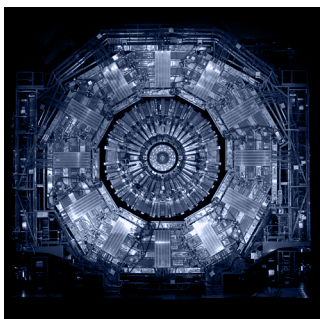
Fig. 26 - Ruben Stemmle, Fig. 27 - Paul Weston, Aquifer thermal energy Diagram of eON Citigen heatpump.



Underground storage:

Dispose of that which is undesired above ground such as cars and data centers.

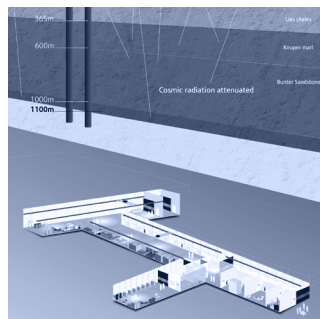
Fig. 28 - Naruecha, Parking Fig. 29 - Bahnhof, Bahnhof underground data center.



Underground labs:

Yielding the special environments the underground offers for the advancement of scientific research.

Fig. 30- CERN, CERN CMS. Fig. 31 - STFC, The Boulby underground laboratory.



the minnesota experimental city

The Minnsota Experimental City was a prototype city envisioned by Athelstan Spilhaus in the early 1960's. He imagined a city based on the principles of recycling which would ultimately eliminate pollution²².

The underground played a crucial role in the functioning of his design. The MXC is an example of the utility focused mindset towards the underground. He even named the underground system "utilidors" short for Utility Corridor System (fig. 32).

The utilidors would house all services, storage of storm water, snow, and waste heat. Heavy manufacturing would be done hundreds of feet below ground-level. Garages would be built under parks and these would be connected to underground tunnels used for transportation.

In this case the underground is still mainly used to dispose the activities which were not wanted in the ideal city above ground such as storage and transportation. But Spilhaus also saw some of the other qualities the underground has to offer such as its stable temperature. Another interesting aspect to this utopian design were all the different ways of connecting the above- and underground he explored.

Despite the idea gaining some traction and funding, it was never realised.

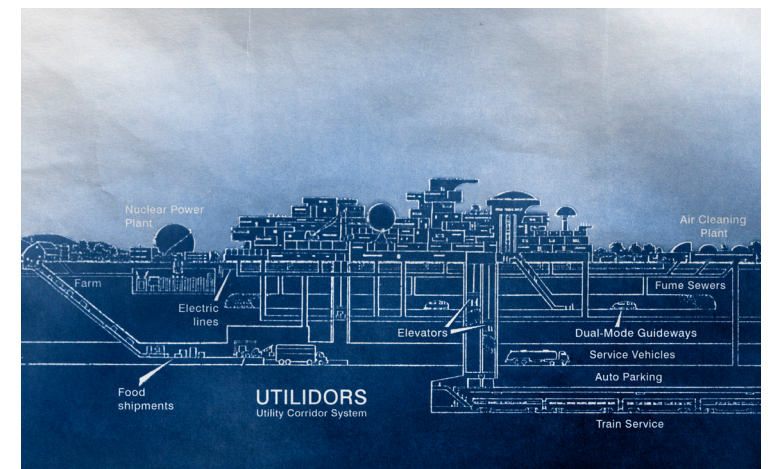


Fig. 32- Athelstan Spilhaus, Underground structures of the MXC- Utilidors

²²Endicott, Johnston, and Lin, Underground Cities.

Guy Rottier was an engineer and architect. His first experiments with underground architecture were earth-sheltered houses. These would allow for the houses to be covered in gardens. In one of his designs he introduced a “lumiduct” which is a tube that would transport daylight into the house covered by earth. This invention would spark the idea for Ecopolis²³ (fig. 33).

Rottier further developed his Ecopolis idea in 1970. He described it as an inhabited green hill with collective spaces organised by their need for sunlight. Lumiducts would pierce through the hill providing daylight on every level.

Guy Rottier saw the opportunity to inhabit the underground by embracing the amount of space it has to offer and the comfortable climate it can create. Experiments with bringing daylight and greenery down into the depths of Ecopolis echoed a rising sentiment to create liveable spaces.

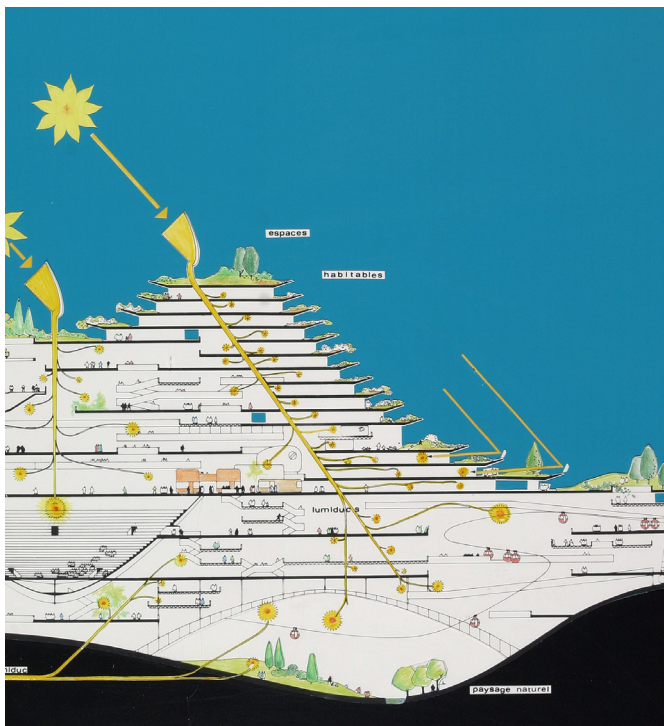


Fig. 33 - Guy Rottier, Ecopolis

²³Endicott, Johnston, and Lin, Underground Cities.

According to the underground resource model devised by Aurèle Parriaux one can view the underground as resource consisting of four types: space, (ground)water, (geo-)materials, and (geothermal) energy²⁴ (fig. 34). A view that one could say is focused on yielding that which is valuable.

The underground resource model advocates for better economic assessment of underground developments. By treating the underground as a valuable resource which has the ability to create 5 -10% more area for city environments and 100% more area for infrastructure as well as a valuable source of energy, water, and materials²⁵ it may be approached from a perspective different to the utilitarian one.

They also try to bring awareness to the need of sustainable development of the underground. Advocating for a more holistic approach to the planning, design, and development of underground urban spaces. Each of the four values mentioned contribute to supporting urban life and are closely linked to each other. The natural environment network underground is influenced by each underground intervention. By finding ways to optimise synergistic use of the underground resources one can increase the value of the project and minimise conflict generated by incompatible developments²⁶.

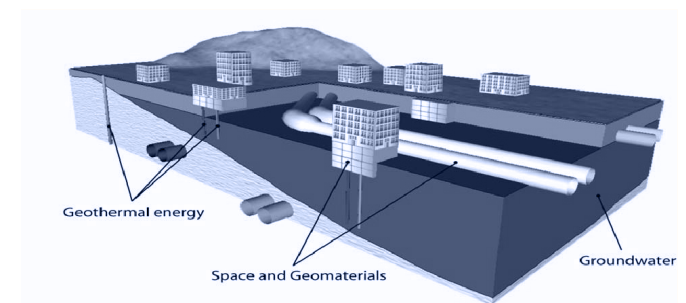


Fig. 34 - Aurèle Parriaux, The subsurface resources model.

²⁴Li and Parriaux, 'URBAN SUSTAINABLE UNDERGROUND RESOURCES MANAGEMENT: THE DEEP CITY CONCEPT'.

²⁵Li and Parriaux.

²⁶Li and Parriaux.

The Minnesota Experimental City and Ecolopis exhibit, despite being conceived only a decade apart, a notable divergence in their conceptualization of underground space. Spilhaus's design treats the underground as a servant space, intended to enhance life on the surface. Conversely, Rottier's vision considers the potential for underground spaces to be served spaces, habitable areas, a concept that aligns with the ambitions of this graduation project. This contrast is recognisable within the evolution of urban public space design above ground.

From an urban planning perspective, the development of above-ground spaces can give an indication of the likely progression of underground spaces. In the early 20th century, public space design shifted from an enlightened to a utilitarian approach²⁷. The advent of high-rise construction posed challenges for street-level liveability, as buildings obstructed light and air. New zoning laws aimed to optimize high-rise construction rather than limit it. Streets primarily facilitated efficient traffic flow for transporting people and goods between buildings, with public spaces relegated to residual areas between properties and infrastructure²⁸.

Following the Great Depression in 1929, America further adopted the utilitarian approach. Despite proposals to integrate public green spaces within densely populated urban centres, efficiency remained the cornerstone of these utopian visions, often represented by extensive freeway networks²⁹. This utilitarian approach, characterized by skyscrapers and predominantly outdoor public spaces, gained international acceptance³⁰.

Post-war reconstruction brought prosperity and mass consumption, leading to a suburban boom at the expense of city centres. To adapt, city centres underwent a transformation. Mixed-use developments and pedestrian-centric public spaces were designed to attract and retain residents amidst a comprehensive array of facilities³¹. These concepts often materialised as arcades and malls.

²⁷Harteveld, 'Interior Public Space'.

²⁸Pimlott and Sam, *Without and Within*.

²⁹Pimlott and Sam.

³⁰Harteveld, 'Interior Public Space'.

³¹Pimlott and Sam, *Without and Within*.

Public space design began to emphasize its role within the city's networks, which extended into buildings (and the underground), separating pedestrians from the vehicular traffic³².

Jane Jacobs, in her 1961 publication "The Death and Life of Great American Cities," highlighted the negative effects of automobile-centric design of cities and advocated for the benefits of human-scaled developments and vibrant street-level public life. This sparked a shift in urban planning towards prioritizing people and their need for liveable spaces over mass consumerism and efficient transportation³³. Designers began to enhance user experience in public spaces by emulating natural landscapes and outdoor environments³⁴. This trend continues to evolve with the growing emphasis on climate change and sustainability, leading designers to adopt a holistic approach to public space design that considers the entire urban ecosystem, inclusive of all organisms.

The development of underground spaces has not kept pace with the ambitions for above-ground urban planning. The initial construction of subways (subterranean-ways) was primarily to facilitate the servicing of underground pipes without the need for repeated pavement removal³⁵. Subsequently, the urban underground assumed various roles, including underground railways, carriageways, and bicycle tunnels. These functions, while privately owned, primarily served the public. The use of underground spaces was largely driven by their ability to minimize disruption to above-ground activities. However, their inherent characteristics of poor accessibility, humidity, and obscurity did not make them popular public gathering places³⁶. The design principles for these spaces adhered to the utilitarian visions of above-ground design but did not significantly evolve beyond this.

Moving forward, it is important to step away from the outdated utilitarian approach and include underground spaces in the holistic design approach of urban environments.

³²Harteveld, 'Interior Public Space'.

³³Pimlott and Sam, *Without and Within*.

³⁴Harteveld, 'Interior Public Space'.

³⁵Harteveld.

³⁶Harteveld.

site choice

THEORY

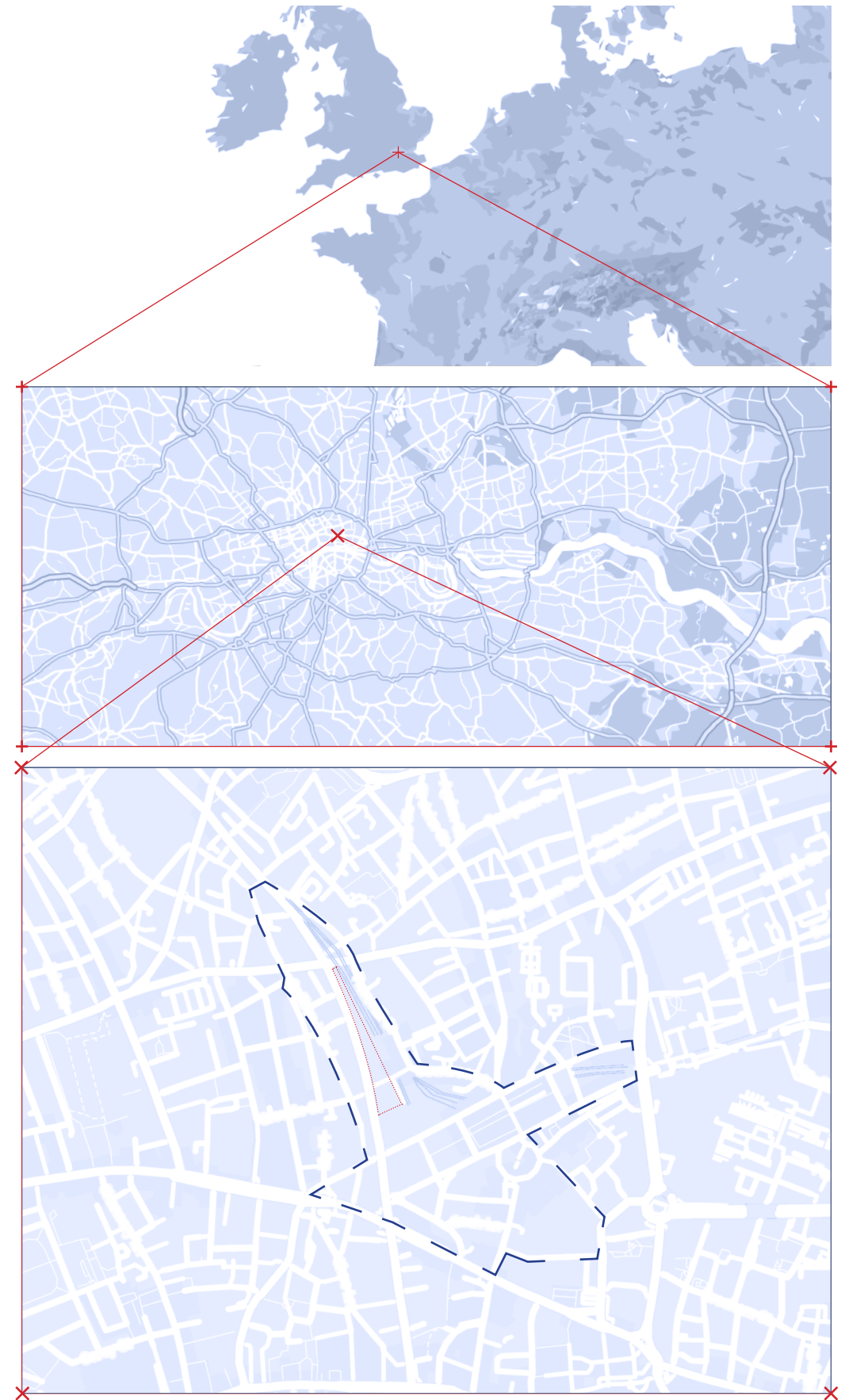
The choice for a site on which to experiment and design a vision for underground environments for future cities has to satisfy certain requirements to test the idea in a both feasible and challenging environment.

The first requirement is that it is situated in a city which lacks space but where further densification is still required.

The second requirement is that the location be in a city in which underground developments have already been done to certain extent. This can provide for an interesting underground landscape to work with.

The third requirement was that the site has a lot of activity. This creates the opportunity for the underground urban developments to serve multiple types of users in different ways.

In the end Farringdon station area in London was chosen for its dense urban context and interesting underground situation, which bears plenty of potential.



London's "The London Plan" published in 2021 addresses London's spatial development strategy for the next 20-25 years. The 2021 plan's main topic is "Good Growth"³⁷.

Good growth is defined as: growth that is socially and economically inclusive and environmentally sustainable.

There are six good growth principles the plan is based on:

1. Building strong and inclusive communities
2. Making the best use of land
3. Creating a healthy city
4. Delivering the homes Londoners need
5. Growing a good economy
6. Increasing efficiency and resilience

The most important and relevant take aways are:

General

Failure to consider certain fundamentals in the past has led to major issues in the present. These are: high housing prices, too much focus on large multi-nationals in the centre of London, poor health, congestion, and environmental quality.

The main goal for the future is to plan for better and more affordable housing, mixed-use developments, less car dependency, and a healthier and smarter city.

³⁷Greater London Authority, 'THE LONDON PLAN 2021'.

Growth Principles:

Building strong and inclusive communities

Traffic dominates too many streets across the city, dividing communities and limiting the interactions that take place in neighbourhoods and town centres.

Better public transport connectivity, accessible and welcoming public space, a range of workspaces in accessible locations, built forms that work with local heritage and identity, and social, physical and environmental infrastructure are important.

Making the best use of land

Prioritise sites which are well-connected by existing or planned public transport.

Proactively explore the potential to intensify the use of land to support additional homes and workspaces, promoting higher density development, particularly in locations that are well-connected to jobs, services, infrastructure and amenities by public transport, walking and cycling.

Creating a healthy city

Improve access to and quality of green spaces, the provision of new green infrastructure, and spaces for play, recreation and sports.

Delivering the homes Londoners need

Create mixed and inclusive communities, with good quality homes that meet high standards of design and provide for identified needs, including for specialist housing.

Growing a good economy

Seek to ensure that London’s economy diversifies and that the benefits of economic success are shared more equitably across London.

Plan for sufficient employment and industrial space in the right locations to support economic development and regeneration.

Promote and support London’s rich heritage and cultural assets, and its role as a 24-hour city.

Increasing efficiency and resilience

Ensure buildings and infrastructure are designed to adapt to a changing climate, making efficient use of water, reducing impacts from natural hazards like flooding and heatwaves, while mitigating and avoiding contributing to the urban heat island effect.

Create a safe and secure environment which is resilient the impact of emergencies including fire and terrorism.

Seek to improve energy efficiency and support the move towards a low carbon circular economy, contributing towards London becoming a zero-carbon city by 2050.

To conclude, London’s goals reflect many of the modern metropolises’ needs. Next to that it is important for London to keep its diverse character and make use of its existing infrastructure and heritage. To ultimately work towards a more liveable city for residents, workers, and tourists.

needs

- better planning
- better connectivity, less traffic dominated streets
- explore potential to intensify the use of sites which are well-connected by public transport
- improve access and quality of green spaces
- more homes
- share benefits of economic success
- increase resilience

underground opportunities

- new city master plans including the underground
- using existing and new underground streets, tunnels, to further separate traffic flows and allow for more smooth and seamless connection between destinations and modalities
- densification around London Underground stations and its underground space
- new underground spaces can relief pressure of above ground and allow for more green spaces or become green space themselves
- spatial relief with underground spaces can create more space for housing and better living environments
- create spaces for different types of economic activities in the same areas
- underground spaces can act as buffer zones to increase city resilience

As mentioned in the introduction, underground spaces have proven to be effective in providing solutions for problems cities are facing. This is also the case for London. Many problems the city is facing are due to lack of space and above ground congestion. Developing underground spaces and working towards a multi-tiered ground floor can help towards solving certain issues.

farringdon area vision

The Farringdon Station Area, this project’s design location, is at the meeting point of three boroughs: Camden, City of London, and for the largest part, Islington. The area is mainly characterised by³⁸:

- Farringdon station currently serves the Thameslink, Crossrail Elizabeth line, and three London Underground lines: Circle line, Hammersmith & City line, and Metropolitan line. It is projected to have 100,000 commuters per day by 2026.
- Smithfield meat market is retaining its function while the poultry market buildings are being transformed into the new Museum of London.
- St. Bartholomew’s Hospital is located just South of the Smithfield markets.
- To the East there is the Diamond Quarter of Hatton Garden.
- The area mainly comprises of office space with more leisure and hospitality services directly around the station. However, the local government projects a large demand for office space as they become scarce and less affordable due to hotels and residential developments buying up more areas.
- The new Museum of London will move to what used to be the Smithfield poultry market.

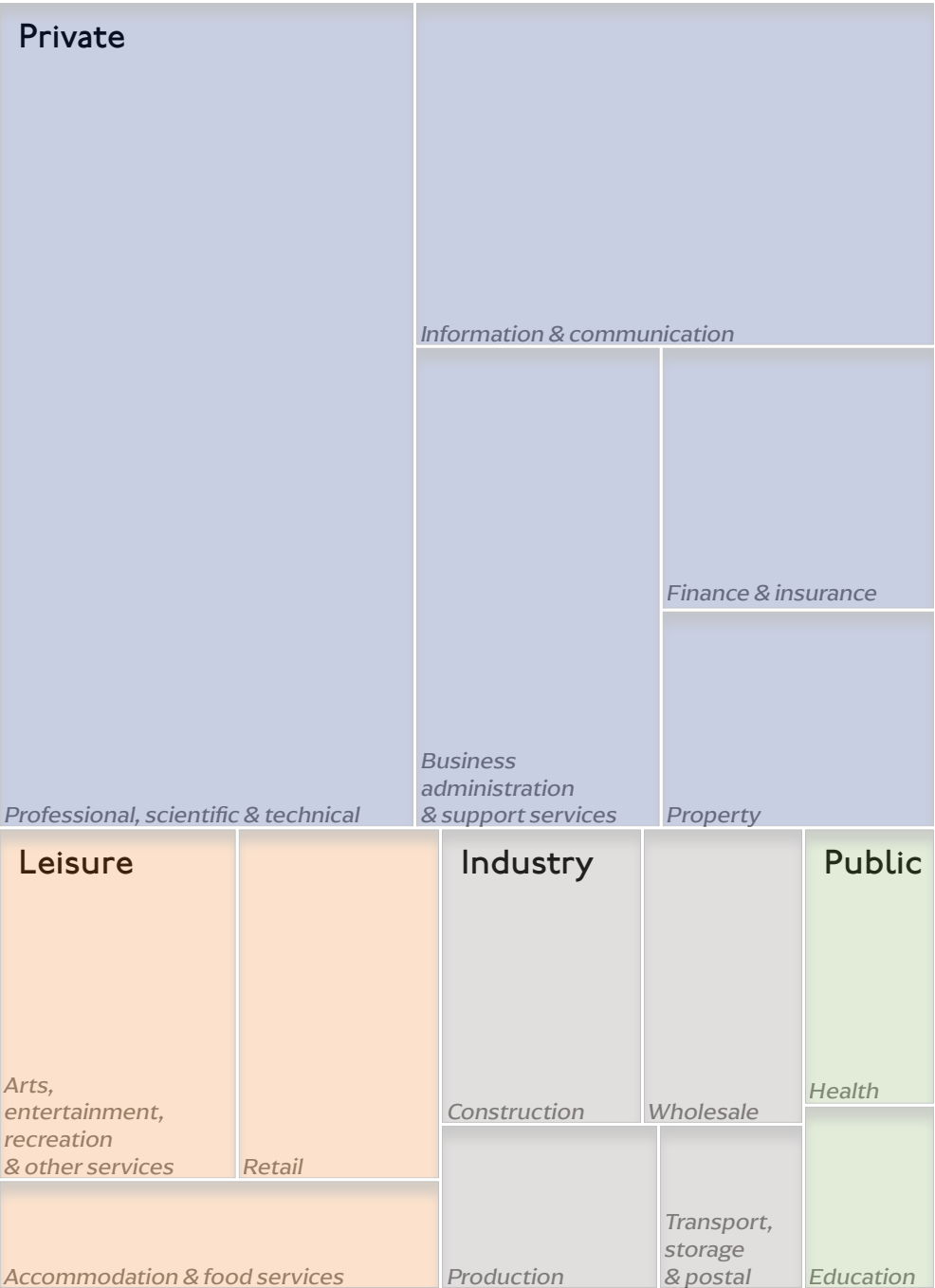
“The Local Plan” per borough in London is based on “The London Plan” but focused on borough specific needs and visions. Analysis of The Local Plan will give further insight into site specific needs and opportunities after having established that London is indeed a suitable city to explore underground development.

³⁸Islington Council, ‘Islington Local Plan’.

THEORY

businesses and distribution in Farringdon

THEORY



Islington, Camden, City of London 2023

Currently

The location is dominated by high level qualification jobs. Big companies such as Goldman Sachs and Amazon have their offices near Farringdon station. These companies require significant amounts of office space. The current lack thereof has inflated the prices in the area making it extremely difficult for SMEs and start-ups to establish in the area.

This also leads to businesses requiring lower levels of qualification not being able to operate in the area and residents in that particular situation not being able to find a job.

Transportation and destinations, including green public spaces are not well connected.

Future

The local government would like to increase the available business floorspace in order to attract SME's and start-ups. As well as more shopping, leisure, and cultural uses to support the area's office function.

Aside from office spaces the government also wants to improve the availability of sustainable transportation modes to transfer to along with the necessary service areas.

Special attention is to be paid to add and link existing small urban green infrastructure to form a larger network that can support the needs of residents and employees in the area.

The creation of single station environment can facilitate pedestrian flow and modal interchange.

³⁹Islington Council, 'Islington Local Plan'.

As above-ground spaces in urban centres became increasingly contested due to continued densification different methods were sought to relieve above ground of congestion (both traffic congestion and building congestion). Moving utilities underground enabled further densification of the above ground creating more room for real estate and some public space. At first utility functions such as sewers, pipelines, cables, and storage spaces were moved underground. Then the development of underground mass transit systems was explored, encouraging city dwellers to utilize these networks for navigation. Nowadays, the convenience of rapid transit has made these systems an integral part of daily life, inevitably expanding public life into the underground⁴⁰.

The idea of underground space serving more than just a utilitarian function was explored in theory by visionaries and theorists such as Guy Rottier. However, these 20th-century utopian ideas never came to fruition due to the lack of engineering know-how to construct underground spaces and create a liveable underground environment.

Despite these challenges, unique projects like the Rockefeller Center Concourse in New York and the multi-level concourse in Place Ville-Marie, Montreal, have successfully brought public life into the underground. These developments have established the necessary supporting functions that allow people to inhabit the underground rather than merely passing through it. However, the primary motivation behind most of these developments was to address above-ground challenges, such as adverse weather conditions or overcrowding⁴¹, which also contributed tremendously to its popularity amongst citizens. Despite their essential role in city infrastructure, underground networks still struggle to match the appeal of above-ground public spaces in practice and have largely remained utilitarian spaces.

⁴⁰Harteveld, 'Interior Public Space'.

⁴¹Harteveld; Pimlott, The Public Interior as Idea and Project.

THEORY

Nevertheless, the utopian ideas of Spilhaus and Rottier, along with the avant-garde plans of I.M Pei & Associates in Montreal laid the foundation for further research into the potential which the underground presents to urban environments. Over the past decades a lot of research has been conducted by theorists⁴² and engineers⁴³ into the possibilities of underground urban development.

What has been lacking is a design approach that combines theory and engineering to explore what liveable underground spaces could look like in practice.

Farringdon station area presents an interesting case in which a vision for underground urban space development can be explored. The area lacks development space and is in need for further densification. At the same time it wants to create a more liveable space to support the increasing amount of commuters, inhabitants, and tourists coming to the area. It also wants to improve the station environment to facilitate better slow traffic flow, modal interchange, and connection between small public spaces in the area. The extensive amount of existing underground spaces in the location suggests that the Farringdon area can embrace this quality and expand its underground network.

In the following chapter, “City,” literature on underground design and planning theory, engineering, and existing underground public spaces will be analysed to identify the challenges these developments face and where the potential lies for the development of underground spaces in cities.

⁴²Admiraal and Cornaro, *Underground Spaces Unveiled*; Frampton, Wong, and Solomon, *Cities without Ground*; Li and Parriaux, ‘URBAN SUSTAINABLE UNDERGROUND RESOURCES MANAGEMENT: THE DEEP CITY CONCEPT’; Endicott, Johnston, and Lin, *Underground Cities*; Von Der Tann et al., ‘From Urban Underground Space (UUS) to Sustainable Underground Urbanism (SUU)’; Mastenbroek, Mercredy, and Baan, *Dig It! Building Bound to the Ground*; Golany and Ojima, *Geo-Space Urban Design*.

⁴³Seo, Lee, and Won, ‘Comparative Analysis of Economic Impacts of Sustainable Vertical Extension Methods for Existing Underground Spaces’; Gong, Lei, and Shen, *Advanced Underground Space Technology*; Ocloi, *Renewable Energy Utilization Using Underground Energy Systems*; Bai, *Underground Engineering*.



“Milestones of progress” is printed on a 1913 poster advertising the underground in London (fig. 37). From a sedan, to a horse drawn coach, to a steam train, to the electrified underground. Despite the socio-psychological aversion towards the underground embedded in our society and our language, the London underground overcame this obstacle and attracted many users by recognising its qualities: ease and comfort (fig. 35-37). Nowadays there is no need to convince people that the underground system is the easiest way to travel through the city. It has become an indispensable part of commuters’ lives in big cities. However, the public use of underground space is mostly limited to transportation and the “definite and necessary functions” (defined by then London Underground architect Charles Holden) that are linked to it.

This thesis is searching for the next “milestone of progress” in the use of the underground in cities, the question is not to convince people of the underground’s qualities or convenience. The question is how to make people want to stay there and how it can become a symbiotic part of the urban landscape?

For the effective utilization of subterranean spaces, comprehensive urban planning at the city level is imperative. Anticipating long-term strategic objectives and a transparent redefinition of land ownership are crucial to overcoming this final hurdle in urban planning and engineering⁴⁴.

This chapter will, on one hand, investigate disciplines related to the governance and utilization of underground spaces in urban contexts, drawing upon existing literature. On the other hand, it will examine the urban design prerequisites that facilitate the emergence of fluid above-underground urban spaces, by reviewing precedents of urban subterranean spaces.

Subsequently, a site analysis and stakeholder analysis will be conducted to gain a deeper understanding of the potential role of underground development, specifically in the Farringdon station area, and to identify potential opportunities. This will allow well informed decisions to be made regarding interventions and new programs that cater to the needs of both London and the Farringdon area.

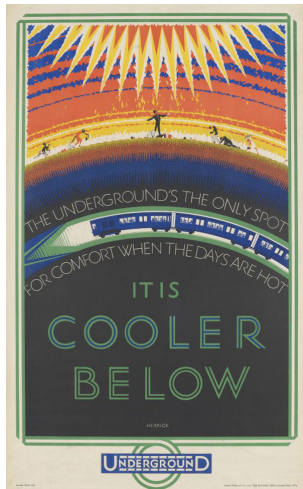


Fig. 35 - Frederick Charles Herrick, It is cooler below, 1926 - London Underground Poster

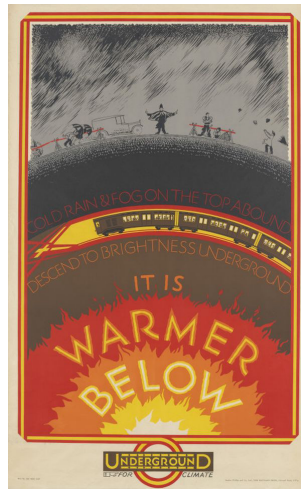


Fig. 36 - Frederick Charles Herrick, It is warmer below, 1927 - London Underground Poster



Fig. 37 - Unknown, Milestones of progress, 1913 - London Underground Poster

⁴⁴Endicott, Johnston, and Lin, Underground Cities.

policy building and urban planning

CITY

Spatial policy plans or strategic plans including underground space are rare. Currently only a few countries have shown interest in developing underground master plans and spatial policy related to underground space use⁴⁵. The lack of such plans is not caused by disinterest but by unawareness⁴⁶. As demonstrated in the previous chapter, the underground can contribute to the improvement of cities in many different ways, through many different uses. It is important to show (through projects like these) how underground developments can benefit across multiple fields.

Then the execution of these plans comes into play, urban planning. Making urban plans which include underground spaces requires new approaches. First is the integration of the vertical dimension aligning the different two dimensional layers in urban environments (such as buildings, pipelines, cables, transportation tunnels...). Second is to take into account the fourth dimension of time (or order)⁴⁷. Due to different types of geological properties of the underground, construction is sometimes limited, once one thing is built underground nothing else can be built under or around it. Thus long-term planning becomes essential.

For example, the Helsinki Underground Master Plan assigns multiple underground spaces for future use in different categories. By foreseeing the future possible development of certain underground spaces it allows for other construction around it to take into account the future possibility of these plans⁴⁸.

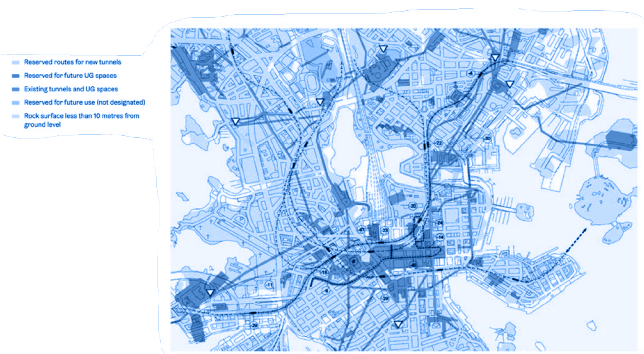


Fig. 38 - Helsinki City Planning Department, Extract of the Helsinki Underground (UG) Master Plan.

⁴⁵Endicott, Johnston, and Lin.

⁴⁶Admiraal and Cornaro, Underground Spaces Unveiled.

⁴⁷Admiraal and Cornaro, Underground Spaces Unveiled.

⁴⁸Endicott, Johnston, and Lin.

governance and legal challenges

CITY

An inevitable question in the case of underground development is the legal issue of land ownership. Who owns the underground? How deep does ownership go?

Generally speaking, anyone who holds the ownership of a piece of land owns anything above and underneath it⁴⁹. Which makes the most obvious way of developing underground projects through expropriation. However, the law is not always clear on this topic. In the Netherlands for example, the government owns the minerals and resources that can be extracted from the underground, as a result this limits the underground space ownership of people who own land above these resources.

Another way of developing the underground is through private ownership and development⁵⁰. These don't happen often yet because of the costs related to underground development and the lack of good business plans.

In certain cases such as Switzerland and Helsinki land ownership is limited to the depth of its economic usage. For instance, 6 meters under residential projects: two levels of basement floors. In Japan the land ownership is limited to 40m below a basement or 10m below foundation piles. Singapore has also changed its land ownership laws since its newly developed interest in underground developments⁵¹.

An interesting proposal however, is to look at underground space governance the same way air space is controlled with air rights in New York, or planned in national airspace. Three dimensional zoning laws might be the solution to the land ownership problem. This can also be paired perfectly with three dimensional urban planning⁵². The difficulty lies in the acquisition of data but recent technology has made underground mapping increasingly easy. Governments are also making maps of its underground landscape.

⁴⁹Admiraal and Cornaro, Underground Spaces Unveiled.

⁵⁰Admiraal and Cornaro, Underground Spaces Unveiled.

⁵¹Admiraal and Cornaro, Underground Spaces Unveiled.

⁵²Admiraal and Cornaro, Underground Spaces Unveiled.

investment and development

CITY

One of the main reasons why the use of urban underground space has stagnated is the reluctance to invest in it, according to civil engineer Han Admiraal and urban planner Antonia Cornaro⁵³. This is a concerning situation because in the long term, the cost of doing nothing outweighs by far the cost of doing something. When space in the city becomes sparse, land prices rocket, and along with it many more problems plague the city.

The most important aspect to making policy decisions as objective as possible is taking into account both economic and social costs and benefits. When it comes to developments these benefits are the value created by the project. Value creation is only one part of the sum, it is about the justification for the project. The other important part is value capture. Value capture is about acquiring the sufficient funds for the project⁵⁴.

The value underground development can create has been extensively discussed in the Theory chapter. The underground is an important resource for our urban areas and can provide a multitude of benefits through good design and development thereof.

For underground developments value capturing can help towards approval of such projects, as reluctance to invest has been one of the main problems. Value capturing proves how and why the project is worth the investment. It is crucial for value capture that underground developments are integrated into urban planning. This way, value of neighbouring developments, tax increment financing (value captured through increased business revenues or rents in the area), public-private partnerships and health benefits (from above ground green spaces) can be projected and considered during financing of the project⁵⁵.

Aside from governmental funding it is important to create the right environment for private investment as well. To achieve this, multipurpose projects with larger and longer-term goals need to be created with enough transparency so that investors can make informed decisions.

⁵³Admiraal and Cornaro, *Underground Spaces Unveiled*.

⁵⁴Admiraal and Cornaro.

⁵⁵Admiraal and Cornaro.

cross-disciplinary collaboration

CITY

The past three chapters made evident that the development of the underground requires multi-stakeholder collaboration from designers, decision makers, and investors. Only if all parties can coordinate and create the environment needed to proceed, can underground projects succeed. Four dimensional urban planning, new land use regulations, and long-term visions allowing for long-term investments are key aspects.

I.M. Pei & Associates were commissioned in the mid-1950s with designing the masterplan of a multi-level downtown core in Montréal connecting Place Ville-Marie, the Central Station, and Place Bonaventure. In 1960 the construction started for what is now over 35 kilometres of underground passageways. Not only does it connect more than 60.000 commuters with their workspaces every day, it also provides access to shops, restaurants, theatres, galleries, and museums. The success of this network, mainly thanks to its quality of protecting its users from the cold winters, spurred the further construction of many informal extensions to this network connecting it to even more spaces⁵⁶.

What made “la ville intérieure” so successful was not only the ease it offered to commuters with its direct connections or the comfort it offered in the harsh winters. It was also its quality that it connected multiple supporting services and its design that resembled a legitimate interior realm and not just a piece of underground infrastructure⁵⁷.

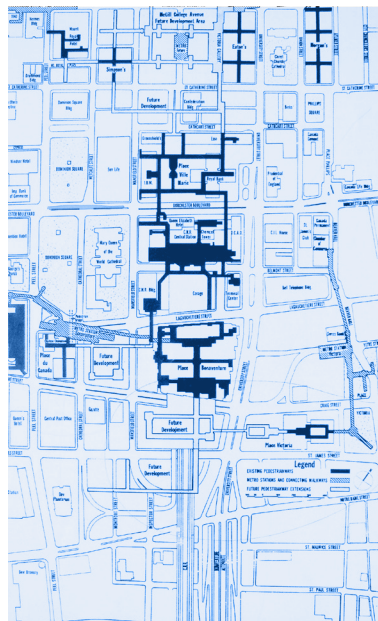


Fig. 39 - Pei Cobb Freed & Partners, Plan showing pedestrian level of Montréal's multi-level downtown core.



Fig. 40 - BAnQ, Boutiques Place-Marie 1966.

⁵⁶Endicott, Johnston, and Lin, *Underground Cities*.

⁵⁷Pimlott, *The Public Interior as Idea and Project*.

The idea of three-dimensional urban plan which was envisioned for the Montréal underground passage reaches its ultimate form in Hong Kong. Footbridges and underground tunnels connect buildings, stations, and malls creating a true three-dimensional urban network within the dense city⁵⁸.

This network is a result of top-down planning and bottom-up solutions. Different parties continuously add to this network to serve different needs. Similarly to the Montréal network, the Hong Kong network also has a large part that is situated within the interior or underground realm and shields its users from the hot and humid climate⁵⁹.

Within this three-dimensional network there are spaces for having lunch, space for performance, spaces for gathering, and much more serving all the different demographic groups in this extremely dense city. This informal quality makes large parts of the Hong Kong network truly public spaces⁶⁰.

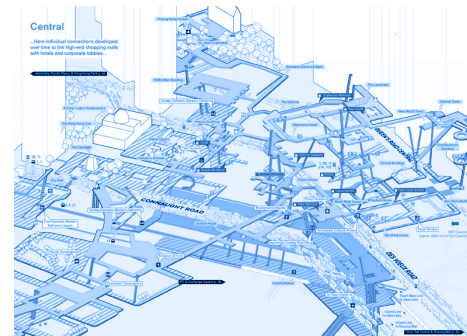


Fig. 41 - Cities without ground, map of Hong Kong Central

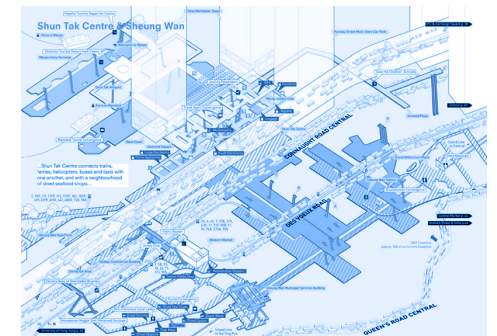


Fig. 42 - Cities without ground, map of Shun Tak Centre & Sheung Wan

⁵⁸Frampton, Wong, and Solomon, *Cities without Ground*.

⁵⁹Frampton, Wong, and Solomon.

⁶⁰Frampton, Wong, and Solomon.

marunouchi - master planning the underground

CITY

The Marunouchi district in Tokyo, encompassing approximately 100 buildings, 4,000 enterprises, and 230,000 employees, is interconnected with Tokyo and beyond via 13 stations and 20 railway lines. The underground infrastructure has become a vital asset for this district, enhancing liveability through improved accessibility and reduced congestion. As a result of comprehensive planning across horizontal and vertical dimensions, as well as above and below ground, the city has successfully developed an underground space that offers a range of functions to support and entertain people, rather than merely serving as a circulation medium⁶¹.

The extensive underground network has been rendered navigable by categorizing it into three primary types of spaces: public underground squares, public underground passageways, and private underground passageways. The public squares act as central nodes in the underground network, promoting efficient wayfinding within the subterranean environment. The passageways, which run parallel to above-ground roads, facilitate orientation for individuals. The transition between above and below ground is eased through the creation of intermediate spaces that integrate vertical connections with supporting amenities such as shops and street furniture. The design of the Marunouchi underground network exemplifies how principles of effective above-ground urbanism can be applied to the development of underground and transitional spaces⁶².

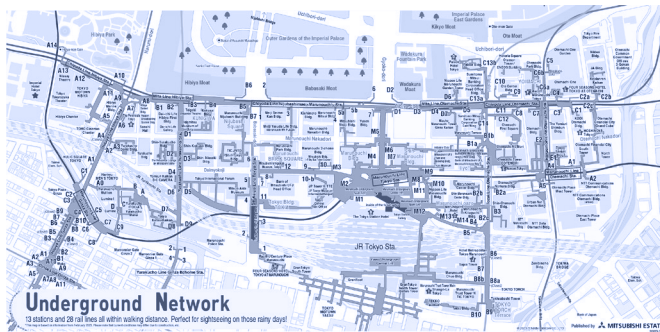


Fig. 43 - Mitsubishi Estate, Map of Marunouchi underground network.



Fig. 44 - Landscape Architects Collaborative, The Industry Club of Japan Building underground plaza.

underground development opportunities

CITY

Urban underground infrastructure is extensive and presents challenges in determining where urban underground spaces can be further developed⁶³. Identifying suitable locations for the development of underground spaces is a subject of discussion in Dominique Perrault's MOOC: Groundscapes. The insights from this course, combined with information from primary literature and technical scientific papers on underground construction, have led to the following conclusion.

The potential for underground development can be primarily categorized into four areas: **repurposing, creating, expanding, and extending.**

Repurposing focuses on the adaptive reuse of existing underground spaces that have become vacant due to decommissioning or disuse. This can occur when such spaces are replaced by newer, improved spaces serving the same function, or when they become redundant due to evolving urban conditions such as the implementation of car-free zones, the advent of wireless telecommunication, peaceful conditions, and other technological advancements.

Within the **repurposing** category, we can distinguish two types of existing underground spaces: infrastructural spaces and storage spaces.

Infrastructural spaces encompass various types of tunnels, such as the decommissioned tunnel between Barbican Station and Snowhill Station, which runs beneath the Smithfield markets. These tunnels offer multiple reuse possibilities. Firstly, their inherent characteristic as a connective element in the city's network

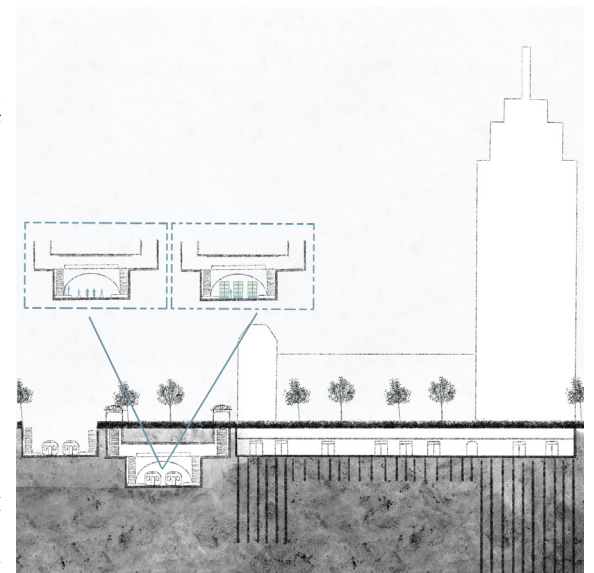


Fig. 45 - Author's work, drawing depicting possible repurposing strategies in urban underground environments.

⁶¹Endicott, Johnston, and Lin, Underground Cities.

⁶²Endicott, Johnston, and Lin, Underground Cities.

⁶³Endicott, Johnston, and Lin, Underground Cities.

allows them to be transformed into new underground pedestrian and bicycle pathways between transport nodes (stations). Secondly, these easily accessible spaces, which benefit from a stable underground climate, can be repurposed as dedicated urban farming areas beneath the city's streets and buildings⁶⁴.

This subcategory also includes disused stations. Cities like London have numerous decommissioned underground stations that were part of the initial underground rail system. Many of these stations served crucial roles during the Second World War, providing shelter and housing vital functions such as military and communication headquarters. In addition to stations, many deep-level air raid shelters were constructed during or immediately after the Second World War. An example is the Kingsway telephone exchange, which is currently being transformed into an experience centre and underground bar, reusing both the buildings and connecting tunnels.

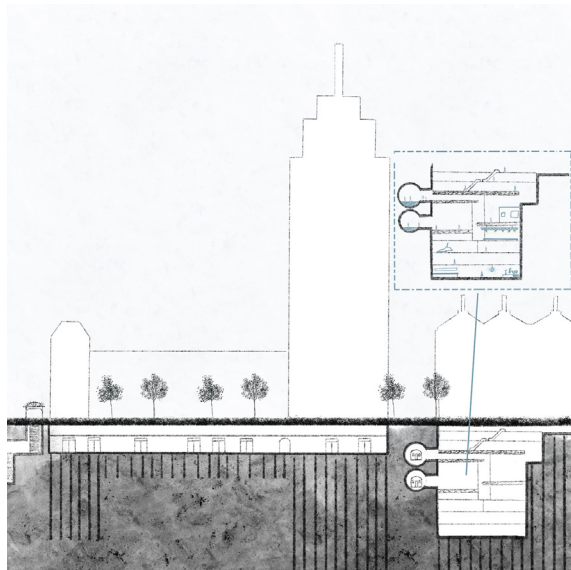


Fig. 46 - Author's work, drawing depicting possible repurposing strategies in urban underground environments.

The second subcategory, storage spaces, includes structures such as basements and parking garages. Basements in existing buildings currently accommodate a variety of functions. While they primarily serve as technical and servant spaces for the building above, some basements house living functions that do not necessarily require daylight, such as gyms, wellness centres, swimming pools, cinemas, and extensions of above-ground functions like museums. Parking garages, an urban infrastructure whose future must be carefully reconsidered as we transition towards car-free cities, can be transformed into more liveable spaces using

⁶⁴Endicott, Johnston, and Lin, *Underground Cities*.

modern technologies that allow daylight to penetrate even the most obscure corners of the underground⁶⁵.

Repurposing strategies for this subcategory could involve opening up the ground floor to expose these underlying levels to daylight, air, and the public realm. Another strategy could be to interconnect them to form a larger network of accessible underground spaces, functioning similarly to the “interior city” in Montréal.

The second primary category is the **creation** of new spaces.

This category can be further divided into two options: the creation of new underground spaces by covering topographical scars in urban areas, and the creation of habitable underground spaces in new developments.

The first option involves the transformation of topographical scars, which are man-made spaces such as railway or highway cuttings, drydocks, and quarries that **create** open-air, below-ground-level spaces without any overlying structure. If underground spaces are deemed economically viable and beneficial to urban areas, efforts can be made to actively seek and cover these spaces. By covering these types of spaces, an additional underground space is created, along with new ground-level space on top, resulting in a net positive contribution to the urban environment. An example of this type of project is the Antwerp Oosterweel Link, where plans are underway to partially cover a below-ground-level highway. The coverings will form new parks for the surrounding neighborhoods and house cultural buildings, while the highway will remain underneath the coverings,

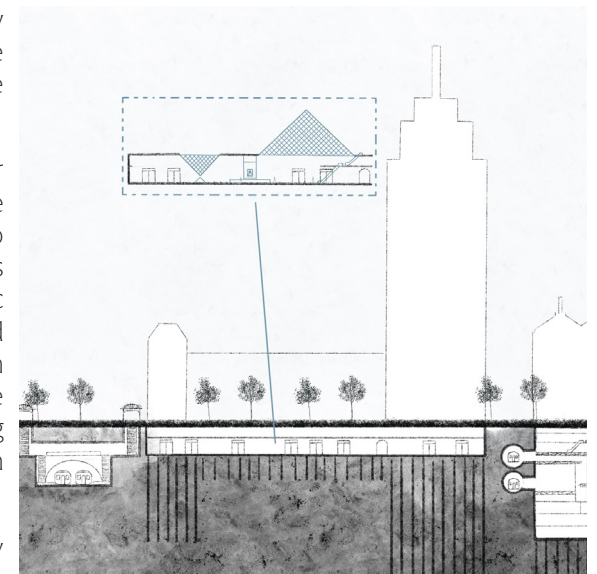


Fig. 47 - Author's work, drawing depicting possible repurposing strategies in urban underground environments.

⁶⁵Perrault, Dominique, *Sublab MOOC*.

with added pedestrian and bicycle paths. While most current projects involve the covering of infrastructure, this approach could certainly extend to the covering of unused topographical scars to create inhabited spaces underneath, as demonstrated by BIG's design of the Danish National Maritime Museum, where parts of a drydock were partially covered to create new spaces underneath and a park above.

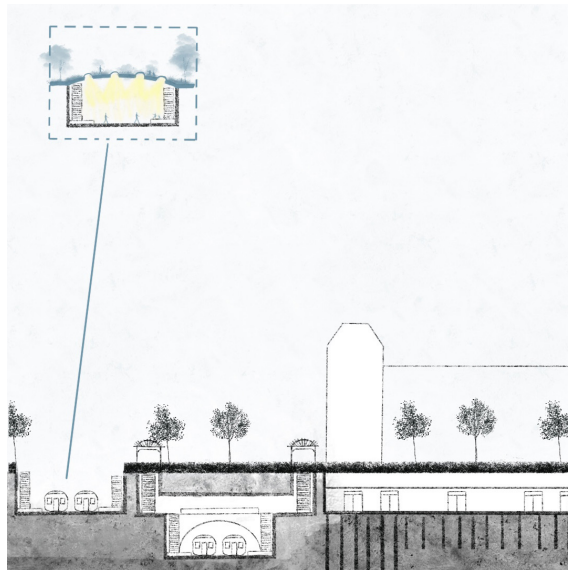


Fig. 48- Author's work, drawing depicting possible creation strategies in urban underground environments.

The second option in this category involves the **creation** of habitable underground spaces in new developments. At present, most developments include only a few underground floors, primarily to accommodate parking or technical spaces, with some including up to two floors of habitable spaces. However, initiating new developments with deeper underground spaces could provide greater long-term value. If additional floors need to be excavated later, it would result in a more costly intervention.

The third primary category is **expansion**, which involves extending into redundant or leftover spaces in the underground. This category explores the potential to add underground volumes to existing structures. While this category is more speculative than the others, it is not beyond the realm of possibility.

The first concept within this category is the **expansion** of underground spaces into interstitial spaces. As underground infrastructure ventures deeper, the space between these deep underground areas and the shallower spaces above could be explored as potential expansion zones. (For example, the deepest point of the London underground is 58.5 meters below the surface.) In Helsinki, certain underground spaces that exist

between existing basements and much deeper utility tunnels are considered in the underground masterplan as spaces reserved for future use⁶⁶.

The second concept involves the **expansion** of underground spaces around the existing deep pile foundations of skyscrapers or structures situated above metro tunnels. In many cases, these pile foundations are drilled into the bedrock layer to secure the building, their depth is not necessarily a result of required friction between the pile and soil. This indicates the possibility of a certain level of redundancy in some foundation structures. The space between the foundation piles could theoretically be expanded into to create new underground spaces, as suggested in Dominique Perrault's MOOC.

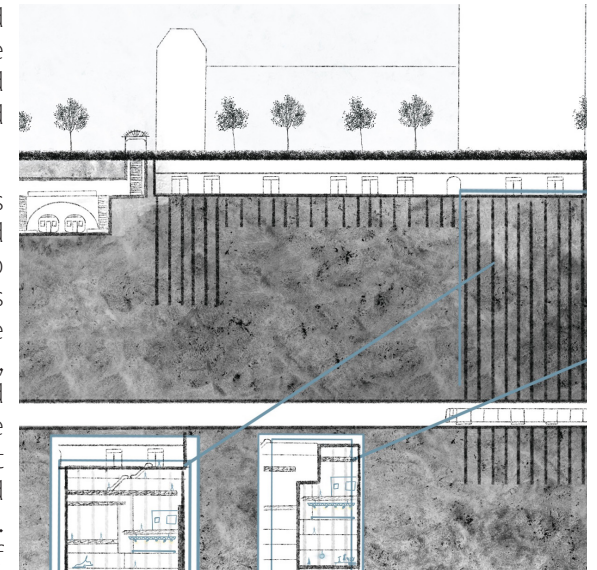


Fig. 49- Author's work, drawing depicting possible expansion strategies in urban underground environments.

The fourth main category is **extension**. With the advent of new technologies, it is becoming increasingly feasible to undertake basement extension projects. These projects involve drilling new foundation piles from the lowest basement level of the existing building and constructing new diaphragm walls from street level. Subsequently, new basement levels are excavated around the new foundation piles. This technique has already been implemented in numerous projects, such as the extension of five additional basement layers beneath the Claridge's hotel in London's Mayfair district.

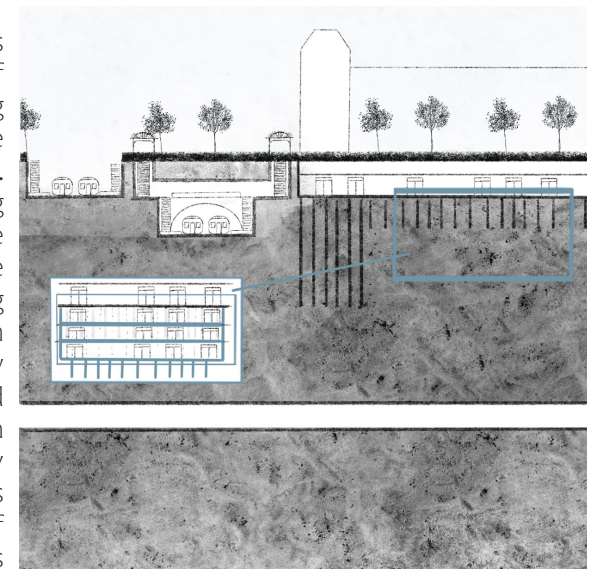


Fig. 50 - Author's work, drawing depicting possible expansion strategies in urban underground environments.

⁶⁶Admiraal and Cornaro, *Underground Spaces Unveiled*.

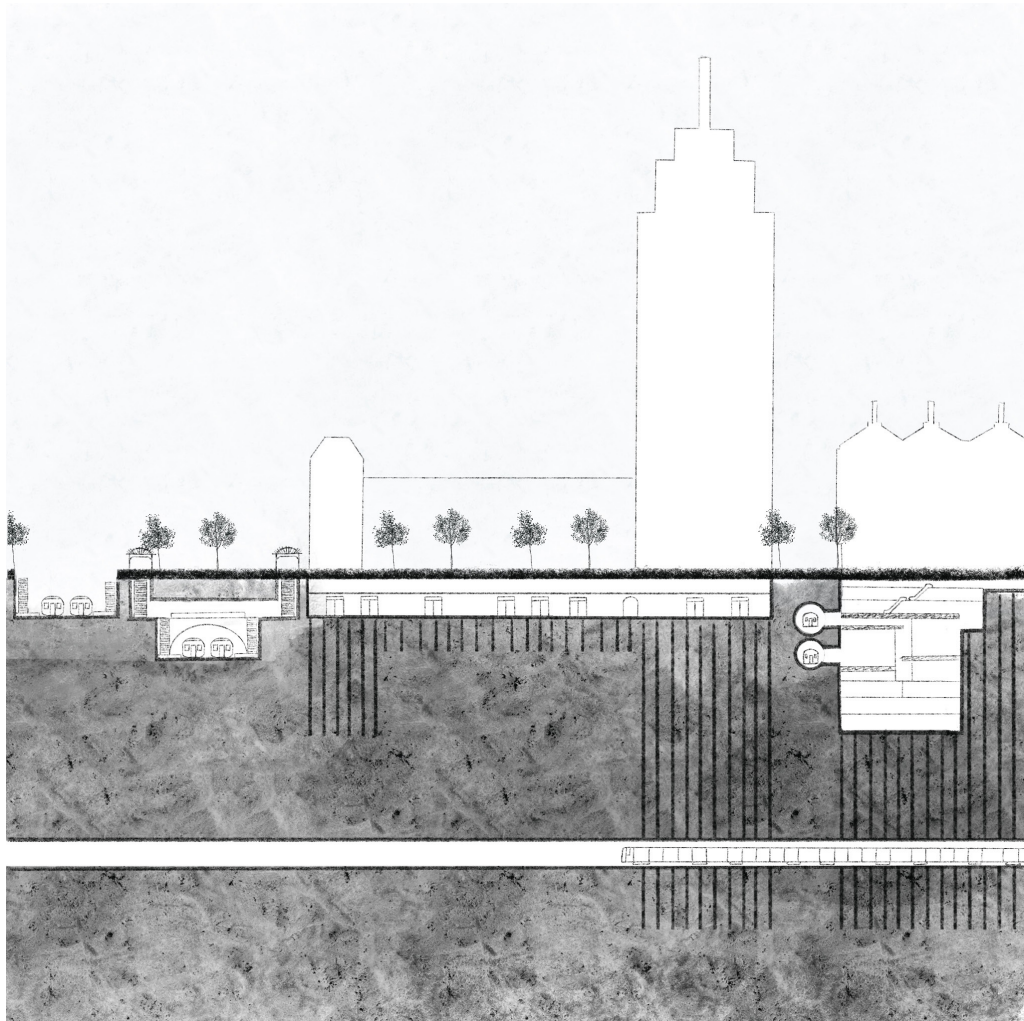


Fig. 51 - Author's work, drawing depicting possible urban underground environment situation in cities.

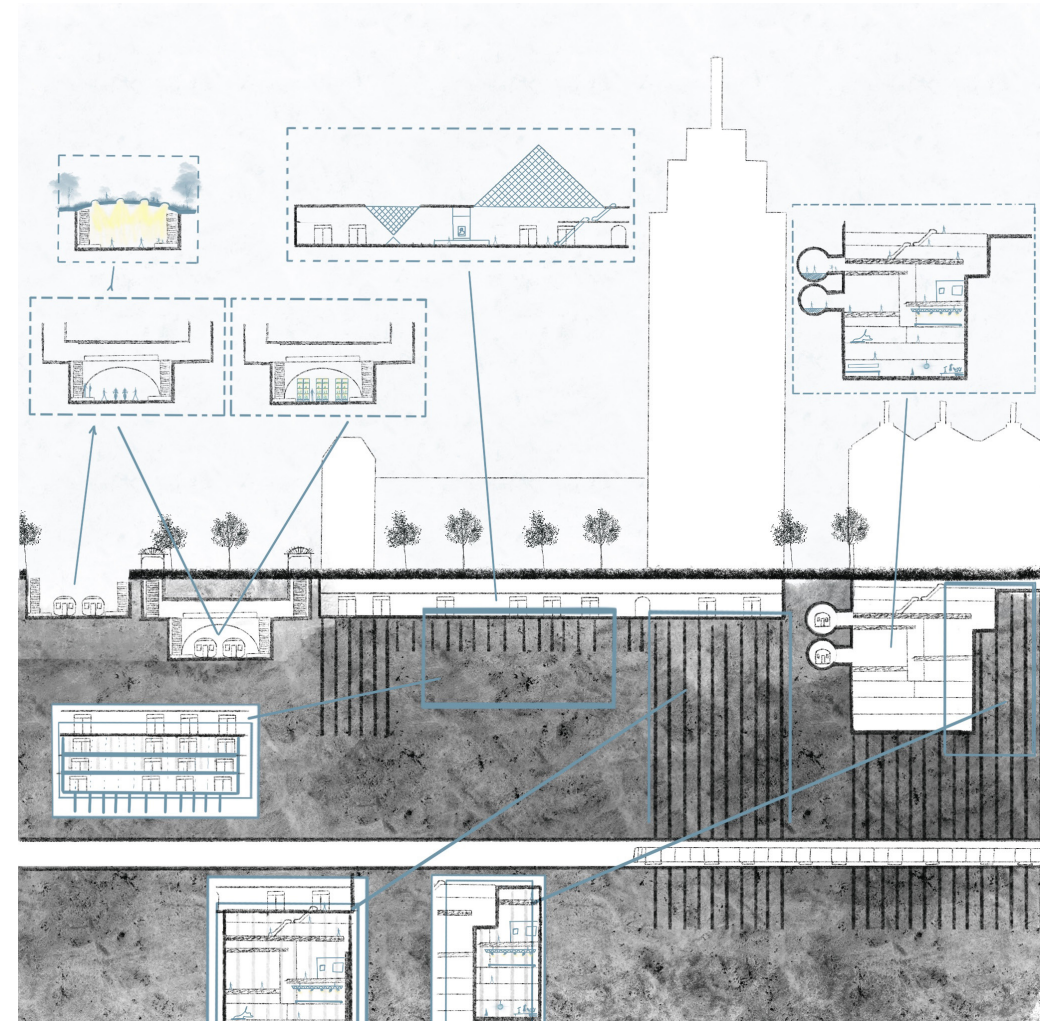


Fig. 52 - Author's work, drawing depicting possible strategies in urban development of underground environments.

going under in the 21st century

CITY

CITY

As highlighted in the initial segment of this chapter, the progression of underground urban development necessitates a collaborative approach involving multiple disciplines. The involvement of numerous stakeholders from both the private and public sectors is crucial. The creation of more habitable spaces that are integral to the urban environment and frequented by users and consumers is the only way to realise value capture.

Examining three examples of successful underground developments in urban settings, the significance of accessibility, publicness, and liveability becomes apparent.

All three examples are well-integrated into their urban contexts, with both vertical and horizontal connections between buildings and close proximity to mass transit stations. Hong Kong exemplifies this connectivity with its three-dimensional network of underground and skybridge connections. Montreal and Marunouchi underscore the importance of supporting functions for public networks. These networks connect offices and cultural programs, which serve as “destinations” for passage users. Along these passages, supporting functions such as shops, cafes, and restaurants can be found. Additionally, free public amenities are vital for creating more liveable public spaces. These can take the form of dedicated street furniture, as seen in Marunouchi, or open spaces that users can freely appropriate, as seen in Hong Kong. These examples also emphasize the importance of effective vertical connections between under- and above-ground levels. In Marunouchi, purposefully designed semi-outdoor squares allow daylight and create a clear visual connection. The more seamless these connections are, the more accessible the different floors become, making it more appealing to explore different underground levels.

This chapter also explored the opportunities for new underground development in urban environments. With the advancements in construction technologies, there are numerous possibilities for new underground development in cities. In the pursuit of sustainable development it can be interesting to explore the many existing underground spaces in cities, such as car parks and large basements, which can be repurposed into inhabited spaces.

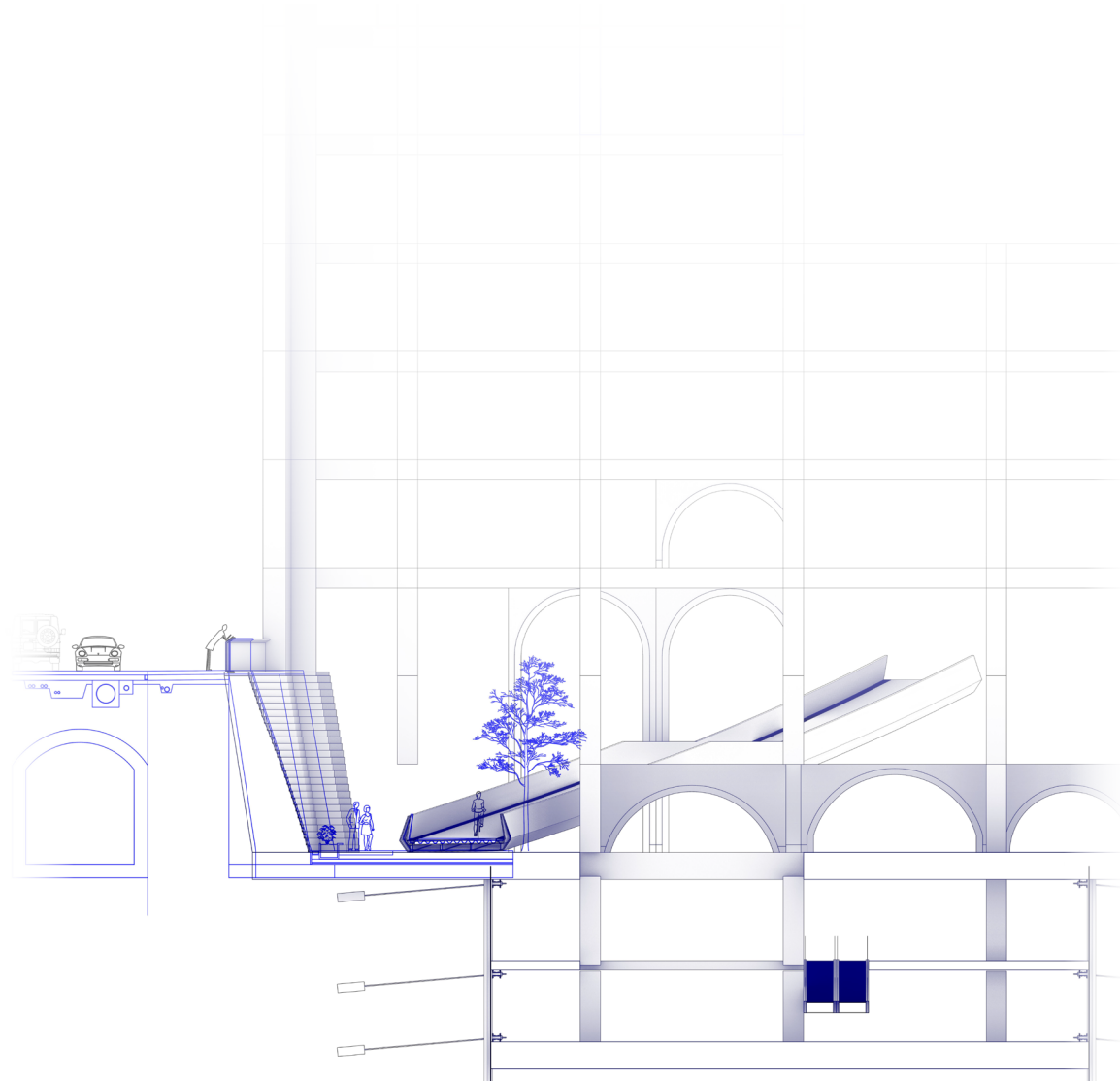




Fig. 53 - Author's work, Farringdon station area figure ground.

site analysis
- programme

CITY

CITY



Fig. 53 - Author's work, Farringdon station area programme.

Farringdon Station area has a rich history. The area which was once known for its market, the Charterhouse and the river fleet (which was covered and now runs under Farringdon road) is now dominated by office buildings.

The figure on the lefts shows the buildings with special functions in the area, all the footprints that are left white are mainly office spaces with a few residential buildings.

Smithfield meat market is retaining its function while the poultry market buildings are being transformed into the new Museum of London.

St. Bartholomew's Hospital is located just South of the Smithfield markets.

To the East there is the Diamond Quarter of Hatton Garden where there is a streetfood market from Monday to Friday serving lunch to all the office employees in the area..

The shopping area comprised of leisure and hospitality services directly around the station supporting the office function.



Fig. 54 - Author's work, Smithfield Market main entrance.



Fig. 55 - Author's work, Saint Bartholomew's Hospital main entrance

site analysis

- public transportation

CITY

CITY

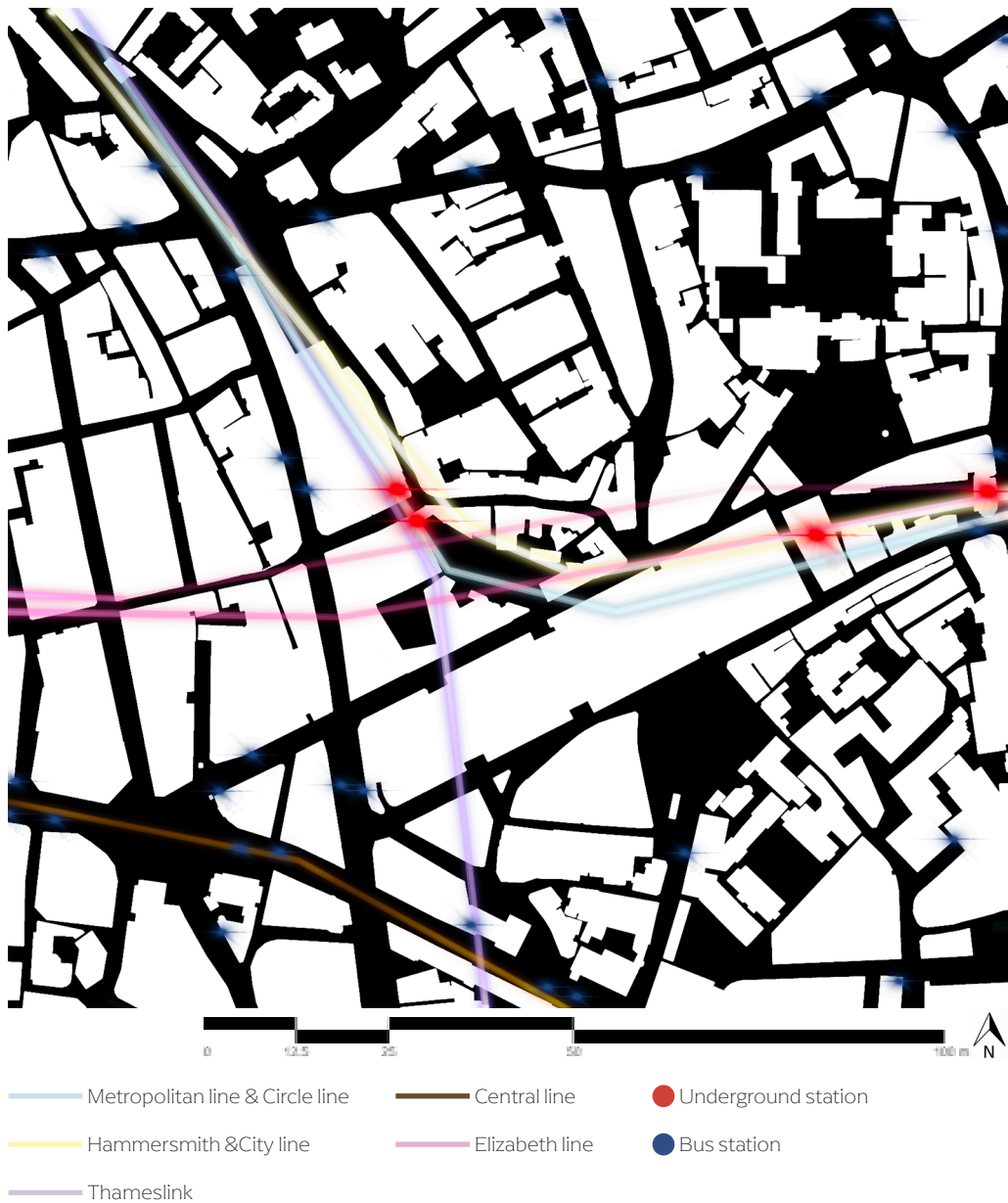


Fig.56 - Author's work, Farringdon station area public transportation.

One of the strengths of Farringdon station area is its accessibility via public transportation. Farringdon station currently serves the Thameslink, Elizabeth line, and three London Underground lines: Circle line, Hammersmith & City line, and Metropolitan line. It is projected to have 100,000 commuters per day by 2026.



Fig.57 - Author's work, Farringdon station entrance



Fig.58 - Author's work, Bus stop on Farringdon road

site analysis
- cycling

CITY

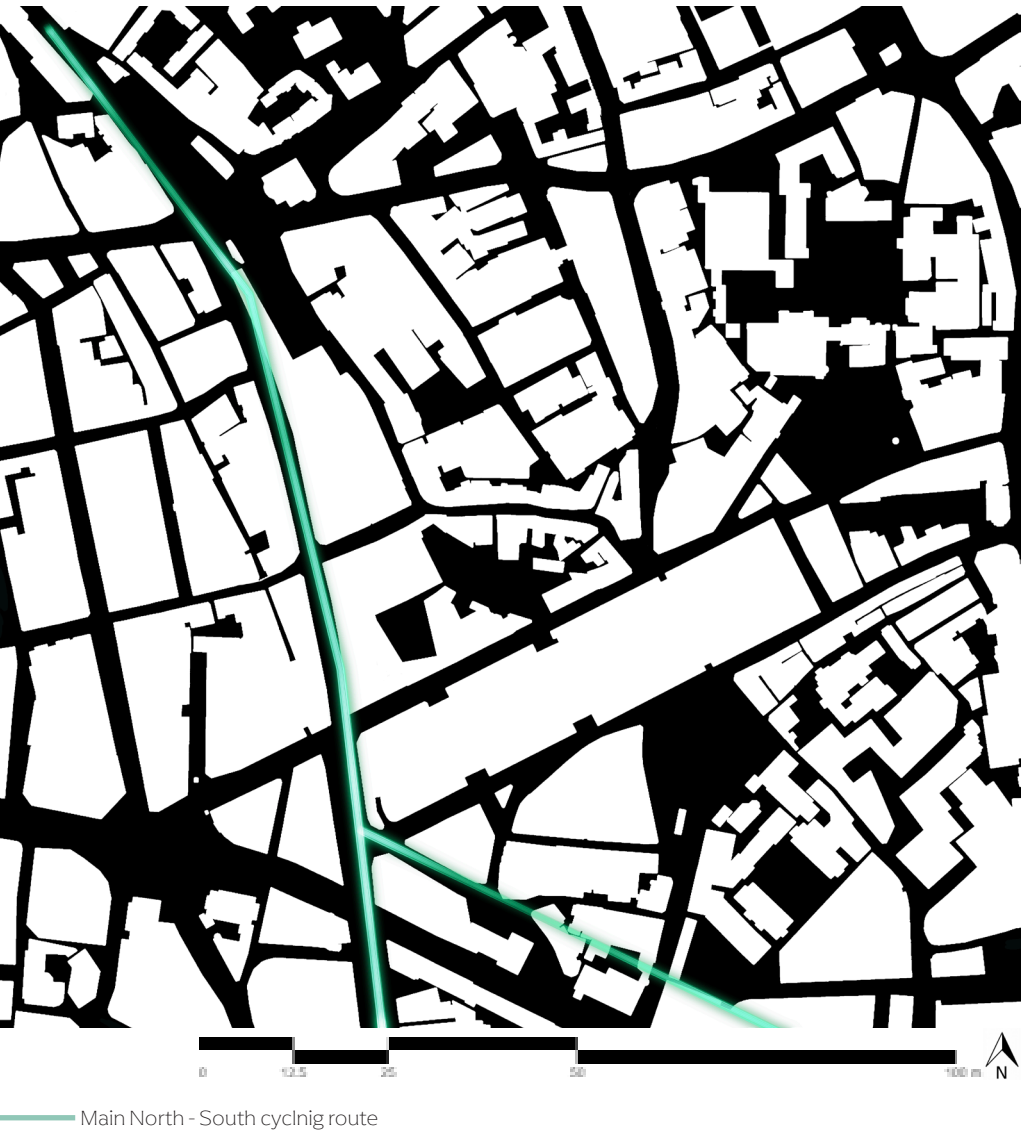


Fig. 59 - Author's work, Farringdon station area major bicycle route.

Farringdon road is one of the main cycling routes connecting the North and the South of the Thames. However, the cycling infrastructure is not very safe at the moment. Large parts are unprotected lanes on the road and require cyclists to cross busy junctions.

CITY



Fig. 60 - Author's work, Cycling lane overlaps with bus lane.



Fig.61 - Author's work, Busy junction.



Fig. 62 - Author's work, Cycling lane on the road next to cars without any separating elements.



Fig. 63 - Author's work, Farringdon station area public space.

Farringdon station area lacks public space, with the arrival of the new Museum of London public space is even more important to accommodate all visitors. Currently the only note worthy public space in the area are small parks adjacent to the Charterhouse, St. Bart's hospital, and Saint James Church's garden.

The lack of public space combined with the fact that there is no room left for any type of developments in the area this poses a threat to its liveability.



Fig. 64 - Author's work, Public corner near Hatton Garden



Fig. 65 - Author's work, Little public park in front of St. Bart's hospital

site analysis
- underground space

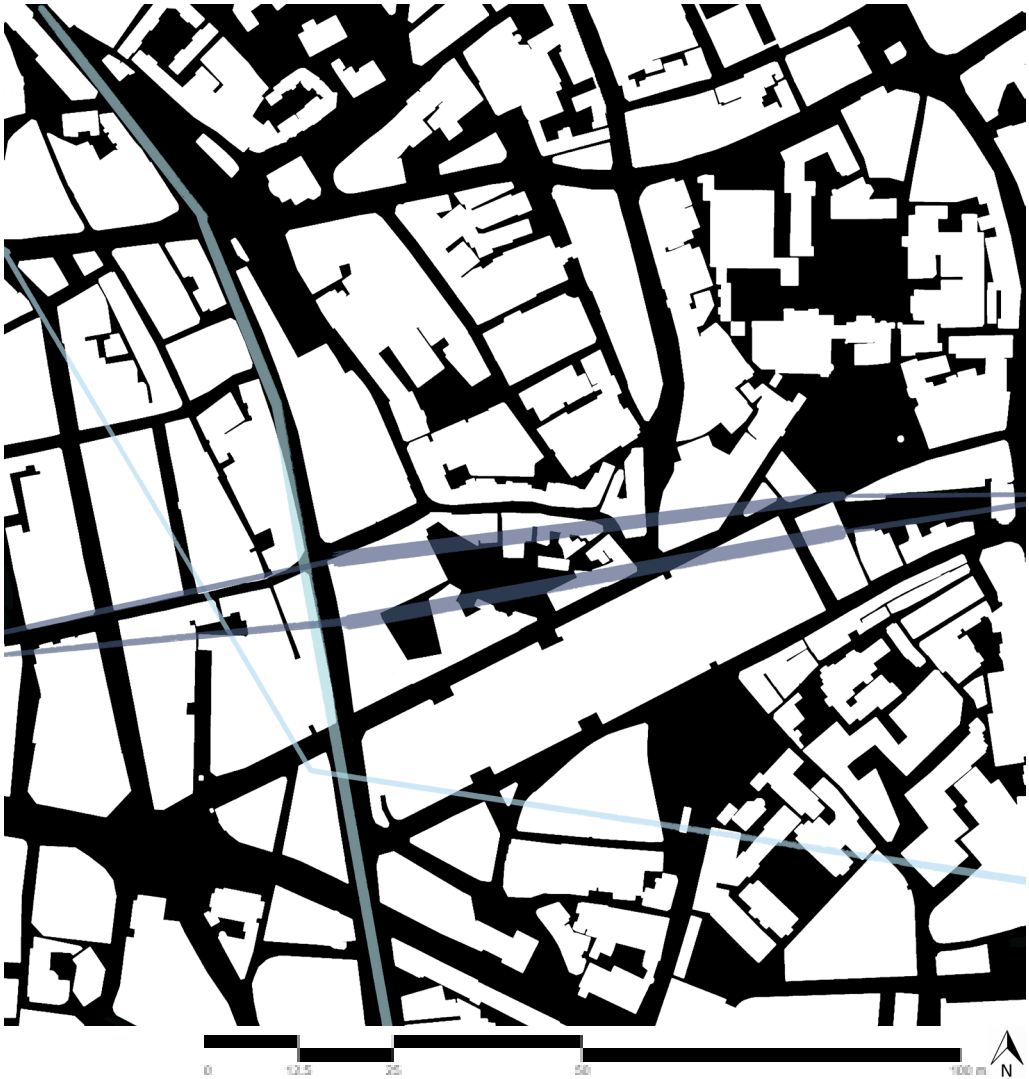
CITY



Underground space around Farringdon station area: basements, railway cuttings, and connections between buildings under the street.

Fig. 67 - Author's work, Farringdon station area underground space.

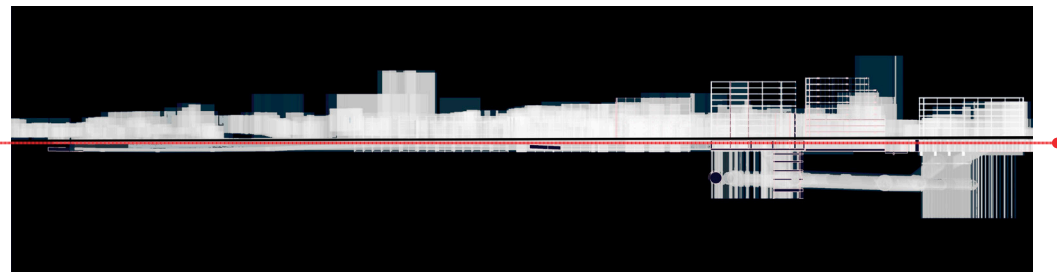
CITY



Post office rail
Fleet river
Elisabeth line

Underground space around Farringdon station area: tunnels

Fig. 68 - Author's work, Farringdon station area underground space.



Section AA'

Farringdon station area has rich underground space usage extending up to 35 meters below ground level.

Three underground lines run on tracks which were part of the first underground rails in London, built in railway cuttings which are between 5 and 8 meter below ground level. These lines run along the basement levels of adjacent buildings. In the case of Smithfield market, the Thameslink line and its old disused rail run through the basement level of the market because they were once used to supply the market with produce.

Underneath Farringdon road runs the river Fleet which has been covered up to be transformed into a sewer.

Also running below Farringdon station area is the old post office railway which is now disused.

Smithfield poultry market, Smithfield meat market, the current London Citigen building which was once the port authority building, and what is now the JJ Watts building are all interconnected underground via tunnels running between basements and under Charterhouse Street.

The newly built Elizabeth line is the newest addition to the collection of underground spaces. The underground tunnel runs between 30 and 35 meters below ground level creating much leftover space between itself and the buildings above.

Fig. 69 - Author's work, Farringdon station area underground space.

site analysis

- users

Commuters

Underground & bus station areas

Employees

Offices, businesses, museum, hospital, universities, Citigen, market

Tourists

Museum of London, Smithfields Market, Hatton Garden, hotels

Customers

Smithfields Market, Hatton Garden, businesses

Patients

St. Bartholomew's Hospital

Students

Different university and school buildings

Visitors

Offices, hospital, universities

Residents

Apartments

Residents

The area has a demographic mainly consisting of young adults and students in one person households. Despite being one of the most densely inhabited areas of London only 13% work in the area. There is also a significant proportion of the population who do not have higher level qualifications which most of the jobs in the area require. A solution is needed to combat this discrepancy.

CITY

CITY



- user related potential use of underground space

Commuters

With the prospect of 100,000+ commuters per day at Farringdon station, having a larger underground network extending through the area providing easier and faster access to different destination is desirable. This will improve connectivity and efficiency. Improving the livability and attractiveness of these new connections is also important.

Employees

Employees enjoy similar benefits as commuters (they are most of the commuters). Mainly new underground expansions could provide them with more public space, leisure activities and hospitality services. Which will drastically improve the quality of their working environment.

Tourists

New developments underground create new destinations for tourists, additional to the existing attractions. This can provide a more varied experience and attract more diverse group of tourists coming to Farringdon for different reasons. More pedestrian friendly areas also improve the tourists' experience in this congested city.

Customers

Farringdon Station area boasts offers a variety of shops in the Farringdon Shopping Area or in the form of BID's (Business improvement districts) such as the Diamond Quarter in Hatton Garden. Underground connections and development can provide customers with different goals with more pleasant shopping experiences.

Patients

There is the possibility to create a more direct underground connection between the Farringdon platforms and St. Bartholomew's Hospital so that patients don't have to cross busy roads or find their way through the Smithfield market buildings.

Students

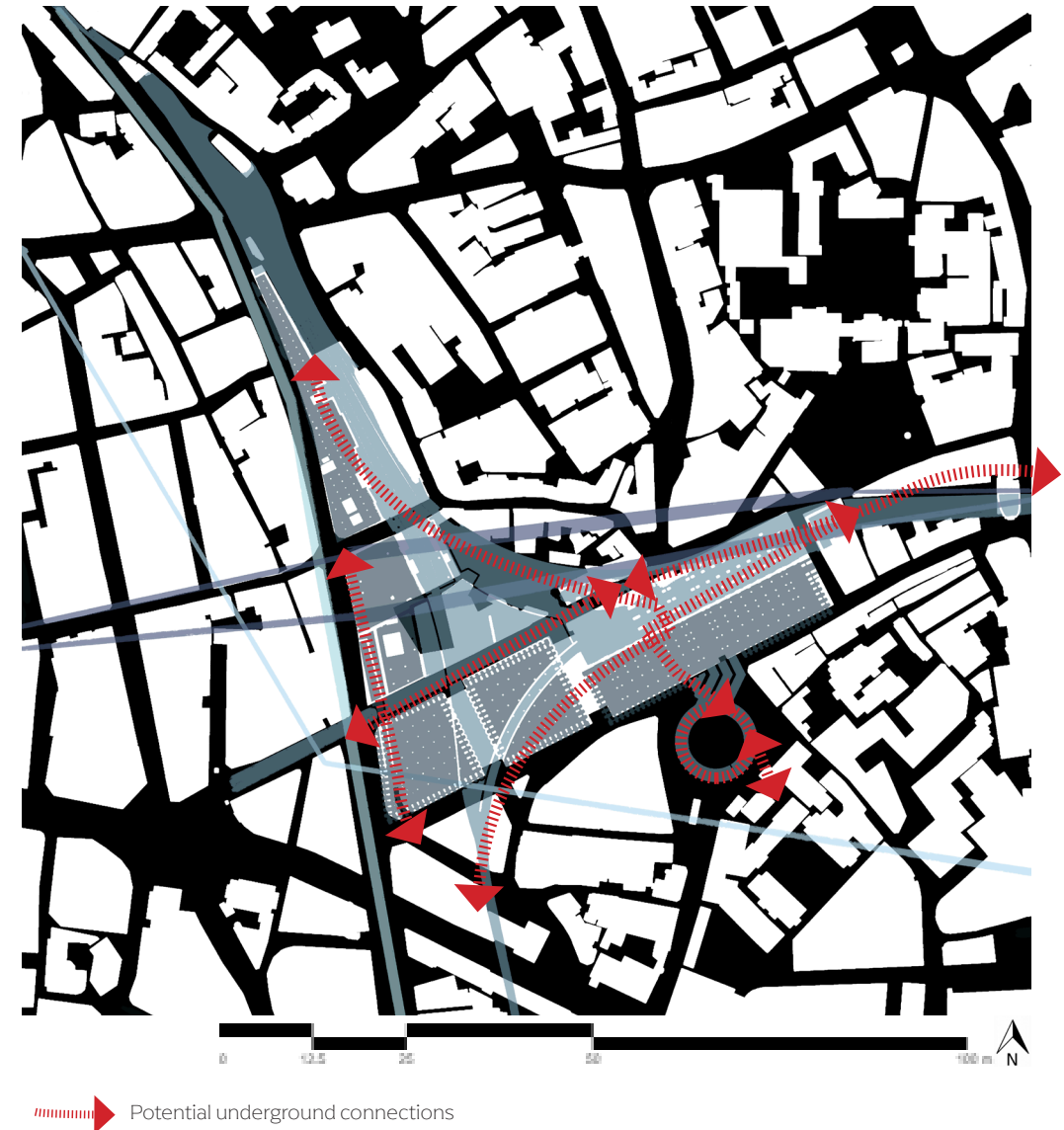
New underground developments can provide students with more leisure services, better public transportation connections, and new spaces to hang out or study. As the underground characteristically has good sound isolation and thermal comfort it could be a nice place to study.

Visitors

Visitors won't frequent this area (neither will tourists). A well developed underground extension can provide a nice welcome to the area. It will be important to make way-finding effortless through the new underground network.

Residents

For residents in the area the station can be a perfect place to change modes of transport. As mentioned before, a significant group of residents can also make use of lower qualification jobs. Many of these jobs can be accommodated in an underground makers-market where noise won't disturb any neighbouring functions.



Farringdon area is facing many problems that are connected to its density and to a certain extent its mono-functionality which poses a strong threat. It is a vibrant area during office hours, Monday – Friday, 9:00-17:00, but after office hours and during the weekends it is very quiet and there isn't a lot of activity. Even though the Smithfield market houses a different function compared to its surrounding buildings, it is only open from midnight till 7:00 in the morning and vacant for the rest of the day.

Farringdon station area also cannot match the demand for office space causing the prices to surge and SME's not being able to establish businesses in the area. This causes gentrification and alienation of a large part of its inhabitants which do not have the higher qualifications needed for work in the area.

The opening of the new museum of London will be part of the solution bringing in visitors during the weekends who might also visit the area. This is a strong opportunity to redesign the public spaces around the museum and the station to make the area more liveable. The new influx of visitors can also spur the opening of new shops and services catering towards new users.

The extra influx of people (commuters) on itself poses a weak threat to the underground station which share an entrance and exit for all the lines (except for one east entrance solely for the Elizabeth line located away from the main destinations in the area). This growth in passenger flow can result in congestion around the station entrances.

The connection between the station and surrounding areas are also not very attractive at the moment. Streets are not very pedestrian and cyclist friendly and public spaces are not well integrated or linked.

However, these threats in the Farringdon station area can also be seen as opportunities to turn the tide. The busy urban area with many different types of visitors and commuters provides a large group of users to make use of new spaces and amenities. Its intrinsic character as a major transportation hub can be embraced to create a well connected area with agreeable public spaces.

Last but not least, existing underground spaces can be transformed and integrated into the urban fabric to facilitate new connections in the area and create more space for the public and for small businesses further supporting the large enterprises which are already settled in the area. These new functions will also bring more activity in the area after office hours and during the weekends.

Farringdon station area can benefit from underground urban development to improve on some of the problems the area is currently facing. The area also shows great potential for integrating underground space into its urban fabric due to the amount of existing underground space and left-over transitional space between its deeper underground spaces and shallow underground spaces.

The design will focus on Farringdon nr20-50 and over-site development of the Elizabeth line West ticket hall. Considering them as future ruins for which a design will be made to transform the buildings to include new underground spaces addressing the problems raised in the analysis. The design proposes to alleviate pressure on the bottleneck entrances of the underground station by expanding and connecting the existing underground levels at -6 meters so that people exiting the underground stations can already spread out at lower levels to more efficiently reach their destinations.

Extra space for offices, leisure, and cultural activities will be created by transforming the basement levels of Farringdon nr20-50 and expanding the Elizabeth line OSD downwards along its foundation piles and boreholes. Creating more than 35,000 m² extra floorspace of which 10,000 m² on the ground floor and minus two level will be dedicated to become public space. The extra public space will improve the liveability of the station and new museum area and provide safe and larger space for pedestrian and cyclists.

The design also aims to integrate the cycling route and new bicycle parking at the station facilitating more sustainable modes of transport and modal interchange. This is done by moving the bicycle path to the -6 meters level connecting it to the new bicycle storage with space for over 3,500 bikes. This new route will also continue underground past the new museum using an existing underground route connecting it both to the South as to the East with the basement levels of the Smithfield market.

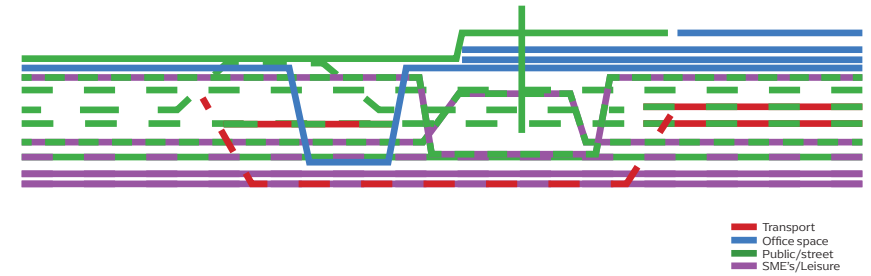


Fig. 70 - Author's work, Diagram showing fluid underground and above-ground space combined with a programme mix.

Even though the design will focus on the two buildings Farringdon 20-25 and Elizabeth line OSD, the potential for more underground development exists in the basement levels of the Smithfield market which is now a car park, and all the way to the disused Snowhill station to create a true underground urban area of Farringdon.

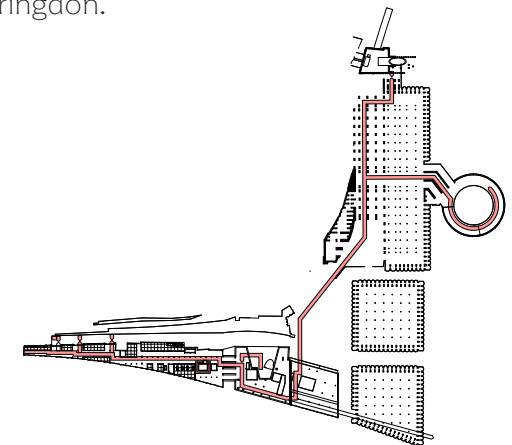


Fig. 70 - Author's work, Potential underground route in Farringdon station area.

The next chapter "building" will further investigate the important design elements identified in the three urban examples, on a building level. A catalogue will be made exploring how three dimensional connections, liveable underground (public) space, and sustainable development thereof can be translated in architectural and urban design.

The investigations conducted in the chapters titled “Theory” and “City” have concluded that the development of underground spaces in urban areas presents a viable strategy for augmenting the quantity of habitable spaces within cities. The creation of these new spaces can also facilitate the development of additional public spaces, thereby enhancing the city’s liveability.

Upon identifying an appropriate site and functions for an underground densification project, the subsequent step involves determining, at the building scale, the elements that contribute to the creation of more habitable underground spaces. This chapter will delve further into the exploration of design elements that offer potential solutions to the challenges associated with underground habitation.

These are: form, light, accessibility, way finding, underground as an urban resource i, underground as an urban resource ii, and vertical + horizontal.

For each element, various options will be considered, each of which may be suitable for different users and situations. Ultimately, during the design explorations of the building, efforts will be made to amalgamate suitable elements and optimally utilize the resources that the underground environment has to offer.

All the gathered knowledge and analyses helped identify an appropriate site, suitable functions, and first design ideas for an underground densification project. This was briefly described in the design proposal. This chapter will also further elaborate on the design. Which will be explained through the design process, following five main principles:

- Activating the underground
- Blurring boundaries
- Liveable underground
- Harnessing new characteristics
- Architectural Language

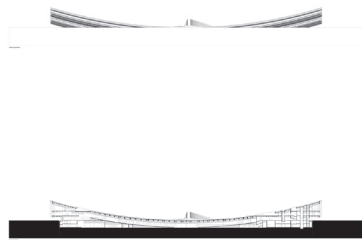
For the purpose of clarity and logic these topics will be explained in order. However, it is important to note that the design process is an iterative process in which all five principles inform each other on multiple scale-levels and in all relevant fields of design.



Part of making the underground and above ground symbiotic is to make it an obvious extension of the urban fabric as we know it. Through elements and form one can suggest that there is more further down.

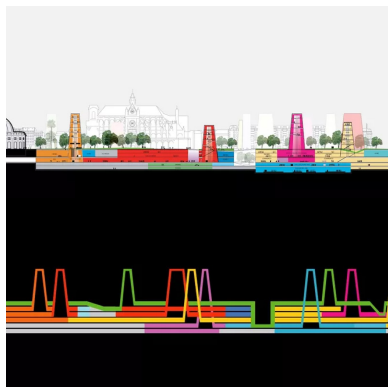
For instance protruding light tubes.

Fig. 71 - Author's image, model with light tubes at Venice Biennale.



A shape which suggests more than one can see.

Fig. 72 - Napur-architect, museum of ethnography.



Protruding elements which allow for visual connection with the lower levels.

Fig. 73 - OMA & XDGA, proposal for Les Halles in Paris.



The design of the interior is at least just as important, if not more important, than the exterior. Daylight from above and outer façade materials give an impression of being in the midst of other buildings. An unclear feeling of being indoors or outdoors, aboveground or underground is achieved.

Fig. 74 - Alberto Campo Baeza, Caja Granda.

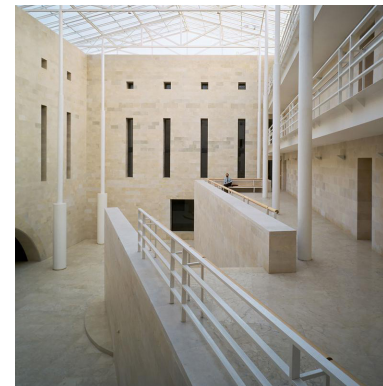


Fig. 75 - Alberto Campo Baeza, Orihuela public library

As mentioned in the design proposal. The project aims to create liveable underground spaces which connect to the public ground floor realm.

The first challenge the underground faces is the lack of day- and sun-light. There are many ways to bring light down into the darker areas of the building.

Different kinds of openings in the building envelope such as light guides, skylights, light shafts, and atria offer space for daylight to enter the building and be transported to lower levels by bouncing off its walls.

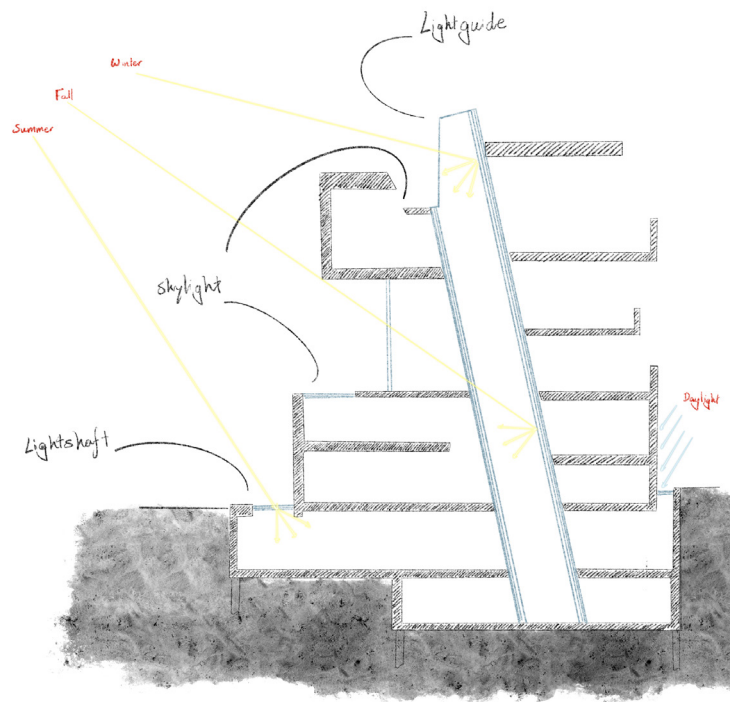


Fig. 76 - Author's work, different types of light atria.

Another strategy is the use of heliobus systems to bring sunlight into building parts located away from windows. The system relies on a pair of mirrors and a light tube, the sunlight is reflected into the light tube via the mirrors and transported to a different location in the building.

The heliobus system can be scaled up to utilise full size atria with mirrors to transport sunlight or scale down to use fiber optic cables to transmit light into lighting fixtures.

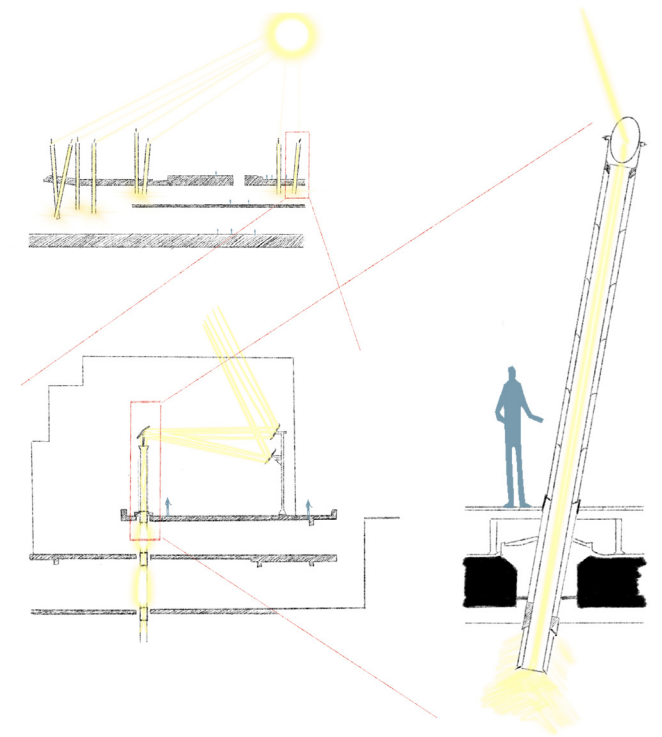


Fig. 77 - Author's work, working of a Heliostat tube.

The strategy for daylighting can be divided into two types [wide & specific]. Larger atria will be created at strategic points and smaller insertions of daylight will be designed in more specific use cases.

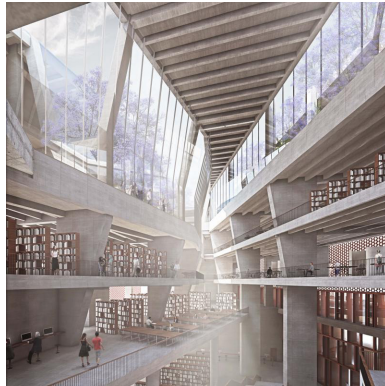


Fig. 78 - McCullough Mulvin Architects, Thapar University Expansion

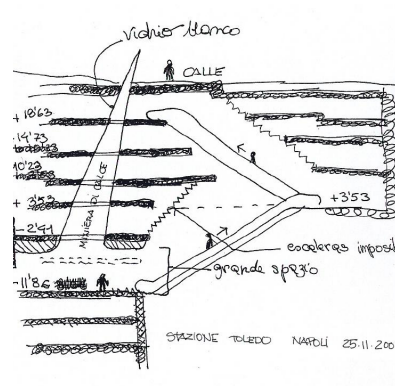


Fig. 79 - Oscar Tusquets Blanca, Toledo Metro Station

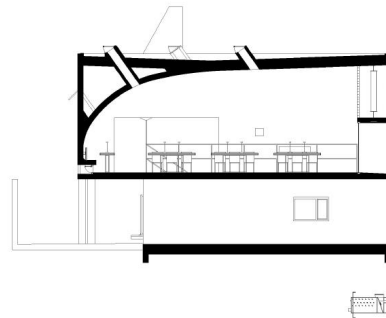


Fig. 80 Vector Architects, Xia Zhi Su Shengliang Seashore Library

Vertical connections can be achieved using ramps, stairs, escalators, and elevators. The most accessible of these is the ramp, however wheelchair accessible ramps take up a lot of space. Ideally a mixture of different elements is achieved and multiple options of traveling between different levels are offered. It is also important to note that traveling vertically can be part of the building itself and that while the network and its circulation routes are an important part of the project. To achieve better connections between different destinations and providing better flows in and around the station area, not only movement is important, it is also important to create places to stay, sit, and gather.



Fig. 81 - Landscape Architects Collaborative, The Industry Club of Japan Building underground plaza.

way finding

BUILDING

Even though a symbiosis or blurring of the boundary between the above ground and the underground is wished it should not come at the cost of clarity. It is important to find new ways to communicate to users where they are situated within the building or landscape. Visual connection between routes and destinations are important (fig. 83) and can be given emphasis by casting daylight upon these spaces (fig. 82). An interesting way of indicating where one is situated can be the use of depth and height in meters instead of which floor you are on (fig. 84).

Next to vertical connections, the building also needs to connect horizontally with its surroundings. Therefore it is important that the building is not only readable from the inside but also from the outside. Wayfinding should also express itself towards the context (fig.85).

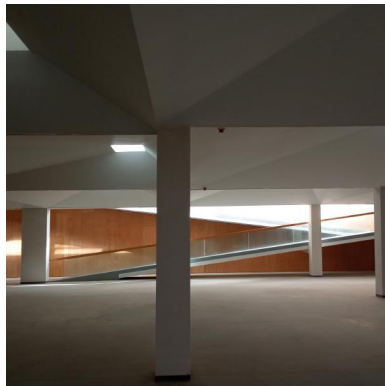


Fig.82 - Sol89, Ayamonte Exhibition and Congress Center



Fig.83 - Esa Ruskeepaa Architects, Perm Museum.

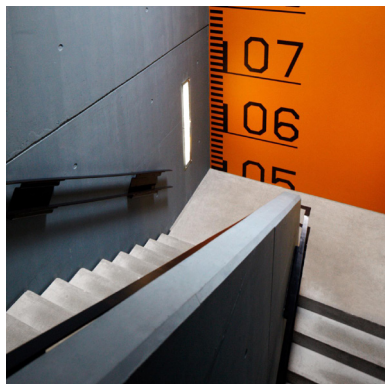


Fig.84 - Longva Arkitektur Ivan Brodey Military Training Facilities

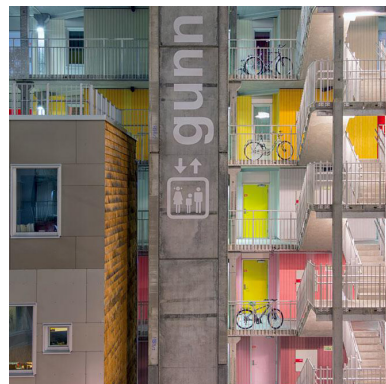


Fig.85 - 3rw Arkitektur, Cecilie Bannow, Gronneviksoren Student Housing

underground as a urban resource i

BUILDING

The project will also explore the idea of underground as an urban resource to achieve a more sustainable design. Remanufacturing excavated materials into building materials used for the new building is a strategy to reduce construction and demolition waste while also creating an architecture that is grounded in its context. The London underground consists of layers of London clay and sand. This material has been used throughout history to bake the London stock brick, which is characterised by its beige-yellow colour. Bricks are not the only building material that can be made using clay. Terracotta columns, rammed earth, and rammed clay can also be used. Rammed clay can be combined with wood floor form works to create clay-wood floors. The clay acts as a sound and heat insulation in the floor and also has an intrinsic fire proof characteristic.

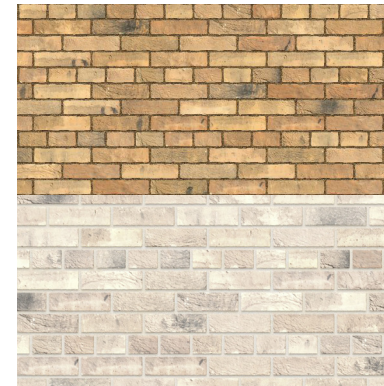


Fig.86 - London stock brick.

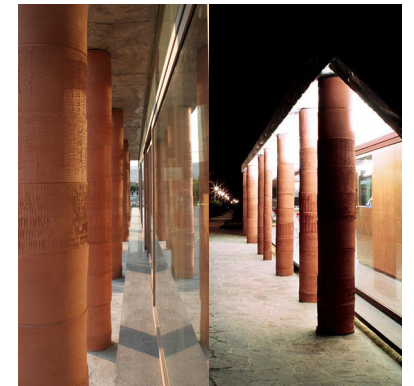


Fig.87 - NOWA, terracotta columns Fitzcarraldo pavilion.

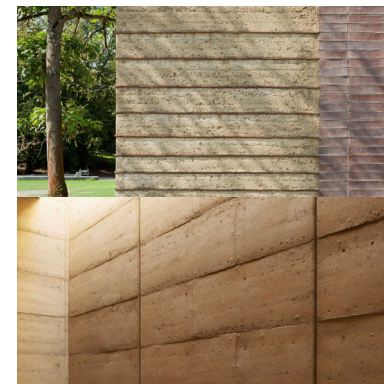


Fig.88 - Boltshauser Architekten, rammed earth walschool pavilion.

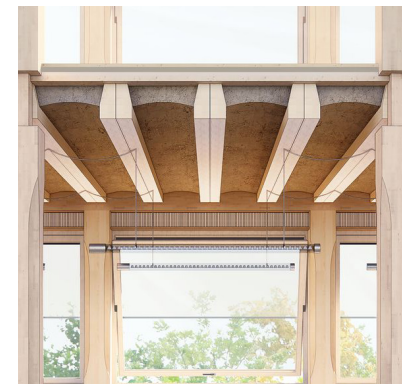


Fig.89 - Hrzog & De Meuron, wood-clay floor in Hortus

underground as a urban resource ii

BUILDING

Not only materials can be extracted for the underground. Energy is also a resource which can be found in the underground. The London Citigen power plant adjacent to the site makes use of geothermal energy to help power the area's energy network. Aside from geothermal energy stores the building can also make use of the excess heat produced by the London underground.

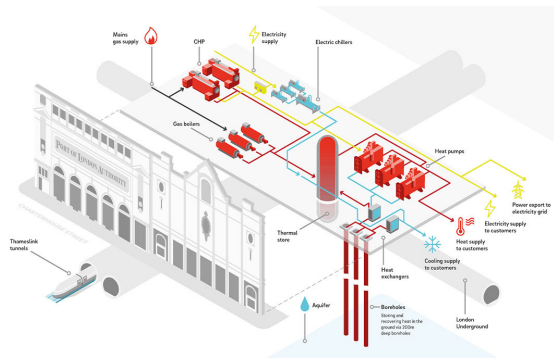


Fig.90 - London Citigen.

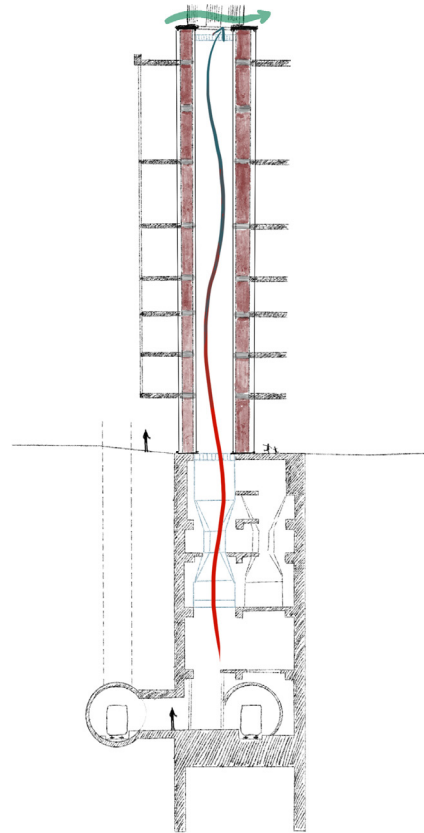


Fig.91 - Author's work, concept diagram for the re-use of excess heat from London underground.

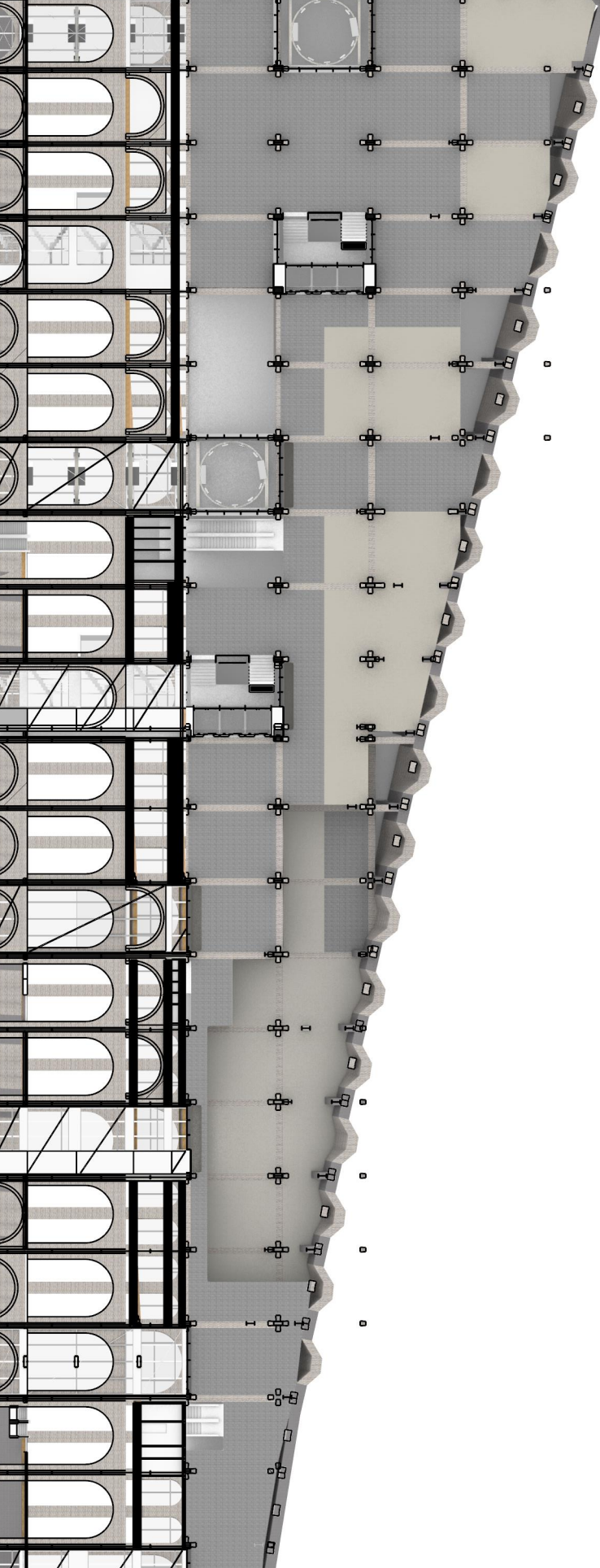
vertical + horizontal

BUILDING

The new idiosyncratic architecture for underground urban developments necessitates a simultaneous consideration of both horizontal and vertical dimensions.

Different elements of the underground development may have inherent main directions, either vertical or horizontal. However, by considering them in a three-dimensional way, it is possible to avoid creating a hierarchy between these elements and to integrate them seamlessly into the overall design. This can help to blend the aboveground and the underground into a fluid environment, breaking down the traditional barriers between these two realms and creating a more cohesive and integrated urban landscape.

In conclusion, the simultaneous consideration of horizontal and vertical dimensions in the design of underground urban developments is not just a necessity, but a unique opportunity to rethink the way we design and experience our urban environments. It allows us to make the most of the available space, improve connectivity, and create more pleasant and livable spaces for everyone.



activating the underground

BUILDING

To activate the underground is to awaken these spaces full of potential which have laid dormant all this time. By analysing their context one can determine suitable functions for different areas within the new underground development. These functions should bring people into these spaces, truly connecting them with their surroundings.

Previous analysis has shown that Farringdon station area has been, and currently is, extensively using underground space (fig. 92, 93, 94). Additionally, further development of the underground can help relieve the area of above ground congestion cause by busy roads and passenger flow bottlenecks cause by station entrances (fig. 95).



Fig. 92 - Author's work, Farringdon station area underground space.

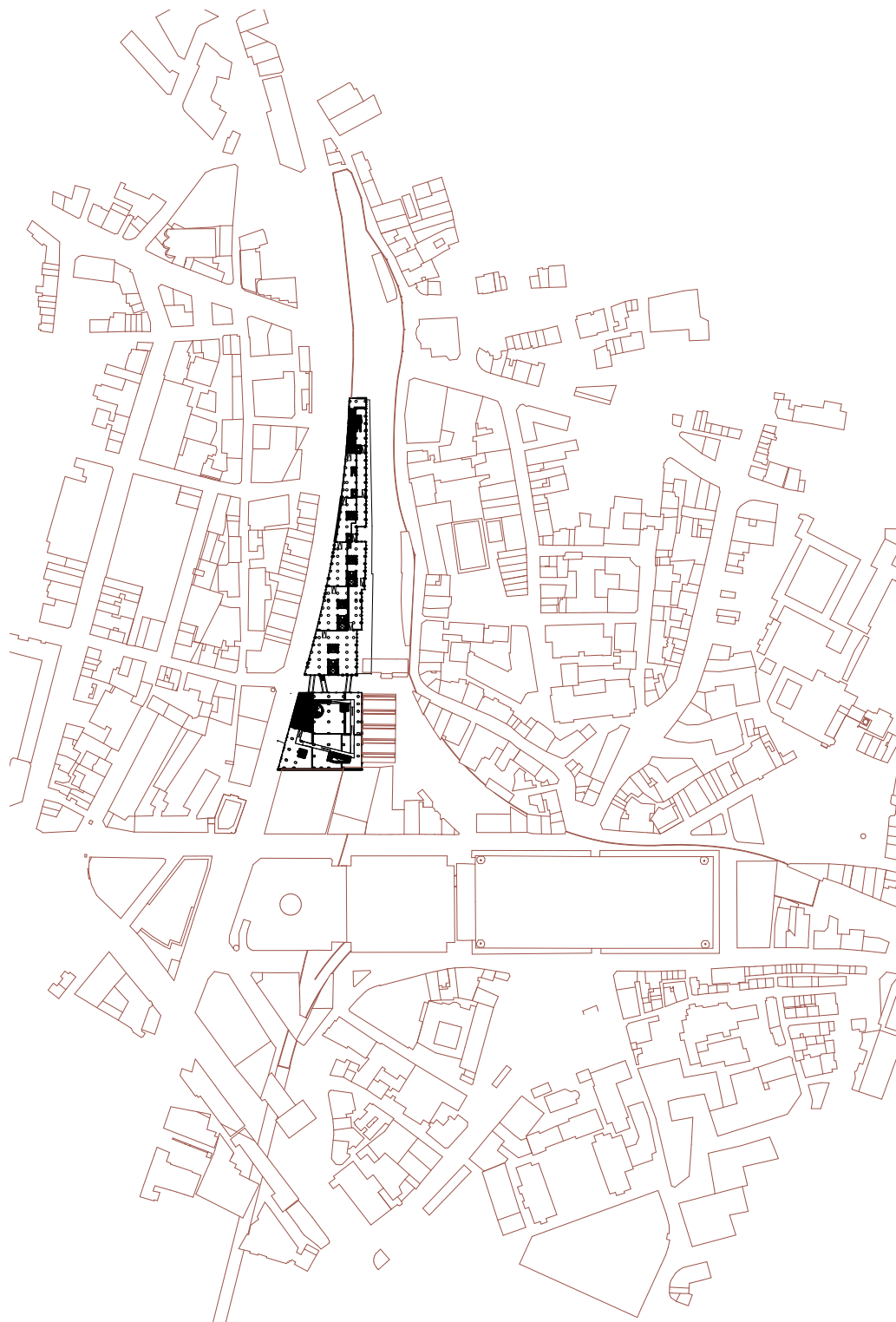


Fig. 93

Project 001.	Think Deep
Drawing	Urban context above ground
Scale	1:500 - 50%
Paper format	255mm x 155mm
Date	30/06/2024
Comments	City of the Future Graduation Studio Hanlin Stuer 5016959



III

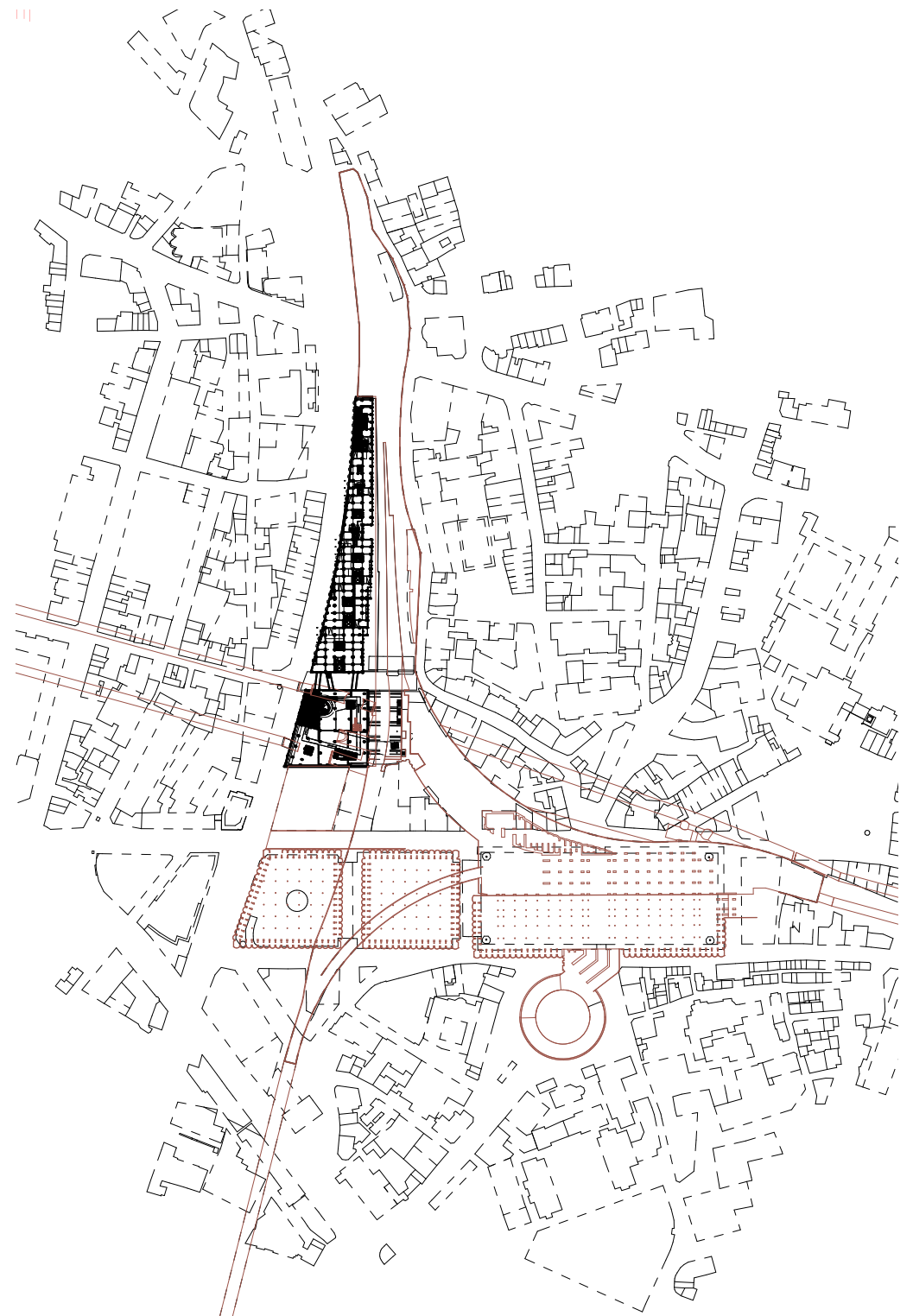


Fig. 94

Project 001.	Think Deep
Drawing	Urban context underground
Scale	1:500 - 50%
Paper format	255mm x 155mm
Date	30/06/2024
Comments	City of the Future Graduation Studio Hanlin Stuer 5016959



Important N-S cycling route

Public transport bottle necks

Busy motor
vehicle roads

Busy motor
vehicle roads

Fig. 95 Congestion in the area



activating the underground

BUILDING

To help with the afore mentioned issues new underground cycling and pedestrian connections are proposed for the area. They make use of the new developments of this design to connect existing underground networks, which will be transformed to become walkable and bikeable routes, with the above ground streets and buildings.

The cycling route (fig. 96) will provide a smoother North-South connection bridging underneath Charterhouse Street avoiding the busy station-side roads and unsafe junction. Then resurfacing after the new Museum of London. There is also a possibility to further extend this underground route to the South making use of disused rail tunnels and station belonging to the old Thameslink line, but the situation of these lines is not yet clearly documented.

The pedestrian route (fig. 97) will allow pedestrians to cross under the busy roads around Smithfield Market and Farringdon Road. It will also provide the more than 100,000 commuters everyday to already spread out in the direction of their destination at platform level. This provides a faster commute, less congestion at the bottle necks discussed previously, and a better spread of people in the area both above- and under-ground.



Fig. 96 New cycling route

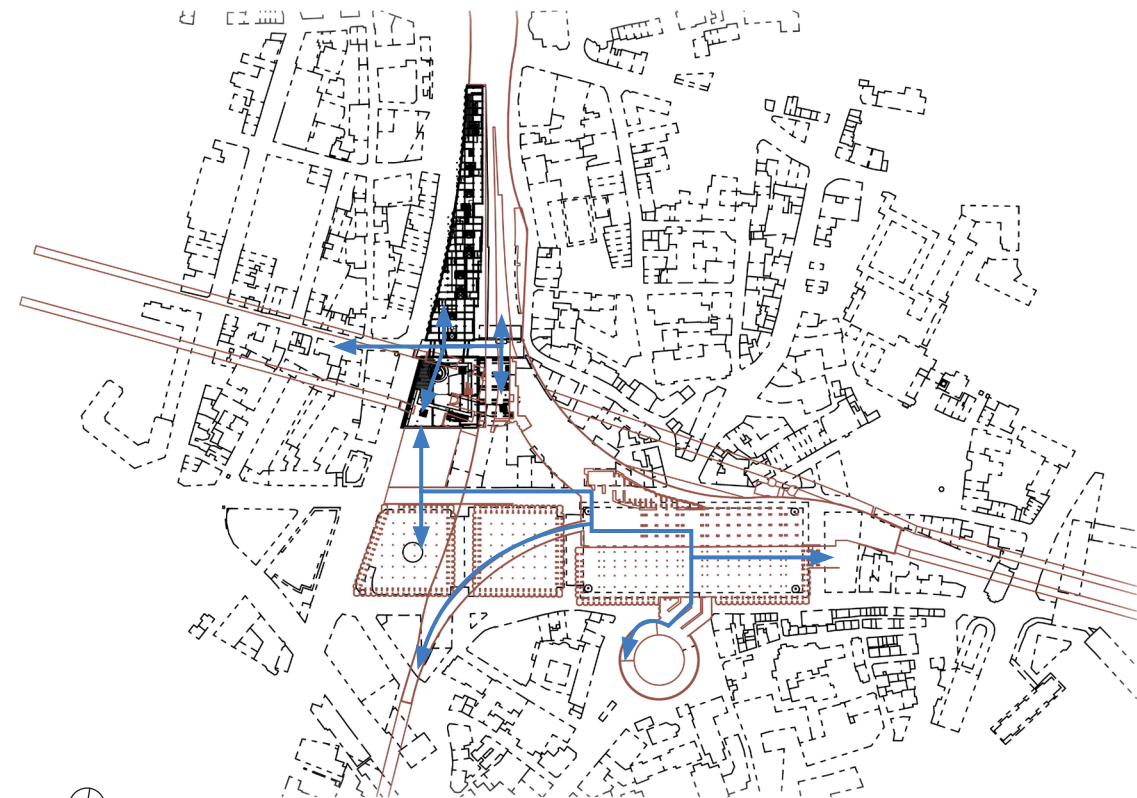


Fig. 97 New pedestrian network

activating the underground

BUILDING

Aside from the new cycling route and pedestrian connections in the new buildings, additional habitable spaces with programming will be added.

This design will make use of three strategies mentioned in chapter two: repurposing, expanding and extending.

The basement levels of Farringdon. nr. 20-50 and the Farringdon West OSD are currently respectively occupied by:

20-50: Technical space + storage space.

OSD: Technical space+ station space.

The basement levels will be repurposed (green hatch in fig. 98 and fig. 99). The lower basement level will primarily serve as a space to accommodate commuters and connect them with the above ground and the new underground pedestrian and bike network. The upper basement level will have space to accommodate short-stay functions such as co-working spaces and services such as dry cleaning, print shops, repair shops etc.

The basement space of the OSD will be expanded downwards around the existing pile foundations (red hatch in fig. 98 and fig. 99). These large piles of 2.1 meters in diameter together with the large boreholes provide enough support to expand around. Depending on the location this expansion will extend the basement by 4 or 8 floors.

Lastly, two extra basement levels will be extended under a small part of Farringdon nr.20-50 (yellow hatch in fig. 99). By extending the foundation piles of the building two new levels will be added to accommodate extra bicycle parking area for better modal interchange around the station.

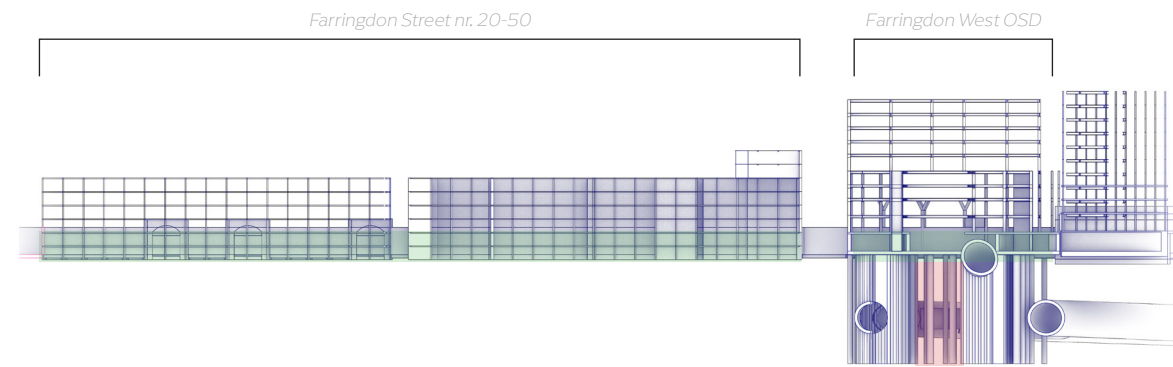


Fig. 98 section existing situation

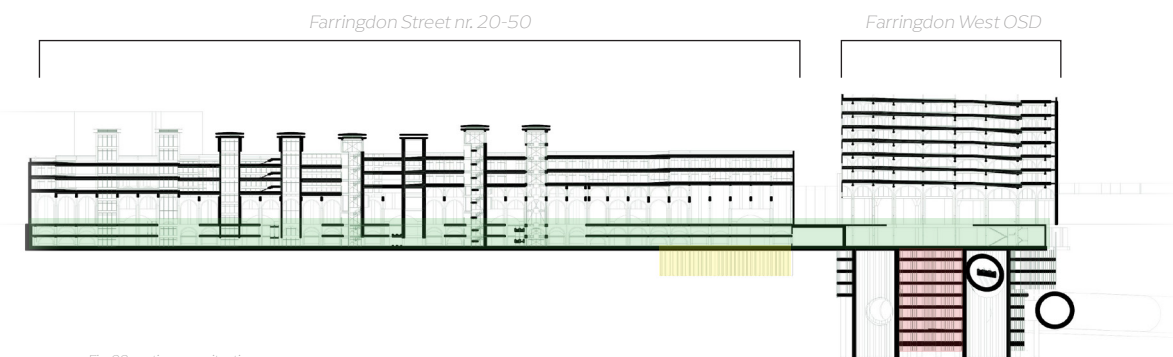


Fig. 99 section new situation

Blurring the boundaries is about the creation of fluid and accessible spaces. The aim is to blur the boundaries between the horizontal and vertical dimension, the above- and underground, and the public and private.

The most important goal of this topic is extension of the ground floor level into multiple levels creating a ground floor realm. The fluidity between the levels will allow more space to become accessible and public, truly weaving them into the urban fabric of the area.

The first aspect of blurring boundaries is the opening of the ground floor realm and blurring the interior of the building with its surroundings. This can be achieved through multiple methods.

The first one is through climatic experience. Bringing daylight, outdoor weather, airflow, and sounds into the depths of the building (both horizontally and vertically) help blur the boundary between being indoors and outdoors. This can help create more spaces that feeling the public outdoor ground floor realm (fig. 100).

The second one is through visual connection and insinuation. Creating clear visual connection or visual cues between different levels and between the interior and exterior creates a feeling of being able to move freely without obstruction. It also helps with more clear way finding in large interior environments (fig. 100).

The boundaries between different levels and between the interior and exterior can also be blurred through the use of similar materials. By creating paved areas inside building with similar paving to the sidewalk or the train platform, the material insinuates a certain connection and continuity from the exterior to the interior and back to the

exterior. Using different types of paving can also suggest different uses, such as creating a difference between spaces for moving and spaces for staying (fig. 101).

Another boundary in urban areas are the buildings themselves. Creating new connections between building underground and above ground help create the three-dimensional urban network such as the one in Hong Kong (fig. 102).

The boundary between private and public has long been difficult to blur. Many buildings still close themselves off from the public using gates, front desks, lobbies... One way enterprises are currently trying to blur this boundary is through the creation of semi-public welcoming spaces. These are similar to lobbies but have a more open character such as having a bar or small coffee place. This invites people to come in and make use of this service without necessarily having to have something to do with the office renting the space. At the same time this then creates the possibility of meeting and connections (fig. 103).

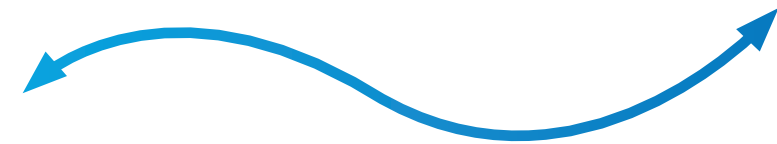
Last but not least, is the boundary of floors. The concept of floor creates boundaries within themselves. Each floor is a separate entity and to go from one to another requires an intentional movement to stairs, escalators or elevators. This boundary could be blurred using entresols, or ramps. However, these are not always as easy to implement in office floors. This project explores a third possibility in which floors are divided into sub-floors, each just one step higher. As a consequence, the sub-floors form a giant spiral staircase which can take one from the lowest floor to the roof seamlessly (fig. 104).



Fig. 100

Daylight, air, sound and weather can be experienced within the ground floor realm and the lower levels. They can even be felt physically at the edges of the building as the facade is kept open.

Daylight is also transported down into the centre of the building with an atrium.



The openness of the ground floor realm and the atrium create plenty of space for visual connection. The inherent quality of the building having facades on two side that start at different levels also gives an interesting visual connection.



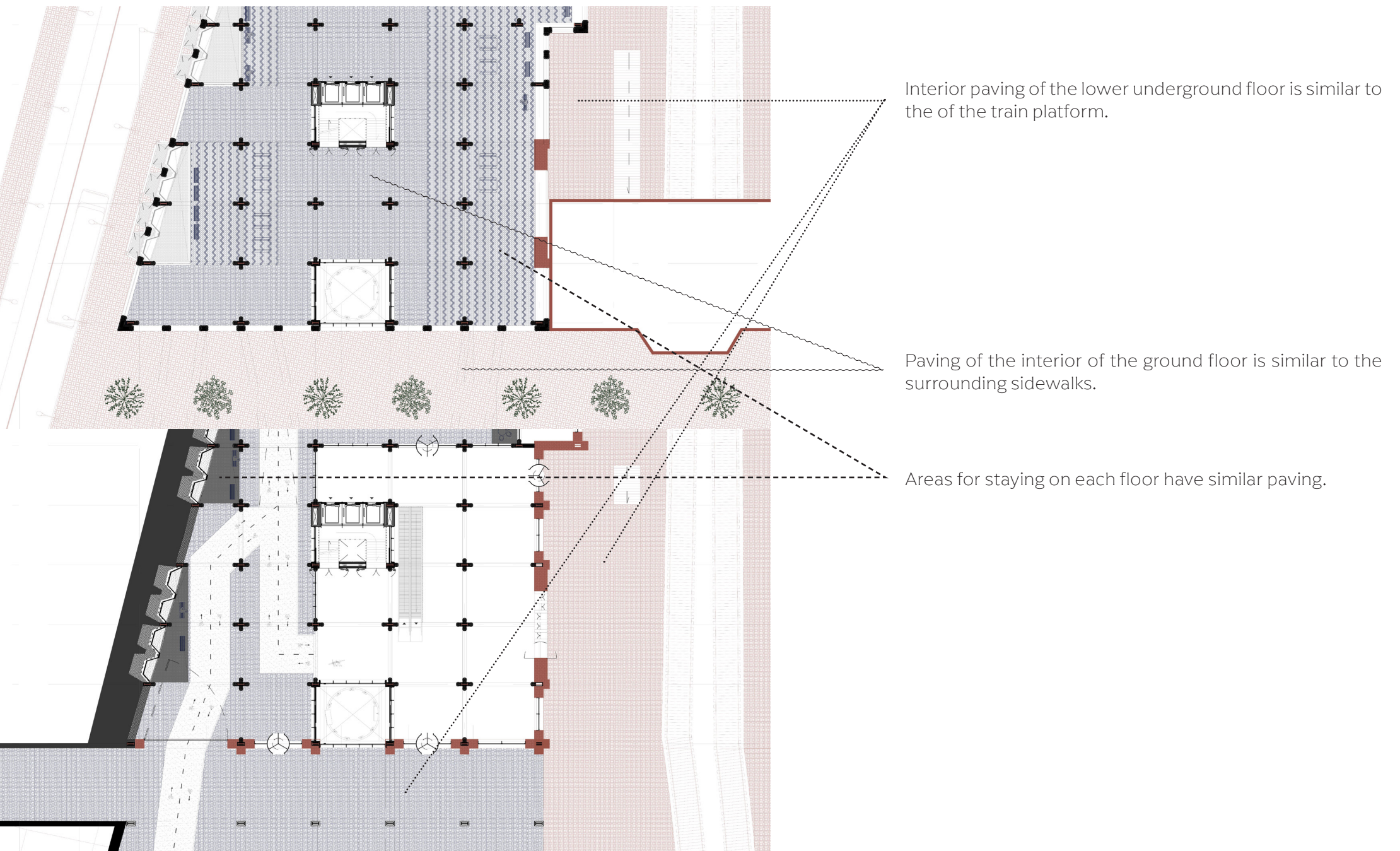


Fig. 101

blurring the boundaries

BUILDING

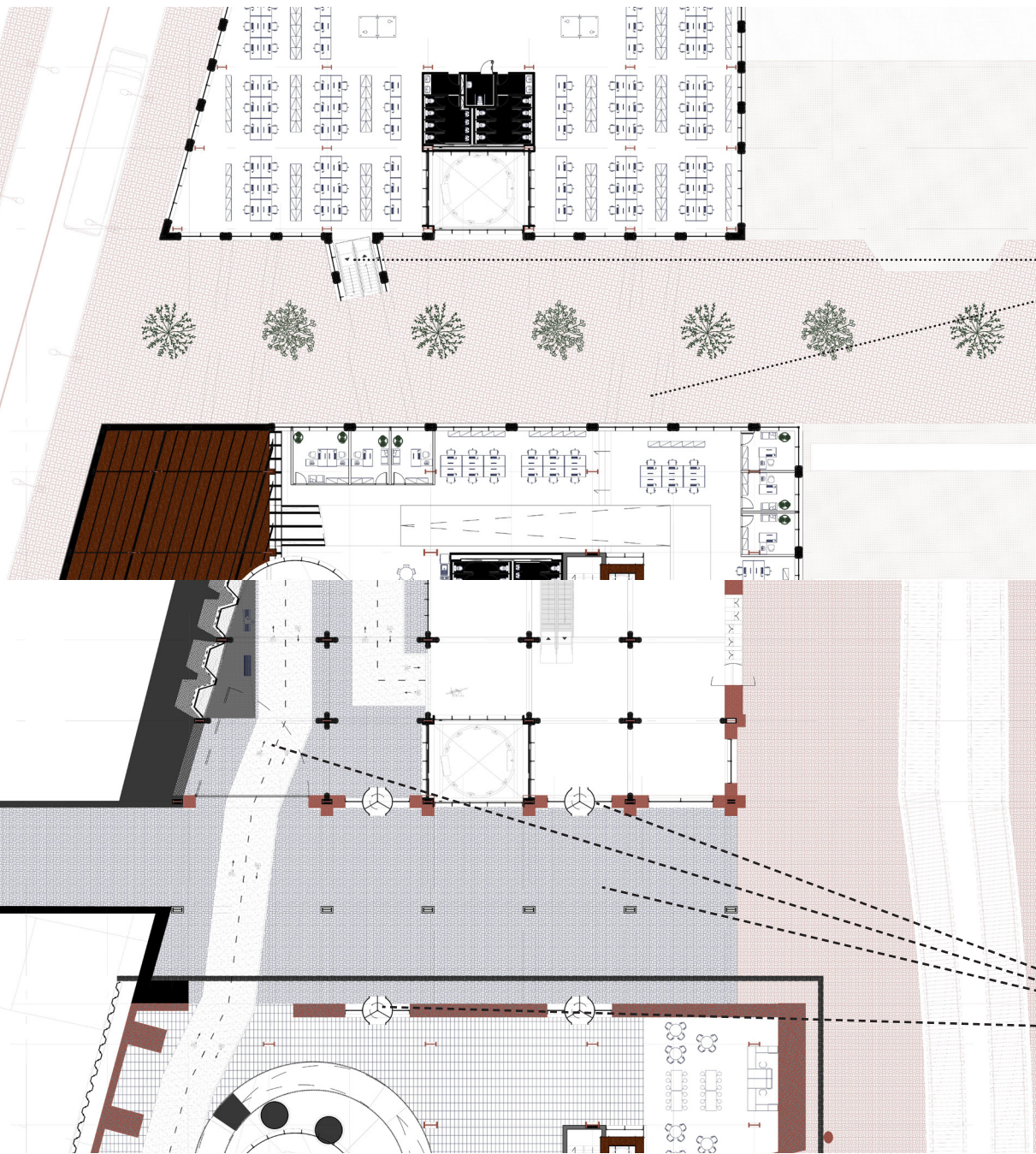
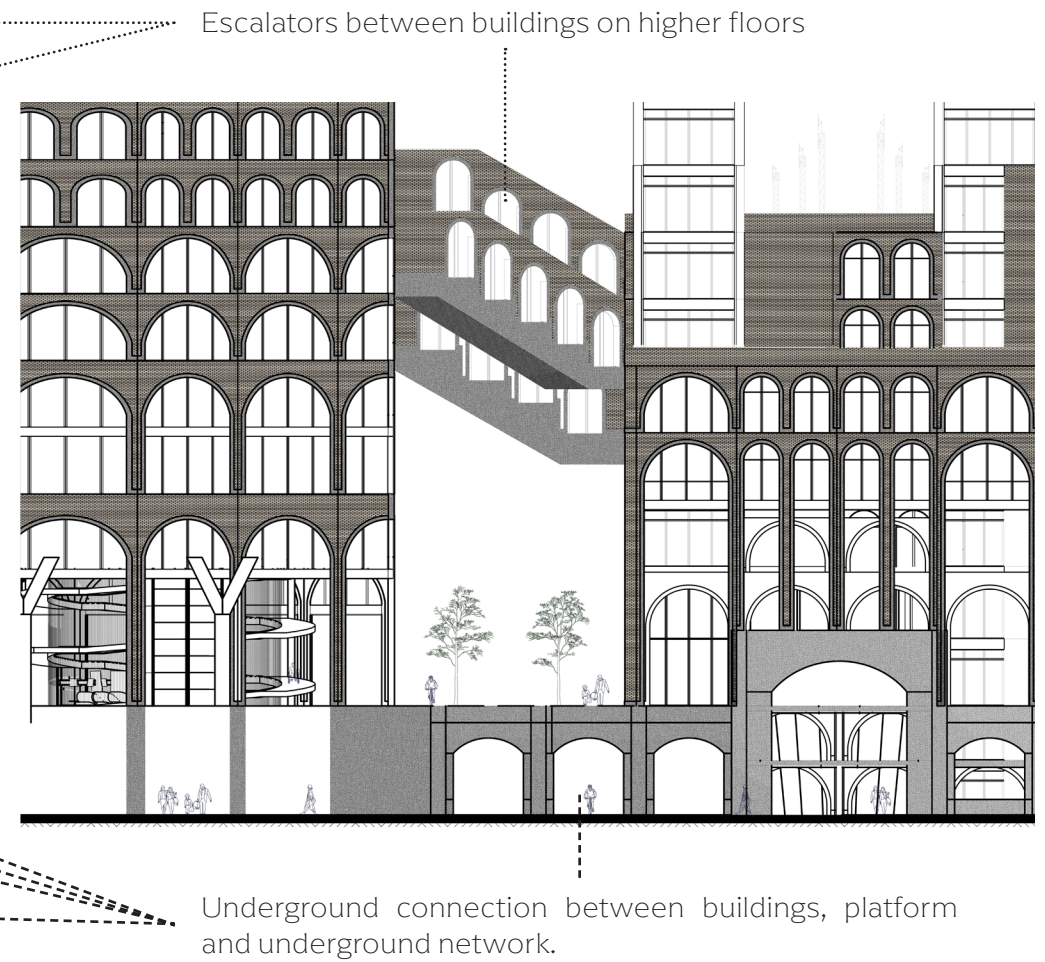
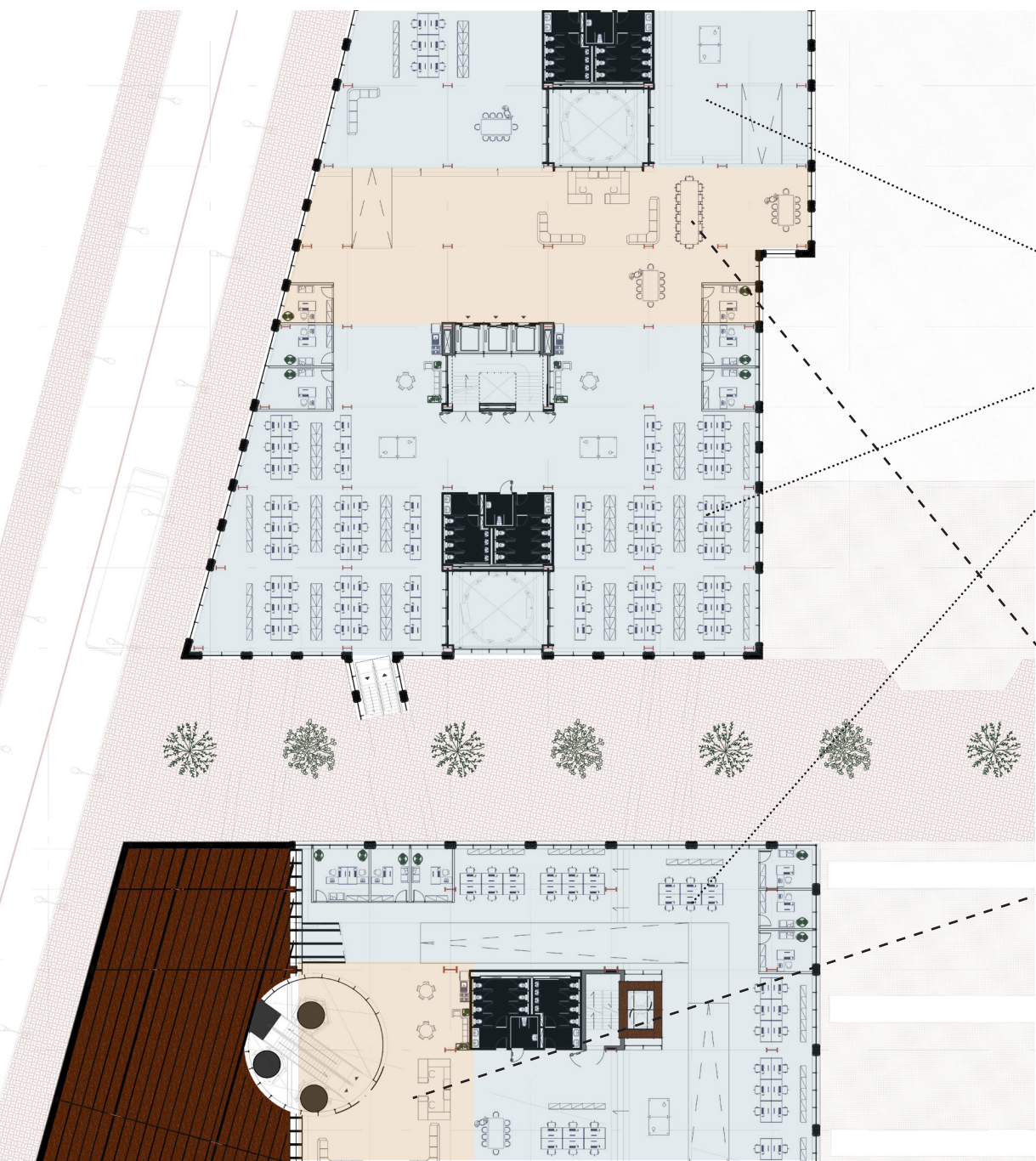


Fig. 102

blurring the boundaries

BUILDING





Private
Offices: open office spaces, closed offices, meeting rooms, leisure spaces, small kitchens, and toilets.

Semi-public
Lobby, front desk, welcoming area, bar, very open.

Fig. 103

blurring the boundaries

BUILDING

blurring the boundaries

BUILDING

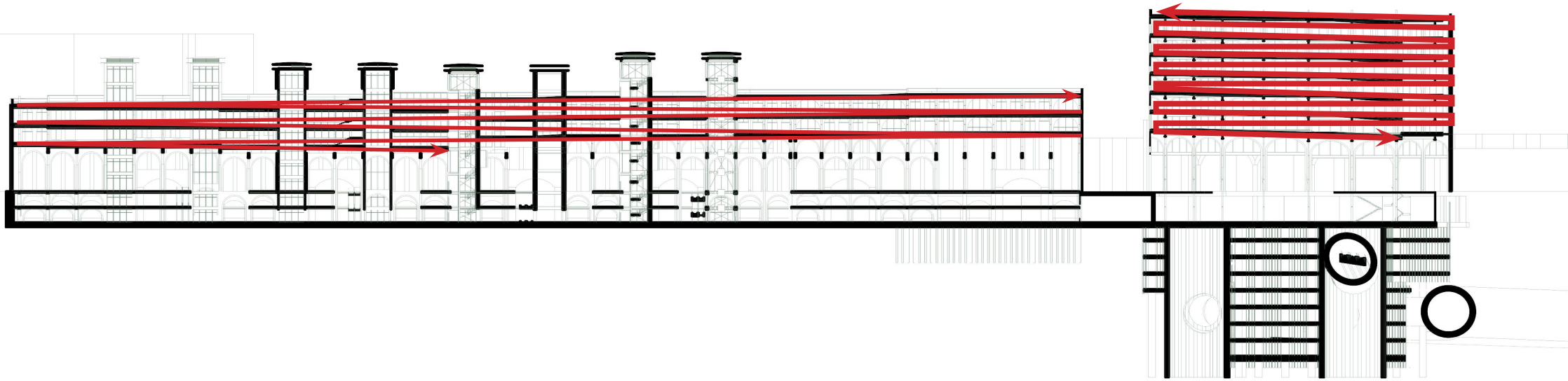


Fig. 104

The floors flow into one another



One of the main issues of expanding the city into the underground is how to create a liveable space. Making the underground liveable is crucial to achieve an inhabited underground network. If people do not frequent the underground, as it was in the past, because of its negative connotation and being unattractive as a place to “be”, then the underground will never be able to really become part of the urban fabric.

To achieve a liveable space a few important aspects need to be considered.

Daylighting is one of the most important aspects to create agreeable spaces. Being able to bring daylight into the underground also can add warmth, pleasantness, and more often than not means that there is also a visual connection in the other direction with where the light comes from. In the design this is achieved through different types of atria and lightshafts (fig. 105, 106, 107). As can be seen in the comparison (fig. 108, fig. 109) daylight makes a big difference in how a space is perceived.

The second aspect is climate, not in the sense of artificially regulated temperatures but in the sense of climatically comfortable spaces. Certain spaces can also remain as outdoor spaces and accept the heat or cold that comes with seasonality. This is achieved by opening the ground floor as mentioned in the previous chapter. Being underground also means no windows, so ventilation is an important topic. Passive ventilation is achieved in this project through different means. In Farringdon nr. 20-50 there is still a possibility to create the effect of cross ventilation because the platform level on one side of the building is lower than the street level on the other side (fig. 110). Further ventilation is aided by the atria which

also function as solar-chimney and wind tower hybrids (fig. 111). In the Farringdon OSD building there are also large solar-chimney and wind tower hybrids. Additionally, being situated above the Elizabeth Underground Line the building can make use of exhaust air from the tunnel to heat up small air shafts which creates an upwards draft and can pull air along from all the floors.

Creating liveable spaces also has to do with its design. By creating places to stay, places for movement, and places for play or performance (fig. 112) one can facilitate the creation of a lively public space. This makes the space more attractive and more safe.

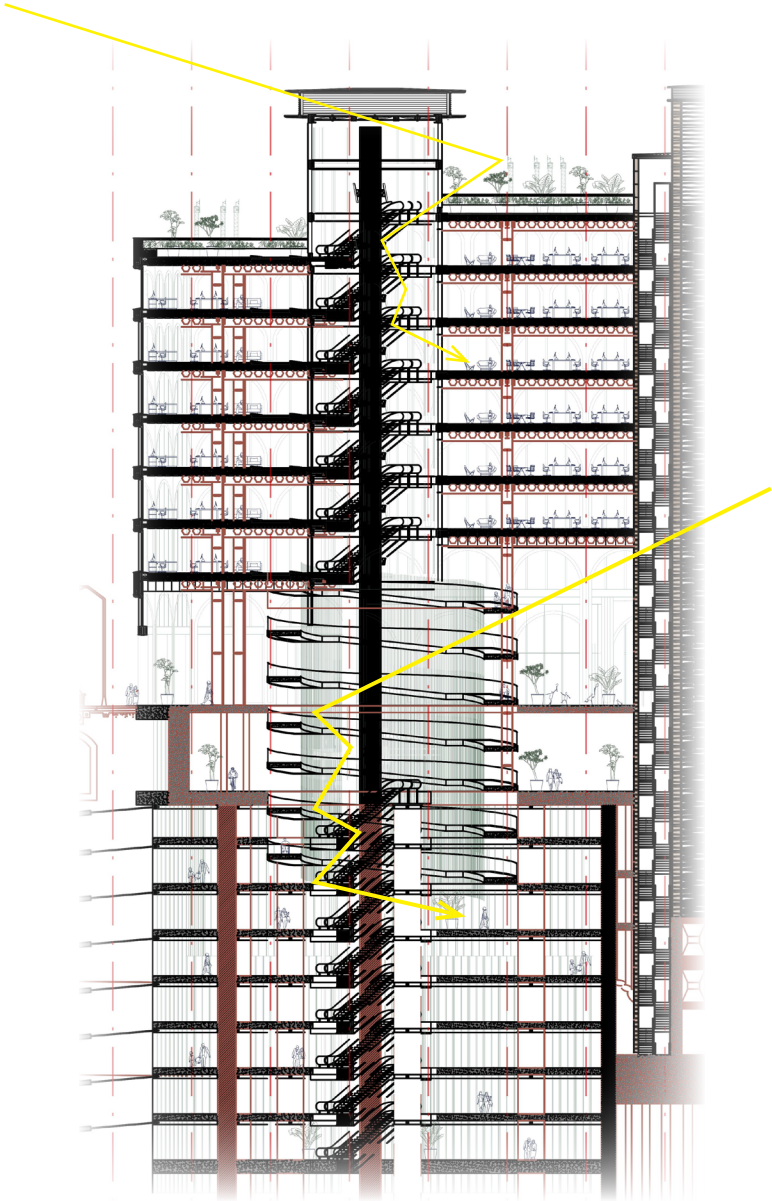


Fig. 105 Atrium Farrington OSD

Opening up the ground floor helps create more space to allow light to hit the atrium and be transported downwards aided by mirrors which can turn according to the orientation of the sun.

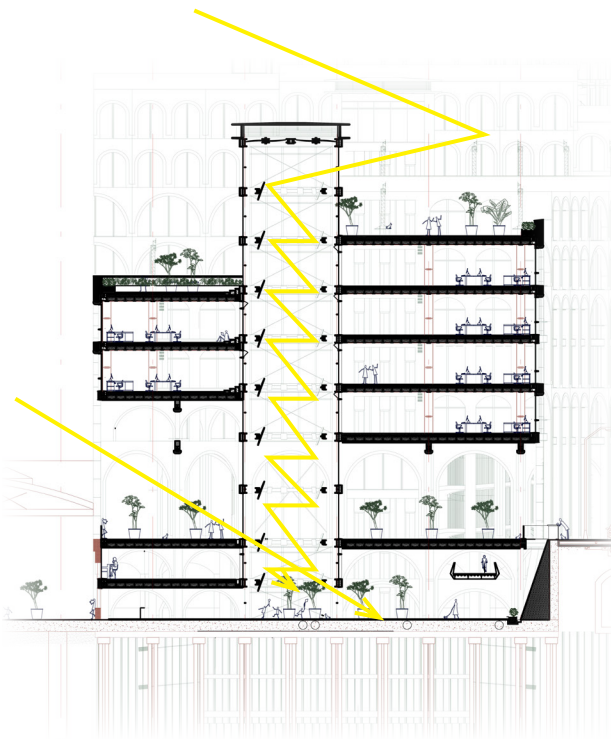


Fig. 106 Atrium Farrington nr. 20-50

More often than not there is also a visual connection established to and from the light source. Even via mirrors an interesting visual connection exists.

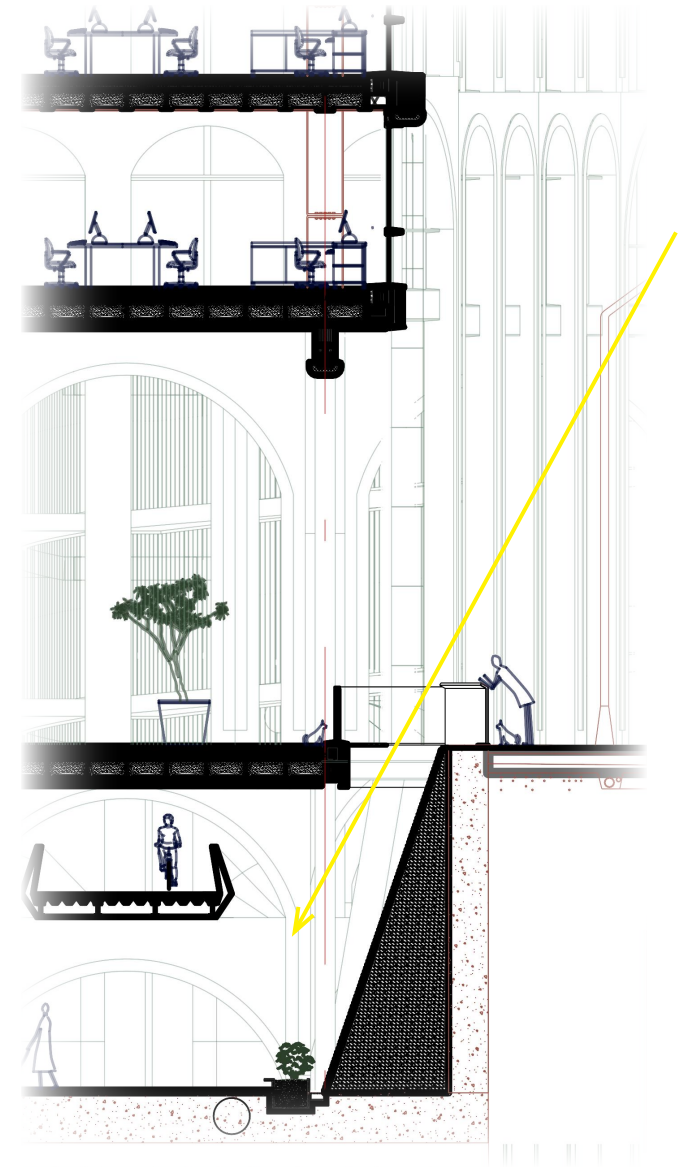


Fig. 107 Light shaft Farrington nr. 20-50

Light shaft can also be simple openings which allow plenty of daylight in and simultaneously let the outside climate in creating a more natural experience in the underground.

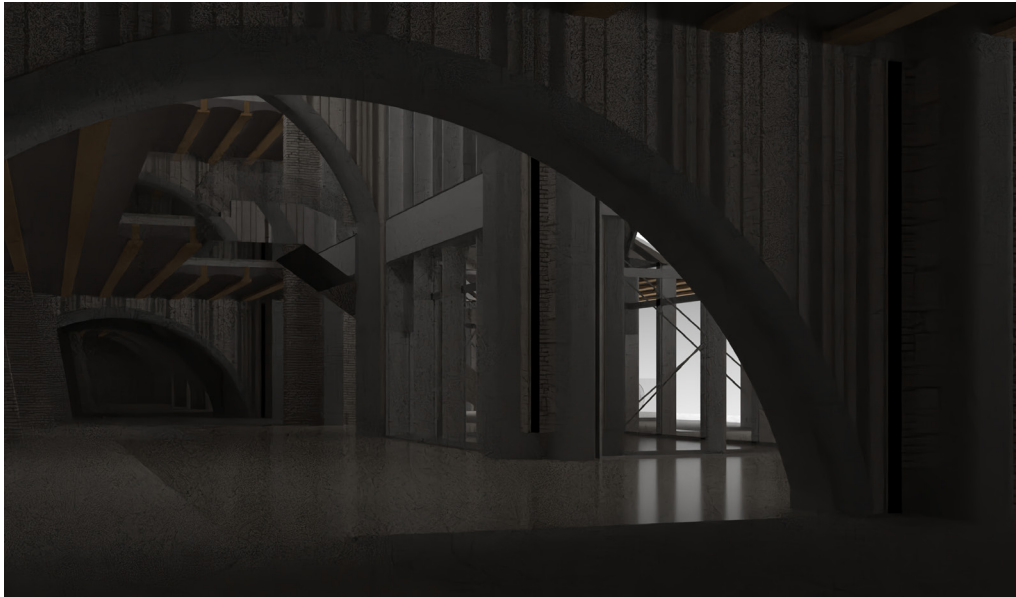


Fig. 108 Lighting in the underground without the aid of mirrors

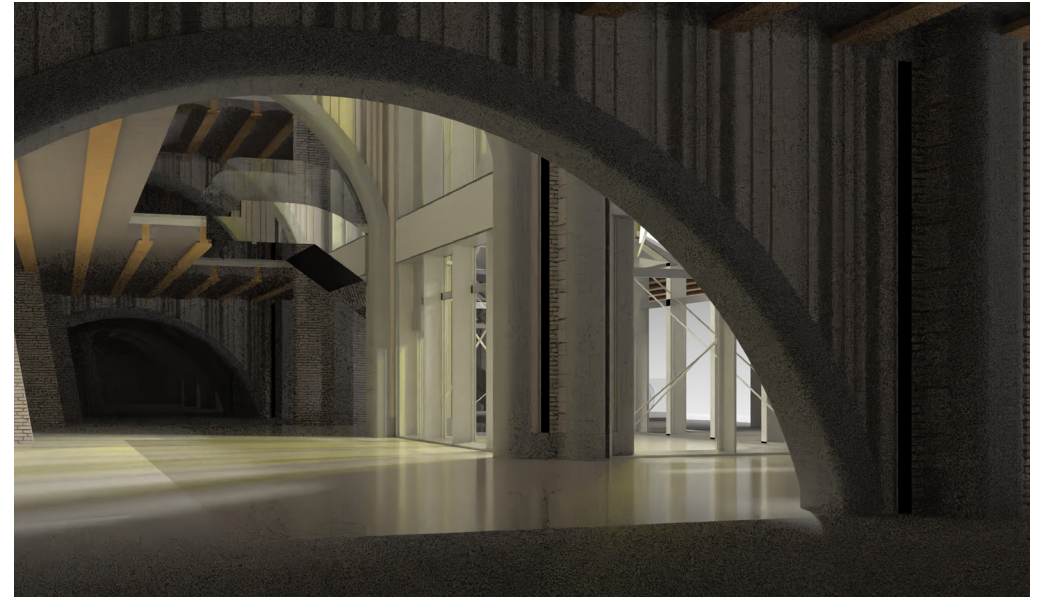


Fig. 109 Lighting in the underground with the aid of mirrors

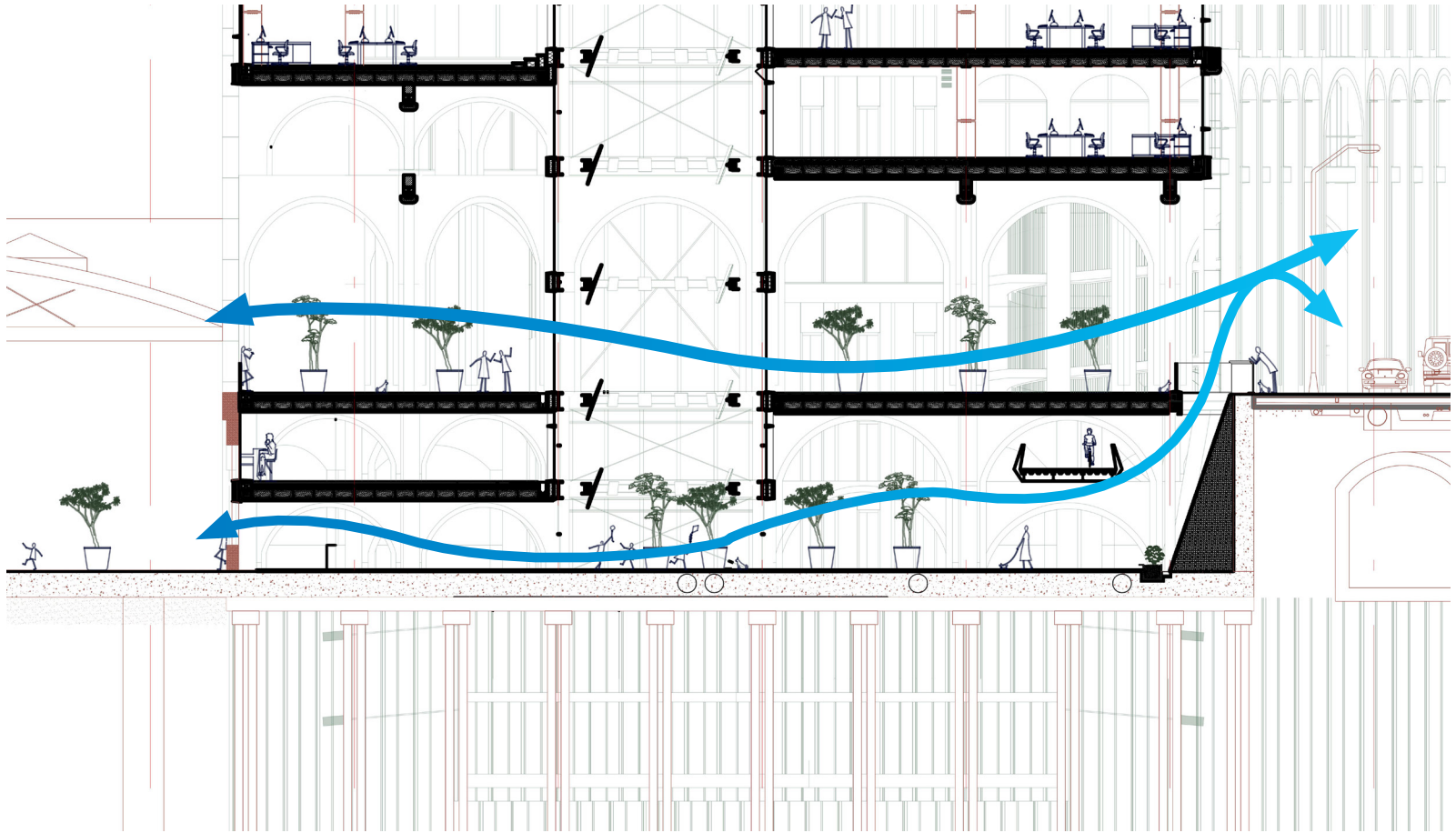


Fig. 110 Crossventilation

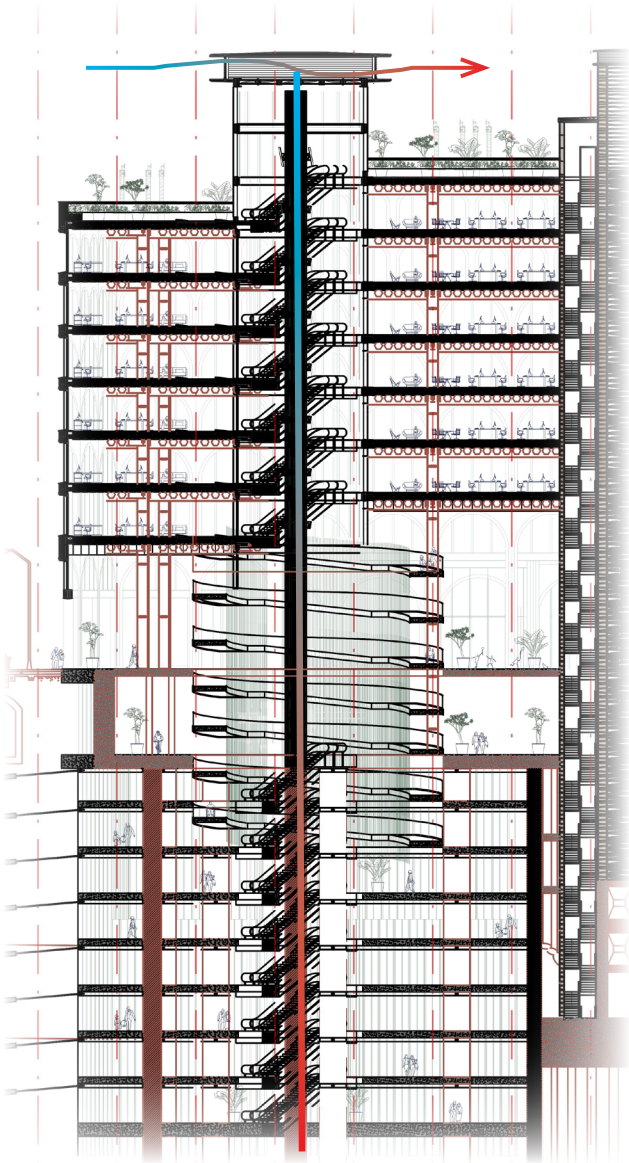
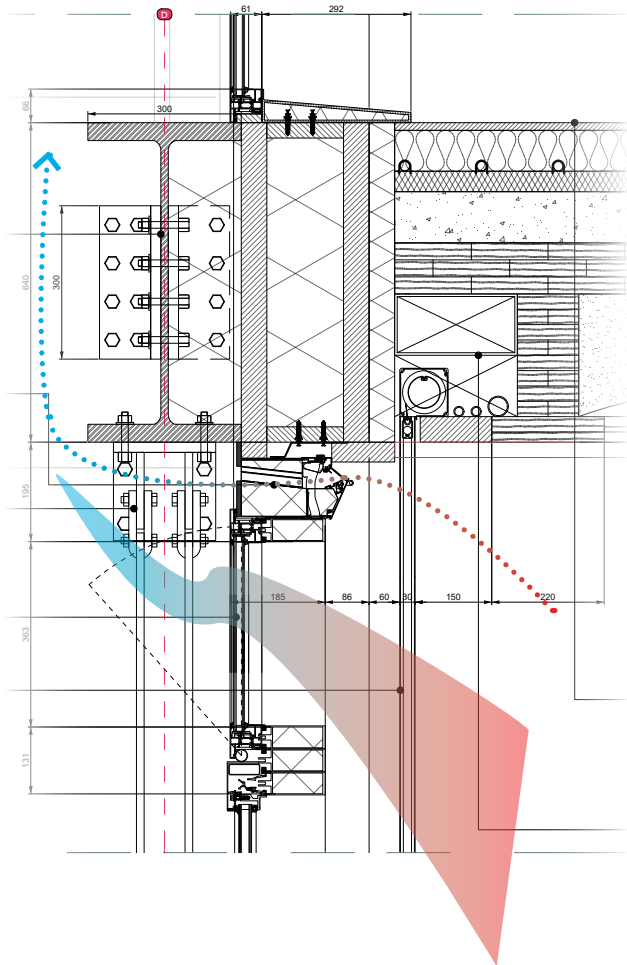
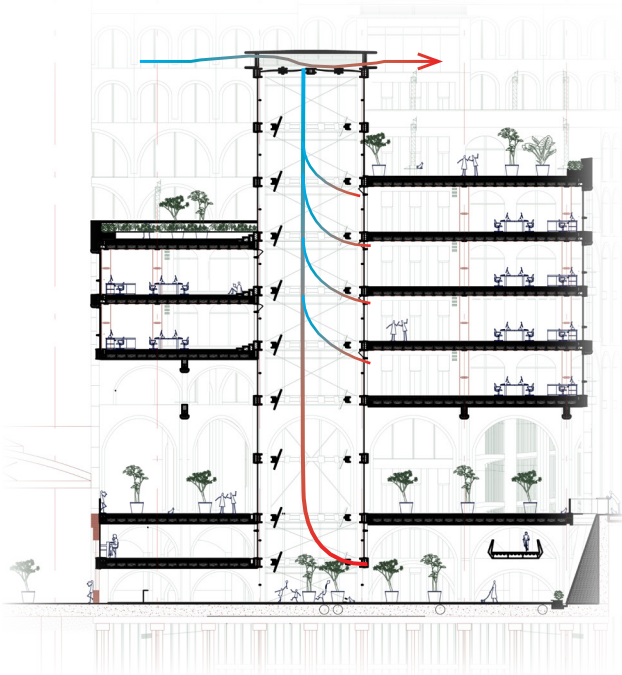


Fig. 111 Working of natural ventilation via solar -chimney and wind tower hybrids.



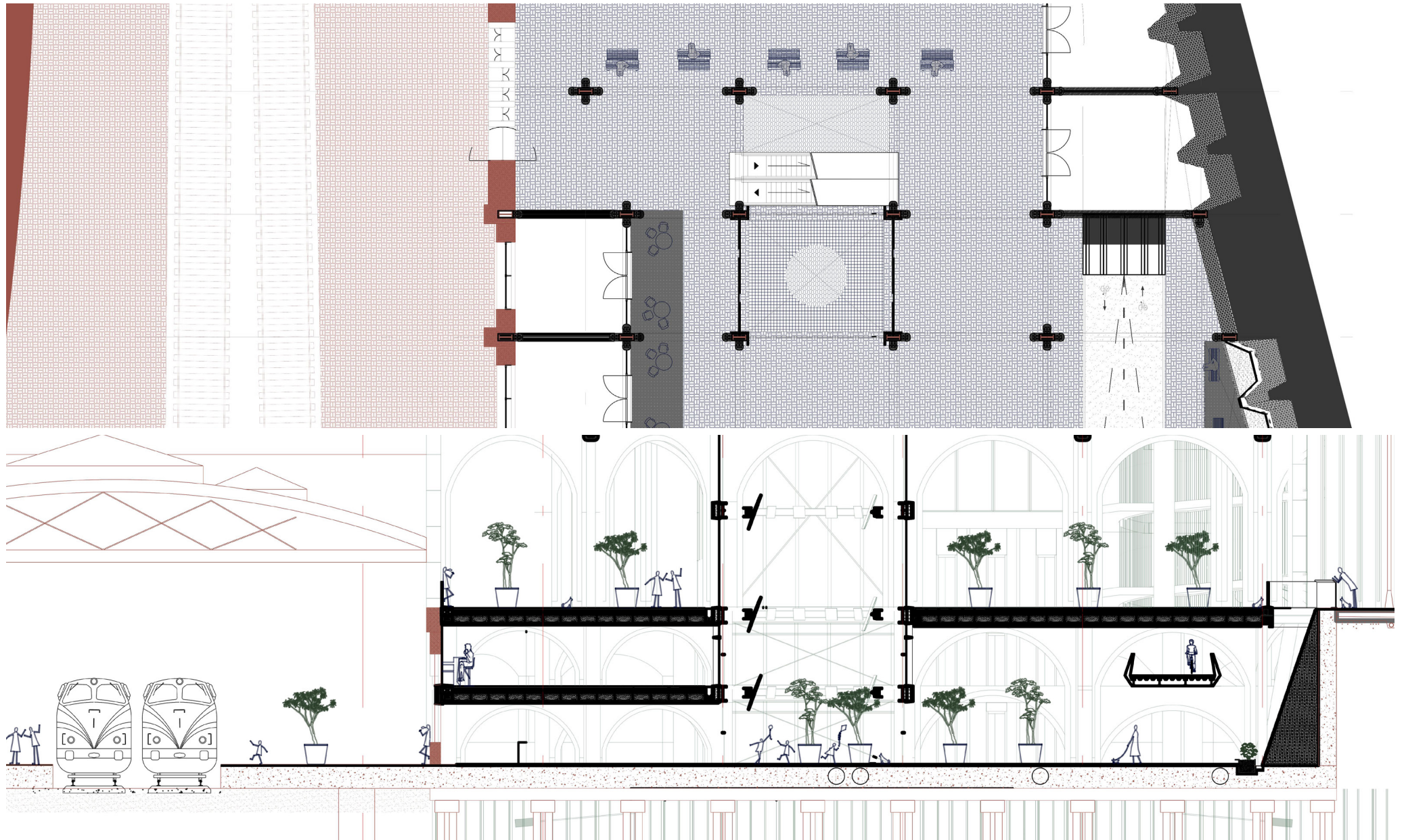


Fig. 112 Open places for playing, staying, and performing.

harnessing new characteristics

BUILDING

Although this project aims to create a concept for future cities in which the underground is seamlessly integrated into the city and does not aim to treat the underground any different than the above ground. The underground remains a different environment with different characteristics compared to the open-air of the above ground.

Thus, to make the underground an integrated part of the city, not only does the underground have to become part of the city, the city also has to become part of the underground. An important part of this graduation project's research and design was also looking into how the new characteristics unlocked by going underground can be harnessed.

What are these urban underground resources?

This thesis obviously makes use of the space resource as has been elaborated on in "activating the underground". Other resources the design makes use of are: energy, geo-materials, and existing materials.

The London Underground produces a lot of excess heat during braking and accelerating. This heat is just pumped out of the tunnels and exhausted into the city above. In the Farringdon OSD building this project explores ways to capture and reuse this excess heat for heating the building. This is done by exhausting the air through a rammed earth chimney that runs through the building. It acts on the one hand as a stove for the immediate surroundings. On the other hand the heat recovery system within the chimney uses the heat to help heat up the floor heating of the Farringdon OSD building (fig. 113, 114, 115).

harnessing new characteristics

BUILDING

Creating extra space underground also means excavating the materials which filled the space before. Often, these materials can be transformed into building materials. Such is the case for this project. The ground under the site mainly consists of London clay, sand, and a little bit of silt. London clay is the material used to make the London Stock bricks which is characterised by its yellow colour. Clay, sand and silt are also good materials to make rammed earth with. Aside from bricks and rammed earth, clay can also be used in combination with wood to create clay-wood floor slabs which use mainly natural materials to achieve sound and thermal insulation, and fire safe floors. These materials are used alongside steel to create the new Farringdon nr.20-50 and Farringdon OSD buildings (fig. 116). In the spirit of harnessing new characteristics the concept of on-site fabrication in disused underground spaces in the vicinity was also explored (fig. 117).

Last but not least, the project talks about building in areas which are already densely built, meaning there is plenty of existing built materials. The project also tried to retain large parts of the structure of the existing buildings and transform them into the new designs. The demolition waste generated by demolishing the other parts of the existing buildings can be used as screed to cover the CLT floor panels.

harnessing new
characteristics

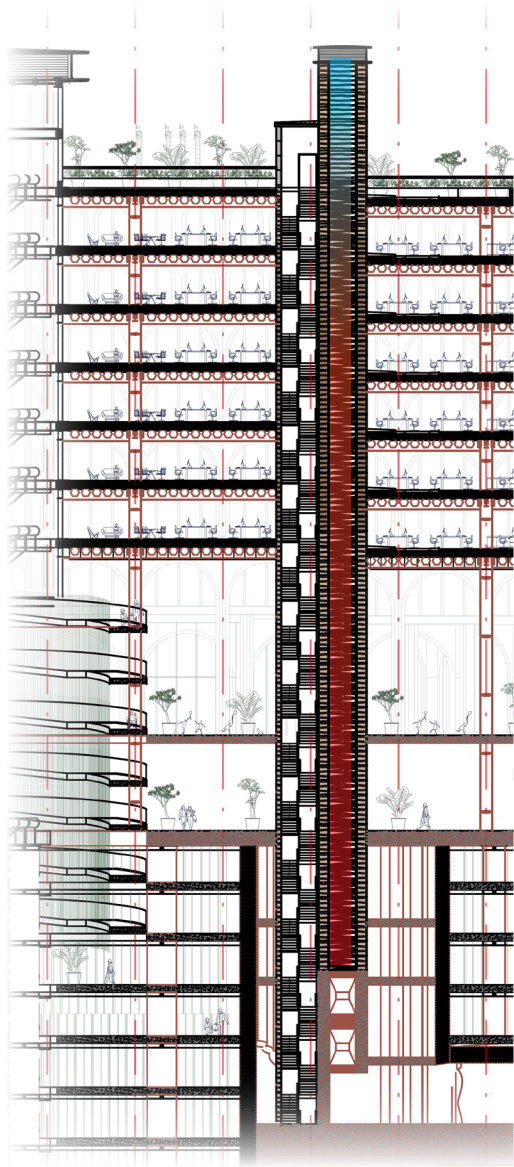


Fig. 113 Working of London Underground Heat Recovery System.

BUILDING

harnessing new
characteristics

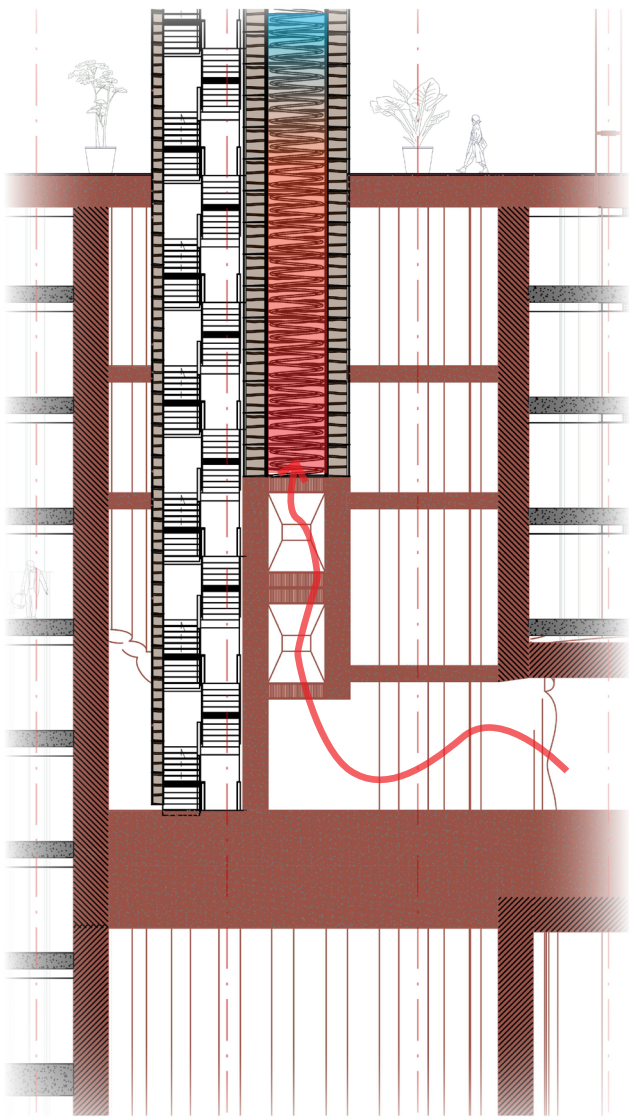


Fig. 114 Working of London Underground Heat Recovery System.

BUILDING

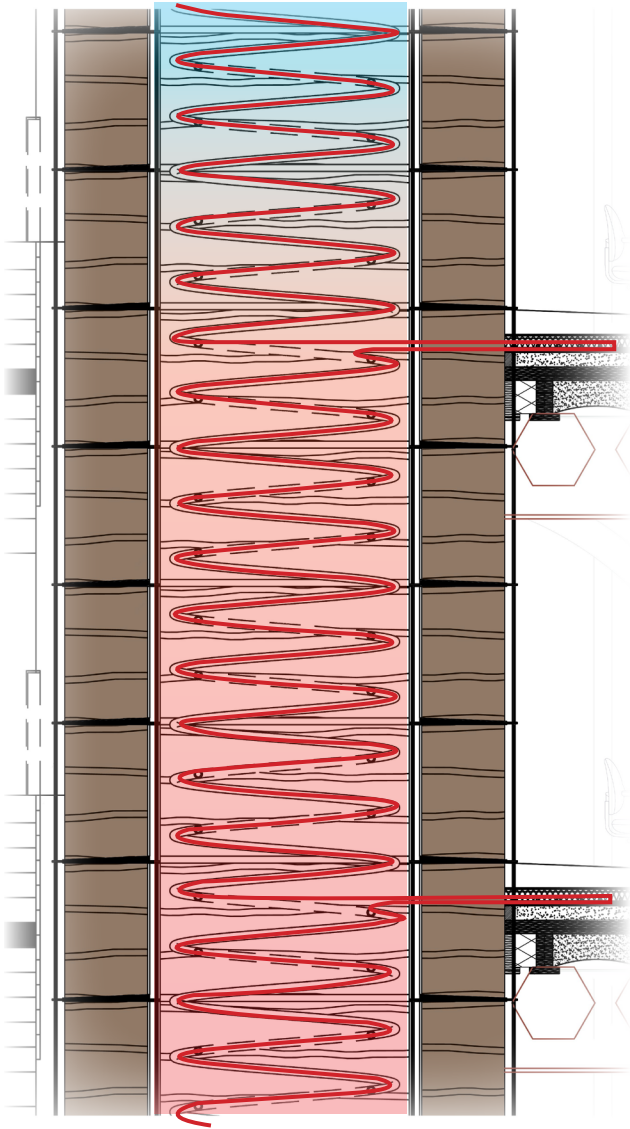


Fig. 115 Working of London Underground Heat Recovery System.

harnessing new
characteristics

BUILDING

harnessing new
characteristics

BUILDING

London stock brick
Demolition waste screed
London clay

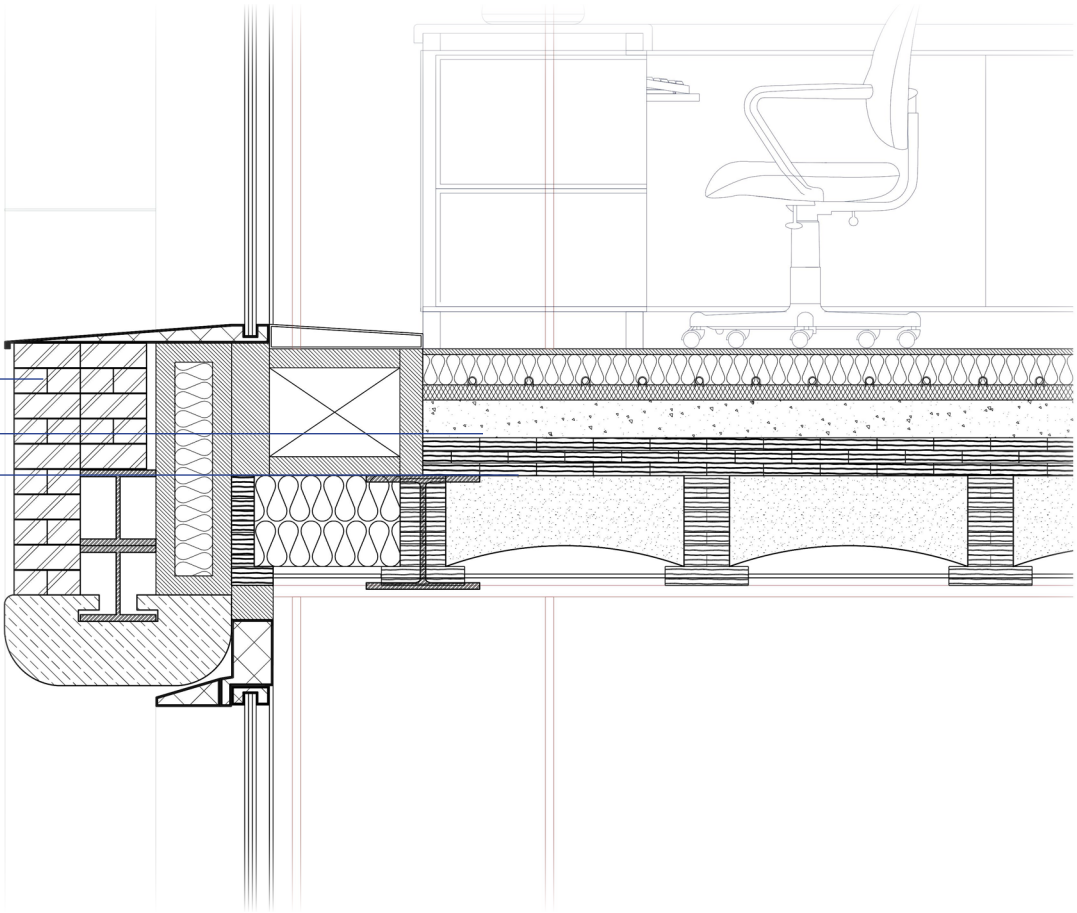


Fig. 116 Geo material use

harnessing new
characteristics

BUILDING

harnessing new
characteristics

BUILDING

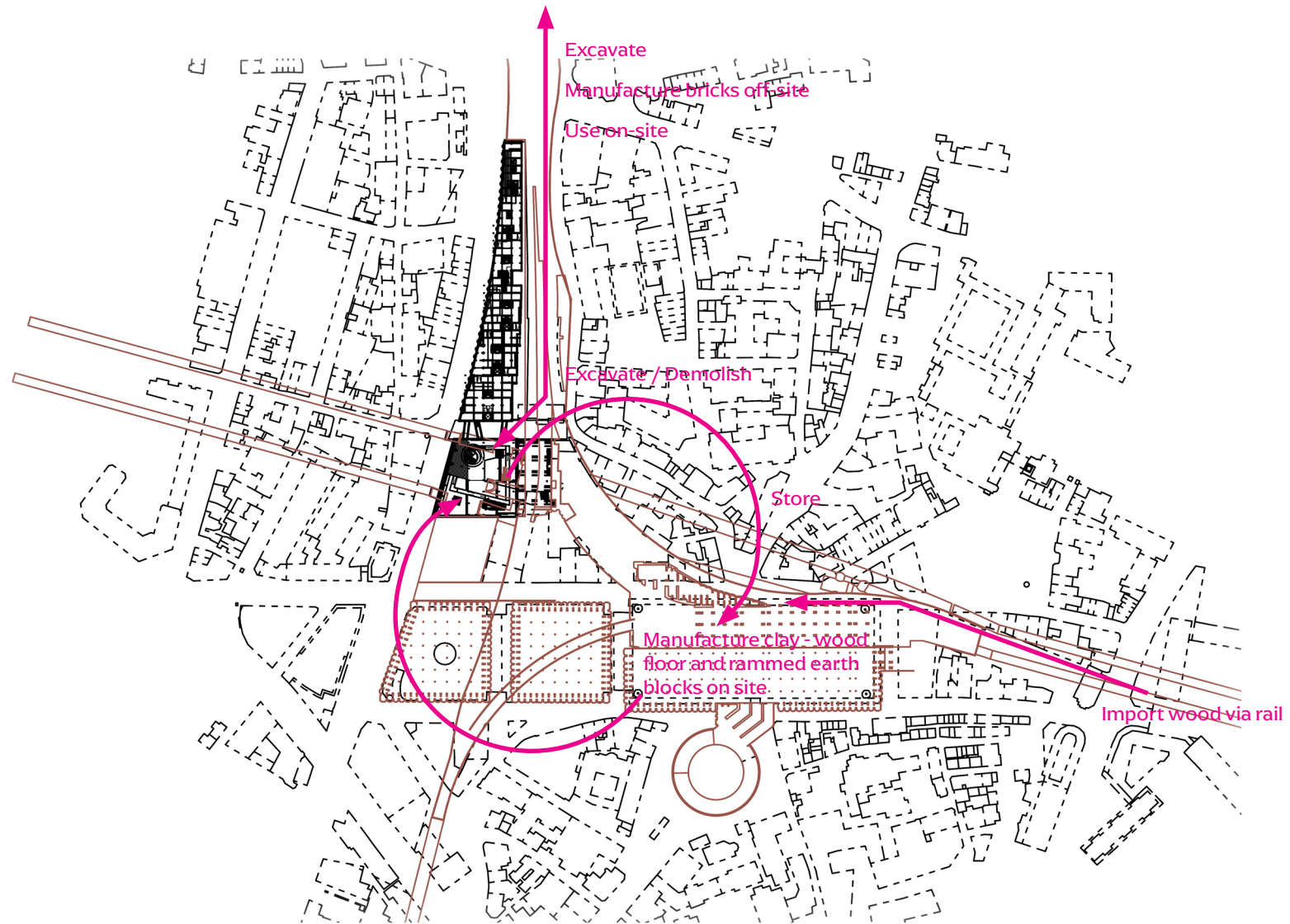


Fig. 117 On-site fabrication

This project also aimed to explore what the architectural language of a new type of building could be in which the underground and above ground are interwoven and seamlessly connected with its surroundings.

In the beginning of the chapter different elements were explored: form, light, accessibility, way finding, underground as an urban resource i, underground as an urban resource ii, and vertical + horizontal. These all affect the architectural design of such a building. Generating new ideas for new architectural interventions such as the atria, the light shafts, the chimneys, the material choices, and the floors. However, merely a collage of all the new elements needed to achieve this new architecture is not enough to connect the building to its surroundings. It is at least just as important to look at the context of the buildings and how that might relate to what the building is trying to achieve on its own and within its surroundings.

Farringdon is characterised by a lot of Victorian architecture. Especially the underground spaces in the area were all constructed around the Victorian era or strongly influenced by it. The basements, tunnels, viaducts, ramps, and historical buildings (fig. 118, 119, 120, 121, 122)) all have a recurring element: the arch.

When thinking about the arch, it is a shape which derives its form from its functionality which is bearing the loads in an efficient way. It is also a very symbolic architectural element. Arches form passages, passage ways, arcades. These are places of movement and places of meeting. Which is what my building is about (fig. 123).

The arch is also a quite flexible shape, it can take on different heights, widths, proportions, and materials.

Which fits nicely in the idea of a building where no floor is necessarily on the same height, where spaces differ and need to be able to be read at a glance. The arch could help with that.

This is why for the architectural expression of the facade and the ground floor realm, the arch was chosen. The classic shape combined with high-tech inserts such as the atria tell the story of this project. A vision for the city of the future, rooted in history and context.

On the next pages you may find the drawings representing the design of the project.



Fig. 118 Farringdon nr. 20-50

Fig. 119 Smithfield Fish Market

Fig. 120 Smithfield Market

Fig. 121 Ramp to basement of Smithfield Market

Fig. 122 St. Bartholomew's Hospital

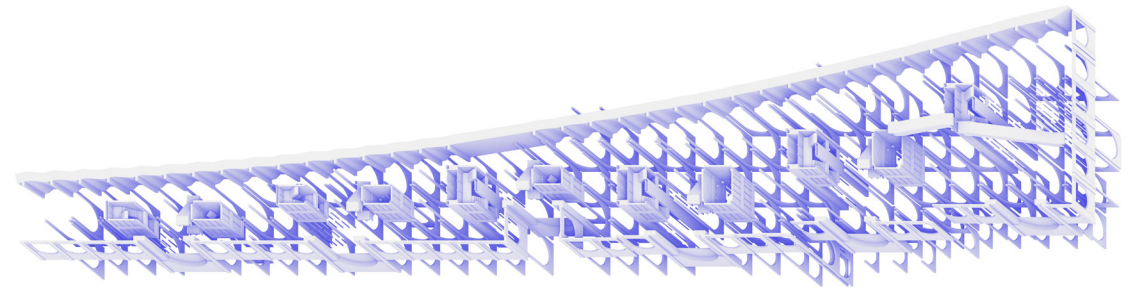
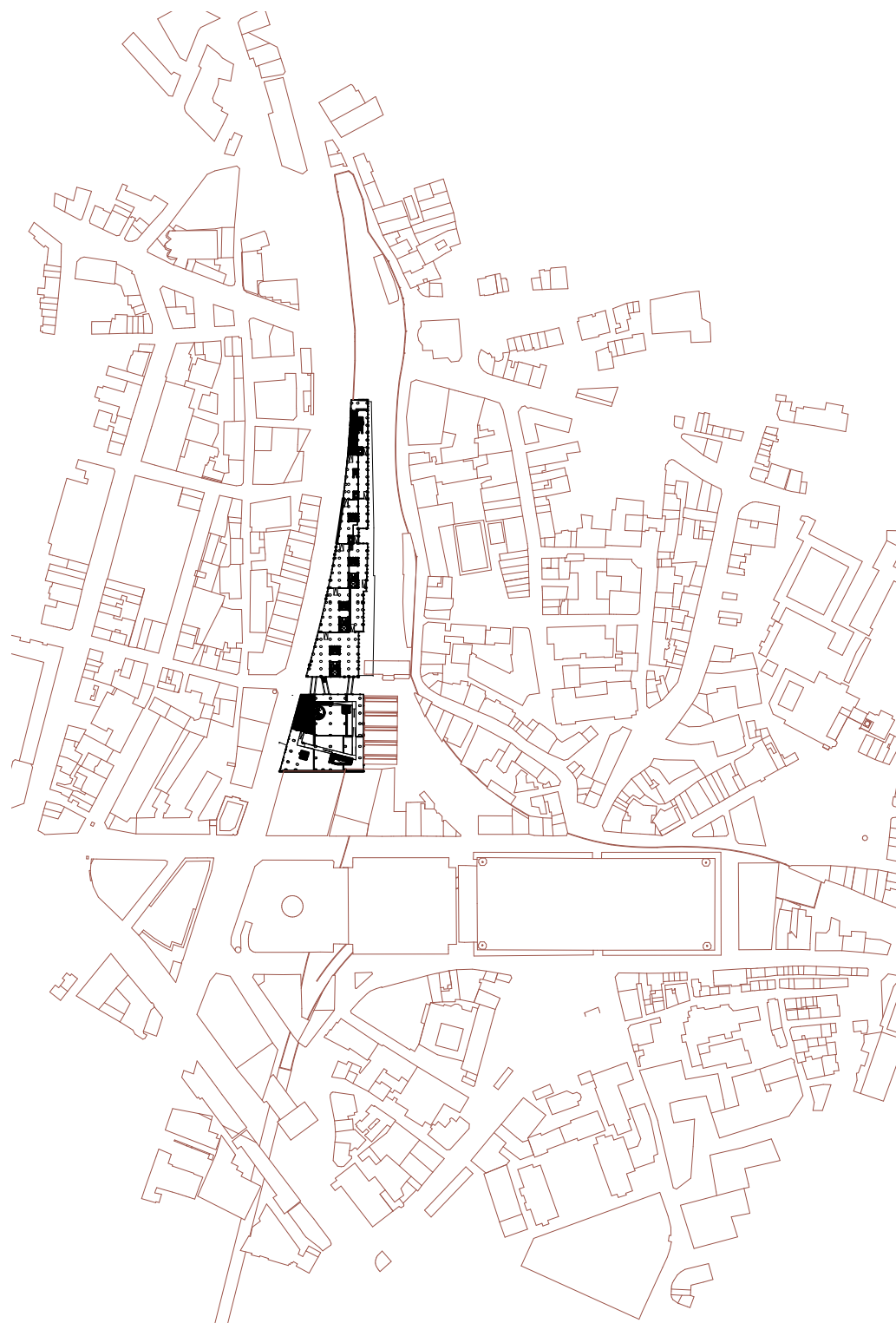
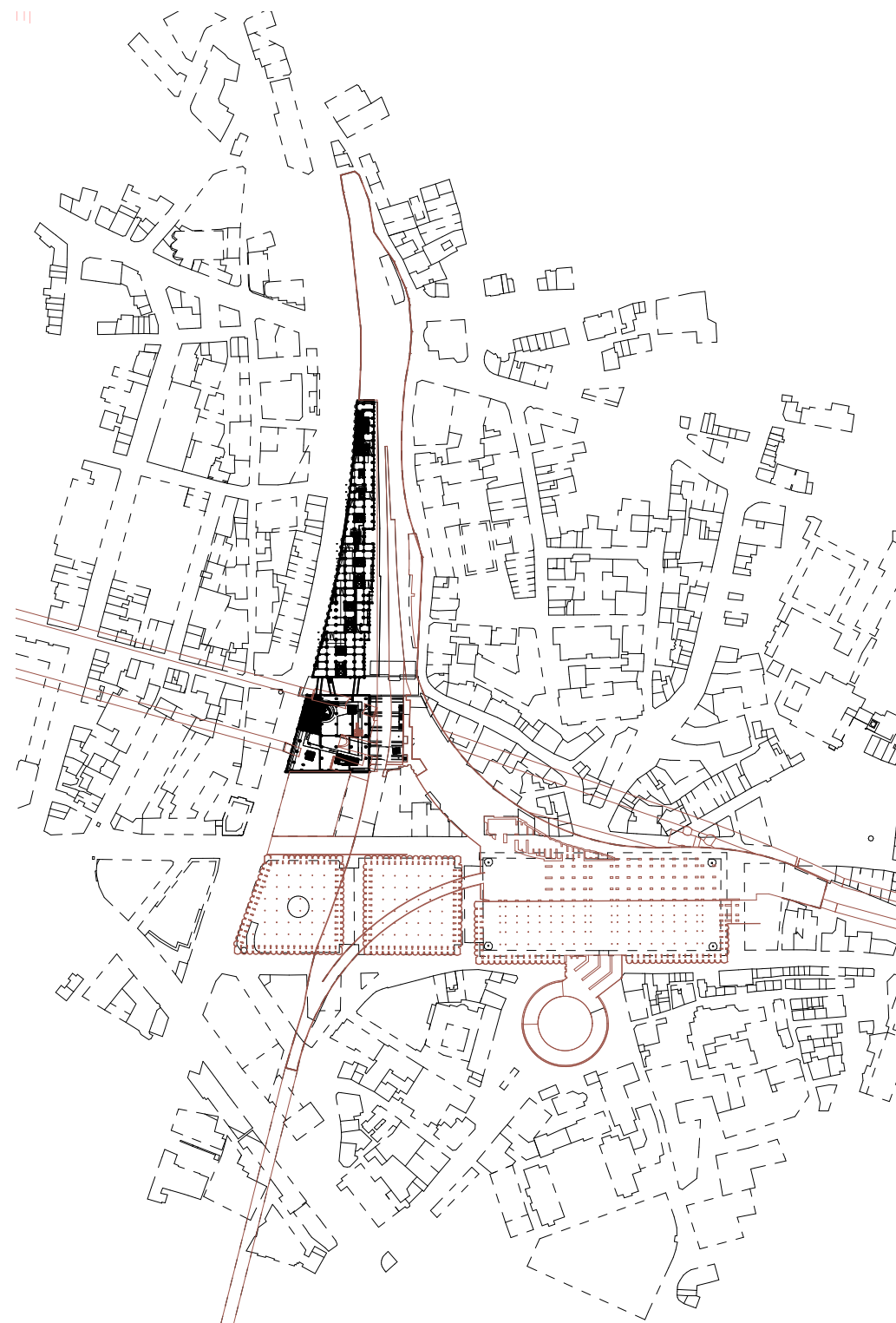


Fig. 123 Arches in the building



Project 001.	Think Deep
Drawing	Urban context above ground
Scale	1:5000 - 50%
Paper format	255mm x 155mm
Date	30/06/2024
Comments	City of the Future Graduation Studio Hanlin Stuer 5016959

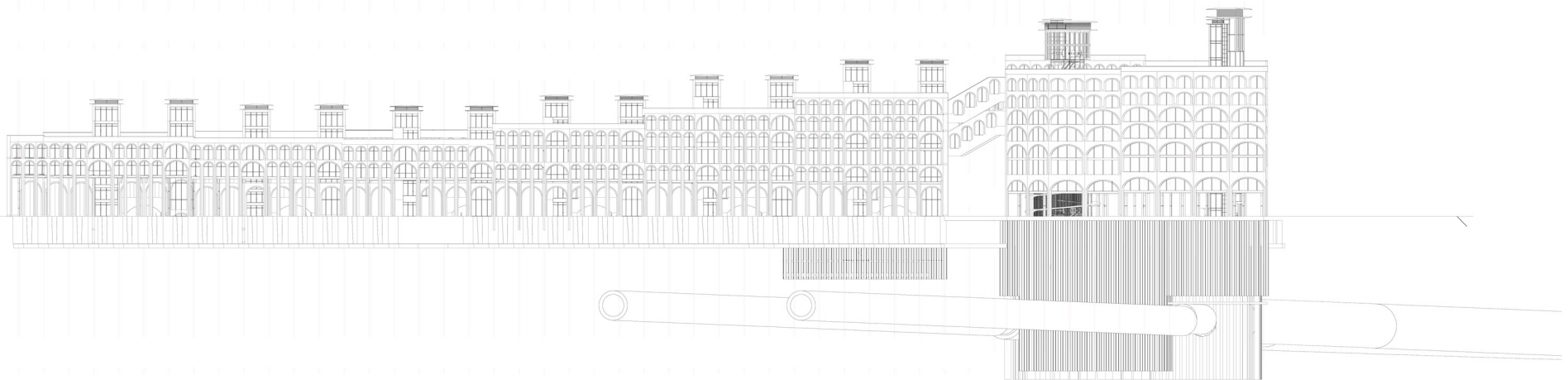


Project 001.	Think Deep
Drawing	Urban context underground
Scale	1:5000 - 50%
Paper format	255mm x 155mm
Date	30/06/2024
Comments	City of the Future Graduation Studio Hanlin Stuer 5016959



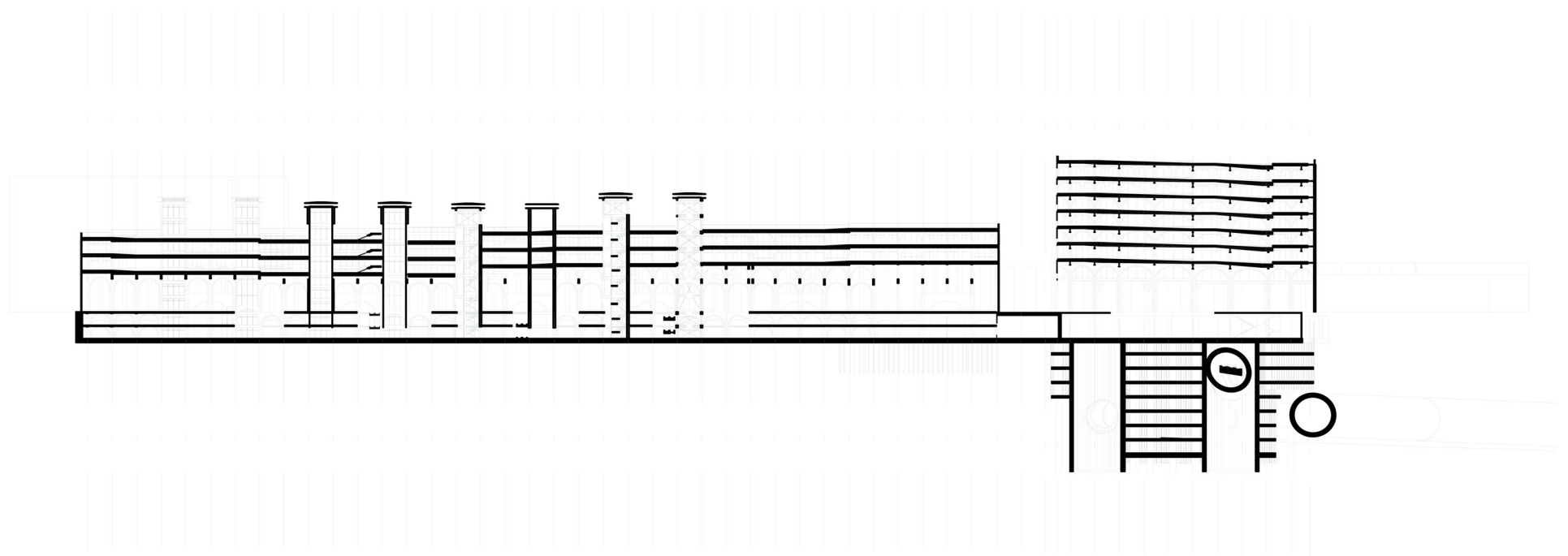


Project 001.	Think Deep
Drawing	Facade NE
Scale	1:500 - 30%
Paper format	255mm x 155mm
Date	30/06/2024
Comments	City of the Future Graduation Studio Hanlin Stuer 5016959



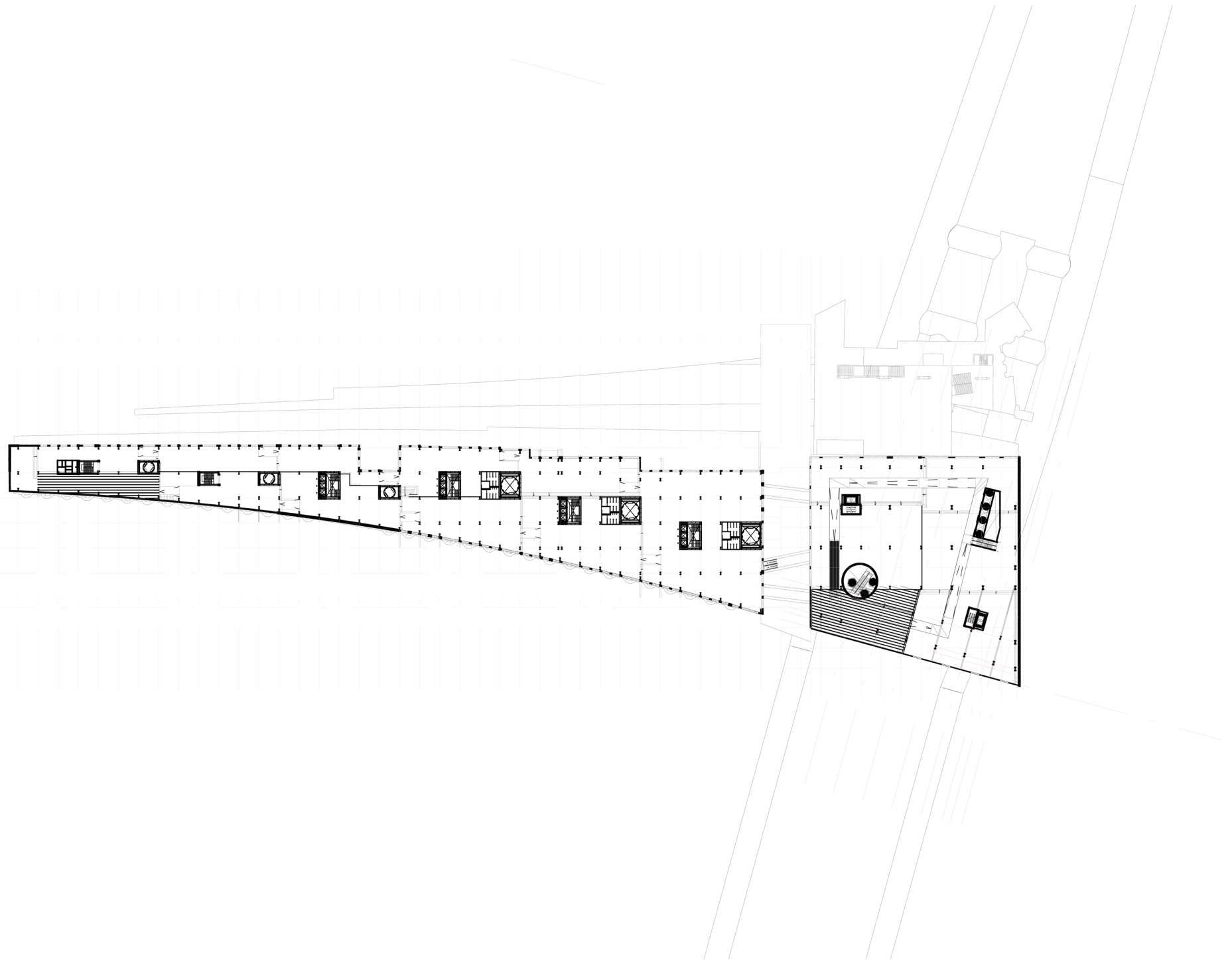
Project 001.	Think Deep
Drawing	Facade SW
Scale	1:500 - 30%
Paper format	255mm x 155mm
Date	30/06/2024
Comments	City of the Future Graduation Studio Hanlin Stuer 5016959





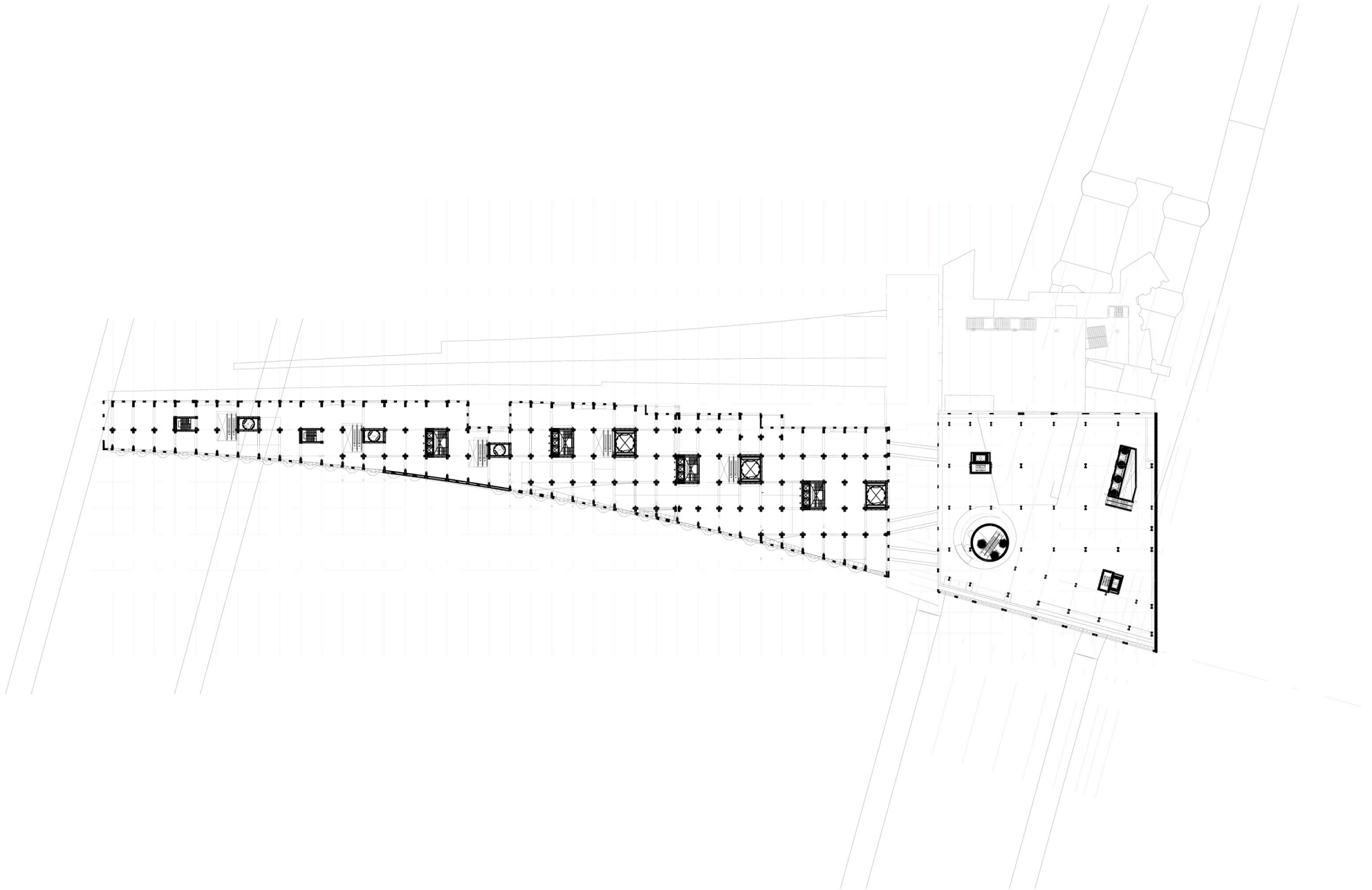
Project 001.	Think Deep
Drawing	Section, whole buildin
Scale	1:500 - 30%
Paper format	255mm x 155mm
Date	30/06/2024
Comments	City of the Future Graduation Studio Hanlin Stuer 5016959



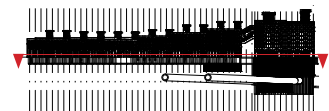


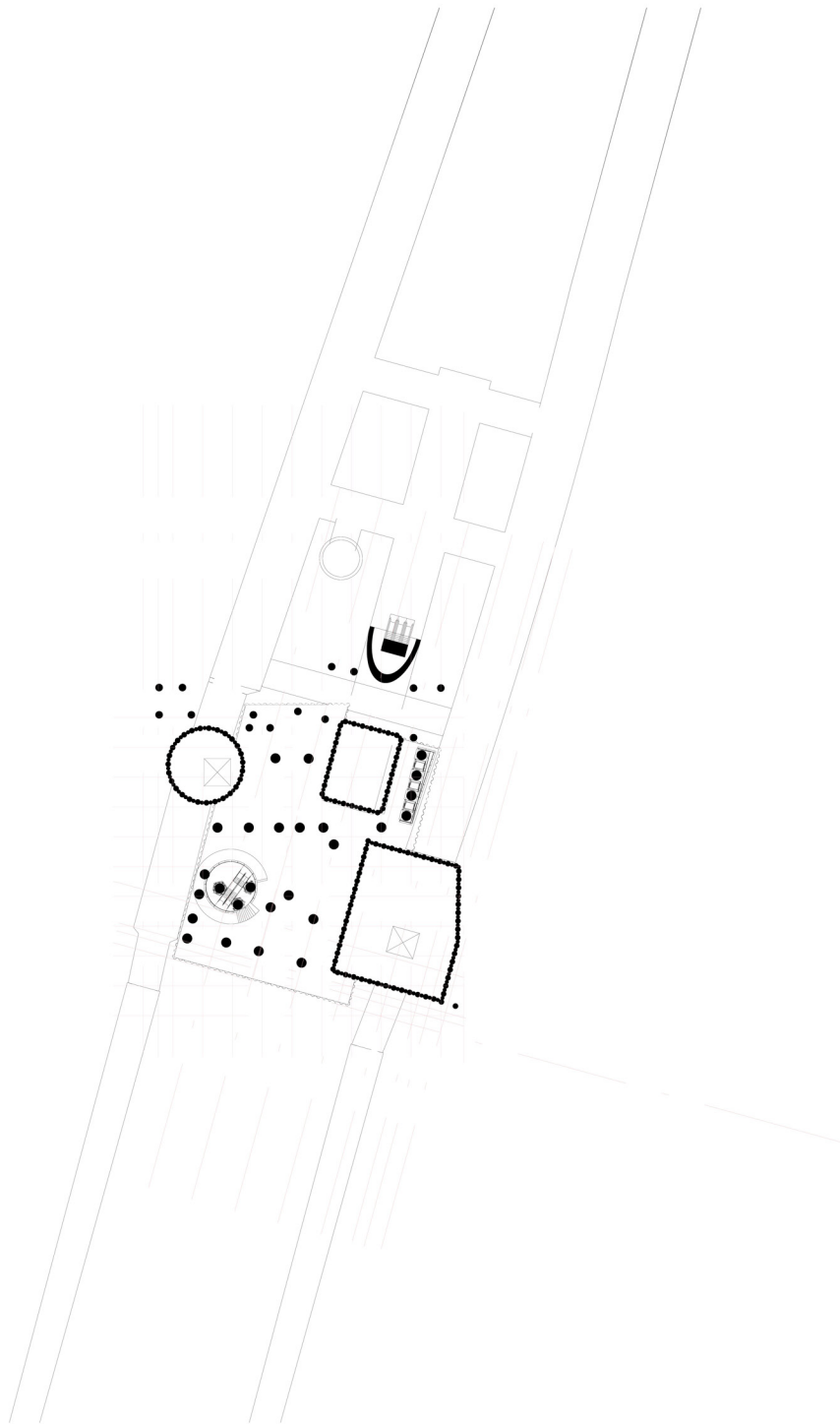
Project 001.	Think Deep
Drawing	Plan +3, office floors - whole building
Scale	1:500 - 30%
Paper format	255mm x 155mm
Date	30/06/2024
Comments	City of the Future Graduation Studio Hanlin Stuer 5016959



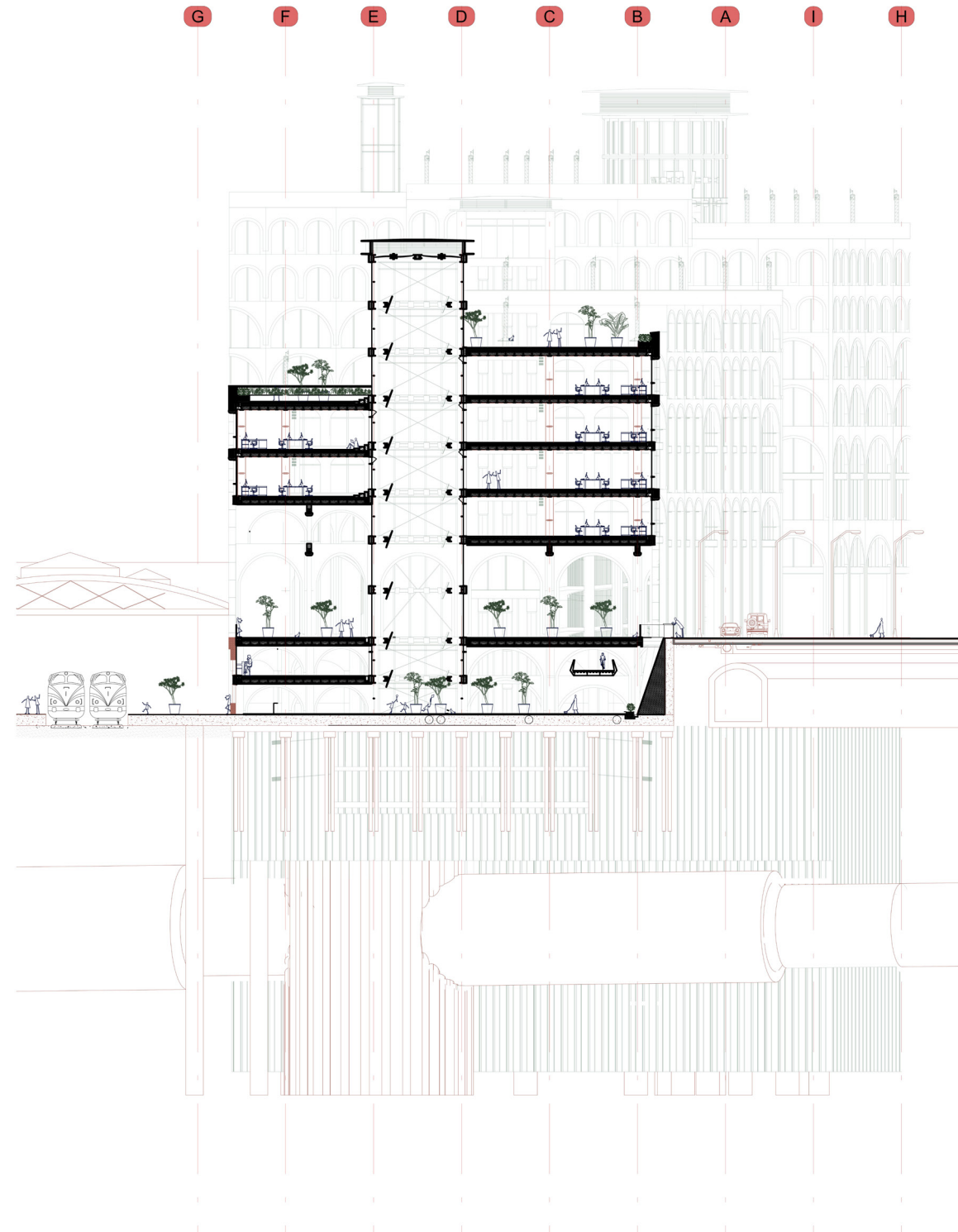
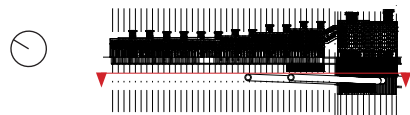


Project 001.	Think Deep
Drawing	Plan ground floor - whole building
Scale	1:500 - 30%
Paper format	255mm x 155mm
Date	30/06/2024
Comments	City of the Future Graduation Studio Hanlin Stuer 5016959



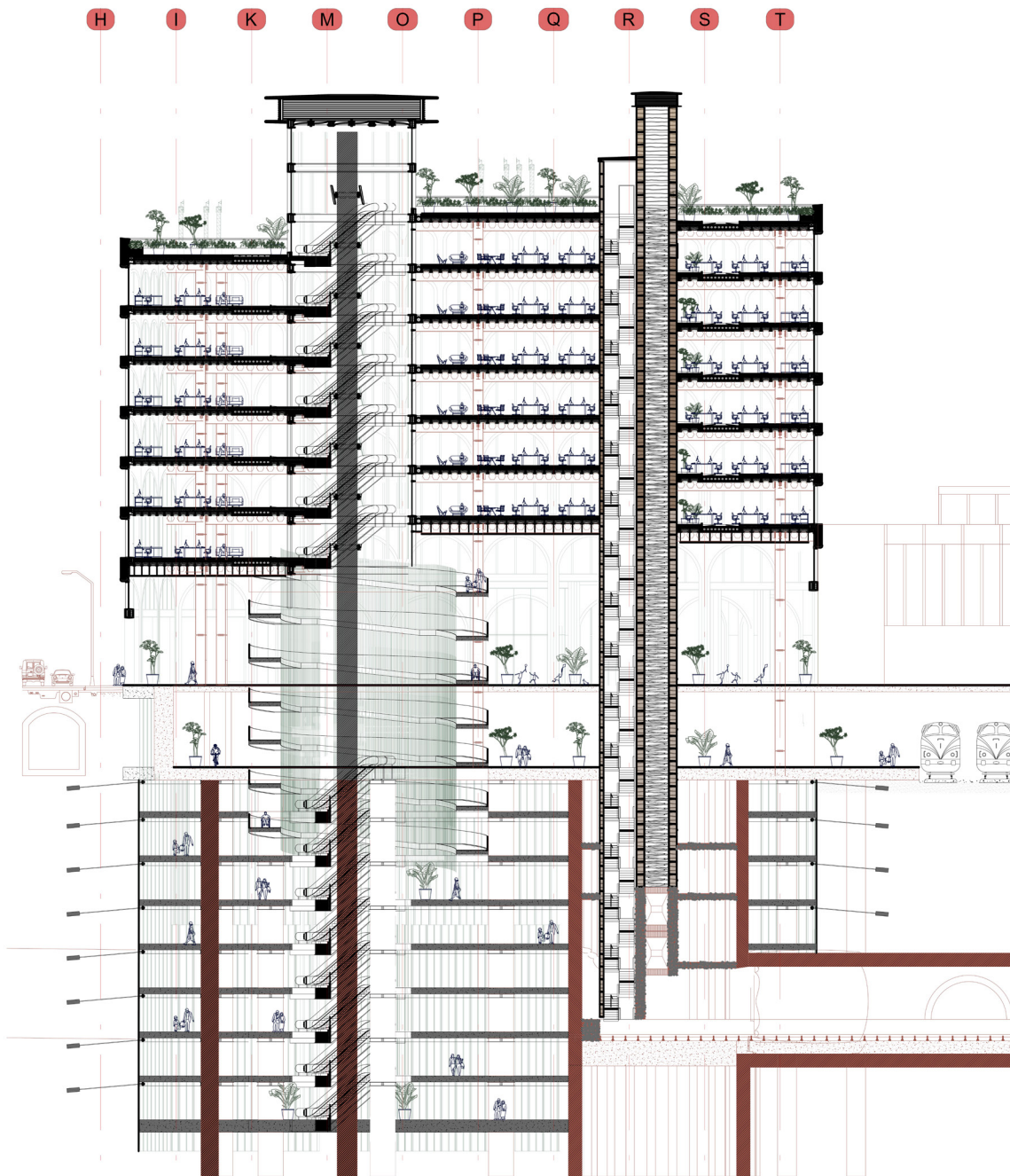


Project 001.	Think Deep
Drawing	Plan -6
Scale	1:500 - 30%
Paper format	255mm x 155mm
Date	30/06/2024
Comments	City of the Future Graduation Studio Hanlin Stuer 5016959

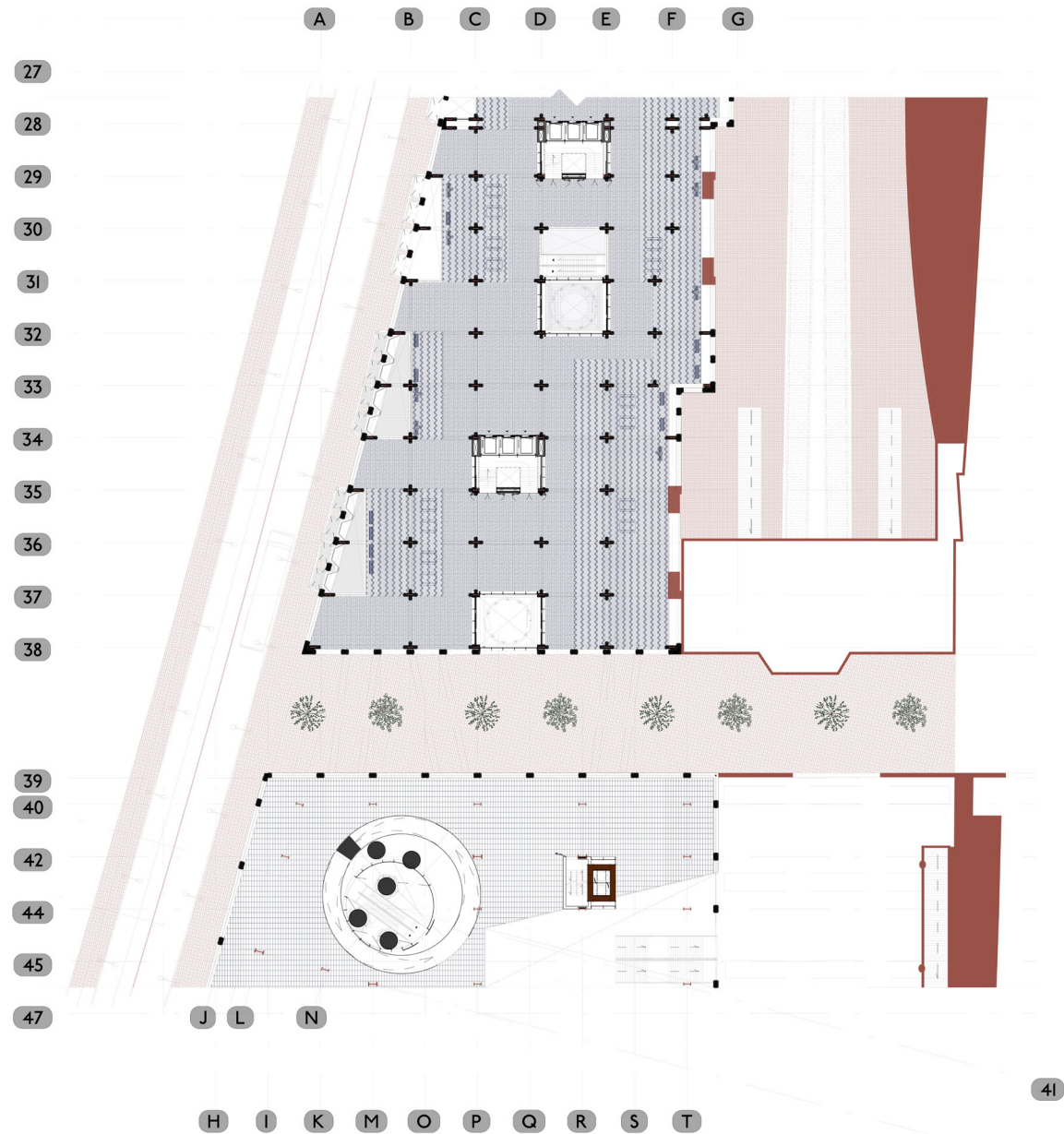


Project 001.	Think Deep
Drawing	Section Farringdon nr. 20-50
Scale	1:100 12.5%
Paper format	255mm x 155mm
Date	30/06/2024
Comments	City of the Future Graduation Studio Hanlin Stuer 5016959



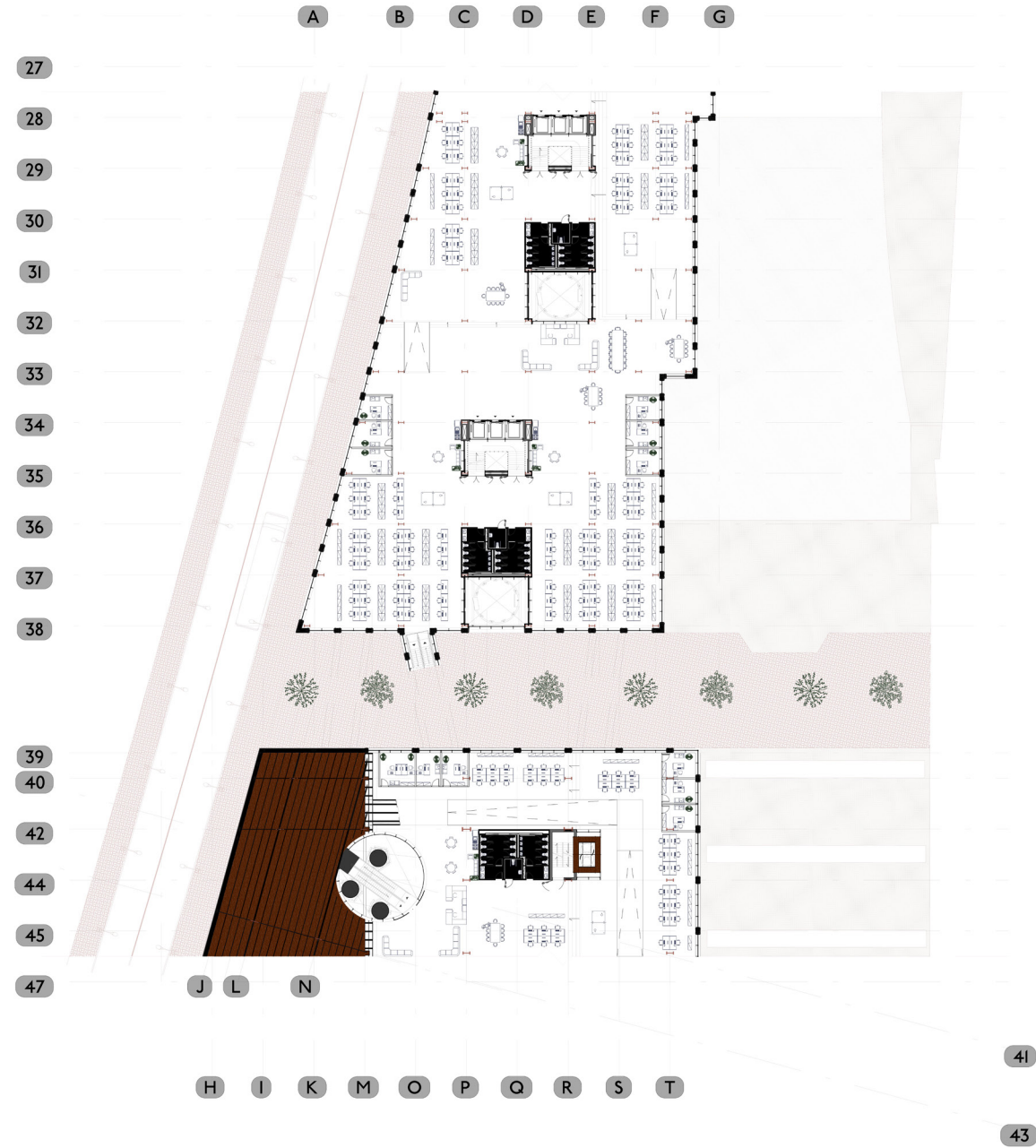


Project 001. Think Deep
 Drawing Section OSD
 Scale 1:100 12.5%
 Paper format 255mm x 155mm
 Date 30/06/2024
 Comments City of the Future Graduation Studio
 Hanlin Stuer 5016959

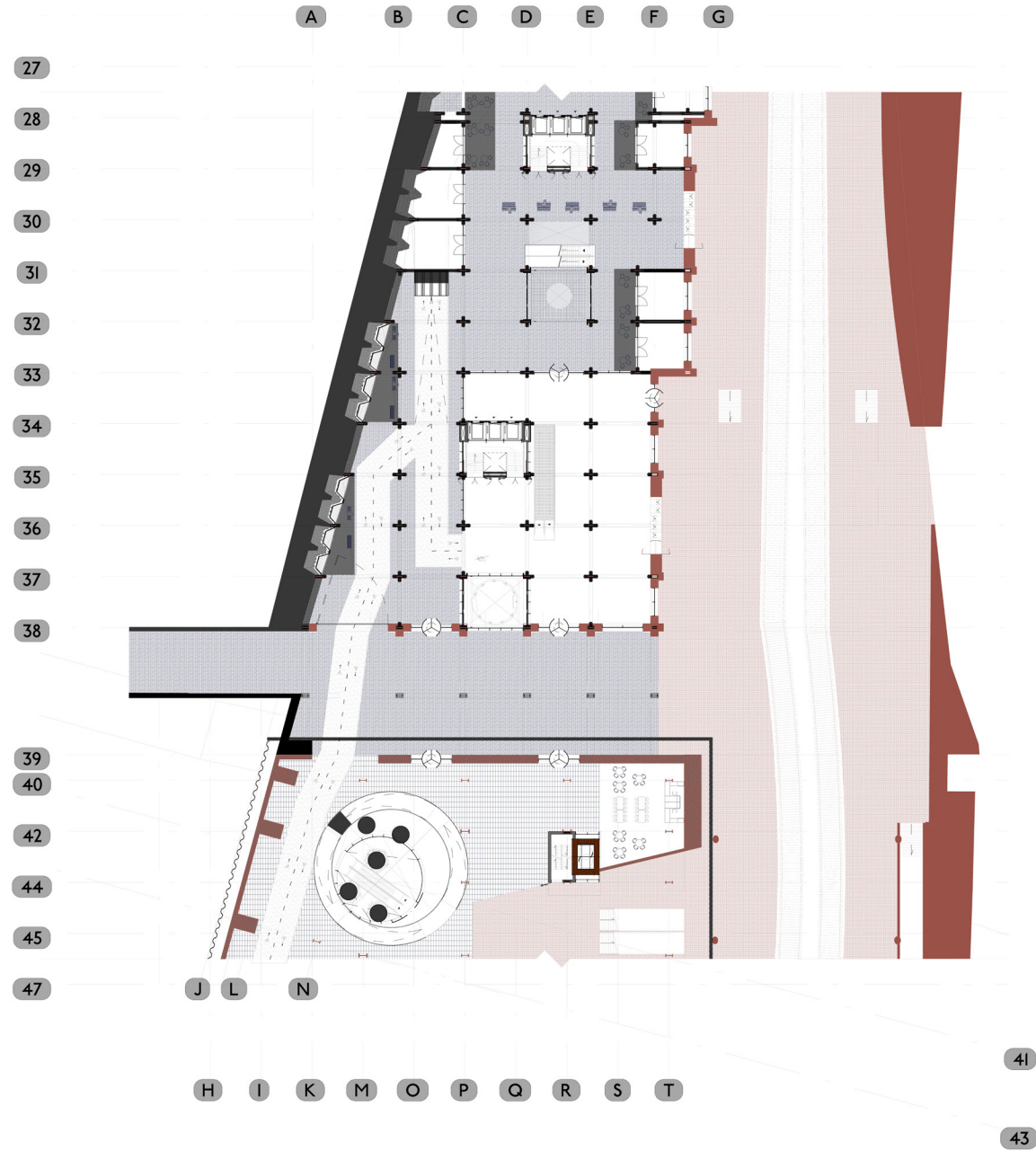


Project 001. Think Deep
 Drawing Plan ground floor
 Scale 1:200 25%
 Paper format 255mm x 155mm
 Date 30/06/2024
 Comments City of the Future Graduation Studio
 Hanlin Stuer 5016959



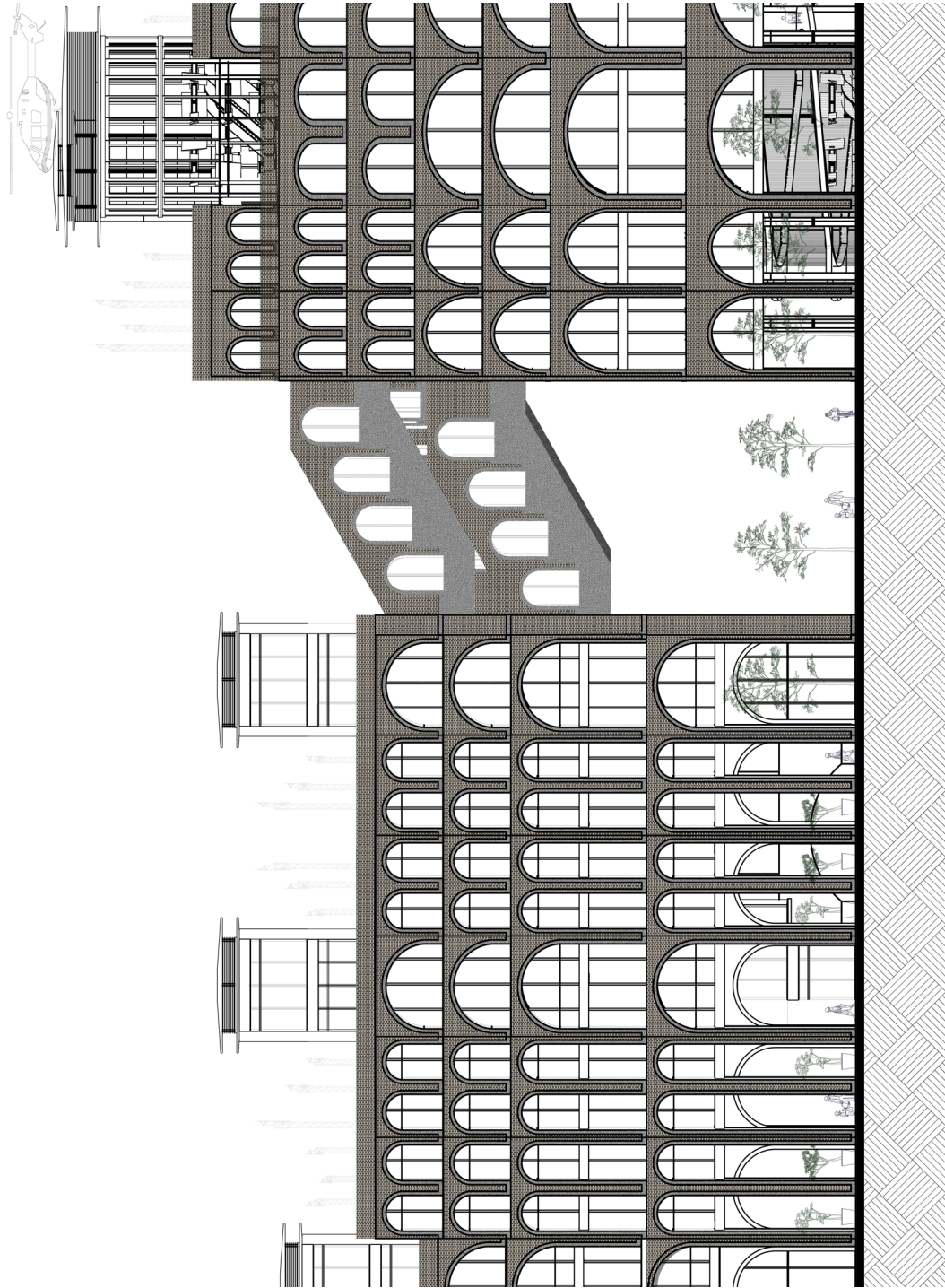


Project 001. Think Deep
Drawing Plan +4, office level
Scale 1:200 25%
Paper format 255mm x 155mm
Date 30/06/2024
Comments City of the Future Graduation Studio
Hanlin Stuer 5016959

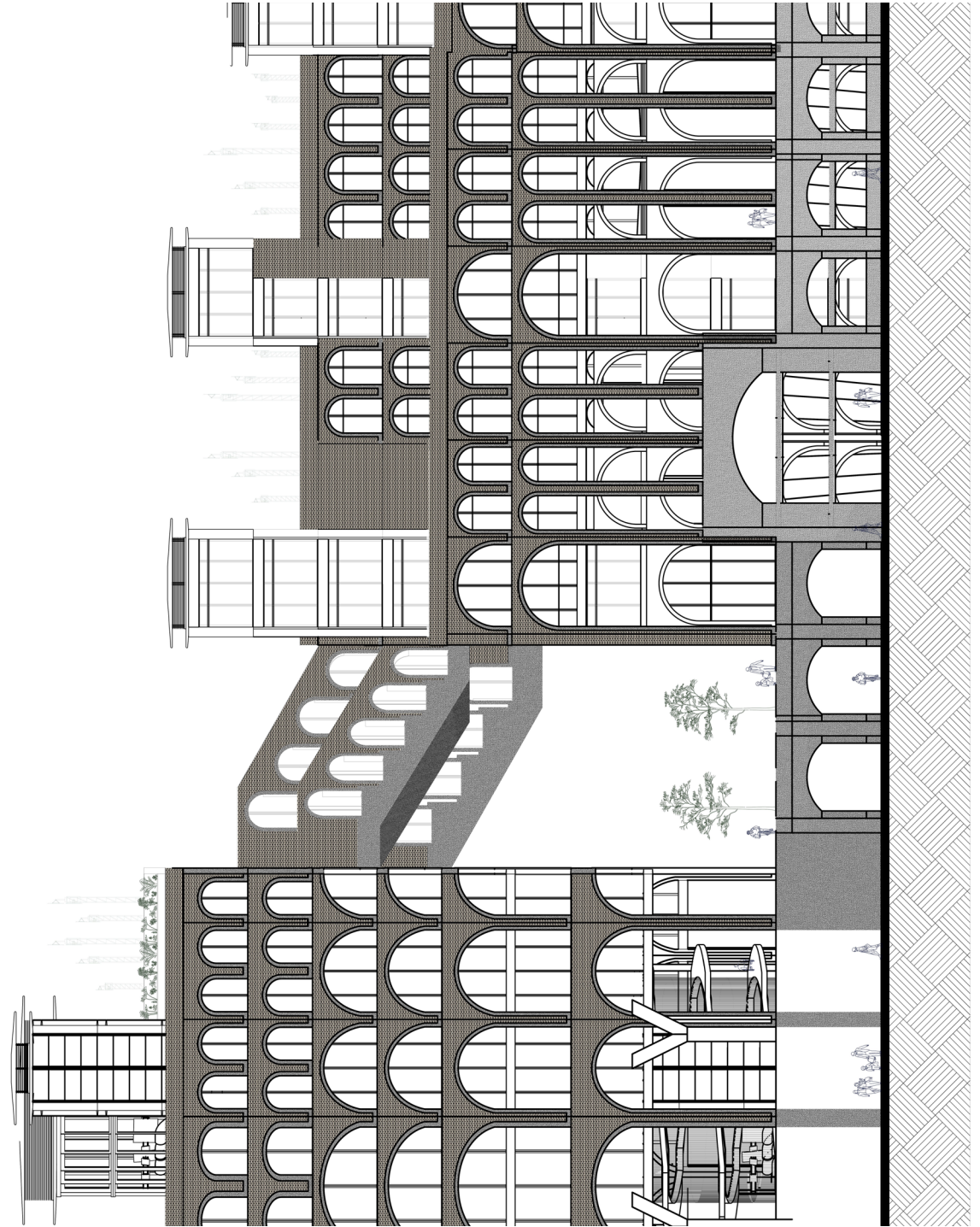
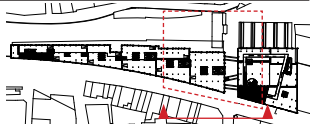


Project 001. Think Deep
Drawing Plan -2, platform level
Scale 1:200 25%
Paper format 255mm x 155mm
Date 30/06/2024
Comments City of the Future Graduation Studio
Hanlin Stuer 5016959

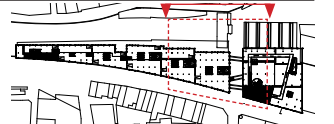


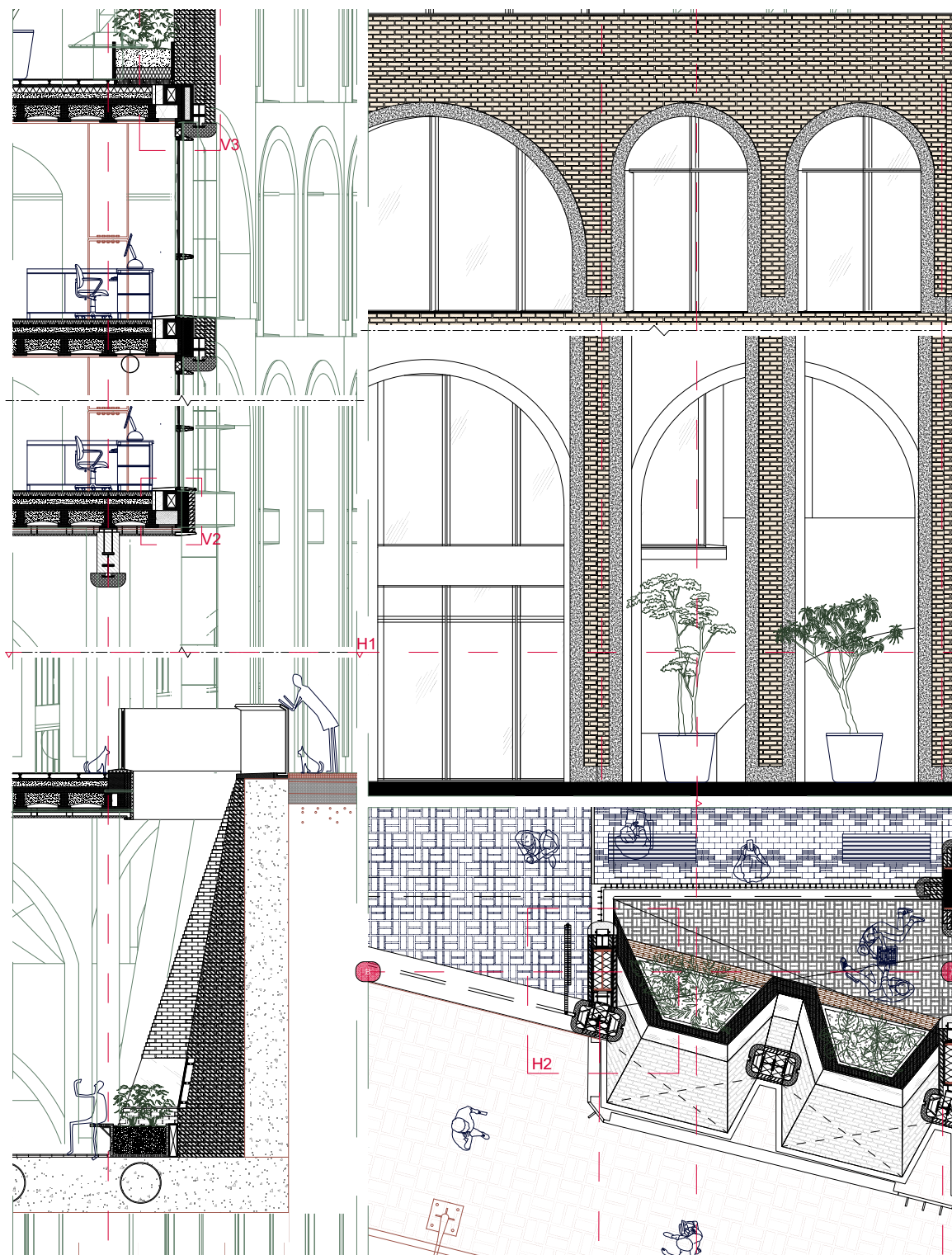


Project 001. Think Deep
 Drawing Facade SW
 Scale 1:200 25%
 Paper format 255mm x 155mm
 Date 30/06/2024
 Comments City of the Future Graduation Studio
 Hanlin Stuer 5016959

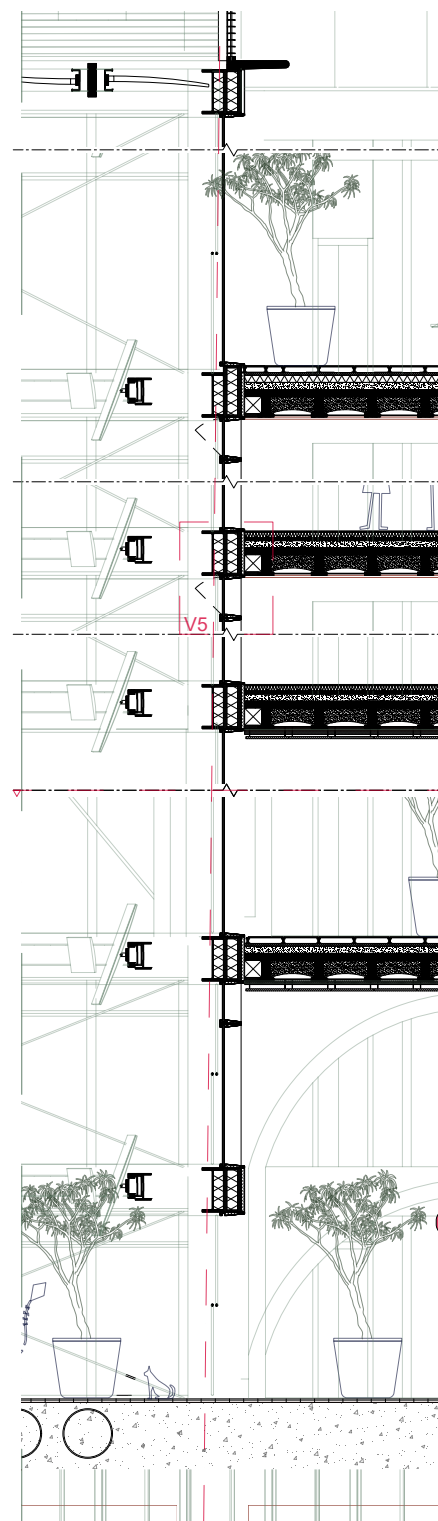


Project 001. Think Deep
 Drawing Facade NE
 Scale 1:200 25%
 Paper format 255mm x 155mm
 Date 30/06/2024
 Comments City of the Future Graduation Studio
 Hanlin Stuer 5016959



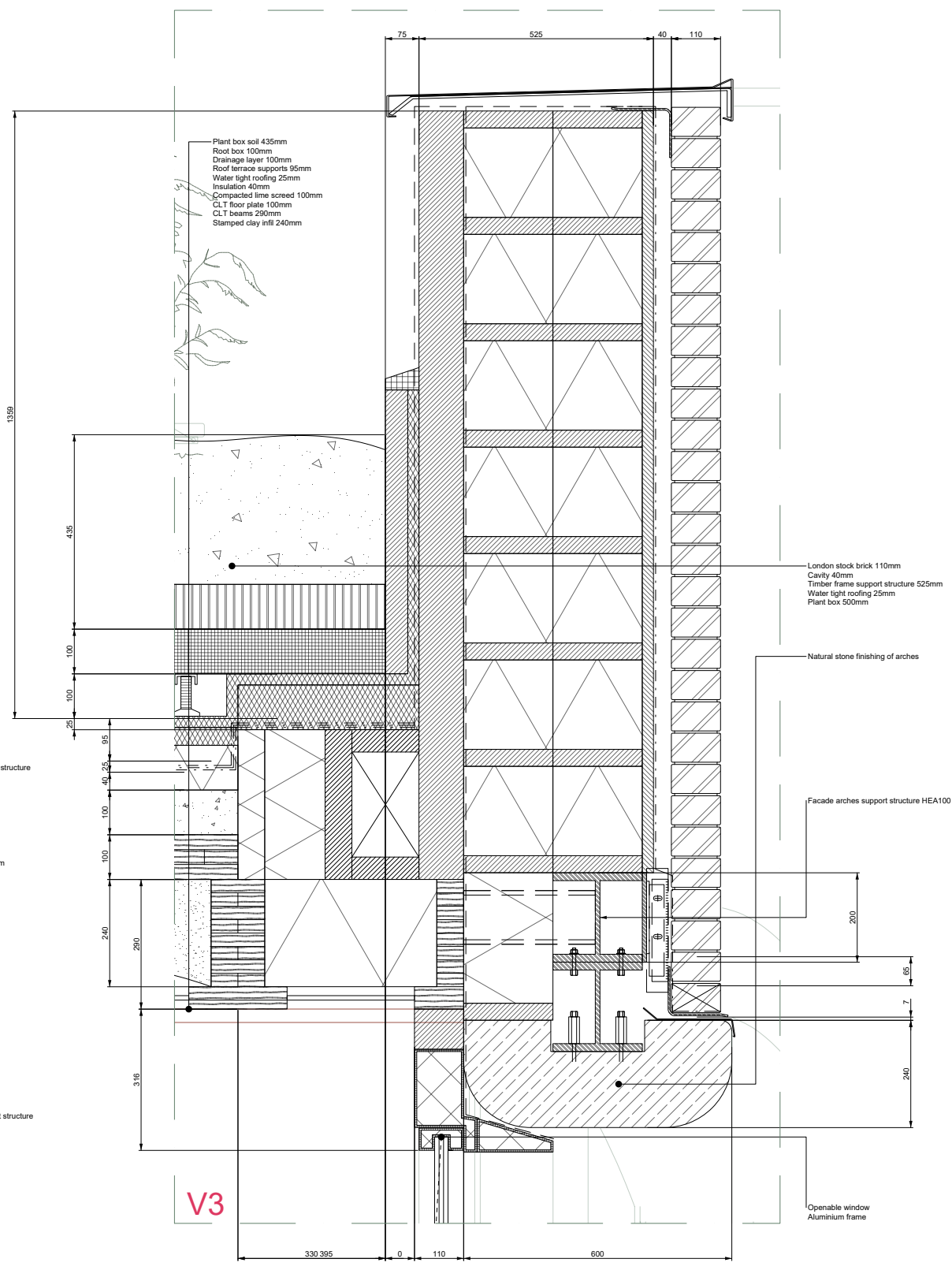
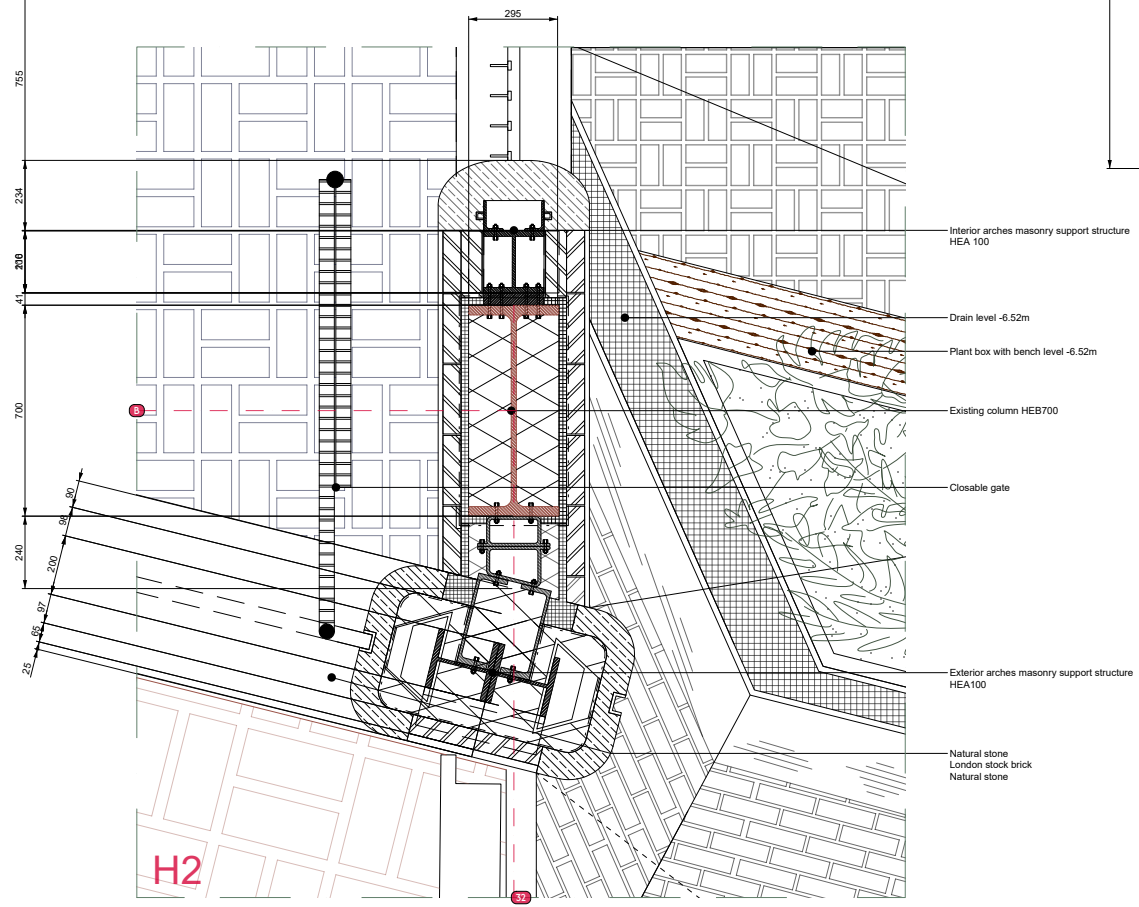
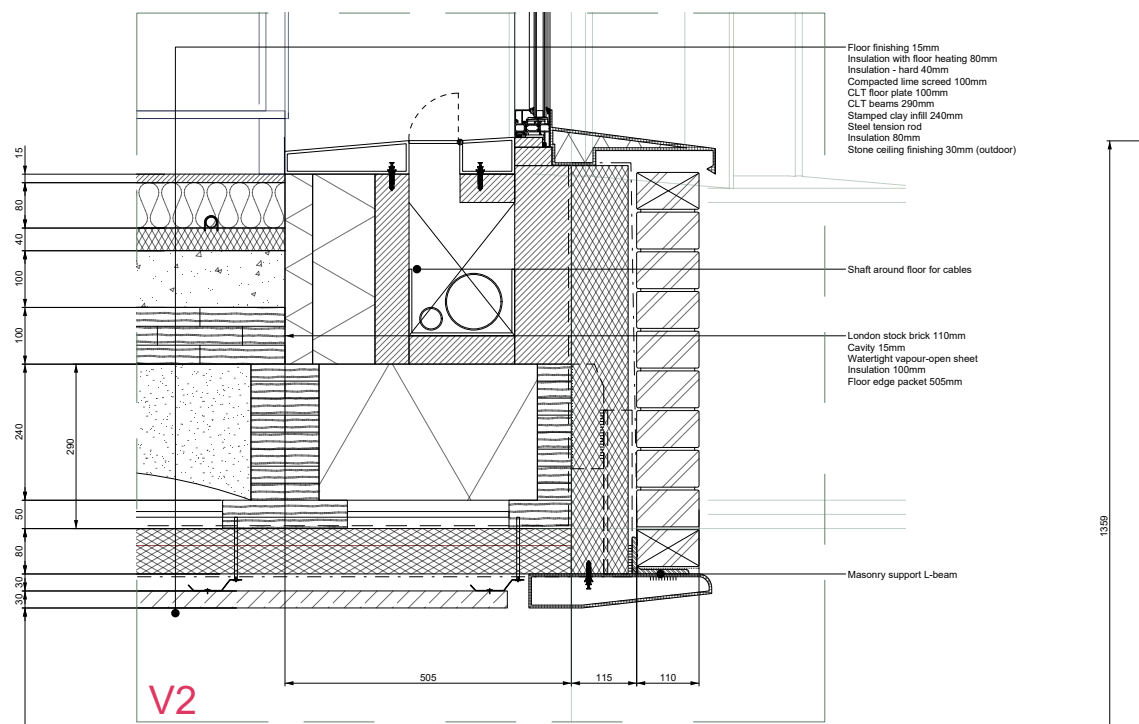


Project 001. Think Deep
Drawing Fragment 1
Scale 1:20 25%
Paper format 255mm x 155mm
Date 30/06/2024
Comments City of the Future Graduation Studio
Hanlin Stuer 5016959

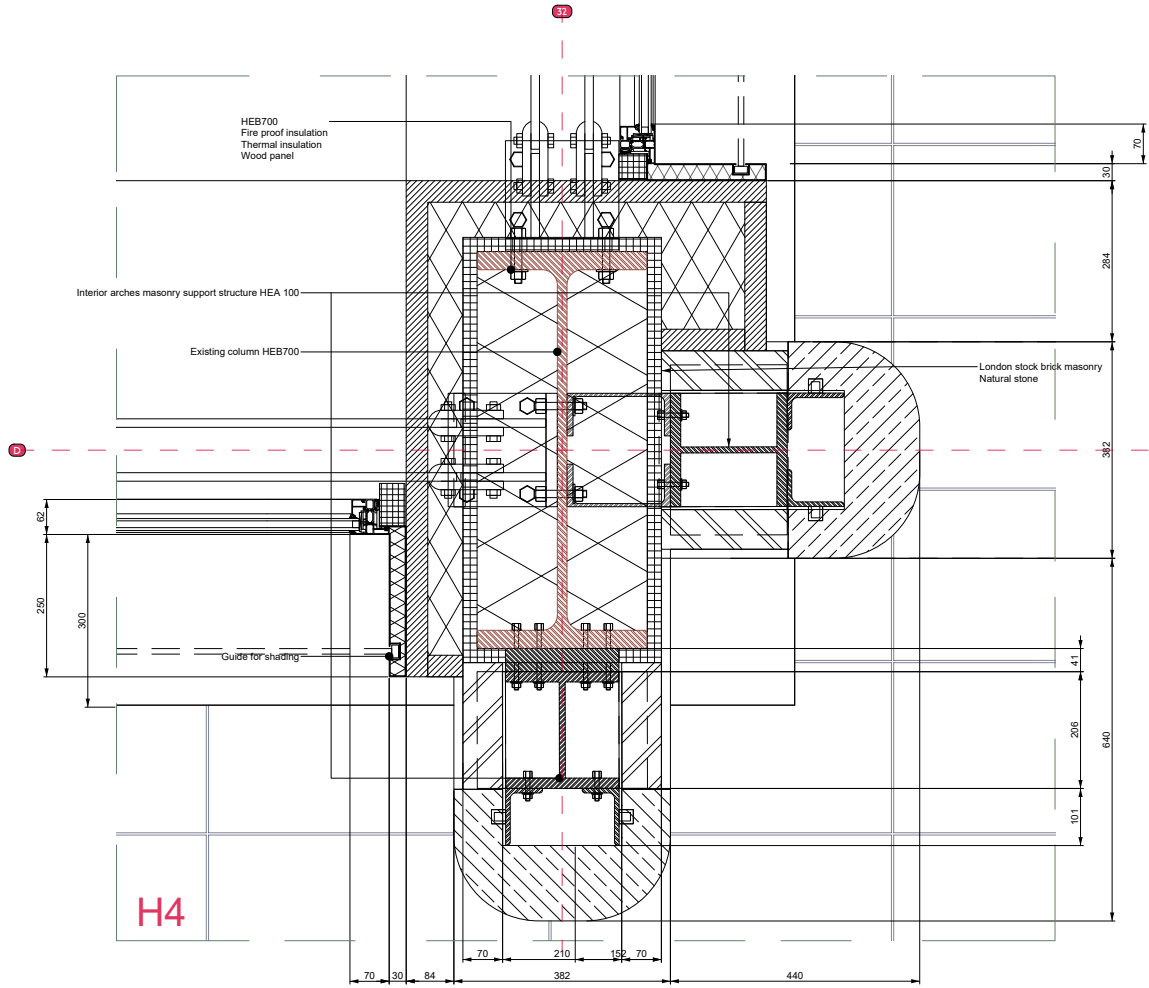
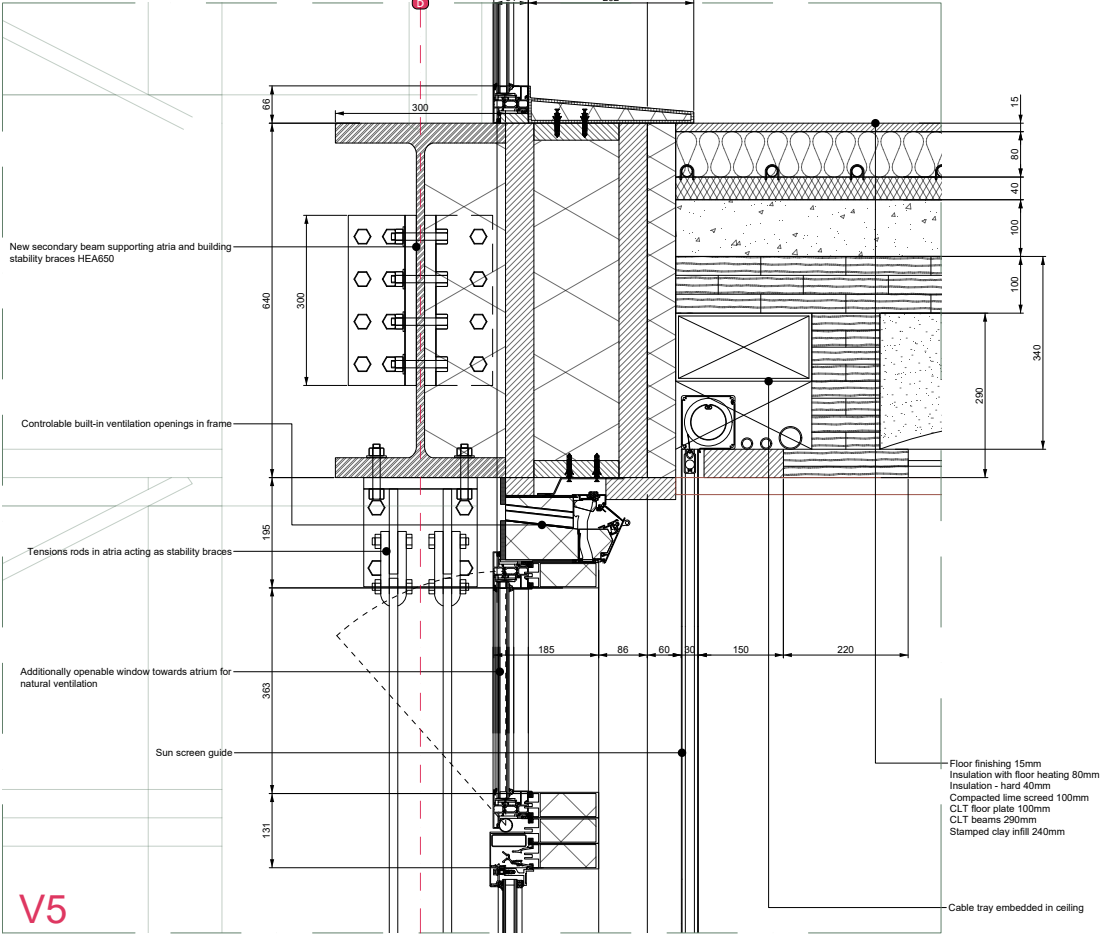


Project 001. Think Deep
Drawing Fragment 2
Scale 1:20 25%
Paper format 255mm x 155mm
Date 30/06/2024
Comments City of the Future Graduation Studio
Hanlin Stuer 5016959





Project 001.	Think Deep
Drawing	Details V2, V3, H2
Scale	1:5 37.5%
Paper format	255mm x 155mm
Date	30/06/2024
Comments	City of the Future Graduation Studio Hanlin Stuer 5016959



Project 001.	Think Deep
Drawing	Details V5, H4
Scale	1:5 37.5%
Paper format	255mm x 155mm
Date	30/06/2024
Comments	City of the Future Graduation Studio Hanlin Stuer 5016959

This graduation project represents an exploration of the potential for underground urban developments and develops a vision for these as an extension of the urban fabric. Initially, my interest in this subject prompted a side ranging investigation into various related topics presented for P1. Tutors pointed to the pitfalls of an insufficiently delineated problem statement and encouraged me to narrow the focus of my research. This feedback led to the establishment of a more defined research and design process, structured in three stages.

The first stage involved researching why underground development has not progressed in tandem with above-ground urban ambitions. This inquiry resulted in both technical and philosophical insights into the constraints of underground development, but primarily led to a conclusion on why the underground should be approached differently and regarded as a valuable, yet underutilized, urban space resource. The advantage of initiating from a theoretical standpoint was that it allowed for a comprehensive understanding of the opportunities the underground presents in the urban environment, in terms of why, how, where, and for whom, without any preconceived architectural notions. This understanding subsequently informed the site selection and initial design proposals based on its analysis, which was presented during P2.

Feedback from P2 emphasized the need to progress towards the design phase and guided the subsequent research and design steps. The focus turned to researching the architectural, urban design, and human experience aspects of underground cities, while setting aside more contextual disciplines such as planning and governance. The research continued by investigating the urban scale representation of the underground, how it

can facilitate new connections, strategic locations in cities for potential (re)development of underground space, elements required to create more liveable underground spaces, and how this applies to the chosen site. Although the design phase appeared to be delayed by the broad scope of the research, this allowed the design to be shaped and informed by insights gained and reflect the vision developed in the earlier stages.

The third part of the research focused on the building scale, examining more technical and specific design elements of the project. Brief research was conducted into all the crucial elements influencing the experience of underground spaces, including circulation, wayfinding, materials, daylighting, heat and energy, and seasonality. This part of the research was conducted concurrently with the design process, as new design ideas sparked additional research topics. Throughout this process, a continuous feedback loop was maintained relating to both design and research with all three mentors covering the fields of architecture, building technology, and urban design. Feedback was collected and incorporated into the design, often in ways that combined requirements and design elements from different disciplines.

The final architectural representation of the project is a mixed-use complex situated above and around the existing Farringdon underground stations. The design is predicated on transforming existing buildings, adding extra underground space, and connecting them to the context. The design incorporates the primary concepts of blurring the boundaries between above- and underground spaces, creating a public ground floor realm in the middle, and an idiosyncratic architecture that responds to the needs and opportunities of the underground addition.

Through this graduation project, I have gained substantial knowledge in the theoretical and practical aspects of underground planning, design, and construction. I have been able to experiment with novel approaches, refined my design process and feel I have a better understanding of how to tackle complex projects.

The project offered a unique opportunity to work in an environment that enables continuous interaction between design and research. While the primary design concept originated from the philosophical ideas explored in the initial research phases, the process underwent a shift after P2. Drawing out design ideas revealed new challenges that necessitated further research. This iterative process was instrumental for a speculative project like this one, leading to a bold proposal and vision for the future city that is in many ways feasible and conceivable.

The approach of integrating research and design proved effective in achieving a high-quality design for a complex project, based on a thorough understanding of the issues at hand. However, this method is time-consuming, which explains why such projects are in practice typically undertaken by large multidisciplinary teams. The City of the Future graduation studio and the AUBS master programme underscore the importance of multidisciplinary collaboration in devising integrated solutions for the built environment.

In this context, an architectural approach to the project necessitates an understanding of different scales and stakeholders, which is essential to formulating a vision for the future city. For instance, the proposed solution to the identified problems in this graduation project cannot be addressed solely within one discipline, but requires

a multifaceted perspective. Urban design plays a pivotal role in linking the building with its context and the city's broader network, as well as fostering urban life within the building's footprint. Likewise, building technology is indispensable for comprehending how the building can operate sustainably and how the structure can accommodate the proposed architecture.

This project offers a novel, yet feasible, perspective on the future city, thereby contributing academic and societal value through exploration and experimentation within future urban environments. The project's implications are hoped to inspire future work and practical applications, potentially leading to the realization of a project based on the proposed concepts.

From the outset, ethical considerations have been integral to the graduation project. This includes the concept of liberating the ground floor to create a more open, accessible, and livable city for all. Further considerations include designing for individuals with mobility impairments, prioritizing the needs of vulnerable road and public space users (such as pedestrians and cyclists), and creating space for diverse economic activities, particularly those outside the white collar professions that dominate in a competitive environment like London.

While aspects of the project may currently appear radical and conceptual, the rapid advancement of cities towards future-proof solutions and technological progress suggest that such visions may not be far off. The increasing number of projects that incorporate or consist of habitable underground spaces can be seen as heralding the transformation of redundant underground spaces such as car parks into vibrant extensions of our urban fabric, and create valuable new spaces in city centres which people love to frequent.

The question of whether subterranean development is the immediate solution to above-ground congestion is an intricate one. It is not a priori so in every situation. One could argue that the first step towards enhancing urban liveability is to address the city's reliance on automobiles and modify the urban landscape accordingly. However, even if private cars become obsolete, other forms of transportation, such as buses, shared rides, trams, and bicycles of varying speeds, will remain ubiquitous. These modes of transport still necessitate space and efficient street networks for city navigation. Moreover, the creation of additional public spaces for inhabitants to interact remains of paramount importance. Aside from merely seeking to relieve above ground pressure, this project also highlights the existence of numerous underground spaces in the city that are currently, or may become, obsolete. It presents a vision for the transformation of these spaces into habitable areas.

Another critical consideration is the permanence of underground interventions and the justification for new excavations or basement extensions. Robert Macfarlane, in his book "Underland," introduces the concept of "deep time," which refers to a timescale that surpasses our usual human references. He cites the example of mining equipment abandoned in depleted mines due to the prohibitive cost of retrieval. These artifacts may eventually become fossils from our era, surfacing millions of years later. The permanent nature of underground interventions, necessitated by the construction required to prevent collapse and leakage, can have a lasting impact on the subterranean ecology. Therefore, looking (deep) into the future is crucial when constructing underground. A start could be made by ending the current practice of creating basement levels with low ceiling heights and to build flexibility into underground spaces, akin to above-ground structures.

To conclude, this graduation project aims to provide a novel perspective on the future city. The potential of underground spaces in the urban environment remains vast and ripe for further exploration and development. The research and design process has broadened my horizon in multiple ways, and I hope to further explore this topic one day in practice.

bibliography

Admiraal, Han, and Antonia Cornaro. *Underground Spaces Unveiled: Planning and Creating the Cities of the Future*. London: ICE Publishing, 2018.

Bai, Yun. *Underground Engineering: Planning, Design, Construction and Operation of the Underground Space*. London [England] ; San Diego, CA: Academic Press, 2019.

Caves as the Origin of Architecture, 2023. https://www.youtube.com/watch?v=uE8hjzIRIFg&ab_channel=LouisianaChannel.

Chen, Renpeng, Gang Zheng, and Changyu Ou, eds. *Proceedings of the 2nd International Symposium on Asia Urban GeoEngineering*. Springer Series in Geomechanics and Geoengineering. Singapore: Springer Singapore, 2018. <https://doi.org/10.1007/978-981-10-6632-0>.

Endicott, John, Pamela Johnston, and Nancy F. Lin, eds. *Underground Cities: New Frontiers in Urban Living*. London: Lund Humphries, 2020.

Frampton, Adam, Clara Wong, and Jonathan Solomon. *Cities without Ground: A Hong Kong Guidebook*. Rafael, Calif.: Oro editions, 2012.

Golany, Gideon, and Toshio Ojima. *Geo-Space Urban Design*. New York, NY Chichester: Wiley, 1996.

Greater London Authority, ed. 'THE LONDON PLAN 2021'. Greater London Authority, March 2021. https://www.london.gov.uk/sites/default/files/the_london_plan_2021.pdf.

Harteveld, Maurice. 'Interior Public Space: On the Mazes in the Network of an Urbanist'. Delft University of technology, 2014.

Islington Council, ed. 'Islington Local Plan', September 2023. <https://www.islington.gov.uk/-/media/sharepoint-lists/public-records/planningandbuildingcontrol/publicity/>

[publicconsultation/20232024/islington-local-plan-adopted-strategic-and-development-management-policies-28-september-2023.f?la=en&hash=80F6F2C5E696F96BE4F115193190146B4556849B](https://www.islington.gov.uk/-/media/sharepoint-lists/public-records/planningandbuildingcontrol/publicity/publicconsultation/20232024/islington-local-plan-adopted-strategic-and-development-management-policies-28-september-2023.f?la=en&hash=80F6F2C5E696F96BE4F115193190146B4556849B).

Macfarlane, Robert. *Underland: A Deep Time Journey*. First published as a Norton paperback. New York, N.Y: W.W. Norton & Company, 2020.

Oćłoń, Paweł. *Renewable Energy Utilization Using Underground Energy Systems*. Vol. 84. Lecture Notes in Energy. Cham: Springer International Publishing, 2021. <https://doi.org/10.1007/978-3-030-75228-6>.

Pimlott, Mark. *The Public Interior as Idea and Project*. Heijningen: Jap Sam Books, 2016.

Pimlott, Mark, and Eleonoor Jap Sam. *Without and within: Essays on Territory and the Interior*. Rotterdam: Episode Publ, 2007.

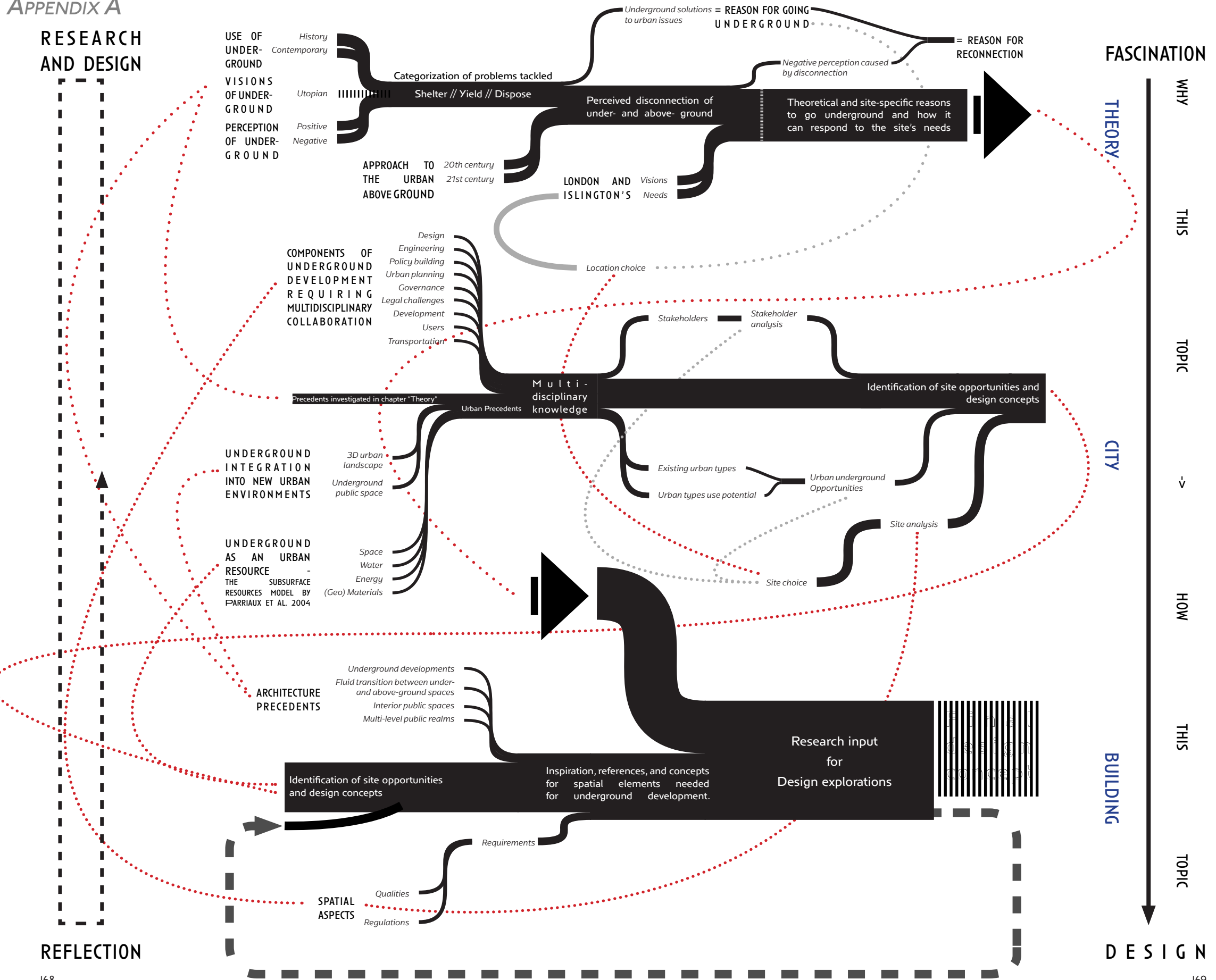
Seo, Soo-yeon, Byunghee Lee, and Jongsung Won. 'Comparative Analysis of Economic Impacts of Sustainable Vertical Extension Methods for Existing Underground Spaces'. *Sustainability* 12, no. 3 (29 January 2020): 975. <https://doi.org/10.3390/su12030975>.

United Nations. 'World Urbanization Prospects The 2018 Revision'. World Urbanization Prospects. New York, N.Y, 2019.

Von Der Tann, Loretta, Stefan Ritter, Sarah Hale, Jenny Langford, and Sean Salazar. 'From Urban Underground Space (UUS) to Sustainable Underground Urbanism (SUU): Shifting the Focus in Urban Underground Scholarship'. *Land Use Policy* 109 (October 2021): 105650. <https://doi.org/10.1016/j.landusepol.2021.105650>.

RESEARCH
AND DESIGN

FASCINATION



REFLECTION

DESIGN