

[suzushisa]

«a pleasant feeling of coolness»

顔にふるる芭蕉涼しや籐の寝椅子

涼しさや蚊帳の中より和歌の浦

水盤に雲呼ぶ石の影涼し

夕立や蟹這い上る簀の子縁

したたりは歯朶に飛び散る清水かな

満潮や涼んでおれば月が出る

Haiku on Coolness by Natsume Sōseki in Japanese (quoted in Terada, n.d.)

Leaves played by a light breeze brush my face

– how cool it lying in this rattan deck chair.

The coolness from within the mosquito net.

The view of Waka no Ura Bay.

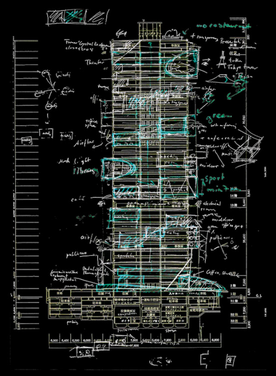
The shadow of a stone calling clouds to the water basin – how cool.

A summer shower, a crab crawls up the slatted veranda.

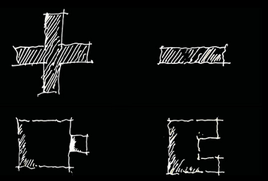
The dripping water splashes onto the fern – how clear the water is.

At high tide, as I sit cooling off, the moon rises.

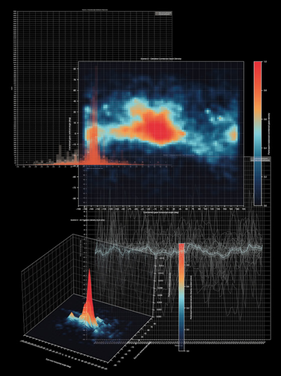
Haiku on Coolness translated into English by the author.



HIGH-RISE OFFICE BUILDING RETROFIT



HEALTH & WELL-BEING

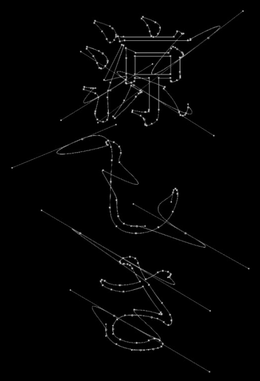


DATA-DRIVEN & INTUITION-LED-DESIGN



JAPANESE VERNACULAR ARCHITECTURAL KNOWLEDGE

Fig. 01. Diagrams to explain the core concepts of this study by the author.



Suzushisa

a pleasant feeling
of coolness

Retrofitting Japan's first high-rise office buidling in response to evolving heat stress conditions through psychological & physiological interventions informed by both data-driven and vernacular Japanese strategies.

Fig. 02. Photograph taken in Tokyo by the author. (2025)

Foreword

This project is grounded in my fascination with the relationship between architecture, data, health and well-being. As well as how data can inform architecture to shape healthier built environments that not only consider physical, but also mental health dimensions. Such a holistic concept evolves in significance, as contemporary challenges such as the Urban Heat Island phenomenon are threatening increasingly densely populated environments, affecting not only environmental, but also built, physiological and psychological realities.

Tokyo, framing the context of this project with its 37 million inhabitants, has experienced in recent years a rise in day- and night-time temperatures that has led to a growing dependence on mechanically driven air conditioning systems, as increased cooling demands produce further anthropogenic heat emissions, reinforcing a feedback loop, which consequently intensifies local overheating. Simultaneously, the Japanese government promotes energy conservation campaigns that shift thermal challenges of heat exposure from a wider environmental context into tangible physical and mental health-impacting conditions within Tokyo's ageing office environments.

The goal of this project is to explore how data-informed design strategies, grounded in vernacular knowledge, environmental measurements and psychological processes, can sustainably transform the growing aging office-building stock into an environment that enhances health and well-being under increasing heat stress conditions. This will be approached by framing the Kasumigaseki building, Japan's first office high-rise building, as the primary case study.



Fig. 03. Photograph taken in Tokyo by the author. (2025).

Acknowledgments

This thesis marks the final step of my Master's graduation process, as well as the culmination of my entire educational journey at TU Delft. My path until now, as well as how this project has evolved, has primarily been shaped by all the people who have provided support in different ways, and I would like to express my sincere gratitude to them, as I would not be in this position without their contributions.

First of all, I would like to thank my graduation tutors Geert Coumans and AnneMarie Eijkelenboom for their guidance, critical reflections, sharing of expertise and continuous encouragement throughout this project. Despite their tight schedules, their weekly feedback, questions and discussions have challenged me to continuously develop both the research and design ambitions of this thesis.

Secondly, I would like to thank all participants of the VR eye-tracking assessment study. Their willingness to contribute their time and experiences provided an essential foundation for this project.
Especially important for me personally were the discussions after each testing session, as their comments not only enriched the research, but also contributed to my understanding of how differently people perceive space, comfort and well-being.

Thirdly, I would like to thank my friends and the people whom I met in Japan, who have continuously provided their support and contributed to the fieldwork, eye-tracking assessment, interviews, questionnaires, and archival document collection during the summer of 2025. Their sharing of knowledge, experiences and perspectives was highly valuable in developing a deeper understanding of people living and working under the increasing conditions of the Urban Heat Island effect in Tokyo.

A special thank you also goes to TU Delft for providing the opportunity to work and thrive within such a highly inspiring and multidisciplinary environment.

Furthermore, the VR equipment of the VR Lab was a crucial component in enabling the development of this research.

Further gratitude goes to Minato City, Tokyo, for granting permission and facilitating the exploratory eye-tracking study within Tokyo's streetscape, which ultimately allowed me to establish the psychological research framework for this project.

Lastly, I would like to thank my parents, my friends and fellow students for their support, patience and encouragement throughout this graduation process. Their confidence in me has provided motivation during both the rewarding and challenging moments of this project.

This thesis is ultimately the result of countless discussions, collaborations, experiences and shared moments, as well as the support of everyone who has accompanied its development along the way.

Thank you!

ありがとうございます!

Table of context

Foreword p. 006

1. Introduction
   1.1 Problem statement p. 014
   1.2 Relevance to architecture and society p. 018
   1.3 Objective and motivation p. 020
      1.4.1 Main Design Question p. 034
      1.4.2 Main Research Question p. 038

2. Approach (how?)
   2.1 Methods p. 044
   2.2 Theoretical Framework p. 058

3. Research by Design
   3.1 Exploring Health-Enhancing Program Integration p. 080
   3.2 Exploring Psychological Heat Stress Mitigation p. 156
   3.3 Exploring Structural Integration p. 184
   3.4 Exploring Physiological Heat Stress Mitigation p. 208
4. Final Design, Conclusion &Integrations
   4.1 Health-Enhancing Program & Psychological Research Integration p. 226
   4.2 Physiological Climate Design p. 266
   4.3 Conclusion p. 302
   4.4 Implication & Recommendations p. 306
   4.5 Reflection p. 310

List of figures p. 314
Literature p. 320
Appendix p. 326

Fig. 04. Photograph taken in Tokyo by the author. (2025).

PART 01

INTRODUCTION

1.1 Problem Statement

The Urban Heat Island (UHI) effect, which has been documented in numerous studies in recent years, refers per definition to the phenomenon in which dense urban areas exhibit significantly higher temperatures compared to their surroundings, which is considered to be influenced by physical and anthropogenic factors, such as artificial land coverage, building geometry and orientation, decrease of evaporative surfaces, the blockage of natural air-flow through dense high-rise developments and anthropogenic heat emissions especially regarding increased building's interior cooling efforts with air-conditioning systems (Ren et al., 2023).

Tokyo, as one of the most densely populated urban areas in the world with 37 million people living within the greater Metropolitan area and around 6,200 people per square kilometre, has been increasingly impacted by the Urban Heat Island phenomenon with a 2.86 °C increase in temperatures since 1900, which is around three times higher than the global average (Migrate & Observatory, 2025).

As Tokyo has been increasingly exposed to higher day- and night-time temperatures during summer periods, as a consequence of the intensifying UHI, growing cooling demands in the metropolitan area have been directly translated into increased energy consumption by air conditioning systems for indoor space cooling, which are predominantly associated with commercial and office buildings concentrated in the central bay area of Tokyo (Hirano & Fujita, 2012).



Fig. 05. NASA, earth observatory, Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS). From Migrate & Observatory (2026)

Energy conservation strategies “Cool Biz“

Despite the increased electricity dependence for growing indoor-cooling demands within the UHI’s impact, energy conservation however has evolved to one of the main objectives of the Japanese government within the Urban Heat Island mitigation initiative. (Hirano & Fujita, 2012) Incidents, such as the Great East Japan Earthquake in 2011, in which the Fukushima nuclear accident caused a severe shortage in the national electricity supply, exposed not only the sensitivity of the national energy system but also accelerated long-term policy efforts towards reduction and energy conservation.

While one of the most prominent initiatives, the “COOL BIZ” energy conservation campaign by the Ministry of Economy, Trade and Industry, has successfully reduced cooling-related electricity consumption by implementing guidelines, such as regulating the air conditioning to higher indoor temperature setpoints of 28°C. This however, has simultaneously shifted thermal stress into indoor work environments and is associated until today with physical & mental health issues related to thermal discomfort and heat stress, indicating growing tensions between governmental energy conservation objectives and healthy conditions for productive indoor work environments during the intensifying Urban Heat Island phenomenon (Tanabe et al., 2015).

This stresses the urgency to reconsider indoor cooling strategies in contemporary office buildings not only in terms of energy reduction, but also with regard to supporting physical and mental well-being, cognitive functioning and occupational health.



Fig. 07. COOL BIZ Guidelines Flyer. From 土岐三菱自動車販売株式会社 (2025).



Fig. 09m COOL BIZ working conditions.
“Le Short Au Bureau, Vraiment ?,” (2025).



Fig. 06. COOL BIZ Guidelines. From 三輪令子(2019).



Fig. 08. COOL BIZ Guidelines Flyer. From Dooley and Ueno (2023).



Fig. 10. COOL BIZ Guidelines Flyer.
From クールビズ実施のご案内関西大学環境保全 (n.d.).

1.2 Relevance to architecture & society

While Tokyo is considered to have one of the highest total office floor areas in the world with approximately 4.350 ha (≈43.499.000m²) of net rentable area in the end of 2025, a not inconsiderable amount of this associated building stock does not meet contemporary environmental and energy performance requirements. As several major energy efficiency acts have been developed within the last 20 years, the average office building age however is 34,6 years old, as well as around 69,10% of the entire office building stock is 20 years old or older and most of these office buildings have been built during Tokyo's bubble era, dating from 1986 to 1991 (Xymax Real Estate Institute Corporation, 2025).

Whereas the significant amount of existing building stock was built prior to current energy efficiency standards, as well as is associated with a relatively higher percentage of long-term vacancy rates, the consideration towards extensive redevelopments with new constructions is necessarily embedded within the constraints of the current population decrease and the productive-age population having declined continuously after peaking in the 1990s. Such preconditions frame questions towards environmental and economical responsibility and direct the building stock urgency towards reforming the existing conditions rather than seeking for new constructions (Xymax Real Estate Institute, 2023b).

This positions the project's challenges into a central, tangible architectural relevant context of retrofitting the aging office building stock towards reducing energy demands, mitigating heat stress and supporting healthier work environments within existing environmental, societal and economic realities.

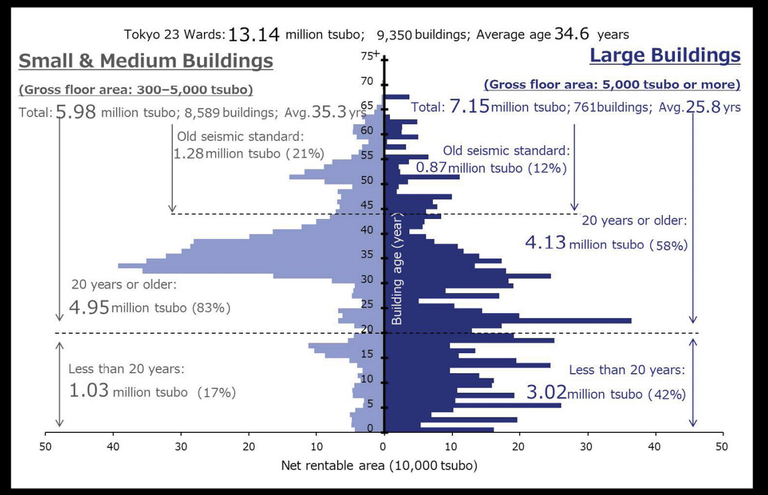


Fig. 11. Tokyo 23 Wards Office Stock Pyramid 2025.
From Xymax Real Estate Institute Corporation (2025).



Fig. 12. Japanese offices in the 1980s.
From 速水健朗 (2023).

1.3 Objective & Motivation

My interest in this project originates in my fascination towards how data-driven design can bridge spatial challenges with health and well-being, encompassing not only the physical but also mental health.

The Urban Heat Island effect, as a multidimensional challenge, sparked my interest, since the invisible phenomenon demands a holistic, actionable and perceptible approach. However, data often has been limited to a measured environmental and physiological scope, whereas the psychological extend, despite its anticipated significance, remains insufficiently integrated into architectural design practice.

The project's motivation is grounded in first-hand observational data, collected in a personal fieldwork in Tokyo from the beginning of July to the end of August 2025.



Fig. 13. Photograph taken in Tokyo by the author. (2025).

Thermal emissions & urban preconditions

While detailed elaborations on the used methods follow, first findings of on-site collected theromography images reveal a clear variation in the rate of thermal emissions and heat accumulation across blue-, green- and greyscapes, different pavement and material properties, as well as intensities in traffic and air-conditioning cooling operation.

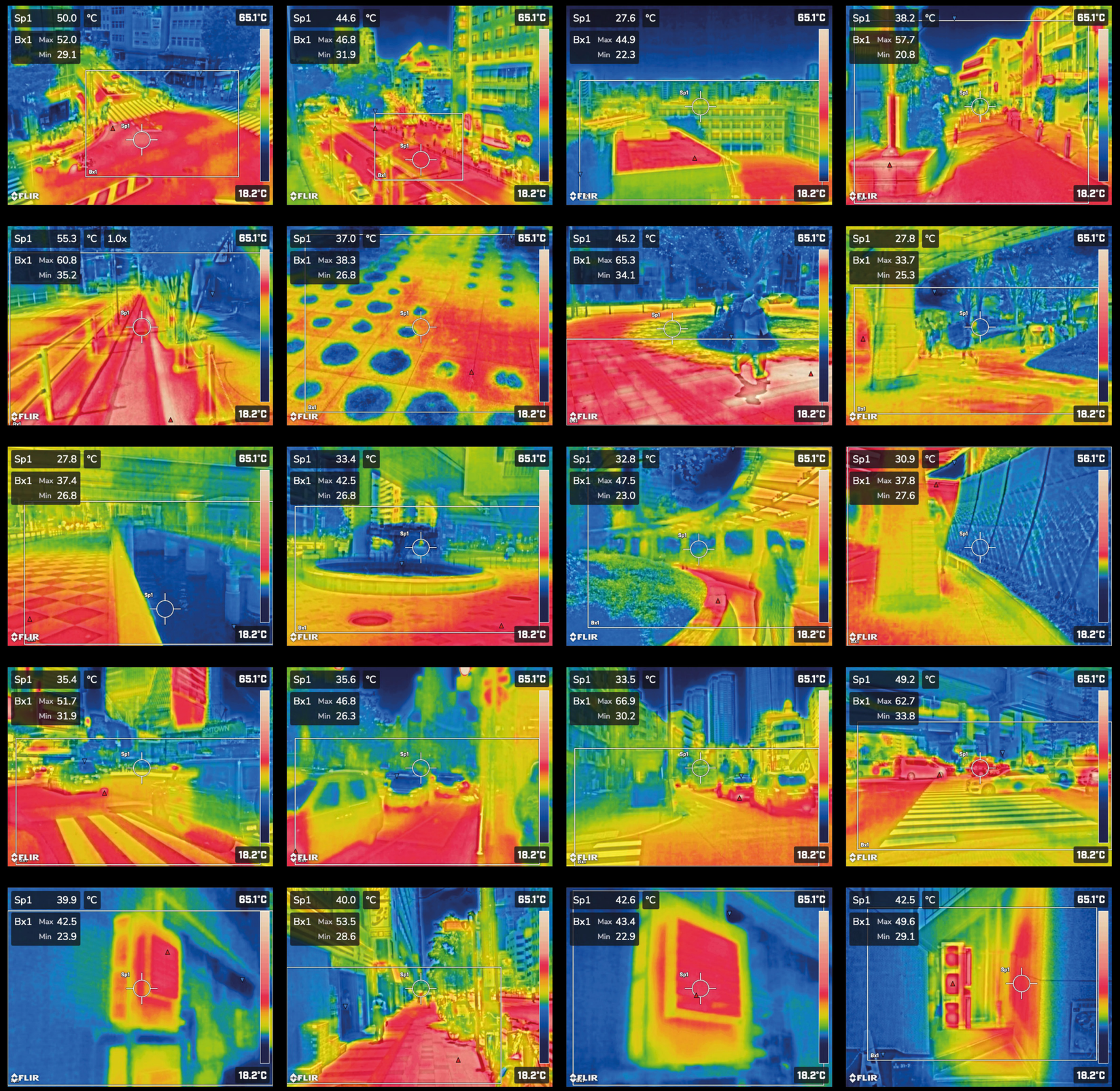


Fig. 14. Thermography Images taken in Tokyo by the author. (2025).

Comfort & heat exposure

Findings within the human impact on heat exposure is reflected in 114 reported experiences as 94,5% indicate effects on their physical and mental health, 43% refrain from going out due to the heat, as well as more than 60% experience fatigue and/or discomfort due to the rising heat emissions. (Fig. 14)

Additionally, while a strong societal reliance on energy intensive artificial climate control is depicted in the 89,2% of experienced comfort towards buildings with air conditioning. Especially interesting is the pronounced appreciation for natural cooling cues, such as tree shades, mist showers and the sound of wind chimes, indicating an innate and well-documented traditional Japanese connection towards natural elements during high temperature conditions.

These findings resonate with traditional Japanese architectural practices of vernacular cooling methods, such as uchimizu (water sprinkling on hot street pavements), open floor plans for airflow-enhancing geometries, Japanese stroll gardens with its waterscapes and engawa as natural climatic buffer zones.



Fig. 15. Questionnaire analysis by the author indicating human comfort within heat exposure. (2025).

Eye-movement & relaxation & heat stress

Another major take-away from the collected data is the high significance of the psychological layer within spatial conditions, as tranquillity and a reduced amount of people are reportedly improving the sense of comfort, whereas a high density of traffic and people are associated with a heightened sensation of heat. The correlation between heat stress and physiological and psychological stress responses is supported in existing scientific research and further extends the scope towards stress mitigation and relaxation showing tendencies of higher resistance towards the impact of heat stress. (Rony & Alamgir, 2023)

This is has been explored spatially within spatial configurations of Tokyo's streetscapes under Urban Heat Island conditions, provoking eye movement patterns associated effects with relaxation and stress reduction, resonating with existing studies on spatial configurations of spatial openness, visual depth, and horizontally structured visual complexity stimulating indicators of reduced psychological, as well as physiological stress (Gao et al., 2025; Goto et al., 2025; Liang et al., 2025).

Informed by these findings, the primary project's objective is to implement retrofitting strategies within the existing aging office-scape, drawing on traditional Japanese architectural knowledge and its vernacular cooling cues, as well as eye-movement patterns associated with relaxation and stress reduction. This extends the objective's dimensions beyond purely measurable energy and environmental performance, towards enhancing both physical and mental well-being under intensifying Urban Heat Island conditions in existing office environments.

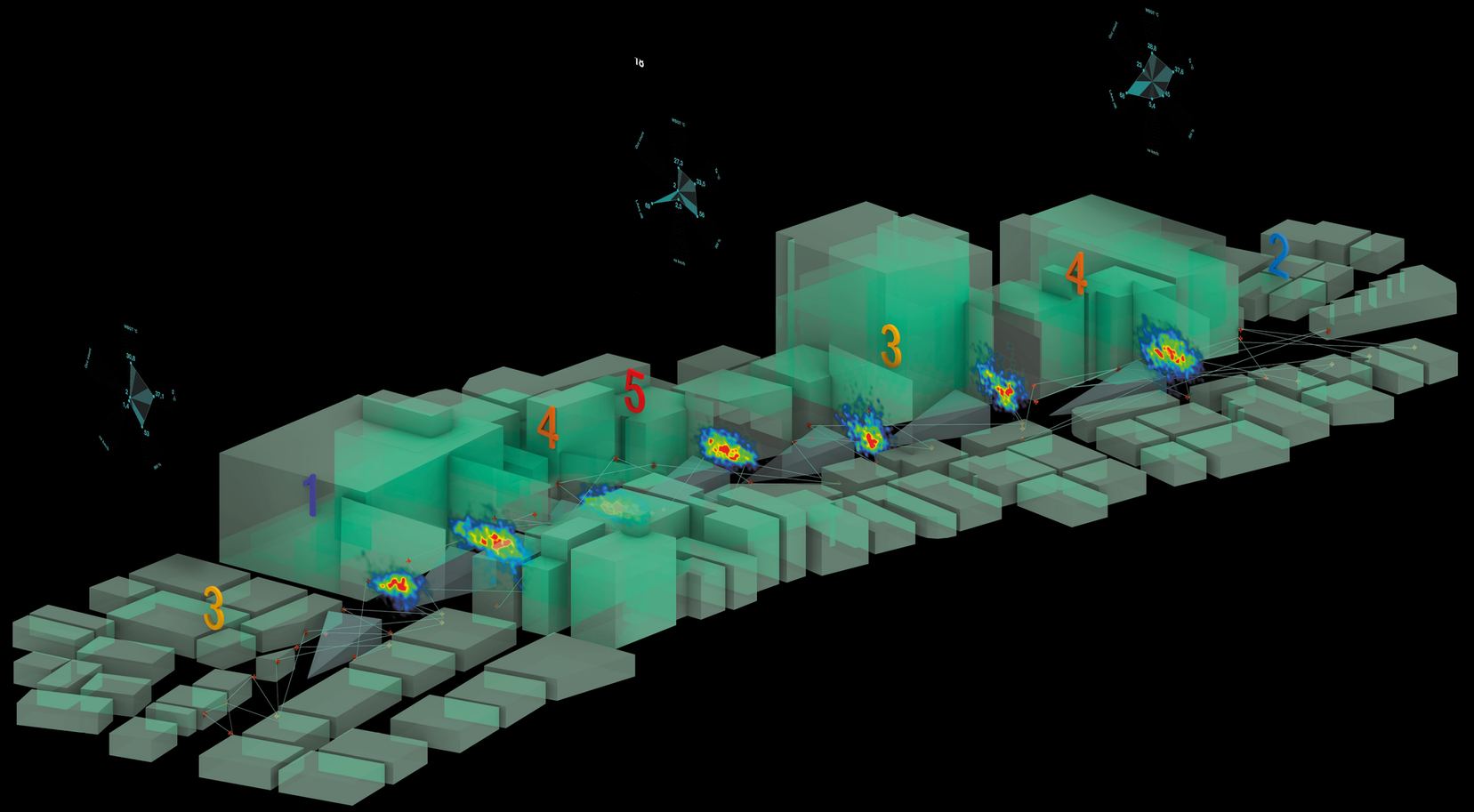
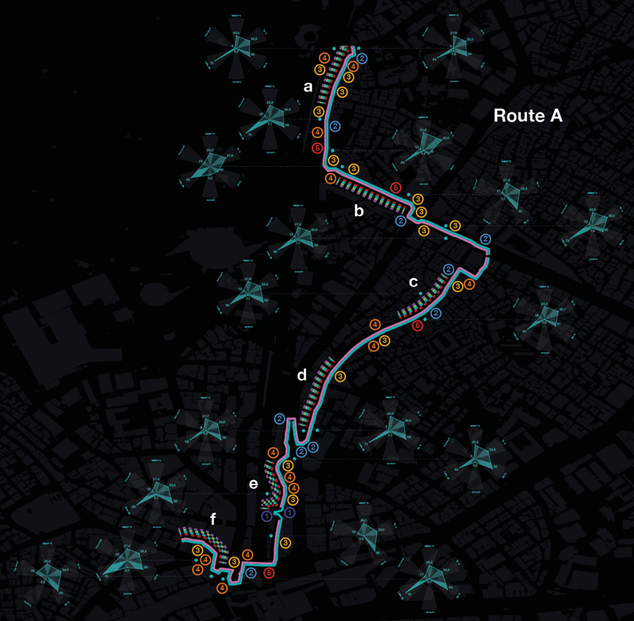


Fig. 16. Eye-tracking study methodology in Tokyo's Streetscape including self-perceived thermal perception. (2025).

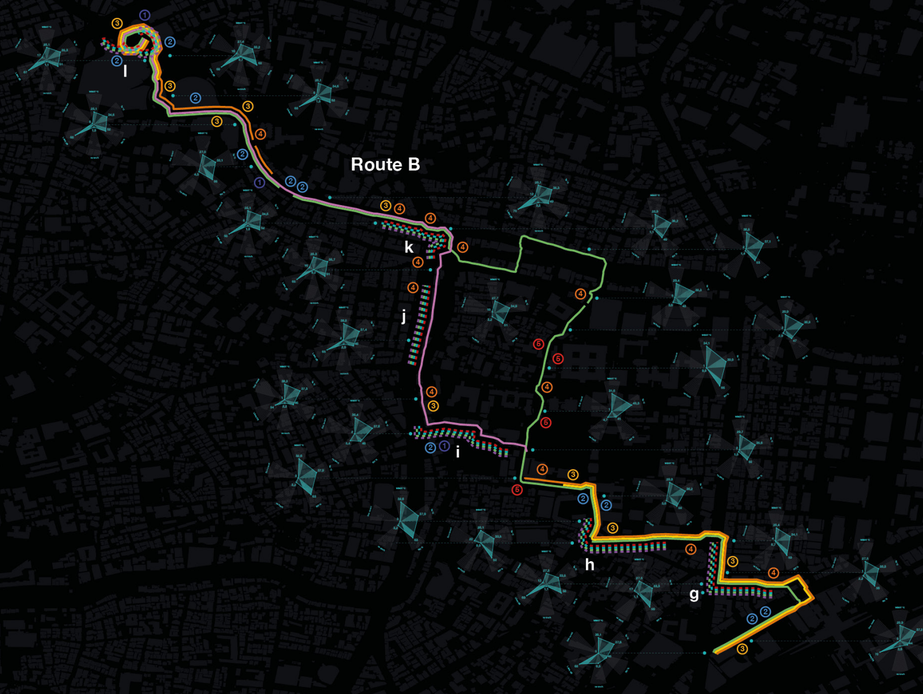








Route A



Route B

Route A

- indoor test person 01 (higashi)
- indoor test person 02 (michika)
- indoor test person 03 (ryotaro)
- indoor test person 04 (mia)
- outdoor test person 02 (michika)
- outdoor test person 05 (yusuke)

Route B

- indoor test person 01 (higashi)
- indoor test person 02 (michika)
- indoor test person 03 (ryotaro)
- indoor test person 04 (mia)
- outdoor test person 03 (ryotaro)
- outdoor test person 05 (yusuke)
- outdoor test person 06 (maria)
- outdoor test person 07 (risako)

Test person's felt temperature

1 2 3 4 5

1 2 3 4 5 indoor test person's identification

1 2 3 4 5 outdoor test person's identification

Fig. 17. Eye-tracking data mapping in Tokyo's Streetscape including self-perceived thermal perception. (2025).

Route A



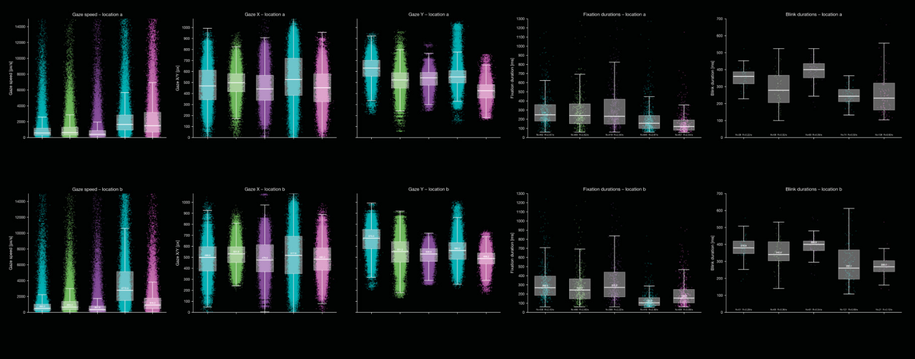


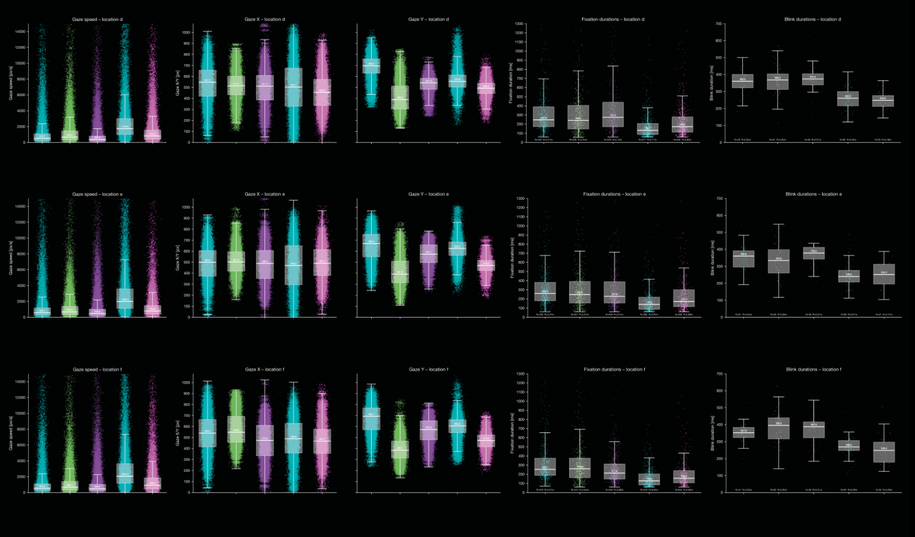












Route B



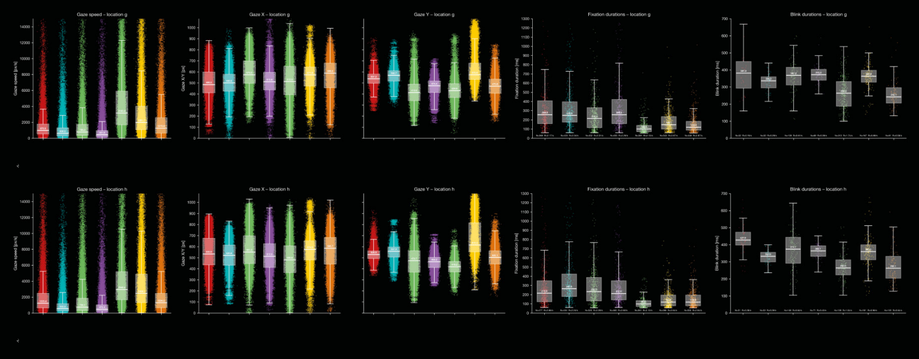












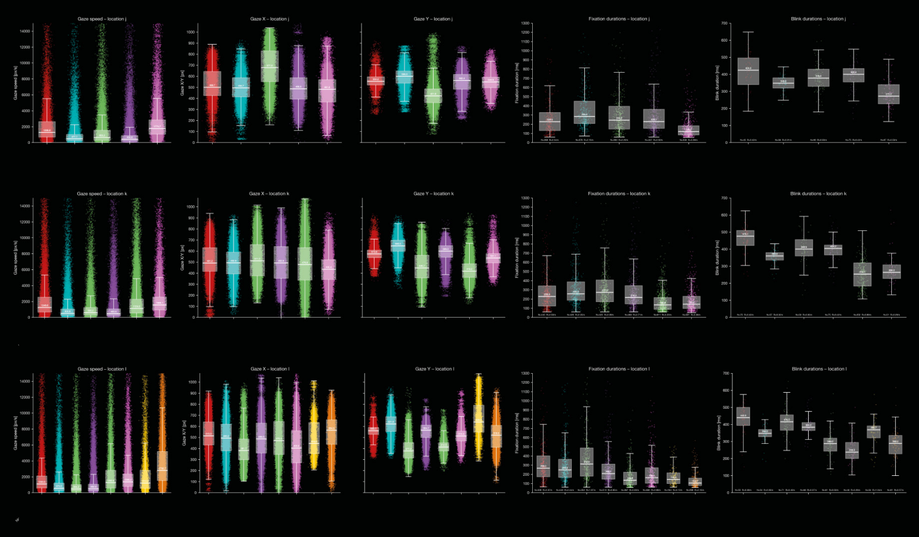


Fig. 18. Eye-tracking data analysis in Tokyo's Streetscape and within a thermally controlled environment. (2025).

Main Design Question

Main Design Question

1.4.1 Main Design Question

How can existing office buildings in Tokyo be retrofitted to reduce both the physiological and psychological layers of heat stress through translations of Japanese vernacular architectural knowledge and spatially informed eye-movement patterns?



Fig. 19. Photograph taken in Kyoto by the author. (2024).

Main Research Question

Main Research Question

1.4.2 Main Research Question

How do translations of Japanese vernacular architectural knowledge and spatially informed eye-movement patterns reduce the physiological and psychological layers of heat stress?

Sub RQ 01:

Which translations of Japanese vernacular architectural knowledge reduce the physiological and psychological layers of heat stress?

Sub RQ 02:

Which eye-movement patterns reduce the physiological and psychological layers of heat stress?

Fig. 20. Photograph taken in Kyoto by the author. (2024).

1.5 Scope of the project

Within the high-density accumulation of office buildings in the central bay area of Tokyo, the Kasumigaseki Building, completed in 1968, is widely known as the very first high-rise office building in Japan with its 36 floors above-ground and 147m height (Gondo, 2021).

This building, treated as a representative prototype in this project, has been chosen as the primary retrofitting casestudy, since it provides a well-documented amount of accessible data on construction, planning, services and use case due to its prominent title.

Despite an already existing record of three renovation periods in between 1989–1994, 1991–2005 and 2006–2009, persistent indoor thermal challenges under COOL BIZ conditions are still documented within the building and the surrounding office area, turning the Kasumigaseki building into a reliable benchmark for the project's retrofitting objectives (朝日新聞, 2024; Kumagai, 2019).

Within the project's scope of the design, the overall approach is to switch periodically between the scale of the building with its direct surrounding for challenging the immediate urban context of increasing Urban Heat Island conditions, the standard office floor for implementing vernacular architectural knowledge, new health-enhancing programmatic integrations and spatial configurations stimulating eye movement patterns for targeting primarily the physiological and psychological dimensions, and the scale of detail for assessing its tangible material realities and technical implementations.

While design and research strategies are expected to result in a constant debate between these scales, existing preconditions and limitations arising from structure, program, availabilities of data, material and environmental conditions, etc., will permanently inform and frame the project's development.



KASUMIGASEKI BUILDING

Fig. 21. Aerial footage of the Kasumigaseki building in 1968. From MITSUI FUDOSAN | Corporate Information | News Releases (n.d.).

PART 02

APPROACH

2.1 Methods

The project follows the research by design methodology, in which analytical research, spatial design and evaluative testing are developed iteratively and in parallel.

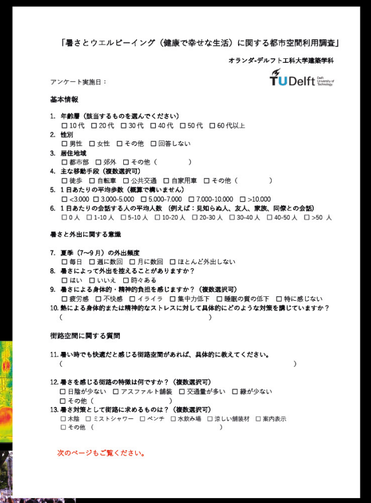
Within the first phase, the project has begun with general desk research on the conditions of the Urban Heat Island effect in Tokyo, establishing an initial understanding of its spatial characteristics, urgency, and relevance. To extend this early theoretical foundation with first hand observational data, an on-site fieldwork in Tokyo was conducted. This exploration has started necessarily earlier, as the data needed to be collected during the summer months with increased UHI conditions.

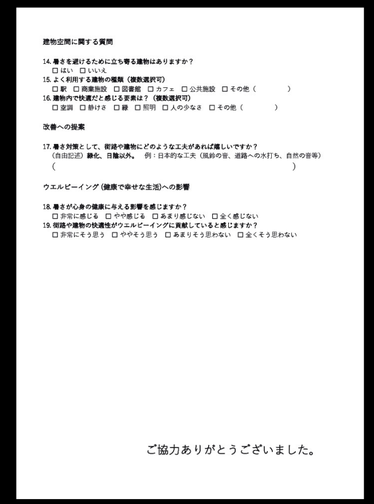
While the findings have been stated earlier in the report, several different methods have been used to establish these results. To quantify the rate of thermal emissions and heat accumulation, measurements were conducted using a heat stress meter for assessing Wet Bulb Globe Temperature (WBGT) and a FLIR C5 thermography camera (sponsored by Thermal Focus).

The assessment of physical and mental issues and/or lifestyle-related restrictions during increasing temperatures was conducted through an anonymous and public questionnaire with 114 participants in public spaces. Furthermore, as further desk research has provided insights into the connection of eye-movement and relaxation, the method of on-site explorative eye-tracking testing was approached in the streetscapes of Tokyo, as well as in an controlled environment.











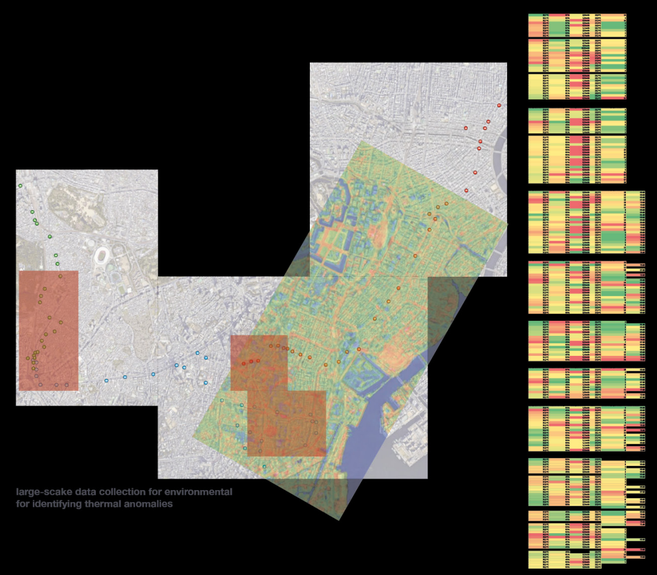


Fig. 22. Matrix of Methods including eye-tracking glasses, thermally controlled indoor environment for indoor eye tracking tests, WBGT-meter, Thermography mapping, acoustic meter and the questsionnaire in Japanese . (2024).

Retrofit Strategies

With the official beginning of the project, the following research included methods of further literature review and desk research dedicated towards deepening insights in the Urban Heat Island effect, heat stress, thermal comfort in UHI and “COOL BIZ” conditions within office environments, traditional Japanese architectural knowledge with its cooling cues, eye-movement patterns and spatial configurations associated with stress reduction, general properties of health-enhancing environments and finally the ageing office building stock in the central bay area of Tokyo.

As the project’s objective is to implement retrofitting strategies within the existing Kasumigaseki building, traditional Japanese architectural knowledge with its vernacular cooling strategies are being implemented to reduce primarily physiological heat stress. While spatial configurations, stimulating eye-behaviour are being integrated, to enhance relaxation through increased eye-movement, promoting reduced psychological heat stress. These strategies are being synthesized into a set of adaptable design principles which can also bridge both physiological and psychological dimension. Additionally health-enhancing programmatic integration inspired by the close urban context around the Kasumigaseki building complement the overall strategy.

The integration, adaptation and implementation of the individual design strategies are informed by the Kasumigaseki building itself, serving as a design filter through its structural, programmatic, environmental and spatial preconditions.

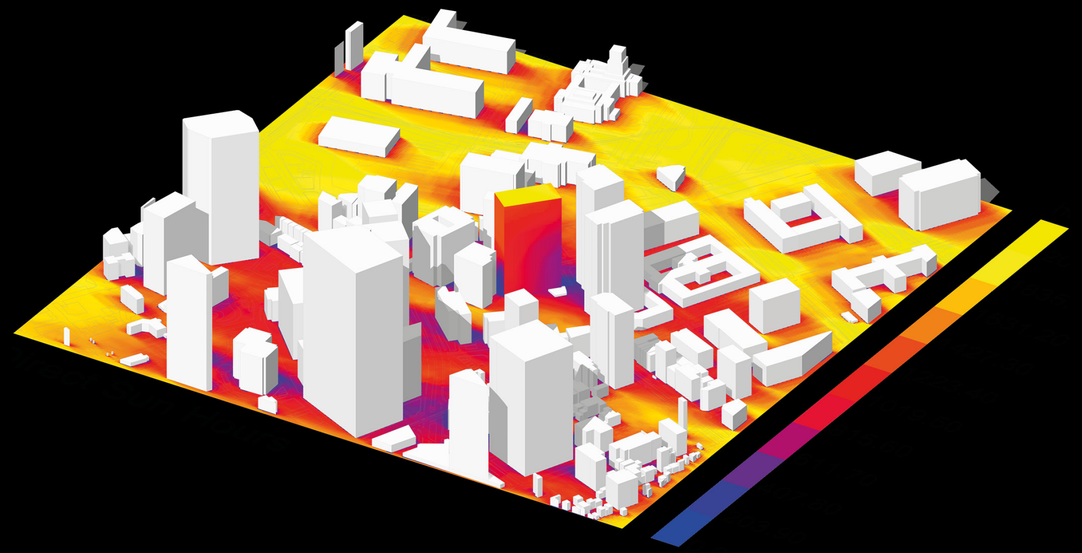


Fig. 23. Sunlight study on the Kasumigaseki building containing its immediate urban context.

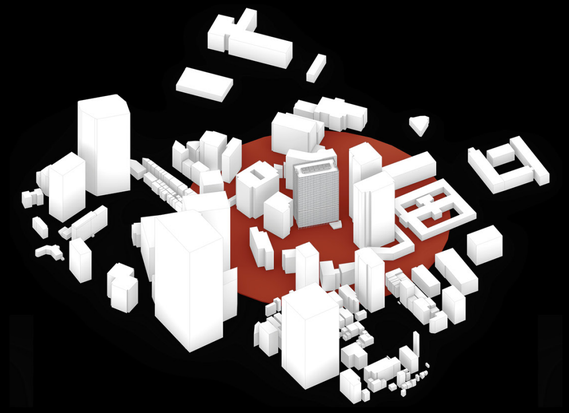
Implementation Scales

Regarding the implementation of design strategies throughout the scales, first, the proceeding retrofit development through design iterations addresses the whole building with its immediate urban context. This scale is considered to inform both the project's physiological climatic concept through model-based physical and digital assessments, including salt-wind and sunlight studies.

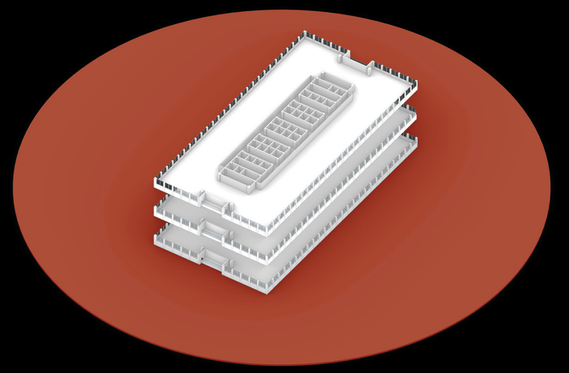
Furthermore this scale is developed with its built environment within a physical and digital site-model and is meant to drive the overall layout of design implementations throughout the building, which includes the both the standard office floor of the Kasumigaseki building, its facade, the ground floor and its surrounding plaza.

The standard office floor provides the base for both physiological and psychologically informed design iterations, integrating new health-enhancing program, relaxation-related eye-movement patterns, japanese vernacular architectural knowledge and spatial integrations of passive cooling strategies.

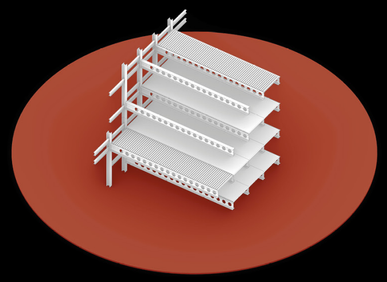
As the project considers a continuous debate between scales within the reiterative process, the scale of the detail and its design integration reinforms the on-going retrofit development repeatedly, maintaining a close connection towards conceptual strategies and technical implementations.



KASUMIGASEKI BUILDING SITE SCALE



KASUMIGASEKI BUILDING FLOORPLAN SCALE



KASUMIGASEKI BUILDING DETAIL SCALE

Fig. 24. Matrix of the project scales, ranging from Site Scale, to Building (Floorplan) Scale to Detail Scale.

VR Eye-Tracking Assessment

As the retrofit proposal is developing, a first iteration of design is evaluated through a VR-based scenes with integrated eye-tracking, a preselected and curated scientifically established questionnaire and the participation of around 30 of participants.

The evaluation is aimed to compare which of the four scenarios, including the proposed retrofit design iterations and the current existing floor layout, stimulate increased gaze movement and speed, as well as more horizontally dispersed fixations.

As these eye-movement patterns are associated with enhancing psychological as well as physiological relaxation, together with the results of the questionnaire, insights into the design principles' effectivity for enhancing relaxation, indicating the potential for higher psychological heat stress resilience, are expected and ultimately inform the final design iteration.

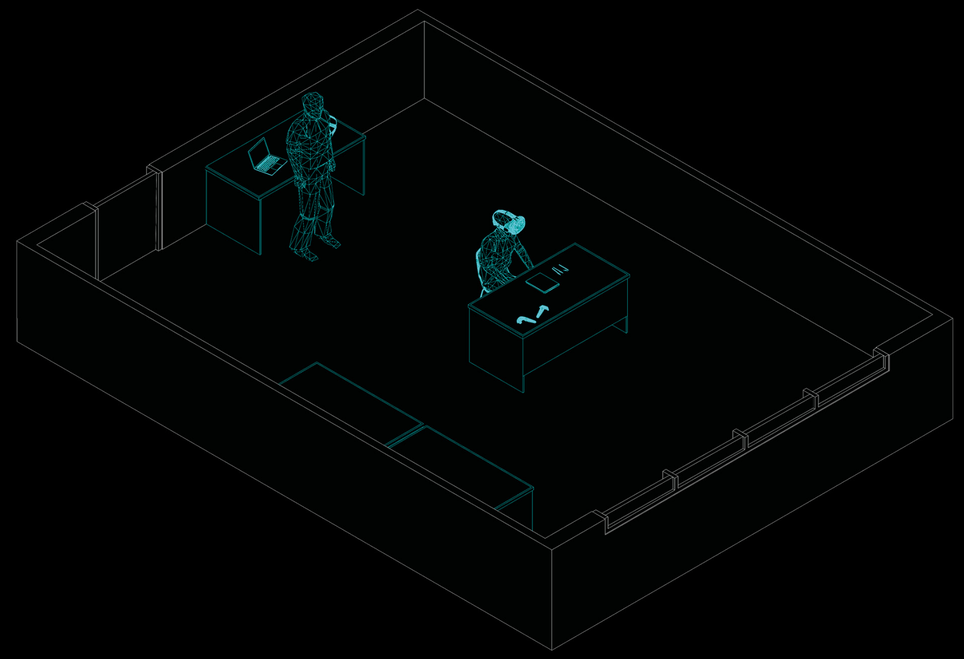


Fig. 25. Expected VR Eye-tracking setup.

Physical Modelling Assessment

Physical modelling, as a second assessment and design driving tool, is chosen to further inform the design integration. This is considered to be applied throughout the design in all scales, ranging from a physical site model (1:1000), a structural model (1:50), a detail model (1:2) and several concept models to prototype abstract ideas to informed design iterations.

While the site model is planned to inform the overall retrofit layout and climatic concept of the project, the structural model is aimed to provide in-depth insights into the buildings structure while testing newly integrated structural rythms. Lastly, the detailed model is reserved for real material explorations regarding wooden joints, connections with the existing structure, etc., grounded in both vernacular architectural knowledge and intuition-led decisions.

As each scale is planned for its own purpose, the visual quality is aimed to be abstracted according to its function, leading to differently distinctive elaborative visual and crafted expressions of material, scale and detail.

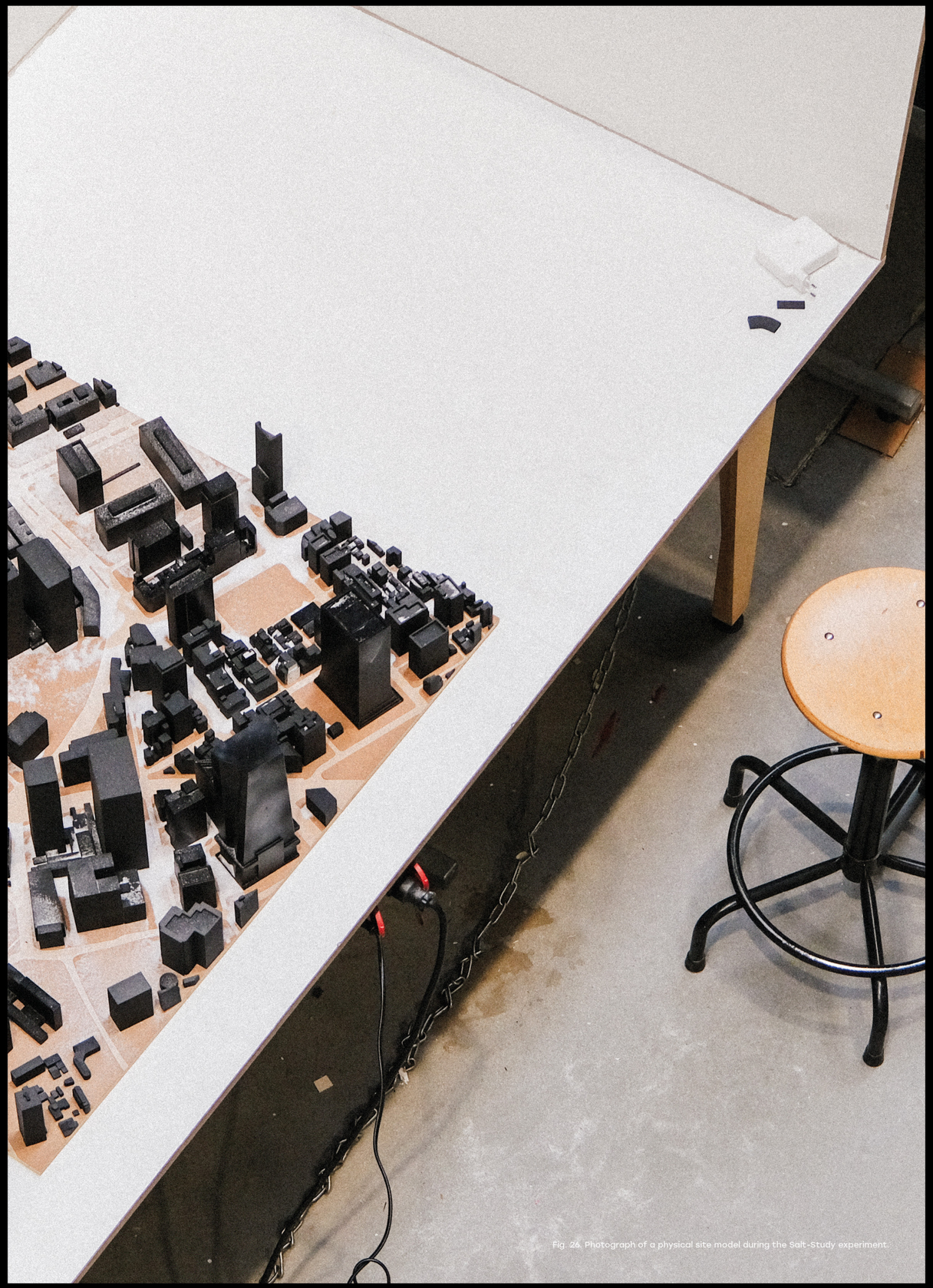


Fig. 26. Photograph of a physical site model during the Salt-Study experiment.

Final Output

The final expected output is a retrofit proposal for the Kasumigaseki building, with an increased focus on the standard office floor as this project's core scale, which challenges the increasing UHI-related environmental constraints, reduces heat stress and energy cooling demands, while enhancing both the physiological health and psychological well-being of its occupants. Furthermore, the building itself, the groundfloor and the plaza in front of the building will extend the final output to offer a full picture within the retrofit proposal of Japan's first high-rise building.



Fig. 27. Photograph taken in Kyoto by the author. (2024).

Theoretical Framework

Theoretical Framework

2.2 Theoretical Framework
Heat stress & relaxation

Extended scientific literature provides insights into heat-related discomfort towards heat stress and indicates that prolonged exposure to elevated temperatures triggers physiological and psychological stress responses, as heat loads exceed the body's capacity to maintain its stable internal temperature, affecting physical and mental health issues (Rony & Alamgir, 2023).

Such stress responses active the sympathetic nervous system (SNS) and inhibit the parasympathetic nervous system (PNS), resulting in enhanced mental workload, (Adeniyi, 2022)(He et al., 2025) which several findings in Tokyo located offices under the "COOL BIZ" conditions have demonstrated within declines of perceived comfort affecting productivity and cognitive performances (Tanabe et al., 2015).

Whereas relaxation, associated with a generalised decrease of sympathetic nervous system activity, is frequently described as the counterpart of stress responses and indicates an increased capacity for heat stress resilience (Benson, 1985).



Fig. 28. Photograph taken in Kyoto by the author. (2024).

Eye movement & relaxation scientific grounding

Correlations between eye movement and stress reduction are examined within the principles of eye movement desensitization and reprocessing (EMDR), where bilateral stimulation through the manipulation of eye movement affects reduced stress responses (Shapiro, 1999).

Furthermore, existing studies report that spatial configurations of Japanese gardens and simulated openness within indoor environments correspond to increased eye movement patterns, associated with psychological as well as physiological relaxation, including extended visual perception through increased horizontal gaze movement, increased gaze speed and wider dispersed fixation points (Gao et al., 2025; Goto et al., 2025; Liang et al., 2025).

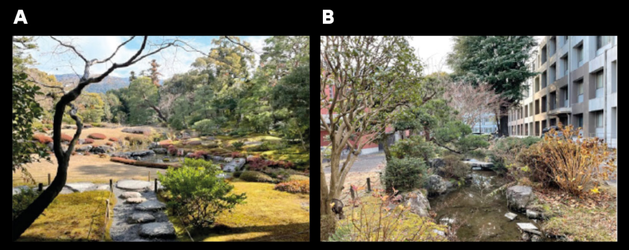


Fig. 29. Comparison: photograph of the Murin-an garden (A) and photograph of the Kyoto University Garden (B). Adapted from Goto et al. (2025).

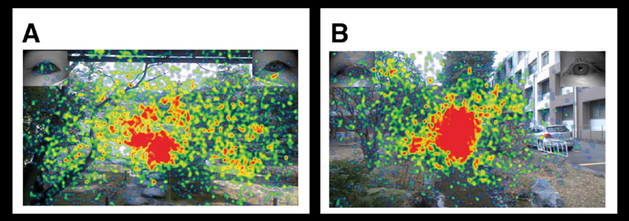


Fig. 30. Comparison: photograph of the Murin-an garden (A) and photograph of the Kyoto University Garden (B) with gaze and fixation heat map overlay. Adapted from Goto et al. (2025).

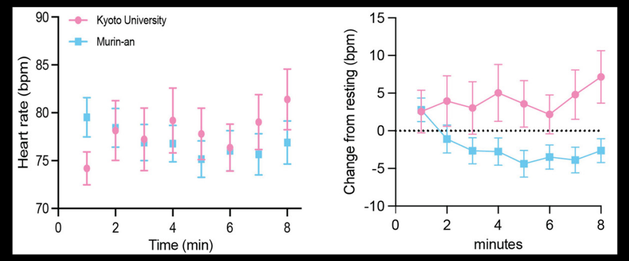


Fig. 31. Comparison: Physiological arousal over time through heart rate assessment. Adapted from Goto et al. (2025).

Eye movement & relaxation in Tokyo‘s explorative study

As these studies suggest that the relaxation effect of increased eye movement is less related to the viewed objects, but rather to their spatial configuration, similar findings were established in the exploratory eye-tracking experiments in Tokyo’s streetscapes.

As wider gaze movement and fixation patterns were observed in routes with spatial configurations of openness, visual depth, distant scenery, horizontally distributed visual stimuli, curved and zig-zag lines, asymmetry, balanced compositions and the absence of strong axial perspectives, vertical dominance, or visual obstructions.

Moreover, while reduced gaze movement is observed in narrow, high-traffic streetscapes, the outdoor findings, associated with relaxation effects, show similarities in eye-movement patterns collected from thermally controlled stationary settings, supporting the spatial pattern’s impact on relaxation.

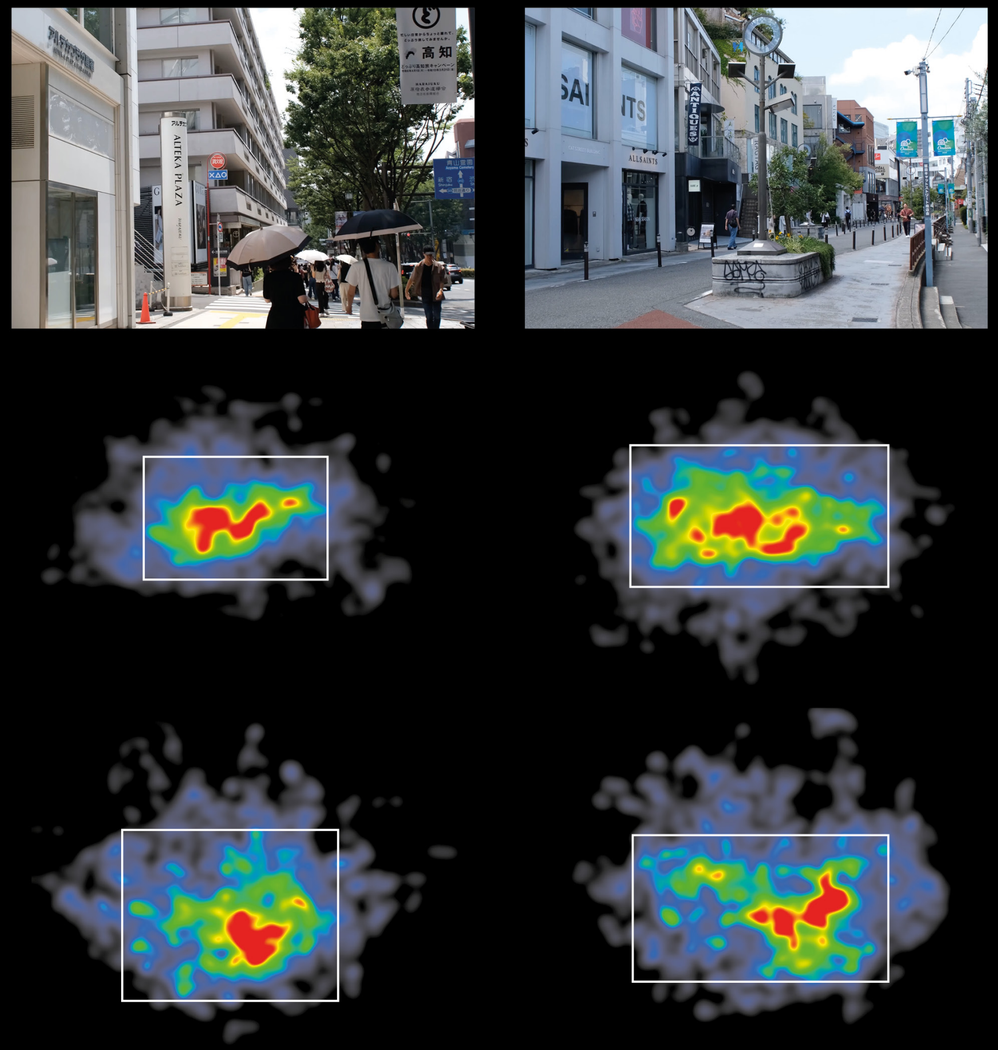
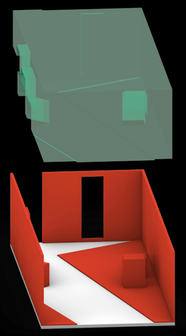


Fig. 32. Photographs comparing streetscapes associated with stress reduction (right) and non-stress reduction effects (left).
Gaze and fixation heat map from each eye tracking street scape study (left) eye-movement not associated with stress reduction (right) associated with stress reduction due to higher gaze and fixation dispersion indicating a wider anticipated field of view and more distributed visual stimulation.

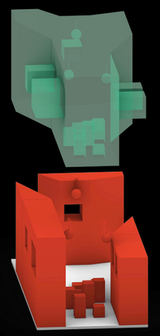


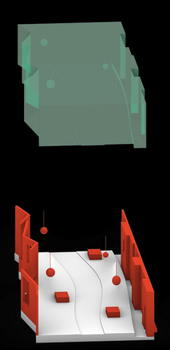


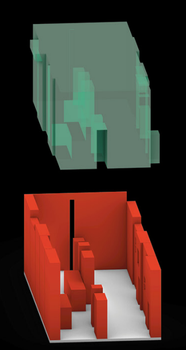


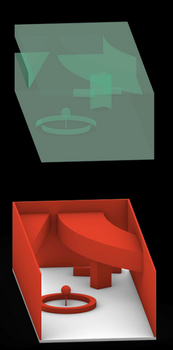


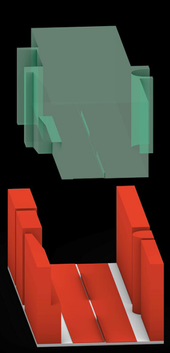














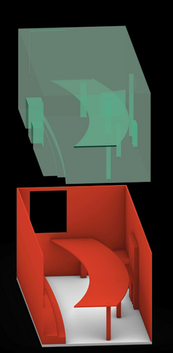



Fig. 33. Spatial configuration-abstractions of Tokyo's streetscape segments analyzed with wearable eye-tracking glasses.

Spatial patterns that affect eye-movement, associated with relaxation

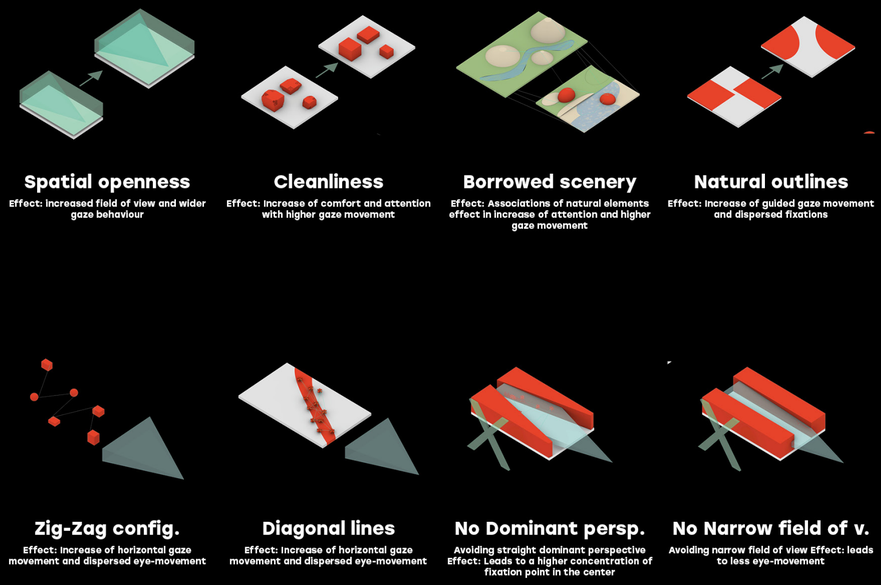


Fig. 34. Spatial configuration patterns that are associated with eye-movements stimulating short-term relaxation.
The patterns are chosen through desk research, literature review and through insights of the exploratory eye-tracking study in Tokyo's streetscape.

Traditional Japanese architectural knowledge & vernacular cooling strategies

General architectural literature informed a deepened understanding into Japanese traditional architecture with its traditional construction methods (Fujimori & Fujitsuka, 2017; Nishii et al., 1999), distinct spatial patterns of stroll gardens (Friedman et al., 1986), different vernacular housing typologies associated with their own climatic approach (Ichinowatari, 1981; Kawashima & Riggs, 1989) and the evolution of traditional Japanese architecture into the contemporary context of Tokyo's high density (Bognár, 1985).

Furthermore, the passive strategies of the vernacular cooling cues as climate mitigation methods are further grounded within existing findings in scientific research, indicating their potential for climate adaptation in the context of the project's retrofit. An evaluation of adapted concepts of natural airflow and evaporation, inspired from vernacular cooling cues, such as uchimizu (sprinkling water on hot pavements) and the spatial openness through modular timber frame structures and wide openings, enhancing airflow, indicated through environmental simulations a potential reduction in energy cooling demands of 10% regarding the maximum cooling load of an office building in Tokyo (Miyazaki et al., 2011).

Additionally, the cooling performance of uchimizu was measured in explorative experiments, which data resulted in a measured decrease of around 1,6°C to 8°C in air temperature locally close to the ground (Solcerova et al., 2018).

Other studies assessed as well the actual thermal conditions of traditional Japanese housings, by focusing on the thermal performance of several vernacular cooling strategies, such as the timber frame structure with bamboo-reinforced clay walls, which both openness and thermal mass regulate indoor climate, the spatial partitions including shoji (translucent) and fusuma (opaque) allow with its movability adaptable spatial sequencing for space-individual environmental control, as well as engawa, a wooden veranda, provides shading and controlled thermal emission inlet. Findings indicate that these elements enable stable indoor temperatures as well during fluctuating outdoor thermal emissions within summer periods (Hosham & Kubota, 2019; Shrestha & Shimizu, 2023). Furthermore, these vernacular principles are associated with potentially providing total energy reductions of 40-50% (Pourbakht, 2025).

Lastly, an informed understanding of Japanese carpentry techniques extends the climatic framework into its structural layers, which is considered to be explored in physical detail models themselves.



Fig. 35. Photograph of Engawa. From Jiro Harada (1936).



Fig. 37. Engawa and openness. From Prokopljević (2020).



Fig. 38. Uchimizu. From Kuniyoshi (n.d.).



Fig. 36. Open Floorplan and timber frame construction. From House of London (2023).

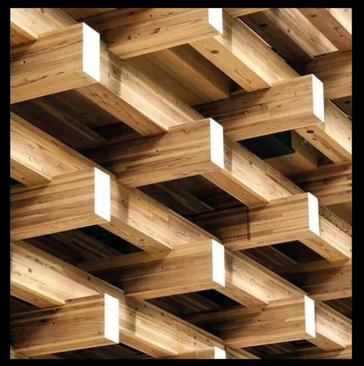
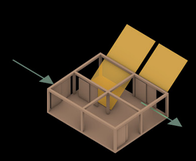


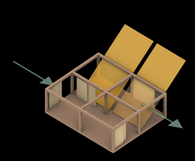
Fig. 39. Photogaph of the Yusuhara Wooden Bridge Museum's detail. From Yusuhara Wooden Bridge Museum (n.d.).

Patterns of vernacular cooling strategies



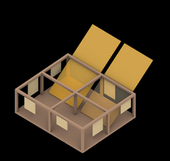
Fusuma/Amado

Opaque, sliding panel as partitions Effect: adaptive thermal thermal control, integration of thermal mass and air-flow enhancing Use case: Winter/Summer



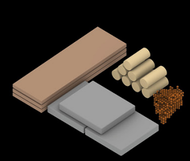
Shoji

Ranslucent, sliding panel Effect: daptive thermal thermal control, while allowing inlet of sunlight Use case: Summer



Sudare

Blind of bamboo strips Effect: shading and blocking thermal emissions Use case: Summer



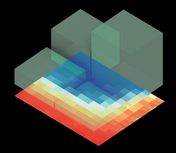
Materials

Timber, earth, bamboo, stone etc. Effect: Spatial configuration and thermal mass Use case: Winter/Summer



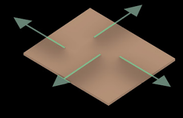
Engawa

Surrounding wooden veranda, buffer zone and soft boundary outside inside Effect: Shading,controlled inlet of thermal radiation and buffer zone (outside-inside), thermal mass controll Use case: Winter/ Summer



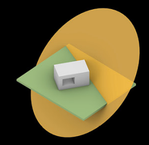
Spatial hierarchy

Spatial importance of kitchen and the bathroom Effect: Heat and warmth guide spatial relations Use case: Summer/winter



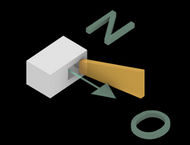
Open floor plan

Openness both towards inside and outside Effect: Airflow enhancing Use case: Summer



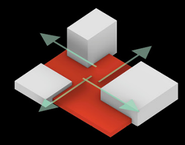
Building orientation

Rotation and placement of the building, reacting to climate conditions Effect: Gaining thermal emissions from the sun in winter/shade in summer, exclude the winter wind and embrace the warm summer breeze Use case: Summer/Winter



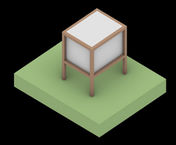
Kamimado

Window to the east, direction of the rising sun Effect: Thermal emissions and sunlight into the building during the early day Use case: Winter



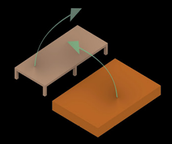
Ma

Inbetween, voide space Effect: Enhancment of airflow, inlet of sunlight, spatial structuring of spaces Use case: Summer



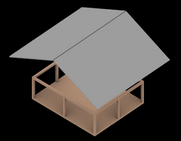
Takayuka jūkyo

Vernacular typology of storage with raised floor, dwelling Effect: humidity protection and enhanced airflow underneath the building Use case: Summer/winter



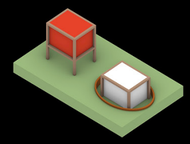
Genkan

Entrance as buffer zone of raised floor and earthen ground (former Doma space), spatial hirarchy and verticality Effect: varying floor conditions for different use (thermal mass, raised floor) Use case: Summer/winter



House and Roof

Roof as most important element for shelter, shelter from environmental conditions Use case: Summer/winter



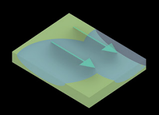
Dividing functions

Seperate vernacular typologies for storage and livingzs¨ Takayuka jūkyo and Tateana jūkyo Effect: Spatial features adapted for use and necessary environmental conditions Use case: Summer/winter



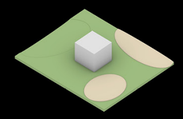
Position of openings

Positioning of the entrance and windows regarding environmental conditions Effect: Catching natural airflow and guiding into the building



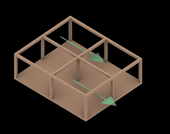
Presence of Water

Waterscape in japanese gardens Effect: Direct evaporative cooling Use case: Summer



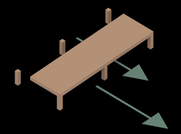
Stroll gardens

Japanese gardens surrounding the building Effect: natural buffer zone (outside-inside) evapotranspiration Use case: Summer



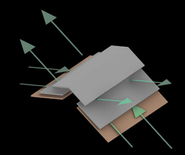
Timber frame

Lightweight and open structure with large openings Effect: Enhancing airflow and low-thermal mass Use case: Summer



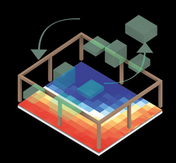
Elevated Floor

Foundation, typology vernacular housing Effect: enhancing airflow underneath the building, reducing accumulation of humidity Use case: Summer



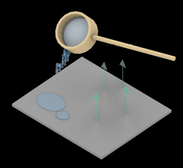
Smoke hole

Planned cutout in a roof structure Effect:Thermal chimney, natural outlet of warm air through the roof, enhancing natural cross ventilation Use case: Summer



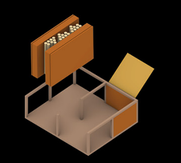
Multifunctional

Mobile furniture, adaptive spatial configurations Effect: Use of spaces according to thermal conditions and seasonal changes Use case: Summer/ winter



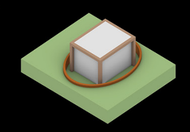
Uchimizu

Sprinkling of water on hot pavements Effect: Evaporation



Use of Clay

Bamboo-reinforced clay walls Effect: Thermal mass Use case: Summer/winter

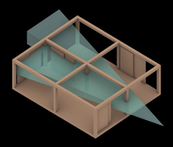


Tateana jūkyo

Vernacular typology of dwelling within a pit and earthen low walls, thatched roof Effect: Thermal mass of the ground and the excavated soil Use case: Summer/ winter

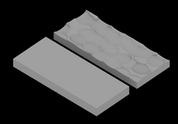
Fig. 40. Vernacular Japanese cooling patterns derived from desk research and literature review.

Patterns of vernacular cooling strategies associated as well with psychological layers



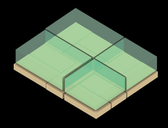
Adaptiveness

Shifting spatial configurations Effect: Expanded visual stimulation, visual depth, balanced stimulation Use case: Winter/ Summer



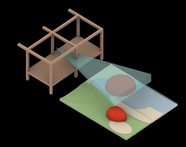
Contrast

Pairing contrasting properties (cleanliness and patina) Effect: Enhanced visual stimulation, sensorial balance Use case: Winter/Summer



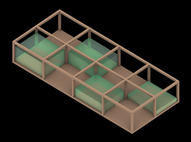
Tatami

Spatial structuring, rhythm Effect: structured visual field Use case: Winter/ Summer



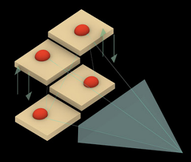
Biophilic elements

Water, plants, stones, seasonal change etc. Effect: visual stimuli, relaxation Use case: Winter/Summer



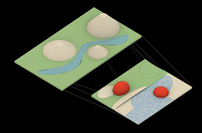
Oku

Spatial hierarchy of function, privacy and spiritual meaning arrange spatial configuration of depth Effect: Distance, curated depth, intervals, openness. Use case: Summer/Winter



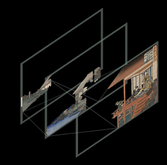
Thresholds

Slight vertical floor changes provide spatial hierarchies Effect: visual stimulations through spatial intervals Use case: Summer



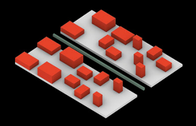
Shakkei

Borrowed scenery, association of natural elements through spatial configuration and mimicking natural curvatures and shapes Effect: Visual depth, increased attention, visual stimulations and widened spatial perception



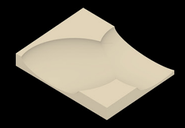
Illusional paintings

Spatial layering in japanese wooden prints Effect: spatial openness and curated visual depth Use case: Summer



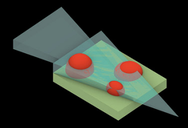
Asymmetry

Spatial configuration Effect: aesthetic balance and visual stimulation Use case: Winter/Summer



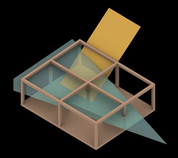
Karensansui

Dry translation of the flow of water Effect: visual depth and visual simulation Use case: Winter/Summer



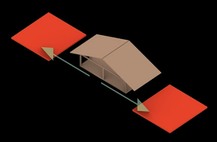
Miegakure

Ide and reveal of obejcts Effect: visual depth, distance Use case: Summer/Winter



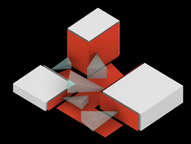
Kiwari and Clarity

Modular & prefabricated system of light timber structure Effect: Spatial repetition and visual openness Use case: Winter/ Summer



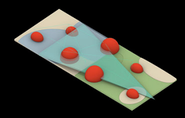
Horizontality

Wide roof overhang of the building Effect: Strengthening horizontality in visual perception Use case: Summer



Ma

Inbetween, voide space Effect: Openness, Visual depth, spatial intervals, depths and distance, spatial balance Use case: Summer



Spatial configuration

Japanese garden and the curation of elements Effect: Visual balance and extended visual stimulation, Openness, Visual depth



Yami

Quality of shadows Effect: visually perceived coolness, enhanced visual attention Use case: Summer

Fig. 41. Vernacular Japanese cooling patterns with psychological layers derived from desk research and literature review.

Part 03

RESEARCH BY DESIGN

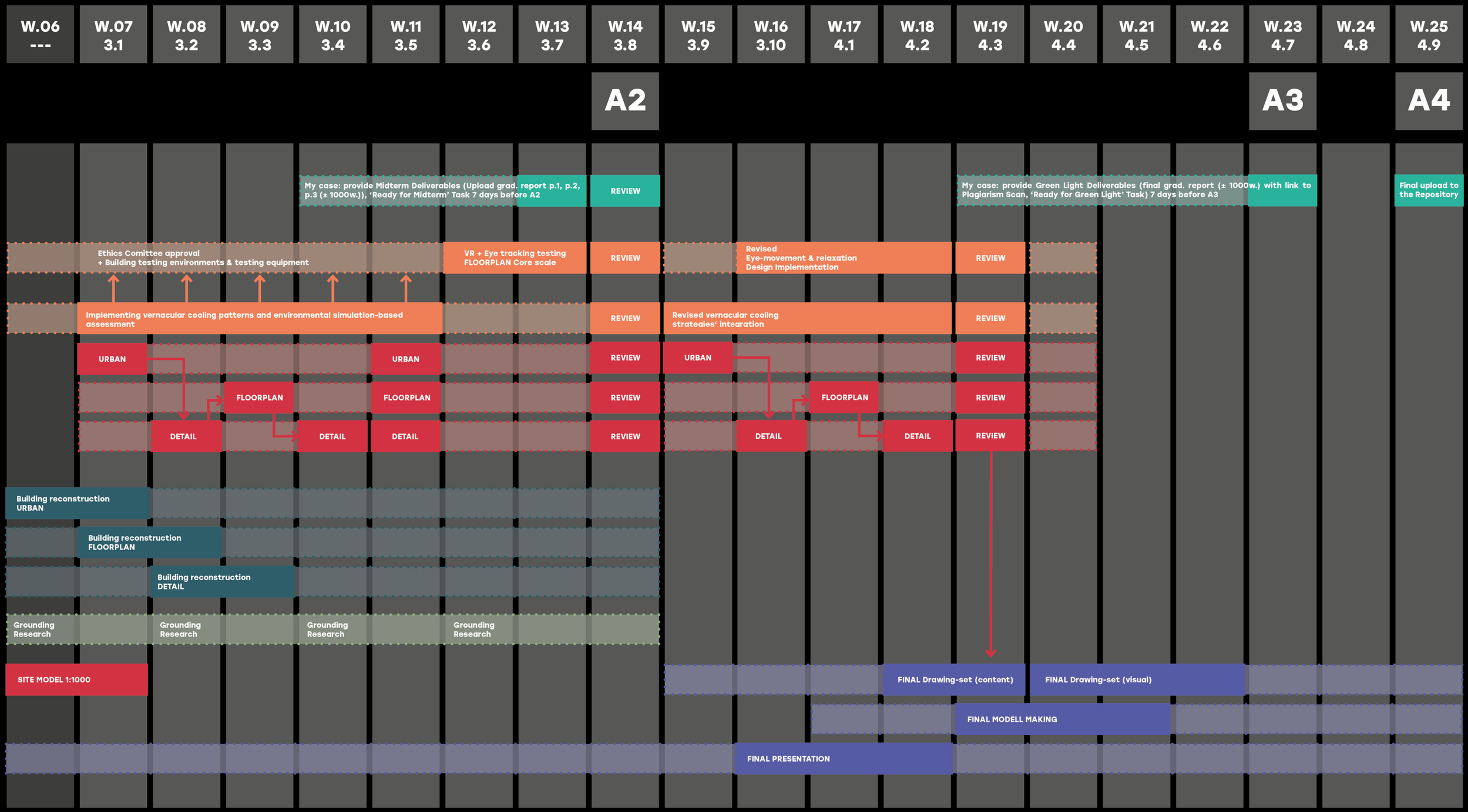


Fig. 39. Project schedule ranging from A1-A4.

A1 -A4 Schedule

3.1 Exploring

HEALTH-ENHANCING PROGRAM INTEGRATION

Urban Context &
Program Distribution Analysis

To contextualise the Kasumigaseki office building within its immediate surroundings and provide a better understanding of the distribution and diversity of the surrounding programmatic functions, green infrastructure, and the overall urban morphology a preliminary spatial analysis is conducted within a 1 km² area. Through geospatial mapping, the surrounding buildings are categorised according to their primary functions, considering governmental, administrative, office, residential, commercial, cultural, and recreational usage.

The resulting mapping indicates a dominant concentration of governmental and office-related functions within the northern and central areas of the urban study scope, this reflects the character of the Kasumigaseki district, recognised internationally as the heart of Japan's government and administration.

Furthermore, the spatial distribution of green spaces is examined to provide insights into the availability of vegetated areas in close proximity of the building and to assess their contribution on microclimatic cooling effects as well as the density of restorative environments. While several green areas are visible within the study scope, their local thermal effect on mitigating accumulating thermal emissions through the occurrence of vegetative surfaces, shading and evapotranspiration seems limited as their distribution appears fragmented and only partially integrated within the surrounding built environment.

Additionally, through an early assessment of the ground topography, a height difference of approximately 24 metres within the 1km2 area can be identified. While these variations remain relatively small at the scale of the district, they provide a preliminary indication of how the gradual elevation changes might result in potential interactions between topography and local airflow conditions.

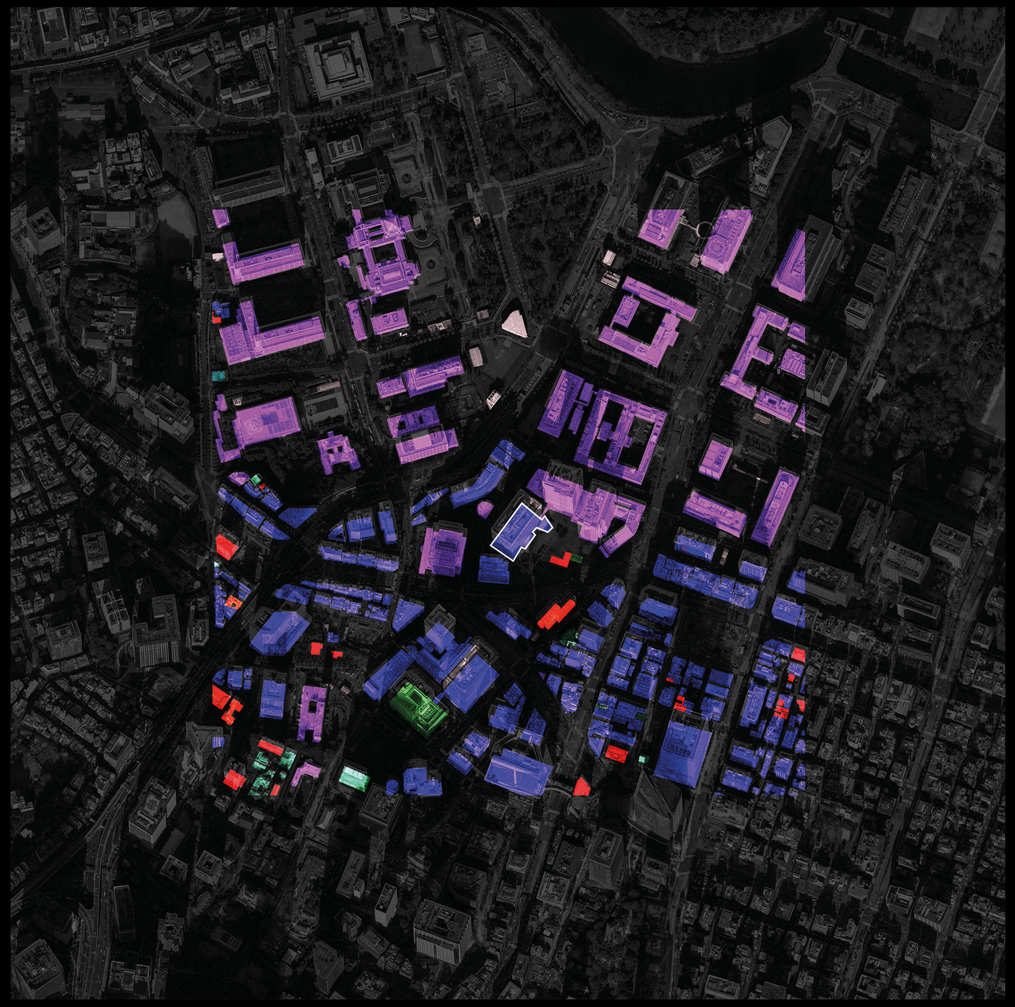


Fig. 42. Site plan diagram with programmatic building mapping to assess urban diversity.

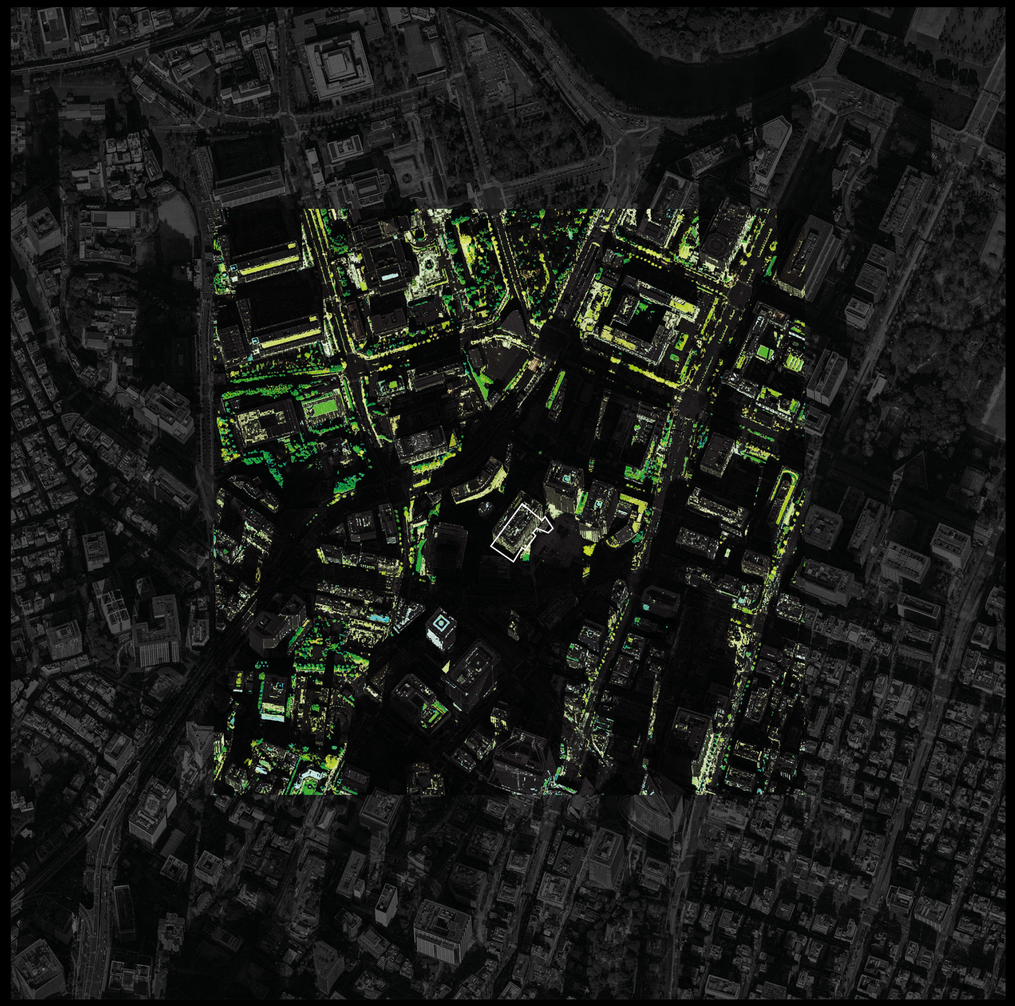


Fig. 43. Site plan diagram with assessment of urban greenery distribution.

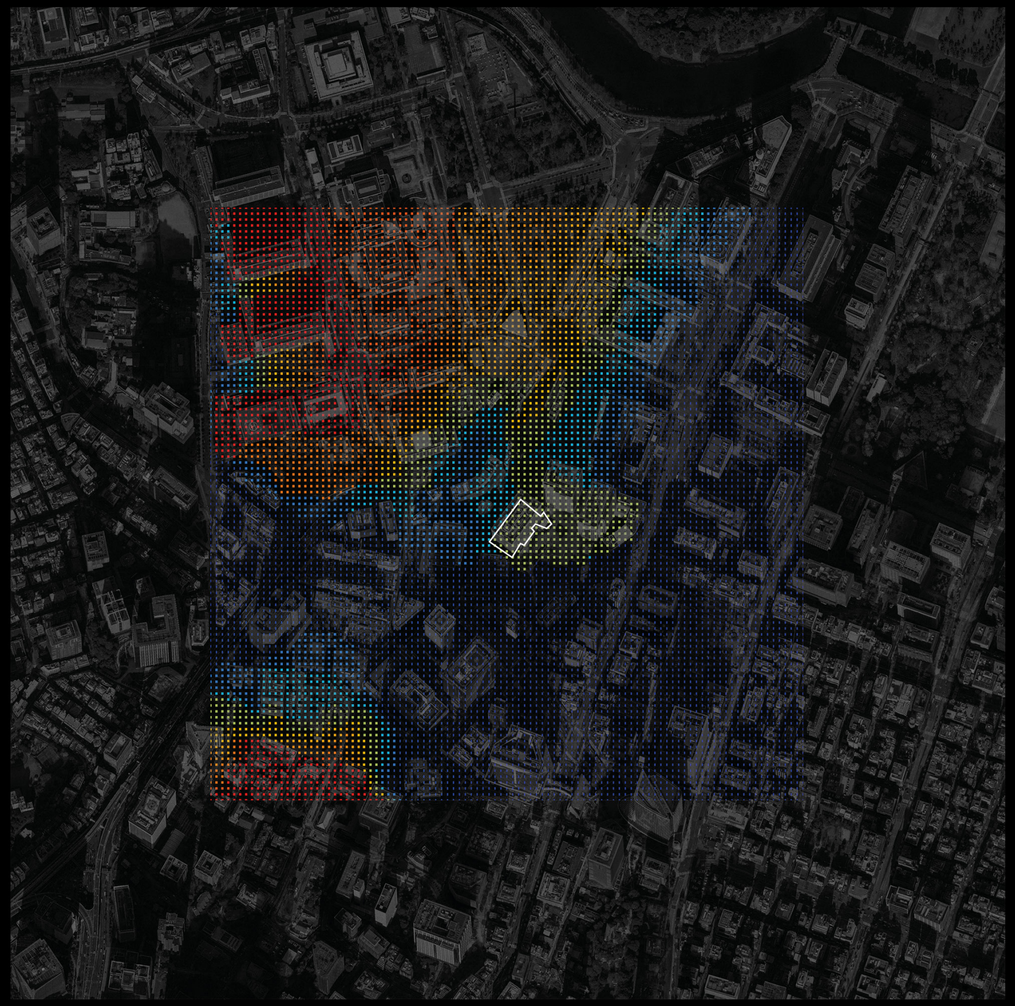


Fig. 44. Site plan diagram with topographical elevation assessment.

Ground Floor Diversity & Vertical Monotony

In the following analysis, the previously examined 1km2 study area is translated from a solely two-dimensional mapping into a three-dimensional reading of the urban environment. The programmatic assessment of distribution and diversity is therefore extended by comparing the ground floor condition with the vertical landscape of a number of selected office buildings. Both layers are reflected through colour palettes that represent the distribution of functions within the district.

While both scales indicate a high urban density, the ground floor appears as a collage of diverse elements, including sports facilities, graveyards, a variety of materials and spatial forms, as well as dispersed pockets of greenery. Beyond the colour pallet, the ground floor becomes a canvas of integrated cultural, religious and restorative niches, resembled in a number of selected smaller shrines.

In contrast, as the focus shifts towards verticality, an increasing monotony becomes visible, both in colour composition, architectural expression and programmatic functions. Within the defined 1 km² study area, eight office buildings are selected for further analysis, representing the evolving landscape of office typologies constructed between 1968 and 2025 within the Kasumigaseki district. While working styles and societal structures have gradually evolved towards greater individuality and diversity over the last 75 years, the vertical organisation of office buildings continues to remain predominantly in its monotony from 1968.

This comparison introduces the approach to reinterpret the ground floor's diversity within the vertical office landscape. By translating elements of the ground level's cultural, historical, religious and active urban layers into the vertical dimension, the office environment can potentially evolve into a more diverse spatial landscape that reflects both on the district's broader past, current and future urban identity.





Fig. 45. Colour palette assessment of urban vertical diversity. Aerial footage. From Pano360 Lite (n.d.).



Fig. 46. Streetscape analysis in the Kasumigaseki district. Screenshot adapted from Google Earth imagery (2026).



Fig. 47. Streetscape analysis in the Kasumigaseki district. Screenshot adapted from Google Earth imagery (2026).



Fig. 48. Streetscape analysis in the Kasumigaseki district. Screenshot adapted from Google Earth imagery (2026).



Fig. 49. Streetscape analysis in the Kasumigaseki district. Screenshot adapted from Google Earth imagery (2026).



Fig. 50. Streetscape analysis in the Kasumigaseki district. Screenshot adapted from Google Earth imagery (2026).



Fig. 51. Streetscape analysis in the Kasumigaseki district. Screenshot adapted from Google Earth imagery (2026).



Fig. 52. Kasumigaseki district map indicating with numbers the 8 referenced office buildings.



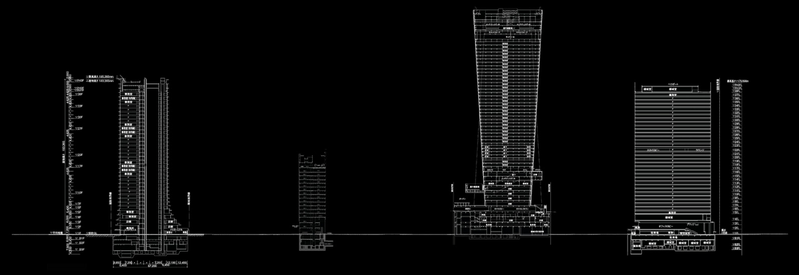
01 KASUMIGASEKI BUILDING

02 SHIN KASUMIGASEKI BUILDING

03 KASUMIGASEKI COMMON GATE

04 TOKYO CLUB BUILDING

05 AKASAKA INTERCITY AIR



06 TORANOMON HILLS BUSINESS TOWER

07 T-LITE BUILDING

08 TORANOMON HILLS STATION TOWER

09 TORANOMON ALCEA OFFICE

Fig. 53. Overview matrix of the 8 referenced office buildings.



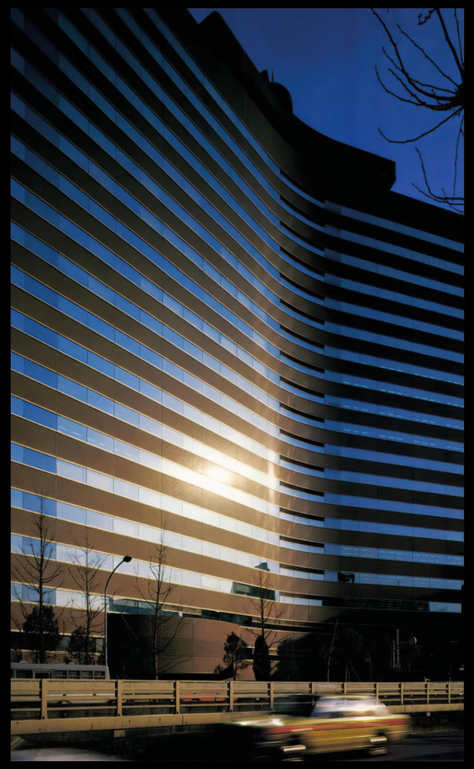
KASUMIGASEKI BUILDING

Completion – 1968

Fig. 54. Photograph of the Kasumigaseki building. From oldthing (n.d.)



Fig. 55. Section Analysis diagram for understanding prorgammatic diversity.



SHIN KASUMIGASEKI BUILDING

Completion – 1985

Fig. 56. Photograph of the Shin Kasumigaseki building. From Shin Kasumigaseki Building | Projects Top | Shinkenchiku.DATA (n.d.).

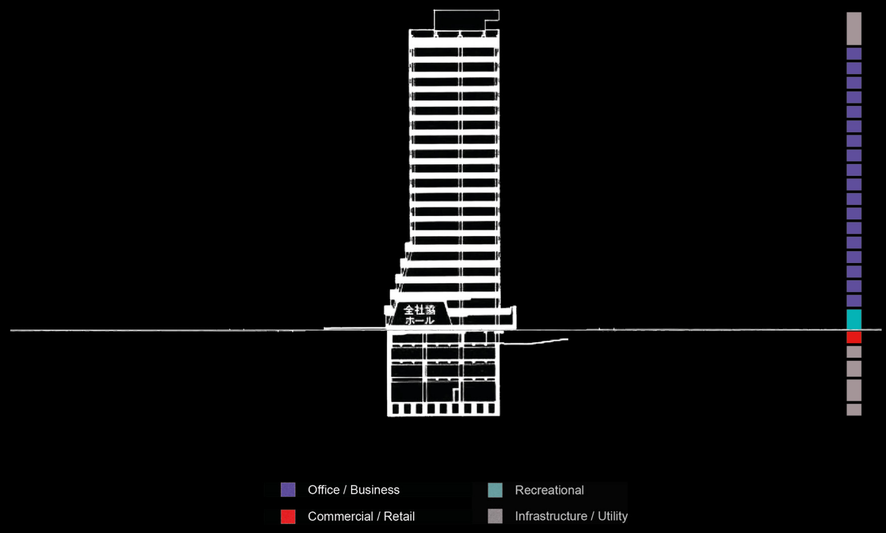


Fig. 57. Section Analysis diagram for understanding prorgammatic diversity.



KASUMIGASEKI COMMON GATE

Completion – 2007

Fig. 58. Photograph of the Kasumigaseki Common Gate building. From 2005.01.07 | 日鉄興和不動産 コーポレートサイト (n.d.).

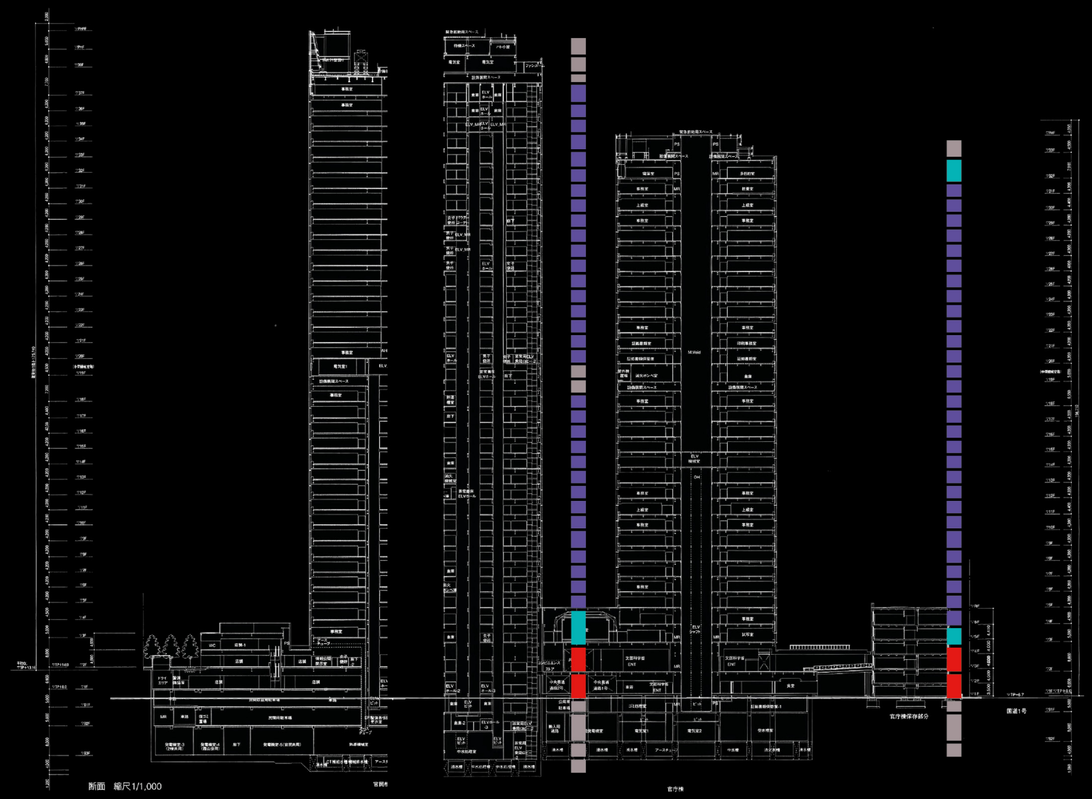


Fig. 59. Section Analysis diagram for understanding prorgammatic diversity.



TOKYO CLUB BILDING

Completion – 2007

Fig. 60. Photograph of the Tokyo Club building. From TOKYO CLUB BUILDING | Projects Top | Shinkenchiku.DATA (n.d).

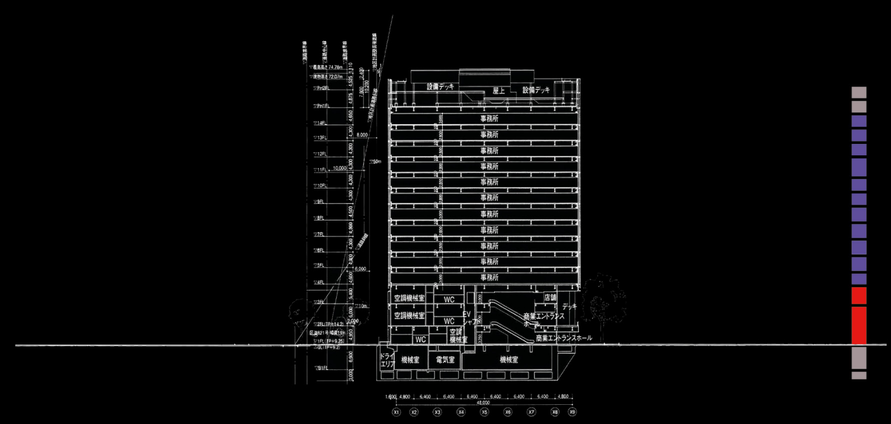


Fig. 61. Scanned Section Analysis diagram for understanding prorgammatic diversity.



AKASAKA
INTERCITY AIR

Completion – 2017

Fig. 62. Photograph of the Akasaka Intercity Air. From 【赤坂インターシティAIR】ポップアップストアやプロモーションに適した超高層複合ビルのイベントスペース(2Fロビー エスカレータ横 (n.d.).

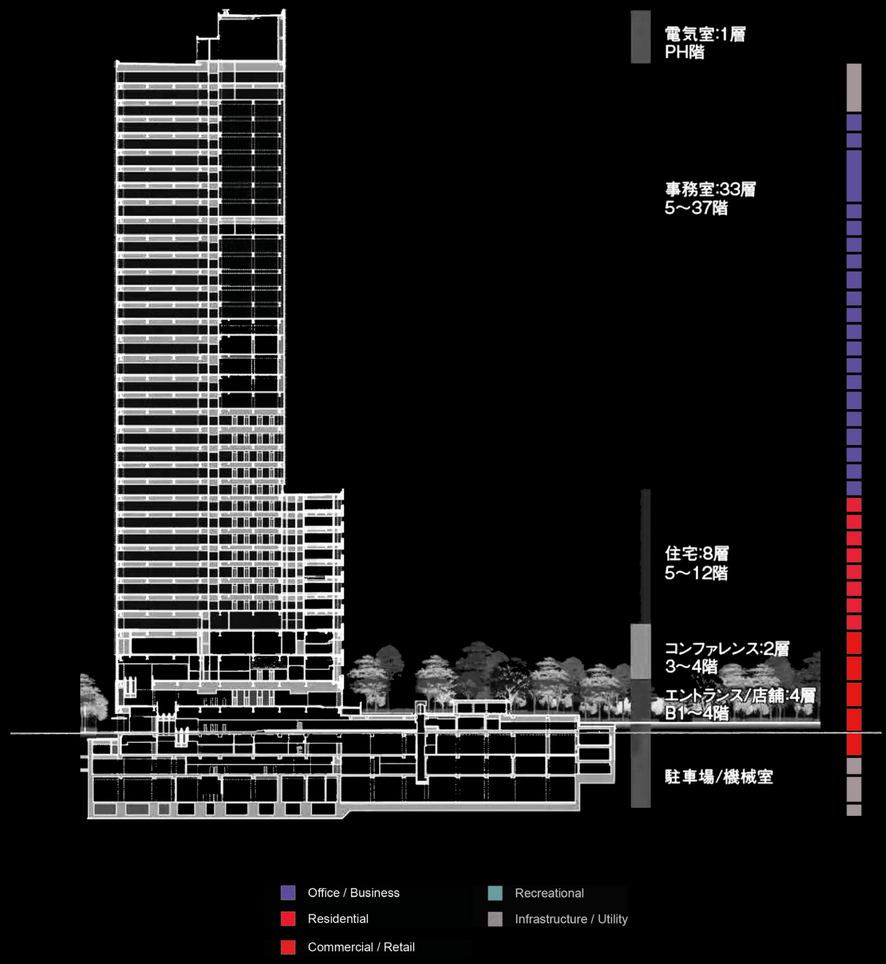


Fig. 63. Section Analysis diagram for understanding prorgammatic diversity.



TORANOMON HILLS BUSINESS TOWER

Completion – 2020

Fig. 64. Photograph of the Toranomon Hills Business Tower. From Meyer, U. (2021).

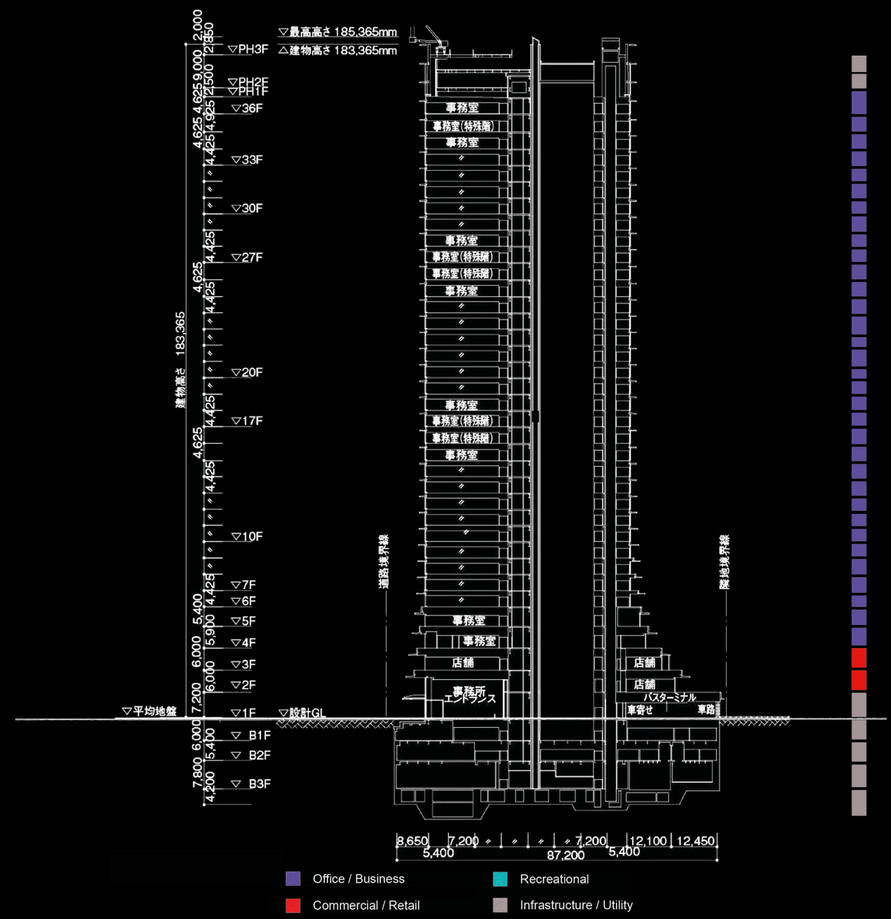


Fig. 65. Section Analysis diagram for understanding prorgammatic diversity.



T-LITE BUILDING

Completion – 2023

Fig. 66. Photograph of the T-Lite Building. From T-LITE | Projects Top | Shinkenchiku.DATA, (n.d.).



Fig. 67. Section Analysis diagram for understanding prorgammatic diversity.



TORANOMONS HILLS STATION TOWER

Completion – 2023

Fig. 68. Photograph of the Toranomon Hills Station Tower. From TORANOMON HILLS STATION TOWER | Projects Top | Shinkenchiku.DATA (n.d.).

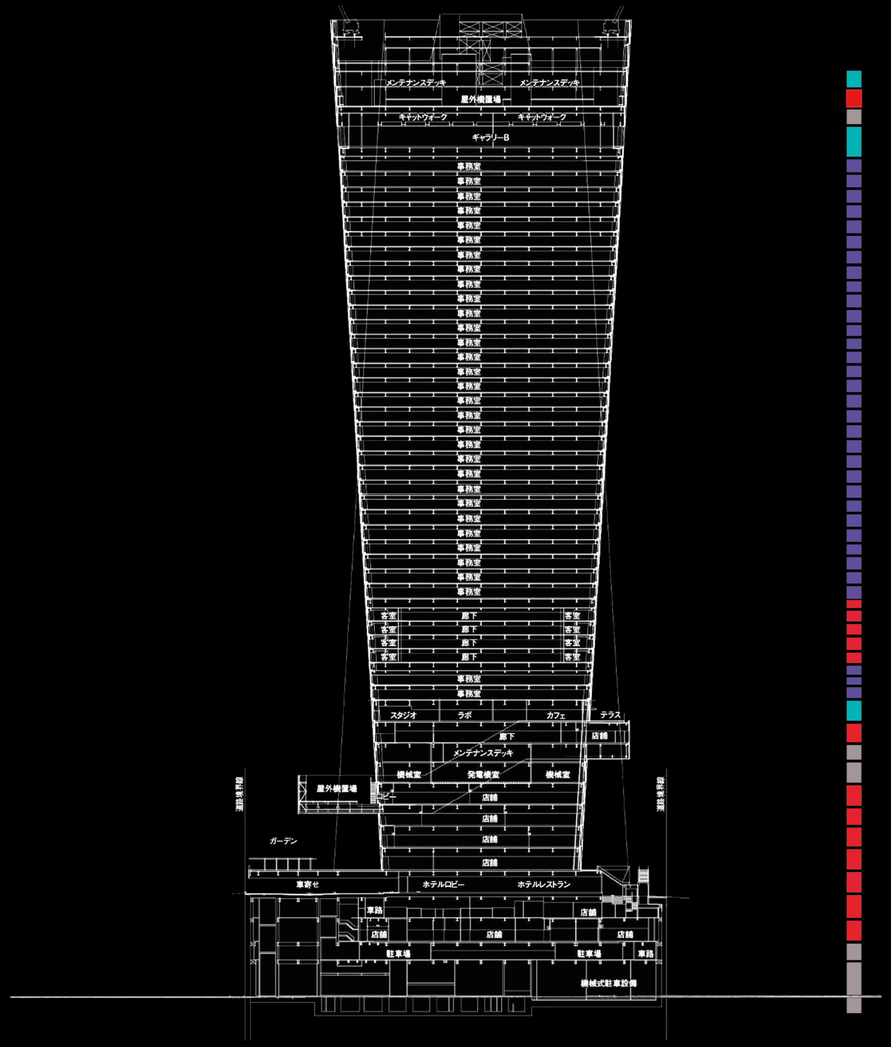


Fig. 69. Section Analysis diagram for understanding prorgammatic diversity.



TORANOMON
ALCEA TOWER

Completion – 2025

Fig. 70. Photograph of the Toranomon Alcea Tower. From TORANOMON ALCEA TOWER | Projects Top | Shinkenchiku.DATA (n.d.).

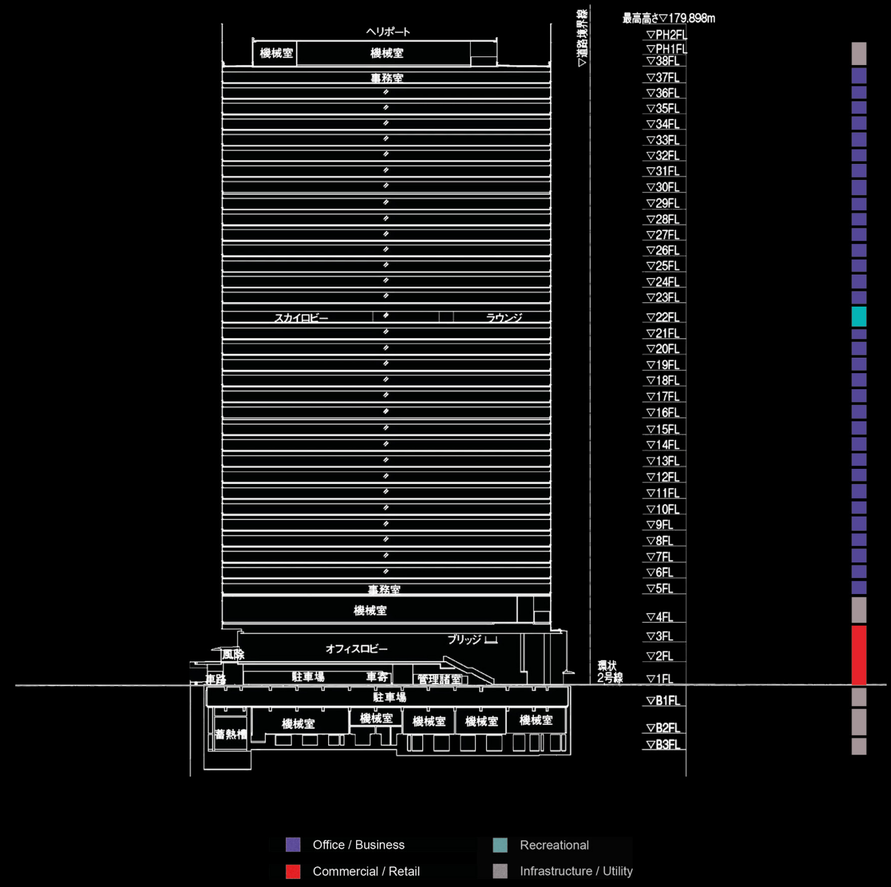
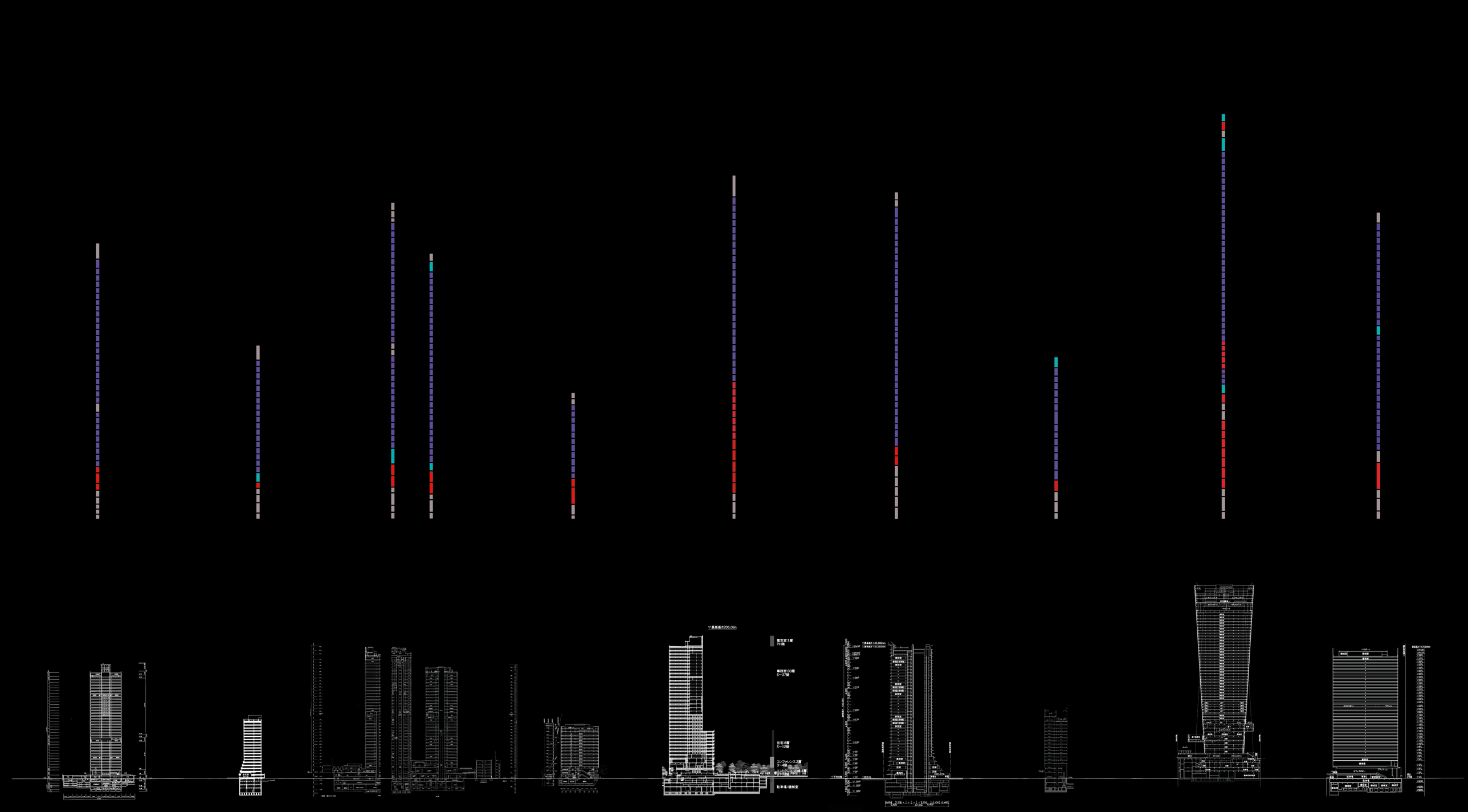


Fig. 71. Section Analysis diagram for understanding prorgammatic diversity.



1968
KASUMIGASEKI BUILDING

1985
SHIN KASUMIGASEKI BUILDING

2007
KASUMIGASEKI COMMON GATE

2007
TOKYO CLUB BUILDING

2017
AKASAKA INTERCITY AIR

2020
TORANOMON HILLS BUSINESS TOWER

2023
T-LITE BUILDING

2023
TORANOMON HILLS STATION TOWER

2025
TORANOMON ALCEA OFFICE

Office / Business
Residential
Commercial / Retail
Recreational
Infrastructure / Utility

Fig. 72. Scanned Section Analysis diagram overview.

Addition + &
Extraction -

Addition (+) and subtraction (-) as spatially transformative strategies have emerged within this project from exploring both contemporary architectural references and traditional Japanese techniques. Both are understood not as opposite actions, but as spatial tools that allow an existing structure to be transformed while maintaining its architectural identity, which provides conceptual guidance for this project's aim to retrofit the Kasumigaseki office building.

The cohesion between addition and substraction can be interpreted from Japanese traditional spatial techniques and material-centred operations such as Ma, in which spatial intervals and voids create rhythm and enhanced perception, or Kintsugi, where the act of repair does not conceal transformation but reveals it as a part of processing change.

Additionally, the notion of stacking and/or inserting different geometries to introduce new programmatic layers is inspired by architectural references such as the Très Grande Bibliothèque by Rem Koolhaas or the Gallery of Jianshang Sports Complex, where different functions occupy distinct spatial volumes, complementing as well the idea of substraction within generating voids and diverse spatial rhythms, found in spatial compositions of projects by OFFICE Kersten Geers David Van Severen.

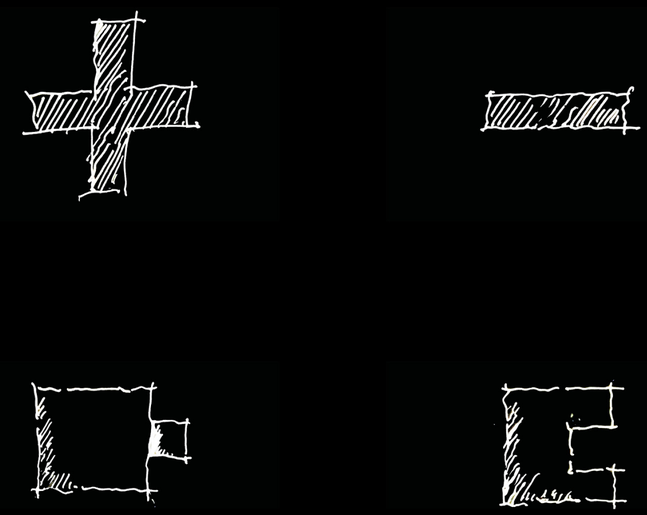


Fig. 73. Addition and substraction concept diagram.



Fig. 74. Photograph of the Taipei Performing Arts Center.
From Crook and Crook (2022).

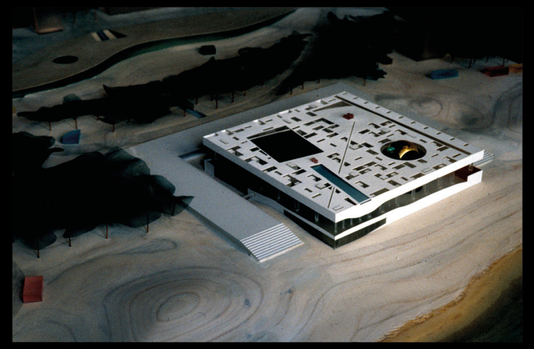


Fig. 75. Photograph of an model of the Agadir Convention Centre.
From Agadir Convention Centre (n.d.).



Fig. 76. Image of a card showing the Pagoda of Yasaka.
From Leaf Publications Co., Ltd. (2020).

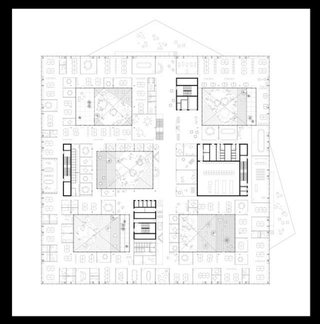


Fig. 77. Floorplan of the RADIO & TELEVISION BUILDING (VRT II).
From RADIO & TELEVISION BUILDING (VRT II) – Brussels (n.d.).

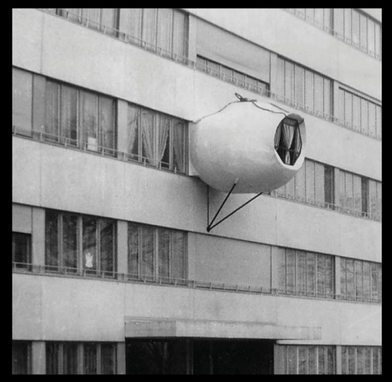


Fig. 78. Photo of the „pirate bubble“.
From Stegmüller et al. (2024).



Fig. 79. RADIO & TELEVISION BUILDING (RTS) – Lausanne.
From RADIO & TELEVISION BUILDING (RTS) – Lausanne (n.d.).

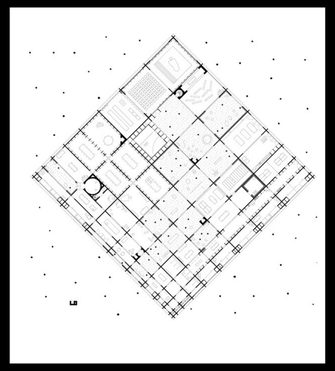


Fig. 80. ARVO PÄRT CENTRE – Laulasmaa.
From ARVO PÄRT CENTRE – Laulasmaa (n.d.)

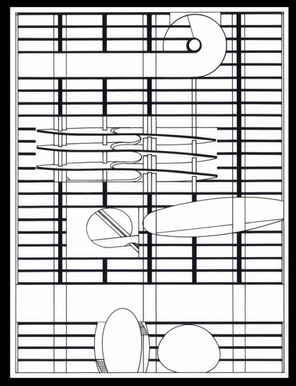


Fig. 81. Section of the Très Grande Bibliothèque.
From OMA . Très Grande Bibliothèque. Paris Tegmark Afasia (23) (n.d.).

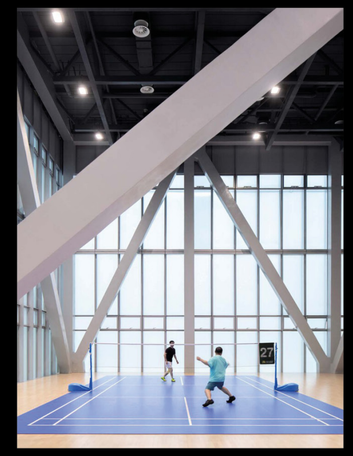


Fig. 82. Photograph of the Jianshang Sports Complex
From OMA . Chen (2025).



Fig. 85. Photograph of the Très Grande Bibliothèque model.
From (OMA, n.d.).



Fig. 86. Kintsugi.
From Burton (2025).

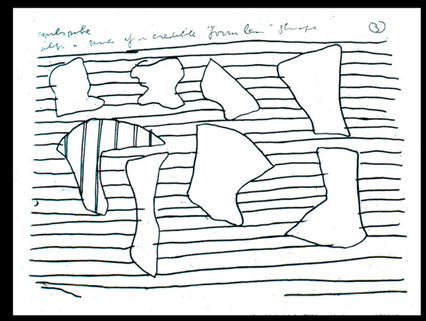


Fig. 87. Sketch of the Très Grande Bibliothèque concept.
From (OMA, 2025).

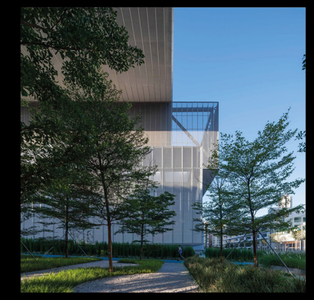


Fig. 83. Photograph of the Jianshang Sports Complex
From OMA . Chen (2025).



Fig. 84. Photograph of the Jianshang Sports Complex
From OMA . Chen (2025).

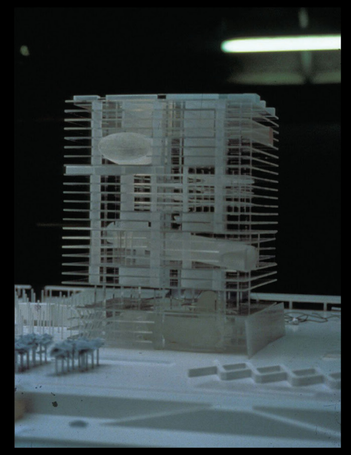


Fig. 88. Photograph of the Très Grande Bibliothèque model.
From (OMA, 2025).

1:1000 Site Scale Form Finding in Urban Perception

The retrofitting process of the Kasumigaseki building begins as a simple block of foam embedded within its immediate urban context. The surrounding environment is represented through a physical model covering the previously analysed 1 km² study area. While earlier research and referential explorations establish the conceptual basis for geometrical extraction (–) and addition (+), the 1:1000 model acts both as an engine for form exploration and as a critical lens for evaluating spatial interventions.

As this stage focuses on form finding, rapid prototyping and geometrical testing of the building itself, the surrounding urban model remains static, while the foam material of the building itself allows quick manipulation, testing and revision. Guiding parameters include urban perception, streetscape-level visibility and the Kasumigaseki building's primary structural logic in its basic divisions of core and usable floor space.

These explorations are later examined at building and detail scales to assess how simple geometric interventions influence spatial perception, architectural performance and constructional complexity.



Fig. 89. Physical Site Model photograph.

STUDY 01



Fig. 90. Physical Site Model photograph including the study 01.

STUDY 02



Fig. 91. Physical Site Model photograph including the study 02.

STUDY 03



Fig. 92. Physical Site Model photograph including the study 03.

STUDY 04



Fig. 93. Physical Site Model photograph including the study 04.

STUDY 05



Fig. 94. Physical Site Model photograph including the study 05.

Vertical Learning Environments as Spatial Reference

While schools, which can be described as typologies of concentration, focus and learning, also share parallels with office environments in their reliance on fixed occupation, spatial efficiency and repetitive daily routines. At the same time, the school typology extends beyond concentrated work through the integration of canteens, sports facilities, wider circulation areas and open common spaces. Such spatial diversity encourages movement, social interaction and moments of recovery within daily routines. Research on educational environments highlights that spatial conditions which support physical activity and social engagement can positively contribute to physical and mental well-being, as well as cognitive performance and learning outcomes (European Commission, 2018).

The Leutschenbach School by Christian Kerez (2009) provides a relevant vertical reference, where spaces meant for concentration, social interaction and recreation, such as libraries, multifunctional spaces, as well as sport facilities, are vertically layered and can intensify interaction and movement through spatial openness and generous ceiling heights.

A second reference of vertical learning environments is the Copenhagen International School Nordhavn, designed by C.F. Møller and built in 2019. Its common base, in which common spaces, shared social and recreational spaces as well as sports facilities, are horizontally and vertically visually connected, creates stimulus for enhancing physical movement and social interaction through a balanced distribution of small recreational spaces and larger common spaces, incorporating, for instance, the canteen while visually connecting the library and a gymnasium both horizontally and vertically.

Together, these examples suggest that for the Kasumigaseki retrofit, it is not sufficient to distribute functions only vertically. Equally important is the horizontal organisation of each floor, enabling movement, encounter and spatial variation within daily work routines.

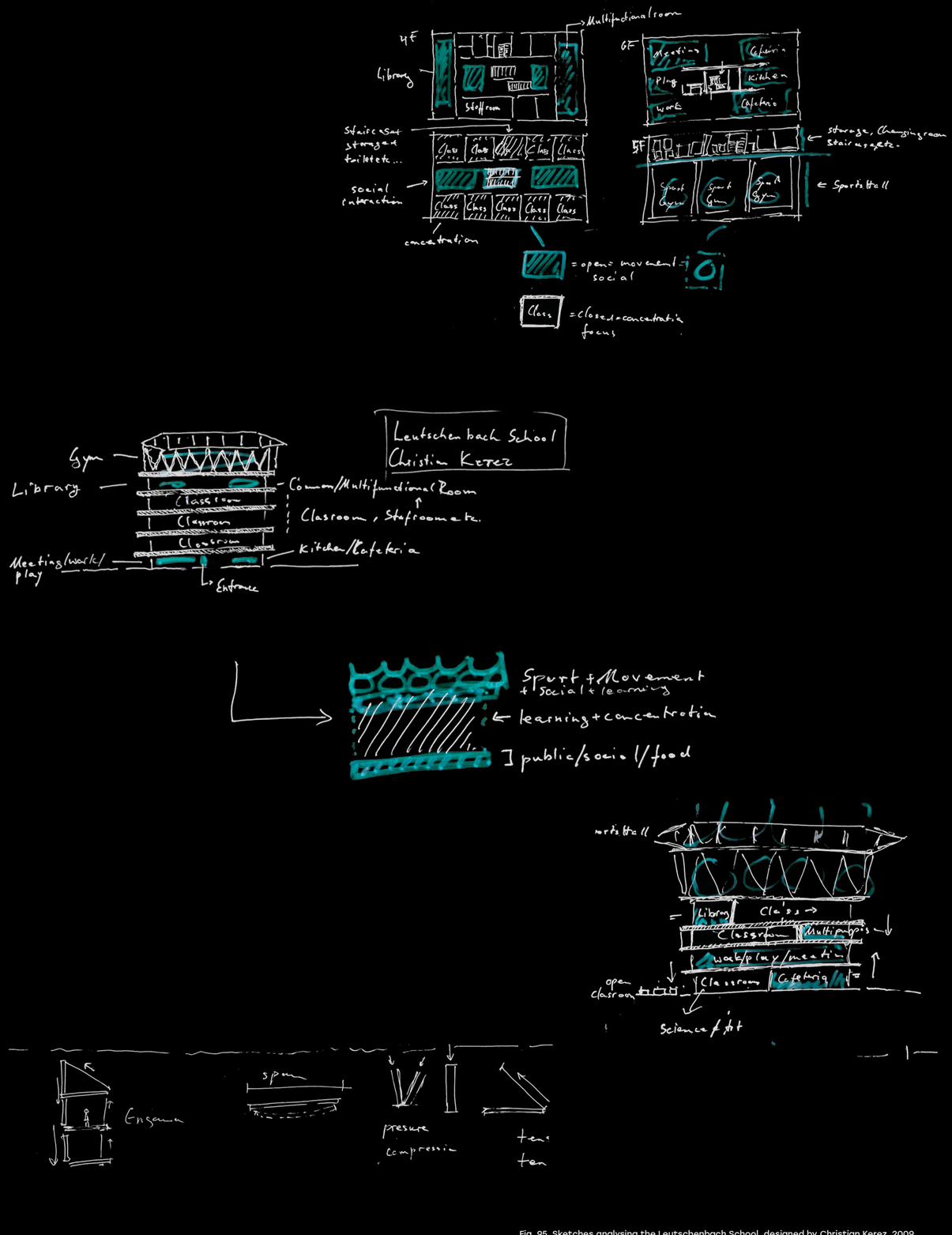


Fig. 95. Sketches analysing the Leutschenbach School, designed by Christian Kerez, 2009.

Christian Kerez
Leutschenbach School, 2009

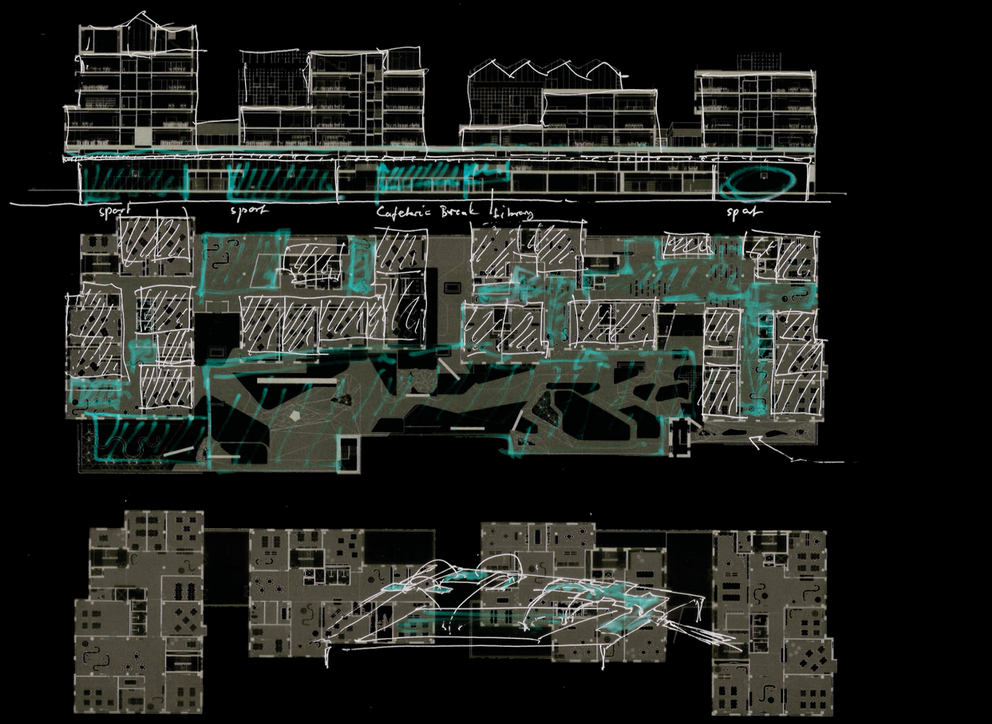


Fig. 96. Sketches analysing the Copenhagen International School Nordhavn, designed by C.F. Møller 2019.

C.F. Møller
Copenhagen International School Nordhavn, 2019

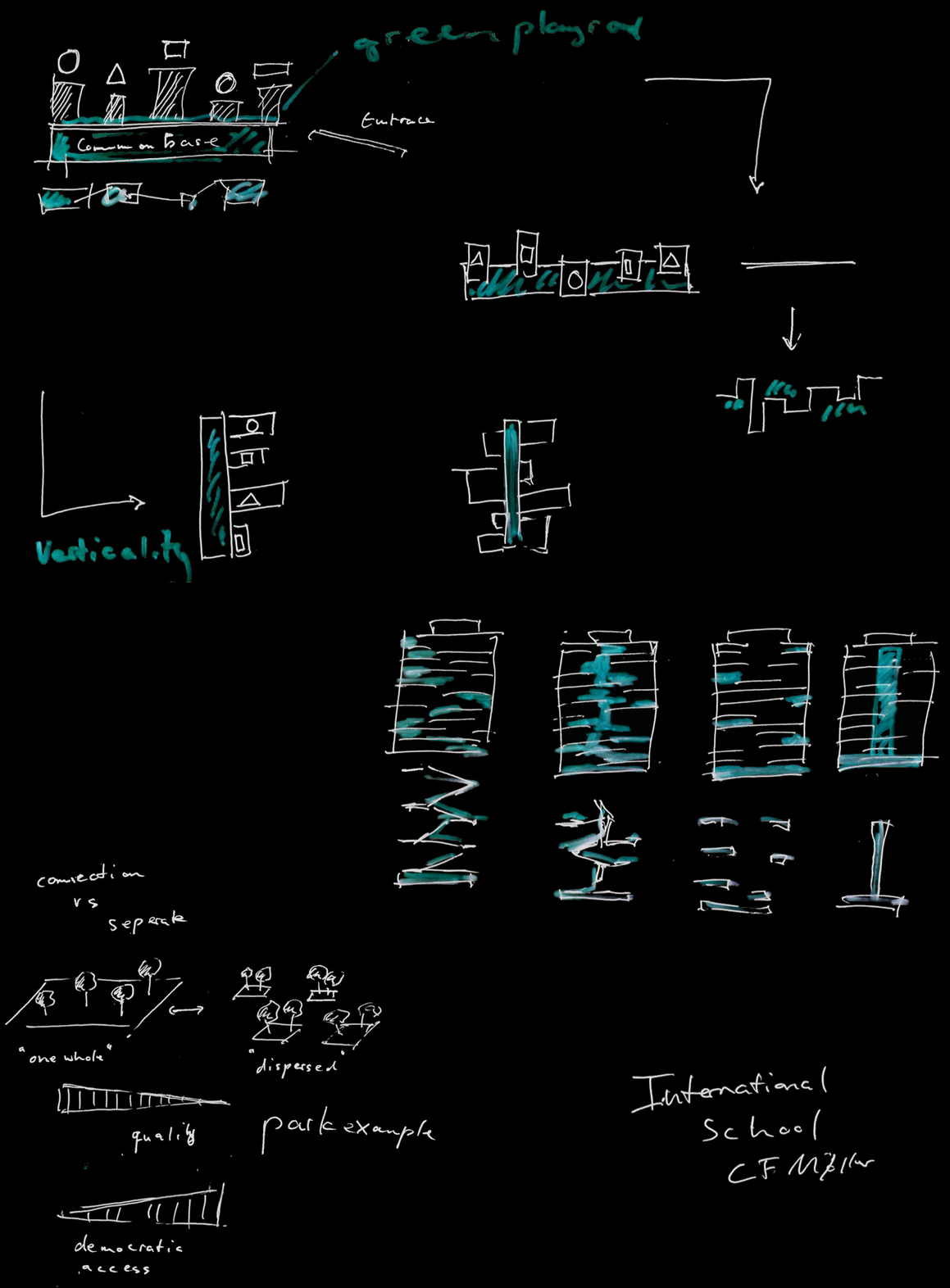


Fig. 97. Sketches analysing the Copenhagen International School Nordhavn, designed by C.F. Møller 2019.

C.F. Møller
Copenhagen International School Nordhavn, 2019

Between Diversity & Density & Spaces

To implement the gained insights of the previously mentioned research and references within the Kasumigaseki building, clusters with health-enhancing programmatic diversity ranging from three to six floors are integrated into the building's organisation.
As a clear understanding of the current occupancy, density and spatial capacity is required, the existing office structure has been analysed. In 1968, the building was planned to operate with an average planning density of approximately 8 m2 per person, resulting in around 330 occupants per standard office floor.
Using this baseline, the total population within each cluster is calculated and translated into spatial requirements for the newly introduced programmatic elements, including total user number, capture rate (frequency of use), simultaneity of use and peak user scenarios, allowing the calculation of the necessary floor area for each intervention.

While the in size differing clusters are meant to translate the spatial, social, and cultural diversity of the Kasumigaseki district's streetscape into the vertical office environment of the Kasumigaseki building, the three-floor cluster, for instance, resembles the variety of shrine niches or the typology of the Yokocho, a narrow and socially dense side street, which are meant to support informal social-interaction, physical activity and short breaks.
The six-floor cluster resembles a Shotengai, a larger street typology with cafés, shops and active circulation, integrating sequences of shared programs such as cafés, conference halls and sports facilities across multiple floors.

At the same time, each intervention is evaluated in relation to physiological and psychological cooling effects. Physiological cooling is addressed through spatial extractions that improve airflow, shading and vegetation, contributing to the reduction of perceived and measured temperature. Psychological cooling is considered through spatial configurations that encourage visual depth, increased horizontal eye-movement, and horizontally dispersed fixation patterns, encouraging moments of relaxation within the work environment.

While the clusters align with contemprary non-fixed-place working conditions and more interactive co-working concepts, the building itself is not meant to be equipped fully with these clusters, as the primary identity of a spatially efficient office environment should be maintained. The clusters are however, considered to be shared working hubs, open to all other floors of the Kasumigaseki building.

In terms of heat stress mitigation, the clusters resemble both psycholgical, physiological and program integrative strategies, while the rest of the office floors is approached primarily only with the integration physiosological passive cooling strategies. This allows the overall retrofit strategy to maintain efficient implementations that balance heat stress mitigation and energy reduction, while minimising financial efforts and preserving the existing occupational density.

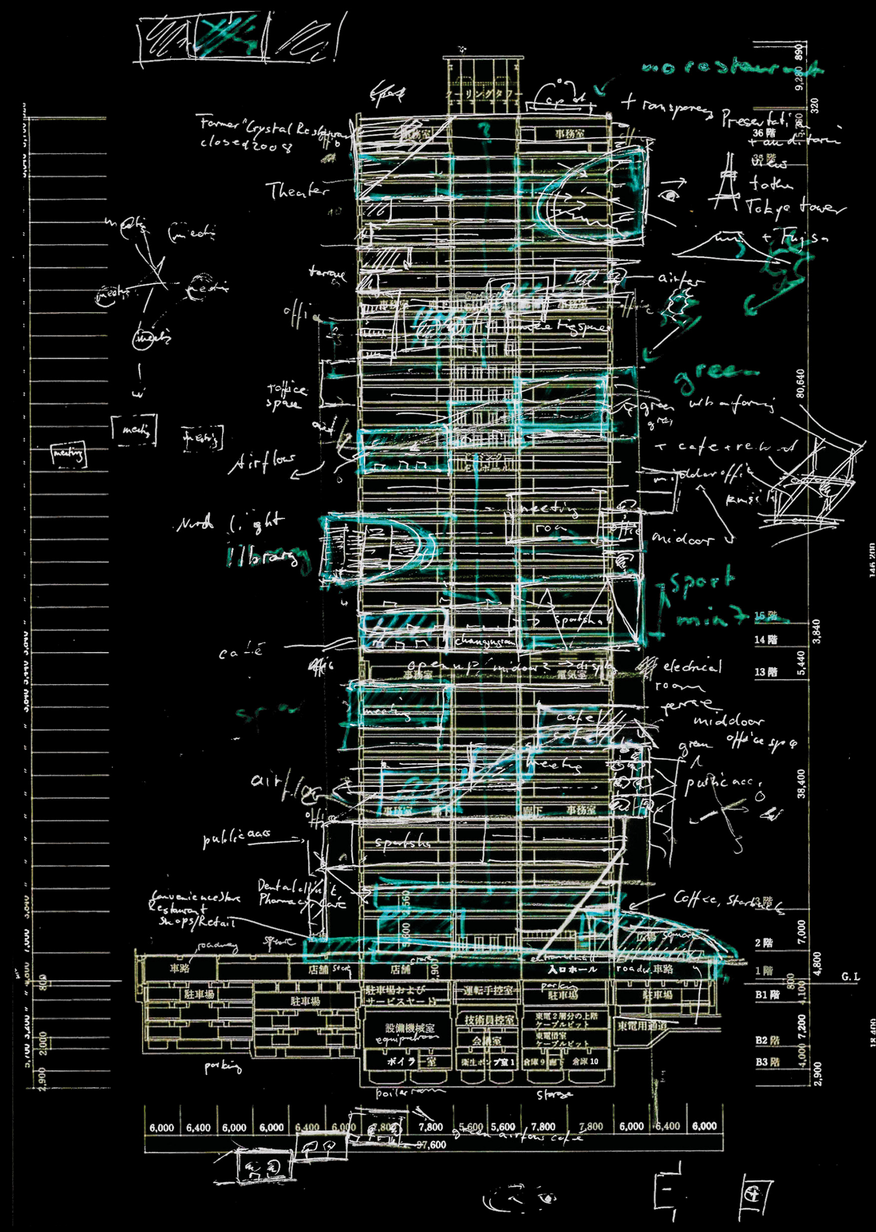


Fig. 98. Retrofit strategy sketch of the whole Kasumigaseki building.

Healthy building program addition matrix

Base calculation for the Kasumigaseki building:

Total building height: 147 m
Total Floor area: 153959 m²
Total loan area: 87012 m²
Usable floor area (office) per floor: 2637 m²
Gross core area: 695 m²
Gross floor area (office) per floor: 3617 m²
Floors: 36F/B3F
Elevators: 31 units, 3 units for storage, 2 units for parking

Occupational density

Planning density for occupation: The minimum standard area per person for the entire office space (excluding the core area, including corridors, locker rooms, etc.) **is approximately 8m²**

Comparison to 1960s office planning guidelines:
desk/workroom area = 3,3 m² × person
circulation = 35% of room area (up to 40%)
storage = 13% of office area

Result: 3,3×(1+0,35+0,13)=3,3×1,48=4,884 m²/person

From existing occupancy derived density (peak-seat density): 616 seats on 1712,82 m²
→ 1712,82 / 616 = 2,78 m²/person

Baseline density for design decisions: 8 m² per person for the entire office space (excluding the core area, including corridors, locker rooms, etc.)
Net office per floor (excl. core): = 2636,73 m²
Office-floor equivalents: = 32,5

Occupancy (design intent)
Per floor: 2636,73 / 8 = 330 people/floor
Per Building: 330 x 32,5 = 10700 people

Peak-seat density (workstation pack ~2,78 m²/person in desk zones

Strategy

Each office floor must still end up supporting **~330 people.**
Aim: To keep employment capacity while improving physical and mental health and spatial quality.

Concept

The project translates the spatial richness of Tokyo's streetscape into a vertical hierarchy of social and ecological clusters, transforming the Kasumigaseki Building from a standardized office stack into a diverse vertical urban landscape where different spatial scales support distinct social, perceptual, and climatic experiences. With the clusters: urban morphology, perception research, climate mitigation, program distribution, architectural intervention are adressed in one system.

Clusters

1/4 Floor cluster:	0,25	floor	x	330	people	=	**82,5**	**people**	x	8	=	**660**	**m2**	(needs to be aimed while improving health and psycholphysiological coolness)
1/2 Floor cluster:	0,5	floor	x	330	people	=	**165**	**people**	x	8	=	**1320**	**m2**	"
1 Floor cluster:	1	floor	x	330	people	=	**330**	**people**	x	8	=	**2640**	**m2**	"
2 Floor cluster:	2	floors	x	330	people	=	**660**	**people**	x	8	=	**5280**	**m2**	"
3 Floor cluster:	3	floors	x	330	people	=	**990**	**people**	x	8	=	**7920**	**m2**	"
4 Floor cluster:	4	floors	x	330	people	=	**1320**	**people**	x	8	=	**10560**	**m2**	(needs to be aimed while improving health and psycholphysiological coolness)
5 Floor cluster:	5	floors	x	330	people	=	**1650**	**people**	x	8	=	**13200**	**m2**	"
6 Floor cluster:	6	floors	x	330	people	=	**1980**	**people**	x	8	=	**15840**	**m2**	"
7 Floor cluster:	7	floors	x	330	people	=	**2310**	**people**	x	8	=	**18480**	**m2**	(needs to be aimed while improving health and psycholphysiological coolness)
8 Floor cluster:	8	floors	x	330	people	=	**2640**	**people**	x	8	=	**21120**	**m2**	"
9 Floor cluster:	9	floors	x	330	people	=	**2970**	**people**	x	8	=	**23760**	**m2**	"
total office floor	32,5	floors	x	330	people	=	**10725**	**people**	x	8	=	**85800**	**m2**	"

Concept density calculation

Capture rates are selected by expected use frequency (daily/weekly/event), simultaneity by dwell time and peak concentration (flow-through vs. lunch vs. scheduled), and floor area by typology-based m² per user/seat, producing peak-load sizing per cluster population.

Program	value	Capture rate	Percentage (in %)	Simultaneity factor	Percentag (in %)
Total user number (cluster)	N	Very frequent (multiple times/day)	30	Strong peak concentration (lunch/events)	40
capture rate (how many of total users use it daily)	C	Frequent (daily or almost daily)	25	Long stay (30–60 min activities)	30
simultaneity factor (how many use it at peak)	S	Occasional (1–3×/week)	15	Medium stay (10–30 min interaction)	25
Peak user P=N×C×S	P	Infrequent (weekly)	10	Short stay (5–10 min breaks)	20
m² per peak user (all-in)	a	Event-based (not daily)	5	Very short stay (passing / quick pause)	15
necessary squaremeter A=P×a	A				
min clear height	h				
"Needs daylight?" (Y/N)	Y/N				
Noise level (low/med/high)	Y/N				

Program Matrix

Cluster type	Urban analogy	Spatial character	Physiological effect	Psychological effect
1 Floor cluster: shrine / engawa 330 people	shrine pocket engawa edge space (縁側) tsuboniwa courtyard vending niche tea room	intimate contemplative shaded micro-climate pockets transitional	localized cooling through vegetation shade and reduced radiant heat improved air movement near façade short restorative breaks reduced physiological stress	moments of pause contemplative atmosphere reduced cognitive fatigue sense of refuge visual relief extende eye movement through openness and visual stimuli

Program	value	Tsuboniwa pocket garden + shaded seating	Engawa edge terrace for work and meeting/discussions/teamwork (threshold, semi-outdoor)	Tea / water corner with snacks/urban farming (healthy micro-café)	Micro "Ma" pause niche/gaps/voids (quiet alcoves + phone-free zone)	Stretch / micro-activity corner/area for yoga, pilates, table tennis (mobility studio) (recovery + mobility)
Total user number (cluster)	N	330	330	330	330	330
capture rate (how many of total users use it daily) in %	C	30	25	30	15	15
simultaneity factor (how many use it at peak) in %	S	20	25	25	20	30
Peak user P=N×C×S	P	19,8	20,625	24,75	9,9	14,85
m² per peak user (all-in)	a	2,5	2,5	3	3,5	5
necessary squaremeter A=P×a	A	49,5	51,5625	74,25	34,65	74,25
min clear height in m	h	3	3	3	3	3
"Needs daylight?"	Yes/No	Yes	Yes	Yes	Yes	Yes
Noise level	low/med/high	low	low	low	low	medium

Cluster type	Urban analogy	Spatial character	Physiological effect	Psychological effect
3 Floor cluster: yokocho 990 people	Yokocho (横丁)	dense, intimate layered visually complex active social edge restorative greenery	shaded microclimate corridors vegetation improving air quality thermal buffering through semi-outdoor spaces movement encouraging physical activity	stimulation through spatial diversity curiosity and exploration social interaction visual richness

Program	value	Yokocho café lane (2–3 counters + shared seating)	Cross-floor "meeting loft" (shared project rooms, bookable) facing a void (visual complexity)	Mid size stroll garden for restorative purposes	Art / culture alley (micro gallery + rotating pieces)	Movmenet studio (Strenght training (gym), climbing wall, sprint lane, table tennis, bouldering)
Total user number (cluster)	N	990	990	990	990	990
capture rate (how many of total users use it daily) in %	C	25	15	25	10	15
simultaneity factor (how many use it at peak) in %	S	25	30	20	20	30
Peak user P=N×C×S	P	61,875	44,55	49,5	19,8	44,55
m² per peak user (all-in)	a	3,5	3,5	4	3	6
necessary squaremeter A=P×a	A	216,5625	155,925	198	59,4	267,3
min clear height in m	h	3	3	5	3	5
"Needs daylight?"	Yes/No	Yes	Yes	Yes	Yes	Yes
Noise level	low/med/high	medium	medium	low	medium	medium

Cluster type	Urban analogy	Spatial character	Physiological effect	Psychological effect
6 Floor cluster: shotengai 1,980 people	Shotegai (商店街) / Kawa (River promenade	lively covered / semi-indoor promenade mixed programs community oriented vegetated corridor cooling landscape	larger vegetation improving cooling evapotranspiration from planting airflow corridors through atrium spaces longer movement paths encouraging walking	sense of community social belonging orientation within the building collective identity

Program	value	Healthy food hall / cantine	Indoor "Kawa promenade" (strolling garden corridor)	Library / quiet reading and work space	Event / lecture room (medium, flexible)	Court studio: Basketbal, volleyball,half court tennis, badminton, jogging loup, climbing terrace
Total user number (cluster)	N	1980	1980	1980	1980	1980
capture rate (how many of total users use it daily) in %	C	25	25	15	5	15
simultaneity factor (how many use it at peak) in %	S	40	20	25	40	30
Peak user P=N×C×S	P	198	99	74,25	39,6	89,1
m² per peak user (all-in)	a	3,5	4	4,5	2,5	8
necessary squaremeter A=P×a	A	693	396	334,125	99	712,8
min clear height in m	h	5	5	3	5	7
"Needs daylight?"	Yes/No	Yes	Yes	Yes	Yes	Yes
Noise level	low/med/high	high	low	low	middle	high

Cluster type	Urban analogy	Spatial character	Physiological effect	Psychological effect	Psychological effect
Whole building/Urban integrative cluster: 10,700 people + surrounding context	Hiroba (urban plaza 広場) Matsuri (festival ground 祭)	open gathering space place of interaction shared field of experience collective environment coexistence of built and natural systems urban integrative community	large vegetation improving microclimate shaded communal landscape improved thermal comfort through vegetation and air volume restorative environmental exposure	collective identity civic experience cultural engagement sense of belonging to a larger community	

Program	value	Sky garden courtyard	Festival forum / exhibition promenade (public culture)	Large presentation / townhall center on the rooftop	Wellbeing "thermal gradient" space (cool/warm recovery, calm) at the ground floor pilotis area	Large sports / movement hall (multi-use: court / class / events) on the rooftop of the Tokyo Club building
Total user number (cluster)	N	10725	10725	10725	10725	10725
capture rate (how many of total users use it daily) in %	C	15	10	5	25	10
simultaneity factor (how many use it at peak) in %	S	25	25	40	20	30
Peak user P=N×C×S	P	402,1875	268,125	214,5	536,25	321,75
m² per peak user (all-in)	a	4	3	2,5	3	8
necessary squaremeter A=P×a	A	1608,75	804,375	536,25	1608,75	2574
min clear height in m	h	4	5	5	5	7
"Needs daylight?"	Yes/No	Yes	Yes	Yes	Yes	Yes
Noise level	low/med/high	medium	medium	medium	medium	medium

Program Matrix

Cluster type	Urban analogy	Spatial character	Physiological effect	Psychological effect
1 Floor cluster: shrine / engawa 330 people	shrine pocket engawa edge space (縁側) tsuboniwa courtyard vending niche tea room	intimate contemplative shaded micro-climate pockets transitional	localized cooling through vegetation shade and reduced radiant heat improved air movement near façade short restorative breaks reduced physiological stress	moments of pause contemplative atmosphere reduced cognitive fatigue sense of refuge visual rellef extende eye movement through openness and visual stimuli

Program	value	Tsuboniwa pocket garden + shaded seating	Engawa edge terrace for work and meeting/discussions/teamwork (threshold, semi-outdoor)	Tea / water corner with snacks/urban farming (healthy micro-café)	Micro “Ma” pause niche/gaps/voids (quiet alcoves + phone-free zone)	Stretch / micro-activity corner/area for yoga, pilates, table tennis (mobility studio) (recovery + mobility)
Total user number (cluster)	N	330	330	330	330	330
capture rate (how many of total users use it daily) in %	C	30	25	30	15	15
simultaneity factor (how many use it at peak) in %	S	20	25	25	20	30
Peak user P=N•C•S	P	19,8	20,625	24,75	9,9	14,85
m² per peak user (all-in)	a	2,5	2,5	3	3,5	5
necessary squaremeter A=P×a	A	49,5	51,5625	74,25	34,65	74,25
min clear height in m	h	3	3	3	3	3
“Needs daylight?”	Yes/No	Yes	Yes	Yes	Yes	Yes
Noise level	low/med/high	low	low	low	low	medium

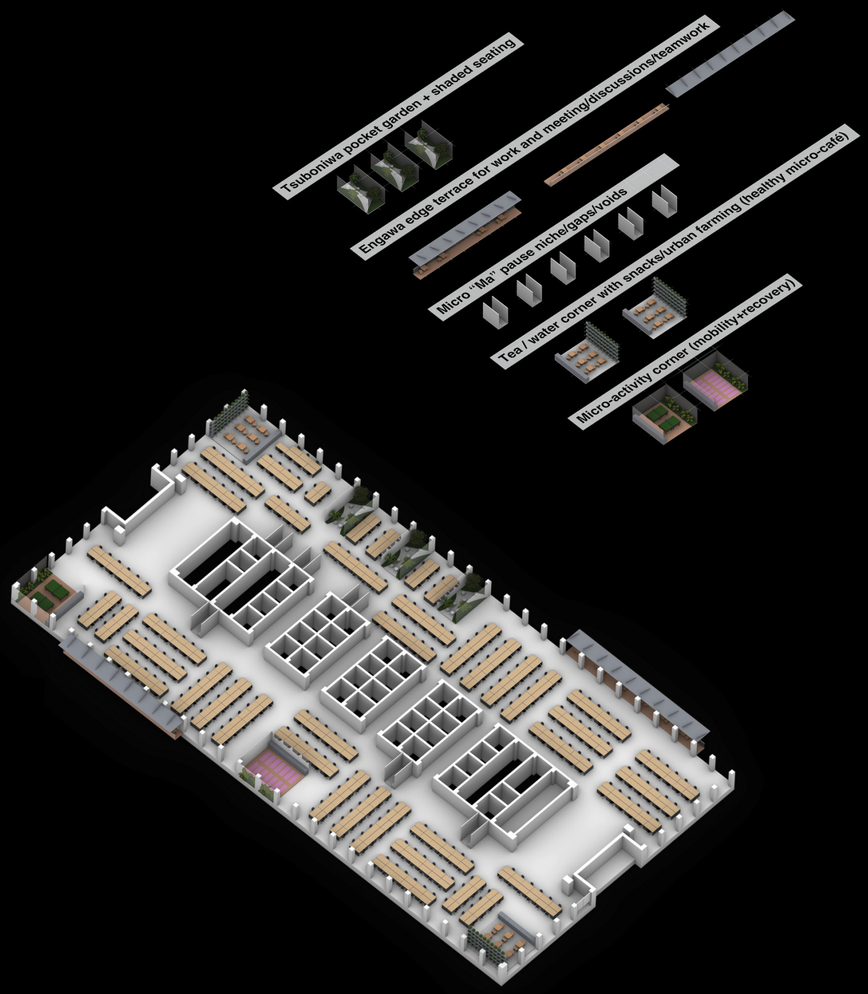


Fig. 99. Single-Floor Cluster programmatic implementation.

Program Matrix

Cluster type	Urban analogy	Spatial character	Physiological effect	Psychological effect
3 Floor cluster: yokocho 990 people	Yokocho (横丁)	dense, intimate layered visually complex active social edge restorative greenery	shaded microclimate corridors vegetation improving air quality thermal buffering through semi-outdoor spaces movement encouraging physical activity	stimulation through spatial diversity curiosity and exploration social interaction visual richness

Program	value	Yokocho café lane (2–3 counters + shared seating)	Cross-floor “meeting loft” (shared project rooms, bookable) facing a void (visual complexity)	Mid size stroll garden for restorative purposes	Art / culture alley (micro gallery + rotating pieces)	Movmenet studio (Strenght training (gym), climbing wall, sprint lane, table tennis, bouldering)
Total user number (cluster)	N	990	990	990	990	990
capture rate (how many of total users use it daily) in %	C	25	15	25	10	15
simultaneity factor (how many use it at peak) in %	S	25	30	20	20	30
Peak user P=N•C•S	P	61,875	44,55	49,5	19,8	44,55
m² per peak user (all-in)	a	3,5	3,5	4	3	6
necessary squaremeter A=P×a	A	216,5625	155,925	198	59,4	267,3
min clear height in m	h	3	3	5	3	5
“Needs daylight?”	Yes/No	Yes	Yes	Yes	Yes	Yes
Noise level	low/med/high	medium	medium	low	medium	medium

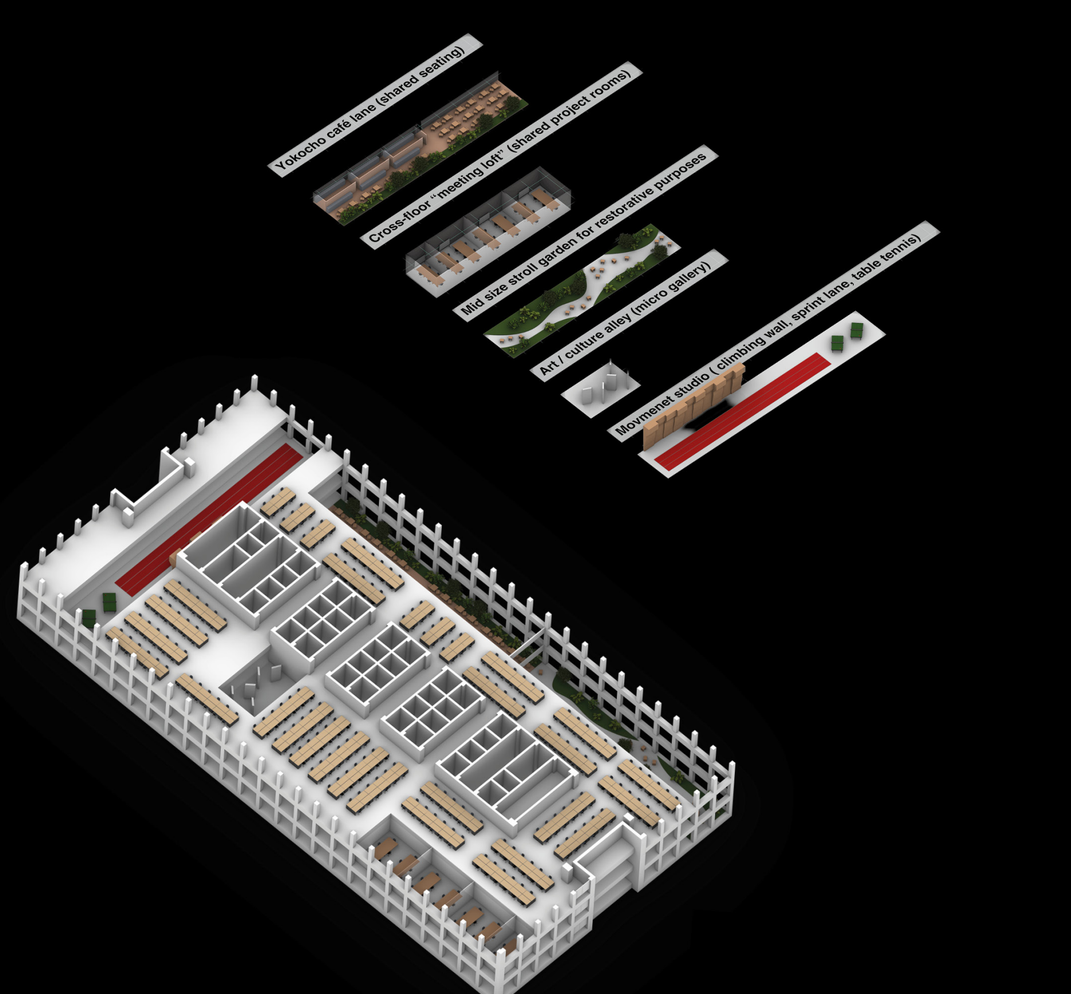


Fig. 100. Three-Floor Cluster programmatic implementation.

Program Matrix

Cluster type	Urban analogy	Spatial character	Physiological effect	Psychological effect
6 Floor cluster: shotengai 1,980 people	Shotegai (商店街) / Kawa (River promenade	lively covered / semi-indoor promenade mixed programs community oriented vegetated corridor cooling landscape	larger vegetation improving cooling evapotranspiration from planting airflow corridors through atrium spaces longer movement paths encouraging walking	sense of community social belonging orientation within the building collective identity

Program	value	Healthy food hall / cantine	Indoor "Kawa promenade" (strolling garden corridor)	Library / quiet reading and work space	Event / lecture room (medium, flexible)	Court studio: Basketbal, volleyball,half court tennis, badminton, jogging loup, climbing terrace
Total user number (cluster)	N	1980	1980	1980	1980	1980
capture rate (how many of total users use it daily) in %	C	25	25	15	5	15
simultaneity factor (how many use it at peak) in %	S	40	20	25	40	30
Peak user P=N•C•S	P	198	99	74,25	39,6	89,1
m^2 per peak user (all-in)	a	3,5	4	4,5	2,5	8
necessary squaremeter A=P×a	A	693	396	334,125	99	712,8
min clear height in m	h	5	5	3	5	7
"Needs daylight?"	Yes/No	Yes	Yes	Yes	Yes	Yes
Noise level	low/med/high	high	low	low	middle	high

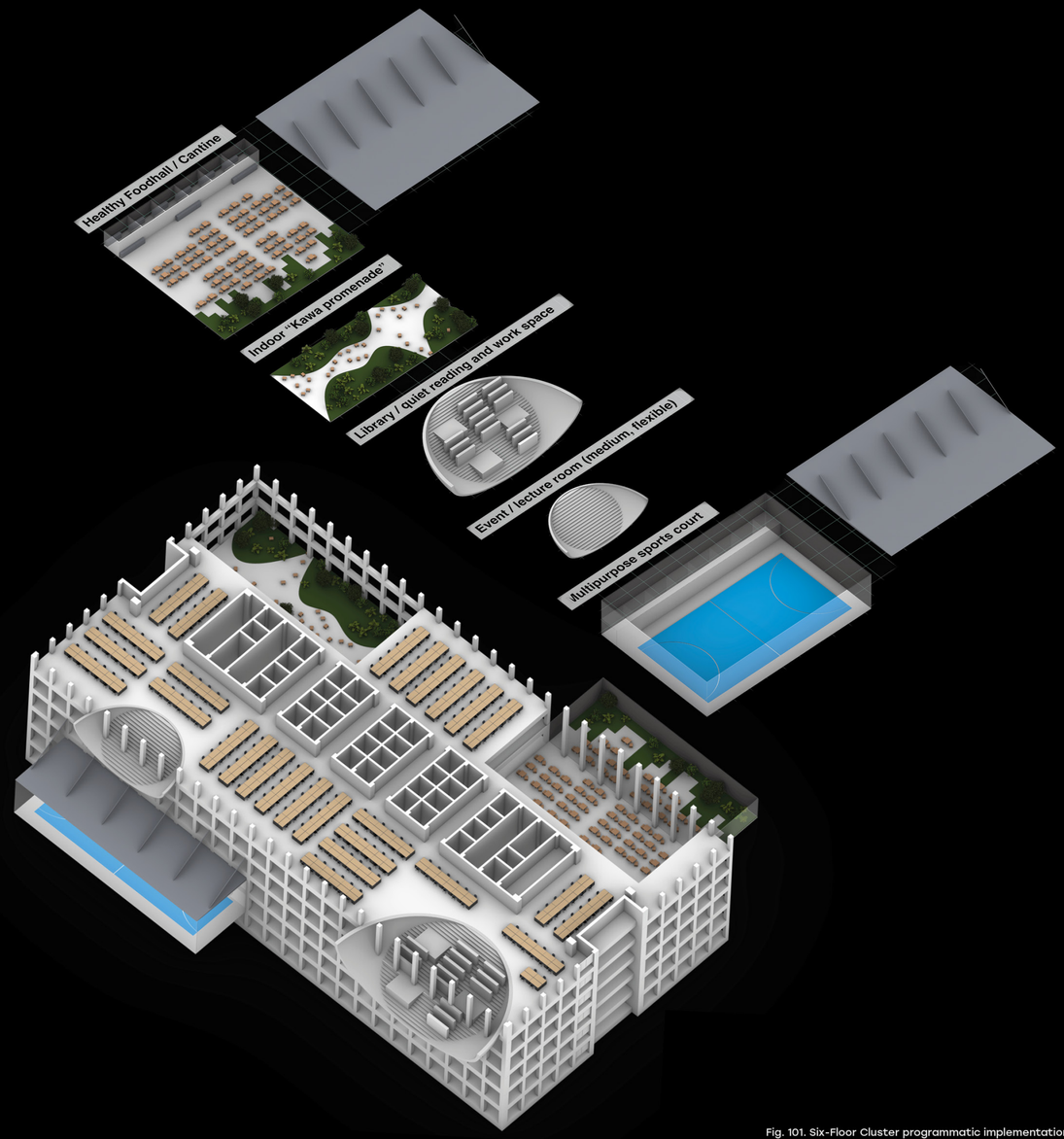
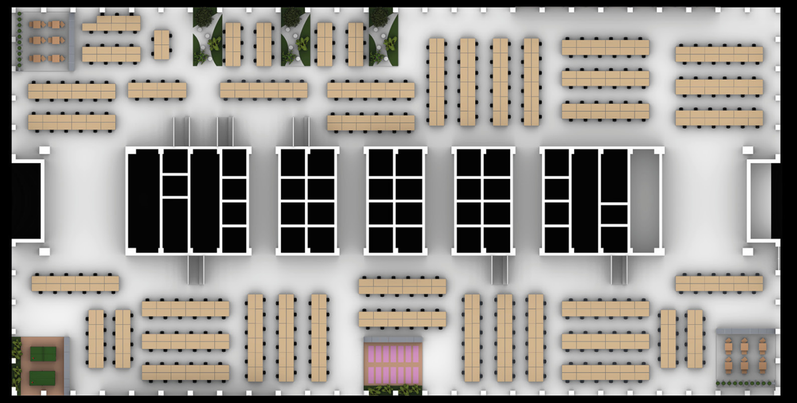


Fig. 101. Six-Floor Cluster programmatic implementation.





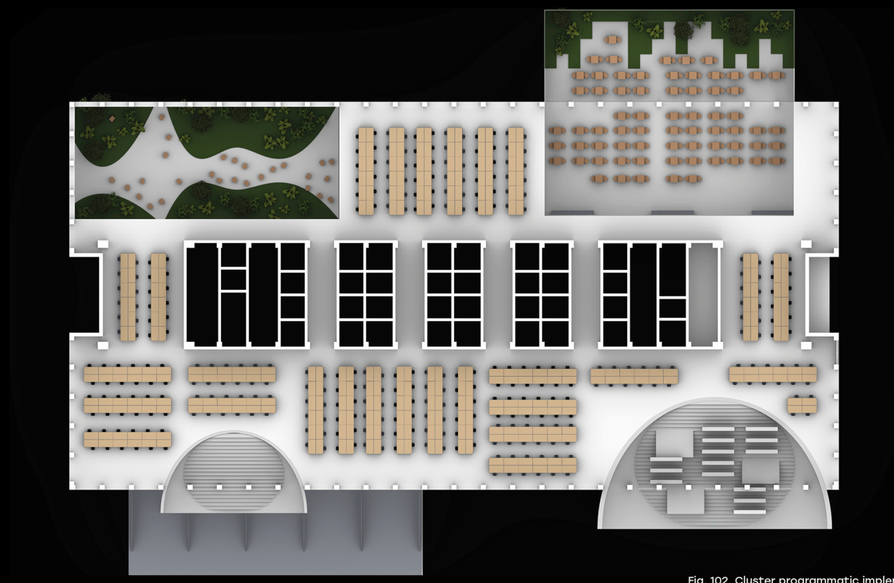


Fig. 102. Cluster programmatic implementation overview.

Structure informed vertical integration

As the definition and the spatial properties of the newly integrative clusters have been defined earlier, the vertical distribution of these implementations is informed by the Kasumigaseki's vertical zoning of the elevator and structural core system.

The Kasumigaseki building, with its 36 above-ground floors and its total height of 147m, contains 29 passenger elevators arranged within the central banks 1-4. Additionally, four service and observation elevators are positioned at the outer ends of the building's core.

The elevator system, as a zoned system, divides the Kasumigaseki building into four service zones ranging from floor 2-12, floor 14-20, floor 21-27 and floor 28-35. (Ikeda et al., 1967).

The floorplans are planned accordingly, as the structural core changes throughout the service zones within the distribution of elevators, accessible core sections, toilets and dedicated storage space. Observations of floorplans reveal that after each shift of a service zone, the elevator cores turn into storage space as an elevator's zone ends.

These findings are taken as a driver for the vertical integration of the 3 clusters, which are integrated after a service zone ends and repurposes the storage space, which has been originally dimensioned for the extensive storage demands of the 1960s, with new health-enhancing programmatic additions, such as central stroll gardens, a café, etc.

The core area, which is turned into a new program, is carefully extracted within the constraints of the existing structure, following the earlier mentioned Japanese concept of Ma, in which the void generates new spatial value complementary to the retrofit strategy of the Kasumigaseki building.

The size of the programmatic implementation and extraction is in its horizontal extent defined by the service zone's horizontal shift, which results in an increasing size of open core use per cluster towards the upper levels.

Regarding the additional support and the visual representation of the clusters and voids, at this stage, the interventions are explored conceptually and will be further developed through the ongoing assessment of the existing structure.

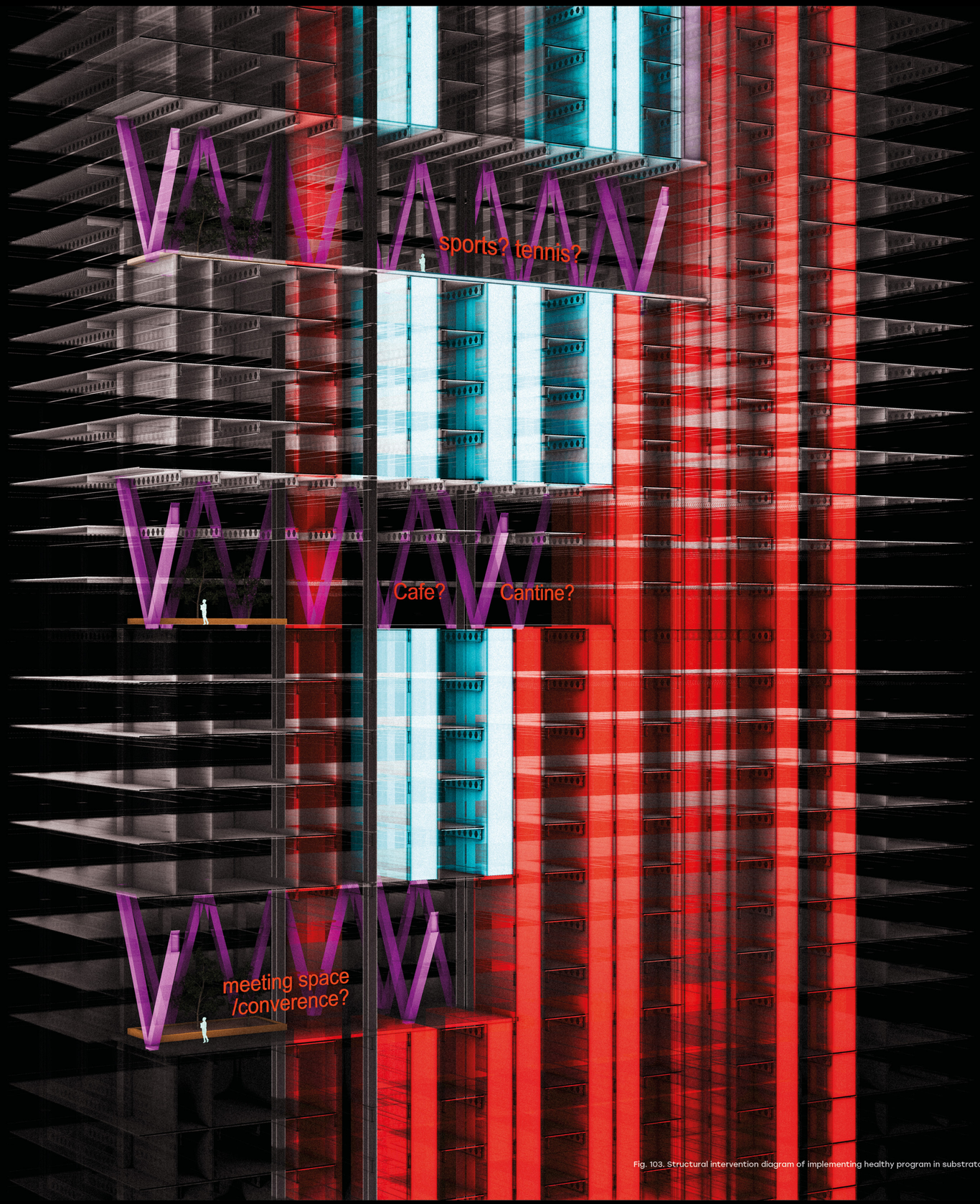
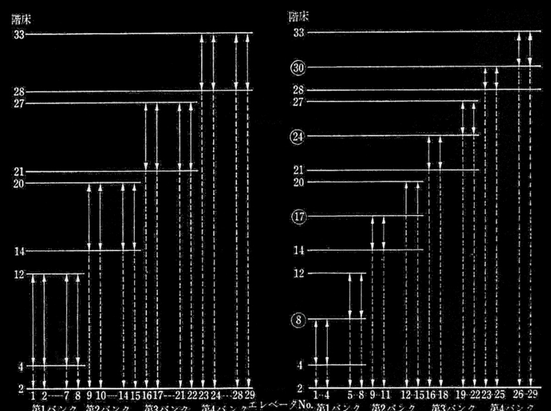
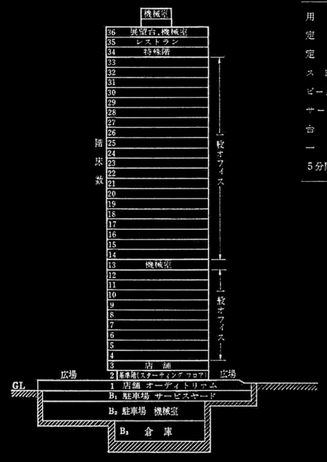


Fig. 103. Structural intervention diagram of implementing healthy program in substratced core space.



（注） （1） 丸わく内の数字は分割階を示す。
（2） 実線はサービス階床，点線はサービスしない不停止階を示す。

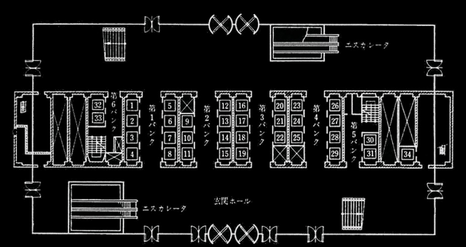
図4 出動時におけるサービス階説明図



（注） 地上36階（147 m），地下3階（14.7 m）
延床面積 157,321.14 m²
収容人口 約10,000人（8 m²/人）

図2 霞ケ関ビル

仕様 ＼ バンクNo.	1	2	3	4	5	6
用途	乗用	乗用	乗用	乗用	サービス用	展望台用
定格速度	150 m/min	210 m/min	240 m/min	300 m/min	150 m/min	300 m/min
定員	24	24	24	24	(5-1) 20 (5-2) 16	22
ストローク	41.4 m	77.6 m	100.6 m	131.3 m	157.2 m	(6-1) 157.2m (6-2) 142.2m
ピーク時の停止階	2-4~12	2-14~20	2-21~27	2-28~33	—	—
サービス階床数	9	7	7	6	40	(6-1) 40 (6-2) 36
台数	8	7	7	7	2	2
一周時間	137 秒	142 秒	151 秒	146 秒	—	—
5分間の輸送能力	14.1%	15.4%	14.5%	17.4%	—	—



（注） （1） 1~34 の数字はエレベータ No. を示す。
（2） レンタブル比＝ 2,640 m² / 3,562 m² ＝74.1%

図3 基準階（スターティングフロア）平面図

Fig. 104. Archival documents on the organisation of elevators within the core of the Kasumigaseki Building. Adapted from Ikeda et al. (1967).

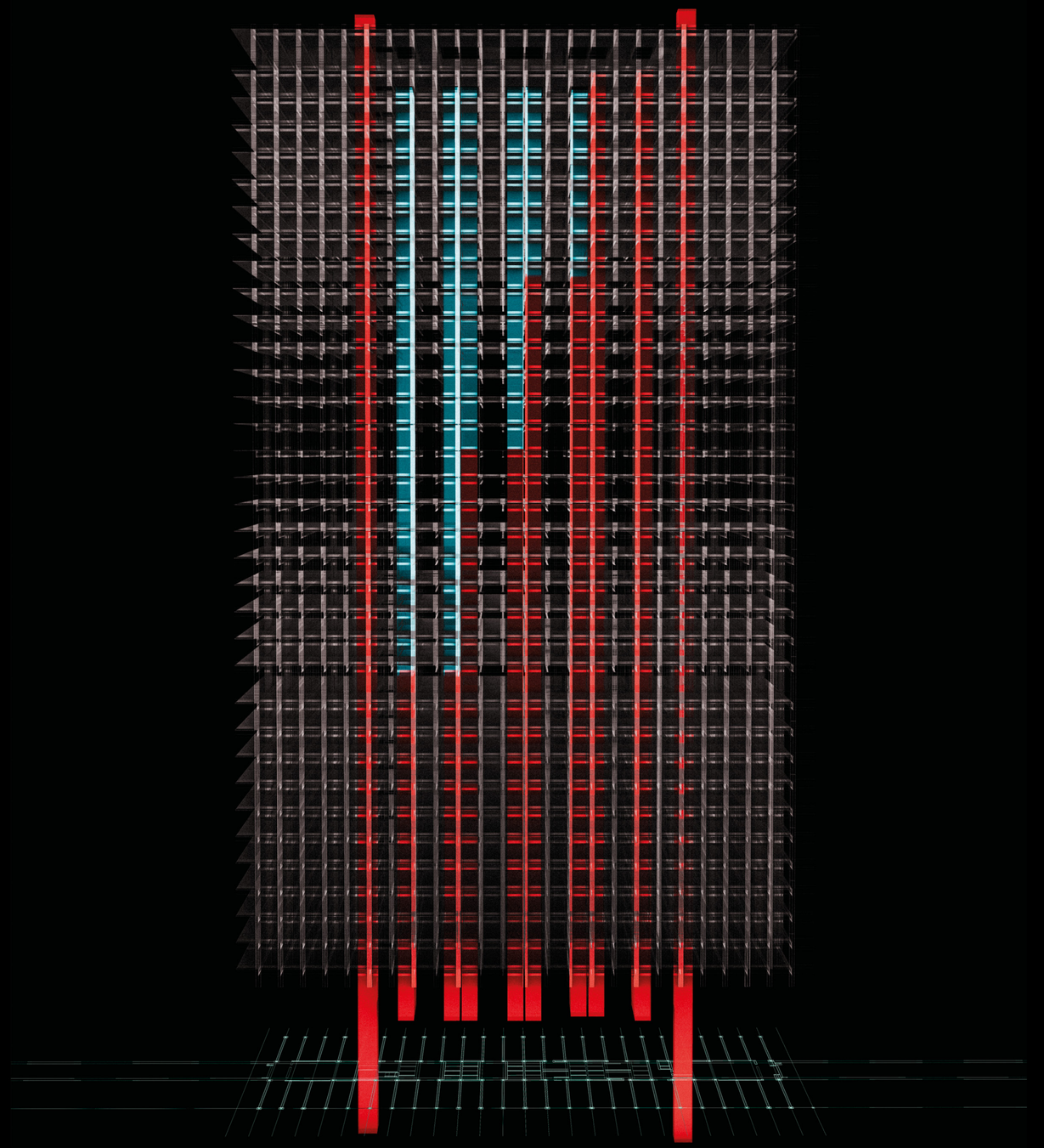
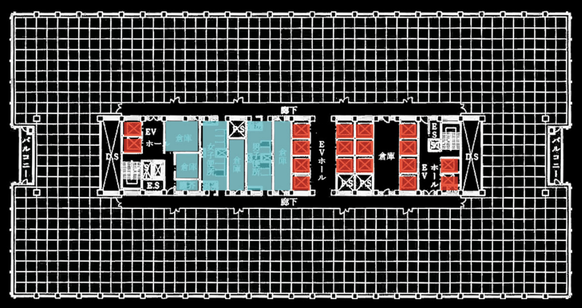
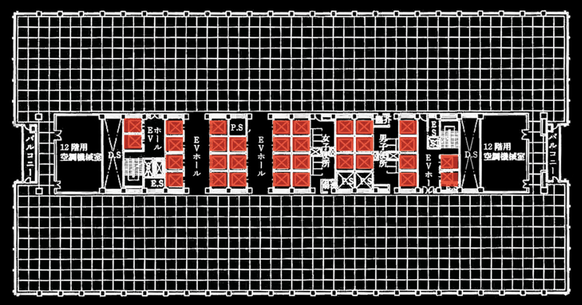


Fig. 105. Structural intervention diagram.



22.-28. floor plan (scanned archive material). Adapted from Ikeda et al. (1967).



12. floor plan (scanned archive material). . Adapted from Ikeda et al. (1967).

34
33
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12

Fig. 106. Structural intervention diagram close-up with archival references.

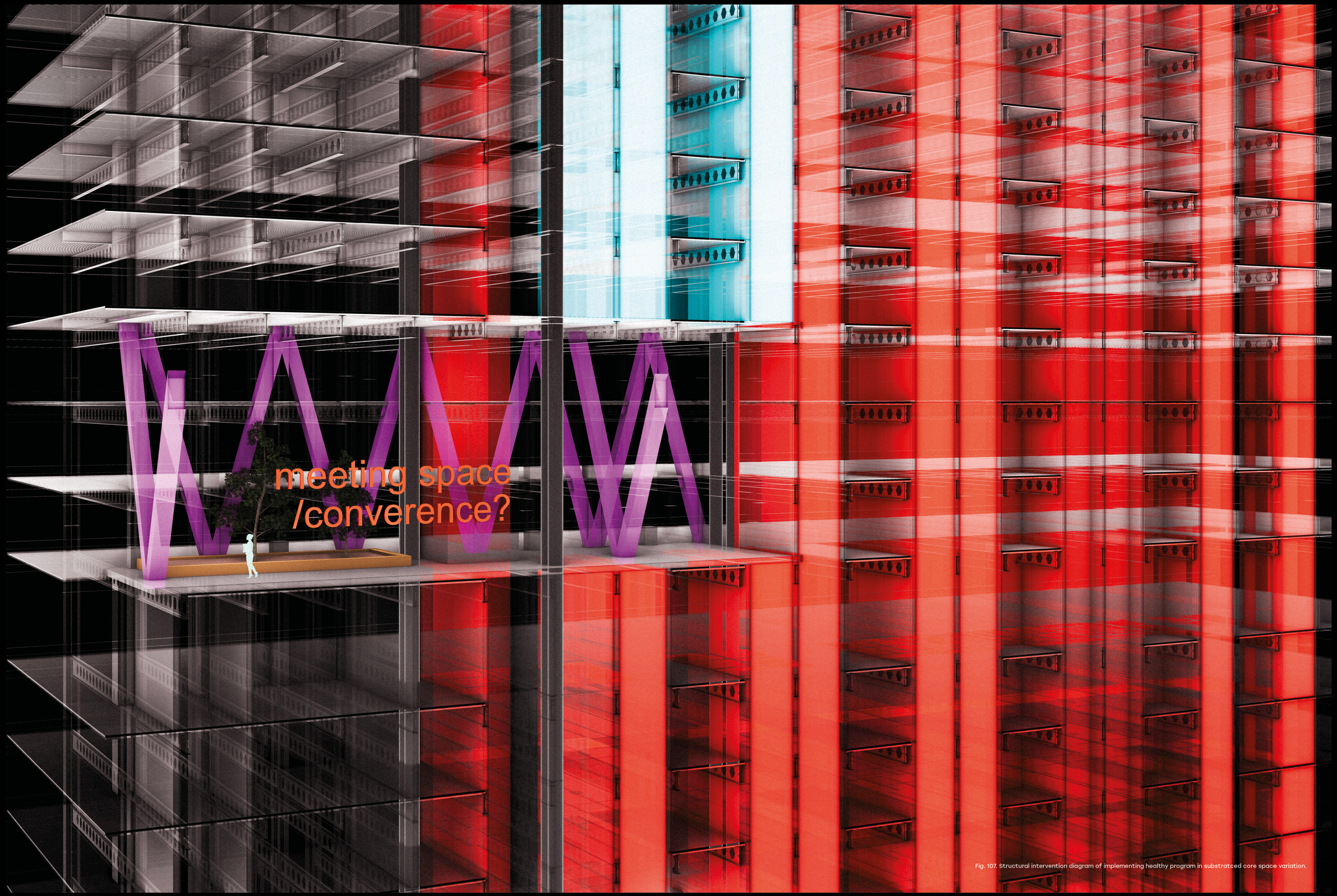


Fig. 107. Structural intervention diagram of implementing healthy program in substratced core space variation.

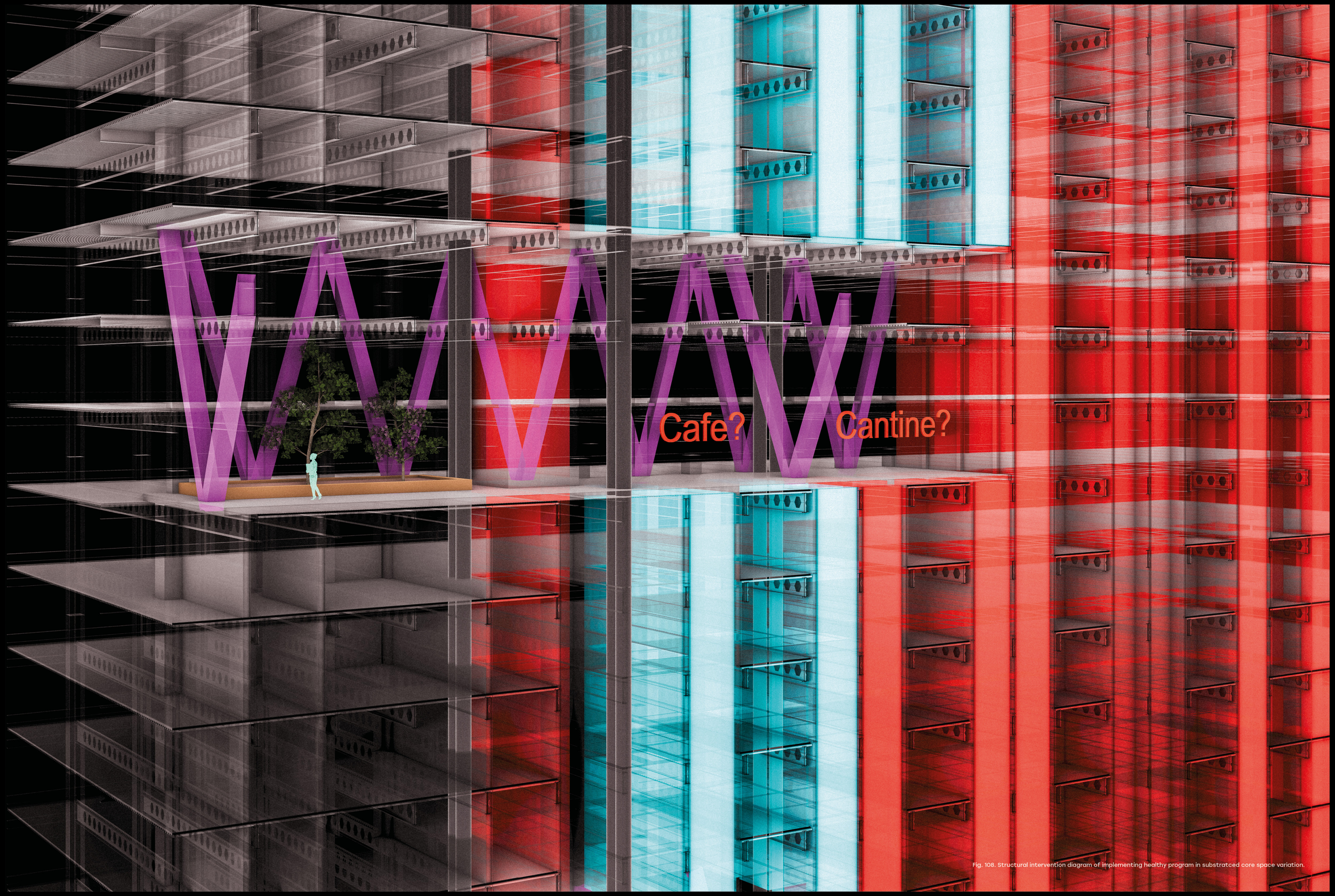


Fig. 108. Structural intervention diagram of implementing healthy program in substratced core space variation.

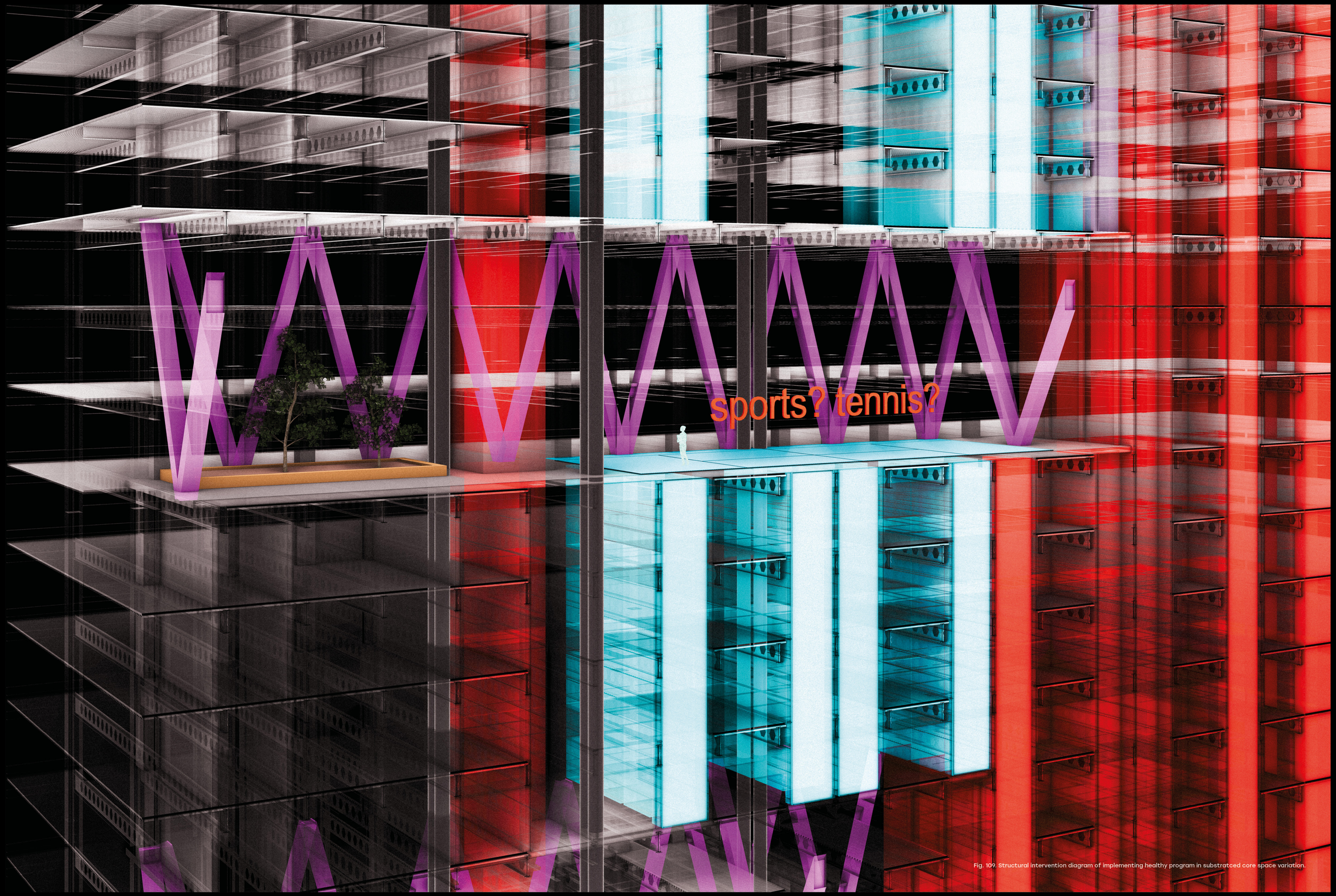
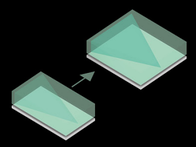


Fig. 109. Structural intervention diagram of implementing healthy program in substratced core space variation.

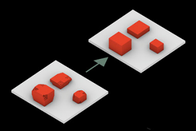
3.2 Exploring

PSYCHOLOGICAL HEAT STRESS MITIGATION



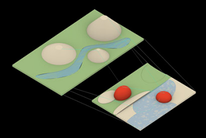
Spatial openness

Effect: Increased field of view and wider gaze behaviour



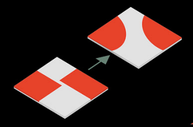
Cleanliness

Effect: Increase of comfort and attention with higher gaze movement



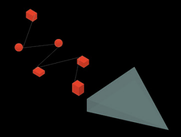
Borrowed scenery

Effect: Associations of natural elements effect in increase of attention and higher gaze movement



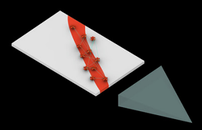
Natural outlines

Effect: Increase of guided gaze movement and dispersed fixations



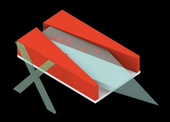
Zig-Zag config.

Effect: Increase of horizontal gaze movement and dispersed eye-movement



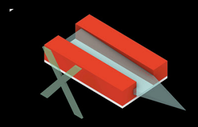
Diagonal lines

Effect: Increase of horizontal gaze movement and dispersed eye-movement



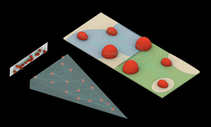
No Dominant persp.

Avoiding straight dominant perspective Effect: Leads to a higher concentration of fixation point in the center



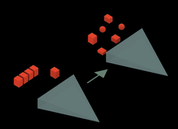
No Narrow field of v.

Avoiding narrow field of view Effect: leads to less eye-movement



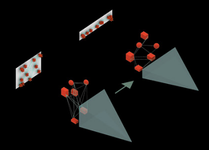
Curated distance

Through spatial layering, curated along fore-,mid-and background) Effect: increase of gaze movement and dispersed fixations between close and distant spatial stimuli



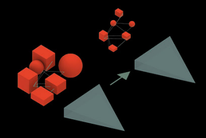
Diversity

Effect: Increase in attention and dispersed spatial stimuli



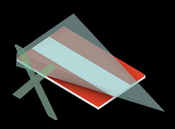
Horiz. distribution

Effect: Increase of horizontal gaze movement and spatial configuration, bilateral stimulation of the brain



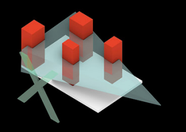
Smaller size

Smaler visual surfaces distributed eavenly Effect: More dispersed visual attention



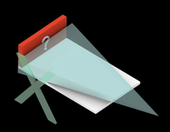
No straight lines

Avoid clear and straight leading lines with symmetry towards a central focal poin Effect: Less horizontal exploration of gaze movement



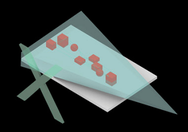
No vertical domin.

Avoid vertical dominance, leading density and visual obstructio Effect: Leads to reduced horizontal exploration of the eye



No lack of stimuli

Avoid plane surfaces without visual stimuli Effect: Leads to reduced attention and less gaze movement and dispersed fixation points

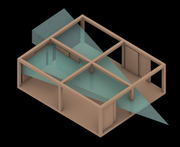


No localisation

Avoid localised or central accumulation of visual stimuli Effect: Leads toaccumulation of fixation points, visual perception is localized and reduces explorative eye movement

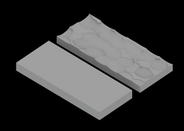
Fig. 110. Psychological relaxation pattern matrix.

SPATIAL PATTERNS THAT AFFECT THE, WITH RELAXATION ASSOCIATED, EYE-MOVEMENT PATTERNS



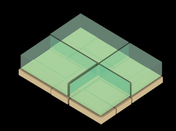
Adaptiveness

Shifting spatial configurations Effect: Expanded visual stimulation, visual depth, balanced stimulation Use case: Winter/ Summer



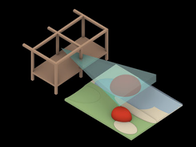
Contrast

Pairing contrasting properties (cleanliness and patina) Effect: Enhanced visual stimulation, sensorial balance Use case: Winter/Summer



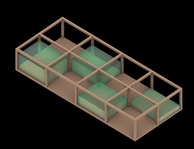
Tatami

Spatial structuring, rhythm Effect: structured visual field Use case: Winter/ Summer



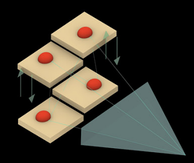
Biophilic elements

Water, plants, stones, seasonal change etc. Effect: visual stimuli, relaxation Use case: Winter/Summer



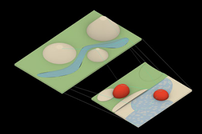
Oku

Spatial hierarchy of function, privacy and spiritual meaning arrange spatial configuration of depth Effect: Distance, curated depth, intervals, openness. Use case: Summer/Winter



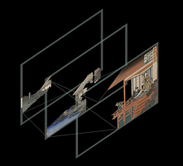
Thresholds

Slight vertical floor changes provide spatial hierarchies Effect: visual stimulations through spatial intervals Use case: Summer



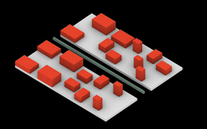
Shakkei

Borrowed scenery, association of natural elements through spatial configuration and mimicking natural curvatures and shapes Effect: Visual depth, increased attention, visual stimulations and widened spatial perception



Illusional paintings

Spatial layering in japanese wooden prints Effect: spatial openness and curated visual depth Use case: Summer



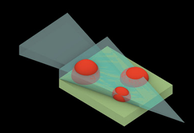
Asymmetry

Spatial configuration Effect: aesthetic balance and visual stimulation Use case: Winter/Summer



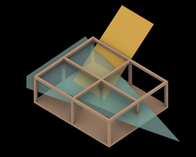
Karensansui

Dry translation of the flow of water Effect: visual depth and visual simulation Use case: Winter/Summer



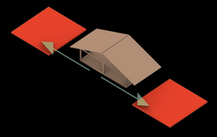
Miegakure

ide and reveal of obejcts Effect: visual depth, distance Use case: Summer/Winter



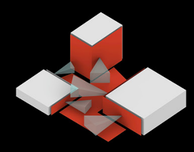
Kiwari and Clarity

Modular & prefabricated system of light timber structure Effect: Spatial repetition and visual openness Use case: Winter/ Summer



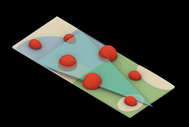
Horizontality

Wide roof overhang of the building Effect: Strengthening horizontality in visual perception Use case: Summer



Ma

Inbetween, voide space Effect: Openness, Visual depth, spatial intervals, depths and distance, spatial balance Use case: Summer



Spatial configuration

Japanese garden and the curation of elements Effect: Visual balance and extended visual stimulation, Openness, Visual depth



Yami

Quality of shadows Effect: visually perceived coolness, enhanced visual attention Use case: Summer

Fig. 111. Vernacular psychological cooling pattern matrix.

PATTERNS OF VERNACULAR COOLING STRATEGIES ASSOCIATED AS WELL WITH PSYCHOLOOGICAL LAYERS

VR-Environment
Scenes Composition

As this project's primary aim is to retrofit the Kasumigaseki building through and stimulating eye-movement associated with short-term relaxation and vernacular architectural knowledge, to mitigate indoor heat stress physiologically and psychologically for healthier vertical office environments, this VR-study with integrated eye-tracking focuses primarily on the psychological responses within the scope of stimulated eye-movement.

The assessment consists of four simulated scenarios that are informed by the theoretical framework on eye movement and relaxation, as well as explorative observations of Tokyo's streetscapes. Additionally, vernacular patterns were selected from desk and literature research to inform spatial configuration in terms of stimulating visual perception, curiosity and interest.

Two main spatial strategies are explored. The first investigates how spatial openness, borrowed scenery, diagonal lines, zig-zag configurations, and curated distance inform horizontally dispersed gaze movement. The second examines how vernacular Japanese patterns of depth, biophilic elements, voids and rhythm (Ma), shadings such as Engawa, different floor heights, natural materials, and timber elements can influence visual perception in terms of dispersed fixations.

As these strategies of openness and vernacular patterns, are already including structural, urban, programmatic façade and overall-building related design studies, this study does not solely reflect on the research progress but exists in constant interaction and discussion between research and design, through which the results are expected to reveal direct insights into various design decisions shaping the final phase of retrofit design strategies actively.

The overall scenario focus is set towards:

Scene a: existing office floor
Scene b: existing office floor + spatial openness
Scene c: existing office floor + vernacular Japanese strategies
Scene d: existing office floor + spatial openness + vernacular Japanese strategies

Scene d combines both approaches in order to avoid the concentrated gaze behavior observed in scene c and the limited fixation stimuli present in scene b.

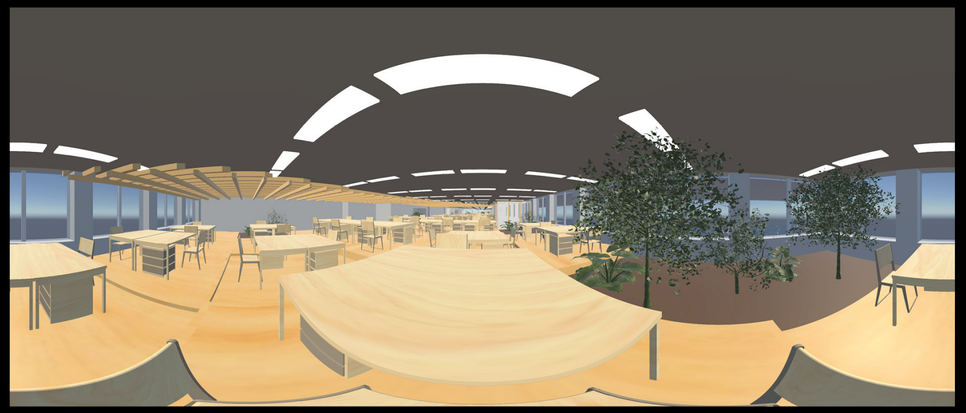
scene a



scene b



scene c



scened

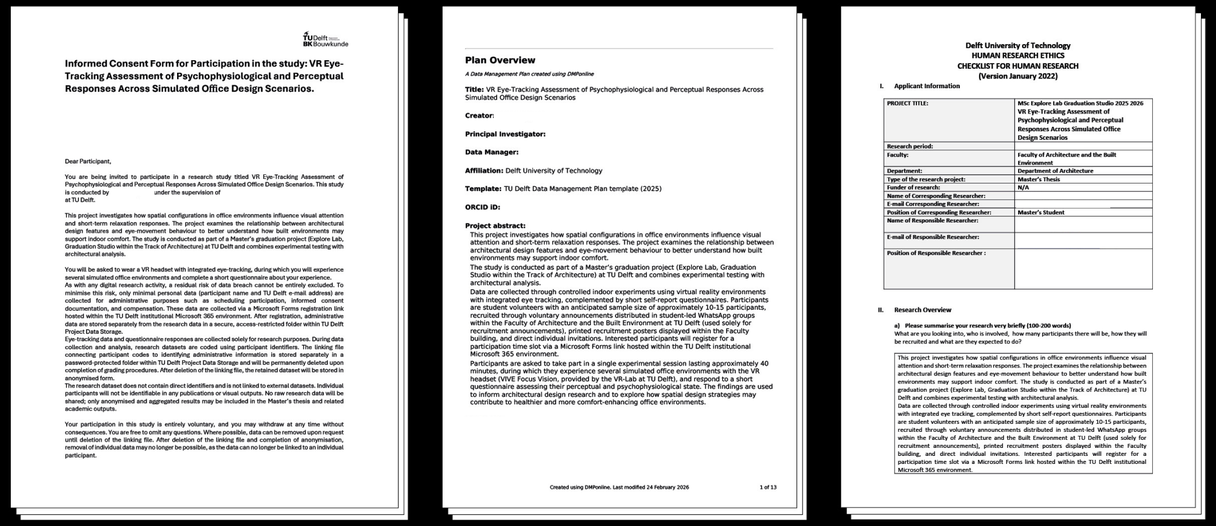


Fig. 112.VR Eye-tracking study Scenes and their spatial configurations.

HREC Approval

The experimental study involving human participants is conducted in accordance with the ethical guidelines of TU Delft. Prior to the start of the experiment, the HREC Checklist, Data Management Plan and the Informed Consent Form have been submitted to the TU Delft Human Research Ethics Committee (HREC) for approval.

This study was granted ethical approval by the TU Delft Human Research Ethics Committee.



TU Delft BK Bouwkunde

Informed Consent Form for Participation in the study: VR Eye-Tracking Assessment of Psychophysiological and Perceptual Responses Across Simulated Office Design Scenarios.

Dear Participant,

You are being invited to participate in a research study titled VR Eye-Tracking Assessment of Psychophysiological and Perceptual Responses Across Simulated Office Design Scenarios. This study is conducted by under the supervision of at TU Delft.

This project investigates how spatial configurations in office environments influence visual attention and short-term relaxation responses. The project examines the relationship between architectural design features and eye-movement behaviour to better understand how built environments may support indoor comfort. The study is conducted as part of a Master's graduation project (Explore Lab, Graduation Studio within the Track of Architecture) at TU Delft and combines experimental testing with architectural analysis.

You will be asked to wear a VR headset with integrated eye-tracking, during which you will experience several simulated office environments and complete a short questionnaire about your experience.
As with any digital research activity, a residual risk of data breach cannot be entirely excluded. To minimise this risk, only minimal personal data (participant name and TU Delft e-mail address) are collected for administrative purposes such as scheduling participation, informed consent documentation, and compensation. These data are collected via a Microsoft Forms registration link hosted within the TU Delft Institutional Microsoft 365 environment. After registration, administrative data are stored separately from the research data in a secure, access-restricted folder within TU Delft Project Data Storage.
Eye-tracking data and questionnaire responses are collected solely for research purposes. During data collection and analysis, research datasets are coded using participant identifiers. The linking file connecting participant codes to identifying administrative information is stored separately in a password-protected folder within TU Delft Project Data Storage and will be permanently deleted upon completion of grading procedures. After deletion of the linking file, the retained dataset will be stored in anonymised form.
The research dataset does not contain direct identifiers and is not linked to external datasets. Individual participants will not be identifiable in any publications or visual outputs. No raw research data will be shared; only anonymised and aggregated results may be included in the Master's thesis and related academic outputs.

Your participation in this study is entirely voluntary, and you may withdraw at any time without consequences. You are free to omit any questions. Where possible, data can be removed upon request until deletion of the linking file. After deletion of the linking file and completion of anonymisation, removal of individual data may no longer be possible, as the data can no longer be linked to an individual participant.

Plan Overview

A Data Management Plan created using DMPonline

Title: VR Eye-Tracking Assessment of Psychophysiological and Perceptual Responses Across Simulated Office Design Scenarios

Creator:

Principal Investigator:

Data Manager:

Affiliation: Delft University of Technology

Template: TU Delft Data Management Plan template (2025)

ORCID ID:

Project abstract:
This project investigates how spatial configurations in office environments influence visual attention and short-term relaxation responses. The project examines the relationship between architectural design features and eye-movement behaviour to better understand how built environments may support indoor comfort.
The study is conducted as part of a Master's graduation project (Explore Lab, Graduation Studio within the Track of Architecture) at TU Delft and combines experimental testing with architectural analysis.
Data are collected through controlled indoor experiments using virtual reality environments with integrated eye tracking, complemented by short self-report questionnaires. Participants are student volunteers with an anticipated sample size of approximately 10-15 participants, recruited through voluntary announcements distributed in student-led WhatsApp groups within the Faculty of Architecture and the Built Environment at TU Delft (used solely for recruitment announcements), printed recruitment posters displayed within the Faculty building, and direct individual invitations. Interested participants will register for a participation time slot via a Microsoft Forms link hosted within the TU Delft institutional Microsoft 365 environment.
Participants are asked to take part in a single experimental session lasting approximately 40 minutes, during which they experience several simulated office environments with the VR headset (VIVE Focus Vision, provided by the VR-Lab at TU Delft), and respond to a short questionnaire assessing their perceptual and psychophysiological state. The findings are used to inform architectural design research and to explore how spatial design strategies may contribute to healthier and more comfort-enhancing office environments.

Delft University of Technology
HUMAN RESEARCH ETHICS
CHECKLIST FOR HUMAN RESEARCH
(Version January 2022)

I. Applicant Information

PROJECT TITLE:	**MSc Explore Lab Graduation Studio 2025 2026 VR Eye-Tracking Assessment of Psychophysiological and Perceptual Responses Across Simulated Office Design Scenarios**
Research period:	
Faculty:	**Faculty of Architecture and the Built Environment**
Department:	**Department of Architecture**
Type of the research project:	**Master's Thesis**
Funder of research:	**N/A**
Name of Corresponding Researcher:	
E-mail Corresponding Researcher:	
Position of Corresponding Researcher:	**Master's Student**
Name of Responsible Researcher:	
E-mail of Responsible Researcher:	
Position of Responsible Researcher :	

II. Research Overview

a) Please summarise your research very briefly (100-200 words)
What are you looking into, who is involved, how many participants there will be, how they will be recruited and what are they expected to do?

This project investigates how spatial configurations in office environments influence visual attention and short-term relaxation responses. The project examines the relationship between architectural design features and eye-movement behaviour to better understand how built environments may support indoor comfort. The study is conducted as part of a Master's graduation project (Explore Lab, Graduation Studio within the Track of Architecture) at TU Delft and combines experimental testing with architectural analysis.
Data are collected through controlled indoor experiments using virtual reality environments with integrated eye tracking, complemented by short self-report questionnaires. Participants are student volunteers with an anticipated sample size of approximately 10-15 participants, recruited through voluntary announcements distributed in student-led WhatsApp groups within the Faculty of Architecture and the Built Environment at TU Delft (used solely for recruitment announcements), printed recruitment posters displayed within the Faculty building, and direct individual invitations. Interested participants will register for a participation time slot via a Microsoft Forms link hosted within the TU Delft institutional Microsoft 365 environment.

Fig. 113. HREC documents.

Acquisition of participants

While all acquisition steps are outlined in the Data Management submitted to the Ethics Committee, participant recruitment for the VR eye-tracking study is conducted through a poster providing initial information about the study. To allow participants to access the registration link, direct invitations are also sent via WhatsApp. Potential participants are not asked to provide any personal information over WhatsApp. Therefore, data submission is exclusively held within the Microsoft Forms as well as within the dedicated TU Delft email address.

After scanning the QR code on the poster or selecting the link in the direct message, a form for choosing the timeslots is made available. After a participant registers for a time slot, each registration receives an automated confirmation mail with the timeslot-specific time and date indication. One week before the study, each participant receives a reminder email.

In total, 31 participants registered and successfully completed the experiments, with no major data loss recorded.

Microsoft Forms
forms.office.com

Hello everyone,

Want to explore how spatial design influences visual perception, cognitive response, and short-term relaxation through a VR eye-tracking study?

I'm conducting an experimental VR session in the TU Delft VR-LAB (BK) as part of my MSc Architecture graduation research, investigating how architectural configurations shape perceptual and psychophysiological responses in immersive simulated office environments.

You'll:
- Experience immersive simulated office environments in VR
- Wear a headset with integrated eye-tracking
- Contribute to experimental research connecting architecture, perception, and wellbeing

Duration ≈ 40 minutes
Compensation: €5 (token of appreciation)
Open to TU Delft students

Register here or via the QR code above:

Participation is completely voluntary.

Questions?

00:04

VR Eye-Tracking Study (Participation Registration)

VR Eye-Tracking Assessment of Psychophysiological and Perceptual Responses Across Simulated Office Design Scenarios
TU Delft MSc Architecture Graduation Research

This study investigates how different spatial configurations in simulated office environments influence visual attention and short-term relaxation responses.The experiment is conducted as part of a Master's graduation project (Explore Lab, Faculty of Architecture and the Built Environment, TU Delft).

What participation involves:
- Wearing a VR headset with integrated eye-tracking
- Experiencing several simulated office environments
- Completing short questionnaires on perceived relaxation and spatial comfort

The session lasts approximately **40 minutes** and takes place at the **ARCH Instruction Room W (BK), 08.02.West.130**. Please arrive **5 minutes before your selected time slot** to allow for preparation and calibration. A compensation of €5 is provided as a token of appreciation for participation.

After submitting this form:
- You will receive an automated confirmation email
- The appointment will be scheduled in your TU Delft calendar
- The Participant Information and Informed Consent Form (ICF) will be sent to you by email

You are kindly requested to read the Informed Consent Form in advance.The consent form will be signed in person before the experimental session begins. Participation is voluntary.

Your name and TU Delft e-mail address are collected **for scheduling and administrative purposes only** and will be stored separately from research data in accordance with TU Delft data protection guidelines.

For questions, please contact:

When you submit this form, it will not automatically collect your details like name and email address unless you provide it yourself.

* Required

1. Forename *
Enter your answer

2. Surname *
Enter your answer

3. **Please select one available testing session** (approx. 40 minutes, TU Delft ARCH Instruction Room W (BK), 08.02.West.130). Participation is voluntary.
Unfortunately, all slots have been taken. We apologise for any caused inconvenience!

4. TU Delft E-mail address *
Enter your answer

You can print a copy of your answer after you submit

Submit

Never give out your password. Report abuse

TU Delft MSc Architecture Graduation Research Experiment

TU Delft

VR Eye-Tracking Study

Experimental investigation of perceptual and physiological responses to simulated office environments.

how? does space evoke relaxation

16.–20.03
Room W, BK

Wear a VR headset with integrated eye-tracking
Experience simulated office environments
Complete short questionnaires

Duration ≈ 40 min
Compensation: €5 (token of appreciation)

Open to TU Delft students
Participation is voluntary.

Participation Registration

Direct contact via E-mail:

Confirmation – VR Eye-Tracking Study Participation

TK

To:

Informed Consent F...
225,1 KB
Download • Preview

Thursday, 26. February 2026 at 14:09

Dear Participant,

Thank you for registering for the VR Eye-Tracking Study conducted as part of the TU Delft MSc Architecture Graduation Project.

Your session details:

Date: 17.03
Time: 16:00-16:40
Location: ARCH Instruction Room W (BK), 08.02.West.130

Please arrive **5 minutes before your scheduled time slot** to allow for preparation and calibration.

What to expect

During the session (approximately 40 minutes), you will:
- Wear a VR headset with integrated eye-tracking
- Experience several simulated office environments
- Complete short questionnaires on your perceptual experience

You will receive a **€5 compensation (token of appreciation)** after participation.

Important: Informed Consent

Attached to this email you will find the Participant Information Sheet and Informed Consent Form (ICF).

Please read the document carefully in advance.
The consent form will be signed **in person before the experimental session begins**.

Participation is voluntary, and you may withdraw at any time without consequences.

If you have any questions, please feel free to contact:

Kind regards,

Fig. 114. Poster, Automated confirmation e-mail and the participation registration sheet, prepared for the aquisation of participants.

ARCH Instruction Room W (BK), 08.02.West.130

During the one-week study period (16.03–20.03.2026), Room W at BK TU Delft is reserved daily from 9:45 to 17:45 to conduct the experiments in a controlled indoor environment without acoustic or visual distractions, ensuring identical conditions for all participants.

Every day, the room is prepared between 9:30 and 9:45 with a consistent spatial setup. A table with a chair for the participant facing the room's monitor is placed in the middle, while three tables on the right side with the MacBook, the experiment's protocol sheets, as well as water, paper cups and the sanitation cloths to clean the headset, pens, controllers and the furniture after each session. On the left side, a table is positioned on which the VR VIVE Focus Vision headset with the controller, as well as the Informed Consent forms and the questionnaires are placed. While each Informed Consent Form is pre-filled with the participant's name and the date, the questionnaires are also prepared with an indivdual study code and participant's specific, equally randomized exposure order.

A poster is placed in the hallway to support participant's orientation. During the sessions one window remains open for ventilation, lighting stays on throughout the day, and the door is kept closed to avoid interruptions. After the six daily sessions end at 17:00, the room is cleaned, and the furniture is reset.

















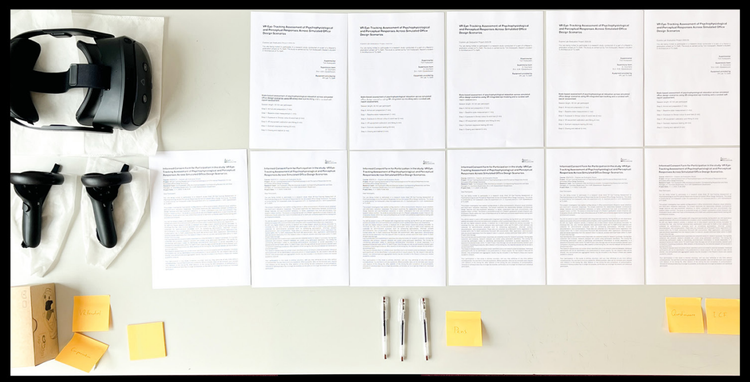


Fig. 115. Room W, Spatial layout prepared for each study session.

Study
In-Session Procedure

At the beginning of each session, the participant is asked to arrive five minutes in advance to avoid delays caused by potential calibration issues. When arriving, the participant is asked to sit at the central table facing the room‘s monitor. The informed consent form is then provided, and the studie‘s procedure, data management, participant‘s rights and the voluntary nature of participation are explained. After both the participant and the corresponding researcher sign the form, the questionnaire sheets are provided, with the first page outlining the steps of the study.

Then, the participant is asked to fill out the baseline questionnaire to document the participant‘s general psychophysiological baseline prior to exposure. This is followed by a Stroop colour & word test in which the participant reads aloud the ink colour of the displayed words. The test is meant for standardising attentional load, reducing variability due to “arriving calm vs. arriving stressed” and increasing comparability of recovery/ restoration effects across scenarios.

After completing the test, the participant watches a short instruction video and receives guidance on calibrating the VR headset. The VR VIVE Focus Vision headset is then fitted, and the participant is informed that all equipment has been sanitised.
The participant is guided through the calibration procedure, which is done for all participants twice to maintain precise eye-tracking and avoid inconsistencies in the data collection. After the calibration has been completed, the participant is asked to confirm whether the gaze sphere, a red dot tracking the gaze, follows their eye movement smoothly.

Once calibration is completed, the first virtual scene is presented. Each scene is viewed for three minutes, controlled by an automated timer to ensure identical exposure durations. After the exposure ends, the participant is asked to fill out the post-exposure questionnaire. This process is repeated for four scenes, with the order randomised across participants to ensure balanced distribution.

After completing all exposures and questionnaires, the participant is invited to share comments or reflections for approximately five to ten minutes. Finally, the participant receives a 5€ compensation and the equipment, table, etc. are sanitized in preparation for the next session.



Fig. 116. Room W, In-Session situation.

Study Questionnaire

The selection of questions within the questionnaire follows the principle of using established and scientifically grounded instruments rather than self-formulated questions, as differences in terminology might result in ambiguity and differing interpretations among participants. Implementing established systems, therefore, improves comparability of responses across participants. Concerning the baseline assessment, the short-form State–Trait Anxiety Inventory (STAI-6) is used to capture participants' initial psychophysiological state before exposure.

Furthermore, to assess the participants' short-term perceptual and physiological responses in post-exposure, selected items from multiple validated instruments are combined. These items include pre-selected elements of the Relaxation State Questionnaire (RSQ) to measure subjective bodily relaxation and immediate physiological indicators such as muscle tension and cardiovascular activation, while selected items from the Perceived Restorativeness Scale (PRS) assess attentional restoration and spatial fascination.

Regarding the rating-scale, a 5-point Likert scale is used to provide sufficient sensitivity within the self-perceived responses of the participants. The 5-point scale allows participants to select a neutral response as well, reducing forced directional bias.

While a combination of multiple items from different scientifically established instruments has the potential to create scientific concerns, the questionnaire consists of a curated selection of items, enabling both a focused and a theoretically grounded assessment aligned with the exploratory nature of the experiment.

VR Eye-Tracking Assessment of Psychophysiological and Perceptual Responses Across Simulated Office Design Scenarios

Explore Lab Graduation Project 2025/26

You are being invited to participate in a research study conducted of a part of a Master's graduation project at TU Delft. The study is carried out by Master's student in Architecture of TU Delft.

State-based assessment of psychophysiological relaxation across simulated office design scenarios using VR-integrated eye tracking and a curated self-report assessment.

Session length: 40 min per participant

Step 0: Arrival and preparation (7 min)

Step 1: Baseline state measurement (1 min)

Step 2: Exposure to Stroop colour & word test (2 min)

Step 3: VR-equipment calibration and fitting (5 min)

Step 4: Scenario exposure testing (20 min)

Step 5: Closing and debrief (5 min)

Baseline Questionnaire (2 min)

Read each statement and then circle the most appropriate number to the right statement to indicate how you feel right now, at this moment. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe the present feelings the best.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. I feel calm.	1	2	3	4	5
2. I am tense.	1	2	3	4	5
3. I feel upset.	1	2	3	4	5
4. I am relaxed.	1	2	3	4	5
5. I feel content.	1	2	3	4	5
6. I am worried.	1	2	3	4	5

Participant code: 01

Post-Exposure Questionnaire (2 min)

Read each statement and then circle the most appropriate number to the right statement to indicate how you feel right now, at this moment. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe the present feelings the best.

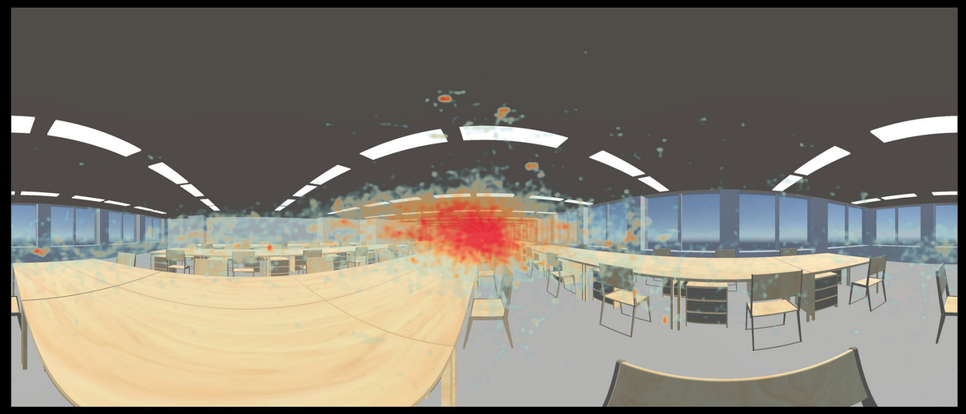
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. My breathing is faster than usual.	1	2	3	4	5
2. My heart is beating faster than usual.	1	2	3	4	5
3. My muscles feel relaxed.	1	2	3	4	5
4. Right now, I am completely calm.	1	2	3	4	5
5. Being here helps me to relax my focus on getting things done.	1	2	3	4	5
6. This place has fascinating qualities.	1	2	3	4	5
7. I want to get to know this place better.	1	2	3	4	5
8. There is a great deal of distraction.	1	2	3	4	5
9. I perceive the space as thermally cooling.	1	2	3	4	5
10. I perceive the space as relaxing.	1	2	3	4	5

Participant code: 01
Scene: a
Exposure: 02

Fig. 117. Questionnaire, prepared individually-coded for each participant and each session.

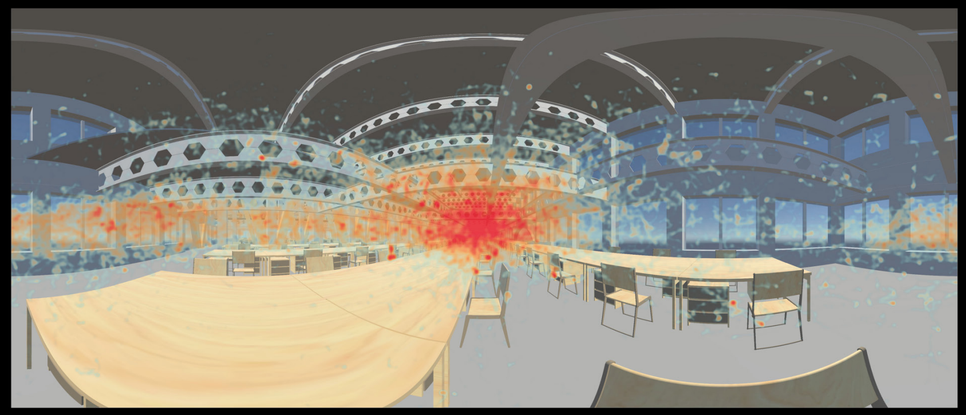
scene a

all 31 participants
included



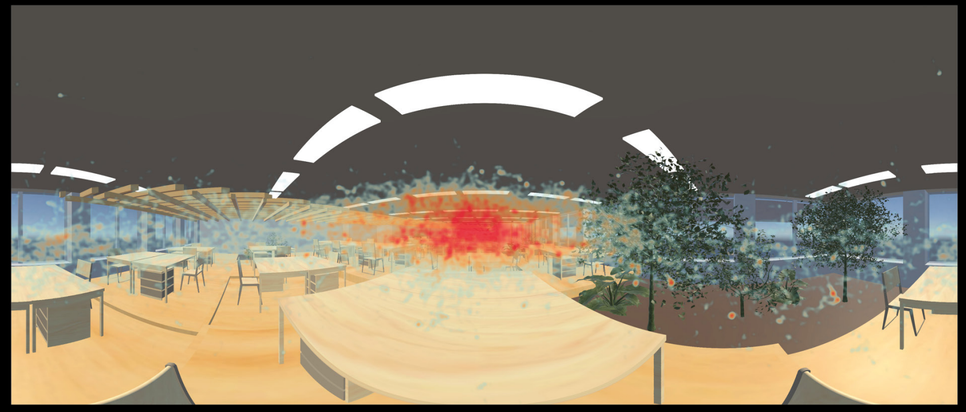
scene b

all 31 participants
included



scene c

all 31 participants
included



scene c

all 31 participants
included

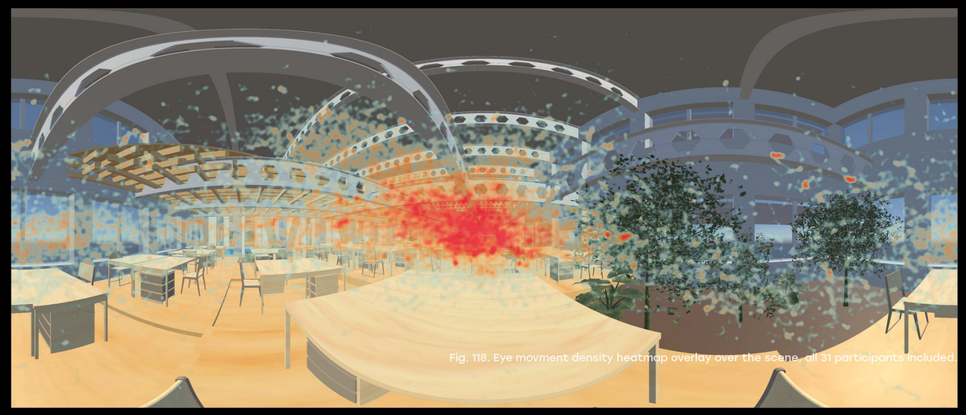
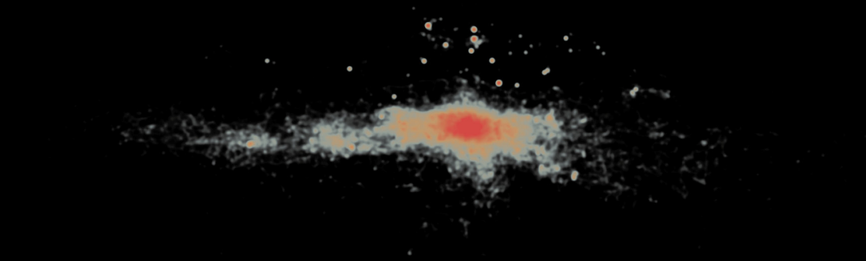


Fig. 118. Eye movment density heatmap overlay over the scene, all 31 participants included.

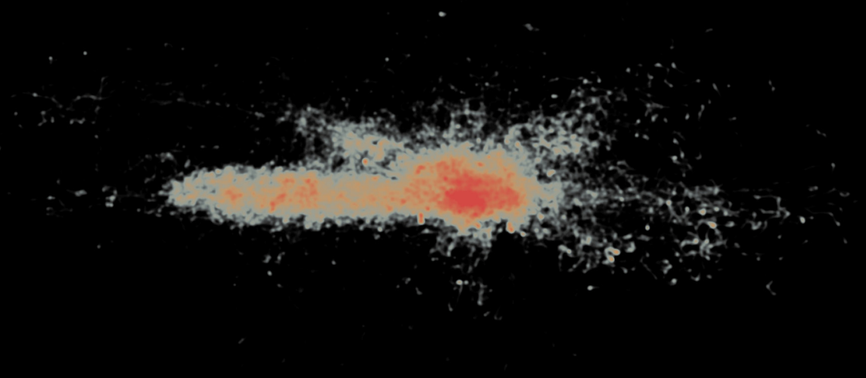
scene a (eye-only)

all 31 participants
included



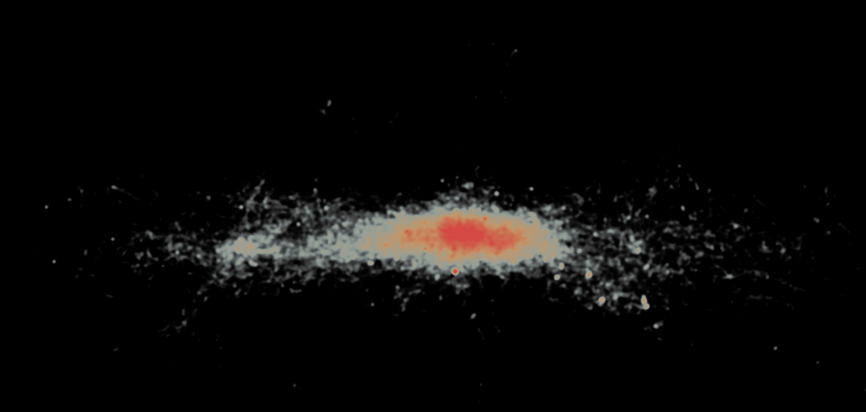
scene b (eye-only)

all 31 participants
included



scene c (eye-only)

all 31 participants
included



scene d (eye-only)

all 31 participants
included

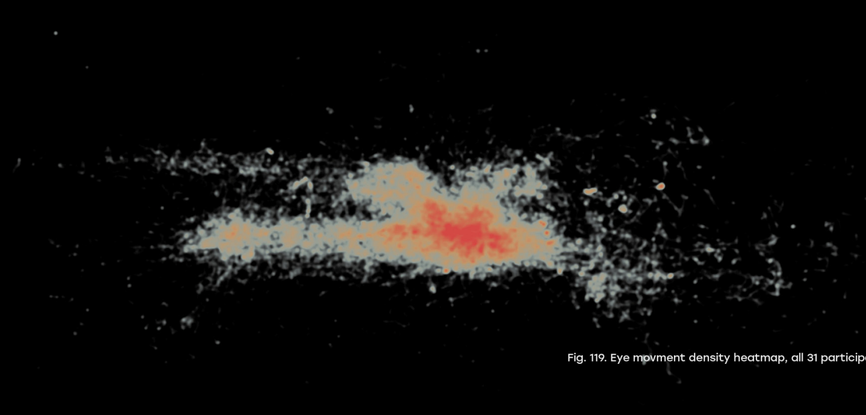


Fig. 119. Eye movment density heatmap, all 31 participants included.

Results & Findings on Informal Post-Session Discussions

At the end of every session, a 5–10 minute questions and comments section is conducted in which participants are invited to share observations on the scenes, their perception, and the questionnaire. Such informal discussion has grown in significance over the whole study as it extends the scope of the study beyond research and design and integrates the human perception, replicating and potentially reflecting the diversity of real occupants.

The overall feedback has brought to attention that the self-perceived perception of each scene is highly personal and individually influenced. While some participants describe scene d, characterised by greenery and spatial openness, as relaxing, others perceive it as overstimulating.

Furthermore, while some participants associate scene c with a sense of relaxation, it remains for others claustrophobic due to the relatively low ceiling in combination with the extended floor depth. The perception towards the steel beams also differs in response, as some mention curiosity, while some reject and dislike the occurrence.

Additionally, repeated comments indicated that missing occupancy, lack of landscape outside the window, as well as glare caused by the VR headset's resolution, potentially impact visual perception and should be considered for future testing.

When comparing the visual perception of a limited number of architecture students and non-architecture students, the heat-map overlay on the right suggests that for architecture students, the structure tends to be more effective in capturing a viewer's attention, while for non-architecture students, the space itself resembles potentially higher effectiveness.

Such comments reveal a high complexity in visual perception, comfort, self-perceived concentration and urges the design strategy to be not limited to one scene, but to allow multiple occupants to choose potentially between spatial properties and configurations, resulting in a vertical office floor landscape that is not limited to design nor to research but is meant to embrace the individuality and diversity of its occupants.



scene d

architecture
students



scene d

non-architecture
students

Fig. 120. Eye movment density heatmap overlay over the scene, comparison with architecture students and non architecture students.

Results
on the Questionnaire

The questionnaire results are displayed in mean values and standard deviation per scene over all participants. The results reveal differences in perceived spatial and restorative qualities across the four scenarios, especially fascination, the desire to further explore the scene, as well as the self-perceived relaxation shift towards agreement in scenes b, c and d.

A significantly higher rate of self-perceived relaxation is noted in scenes c and d, while the perception of interest and fascination tends to accumulate in scenes b and d.

Regarding indicators of physiological arousal, such as breathing or heart rate, the perceived effect is only limited in difference and tends to stay overall within the category of disagreement. The self-perceived relaxation of muscles, the feeling of calmness, as well as focusing and getting things done, however, gradually shift towards agreement from scene a to d.

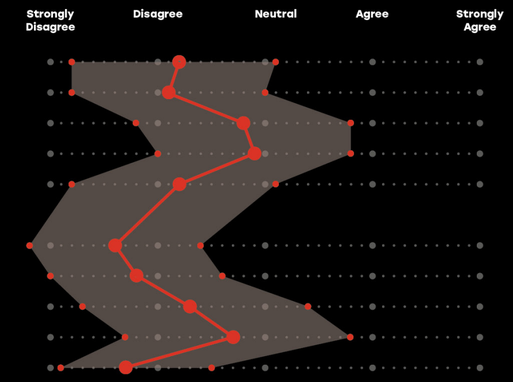
For the design, the results show a not inconsiderable influence of Japanese vernacular techniques, natural materials, integrated greenery, borrowed scenery and the curated distance referenced in Japanese garden design in stimulating interest and curiosity. It can also be noted that spatial openness, characterising scenes of b and d, appears to have a potentially significant impact on self-perceived relaxation.

While the standard deviation, illustrated by the semi-transparent areas, reveals overall clear tendencies across the scenes, a moderate variation between participants is still visible. This suggests that the design should not be limited solely to mean values but should also consider individual perceptions that do not fully align with the mean. Therefore, the retrofit process of the Kasumigaseki building will not be represented exclusively by scene d, but the questionnaire results across all scenes will inform the design in order to incorporate the full range of observed spatial responses.

Fig. 121. Mean Value Results of the Questionnaire including Standard deviation.

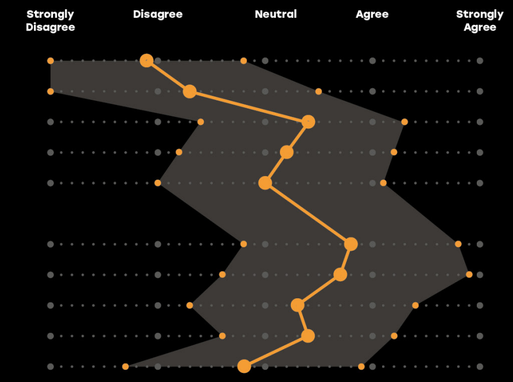
Scene a

1. My breathing is faster than usual.
2. My heart is beating faster than usual.
3. My muscles feel relaxed.
4. Right now, I am completely calm.
5. Being here helps me to relax my focus on getting things done.
6. This place has fascinating qualities.
7. I want to get to know this place better.
8. There is a great deal of distraction.
9. I perceive the space as thermally cooling.
10. I perceive the space as relaxing.



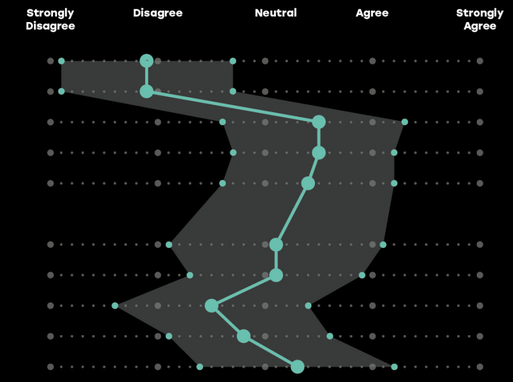
Scene b

1. My breathing is faster than usual.
2. My heart is beating faster than usual.
3. My muscles feel relaxed.
4. Right now, I am completely calm.
5. Being here helps me to relax my focus on getting things done.
6. This place has fascinating qualities.
7. I want to get to know this place better.
8. There is a great deal of distraction.
9. I perceive the space as thermally cooling.
10. I perceive the space as relaxing.



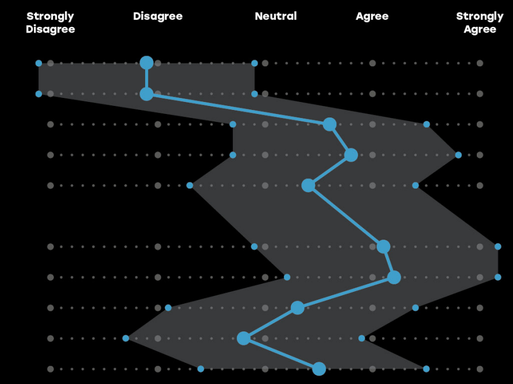
Scene c

1. My breathing is faster than usual.
2. My heart is beating faster than usual.
3. My muscles feel relaxed.
4. Right now, I am completely calm.
5. Being here helps me to relax my focus on getting things done.
6. This place has fascinating qualities.
7. I want to get to know this place better.
8. There is a great deal of distraction.
9. I perceive the space as thermally cooling.
10. I perceive the space as relaxing.



Scene d

1. My breathing is faster than usual.
2. My heart is beating faster than usual.
3. My muscles feel relaxed.
4. Right now, I am completely calm.
5. Being here helps me to relax my focus on getting things done.
6. This place has fascinating qualities.
7. I want to get to know this place better.
8. There is a great deal of distraction.
9. I perceive the space as thermally cooling.
10. I perceive the space as relaxing.



Questionnaire
Research to Design

Expanding on the previous mean-value-based questionnaire results, the questions are categorised into 4 categories including relaxation, fascination, concentration and thermally cooling. While scene a has the lowest values in every category, scene b is considered to perform most efficiently in evoking responses of fascination and the perception of a thermally cooling effect.

Furthermore, scene c is stimulating, with the highest self-perceived enhancement in concentration among all participants, while scene d is both within the category of relaxation and fascination, with higher scores compared to the other scenarios.

As a result of such comparison, each scene, except scene a, is primarily associated with one self-perceived category.

scene b = fascination & thermally cooling
scene c = concentration
scone d = relaxation

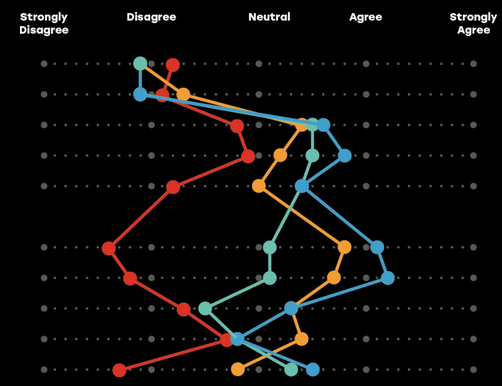
For scene d, fascination is disregarded to simplify the attribution per scene and category.

As this research is meant to be directly integrated into the Kasumigaseki building retrofit process, each category is associated with an office space typology which matches both the spatial properties of each typology as well as the features of each self-perceived psychological response.

With this alignment, not only one scene will be implemented into the Kasumigaseki retrofit approach, but each scene evoking specific psychological effects are considered to be implemented as direct design strategies, that go beyond relaxation and thermally cooling responses and have additionally the potential to improve productivity, focus and shared work experiences.

Scenes
a,b,c,d

1. My breathing is faster than usual.
2. My heart is beating faster than usual.
3. My muscles feel relaxed.
4. Right now, I am completely calm.
5. Being here helps me to relax my focus on getting things done.
6. This place has fascinating qualities.
7. I want to get to know this place better.
8. There is a great deal of distraction.
9. I perceive the space as thermally cooling.
10. I perceive the space as relaxing.



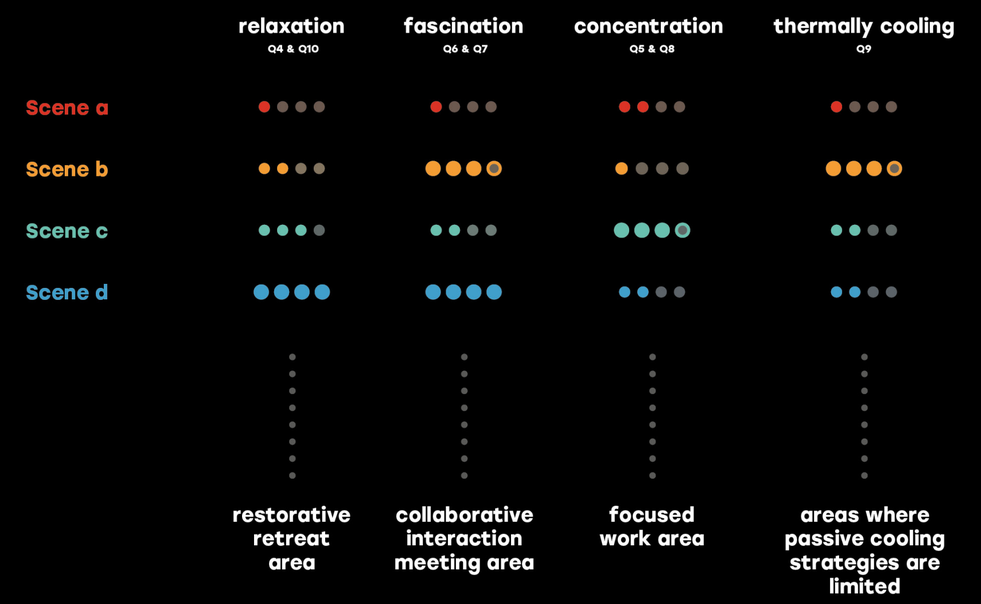


Fig. 122. Mean Value Results and its translation into Office-typologies.

Results on the VR Eye-tracking data

Regarding the eye-tracking results, the data is displayed as mean values across all participants. To identify potential differences in head- and eye-related behavior between the scenes, a repeated-measures ANOVA test is conducted. When the results of the ANOVA test indicate significant differences, paired post-hoc t-tests with Bonferroni correction as well as Cohen's d effect size calculations are performed to both localize the difference per scene, as well as to further examine the range of the noted differences.

Regarding the ANOVA test results, the categories concerning speed (combined, head-only, and eye-only), as well as mean horizontal eye-only dispersion and mean horizontal head-only dispersion, reveal no statistically significant differences between the scenarios ($p > 0.05$). However, combined horizontal dispersion, fixation count, mean fixation count per second, and mean fixation duration reveal statistically significant differences across the scenarios ($p < 0.05$), indicating considerable variation between the four scenes.

Concerning the horizontal dispersion of combined eye and head movement, especially results regarding the scenes of b (large effect) and d (medium) emphasize the impact of spatial openness on horizontal dispersion within the participant's visual perception. The fixation count and fixation count per second demonstrate statistically significant differences, with scenes a, b, and c generally showing higher fixation activity compared to scene d. At the same time, fixation duration tends to increase towards scene d, suggesting longer and potentially more stable visual engagement within this environment.

In terms of design, the heat map overlays on the scene's 360°-view indicate a generally centrally dominant gaze. However, especially the openings towards the core, the steel beams and the timber interwoven structures reveal a notable influence in dispersing the participants' visual attention. Furthermore, as the effect on spatial openness is generally larger, when the visual stimuli are isolated from the Japanese vernacular design implementations, this provides clear guidance for the Kasumigaseki retrofit strategy. In particular, openness and enhanced visual stimuli can be adapted differently across changing programmatic functions in order to stimulate curiosity and interest while avoiding a visually monotonous office environment.

However, as the sample size remains limited to 31 participants, the findings, particularly those derived from the ANOVA analysis, should be interpreted with caution.

	Repeated-Measures ANOVA test p-value across a,b,c,d		a	b	c	d			
Mean combined speed (deg/s)	F(3, 90) = 2.33, p = 0.0797	Average	34,488	38,401	35,467	35,308			
Mean eye-only speed (deg/s)	F(3, 90) = 2.33, p = 0.0801	Average	26,186	28,559	26,835	25,897			
Mean head-only speed (deg/s)	F(3, 90) = 2.23, p = 0.0902	Average	10,433	9,734	11,477	10,265			
Mean combined horiz. speed (deg/s)	F(3, 90) = 1.46, p = 0.2296	Average	28,908	31,625	29,595	29,281			
Mean eye-only horiz. speed (deg/s)	F(3, 90) = 1.49, p = 0.2223	Average	21,100	22,318	21,282	20,370			
Mean head-only horiz. speed (deg/s)	F(3, 90) = 1.53, p = 0.213	Average	8,751	8,499	9,763	8,911			
Combined horiz. dispersion SD (deg)	F(3, 90) = 6.38, p = 5.70×10^{-4}	Average	61,023	75,950	67,165	72,489	Cohens D test:		effect
		Statistic	a-b = 0.00085		b-c = 0.01524		a-b	0,67974	large
			a-c = 0.08327		b-d = 0.37602		a-d	0,49758	medium
			a-d = 0.00512		c-d = 0,11852				
		Bonferroni corrected alpha	p<0.0083		p<0.0083				
Mean eye-only horiz. dispersion SD (deg)	F(3, 90) = 2.40, p = 0.073	Average	36,399	42,046	40,184	41,896			
Mean head-only horiz. dispersion SD (deg)	F(3, 90) = 2.00, p = 0.120	Average	31,585	37,005	34,587	36,669			
Mean fixation count	F(3, 90) = 10.06, p = 8.81×10^{-6}	Average	192,806	199,065	196,226	166,516	Cohens D test:		effect
		Statistic	a-b = 0.42408		b-c = 0,60925		a-d	0,8561	large
			a-c = 0.67089		b-d = 9,27366E-8		b-d	1,17345	very large
			a-d = 0,00118		c-d = 4,43765E-5		c-d	0,98358	large
		Bonferroni corrected alpha	p<0.0083	p<0.0083	p<0.0083	p<0.0083			
Mean fixation counts per seconds	F(3,90) = 10.07, p = 8.75×10^{-6}	Average	1,071	1,106	1,090	0,925	Cohens D test:		effect
		Statistic	a-b = 0,42508		b-c = 0,61043		b-d	1,17378	very large
			a-c = 0,67126		b-d = 9,24095E-08		c-d	0,98409	large
			a-d = 0,00117		c-d = 4,41572E-05				
		Bonferroni corrected alpha	p<0.0083	p<0.0083	p<0.0083	p<0.0083			
Mean fixation duration	F(3,90) = 2.72, p = 0.0493	Average	414,387	376,832	412,580	491,231	Cohens D test:		effect
		Statistic	a-b = 0.42298		b-c = 0.17586		b-d	0,76039	large
			a-c = 0.97390		b-d = 0.00017				
			a-d = 0.13064		c-d = 0.03698				
		Bonferroni corrected alpha	p<0.0083	p<0.0083	p<0.0083	p<0.0083			

Fig. 123. Summary of Repeated-Measure ANOVA tests with Bonferroni coreccted alpha & Cohens D tests

VR Eye-tracking data Research to Design

As first assessments regarding statistical relevance have been approached and should be considered scientifically cautiously, the implementation of the eye-tracking mean value results are considered to be a primary driver for the spatial explorations within the standard offices floor next to the questionnaire results.

Expanding on the mean values within the eye-tracking data, a aligning result can be assessed in comparison with the questionnaire conclusions.

Scene a:

The baseline environment can be characterised with a relatively low visual exploration, as the combined head and eye movement, as well as the horizontal eye-only dispersion, remains lower in comparison with the other scenes. Combined with the reduced fixation frequency, an under-stimulated gaze behaviour framed by a limited number of visual stimuli and repetitive spatial configurations can be assessed.

Scene b:

Scene b is characterised by the highest gaze speed and movement as well as horizontal dispersion. Accompanied by the highest fixation frequency, the pattern indicates broader visual exploration and distributed attention across the wider scene, associated with increased visual engagement. Simultaneously, the higher fixation frequency is considered to indicate higher cognitive load, which leads to the conclusion that the scene stimulates potential fascination within increasing attentional demand and continuous visual scanning, aligning with the self-perceived responses from the questionnaire. (Lu & Pesarakli, 2023)

Scene c:

As the scene provides clear visual stimuli through vegetation, timber elements, etc., the areas of interests (AOIs) suggest guided attention rather than continous scanning, while the lower fixation frequency can be associated with a relatively lower cognitive load through the scene promoting potentially work demanding focus and concentration. (Lu & Pesarakli, 2023)

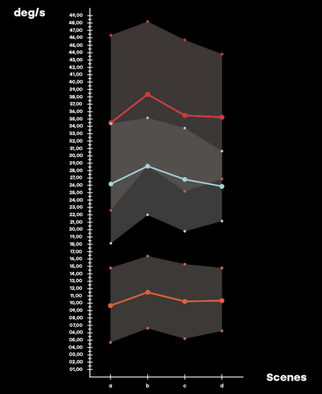
Scene d:

As the scene combines spatial opennes and vernacular integrations, the higher horizontal dispersion of eye-only movement and the lowest fixation frquency indicate together potentially lower perceptual processing demands, while the more guided explorative horizontal eye movement remains stimulated and presumely suggests a balanced eye-movement associated with reduced cognitive load and enhanced perceived relaxation. (Lu & Pesarakli, 2023)

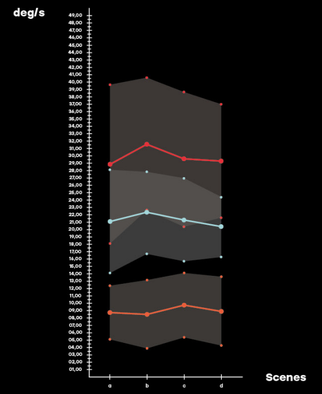
As the self-perceived participants‘ responses align with the measured eye-movement patterns, it can be assumed that the psychological categories matching the spatial design strategies provide an informed framework for the Kasumigaseki building‘s retrofit process enhancing not only relaxation but also promoting concentration, productivity and collaborative work experiences.

Fig. 124. Mean Values with Standard deviation of eye-movement relative to head movement.

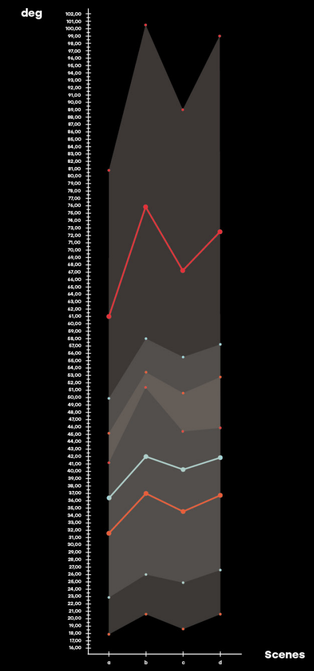
Mean combined speed (deg/s)



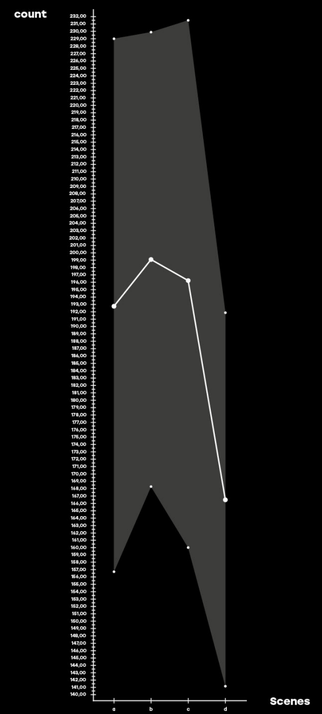
Mean combined horiz. speed (deg/s)



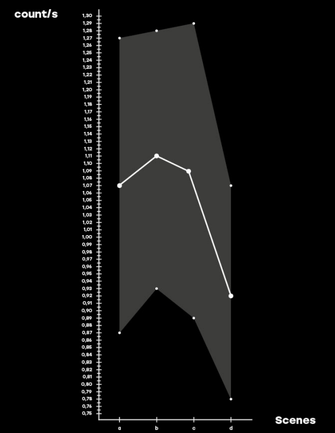
Mean eye-only horiz. dispersion SD (deg)



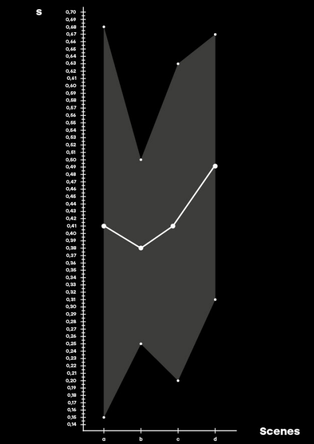
Mean fixation count



Mean fixation counts per seconds



Mean fixation duration (s)



3.3 Exploring

STRUCTURAL INTEGRATION

Archival Material & Original Documentation

To develop a deeper understanding of the Kasumigaseki building regarding its intention, identity, structural logic, performance, as well as its constructional details, archival material of the building, including documentations of its previous retrofitting cycles, has been consulted at the Tokyo Metropolitan Central Library and has been reproduced through photocopies. In addition, the original 1968 publication documenting the newly completed building has been obtained from a second-hand bookstore in Tokyo in order to further understand the architect's original intentions and the building's perceived identity.

As well, Kajima Design & Yamashita Sekkei Inc.(Architects), Kajima Corporation (Constructor and Renovator) and Mitsui Fudosan (Developer) have been contacted to request architectural drawings, including sections, floorplans, constructional details, etc., due to security concerns, as the Kasumigaseki building is an existing and operational building, access and sharing of data were denied by all parties.

While the archival materials, the original publication and extensive research provides a well-informed framework for an in-depth understanding of the building, its structure, infrastructure, renovation history, constructional details etc., remaining uncertainties are treated with care and are supplemented through additional comparable built references, as well as through the analysis of comparing both archival, original and additional documents (external reports, photographic and audiovisual documentations).

As the understanding of the building and its construction evolved, the insights have been translated into a 1:50 structural physical model, allowing potential retrofit strategies to be explored in direct relation to the existing structure. At the same time, the building's historical significance as Japan's first high-rise office tower remains an important reference, encouraging an approach in which the process of transformation is not concealed but revealed as part of the building's evolving identity.

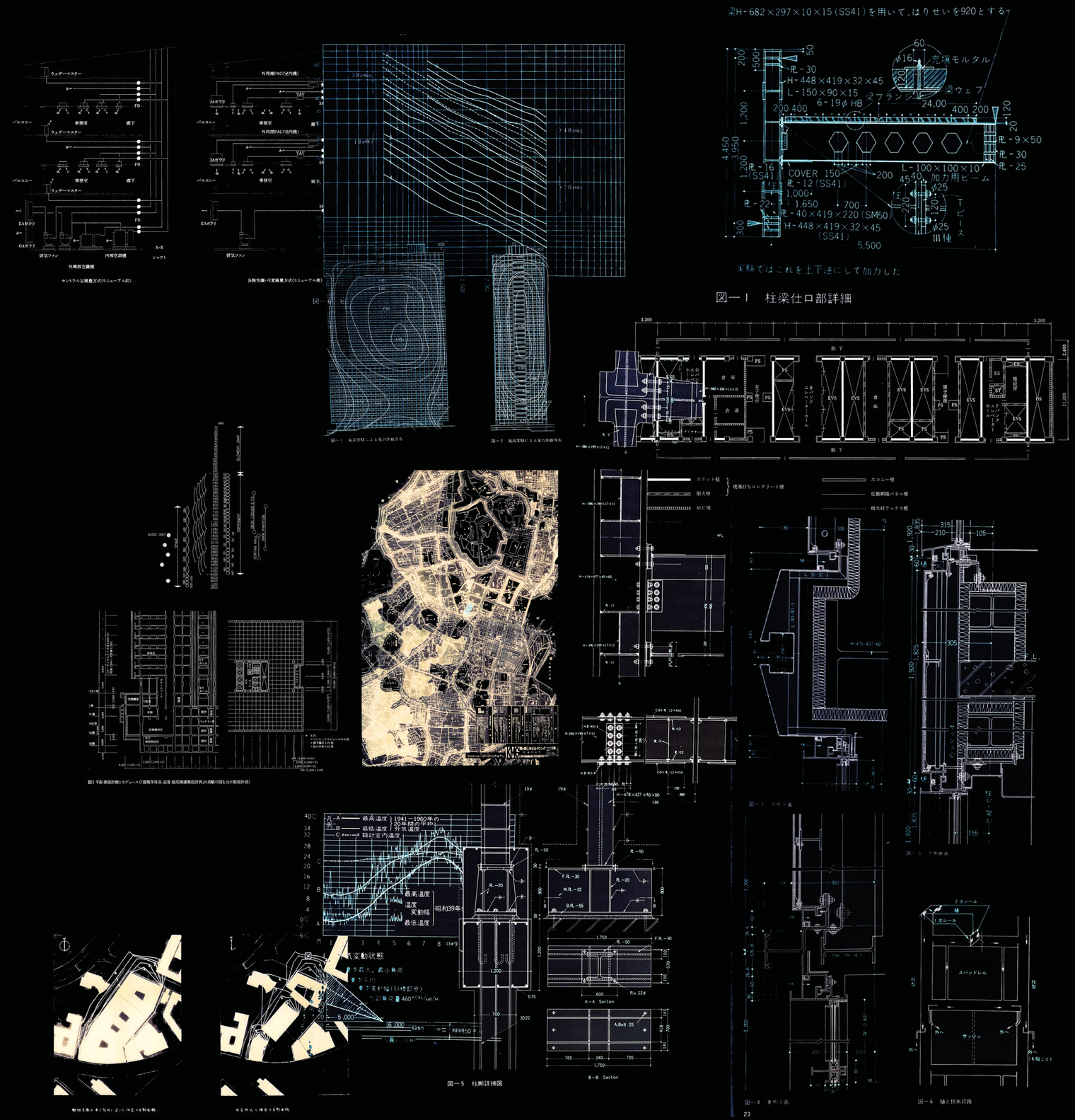


Fig. 125. Selected technical drawings from the Kasumigaseki Building project book. From Kasumigaseki Building Construction Commitee (1968).

1:50 Structural Investigation Model

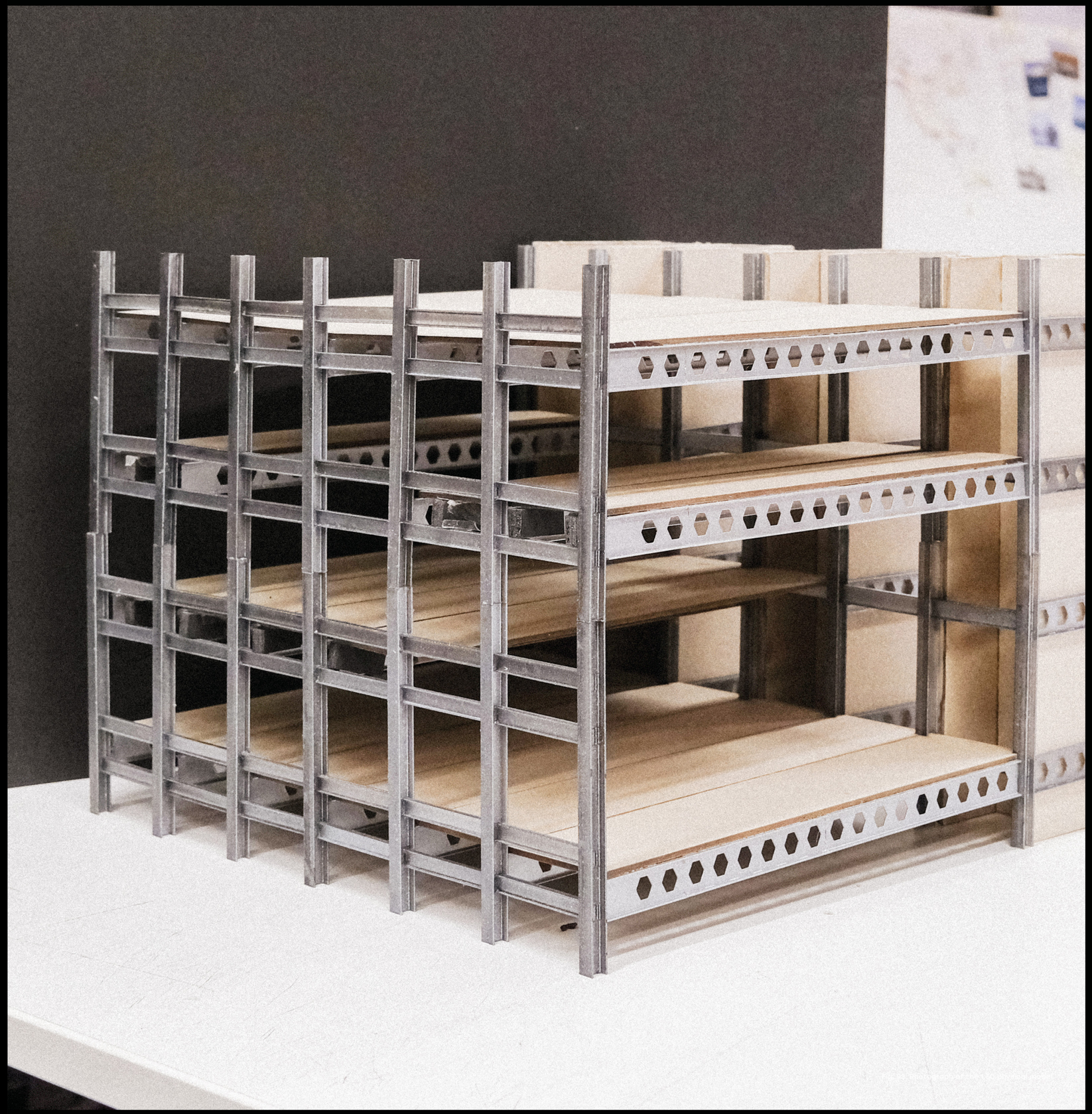


Fig. 126. Technical reconstruction of the existing load-bearing structure of the Kasumigaseki building through a physical study-model 1:50.

Addition + & Extraction - How to make a void (Ma)?

Addition (+) and subtraction (-), as spatially transformative strategies, have been guiding the earlier process of new programmatic integration, the creation of voids and the introduction of new spatial and structural implementations.

The first iteration of these interventions has been assessed in the eye-tracking research, where especially the voids, new structural integrations with timber elements, and the openness through the extraction within the core area have provided impactful insights into the effects of stimulating eye-movement associated with relaxation, fascination and potentially productivity, as well as collaborative work.

These concepts of voids and new structural rhythms through the addition of a new timber structure, however, are necessary to be refined and assessed through the structure of the Kasumigaseki building itself to allow a more in-depth and structurally reliable decision-making.

Therefore, several design studies and prototyping iterations have been approached digitally, in which a new 700mm by 700mm grid is introduced. Despite the structural grid of 3200mm that is given by the load-bearing steel collumns and castellated beam system, the new finer grid is informed by the openings of the castellated beams that offer voids to implement and weave in a new structural system. Timber as a material is chosen not only for its psychological advantages, as it is a natural material, but also for its lightness and the ability to cut out more easily curved shapes, contrasting the rigidity of the existing structure.

Despite several iterations, a three-dimensional timber-steel lattice structural concept was chosen, allowing to integrate smaller timber elements into the structure while creating a more tactile spatial expression compared to bigger and more heavier timber elements. The steel beams within the structural lattice field are reoriented orthogonally to avoid a simple replacement or extraction of structural elements, while integrating a new orientation within the structural field to support both the timber lattice structure and the existing steel structure to distribute the load evenly. As the new lighter structural intervention is placed, voids are meant to be cut out to create the considered openness. This system provides visual anticipation, in which change is not concealed nor replaced by an identical structural system or a concrete slab, but rather revealed by a new material, new rythm and new tactility that allows flexibility in the shape and the extend of the openness of the void. Here, the concept of Ma is embodied by the integration of Japanese carpentry, which is no longer limited to a solely vernacular system but reflects as well the contemporary Japanese architectural expression.

This structural integration is then embedded in the physical model 1:50 to assess both strutcural integration and the spatial expression.



Fig. 127. Kintsugi.
From Burton (2026).

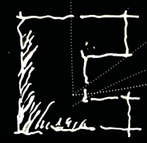




Ma



間



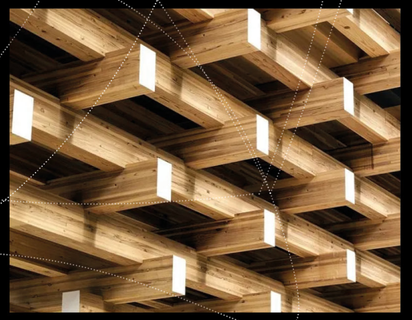


Fig. 128. Photogaph of the Yusuhara Wooden Bridge Museum's detail.
From Yusuhara Wooden Bridge Museum (n.d.).

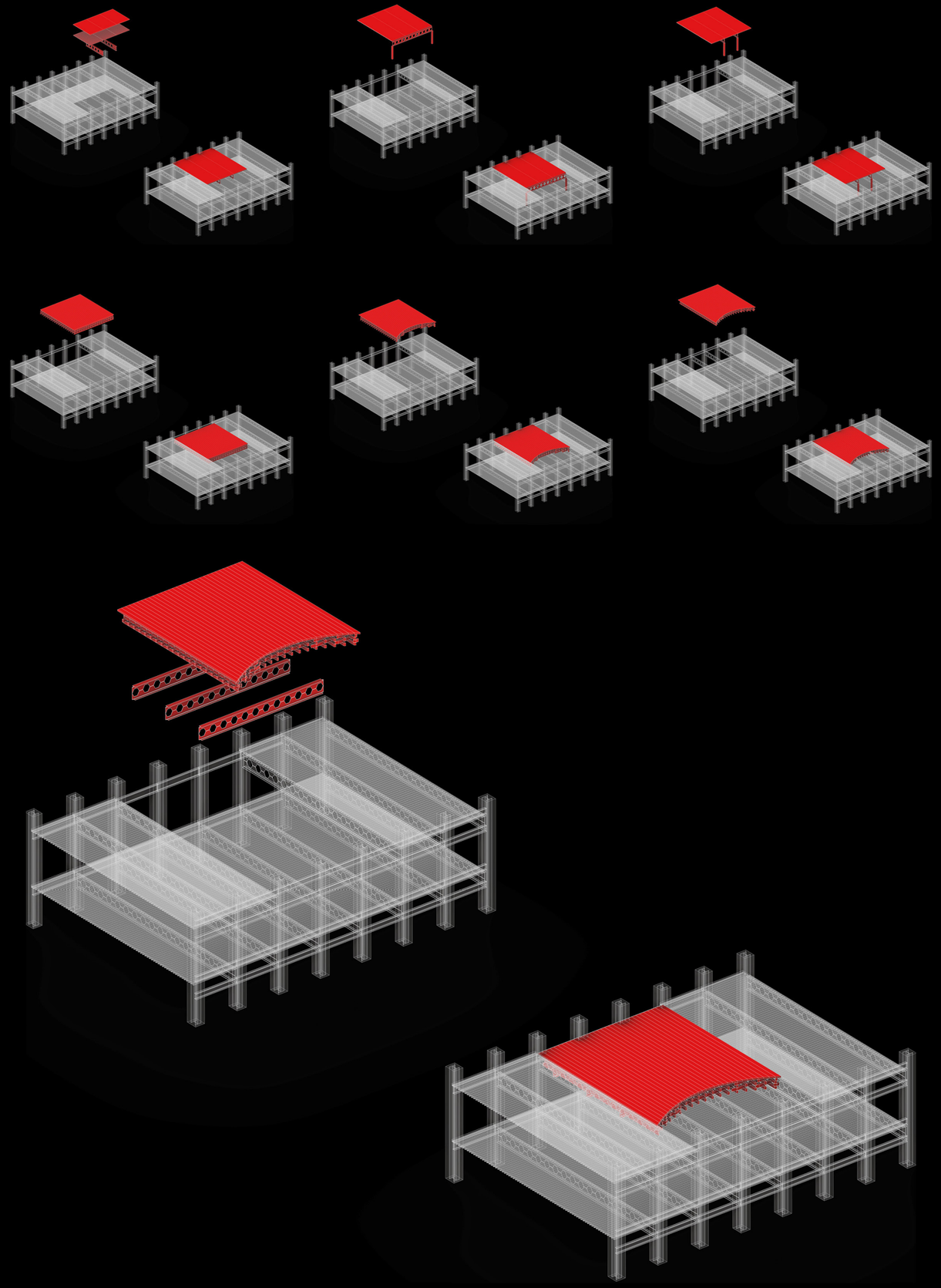


Fig. 129. Structural explorations of implementing a new structural material, rythm while displaying change and not conceiling the process of retrofitting the Kasumigaseki Building.

STUDY

Fig. 130. 1:50 Physical Model study integration.



Fig. 112. 1:50 Physical Model study integration.

STUDY

Fig. 131. 1:50 Physical Model study integration.



Fig. 112. 1:50 Physical Model study integration.

Integration of new program through exploring vernacular japanese woodmaking techniques

The integration of the three-dimensional timber-steel lattice structural concept to create voids is extended towards a more three-dimensional spatial concept of space-making, in which the structural system creates the spatial framework for the new programmatic integration.

As the programmatic health-enhancing interventions are ranging from cafés, sports facilities, conference halls, art spaces, green voids, etc., different sizes and geometries need to be achieved while maintaining one structural system to avoid increased complexity and individual systems per space. Therefore, the structural lattice system is extended with vertical additions that integrate into the 700mm by 700mm grid and can be adapted in length by producing different lengths of timber elements.

Furthermore, a repetitive frame is chosen that is also considered to be produced adaptively according to the spatial needs of the program, shaping the geometry of each space distinctively.

Then the same structural lattice is repeated at the lower end, with again the reoriented steel beams to support both the lattice and the existing steel structure as well as to distribute the loads evenly.

This system has been assessed as well in a physical model, while the fabrication was chosen to be 3D printing, the general spatial coherence and structural system were reviewed.

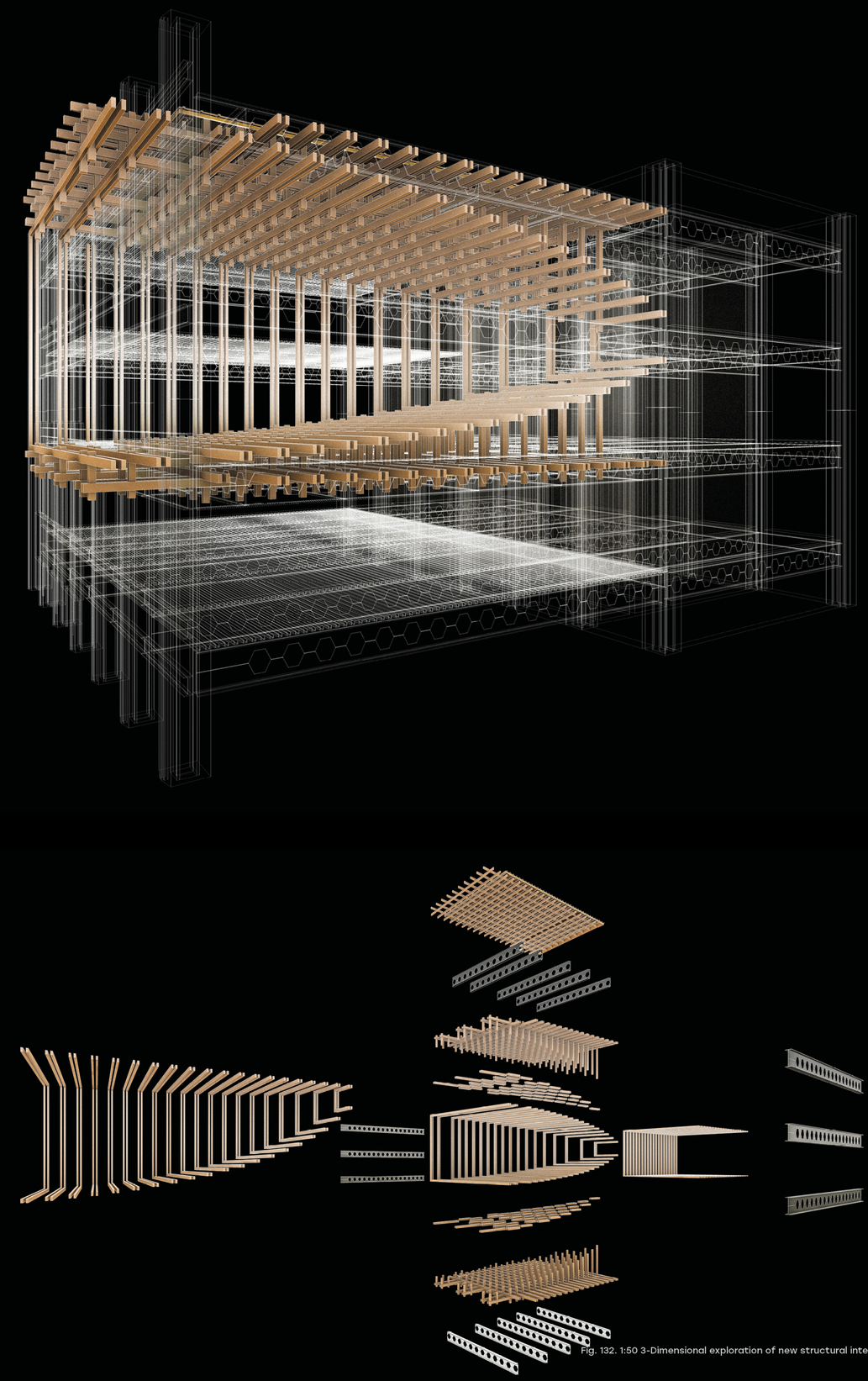
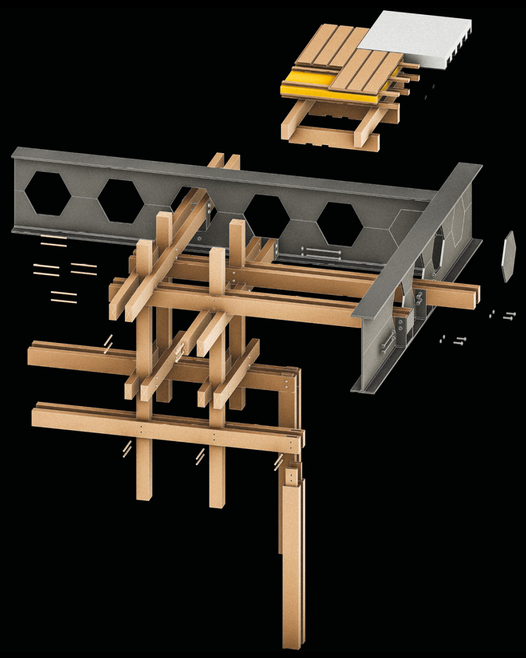


Fig. 132. 1:50 3-Dimensional exploration of new structural integration.



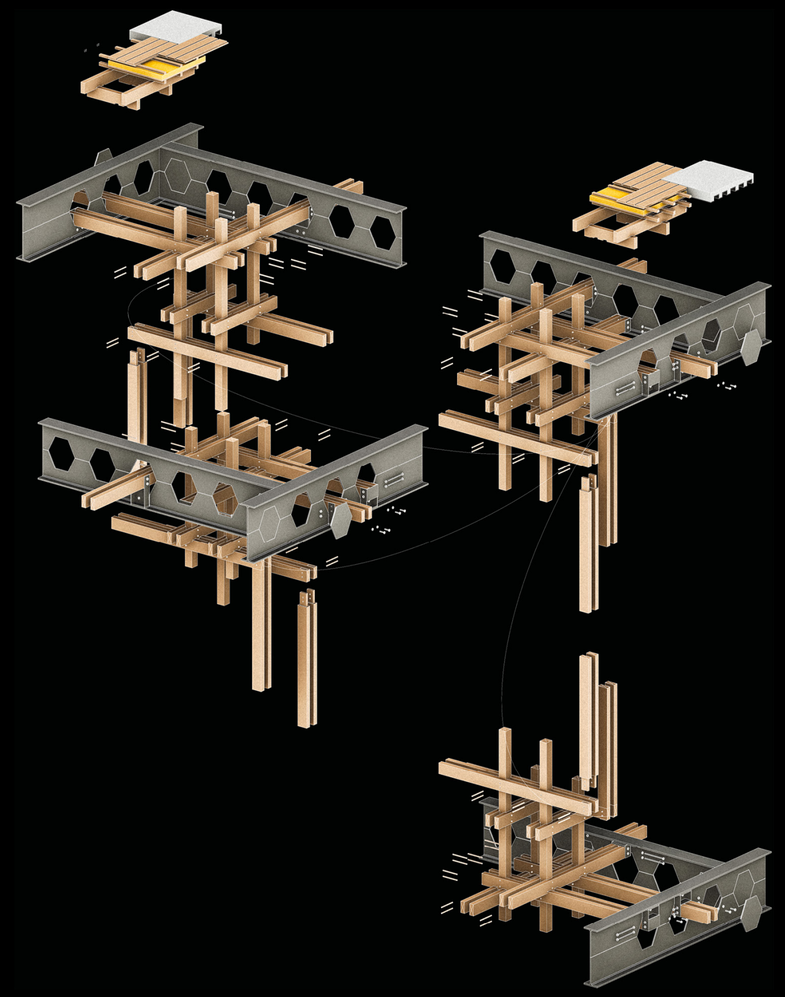


Fig. 133. 1:10 Structural exploration of timber and steel beam joinery.

Japanese vernacular knowledge
Carpentry 1:2 joinery study with Japanese wood-making tools

As the structural system has been only explored digitally as well with 3D printing, the real material, as well as the joinery in detail concerning its steps, preparation and application of fabrication, remained underexplored.

Therefore, Japanese carpentry tools, such as a set of Japanese chisels (Nomi), a Kanna (Plane) were acquired. The chisels are used for the precise cutting and refinement of timber joints, allowing controlled manual shaping of connection surfaces after the specific sections have been pre-cut with both a Japanese hand saw and a bandsaw machine.

The Kanna is applied for accurately smoothing and finishing of the timber surface, which however is not applied to the joinery itself but is tested on seperate timber elements.

While the joinery is explored through several iterations in the scale of 1:2, represented with spruce elements, the full-scale application would be considered as a spruce glulam (GLT) system. The repeated horizontal members are dimensioned at 80x180 mm, while the vertical elements are dimensioned in 140x140 mm with a minimum overlap within the joins each of 30 mm.

It is important to state that the glulam members are not intended to carry the 9.6m span individually through bending alone, as this would not be structurally applicable. Instead, the system functions through structural depth, load redistribution, axial forces in the layered field and stiffness created by the repititon of elements and joinery. This allows the system to be lighter, slimmer and more material efficient.

The choice of smaller spruce GLT members is also motivated through considerations during full-scale application and construction work, as the individual elements, despite being pre-cut, still need to be brought into the building and inserted into the openings of the castellated beams.

While the 1:2 detail provides insights into the structure and fabrication of the joinery, it also deepens an understanding on how the joint is still necessary to be adapted to work with its material properties and necessary tension forces during the assembly to work as a collective system. The joinery is therefore equipped with additional wooden pins to allow increased flexibility and tolerances regarding slight irregularities within the individual GLT members during on-site assembly.





Fig. 134. Japanese Carpentry Study in the Scale 1:2 at the TU Delft Timer workshop space. by using traditional Japanese carpentry tools.



Fig. 135. The used set of traditional Japanese carpentry tools.



Fig. 136. In Process photographs of the 1:2 explorative study of using wood and applying vernacular Japanese knowedge.

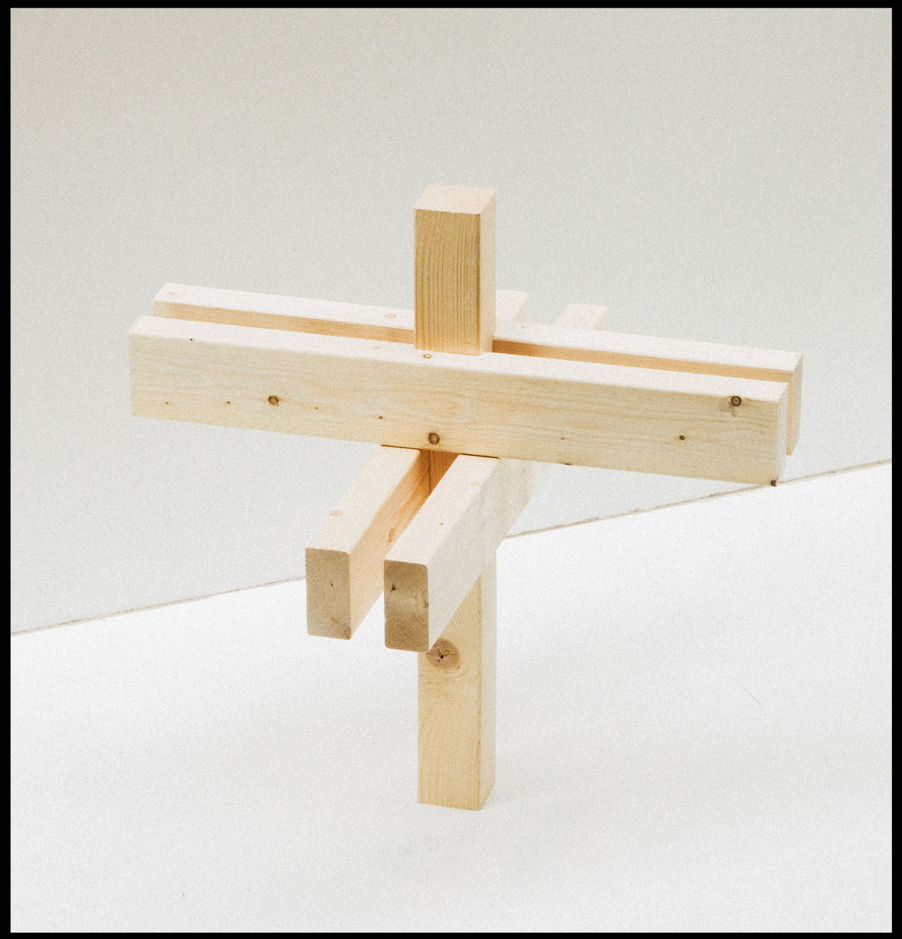


Fig. 137. Photograph of the first 1:2 prototype.

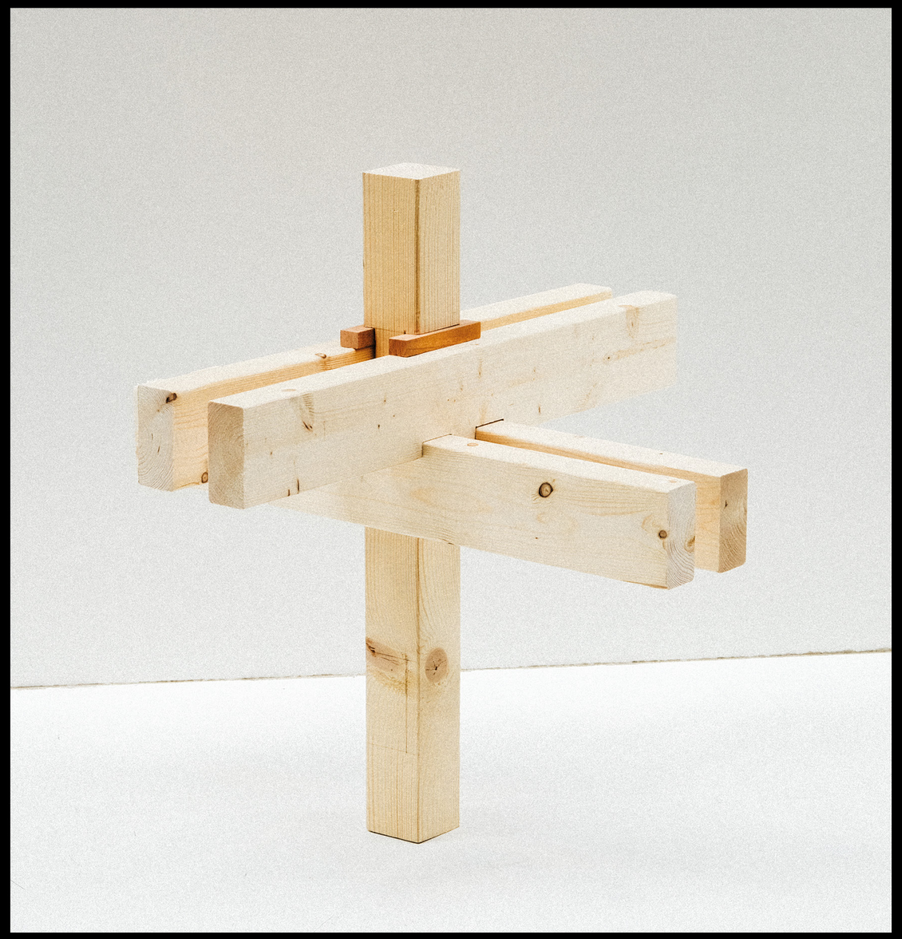


Fig. 138. Photograph of the second 1:2 prototype.

3.4 Exploring

PHYSIOLOGICAL HEAT STRESS MITIGATION

Fig. 139. Photograph of the 1:1000 physical model in process of the Salt-Study for assessing local airflow conditions.

Physical Model Salt-Study & Seasonal Wind Conditions

To reduce physiological heat stress within the Kasumigaseki building, the wind conditions around the Kasumigaseki district during the summer month of August were assessed. Findings suggest that during the early hours of the day until noon, a cooler breeze arrives from the inland mountain regions (approximately 22° North-West), while from the afternoon, the direction shifts, and a fresh sea breeze arrives from the Tokyo Bay area (approximately 22° South-East) (気象庁 Japan Meteorological Agency, n.d.).

Based on these findings, the identified fresh air streams are considered to become a primary environmental driver to supply the building with fresh air, which additionally is considered to reduce cooling loads and decrease energy demands as the incoming airflow is expected to remain comparably cooler than the surrounding urban air mass. Despite the actual cooling capacity needs to be regarded critically, the integration of these airflow conditions into the retrofit strategy contextualises the intervention within localised environmental and climatic conditions.

Furthermore, this approach is considered to reinterpret the Japanese vernacular architectural knowledge of positioning the entrance and windows according to the surrounding environmental conditions to catch natural airflow and to guide it into the building, which functions as a passive measure to reduce internal thermal loads during extensive summer periods.

Mirroring the methods of the architects of the Kasumigaseki building who used a physical model to assess airflow conditions within the surrounding urban context, the earlier applied 1:1000 physical site model representing the surrounding 1km2 study area is used to assess how the wind arrives specifically at the Kasumigaseki building and how fresh air enters the ground floor level.

This assessment is conducted by applying fine grains of salt onto the physical model, and with a fan blowing into the earlier identified wind directions, the salt is gradually displaced.

The study offers insights into the specific areas in which the salt accumulates within the ground floor of the building, allowing the identification of zones where fresh air intake can be integrated into the retrofit strategy.

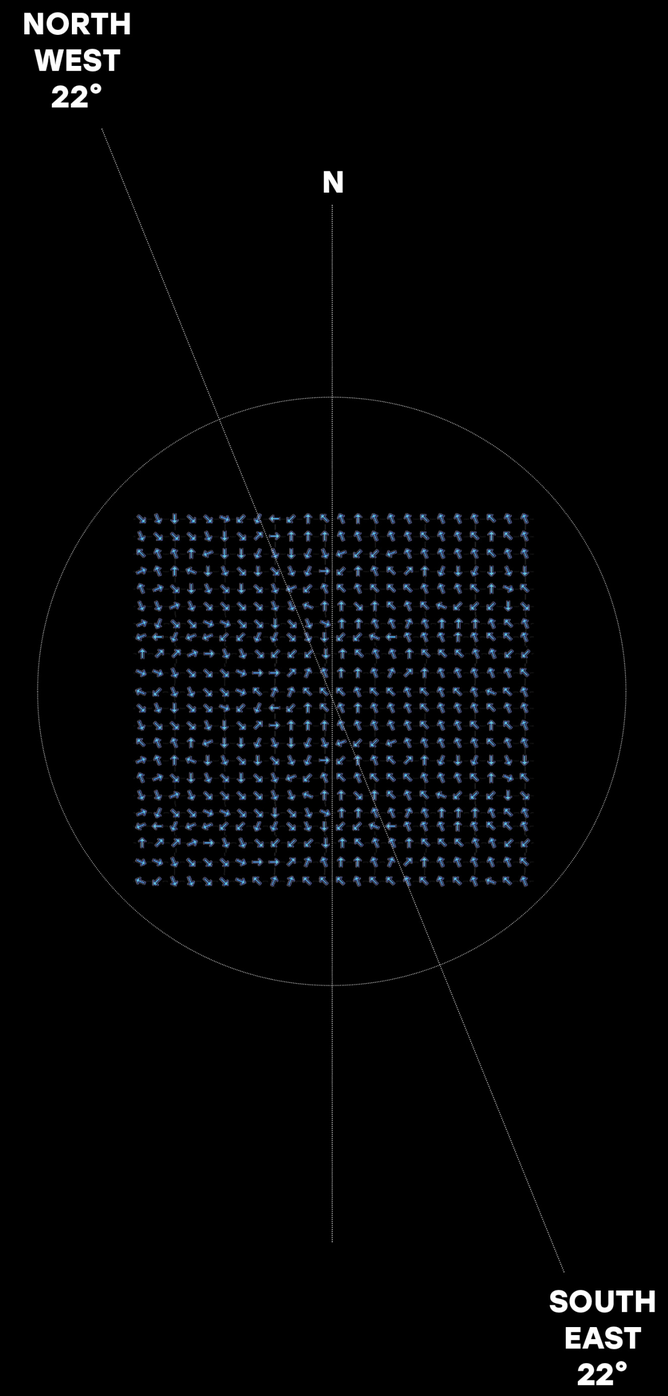


Fig. 140. Diagram of local airflow Assessment in the Kasumigaseki area during August 2025.

FROM NORTH WEST 22°
KASUMIGASEKI DISTRICT AIRFLOW

MORNING - NOON



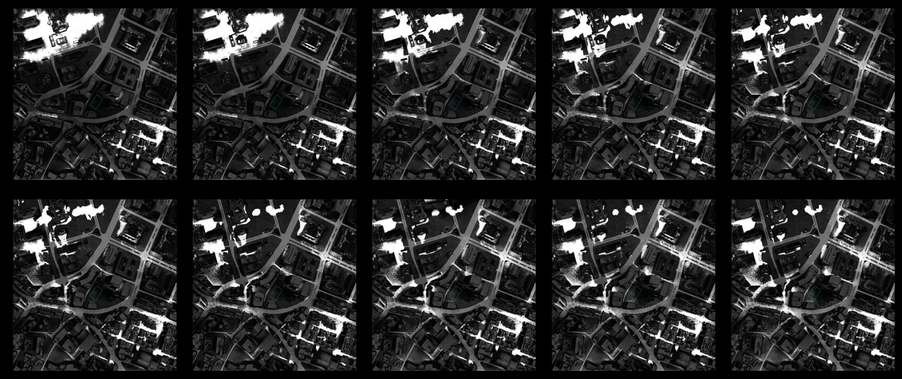


Fig. 141. Photographs of the Salt-Study Airflow Assessment for the Morning Case.

FROM SOUTH EAST 22°
KASUMIGASEKI DISTRICT AIRFLOW

NOON - EVENING



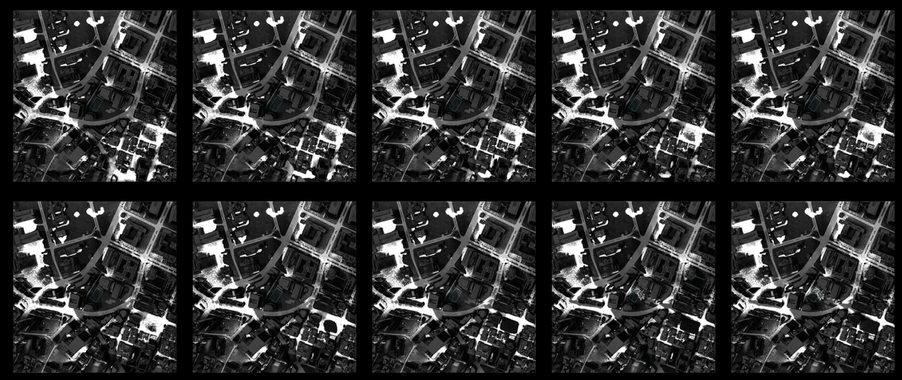


Fig. 142. Photographs of the Salt-Study Airflow Assessment for the Afternoon Case.

Solar Exposure & Adaptive Facade Strategy

As sunlight is a primary factor in terms of physiolocal heat exposure related to thermal perception and comfort, the following analysis focuses on the local sunlight properties of the Kasumigaseki district in Tokyo as well as the building's facade mean-exposure within a 5-month summer and winter period, which is ultimately meant to inform the planning and design of the facade retrofit interventions.

Summer solstice peak altitude = around 78°

Winter solstice peak altitude = around 31°

Regarding the summer and winter solstice peak altitude, a strong seasonal variation of sunlight conditions can be assessed. While in summer, the solar altitude is characterised by 78°, relatively high, the solar altitude during the winter period decreases to around 31°.

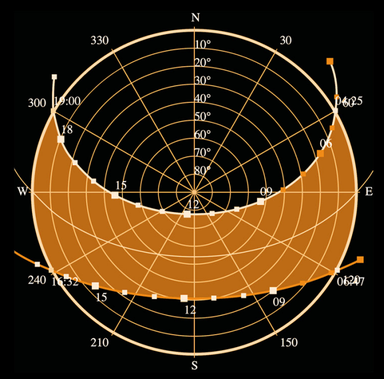
These conditions emphasize on the necessity of horizontal outdoor shading during the sommer months, which resembles a vertical application and reinterpretation of the Japanese engawa typology, as an added wooden veranda functioning as a thermal buffer zone while preventing extensive solar gains to enter the interior space.

While an accessible vertical engawa concept has the potential to function also as an added restorative space for social interaction and relaxation, the application height is considered to be limited to 60m, as regulatory complexity increases significantly beyond this threshold regarding fire safety, structure, evacuation, wind loads and accessible exterior facade systems (Building Standards Act, n.d.).

These regulatory conditions turn the accessible engawa concept beyond 60m into a non-accessible solar shading facade, which emphasises a facade intervention operating heterogeneously compared to a single facade system enforcing monotony.

Furthermore, as in the winter period the solar altitude is relatively low, areas with increased sunlight exposure are expected to be adapted with extended floor-level glazing through which the increased facade openings allow for maximising passive solar gains within the interior spaces to reduce heating emissions and extensive energy consumption during the winter months.

As the solar exposure study is conducted for the summer months (May-September) and winter months (October-February), the selectively implemented facade system in relation to differences in solar exposure becomes crucial. Based on such variance, window openings are increased in areas where the winter solar exposure is higher to maximise thermal gains, while horizontal shading and the engawa concept are selectively applied where both the increased glazing surface and a higher summer solar exposure overlay.

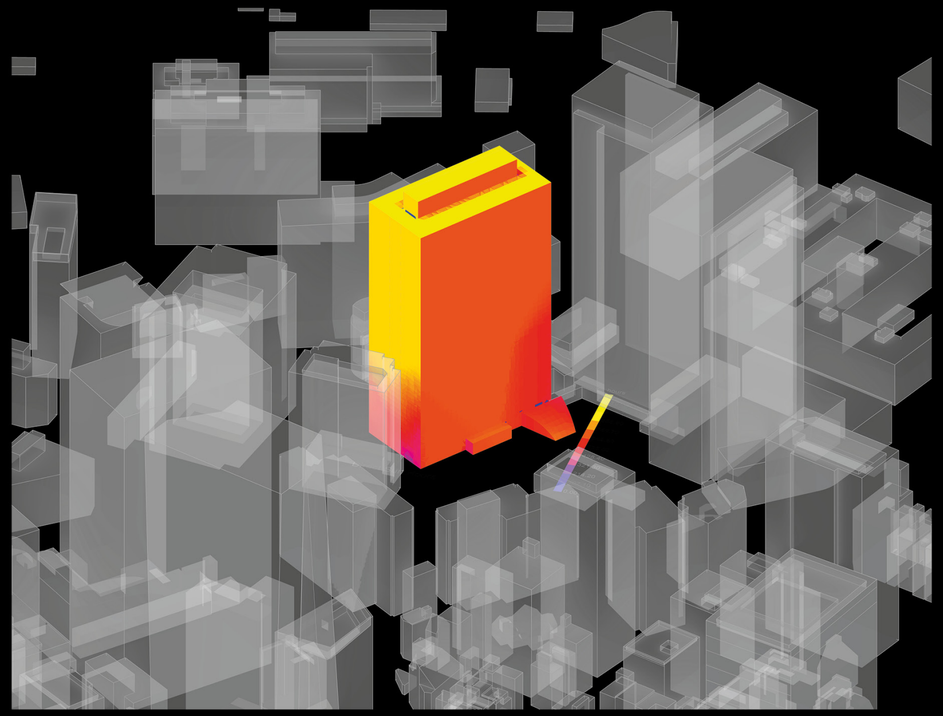


Sun-path diagram, Kasumigaseki district, Tokyo, Japan

Fig. 143. Sunpath Diagram for the Kasumigaseki Distric. Adapted from Gaisma (n.d.).

Solar exposure study
May-September

Obersevation time 9:00-15:00



Axonometry overview

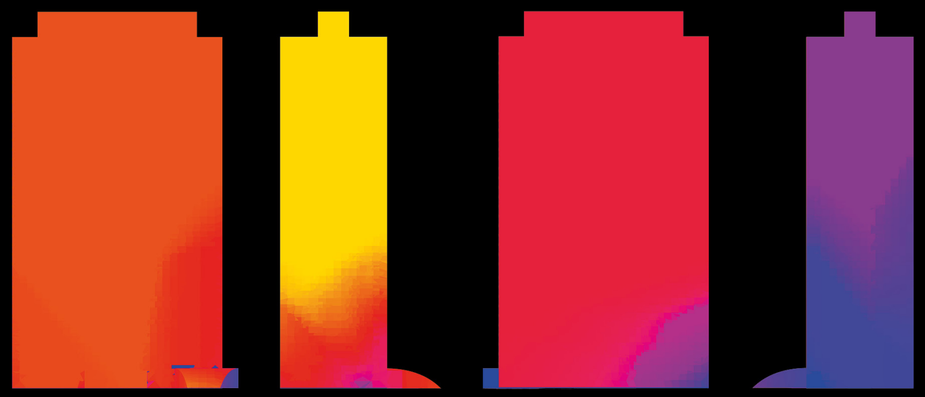
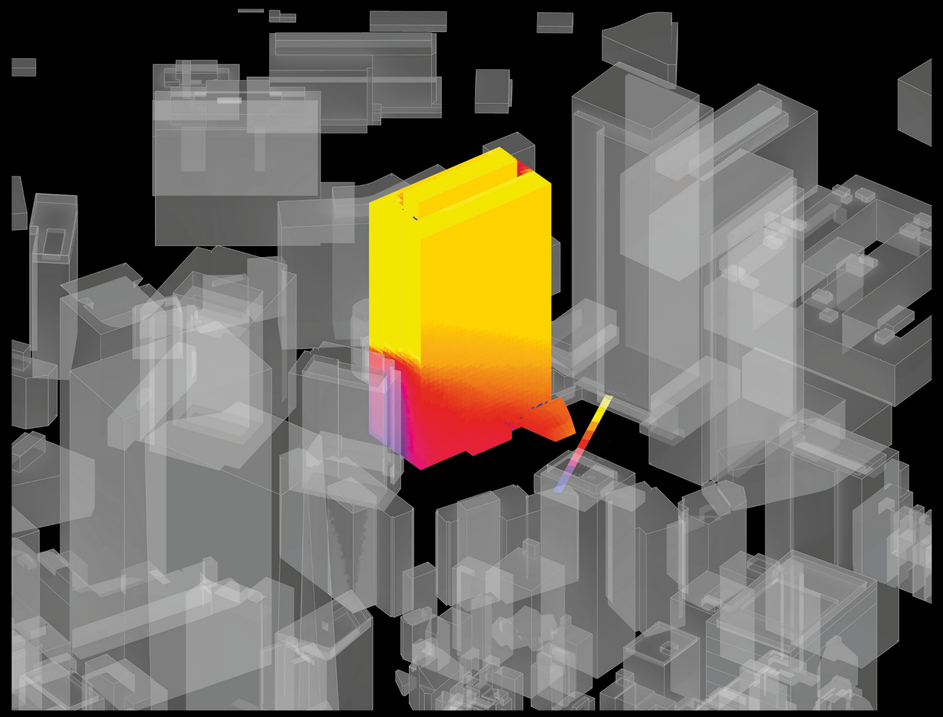


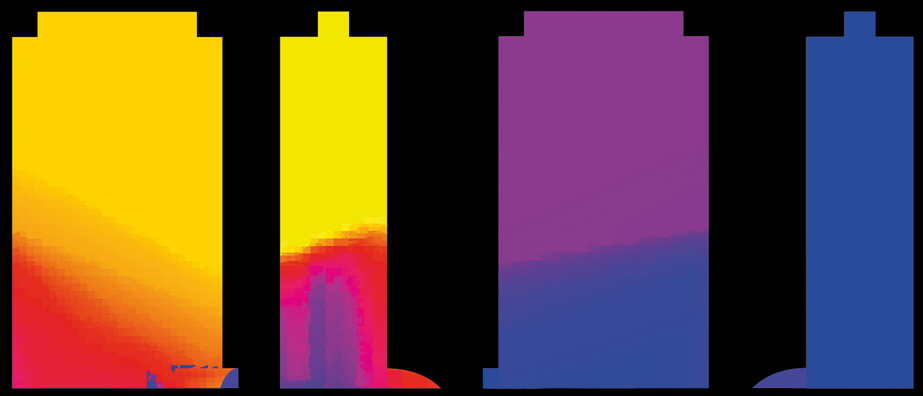
Fig. 144. Solar exposure analysis for the Kasumigaseki building for the Summer Case via Grashopper and Rhinoceros 3D 8.

Solar exposure study
October-February

Obersevation time 9:00-15:00



Axonometry overview



south-east south-west north-west north-east

Fig. 145. Solar exposure analysis for the Kasumigaseki building for the Winter Case via Grashopper and Rhinoceros 3D 8.

Part 04

FINAL DESIGN, Conclusions & Integrations

4.1 Final Design

HEALTH-ENHANCING PROGRAM & PSYCHOLOGICAL RESEARCH INTEGRATION

Health-Enhancing program & Eye-tracking research integration

The developing design of the Kasumigaseki building retrofit project resembles preceding studies on new integrations of health-enhancing programs and spatial strategies informed by the earlier conducted eye-tracking research, combining both desk research and Japanese vernacular spatial knowledge, while promoting relaxation, fascination, concentration, productivity, collaborative work, as well as perceived thermally cooling effects for psychological heat stress mitigation.

The interventions are implemented on the one hand through concise extractions of previously located core sections while on the other hand, structurally integrated through explorations of Japanese carpentry.

Located within two three-floor clusters and one six-floor cluster their size and density of integrations reintepret the urban identity of the Kasumigaseki district's streetscape with its divers spatial moments and different scales of typologies ranging from small shrines, pocket gardens, the Yokocho (small side street with dense shops and cafes), the Shotengai (bigger street with shops an restaurants), as well as larger shrines and temples with green spaces and sports facilities.

The integration of eye-tracking research and health-enhancing programs follows a set of rules throughout all clusters. First, the collaborative work and relaxation areas are located next to the core extraction for enhanced spatial openness. Their vertical distribution is alternated and changes from floor to floor within restorative areas and meeting areas to avoid a rigid separation of program. This also evolves in a horizontal shift, turning the central substraction of the core, the Ma, into a transitional stroll garden in between relaxation and collaboration. The opposite side of the office floorplan is reserved for the areas of concentration, while the central zone accommodates the health-enhancing programs. These are as well slightly shifted within the central area to provide different spatial experiences within the working areas. The accumulation of more open programs in the middle of the floorplan also allows a higher frequency in the exchange of people and occupants from other floors while both the concentration areas, relaxation zones, etc. remain undisturbed.

As crowdedness also has psychological tendencies to make oneself feel hotter, as a finding of the Tokyo streetscape eye-tracking analysis, the central vertical circulation is distributed through smaller spiral staircases within the working areas to, on the one hand, allow occupants to move more easily between work areas and different psychological zones, while the central circulation remains more active in coherence with its programmatic integrations. Additionally, psychological aids, such as wayfinding signs, are intended to be added throughout the building to enhance relaxation and potentially reduce physiological thermal discomfort.

While the clusters are intended to host both psychological, physiological and programmatic strategies, the rest of the office floors are mainly considered to be retrofitted through physiological interventions, which will be discussed in the following.

The physiological passive cooling strategies are, however identical, as they distribute vertically through the whole building, while the new and more complex spatial properties demand the distribution of the existing duct infrastructure, which is nevertheless regarded, as for instance the timber integrations always allow space for reorienting ducts and pipings within the steel beams.

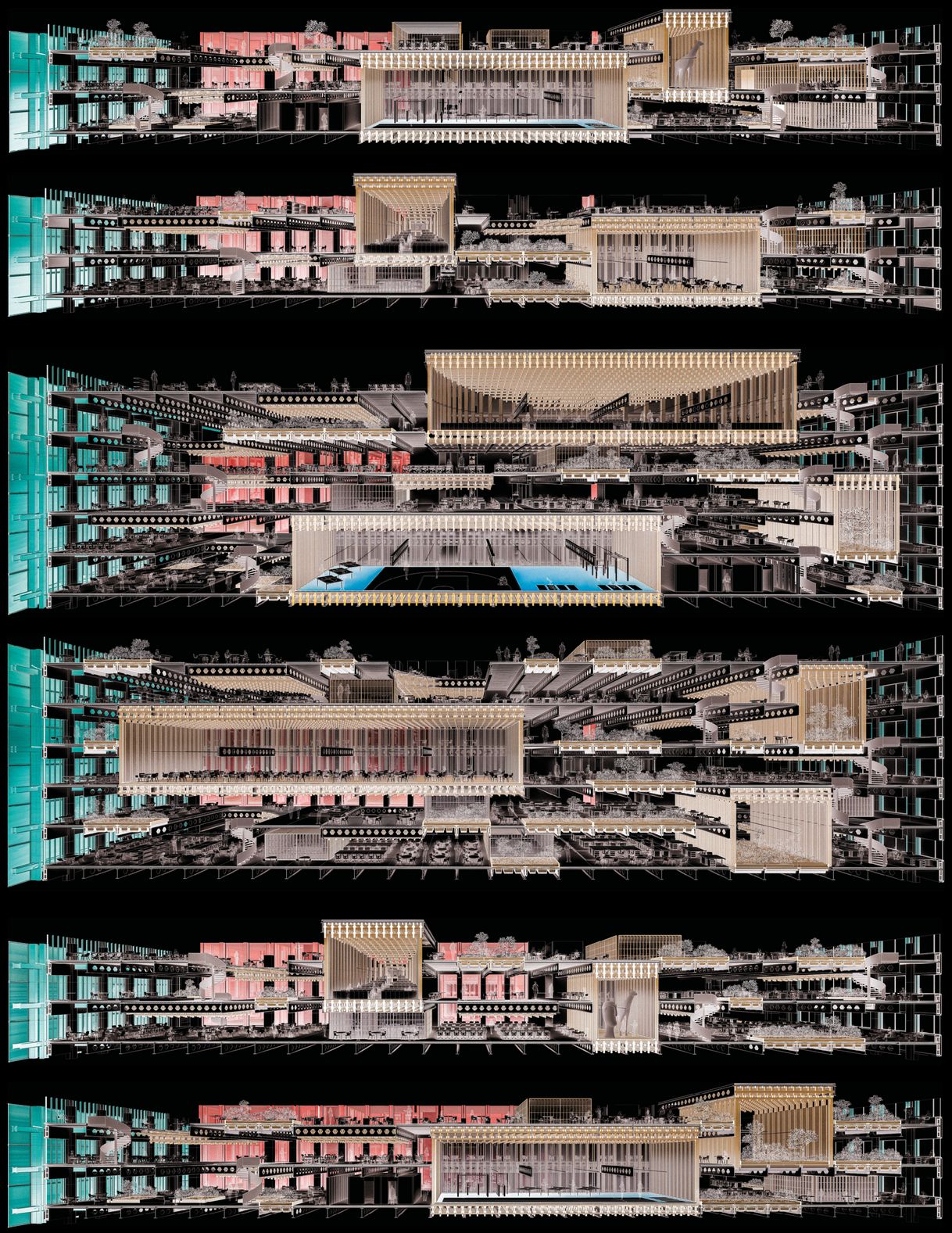
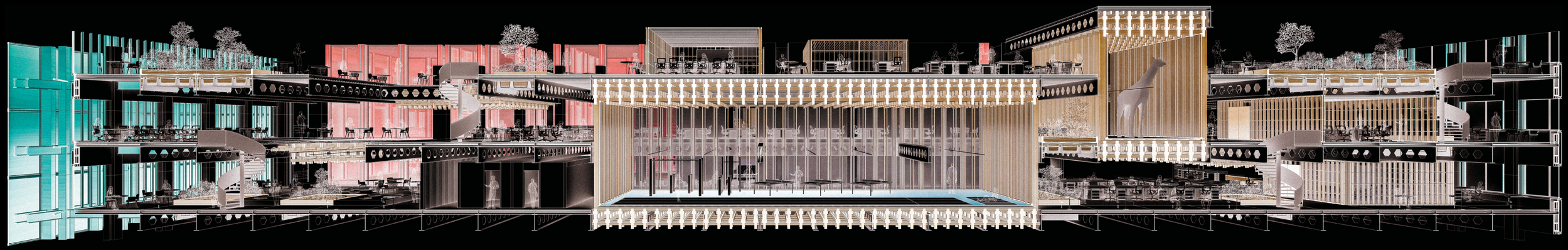
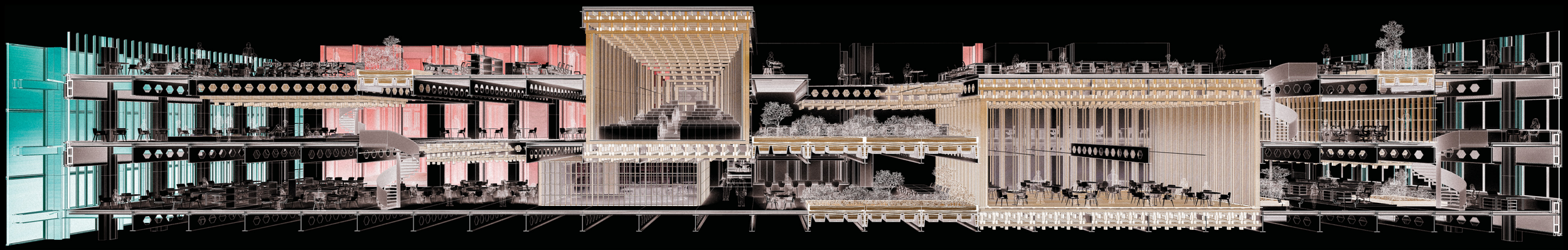


Fig. 146. Perspective Sections of the final design implementations within the 3 Clusters. One six-floor and two three floor clusters.

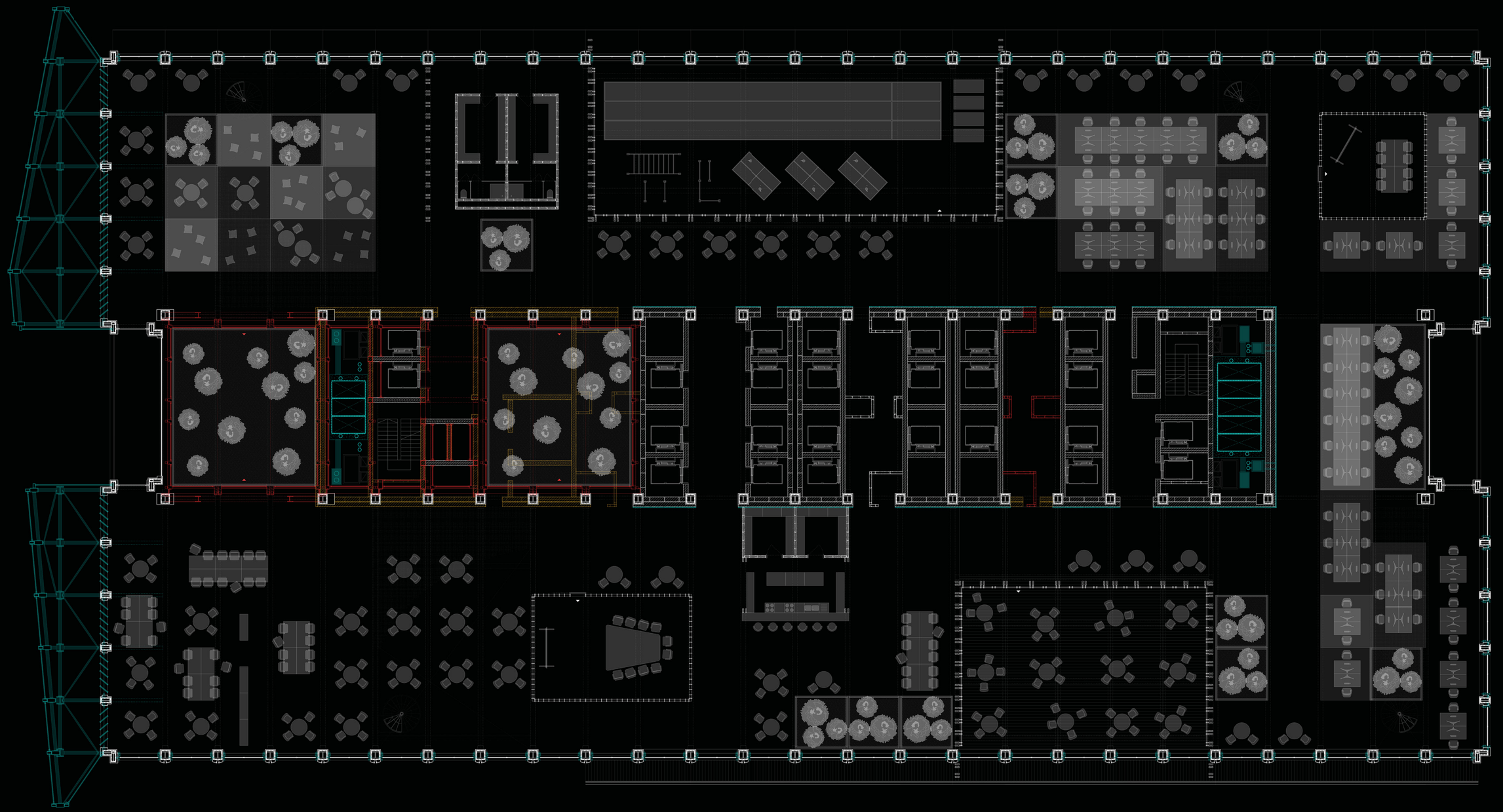


1:50 YOKOCHO (横丁) 3 FLOOR CLUSTER 14.-16. FLOOR NORTH-WEST



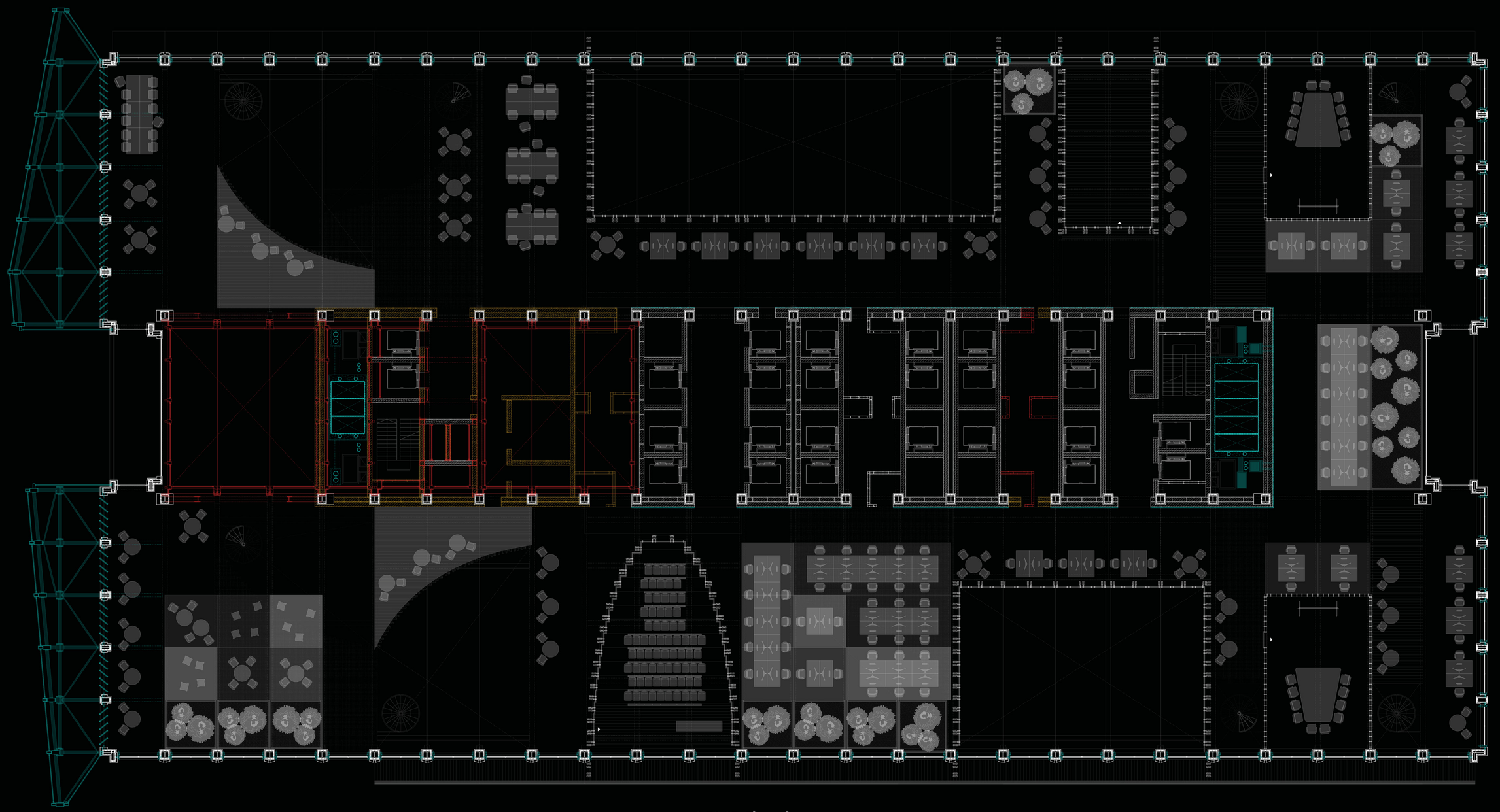
1:50 YOKOCHO (横丁) 3 FLOOR CLUSTER 14.-16. FLOOR SOUTH-EAST

Fig. 147. Perspective Sections Overview of the first 3-floor cluster.



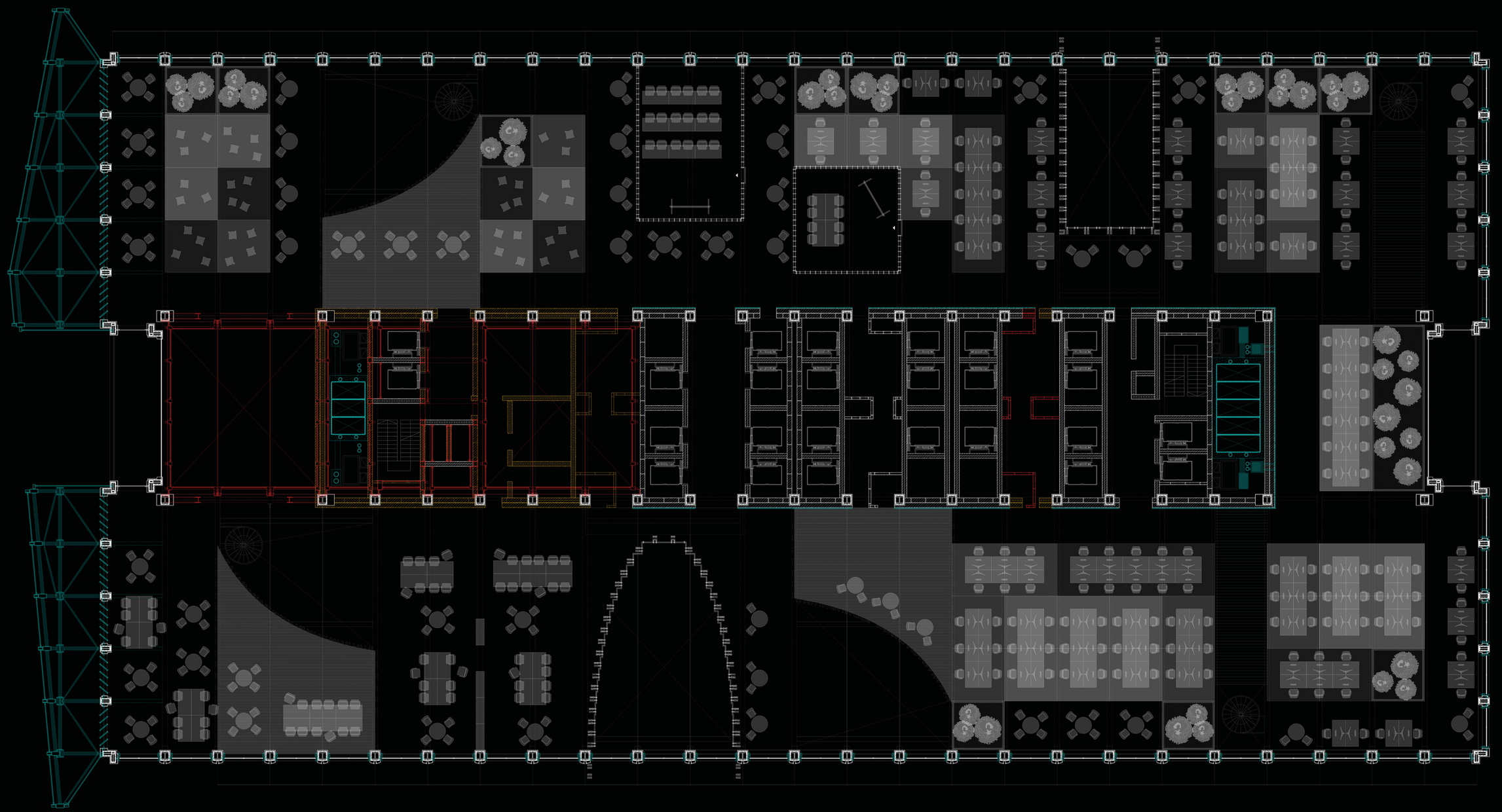
1:50 14. Floorplan

Fig. 148. 14. Floorplan 1:50 (displayed in 1:200)



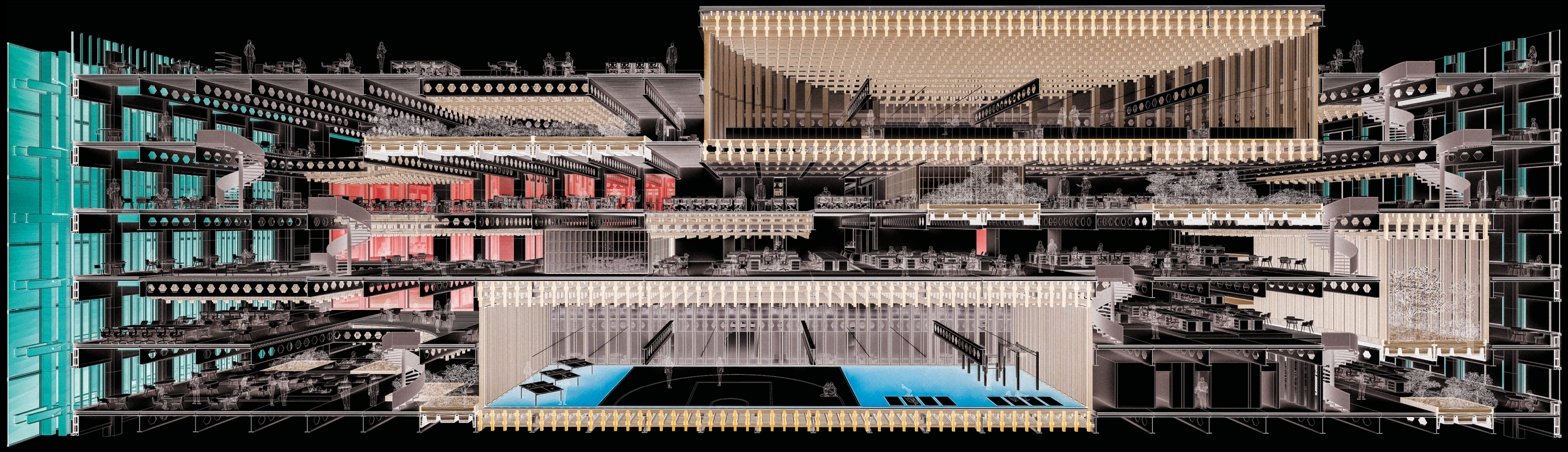
1:50 15. Floorplan

Fig. 149. 15. Floorplan 1:50 (displayed in 1:200)

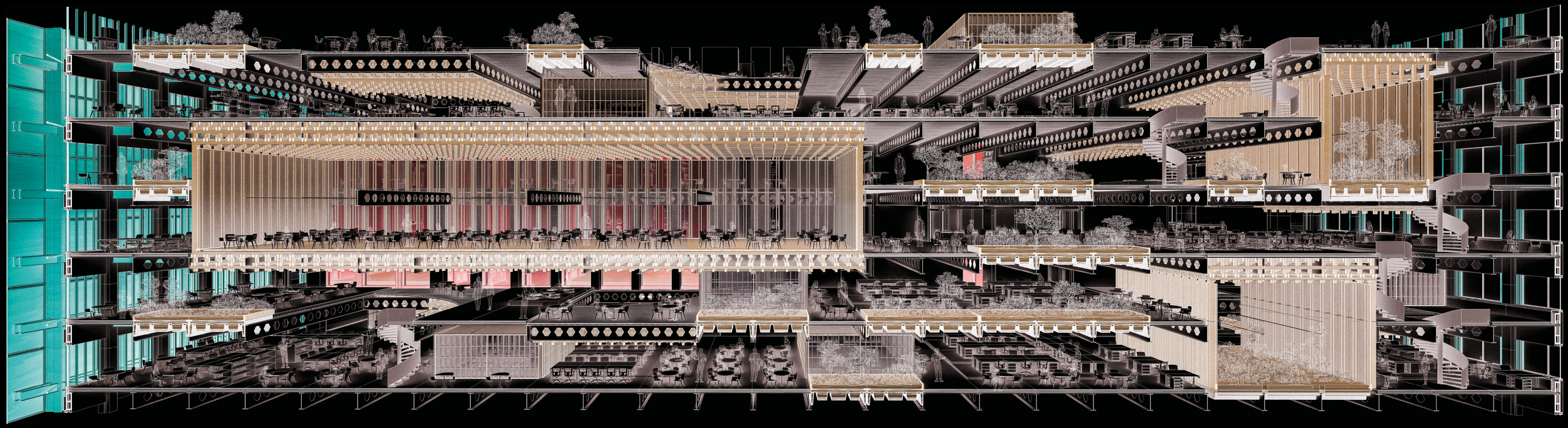


1:50 16. Floorplan

Fig. 150. 16. Floorplan 1:50 (displayed in 1:200)

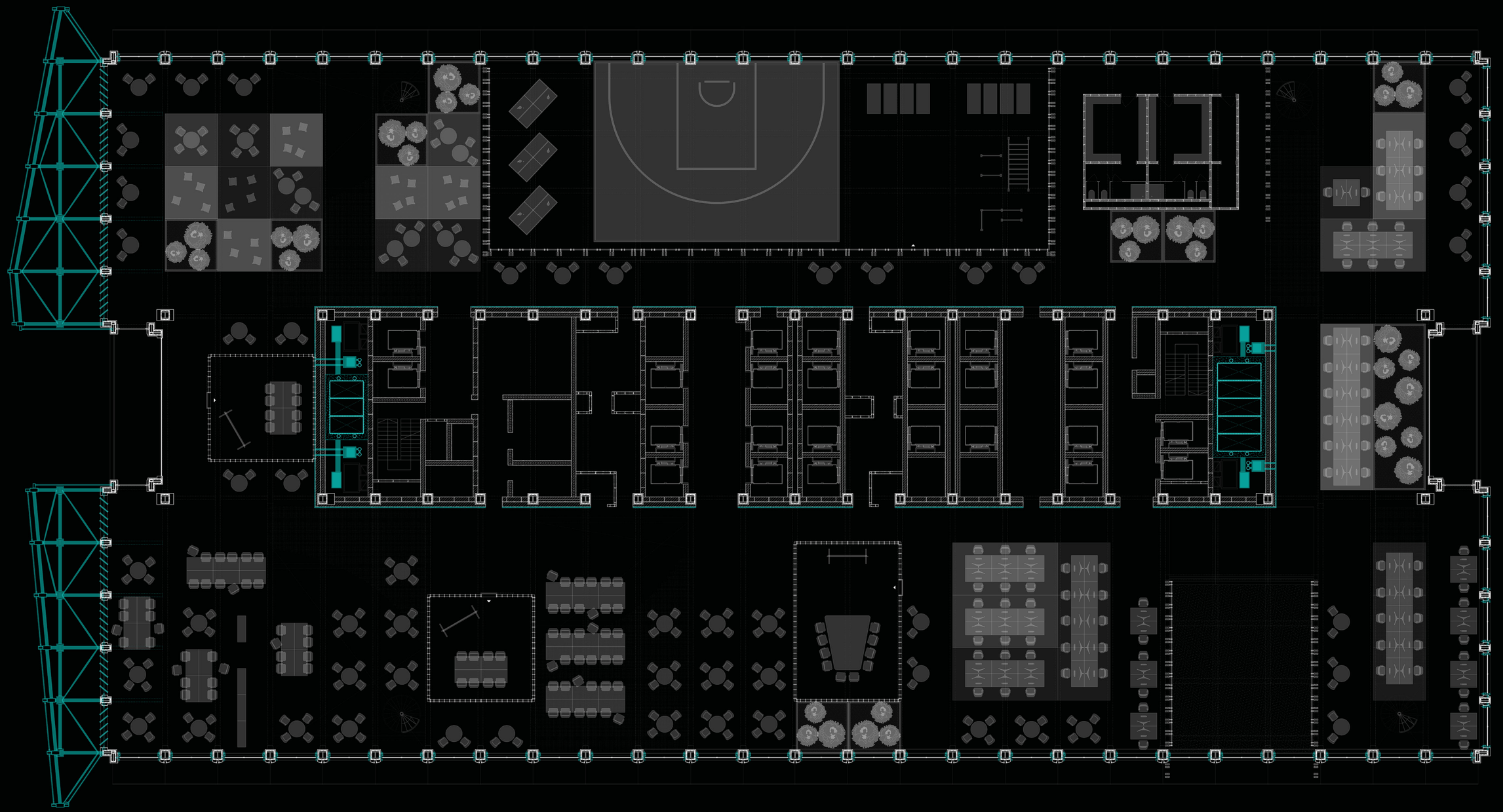


1:50 SHOTENGAI (商店街) 6 FLOOR CLUSTER 21.-26. FLOOR NORTH-WEST



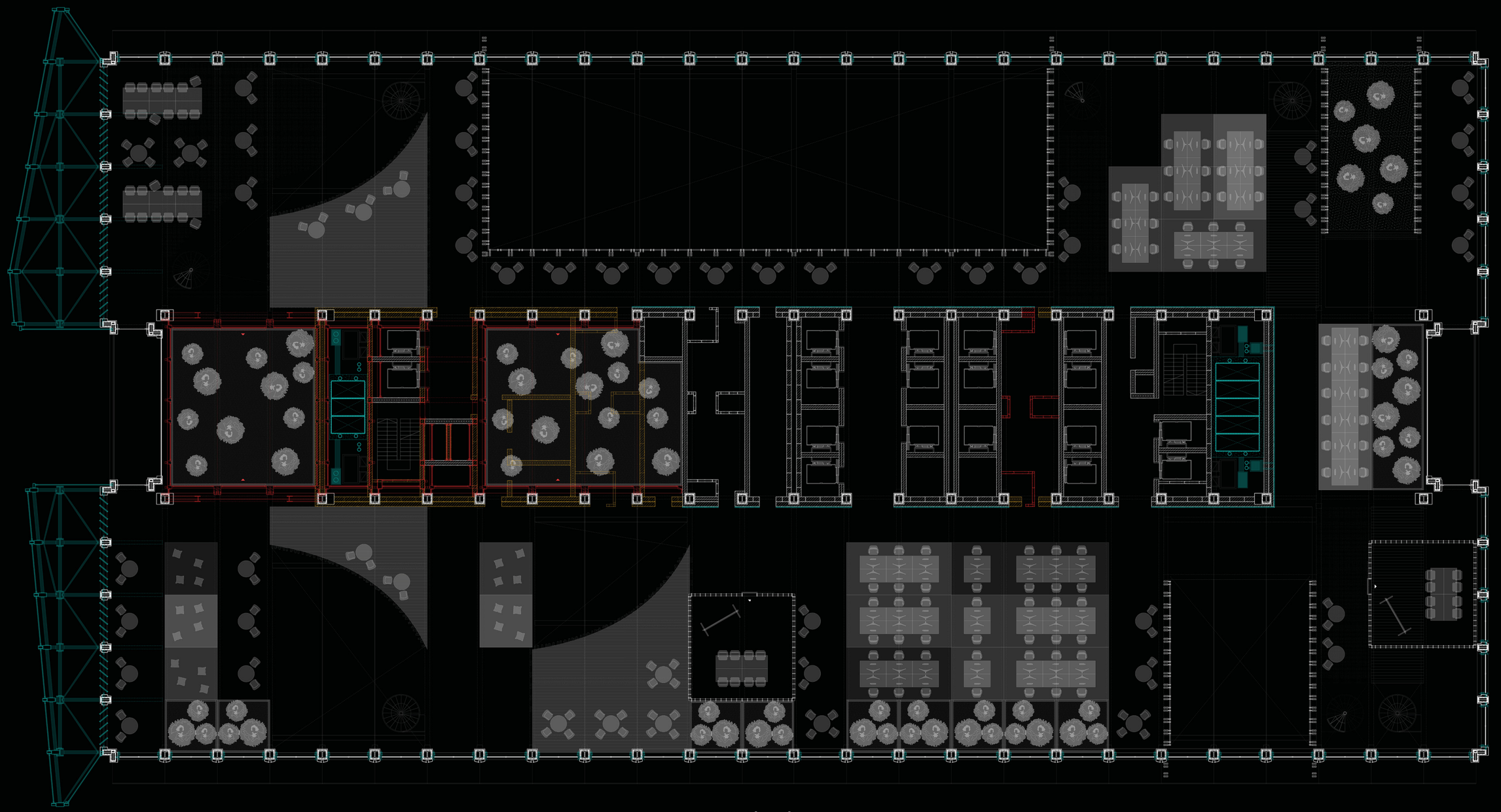
1:50 SHOTENGAI (商店街) 6 FLOOR CLUSTER 21.-26. FLOOR SOUTH-EAST

Fig. 151. Perspective Sections Overview of the only 6-floor cluster.



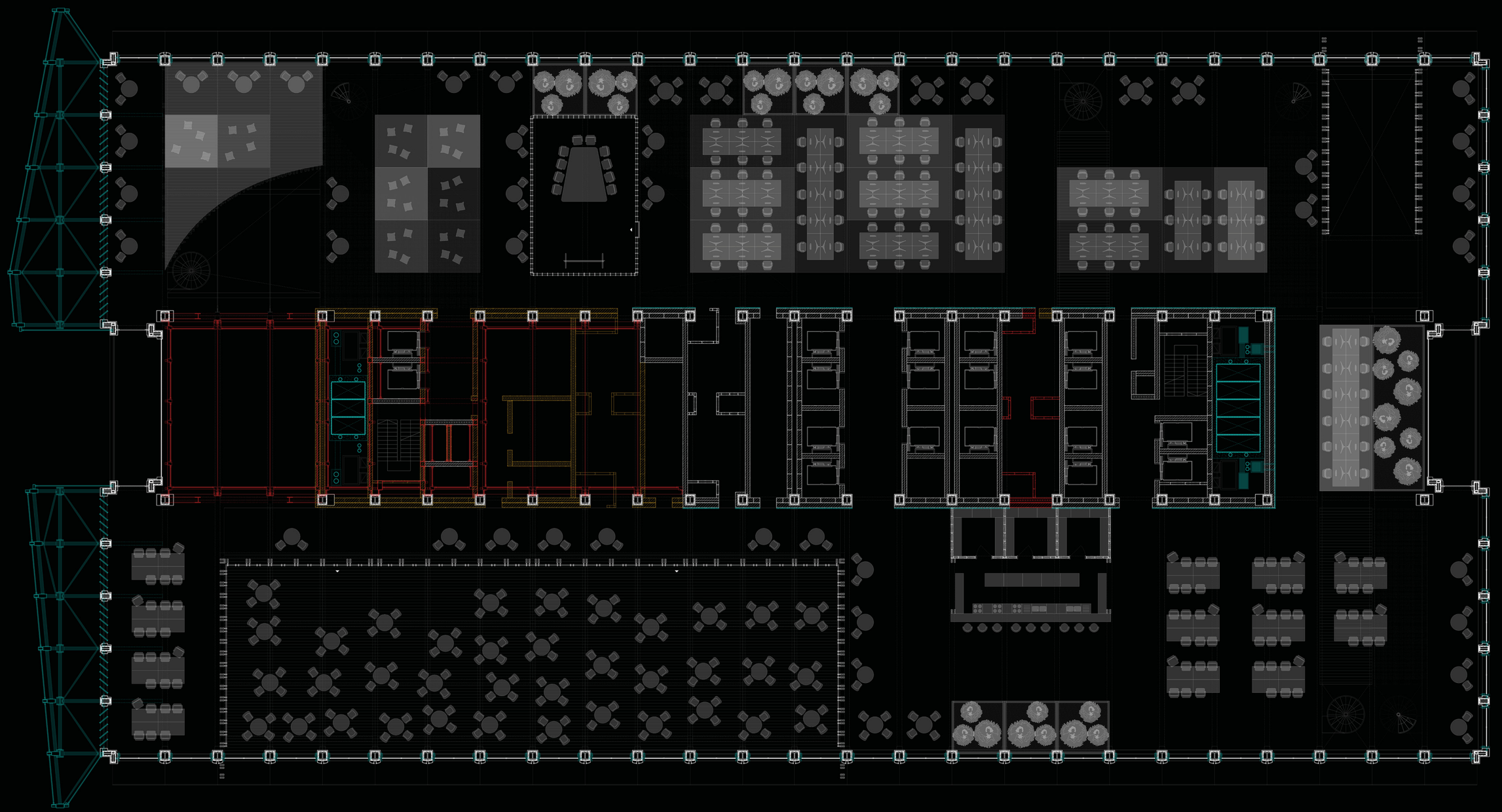
1:50 21. Floorplan

Fig. 152. 21.Floorplan 1:50 (displayed in 1:200)



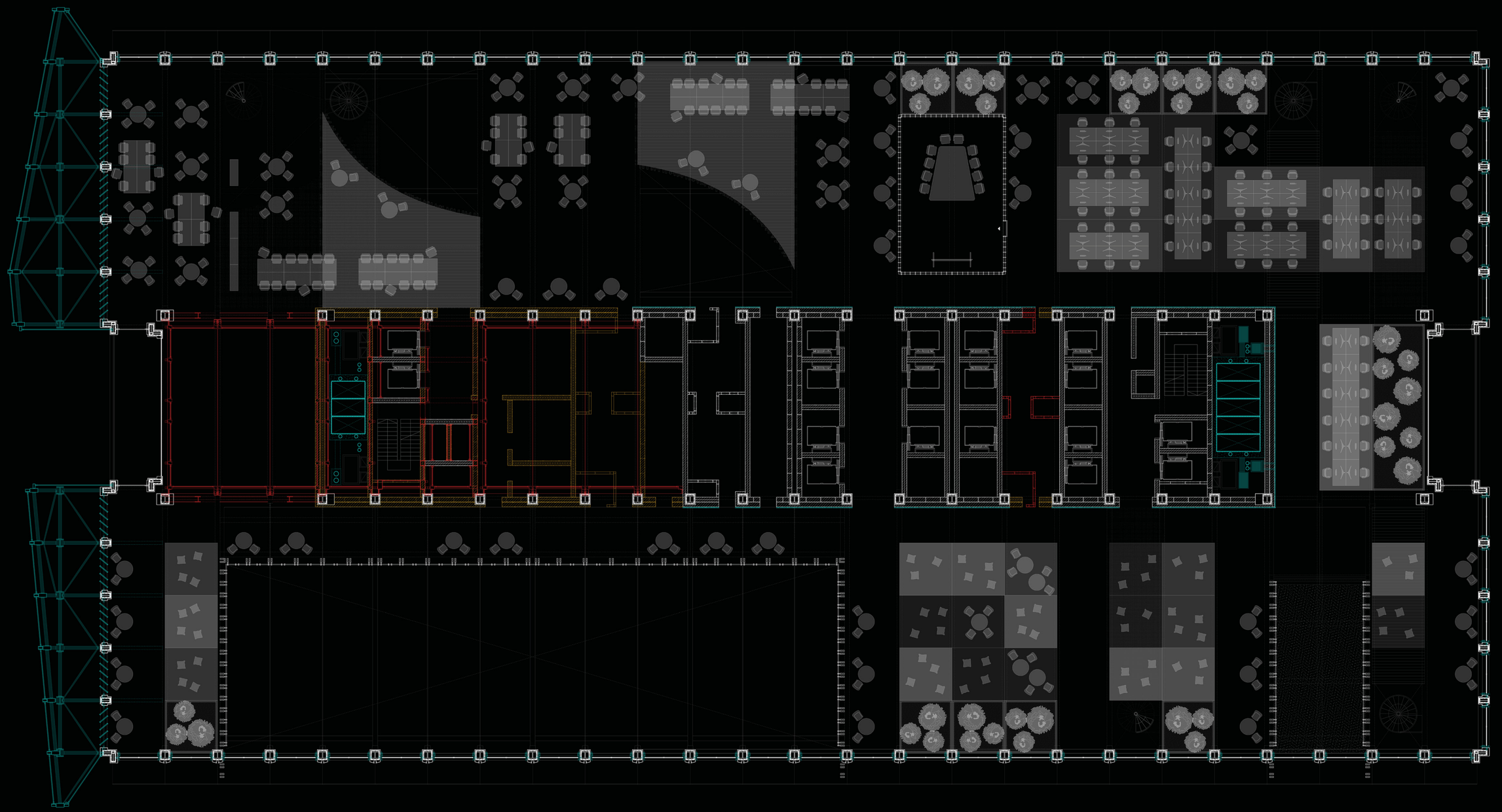
1:50 22. Floorplan

Fig. 153. 22. Floorplan 1:50 (displayed in 1:200)



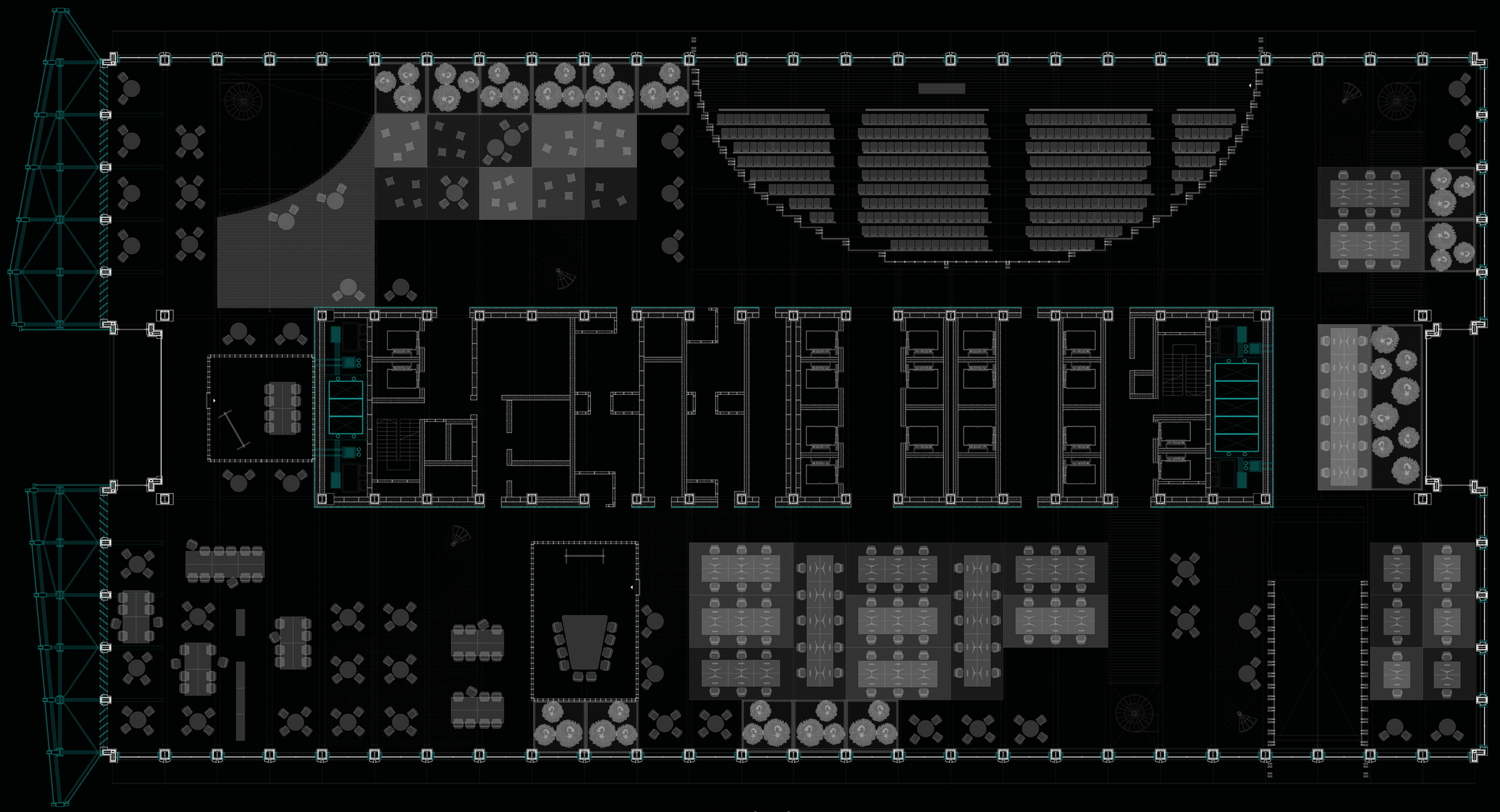
1:50 23. Floorplan

Fig. 154. 23. Floorplan 1:50 (displayed in 1:200)



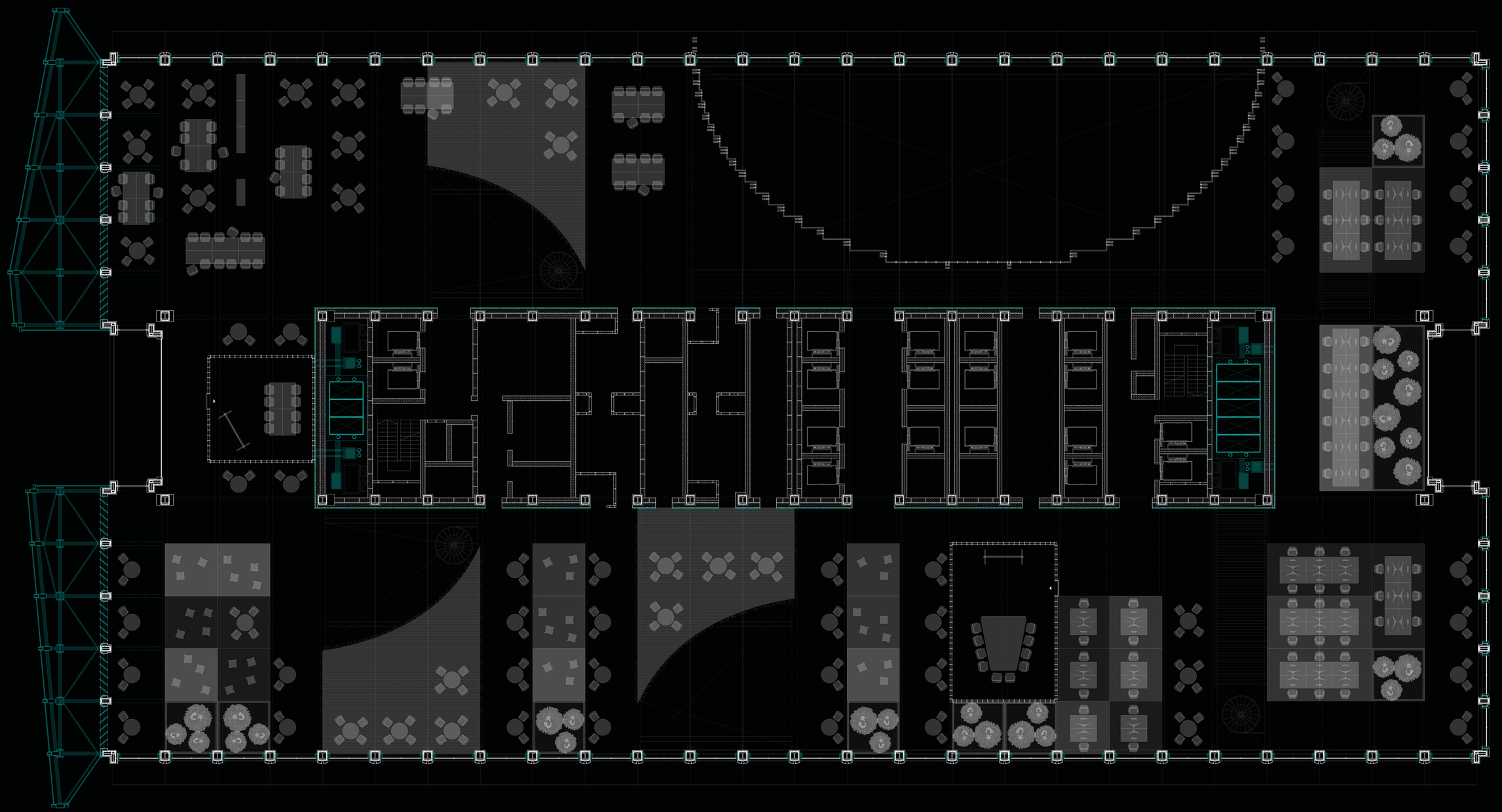
1:50 24. Floorplan

Fig. 155. 24. Floorplan 1:50 (displayed in 1:200)



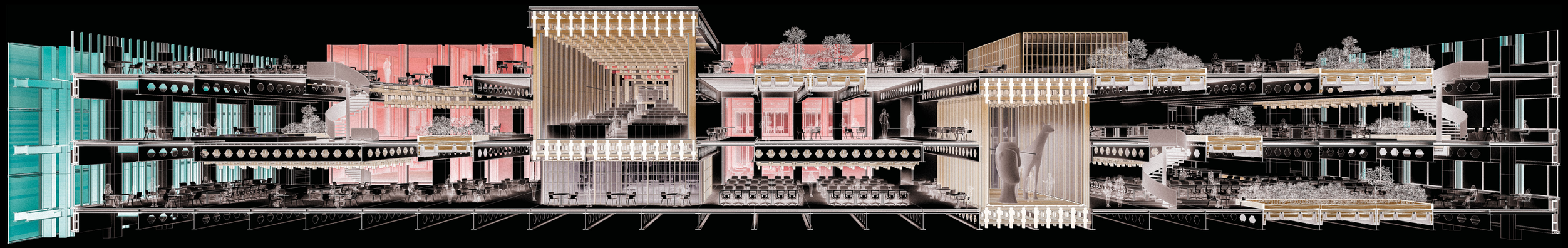
1:50 25. Floorplan

Fig. 156. 25.Floorplan 1:50 (displayed in 1:200)

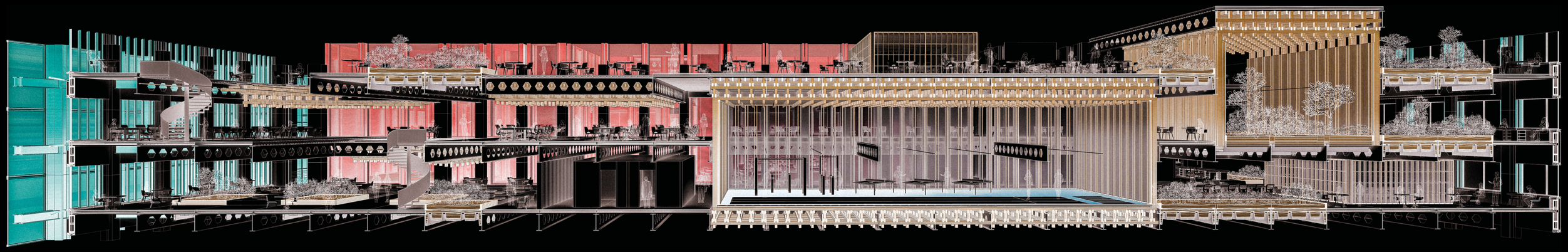


1:50 26. Floorplan

Fig. 157. 26.Floorplan 1:50 (displayed in 1:200)

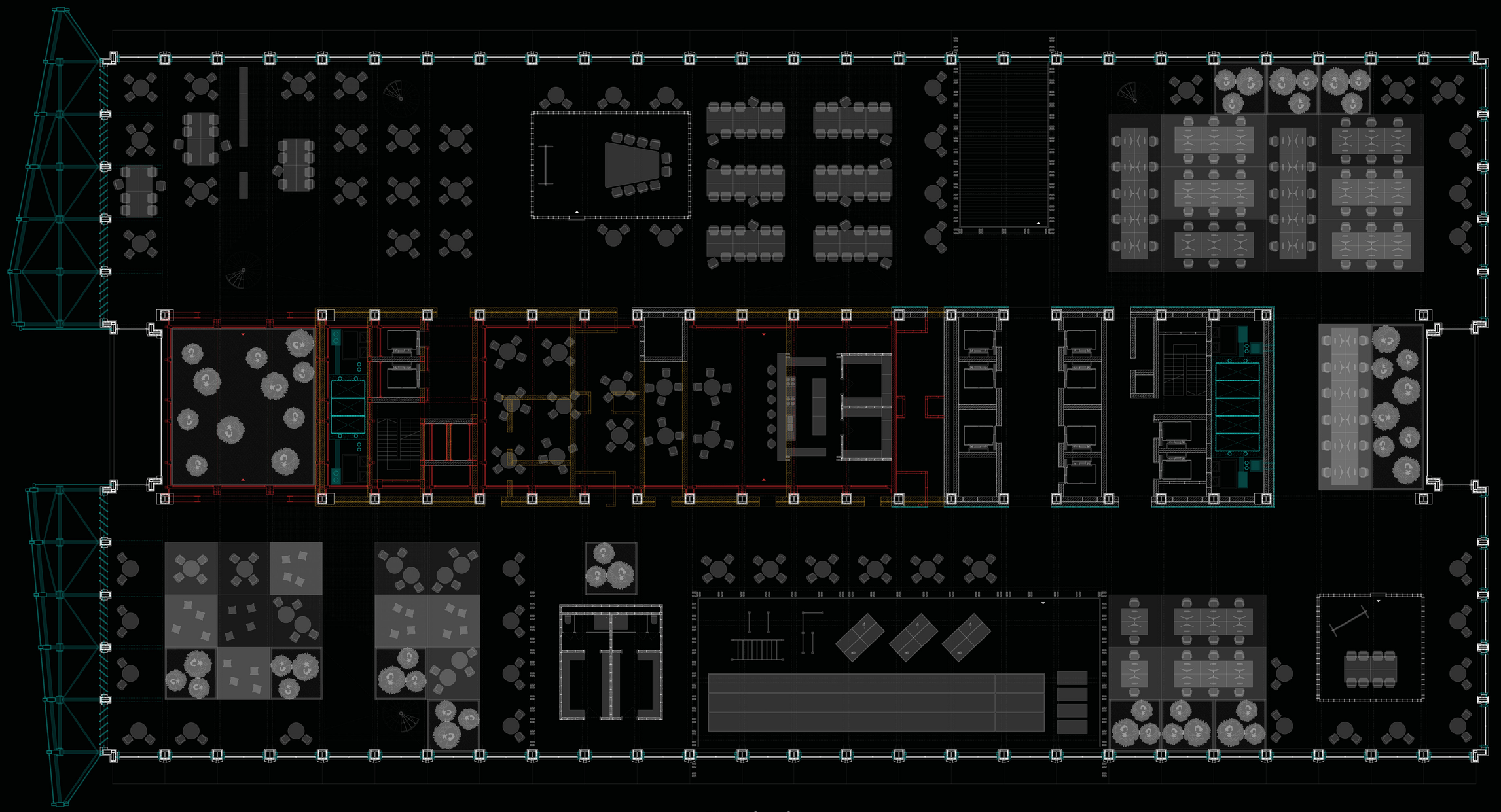


1:50 YOKOCHO (横丁) 3 FLOOR CLUSTER 29.-31. FLOOR NORTH-WEST



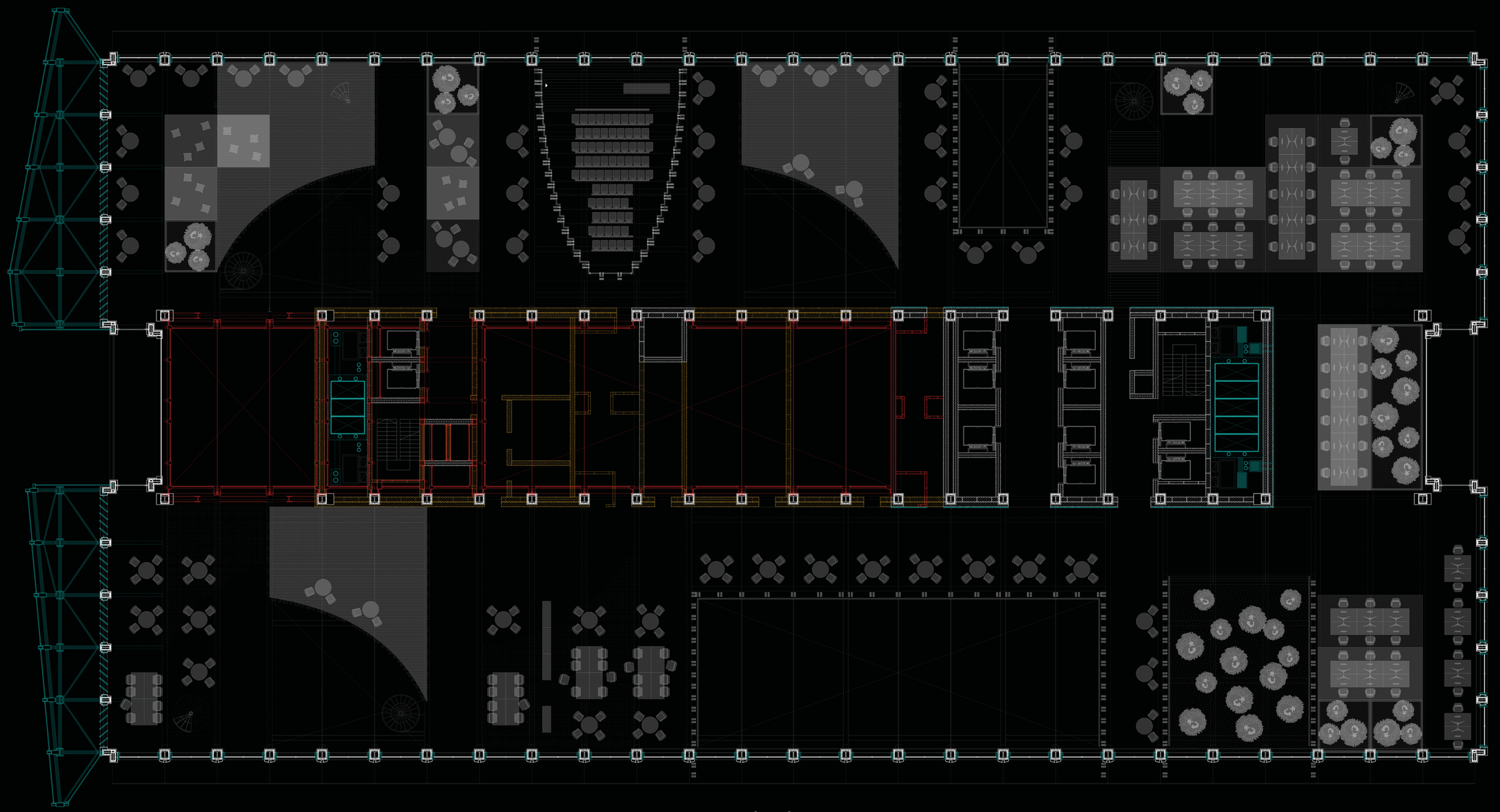
1:50 YOKOCHO (横丁) 3 FLOOR CLUSTER 29.-31. FLOOR SOUTH-EAST

Fig. 158. Perspective Sections Overview of the second 3-floor cluster.



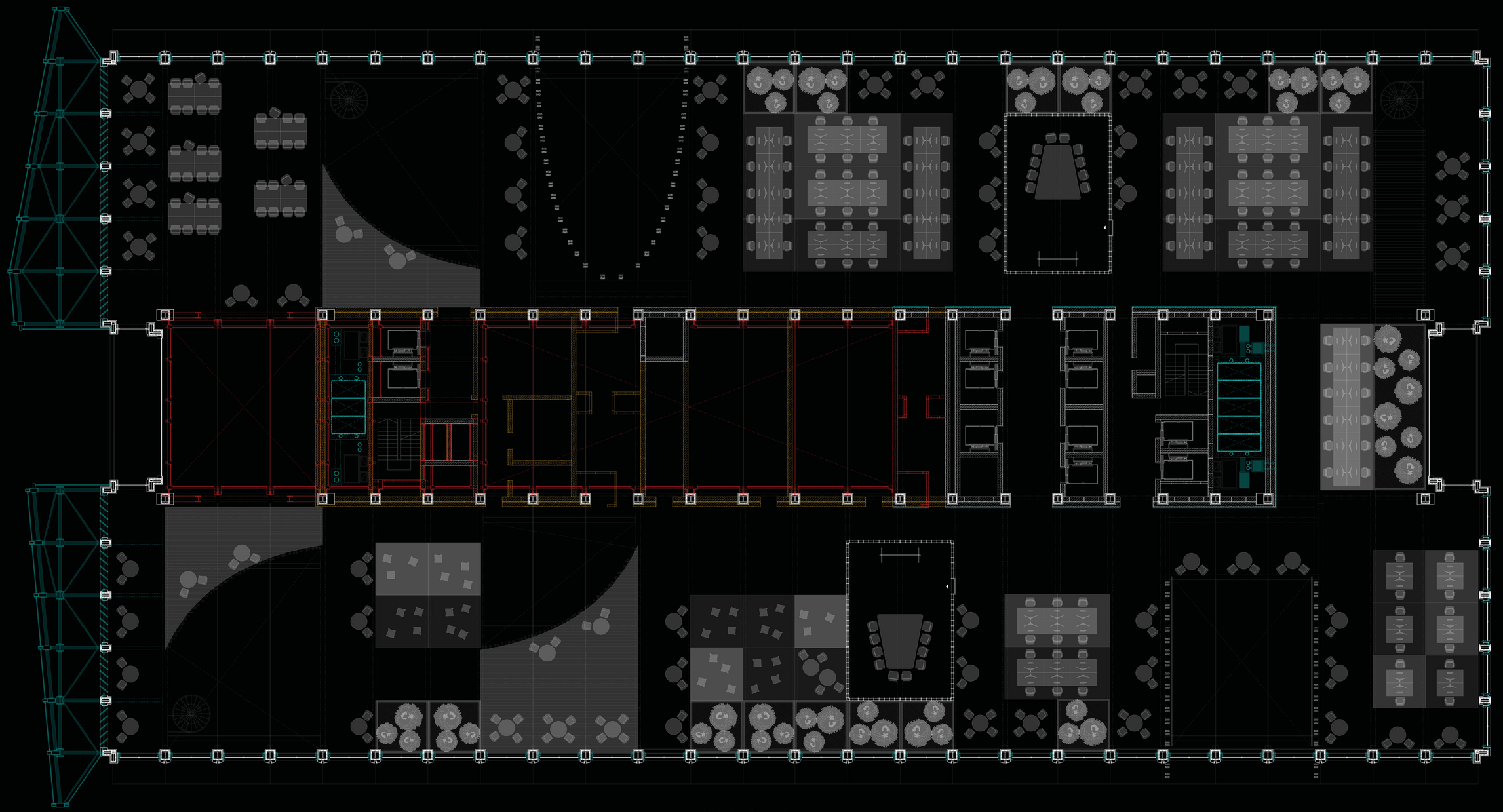
1:50 29. Floorplan

Fig. 159. 29. Floorplan 1:50 (displayed in 1:200)



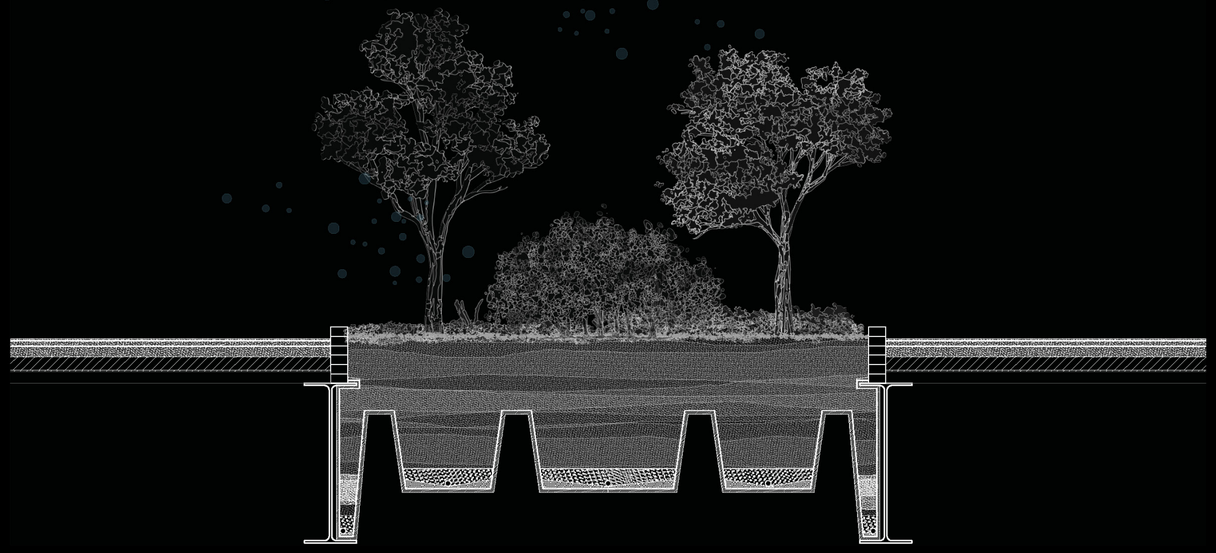
1:50 30. Floorplan

Fig. 160. 30. Floorplan 1:50 (displayed in 1:200)

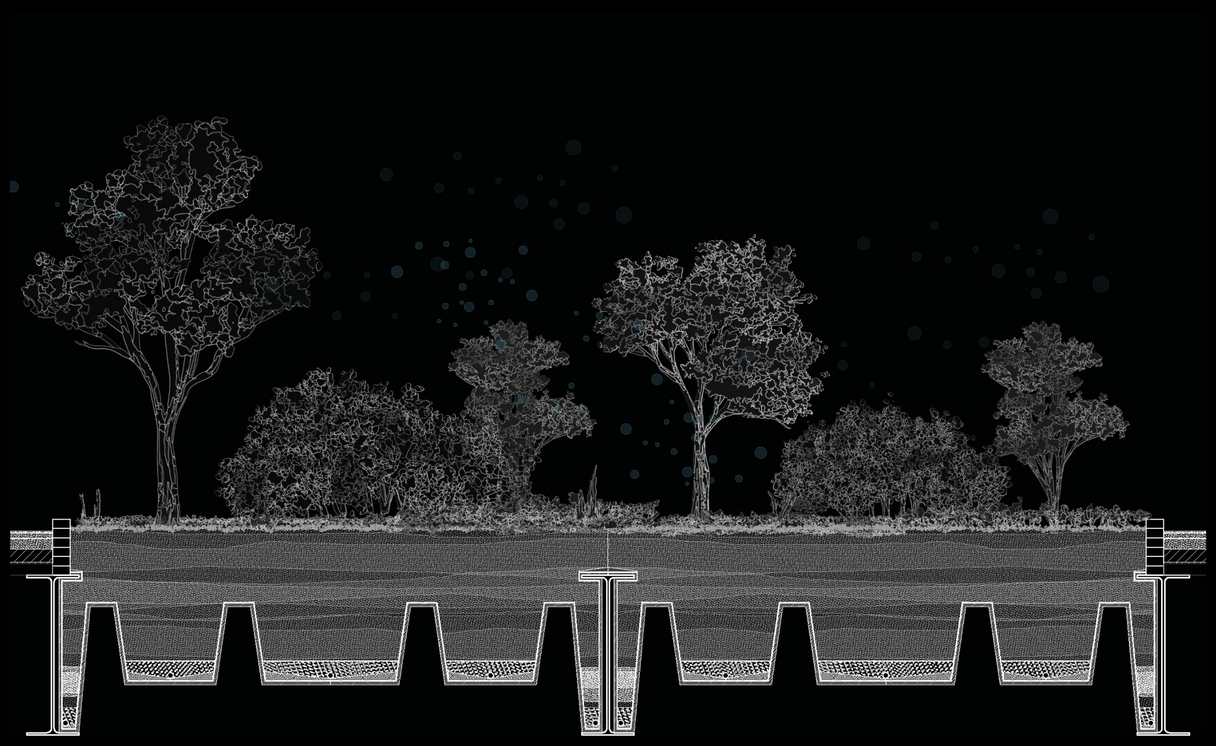


1:50 31. Floorplan

Fig. 161. 31. Floorplan 1:50 (displayed in 1:200)

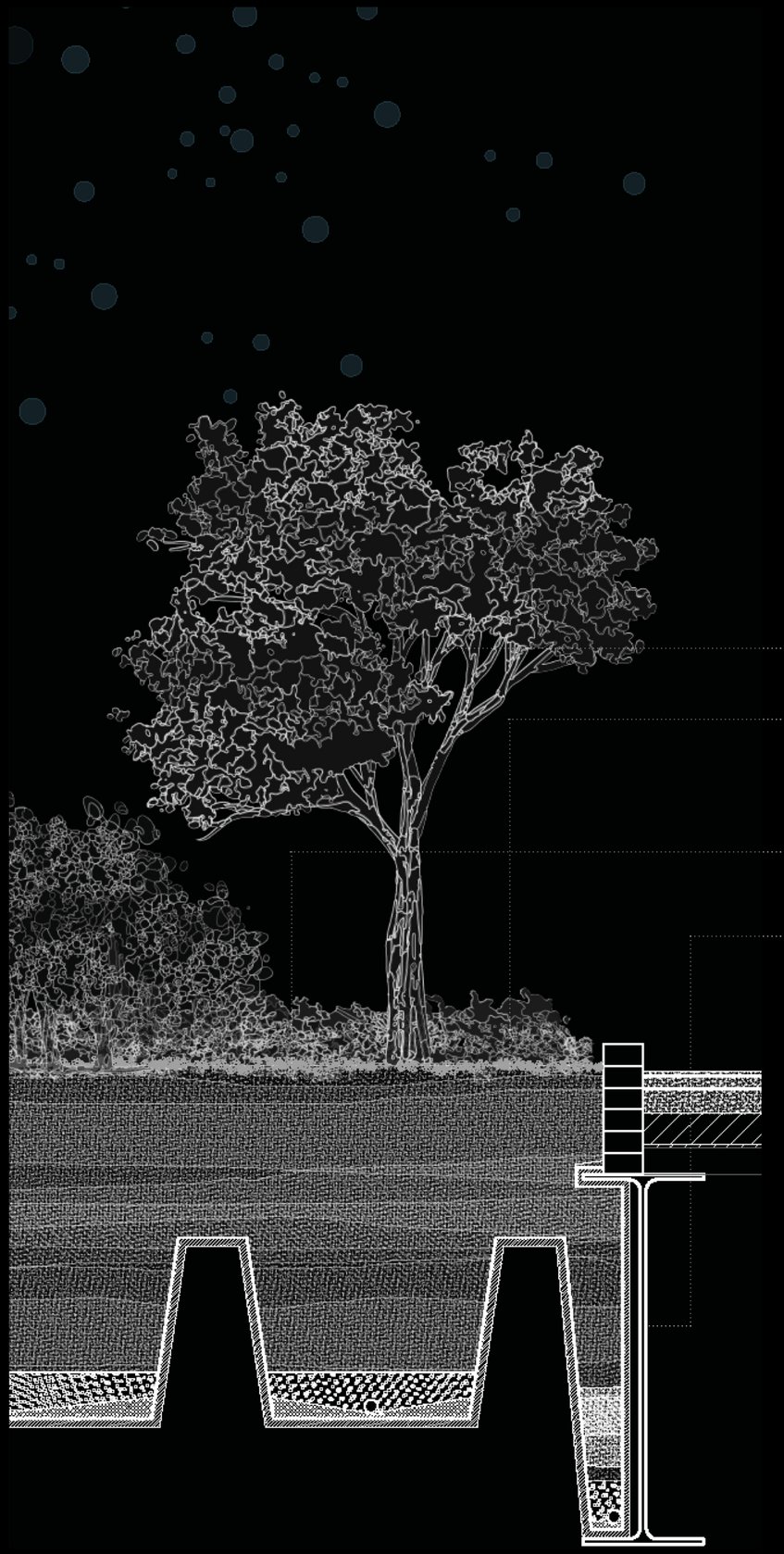


Single Planter Solution 1:25



Multiple Planter Solution 1:25

Fig. 162. 1:25 Planter integration Sections



Integration of lightweight substrate solution 1:10

Tree Types suitable for this substrate (Multistemmed):

Acer campestre,
Betula,
Carpinus betulus,
Gleditsia triacanthos,
Platanus x hispanica,
Pyrus calleryana.

Substrate by the Urban Jungle Project
Dry weight 250kg/m3
Saturated weight 650kg/m3

Water absorption after one hour 40%

Funghi Mulch 30mm
Substrate (depents on the type of the planted tree)
Filter Fabric
Drainage or retention layer
Protection Fabric
Structural Steelframe for the Planters.

A mean substrate depth of 600mm is kept to maintain comparable structural loads to the previous concrete slab and avoid overloading the existing structure of the Kasumigaseki Building

Fig. 163. 1:10 Planter integration Section



Concentration area (textured)

Fig. 164. Interior perspective of a concentration area. Rendered with Chat-GPT. (No geometrical change was made with AI-Tool and application is solely applied within materials and lighting.

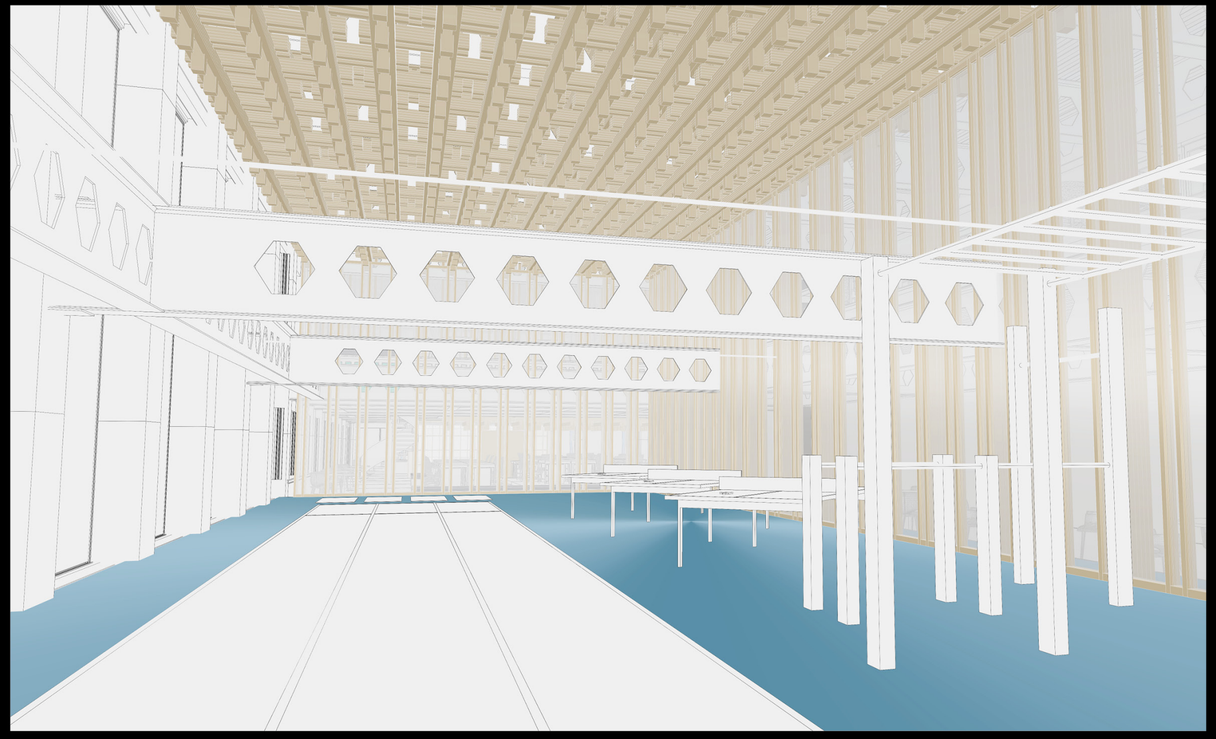


Concentration area (modelled)

Fig. 165. Interior perspective of a concentration area. Base Geometry and Rendering as the output of Rhinoceros 3D 8.



Perspective of a sport facility integration (textured)



Perspective of a sport facility integration (modelled)

Fig. 166 & 167. Interior perspective of a sport facility integration. (No geometrical change was made with AI-Tool and application is solely applied within materials and lighting.



Perspective of a collaborative working area (textured)



Perspective of a collaborative working area (modelled)

Fig. 168 & 169. Interior perspective of a sport facility integration. (No geometrical change was made with AI-Tool and application is solely applied within materials and lighting.

4.2 Final Design

PHYSIOLOGICAL CLIMATE DESIGN

GSHP Hydronic Floor & Radiant Wall System (Core activation)

As one of the primary aims of this Kasumigaseki building retrofit project is to reduce physiological heat stress within the building,

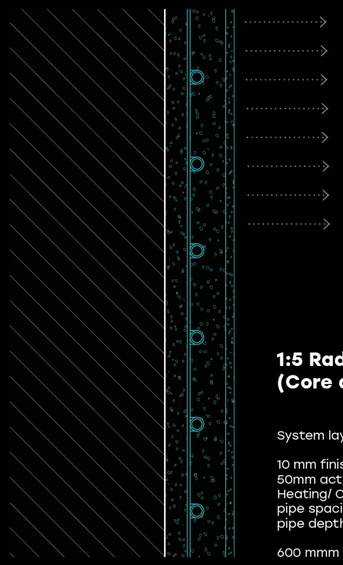
passive cooling principles, inspired by Japanese vernacular architectural knowledge, are applied to both lower indoor thermal loads, as well as decrease energy demands within the existing HVAC system.

The first principle is derived from the Doma, a transitional workspace found in traditional Japanese Minka farmhouses. The space, equipped with an earthen floor, functions through its thermal mass as a natural environmental buffer, absorbing humidity and passively regulating indoor temperatures (Holzhueter & Holzhueter, 2025b).

Based on this concept, additional thermal mass is integrated into the Kasumigaseki building's office floors, where the existing concrete slab is overlaid with a 100 mm clay floor system developed by the Austrian office Atelier Martin Rauch. The overlay is composed of a clay-cork-lime composite on which a hardened clay-casein-straw finishing is applied as a durable surface to resist the extensive office use demands (Rauch & Sauer, 2017).

The application of thermal mass is extended with a plaster-based radiant wall system, consisting of an additional layer of 50 mm plaster and a 10 mm plaster finishing layer, applied on the structural core walls, office-facing side, activating both the plaster layer and the core wall as a radiant cooling mass. The cooling principle in both the clay floor and plaster wall system is achieved by embedding hydronic tubing with a hydronic cooling fluid fed by a per floor distributed Ground Source Heat Pump system (GSHP).

The Ground Source Heat Pump system, conducted with the borehole method, is often applied in Tokyo due to its minimal use in space and resembles therefore optimal conditions for the case of retrofitting. The central distribution of the GSHP system is done within the two central HVAC core sections of the Kasumigaseki building, which have been retrofitted during the first retrofit cycle in 1988, which reduced the original infrastructure from 1968 to a fraction of the originally planned spatial use, opening up space for the new GSHP integration.



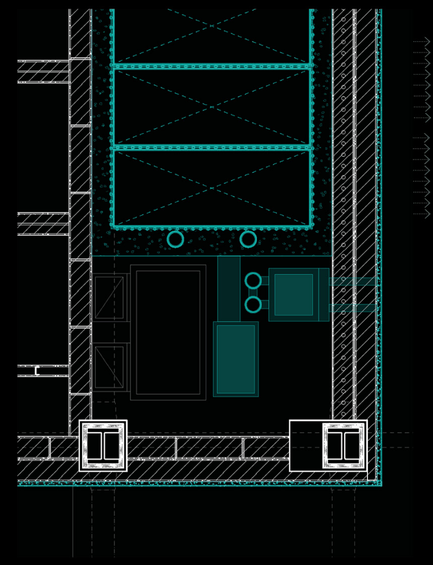
1:5 Radiant Wall system (Core activation)

System layers:

10 mm finish plaster
50mm active plaster
Heating/ Cooling pipes
pipe spacing 100 mm
pipe depth 25mm from the finished surface

600 mmm existing concrete core wall

Fig. 170. 1:5 Detail of the Radiant Wall system



Central vertical distribution of the GSHP Hydronic cooling fluid through the existing ventilation core

Fig. 171. 1:50 Focus on the ventilation core

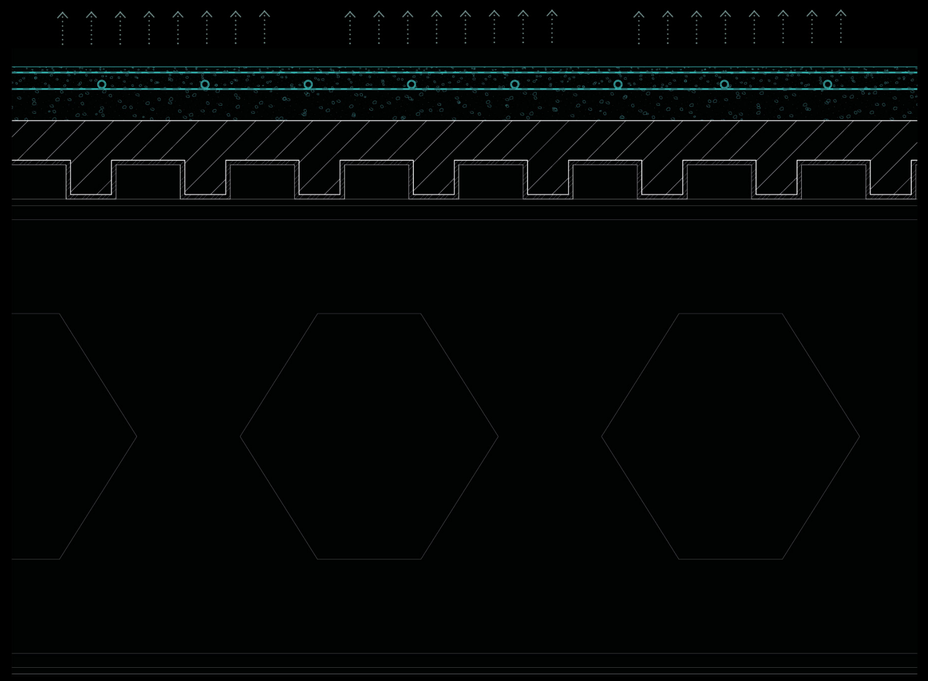


Fig. 172. 1:5 Detail of the Hydroniic GSHP Clay Floor system

1:5 Clay floor system, referencing the vernacular concept of Doma

System layers:

Clay-casein-straw mixture 10 mm
Mesh 2 mm
Clay-straw-sand-pozzolan lime mixture 30mm
Heating/ Cooling pipes
Mesh 2 mm
Clay-cork-pozzolan lime mixture 60mm

152mm existing concrete slab of the Kasumigaseki building



Fig. 173. Image of vernacular use of Doma. From 吉田美帆 (2024).

Hybrid “Mountain-to-Sea” GSHP-Fresh-Air Ventilation System Groundfloor

Additionally, the HVAC core sections are also equipped with an additional ventilation system, which is inspired by the earlier mentioned Japanese vernacular concept of positioning the entrance and windows according to the surrounding environmental conditions to catch natural airflow and to guide it into the building.

Within this concept, a salt-study using a physical model has been approached to assess where the salt accumulates within the ground floor and where fresh air intake can be integrated into the retrofit strategy.

The insights revealed that the cooler breeze of fresh air arriving in the early hours from the North-West located inland mountain regions accumulates in the lower South section of the building‘s ground floor level, while the fresh sea breeze from the South-East Tokyo Bay area is considered to accumulate within the Northern end of the groundfloor.

Coherent with the location of the HVAC core sections, a vent for air intake is added to collect the cooler breeze and distribute it centrally throughout the building.

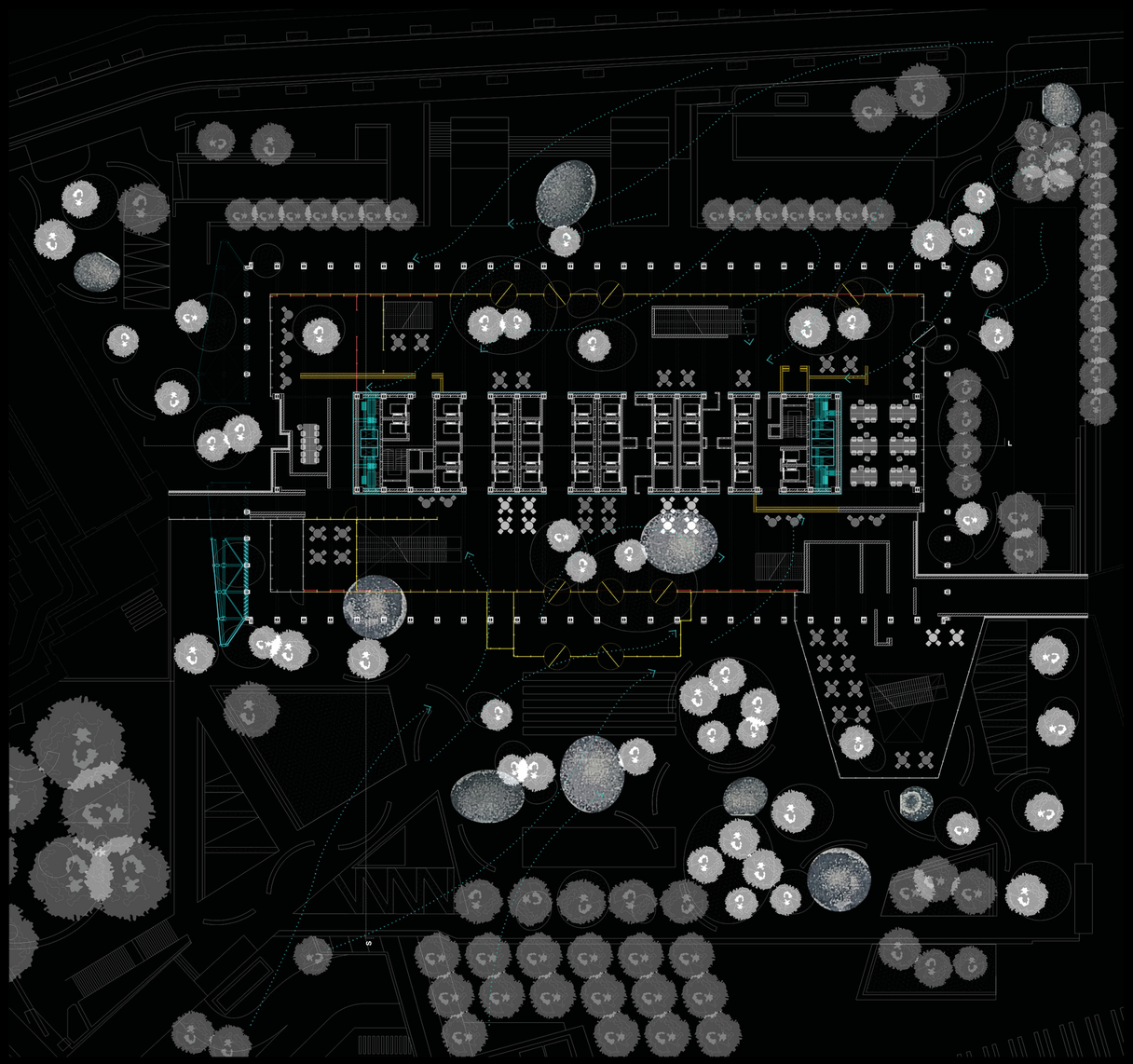


Fig. 174. Ground Floor Area including the Plaza 1:400

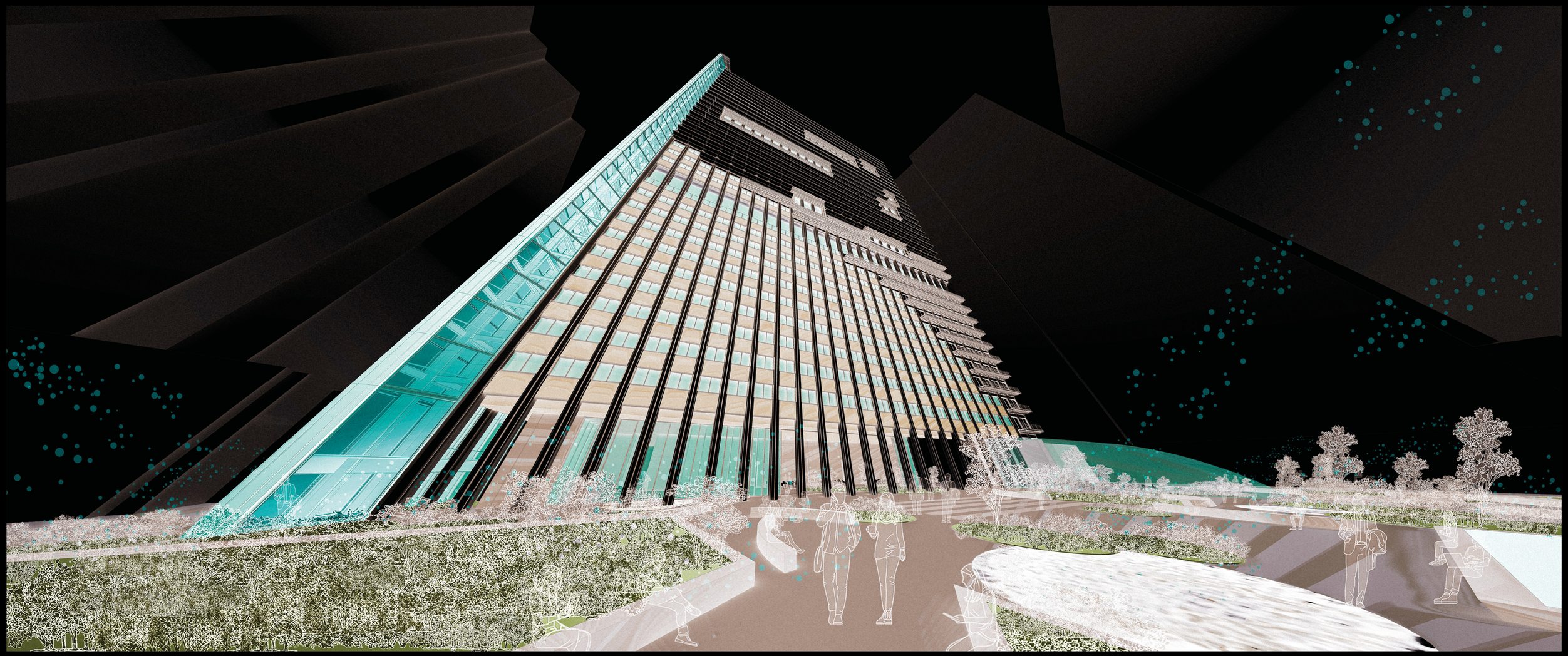


Fig. 175. Outside perspective. Looking at the Kasumigaseki building from the new retrofitted Plaza.

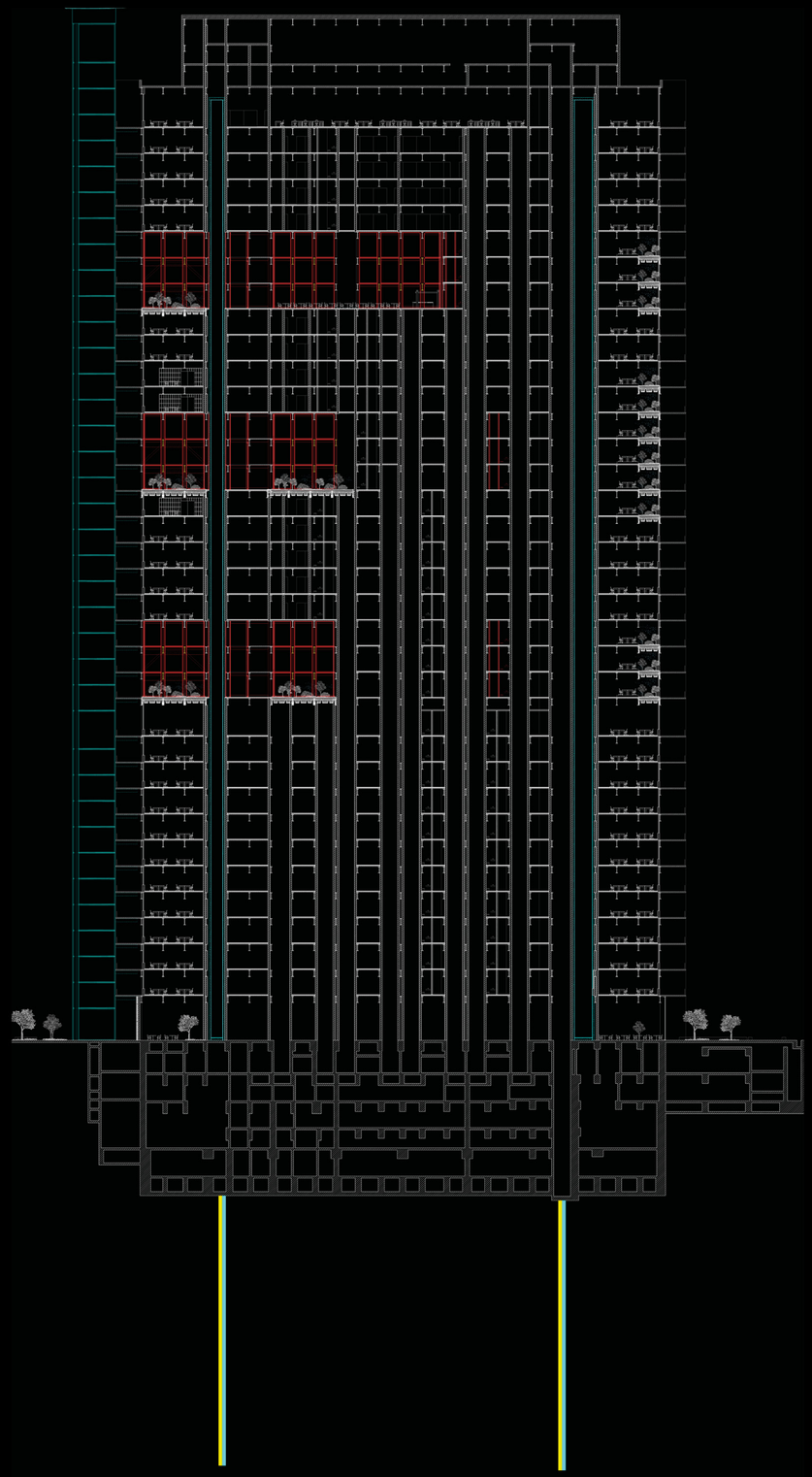


Fig. 176. Longitudinal section 1:100

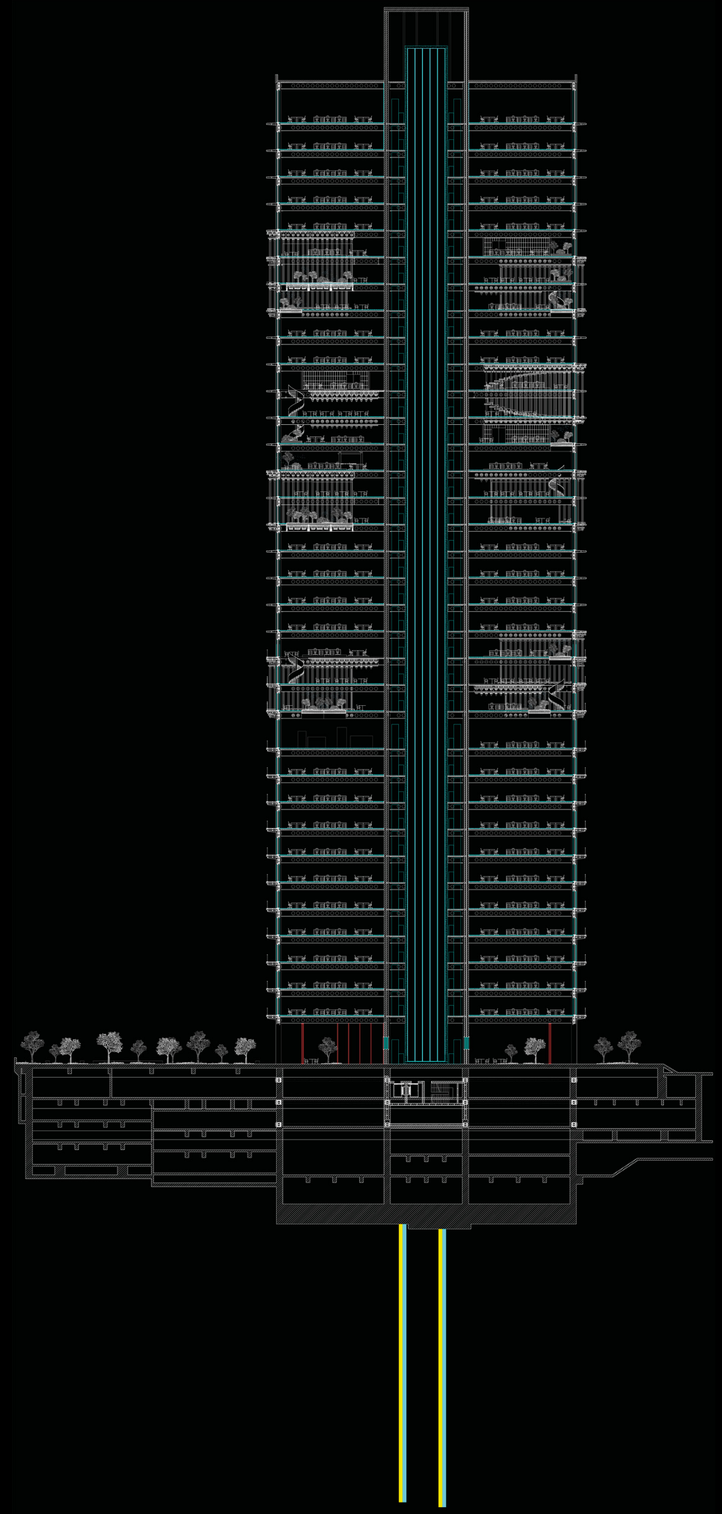


Fig. 177. Cross section 1:100

Hybrid “Mountain-to-Sea” GSHP-Fresh-Air Ventilation System Standart office floor

The central vertical distribution system consists of a series of parallel low-velocity fresh air shafts integrated into the HVAC core infrastructure, supplying the office floors vertically, continuously with passively cooled fresh air.

In terms of cooling the fresh air, passive heat-exchange principles are applied by surrounding the vertical shafts with an additional thermally active lining system, consisting of rammed-earth modular elements combined with a conductive aluminium frame with hydronic cooling loops segmented per floor, which are connected to the earlier mentioned GSHP system. While the cooling capacity is stabilised by the surrounding rammed earth, the system acts as a closed-loop hydronic heat exchanger without introducing moisture into the fresh air stream, which allows the intervention to maintain hygenic air quality standards.

For dimensioning the added central ventilation system, the required fresh air rate of 30 m3/h per person, provided by the Building Standards Act (BSA) and the Act of Maintenance of Sanitation in Buildings, is considered within the calculations.

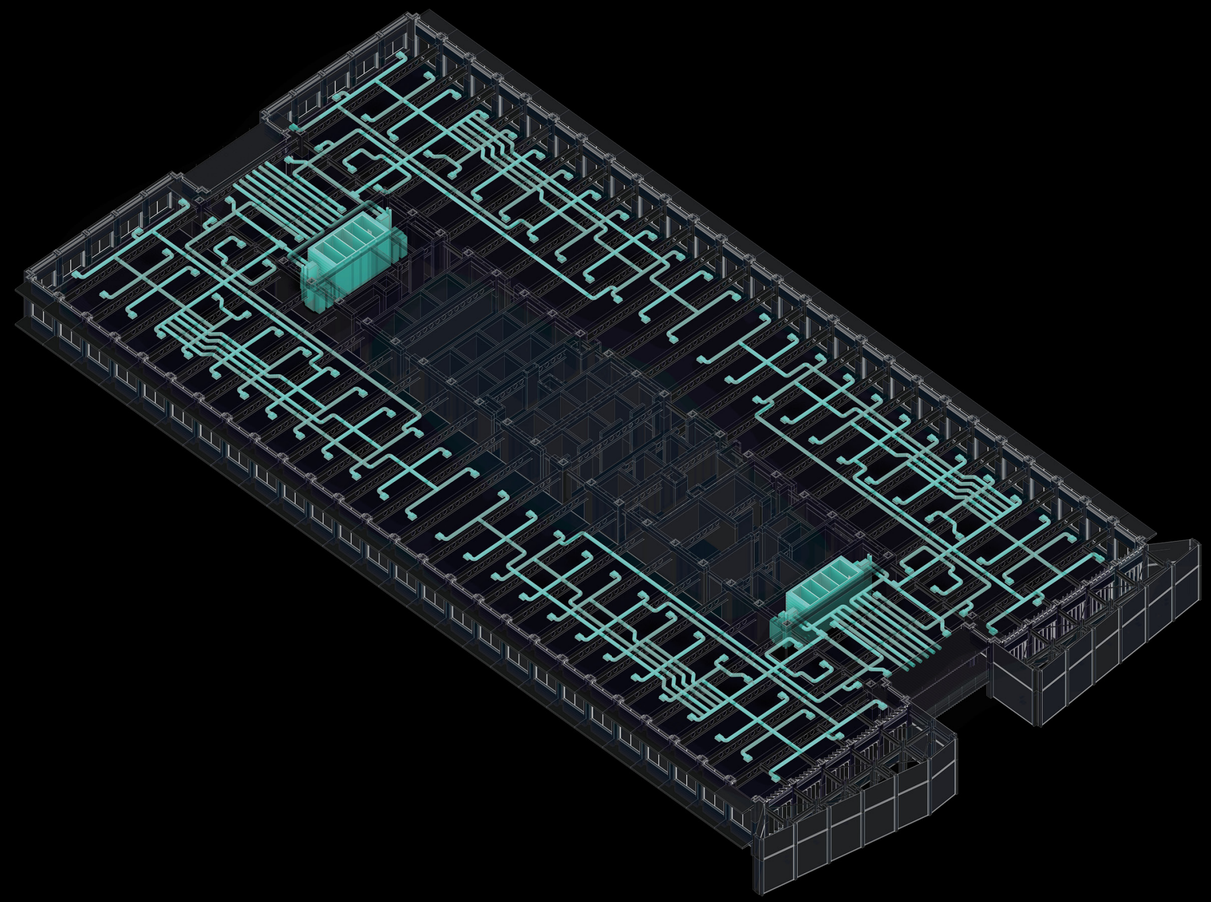
The calculation provides insights that the newly introduced fresh air shafts are dimensioned to theoretically provide the building with passivelycooled air by up to possibly 100% with a moderate, energy-efficient velocity of approximately 4,6 m/s within the main vertical shafts.

As the passively cooled fresh air arrives at an office floor, the air is distributed within the existing, for ventilation dedicated, duct network.

While the new system theoretically allows replacing the existing system, it is primarily considered to work as a supporting hybrid ventilation system. The new integration is reserved to supply the building with cooled fresh air during the early hours of the day and the afternoon when the earlier-mentioned fresh air flow streams occure.

As the ventilation rate, however, needs to constantly be maintained at 8,5 L/s per person and as natural air flow streams have the tendency to fluctuate in their occurrence, especially during the mid-day hours where the wind direction is expected to change, the existing system is regarded to be turned on during such events.

Although neither a complete replacement nor a fully fixed operational division between the passive and mechanical systems can be guaranteed, the introduced passive strategies of vertically pre-cooling the fresh air are expected to significantly reduce the operational energy demand of the existing HVAC infrastructure.



Required fresh air ventilation rate per person:

30 m³/h per person = 8,33 L/s ≈ 8,5 L/s per person

Required fresh air ventilation rate per floor:

considered occupancy per floor = 330 occupants
fresh air rate = 8,5 L/s per person

330 × 8,5 = 2805 L/s ---> 2805 L/s ÷ 1000 = 2,805 m³/s

Required fresh air per floor = 2,8 m³/s

Required fresh air ventilation rate per building (33 office floors):

2,805 m³/s × 33 floors = 92,565 m³/s

Total required fresh air = 92,6 m³/s

Available new shaft area of the parallel low-velocity fresh air shafts per HVAC core (2 x per floor)

6,32 m² for the southern HVAC core ---> contribution of 31,4%
13,83 m² for the northern HVAC core ---> contribution of 68,6%

---> A total of 20,15 m²

southern HVAC core airflow capacity at the required 92,6 m³/s:

southern HVAC core 29,1 m³/s
northern HVAC core 63,5 m³/s

---> A total of 20,15 m²

If 100% of fresh air is attempted to be replaced by the new system:

velocity = airflow ÷ area = 92,565 m³/s ÷ 20,15 m² = 4,59 m/s

average central shaft velocity 4,6 m/s

at 3,0 m/s: 20,15 × 3,0 = 60,45 m³/s airflow cap. ≈ 65% relpacement
at 3,5 m/s: 20,15 × 3,5 = 70,53 m³/s airflow cap. ≈ 76% relpacement
at 4,0 m/s: 20,15 × 4,0 = 80,60 m³/s airflow cap. ≈ 87% relpacement
at 4,5 m/s: 20,15 × 4,5 = 90,68 m³/s airflow cap. ≈ 98% relpacement
at 4,6 m/s: 20,15 × 4,6 = 92,69 m³/s airflow cap. ≈ 100% relpacement

Fig. 178. Axonometry of the new hybrid ventilation system within the standard floorplan, including calculations for regulatory ventilation standards.

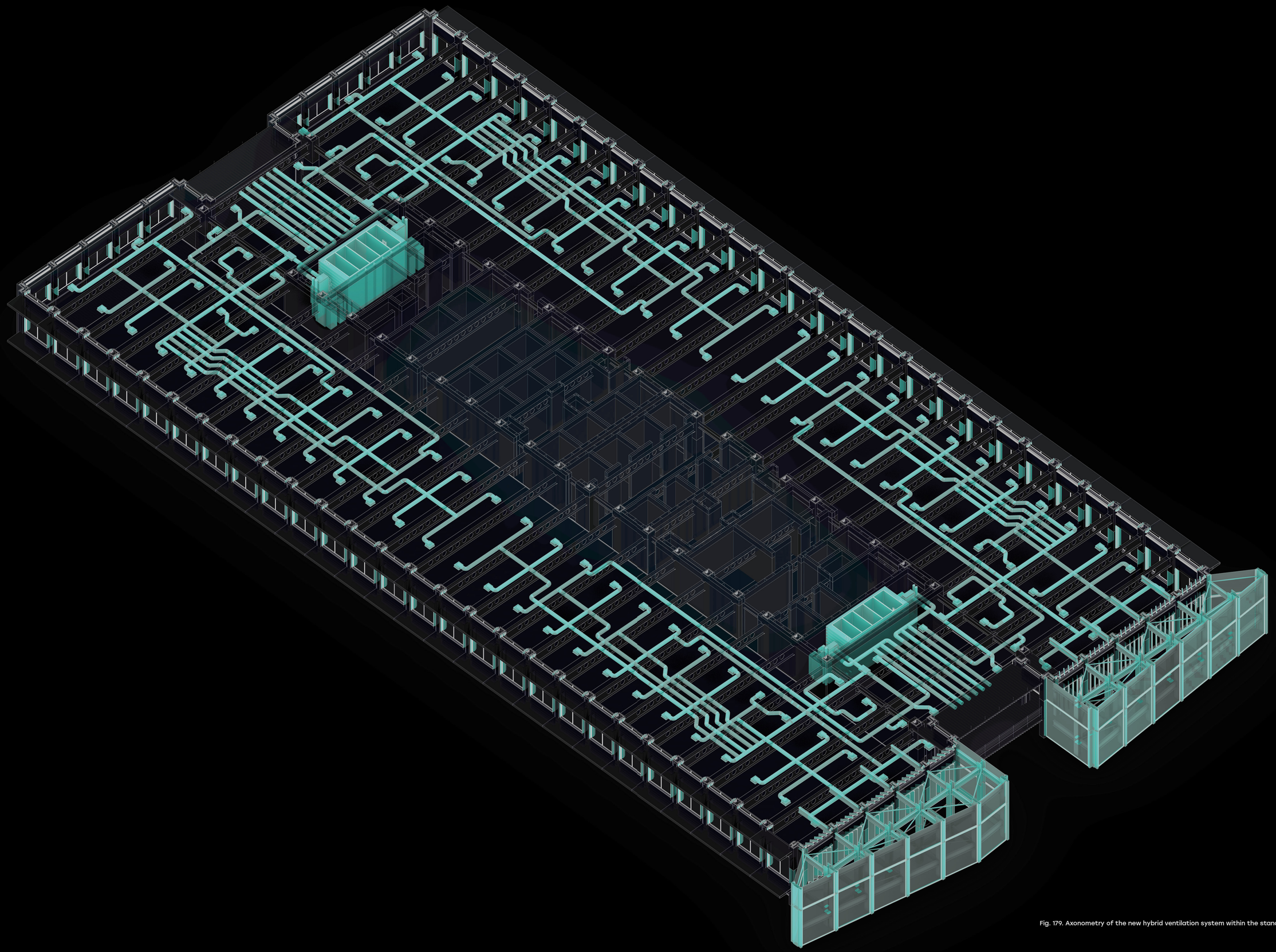


Fig. 179. Axonometry of the new hybrid ventilation system within the standard floorplan.

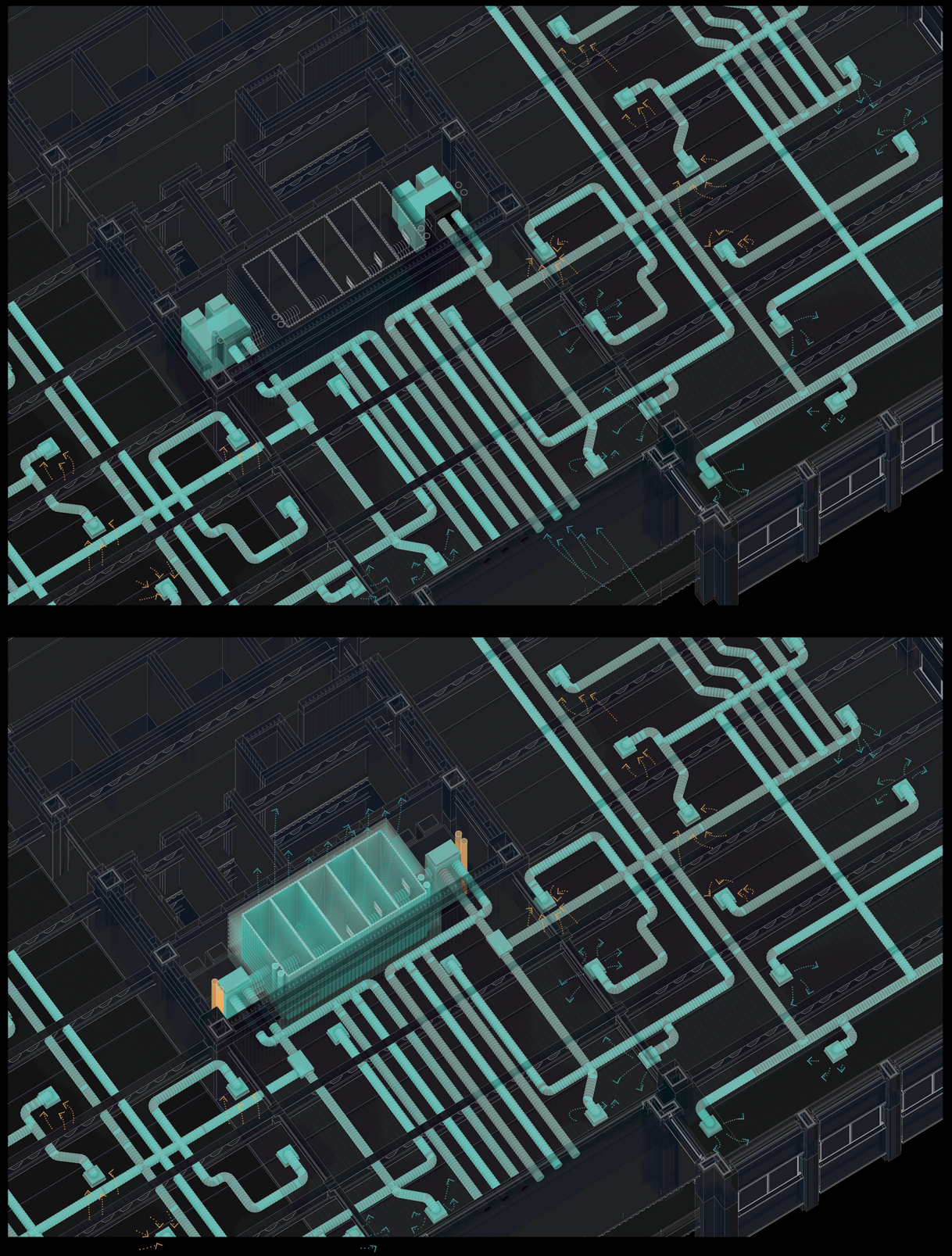


Fig. 180. Comparison of the new and existing ventilation system.

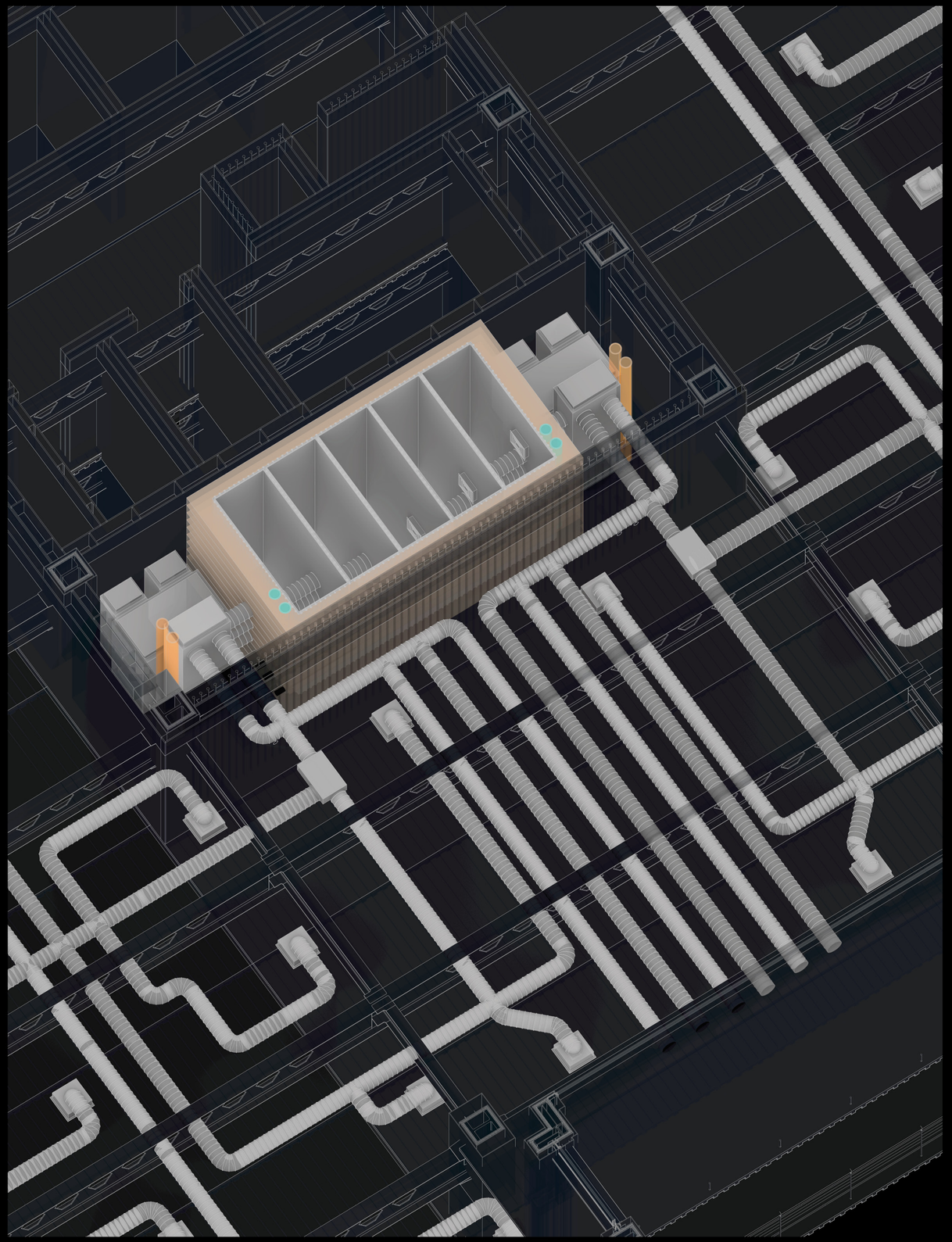


Fig. 181. Complete image of the hybrid ventilation system including materialisation.

Mechanically adaptive ventilation facade

Additional ventilation support is provided by the facade, which is retrofitted according to the earlier introduced solar studies, as well as height threshold regulations.

Furthermore, every facade retrofitted section is equipped with a mechanical ventilation integration, which has been developed for the Akasaka Intercity Air building, built in 2017. The facade allows through pressure difference between the outside and indoor air, to introduce fresh air from outside adaptively while remaining closed if strong winds occure, which is especially crucial during the monsoon season.

Through preliminary calculations, the effective ventilation depth by such facade integration is expected to range from 7,38m to 9,23m, which is derived from multiplying the foor-to-ceiling height by the natural ventilation depth factor of 2 to 2,5. At the corners, where cross ventilation effects are assumed, a factor of 5 is taken through which an effective ventilation depth of 18,45 can be regarded.

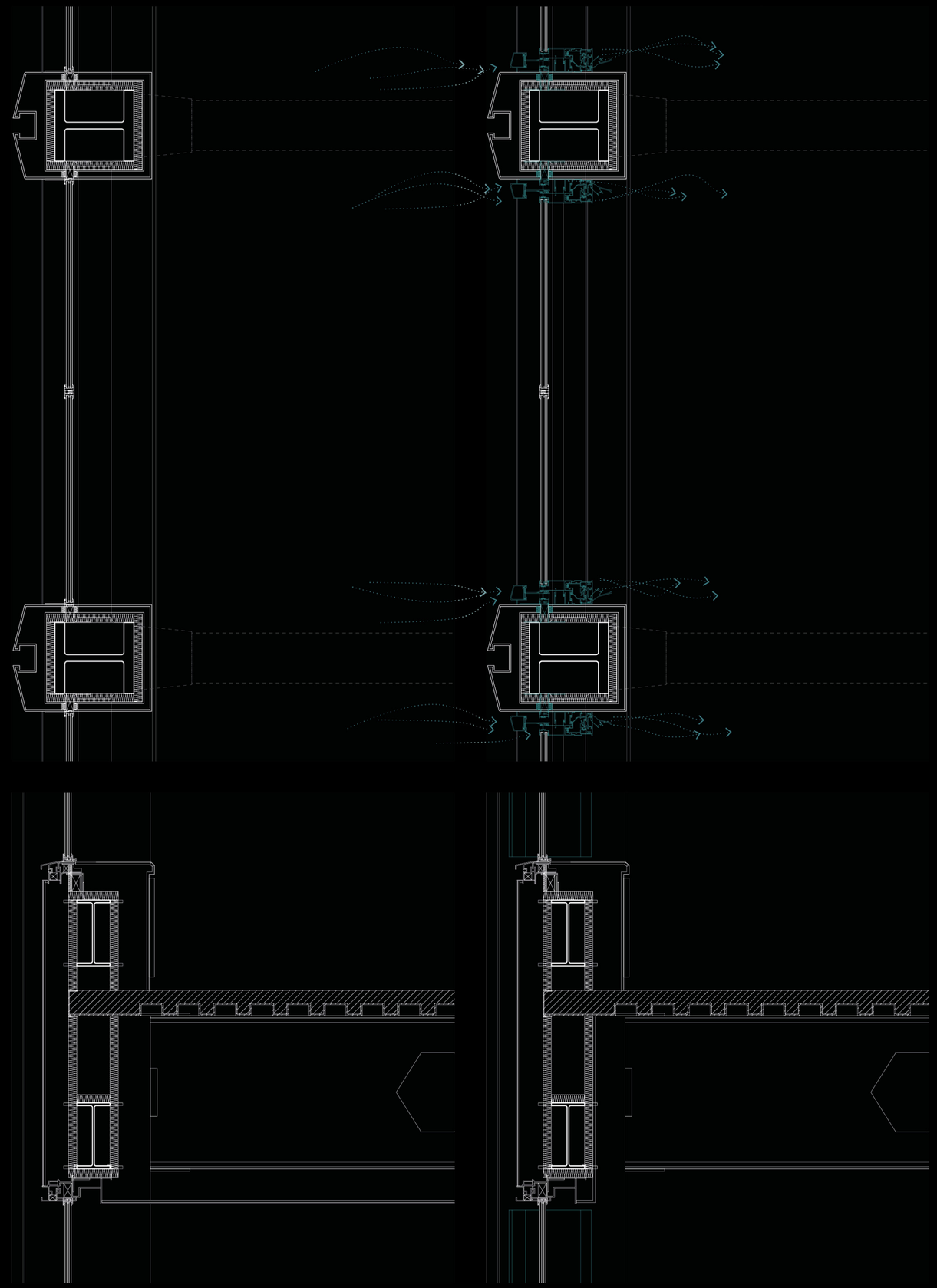


Fig. 182. Comparison of the existing facade and the new facade within the starndard office floors, equipped with an integrative mechanical ventilation system.



AKASAKA
INTERCITY AIR

Completion – 2017

Fig. 183. Photograph of the Akasaka Intercity Air. From 【赤坂インターシティAIR】ポップアップストアやプロモーションに適した超高層複合ビルのイベントスペース(2Fロビー エスカレータ横 (n.d.).

自然換気について

本物件では外部縦フィンにより、建物壁面を流れる外気をより有効に給気できるよう設計されています。
また、瞬間的な突風時には風速の大きな外気の流入による室内の気流の乱れ等を緩和するために風量を調整する弁（定風量弁）を設けてあります。
設計段階で CFD 解析による、縦フィンの換気効果の検討を実施しました。

自然換気解析方法

標準的な気象条件（温度・風速・風向）を使用し、風圧力と温度差による自然換気の換気量を算出します。

［温度差換気］

$$Pt=h\cdot(\rho o-\rho i)\cdot g$$

［風圧力換気］

$$Pu=C\cdot\rho o\cdot Vo^2/2$$

Pt ： 温度差による換気力(Pa)
h ： 給気口と排気口の高さの差(m)
ρo ： 室外空気密度(kg/㎥)
ρi ： 室内空気密度(kg/㎥)
g ： 標準重力加速度(m/s²)
(空気調和衛生工学便覧より)

Pu ： 風による換気力(Pa)
ρo ： 外気密度(kg/㎥)
vo ： 風速(m/s)
C ： 風圧係数

気象条件

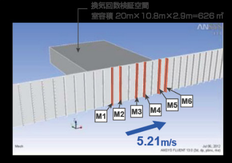
気温、風速、風向は（社）日本建築学会拡張アメダス気象データ 1981-2000 に基づき解析に用います。

解析場所	東京都港区
解析月	4～6月・9～11月
解析時間	8時～20時
平均外部風速	2.0m/s（地上6.5m）

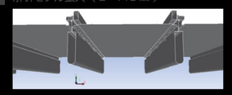
日本建築学会建築物荷重指針・同解説より本解析設定条件

旋回機能	V（べき指数 0.35）
高さ：風速	100m：5.21m/s
（参考）	200m：6.84m/s

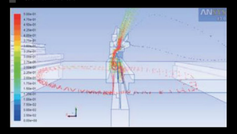
解析モデル（外観）



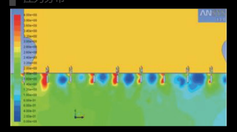
解析モデル拡大（L=440 ㎜）



給気口詳細

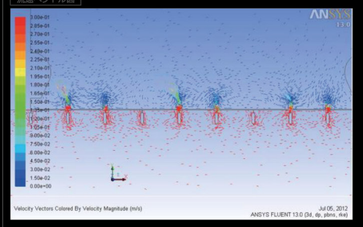


圧力分布



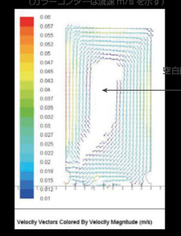
換気解析結果 L=400 ㎜ 方立フィン

流速ベクトル図



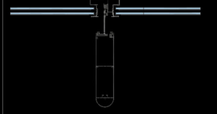
室内空気の流れ

（カラーコンターは流速 m/s を示す）



換気解析結果 方立フィン別 流量・換気回数比較 （設定流速：5.21m/s・換気ホッパー H：2000 ㎜）

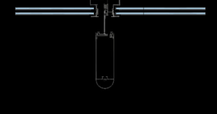
方立フィン L=440 ㎜



方立番号	㎥/s	㎥/h
M1	0.02971	106.94
M2	−0.01322	−47.60
M3	0.02413	86.86
M4	−0.02462	−88.64
M5	0.00604	21.73
M6	−0.02203	−79.30
総流量	0.05987	71.84

流量 ＝ Σ{(M−1)+(M−3)+(M−5)}
215.53 ㎥/h
換気回数 ＝ 流量 / 室容積 0.34 回/h

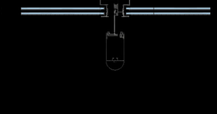
方立フィン L=350 ㎜



方立番号	㎥/s	㎥/h
M1	0.02416	89.96
M2	−0.01223	−44.02
M3	0.03019	108.68
M4	−0.02656	−95.61
M5	0.01058	38.09
M6	−0.02600	−93.87
総流量	−0.05492	77.91

流量 ＝ Σ{(M−1)+(M−3)+(M−5)}
233.73 ㎥/h
換気回数 ＝ 流量 / 室容積 0.37 回/h

方立フィン L=260 ㎜



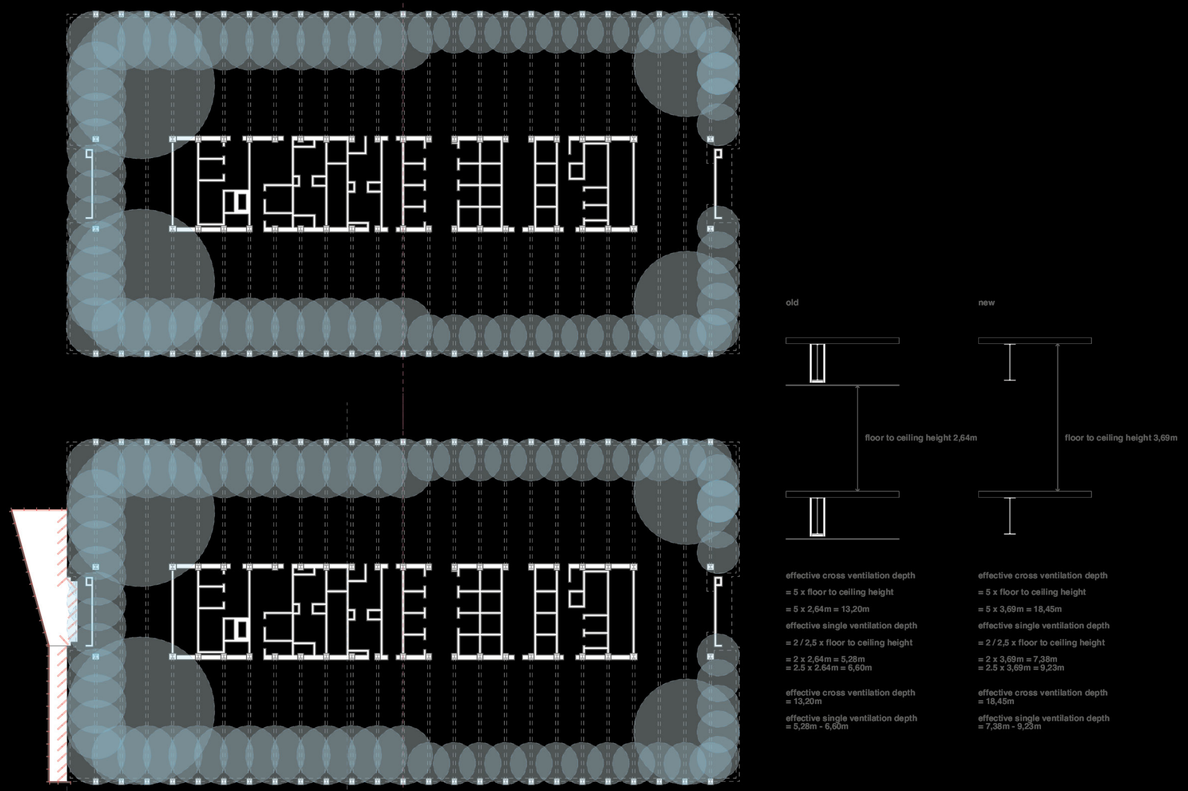
方立番号	㎥/s	㎥/h
M1	0.03381	121.72
M2	−0.01367	−49.22
M3	0.01682	60.54
M4	−0.03077	−110.78
M5	0.01912	68.81
M6	−0.02530	−91.07
総流量	0.06974	83.69

流量 ＝ Σ{(M−1)+(M−3)+(M−5)}
251.07 ㎥/h
換気回数 ＝ 流量 / 室容積 0.40 回/h

LIXIL
Link to Good Living
株式会社 LIXIL ビル事業部 エンジニアリング営業部
私たちは、優れた製品とサービスを通じて、豊かで快適な住生活の未来を創造する「住まいと暮らしの総合住生活企業」です。

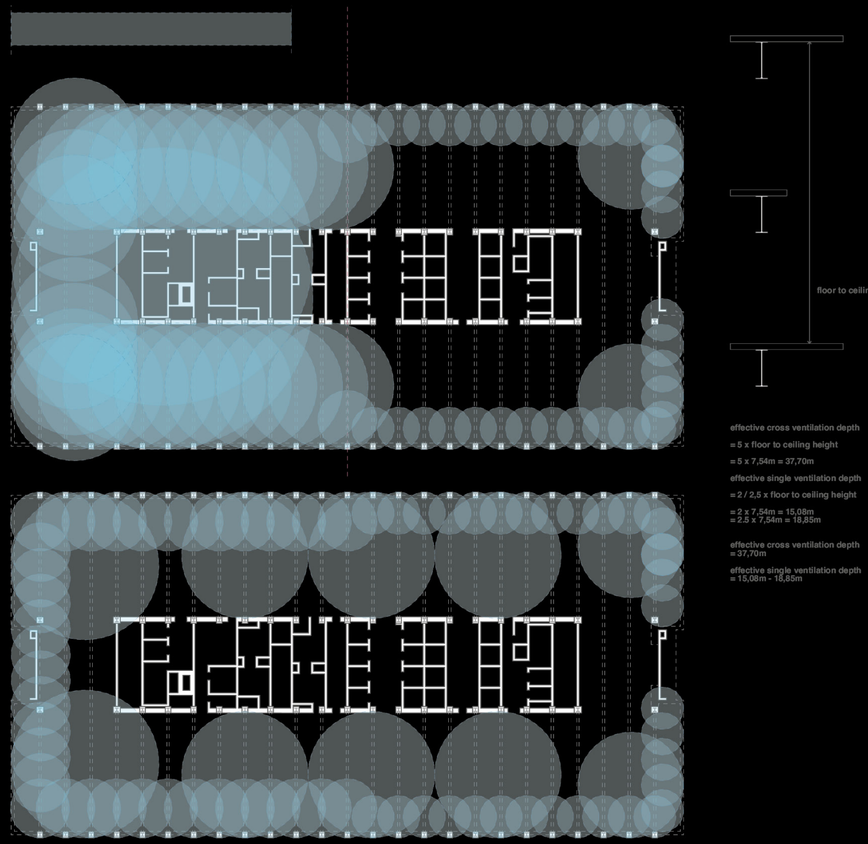
Project：180419_02A

Fig. 184. Data Sheet of the Mechanical ventilation facade system. From LIXIL (2018)



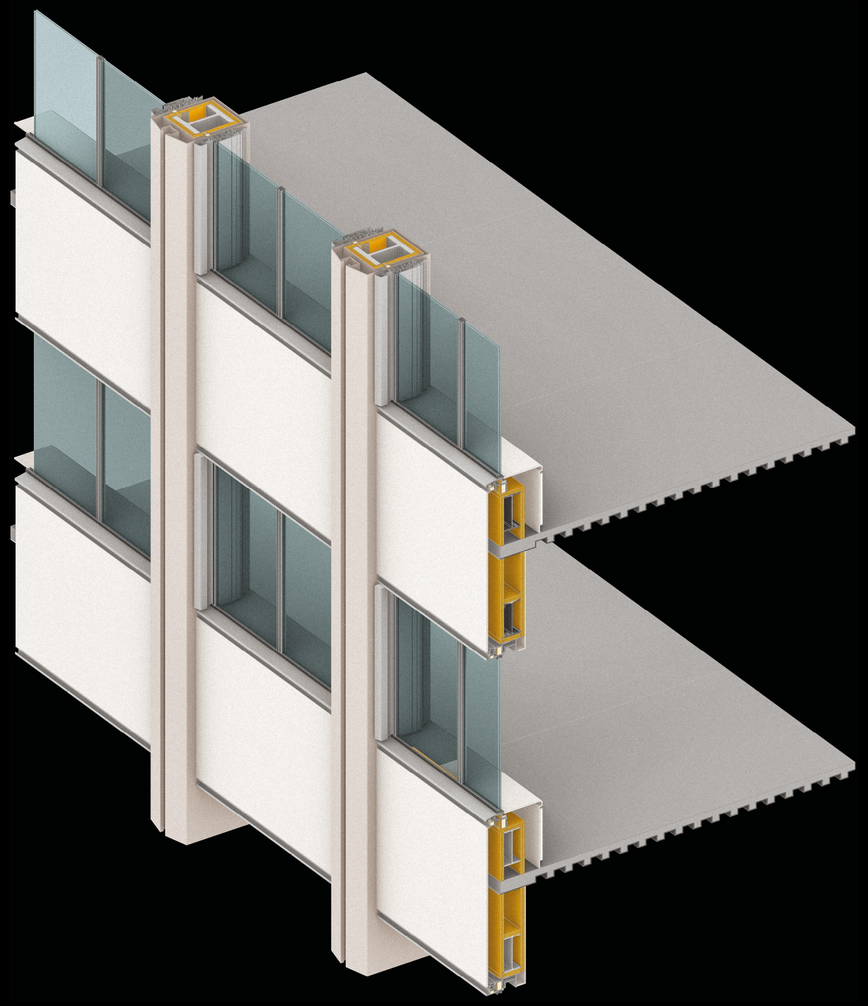
Single-floor assessment for natural ventilation efficiency

Fig. 185. Diagramatic assessment of the new facade ventilation system within single floor conditions.



Double-floor assessment for natural ventilation efficiency

Fig. 186. Diagramatic assessment of the new facade ventilation system within double floor conditions.



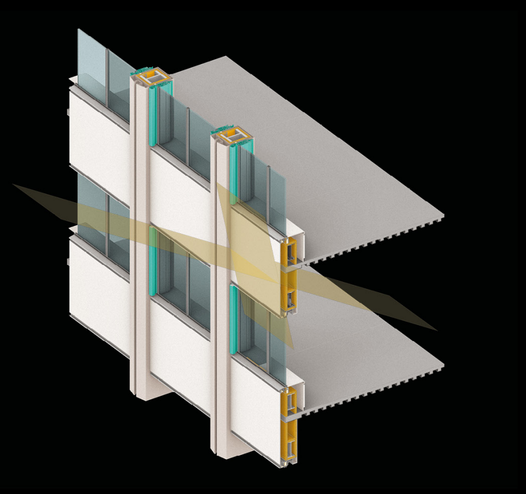
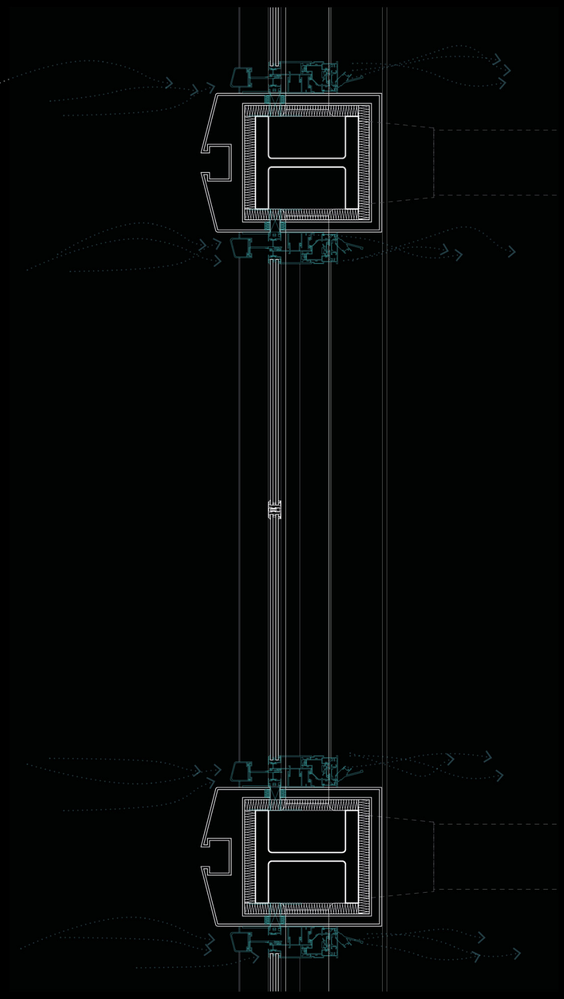


Fig. 187. Axonometry of the existing facade with integrated ventilation additions, extended with a solar exposure assessment.



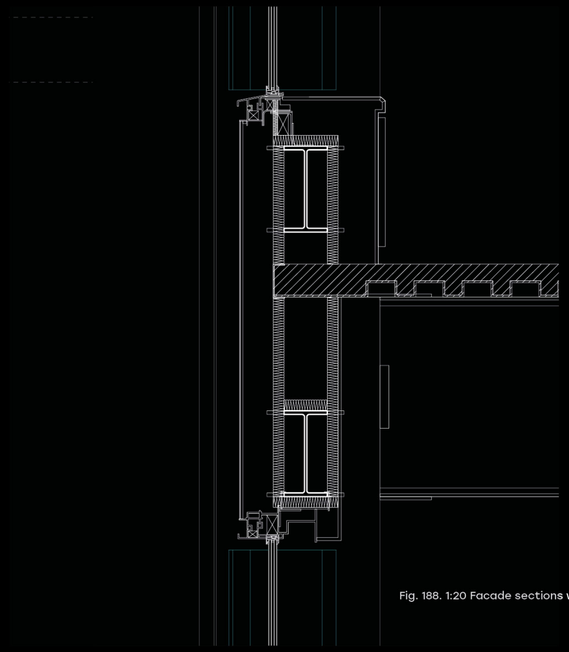
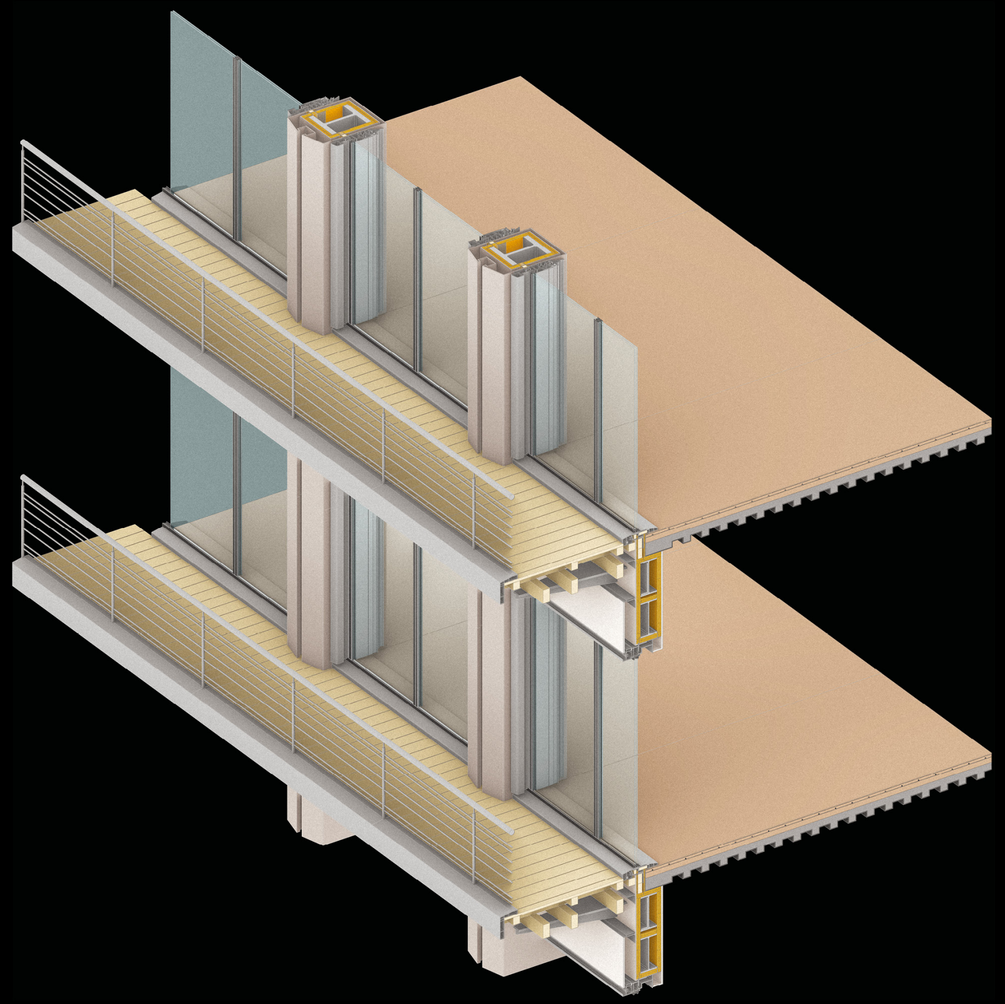


Fig. 188. 1:20 Facade sections with integrated ventilation additions.



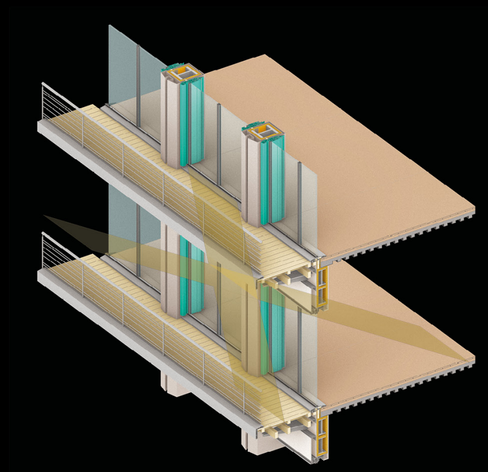
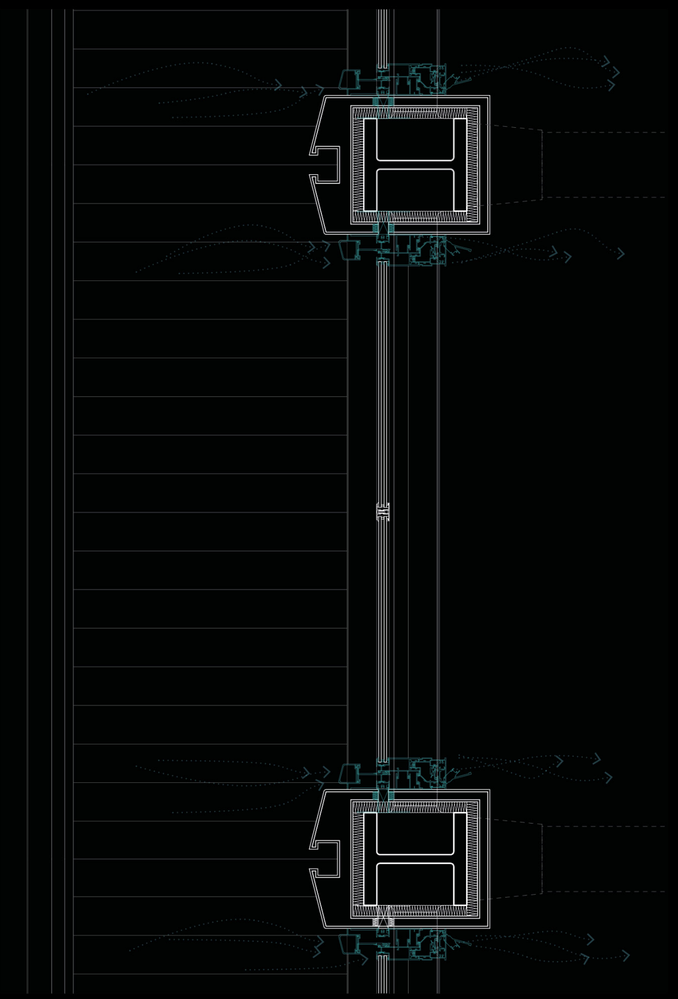


Fig. 189. Axonometry of the new Engawa-facade concept with integrated ventilation additions, extended with a solar exposure assessment.



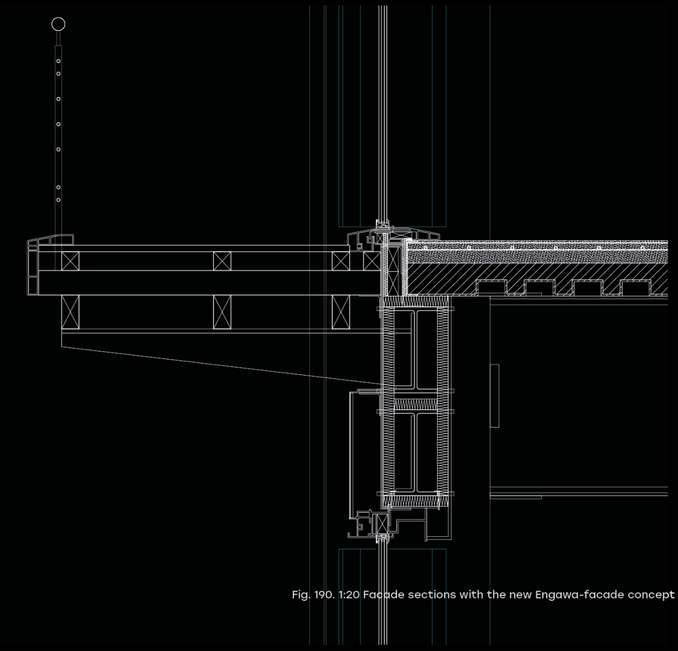
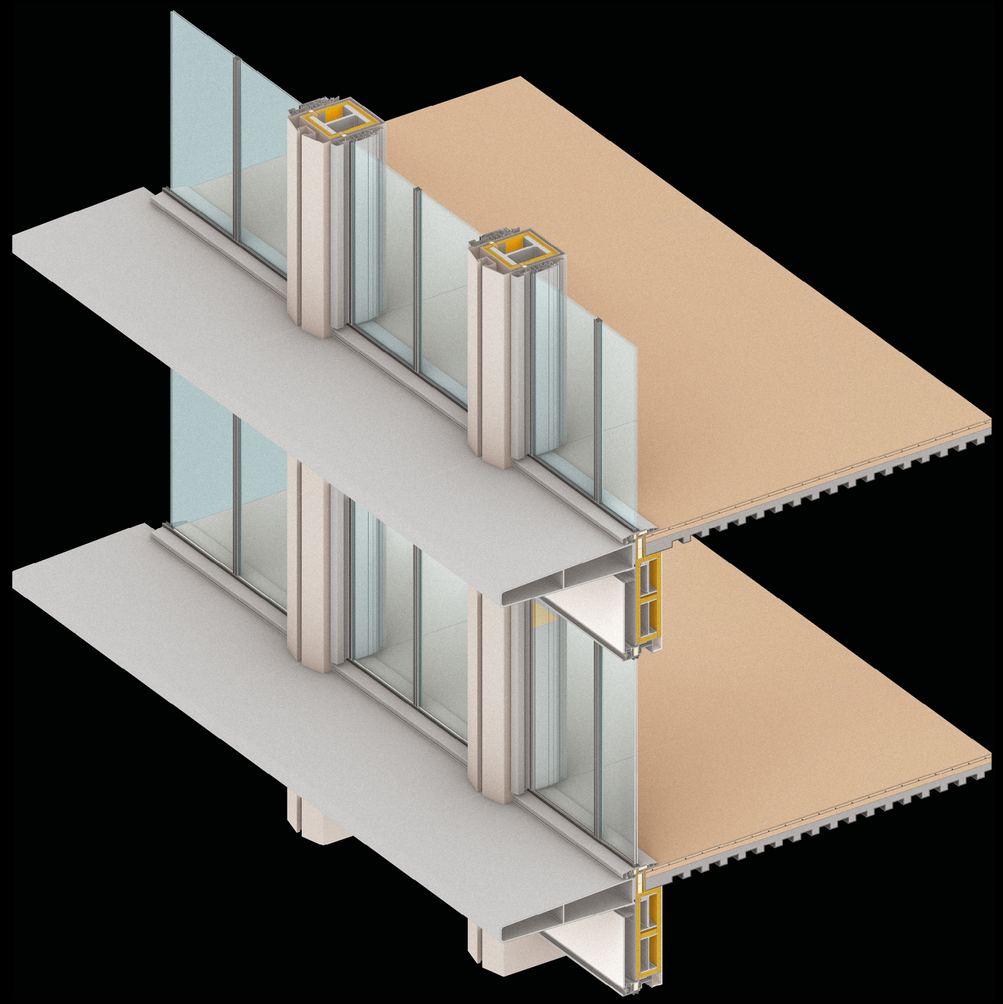


Fig. 190. 1:20 Facade sections with the new Engawa-facade concept and integrated ventilation additions.



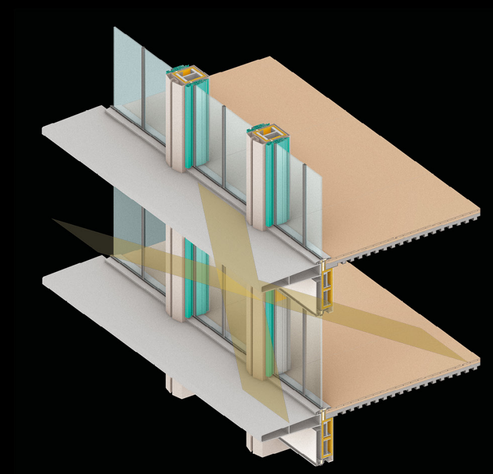


Fig. 191. Axonometry of the new horizontal shading-facade concept with integrated ventilation additions, extended with a solar exposure assessment.

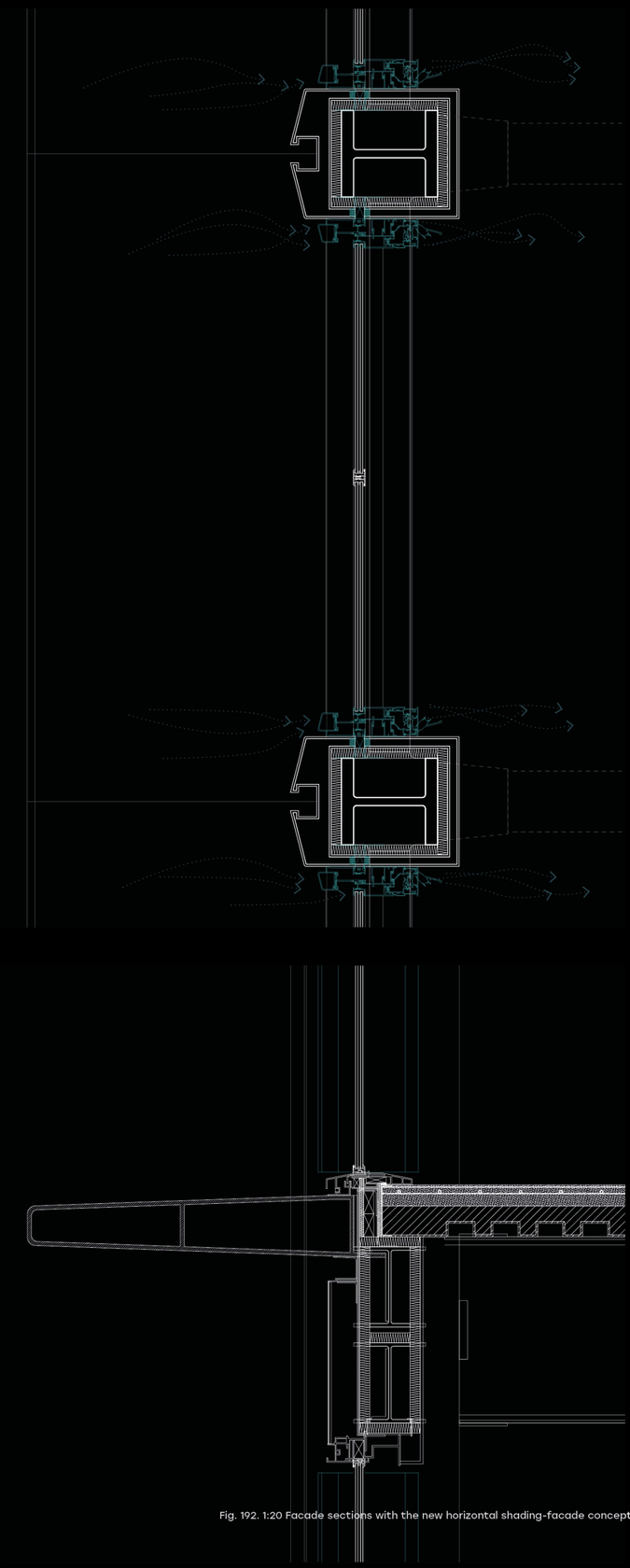


Fig. 192. 1:20 Facade sections with the new horizontal shading-facade concept and integrated ventilation additions.

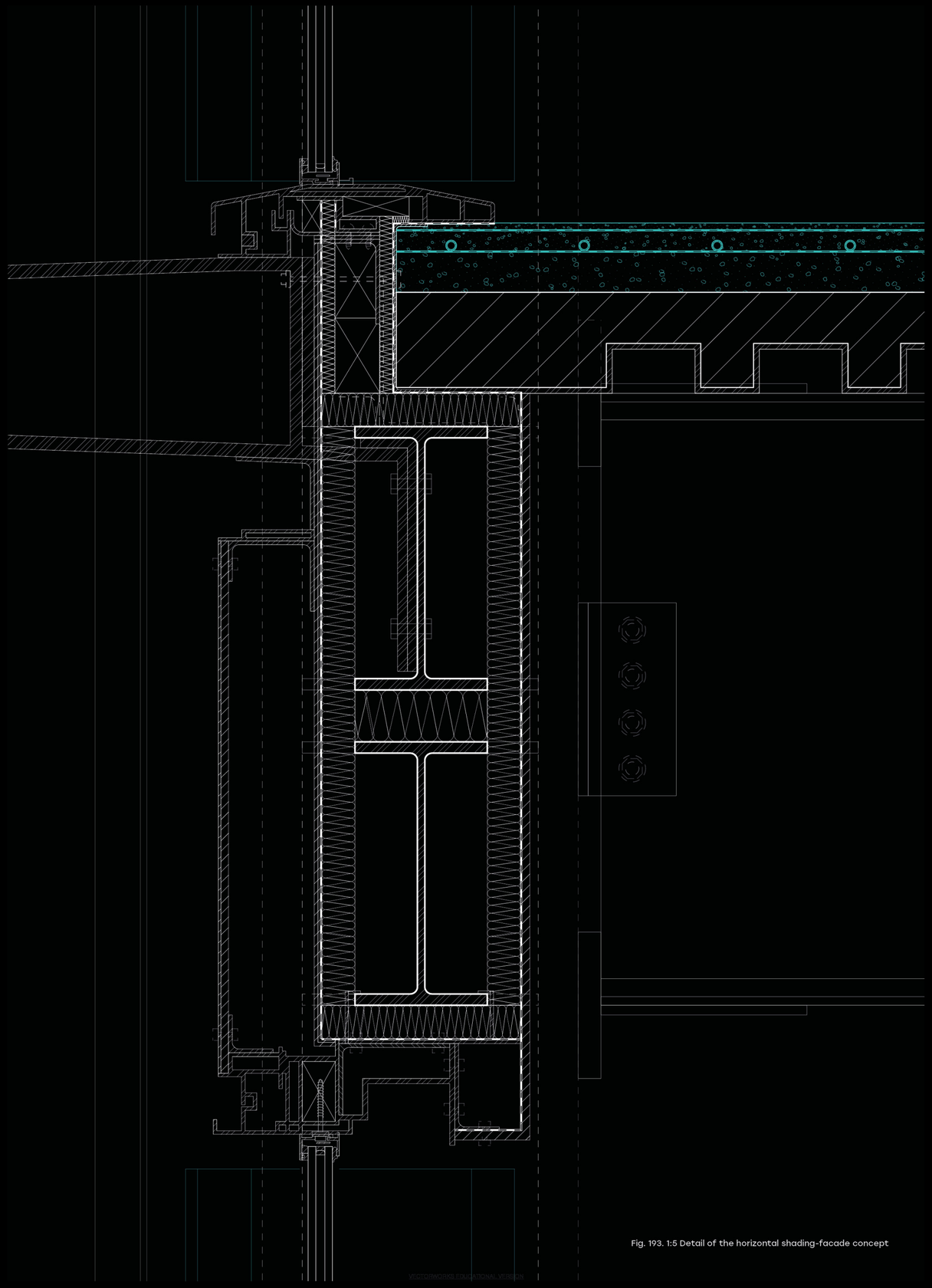


Fig. 193. 1:5 Detail of the horizontal shading-facade concept

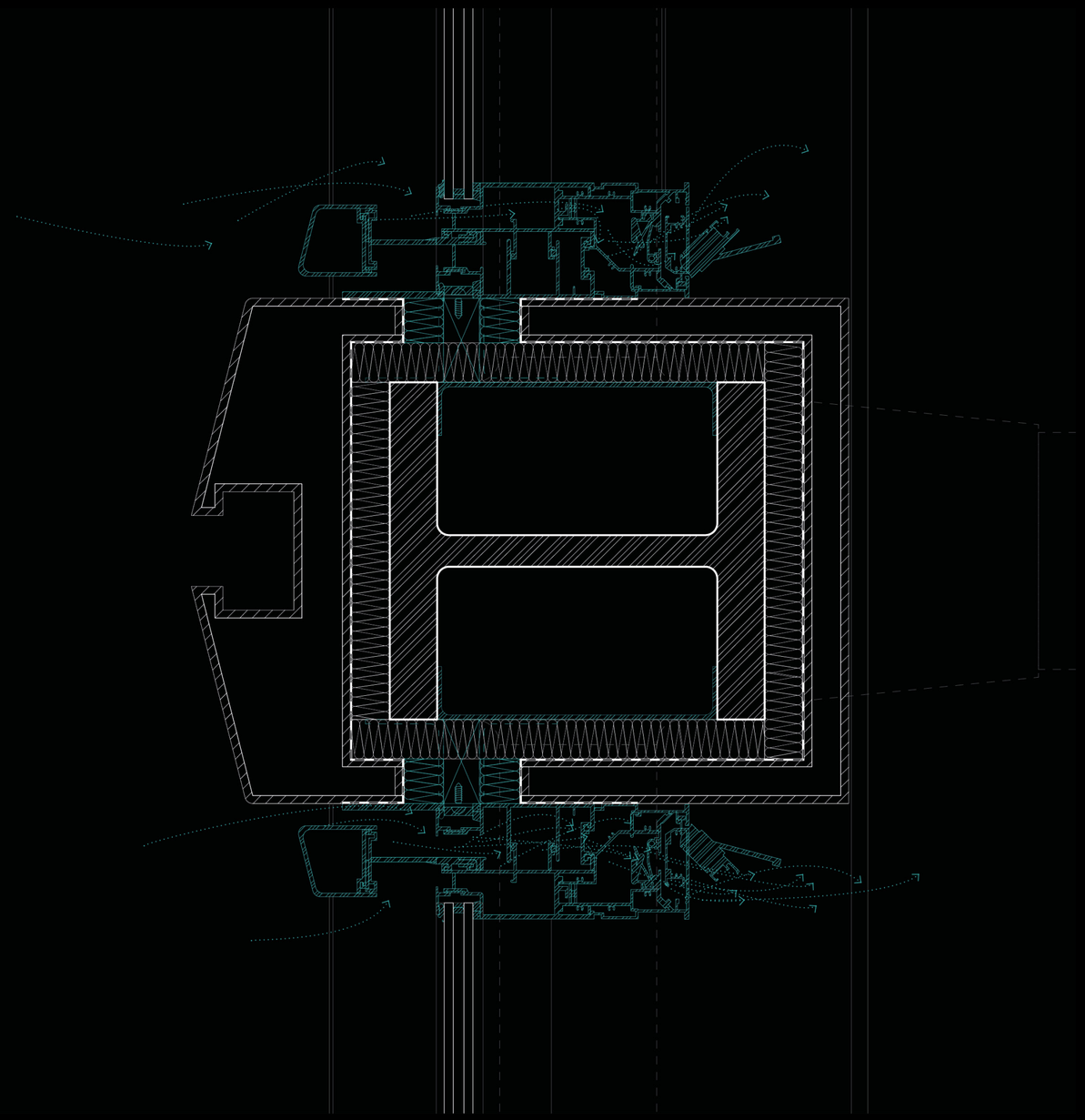


Fig. 194. 1:5 Detail of the mechanical ventilation integration concept

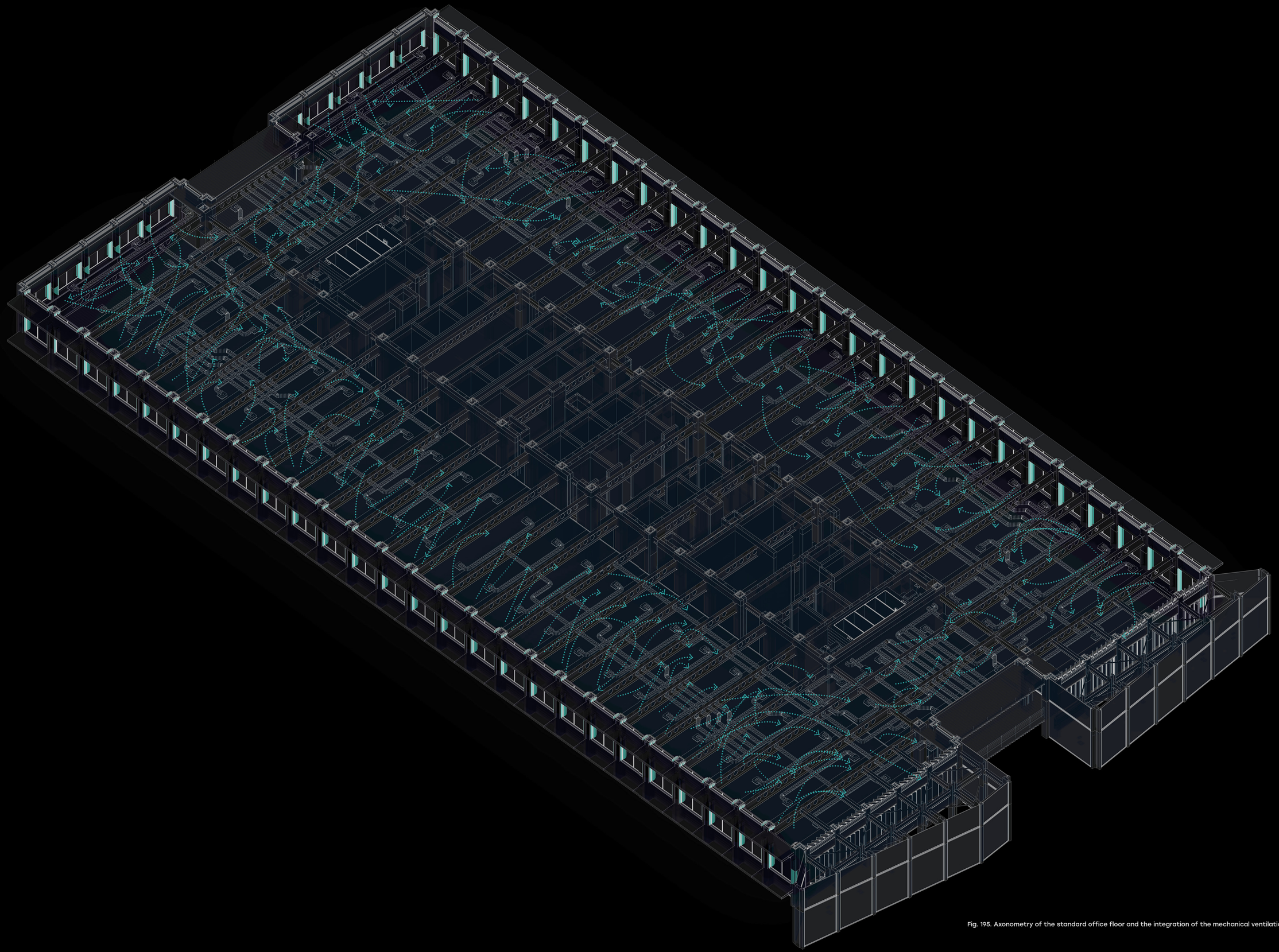


Fig. 195. Axonometry of the standard office floor and the integration of the mechanical ventilation integration.

Solar chimney

As an integrative system for the exhaust, a solar chimney is added to the South-West facing facade. Such an exhaust system is additionally considered to support the existing duct infrastructure while providing not only further reduction of energy demands but also producing energy with integrated semi-translucent solar chimney panels, referenced from the SwissTech convention-centre in Lausanne, Switzerland.

At night, the added ventilation system of the facade, the core and the solar chimney are meant to provide night-time ventilation, which is expected to cool down the additional thermal mass during the night-time hours, which further reduces energy demands during the early hours of the day.

For the winter case, the additional thermal mass with the GSHP system, as well as the wider facade openings, related to the solar exposure during the winter months, are providing similar passive effects for increasing the indoor temperature while reducing extended heating demands.

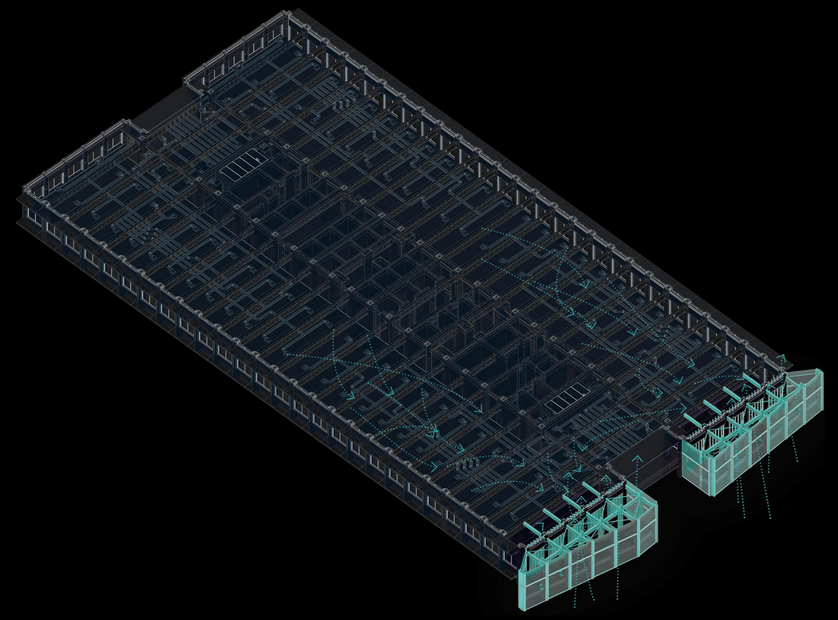


Fig. 196. Axonometry of the standard off ice floor and the integration of the solar chimney.

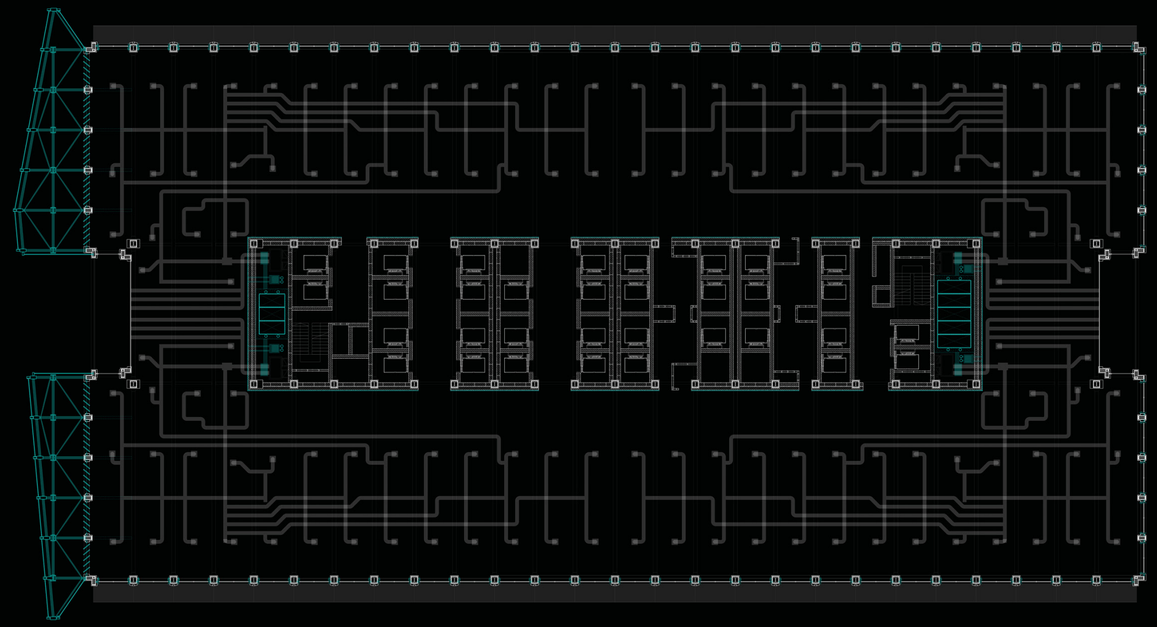


Fig. 197. Climate Concept diagrammatic floorplan

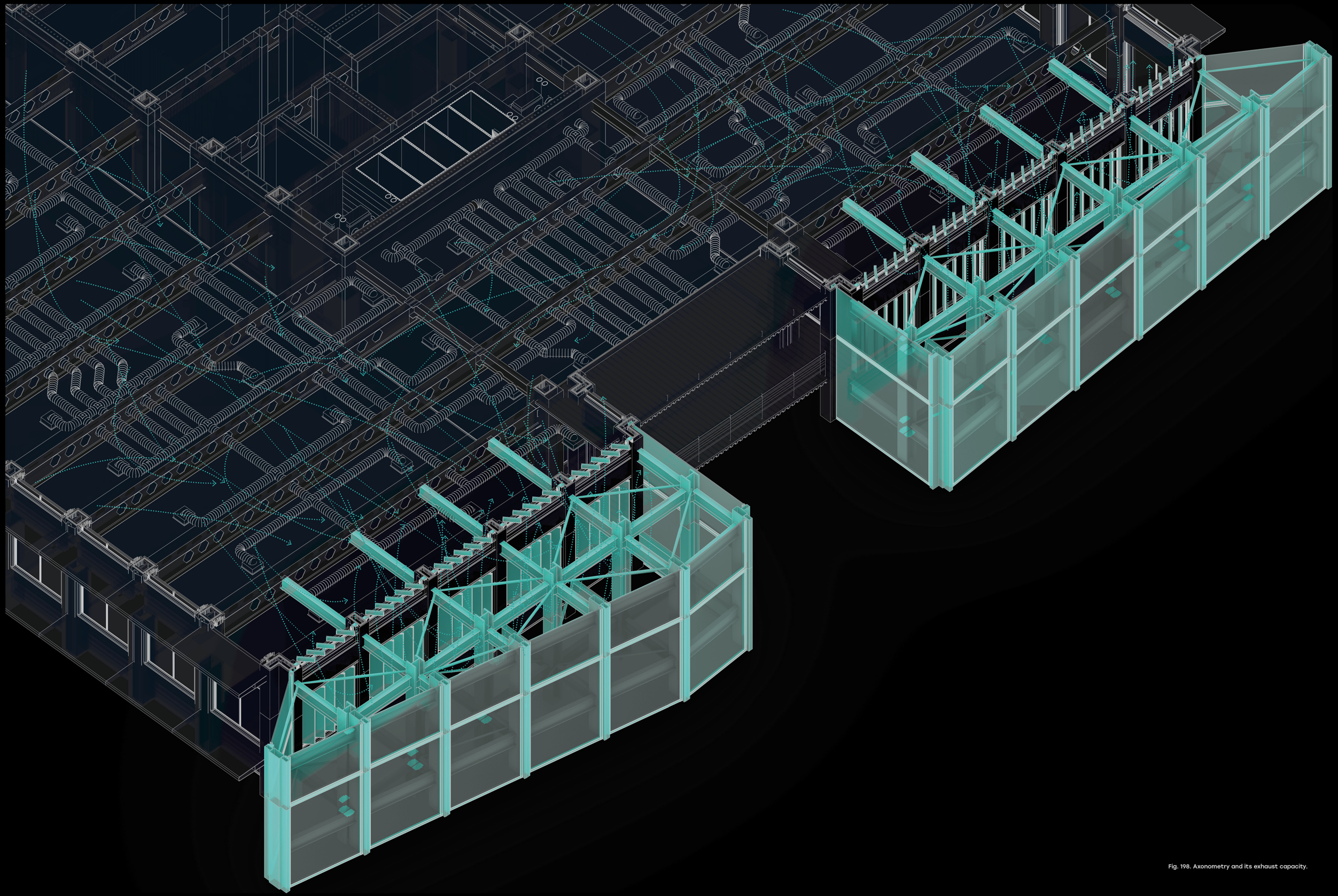


Fig. 198. Axonometry and its exhaust capacity.

4.3 Final Design

Conclusion

Conclusion

To answer the main design question, this project's research and design process has investigated the relation between Japanese vernacular architectural knowledge, specifically with the focus on passive cooling strategies, as well as eye-movement patterns, associated with relaxation, to reduce both physiological and psychological layers of heat stress within the ageing office building stock in Tokyo.

Several vernacular strategies, such as the thermal mass properties of clay, the concept of Ma and its emphasis on voids and spatial openness stimulating airflow, Uchimizu as an evaporative cooling technique and the Engawa as a transitional buffer zone, have been explored throughout the design process in working with the Kasumigaseki building to reduce primarily physiological heat stress.

The overall research-by-design process revealed that the value of the vernacular Japanese architectural knowledge lies, however, less in directly replicating traditional forms, but rather in the translation of its environmental and perceptual principles into the methodology of retrofitting a high-rise office building.

The specific spatial properties of the Kasumigaseki building's verticality with its legal requirements, building's structure, program, standard office floors, urban and environmental context, heritage and identity, have consistently informed and guided the translation of the researched vernacular strategies.

Consequently, the investigation concluded as well in a non-application of a wide range of vernacular concepts, as their applicability within the constraints of retrofitting an existing high-rise building proved to be more feasible and appropriate within new-build constructions.

The project's insights further suggest that the reduction of heat stress cannot be resolved solely through a physiological lens, as the combination of on-site observations, desk research, and VR-eye-tracking assessments emphasised the importance of stimulated horizontal eye-movement associated with an increase in relaxation and psychological thermal resilience.

Therefore, a selection of both vernacular and psychological strategies, such as layered depth, natural materials, curved lines, openness, horizontal distribution of visual stimulations, greenery, differences in heights, etc., was translated within the research-by-design process, which has been consistently assessed by the scope of the Kasumigaseki building's multi-layered retrofit pre-conditions.

Throughout the process, the concept of Suzushisa has evolved from a cultural notion of coolness into an architectural framework that resembles both physiological and psychological dimensions of thermal comfort, health, and well-being, fostering a constant dialogue between environmental performance, spatial perception, material properties and sensory experience, as well as offering an alternative approach towards performance-driven climate adaptation within existing office environments.

Lastly, the most significant finding, emerging from the research-by-design process, lies in the recognition that heat stress reduction should not be addressed solely through physiological or psychological interventions. Instead, the project revealed the crucial value of considering both dimensions iteratively through the continuous translation of research strategies across multiple scales, physical and digital studies, as well as within the VR eye-tracking assessment.

Together these components established a multi-layered methodology through which complex research findings and design principles were transformed into context-specific retrofit interventions for the Kasumigaseki Building.

Main Design Question:

How can existing office buildings in Tokyo be retrofitted to reduce both the physiological and psychological layers of heat stress through translations of Japanese vernacular architectural knowledge and spatially informed eye-movement patterns?

Main Research Question:

How do translations of Japanese vernacular architectural knowledge and spatially informed eye-movement patterns reduce the physiological and psychological layers of heat stress?

Sub RQ 01:

Which translations of Japanese vernacular architectural knowledge reduce the physiological and psychological layers of heat stress?

Sub RQ 02:

Which eye-movement patterns reduce the physiological and psychological layers of heat stress?

Fig. 199. Photograph taken in Tokyo by the author. (2025)

4.4 Final Design

IMPLICATION & RECOMMENDATIONS

Implications & Recommendations

First of all, this project is contextualised within the urgent context of Tokyo, where the Urban Heat Island phenomenon has led to a 2.86 °C increase in temperatures since 1900, to a growing demand in energy and electricity for mechanically cooling office buildings, while simultaneously growing thermal emissions emerging from conventional HVAC systems further intensify environmental conditions.

At the same time, energy conservation campaigns, such as the prominent “COOL BIZ” campaign, have shifted thermal stress into indoor work environments, while being associated until today with physical and mental health issues related to thermal discomfort and heat stress, indicating growing tensions between governmental energy conservation objectives and healthy conditions for productive indoor work environments during the intensifying Urban Heat Island phenomenon.

Additionally, while Tokyo has one of the highest office floor areas in the world with approximately 4.350 ha (≈43.499.000m²) of net rentable area at the end of 2025, the average office building age is 34,6 years old, and most of these office buildings have been built prior to the current energy efficiency standard during 1986 and 1991, resulting in an ageing office-building stock that increasingly requires adaptation to reduce energy demands, mitigate heat stress and support healthier work environments within existing environmental, societal and economic realities.

Within such urgencies, this project suggests an expanded role for architects in addressing climate adaptation beyond solely measurable environmental performance indicators. While passive cooling strategies, as well as cognitive and perceptual dimensions of comfort, remain underexplored within large-scale retrofit projects due to their limited measurability, this project attempts to translate such abstract concepts into actionable spatial strategies.

As vernacular Japanese architectural knowledge is translated into quantifiable passive cooling retrofit interventions and psychological thermal comfort is assessed by numerical eye-movement and questionnaire data, perceptual and passive environmental concepts demonstrate the potential to increasingly inform architectural decision-making.

Through this, the developed data-informed methodology gains significance for the profession by providing a clear framework through which psychological, perceptual and vernacular dimensions of climate control can be integrated systematically within large-scale projects, which simultaneously contribute to efficient heat stress reduction and healthier office work environments.

At the same time, the application of this methodology is not limited to its mitigation of heat stress but explores the potential of eye-movement patterns to support concentration, collaboration and overall workspace productivity. While the project expands its scope of health beyond thermal comfort and positions its purpose closer to the practical demands of contemporary office environments, it bridges abstract notions of spatial perception and vernacular environmental knowledge with architectural practice and its responsibility to address the needs of clients and stakeholders.

This project has offered throughout its research-by-design explorations a range of physiological and psychological heat stress mitigation strategies which consider both smaller and larger interventions into the structural and spatial conditions of the Kasumigaseki Building.

If commissioned to retrofit the Kasumigaseki Building today, the prioritisation of strategies would likely depend on their ability to simultaneously address physiological and psychological dimensions of heat stress while remaining executable within the building’s assessed preconditions.

Especially strategies including the facade adaptations, interventions concerning thermal mass and the redistribution of visual stimuli through timber elements offer the potential to improve both perceptual and physiological thermal comfort while requiring limited structural modifications. Nevertheless, the interventions regarding spatial openness can be considered as well, as they provide the client with a broader range of approaches that not only respond to environmental and perceptual challenges but also reinforce the building’s identity and heritage.

Beyond the Kasumigaseki building, the project, with its multi-layered and multi-scaled strategies, conveys the potential to inform the retrofit of other office environments facing similar challenges, as the comparative study has shown that office environments within both ageing and contemporary office buildings share similar spatial and structural characteristics.

Lastly, while the specific interventions within this project remain dependent on climatic, cultural and spatial contexts, the Urban Heat Island phenomenon itself is increasingly recognised as a global challenge and suggests an extended applicability beyond the context of Tokyo to contribute to wider discussions on climate adaptation and health-enhancing architectural practice.

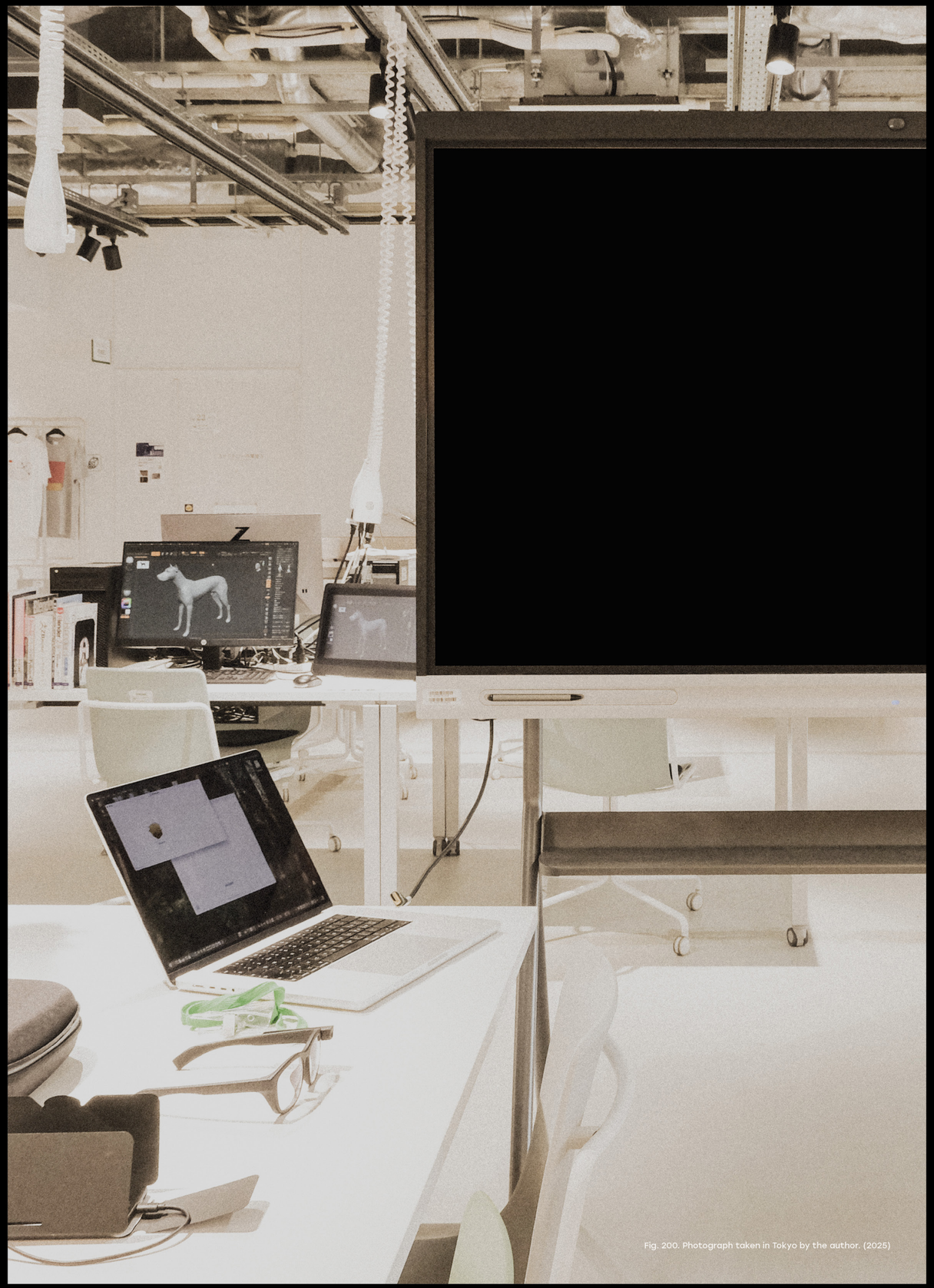


Fig. 200. Photograph taken in Tokyo by the author. (2025)

4.5 Final Design

REFLECTION

Reflection

The original aim for this project has been to retrofit the Kasumigaseki building by implementing physiological, psychological and health-enhancing spatial strategies framed by vernacular Japanese architectural knowledge. Regarding this goal, several methods were chosen in the beginning of this research-by-design project, such as physical model assessments, digital environmental studies, an elaborate immersive occupant-centred VR eye-tracking assessment, an in-depth archival-reconstruction study on the Kasumigaseki building itself, as well as three scales of interventions defining the final output of this study.

First, physical modelling proved particularly valuable throughout the process. The 1:1000 site model enabled the rapid assessment of volumetric principles and environmental airflow conditions within the surrounding urban context, while the 1:50 scale model provided a framework for exploring structural interventions and the 1:2 model functioned as a tool to critically investigate digitally developed concepts. While these studies, together with the digital environmental, structural and archival investigation, each generated in their individual application a rich and divers set of insights, their greatest value emerged through their iterative interaction throughout the project.

Extended by the VR eye-tracking assessment within the scope of occupant-centred spatial perception and psychological comfort, the project has been establishing a valuable framework, emphasising the meaning of repeated translation of findings between a multi-scaled analysis embedded within structural investigations, environmental studies, vernacular knowledge, material explorations and psychophysiological assessments. This reflection on the project's process has ultimetly emphasized for me personally the importance of continuously shifting between methods, scales and forms of knowledge, enabling the translation of complex findings into well-informed architectural interventions.

Beyond the multi-layered process itself, this project has further strengthened my original fascination in how data can bridge architecture with health and well-being, while simultaneously translating this interest into a much more tangible design approach. Especially the VR eye-tracking assessment has personally emerged as the most impactful individual study, as it transformed spatial-cognitive perception and psychophysiological comfort into measurable data, which ultimately has driven the integration of physiological, psychological and vernacular design strategies into the specific retrofit context of the Kasumigaseki building.

At the same time, the value of this assessment should not be regarded solely in the generation of scientific data, but rather in its continuous dialogue with the broader research-by-design process, as repeated translation between the eye-tracking findings and the multi-scaled design investigations enabled the integration, filtering and adaptation of research insights within the retrofit proposal.

Within such research and design duality of translating abstract and often immeasurable concepts into quantifiable and actionable design knowledge revealed to myself a methodology, which I consider as a valuable learning for my future practice, in which design and research develop in continuous dialogue and iteratively inform one another into architectural decision-making.

One of the most significant skills developed throughout this project has been the ability to continuously shift between detailed investigations, design explorations, research assessments and broader project oversight. Due to the complexity of combining the retrofit ambitions of a high-rise office building with physiological and psychological layers of heat stress, digital and physical assessments, immersive occupant-centred research and multiple scales of intervention, an understanding of both individual project components and the overall design direction became essential throughout the process.

Especially the additional VR eye-tracking assessment next to the Explore Lab format, which already demanded extended preparation and coordination, needed to evolve sufficiently in scale to inform the design project with a credible base of insights, while allowing the design development itself to emerge sufficiently.

The aspect of a guiding schedule, the weekly shift in scale, expertise and modes of working where highly crucial for maintaining general oversight and remains, as well as a learning that I intend to carry forward into my future practice.

Simultaneously, the project also confronted me with a tendency towards less efficient refinements, as the digital reconstruction of the Kasumigaseki Building was repeatedly revised as new archival information emerged and the digital model continued to increase in complexity. While this revision, for instance, was intended to improve the accuracy of the overall retrofit interventions, the additional time invested often generated only limited new insights.

Therefore, this project has further emphasised personally the valuable lesson that it is important to recognise when a particular component has reached a sufficient level of development and when attention should instead be redirected towards other aspects of the project. As a becoming architect aiming to maintain a continuous dialogue between research and design, this awareness of balancing refinement with prioritisation remains the final important learning emerging from this process.



Fig. 201. Photograph taken in Tokyo by the author. (2025)

List of Figures

List of Figures

List of Figures

Fig. 05. Migrate, N., & Observatory, N. E. (2026, January 31). Heating Up in Tokyo - NASA Science. NASA Science. https://science.nasa.gov/earth/earth-observatory/heating-up-in-tokyo-148616/.

Fig. 06. 三輪令子. (2019, July 4). クールビズではなく、“スーパー”クールビズを知っていますか? tenki.jp. https://tenki.jp/suppl/r_miwa/2019/07/04/29232.html

Fig. 07. 土岐三菱自動車販売株式会社. (2025, April 23). 「クールビズ」はじめました!! https://tokimitsu.com/pages/23?detail=1&b_id=121&r_id=2687.

Fig. 08. Dooley, B., & Ueno, H. (2023, September 24). How Japan's salarymen embraced short sleeves through "Cool Biz". The New York Times.

Fig. 09. Le short au bureau, vraiment ? (2025, July 1). Courrier International. https://www.courrierinternational.com/stories/style-le-short-au-bureau-vraiment_220126_1.

Fig. 10. クールビズ実施のご案内|関西大学環境保全. (n.d.). https://www.kansai-u.ac.jp/energy/news/2024/05/post-28.html

Fig. 11. Xymax Real Estate Institute Corporation. (2025). Office Stock Pyramid 2025. https://www.xymax.co.jp/english/assets/pdf/news_research/20250115_2.pdf.

Fig. 12. 速水健朗. (2023, December 30). オフィスオートメーションと官僚制. Pen Online. https://www.pen-online.jp/article/015026.html.

Fig. 21. MITSUI FUDOSAN | Corporate Information | News Releases. (n.d.). https://www.mitsuifudosan.co.jp/english/corporate/news/2018/0411/.

Fig. 29. Goto, S., Takase, H., Yamaguchi, K., Kato, T., Sun, M., Koga, A., Liang, T., Poy, I. A., & Herrup, K. (2025). Eye movement patterns drive stress reduction during Japanese garden viewing. Frontiers in Neuroscience, 19, 1581080. https://doi.org/10.3389/fnins.2025.1581080.

Fig. 30. Goto, S., Takase, H., Yamaguchi, K., Kato, T., Sun, M., Koga, A., Liang, T., Poy, I. A., & Herrup, K. (2025). Eye movement patterns drive stress reduction during Japanese garden viewing. Frontiers in Neuroscience, 19, 1581080. https://doi.org/10.3389/fnins.2025.1581080.

Fig. 31. Goto, S., Takase, H., Yamaguchi, K., Kato, T., Sun, M., Koga, A., Liang, T., Poy, I. A., & Herrup, K. (2025). Eye movement patterns drive stress reduction during Japanese garden viewing. Frontiers in Neuroscience, 19, 1581080. https://doi.org/10.3389/fnins.2025.1581080.

Fig. 35. Jiro Harada, 1936, The Lesson of Japanese Architecture, pp.55.

Fig. 36. Japan House London. (2023, November 22). Japanese Houses – Japan House London. https://www.japanhouselondon.uk/read-and-watch/japanese-houses/.

Fig. 37. Prokopljević, J. (2020, September 15). Intermediate space. Blog De Fundación Arquia | Blog De Arquitectura Y Arquitectos. https://blogfundacion.arquia.es/en/2020/08/intermediate-space/.

Fig. 38. Kuniyoshi, U. (n.d.). Japanese Print „Natsu 夏 (Summer) / Shiki no Uchi 四季の内 (The Four Seasons). https://ukiyo-e.org/image/bm/AN00508857_001_l.

Fig. 39. Yusuhara Wooden Bridge Museum. (n.d.). Kengo Kuma and Associates. https://kkaa.co.jp/en/project/yusuhara-wooden-bridge-museum/.

Fig. 45. Pano360 Lite. (n.d.). https://360gigapixels.com/tokyo-tower-panorama-photo/embed.html.

Fig. 46. Google Earth. (n.d.). https://earth.google.com/web/search/kasumigaseki.

Fig. 47. Google Earth. (n.d.). https://earth.google.com/web/search/kasumigaseki.

Fig. 48. Google Earth. (n.d.). https://earth.google.com/web/search/kasumigaseki.

Fig. 49. Google Earth. (n.d.). https://earth.google.com/web/search/kasumigaseki.

Fig. 50. Google Earth. (n.d.). https://earth.google.com/web/search/kasumigaseki.

Fig. 51. Google Earth. (n.d.). https://earth.google.com/web/search/kasumigaseki.

Fig. 54. oldthing. (n.d.). Tokio Tōkyō (東京) Kasumigaseki.. | Postcards affordable. Oldthing. https://oldthing.de/Tokio-Tky--Kasumigaseki-Building-Breakingthrough-the-quake-barrier-1978-0056413611.

Fig. 56. Shin Kasumigaseki Building | Projects Top | Shinkenchiku.DATA. (n.d.). https://data.shinkenchiku.online/en/projects/articles/SK_1987_05_253-0.

Fig. 58. 2005.01.07 | 日鉄興和不動産 コーポレートサイト. (n.d.). 日鉄興和不動産 コーポレートサイト. https://www.nskre.co.jp/company/news/nscp/2005/20050107.html

Fig. 60. TOKYO CLUB BUILDING | Projects Top | Shinkenchiku.DATA. (n.d.). https://data.shinkenchiku.online/en/projects/articles/SK_2007_12_202-0.

Fig. 62.【赤坂インターシティAIR】ポップアップストアやプロモーションに適した超高層複合ビルのイベントスペース(2Fロビー エスカレータ横). (n.d.). ショップカウンター. https://shopcounter.jp/spaces/W3eJfk.

Fig. 64. Meyer, U. (2021, January 14). Below the Atago Mountain in Tokyo. World-Architects. https://www.world-architects.com/en/architecture-news/insight/below-the-atago-mountain-in-tokyo.

Fig. 66. T-LITE | Projects Top | Shinkenchiku.DATA. (n.d.). https://data.shinkenchiku.online/en/projects/articles/SK_2024_03_054-0.

Fig. 68. TORANOMON HILLS STATION TOWER | Projects Top | Shinkenchiku.DATA. (n.d.). https://data.shinkenchiku.online/en/projects/articles/SK_2024_03_040-0.

Fig. 70. TORANOMON ALCEA TOWER | Projects Top | Shinkenchiku.DATA. (n.d.). https://data.shinkenchiku.online/en/projects/articles/SK_2025_06_038-0.

Fig. 74. Crook, L., & Crook, L. (2022, February 3). Long-awaited Taipei Performing Arts Center by OMA captured ahead of opening. Dezeen. https://www.dezeen.com/2021/12/02/taipei-performing-arts-center-by-oma-opening-announcement/

Fig. 75. Agadir Convention Centre. (n.d.). OMA. https://www.oma.com/projects/agadir-convention-centre

Fig. 76. Leaf Publications Co., Ltd. (2020, April 30). The Pagoda of Yasaka and its aftermath. Leaf KYOTO. https://www.leafkyoto.net/en/makai/2020/05/yasakanotou/.

List of Figures

Fig. 77. RADIO & TELEVISION BUILDING (VRT II) – Brussels. (n.d.). Office KGDVS. https://officekgdvs.com/projects/324

Fig. 78. Stegmüller, C., Eugster, D., & Unterfinger, E. (2024, January 24). Seifenblasen aus Beton und Plastik. SWI swissinfo.ch. https://www.swissinfo.ch/ger/wirtschaft/seifenblasen-aus-beton-und-plastik/47001032.

Fig. 79. RADIO & TELEVISION BUILDING (RTS) – Lausanne. (n.d.). Office KGDVS. https://officekgdvs.com/projects/176.

Fig. 80. ARVO PÄRT CENTRE – Laulasmaa. (n.d.). Office KGDVS. https://officekgdvs.com/projects/171.

Fig. 81. OMA . Très Grande Bibliothèque . Paris Tegmark afasia (23). (n.d.). AFASIAARCHZINE.COM. https://afasiaarchzine.com/2025/09/tres-grande-bibliotheque-paris-oma/oma-tres-grande-bibliotheque-paris-tegmark-afasia-23/.

Fig. 82. Chen, C. (2025, May 28). Jianshang Sports Complex / CCDI. ArchDaily. https://www.archdaily.com/992154/jianshang-sports-complex-ccdi.

Fig. 83. Chen, C. (2025, May 28). Jianshang Sports Complex / CCDI. ArchDaily. https://www.archdaily.com/992154/jianshang-sports-complex-ccdi.

Fig. 84. Chen, C. (2025, May 28). Jianshang Sports Complex / CCDI. ArchDaily. https://www.archdaily.com/992154/jianshang-sports-complex-ccdi.

Fig. 85. OMA. (n.d.). AFASIAARCHZINE.COM. https://afasiaarchzine.com/2011/11/oma_26-6/.

Fig. 86. Burton, E. (2025, February 13). Celebrating crafts from the past: Reviving Kintsugi. Design Dash. https://designdash.com/art/celebrating-crafts-from-the-past-reviving-kintsugi/.

Fig. 87. OMA. (2025, December 9). AFASIAARCHZINE.COM. https://afasiaarchzine.com/2025/09/tres-grande-bibliotheque-paris-oma/.

Fig. 88. OMA. (2025, December 9). AFASIAARCHZINE.COM. https://afasiaarchzine.com/2025/09/tres-grande-bibliotheque-paris-oma/.

Fig. 104. Ikeda, T., Abe, A., Inuzuka, I., & Ochi, T. (1967). 霞ヶ関ビル エレベータ群の輸送能力検討―出勤時におけるロビーの混雑状態分析とその対策. 日立評論, 49(10), 1013–1020.

Fig. 125. Kasumigaseki Building Construction Committee. (1968). Kasumigaseki Building 霞が関ビルディング. Mitsui Fudosan.

Fig. 127. Burton, E. (2025, February 13). Celebrating crafts from the past: Reviving Kintsugi. Design Dash. https://designdash.com/art/celebrating-crafts-from-the-past-reviving-kintsugi/.

Fig. 128. Yusuhara Wooden Bridge Museum. (n.d.). Kengo Kuma and Associates. https://kkaa.co.jp/en/project/yusuhara-wooden-bridge-museum/.

Fig. 143. Gaisma. (n.d.). Tokyo, Japan: Sunrise, sunset, dawn and dusk times. https://www.gaisma.com/en/location/tokyo.html.

Fig. 173. 吉田美帆. (2020, March 3). 土間のある暮らしのおすすめ。歴史感じる懐かしい暮らしのメリットとは? Housing Stage. https://www.housingstage.jp/topics/topics-21206.

Fig. 183.【赤坂インターシティAIR】ポップアップストアやプロモーションに適した超高層複合ビルのイベントスペース(2Fロビー エスカレータ横). (n.d.). ショップカウンター. https://shopcounter.jp/spaces/W3eJfk.

Fig. 184. LIXIL. (2018). 赤坂インターシティ AIR 基準部アルミカーテンウォール [Akasaka Intercity AIR standard aluminum curtain wall]. LIXIL Building Business Division.

Literature

Literature

Literature

Adeniyi, M. (2022). Impacts of Environmental Stressors on Autonomic Nervous System. In T. Aslanidis & C. Nouris (Eds), Physiology (Vol. 14). IntechOpen. https://doi.org/10.5772/intechopen.101842

ASHRAE. Thermal Environmental Conditions for Human Occupancy; ANSI/ASHRAE Standard 55-2017;American Society of Heating, Refrigerating and Air-Conditioning Engineers: Atlanta, GA, USA, 2017.

Benson, H. (1985). Stress, Health, and the Relaxation Response. In W. D. Gentry, H. Benson, & C. J. Wolff (Eds), Behavioral Medicine: Work, Stress and Health (pp. 15–32). Springer Netherlands. https://doi.org/10.1007/978-94-009-5179-2_2

Bognár, B. (1985). Contemporary Japanese architecture: Its development and challenge. Van Nostrand Reinhold.

Building Standards Act. (n.d.). Japanese Law Translation. Ministry of Justice, Japan. https://www.japaneselawtranslation.go.jp/en/laws/view/4024/en.

European Commission. (2018). Promoting physical activity in education: Factsheet. European Commission. https://sport.ec.europa.eu/sites/default/files/promoting-physical-activity-in-education-factsheet-2018_ennew.pdf

Friedman, M. S., Brandon, J. R., & Walker Art Center (Eds). (1986). Tokyo: Form and spirit ; [publ. on the occasion of the exhibition Tokyo: Form and Spirit organized by Walker Art Center in collaboration with Japan House Gallery]. Exhibition Tokyo: Form and Spirit. Abrams.

Fujimori, T., & Fujitsuka, M. (2017). Japan's wooden heritage: A journey through a thousand years of architecture (H. Larrabee, Trans.; First edition). Japan Publishing Industry Foundation for Culture.

Gao, X., Geng, Y., Spengler, J. D., Long, J., Liu, N., Luo, Z., Kalantari, S., & Zhuang, W. (2025). Evaluating the impact of spatial openness on stress recovery: A virtual reality experiment study with psychological and physiological measurements. Building and Environment, 269, 112434. https://doi.org/10.1016/j.buildenv.2024.112434

Gondo, T. (2021). Technological development in the construction of Kasumigaseki Building: Japan's first super high-rise. In J. Mascarenhas-Mateus, A. P. Pires, M. M. Caiado, & I. Veiga, History of Construction Cultures (1st edn, pp. 100–107). CRC Press. https://doi.org/10.1201/9781003173359-14

Goto, S., Takase, H., Yamaguchi, K., Kato, T., Sun, M., Koga, A., Liang, T., Poy, I. A., & Herrup, K. (2025). Eye movement patterns drive stress reduction during Japanese garden viewing. Frontiers in Neuroscience, 19, 1581080. https://doi.org/10.3389/fnins.2025.1581080

He, S., Qi, D., Guo, E., Wang, L., Ouyang, Y., & Zheng, L. (2025). Monitoring Construction Workers' Mental Workload Due to Heat Exposure Using Heart Rate Variability and Eye Movement: A Study on Pipe Workers. Sensors, 25(8), 2377. https://doi.org/10.3390/s25082377

Heat stress: what is it and how is it measured? (n.d.-b). Copernicus. https://climate.copernicus.eu/heat-stress-what-it-and-how-it-measured

Hirano, Y., & Fujita, T. (2012). Evaluation of the impact of the urban heat island on residential and commercial energy consumption in Tokyo. Energy, 37(1), 371–383. https://doi.org/10.1016/j.energy.2011.11.018

Holzhueter, K., & Holzhueter, K. (2025b, December 4). Tataki: Japanese traditional earthen floor - The last straw. The Last Straw - The Alternative Journal of Design And Construction. https://www.thelaststraw.org/tataki-japanese-traditional-earthen-floor/

Hosham, A. F., & Kubota, T. (2019). Effects of Building Microclimate on the Thermal Environment of Traditional Japanese Houses during Hot-Humid Summer. Buildings, 9(1), 22. https://doi.org/10.3390/buildings9010022

Ichinowatari, K. (Ed.). (1981). Japan: Climate, space, and concept. Process Architecture Publ.

Ihara, T., Kikegawa, Y., Asahi, K., Genchi, Y., & Kondo, H. (2008). Changes in year-round air temperature and annual energy consumption in office building areas by urban heat-island countermeasures and energy-saving measures. Applied Energy, 85(1), 12–25. https://doi.org/10.1016/j.apenergy.2007.06.012

Ikeda, T., Abe, A., Inuzuka, I., & Ochi, T. (1967). Transportation capacity of elevators for Kasumigaseki Building: Congested situation analysis of the starting lobby in up peak pattern and its solution system [エレベータ群の輸送能力検討—出勤時におけるロビーの混雑状態分析とその対策]. Hitachi Hyoron (Hitachi Review), 49(10), 1013–1020

Kawashima, C., & Riggs, L. E. (1989). Minka: Traditional houses of rural Japan (2. Aufl). Kodansha.

Kumagai, R. (2019). The Kasumigaseki Building's Planning and Technology: Japan's First Skyscraper from the Viewpoint of Renewal. In CIB World Building Congress 2019. https://www.irbnet.de/daten/iconda/CIB_DC33582.pdf

Liang, T., Goto, S., & Sun, M. (2025). The eye movement behavior induced by the design of a Japanese garden and its correlation with relaxation effects. Archnet-IJAR: International Journal of Architectural Research, 19(4), 924–946. https://doi.org/10.1108/ARCH-04-2024-0128

Lu, Z., & Pesarakli, H. (2023). Seeing Is Believing: Using Eye-Tracking Devices in Environmental Research. HERD: Health Environments Research & Design Journal, 16(1), 15–52. https://doi.org/10.1177/19375867221130806

Migrate, N., & Observatory, N. E. (2025, October 23). Heating up in Tokyo - NASA Science. NASA Science. https://science.nasa.gov/earth/earth-observatory/heating-up-in-tokyo-.

Miyazaki, T., Akisawa, A., & Nikai, I. (2011). The cooling performance of a building integrated evaporative cooling system driven by solar energy. Energy and Buildings, 43(9), 2211–2218. https://doi.org/10.1016/j.enbuild.2011.05.004

Nishii, K., Hozumi, K., Horton, H. M., & Nishii, K. (1999). What is Japanese architecture? (5. ed). Kodansha Internat.
Ohashi, Y., Genchi, Y., Kondo, H., Kikegawa, Y., Yoshikado, H., & Hirano, Y. (2007). Influence of Air-Conditioning Waste Heat on Air Temperature in Tokyo during Summer: Numerical Experiments Using an Urban Canopy Model Coupled with a Building Energy Model. Journal of Applied Meteorology and Climatology, 46(1), 66–81. https://doi.org/10.1175/JAM2441.1

Pourbakht, M. (2025). Passive design strategies in traditional Japanese architecture: A case study of the Chochikukyo house. Open Science Journal, 10(1). https://doi.org/10.23954/osj.v10i1.3685

Rauch, M., & Sauer, M. (2017). Gebaute Erde: Gestalten & Konstruieren mit Stampflehm (O. Kapfinger, Ed.; 2., korrigierte Auflage). DETAIL - Institut für internationale Architektur-Dokumentation GmbH & Co. KG.

Literature

Ren, J., Shi, K., Li, Z., Kong, X., & Zhou, H. (2023). A Review on the Impacts of Urban Heat Islands on Outdoor Thermal Comfort. Buildings, 13(6), 1368. https://doi.org/10.3390/buildings13061368

Rony, M. K. K., & Alamgir, H. M. (2023). High temperatures on mental health: Recognizing the association and the need for proactive strategies–A perspective. Health Science Reports, 6(12), e1729. https://doi.org/10.1002/hsr2.1729

Shapiro, F. (1999). Eye Movement Desensitization and Reprocessing (EMDR) and the Anxiety Disorders. Journal of Anxiety Disorders, 13(1–2), 35–67. https://doi.org/10.1016/S0887-6185(98)00038-3

Shrestha, A., & Shimizu, T. (2023). A Field Investigation on the Thermal Environment of Traditional Japanese Houses at UNESCO World Heritage Site: A Case Study of Former Oka House at Iwami Ginzan Silver Mine in the Omori Area in Oda City. In B. Faircloth, M. Pedersen Zari, M. R. Thomsen, & M. Tamke (Eds), Design for Climate Adaptation (pp. 59–78). Springer International Publishing. https://doi.org/10.1007/978-3-031-36320-7_5

Solcerova, A., Van Emmerik, T., Hilgersom, K., Van De Ven, F., & Van De Giesen, N. (2018). Uchimizu: A Cool(ing) Tradition to Locally Decrease Air Temperature. Water, 10(6), 741. https://doi.org/10.3390/w10060741

Tanabe, S., Haneda, M., & Nishihara, N. (2015). Workplace productivity and individual thermal satisfaction. Building and Environment, 91, 42–50. https://doi.org/10.1016/j.buildenv.2015.02.032

Terada, T. (n.d.). Ryōmi sūdai [涼味数題]. Aozora Bunko. https://www.aozora.gr.jp/cards/000042/files/2485_10341.html

Xymax Real Estate Institute. (2023b). The future of the office. https://www.xymax.co.jp/english/assets/pdf/news_research/20230508_2.pdf

Xymax Real Estate Institute Corporation. (2025). Office Stock Pyramid 2025. https://www.xymax.co.jp/english/assets/pdf/news_research/20250115_2.pdf

Zhu, D., Mortazavi, S. M., Maleki, A., Aslani, A., & Yousefi, H. (2020). Analysis of the robustness of energy supply in Japan: Role of renewable energy. Energy Reports, 6, 378–391. https://doi.org/10.1016/j.egyr.2020.01.011

朝日新聞. (2024, July 25). 官僚たちの夏「暑くて仕事にならない」冷房下げられない霞が関の事情. 朝日新聞. https://www.asahi.com/articles/ASS7T3TG4S7TUTFK00TM.html

気象庁 Japan Meteorological Agency. (n.d.). 気象庁|過去の気象データ検索. https://www.data.jma.go.jp/stats/etrn/view/hourly_s1.php?prec_no=44&block_no=47662&year=2025&month=08&day=31&view=g_wsp

5. Appendix

Detailed Eye-tracking data analysis

Detailed Eye-tracking data analysis

Appendix

