Towards Adaptable Post-War Housing

An architecture that uses change for greater significance.

Research Report

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Design Report

Research Report

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Abstract

Adaptability, in contemporary architecture, is defined as the capacity of a building to effectively accommodate the evolving demands of its context, thus maximising its value through life. On the other hand, there is the concept of cultural significance, which addresses the attributes and values of cultural heritage buildings and justifies their designated status.

The negative reputation and/or lack of recognition received by these typologies of housing have an impact on the protection of these buildings today. Although parts of the urban design of Amsterdam Nieuw-West have received recognition of significance, unfortunately, this is not the case for all the architecture of the buildings, of which many have been demolished or transformed without consideration of their potential cultural significance. Potential obsolescence, changed demographics, and rapidly growing demands for energy efficiency, as well as new living standards, all threaten these buildings with demolition or modification before their historic or artistic attributes can even be recognised. Many of the issues stated above continue to be common today, showing a lack of advancement towards adaptable post-war housing.

This research report tries to integrate research methods on attributes with research methods on adaptability. This kind of approach could diversify concepts and reveal complementary characteristics regarding the significance of post-war housing blocks by linking them to adaptability.

The framework used in this research is divided into two distinct parts. Firstly, the classification of building layers and elements; subsequent internal and external connections and attributes; and secondly, the interpretation of all the aforementioned in a dependency structure matrix, revealing relationships, areas of synergy, and associated attributes.

By fusing these different methods, an integrated approach was developed to study post-war housing blocks and reveal the connections between significance and adaptability. To find areas of synergy between these two domains in order to contribute to the development of architecture that genuinely uses change for greater significance.

Keywords: post-war housing; significance; adaptability; heritage; attributes.

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1. Introduction

Even though there are historical examples of adaptability, the modernist movement at the turn of the 20th century was the first to embrace the concept explicitly. Modernism's commitment to abstract symbolism gave rise to the concept of "pure form" and the tenet "form follows function." This allowed the architect to easily define the form of a building based on its use or 'what the building wants to be' **(Jencks, 1973).** According to **Vollmer and Heldring (2017),** the primary driver of social change during the mid-19th century was the Industrial Revolution, which also produced new building materials, building types, and spatial standards. Modernist architecture, and therefore post-war housing, is characterised by attributes like: simple cubic form, industrialised, modular construction, and functional separation. These factors combined to create new urban conditions and the need for structures that could adapt to change **(Schmidt III and Austin, 2016).**

Adaptability, in contemporary architecture, is defined as the capacity of a building to effectively accommodate the evolving demands of its context, thus maximising its value through life **(Schmidt III and Austin, 2016).** An architecture with the ability to develop and change, where elements can be configured, allowing changes in spatial, functional, and technological components without building disruptions. In addition, a gap exists between what architecture wants to be—finished and static—and what architecture is—always shifting in form and purpose. Therefore, buildings should be seen as unfinished to meet society's changing needs **(Schmidt III and Austin, 2016).**

In the case of a redesign, relating the contemporary definition of adaptability to that of modernist post-war housing poses the risk of conflicting values and beliefs. On the one hand, there is a need for buildings to be more adaptable to society's changing functional, technological, and aesthetic needs and extend their value through life. On the other hand, there is the concept of cultural significance, which addresses the attributes and values of cultural heritage buildings and justifies their designated status **(Avrami et al., 2000). Spoormans and Pereira Roders (2020)** revealed a broader range of values and perspectives outside of traditional heritage disciplines. Their findings highlight th e diversity of concepts and emphasise the need for complementary characteristics of different types of value and methods. These can highlight heritage potential and help create attractive and resilient cities.

Furthermore, in this research, a distinction is made between building elements—all the technical elements of which a building consists—and building attributes—the various elements that possess heritage significance.

Values are not taken into consideration because of the scale and time limits of the research process. In addition, the research primarily focuses on elements that logically relate to attributes.

A post-war housing redevelopment needs to consider various defining attributes and the fact that the needs of society are always changing. It should use synergy between the two to highlight heritage potential and help create attractive and resilient cities. Therefore, this research will focus on the development of post-war architecture towards an architecture that uses change for greater significance.

2. Problem Statement

In the introduction, positive attributes regarding post-war housing were mentioned. Yet, according to a literature study by **Havinga et al. (2020),** more than two-thirds of the 17 papers discuss the negative reputation and/or lack of recognition received by these typologies of housing. For instance, according to **Al-Ragam (2013)**: "the international attitude towards modern heritage is apathetic at best and at worst destructive, despite continuous efforts to preserve modern heritage by non-profit organisations such as Docomomo and the Twentieth Century Society." Other papers mention that the idea that these post-war housing typologies have "failed" is only a political assertion from the top down, and the real inhabitants disagree with these ideas **(Al-Ragam, 2013; Roberts, 2017).** In addition, this bad reputation has an impact on getting a building listed today.

According to **Hasche (2016),** the main challenges in the listing of post-war housing as cultural heritage are the fact that potential obsolescence, changed demographics, and rapidly growing demands for energy efficiency, as well as new living standards, all threaten these buildings with demolition or modification before their historic or artistic values can even be recognised.

Although parts of the urban design of Amsterdam Nieuw-West have received recognition of significance (protected cityscape), unfortunately, this is not the case for all the architecture of the buildings, of which many have been demolished or transformed without consideration of their potential cultural significance **(Havinga et al., 2020).** Research on heritage attributes of post-war housing in Amsterdam by **Havinga et al. (2020)** reveals that ten out of seventeen publications address the threat of demolition, either as a current threat or as a threat from the past, due to the state of disrepair and lack of recognition.

Lastly, the EU is developing extensive refurbishment plans to create a built environment that is carbon neutral by 2050, which will require significant changes to the stock of post-war and modernist buildings in order to respond to the global urgency to be more efficient with resources and the sequestration of carbon, which will require more adaptable buildings. Adaptability can be considered a way to reduce the amount of new construction, (re)activate underutilised building stock, and improve component disassembly and deconstruction, thereby extending the useful life of buildings **(Schmidt III and Austin, 2016).**

2.1. State-of-the-Art

The topic of adaptability is researched in the book Adaptability: Theory and Practice, written by Robert Schmitt III, an architect, academic, and Senior Lecturer in Architecture at Loughborough University, and co-author Simon Austin, Professor of Structural Engineering at Loughborough University, UK. The book presents a theoretical framework of concepts and models that form a visual narrative that can assist in defining, communicating, creating, and evaluating adaptability through a review of the literature and case studies. The framework in the book is applicable to all buildings but focuses solely on adaptability **(Schmidt III and Austin, 2016).**

The heritage attributes of post-war housing in Amsterdam Nieuw-West were defined by the **Gemeente Amsterdam (2017)**. The official listing includes a detailed description of the history of the area, the important heritage attributes, and the reasons for protecting them.

In support of the official listing, the attributes were researched in literature by **Havinga et al. (2020)** through the Department of the Built Environment, Eindhoven University of Technology in Eindhoven, the Netherlands. Their research uses a literature review and case studies to reveal the significance levels of attributes according to whether or not sustainable refurbishment requires their preservation.

Heritage values were researched by Lidwine Spoormans, an architect, teacher, and researcher at TU Delft University, and Ana Pereira Roders, an architect, teacher, and Professor in Heritage and Values at TU Delft. Their research revealed a broader range of values and perspectives outside of traditional heritage disciplines. Their findings highlight the diversity of concepts and emphasise the need for complementary characteristics of different types of value and methods. **(Spoormans and Pereira Roders, 2020)**

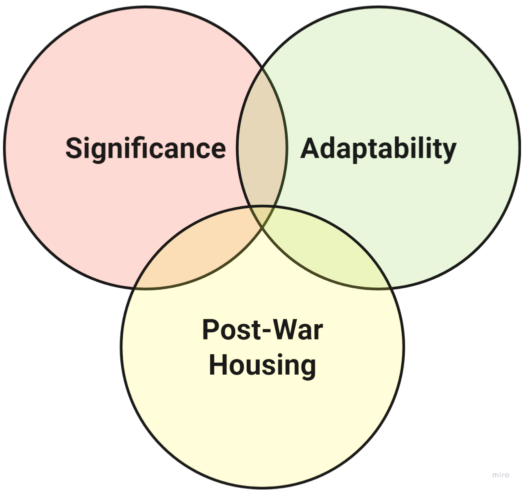


Figure 1: Graphic representation of relations between domains. **(Author)**

2.2. Aims and Objectives

The goal of this study is to integrate research methods on attributes and values with research methods on adaptability (Figure 1). This kind of approach tries to diversify concepts and reveal complementary characteristics regarding the significance of post-war housing blocks (attributes and values) by linking them to adaptability. By fusing these different methods, an integrated approach is developed to study post-war housing blocks and reveal the connections between significance and adaptability. To look for areas of synergy between these two domains in order to contribute to the development of architecture that genuinely uses change for greater significance.

2.3. Research Question

The problem statement, state-of-the-art, aims, and objectives together lead to the formulation of the following research question:

How can post-war housing be redesigned to be more adaptable by using its defining attributes to address the changing needs of society?

Sub-question 1:
How can adaptability be spatially defined at the building level?

Sub-question 2:
How adaptable is post-war housing spatially on the building level?

Sub-question 3:
What are the heritage attributes of post-war housing?

3. Theoretical Framework

The framework used in this research is divided into two distinct parts (Figure 2). Firstly, the classification of building layers and elements; subsequent internal and external connections and attributes; and secondly, the interpretation of all the aforementioned in a dependency structure matrix, revealing relationships and areas of synergy. This two-part process can be repeated after the redesign to reveal the impact of interventions.

The input for the theoretical framework and identification thereof are further discussed in Chapter 4: Methodology.

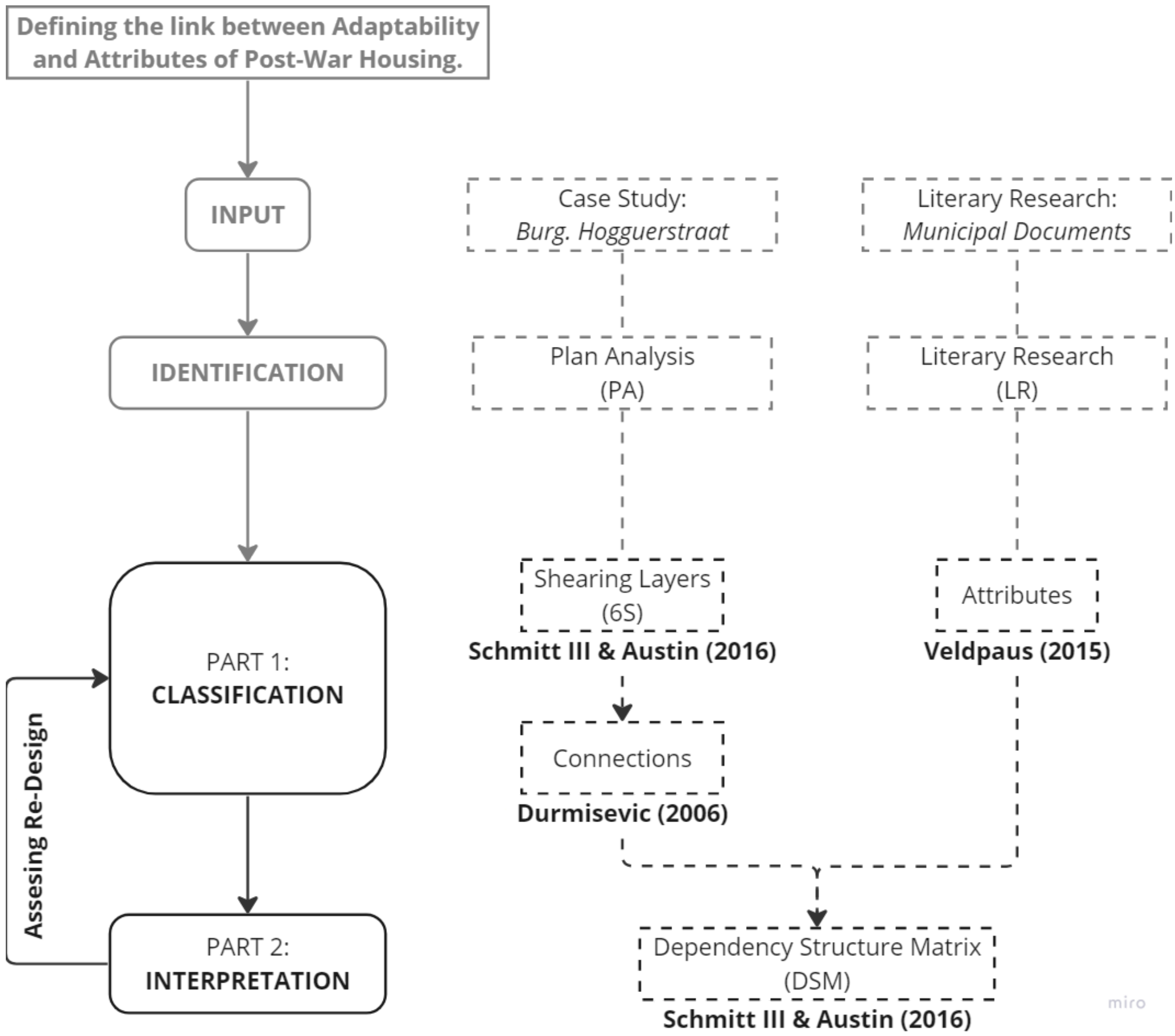


Figure 2: Outline of Methodology and Theoretical Framework. **(Author)**

3.1. Classification

The basis for classification is seeing a building as a series of layers whose interactions define its resistance to change. **Brand (1997)** defines a building as a series of 'shearing layers' that change at different rates (Figure 3). The more layers are connected, the more difficult and expensive it becomes to adapt a building.

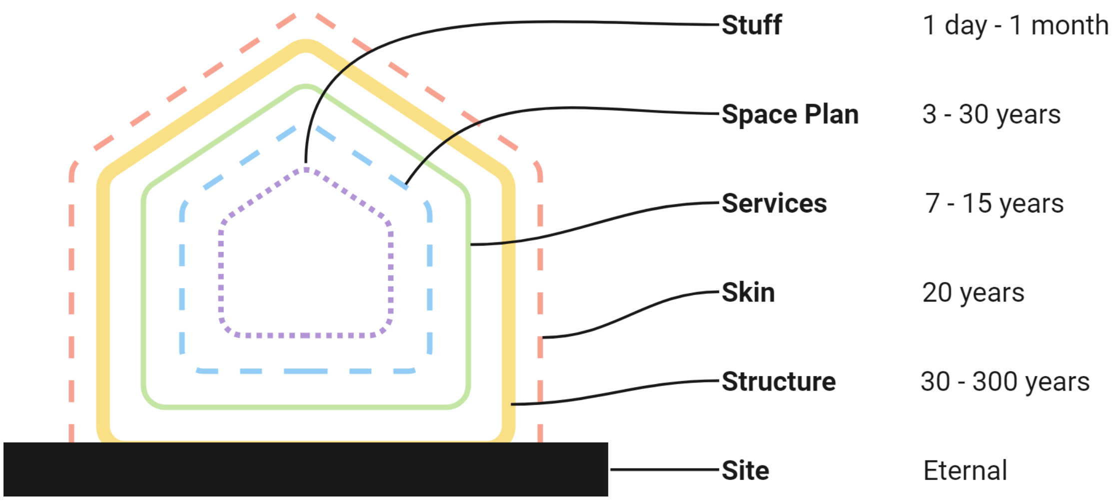


Figure 3: A building as a series of layers, according to Brand. **(Author)**

Schmitt III and Austin (2016) have further modified and expanded Brands' theory. First of all, they refrained from explicitly stating the lifespan of each layer since this relies on the elements selected for a specific typology and its context. Instead, the model indicates the relative rates of change for each layer based on the proximity of dots; as a result, the dotted line in the space plan layer is considerably closer together (faster) than those in the structure layer (Figure 4). Secondly, they have added two layers (surroundings and social) (Figure 4) to provide a more comprehensive interpretation of the layer concept. These additions are crucial when considering the value of a building throughout its life because contemporary architecture needs to have the capacity to effectively accommodate the evolving demands of its context **(Schmidt III and Austin, 2016).** These two additions demonstrate that buildings and their parts cannot be considered in isolation from their context. Users and their social perceptions also shear against the building layers. The social layer is excluded from this part of the research; instead, it will be researched during the subsequent design process.

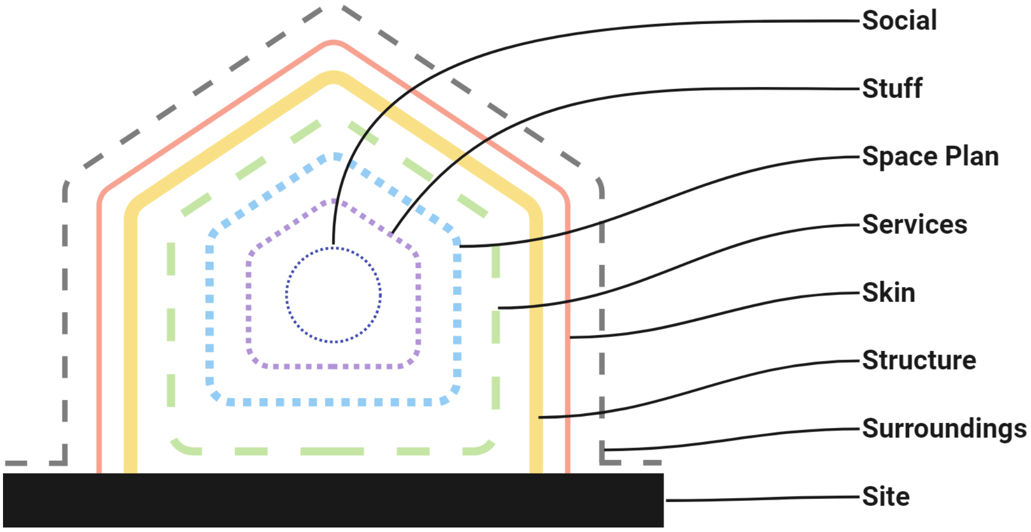


Figure 4: A building as a series of layers, according to Schmitt III and Austin **(Author)**.

The case study will be analysed according to the adapted version of the Building Layers Model by **Schmitt III and Austin (2016).** The model contains the following eight layers:

- **(Surroundings):** *The larger context that surrounds a building, encompassing both natural and man-made elements and attributes; and extends beyond the boundaries of the building's specific site;*
- **Site:** *The legal boundary in which the building is situated;*
- **Structure:** *Elements or Attributes that provide horizontal bracing and primary vertical load transfer;*
- **Skin:** *Elements or Attributes that separate the interior spaces from the exterior spaces, physically and visibly;*
- **Services:** *Elements or Attributes that supply and move physical flows, such as water, electricity, communications, and elevators;*
- ***Space Plan:*** *Elements or Attributes that enclose the spaces that users occupy;*
- ***Stuff:*** *Elements or Attributes that exist within the space users occupy;*
- ***Social:*** *Humans in and around the building who interact with and play a role in the building's life.*

In order to further clarify the types of connections, a series of three connection types is used based on the findings revealed by **Durmisevic (2006)**. The dissertation states that there are two primary design requirements for decomposable connections: 1. components and elements must be maintained apart to prevent infiltration into other systems or components; and 2. chemical techniques (mortar or glue) should be replaced with dry-jointing techniques (screws or bolts). This is visualised (Figure 5) using three different characters (X, \, O).

According to **Durmisevic (2006),** every layer of a building should be subject to these requirements. This makes every construction system demountable, every part and constituent interchangeable, and every material recyclable.

X = **Fixed Connection**
(joint using chemical techniques)

\ = **Semi-Fixed Connection**
(dry-jointed, but infiltrated into other systems or components)

O = **Loose Connection**
(dry-jointed, no infiltration into other systems or components)

Figure 5: Three different classifications of connections. **(Author)**

3.2. Interpretation

The classified elements and attributes will be interpreted by placing them in a dependency structure matrix (DSM). A DSM reveals complex interdependencies between the different building systems. According to **Schmitt III & Austin (2016),** this is crucial for further improvement of a building's adaptability. A DSM is an NxN square cell matrix (Figure 6a) that maps the relationships between elements in a single domain. This research will use a static DSM, analysing the case study at a fixed moment in time.

The majority of DSMs are binary, meaning that a dependency can either be present or absent. However, other DSMs employ colour, numerical values, or other symbols to represent additional system features, such as the strength or type of connection **(Schmidt III and Austin, 2016).** This is visualised (Figure 6b) using the three different characters (X, \, O) as shown in (Figure 5).

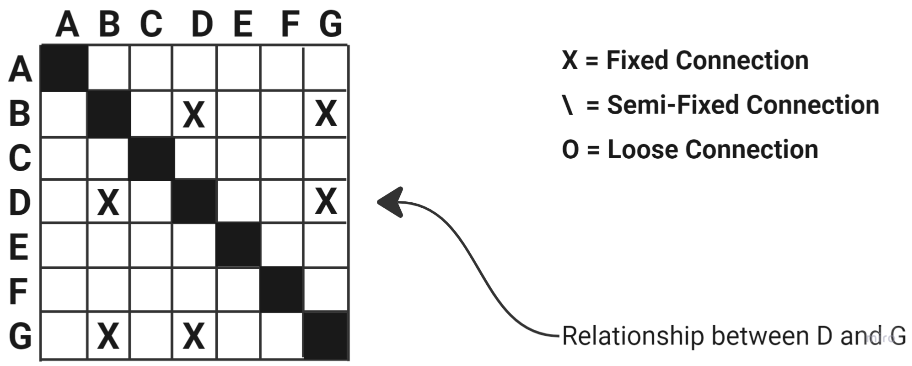


Figure 6a: A DSM composed of seven elements. **(Schmidt III and Austin, 2016)**

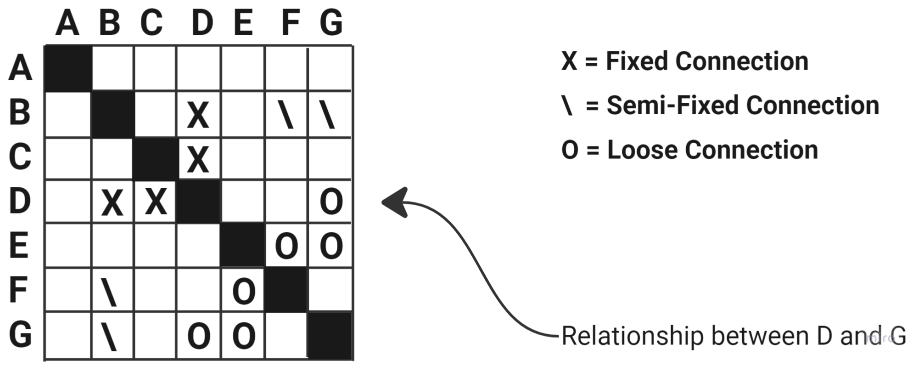


Figure 6b: A DSM composed of elements representing system features. **(Author)**

4. Methodology

The methods used to collect and identify the research's input are described in this chapter. The chapter first includes an explanation of the research methodologies used to answer each of the three research sub questions and subsequent argumentation for locating and collecting the data sources. Second, there will be a description of the chosen case study.

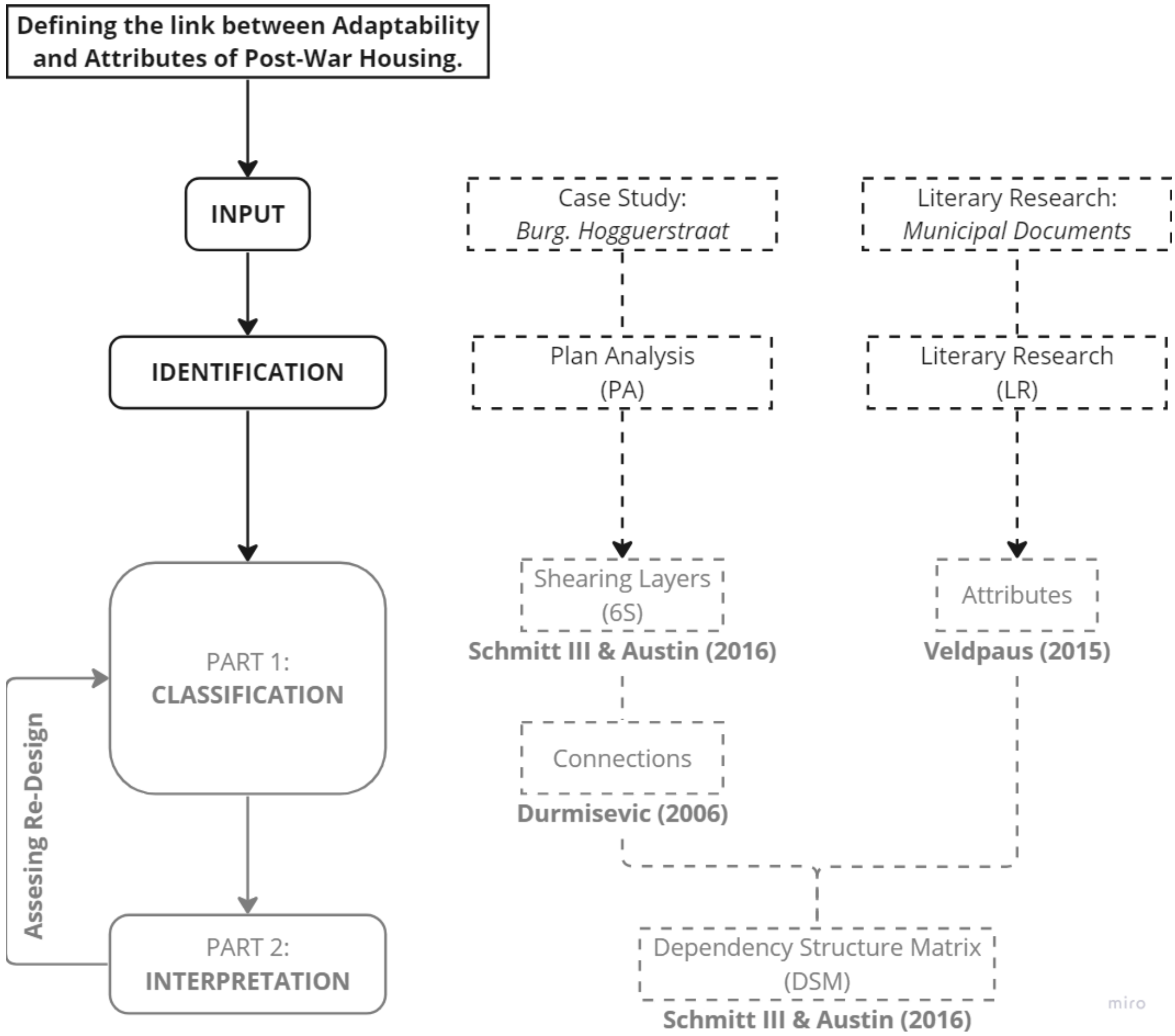


Figure 7: Outline of Methodology and Theoretical Framework. **(Author)**

4.1. Methods and Sources

The first subquestion is: *How can adaptability be spatially defined at the building level?* This question is answered by using two methods: literature research and a theory review. These methods are used to first create a qualitative framework for the classification of building layers and elements; subsequent internal and external connections and attributes; and second, to interpret all the aforementioned in a dependency structure matrix, revealing relationships and areas of synergy. This results in the theoretical framework mentioned before in Chapter 3.

The data sources necessary for the analysis consist of academic literature from multiple sources on adaptability in architecture. An existing academic theory forms the basis for the framework. The framework is then further enriched by adding a theory on decomposable connections and research on tangible and intangible attributes. The framework is then suitable to be used for the analysis of the case study regarding subquestion 2.

The second sub-question is: *How adaptable is post-war housing spatially on the building level?* This question is answered by analysing the selected case study using the aforementioned theoretical framework. The basis for this is seeing the building as a set of six layers. For each layer, the various building components are defined and described using multiple sources. These can be data sources related directly to the case study or data sources that are outside the case study but describe the same components or a system of components. For every component, the type of (decomposable) connection in relation to other components or building systems is defined. The various building components are then classified as elements using a unique code (E-xx). Subsequently, the elements are interpreted using the dependency structure matrix from the theoretical framework.

The data sources necessary for the analysis consist of historical and contemporary photographs and architectural drawings of the original and current states (Figure 8). In addition, the website Funda is used to compare the original state of the case study with the current state. This can visualise changes in layers and elements, which can help with the classification of (decomposable) connections. All the necessary data sources can be accessed through archives, municipal documents, and site visits. After acquiring the primary data, it is to be reproduced using 2D drawing, 3D modelling, and personal writing.

The third sub-question is: *What are the heritage attributes of post-war housing?* This question is answered by analysing the selected case study using the aforementioned theoretical framework. The basis for this is seeing the building as a set of six layers. For each layer, the various building components that have a certain heritage value are defined and described using multiple sources. These can be data sources related directly to the case study or data sources that are outside the case study but describe the same building components. This data is then classified using the tangible and intangible matrix by **Veldpaus (2015)** (Appendix 1) and given a unique code (A-xx). Subsequently, the elements are interpreted using the dependency structure matrix from the theoretical framework.

The data sources necessary for the analysis consist of historical and contemporary photographs, architectural drawings of the original and current states (Figure 9), official listings by municipalities, and the website Funda. Funda is used to compare the original state of the case study with the current state. This can visualise changes in layers and elements, which in turn can reveal new attributes. The data sources can be accessed through archives, municipal documents, and site visits.

In addition, it is important to mention the difference between official listings and literature as a source for identifying attributes. The official listing consists of a document published by the municipality of Amsterdam and contains explanatory notes on the protected cityscape: the Northbank of Sloterplas. A publication by **Havinga et al. (2020)** describing a significance assessment carried out on a selection of representative case studies employing four expert interviews for data collection is the work that was used as literature. The official listing should be interpreted as a collective statement by the municipal department of heritage experts, whereas the literature is based on the perspectives of individual heritage professionals who operate in the same area. As a result, attributes from the official listing will be used as the primary data source for defining attributes, complemented by data from literature to avoid conflicts in data sourcing.

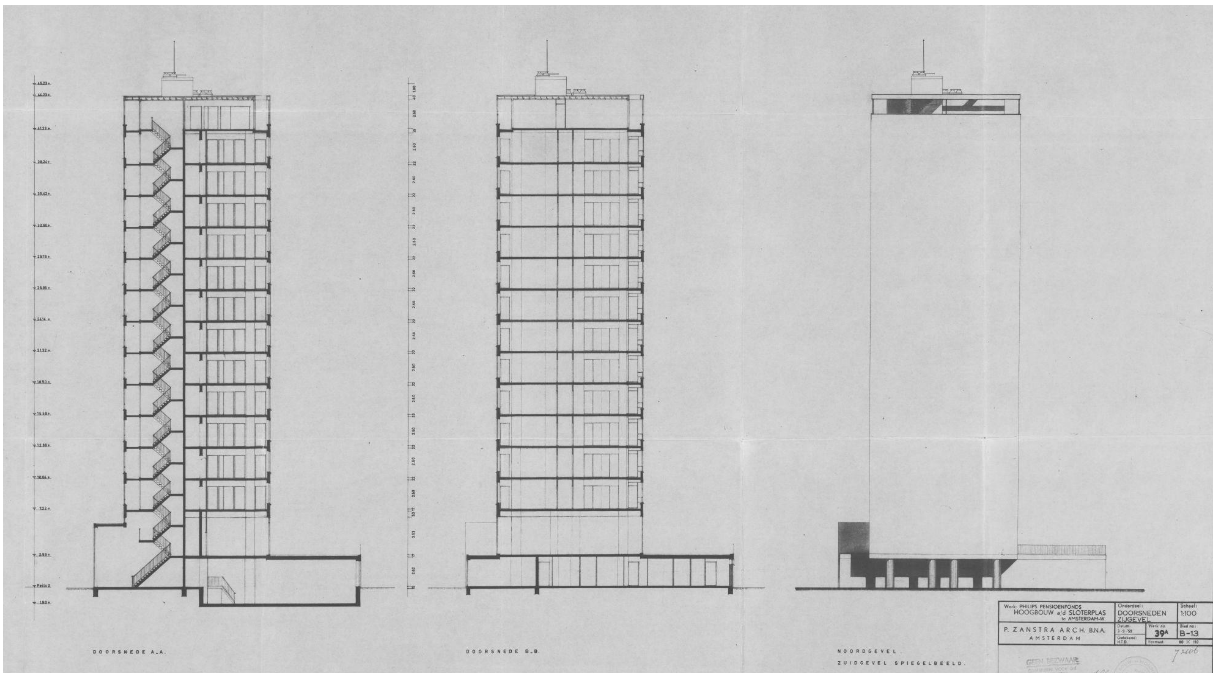


Figure 8: Section Drawings. **(Gemeente Amsterdam & Zandstra, 1961)**

4.2. Case Study

The case study is situated in the neighbourhood of Slotermeer and is part of the Western Garden Cities, which in turn was one of the developments of the General Extension Plan (AUP). On an urban scale, the expansion strategy for each neighbourhood, including Slotermeer, involved the construction of unique amenities that promoted socialising and leisure, such as stores, playgrounds, parks, schools, and churches. The proposal for the UAP was based on the concept of Garden Cities **(Howard, 1898)**, in which every neighbourhood operates as a separate entity (Figure 9). These communities were composed of various dwelling typologies, including single-family homes, villas, and elderly homes. The neighbourhood layout prioritised the best possible orientation to the sun, emphasising the presence of lots of room, light, and air. According to the **Rijksdienst voor het Cultureel Erfgoed (2023),** there is also a hierarchy present in both roads and green spaces, creating gradual transitions from large public spaces to smaller private ones.

In addition, the expansion plan stressed the inclusion of various work opportunities, ranging from offices to light industries and heavy work areas in the Western Docklands. Shops were situated along main roads rather than within residential zones, and traffic was kept apart from residential areas to provide a peaceful living environment **(Westelijke Tuinsteden - Van EesterenMuseum, 2017).**

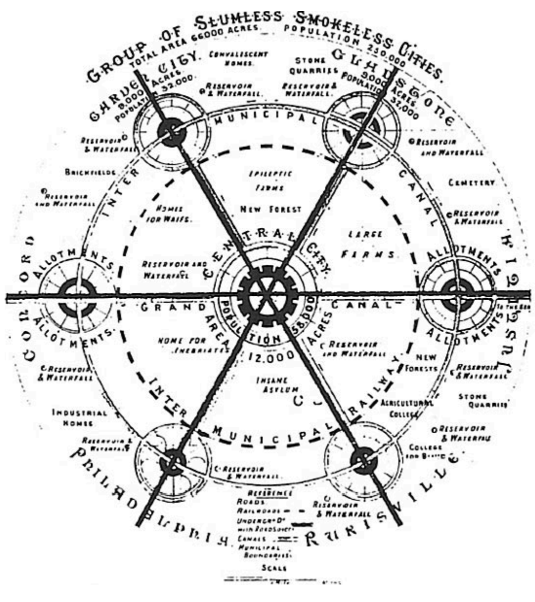


Figure 9: Garden City-concept. **(Howard, 1898)**

The flats, visible from as far away as three discs, situated on the north side of Amsterdam Nieuw-West (Figure 10) are the case study of this research report. These 13-story-high post-war dwellings are located on the Burgemeester Hogguerstraat and were built between 1962 and 1964. **("Burgemeester Hogguerstraat," 2019)** Architect Piet Zandstra embodied the modernist ideology of simple (cubic) form, industrialised and modular construction, and functional separation. In the original design, each building housed 190 apartments spread across thirteen residential floors. In addition, there were two stories containing an office floor on a substructure of garages. **(Gemeente Amsterdam & Zandstra, 1961)**

In recent years, some modifications have been made to the building, including the renovation of external elevators, the replacement of window frames and glazing, and the transformation of the office layer into apartments. **(Gemeente Amsterdam, 2005)**

Figure 10: Three post-war flats, Burgemeester Hogguerstraat. **(Zwierstra, 2012)**

Results

The theoretical framework mentioned in Chapter 3 was applied to the case study of Burgemeester Hogguerstraat, located in Amsterdam Nieuw-West, also known as the Western Garden Cities.

5. Elements

5.1. Surroundings and Site

The legal boundary within which the building is situated and the larger physical context in which a building sits;

Because they are not interwoven with the rest of the structure in a manner relevant to construction, the site and surroundings of the buildings are not included in the identification of elements. Rather, this chapter's sole focus is on the attributes.

5.2. Structure

Elements or Attributes that provide horizontal bracing and primary vertical load transfer;

The building system was not explicitly mentioned in the archive drawings **(Gemeente Amsterdam & Zandstra, 1961).** According to **Van Elk & Priemus (1971),** the building's architect, Piet Zanstra, was associated with the development of the EBA building system. The method of construction used for this building is similar to the EBA system and is therefore taken as a reference.

Primarily, the EBA system was constructed in and around Amsterdam. From 1958 forward, EBA was involved in Gietbouw (in-situ poured concrete structures). In theory, a wide range of housing types, including single-family homes and medium- and high-rise structures, could be constructed. But the majority were constructed in high-rises because the employment of cranes for formwork was advantageous here. **(Van Nunen & Platform31, 2013)**

The gravel concrete used in the construction of the load-bearing walls is cast in place. Depending on the structure's height, the load-bearing walls are either 18 or 23 cm thick **(Van Elk & Priemus, 1971).** There are two types of interior load-bearing walls that can be identified in the drawings **(Gemeente Amsterdam & Zandstra, 1961)**. The first type is a *Reinforced Concrete Party Walls (E-2)***,** which separate the apartments and provide the primary load transfer to the *Reinforced Concrete Foundation (E-1)*, which consists of a series of reinforced concrete beams on top of piles (Figure 15). At the end walls, Reinforced *Concrete Party Walls (E-2)* are incorporated into the facade assembly. The second type of wall are the *Reinforced Concrete Bracing Walls (E-3)* that provide horizontal, but primarily vertical, bracing to the structure (Figure 15). Because they were cast in situ, all previous types of connections can be characterised as fixed connections **(X)**.

Typically, the *Reinforced Concrete Floors (E-5)* are produced on a wooden formwork with a steel or wooden basis, and the load-bearing walls are formed in a steel formwork. Gravel concrete or in-situ cast medium concrete is used for the elements of the structure **(Van Elk & Priemus, 1971)**. The *Reinforced Concrete Stairs (E-7)* are cast in situ and structurally connected to the *Reinforced Concrete Floors (E-5)*. In addition, the floor loads are transferred to the *Reinforced Concrete Party Walls (E-2)* using *Reinforced Concrete Beams (E-4)*, spanning the length of the grid (Figure 15). Because they were cast in situ, all previous types of connections can be characterised as fixed connections **(X)**.

According to **Van Elk & Priemus (1971)** the floors are extended outwards using cast-in-place *Reinforced Concrete Balconies (E-6)* in order to create a gallery on the frontside (+ 1.400 mm) and a balcony on the backside of the apartments (+ 1.200 mm) (Figure 15). Because the balcony elements are cast-in-place, this type of connection can be characterised as a semi-fixed connection **(X)**.

At a depth of 9.010mm and a grid size of 3.750mm on centre and 5.250mm on centre, the structure provides roughly 82 m2 of area for a spacious two-bedroom home.

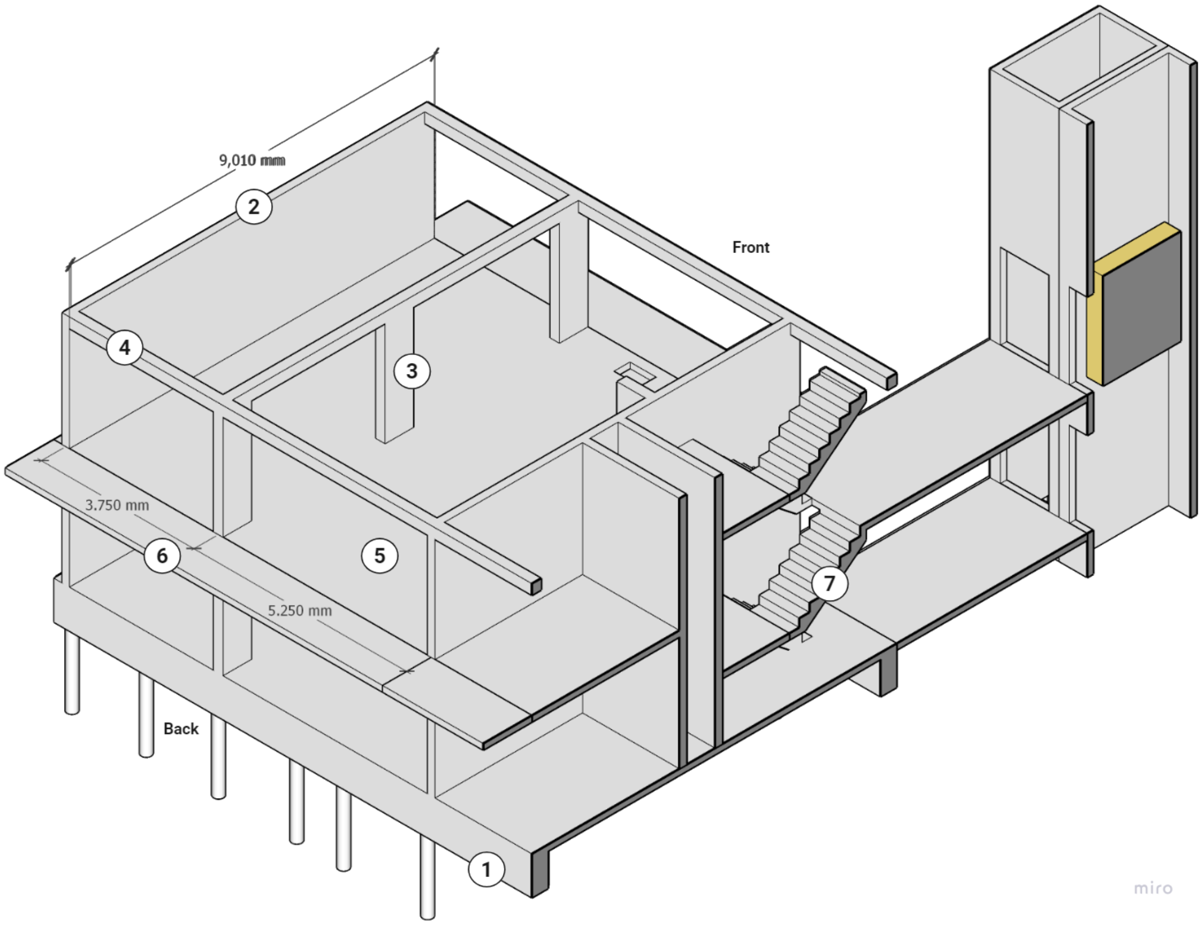


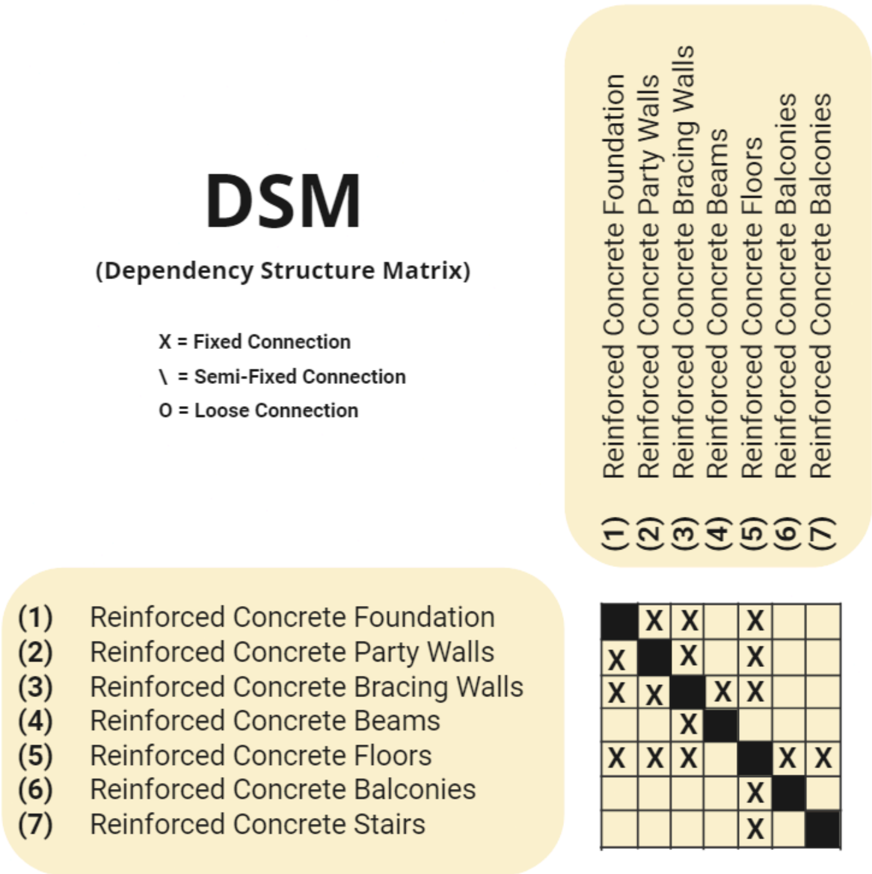
Figure 15: Axonometric of the Structure layer. **(Author)**

List of Elements:

E-1. Reinforced Concrete Foundation
E-2. Reinforced Concrete Party Walls
E-3. Reinforced Concrete Bracing Walls
E-4. Reinforced Concrete Beams
E-5. Reinforced Concrete Floors
E-6. Reinforced Concrete Balconies
E-7. Reinforced Concrete Stairs

Dependency Structure Matrix (DSM)

As shown in Figure 16, all internal connections of the different elements are classified as fixed and reveal that the structure layer of these buildings is not internally adaptable.



	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1)	■	X	X		X		
(2)	X	■	X		X		
(3)	X	X	■	X	X		
(4)			X	■			
(5)	X	X	X		■	X	X
(6)					X	■	
(7)					X		■

Figure 16: DSM shows the internal relationships of the structure layer. **(Author)**

5.3. Skin

Elements or Attributes that separate the interior spaces from the exterior spaces, both physically and visibly;

The drawings by **Gemeente Amsterdam & Zandstra (1961)** state that the *Brick End Walls (E-10)* are constructed using a cavity structure, with an exterior cavity leaf made of half-brick bond masonry and an inner cavity leaf made of gravel concrete, connected using specialised cavity anchors. The inner cavity leaf is equipped with 15 mm of polystyrene foam on the cavity side **(Van Elk & Priemus, 1971).** In addition, the end walls on the east facade contain *East-facing Windows (E-15)*, one for every residential floor.

According to the drawings by **Gemeente Amsterdam & Zandstra (1961),** the longitudinal facades are composed of storey-high facade elements (Figure 17), whether or not combined with *Brick Parapets (E-9)*. On the front side, the storey-high facade elements consist of a composition of *North -facing Windows (E-14*), *Doors (E-16) and Brick Parapets (E-9)*.The parapets are constructed of an outer cavity wall of half-brick bond masonry and an inner cavity wall of aerated concrete panels with a thickness of 75 or 100 mm **(Van Elk & Priemus, 1971).**

On the back side, the storey-high facade elements (Figure 17) consist of a composition of *South -facing Windows (E-13*), *Doors (E-15)* and *Framed Parapets (E-9)*. From inside to out, the parapets are constructed using a 5 mm thick plywood inner lining, a 20 mm wide, weakly ventilated cavity, a 25–30 mm layer of polystyrene foam, and a weather-resistant cladding board. The outer cladding of weather-resistant board material and a rock wool board have been added to the *Reinforced Concrete Party Wall (E-2)* end faces **(Van Elk & Priemus, 1971).**

The roof differentiates itself from the concrete-story floors through the use of wood framing in combination with steel structures. The drawings by **Gemeente Amsterdam & Zandstra (1961)** show that these connections are using dry-jointing techniques; therefore, they can be classified as loose connections **(O).**

Furthermore, the balconies are fitted with two distinct types of *Balustrades (E-11)*, separating the interior from the exterior visibly (Figure 17). An open style balustrade is used on the back side of the buildings, and a closed-style balustrade is used on the front side of the building.

The shaft housing the elevator is located along the longitudinal facade on the front side of the building. The shaft consists of two distinct elements: *Elevator Shaft Windows (E-18)* and *Elevator Shaft Walls (E-19)*.

Lastly, on the ground floor, *Brick Walls (E-12)* are constructed using a cavity structure, with an exterior cavity leaf made of half-brick bond masonry and an inner cavity leaf made of gravel concrete, connected using specialised cavity anchors. The inner cavity leaf is equipped with 15 mm of polystyrene foam on the cavity side **(Van Elk & Priemus, 1971).**

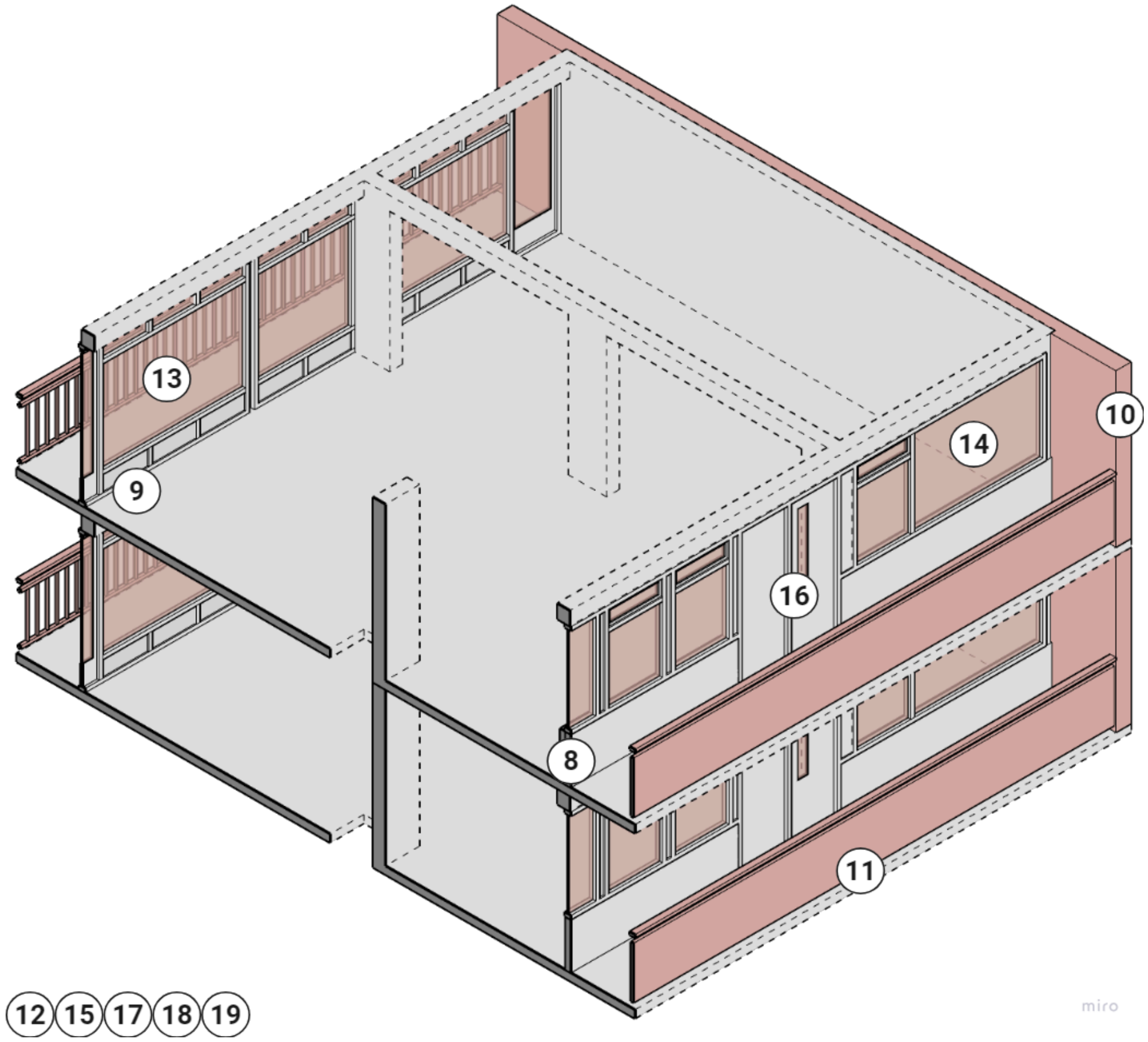


Figure 17: Axonometric of the Skin Layer. **(Author)**

List of Elements:

E-8. Brick Parapets
E-9. Framed Parapets
E-10. Brick End-walls
E-11. Balustrades
E-12. Ground Floor Brick Walls
E-13. South-facing Windows
E-14. North-facing Windows
E-15. East-facing Windows
E-16. Doors
E-17. Roofs
E-18. Elevator Shaft Windows
E-19. Elevator Shafts Walls

Dependency Structure Matrix (DSM)

As shown in Figure 18, most internal connections of the different elements are classified as Loose except for the connections using brickwork to connect to each other. In addition, the *Framed Parapets (E-9), North -facing Windows (E-14*), *South -facing Windows (E-13*), and *Doors (E-16)* together form a single composition of facade elements that are integrated with each other and more difficult to interchange separately. Therefore, Figure 18 reveals that the space plan layer of these buildings is, internally, for the most part adaptive, except for a few elements.

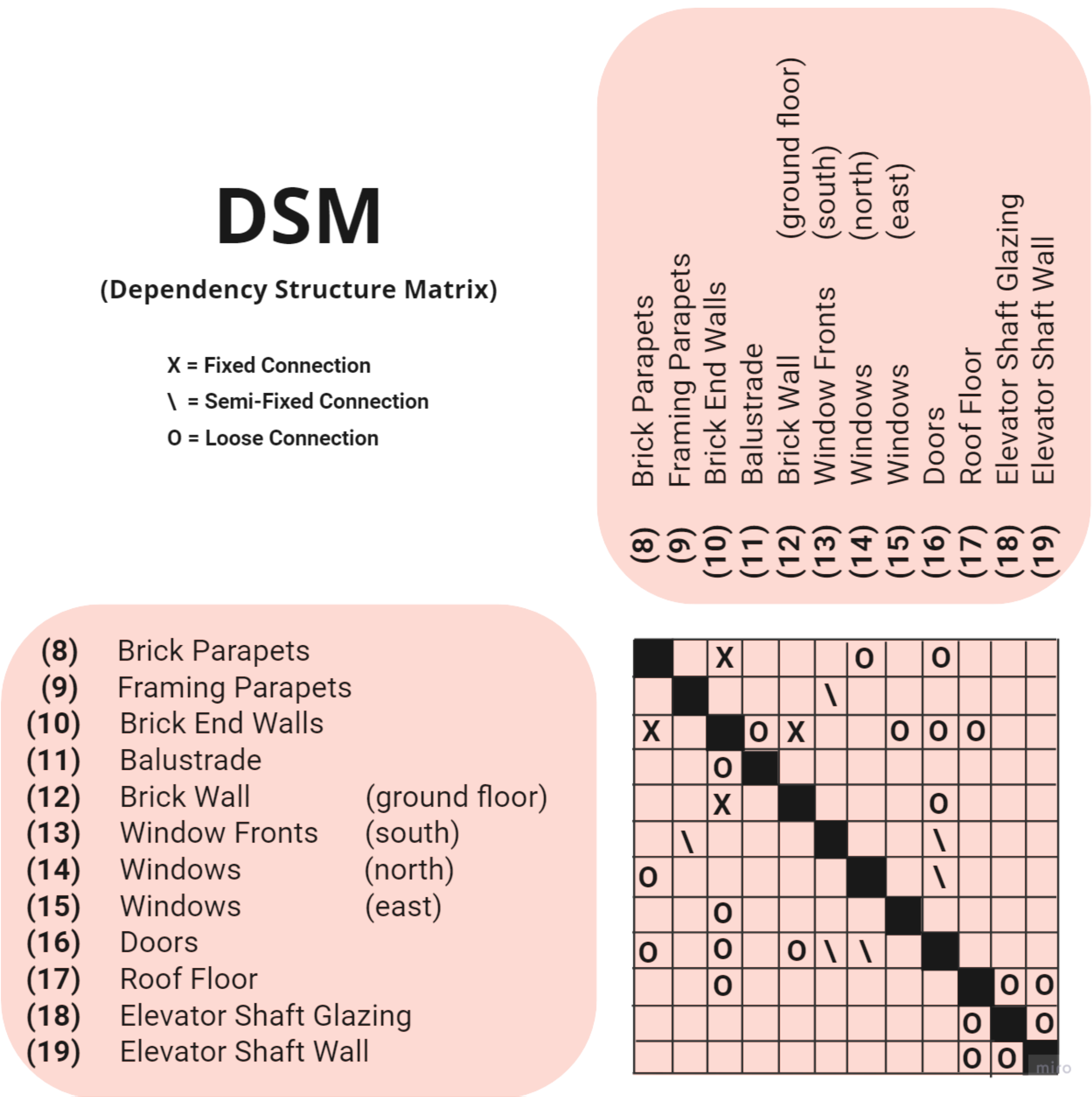


Figure 18: DSM showing internal relationships of the skin layer. **(Author)**

5.4. Space Plan

Elements or Attributes that enclose the spaces that users occupy;

As mentioned in Chapter 2.2 Structure, the structure provides 82 m2 of area for a spacious two-bedroom home (Figure 19)**.** The interior wall partitions are constructed using different materials (Figure 20). *Interior Wall Partitions (Brick) (E-20)* with a thickness of 100 mm are used in selected places. Most of the *Interior Wall Partitions (Framing) (E-21)* are constructed using wood stick-framing equipped with a 12.5 mm layer of gypsum on both sides. The walls are fixed to the structural floor and *Interior Wall Partitions (Brick) (E-20)* using metal anchors; these types of connections are characterised as a loose bond **(O)**. The wooden *Interior Doors (E-22)* used in all apartments are connected to both types of interior wall partitions with metal anchors; this type of connection is characterised as a loose bond. **(O)**

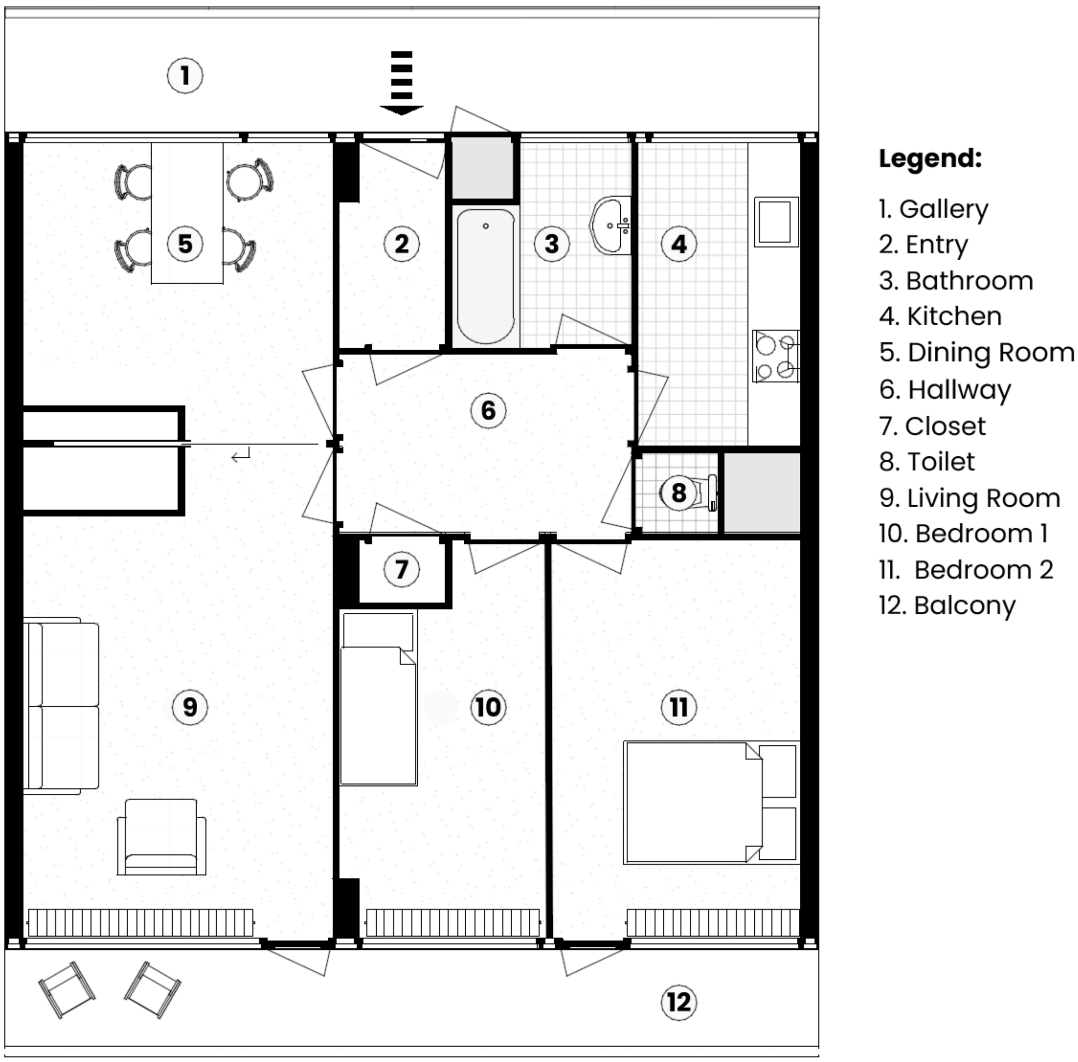


Figure 19: Floor plan for most common apartment typology. **(Author)**

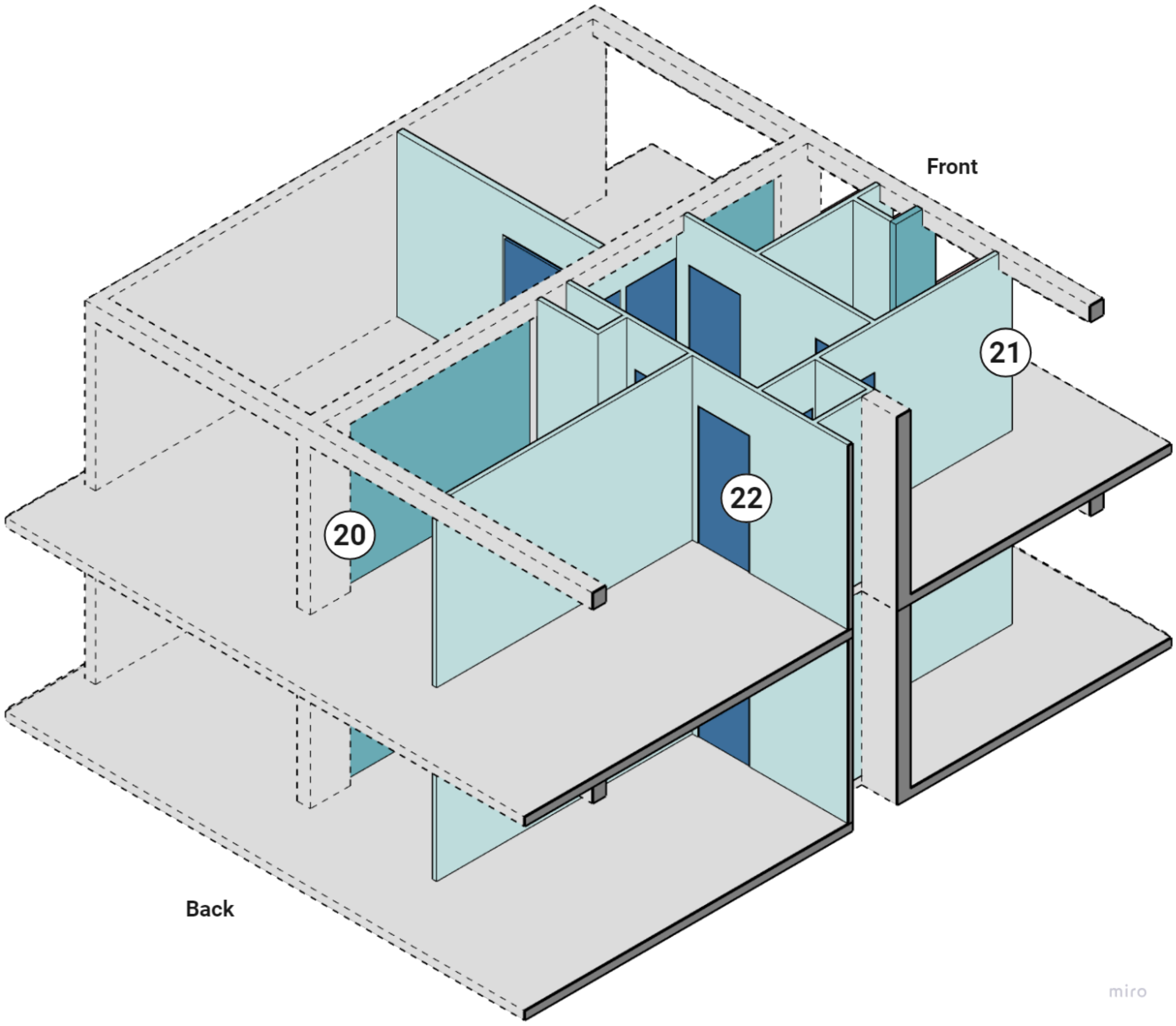


Figure 20: Axonometric of the Space Plan Layer. **(Author)**

List of Elements:

E-20. Interior Wall Partitions (Brick)
E-21. Interior Wall Partitions (Framing)
E-22. Interior Doors

Dependency Structure Matrix (DSM)

As shown in Figure 21, all internal connections of the different elements are classified as loose. Therefore, Figure 21 reveals that the space plan layer of these buildings is internally highly adaptable.

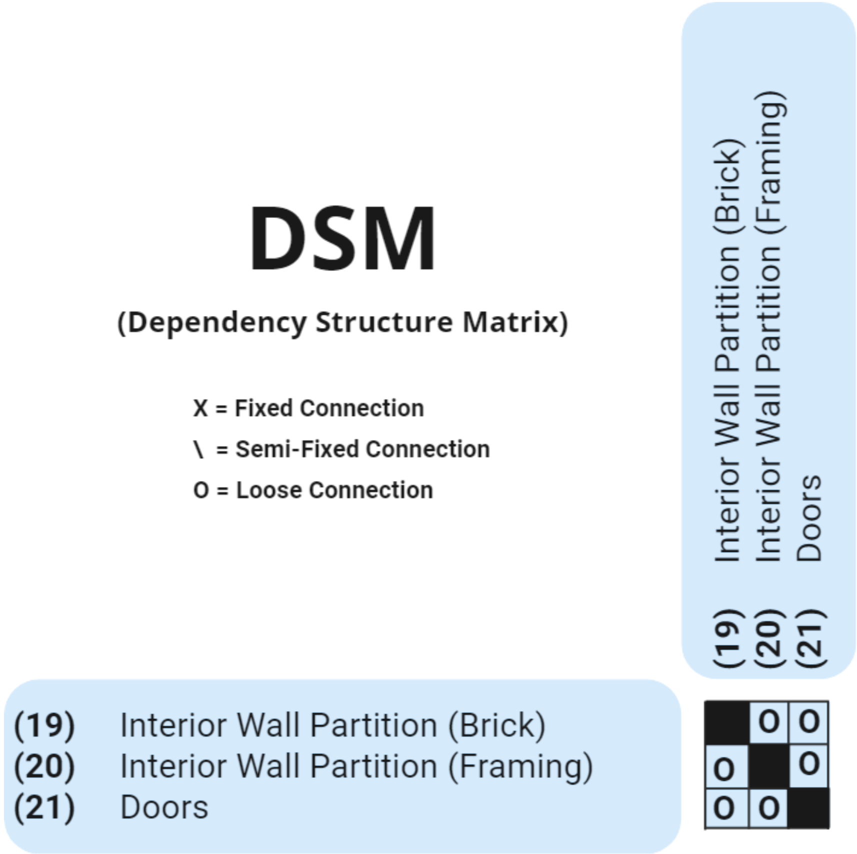


Figure 21: DSM showing internal relationships of the Space Plan layer. **(Author)**

5.5. Services

Elements or Attributes that supply and move physical flows, such as water, electricity, communications, and elevators;

The drawings by **Gemeente Amsterdam & Zandstra (1961)** show most services penetrate the structure in two places, with a few exceptions. Among the exceptions are the *Elevators (E-23)*, which are located along the longitudinal facade on the front side of the building and are installed in the elevator shaft (Figure 22).

Another exception are the *Drainage Pipes (E-28)* for rainwater; according to **Funda Research** in Appendix 2, these penetrate each balcony floor and allow for stormwater runoff into the public sewage system.

The final exception is the *Natural Ventilation (E-26)*, which is integrated into the façade by using either window openings or ventilation grilles (Figure 22). These grilles and openings are located on the front and back sides of the buildings.

According to **Funda Research** in Appendix 2, the apartments are heated and provided with hot water using central block heating. Typical for this system is that heat is generated centrally in a boiler room on ground level and then distributed throughout the entire building. Both the *Hot Water Lines (E-24)* and *Cold Water Lines (E-25)* penetrate the buildings' structure in fixed positions on the grid. The *Hot Water Lines (E-24)* and *Cold Water Lines (E-25)* enter the apartment via the fuse box located on the front sides of the buildings next to the entrance door.

Furthermore, the drawings by **Gemeente Amsterdam & Zandstra (1961)** show the *Gas Lines (E-27)* entering each apartment via the fuse box (Figure 22); these *Gas Lines (E-27)* are only used for *Kitchen Appliances (E-35)*.

The building's *Sewage System (E-29)* is located in a different shaft (Figure 22 located next to one of the *Reinforced Concrete Bracing Walls (E-3)*. All water is discharged using the *Sewage System (E-29)*.

Finally, the building's *Internet Cables (E-30)* and *Electrical Cables (E-31)* also enter each apartment via the fuse box (Figure 22) and are then further distributed through the apartments. The *Electrical Cables (E-31)* also provide power to the boiler and pumps used for the *Hot Water Lines (E-24)* and *Cold Water Lines (E-25),* as well as the power needed to operate the *Elevators (E-23)*. These services are connected using wires and plugs; this type of connection is characterised as a loose bond. **(O)**

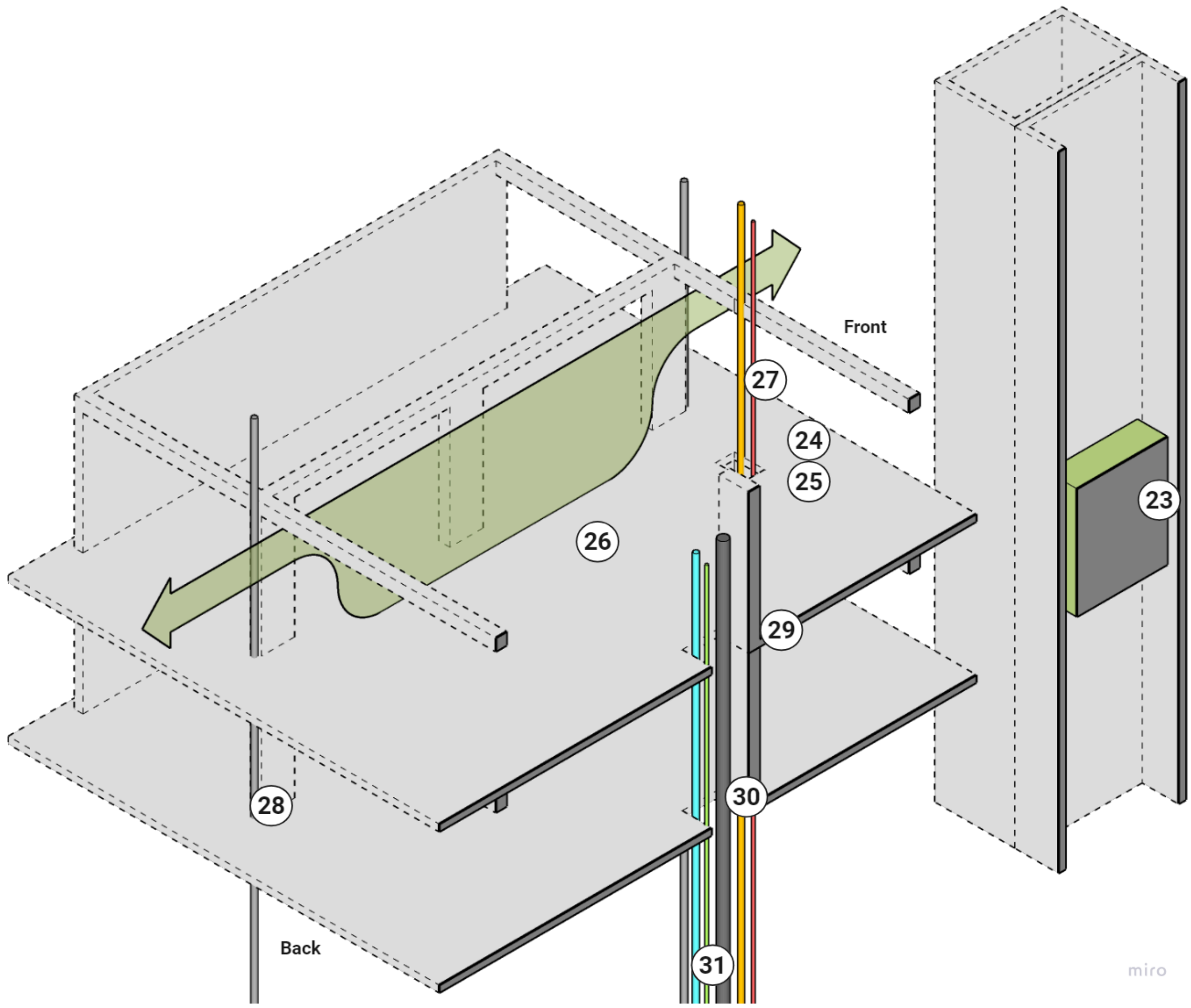


Figure 22: Axonometric of the Services Layer. **(Author)**

List of Elements:

E-23. Elevators
E-24. Hot Water Lines
E-25. Cold Water Lines
E-26. Natural Ventilation
E-27. Gas Lines
E-28. Drainage Pipes
E-29. Sewage System
E-30. Internet Cables
E-31. Electrical Cables

Dependency Structure Matrix (DSM)

As shown in Figure 23, all internal connections of the different elements are classified as loose. Therefore, Figure 23 reveals that the service layer of these buildings is internally highly adaptable.

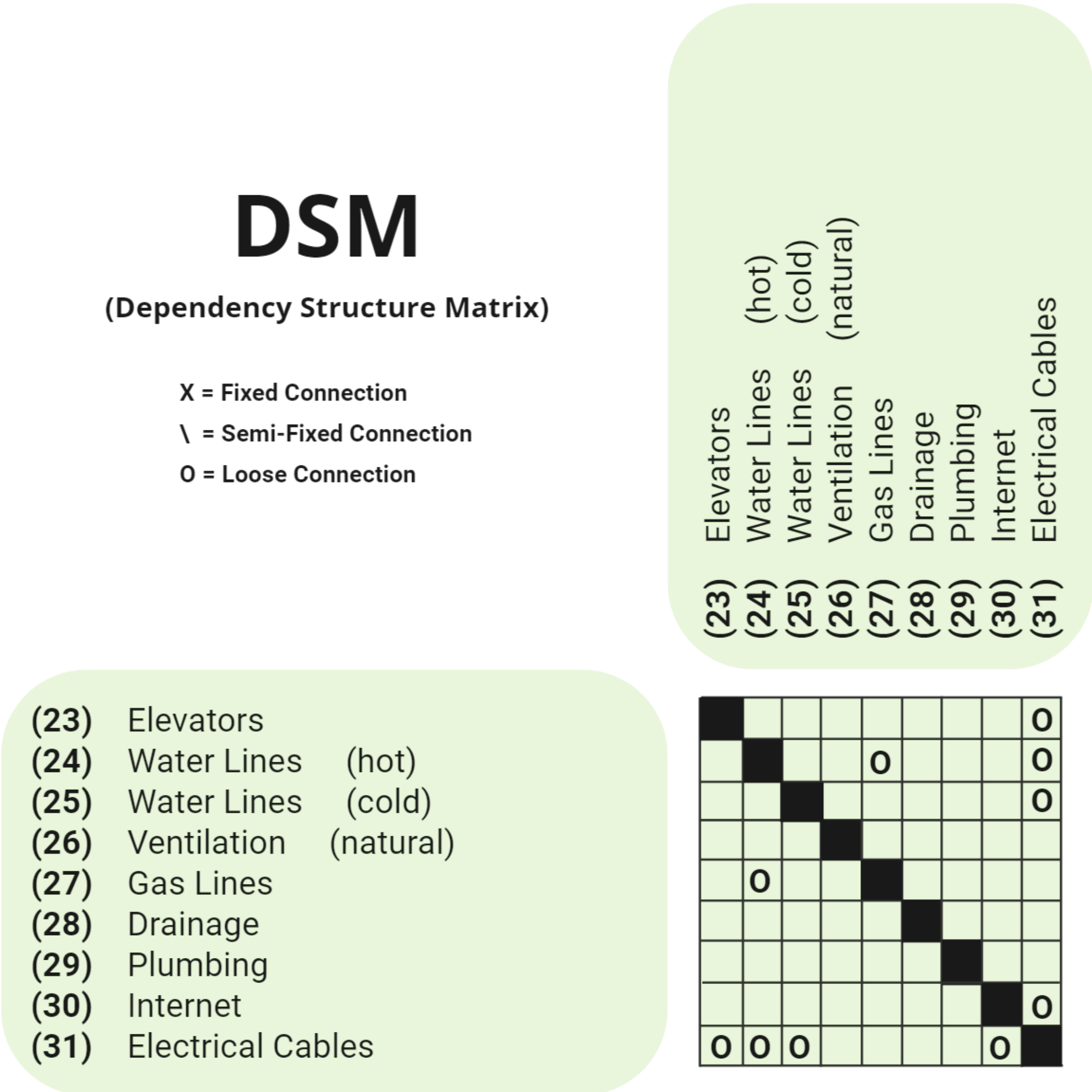


Figure 23: DSM showing internal relationships in the services layer. **(Author)**

5.6. Stuff

Elements or Attributes that exist within the space that users occupy;

It is critical to distinguish between two categories when discussing the layer *of stuff:* enduring and fleeting. First, this is also done by **Schmitt III & Austin (2016)** and is based on the argument that certain elements are more likely to change than others, for example, a chair (fleeting) and a toilet (enduring). In addition, the **Funda Research** in Appendix X shows the same distinction between fixed and fleeting elements. Therefore, only the fixed elements and attributes are taken into account in the *stuff layer*.

The first elements are the *Toilets (E-32)*. According to **Funda Research** (Appendix 2), the *Toilets (E-32)* stay the same or get renovated entirely after the apartments get sold or rented. *Toilets (E-32)* include the actual toilet itself, accessories, and tiles.

According to **Funda Research** (Appendix 2), the *Floor Coverings (E-33)* for the most part consist of laminate flooring and are used throughout the entire apartment except for the bathrooms and toilets (Figure 24).

According to **Funda Research** (Appendix 2), the *Kitchen Cabinets (E-34)* and the *Kitchen Appliances (E-35)* are integrated with each other and stay the same or get renovated entirely after the apartments get sold or rented. The integration of the *Kitchen Cabinets (E-34)* and the *Kitchen Appliances (E-35)* is reversible; this type of connection can be characterised as a loose bond. **(O)**

According to **Funda Research** (Appendix 2), the *Bathrooms (E-36)* stay the same or get renovated entirely after the apartments get sold or rented. *Bathrooms (E-36)* include the actual shower or bathtub itself, the sink, accessories, and tiling.

According to **Funda Research** (Appendix 2), the *Exterior Lighting Fixtures (E-37)* are located on the front side of the buildings near the front door and attached to the underside of the balcony floor (Figure 24).

The *Radiators (E-38)* are located close to the skin layer (Figure 24) underneath the windows. The radiators stay the same or get renovated entirely after the apartments get sold or rented.

Finally, the *Tiling (E-39)* is present in the kitchen, *Bathrooms (E-36)* and *Toilets (E-32)*. The various attributes are fixed using bolts; this type of connection can be characterised as a loose bond. **(O)**

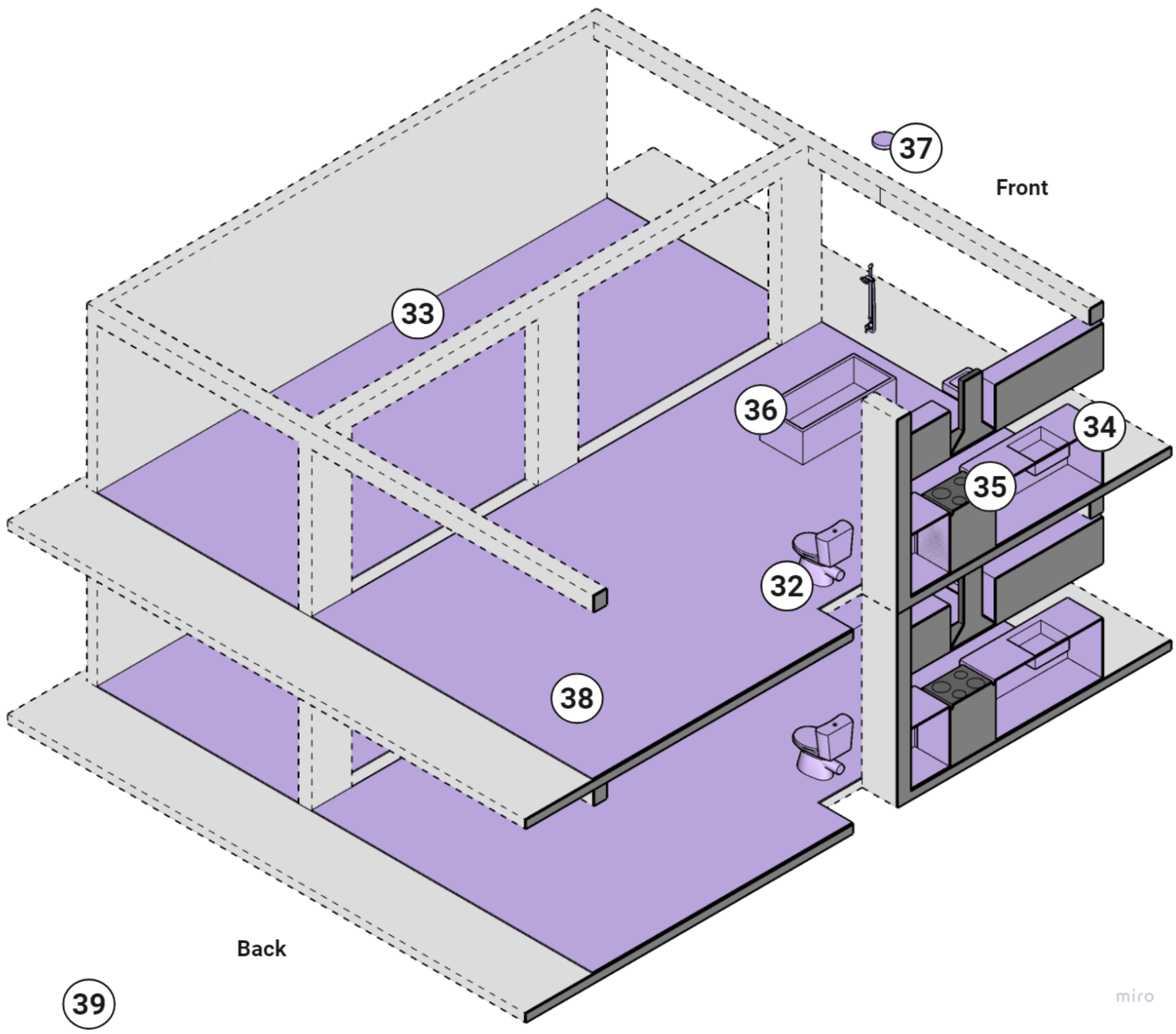


Figure 24: Axonometric of the Stuff Layer. **(Author)**

List of Elements:

E-32. Toilets
E-33. Floor Coverings
E-34. Kitchen Cabinets
E-35. Kitchten Appliances
E-36. Bathrooms
E-37. Lighting (exterior)
E-38. Radiators
E-39. Tiling

Dependency Structure Matrix (DSM)
As shown in Figure 25, all internal connections of the different elements are classified as loose. Therefore, Figure 25 reveals that the service layer of these buildings is internally adaptable.

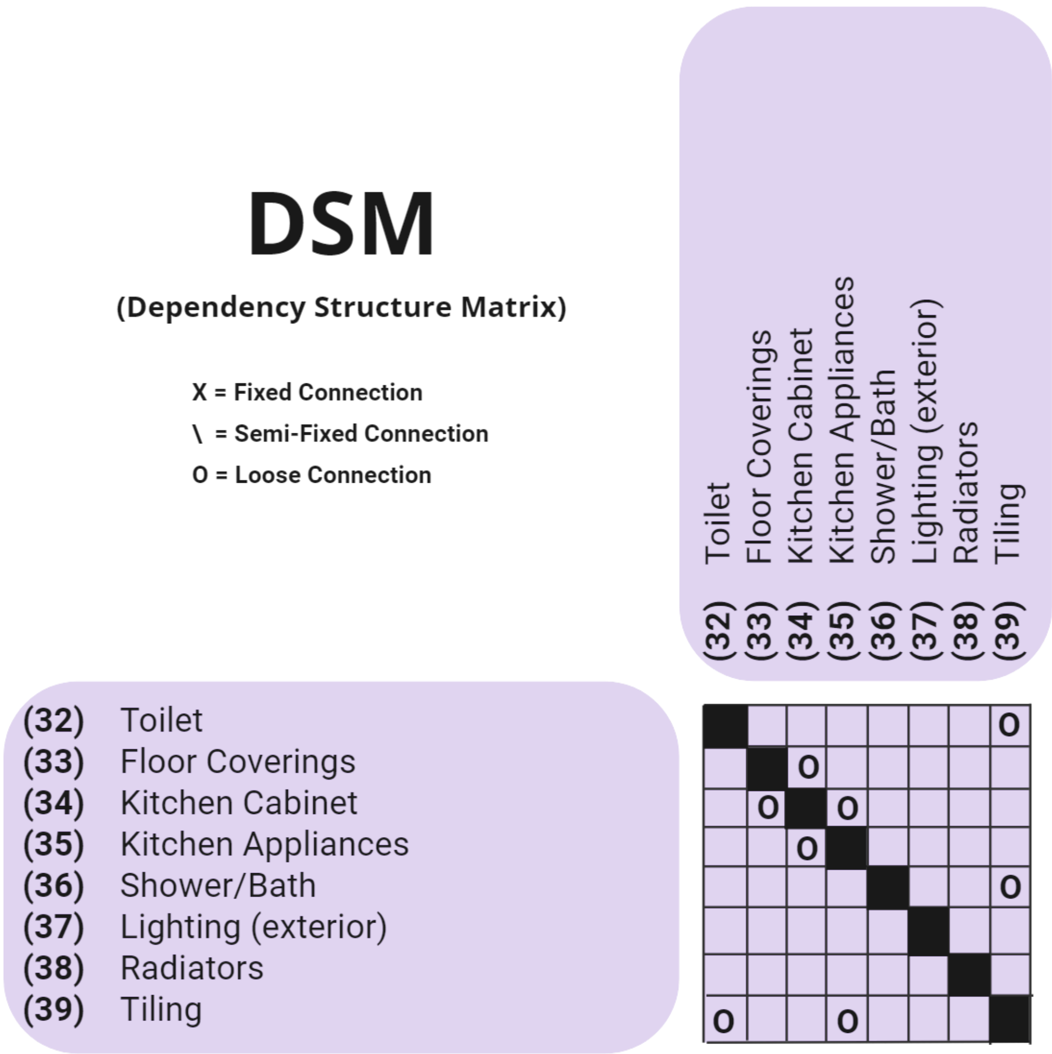


Figure 25: DSM showing internal relationships of the stuff layer. **(Author)**

6. Attributes

6.1. Surroundings and Site

The legal boundary within which the building is situated and the larger physical context in which a building sits;

The case study is located in an area designated as a protected cityscape (Figure 11). The coherence between buildings, greenery, and the design of public spaces is mentioned as being protected **(Gemeente Amsterdam, 2017).** Among the many low- and medium-rise buildings, high-rises were positioned carefully to act as noticeable landmarks. The vegetation is arranged in a hierarchy, ranging from front or back gardens to parks, green belts, courts, and landscapes. In addition, the highway, city lane, district road, neighbourhood street, residential street, and pavement are arranged hierarchically within the infrastructure **(Gemeente Amsterdam, 2017).**

One of the principles of Het Nieuwe Bouwen was to create a cohesive interaction between constructed and unbuilt space, as well as to vary the proportion of high-rise and low-rise buildings, place unique buildings in natural settings, and repeat building blocks. The architecture is predominantly modern, with sombre, unadorned, and meticulous elements, and it is built from brick or using system building. The architecture of a group of buildings is typically the same. This results in surprising contrasts with the surrounding environment **(Rijksdienst voor het Cultureel Erfgoed, 2023).**

Figure 11: Map of Surroundings Analysis. **(Author)**

The three 13-story-high post-war gallery flats, designed by P. Zanstra in 1965, function as an urban wall when viewed across the lake (Figures 12 and 13), emphasising the North Bank's urban ensemble and giving it a metropolitan flair **(Gemeente Amsterdam, 2017).** Many composition studies were created for this, most likely as a result of the designers' search for a configuration of buildings in relation to each other that would satisfy the urban planning principles of Het Nieuwe Bouwen as applied by Van Eesteren and his associates. In which they were prioritising the best possible orientation to the sun and emphasising the presence of lots of light, space, and air.

The ensemble provides both suitably open and free space while also being able to handle the scale of the Sloterplas (Figure 13). From certain perspectives, the high-rise apartments, which are positioned like slats facing each other, resemble a closed wall (Figure 12) and function as a juxtaposition to the open ensemble of Torenwijck on the "rural" side (Figure 13). In addition, the ensemble has an important role in the termination of sightlines from the different sides of the Sloterplas, especially those from the southwest bank.

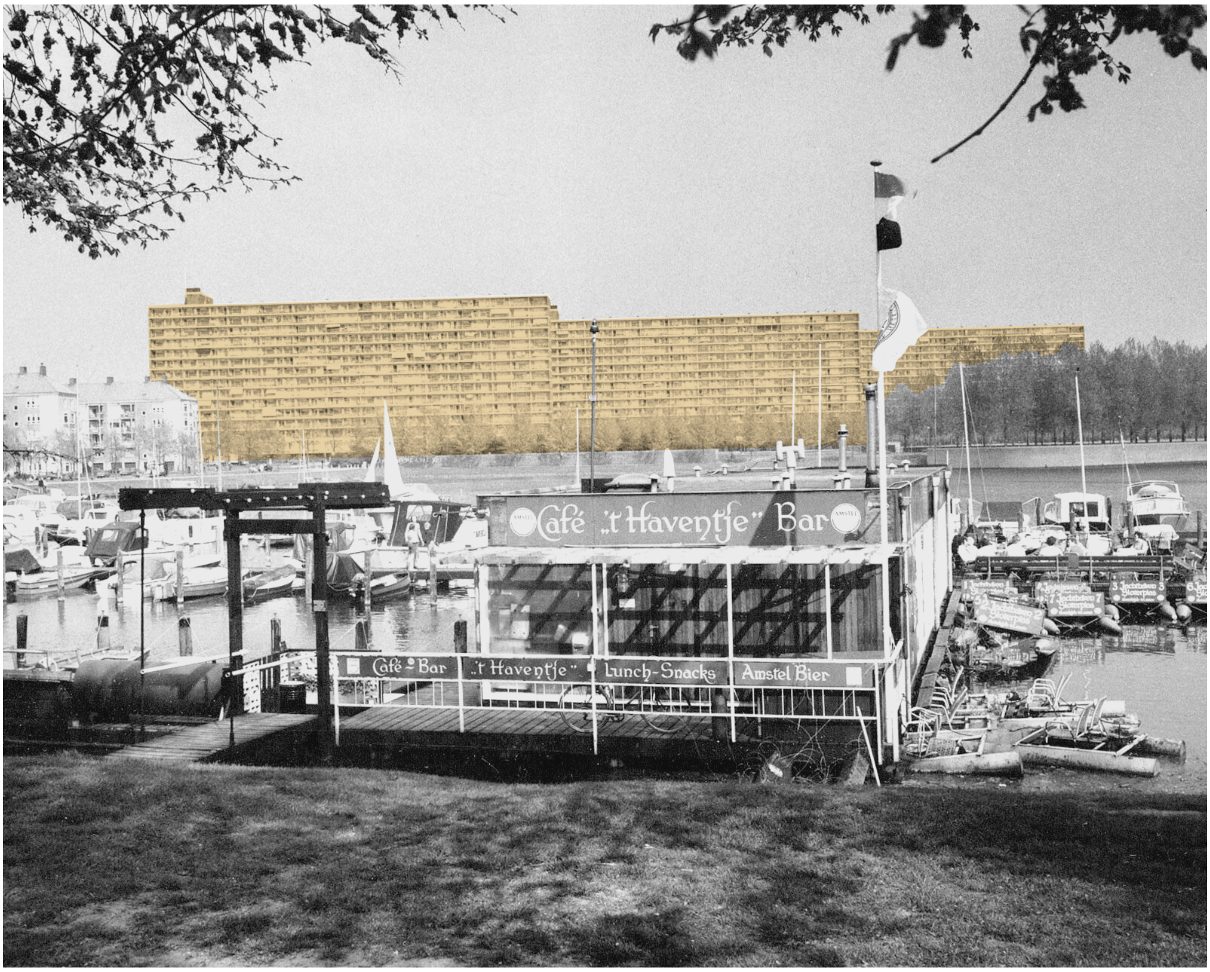


Figure 12: Eye-level perspective of the case study. **(Stadsarchief Amsterdam, z.d.)**

Figure 13: Bird-eye of Western Garden Cities. **(Stadsarchief Amsterdam, z.d.)**

Looking closer at the legal boundary within which the building is situated, the site (Figure 14), the ground level surrounding the flats is marginally lower than the North Bank's overall ground level. White concrete retaining walls (A) were used to manage these height differences. Collective parking areas were, for the largest part, hidden from view on the shaded side. Aldo van Eijk originally designed two playgrounds (B) on the south side, all of which were in the sun and visible from the balconies. Some of the playgrounds can still be recognised on the public area's pavement even though they have been removed. **(Gemeente Amsterdam, 2017)**

Due to shifting cultural and social conditions, the area's significance began to decline in the 1990s. Since then, new construction has made an effort to draw in different kinds of inhabitants. The initial features influence a rising reconsideration. The green spaces are widely valued by the existing population, especially the green structures. **(Rijksdienst voor het Cultureel Erfgoed, 2023)**

Figure 14: Map of Site Analysis. **(Author)**

List of Attributes
The aforementioned elements were, if applicable, classified using the tangible and intangible matrix by **Veldpaus (2014)** in Appendix 1.

Tangible: Asset

A-1 Urban Element: Concrete Retaining Wall;
A-2 Urban Element: Leftovers of two playgrounds by Aldo van Eijck;

A-3 Natural Element: Green Structures.

Tangible: Area

A-4 Ensemble: Similarity of architectural expression between the three buildings.

Intangible: Asset-Related

A-5 Relation: Hierarchy of Infrastructure;
A-6 Relation: Hierarchy of Green Spaces.
A-7 Relation: Coherence between buildings, greenery, and public spaces;
A-8 Relation: Ensemble functions as a Noticeable Landmark;

A-9 Concept: Het Nieuwe Bouwen (light, space and air);

A-10 Character: Proportion, juxtaposition and termination of sightlines;
A-11 Character: modern, sombre, and meticulous.

6.2. Structure

Elements or Attributes that provide horizontal bracing and primary vertical load transfer;

According to **Bureau Monumenten & Archeologie (2010),** the horizontal architectural elements, like galleries and balconies, and the ones that are vertical, like elevators, are interwoven to give the buildings *Articulation and Rhythm (A-12)*.

List of Attributes:
The aforementioned elements were, if applicable, classified using the tangible and intangible matrix by **Veldpaus (2014)** in Appendix 1.

	Intangible: Asset-Related
A-12	Character: Articulation, Composition, and Rhythm.

6.3. Skin

Elements or Attributes that separate the interior spaces from the exterior spaces, both physically and visibly;

Attributes

The buildings have a distinct main form and relatively flat façades. From a distance, its silhouette is visible. As such, the design considers both the view from up close and the view from afar (Chapter 5.2: Surroundings and Site). According to **Bureau Monumenten & Archeologie (2010),** the vertical features of architecture, like staircases, and the horizontal architectural elements, like galleries and balconies, and the ones that are vertical, like stairs, are interwoven to give the buildings articulation and rhythm.

Bureau Monumenten & Archeologie (2010) also mentioned that the details, materials, and colours used in each architectural unit are the same or connected to one another. The facade's overall appearance is determined by their recurrence. Colour, texture, and detailing are used to support the façade rhythm. The most common materials used are concrete and brick. Colour is used in a variety of ways, albeit rather subdued.

In addition, according to conservation experts at the Bureau Monumenten & Archeologie of the city of Amsterdam, window fenestration (the subdivision of windows) is given significance **(Havinga et al., 2020)**. The interplay of lines and the rhythm in the fenestrations are also mentioned to make the building interesting and give it refinement. According to **Funda Research** in Appendix 2, some of the fenestration was lost due to the replacement of wooden windows with PVC-U. This was done in an incoherent way and deteriorates the overall composition of the facade.

List of attributes:

The aforementioned elements were, if applicable, classified using the tangible and intangible matrix by **Veldpaus (2014)** in Appendix 1.

Tangible: Asset

A-13 Building: Distinct main form;
A-14 Building Element: Window Fenestration;
A-15 Building Element: Common Use of Concrete and Brick.

Intangible: Asset-Related

A-16 Character: Articulation, Interplay, and Rhythm;
A-17 Character: colour, texture, and detailing to support the façade rhythm;
A-18 Character: Subdued use of colour;
A-19 Character: Flat Facades;
A-20 Character: Refinement of overall composition.

6.4. Space Plan

Elements or Attributes that enclose the spaces that users occupy;

A significant degree of adaptability is found in the space plan layer, according to **Funda Research** in Appendix 2. Comparing the current apartment layouts to the 1961 original floor plan, many have changed. Examples of this include rearranging kitchens and bathrooms, as well as removing walls and bedrooms to make an open-plan design. Therefore, the buildings' functional floor layouts and freely divisible rooms create a feeling of openness and airiness that is further enhanced by the addition of external, apartment-wide balconies.

This attribute can be used to support the argument for post-war housing's cultural value. Particularly the type of housing found in this case study: mass housing blocks, which can be found all over Europe and beyond.

On the building level, the ground-floor storage units in the apartment buildings give the façades of the buildings a closed-off appearance. This negative attribute results from a reevaluation of how these structures should be connected to public areas **(Havinga et al., 2020).** The ground floor's closed nature results from **CIAM's (1946)** concept, which encouraged dwellings to be built above ground level in order to create a distinct relationship with the street.

List of attributes:

The aforementioned elements were, if applicable, classified using the tangible and intangible matrix by **Veldpaus (2014)** in Appendix 1.

Tangible: Asset

A-21 Building Element (-): Storages on ground floor level.

Intangible: Asset-Related

A-22 Character (+): Significant Degree of Adaptability;
A-23 Character (+): Openness and Airiness;

A-24 Character (-): Closed-off Appearance.

6.5. Services

Elements or Attributes that supply and move physical flows, such as water, electricity, communications, and elevators;

There are no explicit instances of attributes mentioned regarding the *service layer*.

List of attributes:

- None

6.6. Stuff

Elements or Attributes that exist within the space that users occupy;

Attributes

There are no explicit instances of attributes mentioned regarding the *stuff layer*.

List of attributes:

- None

7. Dependency Structure Matrix (DSM

Most layers are internally adaptable. In this paragraph, all the lists were combined into one single DSM (Figure 26), and the external connections for each layer were interpreted, and the following things stood out:

7.1. Elements

Fixed Connections (X)
The external connections between the *Structure* and *Skin* layer are highlighted in light-grey, in the upper left corner of Figure 26. This shows that there are multiple fixed connections between elements from both the *Structure* and *Skin* layer. These consist of elements (Brick Parapets, Brick End Walls and Ground-floor Brick Walls) utilising brickwork to connect to various Structural members (Party Wall, Bracing Wall and Floors). These types of connections have to be either removed, if possible, or changed in order to improve adaptability.

The external connections between the *Service* layer and the *Structure*, *Skin*, and *Space Plan* layer are highlighted in light-grey, off center from the middle, in Figure 26. This shows that there are multiple fixed connections between elements from the *Service* layer (Cold Water Lines, Hot Water Lines, Gas Lines) and the *Structure* (Party Wall, Bracing Wall), *Skin* (Brick Parapets), and *Space Plan* (interior- and exterior wall partitions) layers. These types of connections have to be either removed, if possible, or changed in order to improve adaptability.

The external connections between the *Stuff* and *Skin,* and *Space Plan* layer are highlighted in light-grey, in the lower left corner of Figure 26. This shows that there are multiple fixed connections between elements from the *Stuff* layer (Tiling) and elements from the *Skin* (brick parapets) and *Space Plan* (interior- and exterior wall partitions) layer. These types of connections have to be either removed, if possible, or changed in order to improve adaptability.

Semi-Fixed Connections (\)
There are no external, semi-fixed connections.

Loose Connections (O)
The rest of the external connections were classified as loose connections.

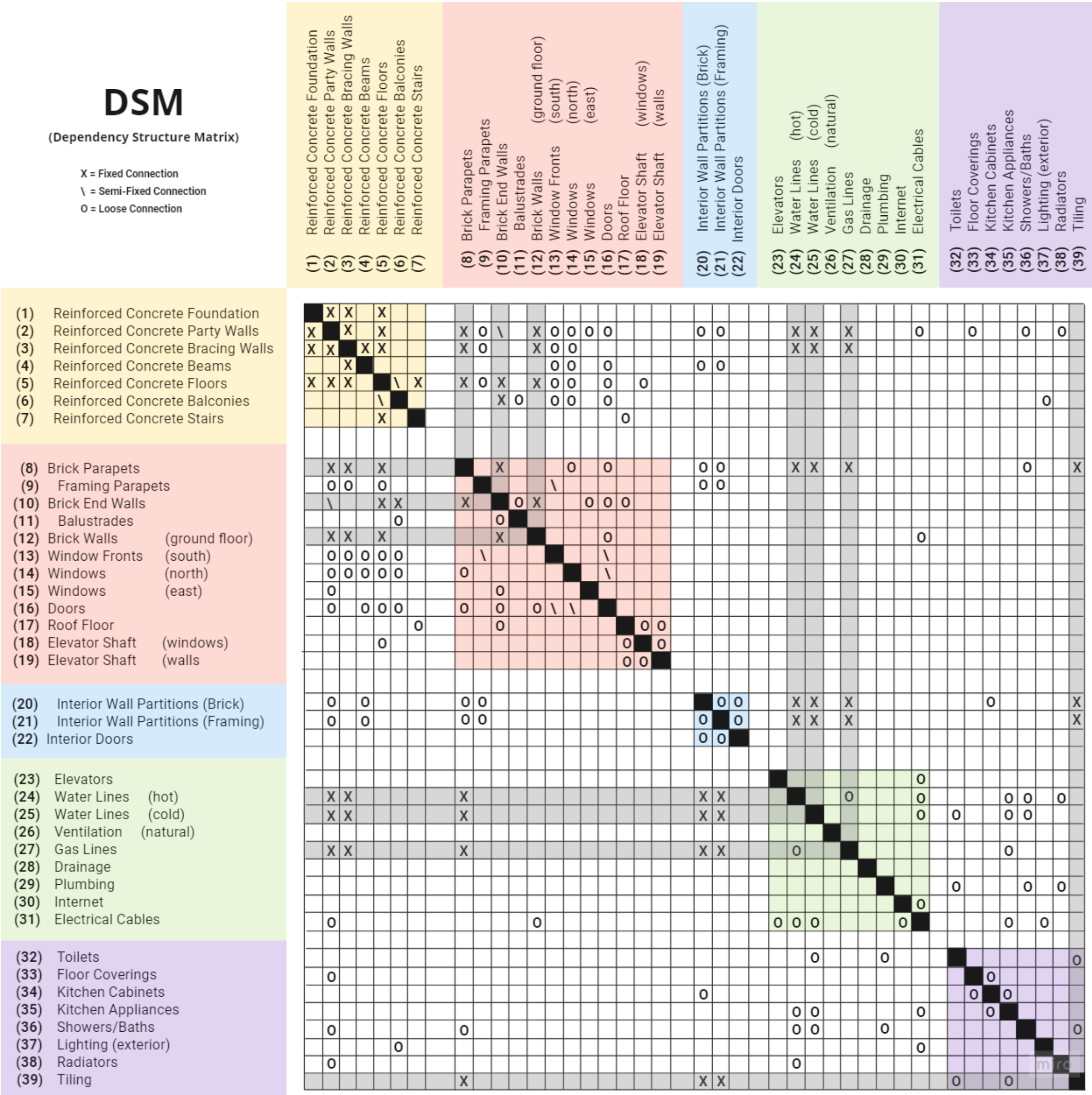


Figure 26: DSM showing external relationships between layers. **(Author)**

7.2. Attributes

When projecting the various identified attributes from the Surroundings/Site, Structure, Skin, and Space Plan layers onto the DSM (Figure 27), the following things stand out:

Building Layer: Surroundings/Site

Figure 27 shows that of all attributes concerning the *Surroundings/Site* layer the following have an affect on the DSM. The similarity of architectural expression between the ensemble of three buildings, coherent relation between buildings, greenery, and public spaces; and the modern, sombre, and meticulous character all affect the *Skin* layer of the building.

The concept of Het Nieuwe Bouwen (light, space and air) affects both the *Skin* and *Space Plan* layer because the configuration of openings and interior wall partitions greatly affect the presence of this concept.

Ultimately, the attributes only affect the *Skin* and *Space Plan* layer, therefore the synergy between adaptability and significance is to be sought for in these layers.

List of Attributes:

Tangible: Area

A-4 Ensemble: Similarity of architectural expression between the three buildings.

Intangible: Asset-Related

A-7 Relation: Coherence between buildings, greenery, and public spaces;
A-9 Concept: Het Nieuwe Bouwen (light, space and air);
A-11 Character: modern, sombre, and meticulous.

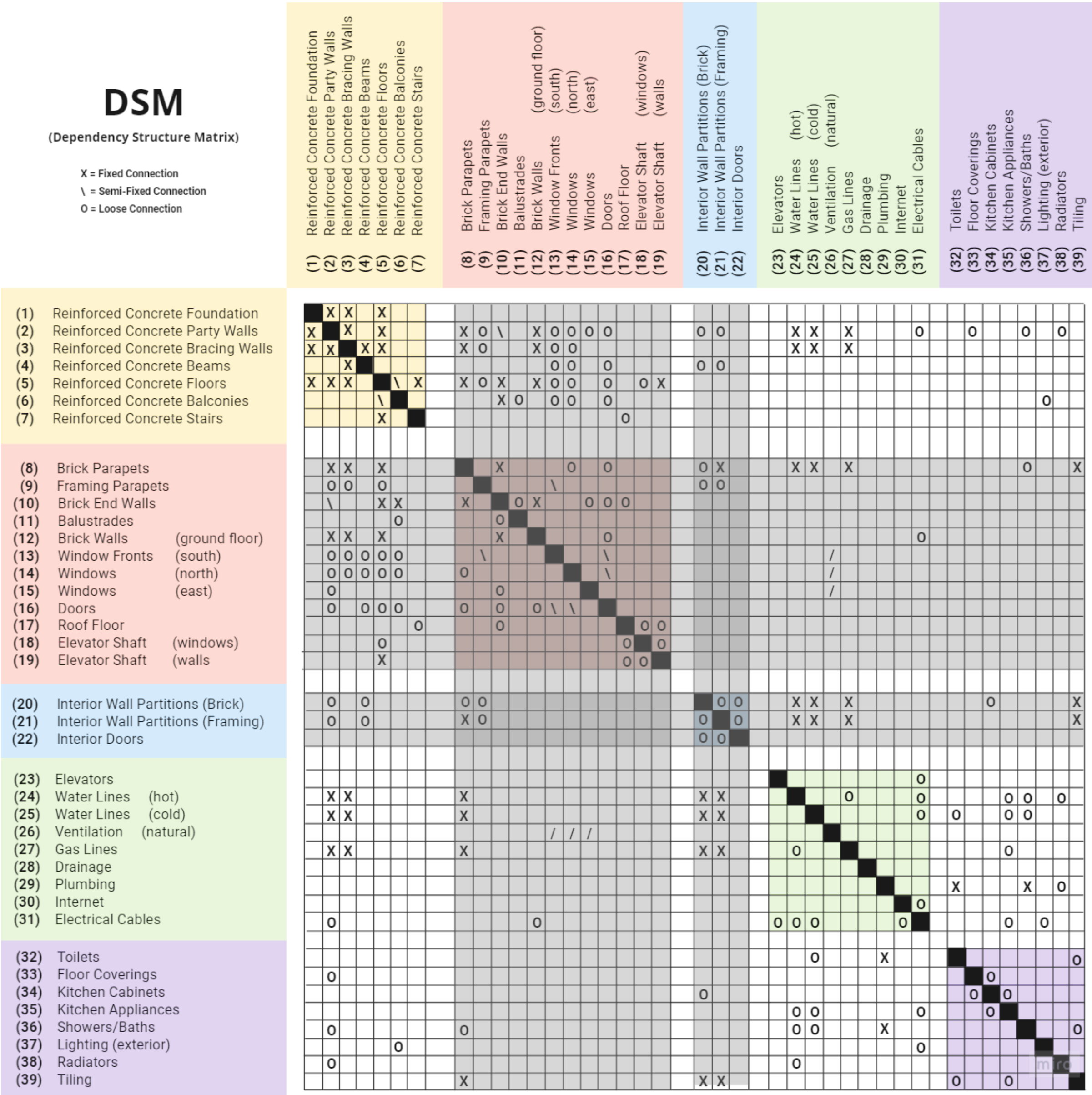


Figure 27: DSM showing relationships with surroundings and site attributes. **(Author)**

Building Layer: Skin

Figure 28 shows that of all attributes concerning the *Skin* layer the following have an affect on the DSM. The window fenestration and common use of concrete and brick are tangible attributes that represent intangible attributes like: articulation, interplay, and rhythm, subdued use of colour, and the use of colour, texture, and detailing to support the façade rhythm all give refinement to the overall composition.

Ultimately, the attributes only affect the *Skin* layer, therefore the synergy between adaptability and significance is to be sought for in these layers.

List of Attributes

Tangible: - Asset

A-14 Building Element: Window Fenestration;
A-15 Building Element: Common use of concrete and brick.

Intangible: Asset-Related

A-16 Character: Articulation, Interplay, and Rhythm;
A-17 Character: colour, texture, and detailing to support the façade rhythm;
A-18 Character: Subdued use of colour;
A-19 Character: Flat Facades;
A-20 Character: Refinement of overall composition.

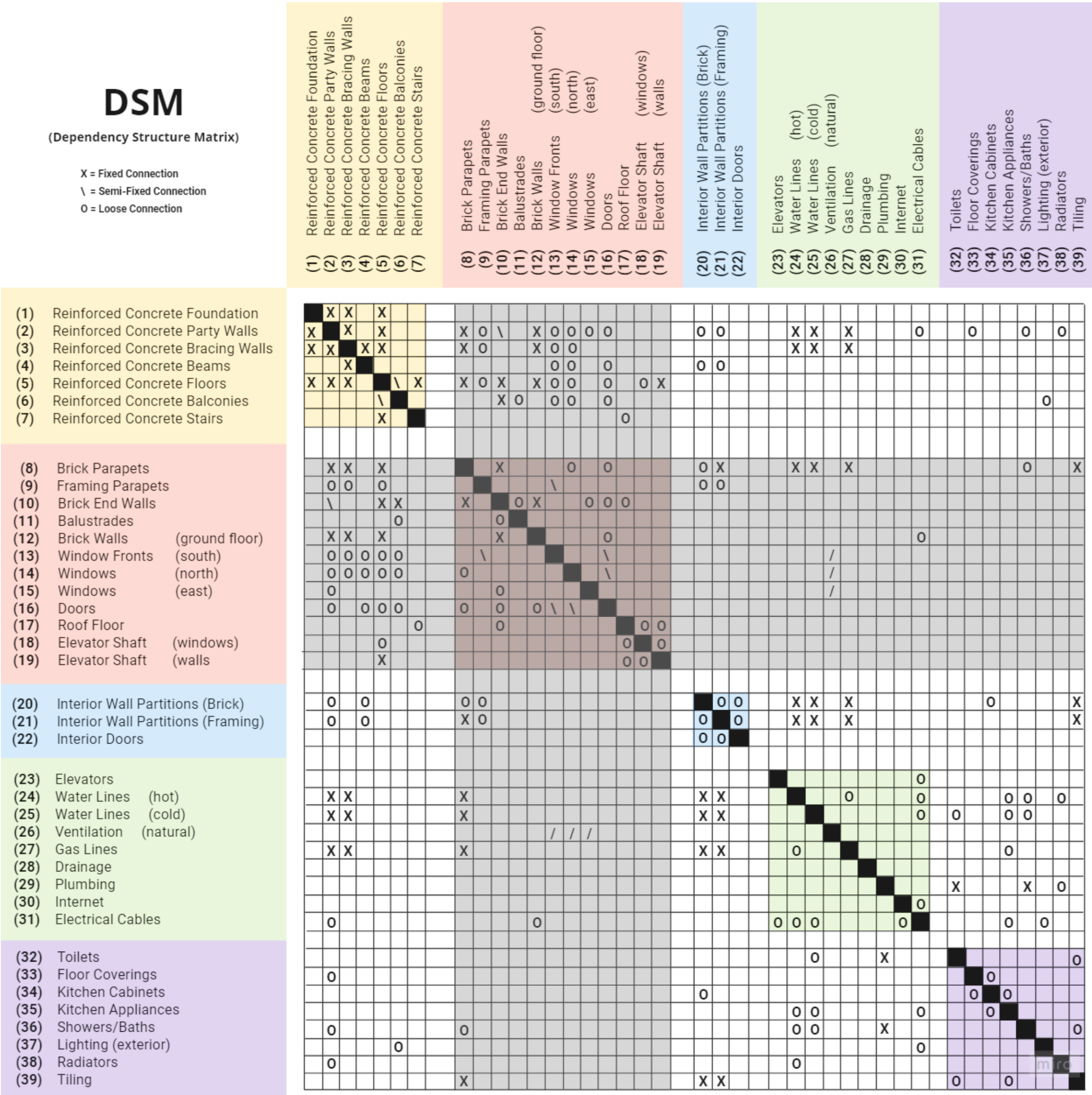


Figure 28: The DSM shows a relationship with skin attributes. **(Author)**

Building Layer: Space Plan

Figure 29 shows that of all attributes concerning the *Space Plan* layer the following have an effect on the DSM. The storages on ground floor level negatively impact the facade giving it a closed-off appearance.

In addition, there is a significant degree of flexibility present in the space plan of the apartments, that can provide openness and airiness.

Ultimately, the attributes only affect the *Skin* and *Space Plan* layer, therefore the synergy between adaptability and significance is to be sought for in these layers.

List of Attributes

Tangible: Asset

A-21 Building Element (-): Storages on ground floor level.

Intangible: Asset-Related

A-22 Character (+): Significant Degree of Flexibility;

A-22 Character (+): Openness and Airiness;

A-24 Character (-): Closed-off Appearance.

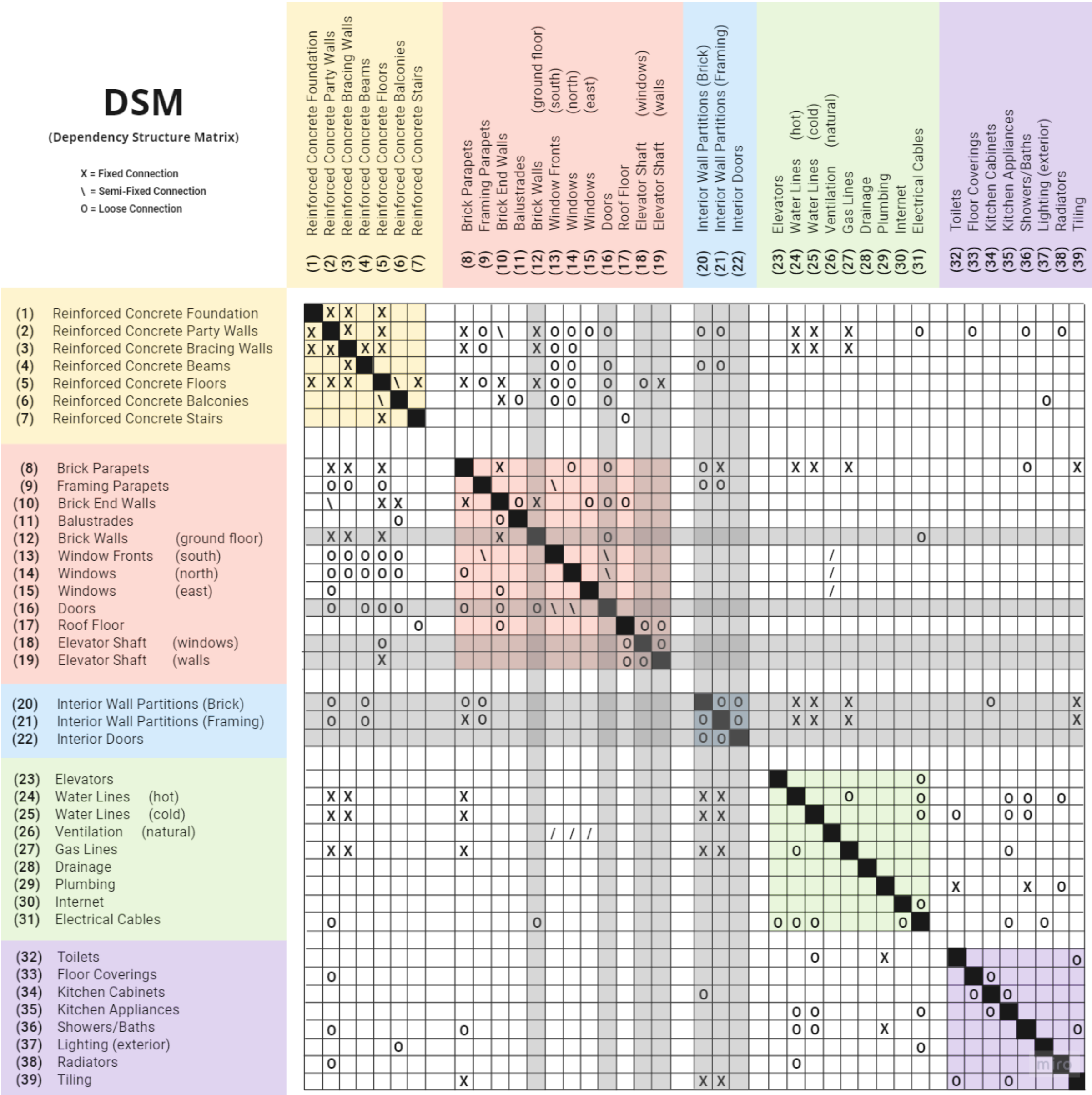


Figure 29: DSM showing relationship with Space Plan attributes. **(Author)**

8. Discussion

In this research report, the results were collected as accurately as possible, but due to some data being unavailable or not being substantial enough, it was not feasible to collect all the necessary details.

It is possible to apply the theoretical framework discussed in Chapter 3 and the methods in Chapter 4 to various kinds of buildings, whether or not they are considered heritage. Nonetheless, there are a few restrictions to take into account:

8.1. Theoretical Framework

The connection-type classification approach is a condensed version of the more intricate methodology of classification that **Durmisevic (2006)** revealed. Although this simplification keeps the research within the graduation track time constraint, it may degrade the quality of the research output.

8.2. Elements

Utilising a dependency structure matrix necessitates a high level of expertise with the details and relationships between the many building layers and the components that constitute them. It depends on careful validation of the connections, which can be difficult due to the various methods and techniques by which elements can depend on one another. Finding adequate boundaries for manual DSM's can be difficult and, therefore, poses the risk that the choices could seem arbitrary **(Schmidt III and Austin, 2016).**

8.3. Attributes

Written texts that discuss the significance of individual buildings, ensembles, and cityscapes play a major role in the attribute classification. In certain situations, documents are unavailable or have not yet been created. As a result, some case studies are unable to offer the necessary quantity or quality of data.

In addition, the research used data from multiple sources. It is important to mention the difference between official listings and literature as a source for identifying attributes. The official listing was seen as a collective statement by the municipal department of heritage experts and seen as the primary source, whereas the literature was based on the perspectives of individual heritage professionals who operate in the same area and therefore seen as a secondary source to confirm or add to the official listing.

Due to time constraints, the research focused only on attributes, while significance is defined by both attributes and values. There are two reasons for this. Firstly, the nature of the research, which is about the classification of building elements, logically relates to attributes. For research on values, a different research framework would be more suitable. Nonetheless, the approach takes into account different values, like historical, technical, and environmental, by combining post-war attributes with adaptability. In future research, the values should be defined using a different framework.

Ultimately, the outcomes of this research ought to be seen as a work in progress; the research period may be viewed as the initial stage within the redesign process. The data will likely be further enhanced during the following design period, which may offer more advanced insights on the adaptability of building layers and their connections to one another.

9. Conclusion

The goal of this research report was to answer the research question and sub-questions: :

How can post-war housing be redesigned to be more adaptable by using its defining attributes to address the changing needs of society?

Sub-question 1:
How can adaptability be spatially defined at the building level?

Sub-question 2:
How adaptable is post-war housing spatially on the building level?

Sub-question 3:
What are the heritage attributes of post-war housing?

9.1. Theoretical Framework

Adaptability, in contemporary architecture, was defined as the capacity of a building to accommodate the evolving demands of its context, thus maximising its value through life **(Schmidt III and Austin, 2016).** An architecture with the ability to develop and change, where elements can be configured, allowing changes in spatial, functional, and technological elements without building disruptions.

The basis for classification was seeing a building as a series of layers whose interactions define its resistance to change **(Brand, 1997).** In order to further clarify the types of connections, a series of three connection types was used based on the findings revealed by **Durmisevic (2006)**. There are two requirements for decomposable connections: 1. components and elements must be maintained apart to prevent infiltration into other systems or components; and 2. chemical techniques should be replaced with dry-jointing techniques. The classified elements and attributes were interpreted by placing them in a dependency structure matrix (DSM), revealing complex interdependencies between the building systems and attributes.

9.2. Elements

The internal DSM's reveal the structure layer of the building to be internally unadaptable. The skin layer is adaptable except for view elements. The space plan layer, in particular, presents a significant degree of adaptability. The use of especially Funda research to reveal this was significant. The significant degree of adaptability has been classified as an attribute that can be used to support the argument for the case studies, heritage value. The rest of the layers (services, skin) represent clear internal adaptability throughout.

The external DSM reveals there are fixed connections between the *structure* and *skin* layer, fixed connections between the *service* layer and the *structure*, *skin*, and *space plan* layer, and fixed connections between the *stuff* and skin and *space plan* layer. These types of connections have to be removed, if possible, or changed in order to improve adaptability.

9.3. Attributes

Furthermore, the research reveals that the surroundings/site, skin, and space plan layers provide all attributes, and when projecting these attributes onto the external DSM, it reveals that the attributes have the most effect on the *skin* and *space plan* layers; therefore, the synergy between adaptability and significance is to be sought in these layers.

Ultimately, the aim of this research report was to explore the concepts of adaptability in relation to heritage. This research report firstly offers a scientific framework that seeks to broaden ideas and highlight contrasting aspects of the importance of post-war housing blocks (values and features) by connecting them to adaptability. Secondly, this research report uses funda as a research method on adaptability to reveal a new attribute. This broadens the current perspective by including a new domain outside of the usual one in heritage discourse.

Valuable dwelling redesigns might be accomplished with the use of this scientific framework and the revealed attribute. Redesigns that concentrate on the advancement of post-war architecture towards an architecture that uses change for greater significance, considering the many unique attributes and the fact that the needs of society are continually changing. This will assist in the development of post-war architecture towards an architecture that uses change for greater significance.

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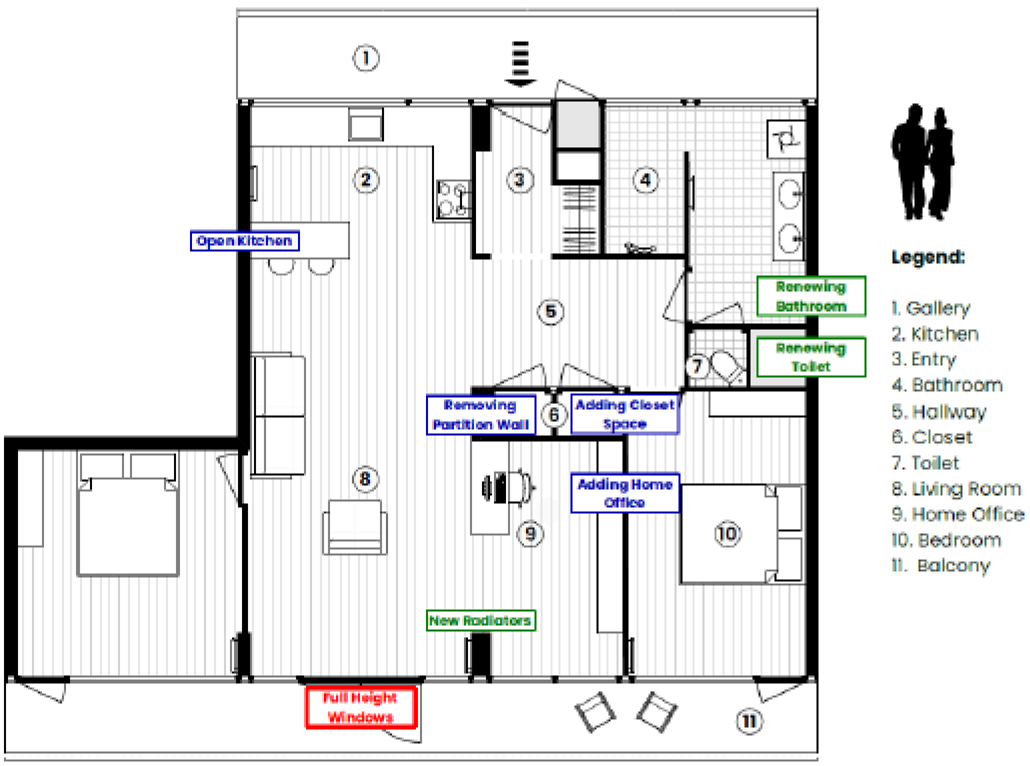
11. List of Figures

12. Appendix 1

Tangible and intangible matrix by **Veldpaus (2014)** retrieved from: https://brunodeandrade.weblog.tudelft.nl/teaching/minor-heritage-design/

			name	short	Long description
		0	-	-	There is no attribute mentioned, or the attribute doesn't belong in any of the other attribute
Intangible	asset related	1	concept	period/style	The intangible attribute is the intended idea, norms, values, expression, style in arts or architecture and the development (phase, evolution) thereof. Often the attribute is related, or represented by, a tangible hertage asset.
		2	relation	relation object-object	The intangible attribute represents a relation with another connected element, location, place or environment. Often the attribute is related, or represented by, a tangible heritage asset.
		3	character	image	The intangible attribute represents defining features, or a specific nature or quality. This can be related to a specific design (e.g. typology, morphology, layout, composition, proportion) or atmosphere (e.g. tranquil, lively, urban, rural).
	societal	4	use	function	The intangible attribute represents a specific (typical, common, special) use or function of a place or environment.
		5	knowledge	traditions, practices or customs	The intangible attribute represents (local) practices, traditions, knowledge, or customs of a community or group. These can be phenomena associated with a place or the understanding of the world by a group of people, which are transmitted and/or repeated and experienced and/or practiced.
		6	association	Relation men-object	The intangible attribute represents human associations with a place, element, location or environment.
		7	community	Society, individuals and their identity	The intangible attribute represents a community or society itself (its members or specific individuals or groups) and/or their cultural identity or diversity.
	process	8	planned	manageme nt	The intangible attribute represents an action, change or process that is intentional and planned, determined by strategies and policies (bureaucracy). The attribute often is a more short or medium term process.
		9	unplanned	developme nt or evolution	The intangible attribute represents an action, change or process that is piecemeal, unintentional, spontaneous and natural, without intervention of policies or strategies. The attribute is often a long-term, slow process.
Tangible	asset	10	building element	part of building	The tangible attribute represents elements or parts of a building. This element can be constructive, constitutive or decorative.
		11	building	whole building	The tangible attribute represents a whole building, structure, construction, edifice, or remains that host(ed) human activities, storage, shelter or other purpose.
		12	urban element	part in the urban landscape	The tangible attribute represents elements, parts, components or aspects of/in the urban landscape. This can be a construction, structure, or space, which is constructive, constitutive, or decorative.
		13	natural element	flora or fauna	The tangible attribute represents specific flora or fauna, like water elements of/in the historic landscape produced by nature. It can be natural or designed.
	area	14	ensemble	group of buildings	The tangible attribute represents a group of buildings or specific urban ensemble or configuration. The combination generates or represents specific history, coherence, variation, significance and has recognizable relations.
		15	context	setting	The tangible attribute represents the buildings or elements surrounding, supporting, or contextualizing the actual heritage. It is situating, adds understanding, often though not necessary geographical proximity.
		16	area	District in the wider (urban) landscape	The tangible attribute represents a district in a wider (urban) landscape, or a specific combination of cultural and or natural elements.
	all	17	layering	stratigraphy	The tangible attribute represents a landscape illustrative of the evolution or development of human society and settlement over time, a diversity of manifestations of the interaction between humankind and its natural environment.
		18	landscape	everything based on significance	The tangible attribute represents the integrated whole, the wider (urban) cultural landscape including (indicated or located) elements, areas or attributes with various levels of significance.

Floorplan #1133



Floorplan #581

Legend:

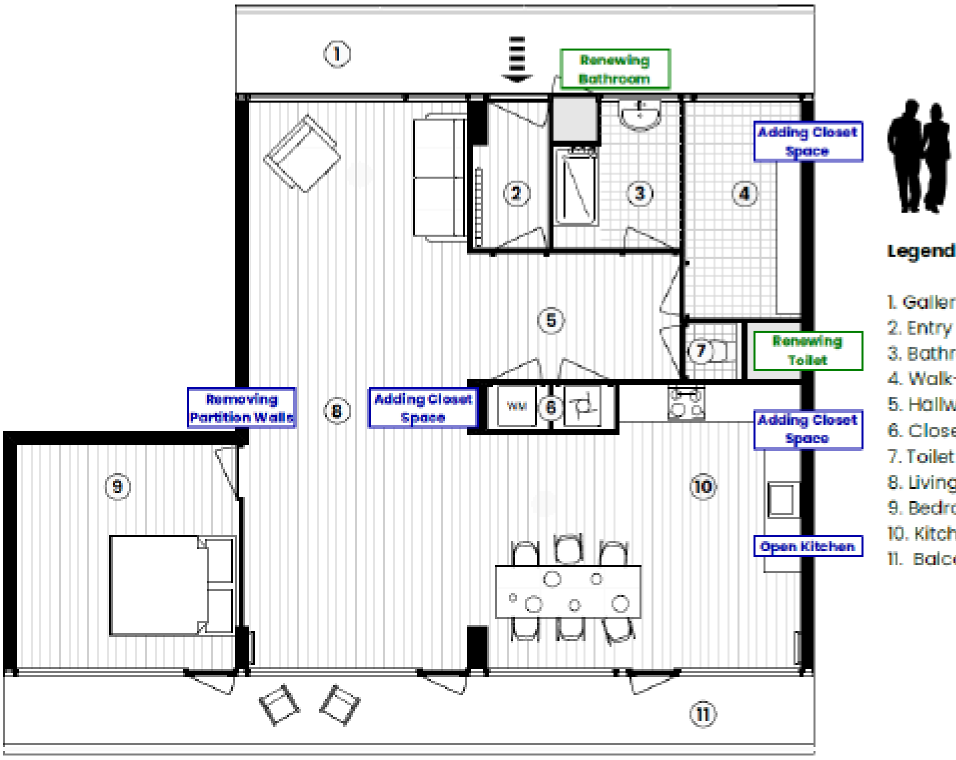
1. Gallery
2. Dining Room
3. Entry
4. Bathroom
5. Hallway
6. Kitchen
7. Coset
8. Toilet
9. Bedroom 1
10. Living Room
11. Bedroom 2
12. Bedroom 3
13. Balcony

Floorplan #581

Legend:

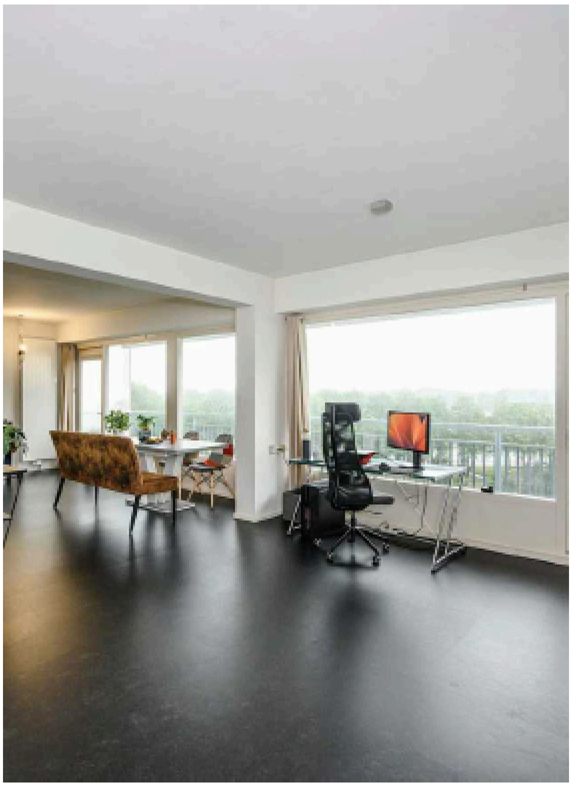
1. Gallery
2. Dining Room
3. Entry
4. Bathroom
5. Hallway
6. Kitchen
7. Coset
8. Toilet
9. Bedroom 1
10. Living Room
11. Bedroom 2
12. Bedroom 3
13. Balcony

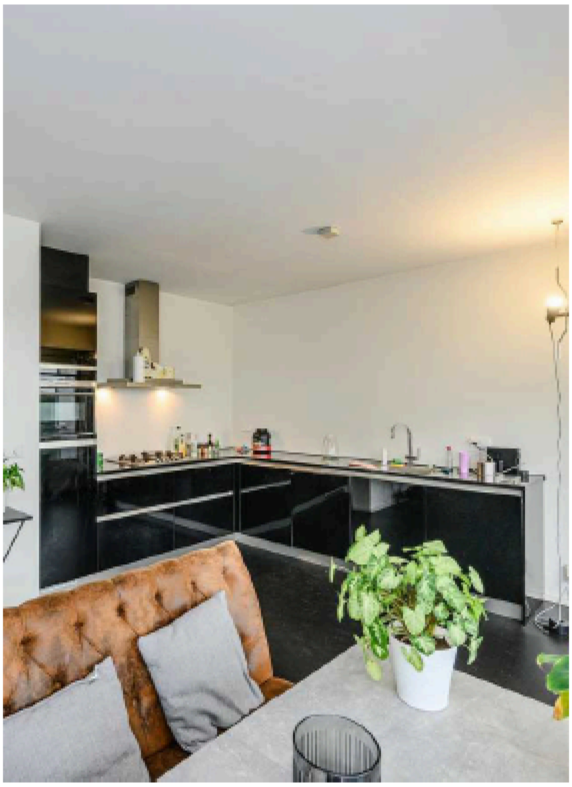
Floorplan #185



Legend:

1. Gallery
2. Entry
3. Bathroom
4. Walk-In Closet
5. Hallway
6. Closet
7. Toilet
8. Living Room
9. Bedroom
10. Kitchen
11. Balcony





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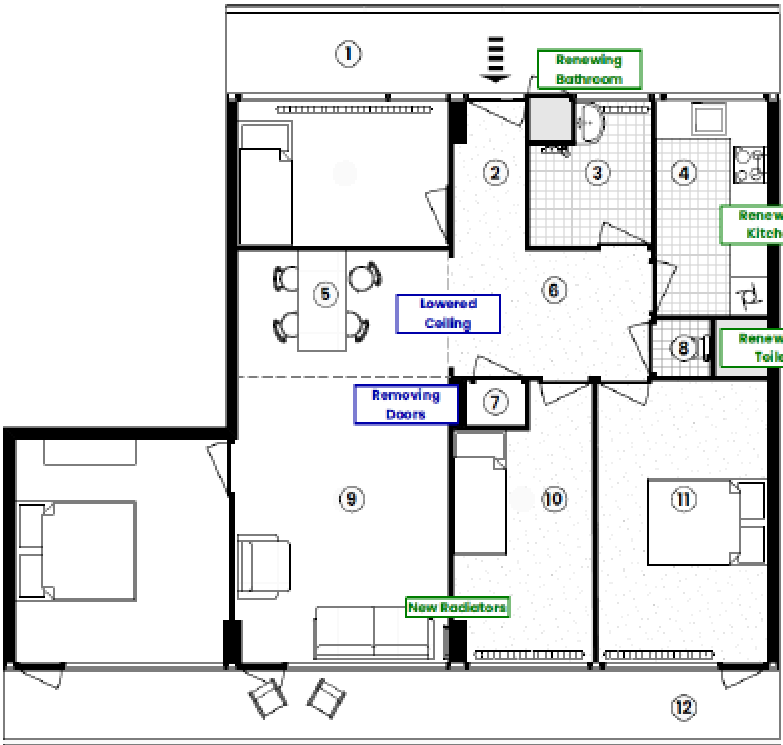
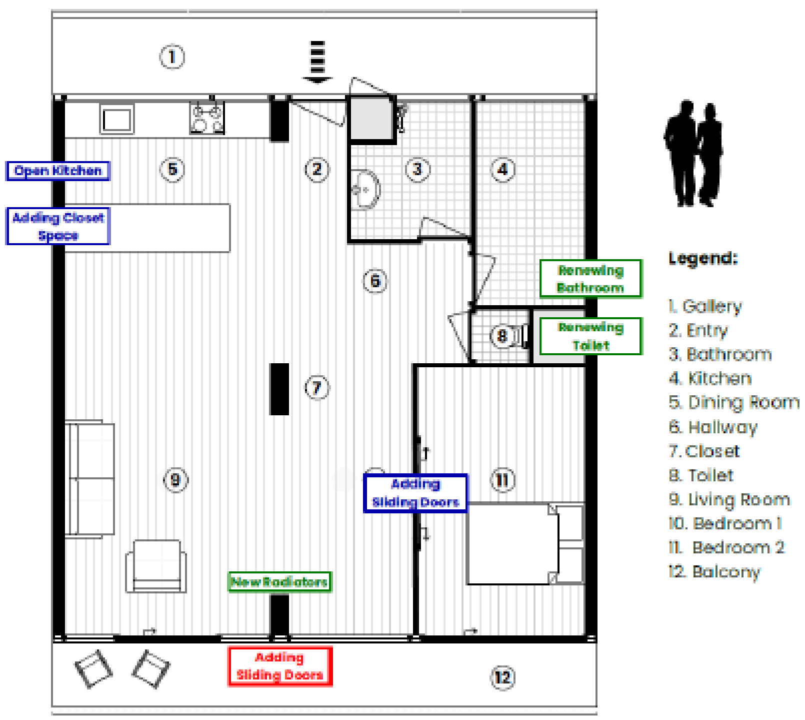
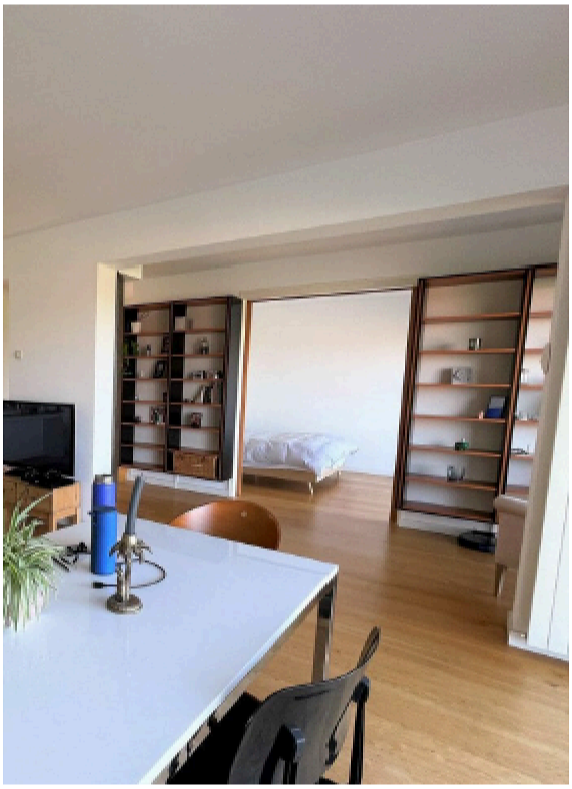


Legend:

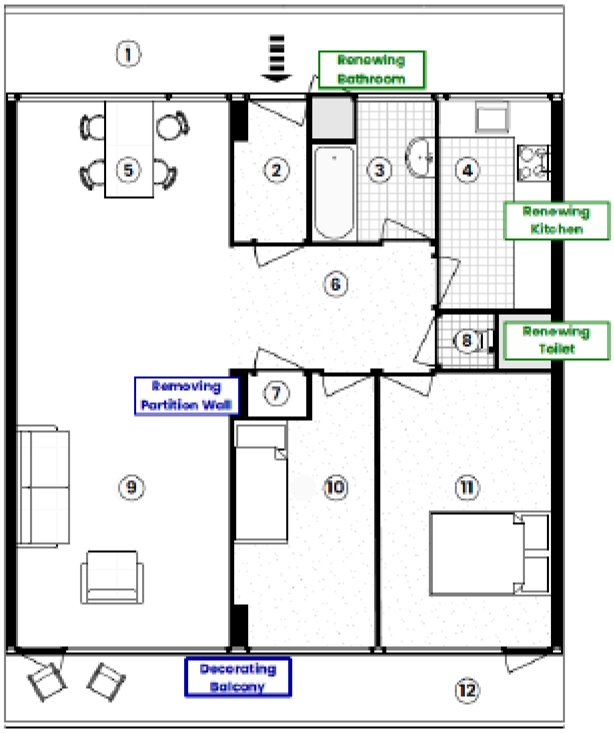
1. Gallery
2. Entry
3. Bathroom
4. Kitchen
5. Dining Room
6. Hallway
7. Closet
8. Toilet
9. Living Room
10. Bedroom 1
11. Bedroom 2
12. Balcony

Floorplan #xxxx





Floorplan #XXXX
(2)



Legend:

1. Gallery
2. Entry
3. Bathroom
4. Kitchen
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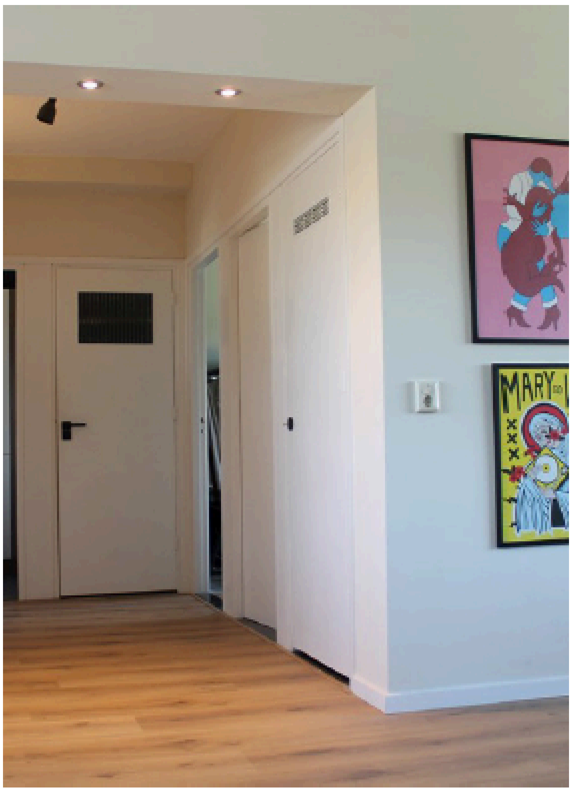
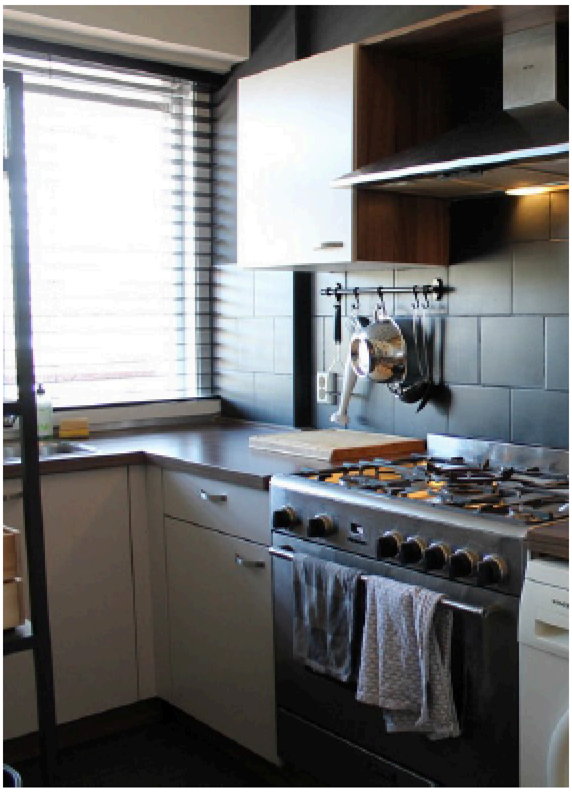
6. Hallway
7. Closet
8. Toilet
9. Living Room
10. Bedroom 1
11. Bedroom 2
12. Balcony





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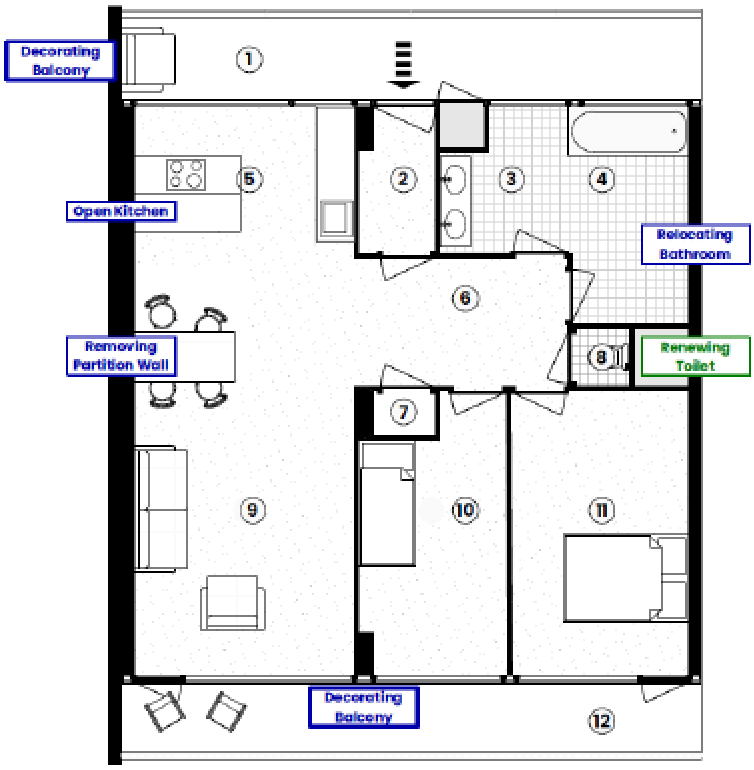

Legend:

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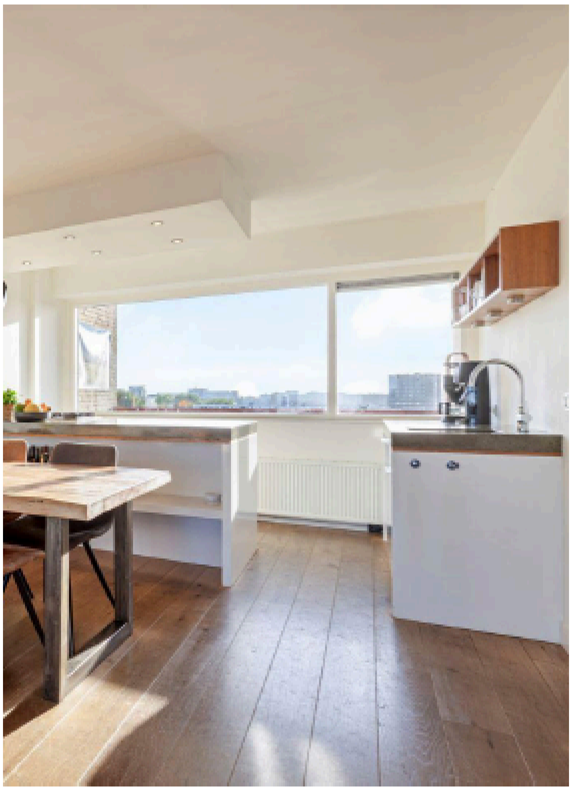
6. Hallway
7. Closet
8. Toilet
9. Living Room
10. Bedroom 1
11. Bedroom 2
12. Balcony



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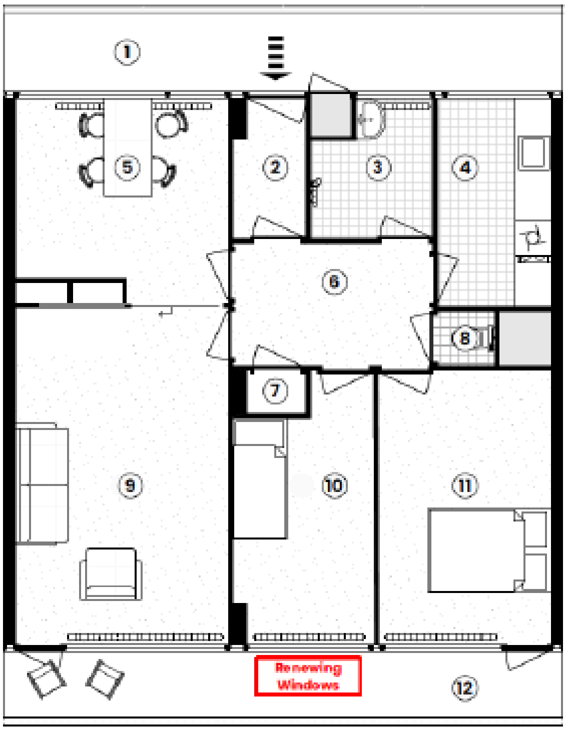

Legend:

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4. Kitchen
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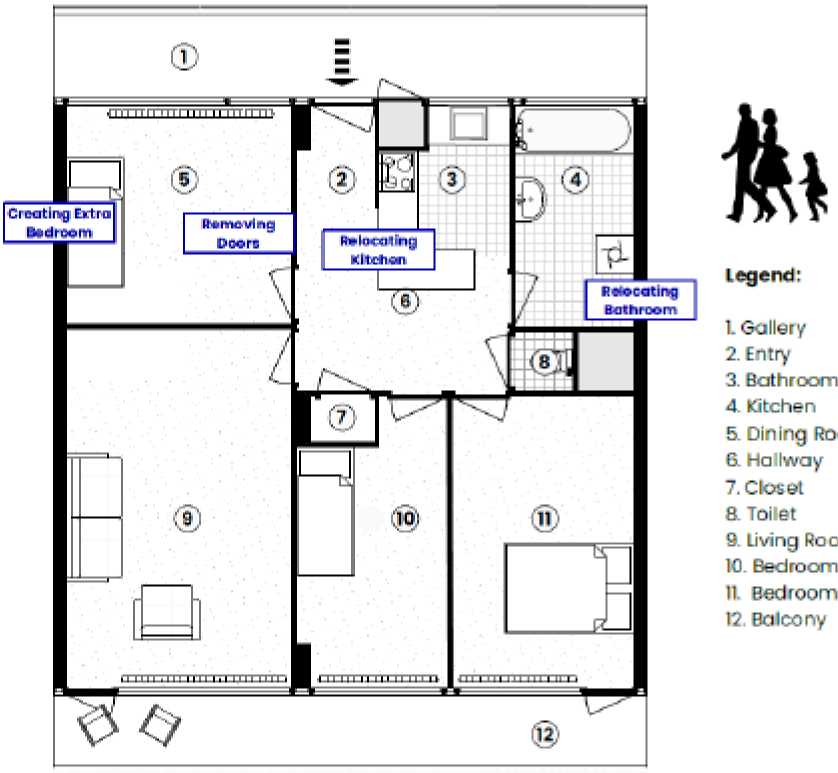
7. Closet
8. Toilet
9. Living Room
10. Bedroom 1
11. Bedroom 2
12. Balcony

Floorplan #987



Legend:

1. Gallery
2. Entry
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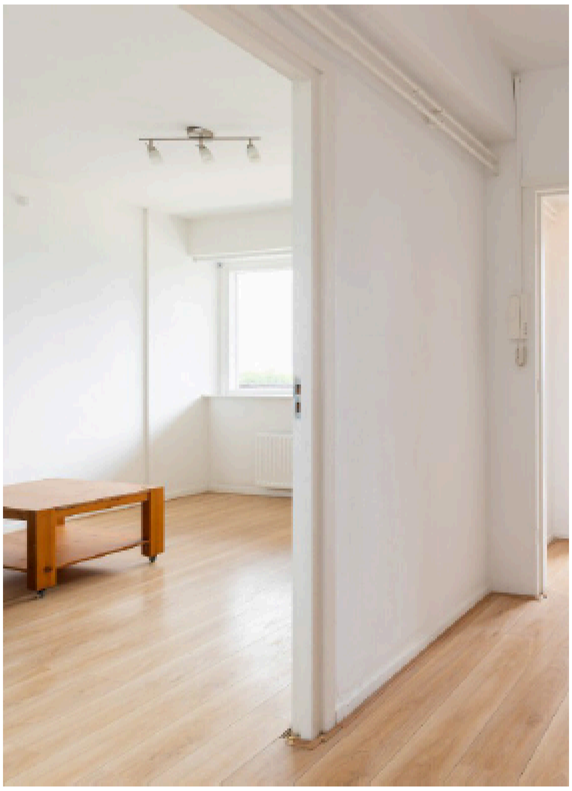
7. Closet
8. Toilet
9. Living Room
10. Bedroom 1
11. Bedroom 2
12. Balcony



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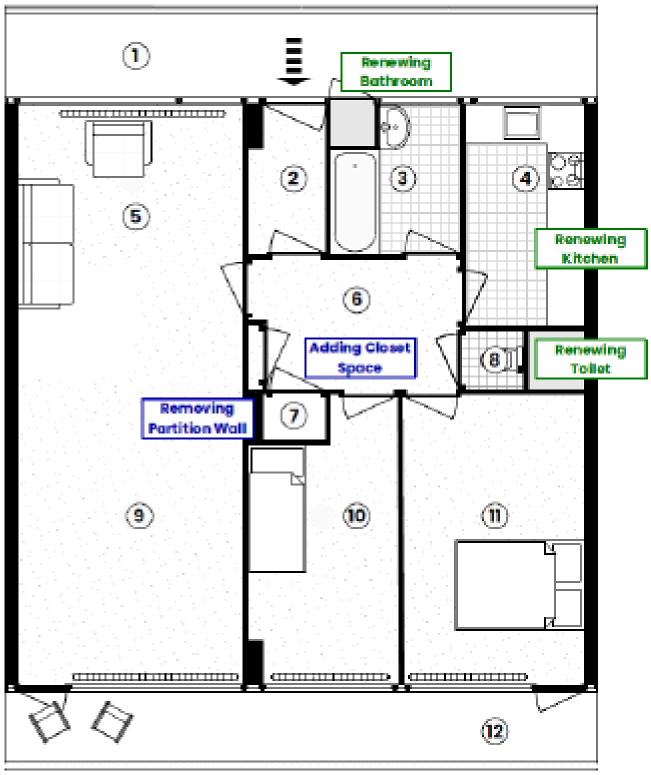

Legend:

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2. Entry
3. Bathroom
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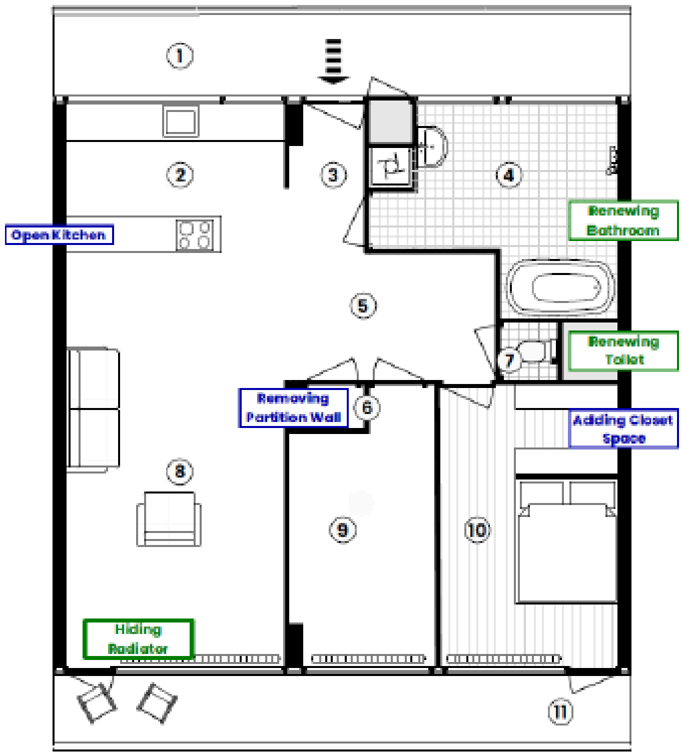
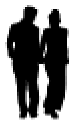
7. Closet
8. Toilet
9. Living Room
10. Bedroom 1
11. Bedroom 2
12. Balcony

Floorplan #879





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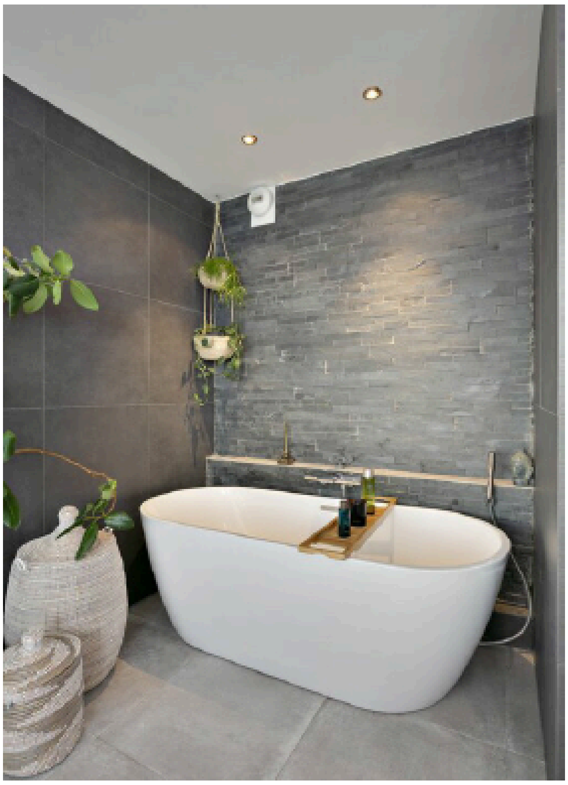
10. Bedroom
11. Balcony



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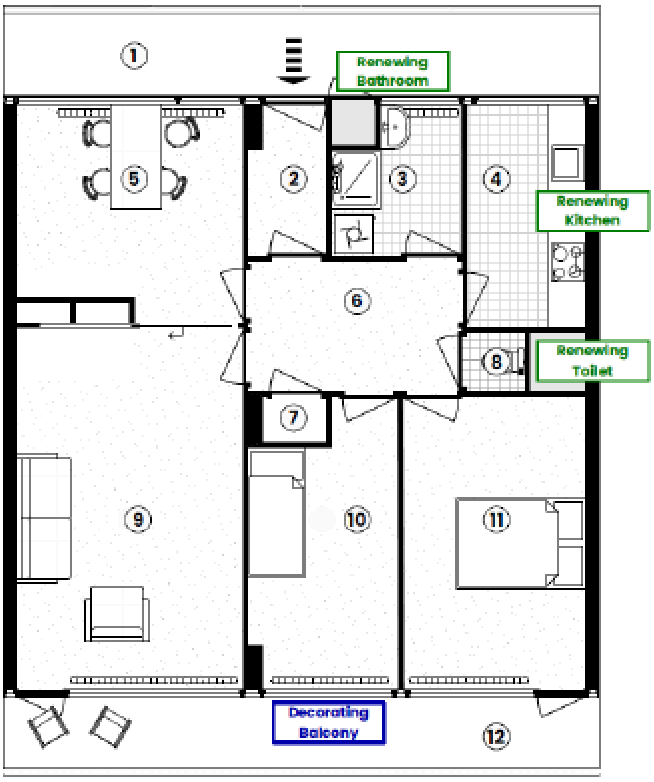

Legend:

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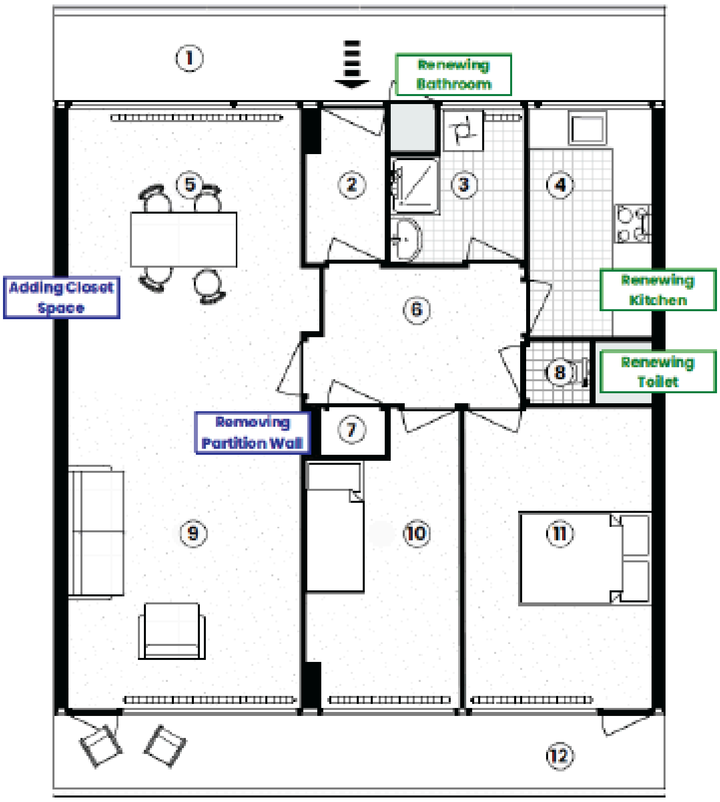
12. Balcony

Floorplan #541



Legend:

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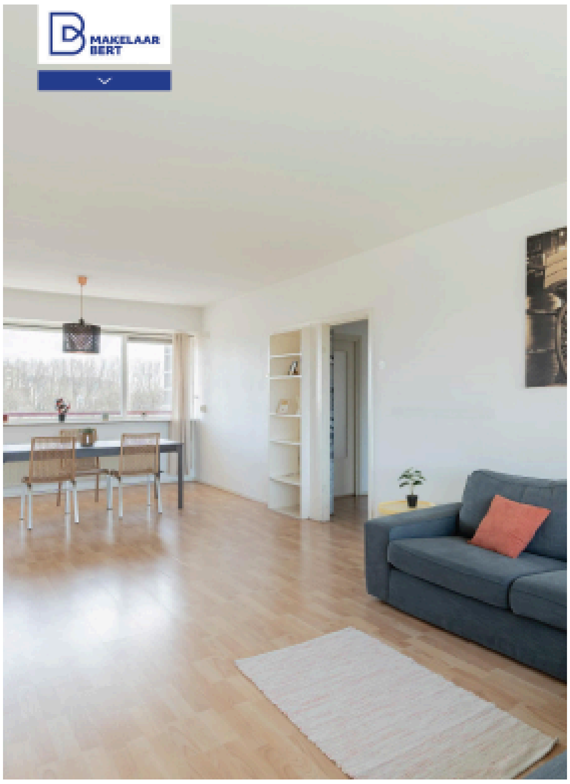
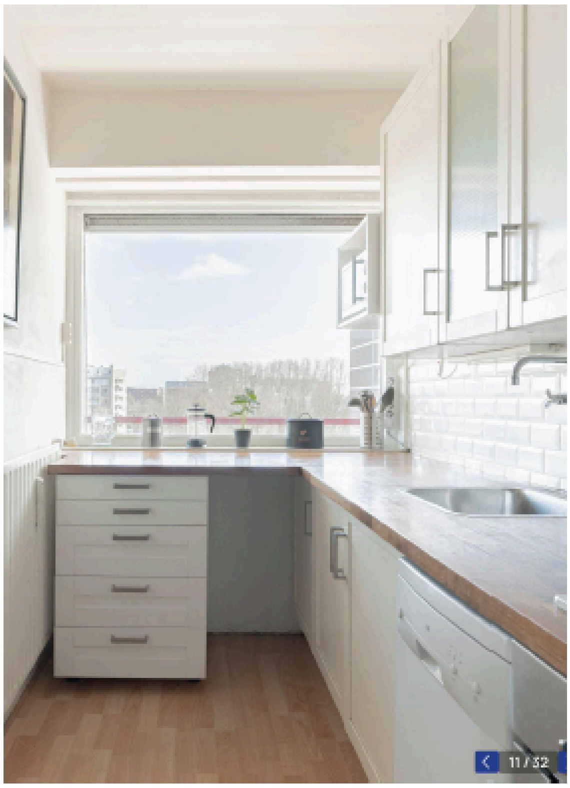
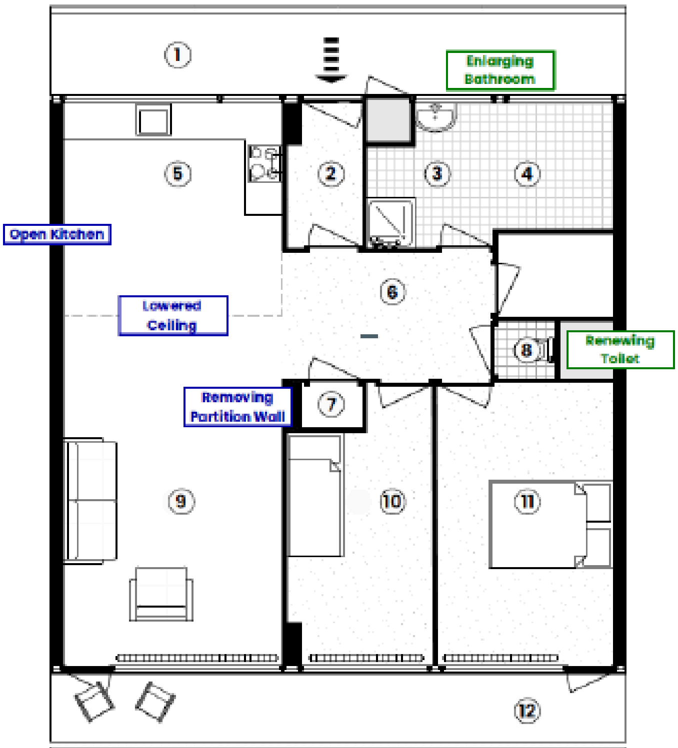
11. Bedroom 2
12. Balcony





Floorplan #533



Legend:

1. Gallery
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11. Bedroom 2
12. Balcony