APPLIED STRATEGIES IN OPEN BUILDING ARCHITECTURE

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ABSTRACT

This research explores the implementation of Open Building principles, focusing on the separation of the Support and Infill to achieve adaptability in architectural design. By combining a literature review and case study analysis of Patch22, Superlofts, and NEXT21, the study identifies eight key strategies that support adaptability: integrated service infrastructure, open structural frameworks, flexible partition systems, dry assembly methods, adaptable façades, capacity for multiple functions, modular grid frameworks, and user-driven customization. These strategies demonstrate the potential for long-term flexibility at both unit and building scales. While the literature provided a theoretical foundation, case studies revealed practical applications and highlighted challenges, such as limited documentation for Superlofts. The findings are broadly applicable to various contexts and building typologies. Future research should address economic, managerial, and material aspects, alongside analysing the Infill perspective of Open Building.

KEYWORDS: OPEN BUILDING, SUPPORT, INFILL, SERVICE INFRASTRUCTURE, ADAPTABILITY, USER-DRIVEN CUSTOMIZATION

I. INTRODUCTION

In the 1960s, architectural rationalization emerged, leading to an industrial approach in the field of housing construction. The primary objective was to build faster and more economically through mass production and standardization (Bundgaard, 2013; Priemus, 1987). While this method effectively met the soaring demand for housing, it yielded long rows of repetitive, monotonous buildings (Bundgaard, 2013). Furthermore, mass standardization insufficiently accommodates the dynamic nature of society: "one-size-fits-all" designs are inadequate to respond to changing individual needs and preferences. This lack of adaptability has contributed to the phenomenon that, in the Netherlands, around 60% of new construction involves the partial or complete demolition of existing structures (Elma, 2006). Emphasizing rapid and efficient construction thus not only undermined architectural diversity but also generated substantial amounts of construction and demolition waste.

In response to the challenges posed by mass standardization, John Habraken introduced the theory of Open Building in 1961 through his book *De mensen en de dragers*. Open Building moves away from rigid, uniform housing solutions by distinguishing between two key systems: the "**Support**", a base structure including load-bearing and shared utilities. And the "**Infill**", interior elements determined by individual occupants. By operating independently, the infill allows personalisation without altering the communal structure, fostering easy adaptability. This adaptability empowers residents to take control of their living spaces, enabling them to modify layouts and components as their needs evolve over time (CIB W104 Open Building implementation conference, 1994).

Habraken's theory fundamentally redefines the relationship between individuals and their built environment. It restores the "natural relation" -the active participation of users in shaping their homes- that was lost in the era of mass housing (Habraken, 1972). By embedding adaptability into the design process, Open Building provides a more sustainable alternative to conventional housing strategies. By enabling flexible, user-centred housing solutions, it offers a direct response to the rigidity and lack of adaptability that is inherent to mass housing.

Open Building theory has seen growing contemporary interest and activity among architects, researchers, and collectives working to translate its concepts into reality. This research aims to contribute to this ongoing dialogue by analysing existing literature and case studies to identify design strategies and principles that can support the implementation of Open Building principles within architectural design. At the core of this research lies the central thematic question: *"Which Open Building strategies from existing case studies have been successfully applied and provide a solid foundation for architectural design based on the principles of Open Building?"*

To answer this main question, the following sub-questions have been formulated:

1. What are the design criteria associated with Open Building?
2. How do existing case studies meet these design criteria?
3. Which design solutions or methods are applied in these case studies to fulfil the Open Building design criteria?

II. METHODOLOGY

This research consists of two main phases: a literature review to establish design criteria and a case study analysis to evaluate their application in practice.

The literature review draws on three key sources: Habraken's *Supports: An Alternative to Mass Housing* (1972), Kendall and Teicher's *Residential Open Building* (2000), and the OpenBuilding.co website. These sources are chosen for their fundamental importance and contemporary relevance. From these, essential principles of Open Building are identified and refined into practical design criteria, focusing on the physical aspects. Uncertainties or overlaps in the criteria are resolved to ensure clarity and applicability, forming the evaluation framework used in the subsequent analysis.

The case study analysis uses this framework to evaluate how the design criteria are applied in real-world projects. Case studies are selected based on the availability of detailed documentation, their apparent adherence to Open Building principles and the diversity of projects. For each project, architectural drawings and technical documentation are reviewed to see how fully the criteria are met. The evaluation process systematically measures how well each criterion is met using the categories "fully met," "partially met," or "not met." This is illustrated through a combination of textual descriptions and visual representations. Additionally, the findings from the case study analysis reflect on the quality of the design criteria, ensuring an iterative and interconnected research process.

This research aims to provide a clear and systematic evaluation of existing Open Building strategies. Through this methodology, an answer will be provided to the thematic research question: *Which Open Building strategies from existing case studies have been successfully applied and provide a solid foundation for architectural design based on the principles of Open Building?* This approach not only evaluates the success of these strategies but also contributes to refining the design framework for future applications in Open Building.

III. RESULTS LITERATURE RESEARCH

This chapter explains the results of the literature research, which establishes design criteria related to Open Building. These criteria address the physical requirements for Support, Infill, and Service Infrastructure and have been derived from three key sources—Supports: An Alternative to Mass Housing (1972), Residential Open Building (2000), and the OpenBuilding.co manifesto. Appendix I explains the method and analysis used to establish the design criteria. Appendix II and Appendix III provide supporting quotes that form the basis for the initial design criteria.

- **Appendix I**: Establishing the design criteria related to Open Building.
- **Appendix II**: Quotes from *Supports: An Alternative to Mass Housing* supporting the established design criteria.
- **Appendix III**: Quotes from *Residential Open Building* supporting the established design criteria.

The first paragraph of this chapter discusses interesting insights uncovered during the establishment of the design criteria. The second paragraph presents the complete set of design criteria.

2.1. Insightful findings from establishing the design criteria

Different terminology
A challenge during the research was the differing terminologies across the sources. Habraken's work referred to 'Support' and 'Support Dwellings,' while later texts like Residential Open Building introduced terms such as 'Base Building' and 'Infill.' Meanwhile, OpenBuilding.co expanded on these ideas with principles linked to specific building layers, such as 'Structure', 'Systems' and 'Space plan'. To create a coherent framework, the final terminology was standardised to three themes: **Support**, **Infill**, and **Service Infrastructure**. This choice reflects a key insight within Open Building: *while the Infill and Support are distinctly separate elements, for a building to function as a building they must still be interconnected. The Service Infrastructure acts as the essential link between these layers*.

Exclusion and modification of design criteria
The process of establishing the design criteria focuses on *avoiding prescriptive solutions* and *ensuring alignment with the physical requirements of Open Building*. A total of 23 initial criteria are excluded. Which include six for specifying predefined design solutions and 12 for addressing topics outside the study's scope of research, such as managerial or economic aspects of Open Building.

One example of exclusion is the criterion suggesting that "Design control should be distributed among multiple stakeholders." While valid within the broader context of Open Building, it is excluded because it addresses to authority distribution in the construction industry rather than the physical requirements of Open Building.

Another example is the suggestion from OpenBuilding.co to implement "Raised floor systems." This criterion is excluded because it represents a predefined design solution, restricting flexibility and predetermining the outcome of a possible design.

A total of ten design criteria were modified to ensure flexibility, clarity, and alignment with the physical requirements of Open Building. Changes include avoiding prescriptive solutions, broadening applicability, and improving precision. For example, the principle "Maximised free layout of floors" is refined because it lacks the precision needed to be a measurable criterion. It is rephrased as "The service infrastructure is designed in such a way so that maximum freedom in the layout of floors is created," shifting the focus from a general idea to a clear and actionable guideline.
The final set represents a focused and actionable foundation for Open Building design criteria that fit within the scope of this research and do not prescribe specific design outcomes.

2.2. Final set design criteria

This paragraph brings together the findings of the literature research, presenting the final set of design criteria for Open Building. The criteria are categorized into three main themes: Support, Infill, and Service Infrastructure. These themes collectively address the physical requirements for constructing buildings that adhere to Open Building principles. By synthesizing insights from key sources and critically analysing the proposed criteria, this paragraph marks the conclusion of the literature phase of the research. Together, the design criteria form a framework for the next phase of research, which involves analysing case studies on applied design strategies trying to fulfil these design criteria.

Support

1. The Support provides sufficient capacity to accommodate adaptability of the space plan over a relatively long period of time.
    a. Each dwelling in a Support allows a variety of layouts.
    b. The Support must allow flexible reconfiguration of unit boundaries, enabling a variety of dwelling sizes.
    c. The Support must have enough capacity to accommodate varying functions, both residential and non-residential function.
2. The Support contains all shared building services.
3. The Support ensures compatibility with diverse infill solutions.
4. The Support must allow for the independent assembly, alteration, and removal of the infill.

Infill

5. The infill is compatible with the support structure.
6. The Infill can independently be assembled, adjusted or disassembled, allowing for flexible placement of elements (e.g., sinks, windows, doors, storage) to accommodate each occupant's personal preferences and daily needs.
7. The façade can be part of the adaptable infill.

Service Infrastructure

8. The Service infrastructure (e.g. water, gas, electricity, drainage) creates maximized freedom within the adaptability of the space plan.
9. The Service infrastructure (e.g. water, gas, electricity, drainage) is designed in such a way that each part can work independently and can be replaced.

The final list of Design Criteria after the reflection that was followed after the case study analysis can be found in Appendix VIII "Post analysis reflection on the design criteria".

IV. Results case study research

This chapter provides an overview of the case study research, highlighting evaluation, and key findings. A more extensive description of the case study research can be found in the following appendices.

- **Appendix IV** showcases the selection of the case studies for this analysis.
- **Appendix V** provides an extensive analysis of the three case studies, including detailed textual and visual explanations per design criterion.
- **Appendix VI** contains a concise textual evaluation for each case study (chapter 3), a complete list of design strategies per case study (chapter 2), and a more detailed explanation of the insightful findings (chapter 3).
- **Appendix VII** offers a clear overview of how each case study meets the design criteria and the design strategies used to achieve them.
- **Appendix VIII** provides a more in-depth explanation of the reflection on the design criteria

3.1. Selecting case studies

The selection of case studies for this research were chosen based on the availability of detailed documentation, their apparent adherence to Open Building principles and the diversity of projects. The final selection of case studies is:

- Patch22 - Tom Frantzen (2016)
- Superlofts - MKA (2015)
- Next 21 - Yositika Utida (1994)

3.2. Fulfilment of the design criteria per case study

This paragraph answers sub-question two: "*How do existing case studies meet these design criteria?*" In the diagram below you can see how well each case study meets each design criterion. Green means "fully met", orange means "partially met" and red means "not met".

Notably, not all Infill-focused design criteria (DC5 and DC6) were evaluated, as this study focusses on the design of the Support, which is the base building. Criterion 7, however, still proved relevant because façade design directly affects the Support's adaptability.

	DC 1	DC1A	DC1B	DC1C	**DC2**	**DC3**	**DC4**	**DC7**	**DC8**	**DC9**
Patch22	Green	Green	Green	Green	Green	Green	Green	Red	Green	Orange
Superlofts	Orange	Green	Green	Red	Orange	Green	Orange	Orange	Orange	Orange
Next21	Orange	Green	Green	Red	Green	Green	Green	Green	Green	Green

Diagram 1: Matrix showcasing how well each case study met each design criterion.

3.3. Applied design strategies

This paragraph answers sub-question three: "*Which design solutions or methods are applied in these case studies to fulfil the Open Building design criteria?*"

1. Open structural frameworks
All three projects incorporate an open structural systems that enable flexibility in layouts and multi dwelling configurations.

Patch22 features a column-and-beam structure connected to a stable core, providing open floor plans. Similarly, NEXT21 also makes use of an open column-beam framework. Superlofts offers generous floor heights and a wide bay width, allowing for flexible layouts and the addition of 70% extra surface area through the added CLT mezzanines.

2. Integrated service infrastructure
Vertical and horizontal Service Infrastructure distribution integrated into the Support is essential for adaptability in Open Building. Patch22 features the Slimline Floor system, which incorporates hollow cavities to allow flexible utility placement throughout the unit. NEXT21 uses a raised floor system and reduced-depth beams, enabling independent routing of utilities and wet areas without interfering with the structural elements.

Superlofts centralizes services within a double core, but its horizontal service distribution relies on infill-based solutions, limiting the extent to which the Support actively facilitates adaptability.

3. Flexible partition systems
Flexible partition walls are a key strategy for enabling reconfiguration of unit boundaries. Both Patch22 and Superlofts use Soundbloc metal stud frames, which allow partitions to be added or removed easily.

4. Capacity for multiple functions
To accommodate diverse uses, the structural framework must support both residential and non-residential functions. Patch22 exceeds residential load requirements with a load-bearing capacity of 4 kN/m^2, enabling it to support various functions, including offices and light industrial uses.

5. Adaptable façades
Flexibility in the design of the façade enhances overall adaptability. NEXT21 enables exterior reconfigurability by integrating façade elements into the infill. It makes use of modular exterior walls, allowing the façade to be removed and reassembled as needed.

Superlofts incorporates a prefabricated façade system with flexibility in window partitioning, though its adaptability post-construction remains uncertain.

6. Dry assembly
Dry assembly techniques are applied in all three projects. NEXT21 divides the building into four independent subsystems (structure, cladding, infill, and services). The dry construction for the cladding, infill and services enables easy assembly, adjustment, and disassembly. Patch22 applies dry assembly for interior partitions and the service infrastructure within the Slimline floor. Superlofts applies dry assembly for the interior partitions and its CLT mezzanine floors.

7. Modular grid
NEXT21 incorporates a 30-centimeter modular grid framework across its four independent sub-systems: structure, cladding, infill, and services. This modular approach ensures precise compatibility between components, enabling seamless reconfiguration and integration. By standardizing dimensions, this strategy allows for flexibility in layout adjustments while maintaining the integrity of the interconnected sub-systems.

8. User-Driven Customization
Encouraging occupant involvement is another key strategy. Superlofts showcases this approach through its "Superliving" platform, which enables residents of the Superloft-community to adopt and share design ideas.

3.3. Insightful findings

This paragraph summarises the insightful findings from the case study analysis. For a more detailed explanation refer to **Appendix V**, **Chapter 3**.

The fundamental principle of Open Building
The separation of the permanent Support from the flexible Infill remains the central principle of Open Building. Although Support and Infill are separate, they remain interconnected via the Service Infrastructure, which acts as the essential link between these layers.

A well-designed Support is the key to long-term adaptability at multiple scales (DC1). Patch22 and NEXT21 fully embed service infrastructure into the Support, facilitating easy reconfiguration of wet areas and installations, whereas Superlofts entrusts horizontal service distribution to the Infill, potentially limiting future adaptability.

Two forms of adaptability

Adaptability manifests in two phases: the design phase and the usage phase. Superlofts exemplifies user-driven customization early on, yet its long-term modifiability (e.g., removing or adjusting mezzanines) remains uncertain. On the other side, NEXT21 demonstrates adaptability in the usage phase through multiple reconfigurations over time.

Proof of concept

Third, NEXT21 also serves as the most proven concept; experiments, including Residence 405, confirm its adaptability despite initial cost and time challenges. In contrast, Patch22 and Superlofts lack documented post-occupancy transformations, underscoring the value of longitudinal studies.

Materiality and building techniques

Materiality across all projects mostly relies on conventional concrete structures, with Patch22 blending concrete and timber. Future research may explore using (more) sustainable materials like CLT or other bio-based solutions in similarly adaptable frameworks.

Limited information on Superlofts

Limited documentation of Superlofts constrained its assessment, particularly regarding service infrastructure details, highlighting the importance of comprehensive technical information for evaluating a building's true capacity for Open Building.

3.4. Reflection on design criteria

This paragraph reflects on specific design criteria (DC1C, DC2, and DC4) and highlights difficulties and areas for refinement based on the case study analysis. For a more detailed discussion and elaboration on these reflections, refer to **Appendix VIII**.

Assessing **DC1C** is a complicated task because it depends on many factors. This study focuses on basic aspects, which are the load-bearing capacity and building dimensions, to understand how adaptable the Support is in basic terms.

The original **DC2**, "The Support contains all shared building services," fails to address the importance of horizontal service distribution. Projects like Patch22 and NEXT21 show that incorporating both vertical and horizontal Service Infrastructure distribution enhances flexibility and aligns with Habraken's vision of the Support as a "shared framework." This results in rephrasing DC2 to "The Support distributes the service infrastructure both horizontally and vertically" highlighting its role in enabling design freedom and adaptability over time.

DC4 has been somewhat misinterpreted in the analysis. While dry assembly methods in Patch22 and NEXT21 were initially credited with fulfilling DC4, these strategies actually align more closely with DC6, which focuses on the independent assembly, adjustment, and disassembly of the Infill itself. True fulfilment of DC4 lies in the Support's ability "to act as an elevated ground" (Habraken, 1972), allowing occupants to add, move, or remove Infill elements without affecting the structural framework. Patch22 and NEXT21 illustrate this principle by offering open flooring systems that enable flexible placement of wet areas and utilities, whereas Superlofts relies more on Infill-based solutions than on an integrated Support system. In essence, DC4 is realized when the Support remains a neutral platform, giving inhabitants complete autonomy in shaping their living environments.

V. CONCLUSION

The relationship between the Support and the Infill lies at the core of Open Building principles, reflecting their distinct roles within the building. The Support functions as a shared framework, encompassing structural and infrastructural foundations. Conversely, the Infill caters to individual household needs, including partitions, kitchens, and personal utilities. This research aimed to explore how this separation is implemented in practice, addressing the research question: *Which Open Building strategies from existing case studies have been successfully applied and provide a solid foundation for architectural design based on Open Building principles?*

The research confirms that the separation of Support and Infill is key to achieving adaptability at multiple scales, from unit layouts to entire buildings. This separation between Support and Infill has been integrated through multiple design strategies.

1. The distribution of horizontal and vertical **Service Infrastructure** has been **integrated into the Support**, enabling flexible utility placement and adaptability of wet areas without interfering with structural elements.
2. **Open structural frameworks**, such as column-and-beam systems and generous floor heights, provide flexibility for various layouts and multi-dwelling configurations.
3. **Flexible partition systems**, such as Soundbloc metal stud frames, allow for the reconfiguration of unit boundaries.
4. **Dry assembly methods** have been applied to facilitate the easy installation, adjustment, and removal of components, ensuring long-term adaptability.
5. **Adaptable façades**, such as modular systems in NEXT21, extend adaptability to the building's exterior.
6. **Capacity for multiple functions**, such as the increased load-bearing capacity in Patch22, ensures that structures can accommodate both residential and non-residential uses in the future.
7. Strategies like **modular grid frameworks**, exemplified by NEXT21, ensure compatibility between building subsystems, enabling seamless reconfiguration.
8. **User-driven customization,** as seen in Superlofts' "Superliving" platform, further enhances adaptability by encouraging residents to contribute to and personalise their living spaces.

Adaptability manifests itself in two phases: the design phase and the usage phase. Involving residents in the design of the initial dwelling is important to achieve diverse layouts and personalised designs. However, it is even of greater value to ensure that buildings incorporate strategies to remain adaptable in the future. The essence of Open Building lies in addressing the challenges of mass standardization, a concept introduced by John Habraken in his 1961 book *De mensen en de dragers*. Open Building rejects rigid, uniform housing solutions in favour of flexible frameworks.

This research combined a literature review with case study analysis to effectively identify and evaluate Open Building strategies. While the literature review provided a strong theoretical foundation, the case studies highlighted practical applications. However, limited documentation for the Superlofts case study restricted the depth of analysis.

The findings are broadly applicable due to the abstract nature of the strategies, which can be adapted to various building typologies, including the transformation of existing structures.

Future research could address economic and management-related criteria to explore broader implications of Open Building. Additionally, further exploration into the use of biobased materials could enhance sustainability within Open Building practices. A focus on the infill perspective within Open Building could also provide valuable insights, particularly regarding innovative infill systems that address service infrastructure challenges.

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APPENDIX I

ESTABLISHING THE DESIGN CRITERIA RELATED TO OPEN BUILDING

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ABSTRACT

This appendix systematically establishes design criteria for Open Building by analysing foundational literature and contemporary principles. It begins with a review of three key resources: Supports: An Alternative to Mass Housing (1972) by John Habraken, Residential Open Building (2000) by Stephen Kendall and Jonathan Teicher, and the OpenBuilding.co manifesto. Each source is analysed to identify principles and translate them into measurable design criteria. The criteria are grouped into three primary themes: Support, Infill, and Service Infrastructure, reflecting the physical requirements for implementing Open Building principles in architectural design. Critical evaluations refine the criteria to ensure they are objective and actionable, and focused on physical requirements. The final set of criteria serves as a framework for analysing case studies in a subsequent phase of the research.

INTRODUCTION

To form design criteria that aim to implement the concept of Open Building into an architectural design this research first needs to dive into the written literature of Open Building. By analysing and deconstructing the current body of knowledge, this chapter seeks to provide an answer to the central question: What are the design criteria related to Open Building?

John Habraken (1928-2023) was a Dutch architect, professor and theorist. His book, "De Dragers en de Mensen" (1961), introduced the idea of separating the support from the infill to allow flexibility and individual customization. Habraken's work has set the basis for contemporary thinking on Open Building.

As the next generation of Open Building enthusiasts grows, the field continues to develop. Collectives like the Council on Open Building in the United States and OpenBuilding.co in the Netherlands contribute to this progress. Architects, theorists, and practitioners involved in these initiatives have expanded the theoretical framework of Open Building and applied its principles in practice through realized projects.

This research is based on key resources in the field of Open Building. These include John Habraken's *Supports: An Alternative to Mass Housing* (1972), which is an English translation of his book '*De Dragers en de Mensen*' written in 1961 *and Residential Open Building* (2000) by Stephen Kendall and Jonathan Teicher, which outlines Open Building methods and projects.

In addition, the website of OpenBuilding.co is used as a more contemporary source. Together, these resources provide a basis for developing design criteria that apply Open Building principles to architectural design.

This document is organized to systematically analyse three key sources related to Open Building. Each source is explored in a dedicated section, beginning with a list of the design criteria derived from that source. These criteria are based on quotes extracted from the resources, which are documented in an appendix for reference. Following this, a critical analysis is conducted to evaluate the relevance, clarity, and applicability of each criterion. Where necessary, criteria may be modified, combined, or discarded based on this analysis. In the concluding chapter, these criteria are synthesized into one cohesive set that serves as the outcome of this research.

The focus of this research is on the physical requirements for constructing buildings that adhere to the principles of Open Building. These requirements are translated into objective and unbiased design criteria, which avoid prescribing specific design solutions. This focus shapes the approach taken under the subheadings 1.2., 2.2 and 3.2.. The research excludes social, economic, managerial and other non-physical aspects of Open Building, centring solely on practical, physical considerations. This ensures that the resulting criteria are universally applicable and suitable for guiding architectural design within the Open Building paradigm.

I. SUPPORTS: AN ALTERNATIVE TO MASS HOUSING (1972)

John Habraken's Supports: An Alternative to Mass Housing introduced the world of architecture to the concept of Open Building through a new way of thinking about housing design. Instead of relying on rigid, top-down systems like mass housing, he proposes a flexible framework that separates shared structural elements (Supports) from customizable, individual spaces (Infill). This approach allows residents to shape their living environments while still benefiting from the efficiency of shared infrastructure. As Habraken states, "Our task therefore is primarily to find a solution to the great problem of society: to find a housing process which allows comfort and human dignity to exist hand-in-hand, while maintaining the urban environment as an aggregate of compact building" (Habraken, 1972, p. 65).

Habraken's system places the user at the centre of the design process, offering opportunities for customization that mass housing often lacks. In his example of a couple creating their home (see below) in a Support structure, he describes how they select prefabricated elements to assemble their dwelling based on their needs (Habraken, 1972, p. 70). This process shows how Support structures allow for personal freedom while maintaining a clear framework for urban organization. Unlike mass housing, where "everything must have its predetermined, unchanging place," (Habraken, 1972, p. 84) support structures create adaptable spaces that can evolve over time to include not just homes but shops, schools, businesses, garages, a doctor, workplaces, the list goes on. (Habraken, 1972, p. 84-85).

A major advantage of the Support Structure is its ability to handle change. Habraken writes, "Support structures fulfil the most important condition of urban design: that the unforeseen can be absorbed" (Habraken, 1972, p. 84). He emphasizes the importance of creating flexible systems rather than static designs, arguing that "by setting up game-rules for the use and subdivision of support structures, we can take part in a powerful movement towards new social relations, new dwelling forms, and new cities" (Habraken, 1972, p. 85).

Example of Habraken's philosophy in practice.
"*A married couple want to settle down in a support-structure city. They find a space in a structure where they can assemble their dwelling. In this particular structure the space is as follows:*

The support structure consists of a concrete construction of a number of floors one above the other, stretching out through the urban environment. Between these floors are the dwellings, side by side. A zone at one side remains free as an open gallery which connects freestanding staircases and elevator shafts, placed at regular intervals. Between two floors there is an open space, until recently taken up by a dwelling but now removed.

This space is limited top and bottom by the support floors, and to the left and the right by the blind walls of the other dwellings. On the gallery side there is nothing, nor on the opposite side: openings which presently will be filled in.

This space suits our couple for various reasons. They decide to have a dwelling constructed there. To this end they study information, trade literature and different manufacturers' displays of support structure dwellings. After much thought, they make up their minds, and visit the showrooms of the manufacturer of their choice. With the help of a representative of the firm an effective arrangement of a dwelling is decided upon. Because support structures have long since become common property and their housing technique perfected, the dwelling in question can be totally formed out of prefabricated elements.

The representative invites our customers to return in a fortnight. The dwelling will then be ready for inspection in the showrooms. At the appointed time, they see a full-scale model of their dwelling. They walk about in it, test doors and windows, visit kitchen and bathroom, try the usefulness of rooms and cupboards. After suggesting a few alterations they decide to buy. The manufacturer transports the parts to the support structure where the dwelling is finally assembled in a short time. The local authorities connect gas, water, electricity and drainage to supplies under the approach gallery and the buyers can move into their new home." (Habraken, 1972, p. 70)

1.1. All design criteria established from 'Supports, An Alternative to Mass Housing'

This paragraph presents all the design criteria established from *Supports, An Alternative to Mass Housing*. All relevant quotes informing these criteria are compiled in **Appendix II**. The criteria are organized under four themes: Support, Support Dwellings, User participation, and Decision-making.

Support

- Support structures must allow for the independent assembly, alteration, and removal of dwellings.
- The more variety housing can assume in the support structure, the better.
- Support structures must be designed for maximum durability and longevity, ensuring they can adapt to unforeseen changes and continue to function effectively across generations, independent of the shorter lifespan of the dwellings they contain.
- The Support structure must have, as far as possible, the same section at any given point, and it must be as long as possible.

Support dwellings

- The infill must be independent from the Support.
- The infill must allow for the flexible placement of elements (e.g., sinks, windows, doors, storage) to accommodate the personal preferences and daily needs of the occupant
- The infill/Support dwelling industry should facilitate a wide range of customizable options across different price ranges, styles, and qualities, allowing individuals to tailor their dwellings to their personal budget and needs.
- The construction of infill/Support dwellings will be industrialized

User Participation

- Encourage user participation in designing and modifying their own living spaces to foster a sense of ownership and satisfaction.

Decision-Making

- Design control should be distributed among multiple stakeholders, allowing for user participation and decentralization to achieve more adaptable and user-centred outcomes, rather than relying solely on centralized authority.
- The construction of Support Structures should be funded and managed by the government or local authority, ensuring alignment with public infrastructure planning and treating them as an integral part of urban development, similar to roads and other essential services.

1.2. Critical analysis on the proposed design criteria

This paragraph critically evaluates all established design criteria. Design criteria approved for progression to the next phase of the literature research (Chapter 4) are marked with a checkmark. Criteria marked with a cross are either excluded or partially modified, with explanations provided in the accompanying text.

Example:

- ✓ Approved design criteria are marked with a checkmark.

- × Excluded design criteria are marked with a cross.

  The reason for exclusion is explained in the text, highlighted in italic.

- × Partially modified design criteria are also marked with a cross.

  The modifications are explained in the text, highlighted in italic.
- ✓ Improved design criteria that will progress to the next phase are marked with a checkmark.

1.2.1 Support

- × Support structures must allow for the independent assembly, alteration, and removal of dwellings.

  This criterion previously emphasized living spaces due to the use of the term 'dwellings.' To broaden its scope and include other potential functions, the term 'dwellings' has been replaced with 'infill.' The revised criterion now states:
- ✓ Support structures must allow for the independent assembly, alteration, and removal of the infill.

- ✓ The more variety housing can assume in the support structure, the better.

- ✓ Support structures must be designed for maximum durability and longevity, ensuring they can adapt to unforeseen changes and continue to function effectively across generations, independent of the shorter lifespan of the dwellings they contain.

- × The Support structure must have, as far as possible, the same section at any given point, and it must be as long as possible.

  This criterion focuses on a specific design solution -a uniform, extended structure- which restricts overall design flexibility and predetermines the outcome. For this reason, it will not be included in further research.

1.2.2. Support dwellings

- × The Support dwellings must be independent from the Support.

  This criterion essentially duplicates an earlier criterion under Support: "Support structures must allow for the independent assembly, alteration, and removal of the infill," but approaches it from the perspective of the Support dwelling. Since the Support is constructed first, fulfilling this requirement within the Support inherently provides an independent environment for the infill. Therefore, this design criterion will not be included in further research.

- ✓ The Support dwellings must allow for the flexible placement of elements (e.g., sinks, windows, doors, storage) to accommodate the personal preferences and daily needs of the occupant.

- × The Support dwelling industry should facilitate a wide range of customizable options across different price ranges, styles, and qualities, allowing individuals to tailor their dwellings to their personal budget and needs.

While this criterion is entirely valid within the broader framework of Open Building, it falls outside the scope of this research. The focus here is on the physical requirements for constructing a building according to Open Building principles, whereas this criterion relates to the Infill industry. As a result, this design criterion will not be included in further research.

1.2.3. User participation

- ✗ Encourage user participation in designing and modifying their own living spaces to foster a sense of ownership and satisfaction.

  While this criterion captures the essence of Open Building, it falls outside the scope of this research. The focus here is on the physical requirements for constructing a building according to Open Building principles, whereas this criterion emphasizes user involvement. For this reason, it will not be included in further research.

1.2.4. Decision-making

- ✗ Design control should be distributed among multiple stakeholders, allowing for user participation and decentralization to achieve more adaptable and user-centred outcomes, rather than relying solely on centralized authority.

  While this criterion is entirely valid within the broader framework of Open Building, it falls outside the scope of this research. The focus here is on the physical requirements for constructing a building according to Open Building principles, whereas this criterion addresses the distribution of authority within the construction industry. For this reason, it will not be included in further research.

- ✗ The construction of Support Structures should be funded and managed by the government or local authority, ensuring alignment with public infrastructure planning and treating them as an integral part of urban development, similar to roads and other essential services.

  While this criterion is entirely valid within the broader framework of Open Building, it falls outside the scope of this research. The focus here is on the physical requirements for constructing a building according to Open Building principles, whereas this criterion addresses government funding and management. For this reason, it will not be included in further research.

II. RESIDENTIAL OPEN BUILDING. (2000)

Residential Open Building by Stephen Kendall and Jonathan Teicher explores how Open Building design strategies can reshape residential architecture. By separating the enduring structural framework (support) from the adaptable interior elements (infill). The text underscores the importance of user engagement, decentralized decision-making, and sustainable design practices. Most of the direct quotes to establish the design criteria originate from Chapter 3, "History and Key Concepts," which lays out the theoretical underpinnings and historical background for the Open Building approach.

2.1. All design criteria established from 'Residential Open Building'

This paragraph presents the design criteria established from Residential Open Building. All relevant quotes informing these criteria are compiled in **Appendix III**. The criteria are organized under five themes: Support, Infill, Services, Environmental Levels and User-friendly process.

Support

- The Support allows for freedom within the adaptability of the space plan. (Capacity)
  - Each dwelling in a Support allows a variety of layouts.
  - The floor area of one dwelling can be altered by changing the boundaries of units within the base building.
  - The Support has enough capacity to adapt to varying functions, some of which may be non-residential in character.
- The Support contains all shared (common) building services, delivering them to the front door or party wall of each dwelling.
- The Support ensures compatibility with diverse infill solutions

Infill

- The infill can independently be assembled, altered or disassembled.
- The infill must meet the demands of a wide variety of individuals in an equally wide variety of base building types.
- The infill is compatible with the support structure.
- The façade is part of the adaptable infill.

Services

- The Service infrastructure (e.g. water, gas, electricity, drainage) creates maximized freedom within the adaptability of the space plan.
- The Service infrastructure (e.g. water, gas, electricity, drainage) is designed in such a way that each part can work independently and can be replaced.

Environmental levels

- Each environmental level should clearly define who is responsible and in control at that level.

User-friendly process

- Provide tools (e.g., software) that empower residents to make informed decisions.

2.2. Critical analysis on the proposed design criteria

This paragraph critically evaluates all established design criteria. Design criteria approved for progression to the next phase of the literature research (Chapter 4) are marked with a checkmark. Criteria marked with a cross are either excluded or partially modified, with explanations provided in the accompanying text.

2.2.1. Support

- ✓ The Support allows for freedom within the adaptability of the space plan. (Capacity)
- ✓ Each dwelling in a Support allows a variety of layouts.
- ✓ The floor area of one dwelling can be altered by changing the boundaries of units within the base building.
- ✓ The Support has enough capacity to adapt to varying functions, some of which may be non-residential in character.
- ✗ The Support contains all shared building services, delivering them to the front door or party wall of each dwelling.

  This criterion includes a predefined design solution by specifying 'delivering them to the front door or party wall of each dwelling,' which restricts overall design flexibility and prescribes the outcome. Therefore, this part of the criterion will be removed. The revised criterion now states:
- ✓ The Support contains all shared building services.
- ✓ The Support ensures compatibility with diverse infill solutions

2.2.2. Infill

- ✓ Infill can independently be assembled, altered or disassembled.
- ✗ The infill must meet the demands of a wide variety of individuals in an equally wide variety of base building types.

  While this criterion is entirely valid within the broader framework of Open Building, it falls outside the scope of this research. The focus here is on the physical requirements for constructing a building according to Open Building principles, whereas <u>this criterion addresses the market dynamics of the Infill</u>. For this reason, it will not be included in further research.
- ✓ The infill is compatible with the support structure.
- ✓ The façade is part of the adaptable infill.

2.2.3. Services

- ✓ The Service infrastructure (e.g. water, gas, electricity, drainage) creates maximized freedom within the adaptability of the space plan.
- ✓ The Service infrastructure (e.g. water, gas, electricity, drainage) is designed in such a way that each part can work independently and can be replaced.

2.2.4. Environmental levels

- ✗ Each environmental level should clearly define who is responsible and in control at that level.

  While this criterion is entirely valid within the broader framework of Open Building, it falls outside the scope of this research. The focus here is on the physical requirements *for constructing a building according to Open Building principles, whereas this criterion addresses the distribution of responsibility within the built environment. For this reason, it will not be included in further research.*

2.2.5. User-friendly process

- × Provide tools (e.g., software) that empower residents to make informed decisions.

  While this criterion is entirely valid within the broader framework of Open Building, it falls outside the scope of this research. The focus here is on the physical requirements for constructing a building according to Open Building principles, whereas this criterion addresses methods for involving residents in the design process. For this reason, it will not be included in further research.

III. OPENBUILDING.CO (2024)

The provided data from OpenBuilding.co represent design principles rather than criteria. Principles are overarching guidelines that define the general approach or values underlying a design, while criteria are specific, measurable requirements. In the first paragraph all the principles will be listed. In the second paragraph, the principles will be analysed and translated into measurable design criteria.

OpenBuilding.co. utilizes Stewart Brand's concept of shearing layers to connect specific design principles to corresponding building layers. This approach aligns closely with the principles of Open Building, which emphasizes separating environmental levels within the building process. Brand's six shearing layers are as follows (Brand, 1994):

- Site: The permanent aspect, representing the land on which the building is situated. ∞
- Structure: The building's structural frame. 30-300 years.
- Skin: The outer façade or enclosure. 20+ years.
- Systems: Building services, such as plumbing or wiring, updated as technology advances. 7-20 years.
- Space Plan: Internal layouts, partitions, and finishes, reconfigured over time to meet changing user requirements. 3-10 years.
- Stuff: The furnishings, equipment, and personal belongings. Under 3 years.

3.1. All design Principles established from 'OpenBuilding.co'

This paragraph presents the design principles established from OpenBuilding.co. under the heading '*Manifesto'* on their website. The criteria are organized under five themes: Site, Structure, Systems, Skin and Space plan.

Site

- Property rights
- Deed of division, maximize the amount of apartment rights
- Freedom of function assignment
- Centralised connection to utilities

Structure

- Infrastructure: robust, oversized
- Meets residential and non-residential requirements
- Vertical connections
- Partition walls disconnected of supports

Systems

- Demountable, separated from the support
- Flexible adjustable
- Maximised free layout of floors
- Raised floor systems
- Centralised cabinets (preferable on ground floor)
- Shared facilities

Skin

- Demountable
- Divisibility/adaptability:
    - Silhouette/double skin façade: great freedom of layout behind a uniform appearance of the façade
    - Collage: freedom of appearance per dwelling or a cluster of units
    - Grid: freedom of appearance in every façade infill

Space plan

- Demountable, flexible adjustable
- Property of inhabitant/user
- Phased investment
- Collective purchase
- Circular materials and systems
- Customized manufacturing

3.2. Critical analysis on the design principles

This paragraph critically evaluates all established design criteria. Design criteria approved for progression to the next phase of the literature research (Chapter 4) are marked with a checkmark. Criteria marked with a cross are either excluded or partially modified, with explanations provided in the accompanying text.

3.2.1. Site

- ✗ Property rights

  This principle is too vague to provide clear or actionable guidance. For this reason, it will not be included in further research.

- ✗ Deed of division, maximize the amount of apartment rights.

  While this principle is valid within the broader framework of Open Building, it falls outside the scope of this research. The focus here is on the physical requirements for constructing a building according to Open Building principles, whereas this principle adresses the management of the built environment. For this reason, it will not be included in further research.

- ✗ Freedom of function assignment

  This design principle suggests a potential direction for a design. It closely resembles an existing criterion outlined earlier in this document: "The Support has enough capacity to adapt to varying functions, some of which may be non-residential in character." A more precise revision of the principle into a design criterion is:
- ✓ The Support has enough freedom to adapt to varying functions.

- ✗ Centralised connection to utilities

  This principle presents a predefined design solution, which restricts overall design flexibility and predetermines the outcome. For this reason it will not be included in this research as a design criterion.

3.2.2. Structure

- ✗ Infrastructure: robust, oversized

  This principle already presents a predefined design solution by specifying "robust" and "oversized," which restricts design flexibility and predetermines the outcome. While this solution is likely to be incorporated into the final design, it should be rephrased to avoid prescribing a specific approach. The primary objective -creating maximum capacity- can be better captured with the following revised criterion:
- ✓ Infrastructure: offers maximum capacity.

- ✓ The structure meets residential and non-residential requirements

- ✗ Vertical connections

  This principle presents a predefined design solution, which restricts design flexibility and predetermines the outcome. For this reason it will not be included in this research as a design criterion.

- ✗ Partition walls disconnected of supports

  This principle presents a predefined design solution, which restricts design flexibility and predetermines the outcome. For this reason it will not be included in this research as a design criterion.

3.2.3. Systems

- ✗ Demountable, separated from the support

This principle provides a direction toward a possible criterion but lacks the specificity required to be a measurable design criterion. It closely aligns with an existing criterion in this document: "The Service infrastructure (e.g., water, gas, electricity, drainage) is designed in such a way that each part can work independently and can be replaced." A more precise revision of this principle, tailored to the "Systems" layer, is:

✓ The service infrastructure must be separated from the support so that it can be demounted without obstructing the support.

× Maximised free layout of floors

This principle suggests a direction for a potential criterion but lacks the precision needed to be a measurable design criterion. It closely aligns with an existing criterion in this document: "The Service infrastructure (e.g., water, gas, electricity, drainage) creates maximized freedom within the adaptability of the space plan." A refined version of this principle, tailored to the "Systems" layer, is:

✓ The service infrastructure is designed in such a way so that maximum freedom in the layout of floors is created.

× Flexible adjustable

This principle is too vague to function as a measurable design criterion. A more precise revision of this principle into a design criterion is:

✓ The service infrastructure has to be flexible and adjustable.

× Raised floor systems

This principle presents a predefined design solution, which restricts design flexibility and predetermines the outcome. For this reason it will not be included in this research as a design criterion.

× Centralised cabinets (preferable on ground floor)

This principle presents a predefined design solution, which restricts design flexibility and predetermines the outcome. For this reason it will not be included in this research as a design criterion.

× Shared facilities

This principle presents a predefined design solution, which restricts design flexibility and predetermines the outcome. For this reason it will not be included in this research as a design criterion.

3.2.4. Skin

× Demountable

This principle suggests a direction for a potential criterion but lacks the precision required to be a measurable design criterion. It closely aligns with an existing criterion in this document: "The façade can be part of the adaptable infill." A refined version of this principle, tailored to the "Skin" layer, is:

✓ The Façade is demountable

× Divisibility/adaptability:
  - × Silhouette/double skin façade: great freedom of layout behind a uniform appearance of the façade
  - × Collage: freedom of appearance per dwelling or a cluster of units
  - × Grid: freedom of appearance in every façade infill

These principles illustrate various strategies for addressing the façade in relation to Open Building. While they highlight the unique characteristics of each approach, they do not provide possible measurable design criteria for Open Building. For this reason these design principles will not be included in further research..

3.2.5. Space plan

- ✗ Demountable, flexible adjustable

  This principle suggests a direction for a potential criterion but lacks the specificity required to be a measurable design criterion. It closely aligns with an existing criterion in this document: "The Support dwellings must allow for the flexible placement of elements (e.g., sinks, windows, doors, storage) to accommodate the personal preferences and daily needs of the occupant." A more precise revision of this principle into a design criterion is:

- ✓ The space plan consists of demountable elements so that it is flexible and adjustable.

- ✗ Property of inhabitant/user

  While this principle is valid within the broader framework of Open Building, it falls outside the scope of this research. The focus here is on the physical requirements for constructing a building according to Open Building principles, whereas <u>this principle addresses ownership within the built environment</u>. For this reason, it will not be included in further research.

- ✗ Phased investment

  While this principle is valid within the broader framework of Open Building, it falls outside the scope of this research. The focus here is on the physical requirements for constructing a building according to Open Building principles, whereas <u>this principle addresses the economic aspects of Open Building</u>. For this reason, it will not be included in further research.

- ✗ Collective purchase

  While this principle is valid within the broader framework of Open Building, it falls outside the scope of this research. The focus here is on the physical requirements for constructing a building according to Open Building principles, whereas <u>this principle addresses the economic aspects of Open Building</u>. For this reason, it will not be included in further research.

- ✗ Circular materials and systems

  While this principle is valid within the broader framework of Open Building, it falls outside the scope of this research. The focus here is on the physical requirements for constructing a building according to Open Building principles, whereas <u>this principle addresses applying materials and systems that are part of a circular economy</u>. For this reason, it will not be included in further research.

- ✗ Customized manufacturing

  This principle suggests a direction for a potential criterion but lacks the specificity required to be a measurable design criterion. It closely aligns with an existing criterion in this document, such as: "The Support dwellings must allow for the flexible placement of elements (e.g., sinks, windows, doors, storage) to accommodate the personal preferences and daily needs of the occupant." A more precise revision of this principle into a design criterion is:

- ✓ The space plan can be customized to accommodate the personal preference and daily needs of the occupant.

IV. Determining the Final Set of Design Criteria

This final chapter integrates all the design criteria identified in earlier sections into a unified framework for Open Building. First, each criterion is sorted under one of three key themes: Support, Infill, or Service Infrastructure. "Support" combines what was previously labelled as Support, Structure, and Site; "Infill" gathers the criteria classified under Support Dwellings and Space Plan; and "Service Infrastructure" includes everything formerly grouped under Services and Systems.

After this sorting, each theme is reviewed to identify and merge overlapping or duplicated criteria. All similar design criteria are grouped together and placed between the designated lines, as shown in the example. Finally, a complete list of the final design criteria is presented, illustrating how Support, Infill, and Service Infrastructure work together in Open Building.

Example:

- Design criteria 1 from Supports, an alternative to Mass Housing
- Design criteria 2 from Supports, an alternative to Mass Housing
- Design criteria 1 from Residential Open Building

    - Design criteria 3 from Supports, an alternative to Mass Housing
    - Design criteria 1 from OpenBuilding.co

- Design criteria 2 from Residential Open Building
- Design criteria 2 from OpenBuilding.co

4.1. Support

4.1.1. Support (organized by resource)

Residential Open Building

- (1) The Support allows for freedom within the adaptability of the space plan. (Capacity)
    - (2) Each dwelling in a Support allows a variety of layouts.
    - (3) The floor area of one dwelling can be altered by changing the boundaries of units within the base building.
    - (4) The Support has enough capacity to adapt to varying functions, some of which may be non-residential in character.
- (5) The Support contains all shared building services.
- (6) The Support ensures compatibility with diverse infill solutions.

Supports, An Alternative to Mass Housing

- (7) Support structures must allow for the independent assembly, alteration, and removal of the infill.
- (8) The more variety housing can assume in the support structure, the better.
- (9) Support structures must be designed for maximum durability and longevity, ensuring they can adapt to unforeseen changes and continue to function effectively across generations, independent of the shorter lifespan of the dwellings they contain.

OpenBuilding.co

- (10) The Support has enough freedom to adapt to varying functions.
- (11) Infrastructure: offers maximum capacity.
- (12) The structure meets residential and non-residential requirements.

4.1.2. Support (organized by similar criteria)

- (1) The Support allows for freedom within the adaptability of the space plan. (Capacity)
- (9) Support structures must be designed for maximum durability and longevity, ensuring they can adapt to unforeseen changes and continue to function effectively across generations, independent of the shorter lifespan of the dwellings they contain.
- (11) Infrastructure: offers maximum capacity.

    - (2) Each dwelling in a Support allows a variety of layouts.

    - (3) The floor area of one dwelling can be altered by changing the boundaries of units within the base building.
    - (8) The more variety housing can assume in the support structure, the better.

    - (4) The Support has enough capacity to adapt to varying functions, some of which may be non-residential in character.
    - (10) The Support has enough freedom to adapt to varying functions.
    - (12) The structure meets residential and non-residential requirements.

- (5) The Support contains all shared building services.

- (6) The Support ensures compatibility with diverse infill solutions.

- (7) Support structures must allow for the independent assembly, alteration, and removal of the infill.

4.1.3. Support (final)

- (1,9,11) The Support provides sufficient capacity to accommodate adaptability of the space plan over a relatively long period of time.
    - (2) Each dwelling in a Support allows a variety of layouts.
    - (3,8) The Support must allow flexible reconfiguration of unit boundaries, enabling a variety of dwelling sizes.
    - (4,10,12) The Support must have enough capacity to accommodate varying functions, both residential and non-residential functions.
- (5) The Support contains all shared building services.
- (6) The Support ensures compatibility with diverse infill solutions.
- (7) The Support must allow for the independent assembly, alteration, and removal of the infill.

4.2. Infill

4.2.1. Infill (organized by resource)

Residential Open Building

- (1) The Infill can independently be assembled, altered or disassembled.
- (2) The infill is compatible with the support structure.
- (3) The façade is part of the adaptable infill.

Supports, dwellings Supports, An Alternative to Mass Housing

- (4) The Support dwellings must allow for the flexible placement of elements (e.g., sinks, windows, doors, storage) to accommodate the personal preferences and daily needs of the occupant.

OpenBuilding.co

- (5) The space plan consists of demountable elements so that it is flexible and adjustable.
- (6) The space plan can be customized to accommodate the personal preference and daily needs of the occupant.
- (7) The façade is demountable.

4.2.2. Infill (organized by similar criteria)

- (2) The infill is compatible with the support structure.

- (1) The Infill can independently be assembled, altered or disassembled.
- (4) The Support dwellings must allow for the flexible placement of elements (e.g., sinks, windows, doors, storage) to accommodate the personal preferences and daily needs of the occupant.
- (5) The space plan consists of demountable elements so that it is flexible and adjustable.
- (6) The space plan can be customized to accommodate the personal preference and daily needs of the occupant.

- (3) The façade is part of the adaptable infill.
- (7) The façade is demountable.

4.2.3. Infill (final)

- (2) The infill is compatible with the support structure.
- (1,4,5,6) The Infill can independently be assembled, adjusted or disassembled, allowing for flexible placement of elements (e.g., sinks, windows, doors, storage) to accommodate each occupant's personal preferences and daily needs.
- (3,7) The façade is part of the adaptable infill.

4.3. Service infrastructure

4.3.1. Service infrastructure (organized by resource)

Residential Open Building

- (1) The Service infrastructure (e.g. water, gas, electricity, drainage) creates maximized freedom within the adaptability of the space plan.
- (2) The Service infrastructure (e.g. water, gas, electricity, drainage) is designed in such a way that each part can work independently and can be replaced.

OpenBuilding.co

- (3) The service infrastructure must be separated from the support so that it can be demounted without obstructing the support.
- (4) The service infrastructure is designed in such a way so that maximum freedom in the layout of floors is created.
- (5) The service infrastructure has to be flexible and adjustable.

4.3.2. Service infrastructure (organized by similar criteria)

- (1) The Service infrastructure (e.g. water, gas, electricity, drainage) creates maximized freedom within the adaptability of the space plan.
- (4) The service infrastructure is designed in such a way so that maximum freedom in the layout of floors is created.
- (5) The service infrastructure has to be flexible and adjustable.

- (2) The Service infrastructure (e.g. water, gas, electricity, drainage) is designed in such a way that each part can work independently and can be replaced.
- (3) The service infrastructure must be separated from the support so that it can be demounted without obstructing the support.

4.3.3. Service infrastructure (final)

- (1,4,5) The Service infrastructure (e.g. water, gas, electricity, drainage) creates maximized freedom within the adaptability of the space plan.
- (2,3) The Service infrastructure (e.g. water, gas, electricity, drainage) is designed in such a way that each part can work independently and can be replaced.

V. FINAL SET OF DESIGN CRITERIA FOR OPEN BUILDING

This final chapter brings together the findings of the research, presenting the final set of design criteria for Open Building. The criteria are categorized into three main themes: Support, Infill, and Service Infrastructure. These themes collectively address the physical requirements for constructing buildings that adhere to Open Building principles. By synthesizing insights from key sources and critically analysing the proposed criteria, this chapter marks the conclusion of the literature phase of the research. Together, the design criteria form a framework for the next phase of research, which involves analysing case studies on applied design strategies trying to fulfil these design criteria.

Support

1. The Support provides sufficient capacity to accommodate adaptability of the space plan over a relatively long period of time.
    a. Each dwelling in a Support allows a variety of layouts.
    b. The Support must allow flexible reconfiguration of unit boundaries, enabling a variety of dwelling sizes.
    c. The Support must have enough capacity to accommodate varying functions, both residential and non-residential function.
2. The Support contains all shared building services.
3. The Support ensures compatibility with diverse infill solutions.
4. The Support must allow for the independent assembly, alteration, and removal of the infill.

Infill

5. The infill is compatible with the support structure.
6. The Infill can independently be assembled, adjusted or disassembled, allowing for flexible placement of elements (e.g., sinks, windows, doors, storage) to accommodate each occupant's personal preferences and daily needs.
7. The façade is part of the adaptable infill.

Service infrastructure

8. The Service infrastructure (e.g. water, gas, electricity, drainage) creates maximized freedom within the adaptability of the space plan.
9. The Service infrastructure (e.g. water, gas, electricity, drainage) is designed in such a way that each part can work independently and can be replaced.

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APPENDIX II

QUOTES FROM *SUPPORT: AN ALTERNATIVE TO MASS HOUSING* SUPPORTING THE ESTABLISHED DESIGN CRITERIA

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ABSTRACT

The design criteria outlined in this Appendix have been derived from 'Supports: an alternative to Mass Housing' written by John Habraken in 1961 and later translated to English in 1972. These criteria are organized under four themes: Support, Support Dwellings, User Participation, and Decision-Making. Each theme is followed by the corresponding design criteria, which are then supported by the quotes from the literature that informed their development.

I. SUPPORT

Support structures must allow for the independent assembly, alteration, and removal of dwellings.

"*We must make constructions which are not in themselves dwellings or even buildings, but are capable of lifting dwellings above the ground; constructions which contain individual dwellings as a bookcase contains books which can be removed and replaced separately; constructions which take over the task of the ground, which provide building sites up in the air, and are permanent like streets. Without for the moment considering their appearance, I would name these constructions support structures, after their function. Every construction, therefore, enabling us to build independent dwellings which do not stand on the ground, is a support structure. I propose this definition: A support structure is a construction which allows the provision of dwellings which can be built, altered and taken down, independently of the others*." (Habraken, 1972, p. 69)

"*I proposed a new role for professionals: the design of 'SUPPORTS,' buildings in which users would find space to control the layout of their own dwelling units (the INFILL). To my thinking, SUPPORT design was design of everything the inhabitants in a large housing project share: a load bearing structure, architectural identification of the whole, shared utility systems, as well as the spaces for circulation and social events.*" (Habraken, 1972, p. 5)

The more variety housing can assume in the support structure, the better.

"*A support structure is quite a different matter from the skeleton construction of a large building, although to the superficial viewer there may appear to be similarities. The skeleton is entirely tied to the single project of which it forms part. It can be realised only when the new building, and all that is connected with it, has been worked out in detail. A support structure, on the other hand, is built in the knowledge that we cannot predict what is going to happen to it. The more variety housing can assume in the support structure, the better. It is therefore not an uncompleted building, but in itself a wholly complete one.*" (Habraken, 1972, p. 71)

Support structures must be designed for maximum durability and longevity, ensuring they can adapt to unforeseen changes and continue to function effectively across generations, independent of the shorter lifespan of the dwellings they contain.

"*Although in designing a support structure we certainly have to keep in mind what is to happen there, its design and building are quite different from those of the dwellings. Similarly, street layout differs from the construction of the buildings alongside it, although there is the strongest connection between the two. As the future content of the support structure can be known only in very general terms, its form and construction must be of the utmost simplicity; all the more so because it is to be constructed on the site. In contrast to the dwellings, it should not have the complicated detailing, nor the precise finish, nor the short-term existence of the factory product. It is brute construction, of the same order as bridges, viaducts, canals or roads: works which have a close connection with the earth and are erected relatively slowly and with difficulty, in all weather conditions. Works, also, which withstand the centuries: the more robust, the more they repay the trouble of their construction*." (Habraken, 1972, p. 71-72)

"*…it would be sensible to plan support structures for as long a life as possible. In contrast to the dwellings they contain, they should withstand the ages. Their age should be no drawback to the development of the support-dwelling technique, for their forms are intended to allow for the unexpected*." (Habraken, 1972, p. 77)

The Support structure must have, as far as possible, the same section at any given point, and it must be as long as possible.

- "*When we apply this method to the building of support structures, the manner in which the groups are composed will of course depend upon the exact nature of the structure. If, for example, it is of reinforced concrete placed in situ, it will be totally different from working in steel framing. But whatever the chosen construction there are two general conditions which must be fulfilled: the support structure must have, as far as possible, the same section at any given point, and it must be as long as possible.*
  The first requirement means that all vertical circulation should preferably be on the outside of the structure. The second suggests that support structures will produce long ribbon-like forms. Both conditions are entirely in accord with the nature of support-structure living, for if we try to achieve the greatest freedom of use, staircases and elevator shafts would be obstacles when placed inside the structure. Similarly, there is no reason to make these structures short: the longer the floors, the easier it will be to partition them into different 'building plots.'
  From this we can form a picture of support-structure ribbons stretching across the land in certain patterns, and flanked by towers containing stairs, lifts, drainage and services connected by walkways on the several floors. When we consider the urban design aspects of support structures we will have an opportunity to look more closely into this image. For the moment, we are concerned with the fact that a rational construction method evidently suits the support-structure idea." (Habraken, 1972, p. 78)

II. Support dwellings

The Support dwellings must be independent from the Support.

"*To allow the development of natural relationships in the urban situation we must, as we saw before, regard each dwelling as independent.*" (Habraken, 1972, p. 69)

"*We must make constructions which are not in themselves dwellings or even buildings, but are capable of lifting dwellings above the ground; constructions which contain individual dwellings as a bookcase contains books which can be removed and replaced separately… …A support structure is a construction which allows the provision of dwellings which can be built, altered and taken down, independently of the others.*" (Habraken, 1972, p. 69)

The Support dwellings must allow for the flexible placement of elements (e.g., sinks, windows, doors, storage) to accommodate the personal preferences and daily needs of the occupant

"*Every housewife wants her sink, stove, refrigerator, cupboards and shelves in a different place from her neighbour, although in all these variations a similar pattern may be discerned. A similar differentiation will always occur in the dwelling, even though every country, every generation, will demonstrate a certain unity. The variety which becomes available and which is of incalculable value to society will show itself especially in minor matters. The instinctive idiosyncrasies of the average person are, in this respect, of far greater importance than the deliberate originality of an individual. The richness of daily life shows itself, after all, in the adaptation of innumerable trifles to personal existence: the placing of a certain window or door, a light switch or storage space, the combination of different spaces or the privacy of a separate room. All these relatively unimportant matters, without which a man would doubtless continue to live, are yet, as we saw, of great consequence. It was because of this that it became necessary to oppose MH, the indifference of which brushed these matters aside.*" (Habraken, 1972, p. 75)

The Support dwelling industry should facilitate a wide range of customizable options across different price ranges, styles, and qualities, allowing individuals to tailor their dwellings to their personal budget and needs.

"*All these groups will have different price ranges, and therefore differ in quality, finish and design. Within each group an infinite variety of combinations is possible. An industry will therefore arise which will market various groups of elements competitively. The trade names of these groups will attain a conceptual power comparable to those of automobiles: concepts which will denote a certain style or quality, efficiency or detailing*." (Habraken, 1972, p. 73-74)

"*The most important thing in this respect is that support dwellings offer an endless range of possibilities. Housing will have its Cadillac as well as its Volkswagen, its Bentley and its deux-chevaux. But there is one most important difference: a dwelling is no automobile and no dwelling need be the same as any other. The automobile allows us to perform a single act: we move from place to place. But a dwelling contains at least one whole life.*" (Habraken, 1972, p. 75)

III. USER PARTICIPATION

Encourage user participation in designing and modifying their own living spaces to foster a sense of ownership and satisfaction.

> *"When searching for the essence of an important aspect of our civilisation we should not only consider what is being done, but above all who does it, and why. In a sense it is, as will appear, much more important to understand how a dwelling comes about than what it looks like. MH takes away a man's act and presents him with a form; it seeks to provide a comfortable form to be used by people who do not have to lift a finger to influence it. Does this not place MH, however skilful it may be, beyond our civilisation? Following this line of thought, it is therefore justified to direct attention to the initiative and activities of the individual. In order to regain control over our housing we must rediscover what has been lost through a long preoccupation with MH, and regard it with a fresh eye."* (Habraken, 1972, p. 21-22)
>
> "*Now, possession is different from property. We may possess something which is not our property, and conversely something may be our property which we do not possess. Property is a legal term, but the idea of possession is deeply rooted in us. In the light of our subject, it is therefore important to realise that possession is inextricably connected with action. To possess something we have to take possession. We have to make it part of ourselves, and it is therefore necessary to reach out for it. To possess something we have to take it in our hand, touch it, test it, put our stamp on it. Something becomes our possession because we make a sign on it, because we give it our name, or defile it, because it shows traces of our existence.*" (Habraken, 1972, p. 22)

IV. DECISION-MAKING

Design control should be distributed among multiple stakeholders, allowing for user participation and decentralization to achieve more adaptable and user-centered outcomes, rather than relying solely on centralized authority.

"*The distribution of design control in a single project is in conflict with the Modernist ideology which believes that fully centralized control is a necessary condition for good architecture and efficient construction."* (Habraken, 1972, p. 6)

The construction of Support Structures should be funded and managed by the government or local authority, ensuring alignment with public infrastructure planning and treating them as an integral part of urban development, similar to roads and other essential services.

- "*At this point we might ask who will be responsible for the building of support structures. It seems obvious to me that this work should be an integral part of all preparatory operations required for the realisation of new neighborhoods. Decisions about road patterns, drainage and public services will depend on what is known about the particular support structures they serve, and where they are positioned. Gas, water, electricity and drainage conduits will have to be carried into the structures to enable connections with single dwellings to be made. While, therefore, the provision of support dwellings can remain in private hands, support structures themselves should be part of government or local authority investment; necessary, like roads and services, for the growth of neighbourhoods or cities. After all, support structures are building ground, and since the preparatory 'cultivation' of the earth's surface for building development is a public undertaking, building ground up in the air forms art of such an enterprise.*" (Habraken, 1972, p. 79)

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1. Habraken, N. J. (1972). Supports: An Alternative to Mass Housing. Architectural Press.

APPENDIX III

QUOTES FROM *RESIDENTIAL OPEN BUILDING* SUPPORTING THE ESTABLISHED DESIGN CRITERIA

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ABSTRACT

The design criteria outlined in this Appendix have been derived from 'Residential Open Building' written by Stephen Kendall and Jonathan Teicher and published in 2000. These criteria are organized under five themes: Support, Infill, Services, Environmental levels, User-friendly process. Each theme is followed by the corresponding design criteria, which are then supported by the quotes from the literature that informed their development.

I. SUPPORT

The Support allows for freedom within the adaptability of the space plan. (Capacity)

"*Capacity analysis is a complex and demanding practice at the core of Open Building. It is founded on two ideas: designing form to be an open-ended and dynamic fabric, and designing space or form with built-in capacity to accommodate more than one 'program of functions' over time.*

- *Each dwelling in a Support allows a variety of layouts.*
- *The floor area of one dwelling can be altered by changing the boundaries of units within the base building.*
- *The Support has enough capacity to adapt to varying functions, some of which may be non-residential in character."*

(Kendall & Teicher, 2000, p. 48)

"*Design of the Support ideally incorporates capacity according to three principles: First, each dwelling in a Support must allow a variety of layouts. Second, it must be possible to alter the floor area by changing the boundaries of units within the base building or expanding it. Third, the Support or its parts must be adaptable to varying functions, some of which may be non-residential in character."* (Kendall & Teicher, 2000, p. 49)

The Support contains all shared (common) building services, delivering them to the front door or party wall of each dwelling.

"*Supports contain all shared (common) building services, delivering them to the front door or party wall of each occupant. Supports can be constructed in any durable materials, incorporating any technical systems*." (Kendall & Teicher, 2000, p. 43)

The Support ensures compatibility with diverse infill solutions

"*Supports must be designed without knowing which particular infill products or systems will be employed, just as infill systems must be developed without knowing where they will be installed.*" (Kendall & Teicher, 2000, p. 49)

II. Infill

The infill can independently be assembled, altered or disassembled.

"*The Support is intended to accommodate and outlast infill changes, to persist largely independent of the individual occupants' choices, while accommodating changing life circumstances*." (Kendall & Teicher, 2000, p. 43)

The infill must meet the demands of a wide variety of individuals in an equally wide variety of base building types.

"*A residential infill system is similar in concept to a commercial office fit-out, but more complex. It is more densely packed with mechanical and other supply systems. As a consumer product, it must meet the demands of a wide variety of individuals in an equally wide variety of base building types*." (Kendall & Teicher, 2000, p. 45)

The infill is compatible with the support structure.

"*Supports must be designed without knowing which particular infill products or systems will be employed, just as infill systems must be developed without knowing where they will be installed. Nonetheless, the form need not be neutral to optimize useful capacity*." (Kendall & Teicher, 2000, p. 49)

The façade is part of the infill and can be adapted.

"*Households in OB projects frequently exercise control when creating or changing their dwelling floor plans, and perhaps their units' facades.*" (Kendall & Teicher, 2000, p. 54)

III. SERVICES

The Service infrastructure (e.g. creates maximized freedom within the adaptability of the space plan.

> "*Locating building structure and common mechanical systems infrastructure (building-level cabling, ducts, main supply and drainage piping, and so on) so as to maximize freedom in designing the infill level, while rationalizing connectivity of mechanical systems between base building and fit-out.*" (Kendall & Teicher, 2000, p. 57)

The Services are designed in such a way that each part can work independently and can be replaced.

> "*Coordinating subsystems for eventual change, thereby allowing them to be independently adjusted or replaced without disrupting other dwellings or subsystems*." (Kendall & Teicher, 2000, p. 57)

IV. ENVIRONMENTAL LEVELS

Each environmental level should clearly define who is responsible and in control at that level.

> "*Distributing control for each environmental level to decision-makers on that level. Establishing legal, contractual and physical frameworks in which the individual household may design or alter their dwelling unit layout, and determine equipment within their own dwelling. Clearly distinguishing collective and individual realms of decision-making, and separating decisions about common spaces and infrastructure from decisions concerning individual dwellings*." (Kendall & Teicher, 2000, p. 56)

V. USER-FRIENDLY PROCESS

Provide tools (e.g., software) that empower residents to make informed decisions.

> "*Providing tools that immediately show dwellers the implications of their design decisions. For example, utilizing software that illustrates the effect of each appliance, system or finish selection on the final installation price of an infill package."* (Kendall & Teicher, 2000, p. 57)

References

1. Kendall, S., & Teicher, J. (2000). Residential Open Building. E & FN Spon.

APPENDIX IV

SELECTION OF OPEN BUILDING CASE STUDIES

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ABSTRACT

This appendix explores then selection of case studies. The research identifies projects that demonstrate the separation principles of Open Building. Case studies were chosen based on three key criteria: the availability of detailed documentation, apparent adherence to Open Building principles, and diversity in construction year, design solutions, and architectural perspective.

The selected case studies,Superlofts by MKA (2015), Patch22 by Tom Frantzen (2016), and NEXT21 by Yositika Utida (1994), offer a comprehensive perspective on the practical implementation of Open Building strategies.

INTRODUCTION

Since the introduction of the Open Building concept, architects and researchers have experimented with its principles. Over the decades, a growing number of projects worldwide have embodied aspects of Open Building, offering insights into how this adaptive approach can be realized in practice. This appendix provides a structured overview of those projects and details the criteria used to select five specific case studies for further analysis.

Chapter 1 gathers and lists all the potential Open Building case studies identified from various sources. Chapter 2 combines these findings into a single comprehensive list. Duplicates are removed, and the resulting projects are then sorted by the year they were built. Chapter 3 explains the rationale behind selecting the projects for further analysis. And also introduces the selected case studies.

I. ALL CASE STUDIES PER SOURCE

1.1. OpenBuilding.co

1. Blackjack - BNB Architects (2015)
2. CiWoCo - GAAGA (2019)
3. De Hoofden - Various architects (2016)
4. Fenix 1 - Mei Architects and Planners (2019)
5. Frame - van Dongen-Koschuch (2018)
6. Canalhouses Amsterdam – (17th century)
7. Het Bosbad – GAAGA (2022)
8. Het Schetsblok - ANA Architecten (2018)
9. Holenkwartier – MKA (future)
10. Juf Nienke – SeARCH (2013)
11. Object One - Space&Matter (2017)
12. Mama One – MKA (future)
13. Patch 22 - Tom Frantzen (2016)
14. Schiecentrale 4B - MEI Architects and Planners (2008)
15. Silodam – MVRDV (2002)
16. Stories - Olaf Gipser Architects (2021)
17. Superlofts – MKA (2015)
18. TOPUP - Frantzen et al (2020)
19. New West - Olaf Gipser (2020)

1.2. Councilofopenbuilding.com

20. TOPUP - Frantzen et al (2020)
21. Molenvliet – Frans van der Werf (1977)
22. Tila – Pia Ilonen (2018)
23. Arabianranta - Kahri and Co (1990-2000)
24. Next 21 - Yositika Utida (1994)

1.3. Residential Open Building

25. Neuwil - Metron Architect Group (1966)
26. Maison Médicale Student Housing 'La Mémé' - Lucien Kroll (1974)
27. Dwelling of Tomorrow, Hollabrunn - Dirisamer, Kuzmich, Uhl, Voss, and Weber (1976)
28. Beverwaard Urban District - (1977)
29. Sterrenburg III - (1977)
30. Papendrecht - (1977)
31. PSSHAK/Adelaide Road - London GLC (Hamdi, Wilkinson) (1979)
32. Hasselderveld - Bert Wauben (1979)
33. Estate Tsurumaki/Town Estate Tsurumaki - HUDc (1983)
34. Keyenburg - (1984)
35. Free Plan Rental - (1985)
36. Support Housing, Wuxi - Bao (1987)
37. Senri Inokodani - Ichiura Architects (1989)
38. Patrimoniums Woningen/Voorburg - RPHS Architects (1990)
39. 'Davidsboden' Apartments - Erny, Gramelsbacher and Schneider (1991)
40. Green Village Utsugidai - (1993)
41. Banner Building - (1994)
42. Next21 - (1994)
43. Pipe-Stairwell Adaptable Housing - (1994)
44. VVO/Laivalahdenkaari - Oy Kahri Architects (1995)
45. Gespleten Hendrik Noord - (1996)
46. Tsukuba Two Step Housing - (1996)

47. Hyogo Century Housing Project - Hyogo Prefecture Housing Authority + Ichiura Architects (1997)
48. Yoshida Next Generation Project - (1998)
49. The Pelgromhof - (1998)
50. HUDc KSI 98 Demonstration Project - (1998)

1.4. Residential Architecture as infrastructure, Open Building in practice

Netherlands

51. Multifunk – ANA Architects (2004)
52. Schiecentrale 4b – Mei Architects & planners (2008)
53. Solids – Baumschlager Eberle Architekten and Inbo Architecten (2011)
54. Superlofts – MKA (2016)
55. Patch22 – Frantzen et al. (2016)
56. Blackjack – BNB Architects and BO6 Architects (2015)
57. Schoonschip – Space&Matter (2020)
58. Smartlofts – Space&Matter (2016)
59. Schetsblok – ANA Architects (2018)
60. CiWoCo – GAAGA (2019)
61. TopUp – Frantzen et al. (2019)
62. Stories – Olaf Gipser (2021)

Finland

63. Arabianranta – Kahri and co (2005)
64. Tila – Pia Ilonen and Sami Vikström (2009)
65. Harkko – Pia Ilonen and Anu Tahvanainen (2019)
66. Aikalisä housing – Ulpu Tiuri and Jukka Lommi (2015)

Russia

67. Tverskoy project – Captial Group (2010)

Global South

68. The Cohuatlán housing project – Jorge Andrade and Andrea Martín Chávez (1978)
69. The Xacalli complex – Jorge Andrade and Andrea Martín Chávez (1998)
70. Chile’s Elemental and the “Half a house” experiment – Aravena (2004)
71. Fidalga Building – Andrade Morttin Arquitetos Associados (2011)
72. Pop Madalena Building – Morttin Arquitetos Associados (2015)
73. Simpatia Street Housing – Alvaro Puntoni (2011)
74. The residences at the Future Africa Campus in Pretoria - Earthworld Architects (2018)
75. Urban Think Tank’s Empower Shack in SA – Alfredo Brillembourgh (2013-)

II. ALL CASE STUDIES SORTED BY TIME

1960s
Neuwil - Metron Architect Group (1966)

1970s
Maison Médicale Student Housing 'La Mémé' - Lucien Kroll (1974)
Dwelling of Tomorrow, Hollabrunn - Dirisamer, Kuzmich, Uhl, Voss, and Weber (1976)
Beverwaard Urban District (1977)
Sterrenburg III (1977)
Papendrecht (1977)
Molenvliet – Frans van der Werf (1977)
PSSHAK/Adelaide Road - London GLC (Hamdi, Wilkinson) (1979)
Hasselderveld - Bert Wauben (1979)
The Cohuatlán Housing Project – Jorge Andrade and Andrea Martín Chávez (1978)

1980s
Estate Tsurumaki/Town Estate Tsurumaki - HUDc + Kan Sogo Design Office (1983)
Keyenburg (1984)
Free Plan Rental (1985)
Support Housing, Wuxi - Bao (1987)
Senri Inokodani - Ichiura Architects (1989)

1990s
Patrimoniums Woningen/Voorburg - RPHS Architects (1990)
'Davidsboden' Apartments - Erny, Gramelsbacher and Schneider (1991)
Green Village Utsugidai (1993)
Next21 - Yositika Utida (1994)
Pipe-Stairwell Adaptable Housing (1994)
VVO/Laivalahdenkaari - Oy Kahri Architects (1995)
Gespleten Hendrik Noord (1996)
Tsukuba Two Step Housing (1996)
Hyogo Century Housing Project - Hyogo Prefecture Housing Authority (1997)
The Pelgromhof (1998)
HUDc KSI 98 Demonstration Project (1998)
The Xacalli Complex – Jorge Andrade and Andrea Martín Chávez (1998)
Arabianranta - Kahri and Co (1990–2000)

2000s
Silodam - MVRDV (2002)
Multifunk – ANA Architects (2004)
Chile's Elemental 'Half a House' Experiment – Aravena (2004)
Arabianranta – Kahri and Co (2005)
Schiecentrale 4B - Mei Architects and Planners (2008)
Tila – Pia Ilonen and Sami Vikström (2009)

2010s
Solids – Baumschlager Eberle Architekten and Inbo Architecten (2011)
Fidalga Building - Andrade Morttin Arquitetos Associados (2011)
Simpatia Street Housing - Alvaro Puntoni (2011)
Juf Nienke - SeARCH (2013)
Urban Think Tank's Empower Shack - Alfredo Brillembourgh (2013–)
Blackjack - BNB Architects and BO6 Architects (2015)
Superlofts - MKA (2015)
Smartlofts - Space&Matter (2016)

Patch 22 - Tom Frantzen (2016)
Object One - Space&Matter (2017)
Het Schetsblok - ANA Architecten (2018)
Frame - van Dongen-Koschuch (2018)
Tila - Pia Ilonen (2018)
Harkko - Pia Ilonen and Anu Tahvanainen (2019)
CiWoCo - GAAGA (2019)
Fenix 1 - Mei Architects and Planners (2019)
TOPUP - Frantzen et al (2020)

2020s
Schoonschip – Space&Matter (2020)
New West - Olaf Gipser (2020)
Stories - Olaf Gipser Architects (2021)
LAB 42 - Benthem en Crouwel (2022)
The Natural Pavilion - DP6 (2022)
Het Bosbad - GAAGA (2022)

Future Projects
Holenkwartier - MKA (future)
Mama One - MKA (future)

III. CHOOSING CASE STUDIES FOR THE OPEN BUILDING ANALYSIS

The selection of case studies for this research were chosen based on the availability of detailed documentation, their apparent adherence to Open Building principles and the diversity of projects. This aims on evaluating how Open Building principles are implemented in diverse contexts.

1. Availability of Information
   A key consideration was the quantity and quality of information available about each project. This included textual resources, such as architectural descriptions, technical analyses, and academic studies, as well as visual documentation, such as drawings, diagrams, and photographs. Projects with comprehensive and accessible documentation were prioritised, as these enable a more thorough and reliable evaluation against the design criteria.

2. Apparent adherence to Open Building principles
   Projects were selected based on their alignment with the fundamental principles of Open Building, such as the separation of Support and Infill, adaptability over time, and user-centred design. Only projects that visibly integrated at least one of these concepts into their design, were chosen for the case study analysis, ensuring relevance to the research focus.

3. Diversity of Projects
   To achieve this, projects with significant overlaps in methods or outcomes were avoided. For example, two projects employing highly similar structural systems or service infrastructure strategies were not included simultaneously. Diversity was sought in the following aspects: Year of Construction, Design Solutions and Architectural Perspective.

Chosen case studies for this analysis
Superlofts - MKA (2015)
Patch 22 - Tom Frantzen (2016)
Next21 - Yositika Utida (1994)

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APPENDIX V
Case Studie Analaysis

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Introduction

This appendix provides an analysis of the three case studies, this includes detailed textual and visual explanations per design criterion.

Analysed case-studies
Patch22 - Tom Frantzen (2016)
Superlofts - MKA (2015)
Next 21 - Yositika Utida (1994)

To avoid repeating words, the design criteria will be assigned with numbers, which will be used from this point onward to refer to each specific criterion.

Support

- **DC1**: The support provides sufficient capacity to accommodate adaptability of the space plan over a relatively long period of time.
- **DC1A**: Each dwelling in a Support allows a variety of layouts.
- **DC1B**: The Support must allow flexible reconfiguration of unit boundaries, enabling a variety of dwelling sizes.
- **DC1C**: The Support must have enough capacity to accommodate varying functions, both residential and non-residential functions.
- **DC2**: The Support contains all shared building services.
- **DC3**: The Support ensures compatibility with diverse infill solutions.
- **DC4**: The Support must allow for the independent assembly, alteration, and removal of the infill.

Infill

- **DC5**: The infill is compatible with the support structure.
- **DC6**: The Infill can independently be assembled, adjusted or disassembled, allowing for flexible placement of elements (e.g., sinks, windows, doors, storage) to accommodate each occupant's personal preferences and daily needs.
- **DC7**: The façade is part of the adaptable infill.

Service infrastructure

- **DC8**: The Service infrastructure creates maximized freedom within the adaptability of the space plan.
- **DC9**: The Service infrastructure is designed in such a way that each part can work independently and can be replaced.

Note on design criteria
Not all 'Infill' design criteria apply to this research. Open Building distinguishes the base building, which provides structure and shared services, from the infill, which addresses individual household needs. Design Criteria 5 and 6, focused on infill, are excluded as this study centres on base buildings. However, Criterion 7, while related to infill, impacts the base building's design and is included.

2D4D9B Infill (elements)

e30613 Support (elements)

1. **Patch22** - Frantzen et. al

DC 1A

Patch22 meets Design Criterion 1a by enabling a variety of dwelling layouts through multiple design strategies:

1. **Slimline Floor system** with prefabricated structural elements and hollow cavities meant for the service infrastructure. The separation of service infrastructure from structural support results in the possibility for future reconfiguration of this service infrastructure. Wet areas can be positioned anywhere within the unit, allowing complete flexibility in floor plan design. (More about this under DC4 and DC8)

2. **Column-and-beam structure** with a stable core providing open floor plans, vertical circulation, and horizontal stability (More about this under DC1C)

3. **Centralized shared building services** within the core, with horizontal distribution to individual units. (More about this under DC2)

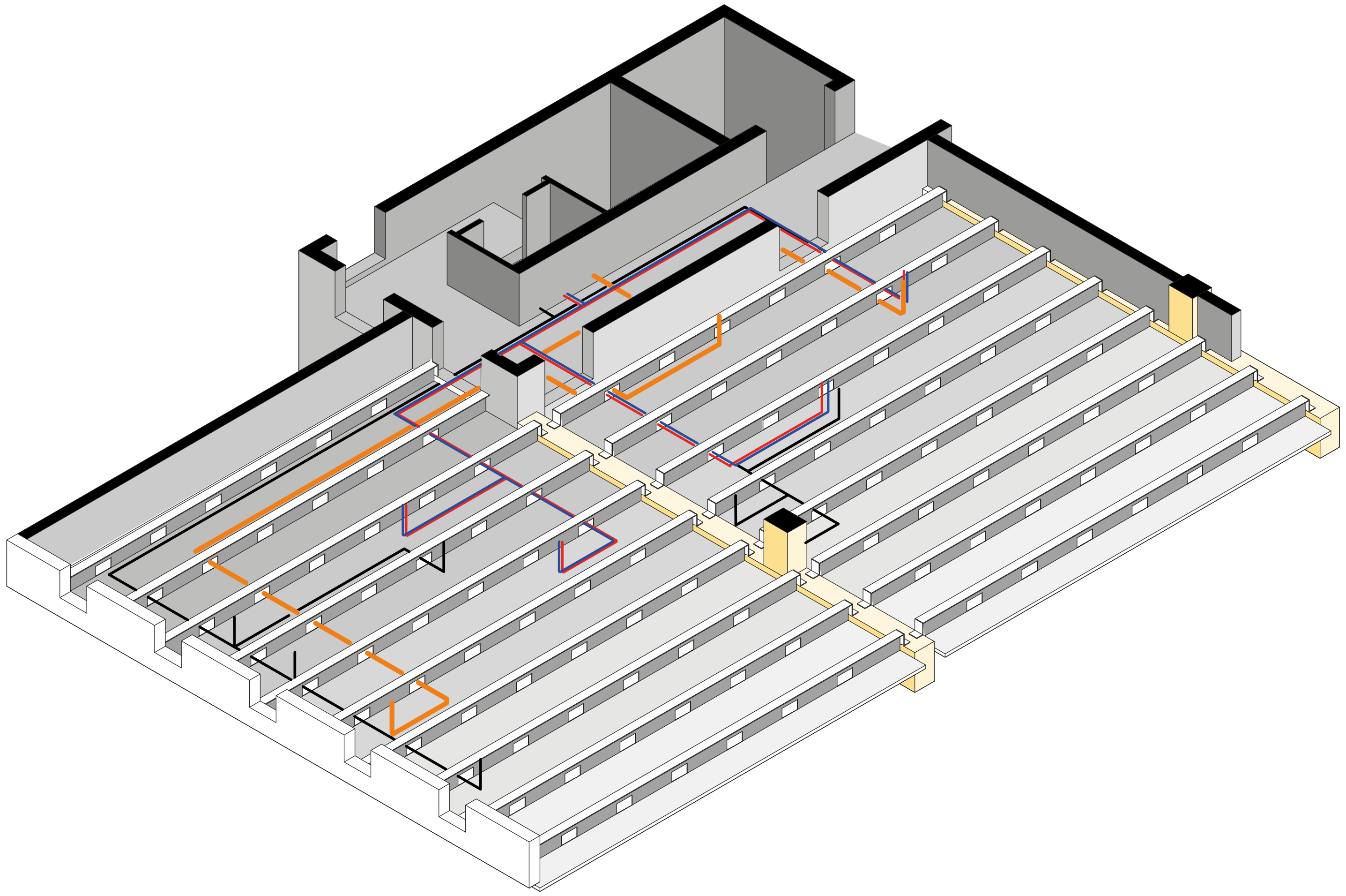


Figure 1. Service Infrastructure within the Slimline floor system. (own work)

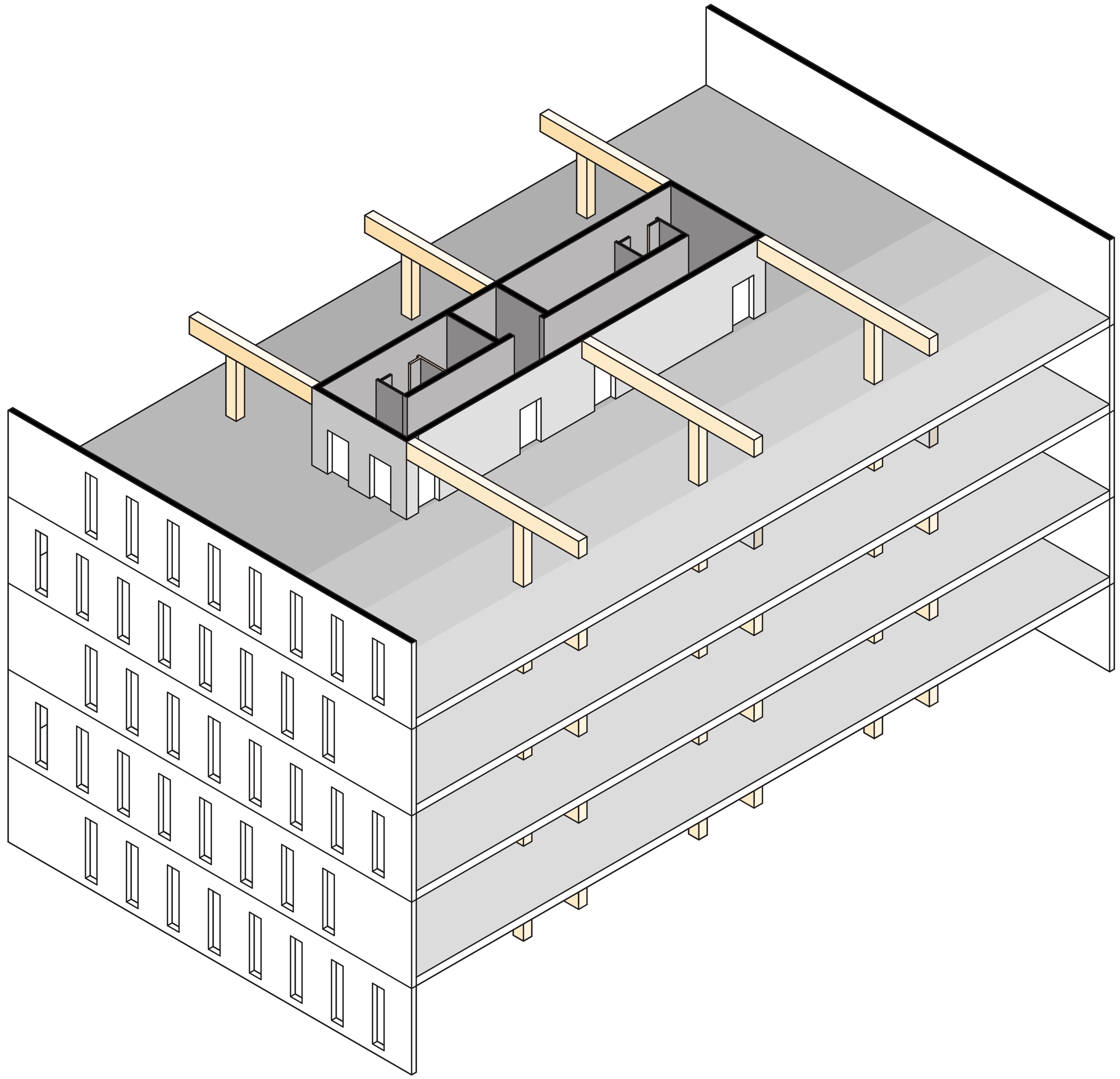


Figure 2. Column and beam structure with stablee core (own work)

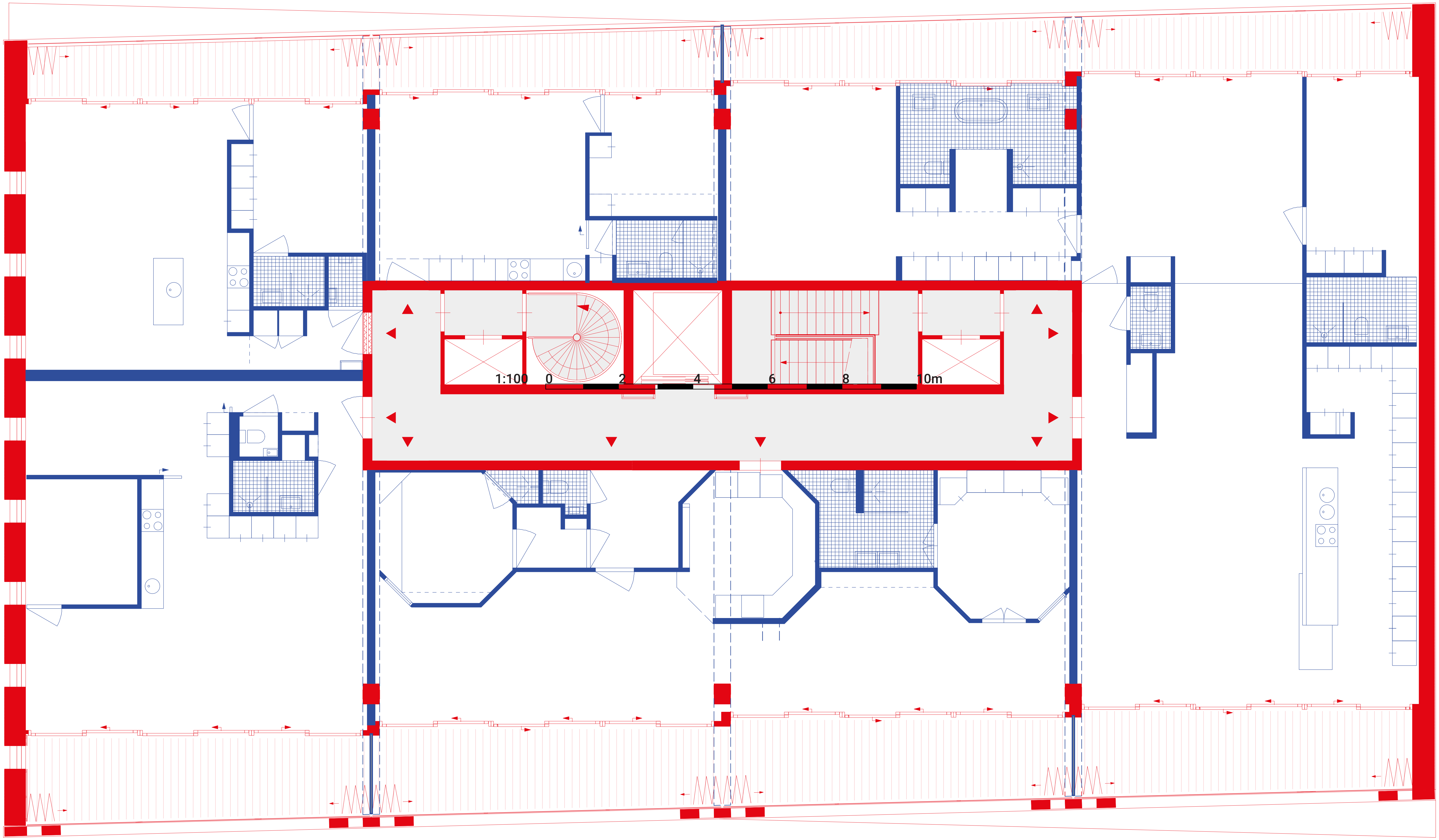


Figure 3. Support and Infill elements within 5th floor highlighted. (Source: Frantzen, 2016; modified by author).

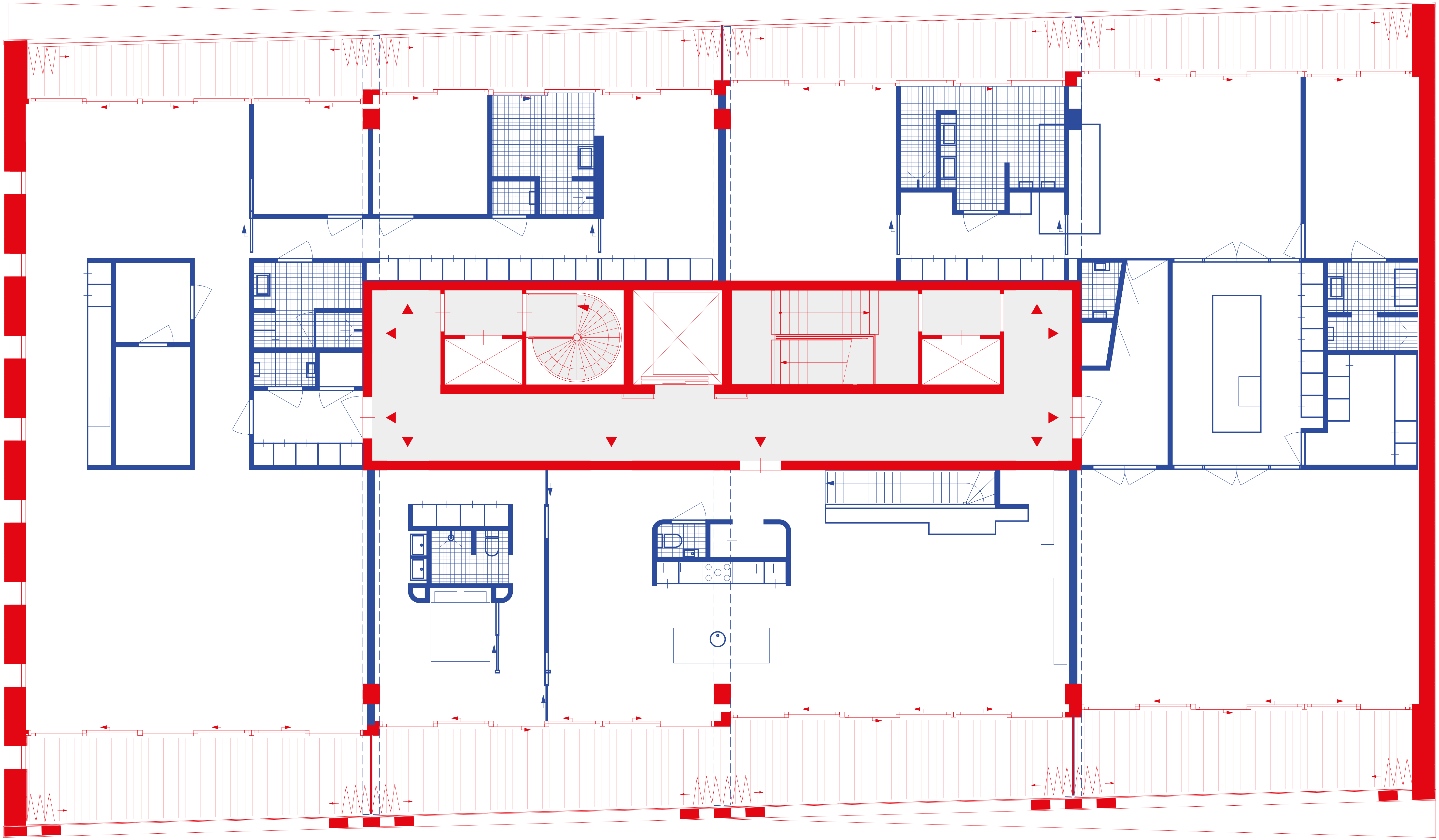


Figure 4. Support and Infill elements within 7th floor highlighted. (Source: Frantzen, 2016; modified by author).

DC 1B

Patch22 meets Design Criterion 1b through the use of lightweight, acoustically decoupled partition walls within an open structure. The column-and-beam structure provides open floor plans, while the partition walls, constructed with Soundbloc metal stud frames (215 mm Gyproc Soundbloc), can be easily added or removed. This allows for the reconfiguration of unit boundaries, enabling apartments to be split or combined. The apartment-dividing walls fall into a gray area between support and infill. While they are adaptable, their modification requires agreement from residents on both sides of the wall before they can be added or removed.

The fixed position of the floor plates limits certain future modifications, such as mezzanines or vertical connections between floors.

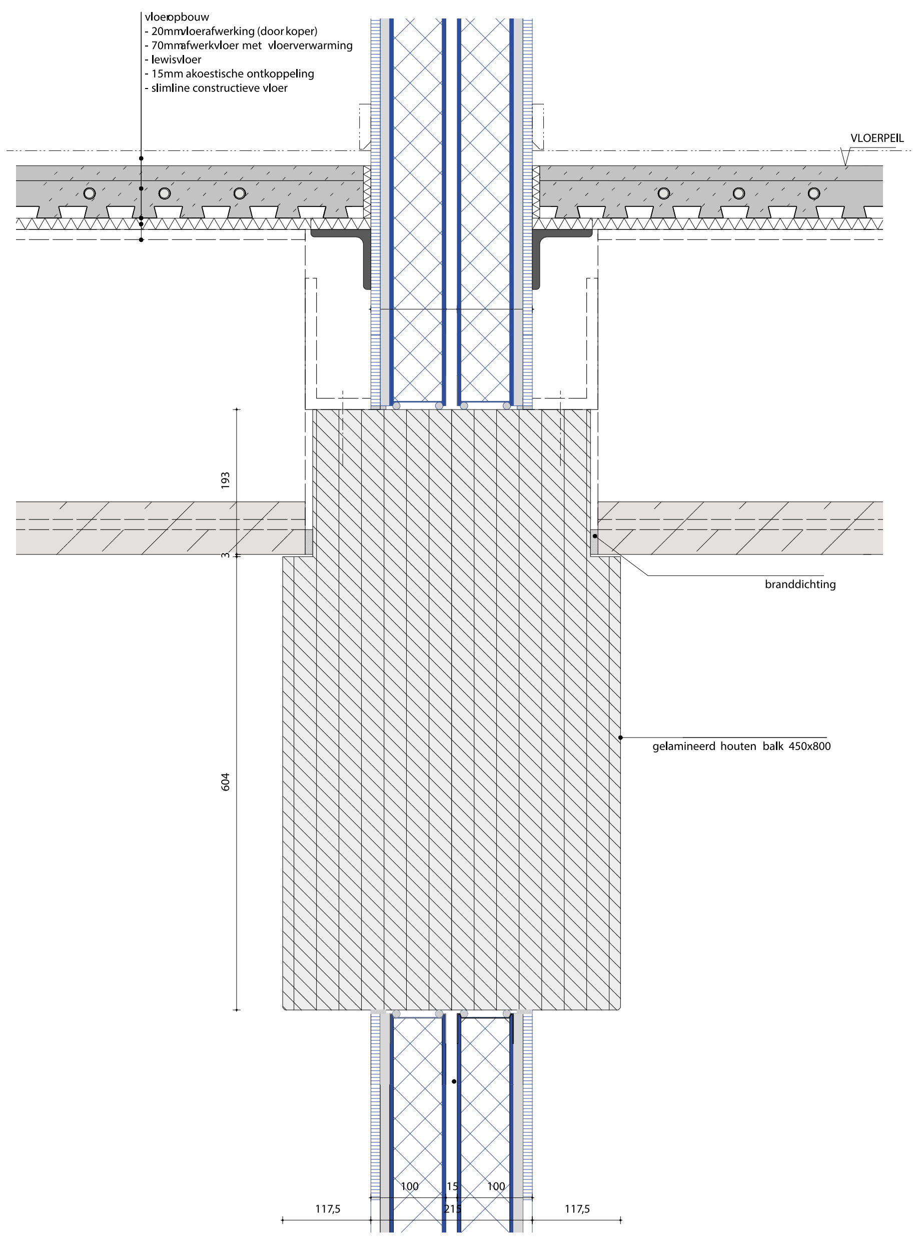


Figure 5. Accoustically decoupled partition walls. (Source: Frantzen, 2016; modified by author).

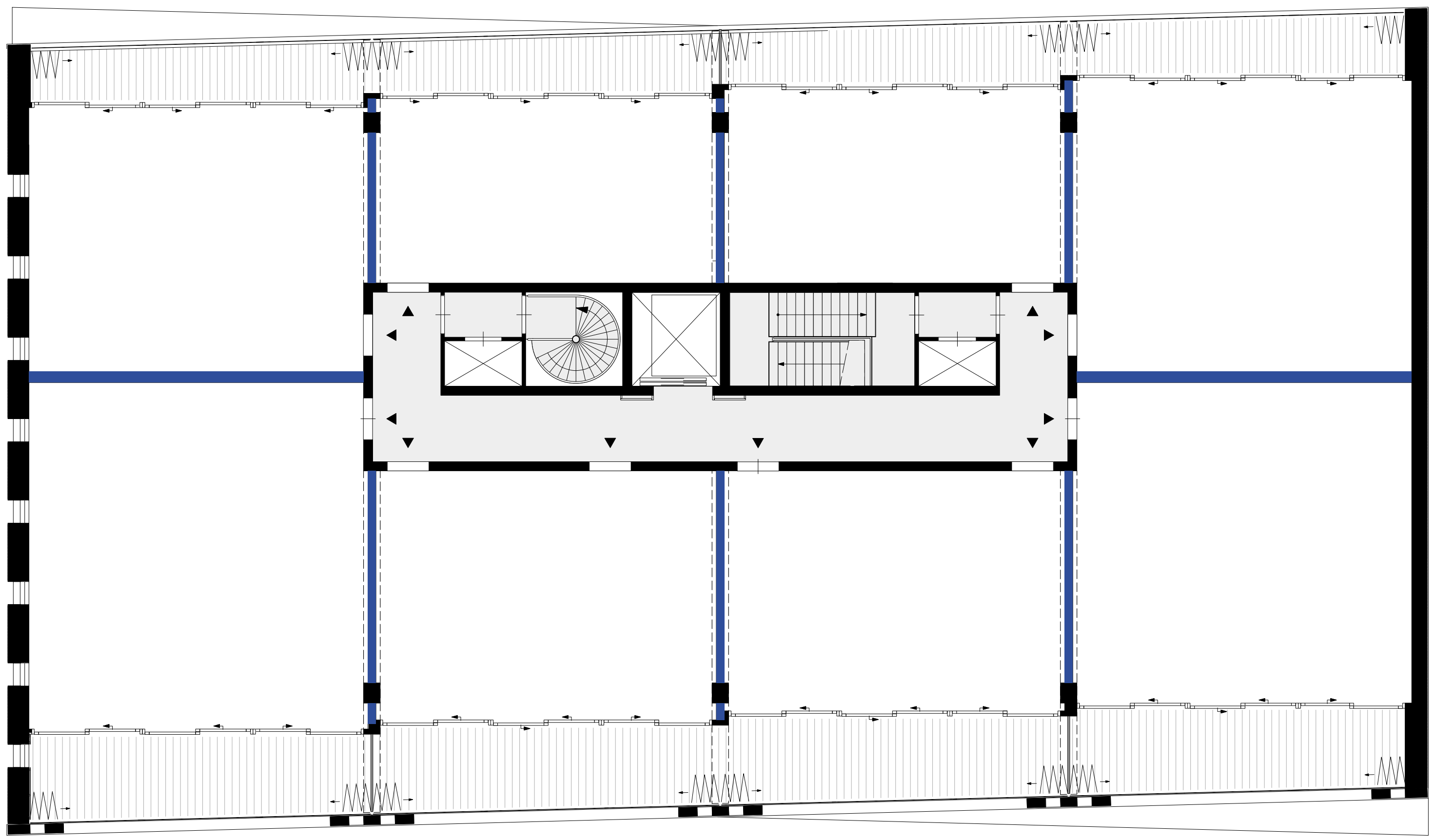


Figure 6. 8 official units. (Source: Frantzen, 2016; modified by author)

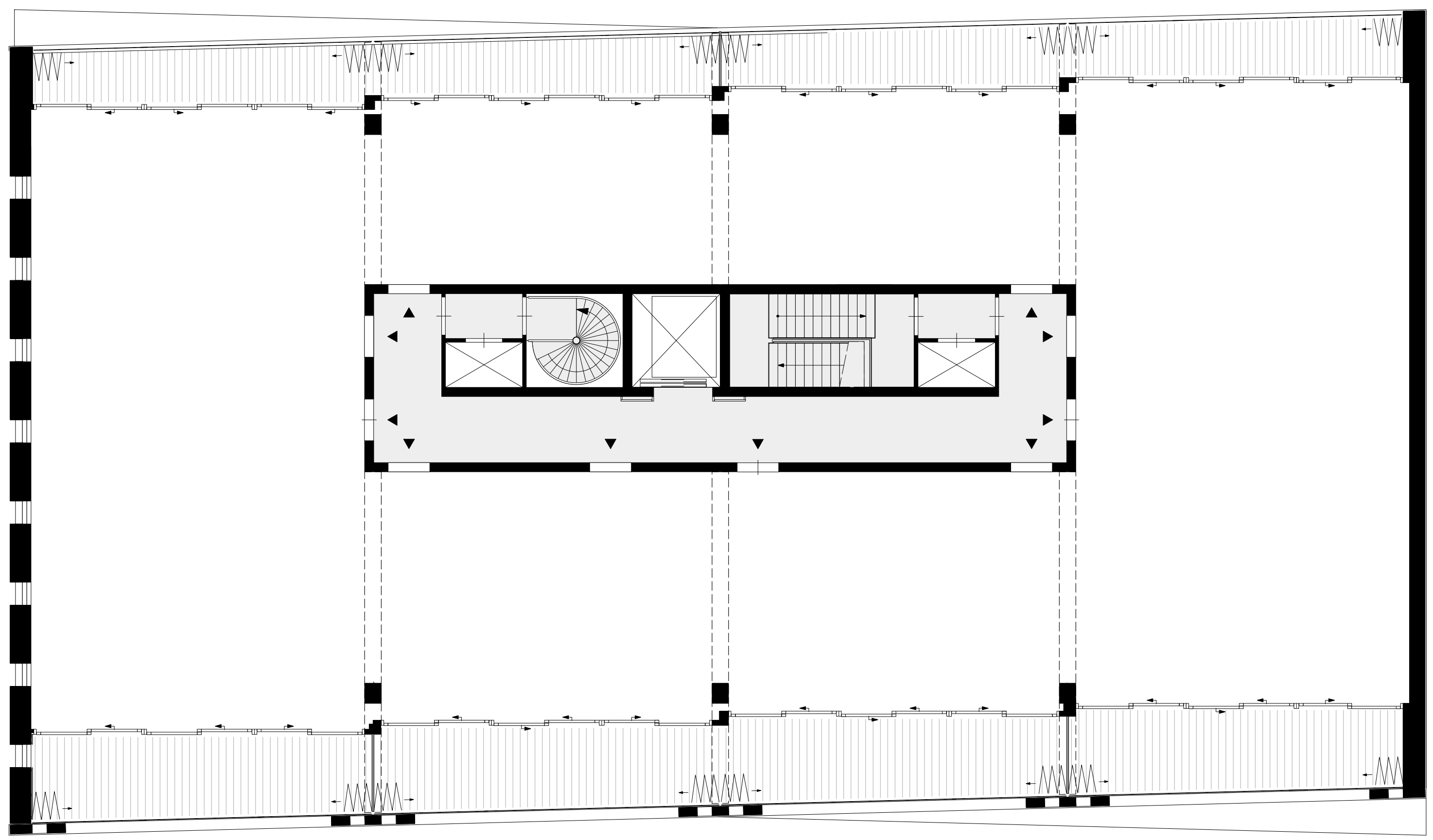


Figure 7. Floorplan without partition walls. (Source: Frantzen, 2016).

Figure 8. Column and beam structure with stablee core as seen on site. (Source: Arketipo Magazine, 2023)

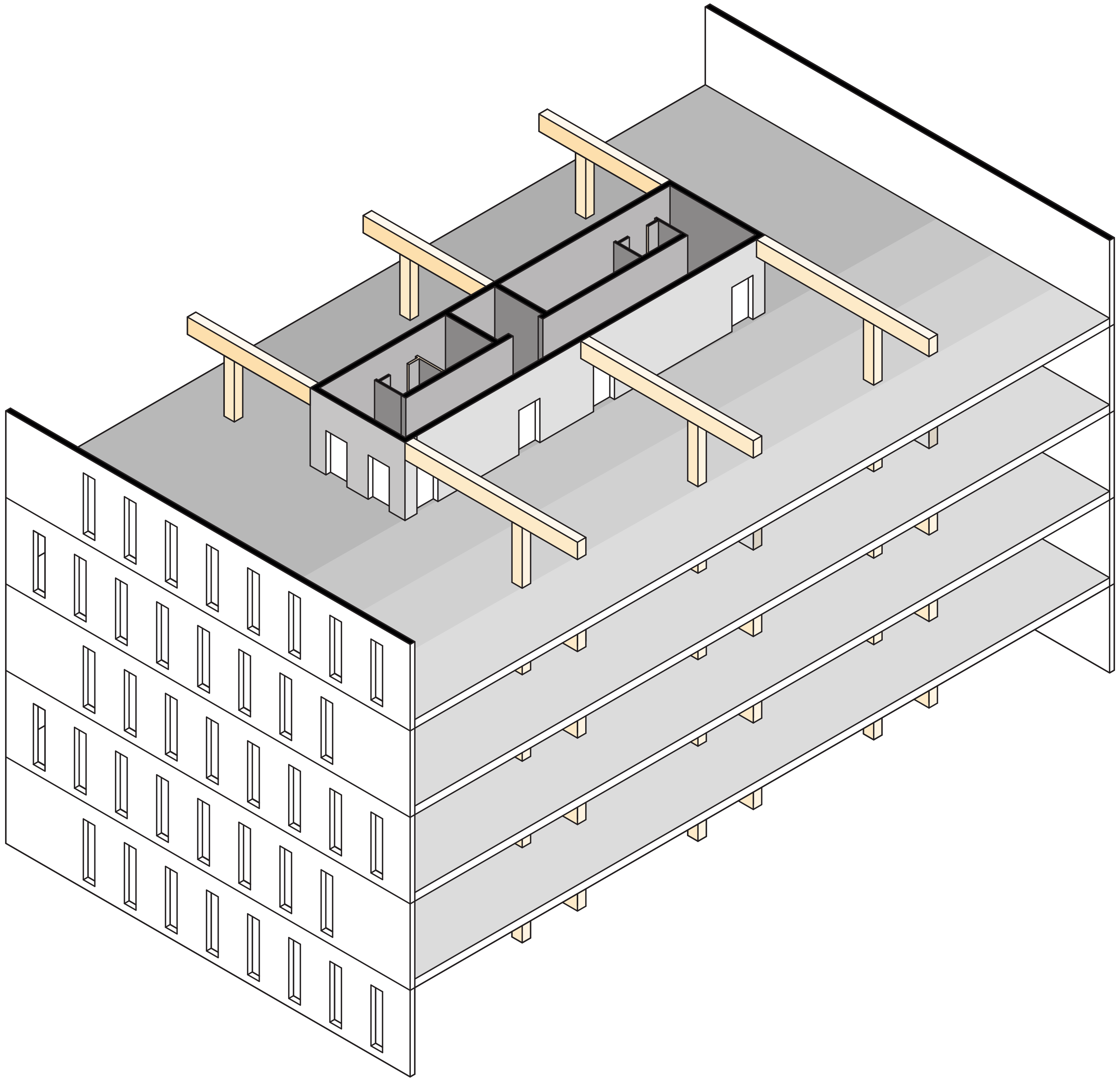


Figure 9. Column and beam structure with stablee core. (own work)

DC 1C

It is important to note that DC1C is difficult to assess, as it depends on a wide range of factors. These include not only the structural load-bearing capacity but also dimensions and other implications that are specifically linked to certain functions, as outlined in building regulations (Bouwbesluit). Reflecting such an extensive range of implications within this design criterion is nearly impossible within the scope of this research. Therefore, this analysis focuses primarily on the structural load-bearing capacity and/or the spaciousness of the structure.

Patch22 meets Design Criterion 1C by facilitating a load-bearing capacity of 4 kN/m² (Frantzen, 2016), which is higher than the minimum requirement for residential functions (2 kN/m², as per Bouwbesluit 2012).

This load-bearing capacity combined with the spacious character, explained under DC1B makes the building very suitable for a change in function.

Patch22 can accommodate the following functions regarding to the load-bearing capacity, as defined Bouwbesluit 2012:

1. Office Function: The open layout is well-suited for office use, which typically requires 2.5-3 kN/m².
2. Accommodation Function: Hotels or guesthouses can be created within the building, as this function aligns with residential load-bearing requirements.
3. Educational Function: Smaller educational spaces, such as training centers, typically require 3-4 kN/m².
4. Light Industrial Function: Activities such as small-scale manufacturing or workshops may be feasible. However, heavy machinery requiring a load-bearing capacity of 5 kN/m² or more cannot be supported.

Additionally, the timber structure is thickened by 80 mm on fire-exposed sides to meet the fire resistance requirements for all building functions, ensuring compliance with safety regulations.

DC 2

Patch22 meets Design Criterion 2 by centralizing all shared building services within the core of the building. Pipes and wiring are horizontally distributed from individual units to a vertical shaft located in the core.

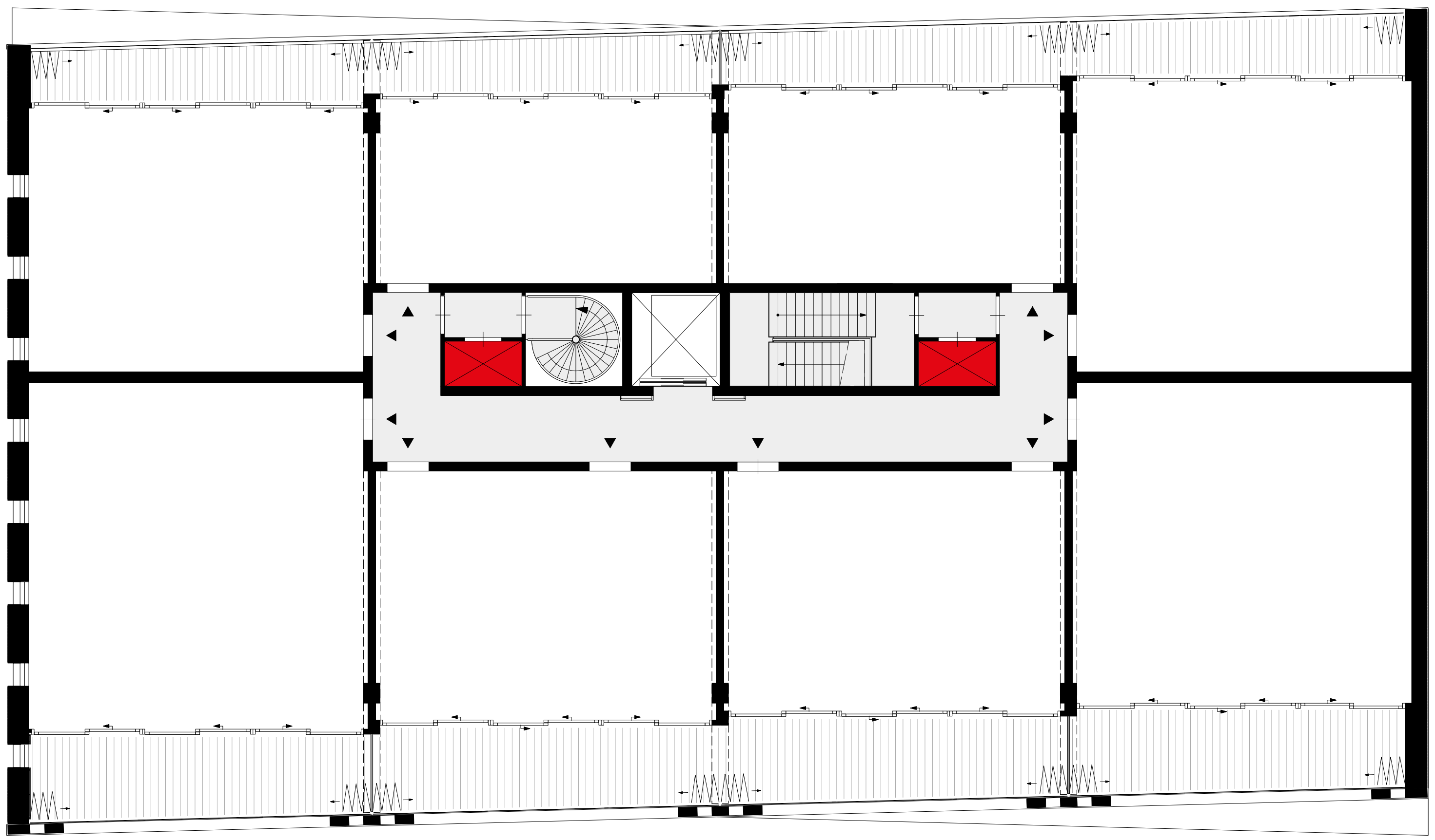


Figure 10. Vertical Service Infrastructure distribution. (Source: Frantzen, 2016; modified by author)

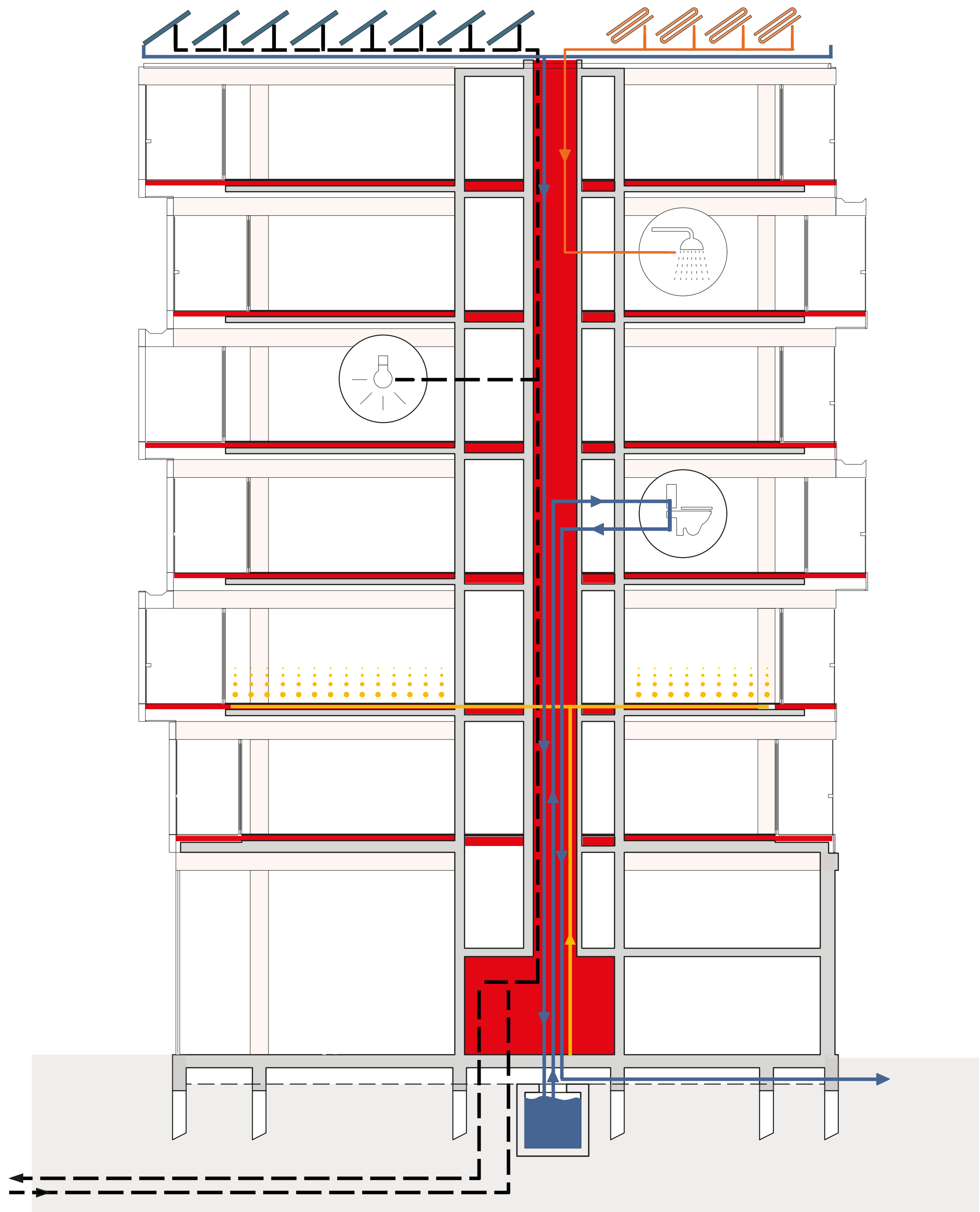
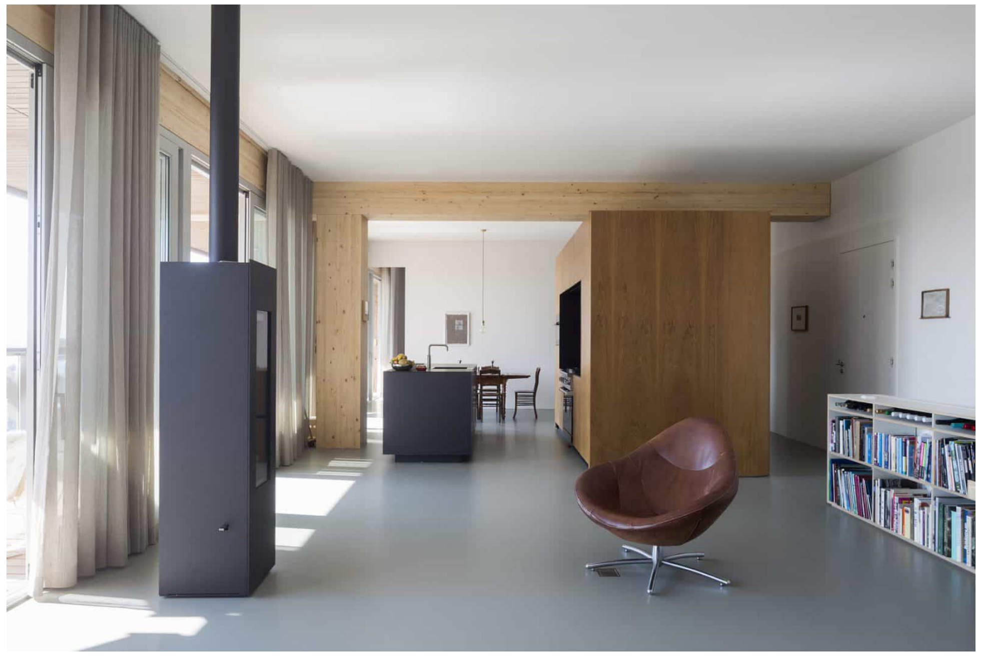


Figure 11. Service Infrastructure distribution through core and Slimline floor. (Source: Frantzen, 2016; modified by author)

DC 3

Patch22 meets Design Criterion 3 by demonstrating compatibility with diverse infill solutions. Photos of different apartments show that various infill systems, each with distinct character, have been applied. A range of design approaches and user preferences can be applied in this buildings Support.



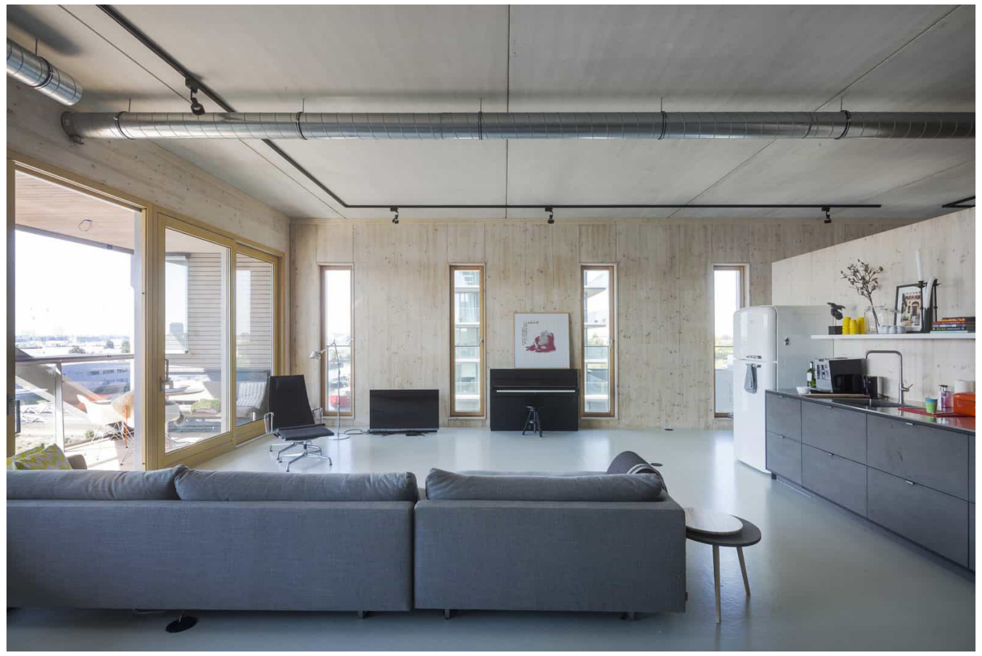


Figure 12, 13, 14, 15, 16. Wide variety of Infill designs. (Source: Patch22, 2017)

DC 4

Patch22 meets Design Criterion 4 through the use of the Slimline Floor system and dry assembly methods. The Slimline system consists of prefabricated structural elements with hollow cavities that allow for the horizontal distribution of pipes and wiring. The top layer of the floor is removable, enabling residents to modify or redesign their service infrastructure over time without impacting the structural support. However, removing this layer requires drilling, making the process labor-intensive (see DC9 for further details).

All services are routed into individual dwellings through openings in the core, connected to the central vertical shaft. However, it is assumed that the service infrastructure requires sleeves to exit the shaft, which slightly impacts and interferes with the support structure.

Additionally, all other infill elements utilize dry assembly methods, allowing for easy alteration and removal.

Disclaimer: The drawings accompanying this analysis are schematic and serve to illustrate the concept of the Slimline Floor system as applied in Patch22.

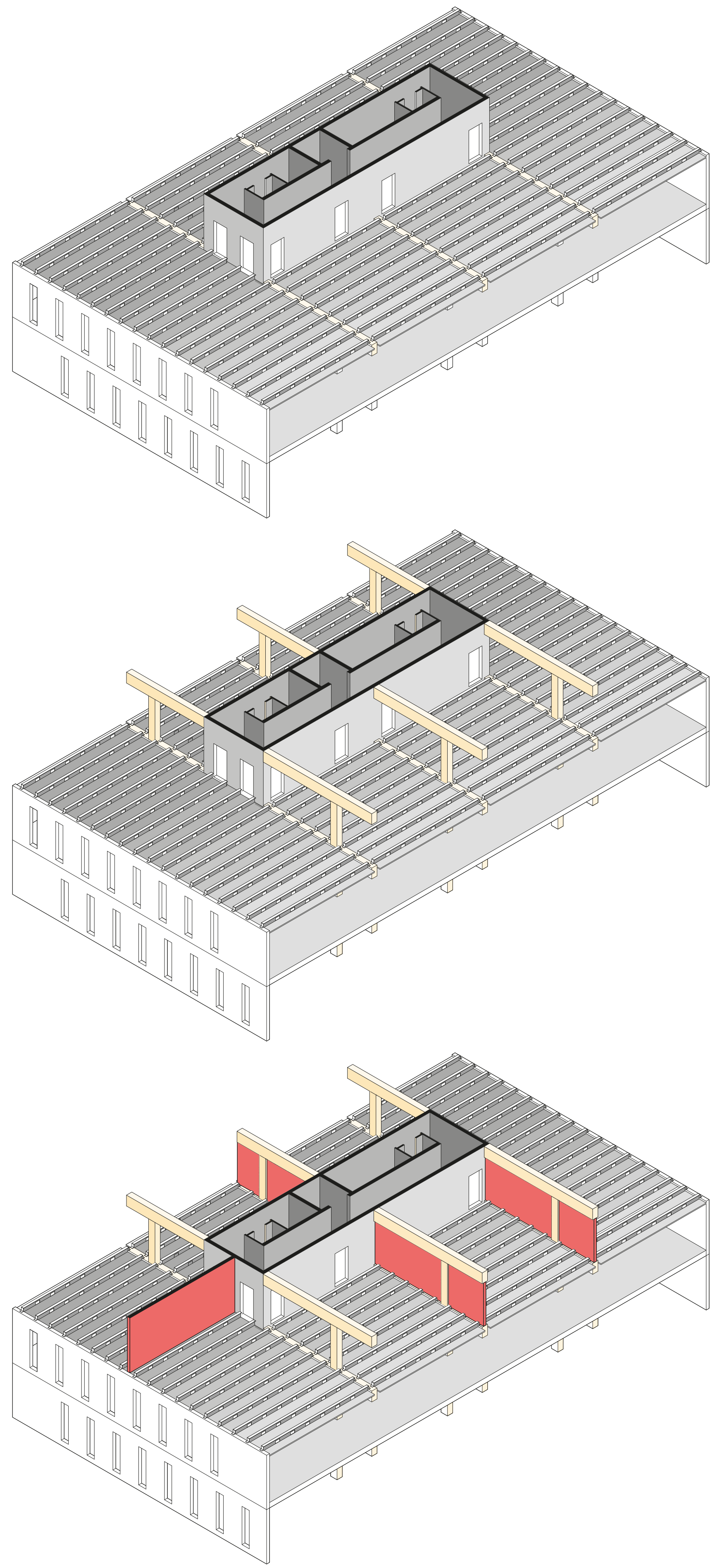


Figure 16, 17, 18. Partition walls dividing the floor plan in multiple dwellings. (own work)

THE SUPPORT MUST ALLOW FOR THE INDEPENDENT ASSEMBLY, ALTERATION, AND REMOVAL OF THE INFILL

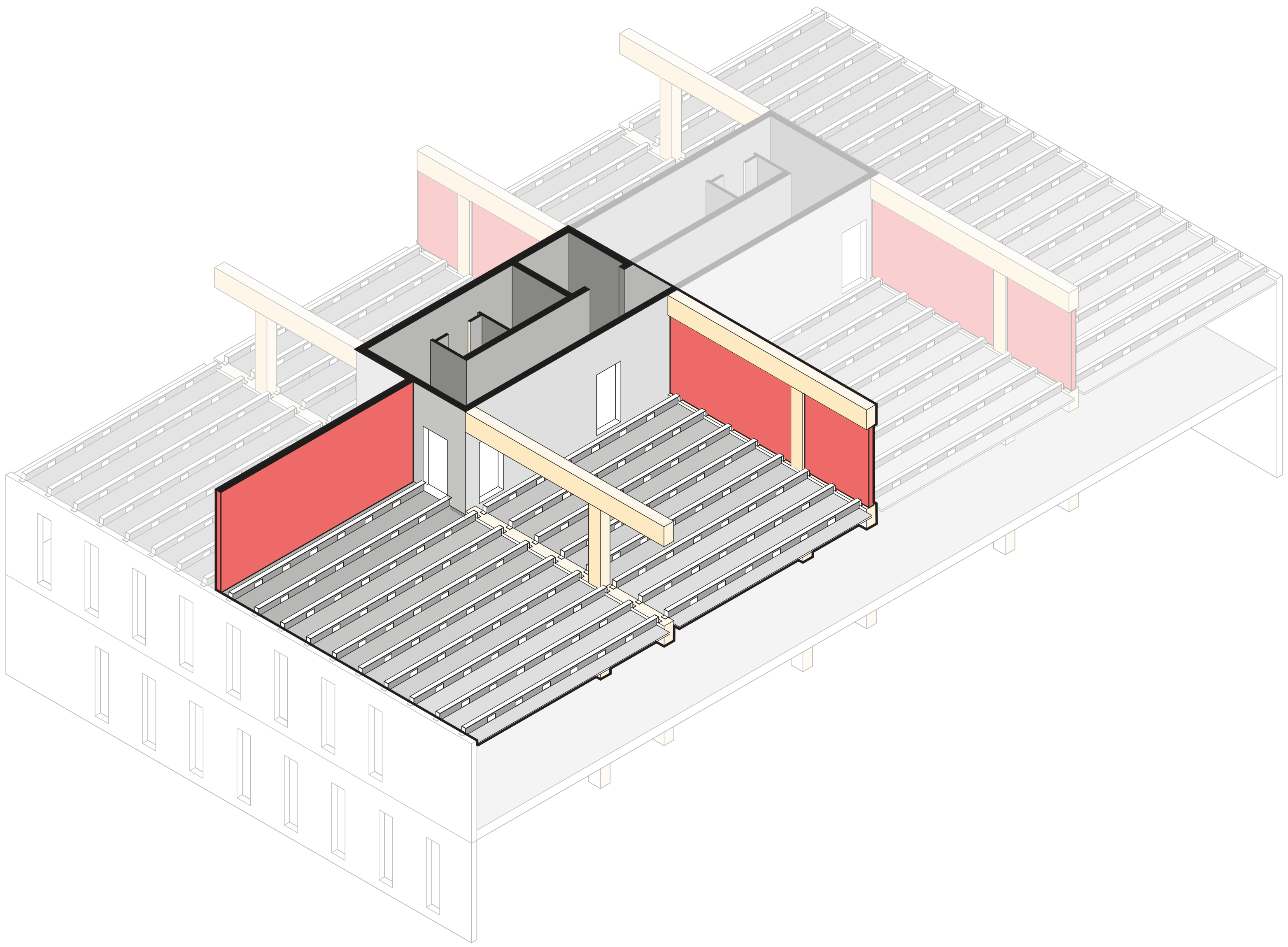


Figure 19. (own work)

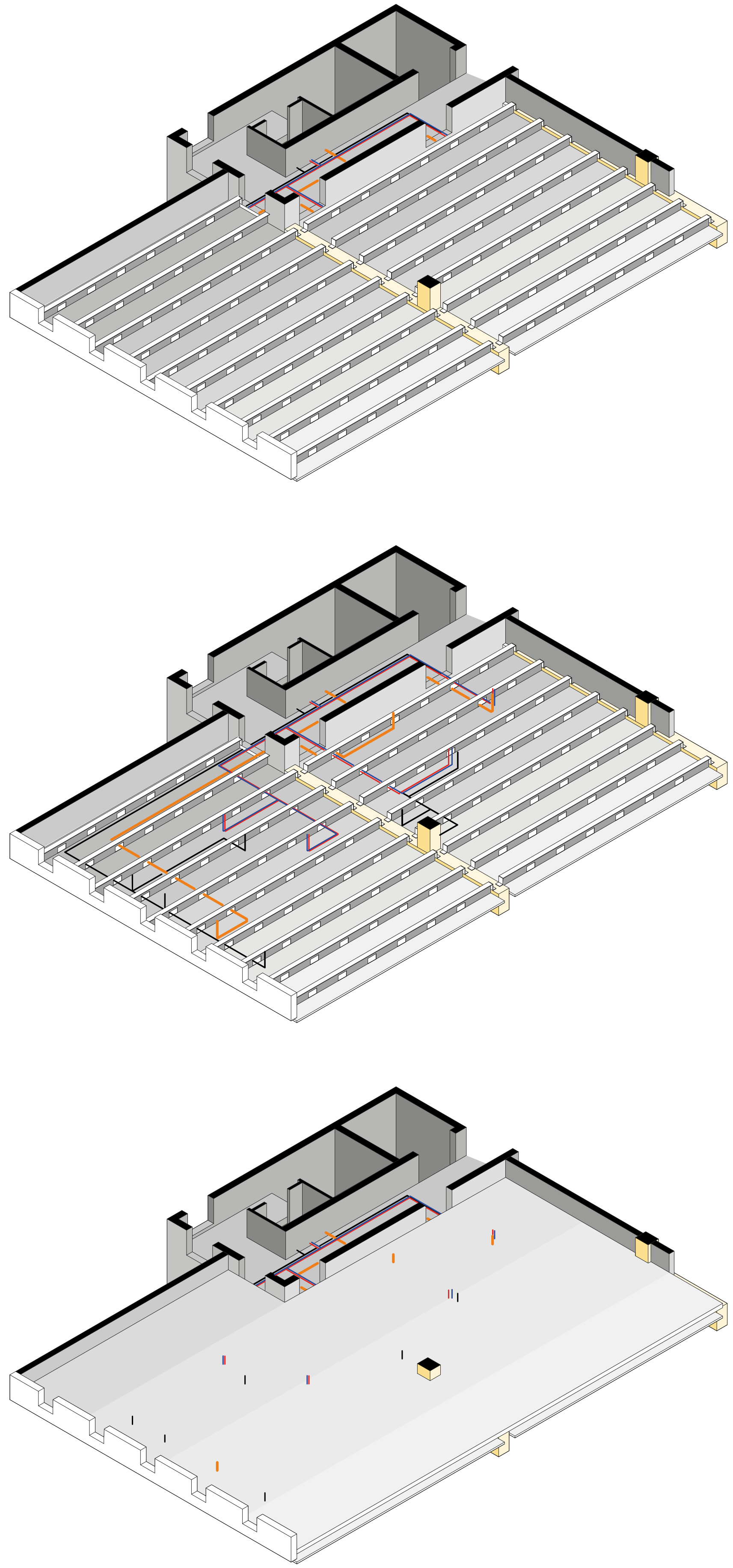


Figure 20, 21, 22. Installing Slimline floorsystem. (own work)

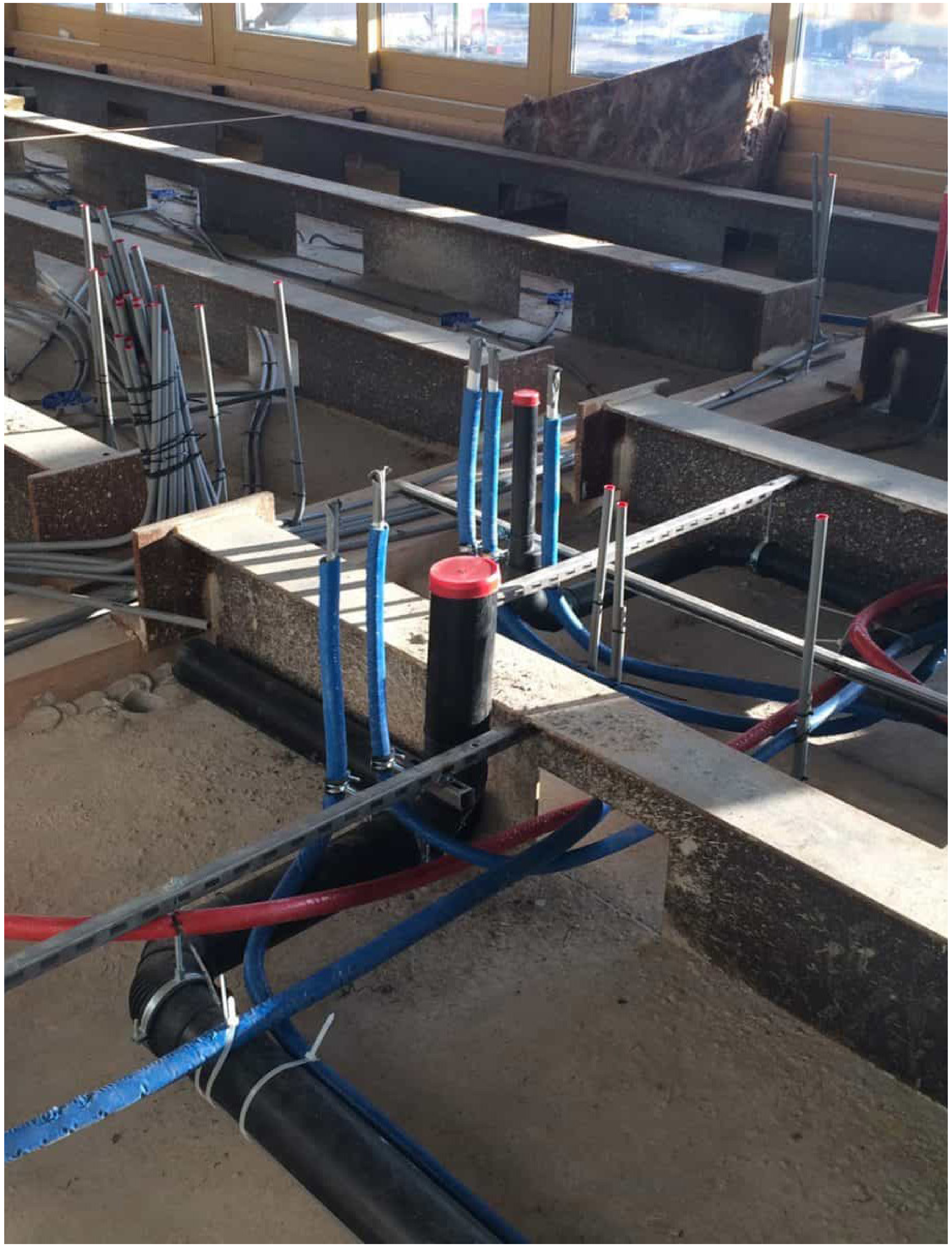


Figure 23. Slimline floor system. (Source: Frantzen, 2016)

Figure 24, 25. (Source: Arketipo Magazine, 2023)

DC 7

Patch22 does not meet Design Criterion 7, as the façade is fixed and considered part of the support structure. This limits adaptability and prevents it from being fully integrated into the infill system. However, residents do have some flexibility in their use of the building envelope. For example, features such as a bathtub can be installed on the enclosed balcony, which could be partially interpreted as part of the façade.

Figure 26. Bathtub on loggia. (Source: Patch22, 2017)

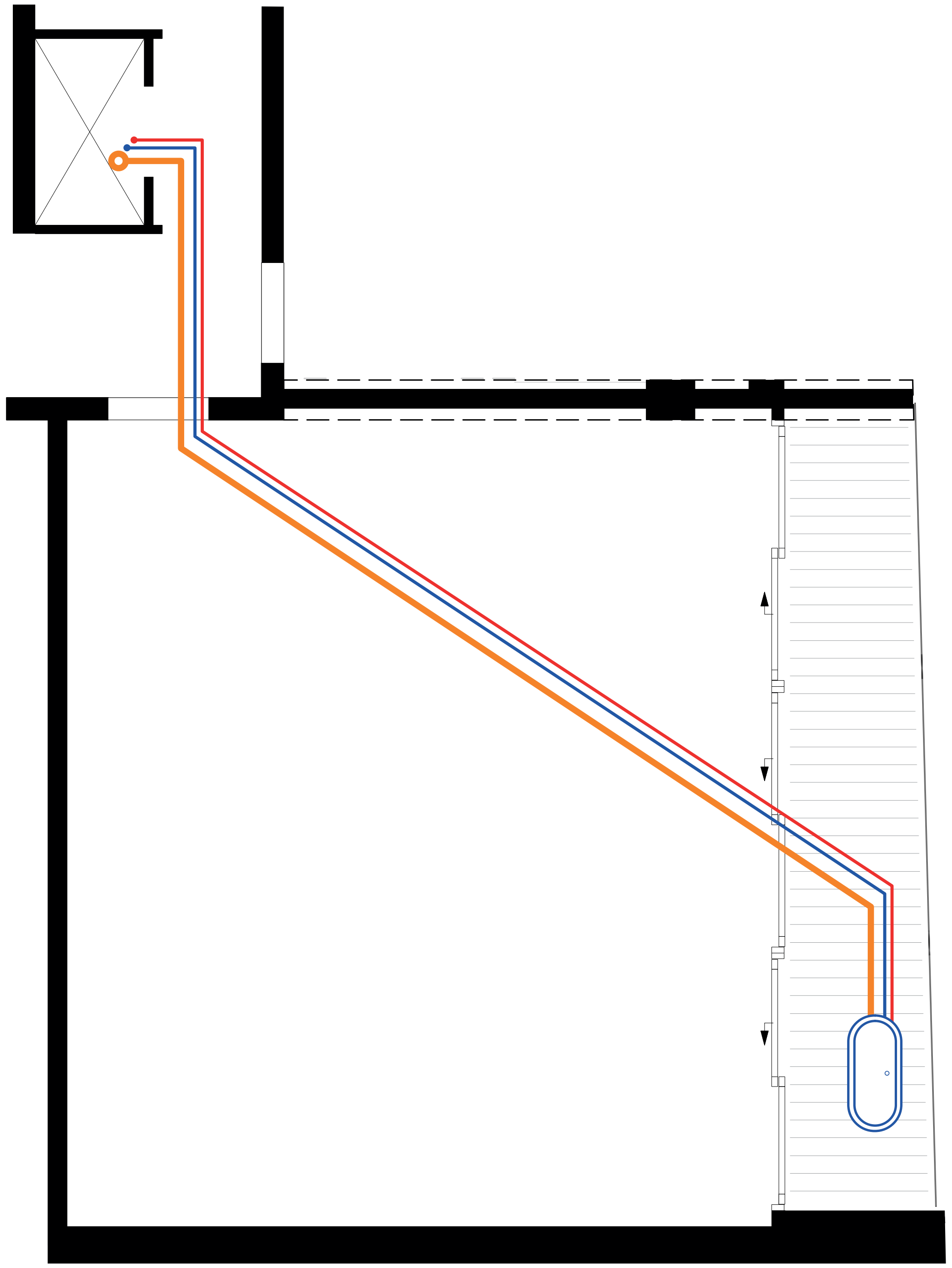
DC 8

Patch22 meets Design Criterion 8 by implementing the Slimline Floor system in a way that maximizes freedom in service infrastructure placement. The system allows for utilities, including water drainage pipes, to be distributed to any point within the apartment, even enabling features like a bathtub to be installed on the balcony.

A key consideration in the design is the slope requirement for wastewater drainage. According to the Bouwbesluit 2012, the minimum slope for wastewater pipes is 1 cm per meter. The Slimline Floor system accounts for this requirement by providing sufficient height to accommodate the slope over the maximum possible distance for wastewater drainage, such as from a toilet to the furthest corner of an apartment.

The maximum distance to the furthest corner is approximately 15-20 meters, requiring a total slope of 15-20 cm for a 40 mm drainage pipe. The architects chose for a Slimline Floor system with the appropriate height to ensure compliance with this drainage requirements. This integration of service infrastructure allows for adaptability without compromising functionality.

Figure 27. Bathtub on loggia. (Source: Patch22, 2017)



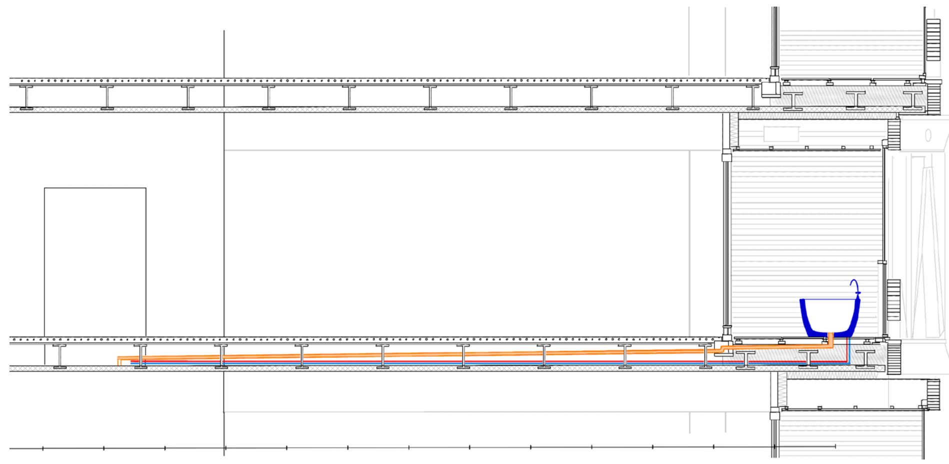


Figure 28, 29. Relation between floorheight and slope requirement for wastewater drainage. (Own work)

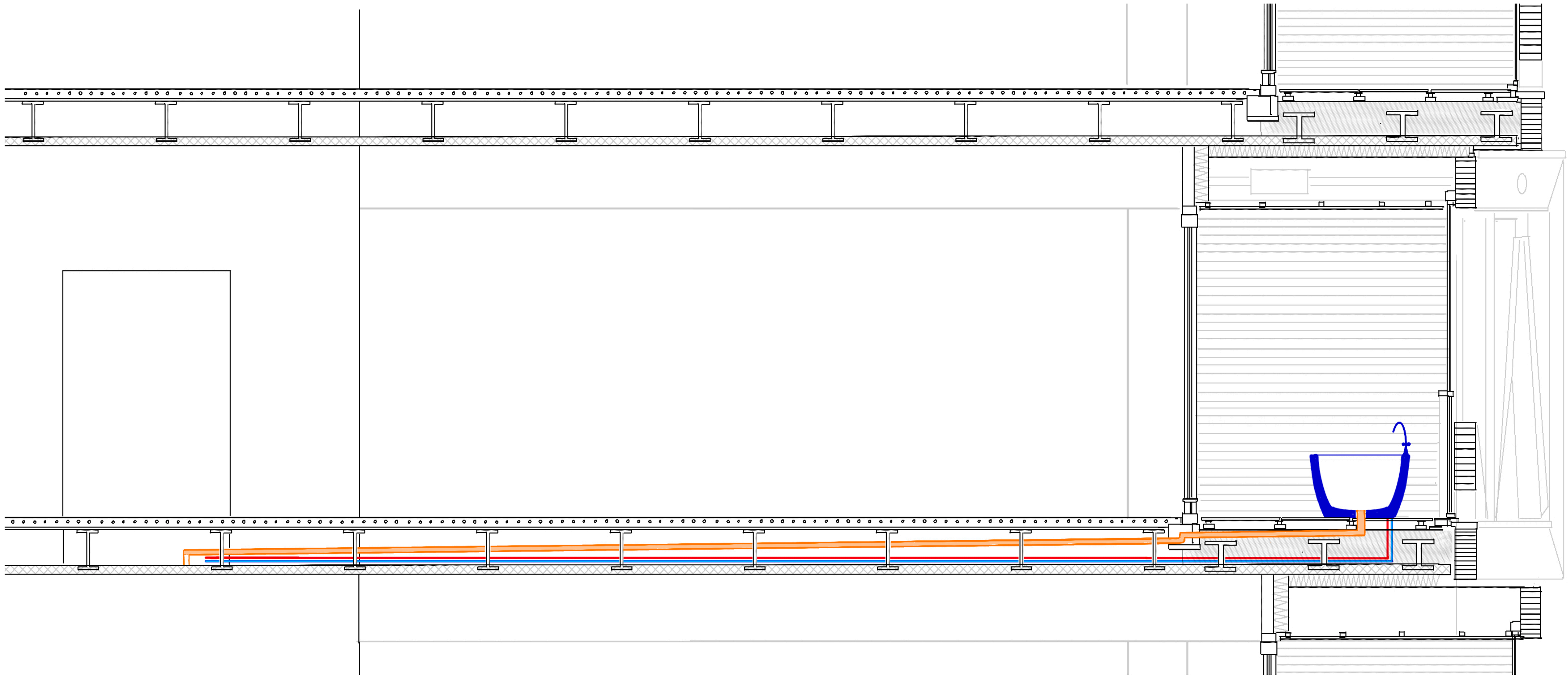


Figure 30. Relation between floorheight and slope requirement for wastewater drainage. (Own work)

1:50 0 1 2 3 4 5m

DC9

Patch22 partially meets Design Criterion 9, as the Slimline Floor system allows residents to design and modify service infrastructure according to their needs. The hollow floor with a removable top layer facilitates access to utilities for future adjustments.

However, the inclusion of a Lewis floor, spanning the entire apartment and not divided into removable sections, limits the practicality of these modifications. To make adjustments to the underlying utilities, the entire floor would need to be removed, rather than just specific sections. This makes the process significantly more labor-intensive and reduces the building's performance on this criterion. While modifications are possible, they require considerable effort, which impacts the flexibility envisioned in the design.

Additionally, it is assumed that the service infrastructure requires sleeves to exit the vertical shaft, which slightly interferes with the structural support. This connection between the service infrastructure and the support structure further impacts the overall adaptability and ease of modification, as any changes would necessitate coordination with the structural components.

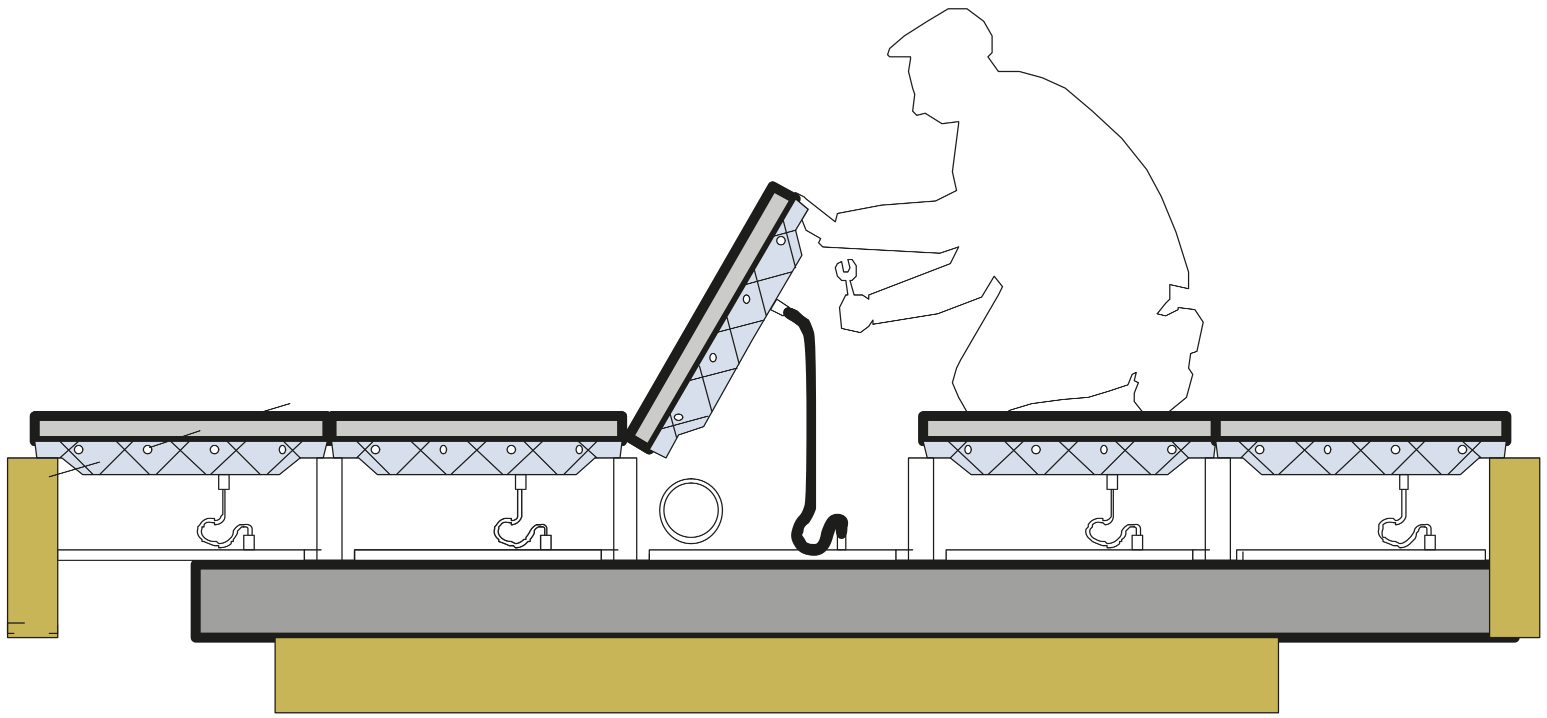


Figure 31. Removable top layer as showed by the architect. (Source: Frantzen, 2016)

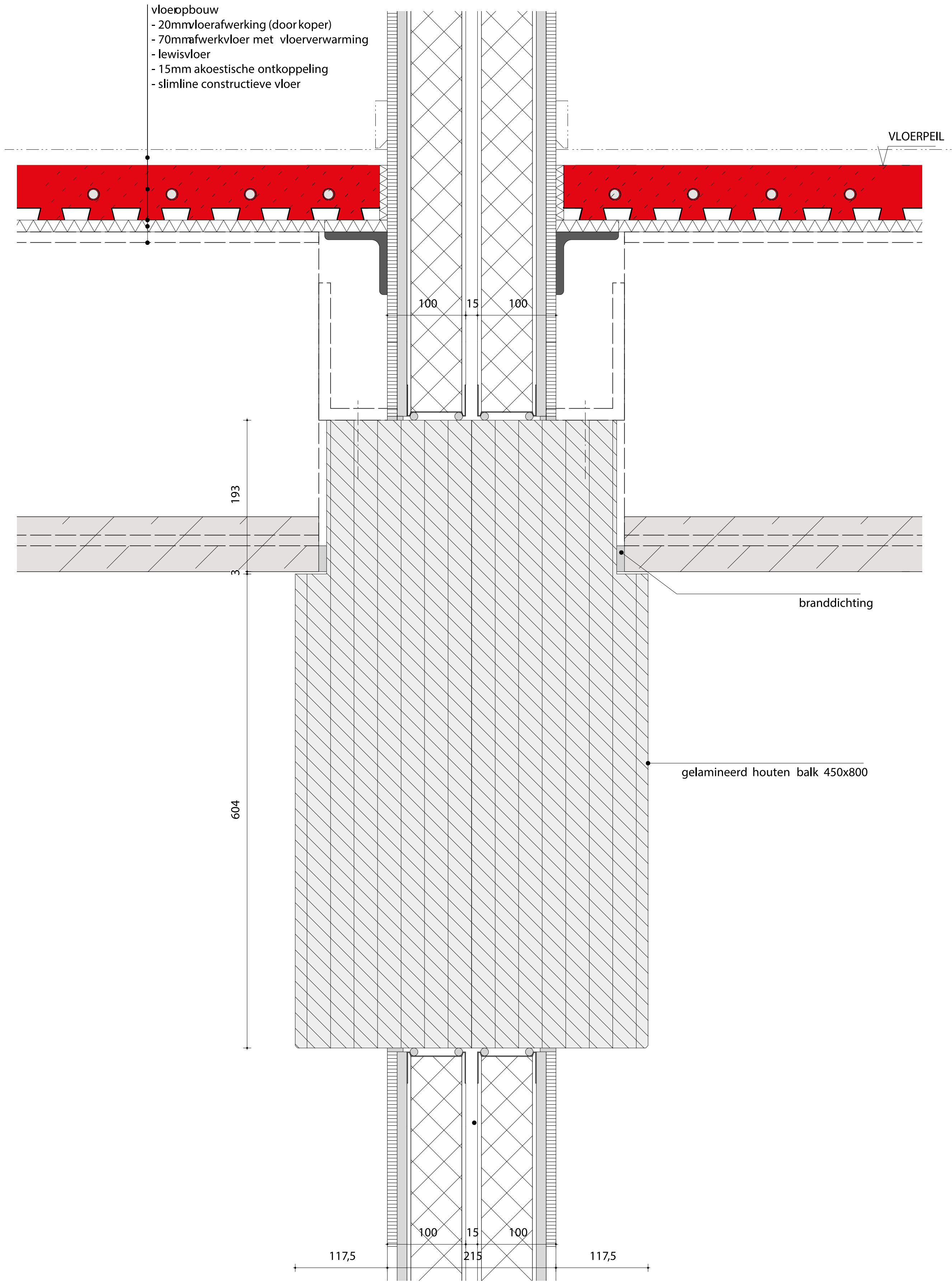


Figure 32. Actual toplayer as seen in details. (Source: Frantzen, 2016; modified by author)

2. Superlofts Houthavens plot 4 - MKA

DC 1A

Superlofts Houthavens Plot 4 meets Design Criterion 1A by enabling a variety of dwelling layouts through multiple design features:

1. Mezzanine floors
   A suspended CLT mezzanine slab allows residents to add up to 70% extra floor area, increasing the layout options. (More about this under DC4.)

2. Smart core
   The placement of all services in a central so called "smart core" enables residents to locate bathrooms and kitchens almost anywhere within the living space, further enhancing layout flexibility. (More about this under DC2 and DC8.)

3. Flexible interior walls and doors
   Interior infill walls and doors are designed to be adaptable, enabling residents to alter their living space to their specific needs.

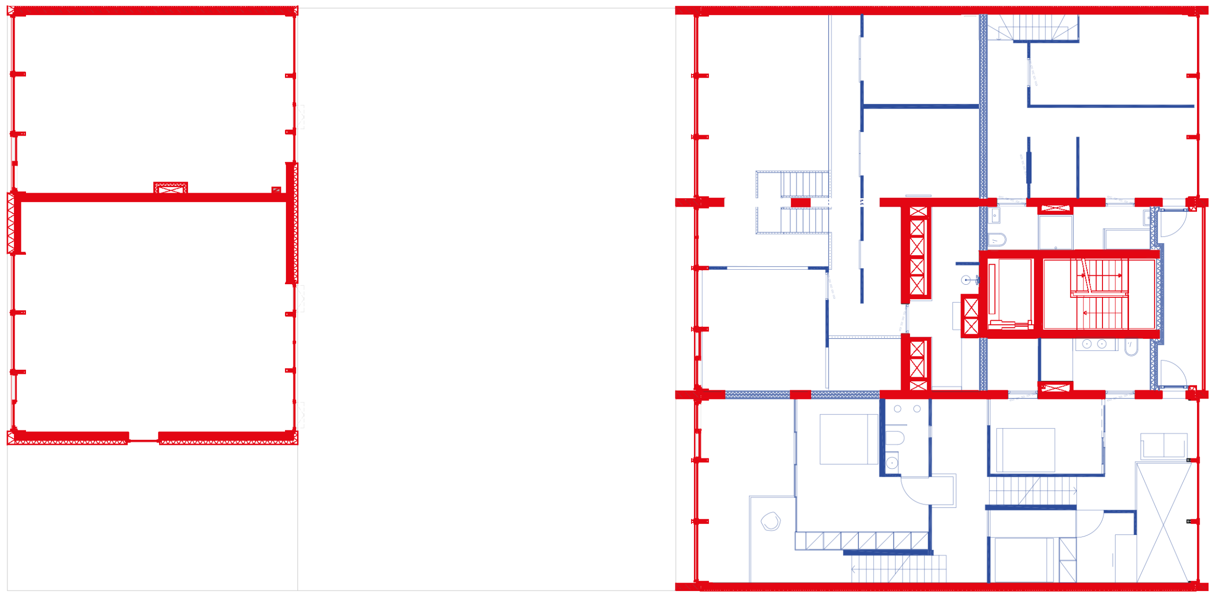


Figure 33. Spacious Support measurements. (Source: ARCAM, n.d.)

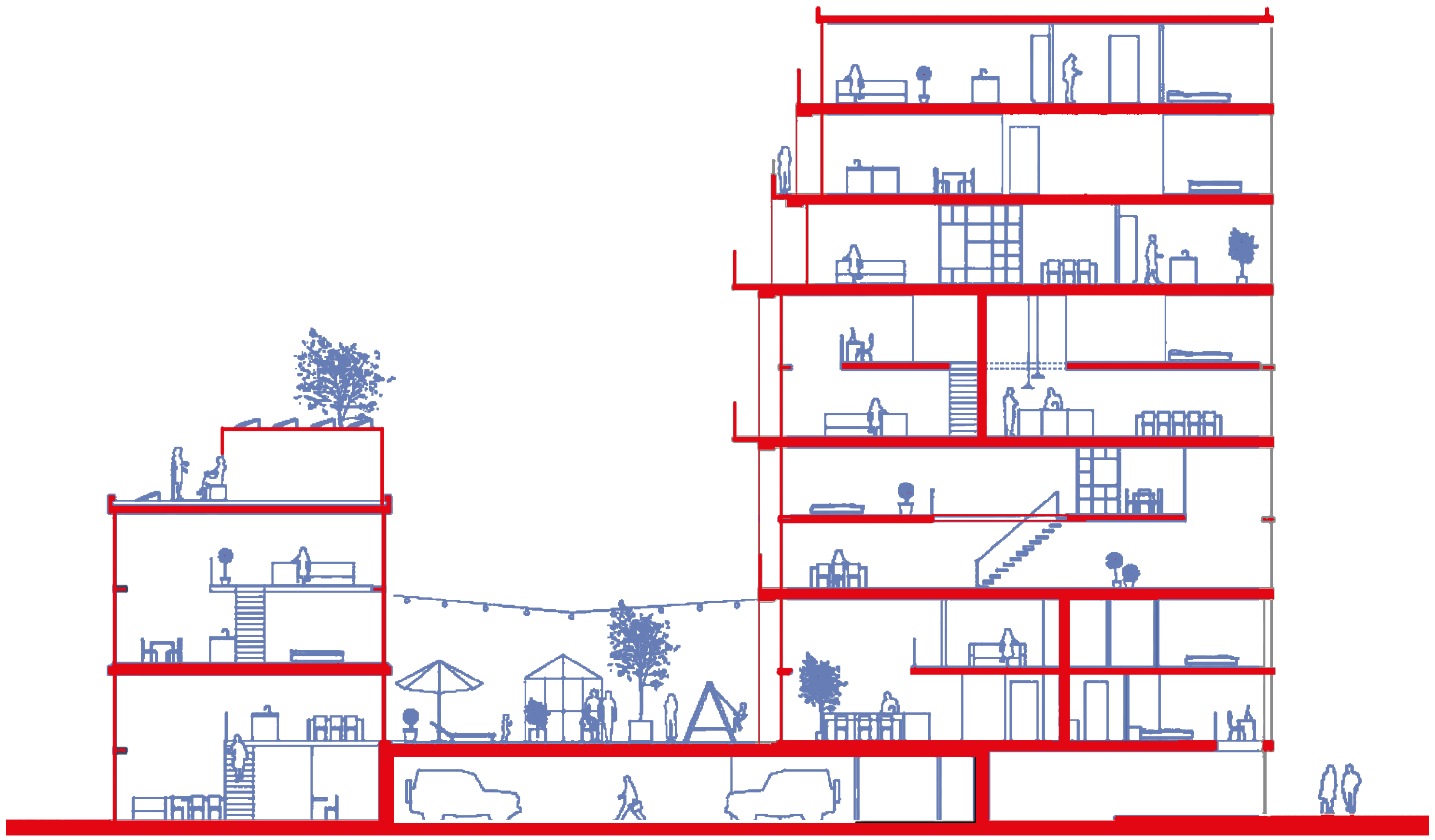


Figure 34, 35. X. (Source: Marc Koehler Architects, n.d.; modified by author).

4. Generous floor height and bay width
   The building includes floor heights of almost 5 meters and a structural bay width of 6.6 meters. This represents an improvement from previous plots (Plot 1 and 2), providing more generous and flexible floorplans.

5. Core location adjustment
   Moving the main smart core to the façade instead of the center, as in previous plots, allows for a more diverse and modular combination of loft types, increasing layout possibilities.

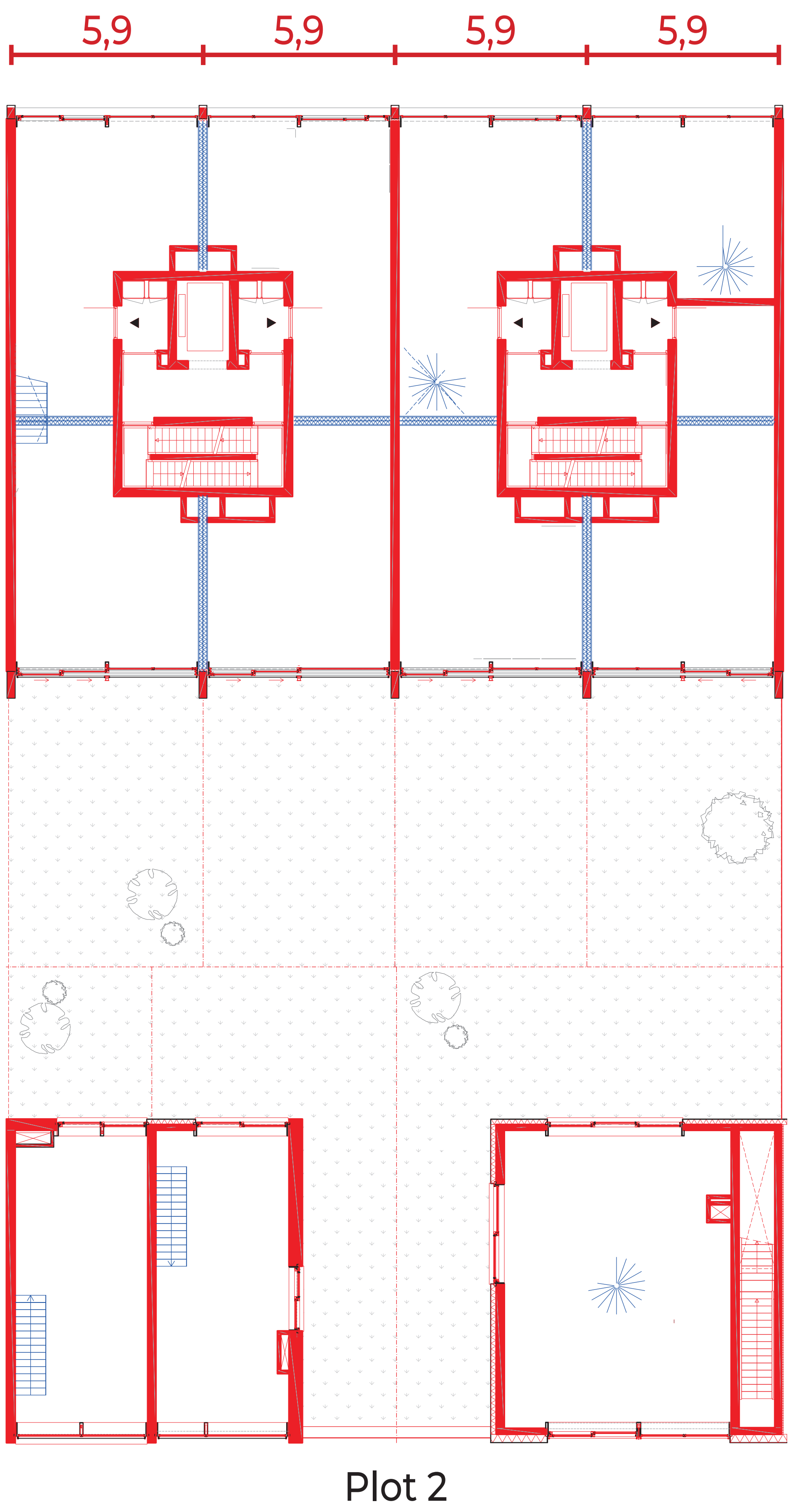


Figure 36. Support and Infill elements highlighted. (Source: Marc Koehler Architects, n.d.; modified by author).

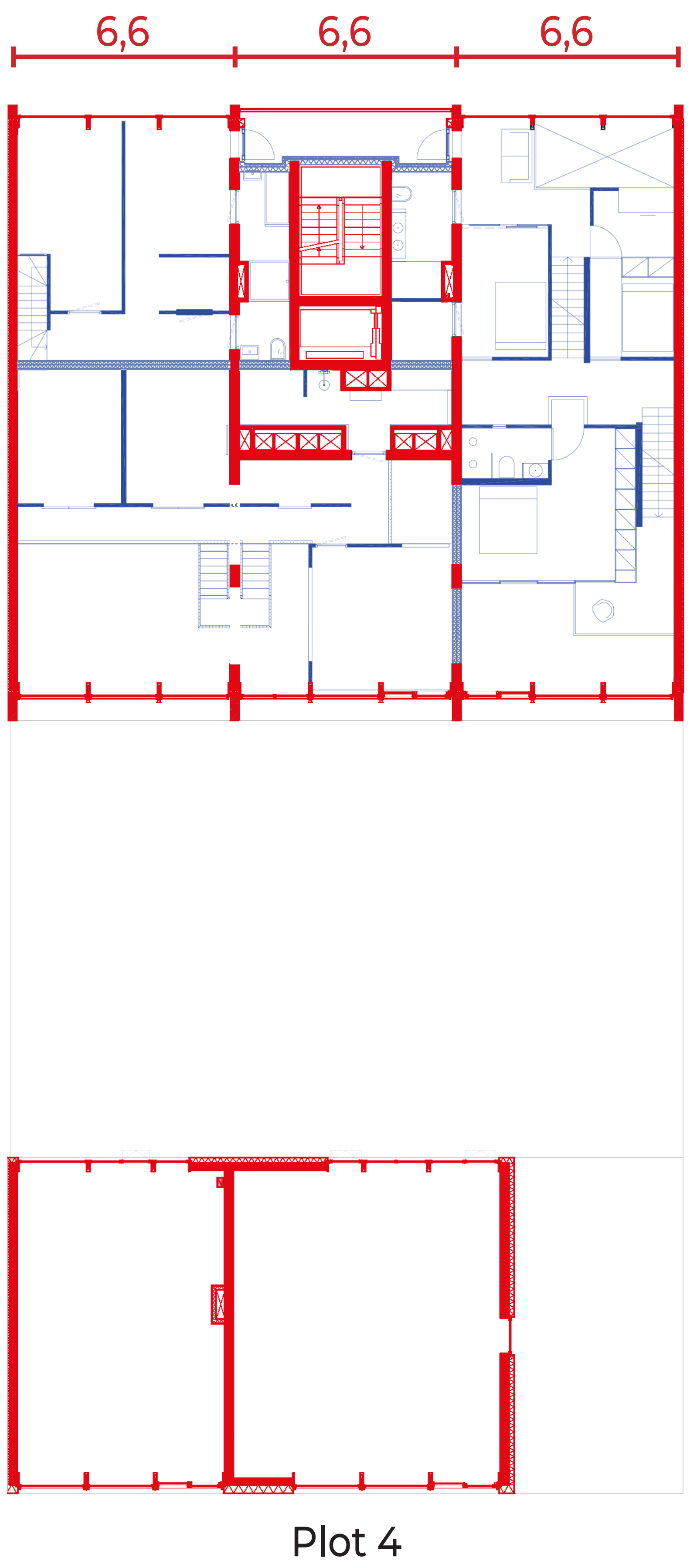


Figure 37. Support and Infill elements highlighted.. (Source: Marc Koehler Architects, n.d.; modified by author).

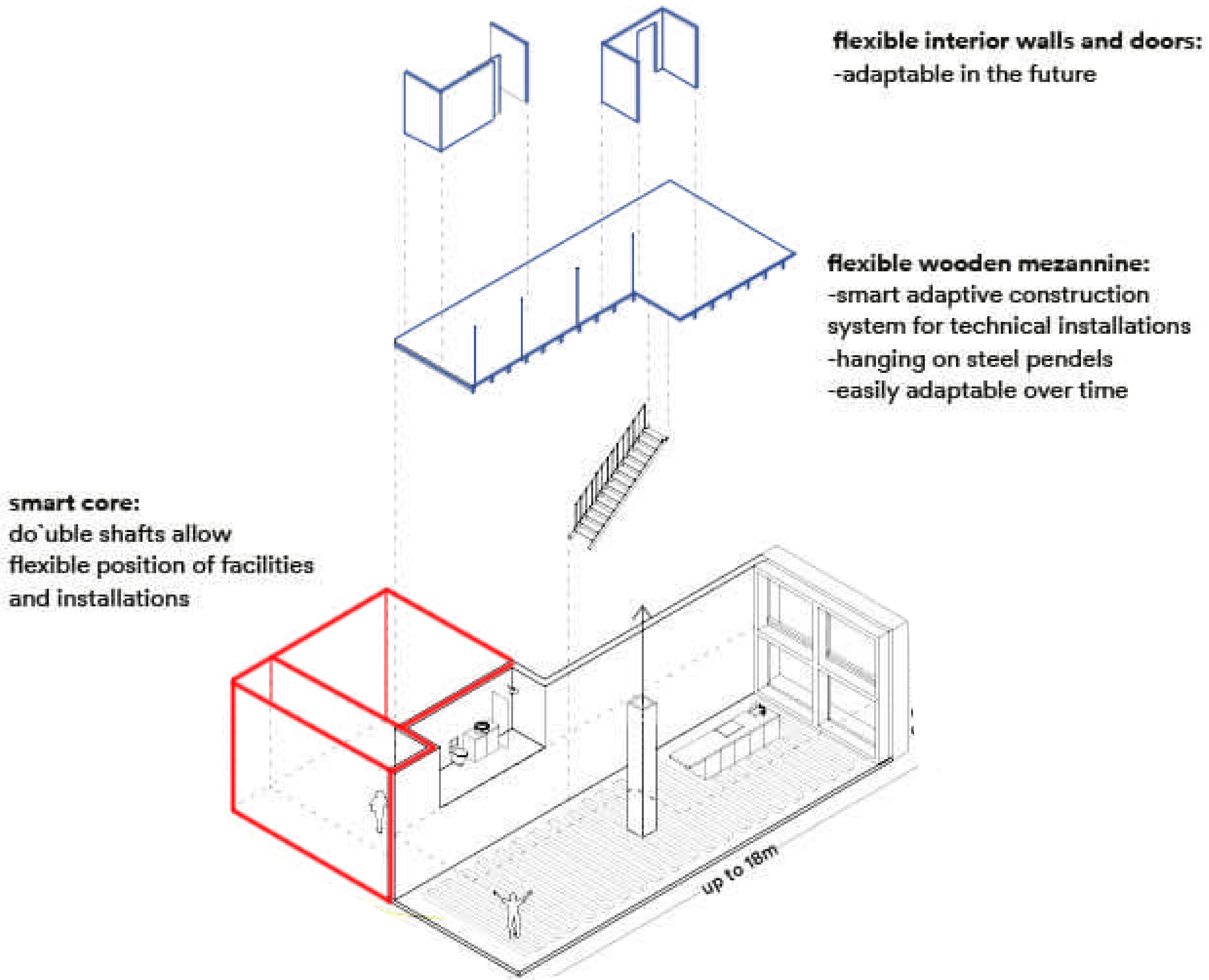


Figure 38. Design strategies marked with red (Support) or blue (Infill). (Source: Marc Koehler Architects, n.d.; modified by author).

DC 1B

Superlofts Houthavens Plot 4 meets Design Criterion 1B. Each floor is divided into five legal units, each with its own front door and electrical meter, grouped around the central core. The first residents have the freedom to choose one, two, or more legal units to create a living space tailored to their needs. Partition walls constructed with Soundbloc metal stud frames can be added or removed, allowing apartments to be split or combined. This adaptability ensures a variety of dwelling sizes and configurations.

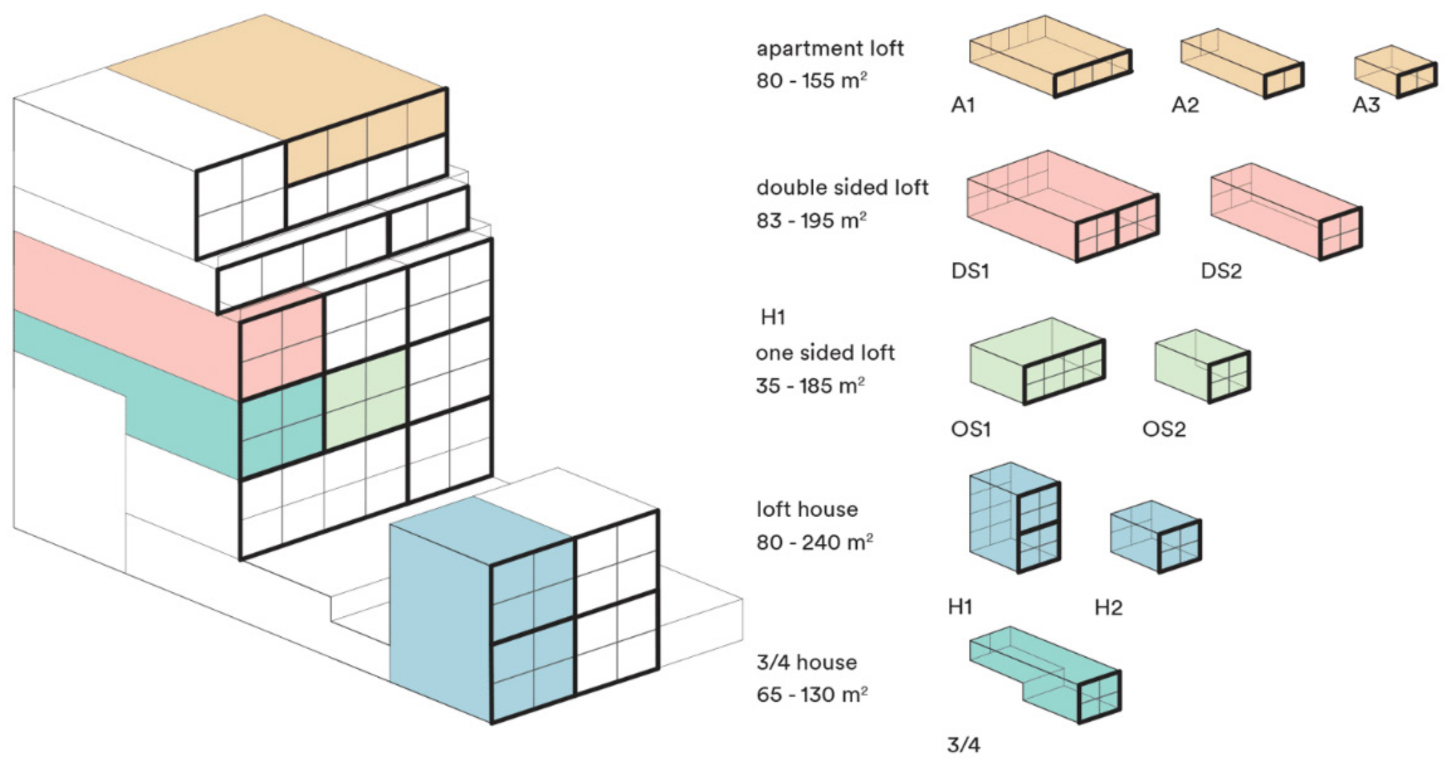


Figure 39. Different dwelling typologies within Superlofts Houthavens plot 4. (Source: Marc Koehler Architects, n.d.)

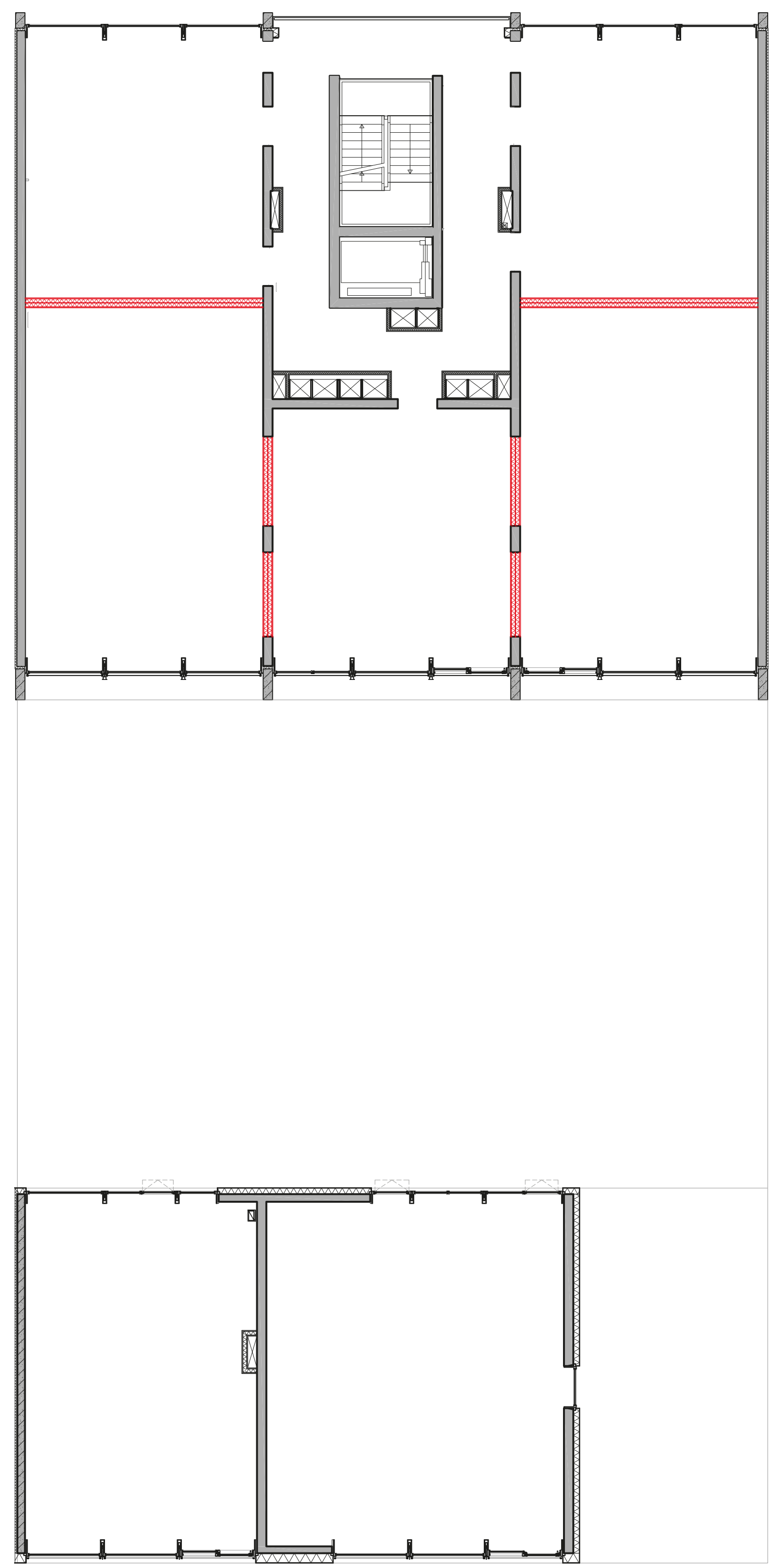


Figure 40. Floorplan with partition walls. (Source: Marc Koehler Architects, n.d.)

DC 1C

It is important to note that DC1C is difficult to assess, as it depends on a wide range of factors. These include not only the structural load-bearing capacity but also dimensions and other implications that are specifically linked to certain functions, as outlined in building regulations (Bouwbesluit). Reflecting such an extensive range of implications within this design criterion is nearly impossible within the scope of this research. Therefore, this analysis focuses primarily on the structural load-bearing capacity and/or the spaciousness of the structure.

Superlofts Houthavens Plot 4 does not meet Design Criterion 1C. The open, light, and spacious base building allready encourages a variety of hybrid uses, such as ateliers, kitchen studios, breweries, and home offices. However, the architect has not indicated any specific design strategies aimed at increasing the load-bearing capacity of the structure to support future functions that may require a higher capacity than residential use. This limits the flexibility of the building in accommodating heavier functions over time.

Figure 41. Spacious Support structure. (Source: ARCAM, n.d.)

DC 2

Superlofts Houthavens Plot 4 partially meets Design Criterion 2. It centralizes al shared building services in the core. Vertical shafts contain all of the infrastructure needed for the services. From this vertical shaft all the pipes move horizontally into the entrence hall as supply points for each dwelling.

If residents prefer to position wet areas away from the core, the horizontal distribution for water and plumbing must be arranged through the Infill, as the Support does not include a horizontal service infrastructure system. The only integrated system within the base building is the floor heating and cooling distribution, assumed to be embedded in the concrete.

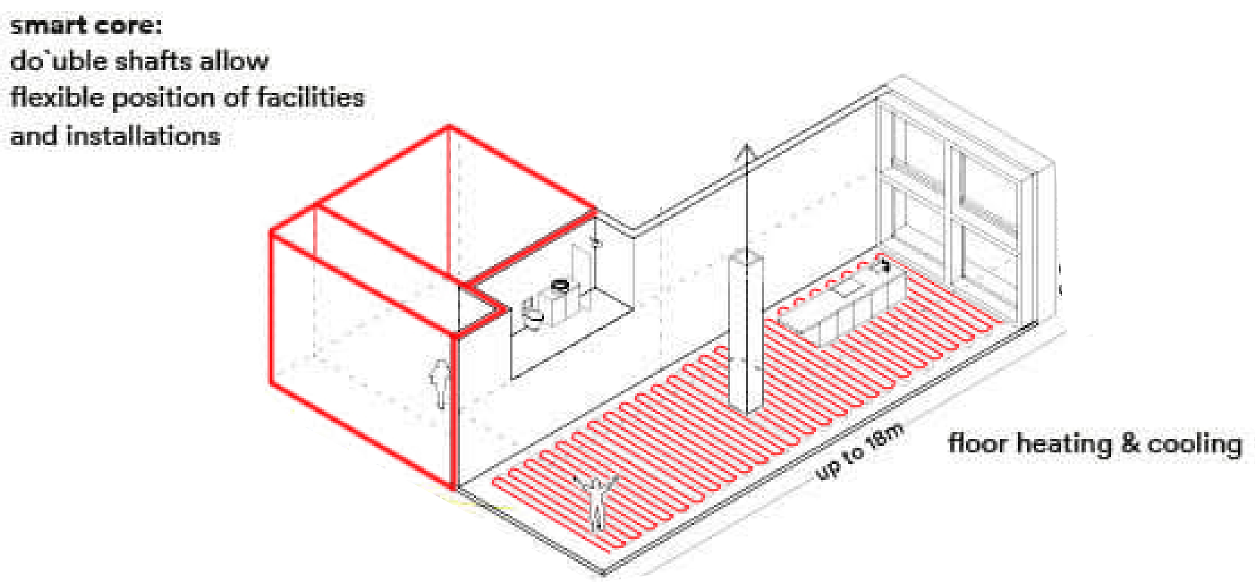


Figure 42. Design strategies marked with red (Support) or blue (Infill). (Source: Marc Koehler Architects, n.d.; modified by author).

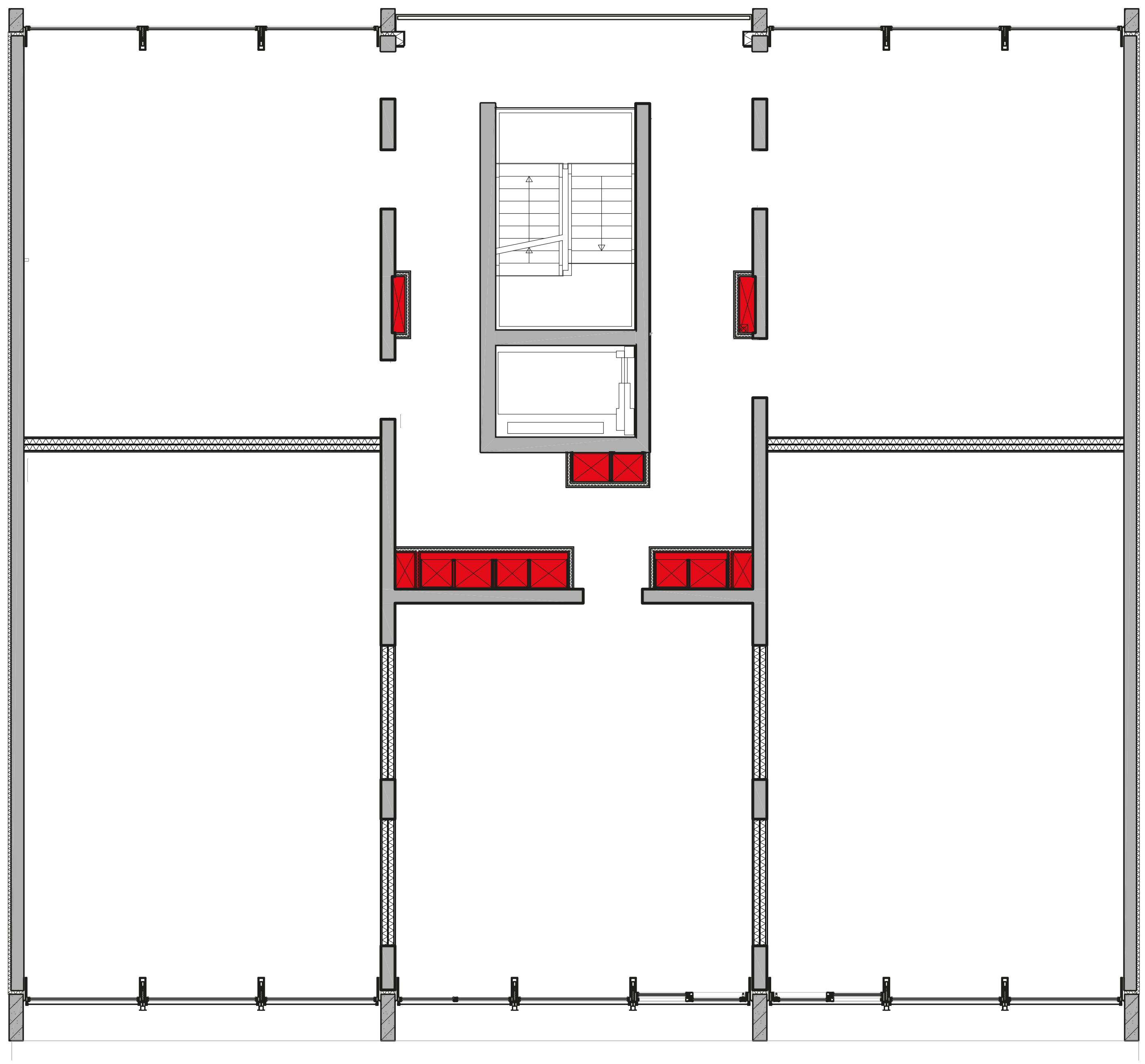


Figure 43. Vertical Service Infrastructure distribution. (Source: Marc Koehler Architects, n.d.; modified by author).

DC 3

Superlofts Houthavens Plot 4 meets Design Criterion 3. The base building, just as all other superlofts, is designed as an open, light, and spacious framework, enabling residents to create highly personalized living spaces.

Additionally, the online Superlofts community, through its "Superliving" platform, supports residents by providing inspiration, exchanging ideas, sharing building tips, and even offering digital drawings of building elements to copy elements of others. This collaborative approach fosters creativity and ensures that a variety of infill solutions can be integrated into the support structure.

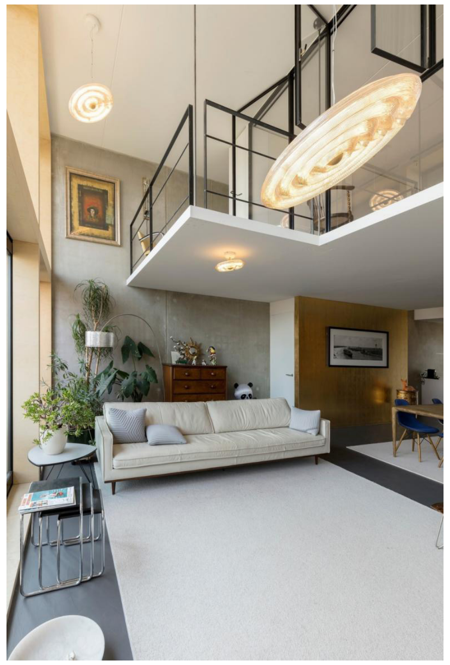


Figure 44, 45. Different Infill designs. (Source: World-Architects, n.d.)

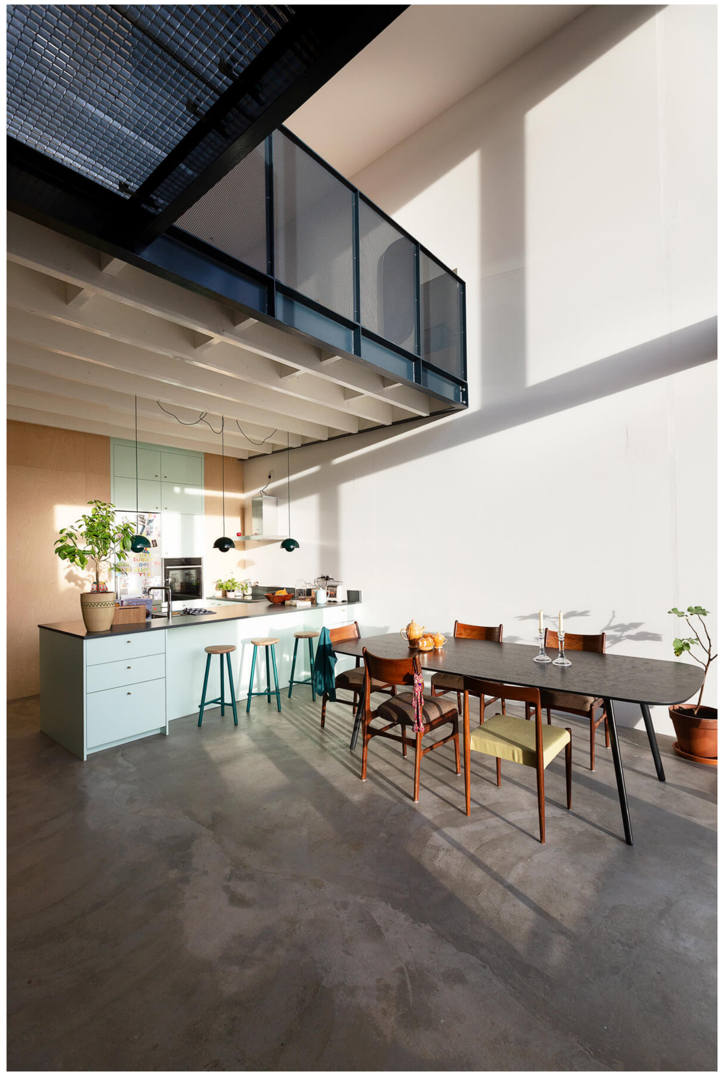


Figure 46, 47, 48. Infill designs from Superloft Houthavens plot 2. (Source: Superlofts, n.d.)

DC 4

Superlofts Houthavens Plot 4 partially meets Design Criterion 4 through the use of dry assembly methods. The infill components, including the mezzanine suspended from the concrete ceiling with steel pendels, as well as walls and doors, are installed using dry construction techniques.

However, it remains uncertain whether the CLT mezzanine floor can be removed or altered. As shown in the figure, the mezzanine consists of relatively large elements, raising questions about whether these components can be moved in and out of the dwelling without removing parts of the prefabricated façade or requiring other significant interventions.

The prefabricated façade, which is screwed onto the concrete load-bearing structure, could theoretically be temporarily detached, allowing larger elements such as the mezzanine floor to be transported into or out of the dwelling.

If this would not be possible and the mezzanine floor is fixed after the initial design of the apartment, it would then be considered part of the Support rather than the infill, as it would no longer be adaptable. Despite this uncertainty, the mezzanine floor system facilitates easy modifications to service infrastructure and other infill components through dry assembly methods, supporting the independent assembly, alteration, and removal of infill components.

To conclude, while the dry assembly methods allow for modifications to the infill, the removability and adaptability of the CLT mezzanine floor remain uncertain.

Figure 50. CLT mezzanine during construction. (Source: Marc Koehler Architects, n.d.)

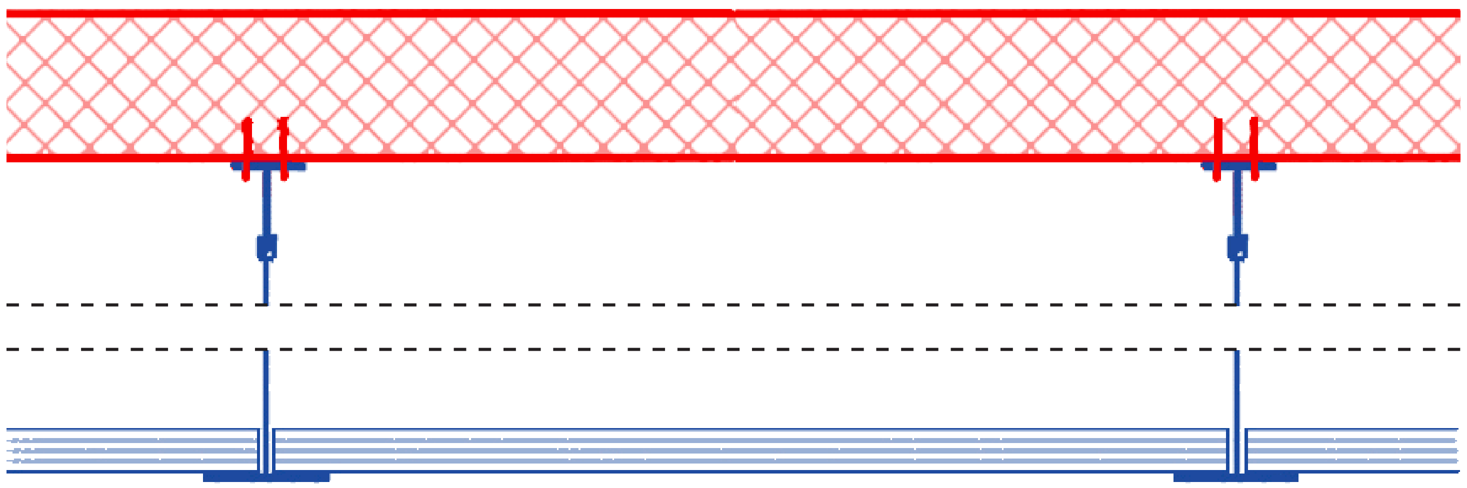


Figure 49. Dry assembly of CLT mezzanine, sketchdetail. (Own work)

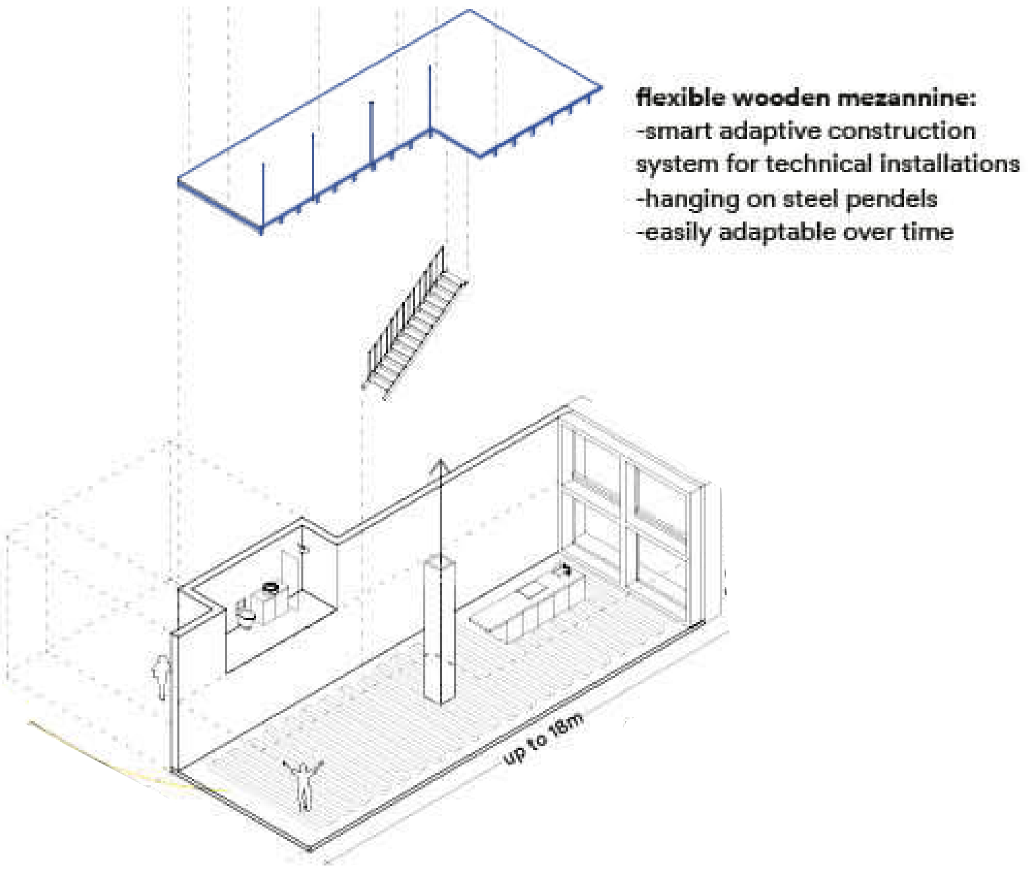


Figure 51. Design strategies marked with red (Support) or blue (Infill).. (Source: Marc Koehler Architects, n.d.; modified by author).

The previous plots (1 and 2) used a different system where timber was placed between fixed steel cross beams. This approach is potentially less adaptive than the system in Plot 4 due to the weight of the fixed steel beams. However, it could also be considered more adaptive, as the elements could be (dis)assembled and transported through an opened door, eliminating the need to remove parts of the façade.

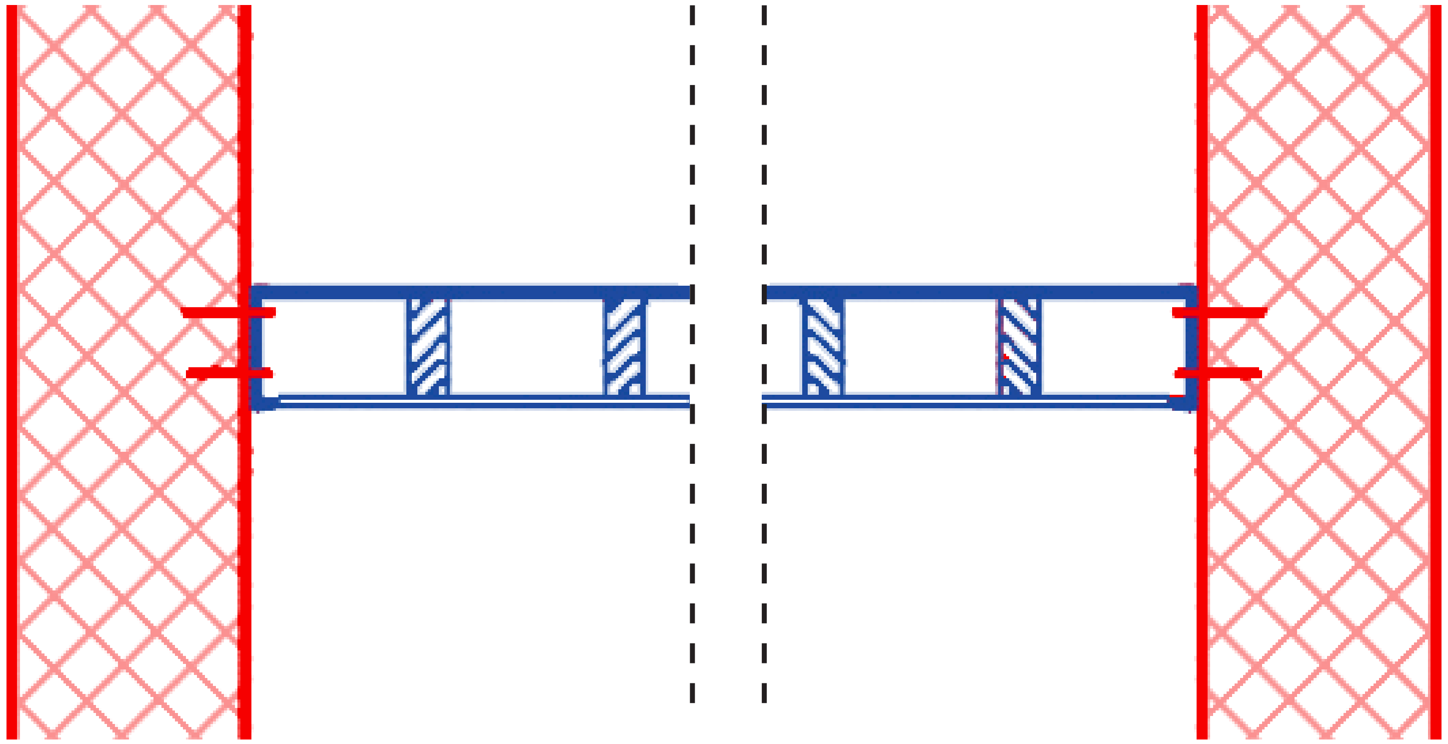


Figure 52. Steel crossbeam within Superlofts Houthavens plot 2, sketch detail. (Own work)

Figure 53, 54. Steel crossbeam supporting the mezzanine floor. (Source: Superlofts, n.d.)

DC 7

Superlofts Houthavens Plot 4 possibly meets Design Criterion 7. The façade is a prefabricated system with a steel beam and aluminum framing. Window frames are tailored to each unit layout and offer flexibility in partitioning and opening systems, at least for the first apartment. While not explicitly stated by the architect, it is possible that these openings could be altered in the future, making parts of the façade potentially adaptable and part of the infill.

Concrete balconies are variable according to the interior layout, but it also remains unclear whether they can be adapted after the initial implementation for the first apartment.

If future alterations to the façade, including window frames and balcony configurations, are feasible, the façade can be considered (partly) part of the infill.

Further clarification from the architect is needed to confirm whether these components can be modified in the future to perfectly fit future infill designs.

Figure 56. Different façade designs. (Source: Marc Koehler Architects, n.d.)

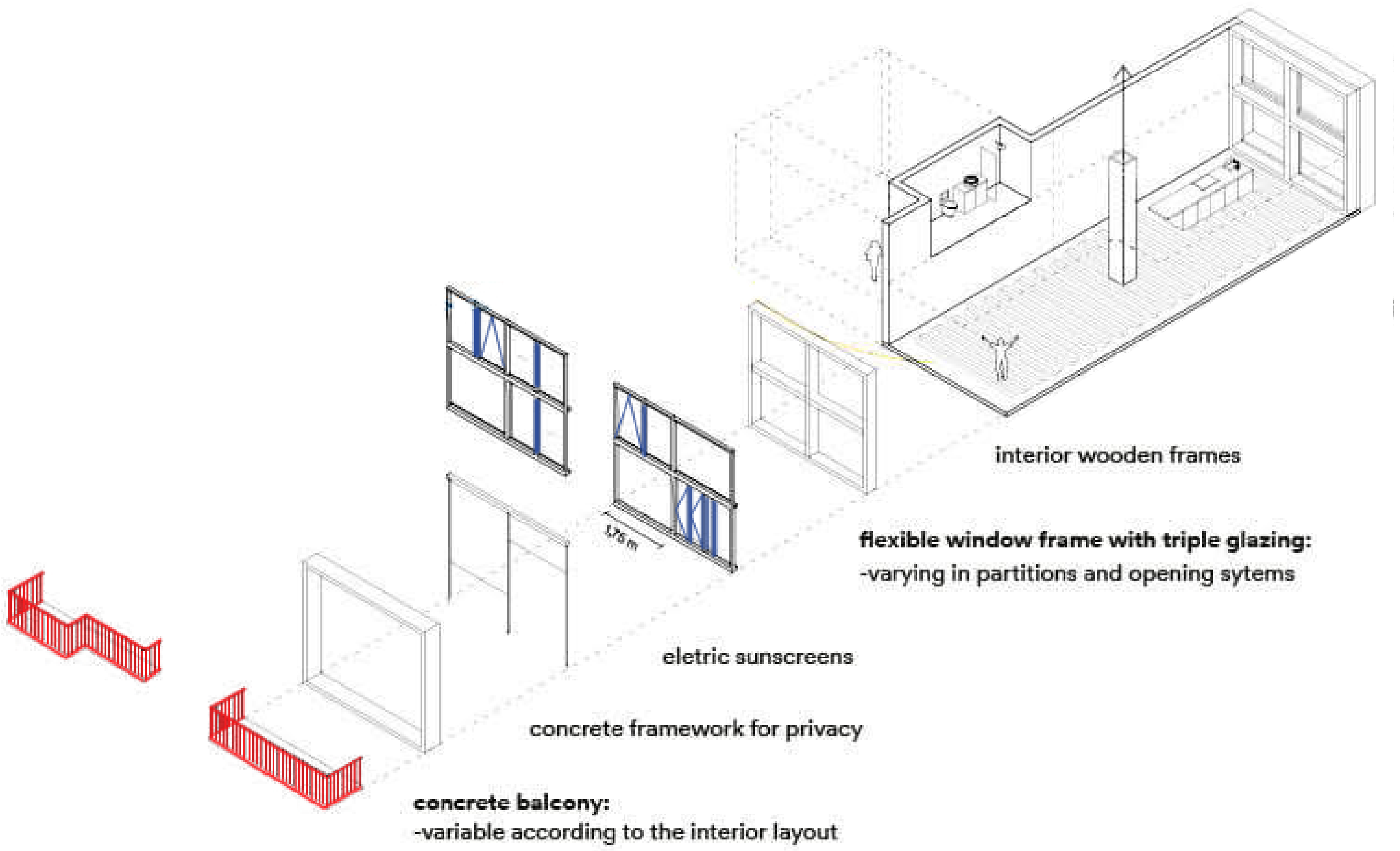


Figure 55. Design strategies marked with red (Support) or blue (Infill). (Source: Marc Koehler Architects, n.d.; modified by author).

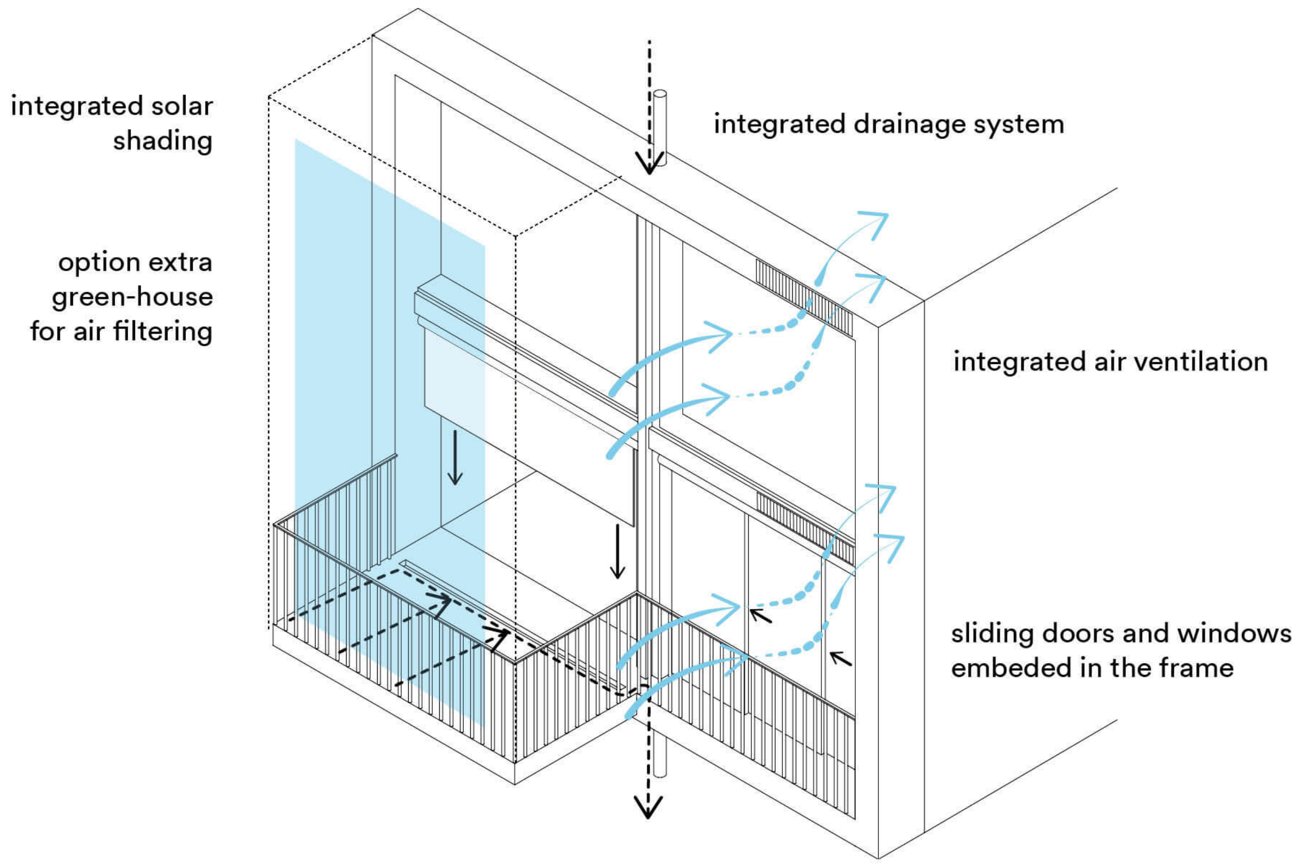


Figure 57. Prefabricated façade system. (Source: Marc Koehler Architects, n.d.)

DC 8

Superlofts Houthavens Plot 4 meets Design Criterion 8 to some extent, but with notable limitations. It is possible that services are delivered capped off, similar to the approach used in the TOPUP project (right down figure), leaving the responsibility of the horizontal service infrastructure distribution to the infill.

Supply points for services are located in the entrance hall of each floor, allowing residents to extend powerlines and utilities **through interior walls** (see middle figure below) **and the CLT mezzanine floors**. According to the architect, the design enables wet areas, such as kitchens and bathrooms, to be positioned almost anywhere within the living space.

The support itself **does not provide a built-in system**, such as a slimline floor, which integrates horizontal service distribution directly into the support. Superlofts only provides supply points at the central hall of each floor. This limits the extent to which the Service Infrastructure **actively supports** the adaptability of the space plan.

For these reasons, the Service Infrastructure in Superlofts Houthavens Plot 4 does not fully meet the criterion of creating sufficient freedom to adapt the space plan. Instead, it shifts the responsibility for adaptability to the infill.

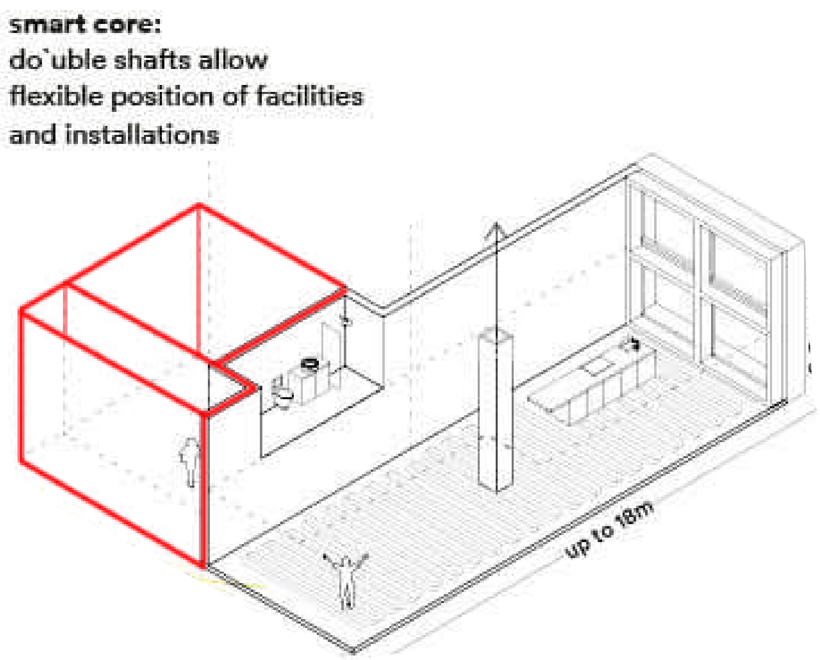


Figure 58. Design strategies marked with red (Support) or blue (Infill).. (Source: Marc Koehler Architects, n.d.; modified by author).

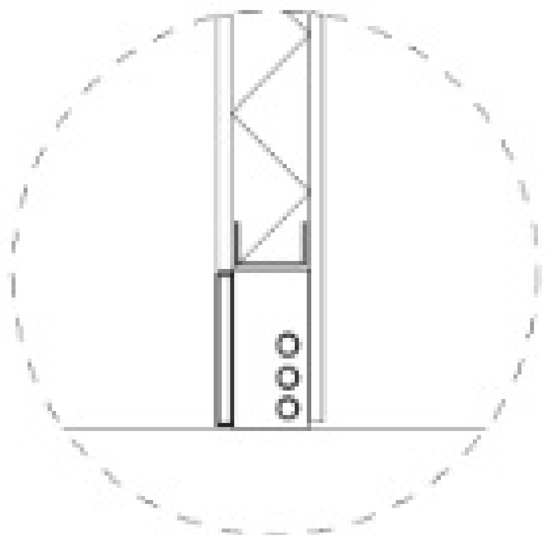


Figure 59. Electric wiring inside interior wall detail. (Source: Marc Koehler Architects, n.d.)

Figure 60. Capped of delivery of piping, example from TOPUP. (Source: Frantzen, 2021)

DC9

Superlofts Houthavens Plot 4 partially meets Design Criterion 9. The vertical shafts contain all necessary service infrastructure, providing accessibility for maintenance and potential adjustments. From these vertical shafts, pipes are distributed horizontally into the entrance hall of each dwelling as supply points for the dwellings. However, it is assumed that sleeves are used to pass through the concrete for this horizontal movement, which slightly interferes with the structural support. This connection between the service infrastructure and the support structure impacts the overall adaptability and ease of modification, as any changes would require coordination with the structural components.

Additionally, the floor heating and cooling distribution system is most likely embedded in the base buildings floor, further limiting its independence and replaceability. These factors result in the service infrastructure being only partially compliant with this criterion.

3. Next 21 - Yositika Utida

DC 1A

NEXT21 fully meets Design Criterion 1A, as the project was explicitly designed for adaptability of layouts within its support structure. The building adopts the principles of the Century Housing System (CHS), which separates the long (century)-lasting structural skeleton from the infill components with a shorter life span.

The 23 'units', as literature calls them, were designed by 13 different architects. Each unit's interior and exterior layout was freely designed within a set of rules. These set of rules follow three design strategies and form the foundation of NEXT21's adaptability.

1. The **open column-beam framework** allows for the elimination of load-bearing walls, providing freedom in placing exterior walls and designing interior layouts.

2. The **building assembly method**, with its four distinct subsystems for 1. structure, 2. cladding, 3. infill, and 4. services, ensures flexibility by allowing independent assembly, alteration, or removal of components.

3. The project is structured around a **30-centimeter modular grid framework**, forming the foundation for its flexible and adaptable design. All elements of all subsystems follow the modular grid, enabling seamless reconfiguration and compatibility with the skeleton.

The combination of this open structural framework allows NEXT21 to offer a variety of layouts tailored to diverse user needs.

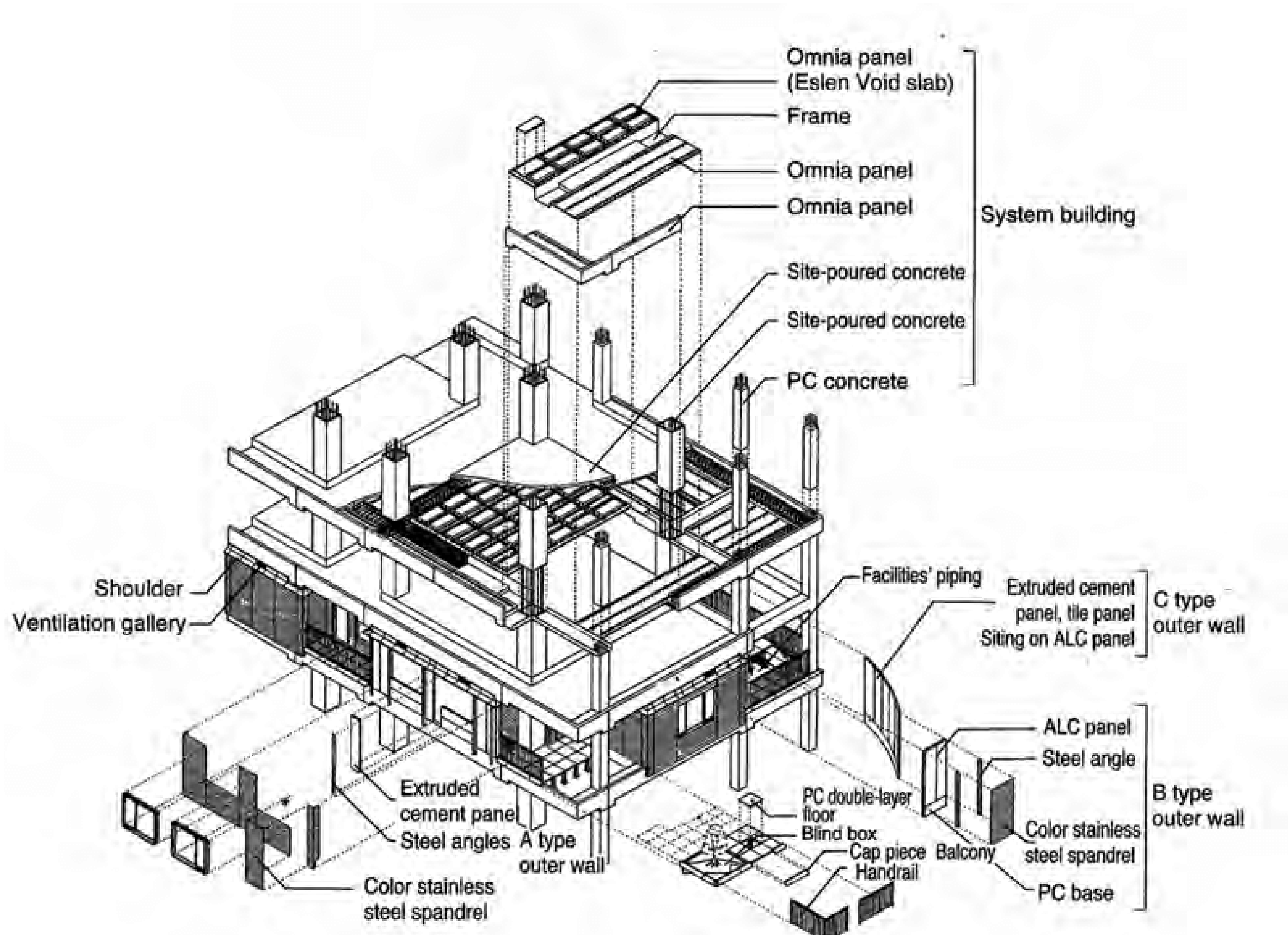


Figure 61. Design strategies. (Source: Osaka Gas Co, 2015)

Figure 62. Rulebook next21. (Source: Osaka Gas Co, 2015)

The owners of the building (Osaka Gas Corporation) conducted two experiments to test the adaptability of the building.

The first experiment, the adaptation of **unit 402** in 1996, aimed to meet the changing needs of a family of four by redesigning the space for greater functionality and comfort. Key strategies included joining terrace spaces, adding a tatami-mat room, relocating the kitchen to improve family interaction, and creating a brighter bathroom. Modular outer walls and flexible piping systems enabled the relocation of water-related facilities and the recycling of components.

While the redesign successfully improved usability and demonstrated the flexibility of NEXT21's construction system, the experiment faced challenges. Interior finishing materials could not be reused, and the high cost (29 million yen) and long timeline (4 months) were significant drawbacks. Despite achieving its functional goals, the experiment highlighted the need for more efficient and cost-effective solutions, particularly for infill systems. This first experiment highlighted that the concept of adaptability was still in its early stages and did not function as smoothly as intended by the architects

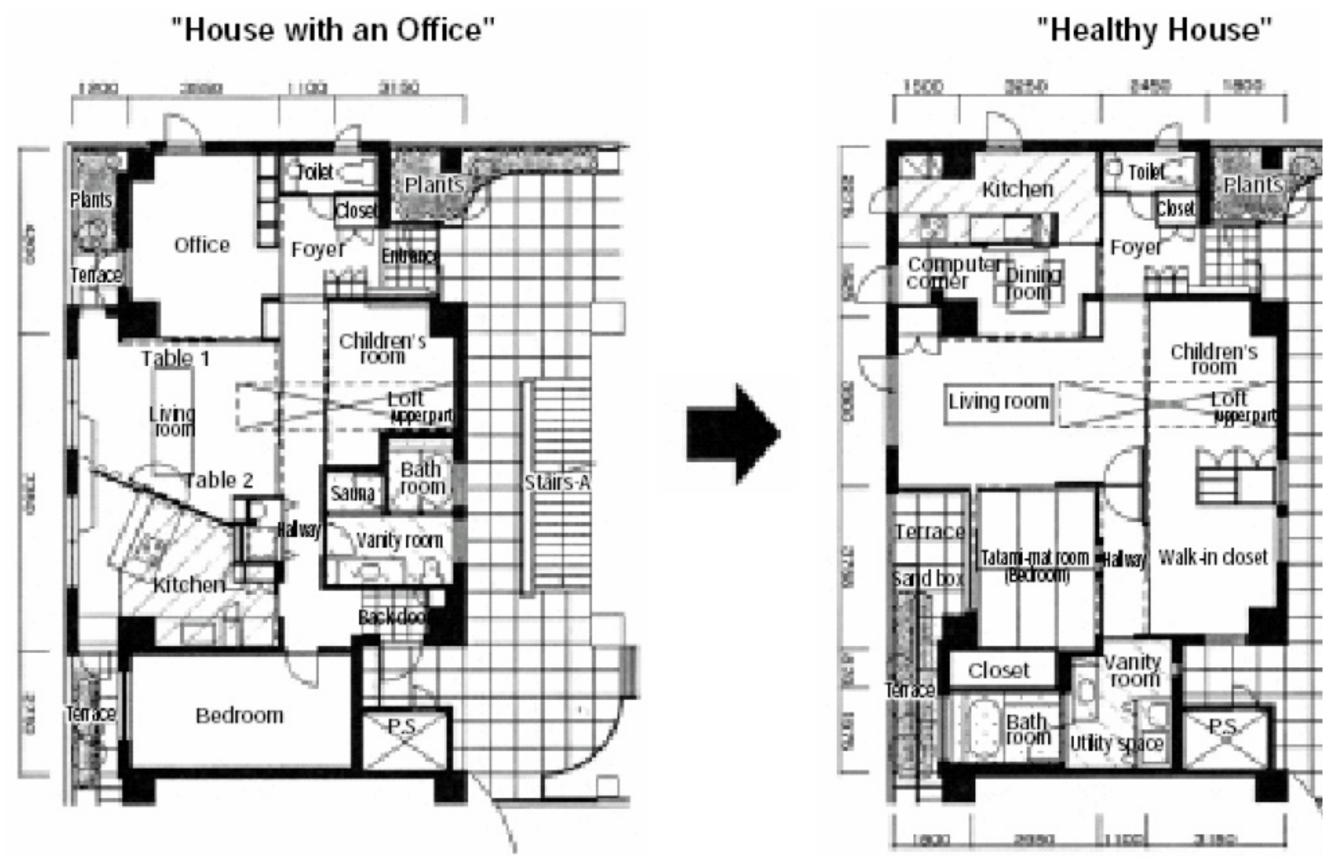


Figure 63. Adaptation of unit 402 (Source: Sasakura, 2005)

The second experiment, the adaptation of **unit 405** in 2003, was carried out in two phases to accommodate the evolving needs of diverse households using a scenario-based planning approach. Strategies included converting a concrete-floor room into a tatami-mat space, relocating the kitchen and floor heating, expanding the bedroom, and utilizing movable partitions and storage furniture. Flexible piping and modular construction systems supported these changes without damaging the base structure.

The experiment was highly successful, with 85% of infill components reused, reducing waste and costs. The remodeling was completed efficiently in 14 working days at a cost of 2 million yen. However, practical issues such as limited storage options for reusable components indicated room for improvement. Overall, this experiment demonstrated significant advancements in adaptability, efficiency, and sustainability.

If you are more interested in these two experiments please read *"Variable infill system rearrangement experiment for residence 405 at Osaka Gas experimental housing NEXT21"* Hiroyuki Sasakura, 2005.

Figure 65, 66, 67. Tatami-mat room before and after. (Source: Sasakura, 2005)

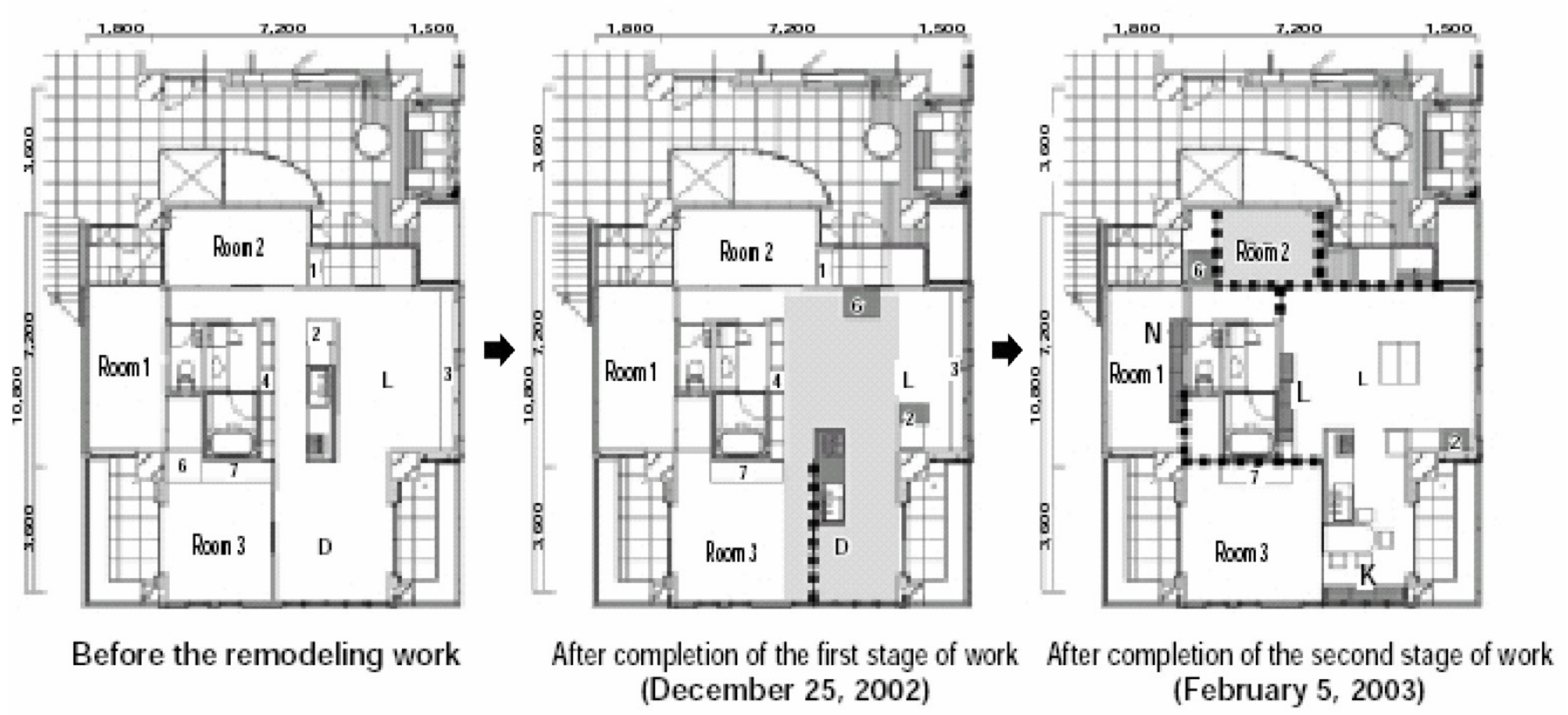
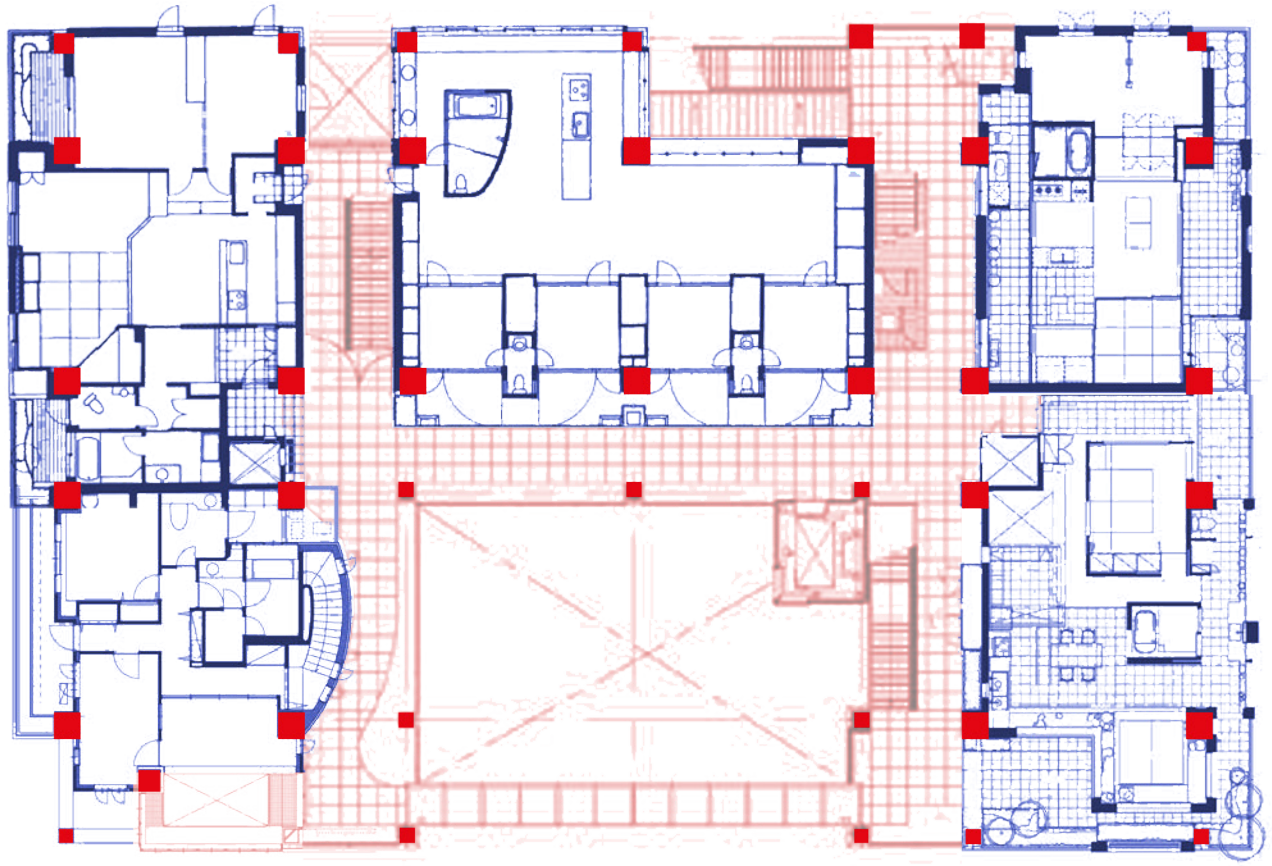


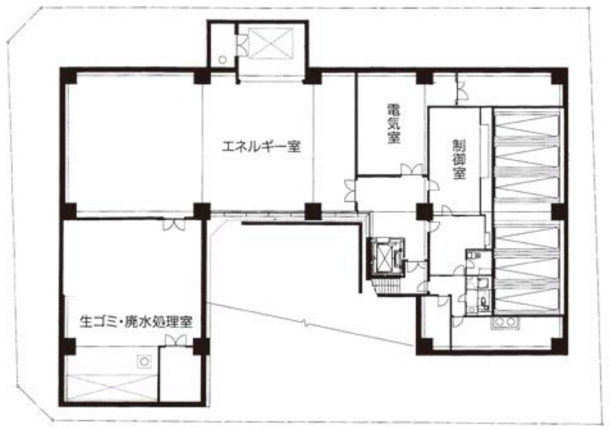
Figure 64. Adaptation of unit 405 in two phases. (Source: Sasakura, 2005)

Figure 68, 69. Living room before and after. (Source: Sasakura, 2005)

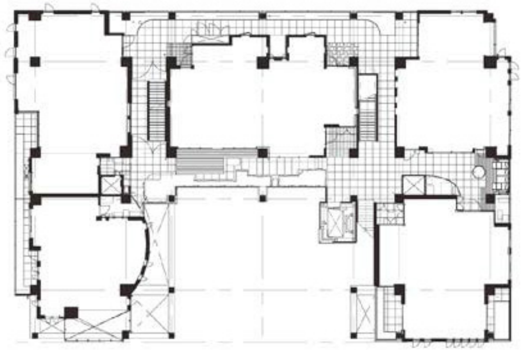


Figur 70. Floorplan 3rd floor, Infill (blue) and Support (red) highlighted (Source: Osaka Gas Co, 2015; modified by author)

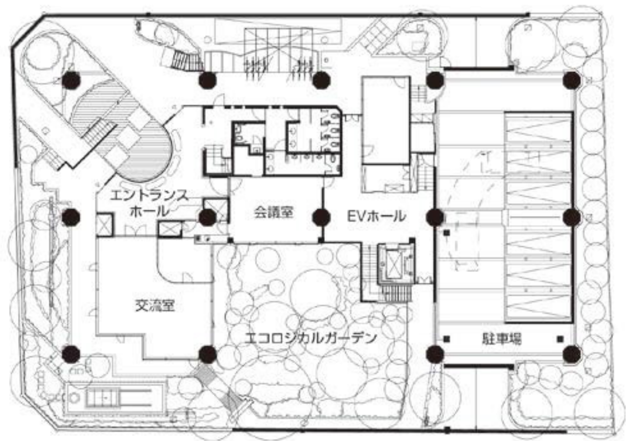
Figur 71: Floorplan 3rd floor, 5 seperate dwellings/islands placed on the support structure (Source: Osaka Gas Co, 2015)



Basement/garage

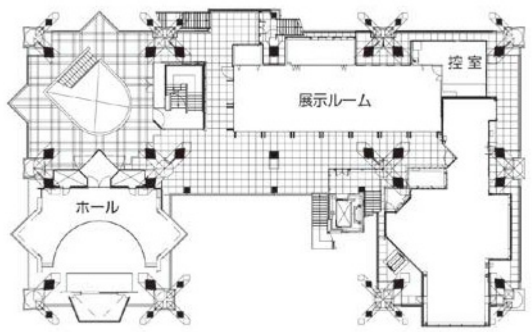


4th floor

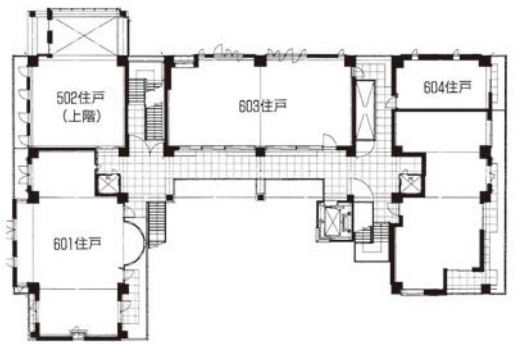


First floor

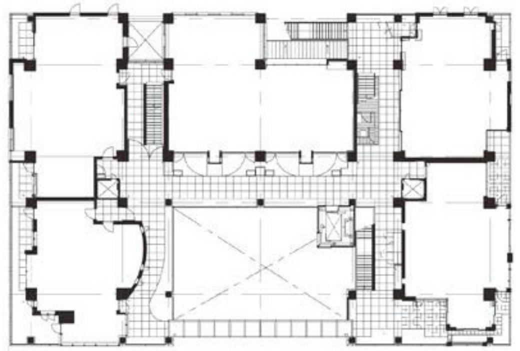
5th floor



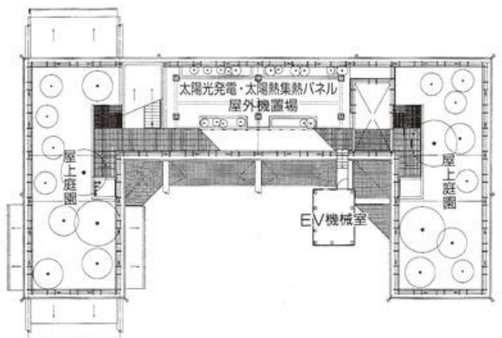
2nd floor



6th floor



3rd floor



roof

Figur 72, 73, 74, 75, 76, 77, 78, 79. Floorplans of every floor within Next21 (Source: Osaka Gas Co, 2015)

DC 1A

Additionally, exterior walls of the dwellings are part of the infill as can be seen in the figure. This design choice means that the façade in NEXT21 is part of the adaptable infill, allowing for even greater flexibility in unit configurations. (More details on this under DC4 & DC7.)

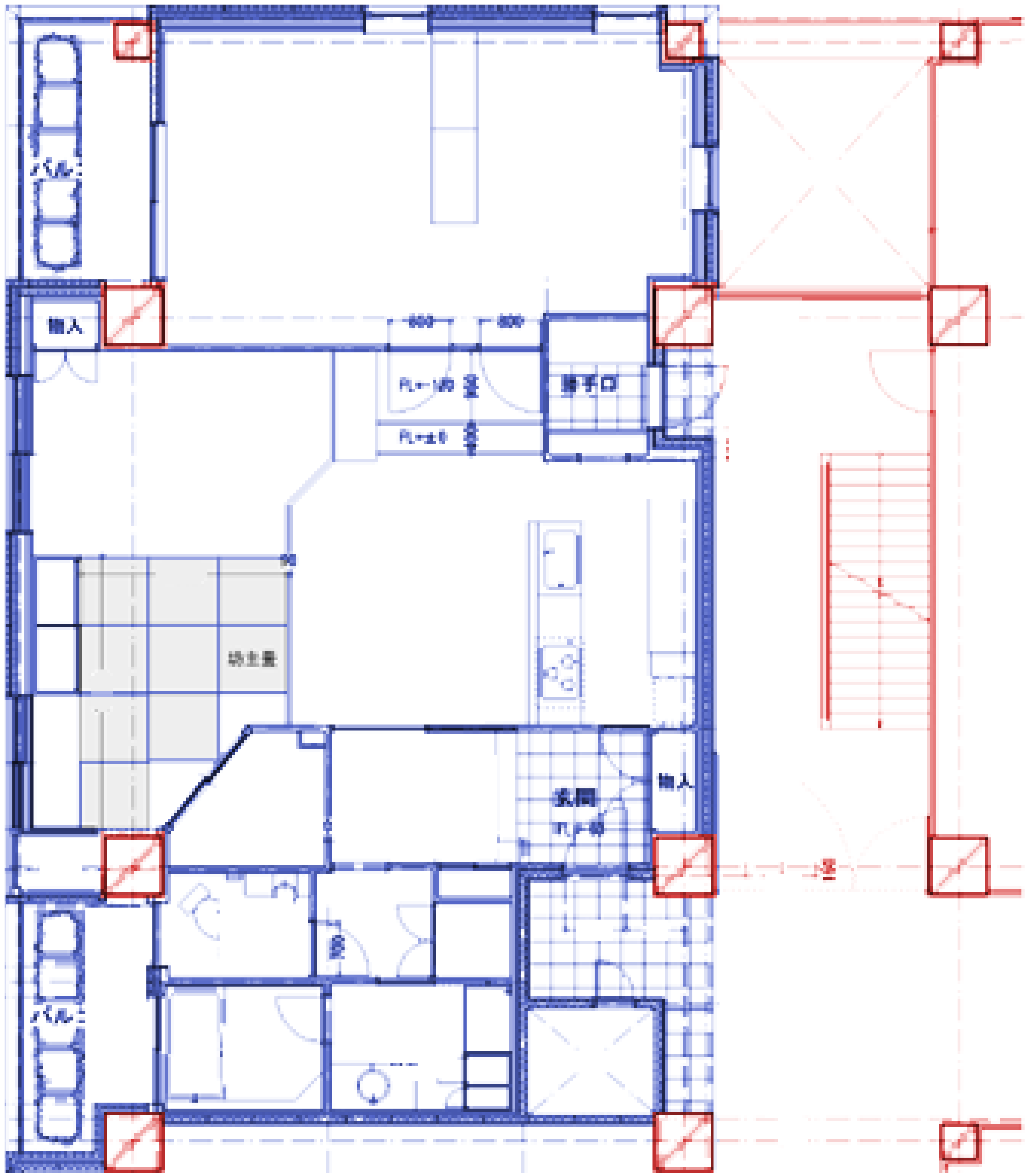
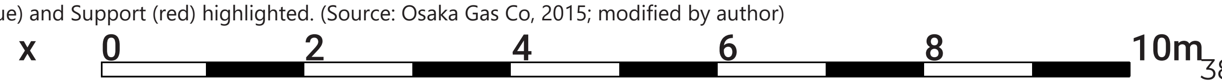


Figure 80. Unit 302, Infill (blue) and Support (red) highlighted. (Source: Osaka Gas Co, 2015; modified by author)



DC 1B

NEXT21 meets Design Criterion 1B through its **open structural system**, which is designed as a rigid-frame structure with 240 mm-thick slabs, ensuring stability and flexibility. The thick column-beam framework, which absorbs earthquake forces eliminates the need for load-bearing walls.

This open framework **in combination with the building assembly method** enables the placement and replacement of exterior walls and the design of interior layouts to accommodate a variety of dwelling types that are adaptable in the future.

An example of NEXT21's flexibility can be seen in the transformation of unit 404, which was split into two separate units (404 and 405) in September 1999. The modular exterior walls were successfully removed and relocated to fit the new housing plans. The north unit reused almost all existing infill components to reduce costs, while the south unit underwent a complete redesign with new infill and water facilities. The remodeling took approximately 2.5 months and cost 9.5 million yen.

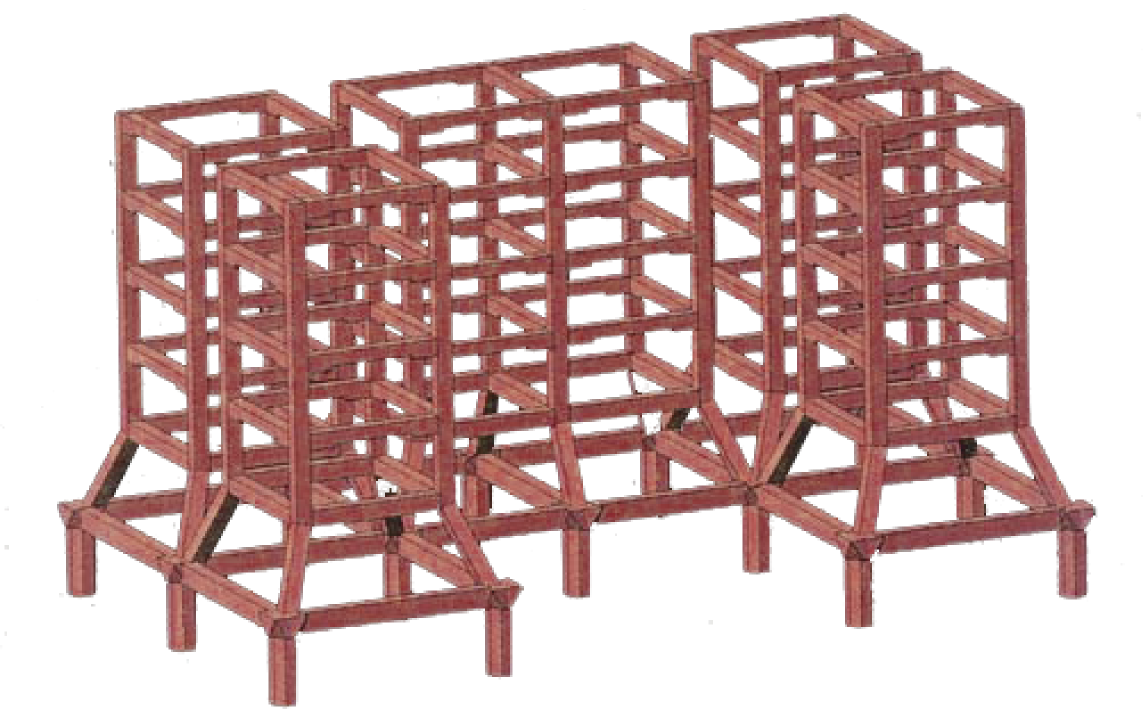


Figure 82. Isometric view of load bearing structure. (Source: Osaka Gas Co, 2015)

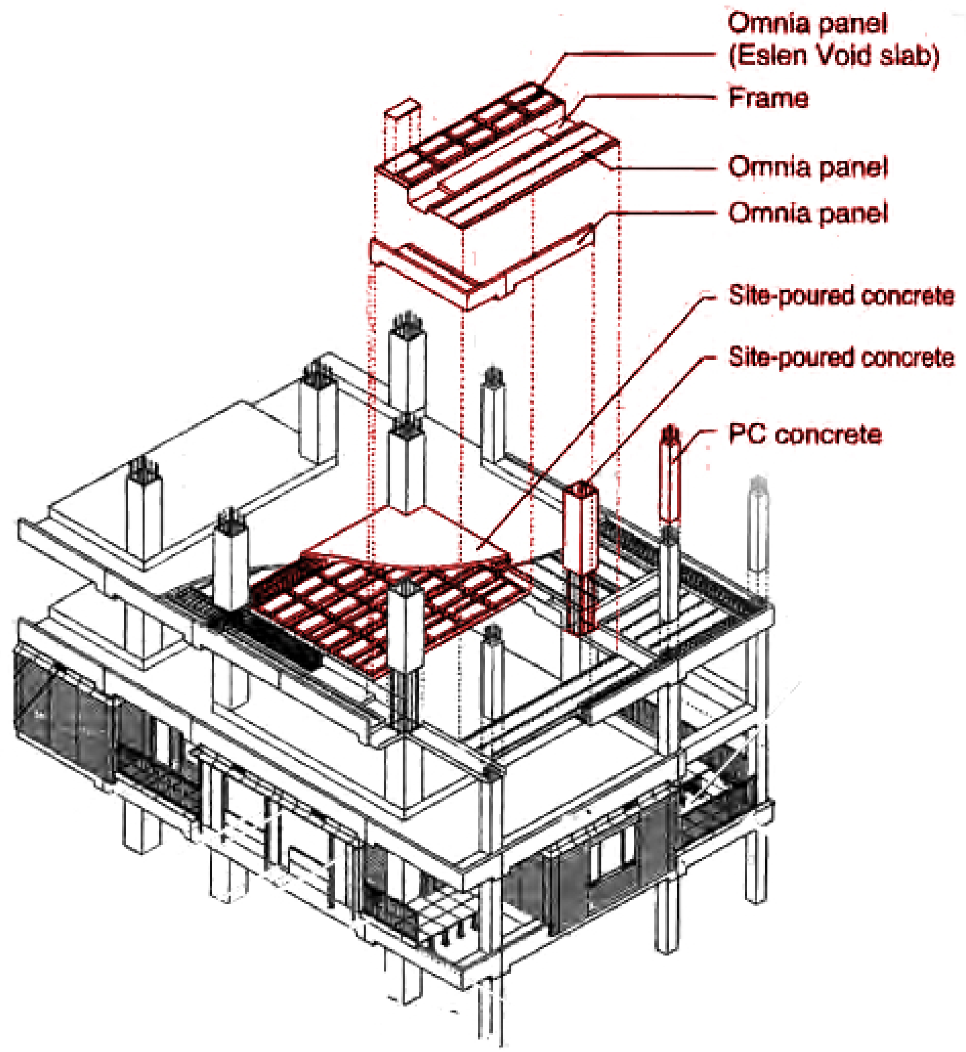


Figure 81. Isometric view of Support elements. (Source: Osaka Gas Co, 2015; modified by author)

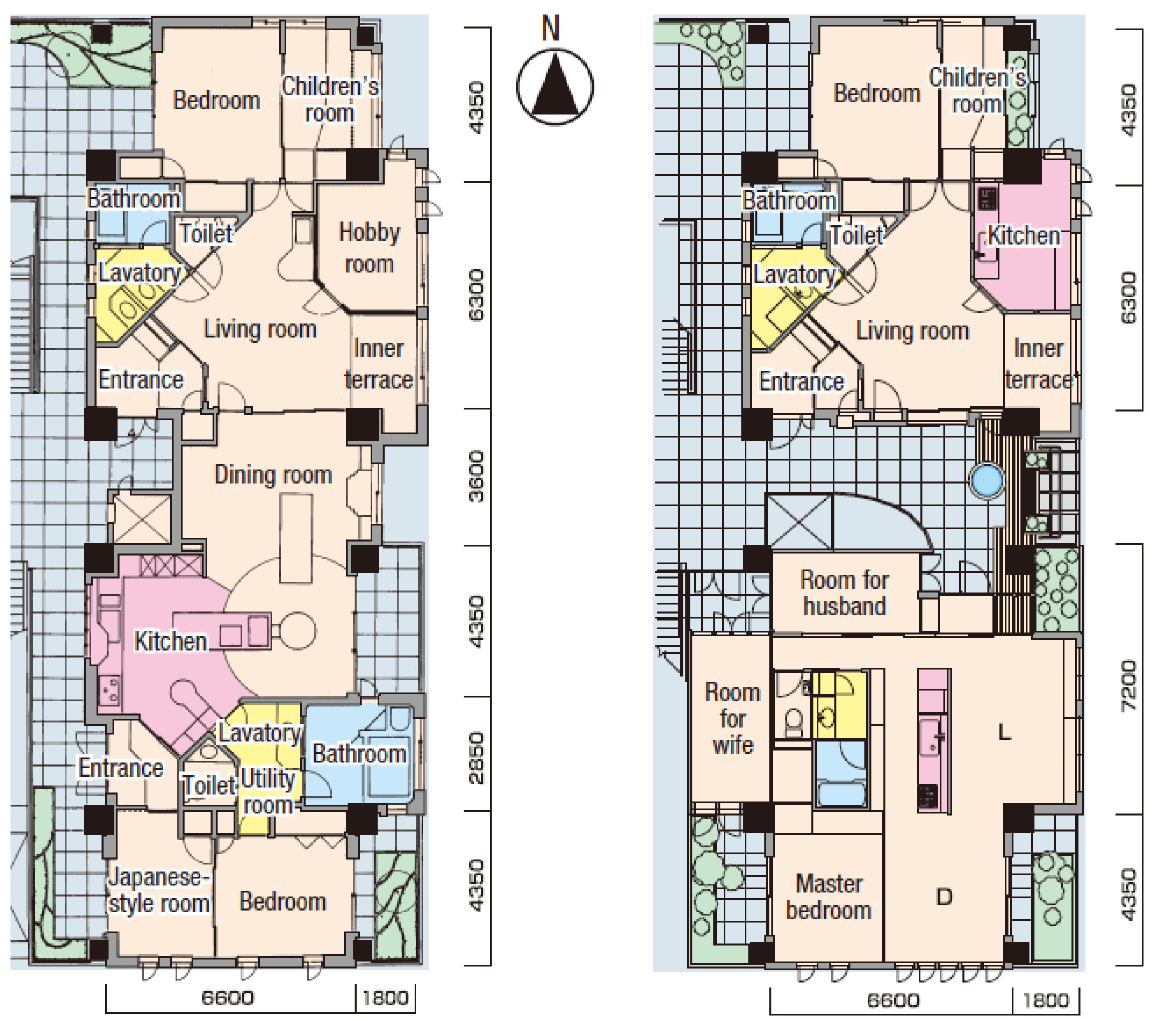


Figure 83. Splitting unit 404 into unit 404 and 405. (Source: Osaka Gas Co, 2015)

DC 1C

It is important to note that DC1C is difficult to assess, as it depends on a wide range of factors. These include not only the structural load-bearing capacity but also dimensions and other implications that are specifically linked to certain functions, as outlined in building regulations (Bouwbesluit). Reflecting such an extensive range of implications within this design criterion is nearly impossible within the scope of this research. Therefore, this analysis focuses primarily on the structural load-bearing capacity and/or the spaciousness of the structure.

NEXT21 does not meet Design Criterion 1C, despite already accommodating multiple functions such as residential, office, and commercial spaces. The building's design does not include explicit strategies to enable changes in function.

The different measurements for the residential and urban floors, with residential spaces being relatively spacious, suggest a certain level of capacity for adaptability. However, this is not sufficient to conclude that NEXT21 fully meets this criterion.

Additionally, there is no information in the literature regarding the load-bearing capacity of the structure or whether it has been enhanced to support functions requiring higher structural demands. This lack of evidence further indicates that NEXT21 does not fulfill the adaptability requirements of this design criterion.

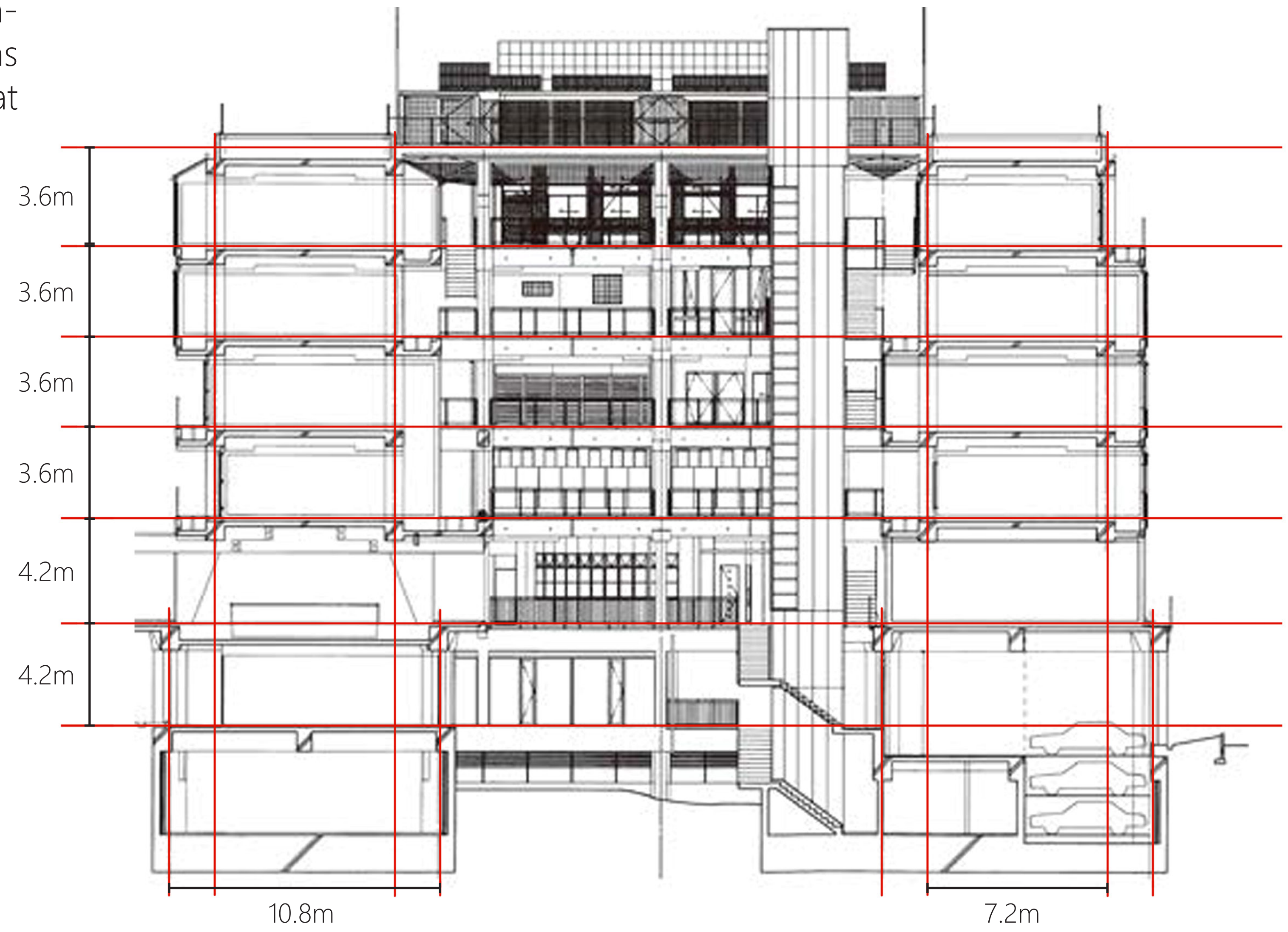


Figure 84. Structural measurements. (Source: Osaka Gas Co, 2015; modified by author)

DC 2

NEXT21 meets Design Criterion 2. The main horizontal utility zones are located under exterior corridors, known as "streets in the air," providing a centralized and organized approach to service distribution. However, while the horizontal distribution is well-documented, there is limited clarity regarding the vertical movement of building services. It is assumed that vertical service distribution occurs at the indicated locations in the figure below, but explicit details are not provided in the available literature.

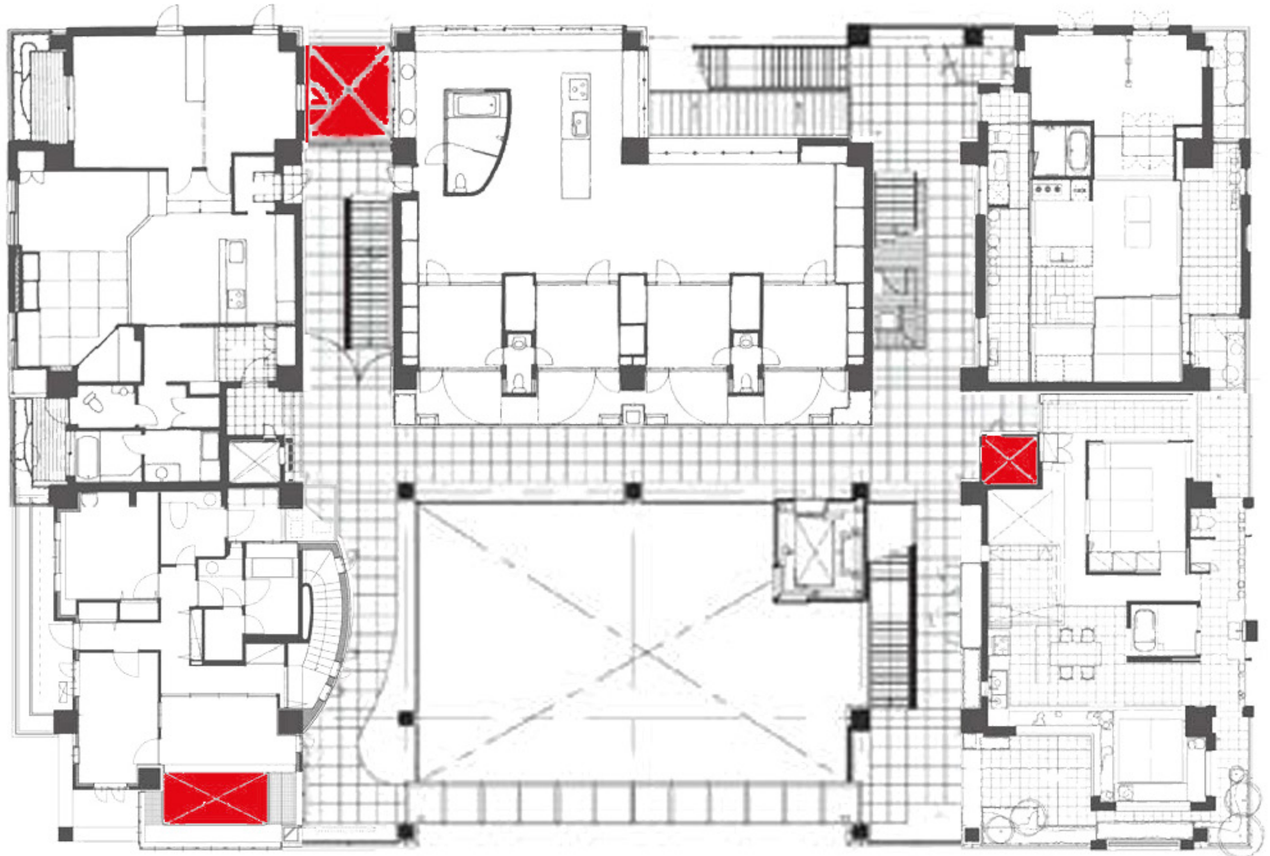


Figure 85. Vertical Service Infrastructure distribution, highlighted in red (Support). (Source: Osaka Gas Co, 2015; modified by author)

Figure 86. Horizontal Service Infrastructure distribution, highlighted in red (Support) (Source: Osaka Gas Co, 2015; modified by author)

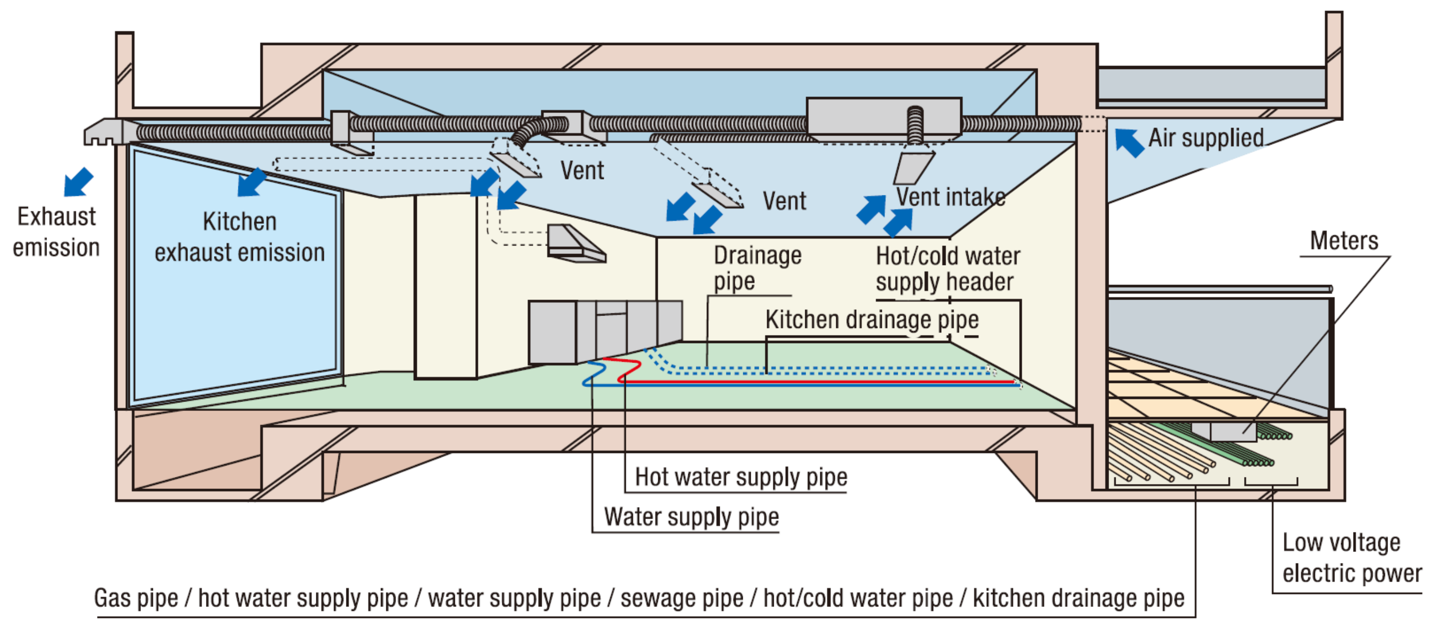


Figure 87. Utility distribution space above ceilings and under raised floors. (Source: Osaka Gas Co, 2015)

DC 3

NEXT21 fully meets Design Criterion 3, as the building's design accommodates diverse infill solutions through its variable subsystems and systematic grid-based framework. The subsystems are fixed using a **dry construction method**, enabling easy removal, relocation, or reuse without causing damage to exterior walls or adjacent infill components. This approach ensures flexibility and compatibility with a wide range of infill elements.

NEXT21 also addresses a common critique of systems buildings—that standardization limits creativity. By integrating non-standardized components, including one-of-a-kind products and handcrafted elements, it demonstrates that unique and creative customized designs can coexist within a highly systematic building framework.





Figure 88, 89, 90, 91, 92. Various Infill design. (Source: Osaka Gas Co, 2015)

DC 4

NEXT21 fully meets Design Criterion 4 through its application of a **modular grid** and **building assembly method**. These principles ensure that infill components, including service infrastructure, façades, and interior walls, can be easily adapted or replaced.

As stated earlier, the building assembly method divides the building into four subsystems: structure, cladding, infill, and services. All subsystems follow the **30-centimeter modular grid**, enabling them to be **independently assembled, altered, or removed** without affecting other components or the building's structural support.

The transformation experiment on unit 402 demonstrated this adaptability. All work was carried out from within the unit using hanging scaffolding, minimizing disruption to neighboring residents. A substantial portion of the removed materials -particularly from the façade- was reused successfully, which can be seen in the figure below.

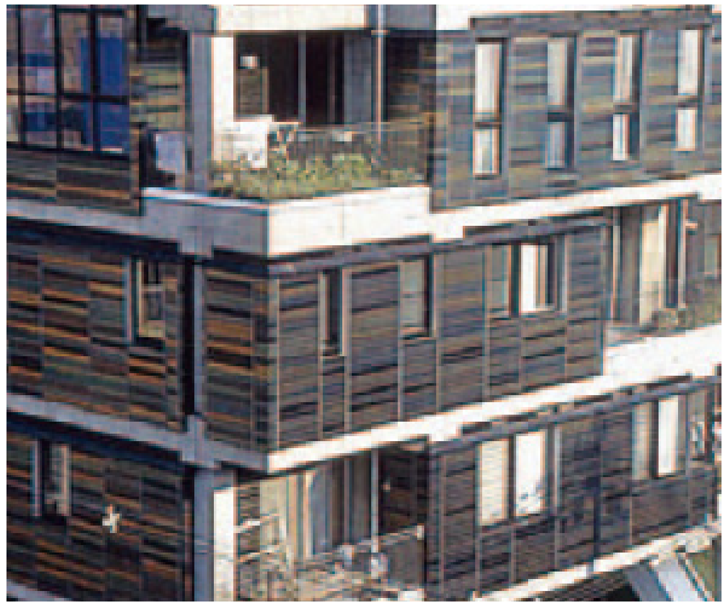


Figure 94, 95. Adaptation of façade, unit 402. (Source: Osaka Gas Co, 2015)

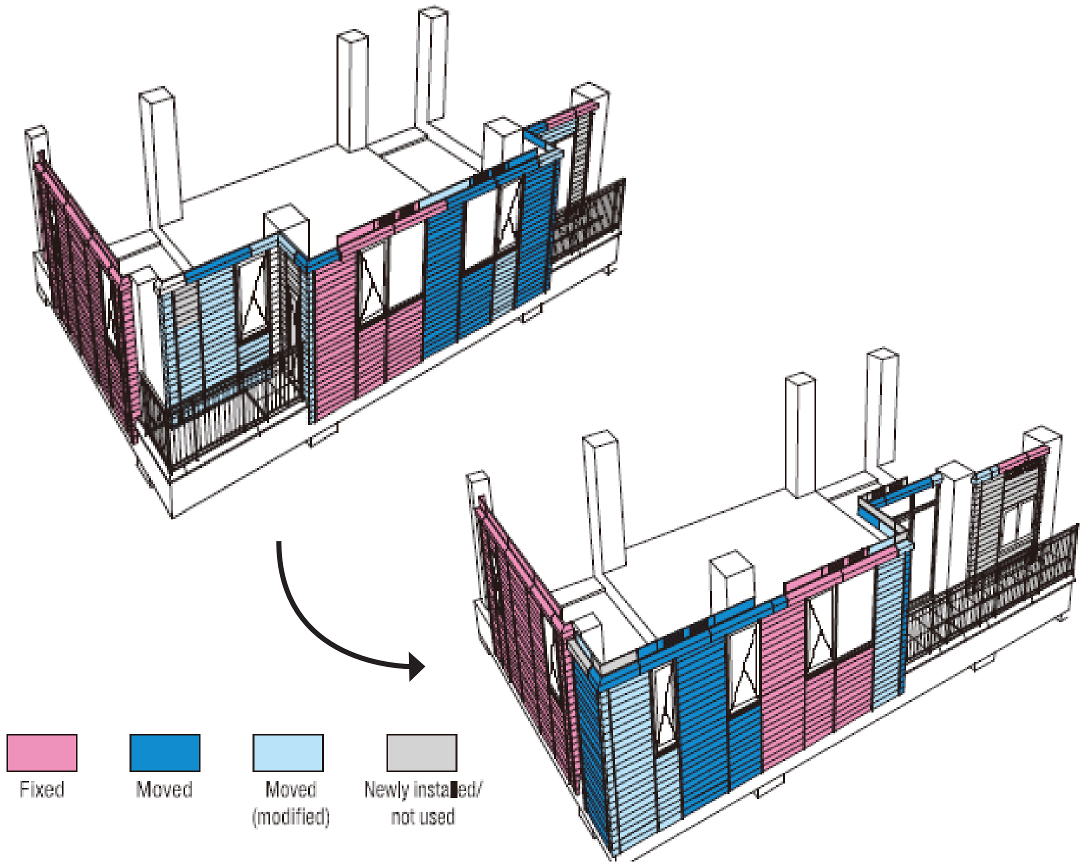


Figure 93. Adaptation of façade, unit 402. (Source: Osaka Gas Co, 2015)

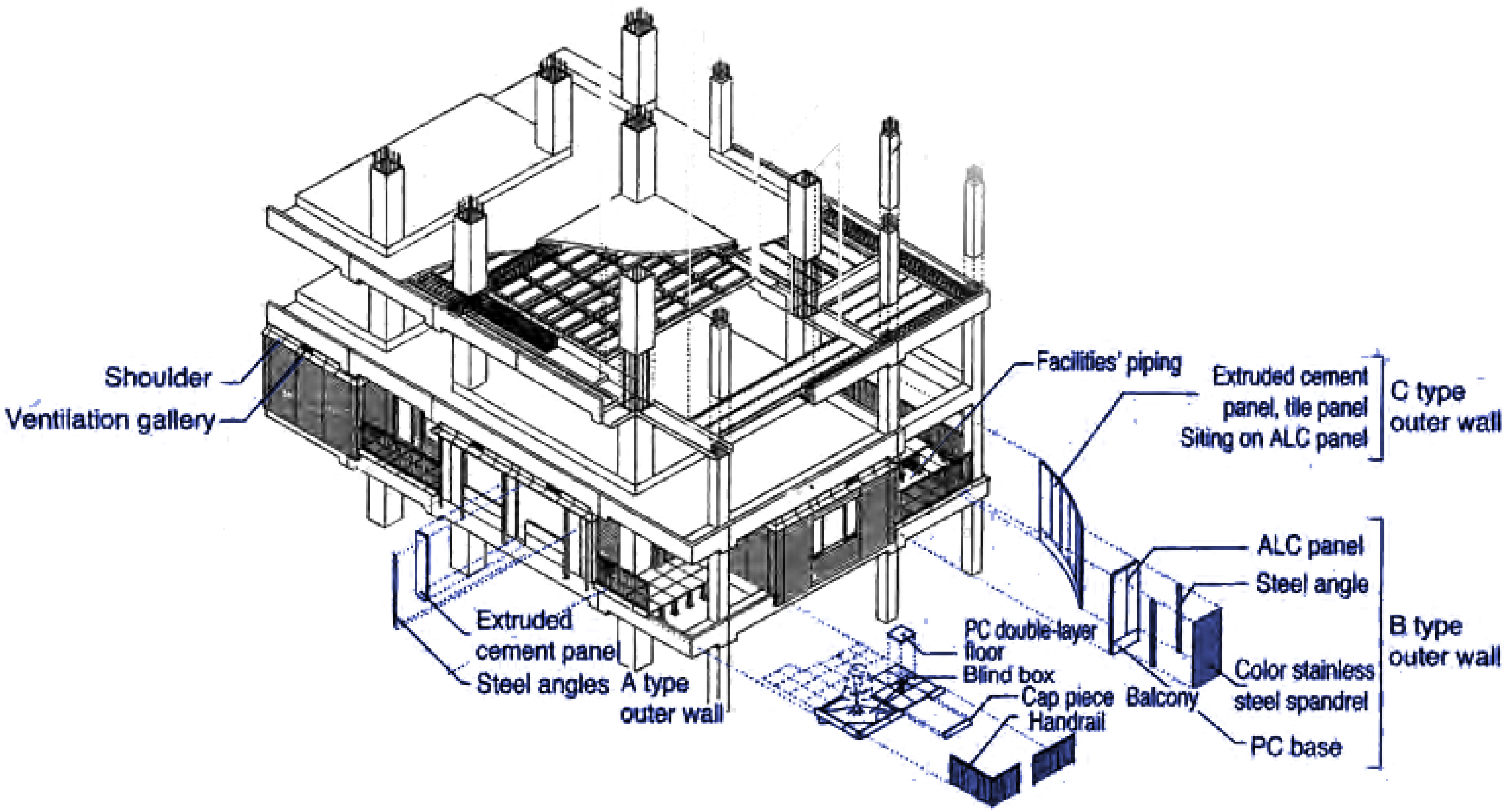


Figure 96. All infill design strategies highlighted. (Source: Osaka Gas Co, 2015; modified by author)

DC 7

NEXT21 meets Design Criterion 7, as the façade cladding follows the 30-centimeter modular grid, enabling elements to be removed, altered, and reassembled.

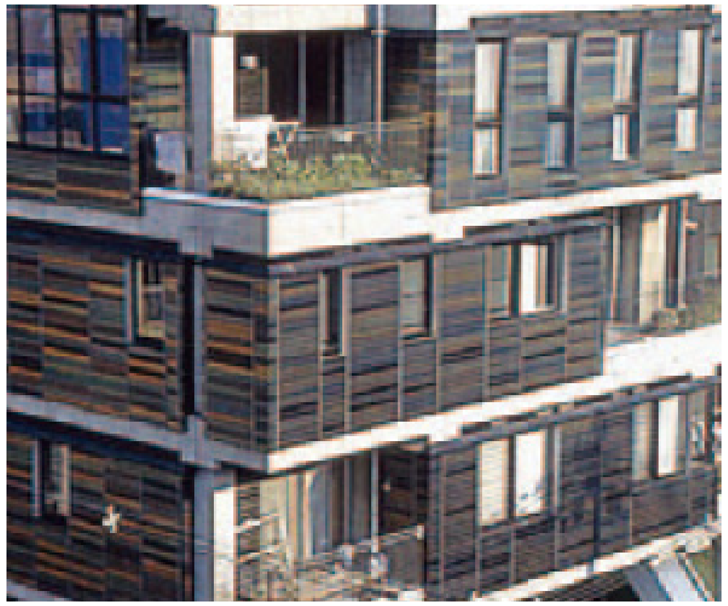


Figure 98, 99. Adaptation of façade, unit 402. (Source: Osaka Gas Co, 2015)

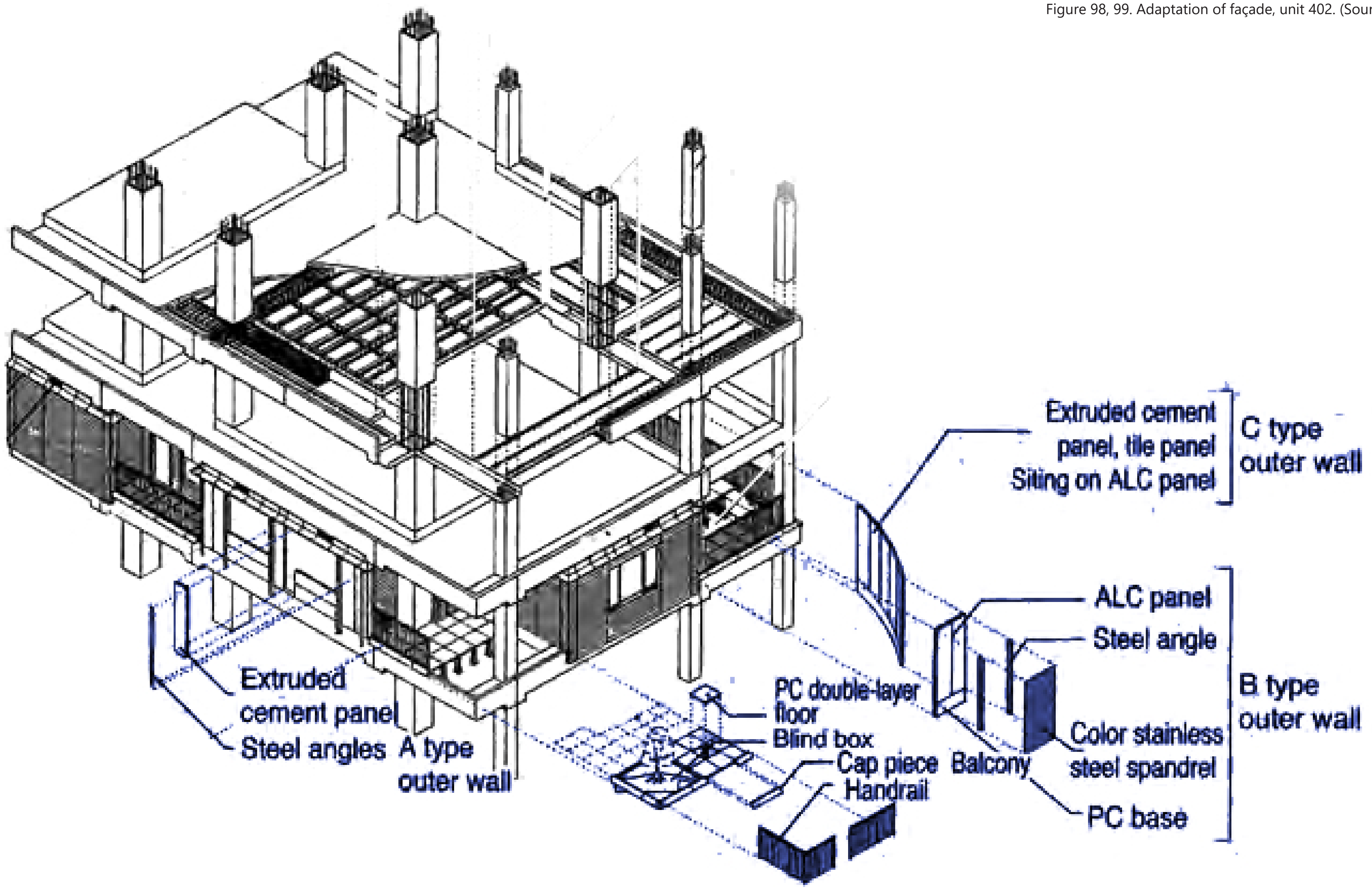


Figure 97. Different façade types, marked in blue (Infill). (Source: Osaka Gas Co, 2015; modified by author)

DC 8

NEXT21 meets Design Criterion 8 due to multiple strategies. Due to the building's generous floor-to-floor heights it is made possible to implement spaces above ceilings and under raised floors. This combined with the reduced depth of structural beams mid-span seperates results in the separtion of the service infrastructure and structural elements. Because of this system, water-related facilities, which are typically difficult to remodel in traditional multiunit housing complexes, can be reworked or relocated without damaging the buildings structure.

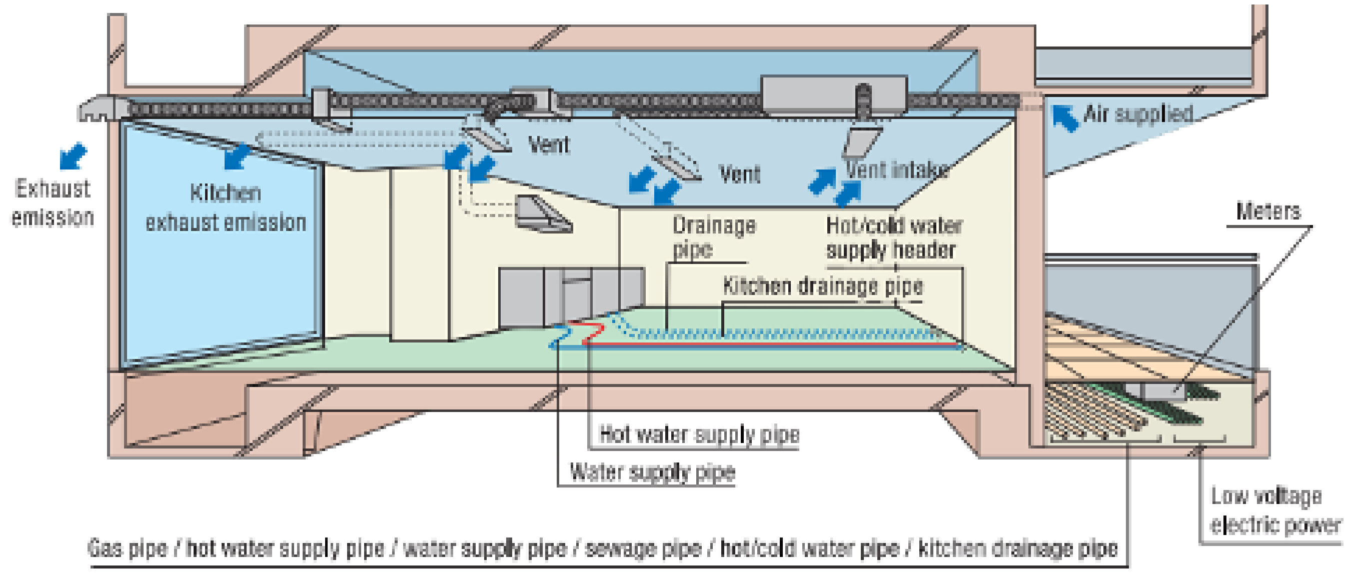


Figure 100. Raised floors and lowered ceilings provice space for Service Infrastructure. (Source: Osaka Gas Co, 2015)

NEXT21 meets Design Criterion 9 through the dry assembly of the four subsystems.

The infrastructure is routed under the common-use corridor, previously referred to as "streets in the air," where a reverse-shaped slab is used as piping space. From this space, services are distributed into individual units underneath raised floor surfaces, avoiding interference with the structural cross beams. This can be seen in the figure right below. The raised floor system allows easy access to the service infrastructure, as the panels can be removed for maintenance, upgrades, or replacement, as can be seen in the figure below.

This design ensures that the service infrastructure can be independently accessed and modified without impacting other building elements.

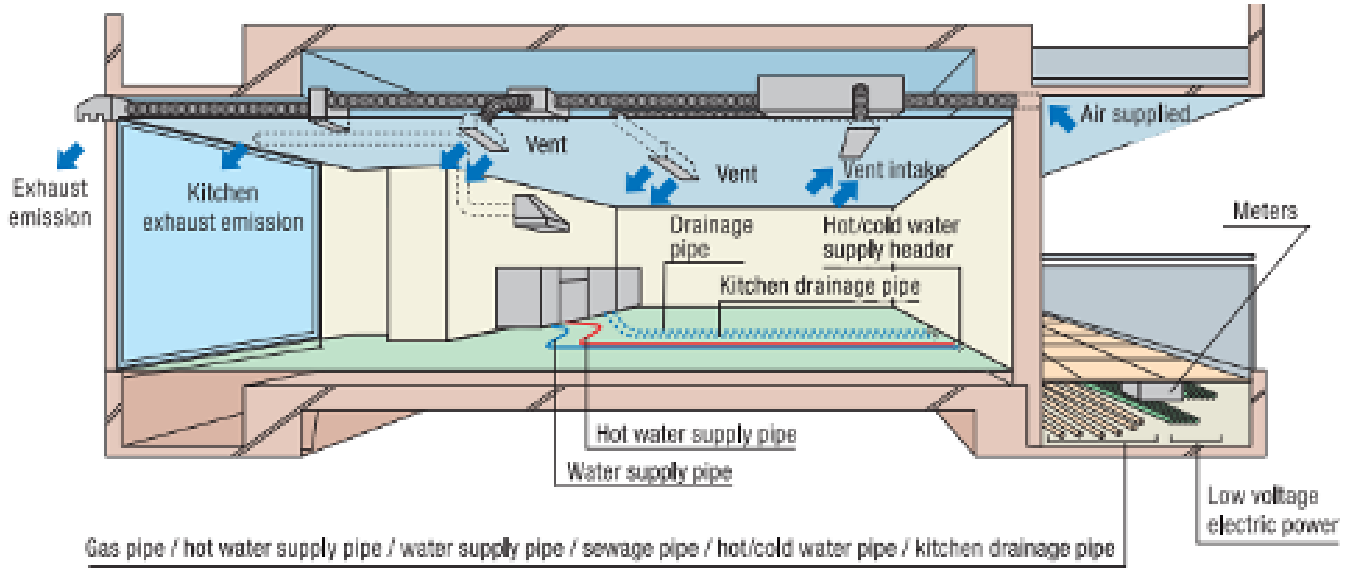


Figure 102. Raised floors and lowered ceilings provice space for Service Infrastructure. (Source: Osaka Gas Co, 2015)

Figure 101. Raised floor with removable top layer. (Source: Kim, 1993)

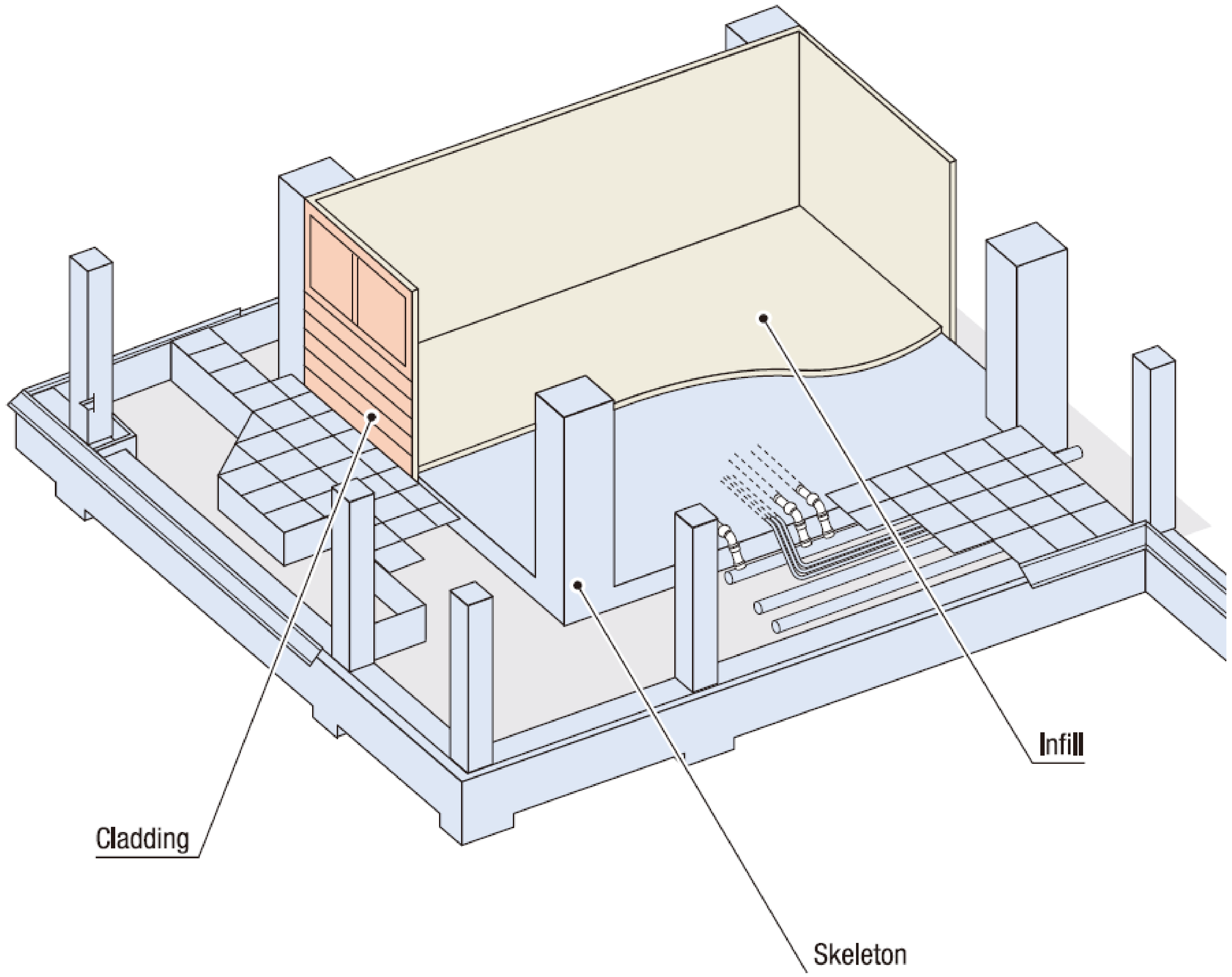


Figure 103. Building services entering a dwelling, isometric drawing. (Source: Osaka Gas Co, 2015)

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APPENDIX VI

TEXTUAL SUMMARY OF THE CASE STUDY ANALYSIS

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ABSTRACT

This appendix provides a detailed textual summary of the case study analysis conducted on three selected projects: Patch22, Superlofts Houthavens Plot 4, and NEXT21. The analysis evaluates how each project applies Open Building principles and meets the established design criteria.

All the key design strategies employed in each project are outlined, focusing on their successes, limitations, and alignment with Open Building principles. Examples include Patch22's Slimline Floor system, Superlofts' user-driven customization, and NEXT21's modular framework. (chapter 1) A detailed breakdown of all design strategies is provided for each case study. (chapter 2)

Finally, insights gained during the analysis are highlighted, such as the importance of separating Support and Infill, the need for service infrastructure integration, and the role of sustainable materials. It also addresses challenges encountered, such as limited documentation in the Superlofts case study and the practical limitations of certain strategies. (chapter 3)

INTRODUCTION

This appendix provides a comprehensive textual summary of the case study analysis, detailing how Patch22, Superlofts Houthavens Plot 4, and NEXT21 apply Open Building principles and meet the established design criteria. Each case study evaluation highlights the key strategies implemented, their alignment with the design criteria, and the successes and limitations observed in practice. This is followed by a concise comparison of the three case study against each design criterion.

Additionally, this appendix outlines the specific design strategies employed in each project in chapter 2 and presents key insights gained during the analysis in chapter 3.

To avoid repeating words, the design criteria will be assigned numbers, which will be used from this point onward to refer to each specific criterion.

Support

- **DC1**: The support provides sufficient capacity to accommodate adaptability of the space plan over a relatively long period of time.
- **DC1A**: Each dwelling in a Support allows a variety of layouts.
- **DC1B**: The Support must allow flexible reconfiguration of unit boundaries, enabling a variety of dwelling sizes.
- **DC1C**: The Support must have enough capacity to accommodate varying functions, both residential and non-residential functions.
- **DC2**: The Support contains all shared building services.
- **DC3**: The Support ensures compatibility with diverse infill solutions.
- **DC4**: The Support must allow for the independent assembly, alteration, and removal of the infill.

Infill

- **DC5**: The infill is compatible with the support structure.
- **DC6**: The Infill can independently be assembled, adjusted or disassembled, allowing for flexible placement of elements (e.g., sinks, windows, doors, storage) to accommodate each occupant's personal preferences and daily needs.
- **DC7**: The façade is part of the adaptable infill.

Service infrastructure

- **DC8**: The Service infrastructure creates maximized freedom within the adaptability of the space plan.
- **DC9**: The Service infrastructure is designed in such a way that each part can work independently and can be replaced.

Note on design criteria

Not all 'Infill' design criteria apply to this research. Open Building distinguishes the base building, which provides structure and shared services, from the infill, which addresses individual household needs. Design Criteria 5 and 6, focused on infill, are excluded as this study centres on base buildings. However, Criterion 7, while related to infill, impacts the base building's design and is included.

I. Concise textual evaluation per case studies

This chapter provides a concise evaluation on the three case studies, Patch22, Superlofts Houthavens Plot 4, and NEXT21, focusing on how each project applies Open Building principles and meets the established design criteria. These evaluations highlight key strategies, successes, and limitations, offering insights into the practical implementation of Open Building.

1.1. Patch22 - Tom Frantzen et al (2016)

Patch22, designed by Tom Frantzen in collaboration with Lemniskade Projects, is located in Amsterdam's Buiksloterham district. the building was constructed in 2016 and consists of 33 living-working units and 600 m² of commercial space. Patch22 emerged as the winning proposal in Amsterdam's 2009 Sustainability Tender, where it was applauded for its emphasis on renewable materials, energy efficiency, and adaptability. The building's design is rooted in long-term sustainability, with features enabling a lifespan of over 100 years.

Patch22 demonstrates a design philosophy focused on adaptability, sustainability, and long-term flexibility. The building integrates several innovative strategies to align with Open Building principles, particularly DC 1: providing sufficient capacity to accommodate adaptability of the space plan over an extended period.

The Slimline Floor system is a key feature, with prefabricated structural elements and hollow cavities. The separation from the service infrastructure from the support through this Slimline Floor system allows residents to independently assemble, adjust, or remove infill components without affecting the main structure. (DC3, DC4). This allows for the flexible placement of wet areas and even accommodates unique features such as placing a bathtub in the loggia (DC1A, DC4, DC8). However, the removable top layer that is applied in this system requires drilling for adjustments, making modifications labour-intensive and limiting overall practicality (DC9). Additionally, sleeves are used to route services through the structural support, creating minor interference that further impacts the ease of modification (DC9).

Flexibility in unit boundaries is achieved through decoupled partition walls constructed with Soundbloc metal stud frames, allowing residents to easily add or remove walls to reconfigure unit layouts (DC1B). The column-and-beam structure, combined with a stable core, provides open floor plans, vertical circulation, and horizontal stability, while accommodating shared building services distributed horizontally to individual units (DC2).

The building's increased load-bearing capacity (4 kN/m²) exceeds typical residential standards, enabling Patch22 to accommodate diverse functions such as offices, accommodations, and light industrial uses (DC1C).

In conclusion, Patch22 is highly adaptable, thanks to features like the Slimline Floor system, decoupled partition walls and increased load-bearing capacity. While removing the floor's top layer can be labour-intensive, the overall design aligns well with Open Building principles, offering significant flexibility in layouts and infill modifications.

1.2. Superlofts - MKA (2015)

Superlofts is more than a single building; it is a concept initiated by Marc Koehler Architects (MKA). The idea originated in Amsterdam's Houthavens district with Blok 0, a pilot project for collective private commissioning (CPC). Under the guidance of "De Hoofden," a group of Dutch architects, Blok 0 allowed residents to design and manage their apartments and shared building facilities. However, challenges such as financing difficulties led to a shift toward hybrid development models, balancing user input with traditional project execution.
The Superlofts concept has since expanded into a global phenomenon. These projects combine adaptable housing solutions with shared community spaces, aiming to enhance urban liveability.

Superlofts Houthavens Plot 4 demonstrates a design philosophy that prioritizes user-driven customization. By implementing design strategies aligned with Open Building principles, the project addresses several key Design Criteria, although certain limitations and uncertainties remain.

The structural framework, featuring generous floor heights (5 meters) and spans (6.6 meters), supports flexible layouts and facilitates potential additions, such as CLT mezzanine floors (DC1, DC1A, DC4). These mezzanines, suspended from the main concrete structure using steel rods, allow for up to 70% additional floor area to be added. However, the removability of this CLT structure is uncertain due to their size and potential dependency on façade alterations (DC4). The prefabricated façade system offers flexibility in window partitioning and openings, but its adaptability after the first design remains unclear, as does the potential to alter variable concrete balconies (DC7).

Flexible partition walls constructed with Soundbloc metal stud frames enable reconfigurable unit boundaries, allowing dwellings to be combined or split (DC1B). The support itself does not provide a built-in system which integrates horizontal service distribution directly into the support. It only provides supply points at the central hall of each floor. This limits the extent to which the Service Infrastructure actively supports the adaptability of the space plan. (DC2, DC8). Instead, the Infill is responsible for implementing solutions like floating floor systems or hollow walls to distribute services away from the central core.

Compatibility with diverse infill solutions is supported by the open and spacious base building and reinforced by the “Superliving” platform, which fosters collaboration and the exchange of design ideas and components (DC3). Dry construction methods for all the infill ensures that components can be assembled, altered, or removed independently of the structural support (DC4).

Superlofts does not fully meet DC1C, as it lacks specific design strategies to enhance load-bearing capacity for heavier functions, limiting its ability to accommodate varying functions beyond residential use. Additionally, while the vertical shafts provide accessible service infrastructure, the horizontal distribution relies on sleeves, which interfere with the structural support, impacting compliance with DC9.

In conclusion, Superlofts Houthavens Plot 4 provides significant adaptability, particularly for the initial group of residents who were directly involved in the design process and offered extensive flexibility to customize their living spaces. However, questions arise about whether the same level of flexibility will be available to future residents. The building’s adaptability may be limited over time, especially if key elements like the CLT mezzanine floors cannot be altered or removed. This potential lack of long-term adaptability suggests that the building may not fully align with Open Building principles, which emphasize ongoing adaptability for multiple generations of users.

1.3 Next 21 - Yositika Utida (1993)

NEXT21, located in Osaka, Japan, is an experimental housing project developed by Osaka Gas Corporation in 1993. The building represents a bold exploration into creating adaptable, sustainable, and user-cantered urban housing. Conceived as a prototype for the future of collective housing, NEXT21 was designed to address the challenges of high-density urban living while enhancing the quality of life for its occupants. The project serves as both a research initiative and a living demonstration of how housing can respond to evolving societal and environmental demands.

NEXT21 demonstrates a forward-thinking approach to adaptability, especially for its time. The project integrates a series of innovative design strategies to address DC1, providing sufficient capacity to accommodate adaptability of the space plan over an extended period.

The open column-beam framework eliminates the need for load-bearing walls, enabling flexible placement of interior and exterior layouts to accommodate diverse unit configurations (DC1A, DC1B). This is supported by the 30-centimeter modular grid, which ensures compatibility between components and allows for seamless reconfiguration of structural and infill elements (DC3, DC4). The building assembly method, dividing the structure into four independent subsystems (structure, cladding, infill, and services), further reinforces adaptability by facilitating the independent assembly, alteration, and removal of components (DC1, DC4, DC9).

Generous floor-to-floor heights allow for utility distribution above ceilings and under raised floors. This in combination with the reduced depth mid span beams enables independent service routing without interfering with structural elements. This provides the flexibility needed for wet area reconfigurations and long-term maintenance (DC2, DC8). Additionally, modular façade components that follow the grid system can be removed and reassembled, making the façade an adaptable part of the infill (DC7).

While NEXT21 achieves a high level of flexibility, it does not meet DC1C, as the structure lacks explicit strategies to facilitate changes in function. Although it accommodates multiple functions (residential, office, commercial), fixed dimensions and the absence of enhanced load-bearing capacity limit its ability to support diverse future uses.

In conclusion, NEXT21 demonstrates how modular frameworks, independent subsystems, and flexible infill strategies can create a highly adaptable residential and mixed-use building. Despite limitations in accommodating functional changes, NEXT21 provides valuable insights into the potential of Open Building principles to enhance user-driven adaptability in urban housing design.

1.4 Comparison of all three case studies against each design criterion

DC1 The support provides sufficient capacity to accommodate adaptability of the space plan over a relatively long period of time.
All three projects feature an open structural system where internal walls are non-load-bearing. Patch22 and NEXT21 provide integrated solutions for installations (Slimline Floor and raised floors, respectively), while Superlofts relies more on residents to incorporate horizontal installation provisions within the infill.

DC1A Each dwelling in a Support allows a variety of layouts.
All projects demonstrate strong adaptability in their spatial layouts. Patch22 and NEXT21 integrate service infrastructure beneath the floors, allowing for greater flexibility in placing wet spaces. Superlofts also offers significant layout freedom, but its horizontal installation distribution is less standardised within the support structure.

DC1B The Support must allow flexible reconfiguration of unit boundaries, enabling a variety of dwelling sizes.
Each project enables the reconfiguration of dwelling boundaries by using non-load-bearing internal walls. Patch22 and Superlofts achieve this through similar metal stud wall systems, while NEXT21 goes further by also treating façade elements as part of the infill.

DC1C The Support must have enough capacity to accommodate varying functions, both residential and non-residential functions.
Patch22 is the most advanced in offering higher load capacity, allowing for a broader range of functional transformations. NEXT21 supports hybrid use but does not specifically accommodate large variations in functions with heavier loads.

DC2 The Support contains all shared building services.
All three projects centralize shared installations around (a) vertical core(s). However, in Superlofts, horizontal service infrastructure is not integrated into the Support, leaving the Infill responsible for routing water, electricity, and plumbing.

DC3 The Support ensures compatibility with diverse infill solutions.
All three projects are clearly designed to accommodate various infill solutions. NEXT21 takes a leading role with its highly modular system and explicit strategy to test architectural diversity. Superlofts and Patch22 also demonstrate diverse infill variants in practice.

DC4 The Support must allow for the independent assembly, alteration, and removal of the infill.
All projects fundamentally meet DC4 by separating the main structure from the infill. However, Patch22 and Superlofts face practical limitations, such as labour-intensive floor modifications (patch22) and uncertainty about possible infill modifications (Superlofts). NEXT21 offers the most extensive and proven independence between support and infill.

DC7 The façade can be part of the adaptable infill.
NEXT21 integrates the façade into the infill, making it fully adaptable and reusable. In contrast, Patch22 considers the façade a fixed part of the support structure. Superlofts occupies a middle ground, with potential for façade adaptation, though its practical feasibility remains unclear.

DC8 The Service infrastructure creates maximized freedom within the adaptability of the space plan.
Patch22 (with the Slimline Floor system) and NEXT21 (with raised floors and a dedicated service zone) provide integrated support systems that optimise flexibility for wet spaces. While Superlofts theoretically offers flexibility, it largely delegates the practical implementation of horizontal distribution to the Infill.

DC9 The Service infrastructure is designed in such a way that each part can work independently and can be replaced.
NEXT21 offers the highest degree of independence and the simplest replacement process. While the infrastructure in Patch22 and Superlofts is separated from the structural system, replacing components is more labour-intensive (e.g., due to the Slimline top layer in Patch22).

II. CONCLUSIVE LIST OF ALL APPLIED DESIGN STRATEGIES PER CASE STUDY

This chapter outlines all the design strategies applied in each case study.

Patch22

- Slimline Floor system (DC1, DC1A, DC4, DC8)
- The removable top layer, (although this top layer cannot be easily removed) (DC4, DC9)
- Decoupled partition walls (DC1, DC1B)
- Column-and-beam structure with a stable core providing (DC1, DC1C)
- Increased load-bearing capacity (DC1, DC1C)
- Centralized shared building services within the core, with horizontal distribution to individual units (DC2)

Superlofts

- Generous floor heights and wide bay width (DC1, DC1A)
- CLT mezzanine floors (DC1, DC1A, DC4)
- Centralized services within the double core (DC2, DC8)
- Decoupled partition walls (DC1, DC1B)
- Dry assembly strategies (DC4)
- Flexible interior walls and doors (DC1, DC1A)
- Online "Superliving" (DC3)
- Prefabricated façade system (DC7)
- Variable concrete balconies (DC7)

Next21

- Open column-beam framework. (DC1, DC1A, DC1B, DC3)
- Building assembly method with four subsystems (structure, cladding, infill, services). (DC1 , DC1A, DC1B, DC3, DC4, DC9)
- 30-centimeter modular grid framework. (DC1, DC1A, DC3, DC4)
- Generous floor-to-floor heights (DC2, DC8)
- Reduced depth mid-span beams (DC8, DC9)
- Dry construction method for cladding, infill, services (DC3, DC4)
- Modular exterior walls as adaptable infill (DC7)
- Raised floor (DC9)

III. INSIGHTFUL FINDINGS

This chapter presents the insights gained during the case study analysis, including a deeper understanding of how Open Building principles are applied in practice, as well as limitations encountered during the research process.

3.1. The fundamental principle of Open Building

The key design criterion that captures the essence of Open Building is Design Criterion 1: The support provides sufficient capacity to accommodate adaptability of the space plan over a relatively long period of time. Essentially, Open Building on the bigger scale seeks to create an environment capable of adapting to a dynamic society. Such as changes in family composition, shifts in occupants, evolving environmental standards. But also larger-scale changes such as social, demographic, or economic shifts that may result in a change of function within a building. All other design criteria - outside DC1- exist to support this overarching goal of ensuring sufficient capacity within the building's Support.

Adaptability at multiple scales, from unit layouts and multi-dwelling configurations to the entire building (DC1 A, B, & C), is achieved by employing strategies that maximize adaptability (DC2, 4, 7, 8, 9).

The fundamental principle that enables sufficient capacity is the separation of the permanent Support from the flexible Infill. This distinction allows spaces to be customized, assembled, or dismantled without affecting the structural framework. Although Support and Infill are separate, they remain interconnected via the Service Infrastructure, which acts as the essential link between these layers. This principle is demonstrated in all three case studies, each applying different strategies:

- **Patch22**: Utilizes the Slimline Floor system, allowing wet areas and installations to be placed virtually anywhere.
- **NEXT21**: Makes use of an extremely modular approach, featuring a 30 cm grid and a clear division into four subsystems (structure, cladding, infill, and services). Reverse-shaped slabs in the Support facilitate a dedicated space for services, resulting in a high degree of reconfigurability for the Infill. This combined with reduced depth mid-span beams and a raised floor allows wet areas and installations to be placed virtually anywhere.
- **Superlofts**: Delivers service infrastructure to the central hall. Its spacious Support does not include a horizontal service infrastructure system. The solution for the horizontal service infrastructure distribution is part of the Infill.

Patch22 and NEXT21 both showcase a decoupled service infrastructure that is integrated into the Support, allowing for easy, independent Infill modifications without altering the Support. By contrast, Superlofts provides service infrastructure untill the central hall without a Support-integrated system, placing the responsibility on Infill-based solutions. Because there is no integral service infrastructure embedded within the Support, future adaptability may be more challenging compared to the other two examples.

3.2. Two forms of Adaptability

Adaptability in architecture can be observed in two distinct phases: the design phase and the usage phase. Adaptability in the design phase involves integrating the occupants' needs into the initial building design. In the usage phase, adaptability refers to the building's capacity to accommodate changes over time, allowing for reconfigurations and adjustments based on shifting user needs or functions.

1. **Adaptability in the Design Phase**: Superlofts demonstrates adaptability during the initial design phase. The concept allows for user-driven customisation, enabling the residents to shape their layouts and spaces to individual needs. For example, its structural framework with generous floor heights provides opportunities for the addition of a CLT mezzanine. However,

questions remain regarding adaptability in the usage phase, specifically concerning the removability/adaptability of the CLT mezzanine.

2. **Adaptability in Usage Phase**:NEXT21 exemplifies adaptability in the usage phase, showcasing how spaces can be reconfigured. The building's modular grid system and independent subsystems allow for seamless adjustments to layouts and infills.

3.3. Materiality and Building techniques.

All analysed case studies heavily rely on traditional materials, particularly concrete. Superlofts and NEXT21 utilise fully concrete structures, while Patch22 integrates concrete with timber elements. Looking forward, the potential for Open Building principles to align with sustainable materials, such as CLT and bio-based options, is an area of significant interest. Can adaptable systems, such as those used in NEXT21 or Superlofts, be effectively applied using alternative materials? Exploring these possibilities could open new pathways for combining sustainability with adaptability.

3.4. Proof of concept

NEXT21 provides a unique perspective as a proven concept. Built in 1993, the building has undergone experiments to validate its adaptability. Early modifications revealed challenges in cost and time efficiency, but later experiments (e.g., Residence 405) proved the concept's feasibility and efficiency.

In contrast, modern case studies such as Patch22 and Superlofts have not yet undergone publicly known experiments or adaptations of dwellings. While their designs appear to align with Open Building principles, they lack concrete evidence of adaptability in practice. This gap underscores the importance of long-term studies to evaluate whether contemporary designs truly meet the demands of Open Building over multiple generations of users.

3.5. Limited information on Superlofts

The analysis of Superlofts faced challenges due to a lack of detailed information, particularly regarding service infrastructure distribution. While general design strategies were evident, assumptions had to be made about key aspects, such as the adaptability of wet areas and the long-term flexibility of mezzanine floors. This limitation impacted the reliability of the case study's evaluation and highlights the importance of comprehensive documentation in architectural research.

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	Patch 22	Superlofts	Next21
The Support			
DC1: The Support provides sufficient capacity to accommodate adaptability of the space plan over a relatively long period of time.	Slimline Floor system, Decoupled partition walls, Column-and-beam structure, Increased load-bearing capacity	Generous floor heights, CLT mezzanine floors, Decoupled partition walls, Flexible interior elements	Open column-beam framework, Building assembly method, modular grid framework
DC1A: Each dwelling in a Support allows a variety of layouts.	Slimline Floor system	Generous floor heights, CLT mezzanine floors, Flexible interior elements	Open column-beam framework, Building assembly method, modular grid framework
DC1B: The Support must allow flexible reconfiguration of unit boundaries, enabling a variety of dwelling sizes.	Decoupled partition walls	Decoupled partition walls	Open column-beam framework, Building assembly method
DC1C: The Support must have enough capacity to accommodate varying functions, both residential and non-residential functions.	Column-and-beam structure, Increased load-bearing capacity		
DC2: The Support contains all shared building services.	Centralized shared building services	Centralized services	Generous floor-to-floor heights
DC3: The Support ensures compatibility with diverse infill solutions.		Online "Superliving" platform	
DC4: The Support must allow for the independent assembly, alteration, and removal of the infill.	Slimline Floor system, removable top layer, Dry assembly strategies	CLT mezzanine floors, Dry assembly strategies	Building assembly method, modular grid framework, Dry assembly strategies
The Infill			
DC7: The façade can be part of the adaptable infill.		Prefabricated façade system, Variable concrete balconies	Modular exterior walls as adaptable infill
The Service Infrastructure			
DC8: The Service infrastructure (e.g. water, gas, electricity, drainage) creates maximized freedom within the adaptability of the space plan.	Slimline Floor system	Centralized services	Generous floor-to-floor heights, Reduced depth mid-span beams
DC9: The Service infrastructure (e.g. water, gas, electricity, drainage) is designed in such a way that each part can work independently and can be replaced.	removable top layer	Centralized services	Building assembly method, Reduced depth mid-span beams, Raised floor system

APPENDIX VIII

POST-ANALYSIS REFLECTION ON THE DESIGN CRITERIA

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ABSTRACT

This appendix reflects on the design criteria for Open Building, addressing challenges and proposing refinements to improve clarity and practical application. Key updates include narrowing the scope of DC1C to measurable aspects, rephrasing DC2 to emphasize horizontal and vertical service distribution, and redefining DC4 as a neutral framework enabling independent infill assembly. The final list of design criteria can be found in the last chapter.

INTRODUCTION

This appendix provides a critical reflection on the design criteria established in the earlier phases of this research, based on insights gained from the case study analysis. The evaluation highlights areas where certain criteria encountered challenges or required rephrasing to better align with the practical application of Open Building principles.

In the last chapter, the final list of Design Criteria is presented.

I. CRITICAL REFLECTION ON THE DESIGN CRITERIA

DC1C: The Support must have enough capacity to accommodate varying functions, both residential and non-residential functions.
Assessing DC1C proves challenging because it involves numerous factors, ranging from structural load-bearing capacity to dimensions and other requirements defined by building regulations (Bouwbesluit). Incorporating every potential functional implication into this single design criterion exceeds the scope of this study. Consequently, the analysis focuses on fundamental aspects such as the load-bearing capacity and the spatial dimensions of the structure, which together provide a foundational indication of the building's potential adaptability.

DC2: The Support contains all shared building services.
Originally, Design Criterion 2 (DC2) stated that "The Support contains all shared building services." However, this wording does not fully capture the necessity of horizontal service infrastructure distribution within the Support. Research findings demonstrate that projects incorporating both vertical and horizontal service distribution in the Support (such as Patch22 and NEXT21) achieve greater flexibility in layout and function, aligning with Habraken's vision of the Support as a "shared framework" for the community—one that is "permanent like streets" and effectively replaces the ground by providing structural and infrastructural foundations at higher levels.

By rephrasing DC2 to "*The Support distributes the service infrastructure both horizontally and vertically*," we emphasize the critical role of the Support in enabling complete freedom of design. The ability to route services to any point within the space plan ensures occupants can easily modify and repurpose areas over time,

DC4: The Support must allow for the independent assembly, alteration, and removal of the infill.
Upon closer examination, DC4 has been somewhat misleading. As Habraken emphasizes, the Support functions much like an extension of the ground, when he is talking about the concept of the Support he says "*constructions which take over the task of the ground, which provide building sites up in the air, and are permanent like streets.*" (Habraken, 1972, p. 69) It provides a neutral framework upon which anything may be built, rather than dictating how the Infill behaves. Independence arises from the nature of the open framework itself, not from any specific intervention by the Support.

In previous analyses, projects were often credited with fulfilling DC4 by employing dry assembly methods. However, these strategies more directly reflect Design Criterion 6 which addresses that the Infill can be assembled, adjusted, or disassembled independently. True compliance with DC4 stems from providing a structural "platform" that does not constrain how or where the Infill is placed—effectively replicating ground conditions at elevated levels.

For example:
- Patch22 and NEXT21 achieve DC4 largely because their open flooring systems allow full freedom in positioning wet areas and other installations without forcing a specific arrangement.
- Superlofts, with its high ceilings and wide spans, also supports independent infill to a degree, but relies more heavily on infill solutions rather than an integrated Support strategy.

Ultimately, a Support that "takes over the task of the ground" grants occupants genuine independence to assemble, modify, and remove their Infill without affecting the primary structure. Thus, DC4 is fulfilled when the building's base (or "flooring") is truly open, allowing inhabitants to create and recreate their living environments much as they would on actual ground.

II. IMPROVED LIST OF DESIGN CRITERIA FOR OPEN BUILDING

This chapter presents the improved list of design criteria for Open Building.

Support

1. The Support provides sufficient capacity to accommodate adaptability of the space plan over a relatively long period of time.
    a. Each dwelling in a Support allows a variety of layouts.
    b. The Support must allow flexible reconfiguration of unit boundaries, enabling a variety of dwelling sizes.
    c. The Support must have enough capacity to accommodate varying functions, both residential and non-residential function.
2. The Support distributes the service infrastructure both horizontally and vertically
3. The Support ensures compatibility with diverse infill solutions.
4. The Support must allow for the independent assembly, alteration, and removal of the infill.

Infill

5. The infill is compatible with the support structure.
6. The Infill can independently be assembled, adjusted or disassembled, allowing for flexible placement of elements (e.g., sinks, windows, doors, storage) to accommodate each occupant's personal preferences and daily needs.
7. The façade is part of the adaptable infill.

Service infrastructure

8. The Service infrastructure (e.g. water, gas, electricity, drainage) creates maximized freedom within the adaptability of the space plan.
9. The Service infrastructure (e.g. water, gas, electricity, drainage) is designed in such a way that each part can work independently and can be replaced.

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