Concrete reconsidered

by

Pjotter Dekkers

In partial fulfilment of the requirements for the degree of
Master of Science
at Delft University of Technology,
to be defended publicly on 19 June 2026.

Faculty: Faculty of Architecture and the Built Environment
Department: Architecture
Programme: Architectural Engineering

Mentors / Supervisors: Anne Snijders
Stephan Verkuijlen
Graduation committee: Marcel Bilow

An electronic version of this thesis is available at http://repository.tudelft.nl

TU Delft

25-10-2017 KM

Keywords:
Parking Garage
Transformation Project
4-Helix model
Innovation hub

Abstract

Eindhoven is entering a new phase of urban and technological growth. Around the railway station, KnoopXL will intensify the city through new housing, workspaces, public space and mobility infrastructure. At the same time, Eindhoven's mobility vision shifts attention away from the private car toward connection, accessibility, making space, health and human-centred movement. These transitions create pressure on existing urban structures, particularly concrete parking garages that were designed for a car-oriented city but now occupy strategic central locations.

This graduation project investigates how the Q-Park Mathildelaan parking garage can be transformed through subtractive architecture, structural retention and on-site material reuse. The project does not approach the garage as an empty plot for redevelopment, but as an existing spatial and material resource. Its concrete frame, TT floor elements, ramps, facade balustrades and central spiral are treated as the starting point for architectural transformation.

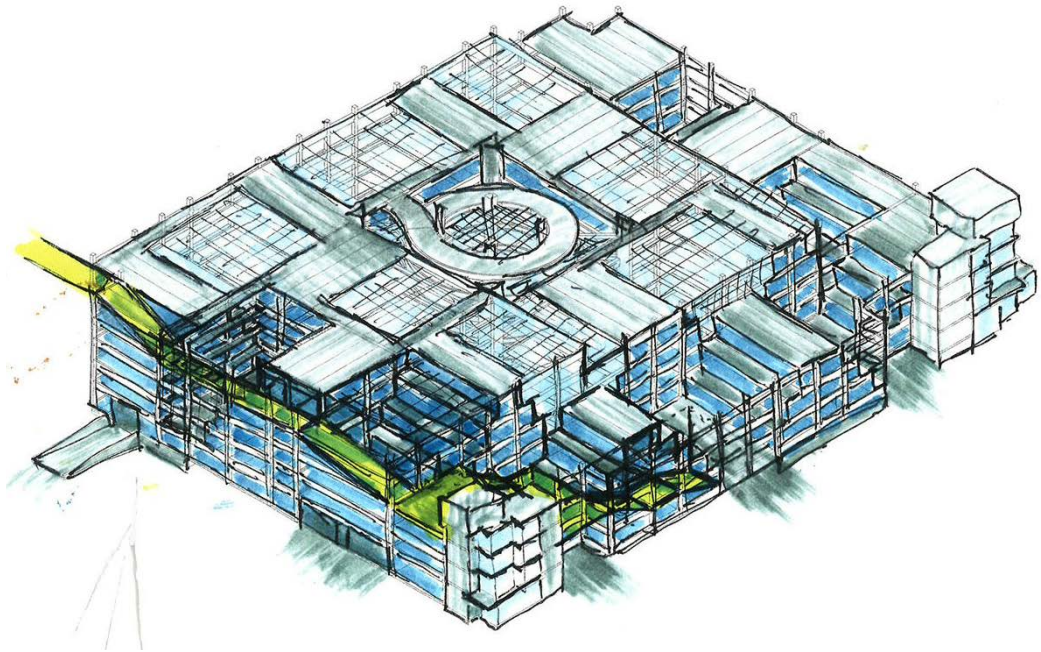
The design proposes a shift from car scale to human scale. Selective removal of floor elements introduces daylight, orientation, atria, terraces, bridges and new circulation routes. Removed concrete elements and facade components are harvested and reused where possible within the project. The building is reprogrammed as a public innovation and mobility hub, combining shared mobility, university-related spaces, startups, MKB workspaces, larger innovation offices, exhibition, event space and collective public areas.

By connecting circular transformation with the Quadruple Helix model, the project positions architecture as a public interface between innovation and everyday urban life. The result is not only a proposal for one garage in Eindhoven, but a design method for reconsidering similar parking structures in Dutch city centres.

25-10-2017 KM

Concrete Reconsidered

Carving the human network



Graduation Report

Pjotter Dekkers
5073286
AR4AE020 - Architectural Engineering Graduation Studio (2025/26 Q2)
Anne Snijders & Stephan Verkuijlen

ABSTRACT

Eindhoven is entering a new phase of urban and technological growth. Around the railway station, KnoopXL will intensify the city through new housing, workspaces, public space and mobility infrastructure. At the same time, Eindhoven's mobility vision shifts attention away from the private car toward connection, accessibility, making space, health and human-centred movement. These transitions create pressure on existing urban structures, particularly concrete parking garages that were designed for a car-oriented city but now occupy strategic central locations.

This graduation project investigates how the Q-Park Mathildelaan parking garage can be transformed through subtractive architecture, structural retention and on-site material reuse. The project does not approach the garage as an empty plot for redevelopment, but as an existing spatial and material resource. Its concrete frame, TT floor elements, ramps, facade balustrades and central spiral are treated as the starting point for architectural transformation.

The design proposes a shift from car scale to human scale. Selective removal of floor elements introduces daylight, orientation, atria, terraces, bridges and new circulation routes. Removed concrete elements and facade components are harvested and reused where possible within the project. The building is reprogrammed as a public innovation and mobility hub, combining shared mobility, university-related spaces, startups, MKB workspaces, larger innovation offices, exhibition, event space and collective public areas.

By connecting circular transformation with the Quadruple Helix model, the project positions architecture as a public interface between innovation and everyday urban life. The result is not only a proposal for one garage in Eindhoven, but a design method for reconsidering similar parking structures in Dutch city centres.

TABLE OF CONTENT

1. Introduction: Eindhoven, growth and the post-car city	p. 6
2. Problem statement, research question and subquestions	p. 10
3. Theoretical background	p. 16
4. Methodology	p. 32
5. Site and urban strategy	p. 36
6. Existing building analysis	p. 44
7. Design framework: carving the human network	p. 54
8. Program strategy	p. 58
9. Design proposal	p. 64
10. Conclusion and reflection	p. 96
11. Appendix	p. 98
12. Source list	p. 140

1. INTRODUCTION

Eindhoven has repeatedly been shaped by periods of accelerated development. Industrial expansion, post-war reconstruction and the later growth of the Brainport ecosystem each produced new buildings, infrastructures and spatial logics. The current phase of growth is again linked to technology and innovation, but it takes place under different environmental and social conditions. Urban space is scarce, construction materials have a high environmental impact and cities are expected to reduce carbon emissions and material waste.

The tension is visible around Eindhoven Central Station. KnoopXL proposes a high-density transformation of the station area, with new towers, public routes, green spaces and mixed urban programmes. This development strengthens Eindhoven as a metropolitan centre, but it also raises a critical question: should urban growth continue to rely mainly on demolition and new construction, or can the city also grow by transforming the structures that already exist?

At the same time, Eindhoven's mobility vision describes a future in which mobility is not only a technical system of vehicles and flows, but a human-centred condition that supports connection, freedom, making space, safety, clean air, health and relaxation. This is directly relevant to parking structures. Buildings that were once central to car accessibility now become spatially questionable in a city that wants to give more room to pedestrians, cycling, public transport, shared mobility and urban life.

The Mathildelaan parking garage is located exactly within this transition. It is a large concrete building designed around the logic of the car, but it stands at a strategic edge between the city centre, Strijp-S, the railway zone and KnoopXL. Its current function is mono-functional and car-oriented, yet its location and structure contain significant urban potential. Demolishing it would remove a large material stock and repeat a linear development model. Transforming it creates the possibility to connect mobility transition, circular construction and public innovation within one architectural project.



Figure 2. Map brainport Eindhoven adressing in red buildings or neigbourhoods that were or are (partly) being demolished to build new housing.And in yellow it is adressing were all high-/deeptech campuses are. (Own work)

(LapLab, n.d.)
(The fututе level, n.d.)
(Data Eindhoven, n.d.)
(Omgevingsvisie Eindhoven, n.d.)

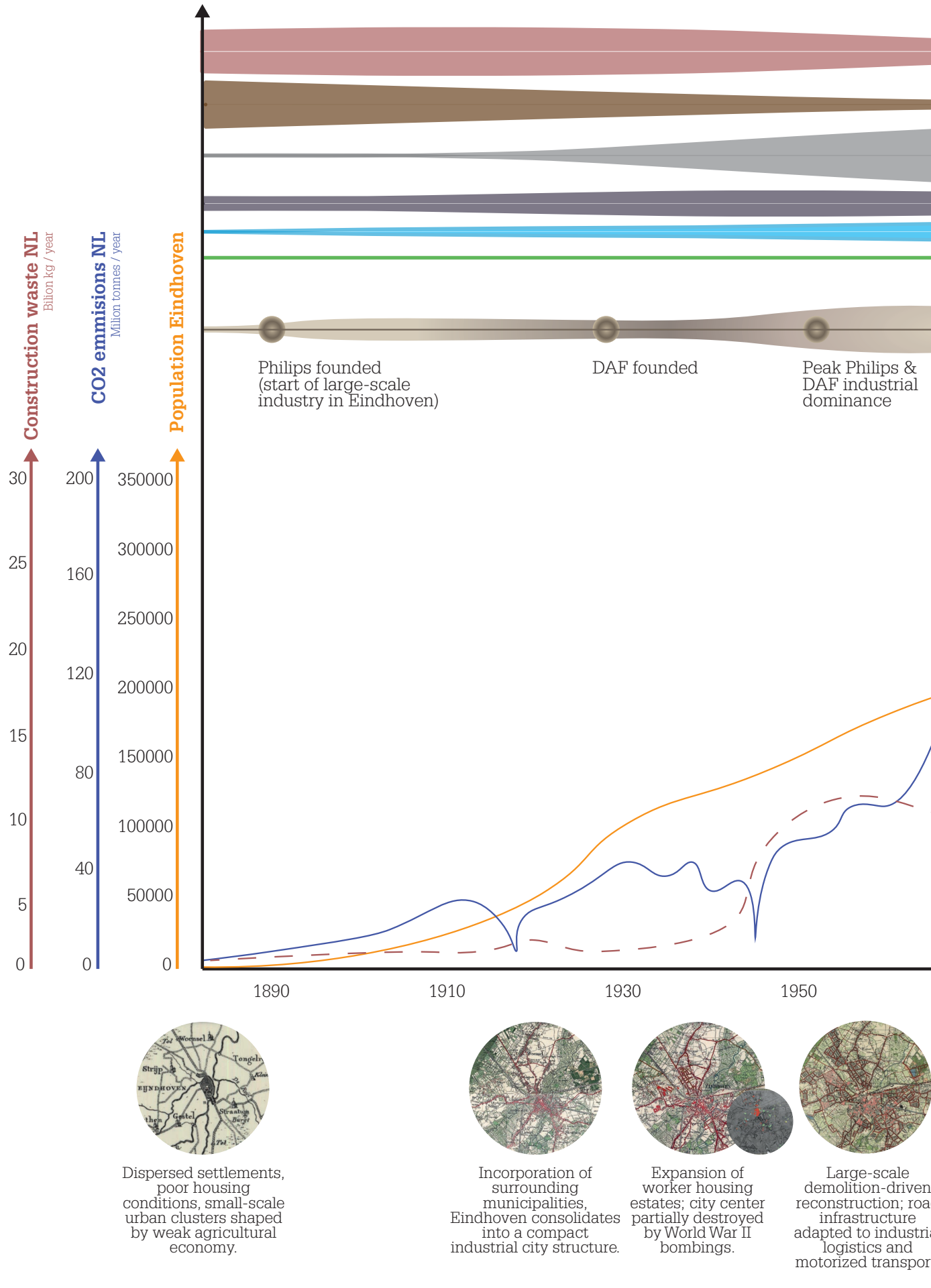
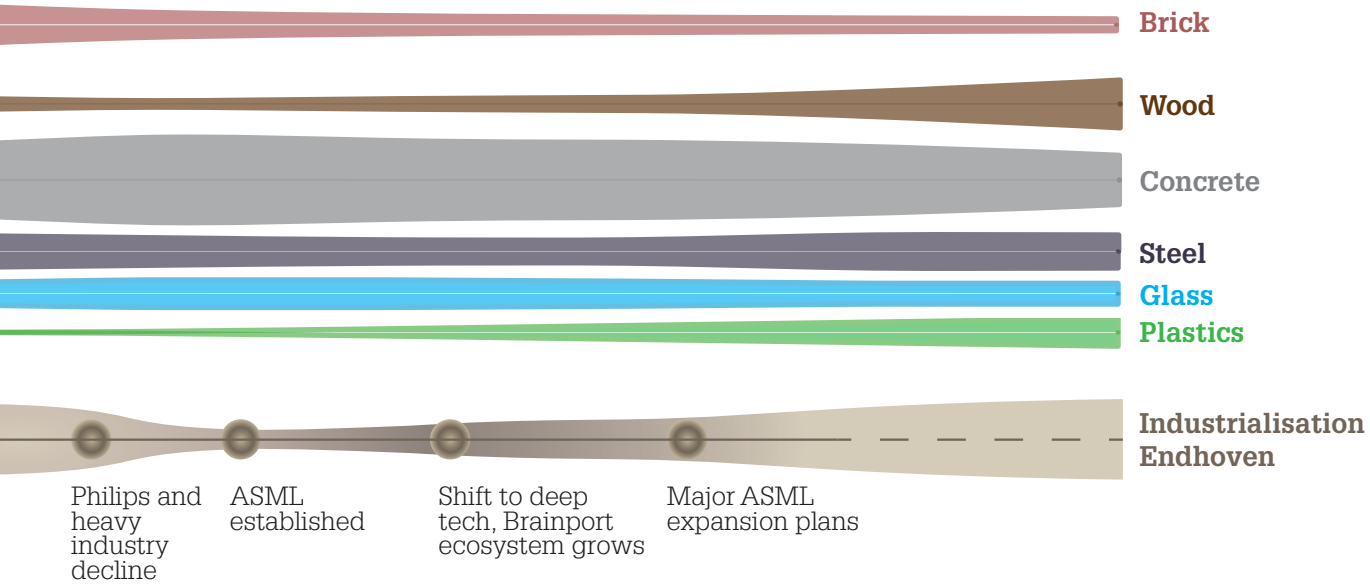
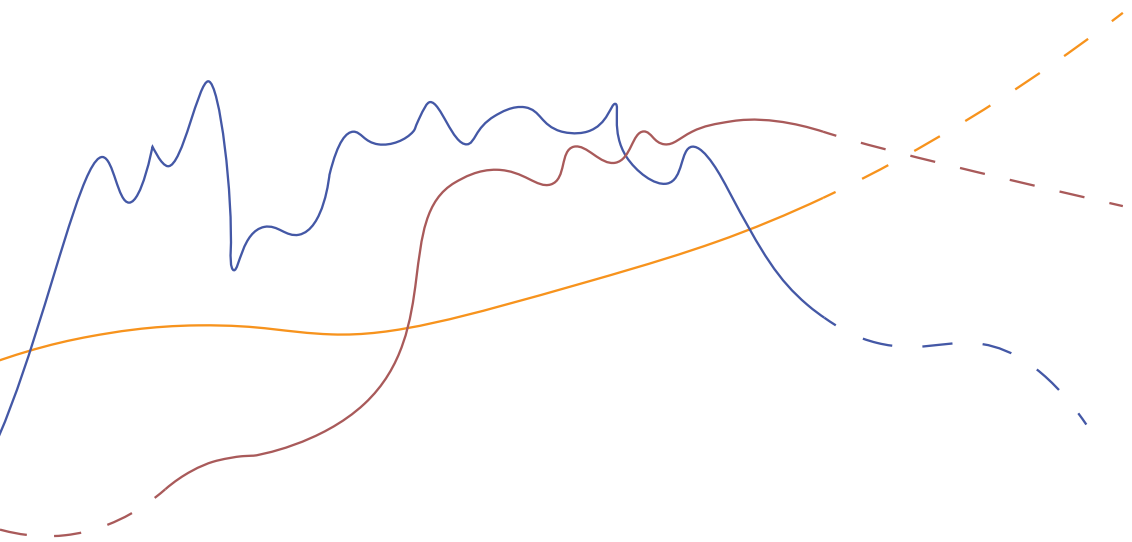


Figure 3. Timeline of Eindhoven growth, industrial development,









Rapid urban expansion, functional zoning, modernist neighborhoods; Eindhoven's surface area and population double.



Industrial decline causes urban vacancies, mono-functional areas, social segregation, and loss of spatial identity.



Inner-city regeneration and campus urbanism emerge; High Tech Campus Eindhoven founded in 1998, reinforcing Brainport and Triple Helix development.

(Encyclopaedia Britannica, n.d.)
(Stichting 18 September, n.d.)
(CLO et al., 2020)
(CE Delft, 2013; 2015)
(Topotijdreis, 2024)
(Gemeente Eindhoven, n.d.)
(Brainport Development, n.d.)

construction activity and material pressure. (Own work)

2. PROBLEM STATEMENT

Eindhoven's renewed economic and technological growth risks reproducing a linear architectural model: raw material extraction, new construction, use, demolition and replacement. This model conflicts with the city's sustainability ambitions and with the circular value of existing concrete buildings. The paradox is that growth promoted as innovative can become materially conservative if it depends on the demolition of robust structures and the production of new ones.

Parking garages form a critical case within this problem. They are structurally robust, centrally located and material-intensive, yet increasingly questioned by changing mobility patterns. Their spatial logic is based on car dimensions, fast movement, repetitive grids and low comfort requirements. For human occupation, however, they create deep floor plates, poor daylight, low floor-to-ceiling heights, sloped floors, weak pedestrian access and difficult integration of climate and acoustic systems.

The problem is therefore not simply that parking garages are obsolete. The problem is that their value is difficult to unlock. Demolition is often the easiest development path, but it discards embodied carbon, structural capacity and urban memory. Transformation is more complex, but it can produce a more circular and spatially meaningful alternative.

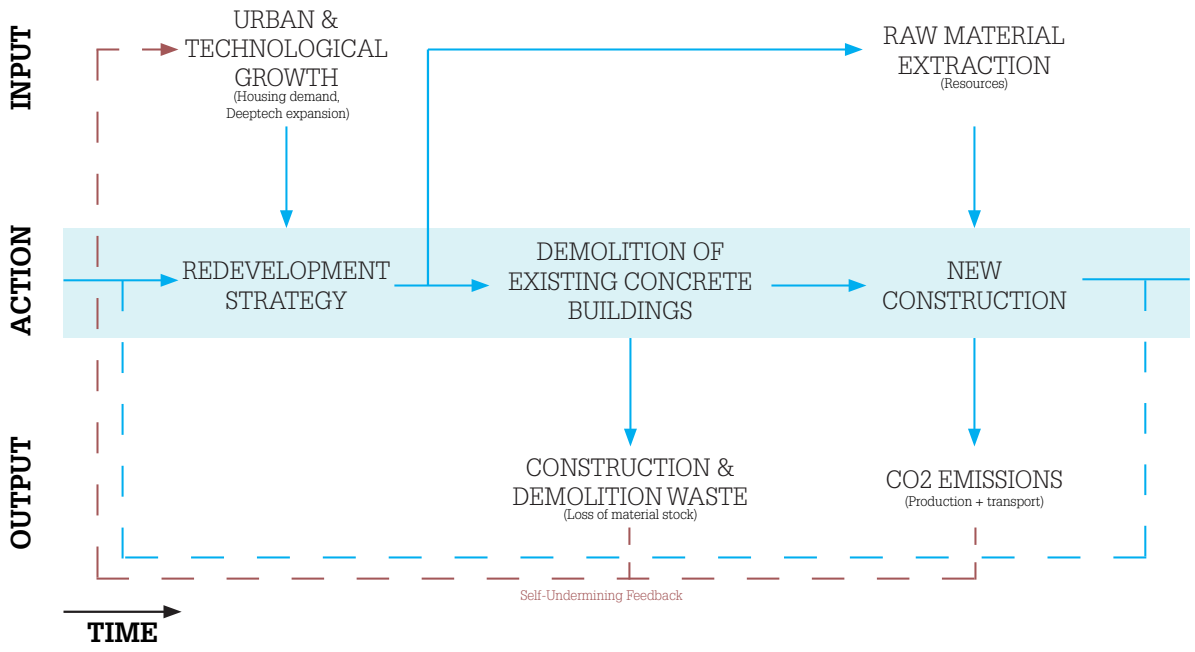
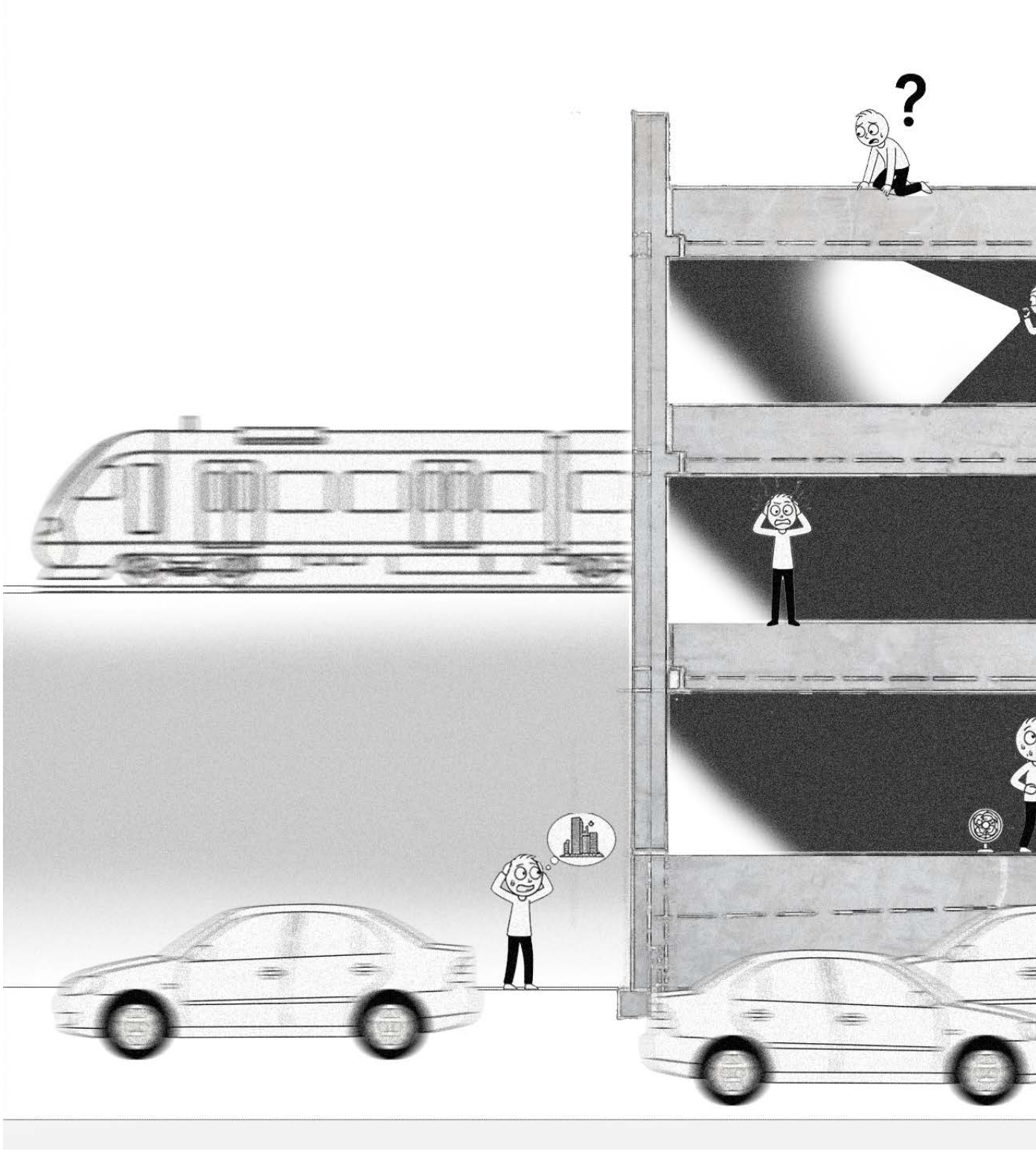


Figure 4. Problem statement diagram: growth, demolition, material extraction, emissions and construction waste. (Own work)





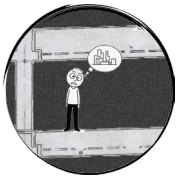
CAR-ORIENTED URBAN LOGIC



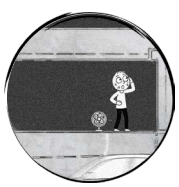
DEMOLITION ENABLES Ddensification



LACK OF INTERNAL CONNECTIONS
inefficient for non-parking uses



LOW ARCHITECTURAL STATUS

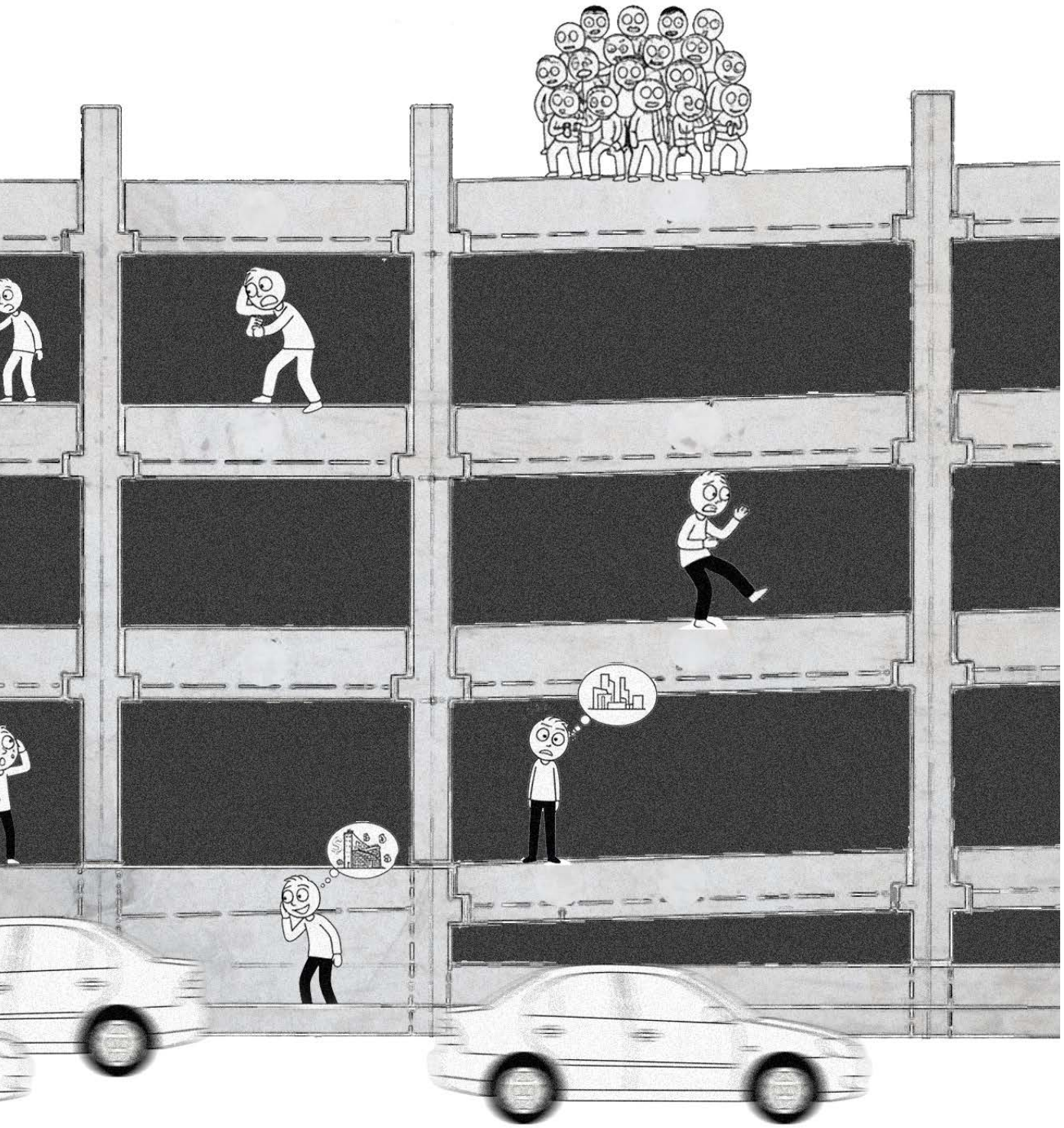


NO IN CLIM



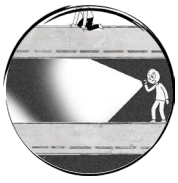
NO A THER

Figure 5. Transformation barriers of concr



ITERGRATED
ATE SYSTEMS

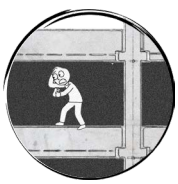
COUSTIC OR
MAL PERFORMANCE



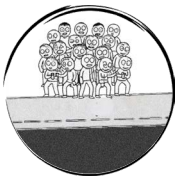
EXCESSIVE BUILDING DEPTH
poor daylight penetration



SLOPED FLOOR PLATES



INCUFFICIENT FLOOR-TO-CEILING HEIGHT



STRUCTURE OPTIMISED FOR VEHICLES

ete parking garages. Drawing (Own work)

MAIN RESEARCH QUESTION

How can the subtractive transformation of an existing concrete parking garage convert car-oriented infrastructure into a circular, human-scale innovation environment for Eindhoven?

SUBQUESTIONS

Urban: How can the transformation of the Mathildelaan garage support the post-car development of Eindhoven and strengthen the connection between the city centre, Strijp-S and KnoopXL?

Typological: Which spatial and technical barriers make parking garages difficult to transform, and how can these barriers become design opportunities?

Material: How can removed concrete elements, facade balustrades and grating infill be harvested and reused within the same building?

Programmatic: Which programme can justify transforming the garage into a public innovation building rather than replacing it with housing?

Architectural: How can subtraction create daylight, orientation, circulation, human scale and social encounter within a deep concrete structure?

Technical: How can climate, acoustics, facade detail, fire safety and structure be integrated without erasing the existing concrete logic?

3. THEORETICAL BACKGROUND

3.1 FROM TRIPLE TO QUADRUPLE HELIX

Eindhoven's innovation economy is often understood through the Triple Helix model, in which government, industry and knowledge institutions collaborate to produce technological and economic development. This model has been important for the Brainport region, but it does not automatically guarantee that innovation becomes visible, accessible or socially embedded in the everyday city.

Paskaleva's Quadruple Helix approach adds citizens and civil society as a fourth actor in the production and assessment of smart cities. The value of this model for architecture is that it shifts innovation from a closed institutional network toward a spatial and public question. If innovation remains hidden within campuses and company environments, the city may experience the effects of growth without understanding or participating in the processes behind it. Architecture can therefore mediate between innovation and citizens by creating spaces where learning, working, mobility and public encounter overlap.(Paskaleva, 2021).

This theoretical position explains the programme of the project. The building is not proposed as housing, although Eindhoven has a housing shortage, because the thesis addresses another part of the same urban transition: the need to make innovation more public, mixed and embedded in the city. The project uses the parking garage as an interface between companies, students, local entrepreneurs, mobility users and citizens.

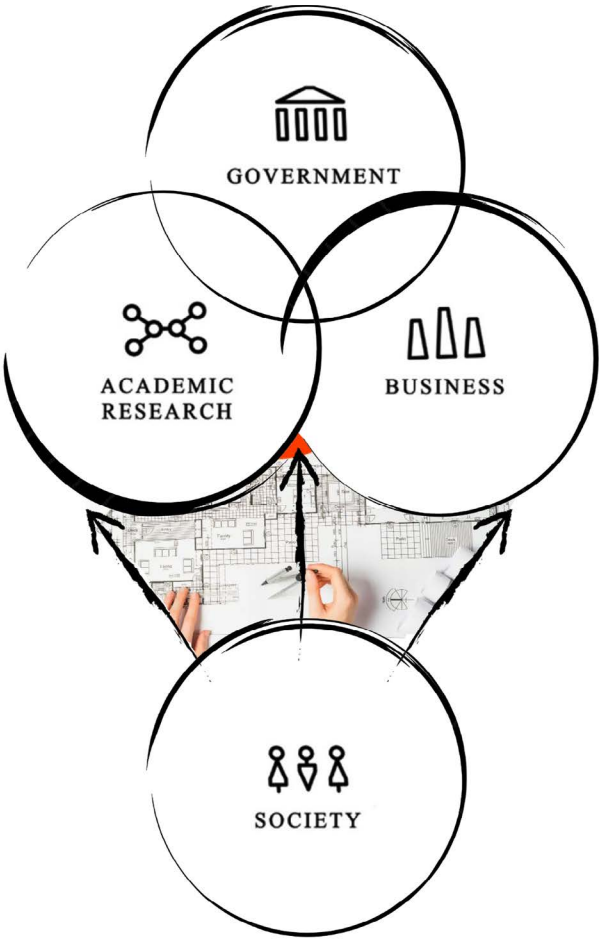


Figure 6 - Diagram visualising how architecture and urban design contribute in transforming the innovation model of Eindhoven from a Triple Helix to an Quadruple Helix. (Ownwork)

3.2 SMART CITIES

The Smart City 1.0 to 3.0 discussion supports this shift. In a technology-driven smart city, innovation is often led by corporations and technical systems. In a more public and participatory smart city, innovation becomes a shared urban process. Urban Living Labs translate this idea spatially by combining experimentation, public access, testing and feedback within real urban environments.

For this project, the Living Lab is not used as a generic label, but as a programmatic and spatial principle. A transformed parking garage can become a place where mobility transition, technical experimentation, education, small companies and public programmes are visible to each other. This is why the project combines a mobility hub, study spaces, startup workspaces, MKB and larger innovation offices, makerspace, event space, restaurant and exhibition.



Figure 7 - Evolution of Eindhoven as a smart city. (Own work)



Figure 8 - Living Lab framework at three scales, with principles from KAW informing the context. (Own work)

(KAW, 2021)

3.3 CONCRETE AS MATERIAL STOCK

Concrete is one of the dominant material stocks in the existing built environment. The environmental issue is not only the production of new concrete, but also the loss of value when existing concrete structures are demolished. Structural reuse is therefore the highest-value circular strategy, because it retains both material and load-bearing capacity in place.

The project uses a hierarchy of concrete reuse. First, the existing primary structure is retained. Second, removed elements are reused as building components where possible. Third, only material that cannot be reused as an element becomes a candidate for recycling. This hierarchy informs the design rules: before cutting, the building is inventoried as a material bank.

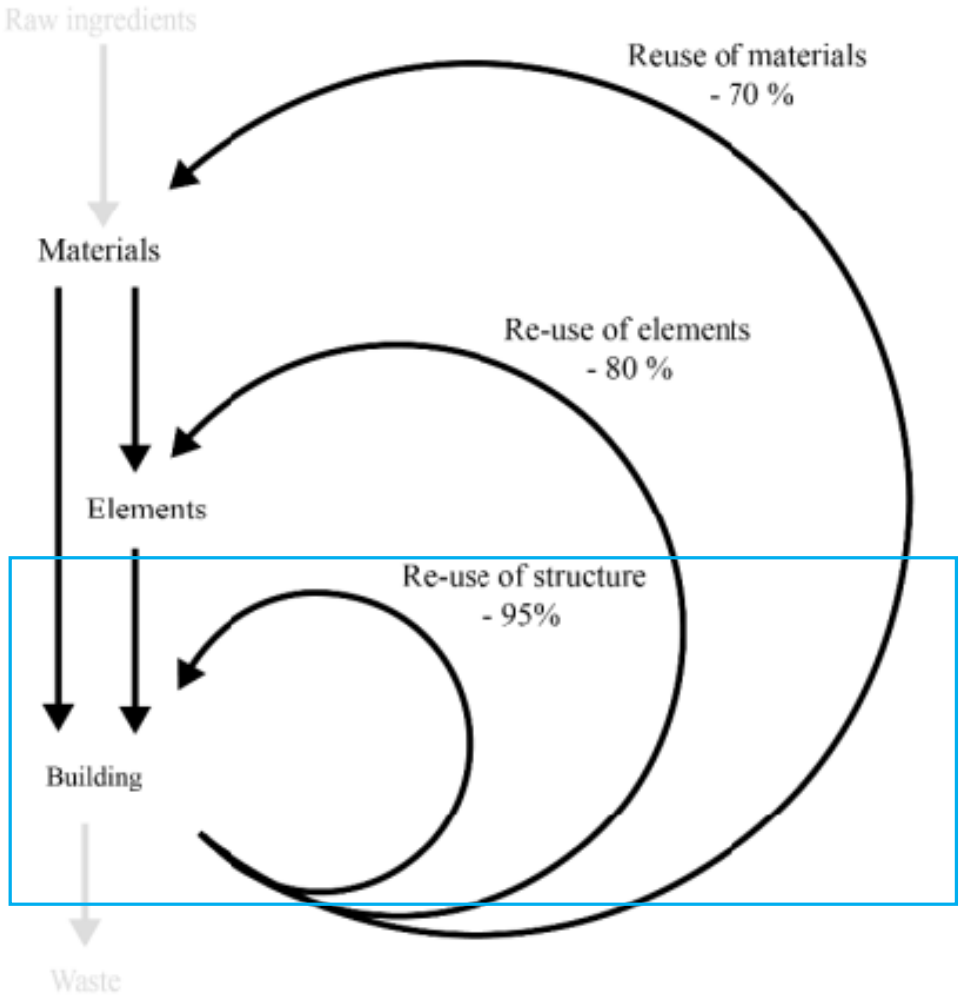


Figure 9 - Environmental benefit of reusing concrete at three value levels. (Baelemans, 2020)

3.4 SUBTRACTIVE TRANSFORMATION

Architectural transformation is often approached additively: new layers, new facades, new structures and new technical systems are attached to an existing building. Subtractive transformation reverses this logic. It asks what spatial, environmental and social value can be created by removing material carefully.

In this project, subtraction is not equivalent to demolition. Demolition erases the building. Subtraction edits the building. Voids are created to bring daylight into deep floor plates, to create orientation, to introduce collective terraces and to change the spatial scale from infrastructure to occupation. The architectural question becomes where removal produces more value than addition.



Figure 10 - Gijs Baker's Chair with holes (1989). This chair explores the idea of material optimization by removing weight where it's not structurally needed. The size and placement of each hole reflect a balance between strength, functionality, and sustainable reuse. (Self made picture Nieuwe Instituut Rotterdam)

3.5 HUMAN SCALE AND PERCEPTION

Human scale is not determined only by the physical size of a building, but also by the way it can be perceived, understood and approached. Large buildings can still feel human when they offer a hierarchy of readable scales. This means that the building should not only have an overall form, but also intermediate rhythms, openings, depths and smaller details that relate to the human body and movement through space.

Alexander describes this as "levels of scale": coherent environments are built up through a range of different sizes, from the larger whole to smaller parts and details (Alexander, 2002). Salingaros similarly argues that human-scale environments depend on smaller-scale structure and perceptual information. When buildings lack this hierarchy, they can become visually monotonous, oversized or difficult to relate to at pedestrian level (Salingaros, 2021).

For this project, this theory is used as a lens to evaluate the transformation from car scale to human scale. A parking garage is typically organised through large repetitive dimensions, efficient vehicle movement and minimal tactile detail. Introducing human scale therefore requires more than changing the programme. It also requires spatial and architectural articulation across multiple scales: from the urban massing of the building, to the rhythm of its facades, to the detail of materials, joints and edges. This theoretical position is later used to assess the exterior facade, interior atrium facades and the transition between public, semi-public and private spaces.



Figure 11. Existing car-scale facade of the Mathildelaan parking garage
Self-made photograph showing the repetitive concrete structure and horizontal facade rhythm of the existing parking garage. The image is used as a starting point for analysing how the facade can be transformed from infrastructural repetition into a more human-scale architectural composition.



Figure 12. Human-scale articulation in a repeated structural grid
Centraal Beheer, Apeldoorn by Herman Hertzberger. The project shows how a repetitive structural system can be broken down into smaller spatial units through rhythm, variation, thresholds and places for occupation.

3.6 CASESTUDIES

3.6.1 THOMAS HEATHERWICK - ZEITZ MOCAA (COMPLETED 2017)

Location: Cape Town, South Africa

Zeitz MOCAA is a transformation of a former concrete grain silo into a public art museum through extensive subtractive interventions. Large volumes of concrete were carved out of the existing structure, creating new spatial qualities while preserving the original structural shell. The project demonstrates how subtractive architecture can unlock higher-value cultural programs within rigid industrial concrete typologies. Rather than demolishing the silo, the design reinterprets its massive concrete structure as a spatial and symbolic asset. This approach aligns with the idea of treating existing buildings as material and structural banks. For this project, Zeitz MOCAA serves as a reference for how subtraction can generate daylight, public accessibility, and cultural value within heavy concrete structures. It shows how removing material can be more transformative than adding new layers.

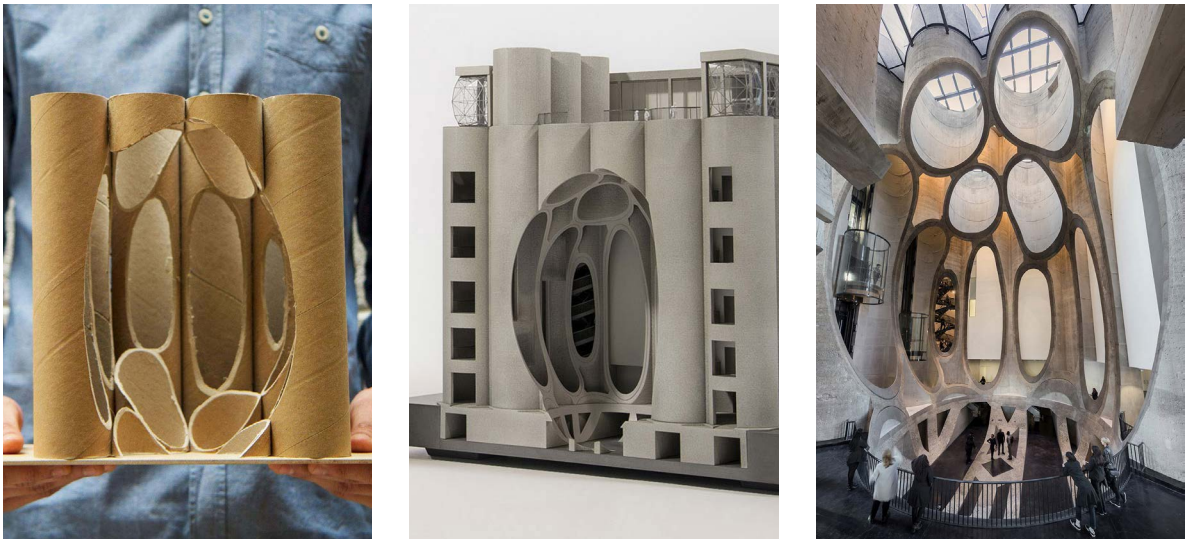


Figure 13,14,15. Design process from structural analysis of cylindrical void carving to architectural form-making and realized building. (Heatherwick studio)

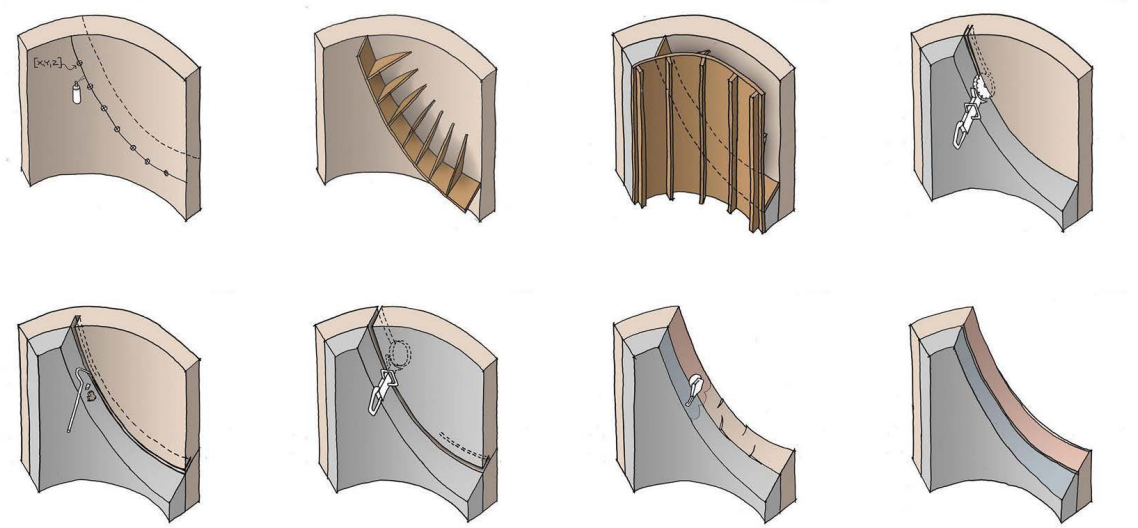


Figure 16. Subtractive intervention strategy: cutting into the existing concrete silo structure to generate spatial voids and daylight. (Heatherwick studio)

3.6.2 ODA ARCHITECTURE NY - OLA PALERMO (COMPLETED 2025)

Location: Buenos Aires, Argentina

OLA Buenos Aires is a major adaptive reuse project by ODA that transforms an existing multi-story concrete parking structure into a dynamic, mixed-use complex. The design retains the primary structural frame and selectively removes concrete to create terraces, public circulation routes, and programmatic voids. New uses include retail, cultural spaces, offices, and elevated outdoor areas that knit the structure into its urban context. This case is highly relevant because it demonstrates how a parking garage can be reprogrammed through structural retention + subtraction + addition into a multi-layered urban building.



Figure 17. OLA Buenos Aires: adaptive reuse of an existing concrete parking structure into a mixed-use urban complex. (ODA Architecture)

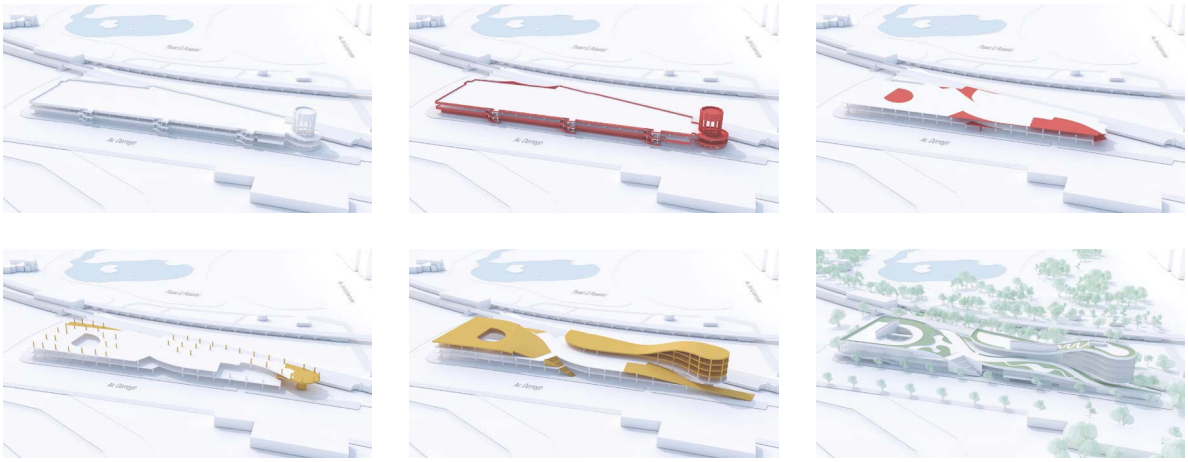


Figure 18. Transformation process of the OLA Buenos Aires parking garage, illustrating selective removal, structural reuse, and programmatic activation. (ODA Architecture)

3.6.3 MEI ARCHITECTS - CITROËN GARAGE PARIS (TENDER 2021)

Location: France, Paris

The former Citroën garage in Paris is an adaptive reuse proposal in which the existing concrete parking structure is selectively dismantled and reconfigured to support a new mixed-use program. Instead of full demolition, structural components are strategically removed to reduce floor depth, improve daylight penetration, and unlock spatial flexibility. Parts of the existing concrete structure are reused within the new design, retaining embodied material value while minimizing additional construction.

This project demonstrates how subtractive transformation can upgrade underutilized parking infrastructures into higher-value urban programs. For this research, the Citroën Garage serves as a technical precedent illustrating how controlled structural subtraction and reuse can function as an alternative to demolition-driven redevelopment of concrete parking typologies.



Figure 19. Design visualization of the transformation of the former Citroën parking garage into a mixed-use building. (MEI Architects)

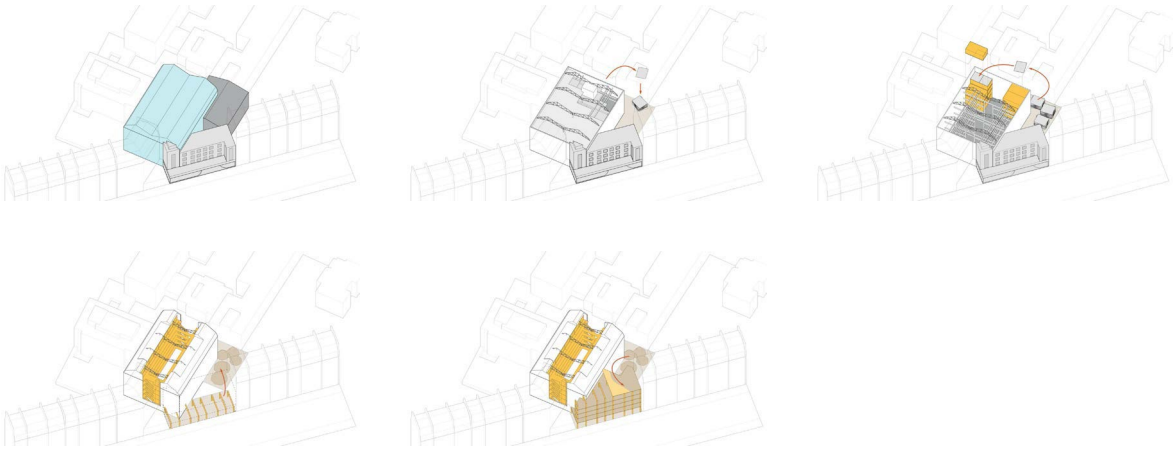


Figure 20. Transformation strategy of the Citroën parking garage, highlighting structural retention and adaptive reuse. (MEI Architects)

4. METHODOLOGY

The project follows a research-by-design methodology. Research and design develop iteratively, rather than in a linear sequence. The existing garage is first analysed as a technical and spatial system. The analysis then produces design rules, which are tested through physical models, digital drawings, sections, details and programme studies.

The method is structured in five steps. First, theoretical research defines the relevance of the Quadruple Helix, living labs, circular concrete reuse and subtractive transformation. Second, site research positions Mathildelaan within the urban transition of KnoopXL and the mobility strategy of Eindhoven. Third, building analysis identifies the constraints of the parking garage: structure, slopes, routing, daylight, compartments, car grid and facade. Fourth, physical prototyping tests what happens when TT floor elements are removed or reused. Fifth, the final design synthesises these findings into a spatial, programmatic and technical proposal.

The physical model is central because the garage cannot be fully understood in plan. Its floors slope continuously and are connected through spiral movement. By constructing the model with removable TT floor fields, the building becomes testable. Elements can be removed, cut, shifted and returned. This allowed quick testing of void size, spatial scale, routes and bridges, and it made the consequences of each intervention visible from inside the building.

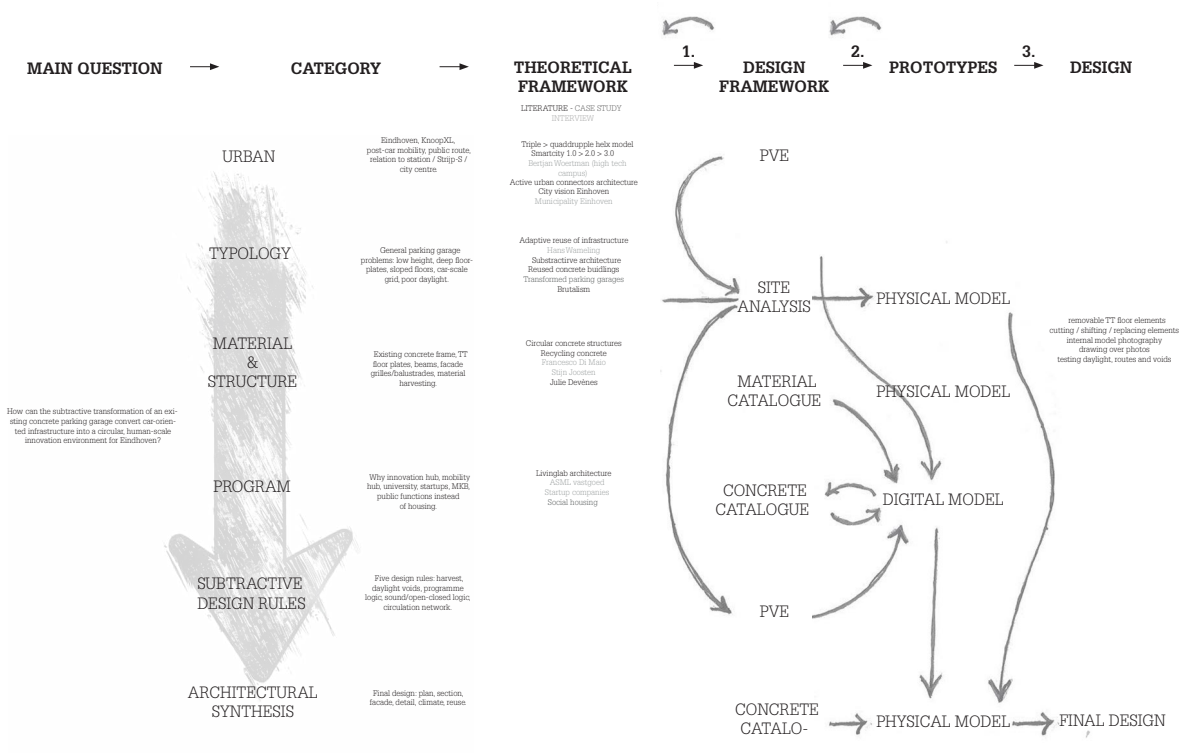


Figure 21. Methodology scheme (own work)

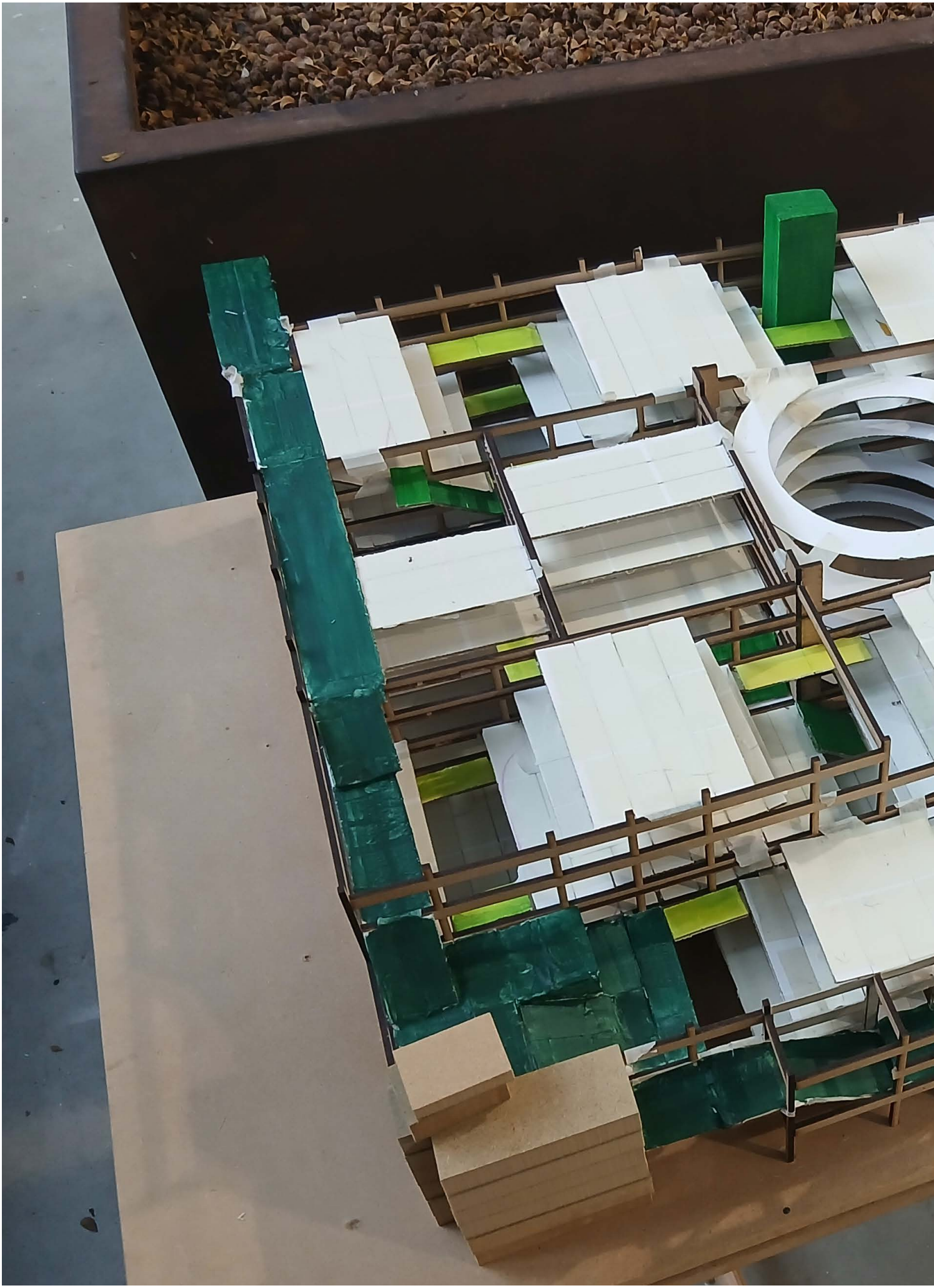


Figure 22. Picture of 1:100 p

physical model (own work)

5. SITE AND URBAN STRATEGY

The Mathildelaan garage is located at a strategic urban hinge. It stands between the existing centre, the railway infrastructure, Strijp-S and the KnoopXL station development. In its current condition, the building is embedded in car infrastructure. Roads, parking access and traffic edges define its relationship to the city. The transformation proposes to reverse this condition by turning the garage from an edge object into a public connector.

The urban proposal reduces the dominance of the road in front of the garage and creates a new public square on Mathildelaan. Destination traffic can still reach essential access points, but the spatial priority changes from through-traffic to arrival, walking, cycling, bus access and public stay. This creates a stronger relationship between the garage, the Klokgebouw side and the wider public realm. The existing fences around the Klokgebouw can be reconsidered because the space in front of the garage becomes a more continuous urban surface.

The future pedestrian bridge across the railway is treated as a key element. Instead of allowing the bridge to pass next to the garage, the proposal shifts the route so that it enters or crosses the building. This creates an urban route through the project. Citizens and visitors do not only pass by the innovation hub; they move through it. In this way the building becomes a point of contact between the city and the innovation ecosystem.

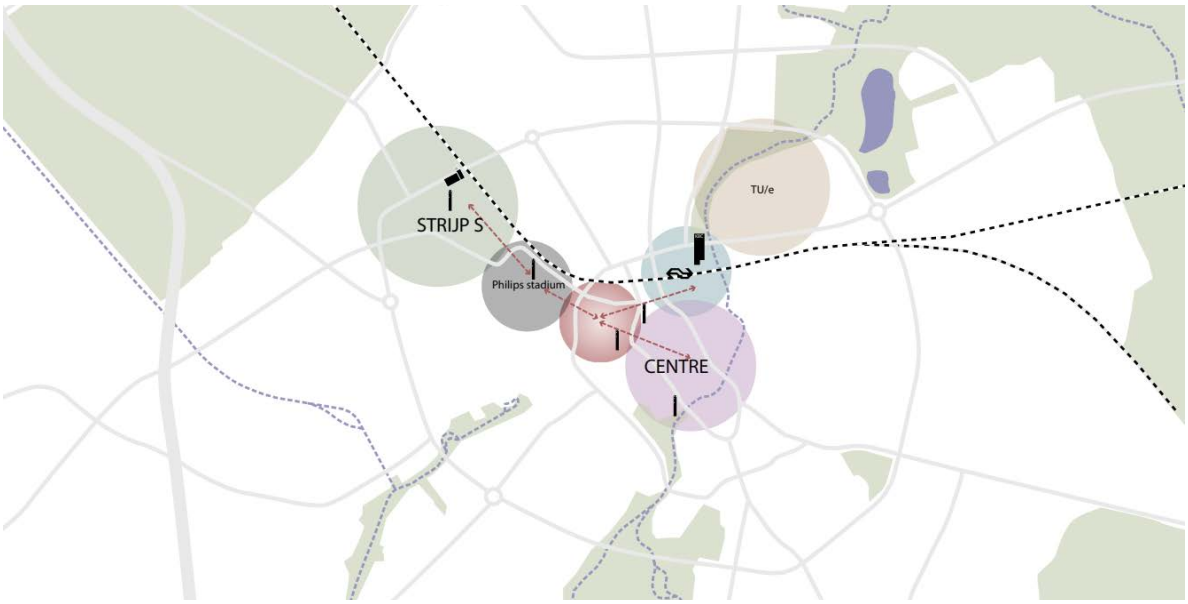


Figure 23. Urban potential of location. (own work)



Figure 24 - Design Knooppunt XL Eindhoven 2040. (Own work and KCAP Architects&Planners)

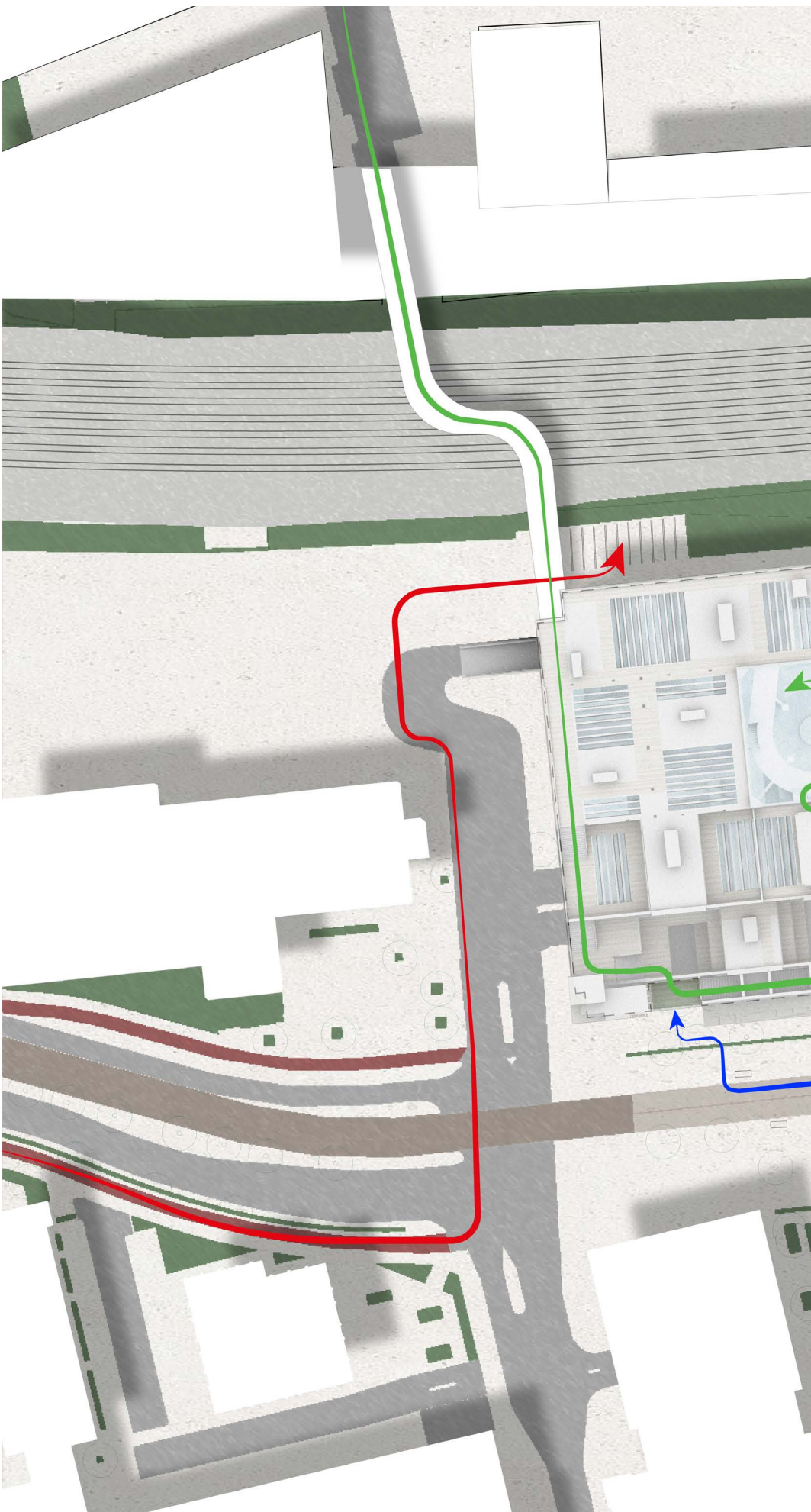
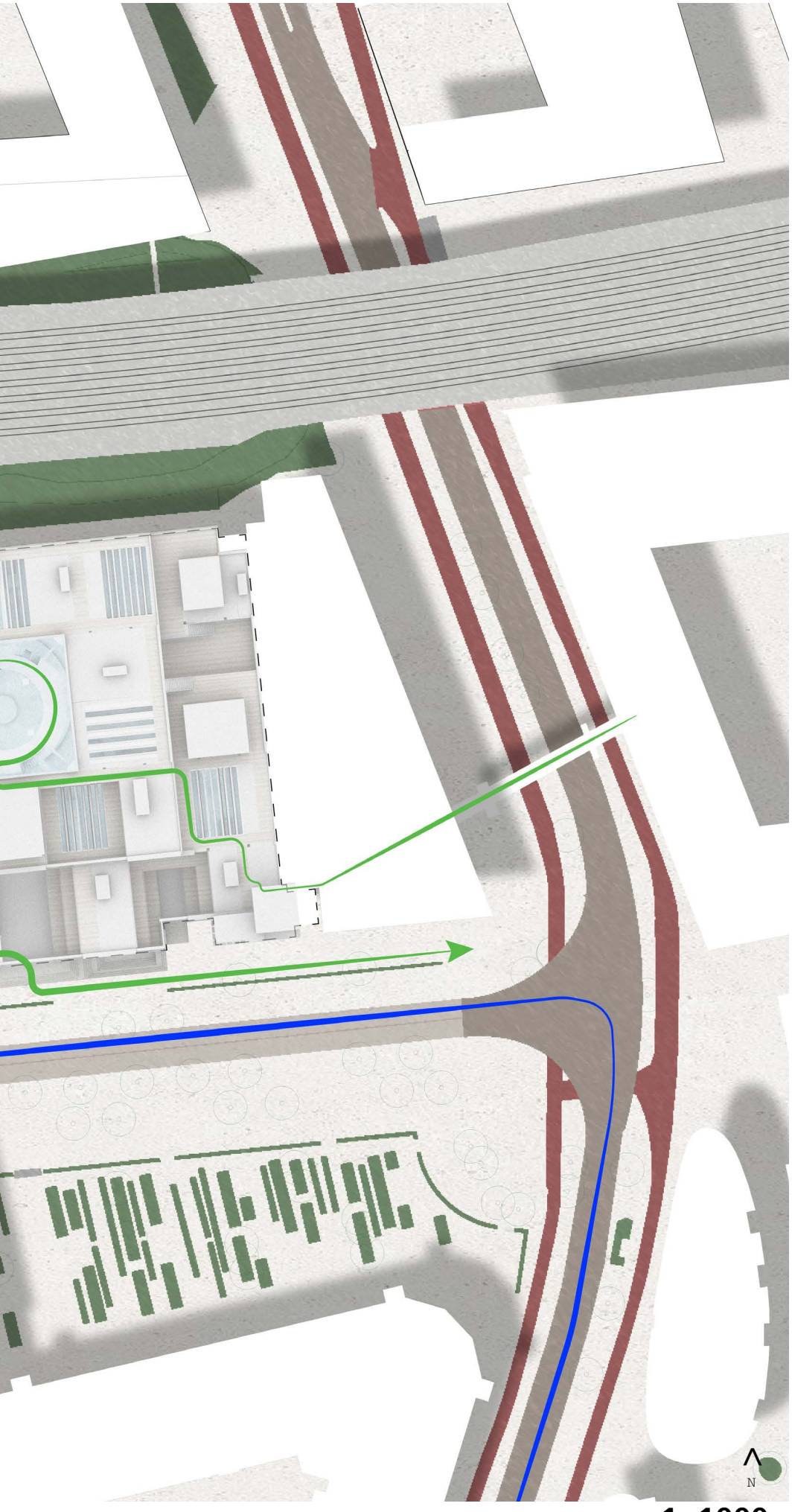


Figure 25. Site design,



= pedestrian

= bike

= bus

1: 1000

scaled 50% (own work)



Figure 26. Model of the future site (Own work)



Figure 27. Model of the future site (Own work)



Figure 28. Model of the



future site (Own work)



Figure 29. Street view of existing



g buidling (thisiseindhoven, n.d.)

6. EXISTING BUILDING ANALYSIS

The existing garage is fundamentally shaped by the dimensions and movement logic of the car. A single parking bay measures 2.4 x 4.8 metres, and this dimension is directly reflected in the building's structural order. The main grid is organised in spans of 4.8 and 7.2 metres, corresponding to the width of two or three parking bays. This means that the building is not only functionally designed for cars, but that the car has also determined its spatial and structural rhythm. The result is a robust and efficient framework, but also one that produces a scale not naturally suited to human occupation.

This car-based logic is reinforced by the concrete structure. The building is composed of prefabricated TT floor plates, approximately 2.4 metres wide and around 16 metres long. Their width corresponds directly to the width of a single parking bay. Their length can be understood as two parking lengths of 4.8 metres, combined with the approximate manoeuvring space required for vehicle turning and access. These large structural elements create deep floor plates and wide open zones, which support parking efficiency but limit daylight penetration and human-scale subdivision.

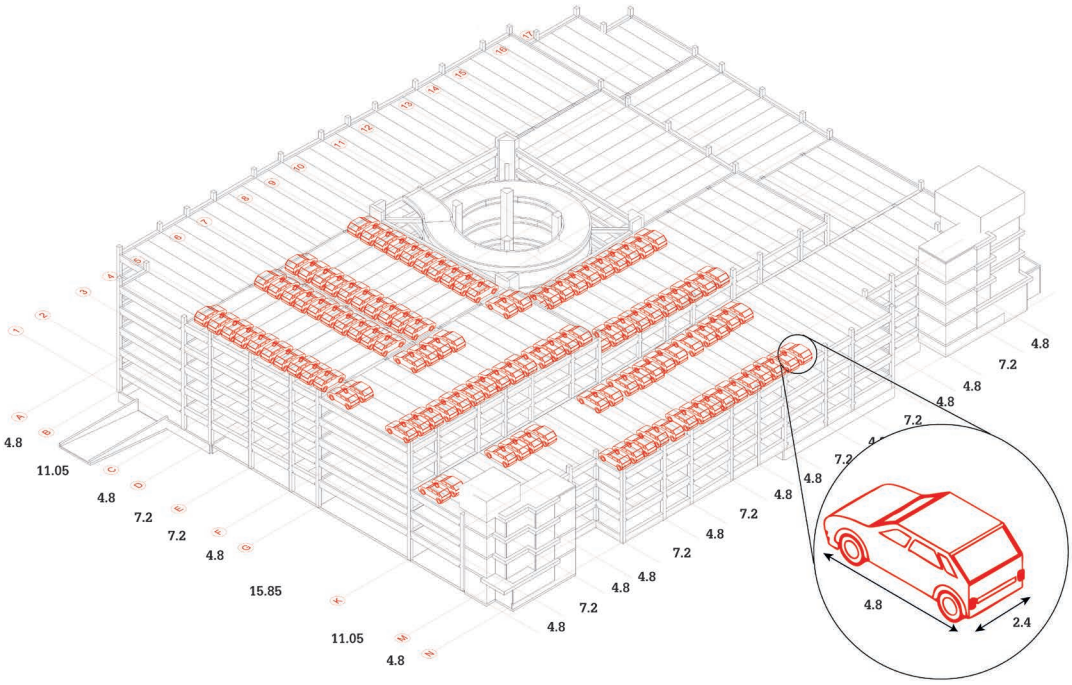


Figure 30. Car module and structural grid analysis

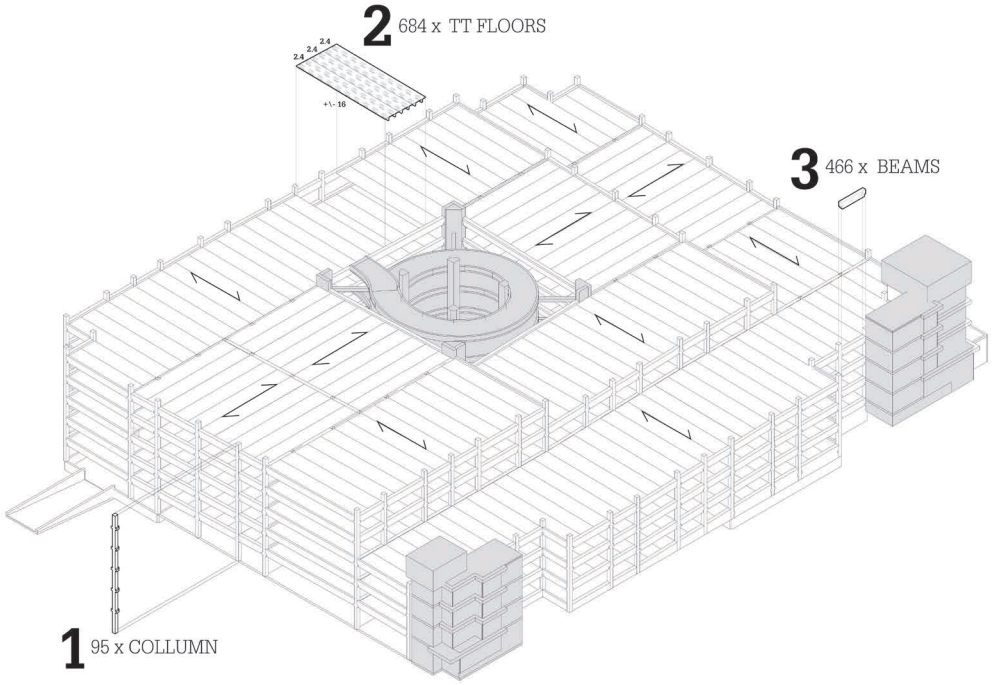


Figure 31. Existing construction analysis

The routing system is equally determined by vehicular movement. The entire building gradually slopes upward, creating a continuous circulation route across the floor plates. In addition to this sloped organisation, the building contains a central double spiral system used for descending traffic, alternating between levels so that cars can move downward more efficiently. Together, the sloped decks, lift cores and spiral circulation create a highly characteristic spatial system. Architecturally, the spiral is one of the strongest existing elements of the garage, but it currently serves the logic of vehicle flow rather than human orientation.

Because the building measures approximately 73.05 metres in depth and 91.2 metres in width, the garage was analytically divided into compartments in order to understand differences in section and slope. Within this system, the darker zones indicate steeper sloped parts that each account for a height difference of approximately 0.8 metres. The lighter zones also contain a slope, approximately 250 mm over 16 metres, which is assumed to support drainage. These sectional variations are important because they explain why the building cannot be read as a stack of flat floors. Instead, it operates as a continuous spatial landscape shaped by car movement.

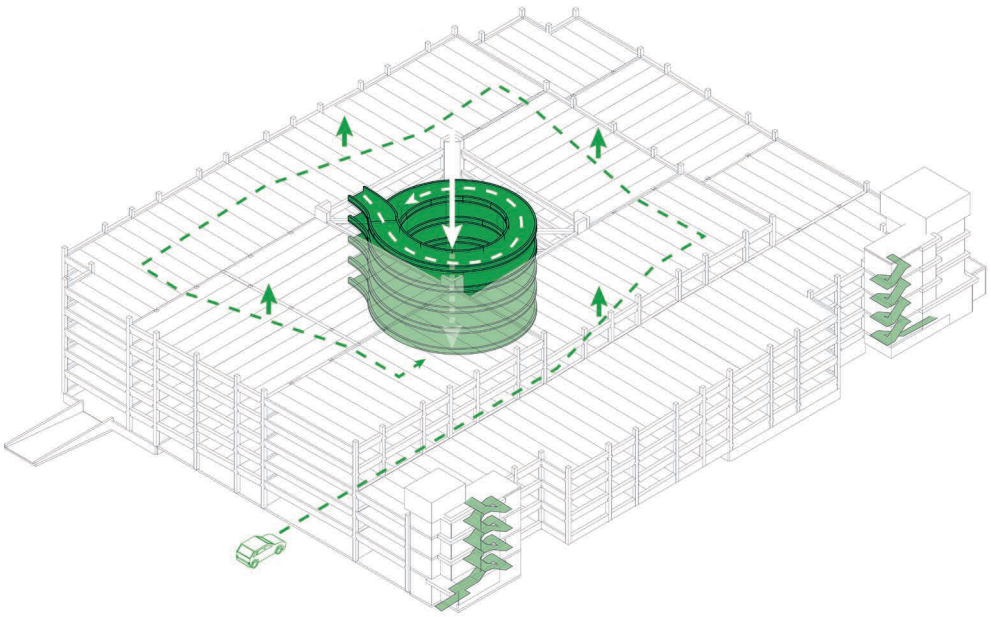


Figure 32. Existing routing analysis

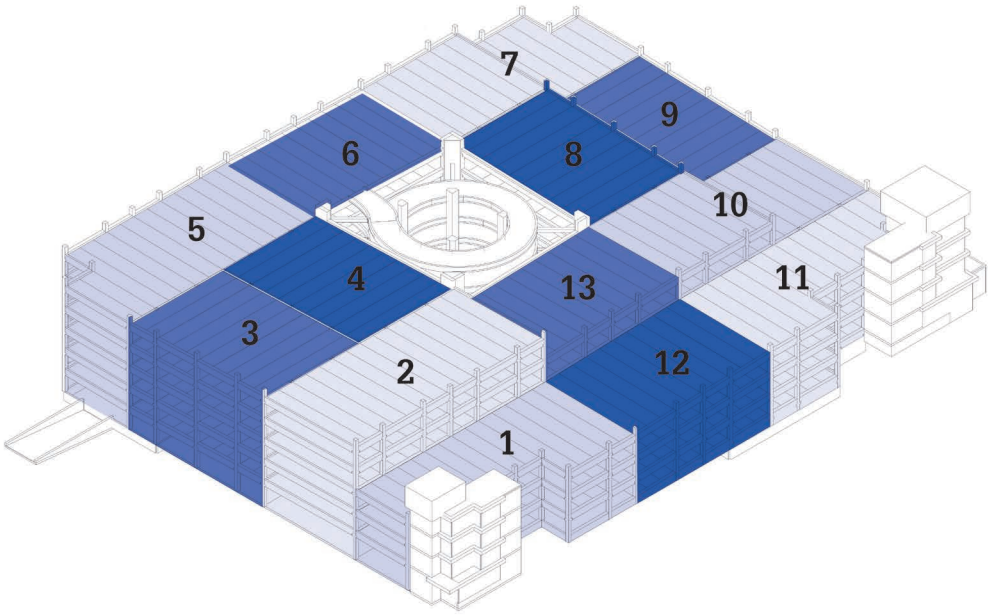


Figure 33. Compartments

The garage is also defined by its environmental orientation. The front facade faces the square and the sunnier side of the site, which creates potential for a more open and public edge. The north side faces the railway and is therefore more exposed to noise, making it more suitable for a relatively closed and protective character. These conditions help define the transformation strategy.

Together, these analyses explain why parking garages are often considered difficult to transform. Their dimensions, structure, routing and environmental conditions are all based on the logic of the car. At the same time, these same conditions also create opportunities. The Mathildelaan garage has a strong concrete structure with a potentially long remaining lifespan, an open column-based layout with large spans, and relatively dry connections between TT plates, beams and columns. These qualities make the building suitable for selective subtraction, reuse of components and programmatic transformation. The task is therefore not to erase the parking garage, but to reinterpret its existing logic as the basis for a new human-scale architecture.

The relevance of this analysis extends beyond one building. Many parking garages in Dutch city centres share similar construction principles, including repetitive concrete grids, ramp-based circulation, deep floor plates, limited floor heights and robust structural capacity. As car use in city centres is increasingly questioned, these structures will come under growing pressure for demolition or redevelopment. The Mathildelaan garage can therefore function as a demonstrator for a broader transformation strategy. The aim is not to produce a unique formal solution, but to develop a set of spatial, structural and material rules that can be adapted to similar parking structures.

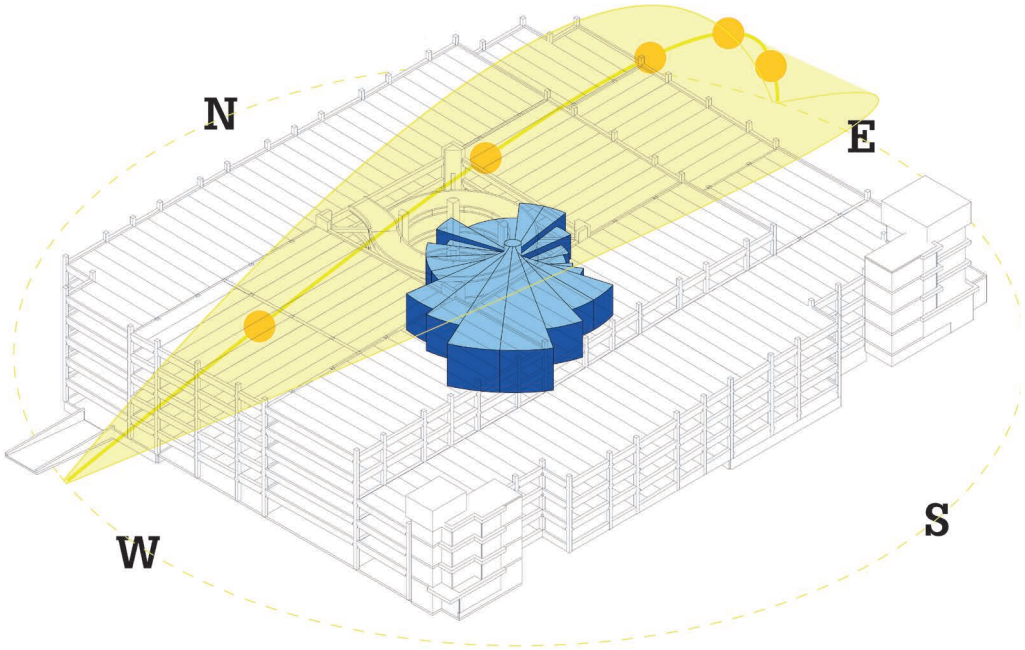


Figure 34. Sun and wind analysis

7. DESIGN FRAMEWORK: CARVING THE HUMAN NETWORK

The design framework translates the analysis into a set of transformation rules. These rules guide where material is removed, where it is reused, how programme is placed and how routes are organised. The framework is called Carving the Human Network because the project transforms an infrastructure of car movement into a spatial network of people, light, encounter and material reuse.

The first rule is harvesting. Before any subtraction takes place, the building is read as a material stock. The facade balustrades and grating infill, TT floor plates and beams are identified as elements that can be removed, stored and reused. This changes the meaning of demolition material: it becomes part of the design inventory.

The second rule is carving for daylight. Each cluster receives at least one void with a minimum width of two TT floor plates, approximately 4.8 metres. The voids do not cut vertically through the building as straight shafts, but step upward as terraces. This terraced geometry allows more sunlight to reach deeper levels, while also creating outdoor collective spaces between the work areas. Model tests showed that smaller alternating cuts brought limited daylight into the building while removing relatively much usable floor area. Larger terraced voids therefore create a clearer spatial effect: they bring light into the depth of the structure, divide the large block into more human-scale parts, and give each floor a more specific identity.

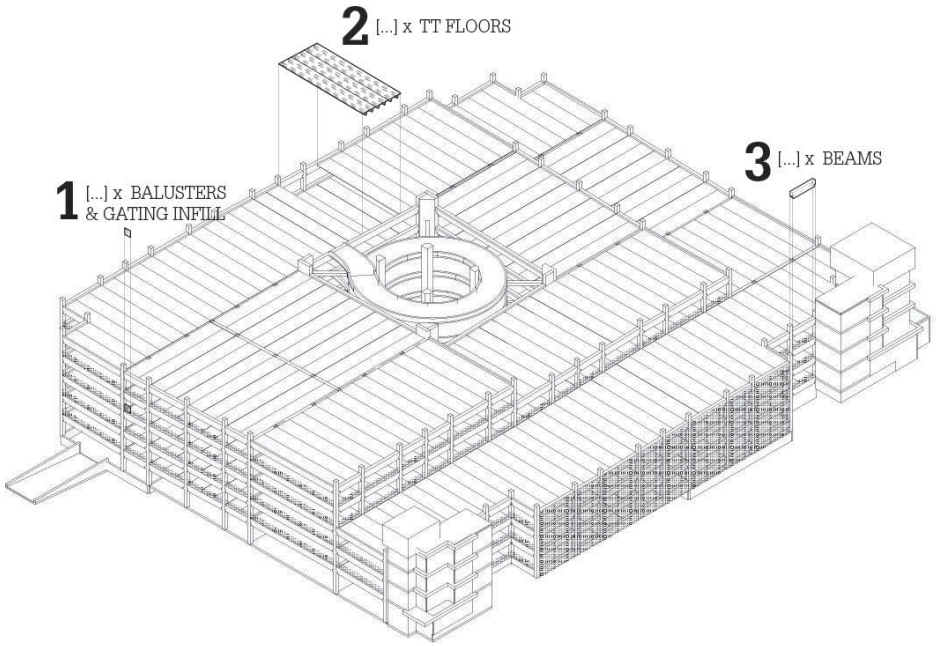


Figure 35. Rule 1: Harvesting the existing material stock. Diagram showing facade balustrades, grating infill, TT floor plates and beams as recoverable resources before subtraction.

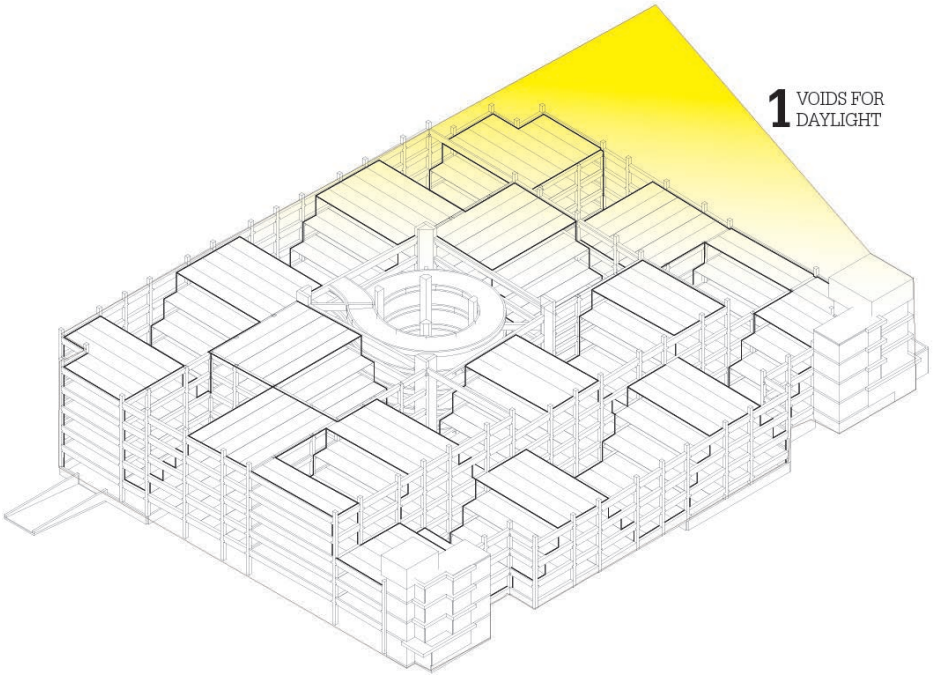


Figure 36. Rule 2: Carving voids for daylight and orientation. Diagram showing complete structural bays removed to bring daylight into the deep floor plate and create spatial clusters.

The third rule is programme by load, privacy, light and floor geometry. Heavy and high-load functions are placed low in the building, where access, logistics and structural capacity are strongest. Public functions are also concentrated near the lower levels and main entrances, where they can connect directly to the square and urban route. Higher and deeper in the building, the programme becomes increasingly private, with lighter workspaces that benefit more from daylight, views and separation from the public ground level. The programme also responds to the sloped floors. Sloped surfaces are treated as movement zones, while level surfaces become places to stay. This follows the original car logic of the garage, but translates it into human use: people move along the slopes, while workspaces, seating areas and tribunes are placed on levelled platforms. As a result, the building becomes a readable interior landscape of routes and places.

The fourth rule is routing as a human network. Additional carvings are made to reveal the main routes in the x and y directions. These axes guide people through the deep floor plate and all lead toward the central spiral, which becomes the heart of the building. Instead of only functioning as a circulation device, the spiral becomes a shared meeting point where users can gather, network, get coffee, rest or orient themselves. New vertical connections are placed within the daylight voids, so that light becomes a guide through the building. Higher in the structure, new horizontal connections are made between clusters by rotating removed TT floor plates and reusing them as bridges. Movement is therefore not only about going efficiently from A to B. It also creates moments of wandering, stopping, visual connection and informal encounter.

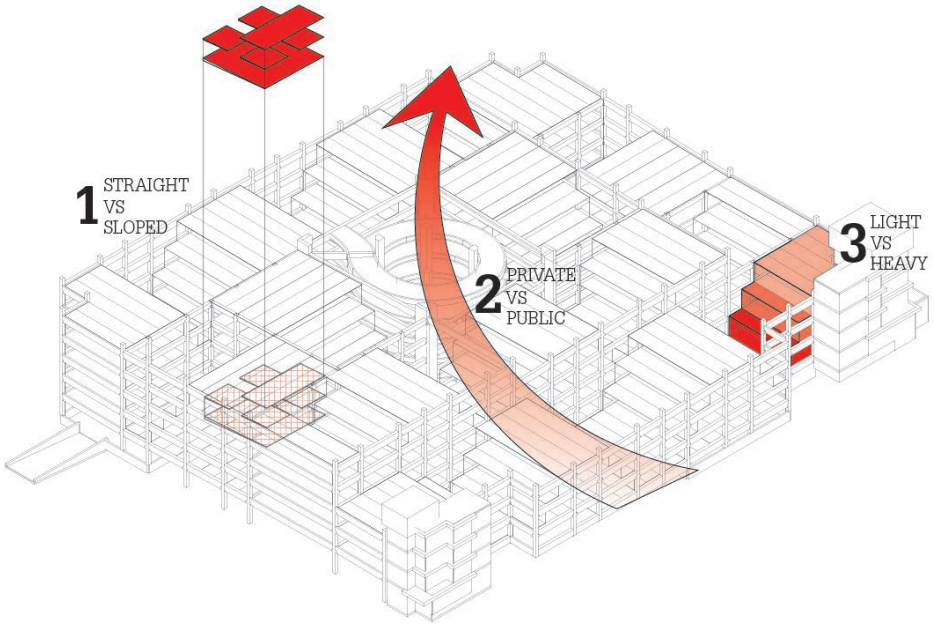


Figure 37. Rule 3: Organising programme by load, privacy and light. Diagram showing heavy/public functions low in the building and lighter/private functions higher and deeper in the structure.

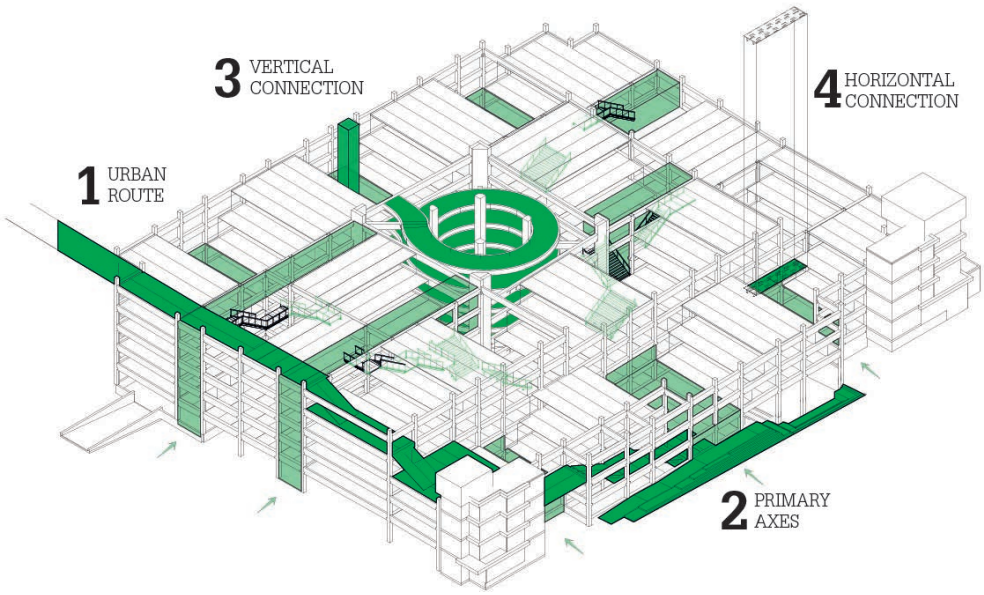


Figure 38. Rule 4: Using the building envelope as sound barrier and public interface. Diagram showing open public side versus more closed railway side.

The fifth rule is environmental orientation. Toward the railway side, the building is more closed and can work as a sound barrier. Toward the public side, the building opens itself to the city through entrances, terraces and visible activity.

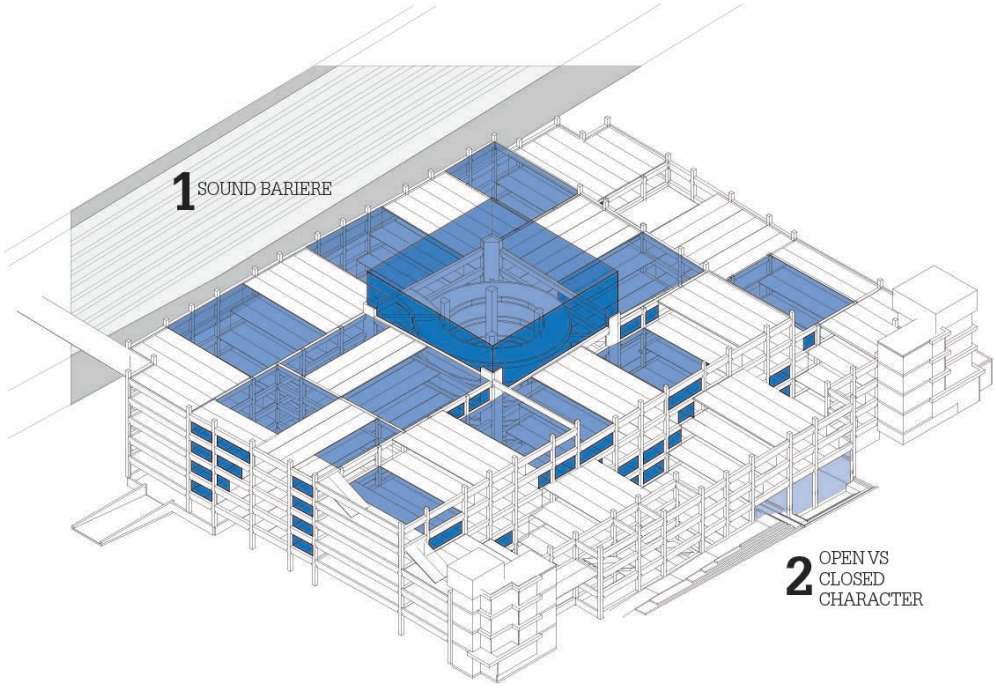


Figure 39. Rule 5: Creating a human network through routes and bridges. Diagram showing urban route, primary axes, stairs, bridges and central spiral.

8. PROGRAM STRATEGY

8.1 PROGRAM PLACING

The programme is chosen to respond to both the site and the theoretical framework. The project does not simply fill the garage with offices. It creates a public innovation environment where different scales of use overlap: mobility, education, startups, MKB, larger innovation companies, shared production, exhibition and public gathering.

This choice requires explanation because Eindhoven also has a housing shortage. The project does not deny this need, but argues that the Mathildelaan garage can address another urgent aspect of Eindhoven's growth. The expansion of the innovation economy should not only produce new campuses and private work environments. If innovation is to become part of the city, it needs public interfaces where citizens, students, small companies and larger organisations can meet. This position follows the Quadruple Helix reading of Paskaleva: innovation becomes more socially valuable when society is not only a user, but an active actor within the system.

The mobility hub forms the public anchor of the programme. It replaces the old parking logic with shared and active mobility, while still acknowledging that the building has an infrastructural history. The university and study spaces introduce the knowledge-institution layer. Startup spaces, small MKB units and larger innovation offices create a gradient of company scales. Public functions such as exhibition, event space, restaurant, tribunes and collective atria prevent the building from becoming a closed office block.

The programme is placed according to the existing structure. Heavy, public and high-load functions are located at lower levels. Spaces that require direct logistics, larger crowds or less daylight can use the robust base of the building. Smaller workspaces and more private offices are placed higher, close to terraces and daylight voids. This creates a spatial gradient from public and collective at the base to quieter and more individual workspaces higher in the building.

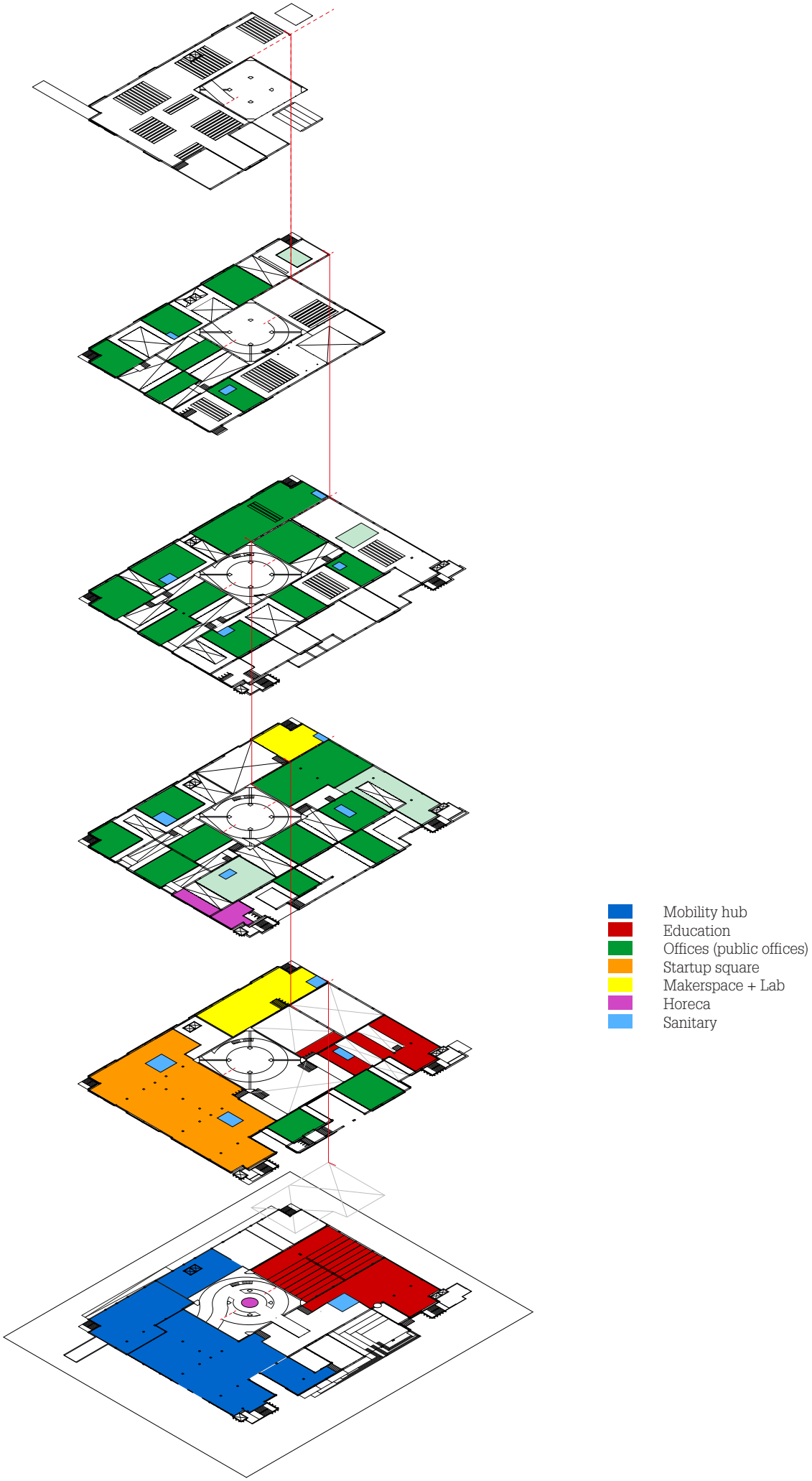


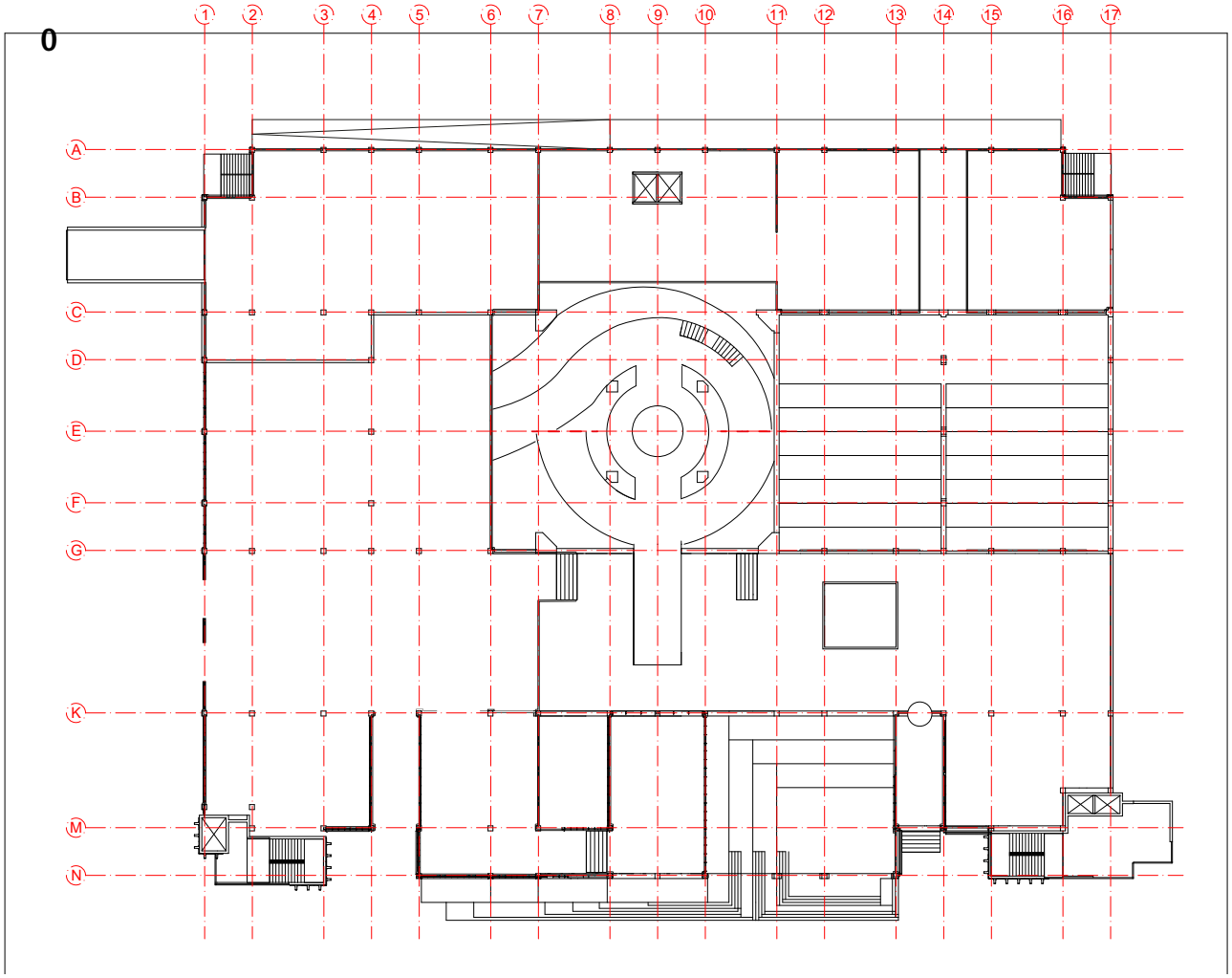
Figure 40. Programmatic distribution of the transformed parking structure.

8.2 STRUCTURAL CAPACITY AS DESIGN INPUT

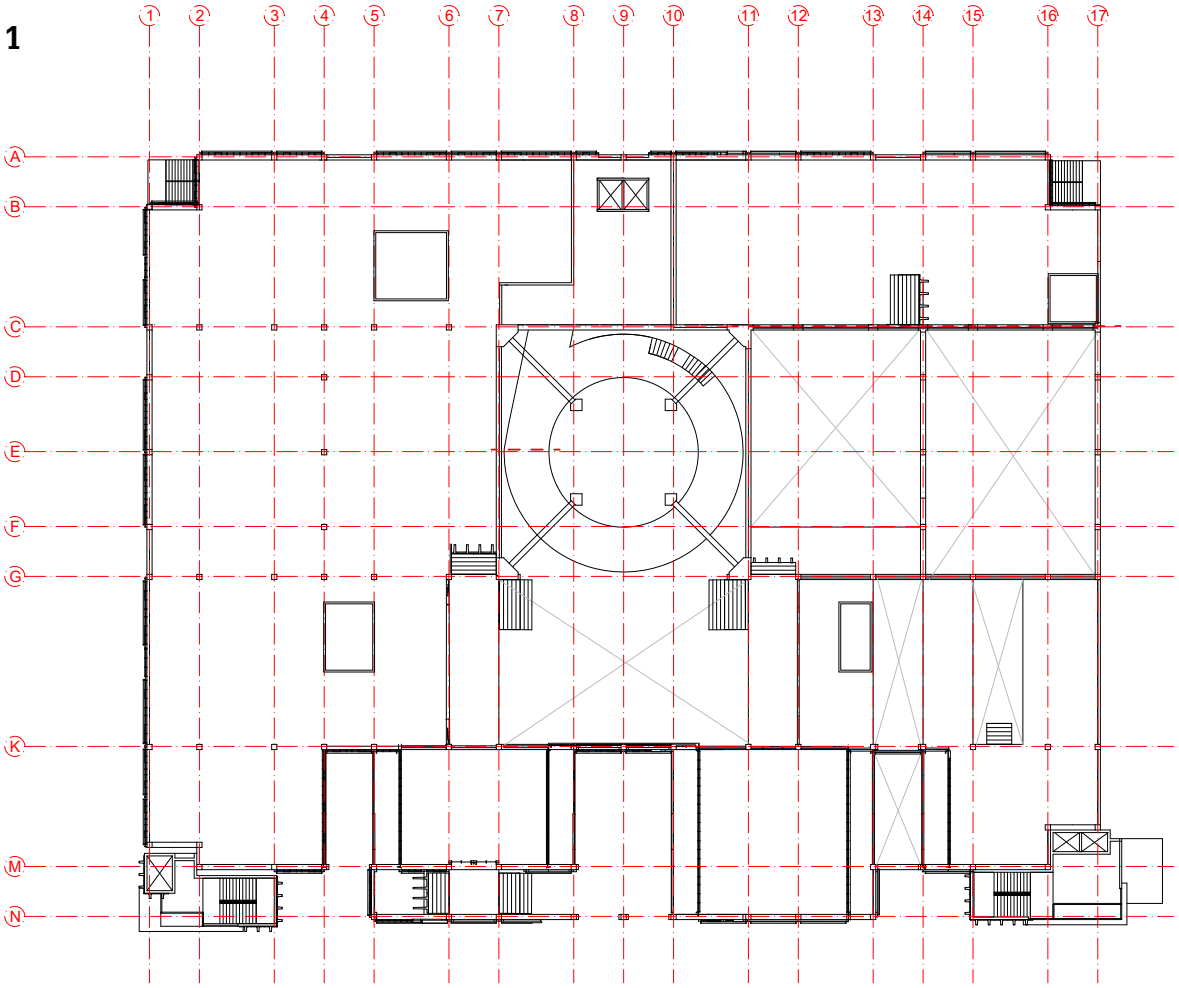
The structural calculation model showed that the usable capacity of several parts of the existing structure is approximately 2.7 kN/m², rather than the initially assumed 2.0 kN/m². This changed the programme strategy: office occupation loads of approximately 2.5 kN/m² became possible in specific zones, while heavier movement loads of around 3.0 kN/m² required more careful placement. As a result, corridors, bridges and concentrated circulation are positioned closer to the main structural lines instead of in the middle of the TT floor plates.

Parameter	**Formula**	**Unit**
Moment capacity Mrd	922,2894282	kNm
Span L	7,2	m
Influence width	16,35	m
Permanent load gk	6	kN/m²
Max line load q_allow	142,3286155	kN/m
Max floor load total	8,705114095	kN/m²
Max variable load qk_allow	2,705114095	kN/m²

0


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
A B C D E F G K M N

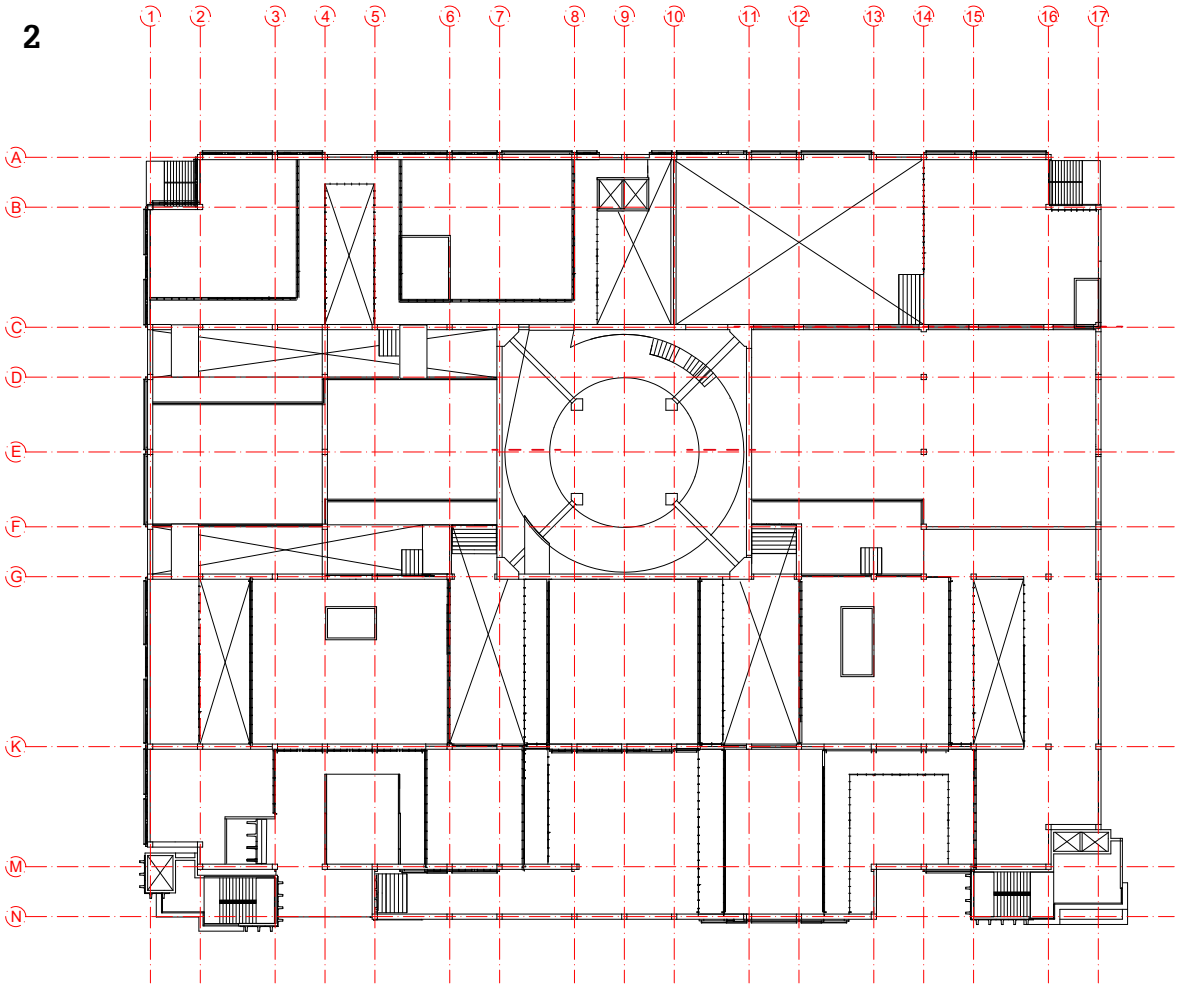
1


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
A B C D E F G K M N

N

1: 500

2



3

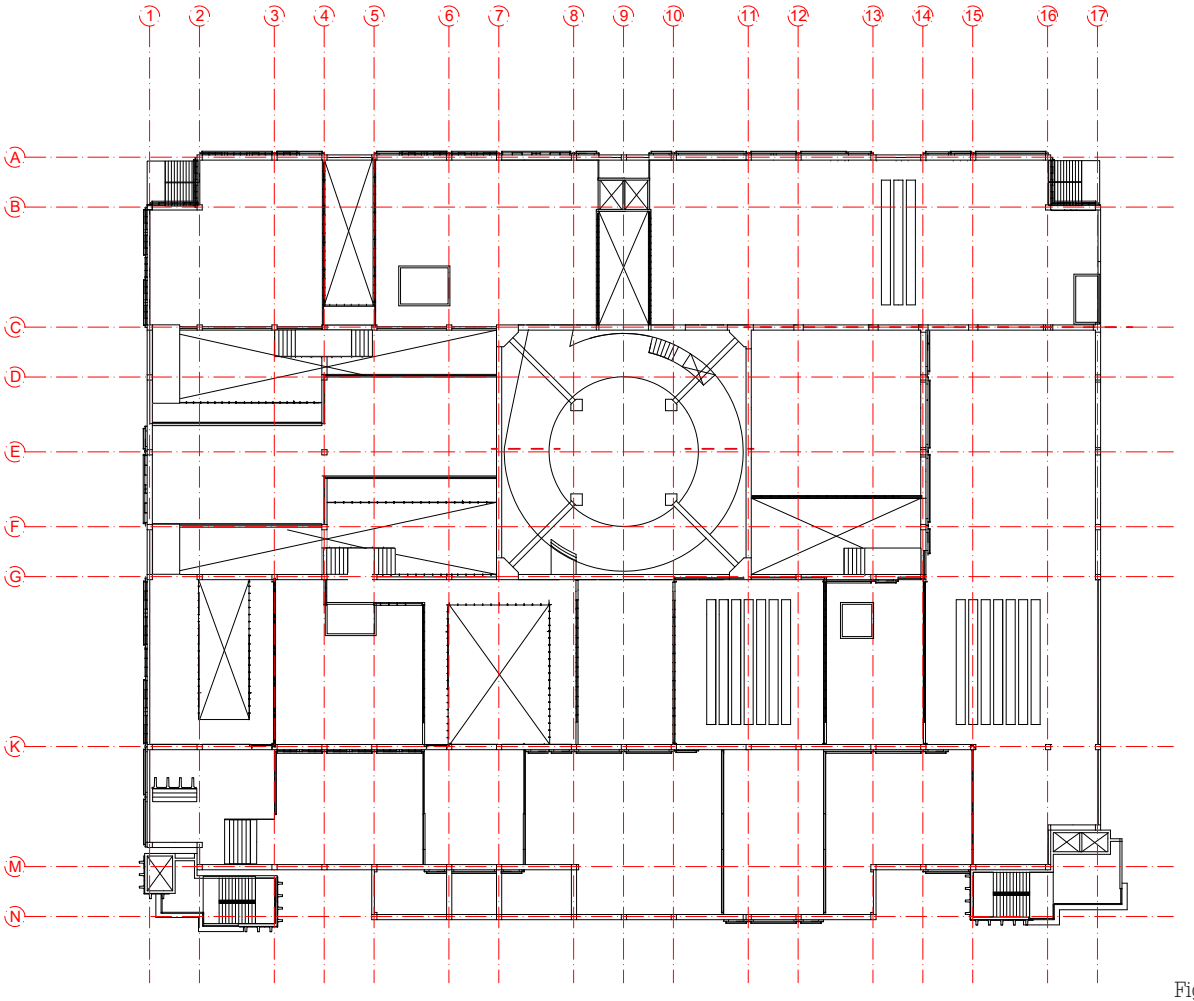
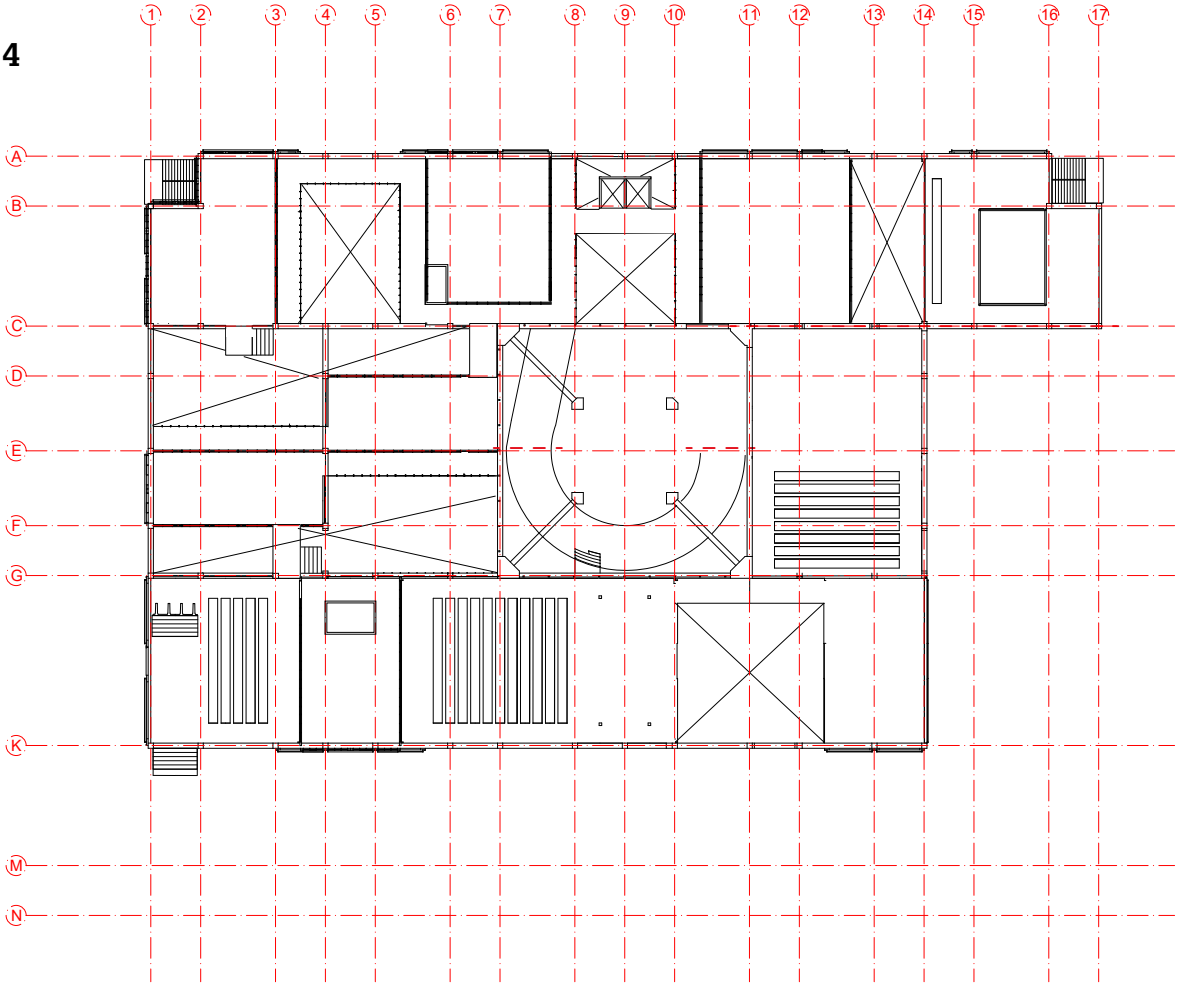
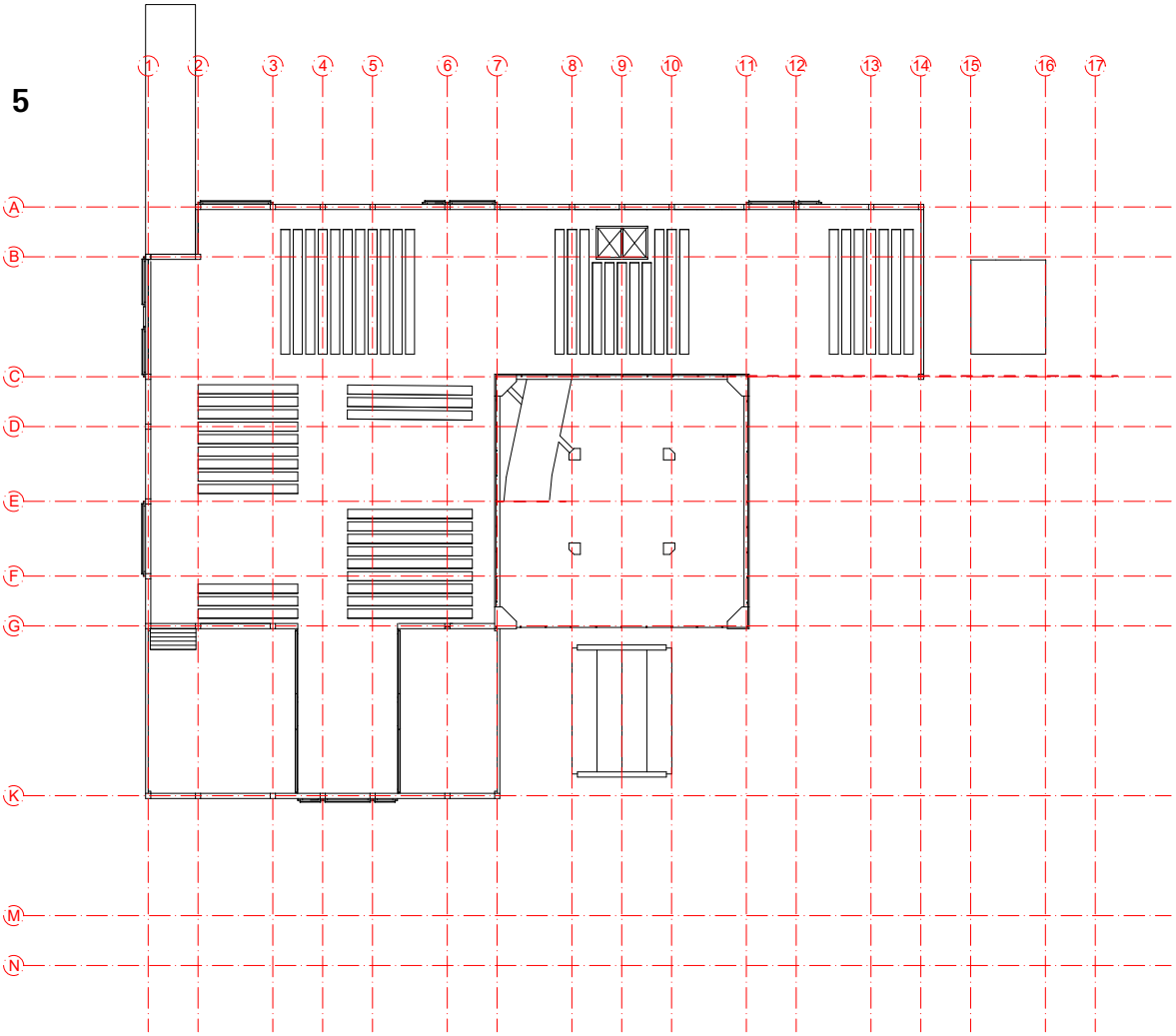


Figure 41. All floorplans. Sca

4



5



N

1: 500

led to 35% of its original size

9. DESIGN PROPOSAL

9.1 URBAN THRESHOLD AND THREE ENTRANCES

The transformation starts at the front facade along Mathildelaan. In the existing situation, the garage is primarily read as a closed infrastructural block. The new design changes this relation by opening the building toward the square and giving the facade a clearer public role. The former garage edge becomes a threshold between the city and the interior.

The front side is organised through three main entrances. Each entrance is connected to one of the main programme zones: mobility, work and study. This gives the large building a more legible public address. Instead of one anonymous garage entrance, the facade receives a sequence of access points that divide the scale of the building and guide different users into the interior.



Figure 42. Url

Human scale is introduced at the front facade through this division into entrances, passages and visible activity. The large parking structure is no longer approached as one continuous block, but as a facade with different rhythms and points of access. The larger cuts make the building readable from the square, while the smaller facade rhythms, reused elements and shadow lines create a more approachable scale at street level. The three renders show how each entrance gives a different identity to the programme behind it, while still belonging to one transformed concrete structure.

The three entrances are approached through exterior passages, which pull people from the square into the building. These passages create a gradual transition between public space and interior programme. The division into three entrances also prevents the building from becoming one single undifferentiated volume. It allows the mobility hub, the innovation/work areas and the study programme to have their own identity, while still remaining connected through the central interior network.



ban elevation



Figure 43. Mobilityhub entrance



Figure 44. Education entrance



Figure 45. Main



(work) entrance

9.2 GROUND FLOOR PLAN: FROM SQUARE TO INTERIOR

The ground floor plan establishes the new public logic of the building. The former parking garage no longer functions as a closed storage machine for cars, but as a layered threshold between the city and the interior. The square on Mathildelaan extends into the building through the entrance tribune with garage doors. When these doors are opened, the boundary between square and interior becomes less fixed. The public route continues through the building toward the future bridge connection, turning the garage into an urban passage rather than an urban obstacle.

The plan shows a clear division between three main entrances and three main functional zones: mobility, work and education. Each entrance is approached through an exterior passage, guiding users from the square into the building while keeping the flows legible. Vehicle access to the mobility hub is organised from the side and rear, while the public and educational routes are connected more directly to the front and central spiral. This creates separation where needed, without isolating the different users from each other.

From the entrances, users are guided toward the central spiral and the stairs surrounding it. From this point, the route branches toward the rear, west and east compartments of the building.

The existing asphalt floor is retained where movement remains dominant. Where spaces become places to stay, such as study areas, seating zones or coffee points, the floor finish changes to create a warmer and more comfortable atmosphere. This contrast helps make the ground floor readable: asphalt marks movement, while softer materials mark occupation.

In the lecture hall, the original slope of the garage is used more directly: the existing height difference of approximately 2.4 metres over 24 metres becomes the basis for a stepped tribune. Harvested TT floor plates are reused to form these platforms, linking the lecture space to the material logic of the existing structure. A movable partition can divide the hall into two smaller rooms, allowing the space to shift between one larger collective lecture setting and two more flexible teaching or workshop spaces.

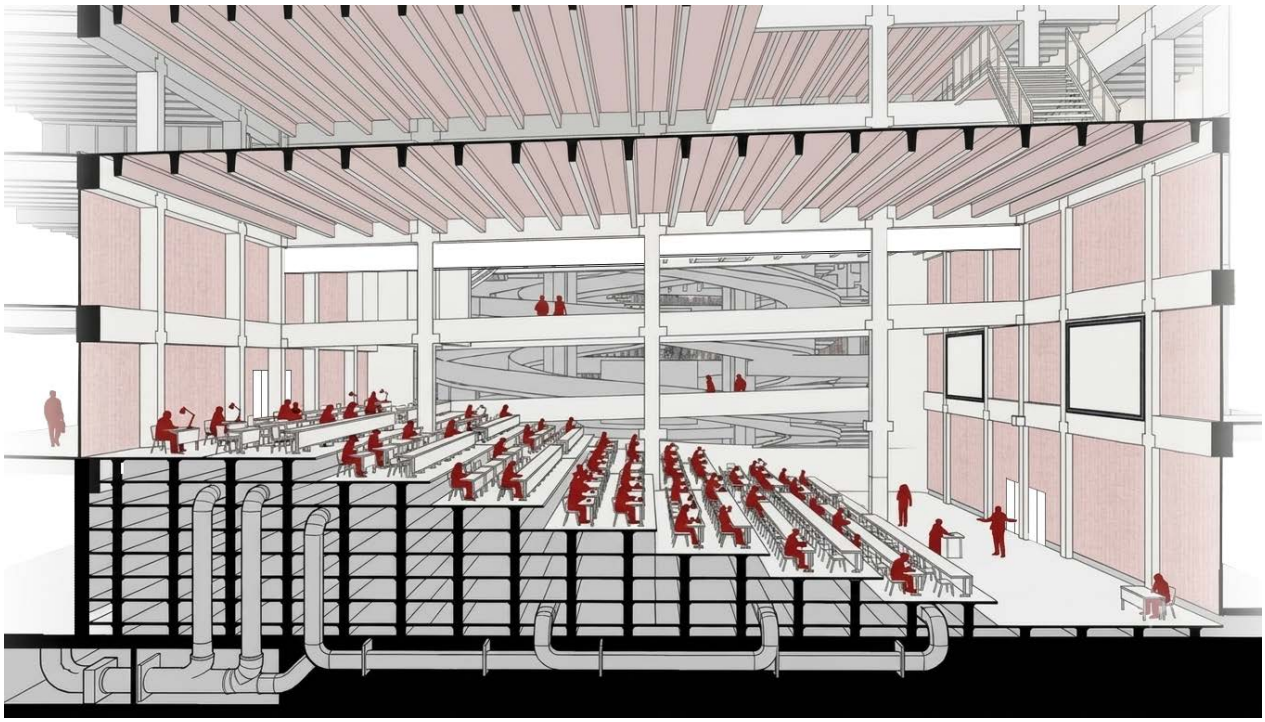


Figure 46. Lecturehall diagram

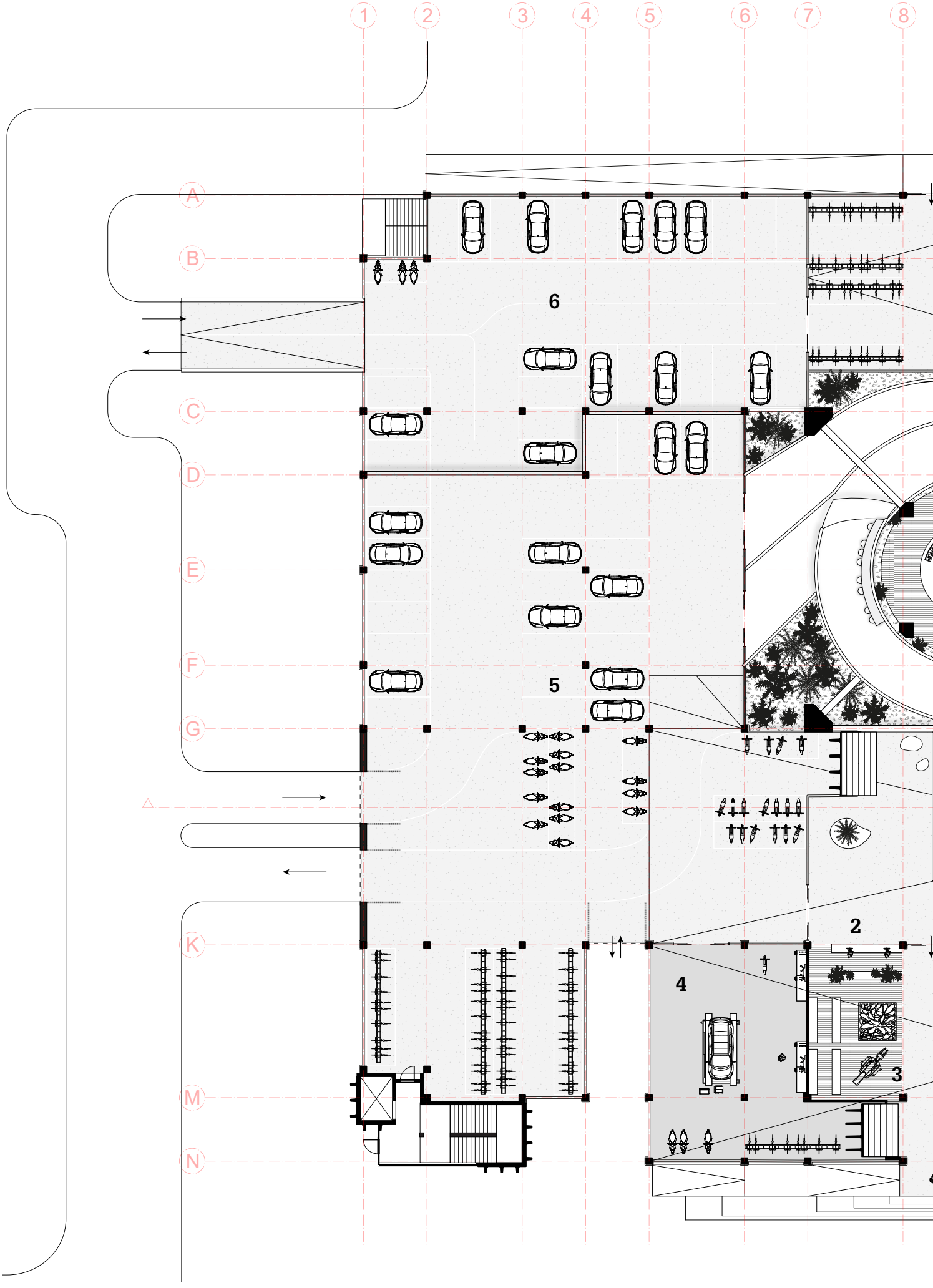
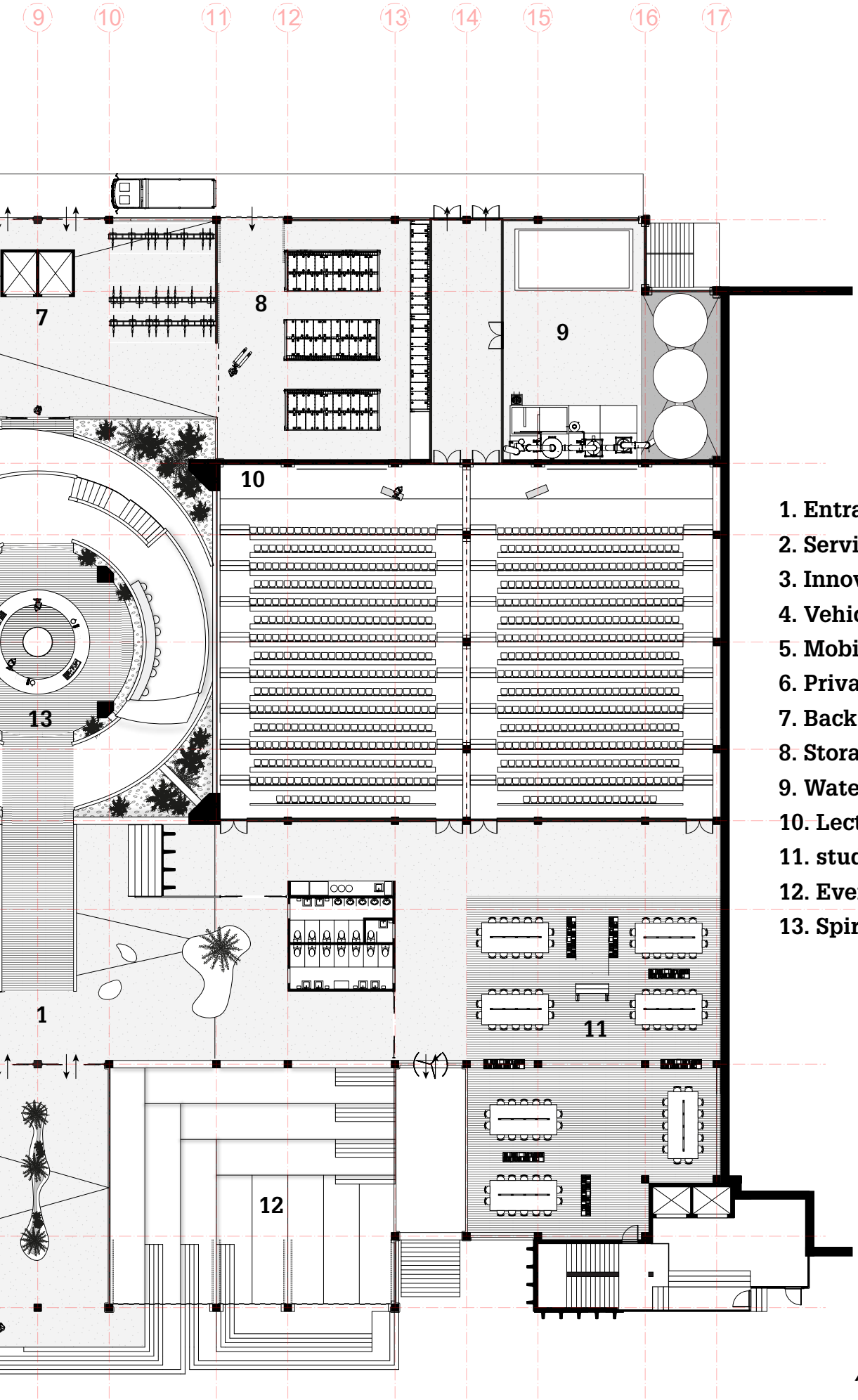


Figure 47. Ground floor plan of the transformed pa



1. Entrance hall
2. Service desk
3. Innovation exhibition
4. Vehicle repair shop
5. Mobility hub
6. Private parking
7. Back entrance
8. Storage and mail
9. Water instalations
10. Lecture hall
11. study places
12. Event square
13. Spiral with kiosk

N

1: 100

rking structure. Scaled to 27.5% of its original size

9.3 INTERIOR NETWORK AND CIRCULATION

The interior circulation is designed as a human network rather than a car route. In the existing garage, movement is organised around efficiency, slope and vehicle turning. In the transformation, movement becomes a way to orient, meet, pause and move through the different programmes.

Additional carvings are made to reveal the main routes in the x and y directions. These routes guide users through the deep floor plate and connect the three main programme zones. All primary routes lead toward the central spiral, which becomes the heart of the building. Around this point, people can meet, get coffee, rest, orient themselves or continue toward another part of the building.

Vertical circulation is placed in relation to the new daylight voids. This means that movement is connected to light. Users are not only directed by signs or corridors, but by the spatial quality of the building itself. Light, voids and stairs work together to guide people through the structure.

Higher in the building, new bridges connect the different clusters. These bridges are made by reusing removed TT floor plates and rotating them into new positions. This creates horizontal connections while keeping the material logic of the original structure visible. Movement is therefore not only functional. It becomes part of the architectural experience of the building, allowing users to wander, stop, look across voids and encounter other people.



Figure 48. Working model for testing interior circulation
Physical model testing routes, stairs, bridges and voids within the existing sloped parking structure.



Figure 49. Interior view from the entrance toward the west wing
Collage showing how the entrance hall opens toward the west wing and how light enters the interior to guide movement and orientation.

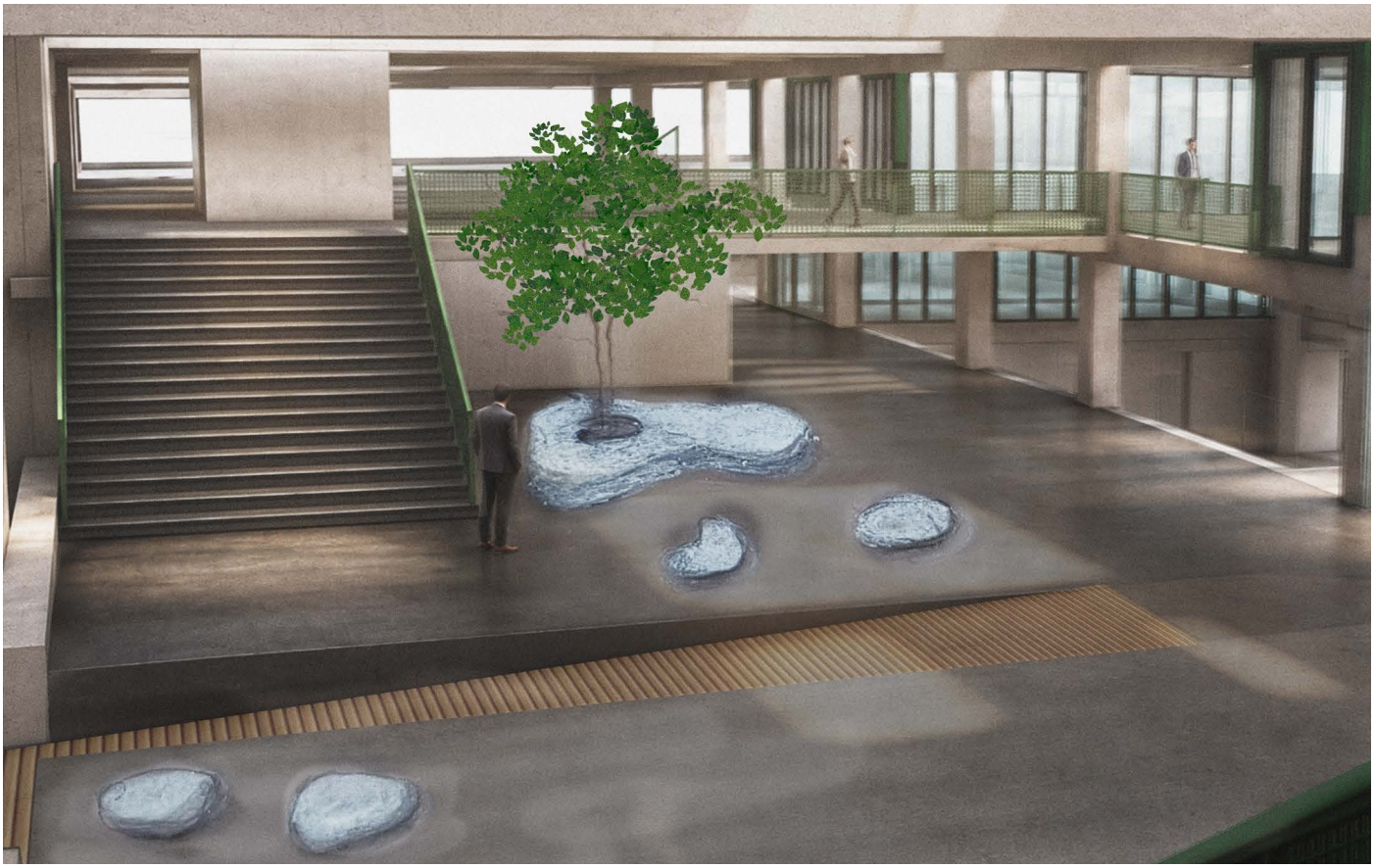


Figure 50. Interior view from the west-wing stair toward the east wing
Collage showing the visual connection between clusters and how daylight, stairs and voids structure movement through the building

9.4 SECTION: CARVING DAYLIGHT AND PUBLIC-PRIVATE GRADIENT

The section is the main place where the transformation becomes visible. The existing garage has deep floor plates and limited daylight penetration. To make the building suitable for human occupation, the design introduces terraced voids within each cluster. These voids are not straight shafts, but step upward through the structure.

Each cluster receives at least one void with a minimum width of two TT floor plates, approximately 4.8 metres. This dimension follows the logic of the existing construction: removing complete elements is more structurally legible than cutting randomly through prestressed concrete. The terraced shape allows daylight to reach deeper into the building and creates collective outdoor spaces between the work areas.

The terraced voids also create human scale in section. Instead of one deep and repetitive parking volume, the building is divided into smaller spatial identities. Each floor receives a different relation to light, view, terrace and collective space. This makes the section readable as a sequence of places rather than as a continuous car deck. The voids therefore work at several levels at once: they bring daylight, support orientation, create social terraces and break the infrastructural scale of the garage into more inhabitable parts.

The section also shows the programme gradient. Heavy, public and high-load functions are placed low in the building, where access, logistics and structural capacity are strongest. Higher and deeper in the building, the programme becomes more private and lighter. Offices and smaller workspaces benefit from daylight, views and distance from the public ground floor. The building therefore moves from public to private, from heavy to light, and from collective to more individual spaces.

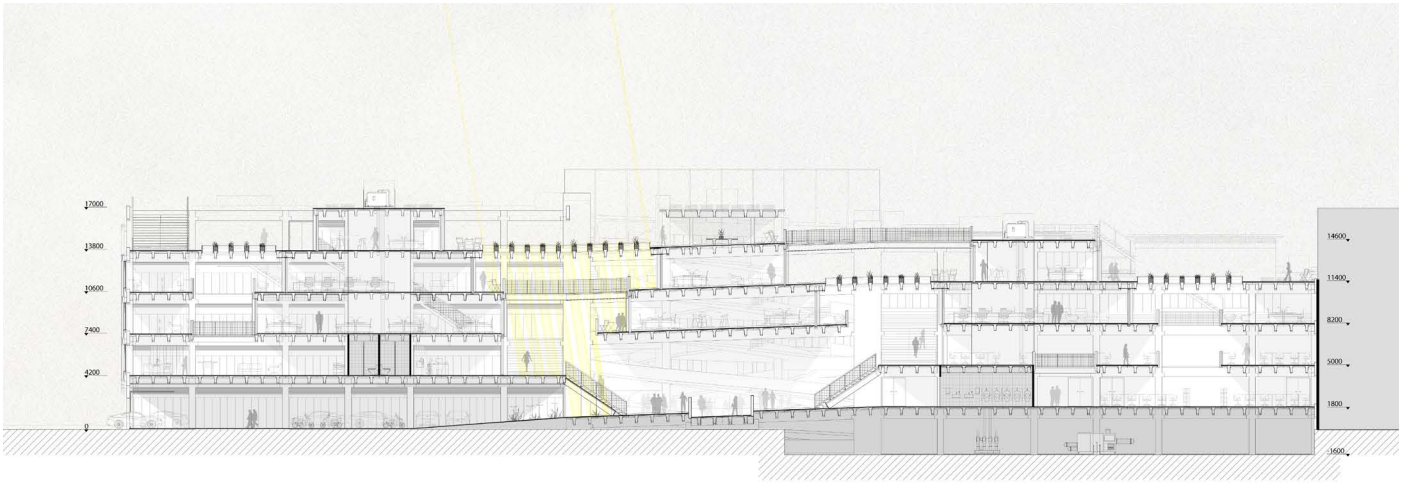


Figure 51. Daylight strategy in section

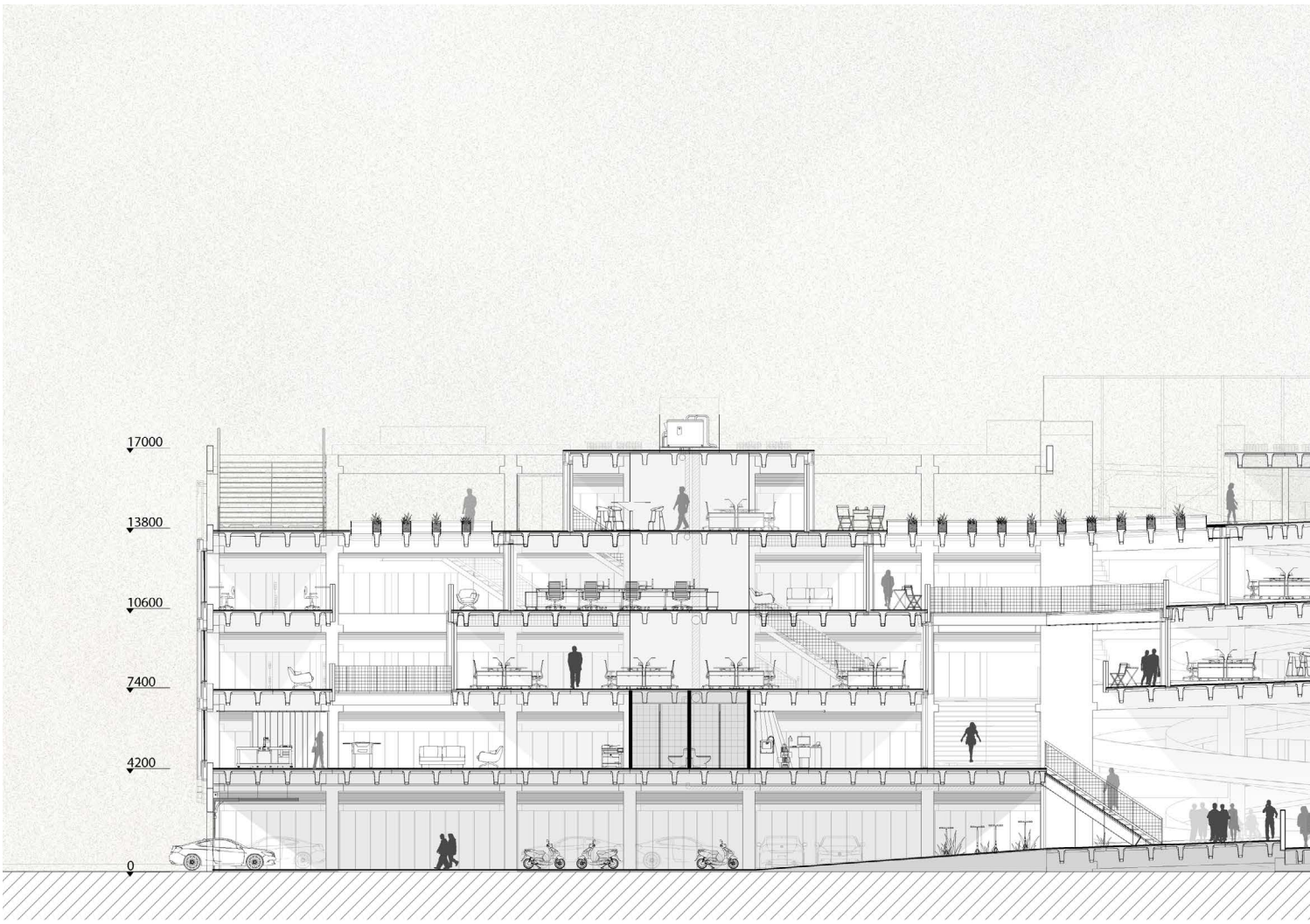
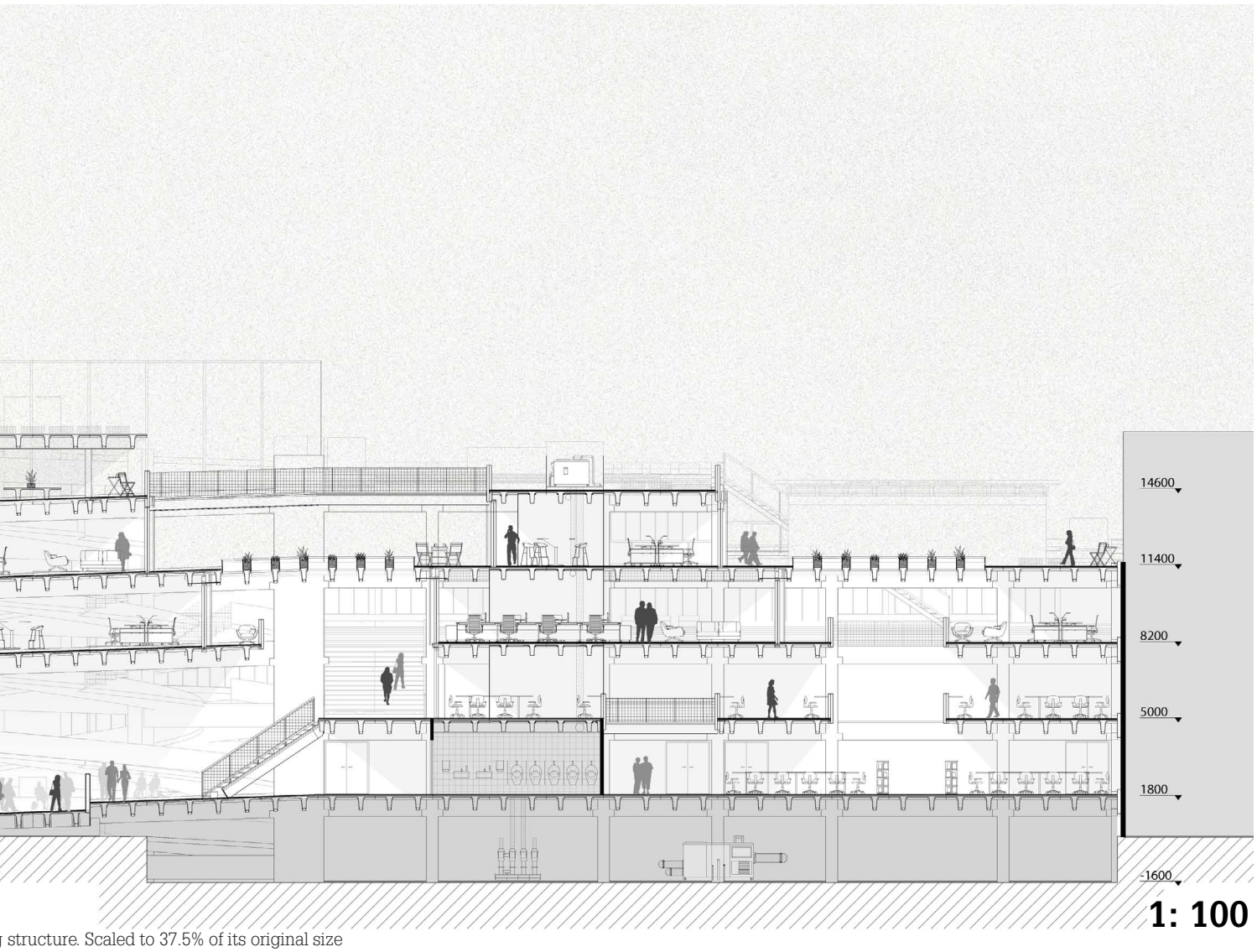


Figure 52. Section of the transformed parking



1: 100

g structure. Scaled to 37.5% of its original size

9.5 DETAIL, MATERIAL REUSE AND CLIMATE

The detail strategy connects the architectural proposal to the material logic of the existing garage. Before subtraction takes place, the building is read as a material stock. Facade balustrades, grating infill, TT floor plates and beams are identified as elements that can be removed, stored and reused. This changes the meaning of demolition material: it becomes part of the design inventory.

Removed TT floor plates are reused as bridges, platforms and parts of the new internal routes. Beams from removed elements can be used as additional support where new bridges or stairs are inserted. Existing facade components, such as balustrades and grilles, are cut and reassembled as facade layers, sun shading or interior edge elements. This strategy keeps the material memory of the garage visible while reducing the need for new construction materials.



1: 20

Figure 53. Detailed section. Scaled to 6,25% of its original size

Bouwdetail gebaseerd op: Rc dak ≥ **6,3 m²·K/W** U-vliesgevel ≤ **1,65 W/m²·K** qv10-waarde ≤ **0,4 dm³/s per m²**

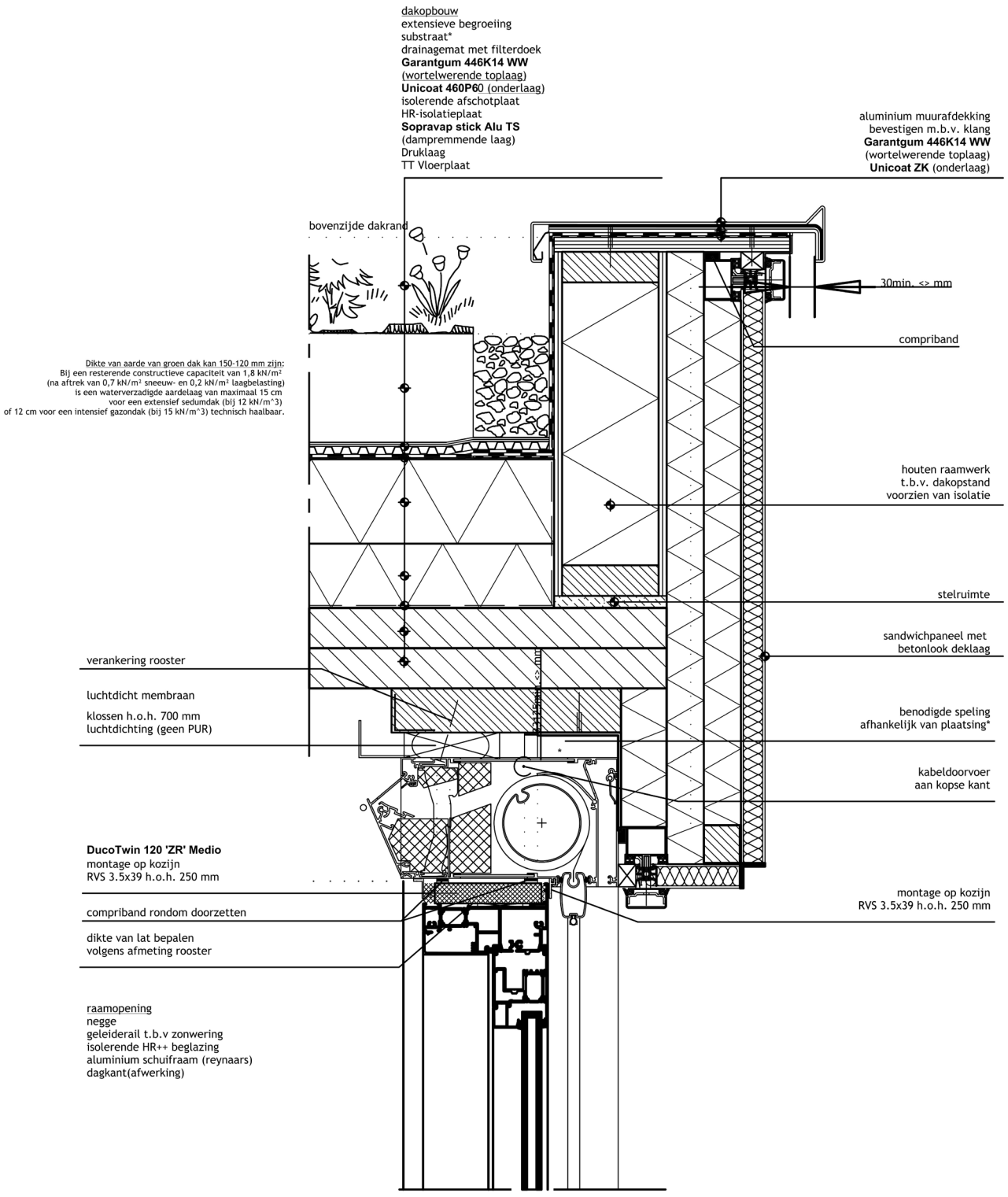


Figure 54. Detail roof corner. scaled to 67.5% of the original size

Bouwdetail gebaseerd op: Rc dak ≥ **6,3 m²·K/W** U-daklicht ≤ **1,6 W/ m²·K** qv10-waarde ≤ **0,625 dm³/s per m²**

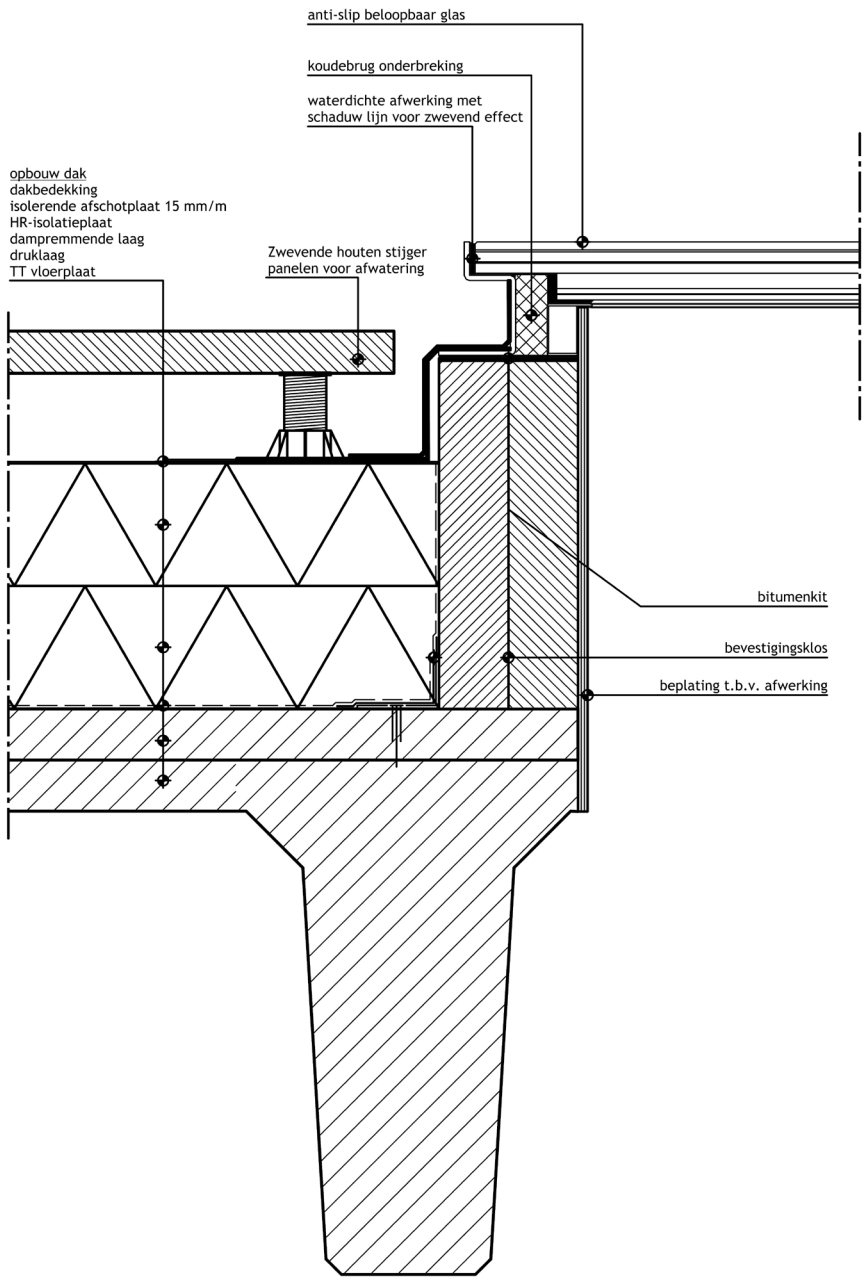


Figure 55. Detail Skylight. scaled to 67.5% of the original size

15-20 mm industrial oak / engineered oak floor finish
18-25 mm plywood subfloor
20 mm acoustic impact mat
Adjustable timber battens / metal supports
Mineral wool infill where possible
Existing sloped TT concrete floor plate

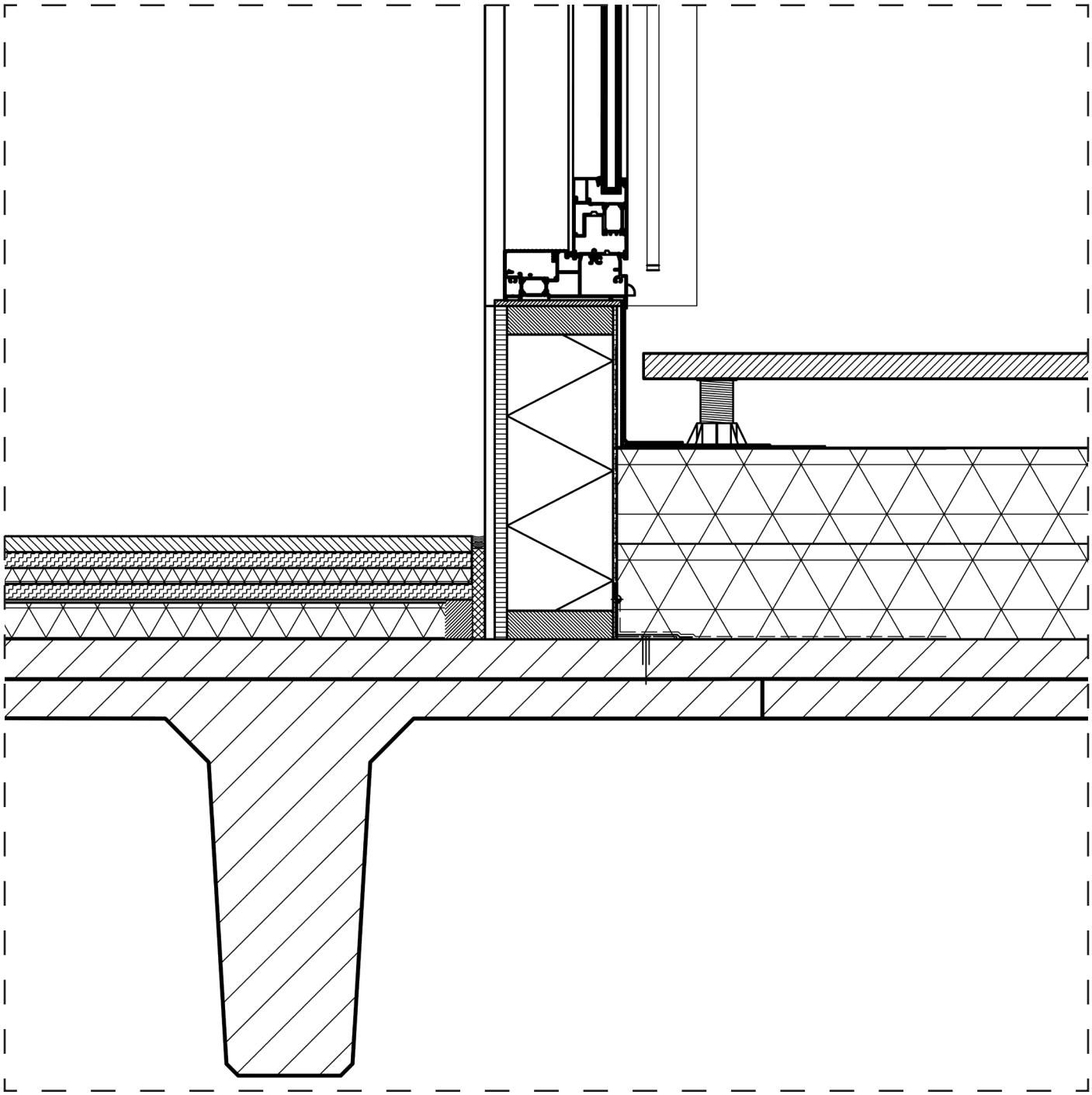


Figure 56. Detail inside to roofgarden. scaled to 67.5% of the original size

Sheet aluminium coping with drip edge
3-ply waterproofing membrane / sealant layer
12 mm cement-bonded particle board as rigid exterior backing
130 mm mineral wool thermal insulation
16 mm OSB structural sheathing
13 mm gypsum board interior cladding

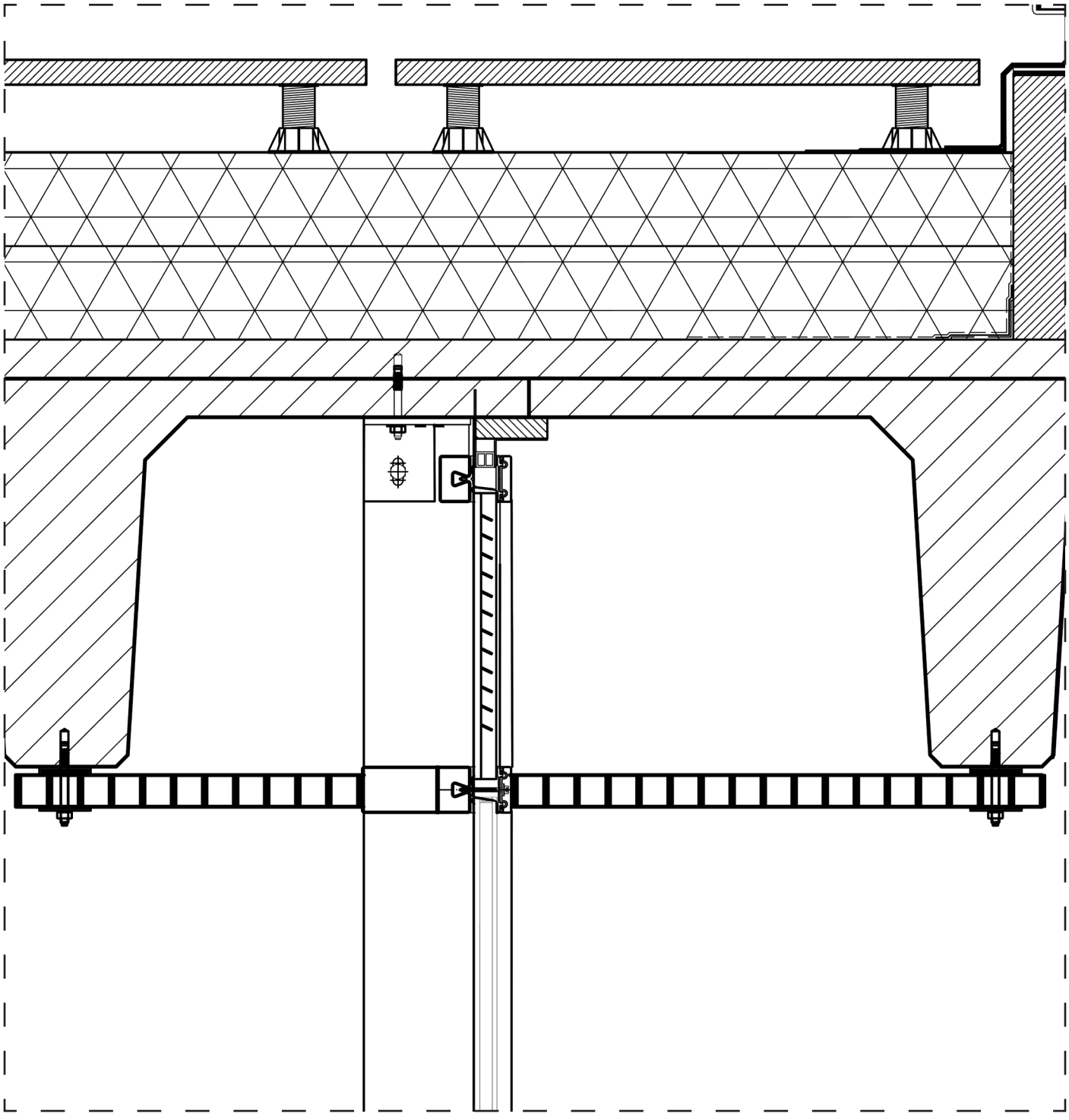


Figure 57. Detail Grating ceiling. scaled to 67.5% of the original size

Reused facade grating mounted to underside of TT beams
Steel fixing plate to TT beam
M8 / M10 bolt connection
Ventilation grille between continuous window profiles
Air transfer from office to atrium
30 mm acoustic laminated double glazing
Reused steel RHS baluster frame, 60 x 100 mm
New shallow welded steel glazing profile on reused baluster
Setting blocks / glazing blocks
Steel fixing bracket to existing ceiling structure



30 mm acoustic laminated double glazing
Reused steel RHS baluster frame, 60 x 100 mm
New shallow welded steel glazing profile on reused baluster
Setting blocks / glazing blocks
Steel fixing bracket to existing floor structure
5-10 mm flexible sealant joint at floor finish
Floating floor build-up kept free from steel frame

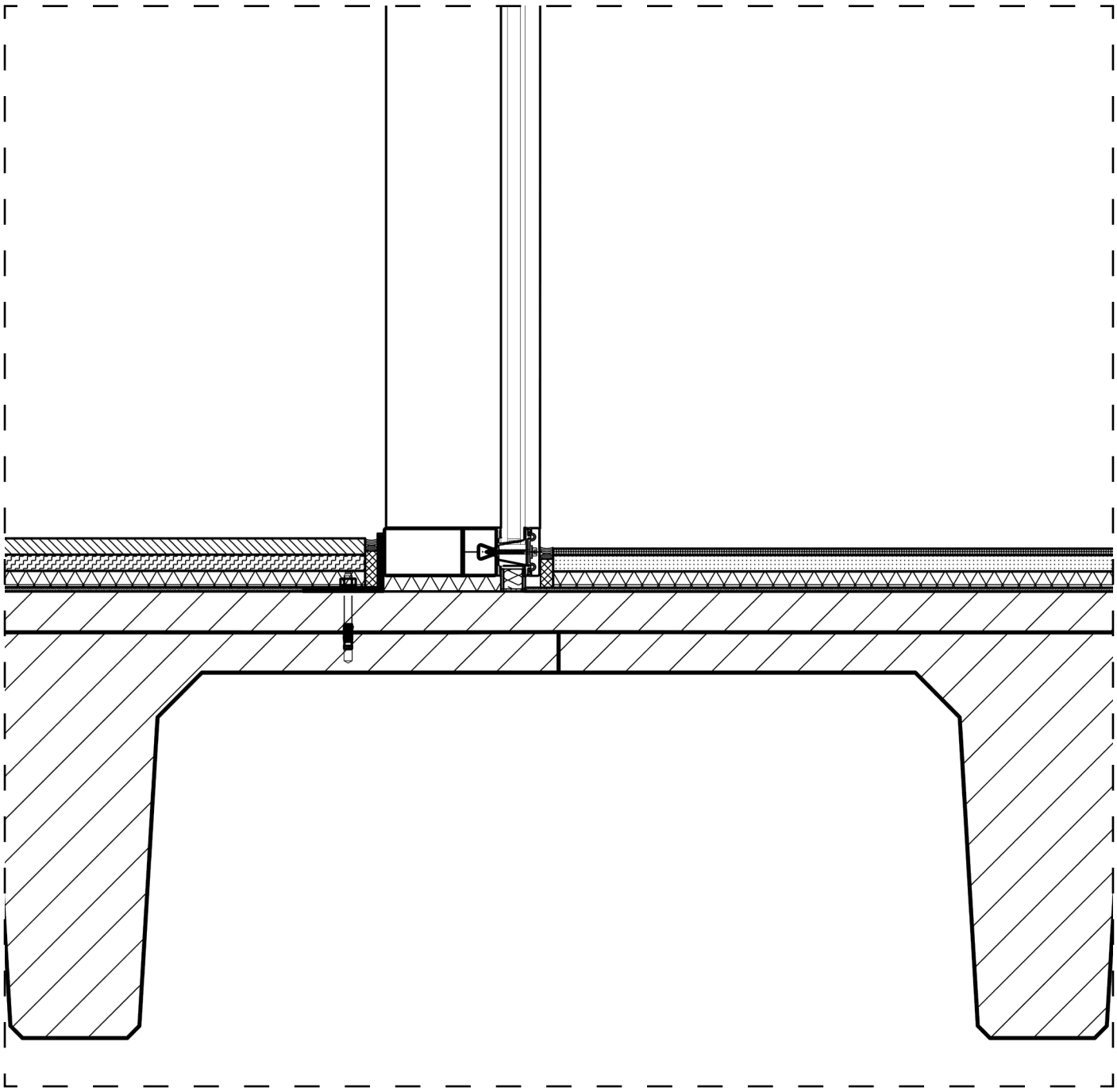
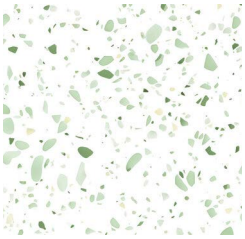


Figure 58. Detail 2 transition floor types. scaled to 67.5% of the original size

8 mm Duracryl Durabella Biopolymer Terrazzo
White-grey binder with recycled green glass aggregate
Primer / bonding layer according to Duracryl specification
20 mm cementitious board / rigid dry screed board
20 mm acoustic impact insulation layer
2-10 mm local levelling compound where required
Existing concrete pressure layer / TT floor plate



Reused facade grating panel
Reused steel RHS baluster frame, 60 x 100 mm
Steel fixing tabs / welded brackets
M8 / M10 bolt connection to baluster frame

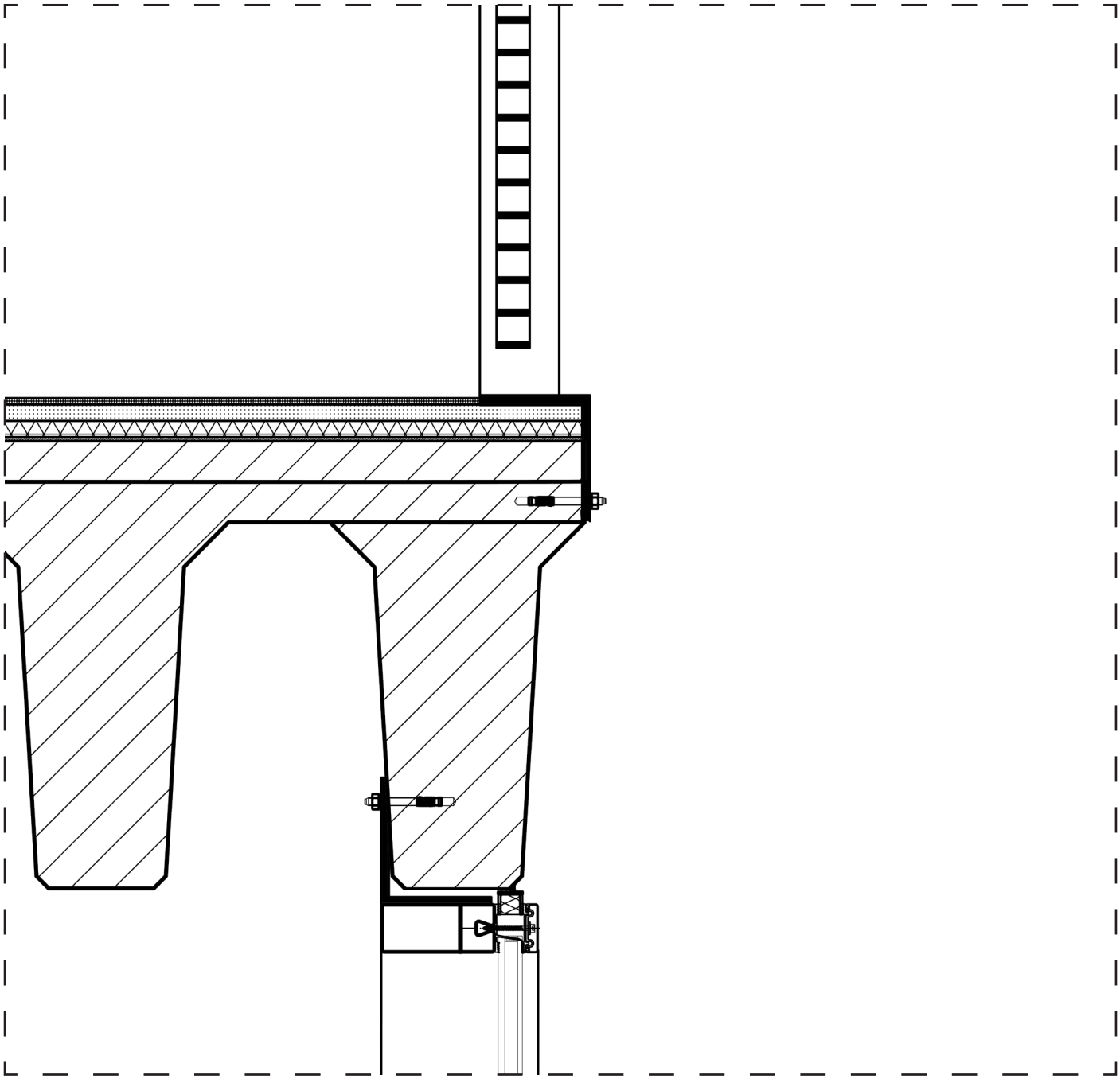


Figure 59. Detail reused baluster. scaled to 67.5% of the original size

Existing concrete T-beam
Existing TT floor plate
Reused steel RHS baluster, 60 x 100 mm
Steel base plate, approx. 200 x 150 x 10 mm
M12 chemical anchors into existing concrete
30 mm acoustic laminated double glazing
New shallow welded steel glazing profile
Flexible sealant joint

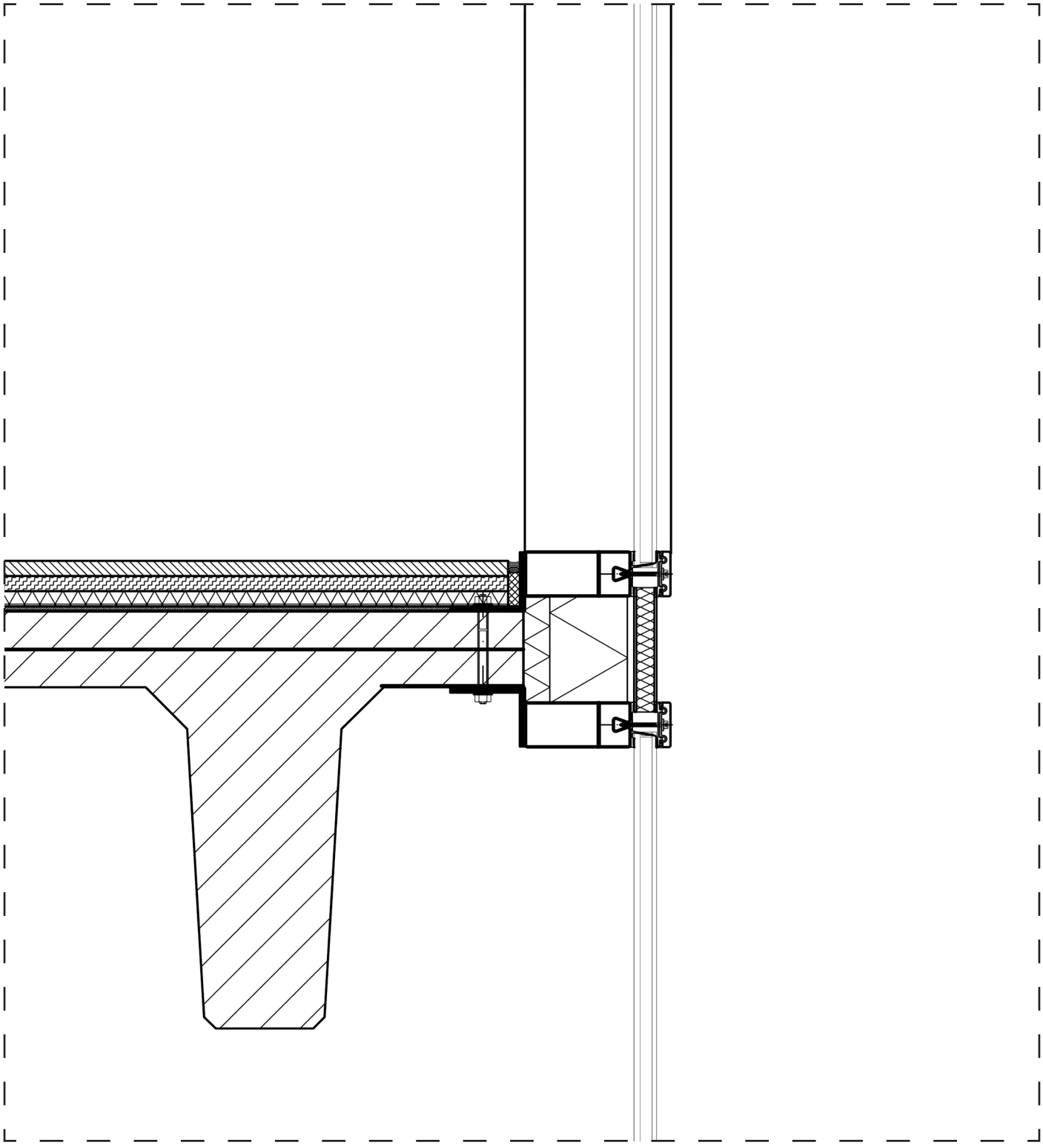


Figure 60. Detail curtain wall. scaled to 67.5% of the original size

Reused steel RHS baluster frame, 60 x 100 mm
Custom welded steel glazing / panel profile
Interior steel-faced sandwich panel, approx. 30 mm
Recycled steel sheet facing)
Steel pressure plate / clamp profile
EPDM / rubber compression gasket
Screw fixing into welded steel profile
Flexible sealant joint where required

Existing asphalt floor finish retained
Open-cut reused steel baluster used as bottom glazing channel, 60 x 100 mm
Rubber glazing gasket inside steel channel
Setting blocks / glazing blocks below glass
30 mm acoustic laminated double glazing
Fixing to existing concrete pressure layer & TT floor plate
Top glass fixing connected to continuous steel facade profile

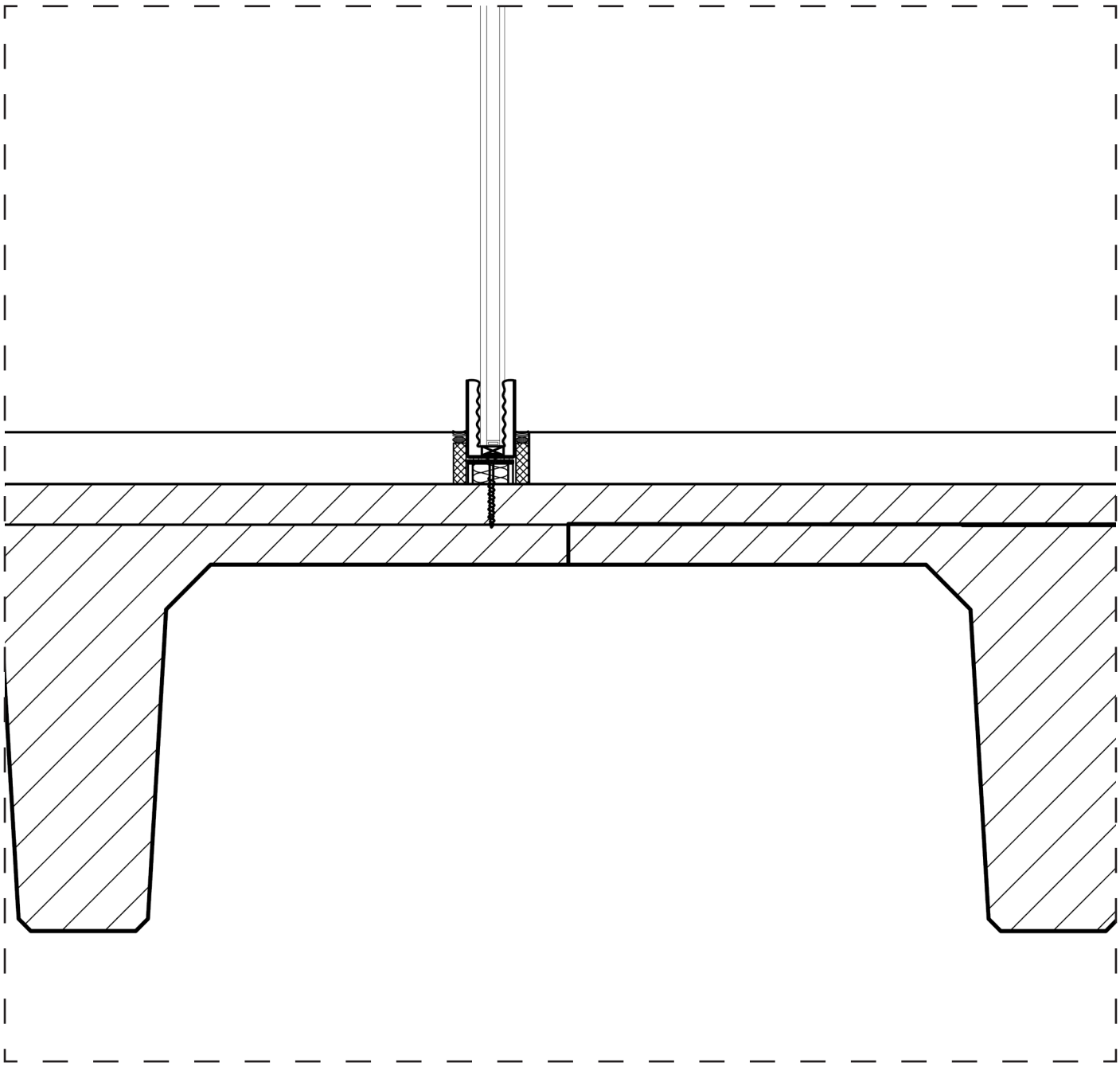


Figure 61. Detail window to asphalt. scaled to 67.5% of the original size

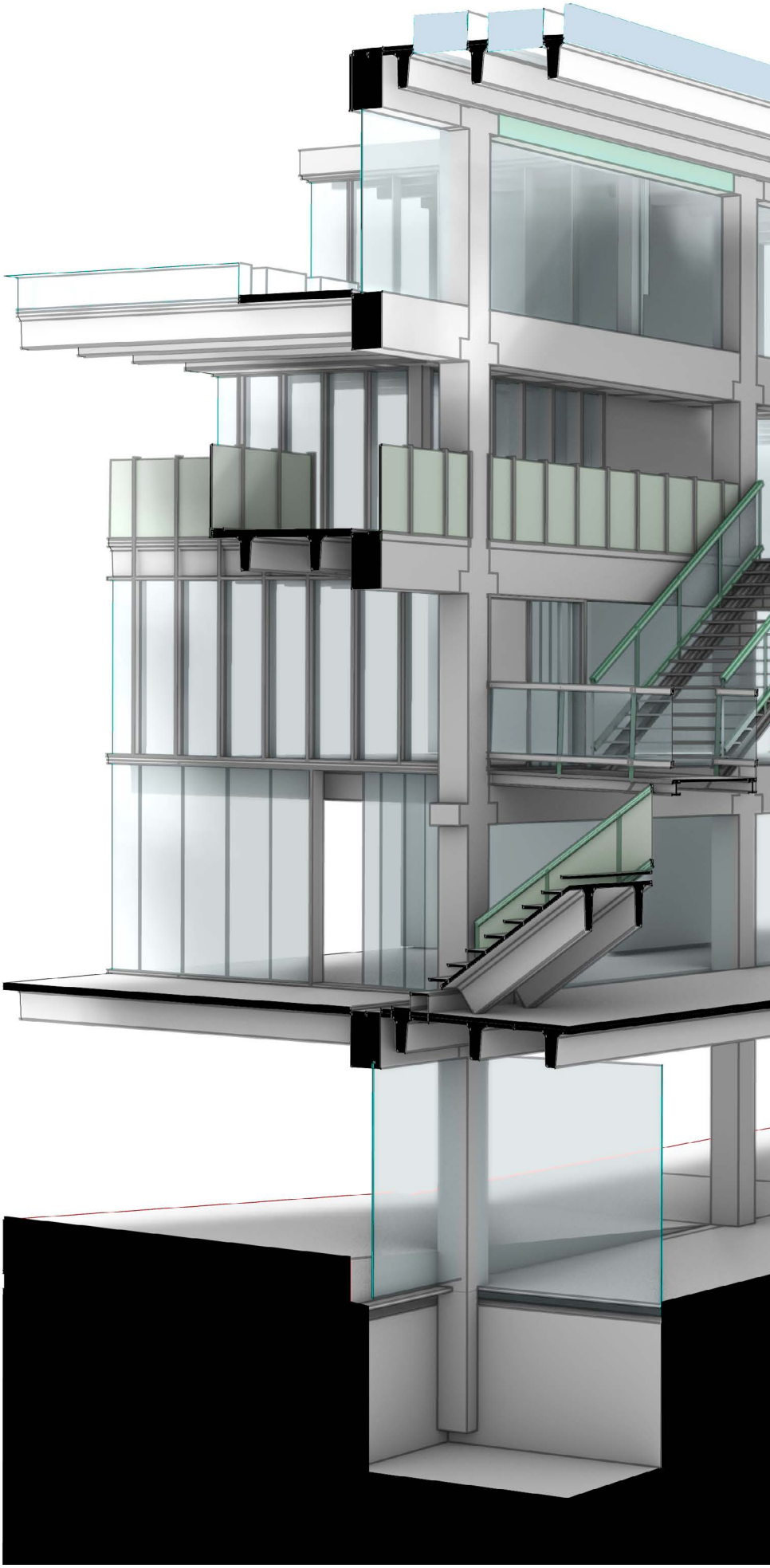


Figure 62. Preview mod



del 1:50 (In the making)

The climate strategy directly responds to the structural constraints of the existing parking garage. With a restrictive floor-to-ceiling height of just 3.2 meters, conventional suspended ceilings and dual-duct HVAC networks are physically impossible. Therefore, the design adopts an exposed 'All-Air' induction strategy that eliminates return ductwork at the ceiling level, saving 50% of the horizontal installation zone and preserving a generous free height of 2.75 meters.

What makes this building's climate network unique is that the architectural components themselves act as the primary infrastructure. Fresh air is supplied by individual Air Handling Units located on the roof of each 1,900 m² cluster. This air is transported vertically through the central wet-cores and distributed horizontally into the offices via wide, shallow rectangular ducts tucked tightly between the concrete ribs of the TT-floor plates. These ducts feed high-efficiency, exposed induction units that temper local room air without any embedded water piping in the concrete structure.

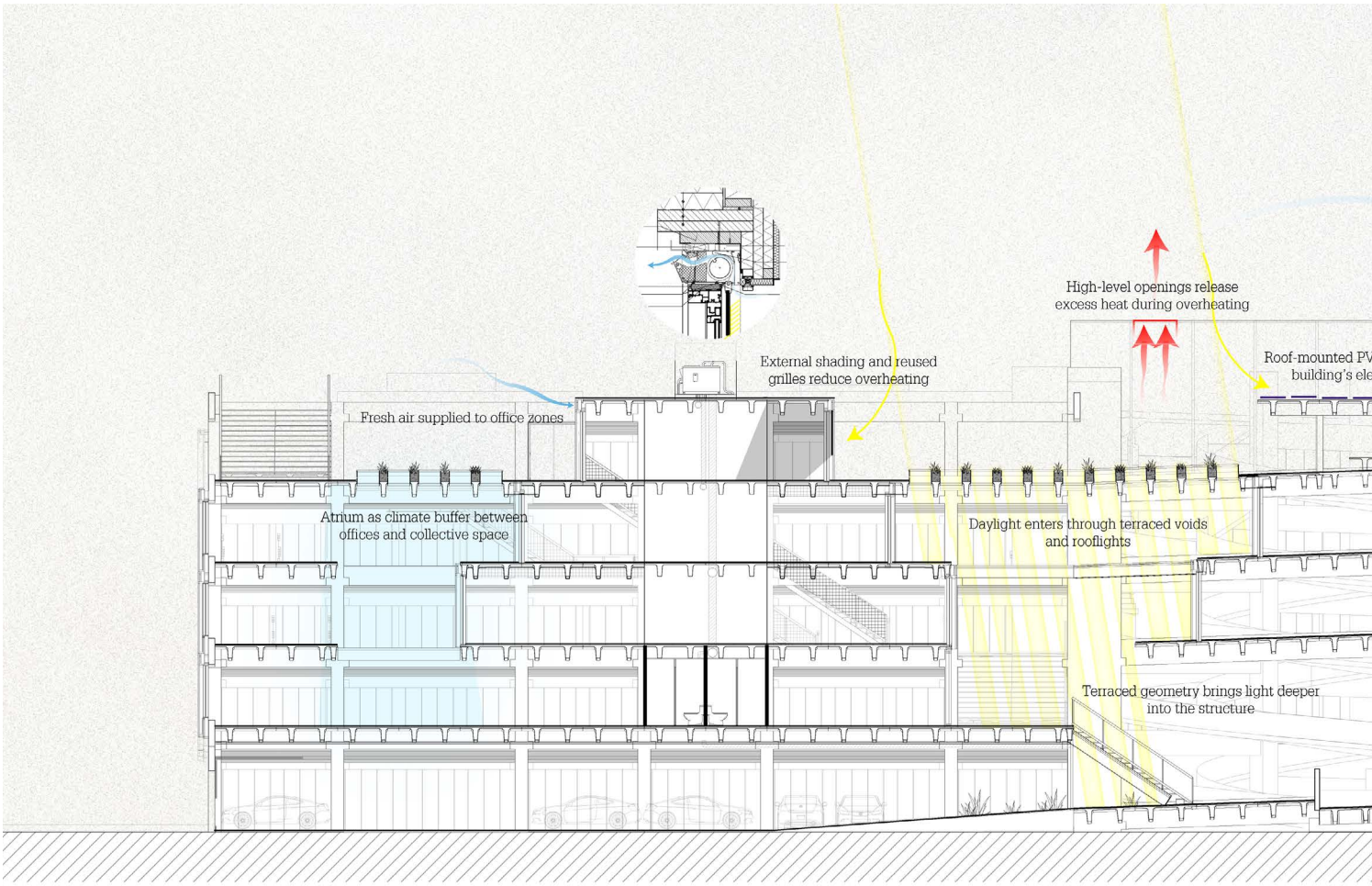
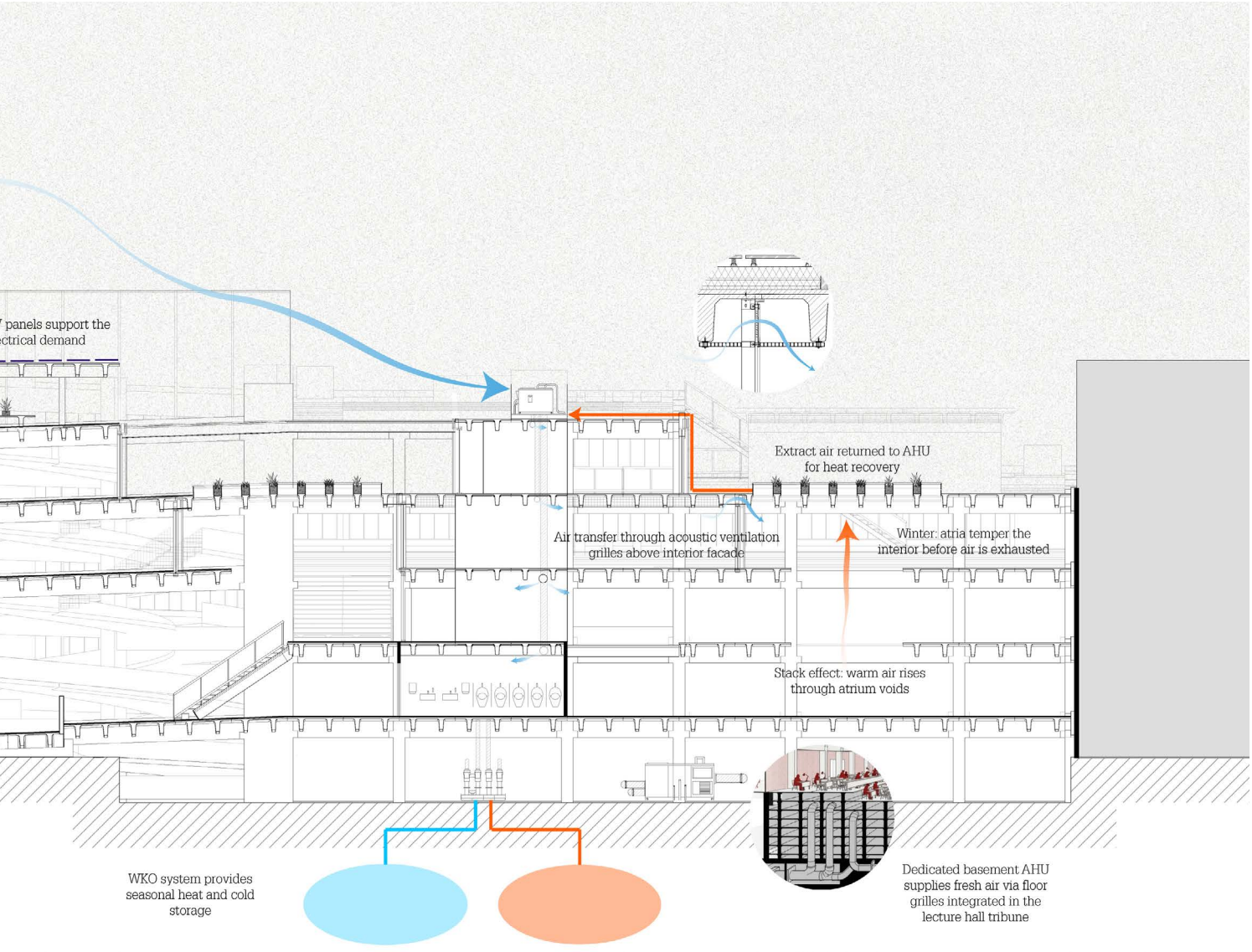


Figure 63. Cli

Instead of a closed loop of return piping, the building utilizes the central atria as a low-pressure return plenum. The offices operate under a slight overpressure; stale air naturally flows out of the workspaces through acoustic transfer grilles into the adjacent atrium voids. This warm return air rises to the top of the atrium where it is captured and routed back to the roof, creating a highly efficient building loop connected to a central heat pump and groundwater system (WKO) in the main basement.

The large lecture hall utilizes a completely separate architectural logic. A dedicated basement unit pressurizes the airtight plenum space directly beneath the concrete tribune. Air is introduced into the auditorium at a low velocity through displacement ventilation grilles integrated into the stair risers. This utilizes natural buoyancy—the heat generated by the audience causes the air to rise gently toward the ceiling, creating an ideal acoustic and thermal environment.



mate diagram

10. CONCLUSION AND REFLECTION

10.1 CONCLUSION

This project investigates how a concrete parking garage can be transformed from car-oriented infrastructure into a circular and human-scale urban building. The research started from an interest in concrete optimisation, but shifted during the process toward the transformation of parking structures. This shift was important because the Mathildelaan garage was not simply an over-dimensioned structure from which material could be removed freely. It proved to be a complex spatial and technical system, shaped by TT floor elements, sloped decks, low floor-to-ceiling heights, ramp circulation, limited daylight and fire-safety constraints.

The design therefore uses subtraction not as demolition, but as a controlled architectural method. By removing selected structural bays, the deep floor plate is opened for daylight, orientation and social encounter. The existing spiral, ramps and concrete frame are not erased, but reinterpreted as part of a new human network. Removed elements, such as TT floor plates, beams, facade balustrades and grating infill, are treated as a material stock that can be reused within the project. In this way, subtraction becomes both a spatial and circular strategy.

The programme supports this transformation. Instead of replacing the garage with housing, the project introduces a public innovation environment where mobility, education, startups, MKB, larger companies and civic functions overlap. This responds to the theoretical position developed in the research: if Eindhoven's innovation economy is to move beyond a closed Triple Helix model, architecture must help create spaces where citizens, knowledge institutions, government and industry can meet. Based on the Quadruple Helix approach described by Paskaleva, the building is positioned as a public interface between innovation and everyday urban life, rather than as an isolated campus environment.

10.2 IMPLICATIONS AND TRANSFERABILITY

The project is strongest as a method and set of transformation rules. The exact architectural form could still develop further, but the project establishes a clear framework: harvest existing elements before removing them, subtract according to structural logic, use voids for daylight and orientation, place heavy and public functions low in the building, place lighter and more private workspaces higher up, transform car routes into human routes, and reuse removed elements on-site. These rules give the design a logic that can continue to be tested and adapted.

The relevance of this approach extends beyond the Mathildelaan garage. Many parking garages in Dutch city centres share similar characteristics: repetitive concrete grids, deep floor plates, ramp-based circulation, low floor heights and robust structural capacity. As cities reduce the dominance of private cars in central areas, these structures will increasingly come under pressure for demolition or redevelopment. This project argues that they should not automatically be treated as obsolete urban leftovers, but as existing structural and material frameworks that can be edited into new public architecture.

10.3 REFLECTION AND LIMITATIONS

The physical model was essential to the design process. The garage is difficult to understand only through plan drawings because the floors are not stacked as simple horizontal levels. They form a continuous sloped system connected to a central spiral. By constructing the model with removable TT floor plates, the building became testable. Elements could be removed, cut, shifted and placed back in different positions. This changed the design directly: smaller openings did not sufficiently improve daylight or spatial quality, which led to larger and more strategic terraced voids.

The project also changed my understanding of subtraction. At the beginning, subtraction was mainly connected to material reduction. During the process, it became a broader design method. Removing material can create daylight, orientation, collective terraces, visual connections and a more human scale. Subtraction is therefore not only a sustainable strategy, but also a spatial and social strategy.

Several aspects still require further development. The office layouts and transitions between collective and private spaces could be refined further. Fire safety remains a major technical concern, especially because the design connects atria, public routes and mixed programmes within an existing concrete structure. This would require further testing with a specialist. The treatment of the existing asphalt also remains an assumption: in the final proposal, asphalt is retained in public movement zones, while it is removed locally where new interior floor build-ups are introduced. This decision should still be technically verified in relation to adhesion, acoustics, fire behaviour and indoor comfort.

If the project were developed further, I would focus on the material atmosphere of the workspaces and on the central spiral. The spiral is one of the strongest existing spatial elements of the garage, but it could become more than an orientation point. It has the potential to become the social heart of the building, where the former logic of car movement is most clearly transformed into a space for people.

A final reflection concerns the integration of architecture and technique. This project helped me understand that technical constraints do not have to be solved after the architectural idea is made. Structure, reuse, daylight, climate, acoustics, fire safety and detailing can become the basis of the architectural idea itself. The broader lesson is therefore not simply that parking garages can be reused, but that their existing constraints can become the starting point for a more careful, circular and human form of architecture.

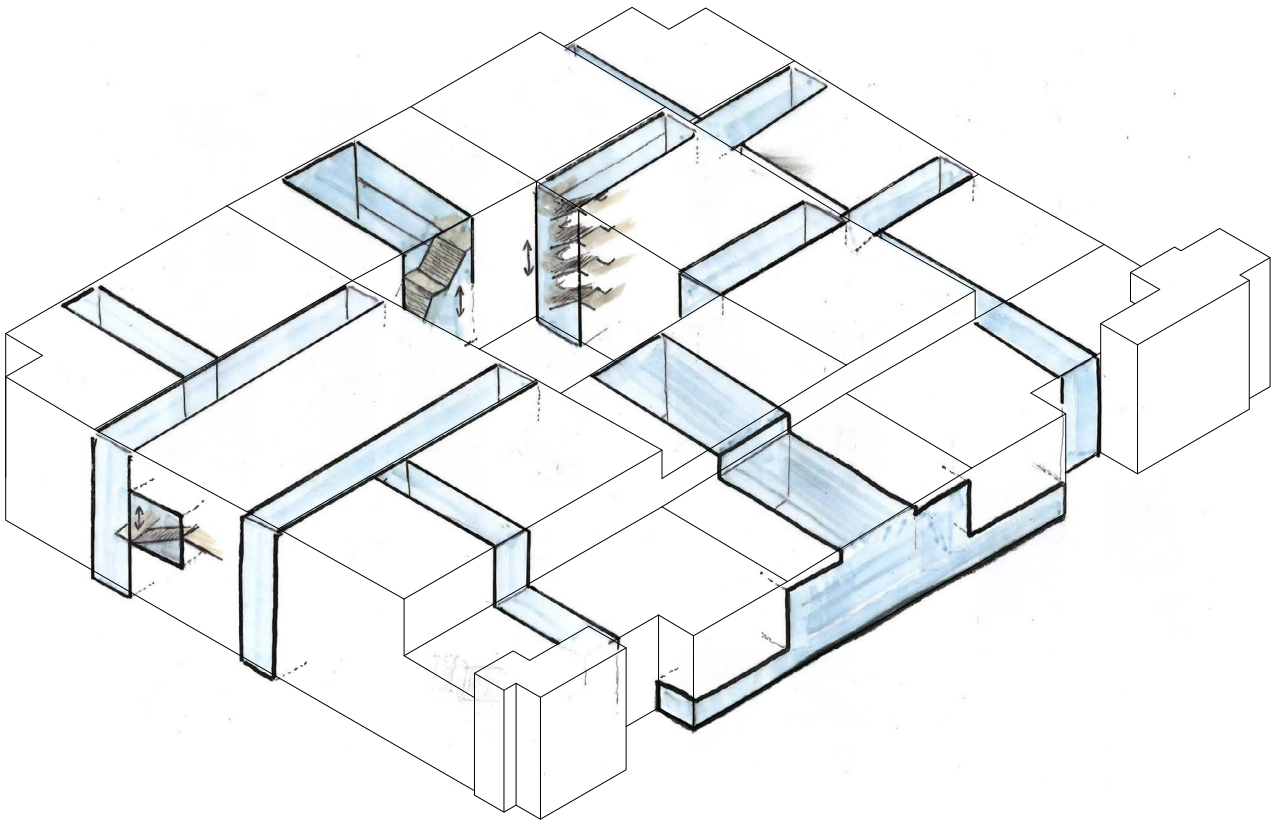
APPENDIX 1. DESIGN PROCESS AND MODEL TESTING

This appendix documents the design process behind the final proposal. The material is not presented as a separate design, but as evidence of the research-by-design method. Through physical model testing, internal model photography, digital sketching and repeated sectional studies, the project tested how subtraction could create daylight, orientation, circulation, social encounter and human scale within the existing parking garage.

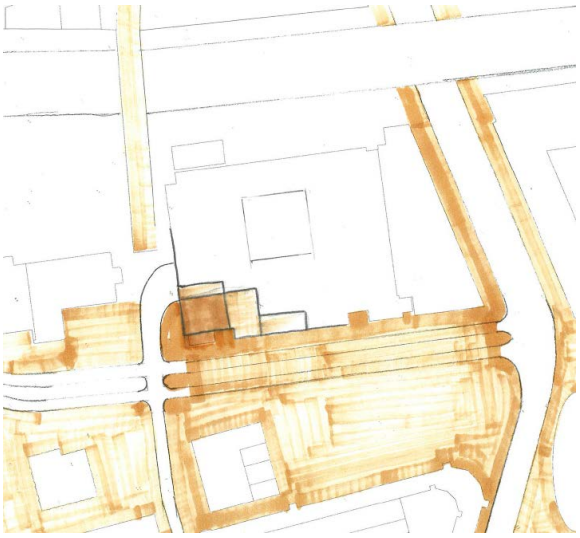
The process is organised into four themes: carving for clarity, adding human scale, designing encounters and the logic of change. Together, these studies show how the final design rules developed from spatial testing rather than from a fixed formal idea.

CARVING FOR CLARITY

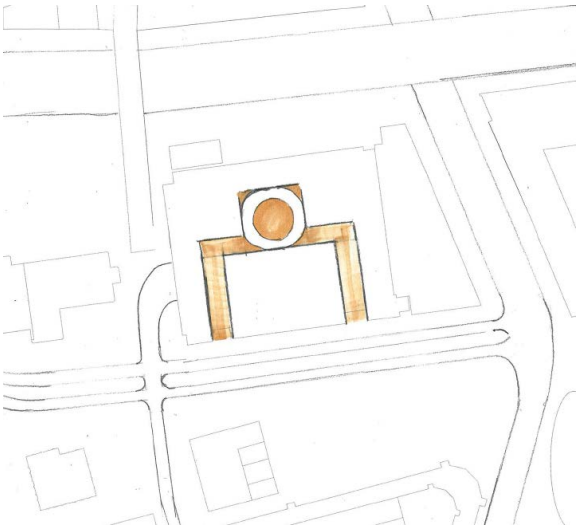
This series of experiments focused on the legibility of the building. While a car requires no landmarks, a human does. By cutting large volumes out of the mass, it was investigated how the city could be drawn inward and how users could orient themselves within the previously uniform, deep floor fields. The prototype demonstrated that vertical voids are essential to break the 30-meter deep mass.

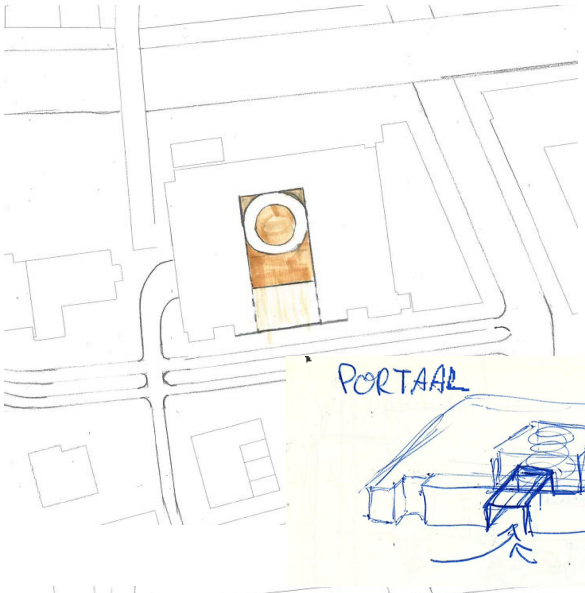


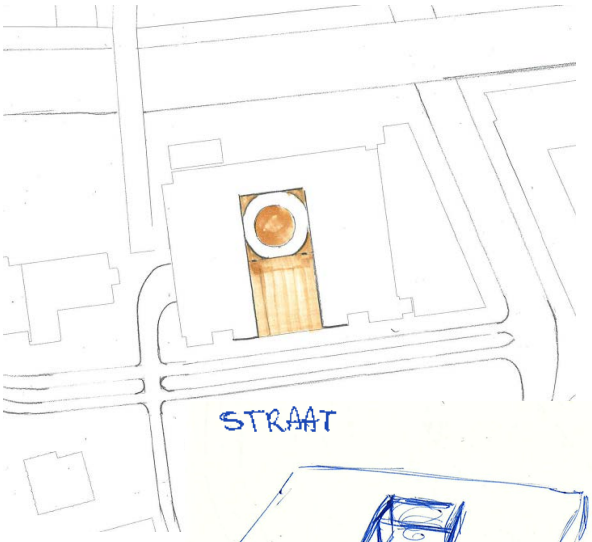
Intervention: The Main Entrance

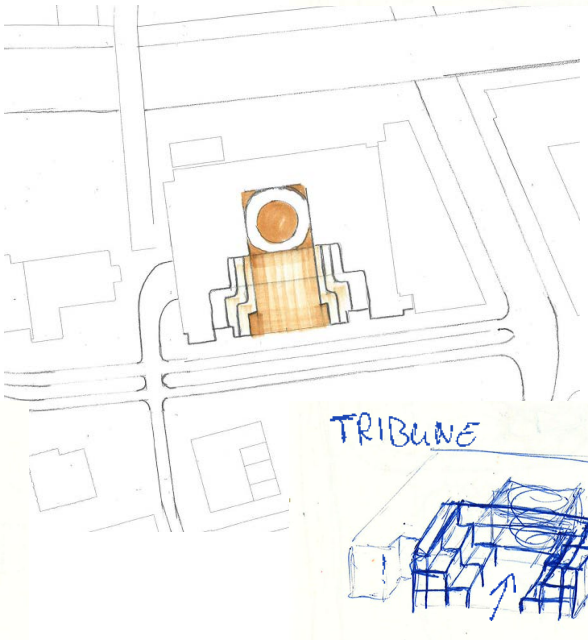












Intervention: Breaking the Mass

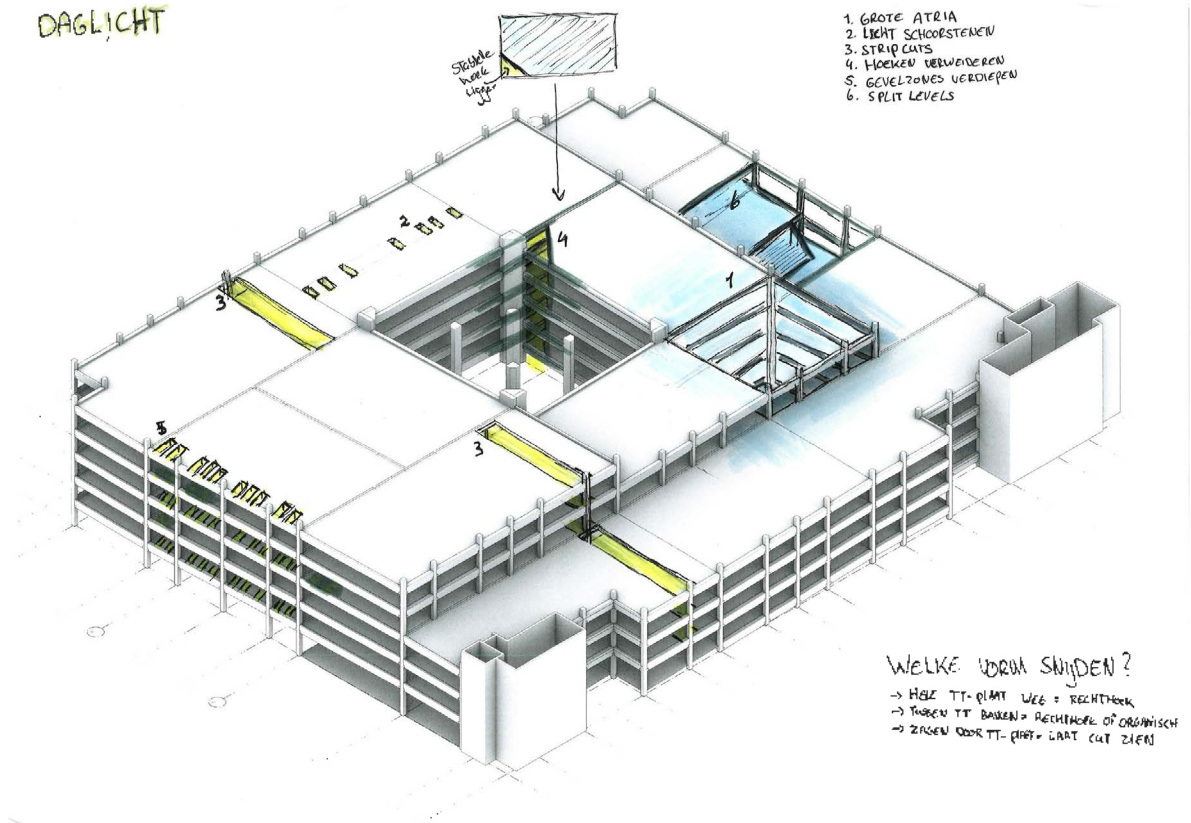








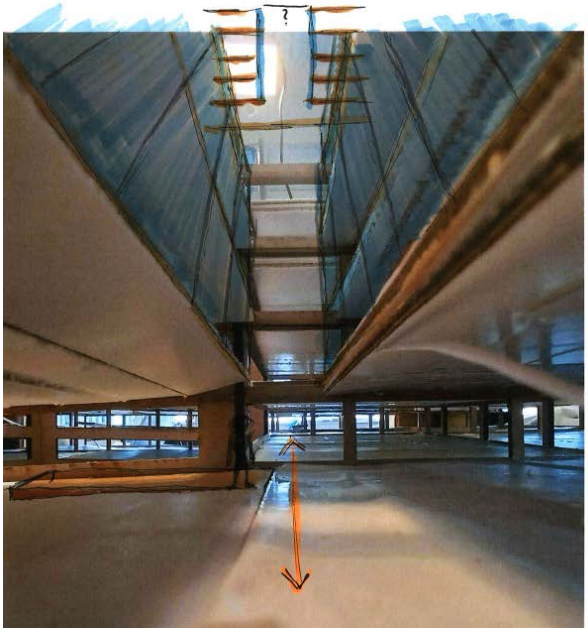
Intervention: Daylight Voids

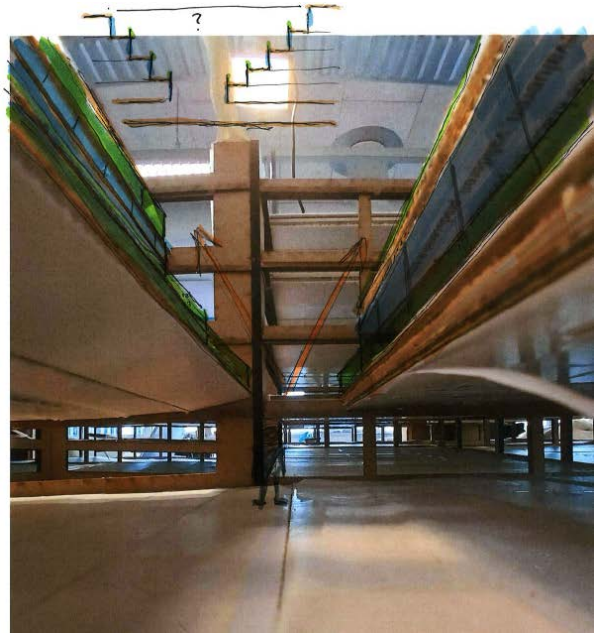


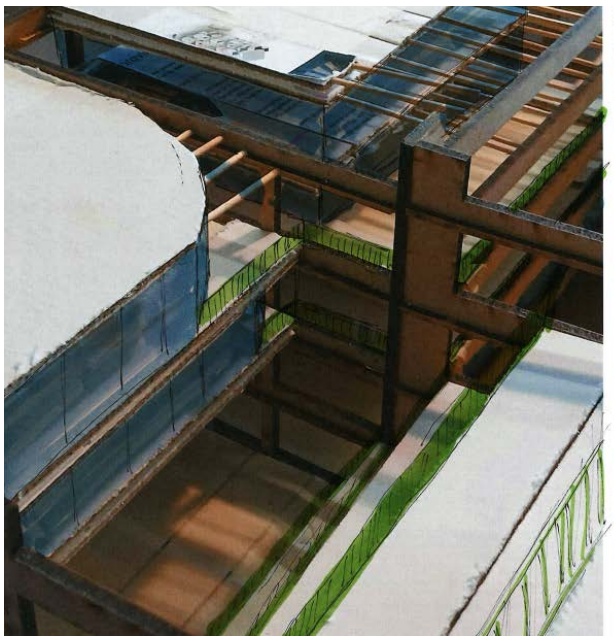








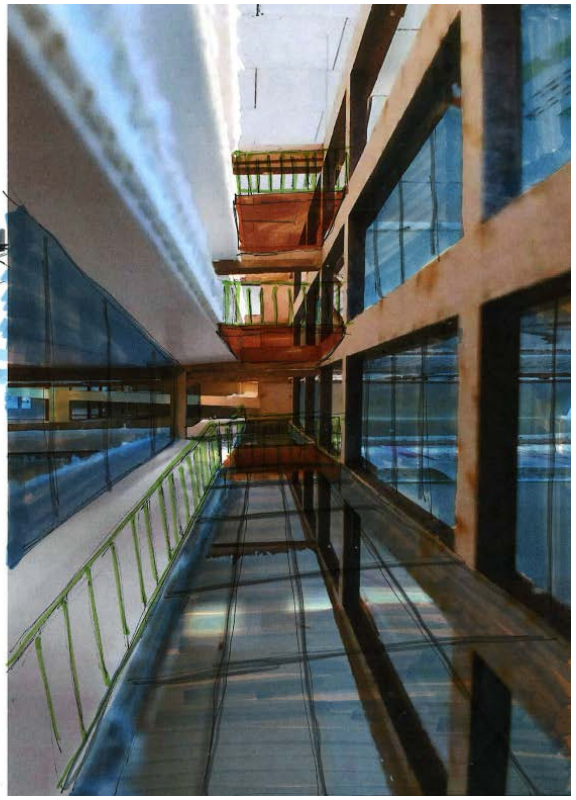


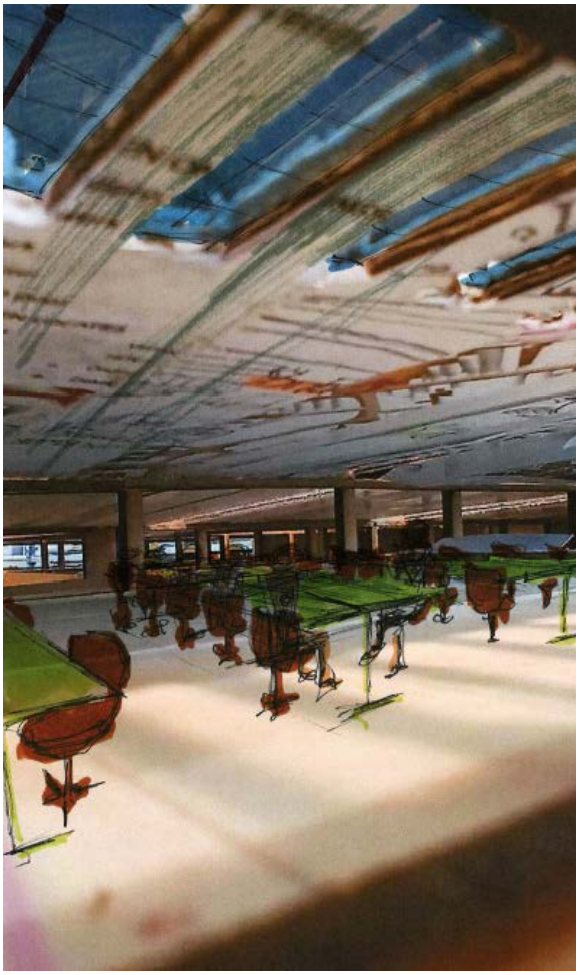










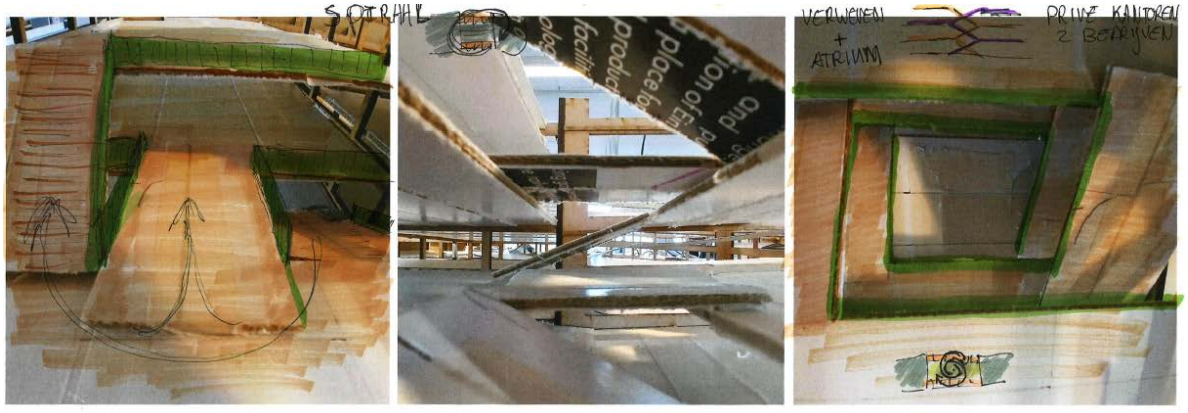




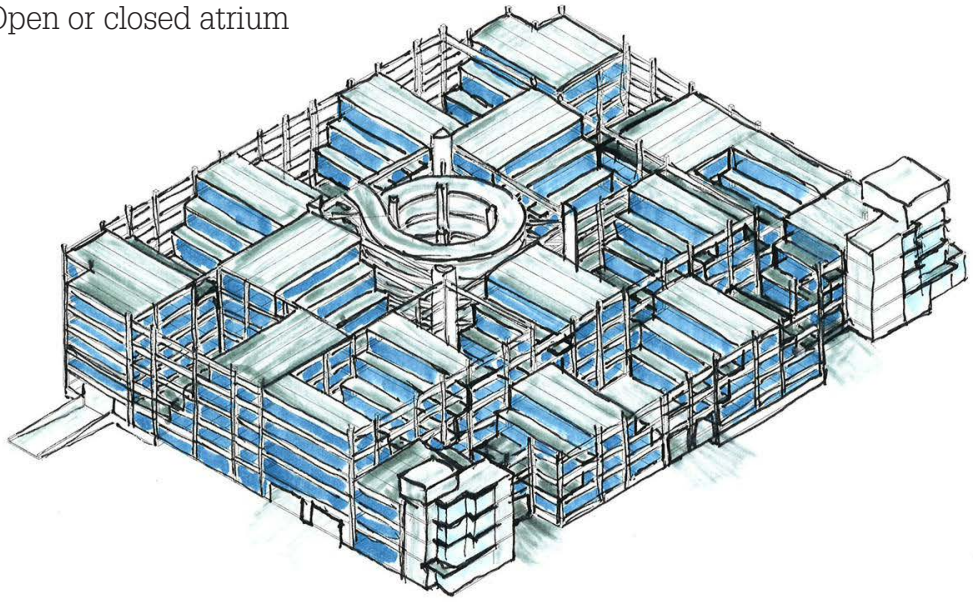
Intervention: Vertical Circulation

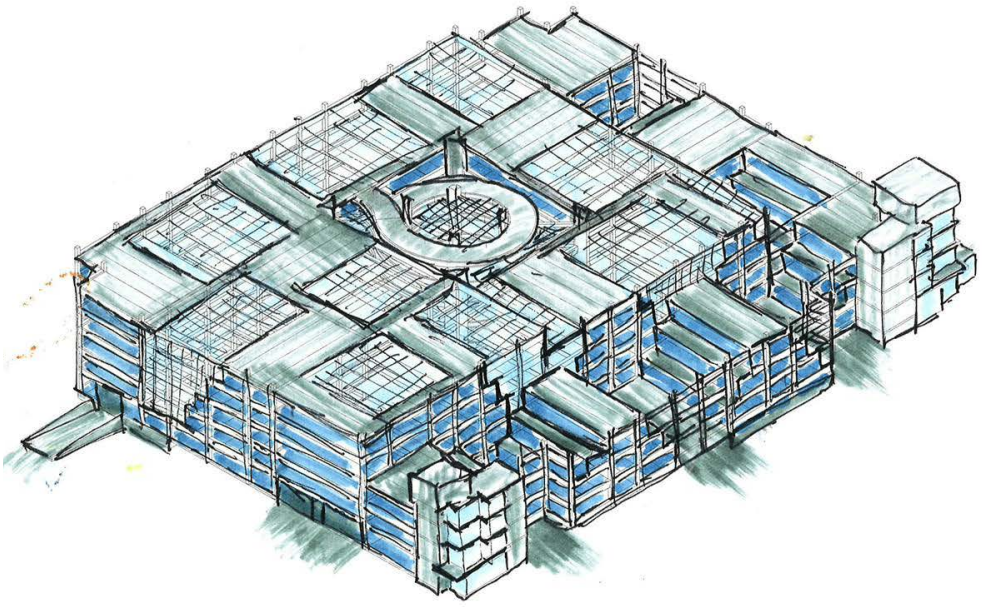


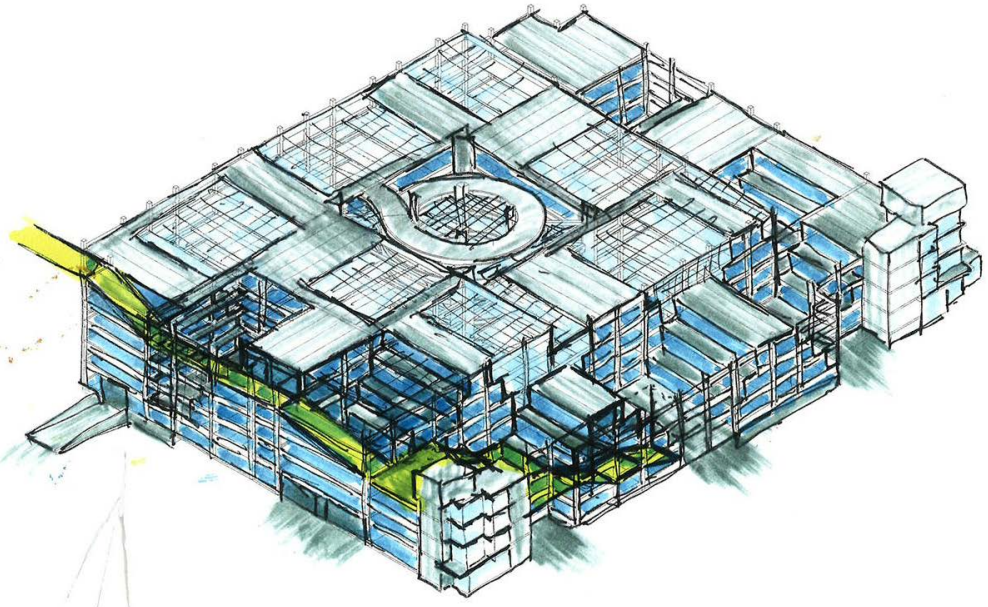




Intervention: Open or closed atrium

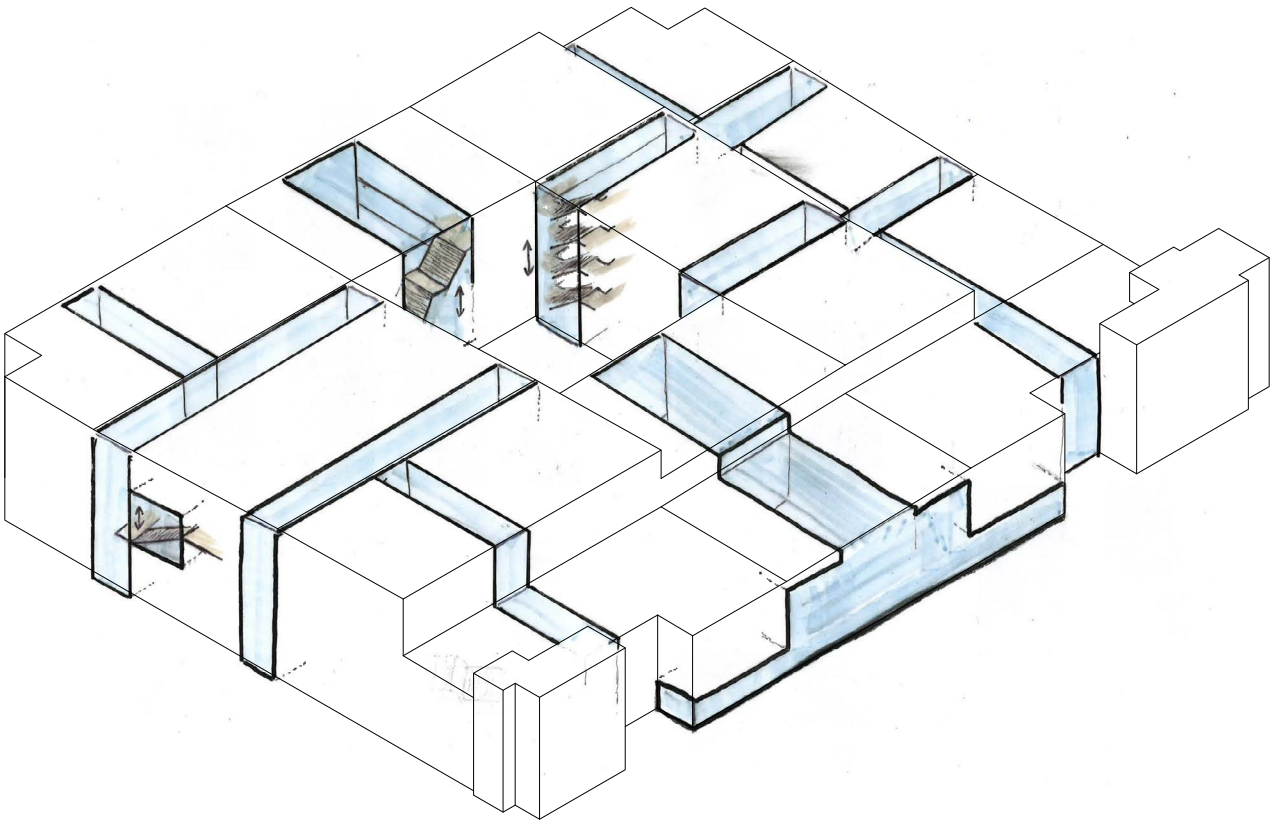




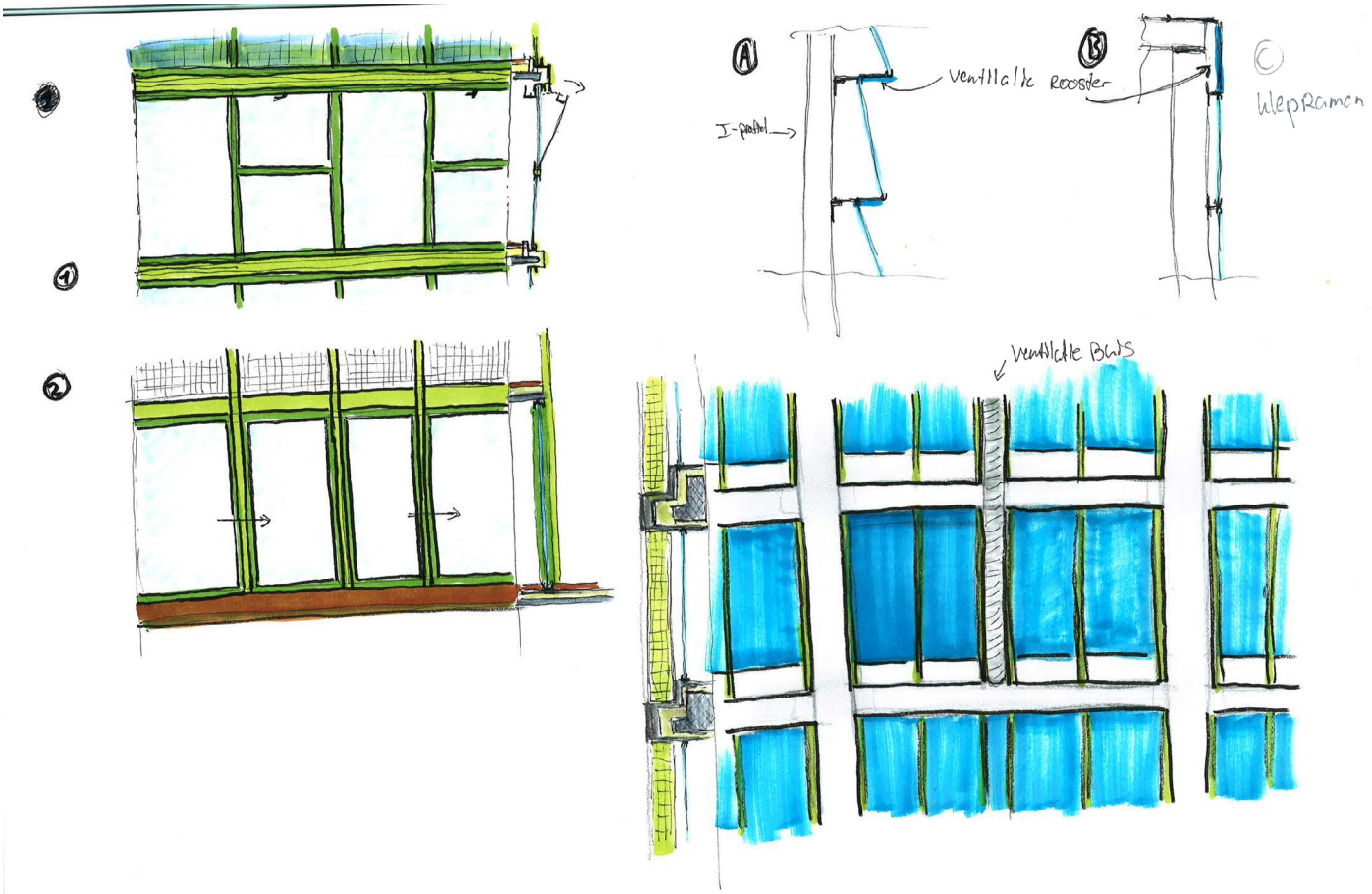


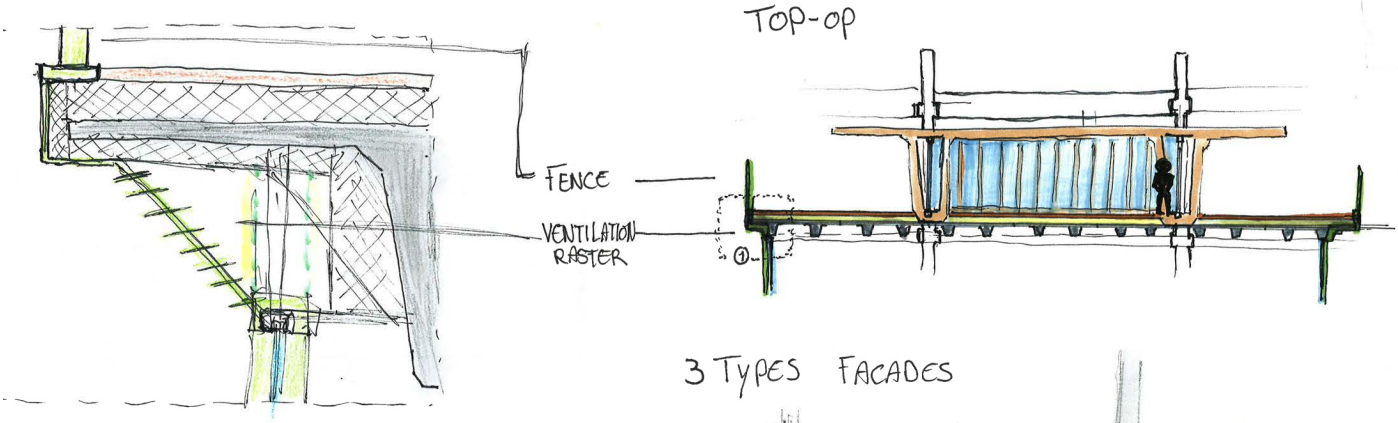
ADDING HUMAN SCALE

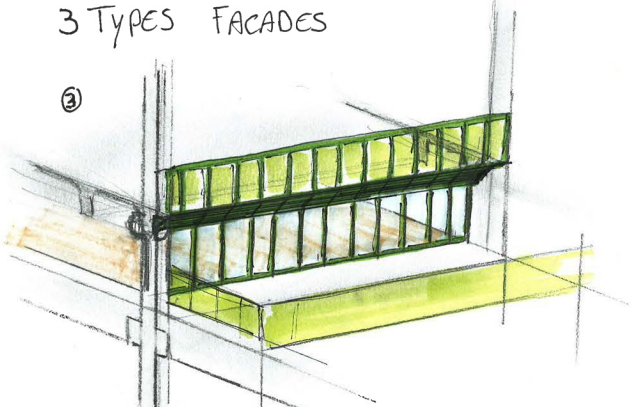
These iterations addressed the intimidating dimensions of the garage. The prototype showed that the human scale is implemented by breaking up the extreme depths of the floor plates and adjusting the problematic low ceiling heights. Furthermore, the facade design incorporates 'Tactile Complexity' (Nikos Salingaros), ensuring that as a user approaches the building, the level of detail increases to provide a sense of comfort and human touch.

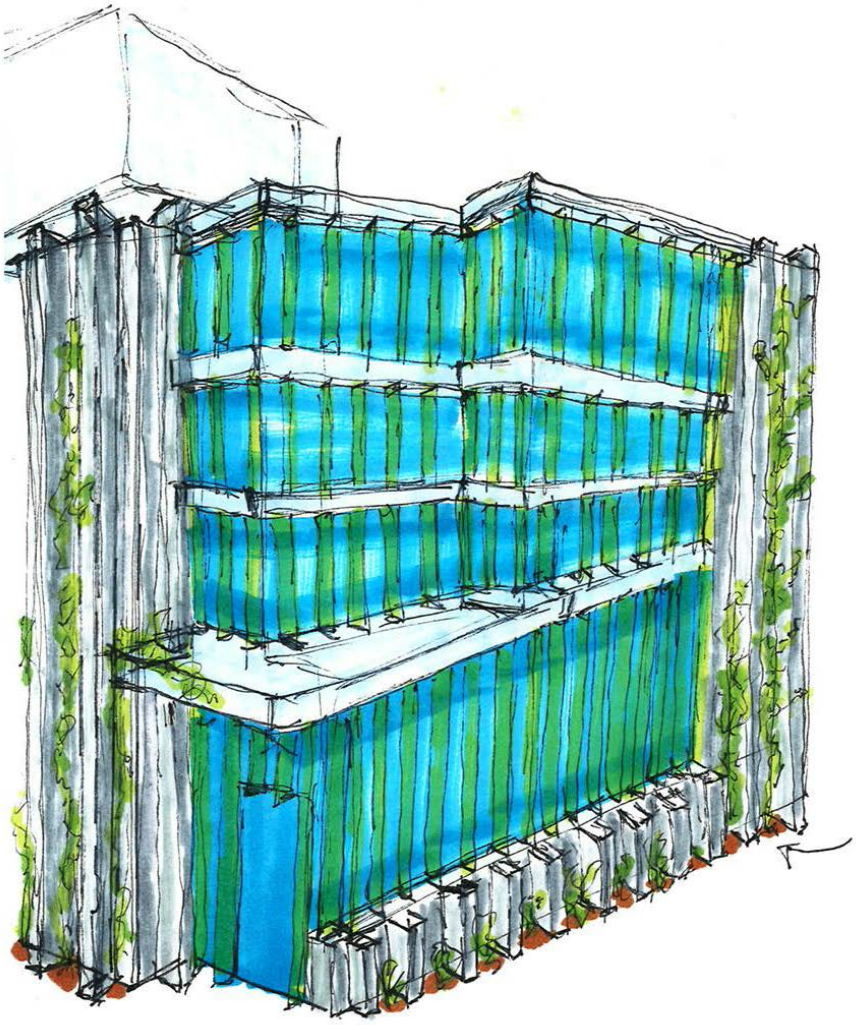


Intervention: Facade Scaling



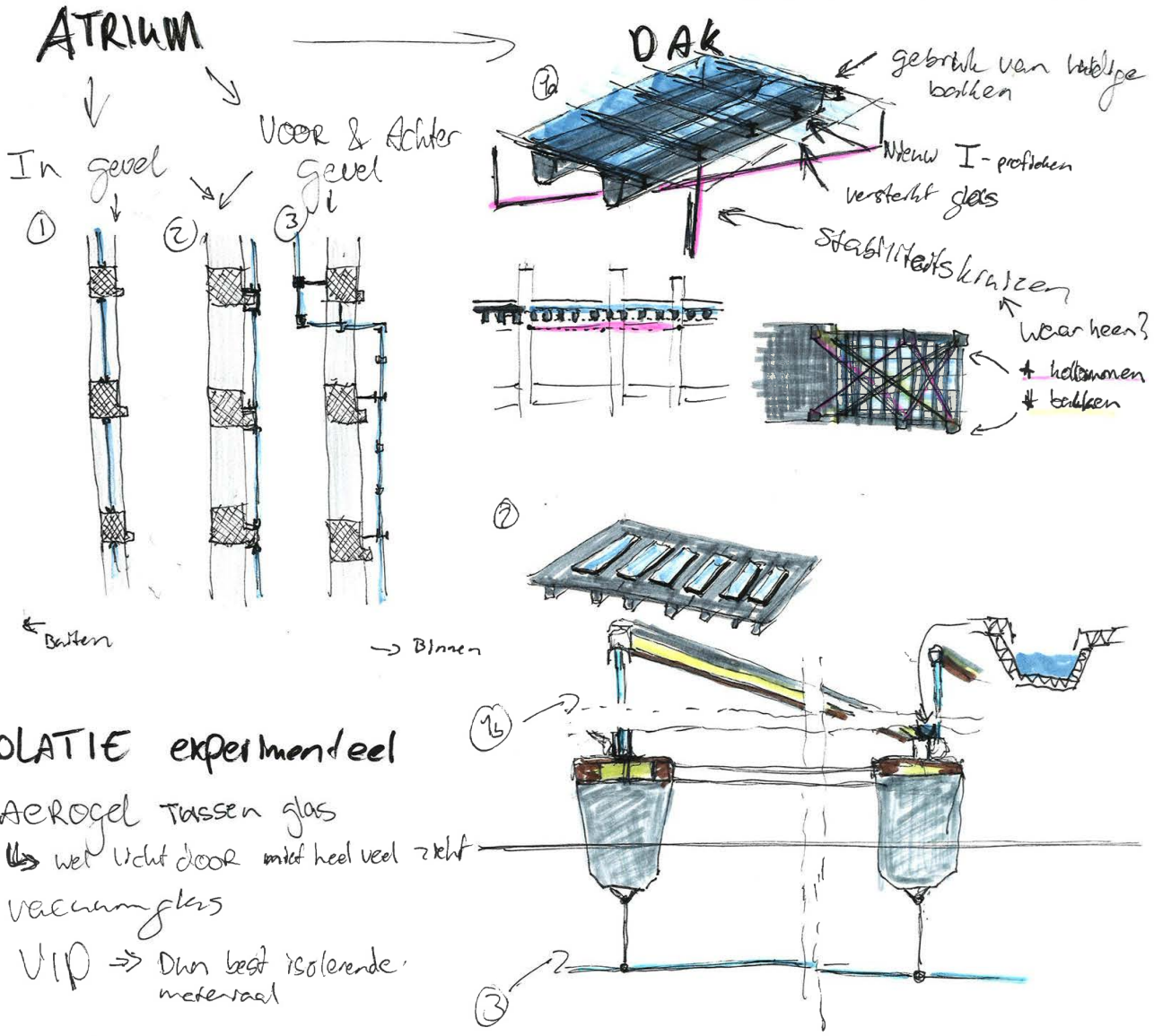


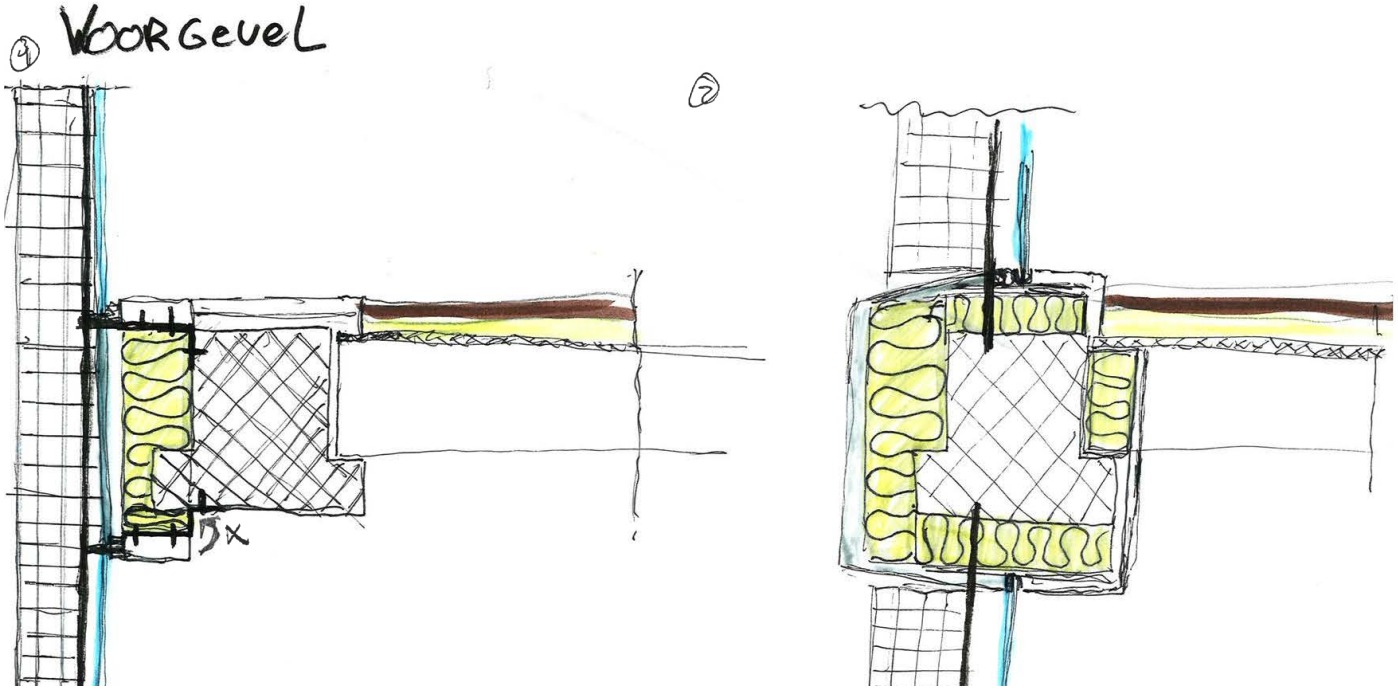




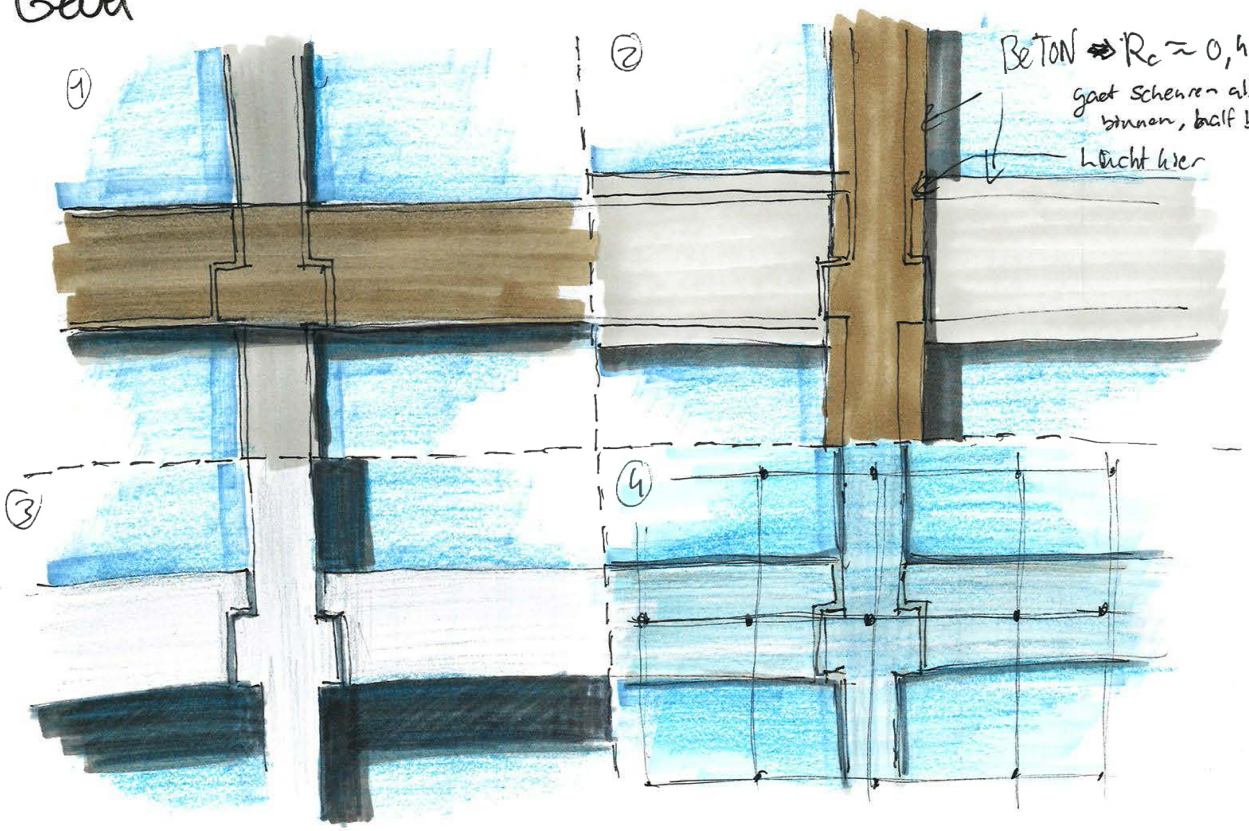
tussen gevels planten laten groeien en nestjes plaatsen

* klimplant tast niet de constructie aan maar extra gevel


ATRIUM
In gevel
Voor & Achter Gevel
1
2
3
Buiten
Binnen
DAK
gebruik van bestaande balken
Nieuw I-profielen
versterkt glas
Stabiliteitskrachten
waarheen?
+ hellingmuren
+ balken
ISOLATIE experimenteel
1 Aerogel tussen glas
wel licht door maar heel veel warmte
2 vacuumglas
3 VIP => Dun best isolerende materiaal


VOORGEVEL
1
2
DX

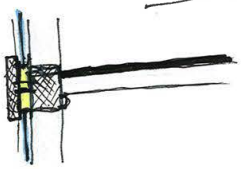
Gevel



Opties:

Buitengevel

1

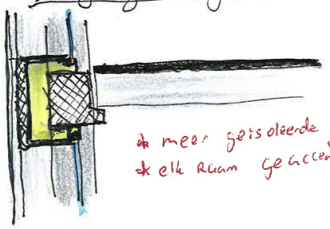


Nieuwe gevel voor constructie

+ vlakke gevel ⇒ 1 gevel geheel

Ingelegde gevel

2

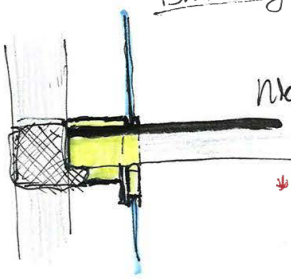


Nieuwe gevel om constructie

* meer geïsoleerde gevel
* elk Ruam geaccentueerd

Binnengevel

3

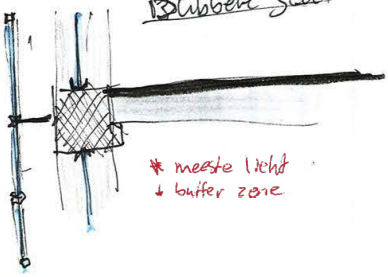


Nieuwe gevel achter constructie

* Constructie accentueert

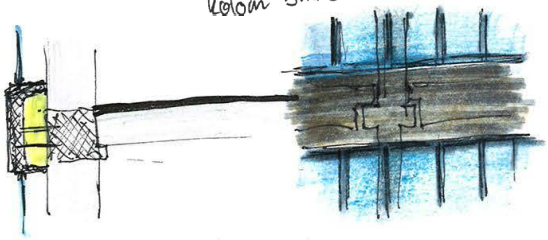
Bubbelse Gevel

4



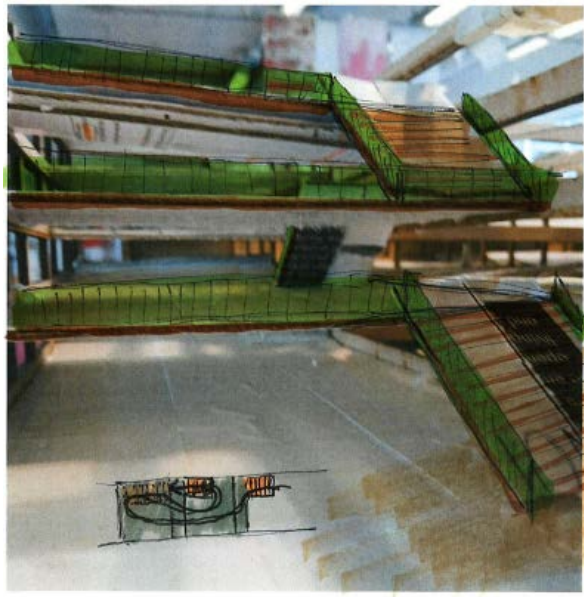
* meeste licht
↓ buffer zone

5 Hybride = Panelen voor liggers
Ruam om panelen
Kolom binnen



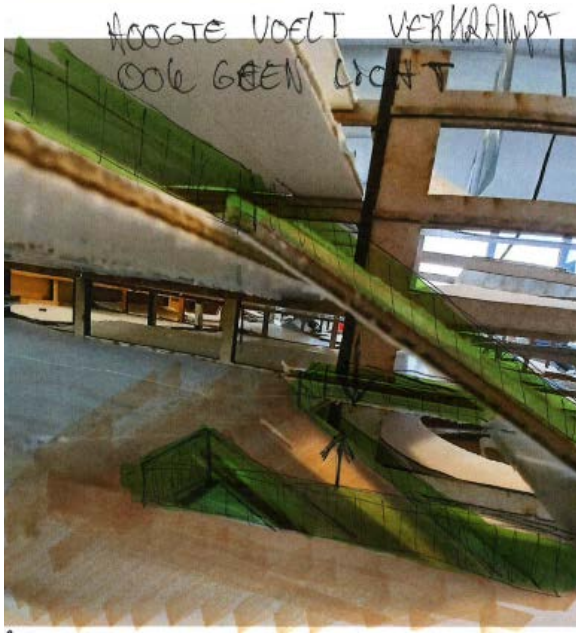
* horizontaliteit
accentueert hellingen

Intervention: Room Proportions (Addressing Height vs. Depth)



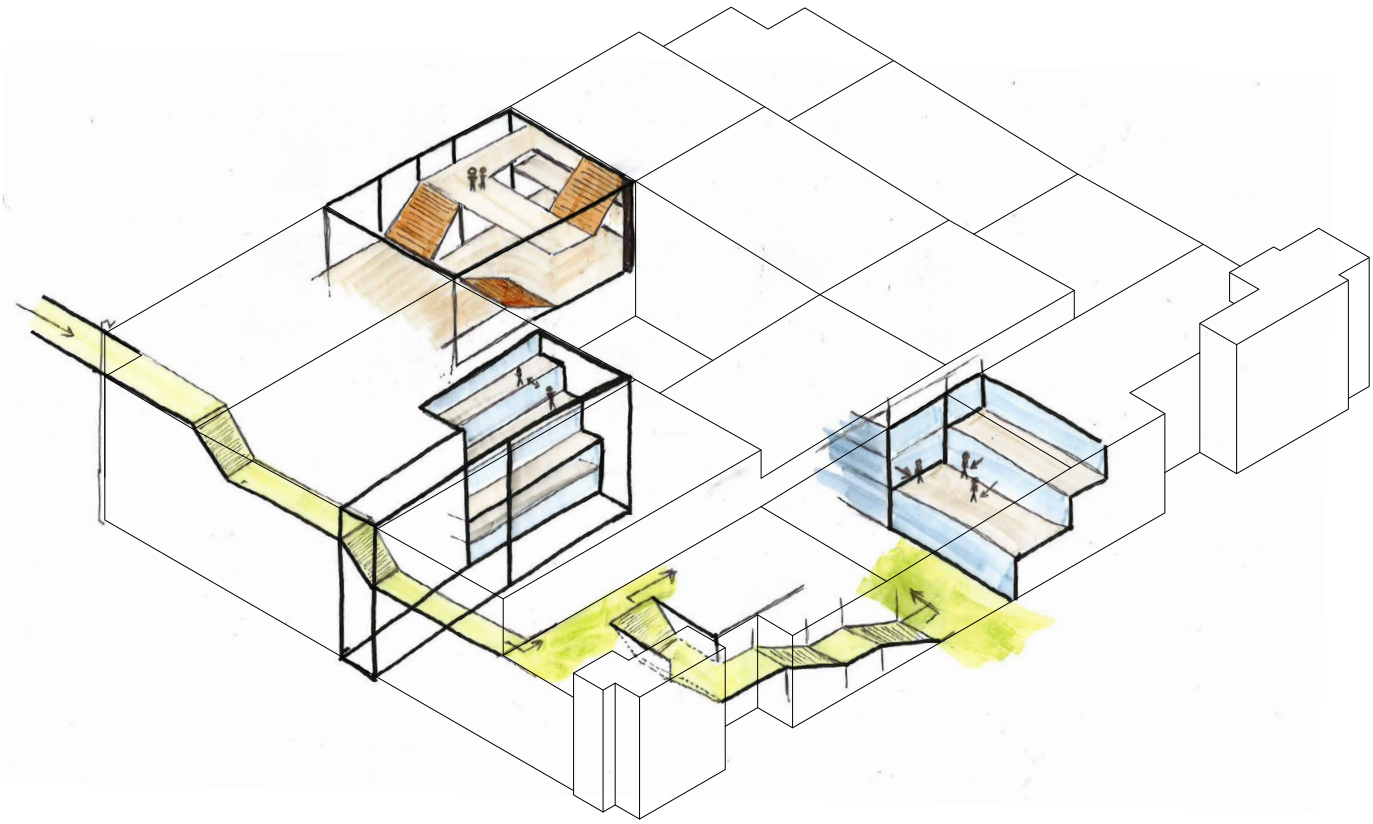




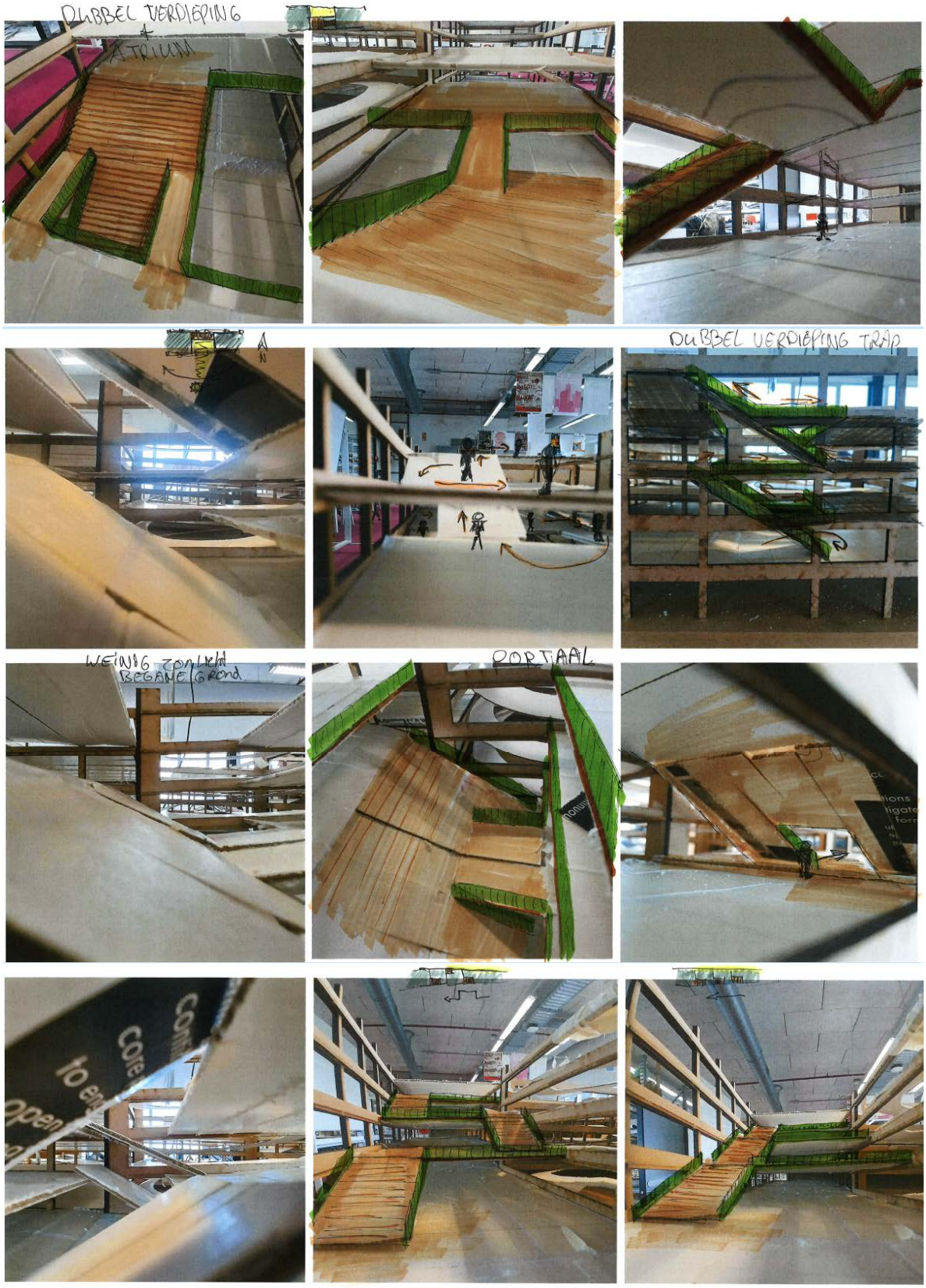


DESIGNING ENCOUNTERS

The goal was to create a physical network. By widening the circulation paths (stairs and slopes) and linking them to voids, spaces for accidental encounters were created. Above showed how terraces attached to the voids not only capture light but also facilitate vertical visual connections, which are essential for a functioning innovation ecosystem.

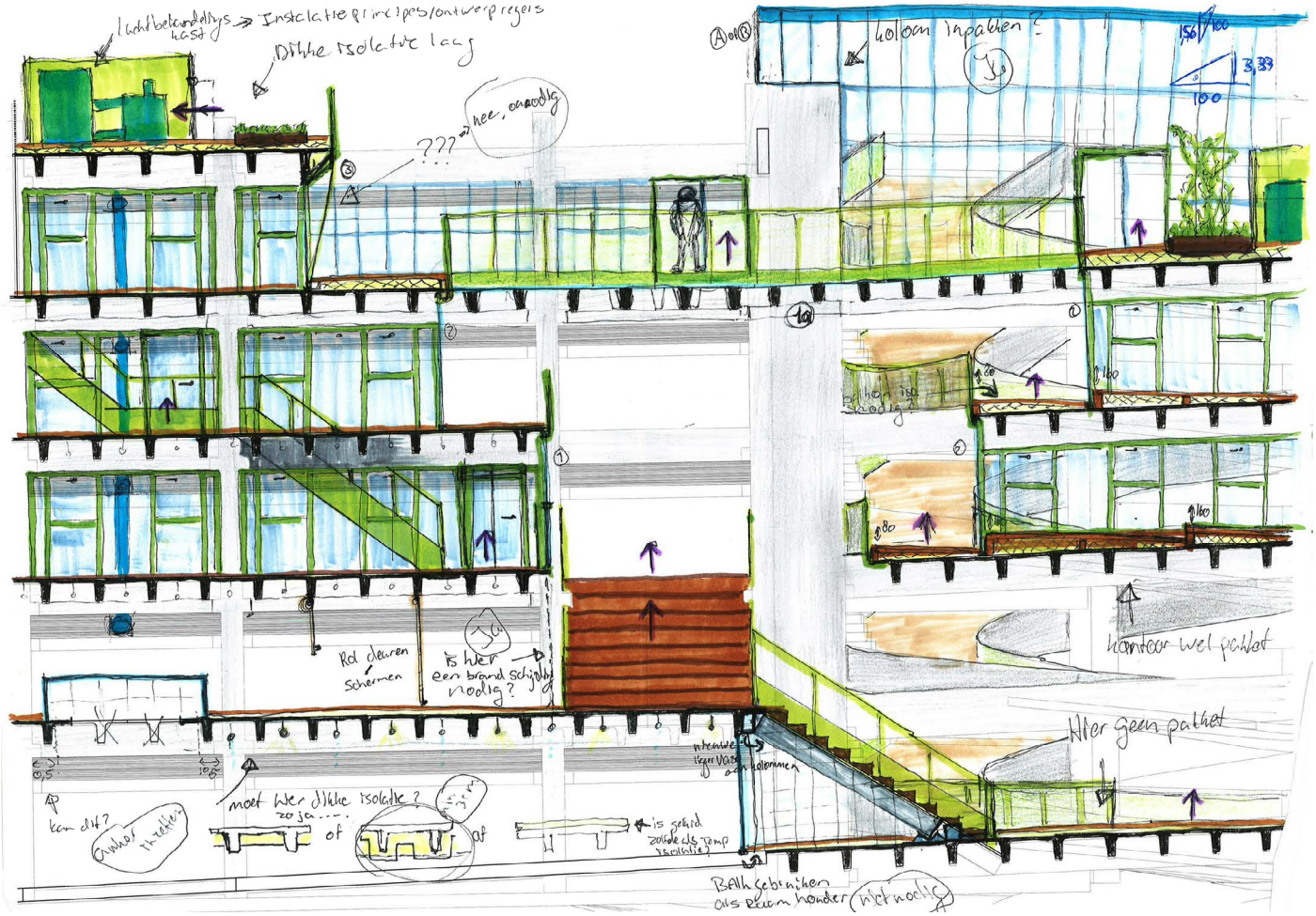


Intervention: Social Circulation



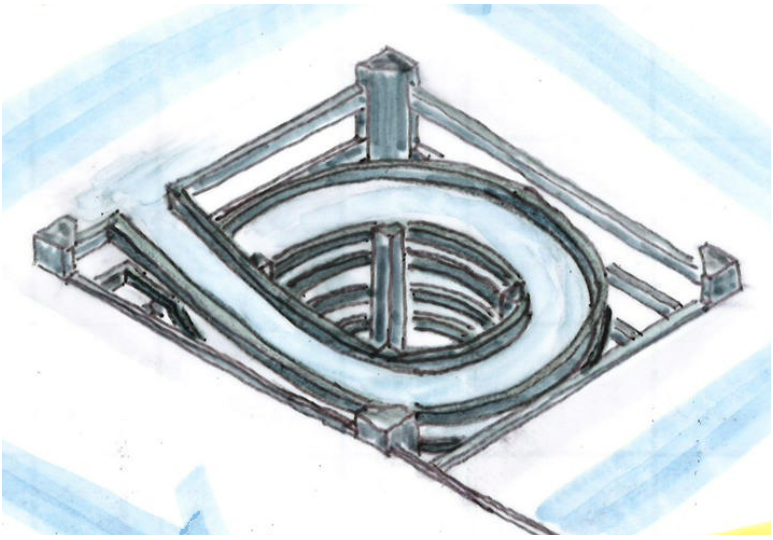
Intervention: Meeting Terraces

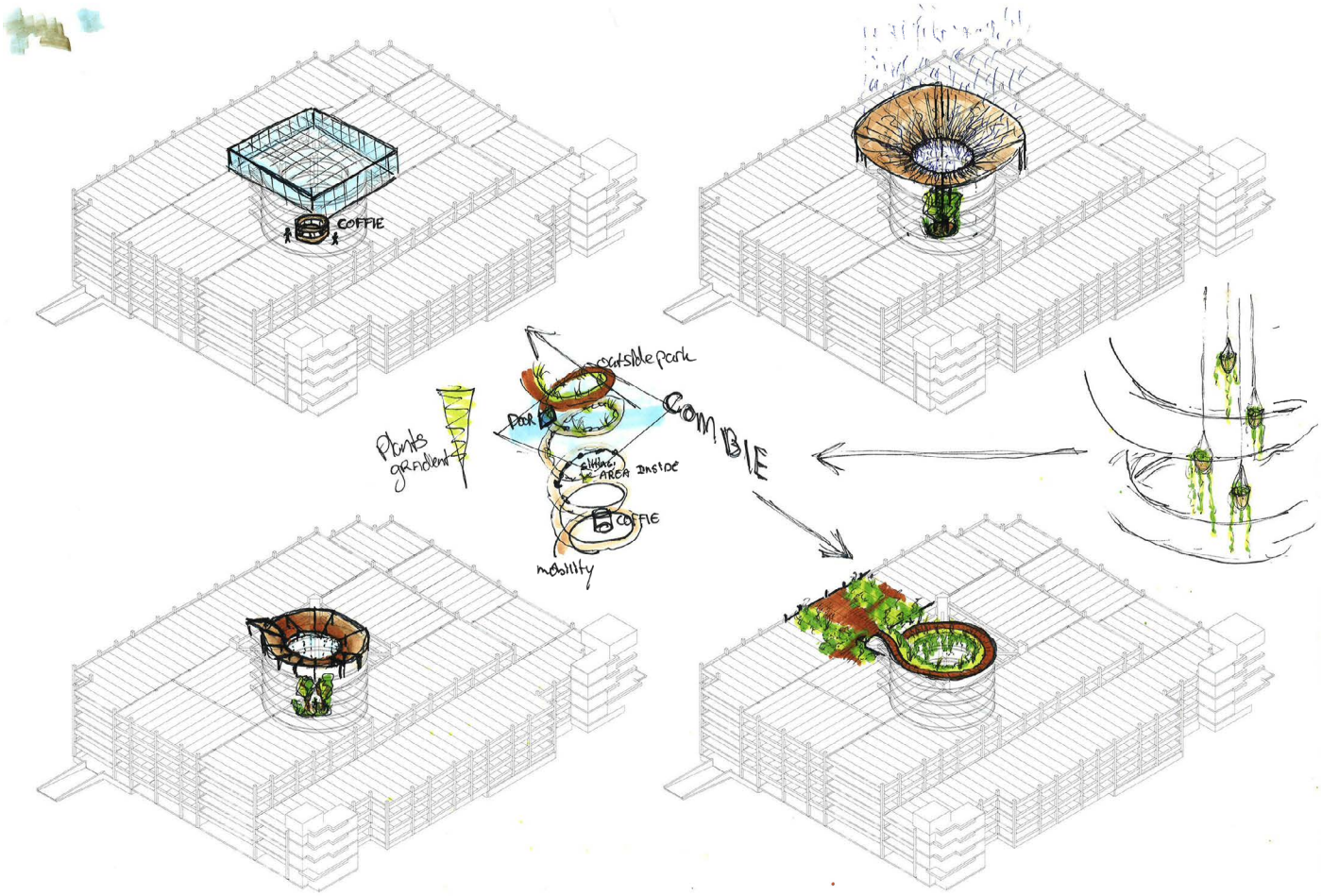




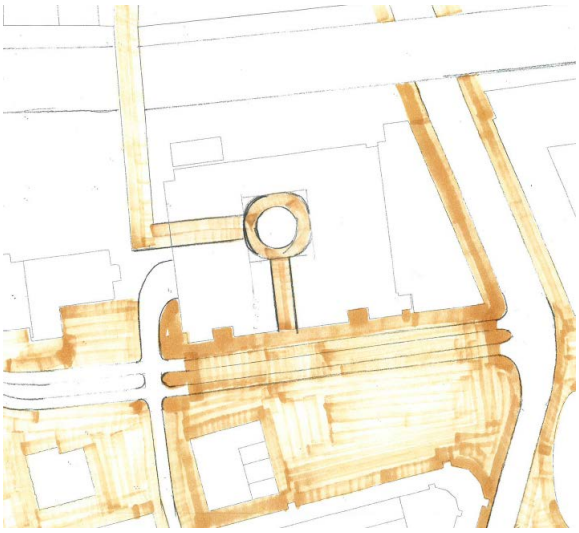
Intervention: The Heart of the Building (Central Interaction Core)

The central spiral ramp is transformed into the building's primary social connector, serving as the vertical heart of the innovation hub. It functions as a central node where all internal circulation routes converge, ensuring that movement through the building naturally leads to interaction. By integrating coffee corners and lounges this helical void becomes a vibrant center for collective exchange.Its also the connection to the roof.

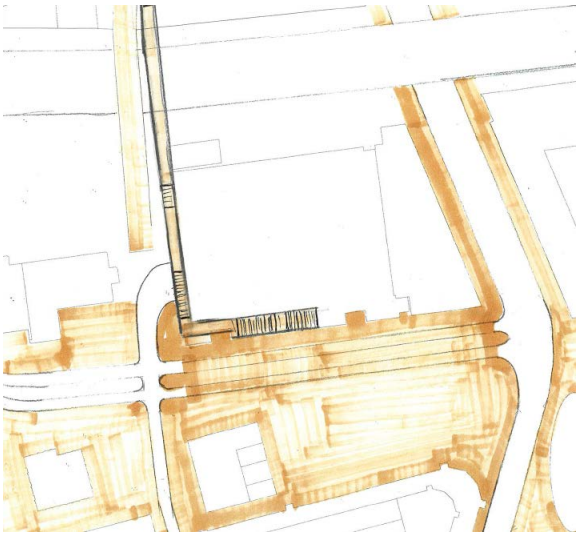


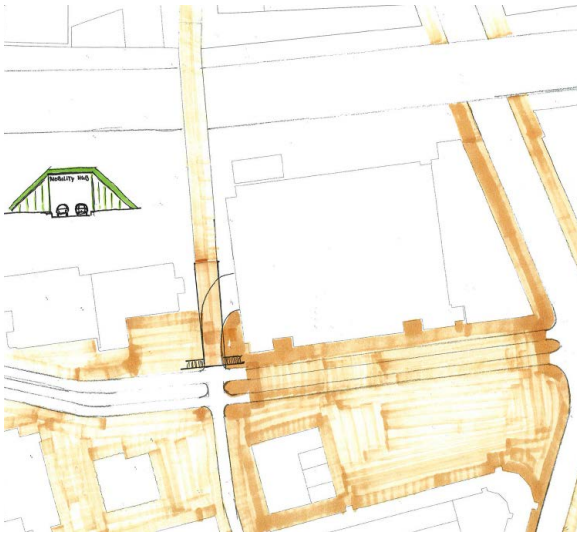


Intervention: Urban Innovation Route







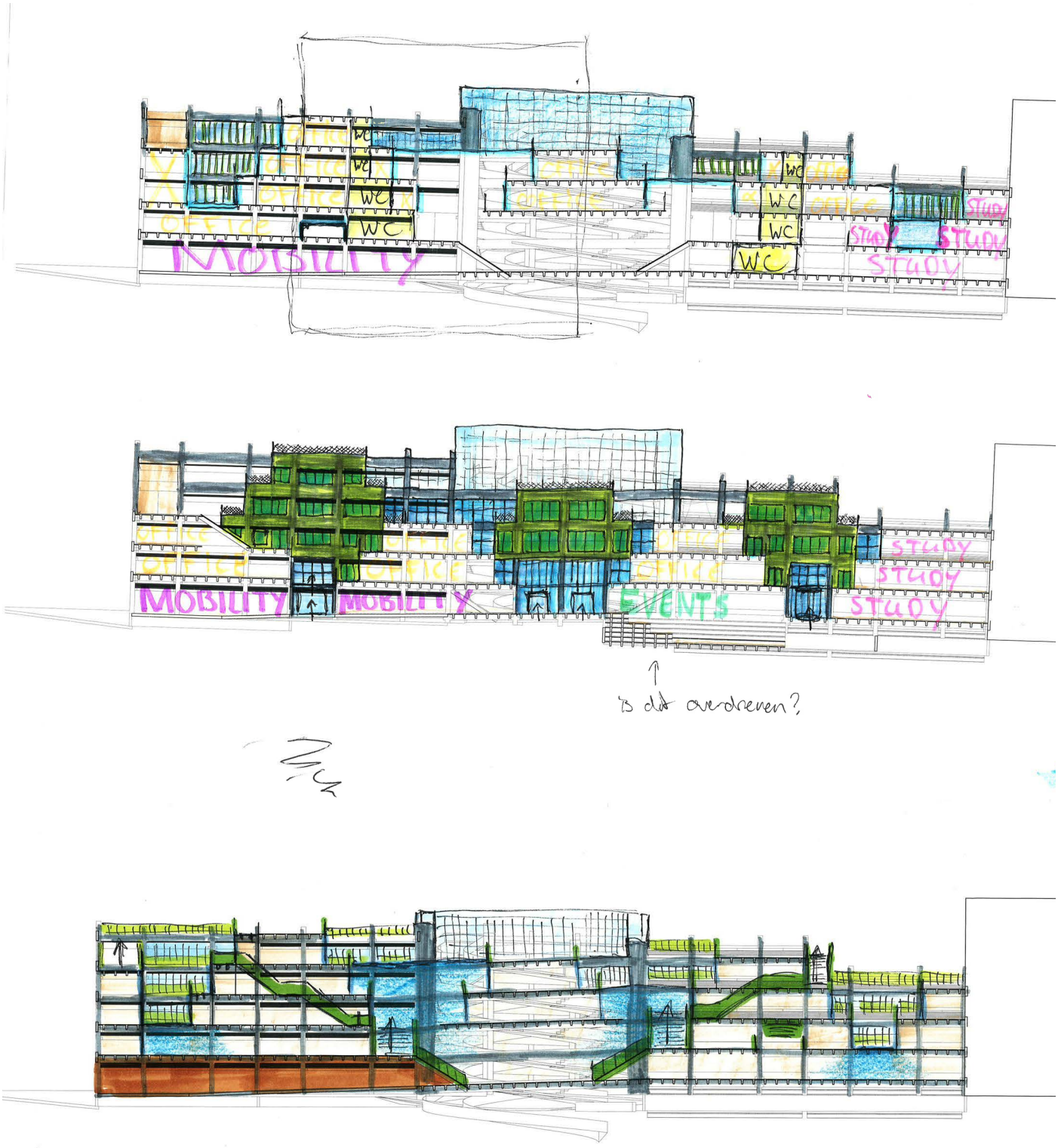


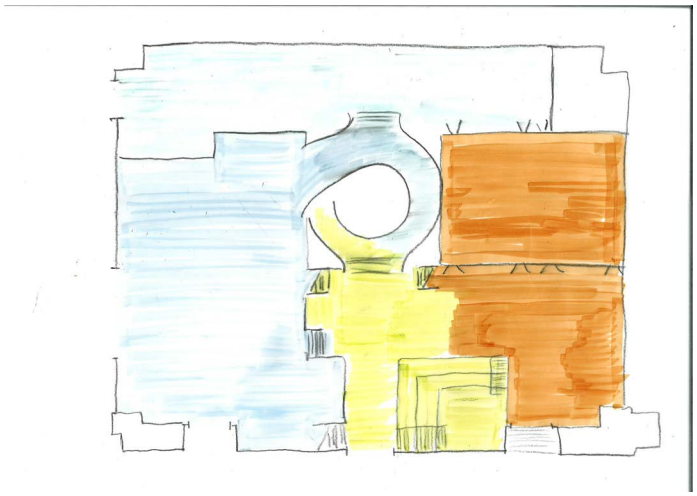




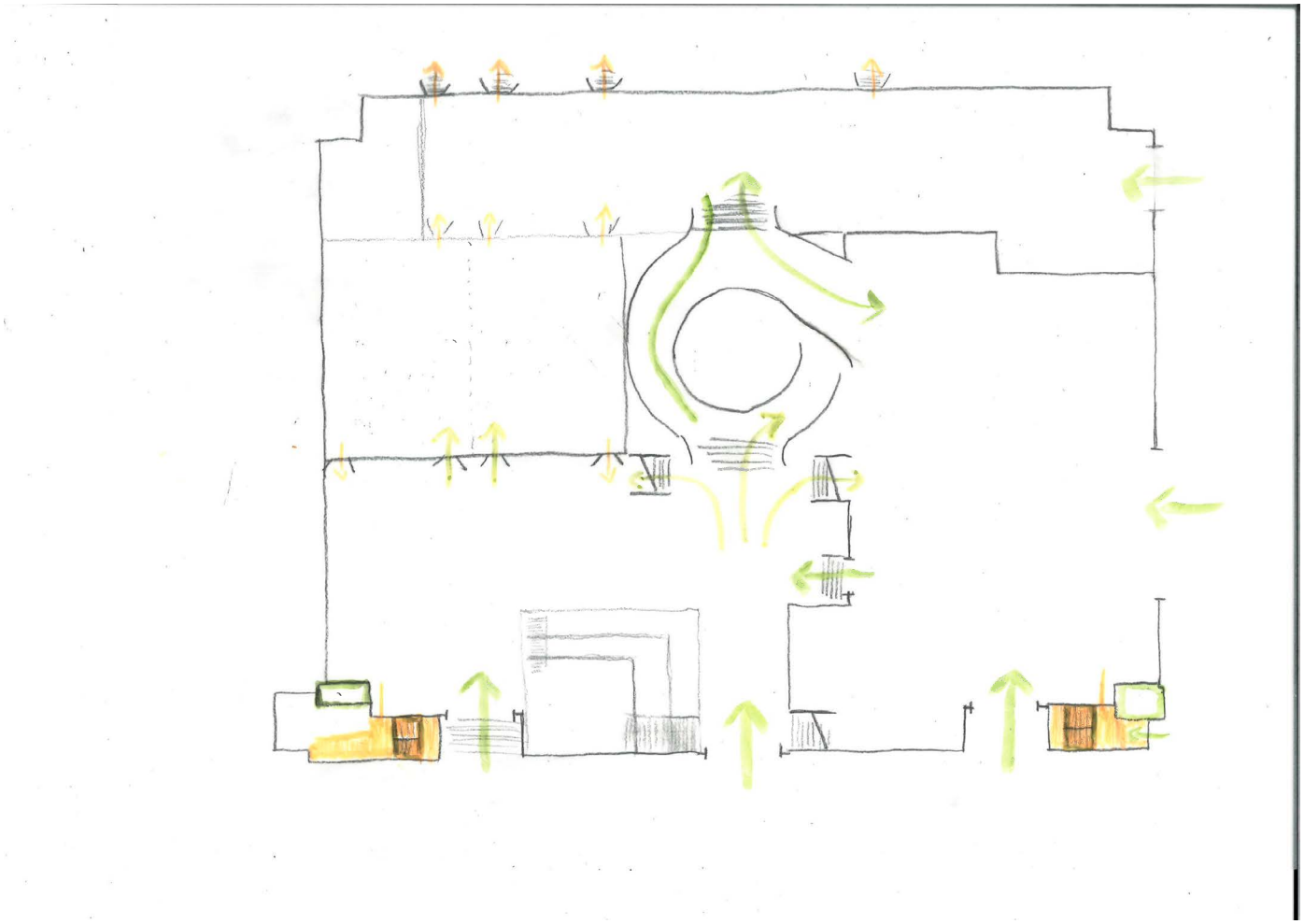


Intervention: placing program



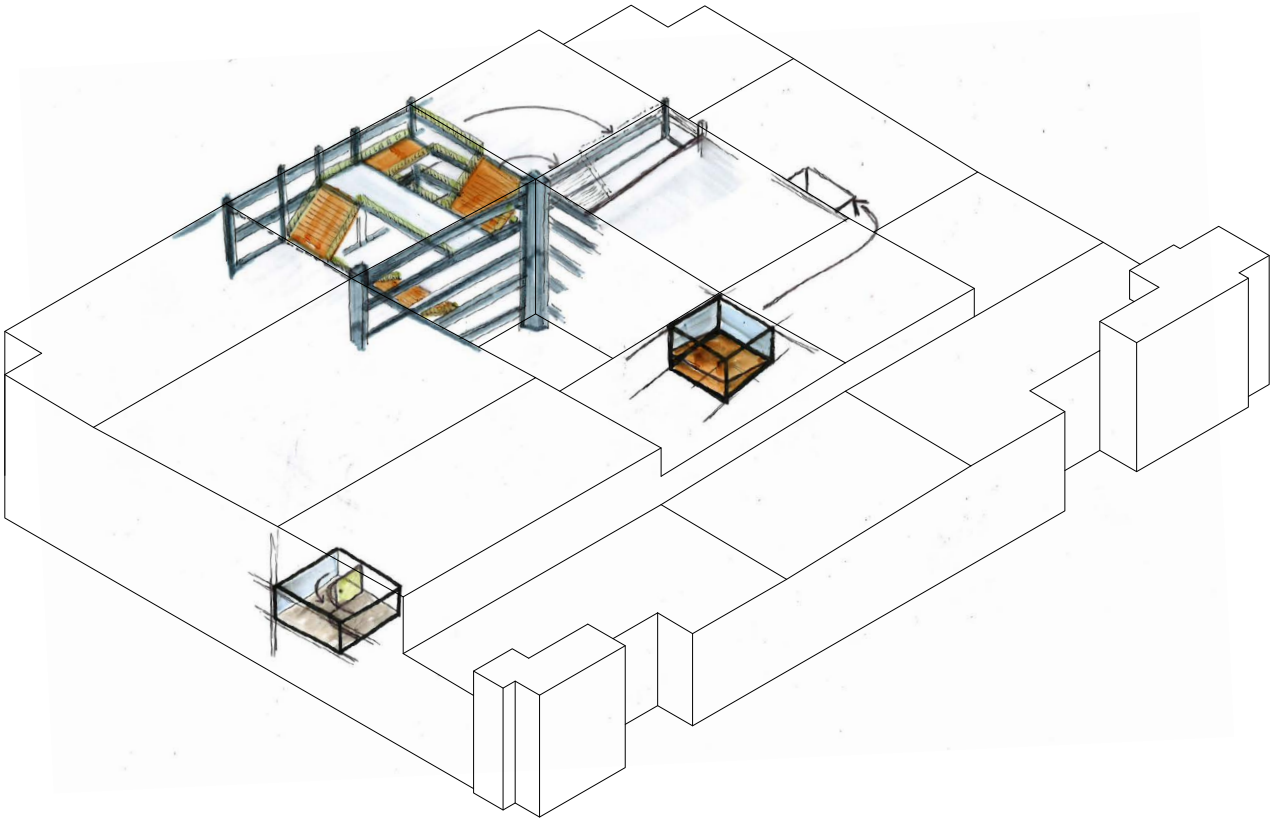


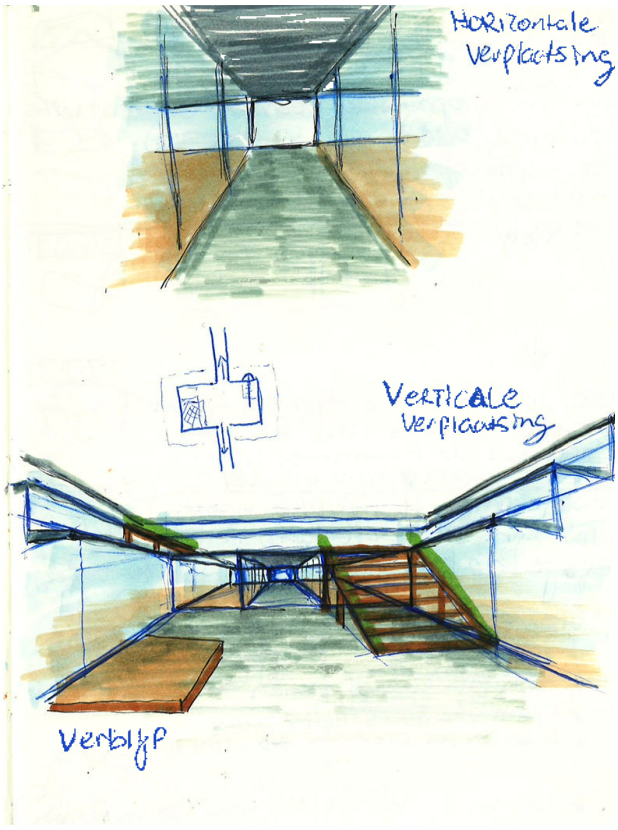

= Businesses/shops
= modern/start-up businesses
= offices
= open office
= kitchen/space

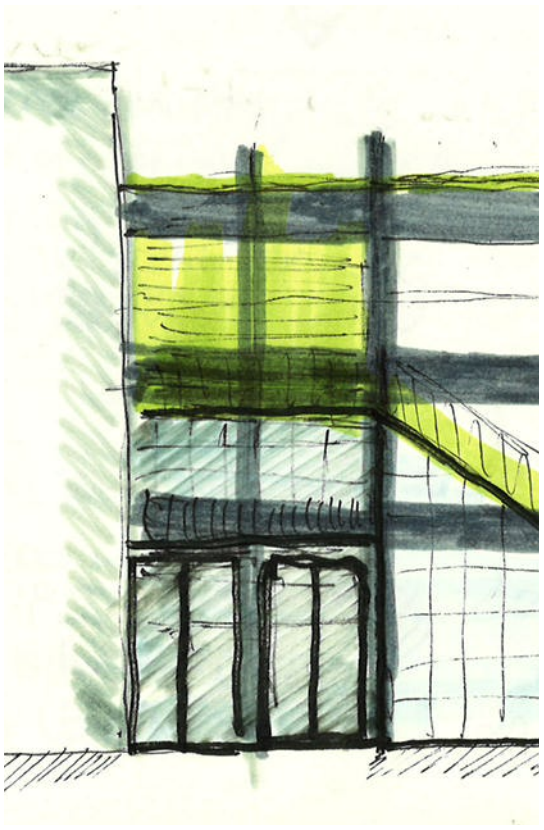


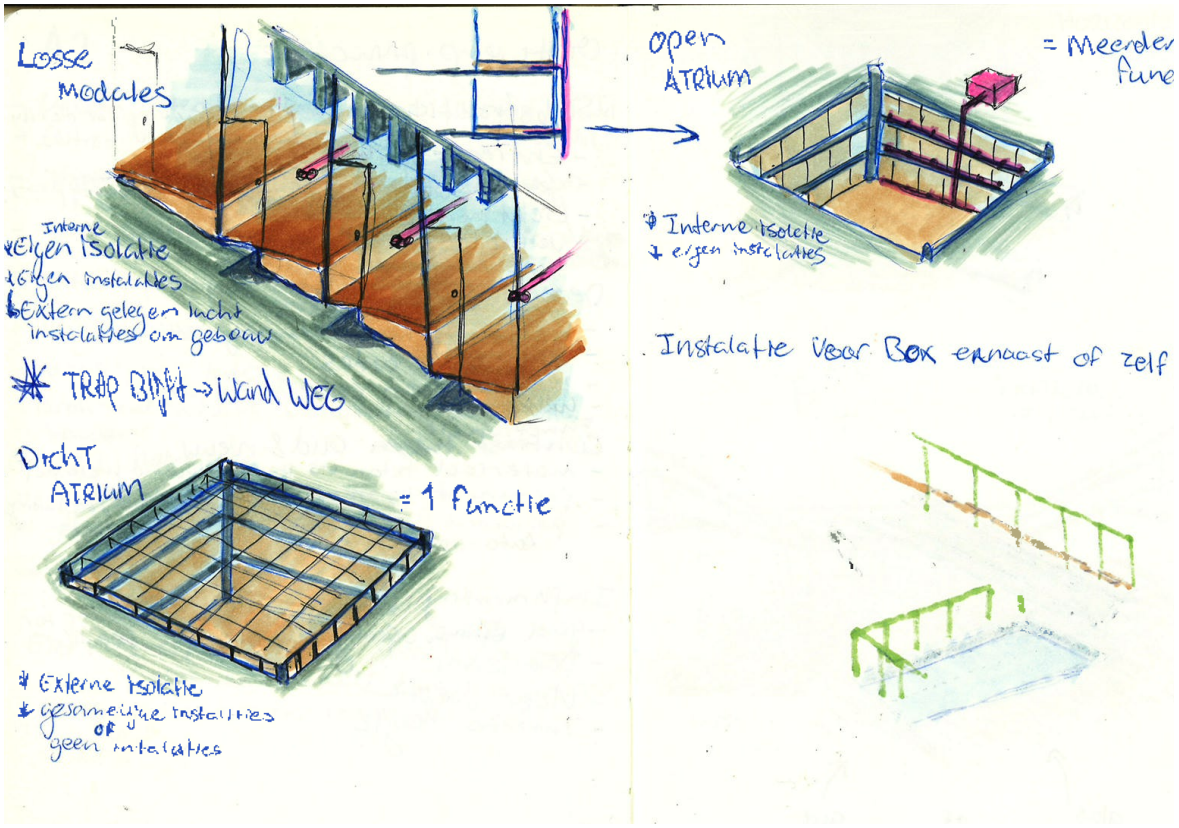
THE LOGIC OF CHANGE

The final iterations explored the tension between the static concrete shell and the dynamic human program. The result confirms that the building must move with the future needs of its users. While the horizontal concrete paths preserve the history of the garage, the new “human” interventions are modular and flexible. This logic ensures that the innovation hub can adapt its internal walls, climate systems, and accessibility as the tech sector evolves.
s




Horizontale verplaatsing
Verticale verplaatsing
Verblijf



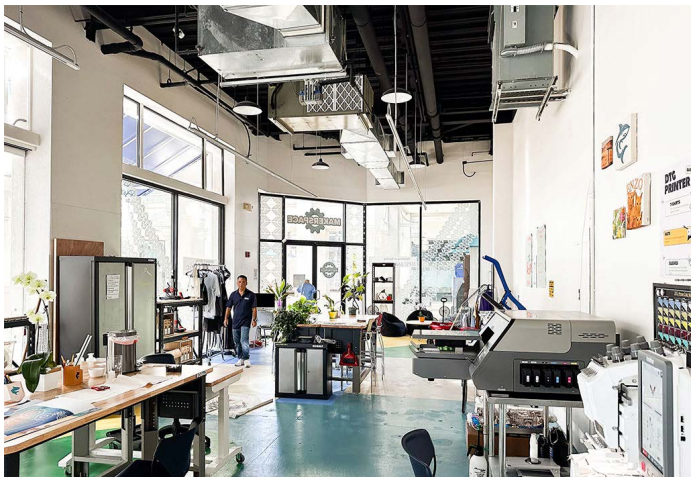

Losse modules
Interne
eigen isolatie
eigen installaties
Extern gelegen incht
installaties om gebouw
TRAP BIJ -> wand WEG
Dicht
ATRium
= 1 functie
Externe isolatie
gezamenlijke installaties
of
geen installaties
open
ATRium
= Meerder
func
Interne isolatie
eigen installaties
Installatie voor Box evnaast of zelf

APPENDIX 2 - PVE

This appendix contains the programme of requirements used to test the suitability of different functions within the existing parking garage structure. The table compares programme types according to area, flexibility, accessibility, logistics, fire safety, daylight, acoustics, ventilation, structural load and floor-to-ceiling height. The PVE was used as a design tool to determine which functions could be placed in the lower, heavier and more public parts of the building, and which functions required lighter, quieter or more daylight-rich conditions higher in the structure.

MAKERSPACE

TOTAL AREA	1000 M2
AREA PP	10 M2
CLUSTER	-
FLEXIBILITY	LOW
ACCESIBILITY	PRIVATE
LOGISTICS	PEOPLE, GOODS
FIRE SAFETY	HIGH SAFETY
DAYLIGHT	IN DIRECT
ACCOUSTICS	HIGH
VENTILATION	EXTRA GROOT EN APPART
STRUCTURE NORM	5 KN/M2
FLOOR-CEILING HEIGHT	5 M



STARTUP SQUARE

TOTAL AREA	5000 M2
AREA PP	10 M2
CLUSTER	10-20 M2
FLEXIBILITY	HIGH
ACCESIBILITY	SEMI PUBLIC
LOGISTICS	GOODS, PEOPLE
FIRE SAFETY	SPRINKLER, COMPARTEMENT (30-60 MIN)
DAYLIGHT	DIRECT
ACCOUSTICS	NORMAL
VENTILATION	TYPE D, NORMAL
STRUCTURE NORM	3 KN/M2
FLOOR-CEILING HEIGHT	3 M



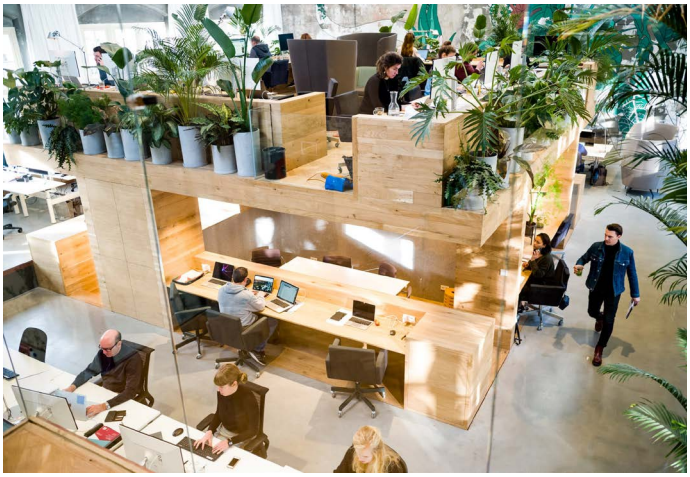




OPEN OFFICE

TOTAL AREA	1500 M2
AREA PP	5 M2
CLUSTER	5 M2
FLEXIBILITY	HIGH
ACCESIBILITY	SEMI PUBLIC
LOGISTICS	PEOPLE
FIRE SAFETY	SPRINKLER, COMPARTEMENT (30-60 MIN)
DAYLIGHT	DIRECT
ACCOUSTICS	NORMAL
VENTILATION	TYPE D, NORMAL
STRUCTURE NORM	2,5 KN/M2
FLOOR-CEILING HEIGHT	2,6 M







MEETING ROOMS

TOTAL AREA	600 M2
AREA PP	1,5 M2
CLUSTER	1,5-12-24 M2
FLEXIBILITY	HIGH
ACCESIBILITY	SEMI PUBLIC
LOGISTICS	PEOPLE
FIRE SAFETY	SPRINKLER
DAYLIGHT	IN-DIRECT
ACCOUSTICS	GOOD
VENTILATION	TYPE D, NORMAL/HIGH???
STRUCTURE NORM	2,5 KN/M2
FLOOR-CEILING HEIGHT	2,6 M





SMALL OFFICE

TOTAL AREA	1500 M2
AREA PP	10 M2
CLUSTER	30-50 M2
FLEXIBILITY	HIGH
ACCESIBILITY	PRIVATE
LOGISTICS	PEOPLE (GOODS)
FIRE SAFETY	SPRINKLER, COMPARTEMENT (30-60 MIN)
DAYLIGHT	DIRECT
ACCOUSTICS	NORMAL
VENTILATION	TYPE D, NORMAL
STRUCTURE NORM	2,5 KN/M2
FLOOR-CEILING HEIGHT	2,6 M



SEMI BIG OFFICE

TOTAL AREA	2000 M2
AREA PP	10 M2
CLUSTER	50-200 M2
FLEXIBILITY	HIGH
ACCESIBILITY	PRIVATE
LOGISTICS	PEOPLE (GOODS)
FIRE SAFETY	SPRINKLER, COMPARTEMENT (30-60 MIN)
DAYLIGHT	DIRECT
ACCOUSTICS	NORMAL
VENTILATION	TYPE D, NORMAL
STRUCTURE NORM	2,5 KN/M2
FLOOR-CEILING HEIGHT	2,6 M

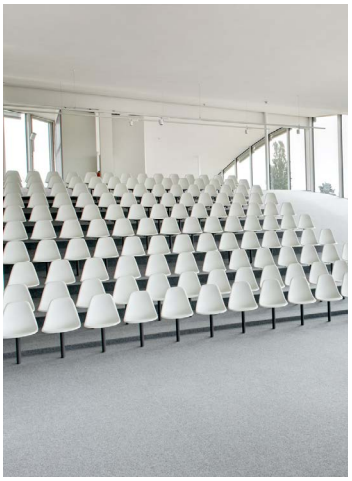
BIG COPERATE UNIT

TOTAL AREA	2000 M2
AREA PP	10 M2
CLUSTER	1000 M2
FLEXIBILITY	HIGH
ACCESIBILITY	(VERY) PRIVATE
LOGISTICS	PEOPLE
FIRE SAFETY	SPRINKLER, COMPARTEMENT (30-60 MIN)
DAYLIGHT	DIRECT
ACCOUSTICS	NORMAL
VENTILATION	TYPE D, NORMAL
STRUCTURE NORM	2,5 KN/M2
FLOOR-CEILING HEIGHT	2,6 M



THEATER SMALL

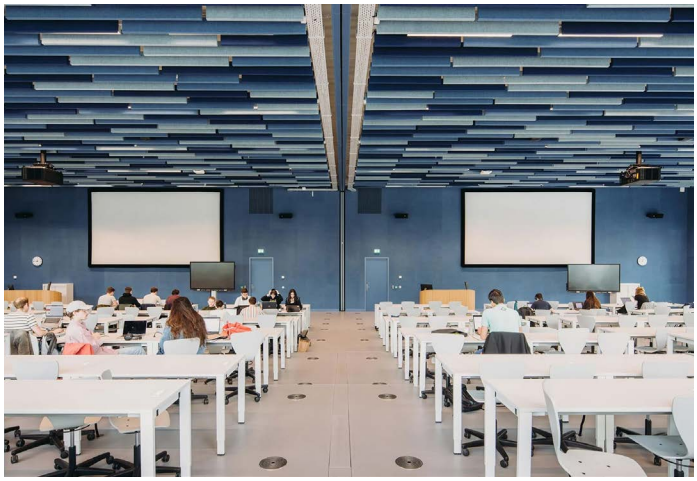
TOTAL AREA	800 M2
AREA PP	1 M2
CLUSTER	40-100 M2
FLEXIBILITY	NORMAL
ACCESIBILITY	SEMI PRIVATE
LOGISTICS	PEOPLE, GOODS
FIRE SAFETY	....
DAYLIGHT	IN-DIRECT
ACCOUSTICS	HIGH
VENTILATION	TYPE D, HIGH
STRUCTURE NORM	5 KN/M2
FLOOR-CEILING HEIGHT	5 M





THEATER BIG
COLLEGE ZAAL

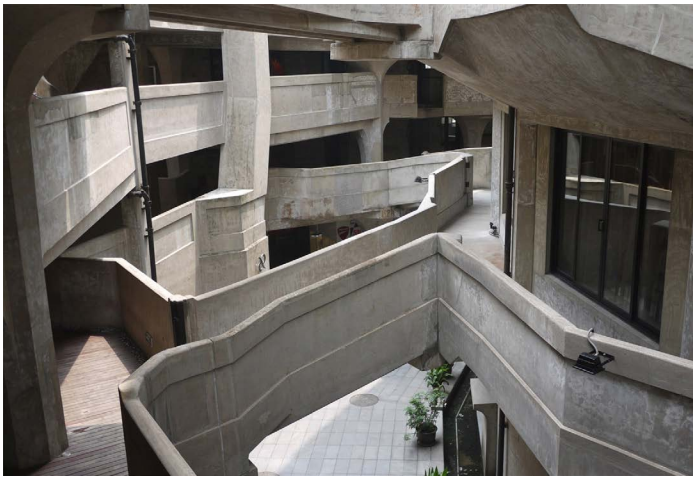
TOTAL AREA	800 M2
AREA PP	1 M2
CLUSTER	800 M2
FLEXIBILITY	LOW-NORMAL
ACCESIBILITY	SEMI PRIVATE
LOGISTICS	PEOPLE, GOODS
FIRE SAFETY	SPRINKLER, COMPARTEMENT (60 MIN)
DAYLIGHT	NOT
ACCOUSTICS	HIGH
VENTILATION	TYPE D, HIGH
STRUCTURE NORM	5 KN/M2
FLOOR-CEILING HEIGHT	5-7 M



SPIRAL

TOTAL AREA	-
AREA PP	-
CLUSTER	-
FLEXIBILITY	NOT
ACCESIBILITY	PUBLIC
LOGISTICS	PEOPLE
FIRE SAFETY	....
DAYLIGHT	DIRECT
ACCOUSTICS	LOW
VENTILATION	....
STRUCTURE NORM	.....
FLOOR-CEILING HEIGHT	..... M







EXPO

TOTAL AREA	-
AREA PP	-
CLUSTER	-
FLEXIBILITY	HIGH
ACCESIBILITY	PUBLIC
LOGISTICS	PEOPLE, GOODS
FIRE SAFETY	....
DAYLIGHT	IN-DIRECT
ACCOUSTICS	LOW
VENTILATION	?
STRUCTURE NORM	5 KN/M2
FLOOR-CEILING HEIGHT	2,7-5 M

EVENTRUIMTE

TOTAL AREA	1200 M2
AREA PP	1 M2
CLUSTER	FLEXIBEL
FLEXIBILITY	HIGH
ACCESIBILITY	SEMI PUBLIC
LOGISTICS	PEOPLE, GOODS
FIRE SAFETY	HIGH RISK
DAYLIGHT	DIRECT
ACCOUSTICS	NORMAL
VENTILATION	TYPE D, HIGH
STRUCTURE NORM	5 KN/M2
FLOOR-CEILING HEIGHT	5 M

LOUNGES

TOTAL AREA	...
AREA PP	4 M2
CLUSTER	MULTIPLE
FLEXIBILITY	HIGH
ACCESIBILITY	(SEMI)PUBLIC
LOGISTICS	PEOPLE
FIRE SAFETY	....
DAYLIGHT	IN DIRECT
ACCOUSTICS	SEMI
VENTILATION	TYPE D
STRUCTURE NORM	3 KN/M2
FLOOR-CEILING HEIGHT	2,6 M

SANITAIR

TOTAL AREA	-
AREA PP	-
CLUSTER	-
FLEXIBILITY	LOW
ACCESIBILITY	....
LOGISTICS	PEOPLE
FIRE SAFETY	....
DAYLIGHT	NO
ACCOUSTICS	LOW
VENTILATION	AFVOER ALLEEN
STRUCTURE NORM	2-3 KN/M2
FLOOR-CEILING HEIGHT	2,3 M

PANTRIES

TOTAL AREA	-
AREA PP	-
CLUSTER	-
FLEXIBILITY	LOW
ACCESIBILITY	(SEMI) PUBLIC
LOGISTICS	PEOPLE
FIRE SAFETY	....
DAYLIGHT	IN DIRECT
ACCOUSTICS	LOW
VENTILATION	TYPE D
STRUCTURE NORM	3 KN/M2
FLOOR-CEILING HEIGHT	2,6 M

RESTAURANT/BAR

TOTAL AREA	-
AREA PP	-
CLUSTER	-
FLEXIBILITY	LOW
ACCESIBILITY	PUBLIC
LOGISTICS	PEOPLE
FIRE SAFETY	....
DAYLIGHT	DIRECT
ACCOUSTICS	LOW
VENTILATION	....
STRUCTURE NORM	5 KN/M2
FLOOR-CEILING HEIGHT	..... M

ENTREEHAL

TOTAL AREA	....
AREA PP	....
CLUSTER	-
FLEXIBILITY	NORMAL
ACCESIBILITY	PUBLIC
LOGISTICS	PEOPLE
FIRE SAFETY	....
DAYLIGHT	DIRECT
ACCOUSTICS	LOW???
VENTILATION	???
STRUCTURE NORM	5 KN/M2
FLOOR-CEILING HEIGHT	..... M

OPSLAG

TOTAL AREA	-
AREA PP	-
CLUSTER	-
FLEXIBILITY	HIGH/LOW
ACCESIBILITY	PRIVATE
LOGISTICS	PEOPLE, GOODS
FIRE SAFETY	....
DAYLIGHT	NO
ACCOUSTICS	LOW
VENTILATION	???
STRUCTURE NORM	5 KN/M2
FLOOR-CEILING HEIGHT	..... M

APPENDIX 3 - EXTENDED THEORE-

This appendix contains the extended theoretical background that informed the main report. The main report only includes the theoretical concepts directly needed to understand the design argument. This appendix expands on the environmental impact of concrete, the hierarchy of concrete reuse, subtractive architecture, Smart City development and Living Lab principles. These themes support the project's position that transformation should prioritise structural retention, element reuse and public embedding of innovation.

CONCRETE AS ENVIRONMENTAL CHALLENGE

The construction sector is one of the most resource-intensive industries worldwide and generates the largest waste stream within construction and demolition activities. Concrete and other mineral-based materials account for the majority of this waste due to their extensive use in structural systems and infrastructure. Although recycling rates of concrete are increasing, recycled concrete is still predominantly downcycled into low-grade applications such as road base and fill material, resulting in a significant loss of material and energetic value (Baelemans, 2020).

In parallel, concrete production contributes substantially to environmental impact through cement manufacturing, material extraction, and transport. As large numbers of post-war buildings reach the end of their technical lifespan, concrete waste streams are expected to grow rapidly, intensifying pressure on landfills, transport networks, and primary aggregate resources.

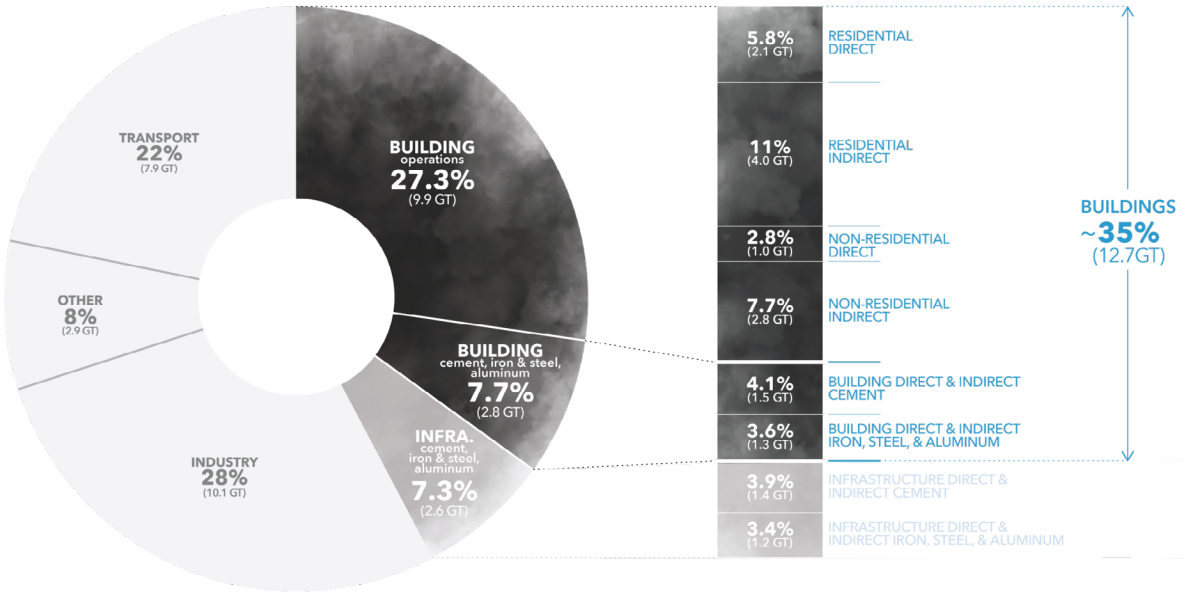


Figure 9 - Total annual global CO2 emmisions. (Architecture2030, n.d.)

THREE PATHWAYS FOR RECYCLING AND REUSE OF CONCRETE

Concrete reuse strategies can be understood as a clear hierarchy based on environmental impact, material retention, and required additional resources.

The most sustainable pathway is reuse of existing structures, in which the primary load-bearing system is preserved and adapted. By maintaining the structural frame in place, demolition, material reprocessing, and transport are largely avoided. Studies indicate that structural reuse can reduce environmental impact by up to 90% compared to new construction, as both embodied energy and material value remain embedded within the building fabric (Hasik, 2019). This pathway will be the main focus of the project.

The second pathway is reuse of concrete elements, such as slabs, beams, or panels. While this strategy retains significant material value, it requires disassembly, transport, and reinstallation, which introduce additional energy use and emissions. As a result, environmental savings are typically lower, approximately upto 80% compared to new construction (Glias, 2014). More conservative life-cycle assessments report reductions of approximately 35–55%, depending on the number of reuse cycles (Naber, 2012).

The least sustainable pathway is recycling concrete into aggregates, where concrete is crushed and processed into secondary raw materials. In theory, advanced recycling techniques could recover up to 70% of the material value, including partial reuse of the cement fraction; however, such technologies are not yet widely implemented at market scale (Schepper, 2014). In current practice in the Netrlands, recycling mainly results in coarse and fine aggregates, achieving environmental impact reductions of approximately 25% (CLO / EC, 2017–2020). As a result, recycling remains a fallback option when structural or element reuse is no longer feasible.

LEARNING FROM THE PAST

Historically, periods of material scarcity led to highly efficient construction systems in which structure, form, and function were tightly aligned, as material use had to be optimized out of necessity. In contrast, many post-war concrete buildings emerged from a context of industrial growth and material abundance, in which robustness, standardisation, and speed of construction were prioritised over material efficiency and adaptability. As described by Forty (2012), this shift produced modernist and Brutalist architecture in which concrete was used generously to express structural power and permanence rather than optimisation.

This project reframes subtraction as a deliberate response to renewed conditions of resource scarcity by physically removing material from post-war concrete buildings, addressing the excesses embedded in their original construction logic. In this sense, subtractive architecture can be understood as an inversion of brutalism: not through stylistic opposition, but by reversing its material logic.

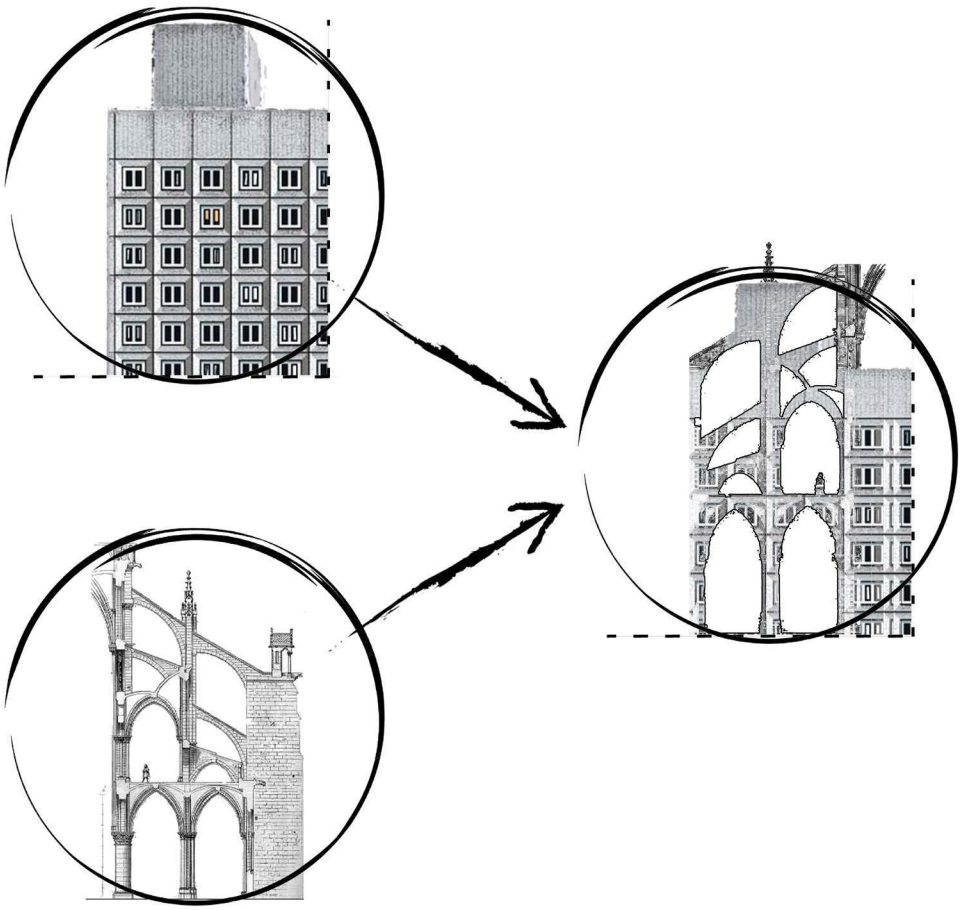


Diagram illustrating the combination of Gothic and Brutalist elements through deliberate material subtraction. (Selfmade)

SMART CITIES

Smart city discourse has evolved through three phases that closely align with the evolution of helix models. Smart City 1.0 was technology-driven and corporation-led, a condition Eindhoven already embodied a century ago through Philips' industrial dominance. Today, Eindhoven largely operates within Smart City 2.0, where innovation is organized through government–industry–knowledge collaborations, materialized in campus developments located at the city's edges (see Fig. 3), a spatial separation that reinforces the gap between innovation and everyday urban life (Paskaleva, 2021). Advancing toward Smart City 3.0 requires embedding innovation within the city centre itself, enabling citizen participation.

Urban Living Labs have emerged as a spatial and organizational framework to operationalize Smart City 3.0. Rather than treating participation as a policy goal, Living Labs embed experimentation directly within the built environment. At the urban scale, they reposition innovation from peripheral campuses into everyday city life. At the programmatic scale, they combine working, learning, and public functions to enable continuous interaction between stakeholders. At the material and construction scale, they allow buildings themselves to become testbeds, where structural systems and material reuse strategies can be developed, tested, and adapted over time. Within this framework, architecture functions as an active interface that translates technological innovation into shared spatial and societal value.

APPENDIX 4 - CONSTRUCTION CALCULATOR

Category	Parameter	Value	Unit	Notes
Geometry	Span L	7,2	m	Beam span
Geometry	Influence width b	16,35	m	Tributary floor width carried by beam
Geometry	Beam width bw	500	mm	Concrete beam width
Geometry	Beam height h	609	mm	Total beam height
Geometry	Effective cover	40	mm	Concrete cover + stirrup
Material	Concrete strength fck	45	MPa	Concrete class
Material	Steel strength fyk	400	MPa	Reinforcement steel
Reinforcement	Tension steel As	5178	mm²	Total bottom reinforcement area
Loads	Permanent load gk	6	kN/m²	Self weight + finishes
Loads	Variable load qk	2	kN/m²	Parking=2, Office=2.5-4

Calculation	Formula / Result	Unit
Effective depth d	569	mm
Moment of inertia I	9411105375	mm4
Line load q (SLS)	130,8	kN/m
ULS line load qd	181,485	kN/m
Max moment M_ed	1176,0228	kNm
Max shear V_ed	653,346	kN
Steel design strength fyd	347,826087	MPa
Lever arm z	512,1	mm

Moment resistance M_rd	922,2894282	kNm
Unity check M_ed/M_rd	1,275112523	

Parameter	Formula	Unit
Moment capacity Mrd	922,2894282	kNm
Span L	7,2	m
Influence width	16,35	m
Permanent load gk	6	kN/m²
Max line load q_allow	142,3286155	kN/m
Max floor load total	8,705114095	kN/m²
Max variable load qk_allow	2,705114095	kN/m²

8. BIBLIOGRAPHY

ACADEMIC & THEORETICAL SOURCES

Banham, R. (1966). The New Brutalism: Ethic or Aesthetic? London: Architectural Press.

Forty, A. (2012). Concrete and Culture: A Material History. London: Reaktion Books.
Paskaleva, K. A. (2021). Co-producing smart cities: A quadruple helix approach to assessment. European Planning Studies, 29(3), 1–20.

Hasik, V., Escott, E., Bates, R., Carlisle, S., Faircloth, B., & Bilec, M. M. (2019). Comparative whole-building life cycle assessment of renovation and new construction. Building and Environment, 161, 106218. https://doi.org/10.1016/j.buildenv.2019.106218

Alexander, C. (2002). The nature of order: Book 1: The phenomenon of life. Center for Environmental Structure.

Salingaros, N. A. (2021). Rules for urban space: Design patterns create the human scale. Journal of Urban Research and Development, 2(1), 4-16.

CONCRETE, CIRCULARITY & CONSTRUCTION IMPACT

Baelemans, M. (2014). Environmental benefit of reusing concrete at building, component and material level (Master's thesis). KU Leuven.

CE Delft. (2013). Environmental impact of concrete use in the Dutch construction industry. Delft: CE Delft.

CE Delft. (2015). Hard facts on the Dutch construction sector. Delft: CE Delft.

Glias, A., Pasterkamp, S., & Peters, P. (2014). Betonskelet als donor. Cement, 46–51.

Naber, N. (2012). Reuse of hollow core slabs from office buildings to residential buildings (Master's thesis). Eindhoven University of Technology.

Schepper, M. de. (2014). Completely recyclable concrete for a more environment-friendly construction sector (Doctoral dissertation). Ghent University.

CLO, CBS, PBL, & RIVM. (2020). Bouw- en sloopafval: vrijkomen en verwerking, 1985–2018. Den Haag.

European Commission. (n.d.). Construction and demolition waste. European Union.

URBAN DEVELOPMENT, POLICY & EINDHOVEN CONTEXT

Gemeente Eindhoven. (n.d.). Omgevingsvisie Eindhoven 2025. Eindhoven.

Encyclopaedia Britannica. (n.d.). Eindhoven. Retrieved from https://www.britannica.com

Stichting 18 September. (n.d.). Bombardementen op Eindhoven. https://stichting-18september.nl/bombardementen-op-eindhoven/

Topotijdreis. (2024). Historische kaarten van Eindhoven. https://www.topotijdreis.nl

Architecture 2030. (n.d.). Why buildings? http://architecture2030.org/why-the-built-environment/why-buildings/

LIVING LABS, SMART CITY & INNOVATION SPACES

KAW Architects & Planners. (n.d.). Living Lab 040 Eindhoven. https://www.kaw.nl/projecten/living-lab-040-eindhoven/

The Future Level. (n.d.). Unieke locatie Eindhoven. https://thefuturelevel.nl/unieke-locatie/

LAPLAB. (n.d.). BIC Campus Eindhoven. https://laplab.eu/projects/bic-campus-eindhoven

ARCHITECTURAL CASE STUDIES & DESIGN REFERENCES

Heatherwick Studio. (2017). Zeitz Museum of Contemporary Art Africa (MOCAA). Cape Town.

ODA New York. (2021). OLA Palermo. Buenos Aires.

Mei Architects and Planners. (2019). Citroën Garage Paris: Adaptive reuse proposal. Paris.

KCAP Architects & Planners. (n.d.). KnoopXL Eindhoven. Rotterdam / Eindhoven.

Bakker, G. (1989). Gatenstoel. Droog Design.

STATEMENT ON THE USE OF ARTIFICIAL INTELLIGENCE (AI)

Artificial Intelligence (AI) was utilized as a supportive tool in the preparation and linguistic refinement of this report. AI tools were specifically employed for translating draft materials from Dutch to English, correcting grammatical errors, and improving sentence structures to ensure an academic standard. Furthermore, AI was used to condense complex sections and improve the clarity of the core arguments. Notwithstanding this assistance, the final content, structural analysis, and design conclusions remain entirely the responsibility of the author, who has reviewed and verified all AI-generated outputs.