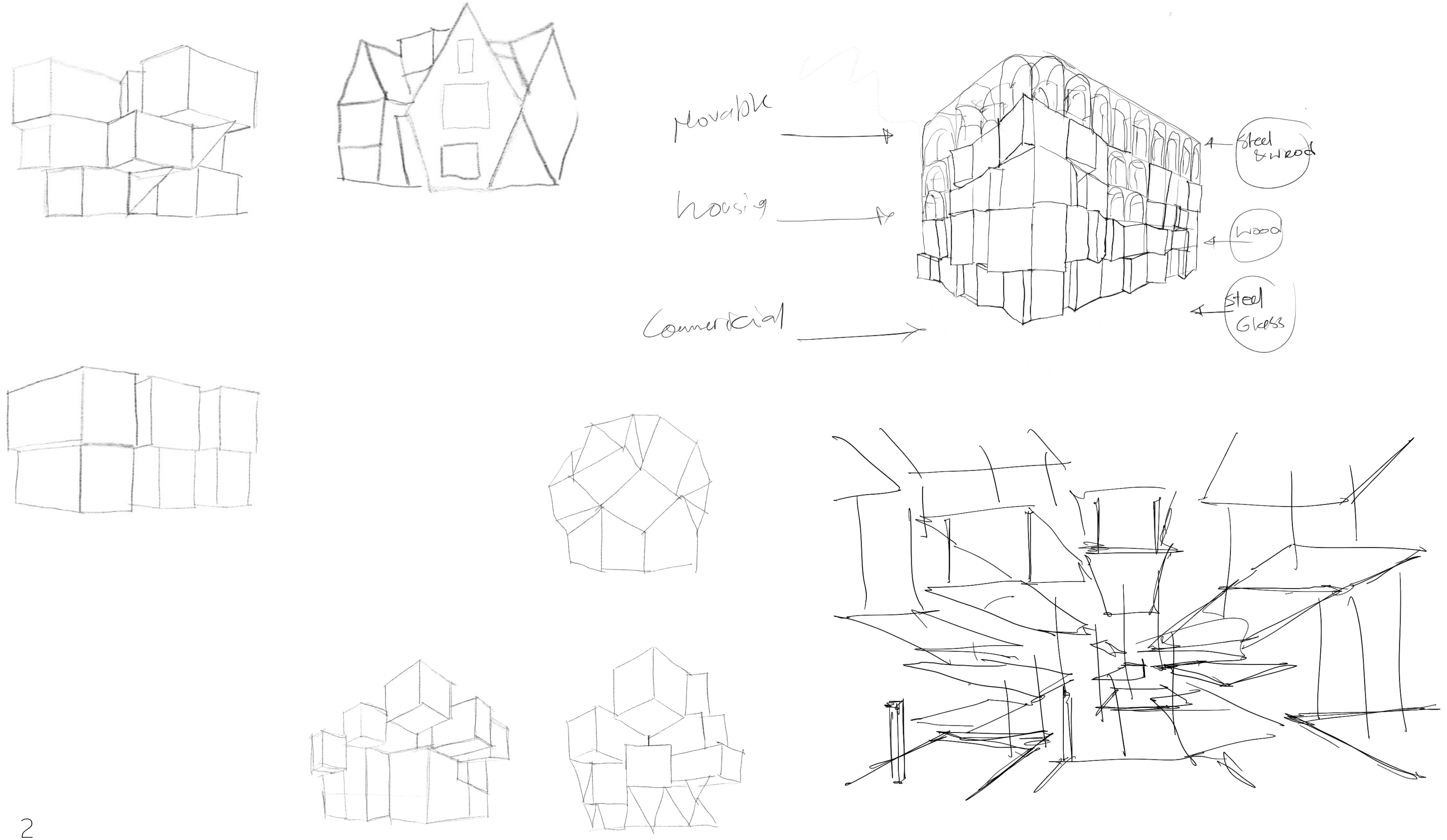
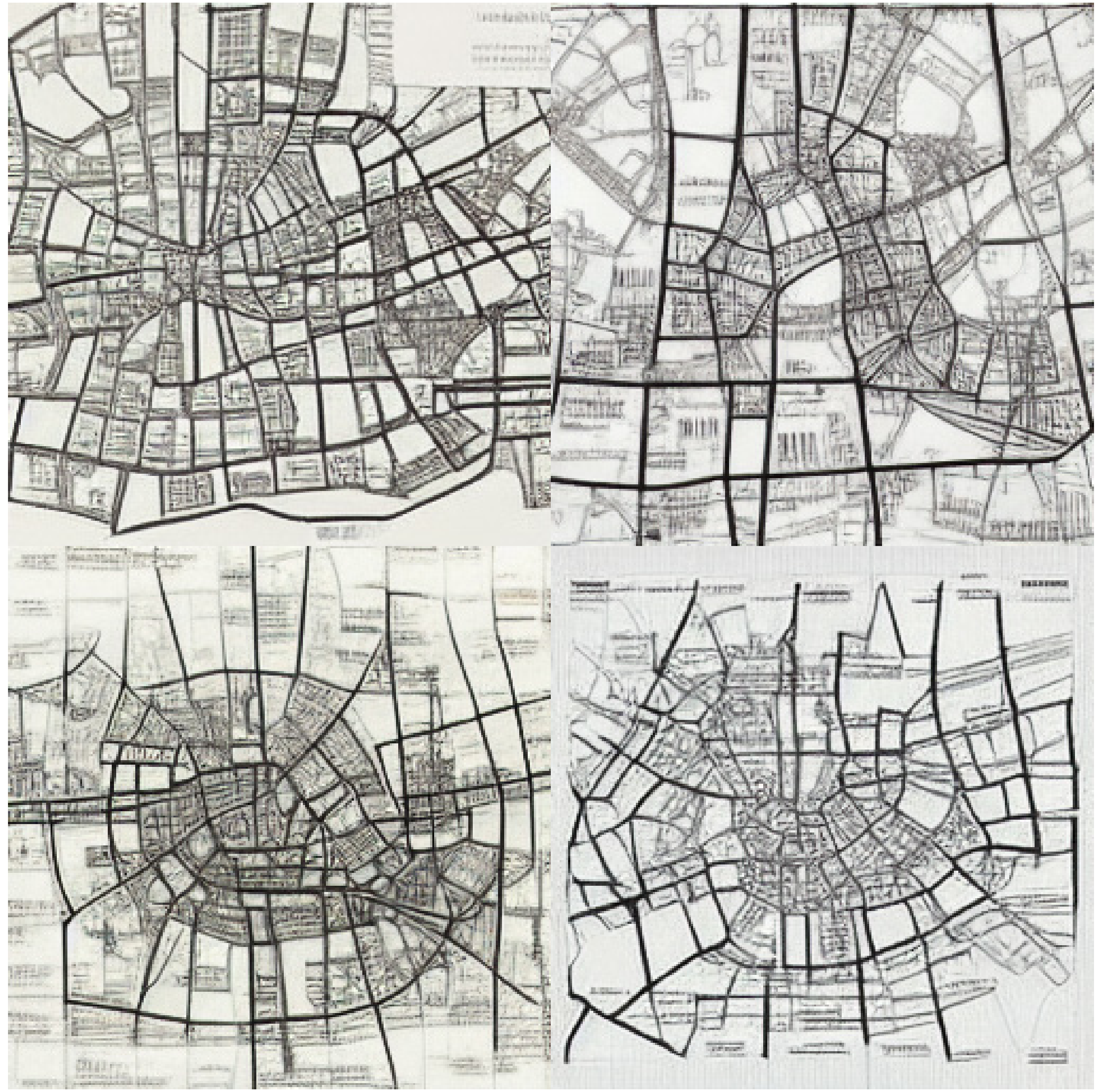
APRON CITY
A NEW FORM OF STRUCTURALISM

Tarik Alboustani | **Mentors:** Thijs Asselbergs, Gilbert Koskamp, Hans Hoogenboom, Hubert van der Meel, Pirouz Nourian
Kosala Bandara- Autodesk Research
Faculty of Architecture & the Built Environment, Delft University of Technology
Julianalaan 134, 2628BL Delft | 4627709

Conceptual Studies Sketches



Urban Grid using Ai (Mimic Amsterdam Grid - Mid Journey)



ABSTRACT

System Design in the built environment is one of the most influential design paradigms in architecture and construction. This paper seeks to amalgamate empirical design strategies with various architectural principles, including the notion of "open buildings" or "open-ended architecture," as well as Structuralism, all within a computational design framework employing discrete aggregation. Structuralism articulated by Herman Herzberger, represents a "concept rather than a style," distinguishing the structure from the infill through individuality. It is important to note that the advanced technologies available for data collection and analysis did not exist during the 1960s Structuralist movement. Thus, this paper endeavours to forge a novel methodology, drawing inspiration from historical system design practices in architecture.

KEYWORDS: Housing, Open Studio, Game Design, Product development, Structuralism

I. INTRODUCTION

Housing design has undergone radical changes since system design became prevalent in the last century. Technologies now play a pivotal role in shaping new architectural languages. The concept of openness, whether in source code or building design, empowers users to leverage the work of others in the tech world. Similarly, in architecture, embracing an open building concept enables project teams, stakeholders, and users to benefit from adaptability. This means creating spaces that can evolve to meet changing user needs over time. As Stewart Brand argues, "Buildings learn what happens after they are built," emphasizing the importance of adaptability across various aspects of a building (Brand, 1994).

An open building is one that grants engineers, designers, and users access to its data, information, and specifications, allowing them to make adjustments, modifications, improvements, or innovations for its future. Given the relatively short lifespan of the building components, as estimated by Brand—site, structure, skin, services, interior, and furnishings—can anything endure except the building plot and foundation? This prompts the question of whether our designs should be conceived as enduring works of art. Architects, like structural engineers and consultants, must acknowledge their social and cultural responsibilities and focus on creating and shaping spaces (Hertzberger, 2000, p.9).

This research aims to introduce a new approach to design thinking through system design, a methodology influenced by the cybernetic advancements of the 1960s and further propelled by current cutting-edge building technologies. It treats the design process as akin to product development, integrating the aesthetic values inherent in architectural design.

The research experiment unfolds in three main stages. The first phase establishes the project's context and program requirements. In the second stage, the methodology defines personalized spaces and functions based on autonomous self-learning design principles. Mathematical game theory will aid in creating the configurator, ultimately yielding the final design—a product of the system design method, ready to be refined and presented.

2.0. PROBLEM STATEMENT AND FRAMEWORK

The critical issues in housing development are outlined as follows:

1. High Demand for Housing: This demand arises from a shortage of development compared to market needs. Factors such as war, migration, and economic growth can also contribute to this need.

2. Escalating Construction Costs and Real Estate Prices: These factors limit design options and often lead to a decrease in aesthetic value during the design process.

3. Need for Future Adaptability: There is a growing demand for housing to be adaptable to future changes, driven by evolving functional program needs.

4. Early Involvement of Occupants/Users: Engaging the occupants/users of a project in the early design stages and ensuring "equality" in the design process among stakeholders is crucial.

The introduction of Cybernetics in the late 20th century brought about a paradigm shift, giving rise to what we now term as "system design." While we may not have control over the costs of materials or land, we can engineer an optimal construction approach that minimizes costs and maximizes the utility of our designed spaces.

The advent of "system design" in the previous century prompted many architects to explore design automation for achieving mass production and affordable housing solutions. However, this design approach, characterized by systematic, prefab-ed, and automated methods, often prioritizes functionality over aesthetic considerations, treating aesthetics as a by-product. Furthermore, the sense of ownership and belonging was frequently overlooked, as exemplified by the rush to construct affordable housing in the aftermath of WWII. This haste led to compromised development in terms of design quality and sustainability, and even greater social consequences (Hess, Tammaru, Ham, 2018).

The urgency to provide affordable housing in the aftermath of WWII resulted in compromised development. This compromise manifested in terms of diminished design quality and sustainability, and led to even greater social consequences (Hess, Tammaru, Ham, 2018).

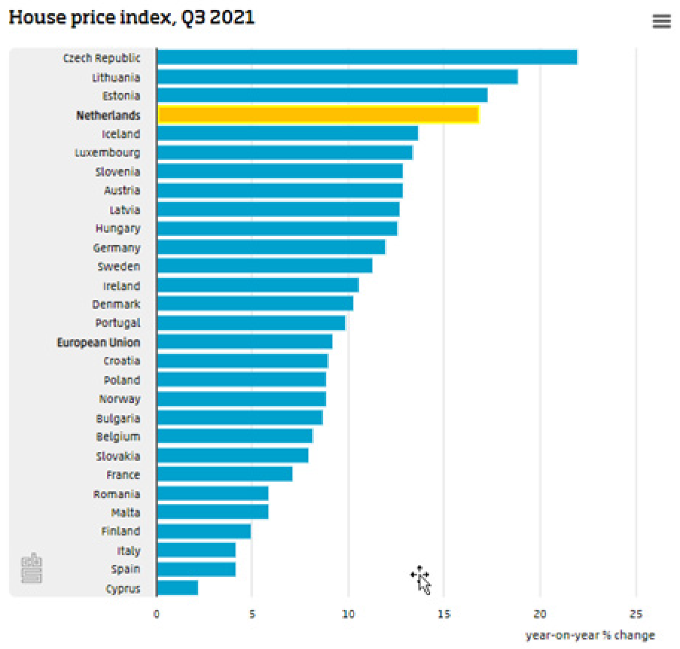


Figure 1. Housing prices increase by 17% in the Netherlands, Source Cbs.nl.

The need to cater to participant's requirements, environmental considerations, and program specifications has propelled a shift towards prioritizing the computation of the environment before its actual design. This transition necessitates a computational workflow to manage the complexity arising from numerous design variables and adaptations.

Despite significant strides in sustainability, architecture finds itself at a similar juncture. In the book "Van Stoel tot Stand," Jaap Bakema questions whether architects are still needed to design modular housing. With the widespread integration of technology across various fields, architects remain indispensable, albeit with different tools from those employed during Bakema's era. The post-WWII era witnessed the emergence of systematic design, which led to the development of large housing estates. However, this approach drew criticism for its visible uniformity and repetitive nature, lacking an appreciation for design evolution. In most cases, these houses were not inhabited by decision-makers; policymakers seldom resided in such large estates and visited only when absolutely necessary.

Interestingly, many of these large-scale estates were meticulously planned. The towering structures of these housing estates garnered significant attention. However, residents often found them aesthetically unsatisfying. Given the choice, they would opt to relocate (Hess, Tammaru, Ham, 2018).

Various motives underlie the development of such housing, prompting a reassessment of mass configurable housing design and architecture. Factors include shortages resulting from war damage, demographic shifts, rural-to-urban migration, international migration, and increasing prosperity. Economic and technological changes also played a role, as volume and speed became imperative for labor-saving reasons in housing construction.
There was a prevailing belief that architecture could contribute to a more equitable society. Modernist principles applied to housing and urban planning were seen as the path to achieving a more egalitarian community. This aspiration for an egalitarian functional city represented a powerful affirmation of the idea that technological interventions in development could be managed more effectively than ever before.

To prevent urban sprawl from encroaching on the countryside, high-density housing was viewed as a means to safeguard nature. This was particularly seen as a solution to protect against the sprawl associated with single-family houses (Mentzel, 1989). Governmental support played a pivotal role in this endeavor. For instance, large housing estates were linked with slum clearance efforts in Britain, and additional subsidies were provided to alleviate building costs. In the Netherlands, a 25% extra subsidy was granted in 1963 for prefab housing systems. Given these factors, it is imperative that we reconsider system design in this context. The mounting pressure of soaring housing costs underscores the necessity for equitable system design architecture. A well-conceived plan that does not result in *viable housing development may face abandonment, much like the structuralism movement of the 1960s.*

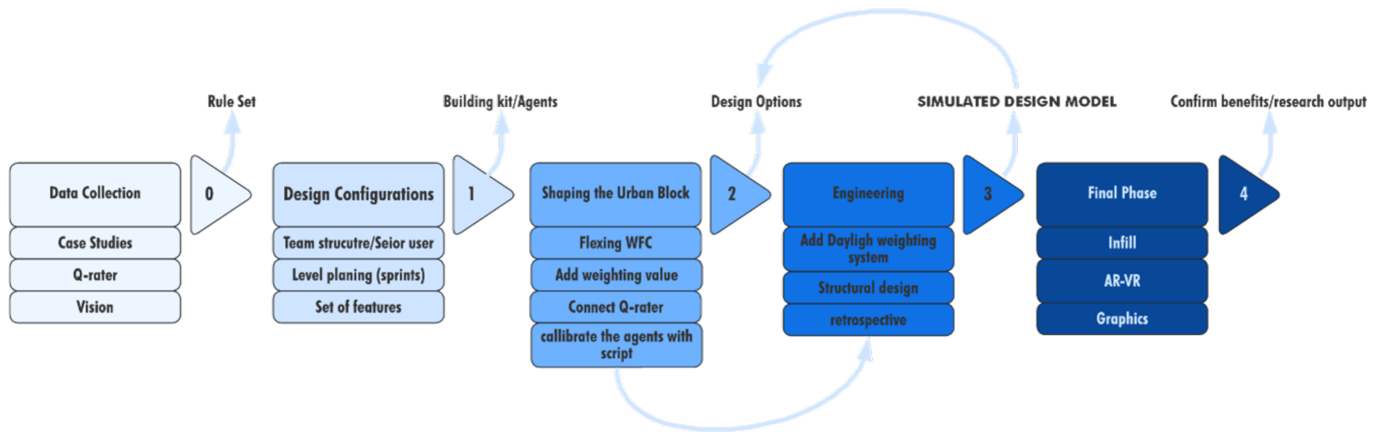
3.0. OBJECTIVES, DELIVERABLES & RESEARCH QUESTIONS

The research focuses on applying system design to the main aesthetic principles in architecture using the empirical design method for the main question. This method led to formulate the main question into the following:
-How to create adaptable architecture (open building) using computational workflow?

And to the sub-question:
-What is the best practice in system design-based methodology to create an adaptable design configuration?
-How can the design process and user needs integrate with engineering in system design?

The Main Objectives of the research:
- Provide a new system design methodology that involves (Product Design Method) in an agile way that changes throughout the project's life and after accomplishing the building.
- Provide design workflow that is adaptable and changeable based on users' stories and set of rules.
- Improve the design aesthetics starting from the preliminary design stage.
- Increase the densification of the program with the ability to apply engineering requirements (Solar gain, daylight

The techniques followed in the research are:
- Mapping aesthetic design principles.
- Empirical method (priorities user stories)
- Analyse case studies (related to similar design methodology)
(Combine all techniques and place them in appendixes and only right the necessary sufficient in one tillite)



4.2 Project Location and requirements

Based on the vision set by the authority, The main principle of the Municipal master plan of Marineterrein is to create a place where the area is internationally oriented and an incubator for an innovative startup. Additionally, it will be cultural, sports, educational and living place. Although, the Defence area in Marineterrein is set to be removed. However, the Ministry of Defence wishes to remain present in any plans.
The objectives set for the future of the Marineterrein area by the local authority and economic board aim to make the area 2025 one of the top 3 most innovative regions in the E.U. [Amsterdam Economic Board, 2022]. The use of advanced materials solutions, zero-emission transportation, and improving the city's lifestyle are key factors the plan relies on to improve residents' quality of life and life expectancy by two additional years.

Amsterdam 1600 Amsterdam 1800 Amsterdam 1940

Figure D-1: Amsterdam maps through the history from 1600 to 1940. Sources google-History map.

5.0 WORK BREAKDOWN STRUCTURE & TIME PLANNING

The research has four main phases:
- Data collection Phase
- Design configuration Phase
- Shaping the Urban Block Phase
- Engineering Phase
- Final Design

The research output (abstract process) will implement a game design method influenced by different levels of dominance ineach design variable (weighting criteria). The graph below is implemented through the computational workflow.

5.1.0 Phase One: Data Collection (P1-P2)

The data collection went through two steps. First, by looking at similar case studies representing system design and well-known architectural examples, these case studies give the best standards in terms of the structuralist approach. Learning from experience is the central part of product development that involves the iteration of any new project based on this past trial to reduce the risk of failure. The second source of data collected is the site survey of Marineterrein. This survey covers aspects of the program selection process and basic site layout. The survey was proposed as an initial concept to provide a dynamic programme adapted to different users' wishes. However, the Marineterrein authority based their future development on users' participation through the Q-rater method (not defined) that helps them decide on on-site development. Since the administration fully controls the site, the proposed method is expected to be compulsory on any tenants or leases as part of community giveback. A similar test proposal will be used to simulate the Q-rater impact on design weighting.

5.1.1 Collected User Stories Case Study One (Centraal Beheer Apeldoorn /The Cube Hoses Rotterdam):

(User stories), The collection uses information collected from evaluation surveys gathered from the case (used by occupants, visitors who lived long/short time). These are the info that will influence the system design configuration and program requirements.

Two case studies were selected to represent system design in its past method. The Cube housing project in Rotterdam by Piet Blom built 1977 and Centraal Beheer offices were designed by Herman Hertzberger. These examples illustrate the process of (learning from the past) in the system design phase.

Each project collects user story data in different methods (Appendix B). For Centraal Beheer, the project was abundant at the time of the study due to this fact; the videos, literature review and personal interviews with the architect were the primary sources of users' feedback and input.

On the contrary, the cube houses in Rotterdam are still occupied by residents and have not faced any significant change in the functional programme. The user stories were collected via two steps: a building evaluation form sent to occupants who lived or experienced living in the building. In the second step, a literature review was used to collect other technical information to help in the system design rating of the building.

Table 3: The Cube houses Rotterdam's user stories from the site survey and aesthetics analysis

Data Collection and implementation have two levels of influence on the design. In the first level, the questionnaire aims to improve the current program proposed by the Amsterdam municipality and keep more freedom for the program to be dynamic and change rather than being in a fixed location.

5.2.0 Design configuration phase

This process starts by creating configurations based on the set of requirements. As the research aims to answer adaptability and densification, the configuration design will consider the latter aspects. The design of the configuration phase is the basic setup for applying the system design method with any mathematical approach. In the research, the proposed algorithm "Wave function collapse" developed for game design by Maxim Gumin, initially used for game development, is applied to answer the first question for achieving adaptable building. There are aggregation design methods and game theories, such as complex systems by Manual de Landa, where the agents perform independently (The plug-in BOID developed by Jan Pernecky). Another example of game design is Voxel Synthesis, its methodology being implemented widely by structural engineers in a similar method, called finite element analysis. As the volumetric units of structure and calculation are called voxels, the style resulting from this mode of composition is often called voxelisation, in which each voxel holds the data. The discretising theory is an excellent example of combining big data in architecture and engineering, which also can be combined with WFC theory. What makes discreet aggregations in the proposed workflow unique is the possibility of assigning the exact discretisation to a particular block with its rules. The ability to define precise rules applied to these "agents" will allow the designer to have greater control over the final design approach and use the engineering in parallel.

5.3.0 Shaping the Urban Block Phase:

The Transition from Urban block design to the smaller configuration will be through different scales and software. Starting by using the Space planning powered AI design tool "Autodesk Forma", the urban block will be evaluated in terms of Daylight, Solar light analysis through winter/summer transition days to show the hourly rate that the façade is able to gain in these two different sessions. Additionally, the blocks will be evaluated in terms of view quality (distance from the façade) and view to the area where the views mainly laying in the water &/or the public activity centre.

The zoom-in development will be followed with WFC "wave function collapse". Additional customisation will be added to the current developed source code by Jan Pernecky plug-in monoceroses. The addition will include a weighting system for the discretised elements. The weighting system will be connected to the Q-rater developed by Liesbeth Jansen and Thijs Meijer of the Bureau Marineterrein Amsterdam and later will include a weighting system for daylight colourmap.

5.3.1 Densifying the functional programme using WFC wave function collapse:

Filling the module's design in any envelope regardless of the envelope's geometrical shape. These will create no gaps and connected modules that have already a predefined set of rules. This algorithm is a type of discrete mathematical aggregation

4.0. METHODOLOGY

The research follows three main methods of evaluating and conducting the design exploration method: architectural aesthetics, empirical product development (using case studies and user stories), and combining the latter with computational workflow using game design.

The software tools that will be applied to the research are as follow:

- C sharp coding.
- Forma Ai
- Autodesk Revit 2023.
-Autodesk Inventor 2023
- Autodesk Insight.
- Rhino 7 and plug-in related (Grasshopper, Monoceroses, ladybug, Honeybee)
- Typeform website to collect users' stories.

The techniques followed in the research are:

- Mapping aesthetic design principles.
- Empirical method (priorities user stories)
- Analyse case studies (related to similar design methodology)

(Combine all techniques and place them in appendixes and only right the necessary sufficient in one tillite)

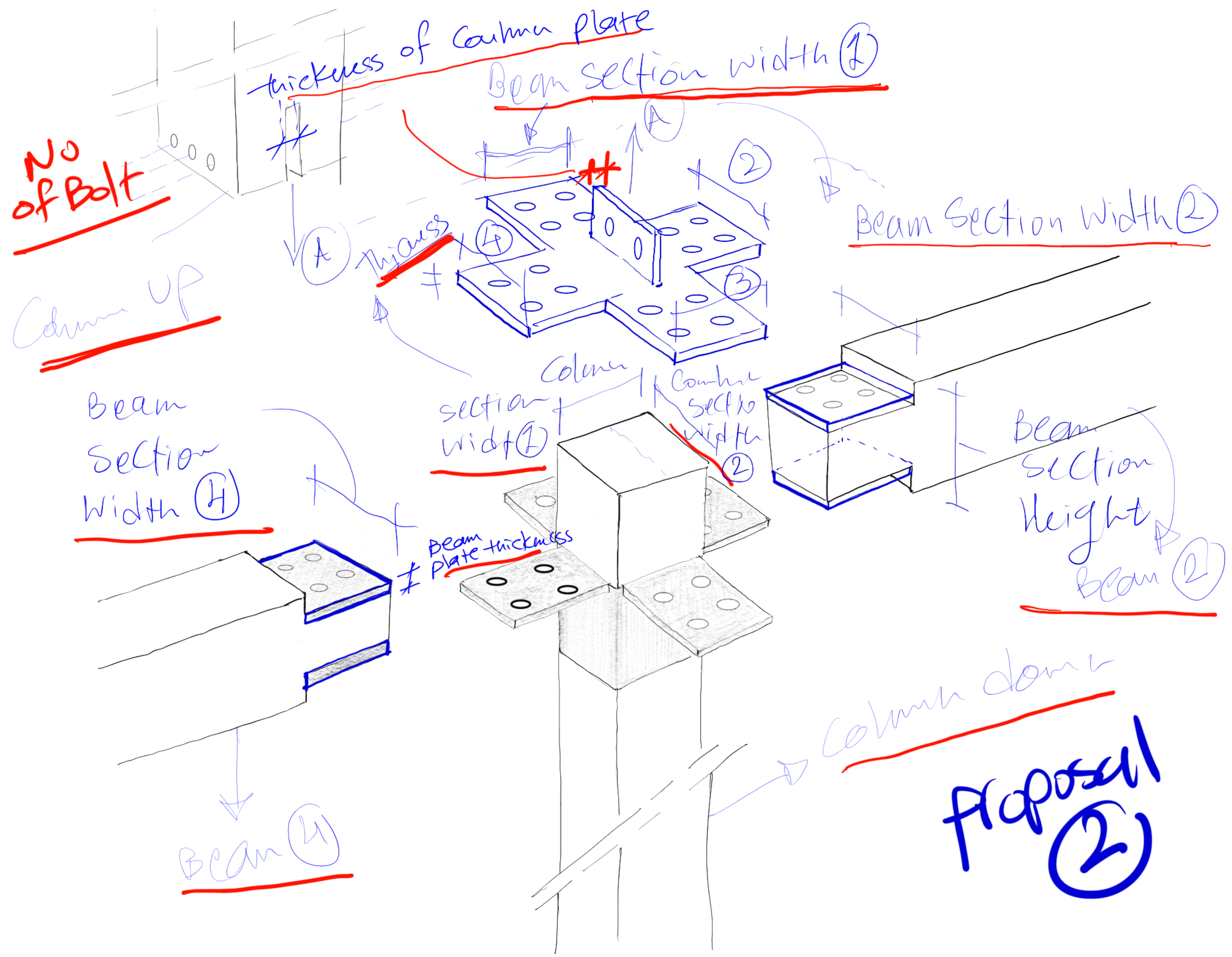
6 Project Location and requirements

Based on the vision set by the authority, The main principle of the Municipal master plan of Marineterrein is to create a place where the area is internationally oriented and an incubator for an innovative startup. Additionally, it will be cultural, sports, educational and living place. Although, the Defence area in Marineterrein is set to be removed. However, the Ministry of Defence wishes to remain present in any plans.
The objectives set for the future of the Marineterrein area by the local authority and economic board aim to make the area 2025 one of the top 3 most innovative regions in the E.U. [Amsterdam Economic Board, 2022]. The use of advanced materials solutions, zero-emission transportation, and improving the city's lifestyle are key factors the plan relies on to improve residents' quality of life and life expectancy by two additional years.
5.0 WORK BREAKDOWN STRUCTURE & TIME PLANNING

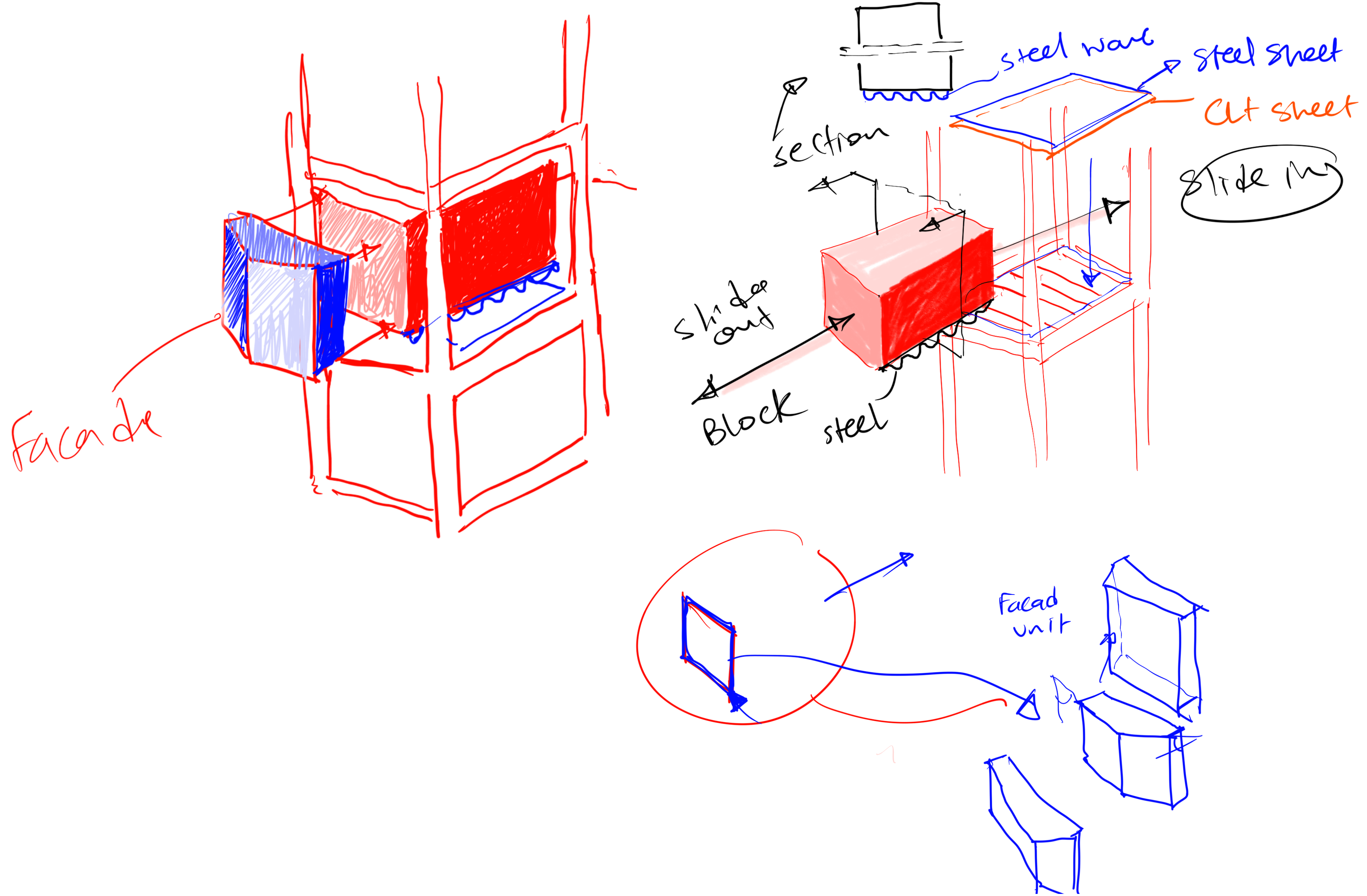
The research has four main phases:
- Data collection Phase
- Design configuration Phase
- Shaping the Urban Block Phase
- Engineering Phase
- Final Design

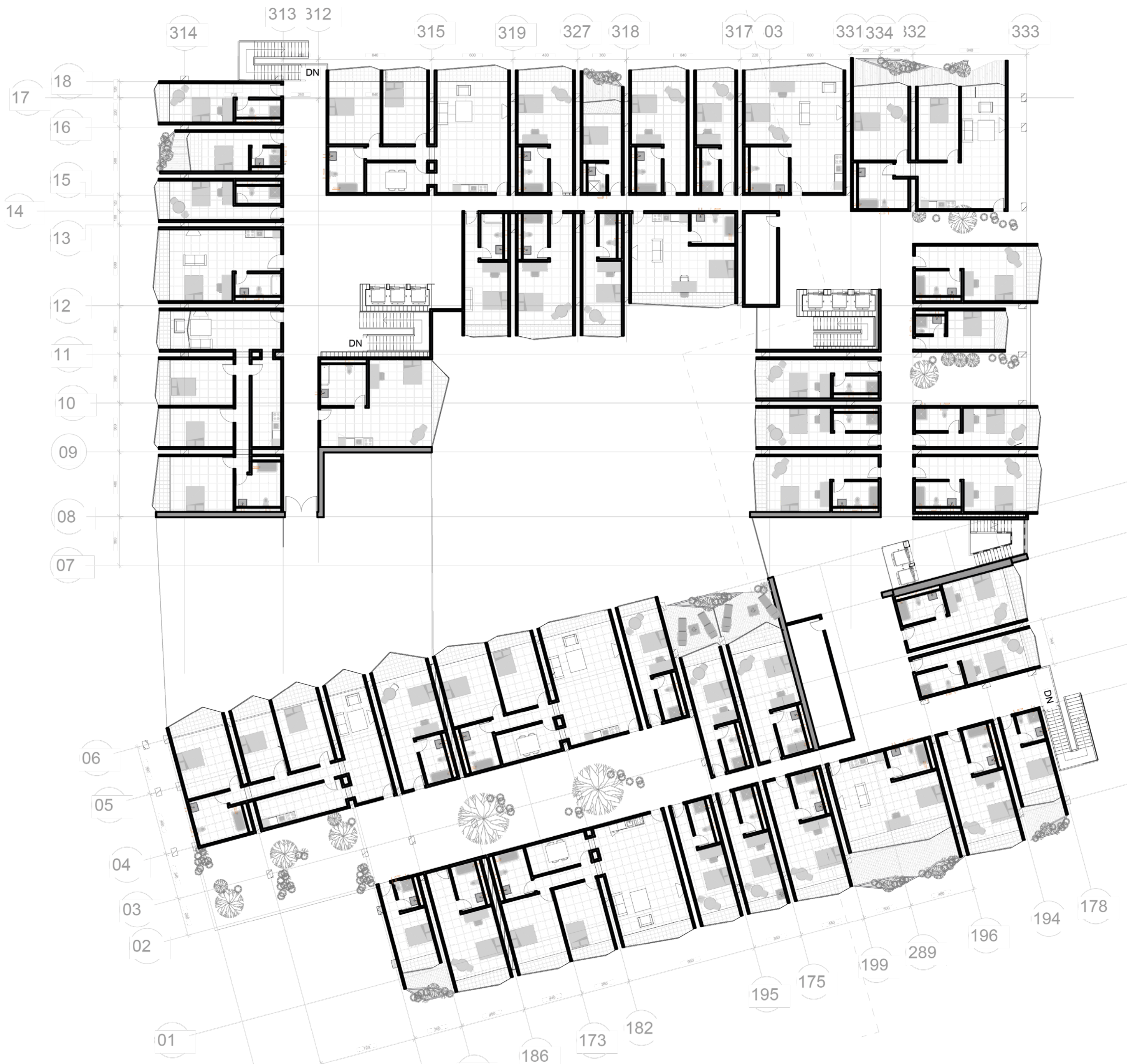

De opleidingsgebouwen van de TOKM. Bron: Nederlands Instituut Militaire Historie.

Structural Studies Sketches



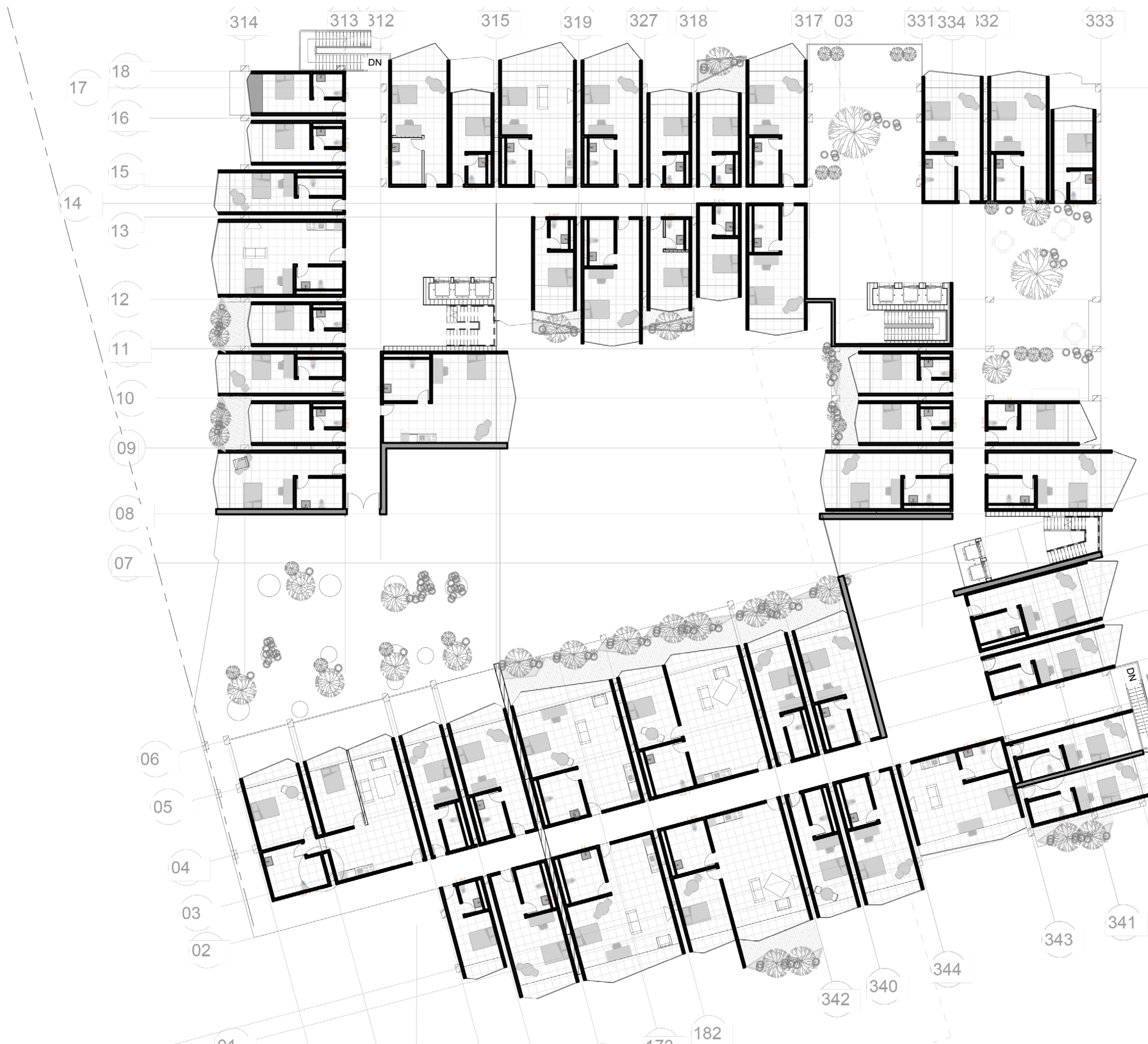
Unit Movement study





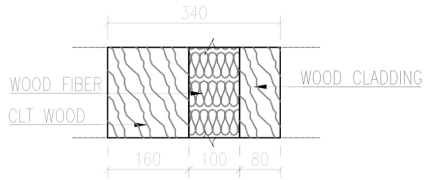
BUILDING A - FIRST FLOOR

SCALE 1:200



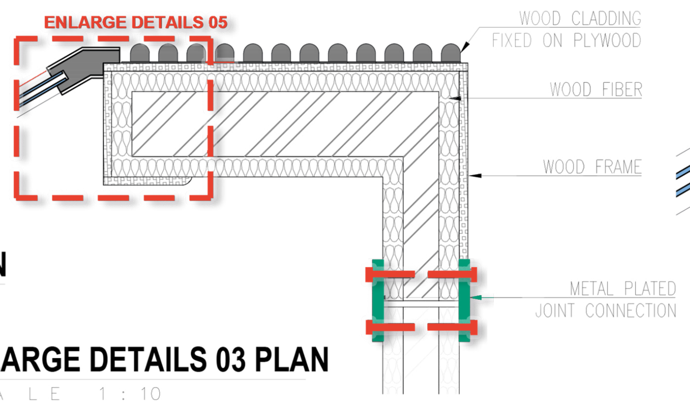
BUILDING A -SECOND FLOOR

SCALE 1:200



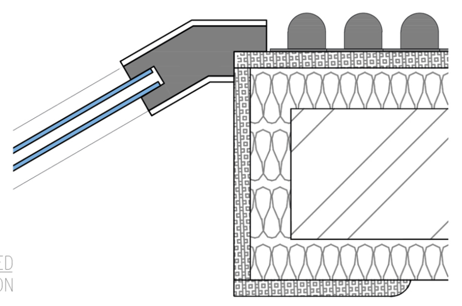
ENLARGE DETAILS 03 SECTION

SCALE 1 : 10



ENLARGE DETAILS 03 PLAN

SCALE 1 : 10

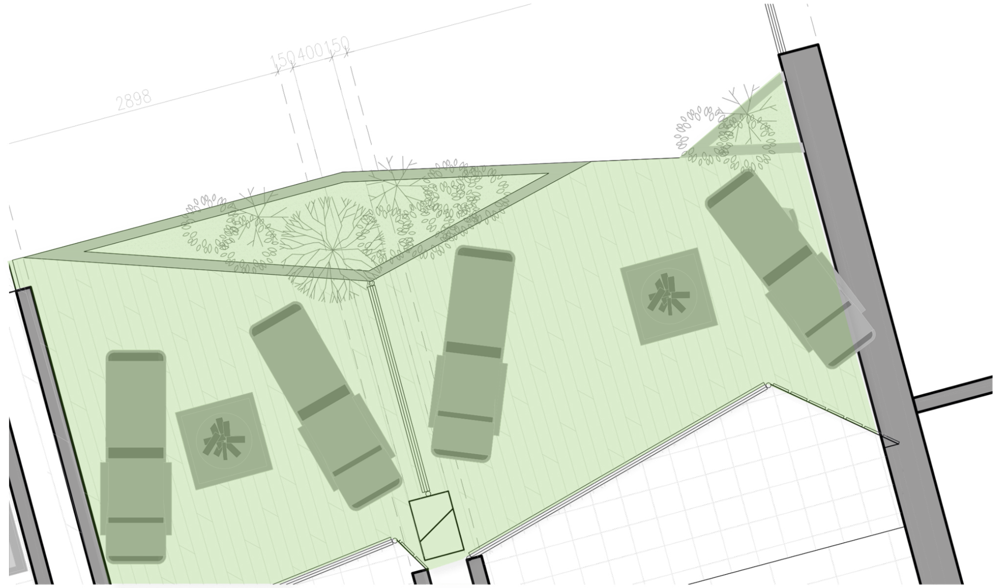


ENLARGE DETAILS 05

SCALE 1 : 5

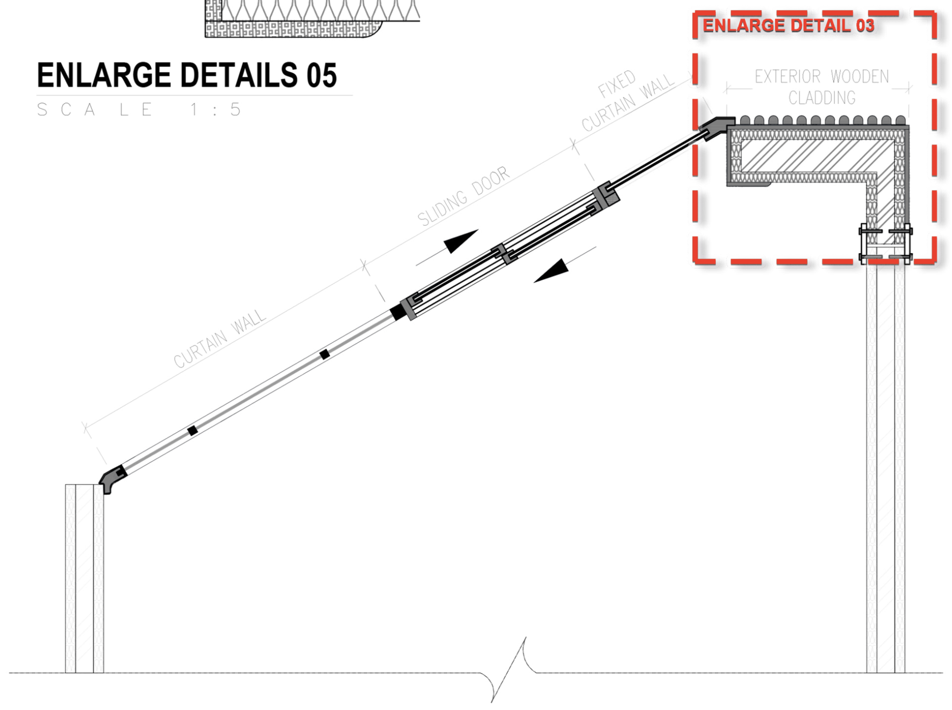
STAIRCASE DETAILS

SCALE 1 : 50



ENLARGE DETAILS 01

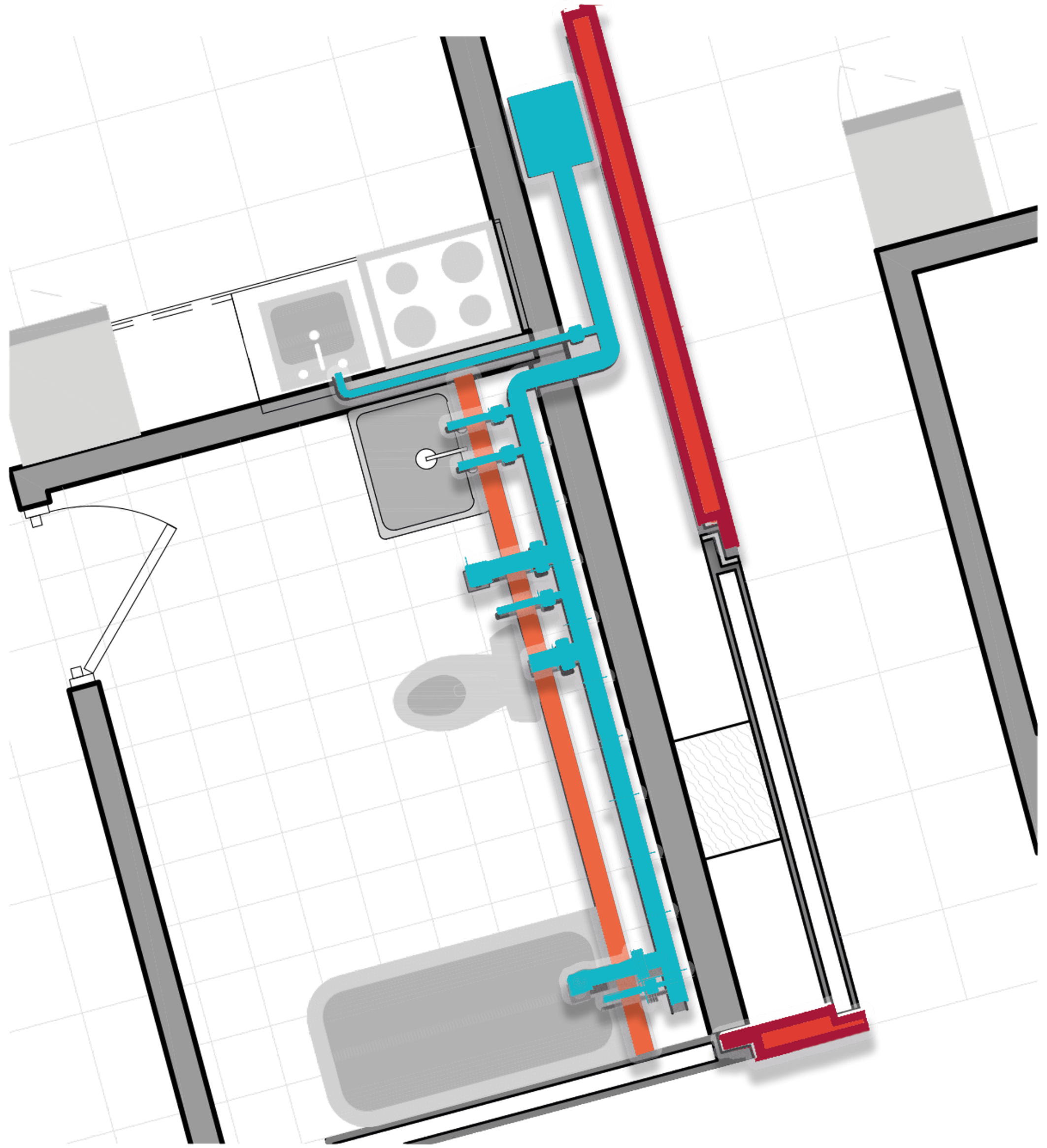
SCALE 1 : 50



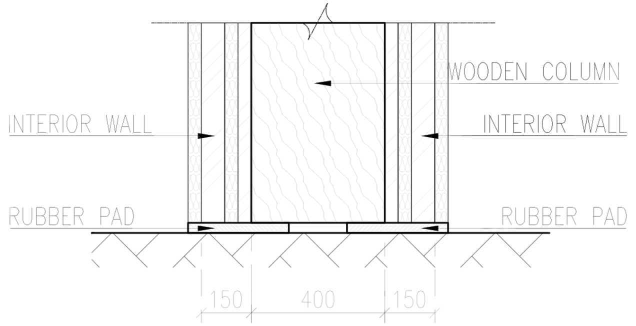
ENLARGE DETAILS 02

SCALE 1 : 20

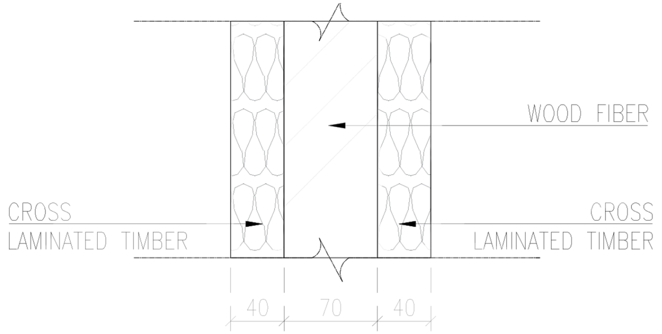
8. Building Level Details



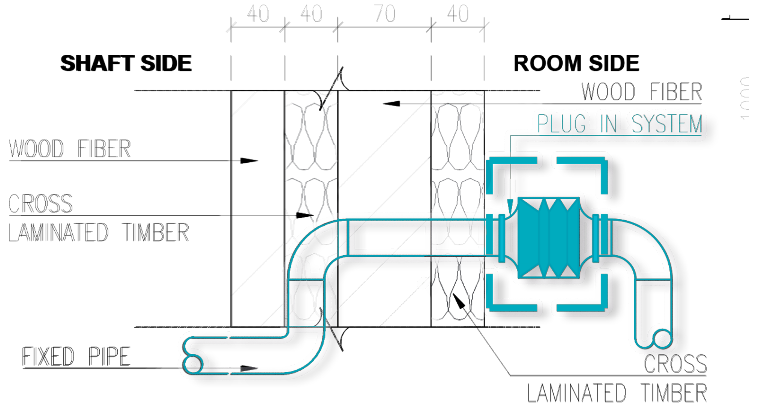
ENLARGE DETAILS 04



TYPICAL COLUMN DETAILS
SCALE 1 : 20



TYPICAL INTERIOR WALL DETAILS
SCALE 1 : 5



TYPICAL SHAFT WALL DETAILS
SCALE 1 : 5

8. Building Level Details