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SENSITIVE INTEGRATION OF UNDERGROUND SPACES IN HELSINKI'S URBAN FABRIC: FROM GEOLOGY TO ARCHITECTURE

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Abstract: The increasingly prevalent development of planning underground urban spaces and their application in urban environments raises new questions related to the design of underground structures. Specifically, the challenges in designing underground structures within the geological space and the emergence of new imaginary representations in the world of architecture necessitate a reevaluation of the role of the underground architect in the future and the further advancement of urban environments. This paper explores new approaches to urban design that would help address the current ecological and sociological challenges faced by today's urban environments. As a model, existing underground spaces in Helsinki (Finland) were studied, focusing on how, through architectural and sensory perception, these spaces can evolve into eco-socially acceptable areas, overcoming the current limitations posed by established practices, regulations, and standards. The methodological approach is based on a dialogue between multiple scientific fields: architecture, urbanism, cognitive sciences, geology, and engineering. The aim of the research is to develop specific methodological tools for future underground architects, which would enable a better understanding of underground urban spaces, their sensitivity in pushing the boundaries of design, and their integration into existing urban environments. In addition to revealing that the role of the architect in a highly technical-technological environment is complex, the paper also demonstrates a structural gradation from the geological dimension to architectural space, through human perception, to the graphic and sensory representation of underground structures, thereby illustrating the specific methods used in the study of selected underground spaces. As a result, guidelines and recommendations emerge, intended for project managers seeking tools to mobilize new skills in the field of underground space/structure design. Therefore, this paper should not be interpreted as a list of reproducible solutions for every territory but rather as a sharing of research tools and methodologies applicable in professional practice.

Keywords: Eco-social Resilience - Helsinki - Spatial Materiality - Sensory Perception - Underground Architecture

1. INTRODUCTION

This study is part of our final-year project at architecture school. It stems from a personal and professional inquiry developed over the years: the role of the underground in the making of the contemporary city. Too often reduced to an abstract line on a plan or confined to purely technical use, the urban ground appeared to us as the hidden side of the city, full of architectural, urban, and sensory potential that remains largely untapped. From this arose a central reflection: how can we recover the memory of these invisible spaces? How can we reveal their sensory and imaginative dimensions?

The city of Helsinki emerged as an ideal case study. Known for its exemplary underground planning policy, its favorable granite geology, and a network of underground spaces carefully integrated into urban planning, Helsinki

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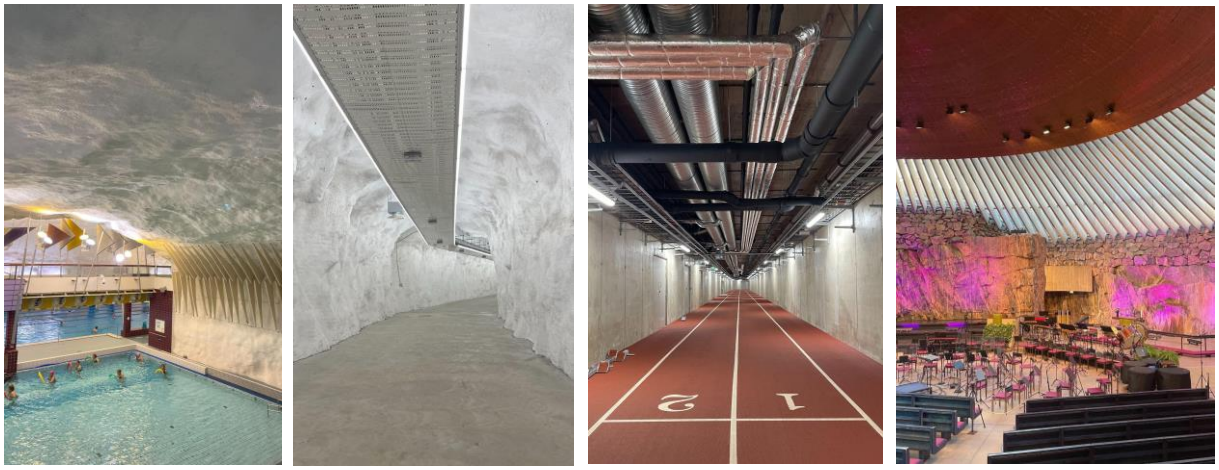
represents a model still largely unknown to the general public. These spatial configurations—sometimes monumental, often invisible, deeply resonated with us (see Figure 1)



Set of photographs of the underground spaces in Helsinki, taken during the survey in November 2023.

As future architects, we felt the need to explore a new way of thinking about the city, one that complements the approaches taught in traditional academic curricula. An approach that addresses environmental, social, and technical challenges while also enhancing the sensory richness of architectural experience. The central question guiding our work is: **In a context of urban densification, environmental crises, and increasing demands for sustainable infrastructure, how can a redefinition of the architect's role contribute to enriching urban underground environments?**

Our approach is based on two complementary axes. The first involves developing specific methodological tools to understand underground spaces, their dynamics and their potential for integration within the city. The second aims to translate these tools into concrete architectural proposals that embody the spatial, constructive, and sensory qualities of the subterranean realm. These experiments were carried out at multiple scales, from urban readings to architectural details, and led us to challenge certain traditional graphic representation methods. Indeed, how can we represent and convey the experience of inherently invisible spaces? What kind of narrative can we develop to legitimize their inclusion in the contemporary urban story?

Our project presents a series of architectural fragments designed as interfaces between the surface and the underground, revealing the richness of Helsinki's subterranean landscape. It is both a critical investigation, questioning the conventional functions of the underground (technical, logistical, hidden), and a sensitive proposal aimed at renewing urban imaginaries. By moving beyond purely technical considerations, we strive to adopt a holistic approach to underground architecture, interweaving geological knowledge, spatial design, and human perception. This exploration highlights the impact of underground materiality on the senses, on usage, and on memory with the goal of designing spaces that are sustainable, sensorially rich, and meaningful. This study is intended for anyone interested in the urban invisible: architects, urban planners, engineers, artists, geologists, or simply the curious. It aims to reinvent our relationship with the ground and to open the way for a new way of imagining and designing the city, one that is conceived simultaneously above and below ground, in response to the challenges of tomorrow.

2. MATERIAL AND METHODS: HOW TO GRASP THE INVISIBLE SPACE FROM A METHODOLOGICAL PERSPECTIVE?

To carry out this research project, we established a structured methodological framework divided into several chronological phases, with the goal of designing architectural proposals presented in the third part of this work. This methodology is organized around three key stages: before our stay in Helsinki (preparation and research), during our time on site in November 2023 (fieldwork, surveys, documentation), and after, through a cartographic production informed by our observations. Our approach thus lies at the intersection of three complementary modes of inquiry: theoretical research (state of the art), action-based research (in situ exploration tools), and research through creation (by translating our analysis into design proposals).

2.1. Theoretical Contribution on the Underground: Conceptualization and State of the Art

Initially, we relied on a theoretical framework to familiarize ourselves with certain concepts related to the underground and to conduct a state-of-the-art review of writings on the underground spaces of Helsinki before proceeding with our fieldwork.

The term "urban mangroves", borrowed from architect David Mangin[3], is used to describe the dense and branching underground networks of large cities, resembling the roots of a mangrove. It highlights the interplay between transport hubs, destinations, and interfaces in excavated spaces. These spaces, though underground, are highly valued for their commercial profitability and their ability to facilitate urban mobility. However, this raises the question of whether these spaces can accommodate uses beyond commerce. According to Deleuze et Guattari[4], the root represents a centralized, hierarchical system. In contrast, the rhizome embodies a horizontal, decentralized structure that is in constant expansion. When applied to underground urban networks, it reveals a multitude of connections between independent cores. Unlike the mangrove, the rhizome provides a relevant theoretical framework for thinking about the complex organization of the underground.

Additionally, we drew upon four underground projects that illustrate different contemporary uses of the underground, revealing both its potential and its limitations. The Earthscraper in Mexico city[5] demonstrates that excavation allows for densification without affecting heritage, but it raises social, regulatory, and acceptability issues related to underground living. Data centers and logistical tunnels[6] reveal a strategic use tied to technology, but raise concerns about surveillance, data security, profitability, and energy sustainability. Underground farms[7] respond to the scarcity of urban agricultural land but raise questions about artificiality, energy consumption, and ecological viability. These cases raise a central question: how far can we legitimately dig, and under what conditions?

To frame our approach, we also integrated theoretical references on the concept of the underground, particularly through the idea of the Critical Zone. This concept, developed by researchers such as Bruno Latour, refers to a thin layer of the Earth where rocks, water, life, and humans interact.[8] It allowed us to reposition the underground as a living, dynamic space, constantly interacting with its environment. In parallel, we drew upon the work of architects, artists, and writers on the sensory perceptions of architecture. These references guided our attention toward the materiality of the ground, the atmospheres, and the perceptible clues within underground spaces. As architect Bruno Barroca notes, "The quality of these thick or interior spaces, mostly invisible from the outside, is primarily assessed through the experience of the body in motion, the factors of ambiance (light, heat, sound, smell...), and the clarity of their organization"[9].

2.2. Surveying the City of Helsinki: Between Sensory Mapping and Exchanges

In November 2023, we spent around ten days in Helsinki to conduct an in-depth field survey and further develop our methodological approach. This immersion allowed us to confront our initial hypotheses with on-the-ground realities through meetings with specialists in architecture, urban planning, engineering, and geology. We also employed various observation tools, such as photography during visits to underground spaces, sound recordings to capture the atmosphere of these places, and short street interviews aimed at gathering perceptions, subjective representations, and imaginaries held by Helsinki's residents regarding the presence of the underground in their city.

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[3] Mangin, D. & Girodo, M. (2016). Mangroves urbaines : du métro à la ville (Paris, Montréal, Singapour), Paris : La Découverte (collection Dominique Carré).

[4] Krtolica, I. (2021). Le rhizome deleuzo-guattarien « Entre » philosophie, science, histoire et anthropologie. Rue Descartes, 99, 39-51. https://doi.org/10.3917/rdes.099.0039

[5] Tahmasebinia, F., Yu, K., Bao, J., Chammoun, G., Chang, E., Sepasgozar, S., & Alonso Marroquin, F. (2020). Earthscraper: A Smart Solution for Developing Future Underground Cities. IntechOpen. doi: 10.5772/intechopen.87217

[6] Beqiri, J. (2021). The implications of technological progress in architectural thinking: The future impossibility for an architecture of hiding. IOP Conf. Series: Earth and Environmental Science 703 012001, doi:10.1088/1755-1315/703/1/012001

[7] Labbé, M. (2016). Architecture of underground spaces: From isolated innovations to connected urbanism. Tunnelling and Underground Space Technology.

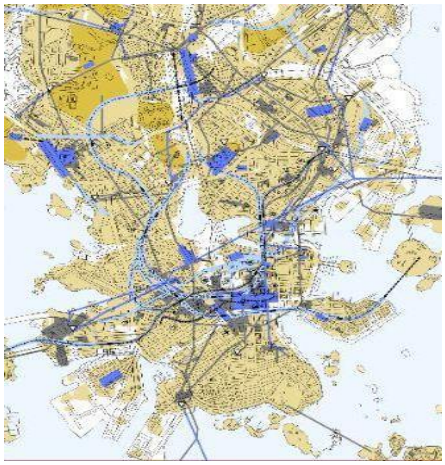
[8] Gaillardet, J., & Boudia, S. (2021). La Zone critique : Vers de nouvelles pratiques scientifiques pour réduire les ignorances dans l'anthropocène. Revue d'anthropologie des connaissances, 15(4). https://journals.openedition.org/rac/25340

[9] Barroca, B. (2019). Espaces souterrains et synergies spatiales. Communications, 105(2), 195–205.

2.3. Cartographic Methodology Post-Surveying

Following our field survey, various site recordings, and the documents available to us online, we developed a cartographic analysis method structured around three key aspects: first, underground urban planning, including an understanding of the existing masterplan; second, an analysis of the underground landscape in relation to the geological characteristics of the ground; and finally, a study of the in-between spaces that connect the surface and the underground.

1. Analysis of Underground Urbanism: Overall Concept of Development and Planning of Underground Space in Helsinki



Master plan of Helsinki's underground spaces, created by the City of Helsinki's Urban Planning Department and approved in December 2010.

In Helsinki, the planning of underground spaces is governed by a masterplan developed as early as the 2000s, based on a long-term strategic management approach. This guiding plan, which is regularly updated, coordinates current and future uses of the underground in relation to the surface urban fabric. It identifies available bedrock resources, allocates land reserves, and defines planning criteria such as soil quality, accessibility, and potential uses. More than 200 kilometers of tunnels and 400 underground facilities have already been documented.[10]

Based on this masterplan, the method of depth-layer decomposition helped clarify the vertical organization of underground spaces in Helsinki, which is often difficult to interpret in traditional plans. Each stratum serves specific functions: the levels closest to the surface (K1 to K2, up to -5 meters) accommodate cellars, shops, and parking facilities, while intermediate levels (down to -30 meters) house the metro and deeper parking structures. The lower layers (down to -70 meters) are reserved for road tunnels, military, and technical infrastructures. This stratification reveals a lack of direct interconnection between levels, with the few existing links being of a military nature.

Excerpts of plans showing different depth layers of underground spaces in central Helsinki (1: between -10 and -20m; 2: between -30 and -40m; and 3: between -40 and -70m), personal work, 2024.

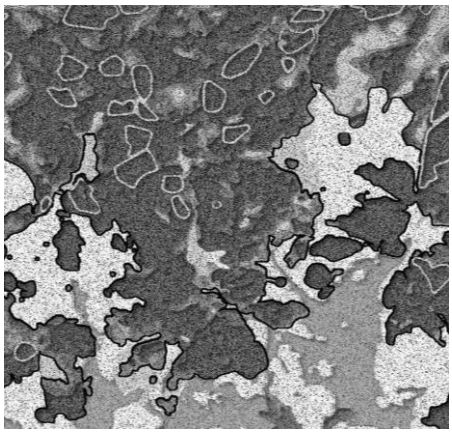
2. The Underground Landscape of Helsinki: Geological Foundation and Architectural Potential

The underground landscape of Helsinki reveals its complexity and geological history through its visible rock stratifications on the map (Figure 5). The predominant presence of plutonic rock, particularly granite, is shown in orange. The geotechnical properties of Helsinki's soil are bimodal, consisting of soft clay and hard bedrock. One-third of the ground is made up of clay with an average thickness of 3 meters. The average depth of the bedrock substrate is 7 meters, but it varies from 0 to 70 meters.[11] This hard and relatively shallow bedrock is ideal for excavation by blasting, requiring minimal support and providing a stable foundation for construction.

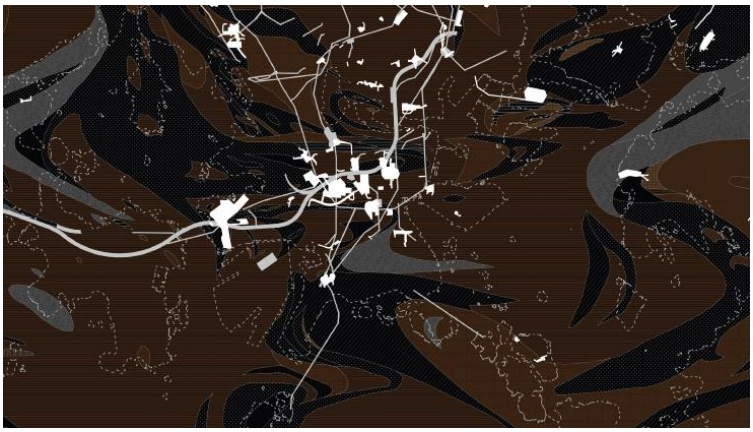
[10] Vähäaho, I. (2018). Urban Underground Space - Sustainable Property Development in Helsinki. City of Helsinki, Urban Environment Publications. ISBN 978-952-331-436-8

[11] Ikävalko, O., Satola, I., & Hoivanen, R. (2016). Helsinki TU1206 COST Sub-Urban WG1 Report (22 p.).

The city has strategically reserved vast rocky areas for future developments, recognizing their potential. These favorable geological characteristics, combined with the harshness of the winter climate, have been the main drivers behind the development of this unique underground dimension in Helsinki.



Map of the bedrock depth and designated rocky zones in Helsinki, personal photograph, 2024.



Guide map of Helsinki's underground spaces overlaid on the rock strata, personal work, 2024.

3. Survey of Interfaces Between the Underground World and the Aboveground World

The survey of interfaces served as a methodological tool to analyze the relationship between underground spaces and the surface. By identifying and mapping visible surface clues, such as staircases, elevators, ventilation shafts, light wells, military doors, and more, we were able to decipher the hidden morphology of buried infrastructures. This work relied on a detailed reading of the urban landscape, combined with an overlay of underground and aerial plans to locate and classify the interfaces into eight major typologies, which we will analyze later.

This survey made the invisible visible, helped us understand the flows (air, light, matter) between the two levels, and questioned their complementarity. It reveals the necessity to conceive surface and underground spaces jointly, within a logic of integrated synergy.

3. RESULTS: CONCLUSIONS DRAWN FROM THE METHODOLOGICAL TOOLS

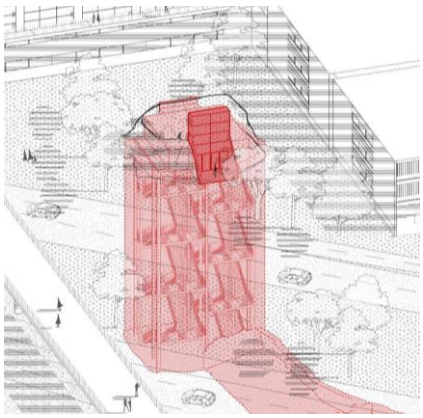
Returning to the central question concerning the architect's role in designing underground spaces and their use of the methodological tools employed, we now present the conclusions drawn from these analyses. These results shed light on new perspectives for integrating the underground into urban projects, taking into account its spatial, technical, and sensory specificities.

3.1. A "peri-urban" underground space

The hypothesis of an underground city in Helsinki is actually invalidated by the way the subsurface is used. It does not form an integrated urban network but acts as a dependent and subordinate space. Like the suburban belt, the underground surrounds the city and serves it, but does not function autonomously. It mainly hosts technical or service functions, similar to those historically relegated to the urban outskirts. This functional and symbolic marginality reinforces its status as a "suburb of the above-ground," according to Monique Labbé[12]. The underground becomes a receptacle for what the surface rejects, despite strategic planning. This raises questions about the sustainability of its exploitation and the limits needed to avoid depleting the geological resource.

[12] Labbé, M. (2004). Offre et demande d'espace souterrain. In Vingt mille lieux sous les terres: espaces publics souterrains. Lausanne : PPUR presses polytechnique, p.167

3.2. Atlas of interface typologies in Helsinki through redrawing and surveys



Excerpt from the illustrations of the atlas of interface typologies in Helsinki, personal work, 2024.

Based on our photographic surveys conducted on-site in Helsinki and a cross-analysis of urban plans, we identified and redrew eight typologies of underground interfaces. The kiosk, a small access structure often located on sidewalks, provides a sheltered transition to the depths. The station, more developed, offers a designed threshold, marking a symbolic pause. The concealed interface, intended for emergencies, remains invisible and inaccessible under normal circumstances. Respiratory structures enable ventilation, though they remain discreet at the surface. The significant device stages a view into the underground, giving public value to the buried space. The fissure in the rocky landscape inserts itself into the granite, evoking depth without explicitly revealing it. Gentle, raw, and expansive slopes accommodate vehicles and sometimes pedestrians leading to deeper spaces. Finally, the emerging shaft, a small discreet element, signals the presence of the underground at the base of façades. Each interface has been graphically reconstructed to reveal the spatial, functional, and symbolic logics of the connection between surface and underground.

3.3. The materiality of the subsurface: an organism of flows

In Helsinki, the qualities of the underground are primarily determined by its bedrock. However, the quality of an underground space is not limited to the quality of its rock. The subsurface is a complex domain at the heart of the "Critical Zone," where interactions occur between the atmospheric, hydric, geological, and biological spheres[13]. Its materiality is a dynamic entity, formed through the progressive transformation of matter[14], capable of evoking physical sensations and psychological interpretations through its depth, density, and texture. Architect Clotilde Félix-Fromentin describes it as a "giant organism"[15] traversed by flows of materials and information.

Observations in Helsinki reveal this complexity. Uncoated rock walls show tectonic fractures, tool marks, and chemical reactions, such as green, white, and brown stains caused by interactions between living and non-living elements. These phenomena, including efflorescence from water on sprayed concrete and green stains linked to moisture, illustrate constant interactions. Small basins collecting water leaks from ceilings provide a concrete example of managing these material flows and their influence on design.

Therefore, underground architectural design must respond to this changing environment by considering these flows and interactions to ensure the safety and viability of the spaces. Rather than hiding these physical and chemical reactions, which are often perceived as flaws, the challenge is to integrate them in order to affirm the unique identity of the underground landscape. This requires careful planning to address geotechnical risks and ensure the resilience and sustainability of these structures.

Organic reaction, water collection cups, marks left by drilling tools, efflorescence phenomenon, Formula Center leisure center, personal photographs, november 2023, Helsinki.

[13] Valentin, C. (2018). Les sols au cœur de la zone critique (Série Les sols). ISTE editions.

[14] His, G. (2015). La matérialité comme récit : d'un récit culturel à la production d'une pensée. Bulletin des bibliothèques de France (BBF), (4), 30-44.

[15] Grout, C., Blain, C., Coulais, J. F., Françoise, C., Sylvie, S., Guillerme, A., et al. (2017). La ville souterraine : représentations et conception. La part de l'invisible (Vol. Les dossiers du Latch). L/E de Lille.

3.4. Sensory cues of the underground world: rethinking the design of subterranean architecture

Drawing on observations made in Helsinki and various case studies, we explored the materiality of the underground through human perceptions, focusing on key themes: matter, light, temporality, and vegetation. Underground spaces possess a unique spatiality where sensations are heightened due to their intrinsic characteristics. Their design requires a different approach than surface projects. What are the sensory cues of the underground world? How does the relationship between users and their environment make the underground perceptible? Colonizing the subsurface should not simply be an escape from surface spaces. Burial should not be a way to avoid. To reinvest the imagination in these spaces, they must strive to "create a world." Underground architecture must therefore consider atmospheres more extensively to offer a pleasant and sensitive experience.

Matter and surface constitute the very essence of the underground experience, where perception goes beyond simple geometry to embrace an aesthetic and empathetic dimension. In these spaces, matter predominates and shapes form, directly influencing our comfort and sensations. The choice of robust materials such as stone and concrete, essential to withstand underground constraints, presents the challenge of preserving the intrinsic identity of these places. To achieve this, a technique of partial lining is often favored. This method involves leaving natural rock or the primary structure exposed in places. Far from being a mere artifice, this scenographic revelation of raw material highlights the power and thickness of the surrounding mass, offering a tactile and visual understanding of the environment.

In Helsinki, the underground material, notably granite, is intrinsically linked to architectural design. Its structural robustness is fundamental, of course, but it is through the subtle play of its finishes, the light that sculpts it, and the sensation it produces to the touch that it becomes an essential actor in creating sensory atmospheres.

Light plays a direct role in the design of underground spaces, influencing their quality, habitability, and acceptance. Often perceived as dark and oppressive, the underground can instead become a sensitive and attractive place through careful use of natural light, without necessarily relying on artificial lighting.[16] Natural light reveals the carved volumes, structures atmospheres, marks thresholds, and guides the perception of emptiness. Due to its rarity, it enhances contrasts and strengthens the spatial experience. Devices such as light wells, narrow openings, or reflections create subtle connections with the outside. Light can also blur the boundaries between surface and depth, challenging the distinctions between interior and exterior.[17] Finally, it contributes to orientation, thermal comfort, and sensory acclimatization upon descent.

Projections of colored lights on the rock wall of the Finlandia parking lot, personal photograph, november 2023, Helsinki.

To enrich the experience of underground spaces, artificial lighting remains essential, allowing the creation of a "unity without uniformity." Architects distinguish five types of lighting atmospheres: base lighting (indirect, diffuse, warm), threshold lighting (such as showers or light gates), pathway lighting (regular punctuations), line lighting (graphic, colored, emphasizing movement), and event lighting (exceptional installations).[18] Depending on the project, light sources may be either prominently visible or skillfully concealed.

Colored illumination of the vaults in the cold water reservoir in downtown Helsinki. https://www.researchgate.net/publica - tion/326914950_Urban_Underground_Space_S ustainable_Property_Development_in_Helsinki

Tubular structures bringing natural light into the Potsdamer Platz Berlin metro station. https://www.krapfag.ch/en/reference-projects/metal-construction/light-pipes-berlin-potsdamer-platz/

16 Zunino, G. (2013). Pour une urbanité souterraine de qualité. Urbanités.

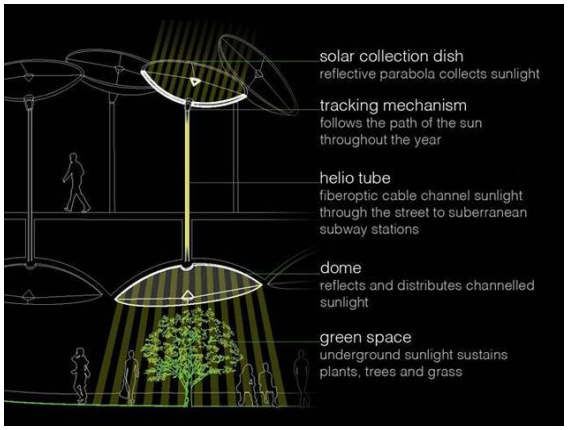
17 Thibaud, J-P. (1996). Mouvement et perception des ambiances souterraines.

18 Kohn, B., & Vaysse, J. P. (2004). Stratégies du projet souterrain : charte architecturale du métro du Turin. In P. Von Meiss & F. Radu (Éd.), Vingt mille lieux sous les terres : espaces publics souterrains (pp. 136-147). Presses polytechniques et universitaires romandes.

Temporality can initially be approached through adaptability and shared use [19], allowing the underground to be thought of as an evolving space capable of hosting multiple functions depending on the time (day/night, seasons, future uses). In Helsinki, the climatic contrasts emphasize the value of these stable and protected spaces. Their design must anticipate reversible and overlapping uses, integrating sensitive interfaces between surface and underground (light, air, water, sound) from the early design stage. This approach helps to anchor the underground within the urban system as a fully-fledged public space.

Considering temporality in the design of underground architecture also means addressing the impact of the absence of natural temporal cues on users, a challenge especially relevant in climates like Helsinki, where dependence on daylight is reduced. Studies have shown that deprived of sunlight and time indicators, individuals develop "social clocks" to adapt, highlighting human resilience and the need to recreate these temporal references.[20] To counter temporal disorientation, designers incorporate solutions such as lighting that simulates the circadian cycle[21], reproducing the intensity and color of natural light. Additionally, integrating light wells or windows in semi-buried structures, as seen in the Amos Rex Museum, helps maintain a visual connection with the outside and allows users to perceive the passage of time. Ultimately, the goal is to minimize the disruption between the surface rhythm of life and the underground experience, thereby ensuring user well-being and functionality.

From a certain depth, the temperature of the underground remains stable, independent of daily weather variations such as rain, wind, or sunlight. Often, the physical boundary between the underground space and the outside is airtight and insulated from temperature fluctuations.[22] However, the perception of the climate by users remains a challenge, as elements like air temperature, humidity levels, and air movement serve as important sensory cues.[23] To compensate for this sensory disconnection, architects explore innovative solutions. For example, artistic or structural devices, such as the moving cables at Saint-Maur station or Susumu Shingu's kinetic sails at Osaka airport, are designed to make the invisible presence of air and its movements perceptible, enriching the underground spatial experience. Water, although a major technical constraint, is also used to connect the underground to the surface: water leaks from groundwater tables can indicate external hydrological and climatic conditions, as demonstrated by Kungsträdgården station and the Temppeliaukio Church. Rainwater is deliberately allowed to flow along the rock walls, creating a visual and sensory connection to the outside.



Lowline Project, transmission of natural light via fiber optics, designed by James Ramsey and Dan Barasch
http://thelowline.org/about/project/

Vegetation positively influences users' perception and the functionality of spaces, demonstrating that life can thrive underground. It enhances aesthetics and purifies the air, making the environment more acceptable and welcoming. Scientifically proven, exposure to nature, even underground, has therapeutic effects on psychological, cognitive, and physiological health, reducing the fear of confinement.[24] To overcome challenges related to the absence of natural light, innovative solutions such as fiber optic transmission have been developed, enabling photosynthesis and plant growth. Finally, the integration of green walls and the selection of suitable plants improve acoustic comfort and open future possibilities, such as underground agriculture, to optimize space use.

19 Pradel, B. (2013). Processus de réversibilité et rythmes des transformations urbaines : penser la ville à pile ou face ?. in Scherrer, F. & Vanier, M., Villes, territoires, réversibilité. Paris : Hermann, pp. 237-248

20 Tafforin, C., Christian, C., & Roumian, J. (2023). Social Clock and Social Sun as Adaptive Strategies of Human Behavior Without Time Cues and Sunlight in an Underground Environment. Journal of Humanities and Social Sciences Studies, 5, 15-26.

21 Duez, H., & Pourcet, B. (2022, août 1). Récepteurs nucléaires et rythmes circadiens. Med Sci (Paris), 38(8-9), 669-678.

22 Guide énergie, La région Auvergne-Rhône-Alpes

23 Von Meiss, P., & Radu, F. (2004). Vingt mille lieux sous les terres : espaces publics souterrains. Presses polytechniques et universitaires romandes..

24 Santé, environnement et changement climatique. Santé humaine et diversité biologique. Rapport du Directeur général.

3.5. Representations of the invisible space: underlying issues

In Helsinki, the mapping of underground spaces is currently limited. The only existing document, a master plan, reveals a gap between the perception and the reality of these infrastructures. As demonstrated by the method of decomposition by depth layers, Helsinki's underground spaces do not form an interconnected network. Rather, they appear as a series of independent "nodes." These nodes, often isolated and not connected to the metro or to each other, serve specific functions. Movement between them depends entirely on the surface. This disconnection is intentional, notably for security and military reasons, as required by the underground master plan[25]. Thus, the development of an interconnected underground network is secondary to the safety and proper functioning of existing spaces.

As a unique form of architecture shaping void within solid, the underground demands a specific form of representation. It is necessary to reclaim traditional methods such as sections, plans, and elevations and adapt them to this particularity. This reinterpretation involves several approaches: using the negative, extending sections into the subsurface, exploring materiality through models, collages, and decomposition into depth strata. These representational tools are essential to convey the spatiality of the underground, express concepts and atmospheres, develop projects, and clarify the technical aspects of construction and maintenance. Accurate and appropriate representation is an indispensable preliminary step for the effective design and management of underground spaces, thereby facilitating communication among all stakeholders.

3.6. Critical reflection on underground programming

Finally, based on our state of the art and field survey, we can conclude that the programming of underground spaces today remains predominantly functional, technical, or defensive, particularly in Helsinki, where these places are seldom conceived as spaces of urbanity or social interaction.[26] Considered mainly as conduits for flows or shelters, they struggle to be perceived as genuine public spaces. However, a programming approach that integrates human dimensions, light, air, and connections to the surface level could transform these places into high-quality urban environments.[27] It would require moving beyond a purely utilitarian logic to imagine mixed, evolving, and sensitive uses. This implies redefining the relationship between surface and depth by incorporating the underground into an urban strategy of synergy. Finally, energy, climate, and construction challenges (such as the reuse of excavated materials) further strengthen the case for a renewed approach to the subsurface as an active component of the city.

4. DISCUSSION: THE INVISIBLE AS A FOUNDATION FOR AN ARCHITECTURAL NARRATIVE

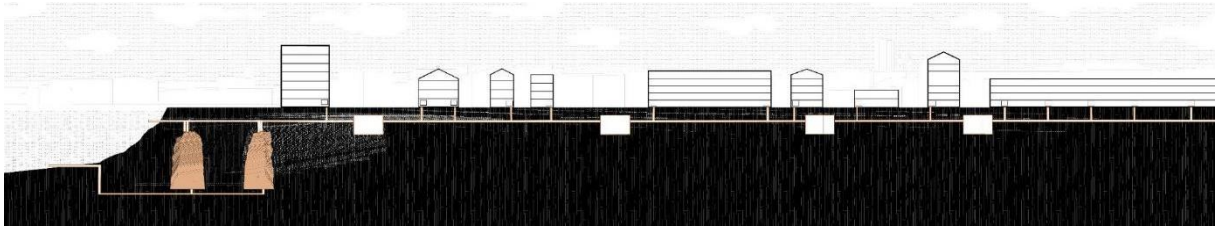
Building on the conclusions drawn from our methodological tools in the first and second parts, we propose in this final section to envision the underground of Helsinki through architectural experiments called "fragments of the invisible space." These consist of about ten projects exploring the potentials of the underground beyond mere infrastructure. Some of these "fragments" represent symbolic or critical projects, questioning the underground as a consumer of material and involving heavy processes. Other fragments reconnect with the living by highlighting natural elements and underground cycles (water, soil, climate) without obstructing them. Most also aim to take advantage of the environmental qualities of the subsurface (energy, thermal inertia), while carefully managing the interfaces between surface and depth (light, air, water, sound). Finally, they raise the question of possible uses: what role and urban functions can these buried spaces have?

[25] Vähäaho, I. (2011). Helsinki Experience with Master Planning for Use of Underground Space, Conference on Planning and Development of Underground Space

[26] Deraëve, S. (2018). Des cartes pour représenter les profondeurs de la ville verticale. Géographie et cultures, 107, 67-87.

[27] Zunino, G. (2013). Pour une urbanité souterraine de qualité. Urbanités.

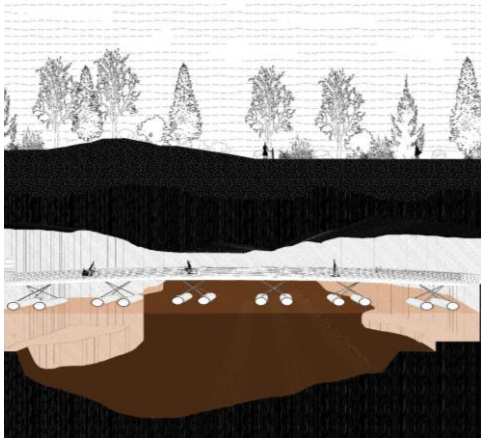
4.1. Fragment "Aquathermy"



Perspective section illustration of the "Polar Night" fragment in Helsinki, underground market, personal work, 2024.

The project explores the deep relationship between Helsinki and water, a central element of its urban identity. The route runs along the quays of the Kruununhaka district, where sounds and architecture engage in a sensitive symbiosis between art and nature. Beneath the surface, a vast aquathermal system exploits the heat stored in water-filled caverns nestled within the granite. This underground network uses heat pumps to capture, transfer, and redistribute thermal energy throughout the year. The system maintains ecological balance by returning the water to the sea at a constant temperature. Thus, water becomes the discreet engine of a sustainable and poetic energy future for the city.

4.2. Fragment "Confined Aquifer"

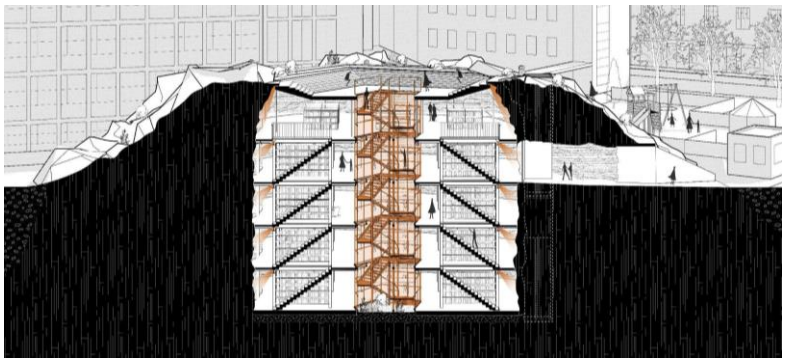


Perspective section illustration of the "Confined Aquifer" fragment in Helsinki, bike path, personal work, 2024.

The project offers an immersive cycling experience in the Kluuvi district, where the cyclist traverses the city while engaging in a subtle exploration of the relationship between the underground and the surface. A bike path connects two major axes and transports users through a space where time and climate become almost indefinable. The route symbolically passes above a groundwater table, a living ecosystem that responds to climatic conditions, revealing the constant dynamics between underground waters and surface phenomena. This crossing is made via a floating footbridge that fluctuates with the water levels, offering a tactile experience of the invisible variations below. In this silent cavern, the visitor becomes a witness to the secret vastness of subterranean water, providing a profound awareness of the beauty and fragility of this natural balance. The project invites meditation on the interconnection between earth, water, and climate, while offering a poetic glimpse into the city's underground world.

4.3. Fragment "Pit"

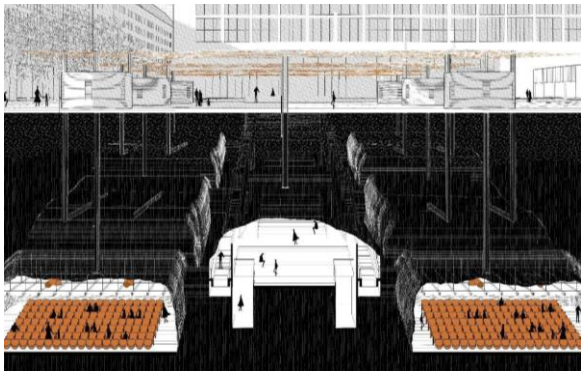
Photograph of the model produced for the "Pit" fragment, personal work.



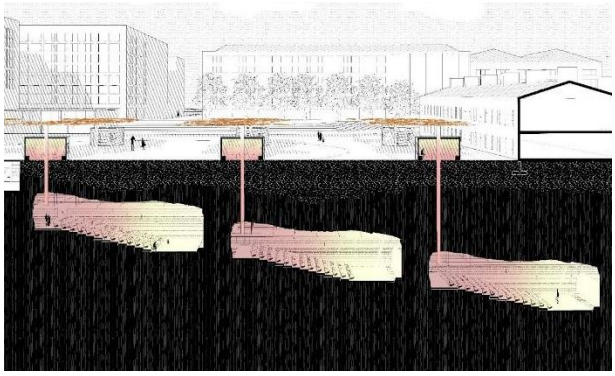
Perspective section illustration of the "Pit" fragment in Helsinki, underground library, personal work, 2024.

The Pit project is an underground library carved into a granite hill, where books are protected from direct light and climatic variations. The wooden architecture visually integrates with the rock while standing apart from it, allowing water to flow freely through the fissures, enhancing the atmosphere of the space. Natural ventilation is organized around a central pit, ensuring renewed air. Soft lighting highlights the granite's textures, offering a tactile reading of the space. This fragment demonstrates how an interface can address technical challenges while enriching the project through its design. Here, water is not constrained but integrated, contributing to the poetry of the place. The sequence of thresholds, ascending, crossing, descending, blurs the boundaries between outside and inside.

4.4. Fragment "Cine-thermy"



Cross perspective section illustration of the "Cine-thermy" fragment in Helsinki, underground cinema, personal work, 2024.



Longitudinal perspective section illustration of the "Cine-thermy" fragment in Helsinki, underground cinema, personal work, 2024.

The project transforms Narinkka Square in Kamppi into a dynamic crossroads where commercial life, culture, and mobility intersect beneath a large canopy. This structure conceals airflow between the ground and the underground, and houses an underground cinema accessible via a central staircase. Inspired by natural caves, the interior architecture blends rock and light to create an immersive atmosphere. Heat generated by spectators and equipment is recovered through a cine-thermal system and redistributed to surface installations. A network of pipes ensures natural ventilation and supports the structure. The project thus combines geology, energy, and architecture into a coherent and sustainable whole.

5. CONCLUSION

Exploring Helsinki's underground spaces led us to question the architect's role in relation to these invisible territories, often reduced to technical or utilitarian functions. Despite exemplary planning and a rich geological setting, the underground remains largely compartmentalized, poorly connected to everyday urban uses, and rarely designed as a space for living. It is still conceived mainly as a network of services dominated by logistical, security, or defensive logics.

Our approach, combining theoretical analysis, sensitive surveying, and project-based experiments, aimed to move beyond this fragmented vision. We sought to build a broader understanding of the underground by considering its materiality, light, atmospheres, flows, and its place within contemporary urban narratives. These elements reveal a spatial and sensory potential that remains underexploited, which only a transversal approach can activate.
The architectural fragments developed in this work propose another way to conceive these spaces as extensions of the public realm, places for climatic, social, or cultural experimentation. They show that when designed in synergy with the surface, integrating the soil's unique qualities and working on the interfaces, the underground can accommodate mixed, evolving, and meaningful uses.

This is not about idealizing these spaces or proposing a single model, but rather recognizing them as a legitimate field of intervention that requires specific tools: adapted mapping, rethought modes of representation, and attention to perception and temporality. The underground thus becomes an active component of urban production, both a physical constraint and a resource for the city.

This work does not offer turnkey solutions, but rather a framework and design tools adaptable to other contexts. It calls for an evolution in the architect's role, one able to navigate between surface and depth, between technicality and perception, to fully integrate the underground into contemporary urban thinking.

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