Adaptability in Architecture
Empowering User influence in Architecture

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Abstract

Standardisation in dwelling architecture has led to mass housing projects to be built within a short period of time. With increasing standardisation, the needs of the actual user of the building have been lost. Adaptable housing is a way of creating a more user-oriented approach within the architecture of buildings. This research paper explores the concept of adaptable architecture design which all started with theories of Habraken and Brand. These were picked up by other theorists Schmidt III and Austin, and Schneider and Till who searched into implementations of adaptable architecture design with the actual benefits to the user. Four contemporary residential building projects are analysed of which are two greatly adaptable in dwelling plans and the other two are adaptable in matters of use. This research gives guidelines for the implementation of adaptable architecture to design with a user-oriented approach for a design project of working and living in the Merwevierhaven in Rotterdam.

Keywords:

Adaptability, design implementations, dwellings, flexibility, user empowerment.

| Contents

1| Introduction

Mass housing in the Netherlands has led to a degrees of user focused dwelling design. Buildings have become unadaptable to evolving needs of residents through time. With changing social, sustainable, and economical developments the mass housing stock is not viable anymore. Dwellings traditionally evolved in response to social, and cultural needs and became one with the identity of its occupants (2013). Architecture is in need to accept adaptability and flexibility to withstand the increasing need of change in society today and to create a new balance between building and user (2010). Since the beginning of adaptable architecture in 20th century new methods of adaptability came along with technological advancements through time (2022b). The core concepts of achieving adaptability are still maintained and seen as fundamental to adaptive design (2022b). In current times these ideas can be developed by implementing innovative techniques and evolved design methods, creating a living environment in dwellings which can match with the needs of the residents.

History shows that the problem of the housing stock can be resolved by building mass housing. However, today's requirements for housing quality vary per person as well as per period, and most of the multi-family housing in the Netherlands is inflexible and designed for a single type of occupancy (2018). Large neighbourhoods as the row houses of the 60's and the VINEX neighbourhoods in 2000 show the consequence of mass housing as generic models of façade, layout, and location. These places have a lack of user-perspective in designing dwellings and led to a housing stock that is not able to adapt to changing actors. Urban areas and dwellings need to have the possibility to develop without being completely changed. Mass housing is focused on designing one typology of dwelling corresponding to a specific type of household at a specific point in time. The long-term thinking in architecture is lost, while this is needed with the uncertainty of future settlement and individualistic housing demands (Schneider and Till, 2005a). Buildings are likely to be demolished after 50 years due to non-comparable user demands of today. In architecture the user needs to be the focus again.

1| Introduction

Long term thinking and user oriented designing sets the course towards buildings with the possibility to be adapted and developed in time. Adaptability in architecture is the ability to develop and change, where elements can be configurated, allowing changes in spatial, functional, and technological components without disruptions of a building (Schmidt III and Austin, 2016). Adaptable buildings have the possibility to continuously change in its components and building spaces, creating opportunities for different usages and in this way last longer lifespans (2010). Adaptable housing can be defined as housing that is designed for choice at the design stage, both in terms of social use and construction, or designed for change over its lifetime. The degree of adaptability can be determined in two ways, first by the term adaptability as being capable of different social uses, achieved through designing rooms which can be used in a variety of ways (Schneider and Till, 2007). Second, as flexibility what means different physical arrangements, achieved by changing physical elements (Schneider and Till, 2007). Within this research the word of use is adaptable architecture. Flexibility is a method to realise adaptability in a design.

1.1 Opportunities

The city of Rotterdam is changing and in development of making its former harbour terrains subjects of new city districts. The harbour of Rotterdam is innovating its processes and relocating its activities towards the sea. The municipality of Rotterdam reclaims these former harbour terrains to develop neighbourhoods of working and living (2019). The former harbour Merwevierhaven (M4H) is the location of the design assignment in realising a mixed-use project. M4H is located in between the city of Rotterdam and today's harbour ideally located to become a new type of neighbourhood in the city of Rotterdam (2019). Within the masterplan by Delva Landcape Architecture & Urbanism the area will be called a "Makersdistrict" a new ditrict of working and living (2019). Innovation in dwelling and production architecture is needed to investigate to realise a new city district which is viable for the future. This research paper focused on using adaptable architecture to realise a user-oriented design for a mixed-use buildign project in M4H.

1.2 Problem statement

In the 1960's criticism emerged on how mass housing was being realised. John Habraken, a Dutch architect wrote the book "Supports, An alternative to mass housing" as critical notion that the architecture of housing lost the connection between building and user (1961). Houses were designed as industrialised products for the mass with the building being the priority. Dwelling designs were based on a fixed framework and every type of person needed to fit in (1961). Stewart Brand, writer of the book "How Buildings Learn" of 1994 mentioned; a building that is not capable to change in time, is likely to be demolished when its lifespan has passed (1994). Brand came up with the theory of buildings with the possibility to adapt have a long lifetime (1994). Adaptability in a building can be added if these result in better buildings. However, adaptable architecture as Open Building is known to be expensive. Adaptable architecture with fixed elements has the problem of having many ways in implementations all with different possible outcomes. What is exactly the needed adaptability to give the user empowerment over its own dwelling and what is needed to realise such a project at M4H?

1| Introduction

1.3 Research question

The research focusses on understanding how a dwelling can be realised with more control and acceptance of the user. The main question to be answered in this research will be:

"How can design strategies with implementation of adaptable architecture in building projects create more user-oriented dwellings."

To answer this main question, sub-questions will help understand adaptable architecture design approaches:

"What are the positions of John Habraken and Stewart Brand in adaptable housing design?"
"What are methods and means of adaptable architecture?"
"What elements can be used to design a dwelling with a user-oriented approach?"

The answers to these questions will come from theoretical research, and analysing case studies. These are of assistance for the design assignment at M4H.

1.4 Relevance

The research is part of the design project in the masterplan for the Merwevierhaven by DELVA. This location will be characterised by small production facilities and residential building within the same neighbourhood as well as in the same building. This will lead to a diverse productive city environment by reintegrating low emission manufacturing and new forms of mixed-use developments for production of physical goods in the city. In this way cities strengthen the transition to circular economies and vital cities, and create the possibility of sharing goods and skills, learning and interaction between different people (2022e). At M4H the success is possible in the variation of dwellings and workplaces, making the distinction at both building and urban scale contributing to a positive sense of neighbourhood identity, as Francis Hollis researched in “The Workhome” (2018). This mix of primary uses in a city will have a positive impact on city life. As primary uses are functions as dwellings, offices, and factories which bring in people to specific places in the city. In a successful neighbourhood there needs to be more than one primary function and by combining it ensures the presence of people who go outdoors on different time schedules. As a result, people appear at different times on the street what makes it livelier and more attractive (1961).

1| Introduction

1.5 Theoretical framework

This research will use the theoretical aspects of Open Building and Building Layers by John Habraken and Stewart Brand for understanding the origin of adaptable architecture. Theoretical writers after the year 2000 as Schneider and Till, Schmidt III and Austin are known for their research combining adaptable architecture methods and the involvement of the user in architecture. Next to these four main resources of theory other writers will expand the knowledge in understanding adaptable architecture and the influence of an individual in building design. Analyses of contemporary dwelling projects with adaptable architecture, and Open Building design are used to investigate technological and spatial qualities.

1.6 Methods

The research will be based on theories behind adaptable architecture. Primary and secondary sources will be analysed. The research results in architectural implementations used in the design project. This architectural design will be framed within the masterplan M4H by DELVA. As with analyses of the location and the city of Rotterdam to gain an architectural approach towards the design assignment. The following contemporary projects will be analysed in floor level, dwelling design, amount of adaptability, and the use of flexible elements. A short description of the projects can be seen in table 1.

Project	Location	Completed	Ownership	Function	Adaptability
Patch22	Amsterdam, NL	2016	Private	Work – Living	Open Building
Het Schetsblok	Amsterdam, NL	2018	Private	Residential	Open Building
Unite	Dijon, FR	2019	Private	Residential	Adaptable spaces
Zollhaus	Zurich, CH	2020	Cooperative	Residential	Moving households

Tbl. 1: Case study projects which are analysed.

1.7 Structure

The research is focused on a theoretical approach toward user involvement in dwelling design. It will conclude with design implementations at the project location in M4H. The research will be structured in a chronological order as in the list below.

1. The history of adaptable architecture by Habraken and Brand.
2. Useable adaptable architecture elements within building design.
3. Case studies in adaptable architecture of today.
4. How to realise adaptable architecture typologies within a mixed-use environment.

1.8 Preliminary conclusion

Adaptive architecture is the beginning in giving more control to the user in determining what activities to do inside. It is not about giving the user the full responsibility as can be seen at Open Building projects. This is about over dimensioning a building with ideas and technologies which are expensive, but probably never used during the lifetime of the building. Its about giving the resident the possibility to change spaces depending on their daily activities. Implementing flexible elements that can join or divide spaces or give the opportunity to develop the interior. When the user can determine how to use space, the architect will have the role of implementing the guidlines of this space.

1| Introduction

1.9 Relation research & design

The theoretical insights and case study analyses are of use for the completion of the project design. The research is seen as assistance in realising a mixed-use building in M4H. By doing research into adaptable architecture together with the come about of mixed-use neighbourhoods the knowledge can be combined. The research will mainly gain insights at the level of the dwellings within the project and the mixed-use neighbourhood is used for the design of project.

1.10 Personal fascination

"My whole life I lived in the same house until I was nineteen years old and moved to study in Delft. My brother and sister left the house as well, leaving the dwelling behind with only my father and other sister living there and three empty bedrooms. The floorspace available for the two of them is large and my other siblings and I only pass by occasionally. Within my master's I started looking into solutions to use floorspace per person more efficiently. At the studio BK-Launch I learned about John Habraken and the Open Building movement but found out that these projects do not match with current society demands. These projects are based on the technical matters that are possible instead of what the user wants. This research at Advanced Housing Design gives the possibility to investigate more user-oriented approach of dwelling design. The first theoretical aspect led to adaptable architecture to be about the user empowerment in housing projects. This gives the opportunity to develop my dwelling design skills and look for new opportunities the resident can play in residential architecture."

2| History of Adaptable Architecture

Adaptable architecture emerged as a paradigm shift in the modernist movement, with the aim of designing buildings that prioritise the individual needs and preferences of users, particularly in the context of dwelling design. The initial concepts of adaptable architecture were first conceived in 1930 by prominent modernist architects, such as Van der Rohe and Le Corbusier (2002). In subsequent decades, the idea of prioritising individual needs gained new traction in the 1960's, and adaptable housing design from this era continue to be recognised and referenced in contemporary discourse. The housing crisis of the 60's in the Netherlands made the Dutch architect John Habraken think about innovating dwelling design. His ideas spread globally ever since, however the theory is already sixty years old the most important notes are still relevant in the present. Thirty years later in the 1990's Stewart Brand an architecture theorist became known for his theory of a "Learning Building" a building that can adapt in time. He became known for his ideas that a building contains of six layers, each with its own lifespan. Habraken and Brand are founders of today known Open Building and adaptable architecture.

2| History of Adaptable Architecture

2.1 Supports

The 1960's witnessed a renewed focus on user engagement in the field of architecture, which in turn stimulated interest in adaptable housing as a means of providing user choice and flexibility in housing design (1992). This shift in thinking was driven, in part, by critiques such as those put forth by Habraken, who identified limitations in the static and standardised mass housing designs that emerged in the post-World War Two period (1961). Habraken's critiques stimulated to reconsider the relationship between mass housing and human needs and promoted the development of more adaptable and user-responsive housing designs. Habraken made his critic clear in his book "Supports, An Alternative to Mass Housing", in Dutch: "De Dragers en de Mensen" in 1961, and became known international. As Habraken mentioned in his book, mass housing is the construction and design of many dwellings in one task (1961). This approach has led to a general way of housing the whole society, but it neglects the idea that every individual user has other needs and mass housing does not make every living requirement possible. In his theory he defines housing as a purpose instead of an object. Enabling individuals to have a more active role in the design of their dwellings is essential in ensuring that individuals can accommodate their diverse and evolving needs

Dwellings that cater to the ideas of their inhabitants are considered independent. These independent dwellings are not only detached houses but mostly seen as dwellings within in the city. Habraken did not make a visual explanation of what such buildings could look like but made a definition of how independent housing could be realised. A visualisation could only limit the creative thinking and reduce the possible innovation in this field. Habraken had the following definition to realise such housing calling a Support (= Drager): "The support is a construction in which several dwellings can be assembled, each of which can be built, rebuilt or demolished independently of the other dwelling within it" (1961, p.84). The support should not be seen as the skeleton of the building, but as the whole building itself with the possibility to make changes inside of it without adjusting the outside (1961). As Habraken mentioned in the book "Residential Open Building", the future is unknown and to accommodate it we need to be able to give space to let change

occur (2001). What means that the Support must accommodate the unknown and have a long lifespan, in contrary to the dwellings which will change with the residents, because their interest will keep changing (1961). The dwellings are the flexible part of the building accommodated by Supports that make maximum change possible to every type of function. Habraken mentioned the functions within the Supports; the Infill, as the Infill to be changeable according to the demands of its users (1961). Although the theory of Habraken is 60 years old there is still importance and relevance in the capacity to realise adaptable buildings. Supports and Infill will make it possible to allow a constant renewal of dwellings according to the needs of the individual residents without changing the building and by prolonging its lifespan.

2.2 Six layers

People, buildings, and cities are constantly developing, because of changing demands, needs or findings of people who live or work in them. People will always try to change buildings inside or outside to their own needs and in this way, buildings are tended to change more often than people do. As Stewart Brand writer of the book "How Buildings Learn" mentions in his tv series; people, buildings, and cities, everything learns in time and in this way, everything changes in time (1997d). Brand mentions, buildings which last are the ones that are loved and cherished, or capable to adapt (1997f). When a building is not able to adapt anymore it will presumably be demolished what made Brand focus on extending this lifespan and see how a building is possible to adapt. His theory starts with the architect Frank Duffy, who is a British architect noted for his research and design work in the changing nature of the modern office. Duffy states a building does not exist, "A building properly conceived is several layers of longevity of built components" (1990, p.17). He distinguishes a building out of four layers; Shell, Service, Scenery, and Set (1990, p.17). The layers interpret a building not made from different materials, but layers of time (2009). Brand worked further on the ideas of Duffy expanding the four S's into the "six S's": Site, Structure, Skin, Services, Space plan, and Stuff (1994, p.13). Every layer has its own lifespan the outer layers have the longest lifespan, the "Structure" will last at least between 50 – 300 years. The inner

layers change more often as users of a building deal all day with the space plan and stuff inside a building making the interior to change within ten years (1994). These layers can be seen in figure 1, which shows how slow elements as the structure dominates the faster layers as Skin and Services (1994).

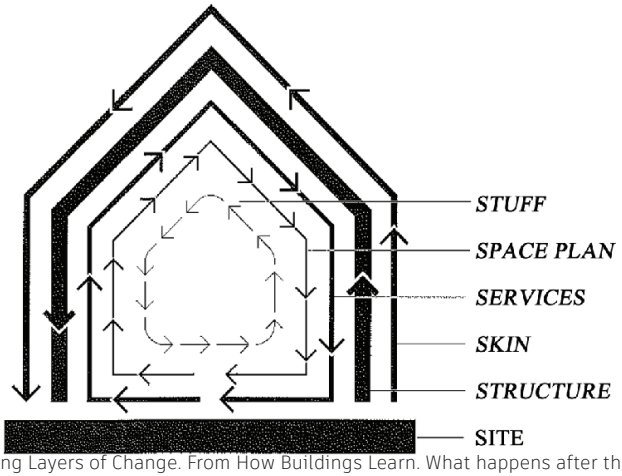


Fig. 1 : Shearing Layers of Change. From How Buildings Learn. What happens after they're built (1st ed., p. 13), by Stewart Brand, 1994, Penguin Books. Copyright 1994 by Stewart Brand.

Due to what users or outside forces do to a building it changes on the inside or outside in time. The stuff and space plan need to be most easily to change, the other layers need to be possible to adapt in the distant future. As Brand explains: "What cannot change is not possible to develop in time" (1994, p.9). A non-changeable building will presumably be demolished at one point. An important design task emerges to realise an adaptive building it needs to allow shifts between the different layers. If this does not occur, it will block the flow change within the building. To design a building with these layers in mind, Brand mentions to think about the user (1997a). As mentioned before, a building keeps on changing because the user wants to or needs to change the building. When it is possible to predict who will be using the building for a long period of time the building can be best fitted to the needs of the user. However, buildings are always predictions of the future and nobody knowns what the future will look like, the building is probably not ready

for its future function (1997c). To overcome this problem a building needs to have a good basic structure which can last for a long time and the other layers need to be able to adapt easily when new innovations or materials are needed. Brand names this a “learning building”: “A building that can adapt and change in time with the demands of its users” (1997f). Brand and Habraken do share this theory by having a fixed structure and adaptable elements what will extend the lifespan of a building, and by knowing the user the building can be best fitted in.

In the pursuit of enhancing the durability of buildings, Brand advocated for the application of scenario plannings as a strategy that can effectively accommodate unforeseeable changes, see figure 2 (1994). The method is having the option to change direction which aims to mitigate risk of being constrained by a static building design that fails to account by evolving needs and circumstances (1994). The essence is too diverse the possible future outcomes of the building by developing scenarios that are plausible and surprising, as in figure 2 (1994). By knowing possible future outcomes these can be implemented in early stages of the preliminary design and programming of the building.

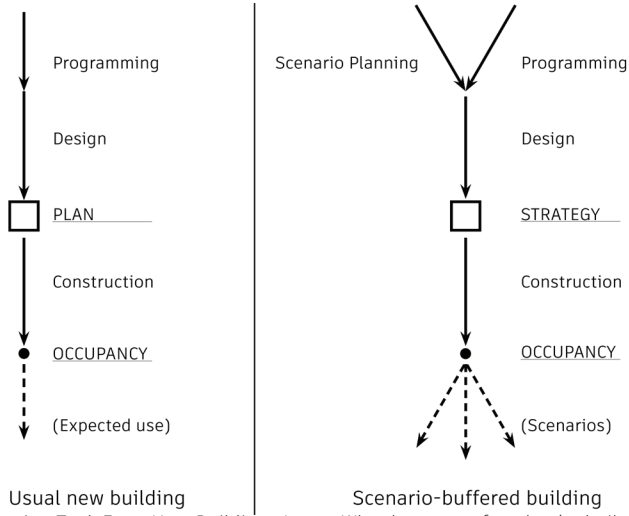


Fig. 2 : Scenario Planning Tool. From How Buildings Learn. What happens after they’re built (1st ed., p. 60), by Stewart Brand, 1994, Penguin Books. Copyright 1994 by Stewart Brand.

3| Adaptable Architecture Elements

The traditional approach to mass housing, which views dwellers solely as standardised consumers, fails to account the potential benefits of increased user involvement in the design process and the provision of adaptable living spaces that can accommodate changing needs over time. The original Open Building approaches of Habraken and Brand can be combined with adaptable architecture what is focused on design together with the changing needs of the users. Authors of the book “Adaptable Architecture” Robert Schmidt III and Simon Austin, mention architecture today wanting to be static and finished, however, it always is shifting in from and purpose (Schmidt III and Austin, 2016). Schmidt III and Austin stimulate to see buildings as unfinished to meet the changing demands of society (Schmidt III and Austin, 2016). Two other authors Tatjana Schneider and Jeremy Till focused their research in flexible housing as providing the user more choice and with this user-satisfaction what will increase social benefits (Schneider and Till, 2007). This comes from providing the user more notion in the architecture where the user has the possibility to customise, adapt, and make change (Schneider and Till, 2007).

3| Adaptable Architecture Elements

3.1 Elements of adaptability

Schmidt III and Austin propose that adaptability in architecture should be viewed not solely as a technical capacity but rather a mindset that is shaped by the complex interaction between human building. This interaction involves the consideration of human needs, physical approaches, and spatial forms (Schmidt III and Austin, 2016). To better understand adaptability, it can be broken down into three aspects: specificity of the building, strategic focus, and the object with adaptability. The specificity of the building refers to how the design can accommodate diverse and changing uses, while strategic focus involves identifying the areas where adaptability is needed and how it can be used. Object with adaptability refers to the incorporation of flexible design features that allow for changes in the future (Schmidt III and Austin, 2016). By taking these factors into account, architects and designers can create more adaptable buildings that better align with the needs and preferences of their users.

Specificity

The assessment of the degree of spaciousness and utility within a design can be approached through two distinct perspectives, contingent upon the intended purpose of the space. Schmidt III and Austin define two dimensions as “tight-fit” and “loose-fit” (Schmidt III and Austin, 2016). Tight-fit means adaptability which is not adaptable in spatial matters (Schmidt III and Austin, 2016). This means the role of the designer is to make a suitable fit to a specific user. The other dimension loose-fit means spatiality is in excess (Schmidt III and Austin, 2016). Compliant with Open Building, the user has freedom to adapt the space, because the architect does not define the spaces and creates the possibility for the user to vary in their own spatial interpretations. While it is important for a building design to be adaptable, it is equally important for the user to be willing to make necessary adjustments for the space to function optimally (Schmidt III and Austin, 2016).

Strategic focus

Contemporary adaptable architecture projects often prioritise technology to enhance adaptability; nevertheless, the implementation of such strategies can be financially demanding and entail complex problem-solving methods, often catering to singular issues. Schmidt III and Austin suggest using simple aspects of planning in which the approach of adaptability is in the understanding of how people may use a space (Schmidt III and Austin, 2016). Adaptability can be seen as an occupational process in which process and methodology are to understand how spaces inside work. Some people will use rooms during the day more often that others and the floorplan can be designed to react to this variety in use. Technology helps to react on aspects making concepts stronger. However, spaces work best when they are well planned and organised and technology is added to strengthen is qualities.

Object

The statement, "The building must adapt is as limiting as expecting the occupants to be adptable," as posited by Schmidt III and Austin (2016, p.54), emphasises the importance of a symbiotic relationship between the building and its occupants in achieving adaptability. However, the idea that the building and occupants must change together can be challenging to implement in practice. Schmidt III and Austin suggest that understanding the organisational needs of the building and its users is crucial for creating adaptable spaces, rather than solely focusing on the physical aspects of the building. To achieve a balance between the use of the building and possible adaptations, designers must consider the specific needs of their users and create spaces that are flexible enough to accommodate future changes while still meeting the needs of the present. By prioritising the needs of the occupants in the design process, designers can create more adaptable buildings that facilitate user satisfaction.

3| Adaptable Architecture Elements

3.2 Use of levels

One general approach towards adaptable architecture, cannot be given, every project is different with a variety of users and demands. Adaptable architecture can be read at distinctive levels of use; the building, the house, and the individual room (Schneider and Till, 2007). The user's daily activities primarily occur within individual rooms, making them an optimal location on implementing adaptability features to enhance usability.

Unmarked spaces

In tradition building design, the form, position, and function of rooms are typically predetermined. However, the potential of adaptable use increases when these aspects are left behind, making rooms to become spaces in which the functions are assigned by the users themselves (Schneider and Till, 2007). To achieve this is to leave the floorplans open that enable the spaces to vary in daily activities. This requires designing spaces without strictly defined functions and apply a flexible transitional room to make connections between various spaces (Schneider and Till, 2007).

Flow in spaces

By means of efficiency circulation spaces in building plans are often reduced to its minimum. However, movement in a building needs to be seen not as function but a social activity (Schneider and Till, 2007). Making these spaces wider gives them more usability and by letting the categorisation of rooms disappear spaces can be connected next to each other, giving the user the possibility to move around and configure the dwelling to their needs (Schneider and Till, 2005). By usage of mobile elements as means of creating flexible spaces, the circulation within a dwelling can be enhanced, as the mobile elements can be used to open and close off spaces as needed. This approach empowers users to take greater ownership of the space, leading to a more user-determined dwelling.

Mobile elements

Moveable elements in standard dwelling design soften the social structuring and expectations. Moveable elements can rearrange the structure and use of the floorplan. Sliding walls and dividers can be used to realise a fluid notion of space which can be divided, separated,

or opened according to the demands of the users (Schneider and Till, 2007). However, the use of mobile elements relies on the users themselves and is very determinate as often there is one possible option of dividing or opening the space (Schneider and Till, 2007). What types of moving elements is depending on the meaning and space of the room.

3.3 Costs of change

Contemporary building project that aims to be adaptable often come with high construction costs. This is because they are often designed as open building projects with a lot of over dimensioned elements offering user maximum freedom to change the layout of their dwelling or workspace (2014). This amount of flexibility seems interesting however in practise it is barely used (2021). Several reasons can be mentioned for this, including the fact that changing the layout of an open building often requires dismantling walls and reorganising systems which is expensive (De Architect, 2016). Furthermore, many users are not aware they live in a flexible building and do not make use of the flexible advantages of the building (1994, 2021). As a result, it is important to implement a user-oriented approach to flexibility in buildings. This can be achieved by focusing on adaptable forms within dwellings, which are fixed but can be adapted more in daily use than in lifetime use. By doing so, users can better understand how the flexibility works and how it can be used, resulting in more efficient, cost effective, and user-oriented adaptability in buildings.

4| Projects

To explore the implementation of adaptability and flexibility in contemporary residential buildings, analysis of four different projects will be made. The selected projects have been chosen based on their usage of innovative ideas in designing adaptable architecture that prioritises the user in different ways.

4| Projects

4.1| Patch22

Architect:	Frantzen et. al.
Location:	Amsterdam, The Netherlands
Year completed:	2016 (Year began 2009)
Program:	Work – Living 26 apartments 2 offices
Client type:	Private

The city of Amsterdam was looking for building proposals that prioritised sustainability. For this reason, Patch22 a 30-meter-high timber structure building was chosen to be built in the old harbour of Amsterdam (De Architect, 2016). Tom Frantzen, the architect, and developer of the project wanted to realise a building with a maximum use of the Open Building principles. Patch22 is realised with a great degree of flexibility, and high level of sustainability, with the idea to construct a building which will last for long time (Patch22, 2016). The core is the fixed element of the building making an open layout around it possible for owners to adjust to their needs. The ceiling height of four meters make it possible to anticipate on changing future uses and create the possibility to combine working and living spaces (Frantzen, 2016). Frantzen did not design all the interiors but helped the owners in the process of designing their homes. As Frantzen mentioned, “We wanted to give people freedom to design their own villa” (Patch22, 2016).

The maximum amount of flexibility per floorlevel has been realised by organising the circulation in the concrete core. As mentioned before by Schmidt III and Austin by good planning, the hallway has multiple front doors giving the opportunity to divide the apartments. The structure is mostly cross laminated timber in the façade, columns, and beams. Together with the concrete core and the wooden façade the open spaces for the dwellings are created. A raised floor has been used to put installations underneath making it possible to easily change the technical systems and give the residents freedom in designing their interior (Patch22, 2016). The installations are realised by horizontal distribution as Schneider

Fig. 3: Patch22. From: “Pieters Bouwtechniek,” by L. Kramer and Pieters Bouwtechniek. 2016 (https://www.pietersbouwtechniek.nl/projecten/patch22).

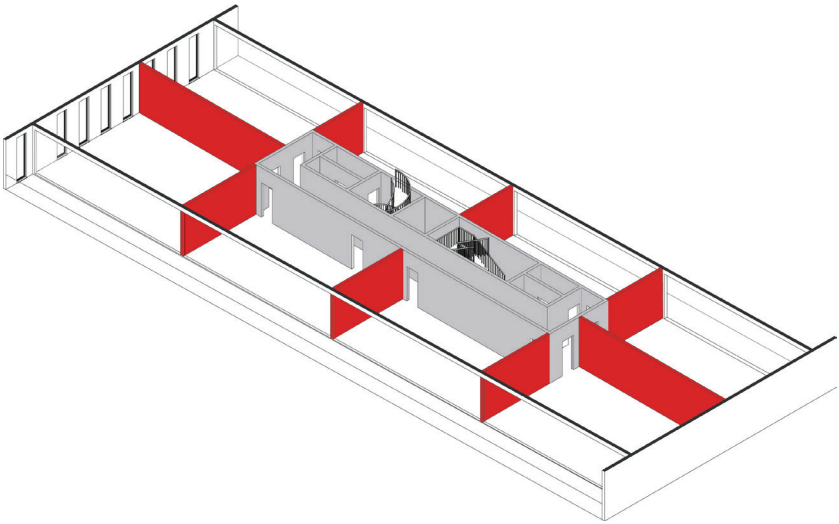


Fig. 4: Possible divisions of the floor level.

and Till name this (Schneider and Till, 2007). To keep the overall principle of layering possible horizontal runs of installations need to be accessible, and maintainable. With this approach walls and furniture can be located without restrictions (Patch22, 2016).

The project has been developed in the middle of the crisis years 2009-2014. Due to this it was not expected to have middle-class incomes getting a mortgage for 100m2. What made Frantzen decide to realise larger dwellings (2016b). To make it possible to divide an apartment of 200m2 in the future each dwelling is partitioned in apartment rights by 70m2, making it easier to sell again or divide in the future (De Architect, 2016). The project is known to be over dimensioned with the idea to make it possible to have a variety of functions at every floor level and to keep the possibility open to completely change the dwelling interiors if users want this. However, almost first and also second inhabitants did not change the interior. Some even mentioned to never completely change the whole dwelling again (2021b).

Patch 22 can be seen as a success in showing the potential of implementing a maximum amount of flexibility in a building, but it has its limitations in user-orientation. Although this project shows the possibilities of open building, the hight construction costs to realise such flexibility may not always be practical in the long term. Furthermore, time will show whether the implemented flexibility will be worked with by the users in the long term. However, the project shows what can be realised by implementing flexibility in the built environment.

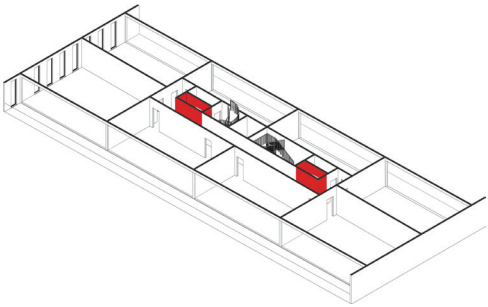


Fig. 5 : Service shafts in the core to create an open floorplan around.

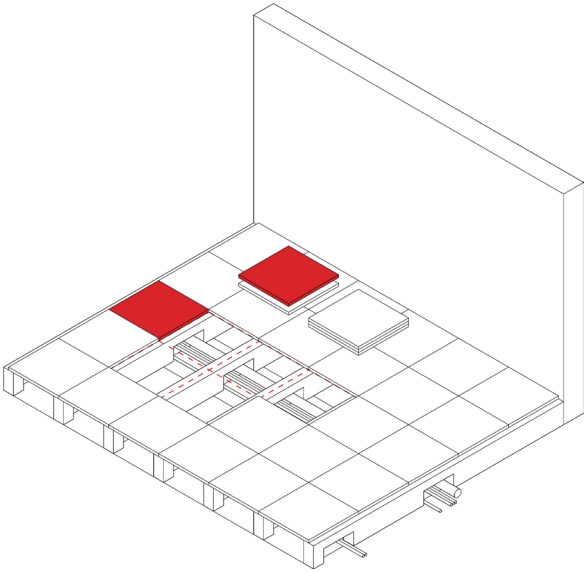


Fig. 6: Horizontal service distribution of wich floorpanels can be taken out for change.

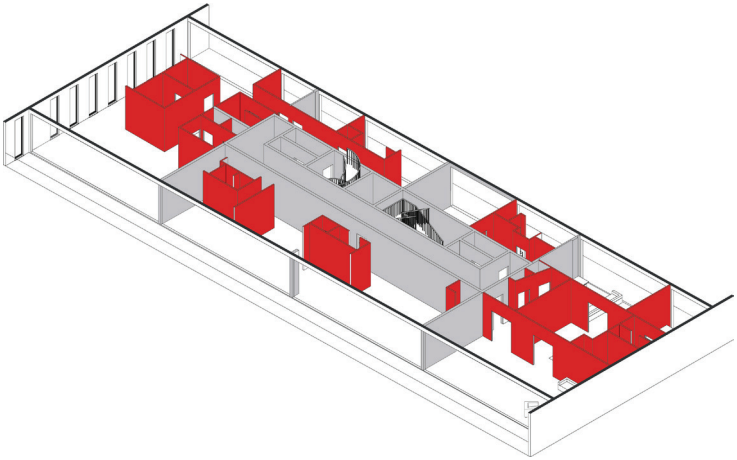


Fig. 7: Contemporary floorplan level 7.

4| Projects

4.2 Zollhaus

Architect:	Enzmann Fischer Partner AG
Location:	Zurich, Switzerland
Year completed:	2020 (Year began 2012)
Program:	53 apartments 12 collective spaces
Client type:	Cooperative

The Zollhaus is a project realised in the city centre of Zurich in between a neighbourhood and railways. The project counteracts the segregation in the neighbourhood by realising affordable housing, and diverse dwelling types (Genosschenschaft Kalkbreite [Kalkbreite], 2012). The Zollhaus is realised as a cooperative project with an open plinth, public functions, and shared spaces. The design of the building is the focus on how a community will live together (Lengkeek and Kuenzli, 2021). The design is all about community living and providing this as best as possible, with a human centric approach in making the best suitable way of living for its residents. Even the value to the city in realising on top of the plinth a garden which is publicly accessible.

The idea of Zollhaus is realising adaptability within the project not technically or spatially but organisationally. Dwellings have a great variety of types, sizes, and forms, but all are equal nevertheless difference in size or orientation (Lengkeek and Kuenzli, 2021). The adaptability is an obligation of the members and the cooperative association to find suitable housing. Lengkeek and Kuenzli explain it as, when a household is expanding, they can ask for a bigger dwelling. When a household shrinks the bigger apartments become available for new families (Lengkeek and Kuenzli, 2021). Residents can keep living in the same building without having to move if family dynamics change. The rents are low and kept low by reducing the dwelling spaces resulting in 35m2 per user (Khatibi, 2022). In the cooperative form the residents benefit in the rent as tenants to all have a share in the value development of the building. The rent of dwellings is based on the cost price of the dwelling resulting in

Fig. 8: Zollhaus. From “Genossenschaft Kalkbreite,” by Genossenschaft Kalkbreite, 2021 (https://www.kalkbreite.net/wp-content/uploads/2022/03/14Zollstrasse_Aussenaufnahmen_06.2021_01243-scaled-1-e1667472823149-1130x854.jpg).

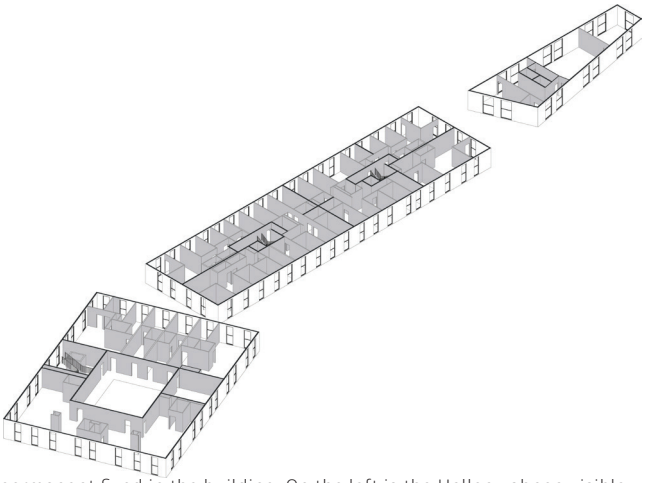


Fig. 9: Walls are permanent fixed in the building. On the left is the Hallenwohnen visible.

a limited increase of the rent (Kuenzli & Lenkgeek, 2021). For the small dwelling spaces, the concessions are spacious shared rooms (2021). As Lengkeek and Kuenzli explain about sharing: “What you don’t need in your own home on a daily basis, you can collectively organise outside” (Lengkeek and Kuenzli, 2021, p.156).

To innovate the project realised the concept of the “Hallenwohnen” which can be compared with an Open Building apartment. These are implemented in a basic structure with fixed sanitary facilities and a further empty casco which is filled in by the residents (Hochbauten, 2014). A Concrete core and concrete columns in the façade make an open space plan possible. However, the fixed sanitary facilities are fixed and limit the spatial possibilities. The rest of the building has been designed with a fixed concrete wall structure in which the different dwelling types and shared spaces are located.

Zollhaus shows adaptability is not always in matter of elements but also in organisation. The combination of dwellings shows that a loose-fit of the Hallenwohnen can be combined with the tight-fit other dwellings within one project. The cooperative form gives valuable notice into the design strategy to design for the community, in building and neighbourhood scale, and not only the individual user.

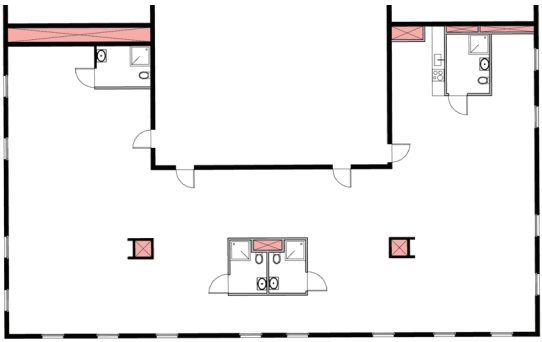


Fig. 10: Floorplan of the Hallenwohnen.

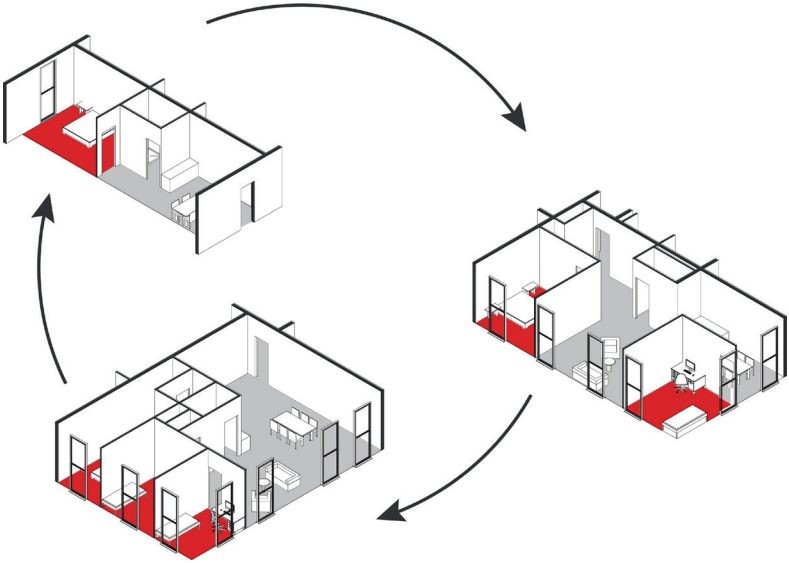


Fig. 11: As the cooperative works, households can move between dwellings when the family is expanding. Keeping the flow in the building.

Fig. 12: Variety of dwellings, different to type of household.

4| Projects

4.3 Het Schetsblok

Architect:	ANA Architecten
Location:	Amsterdam, The Netherlands
Year completed:	2018 (Year began 2015)
Program:	25 apartments
Client type:	Private

The city of Amsterdam wanted to encourage self-build projects. A community of people decided to realise a self-build project in the form of Collective Private Ownership (CPO). Residents could decide themselves how much to invest in their dwelling (Openbuilding.co, 2020). The project consists of twenty-five unique dwellings designed together with the residents. The project is a result of an inventory of the residents wishes (ANA Architecten [ANA], 2020). ANA designed a flexible construction that became the basis for a modular layout of the dwellings, based on the ideas of Open Building (EUmiesaward, 2020). Because of this the apartments can be made different in position, size, layout and combined on top of each other. (ANA Architecten [ANA], 2020). The focus of the project was designing together with the future residents.

The flexibility is realised by organising the services based on vertical distribution, as Schneider and Till name this (Schneider and Till, 2007). The shafts are positioned at the corners of the core with the circulation space inside the core. The wet rooms are flexible but often situated near the shafts to keep the installation costs low. To make vertical distribution of services future proof they need to be realised in being always accessible and big enough to provide space for developments in technology (Schneider and Till, 2007).

The construction consists of a load-bearing core, columns in the façade and concrete floors span between core and façade. Partition walls can be demounted and shifted anywhere in the open plan. Restrictions in its flexibility are the screed and floor heating that need to be removed and reinstalled if houses are divided or joined

Fig. 13: Het Schetsblok. From “Architectenweb” by L. Kramer, 2019 (https://architectenweb.nl/nieuws/artikel.aspx?ID=46023#photoid=315617).

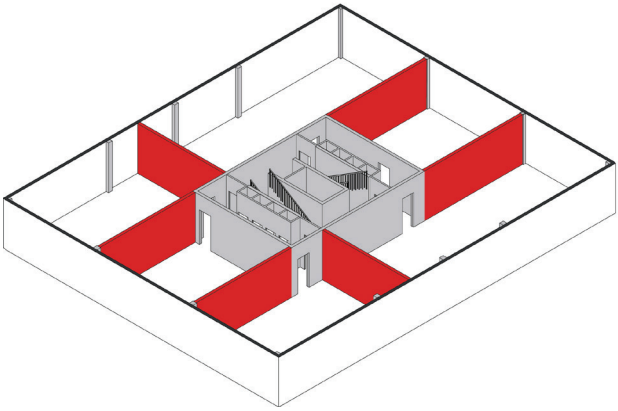


Fig. 14: One of a variety of possible divisions in layout per floor level.

(Openbuilding.co, 2020). In the façade flexibility has played a role in technological innovations. With a system of a main grid and a sub-grid in which the main grid allows future customisation and adaptation. The base of the building will be untouched but other elements can be renewed in time (ANA Architecten [ANA], 2020).

Het Schetsblok presents a compelling case for the importance of recognising the different layers of a building and designing with adaptability in mind. By allowing these layers to work independently the building has been designed to make developments in the future. However, the focus on the user is only visible in the design process of the dwellings and not in future use.

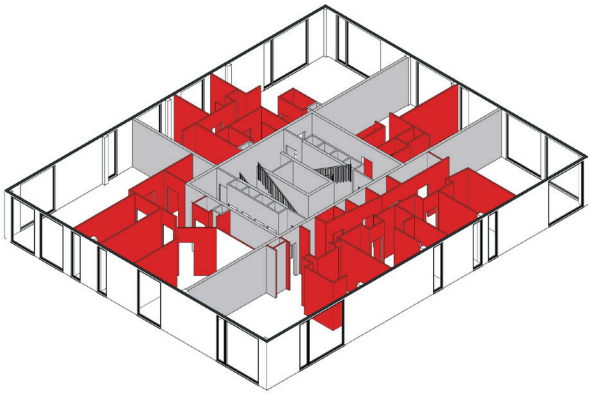


Fig. 15: Contemporary floorplan level 3.

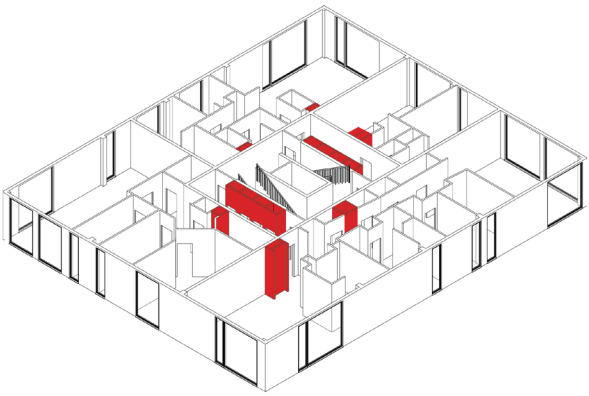


Fig. 16: Service elements organised around and in the core of the building.

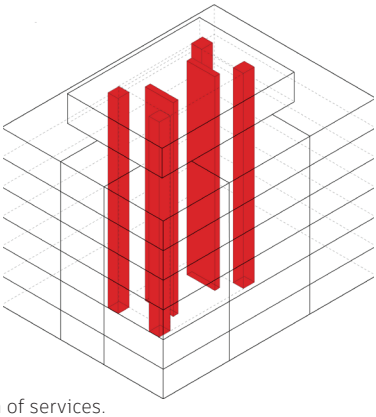


Fig. 17: Vertical distribution of services.

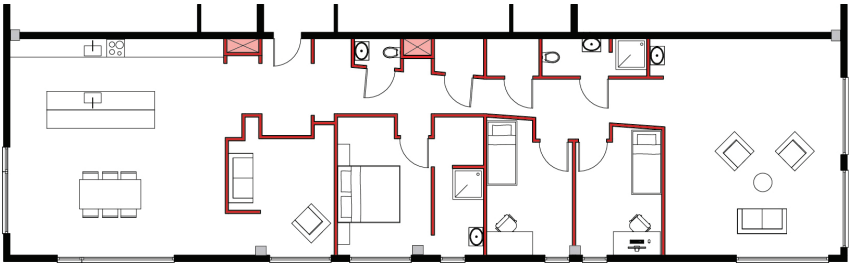


Fig. 18: Dwelling floorplan with temporary walls.

4| Projects

4.4 Unite

Architect:	Sophie Delhay Architecte
Location:	Dijon, France
Year completed:	2019
Program:	40 apartments 1 collective space
Client type:	Private

Unite is designed in between existing buildings and future denser constructions of the neighbourhood unfolding between the two scales. In the building is one large, shared space with outside area, which is accessible from the apartments as well as directly from the public space to be used by different users. The concept of the dwellings is to prioritize the user by realising adaptable houses in which the resident can determine the space (2023).

The dwellings are structured as identical square rooms with a terrace or loggia of the same size. The principles of sliding walls, functionally neutral rooms, and indeterminacy are used to make the dwellings adaptable (Schneider and Till, 2007). The design is about social activities of people free to make their own adaptable way of living to changing daily activities of its residents, as the architect Sophie Delhay mentions it (2023). The spaces are fixed within a grid of 3.6 by 3.6 metres. Sliding doors are used to create possibilities in opening-up or closing of different depending on the needs of the residents, with the spaces itself designed to be tight-fit. Delhay decides the amount of floor area the user needs in every room but gives the resident the role to determine what they do in every space.

Often architects designed adaptable architecture by walls that can be moved to provide an open plan or to divide a space (Schneider and Till, 2007). In Unite the sliding walls are tough and acoustically isolating to allow different layouts in a semipermanent basis. The sliding partitions increase the options in ways to use the rooms or combination of rooms (2023). The spatial quality added makes different usages through the day or in general of the dwelling

Fig. 19: Unite. From “Archdaily” by B. Verney, 2019 (https://www.archdaily.com/929995/unite-s-experimental-housing-sophie-delhay-architecture/5df038f53312fdecff000192-unite-s-experimental-housing-sophie-delhay-architecture-photo?next_project=no).

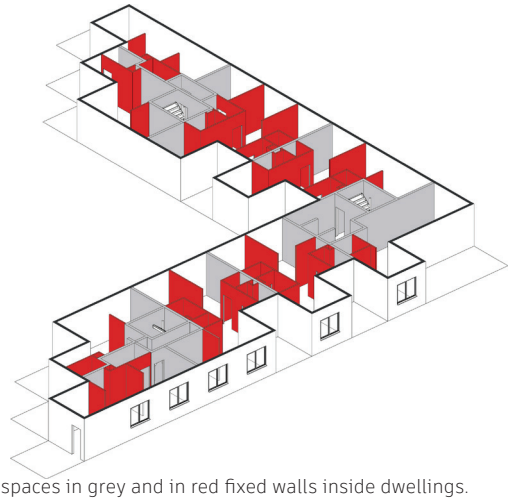


Fig. 20: Circulation spaces in grey and in red fixed walls inside dwellings.

possible, see figure 21. The project is in this manner planning driven. Often rooms are labelled and then designed to a specific function as Schneider and Till explain (Schneider and Till, 2007). This leads to a plan that reads out where and how activities should happen. In Unite the labels are removed and make the spaces becoming independent entities to be used according to the needs of the users, which inevitably change over time (Schneider and Till, 2007). Unite uses a neutral room in the dwelling's centre which can be used as room and circulation space between the other rooms. A dwelling could be used as two bedrooms and a living room for a small family, or as a shared apartment for three adults. The spaces can be opened during the day to give space for activities and at night they can be closed off to provide privacy for every user. Adaptability is created in use with flexible elements which are determined by the user.

Unite shows the value of adaptability in realising a user-oriented approach to dwelling design. The tight-fit plan of the dwellings allows for effective use of space, while the loose-fit design contains the changing needs of the users in daily use. However, this is realised by only providing flexibility using sliding doors. The users can determine by their own control the use of the complete space.

Fig. 21: The layout of the spaces create different possible uses during the day and can be closed for privacy in the evening.

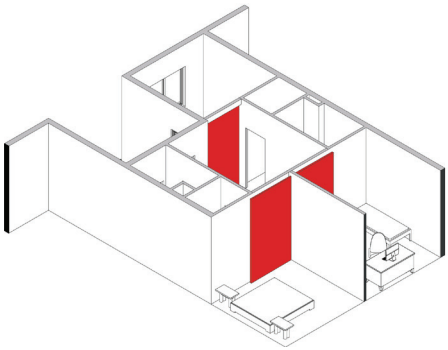


Fig. 22: Sliding doors to close of spaces.

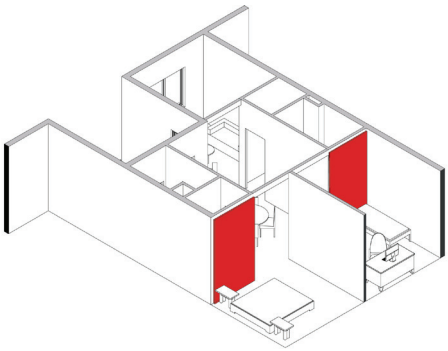


Fig. 23: Sliding doors to join spaces.

5| Design implementations

One typology of adaptable architecture can never be made, every project is different in context, user, and system. Designing an adaptable building is a thoughtful process of analysing the environment and future users by making a statement in what the project should hold. The origin of adaptable architecture is the empowerment of the residents living in the building (1961). Without consideration of user, adaptability is not needed and without context the building can be placed everywhere but does not belong anywhere (2022b). In architecture buildings are designed to correspond with its environment, without this the building is likely to be demolished (1994). As a result, architecture is a balance of the user, the place, and the adaptable system used (2022b). One general system for adaptability in a building cannot be designed. The design at M4H should correspond with its context, anticipate on its possible future, and have most important notice on the users of building.

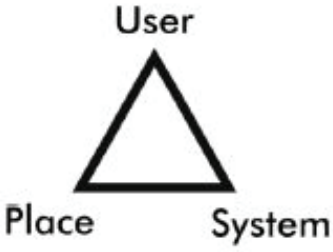


Fig. 24: The relation between user, place, and system.

5| Design implementations

5.1 Typology of design

For the user

Adaptable architecture in this research is about implementing adaptability in the building with a user-oriented approach. For this the design of the space inside and the floorplan is of most value to the user. It can be identified that the architect has two approaches for adaptability, being soft and hard. The soft approach means a plan can be adapted to the needs of the users by themselves. The hard approach means a plan that is specifically determining its use, the user only reacts to what is possible (Schneider and Till, 2007). The user will need the space in everyday life, however the changes of everyday life can be order and chaos. The dwelling plan needs to be able to overcome these fluctuations to be of value to the user (Schneider and Till, 2005b). So, the spaces inside must be clear in use and have not too much different choices in how these can be filled in (1994). Examples of projects with too much choice are Open Building projects with their open floorplan for which future residents always need an architect or designer to make the plan (De Architect, 2016). And the example of the Rietveld-Schroder huis in which only Mrs Schroder determined when all folding walls were closed and opened. Providing too many choices in terms of adaptability can lead to use confusion and leads to intended flexibility unused, resulting in additional costs, as Brand observed (1994). By providing clarity in the flexible elements or adaptability in the space the choices made must be not to big but easy to understand for everyone.

Insights

From the research following inputs are gathered to be of use in realising an adaptable building project.

1. Use of space

Give the user responsibility in deciding how a dwelling is used by providing adaptability in use and flexibility in elements. Spaces can vary in function every day, every week, or every year, its all determined by the user. They are fixed in size and plan to provide not too much choice to the user and organised so every user can deal with their own activities. Flexible elements as sliding doors can be used without additional costs to divide or join rooms during the day.

2. Modular elements
A building needs to be able to adapt in time, to changing requirements or situations in the future. Using elements that can be easily demounted without disrupting other building parts makes the building possible to keep developing. By using modular and circular elements a sustainable building structure can be realised with a long lifespan.

3. Cooperative ownership
A cooperative ownership for the building organisation strengthens the value for the residents, city, and the building. As the cooperative uses adaptability for the households to change between the dwellings not in spatial but organisational way. Furthermore, in providing affordable housing and creating a sense of community between the users.

4. Sharing spaces
Using a variety of shared spaces throughout the building will keep dwellings smaller as functions can be shared. The spaces can be used for residents and neighbourhood gatherings providing a greater sense of community living. The shared spaces at different floor levels make residents more likely to encounter each other.

5. Long term thinking
The future is unknown and, in this way, important to observe. Setting up different scenarios of possible future circumstances will keep the building more viable when changes occur. In the early design stage these scenarios can be implemented to overcome the challenge without having to make large adjustments.

5| Design implementations

Architecture is a dynamic field that is constantly evolving, as buildings must be designed to not only meet current needs but also adapt to changing circumstances and future requirements. Buildings will develop, improve, and adjust to accommodate the needs of time. Time and building are intertwined and the applications for user-oriented adaptability mentioned before can be combined with lifespans as well. When working with these additions these lifespans need to be bear in mind.

Long term thinking is about the users, the context, and the adaptable system for at least upcoming 100 years. This is about the masterplan and possible future scenarios of the building:

The modular used elements are part of the building construction and will need to change in every 25-50 years due to developments in technology.

The cooperative will organise the building for a long time but will make plans as well for around the 10 years to meet the demands of the users.

The same goes with the shared spaces which are used by the residents and will change within 5 years due to changing interests of residents. However, it is depending on the function of the shared spaces.

The use of spaces and the adaptability of spaces is completely user specific. The infill of a house will change every few years and the use of the floorplans changes every day; however the fixed framework of the dwellings will last longer.

What can be concluded is the user determines the use and architecture of the building in the shortest period as of daily use and the shared spaces, however the user is the most important in the architectural idea of the building.

5.2 Design at M4H

The district M4H is an old harbour terrain at the edge of the city centre of Rotterdam and the harbour of Rotterdam. The district was the location for the transhipment of goods, long-time known for the transhipment of citrus fruits. Today the area has a lot of vacant plots and only a few transhipment companies, a waste collector, a powerplant, and newly located creative companies. The area has due to its history a great excess to the water that can be used for logistics of companies and public transport via the water what leads to less traffic on the streets. A dike which protects the land inwards, surrounds the area making it isolated from neighbourhoods around. However, this isolation can be used to become an autonomous district which can strengthen its character. The former harbour buildings can be transformed as characters of the history of the area, this will strengthen the identity of M4H. The project location is next to the water and can be used for the transhipment of goods by companies in the district, leisure activities, and develop the biodiversity.

Scenario's

The future in unknown, however the project can be prepared for a variety of challenges making it more viable for the future. Different scenarios are thought about that can be overcome by the design of the project. The scenario tool by Brand explained in chapter 2.2 'Six layers' is used as guide to investigate the challenges. First, major issues are investigated; second design ideas are created that can challenge these major issues; and at last, a strategy for the overall building design is discussed.

Major issues

The project at M4H knowns three possible scenarios that are most likely to become of true in the future. These are climate change, with rising sea levels; relocation of work abroad, with no work in the district anymore; and the possibility of becoming a major production location, due to need of more harbour labour inland.

5| Design implementations

Design solutions

1. Climate change, to overcome the risk of rising sea levels the building has been realised on top of a concrete box. Within this box are car parking, storage boxes, and bicycle parking. The box is realised a few meters in the ground leaving a height of 1.5 meters above ground. This 1.5 meter above ground is heigh enough in any case of rising sea level in coming 150 years.
2. Residential area, if the ongoing move of work abroad is continuing the area will need to shift from work and living towards only living. The factory hall at the ground floor is designed as a large open space to have a variety of functions, for example a large skate park, event hall, or art exhibition.
3. Factory site, in case of the harbour in need of more space for production or innovation. The M4H district can be completely transformed into a work-related district. The project is realised with adaptable floor levels, at ground floor up to fifth floor, with enough height for production and office space, the fifth floor up to the tenth floor can be transformed into an office or hotel for workers, and the top ten floors be completely dismantled.

Strategy

The project building is implemented with the different design solutions to overcome most likely to happen scenarios. The building is realised with the strategy to be adapted in case of changing events. The building is realised into three layers what makes it possible to in case of change use these three layers to have a different approach and keep the building viable also after the needed changes. By using a modular construction and open construction the building can be transformed without expensive interventions. The building is realised to be adaptable at the scale of the project as well as the scale of the dwellings. Providing the adaptability even at the smaller scale of the user giving the user the responsibility to make change possible if personal situations need this.

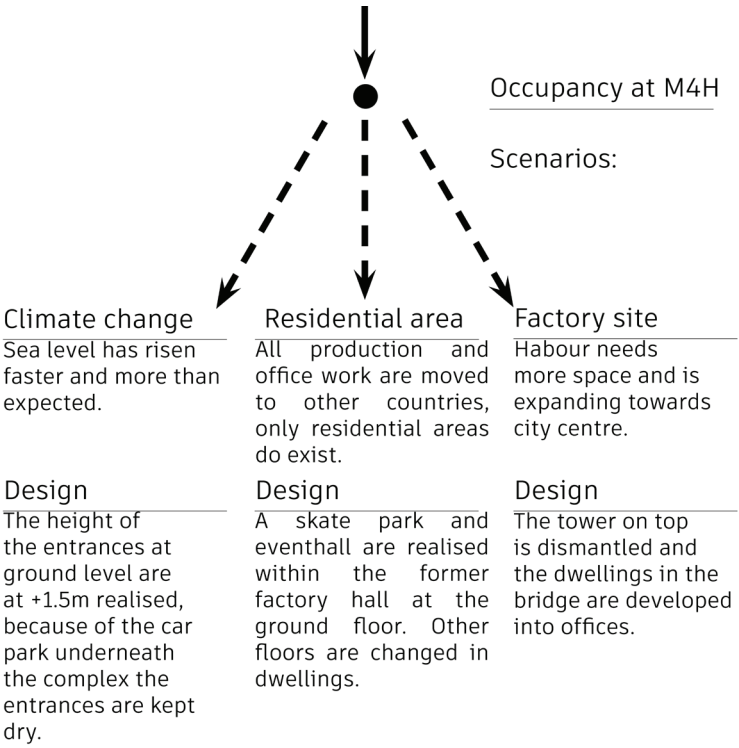


Fig. 25: Scenariotool of Brand used as design tool for M4H project.

Building

The focal points of this project are internal and external adaptability, the importance of a building that can react to changing needs and circumstances on the inside and outside. The building has three distinctive layers that as can be seen in figure 26: the Base (1), Bridge (2), and Tower (3). Every layer is different in matters of adaptability, work/live ratio, and outdoor space.

The base is characterised in being completely adaptable, mostly work and some dwellings oriented, and has public accessible outdoor space. At the ground floor a large open factory hall is situated to be used by one company or it can be divided for multiple smaller companies. Level two is a large open floorplan to be used as office space and workshop space. The two top floors of the base are categorised as work homes, every dwelling has a separate room with a separate entrance to receive clients. The companies in the base can use different shared workspaces, meeting rooms, and a canteen. The sharing of services and knowledge is promoted by meeting people throughout the building via a large staircase where people are forced to run into each other. A large public rooftop is created on top of the factory hall for residents, employees, and to be used by the neighbourhood. The adaptability in the base is in the height of the floor levels and the use of concrete column structure in which every type of function can be implemented.

The bridge's identity is the large open park in its centre surrounded by dwellings. The bridge, at a height of twenty meters, can be seen as an extension of the street or parks at the ground floor. The ownership of this part of the building is together with the tower a cooperative what makes it possible to realise a park as great value to its residents. The dwellings vary in typology for households as starters, small and large families, and elderly. The cooperative makes it possible when a household grows, they can move to a bigger dwelling. The park works as being semi-private as being only accessible by people of the bridge and the tower. Shared spaces are oriented around this open space realise extra functions which are not available inside the dwellings.

The tower is the more private oriented approach of the project. Every floor level gives space to three different dwelling typologies. The adaptability is completely integrated in the floorplans by use of the residents and implementing sliding doors to give the user complete responsibility. The floorplans of the rooms are based on a grid of 3.6 by 3.6 meters making a variety of functions possible in every space. The outdoor spaces in the tower are loggias in every dwelling, to give the residents are private outdoor space.

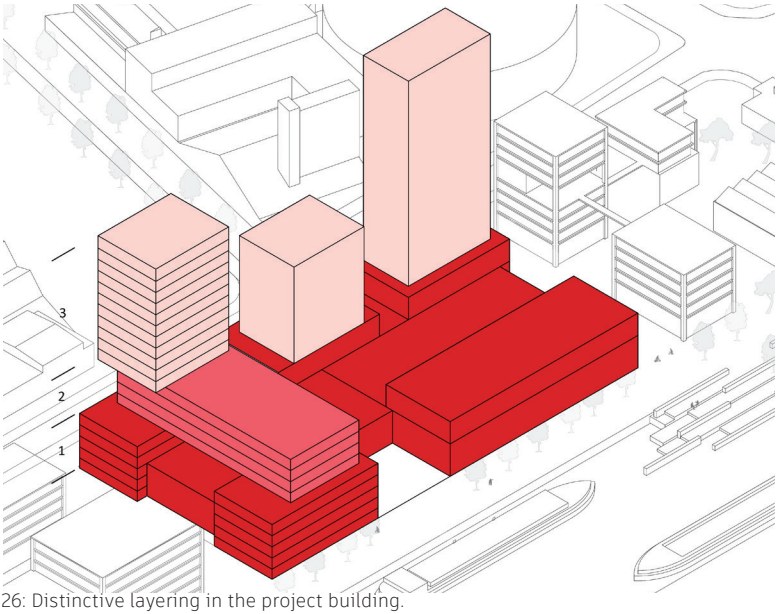


Fig. 26: Distinctive layering in the project building.

5| Design implementations

Implementation at M4H

The design recommendations in chapter 5.1 are used in the project at building and dwelling scale. The building scale is about extending the lifespan of the building and the dwelling scale is about user empowerment at human scale.

Modular building elements:
The building is designed with the ideas of the building layers by Brand. Circular modular elements in the façade and internal systems are used to keep the building developing which expands its lifespan.

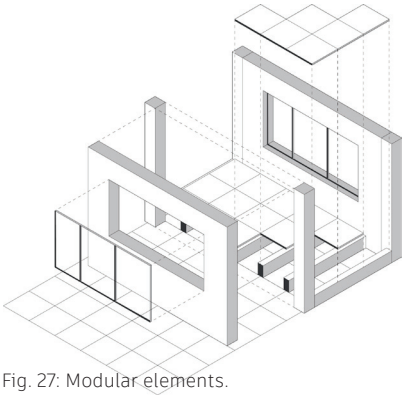


Fig. 27: Modular elements.

Shared spaces:
Circulation spaces, shared rooms, and garden are all oriented to let people run into each other creating a stronger community responsibility and feeling. Furthermore, the functions which are not needed daily are shared with other residents and employees making more efficient use of de floorspace in dwellings.

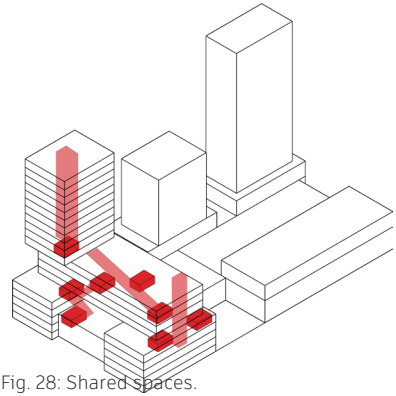


Fig. 28: Shared spaces.

Vertical services in core:
All service facilities are organised in the core of the building. This gives the possibility in need of service changes these are easily accessible, and the area around the core has freedom in floorplans.

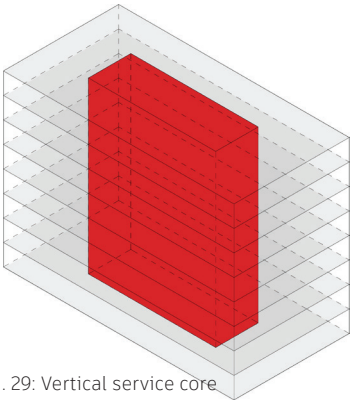


Fig. 29: Vertical service core

5| Design implementations

The dwellings are organised around the daily activities of the users. However, every resident has its own daily routine and organisation of their dwelling. So, it is all organised as a fixed framework in which the users are given a great amount of freedom in implementing their own activities. Adaptability in use, and flexible elements to determine use are key components of the dwelling's layout. Spaces can provide a variety of use by not being planned, only the bathroom, kitchen, and technical systems are fixed in place. The rooms all have the same spatial quality and by joining these this can be expanded and by dividing this can create privacy. The dwellings are all about user empowerment.

Fixed grid:
The building spaces are based on a grid of 3.6 by 3.6 meters. Given that these measurements are most optimal to realise housing and office spaces in the same building and gives the possibility to vary in use.

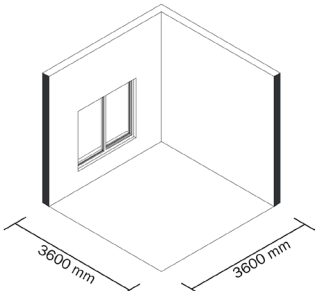


Fig. 30: Ideal space measurements.

Tight fit:
The walls in every space are fixed giving users the guidelines in how the space works. However, the infill is organised as a loose fit so residents can decide their own activities.

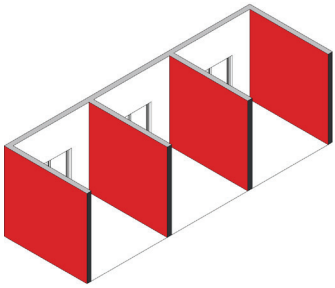


Fig. 31: Fixed partition walls.

Variety in use:
The spaces are all organised within a grid and tight fit layout. Due to this organisation the responsibility of use in every space is for the resident giving them great user-empowerment.

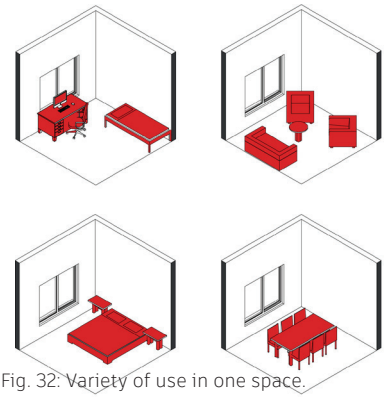


Fig. 32: Variety of use in one space.

Neutral zones:
The rooms are all organised around one neutral zone a space which is an over dimensioned hallway or the size of a room. This neutral zone connects spaces and is a space on its own.

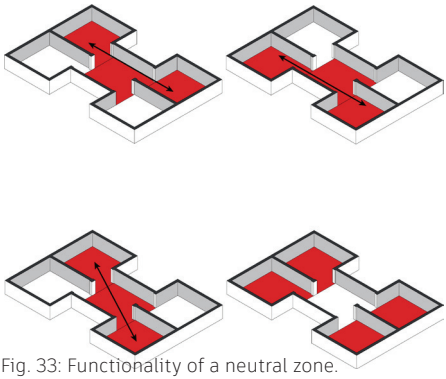


Fig. 33: Functionality of a neutral zone.

Sliding doors:
In the dwellings sliding doors are realised as flexible elements making adaptable use of the spaces. The sliding doors join or divide the space as determined by the user.

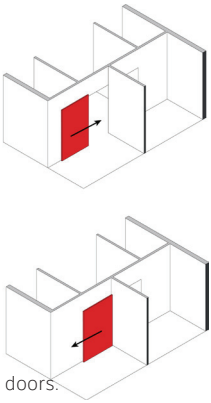
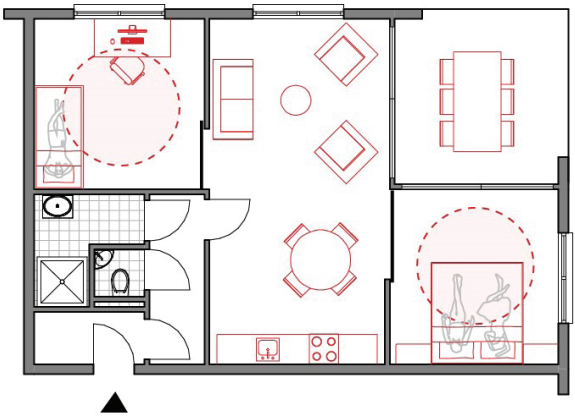
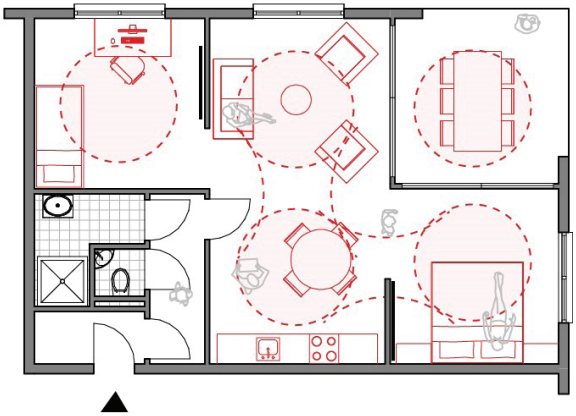


Fig. 34: Sliding doors.

5| Design implementations

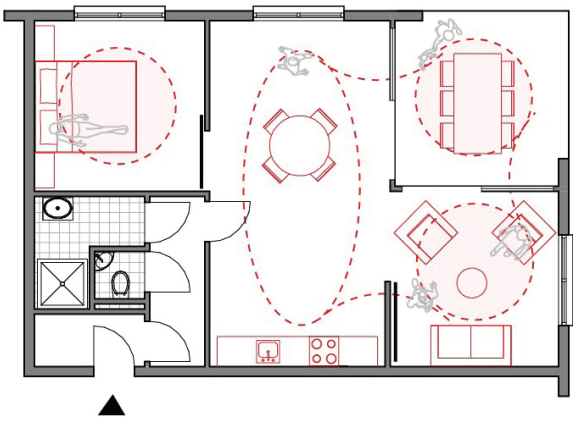
Use of the dwelling during night with closed sliding doors.

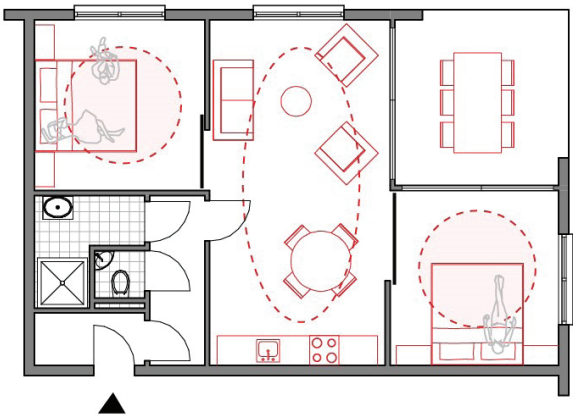




Use of the dwelling during day with opened sliding doors.

Use of the dwelling with one bedroom.





Two couples living in the same dwelling.

Fig. 35: One typical floorplan of M4H project with different possible uses.

6| Conclusion

This paper aimed to answer the main research question of: “How can design strategies with implementation of adaptable architecture in building projects create more user-oriented dwellings.” Several sub-questions helped to create an answer to this question. Earlier criticism on mass housing by Habraken led to an understanding of the housing crisis in the 60’s but also shows the comparisons with the housing crisis of today, where the user is a customer to decide between standardised products. The ideas of Habraken and Brand matched between the ideas of supports and infill, of which supports are the structure and the infill the floorplans and stuff of the residents. The supports are the framework in which users can change the infill depending on challenges they come along. This idea gives the user a lot of freedom, however as seen in open building projects to much freedom comes with high costs and implemented flexibility which is never used. Habraken used flexibility with a social goal towards the user, and Brand used it to extend the lifespan of the built environment. Together these ideas are a strong base in further developing adaptable architecture with a focus on its users.

As methods and means to give the user its self-fulfilling environment the principal is in combining use and technology. It is the role of the architect to design the plan of how building and user will work. The architect plays an active role in locating, walls, services, and space. The other role is by working in the background determining possible uses in the building but let the user decide their own activities. By undefined spaces and moveable elements, the user is actively encouraged to take part in its own dwelling design. However, in time a building cannot always be fully adaptable as it is a synthesis between building and user, the user sometimes needs to adapt too.

Designing an adaptable building cannot be organised within one general approach. Every project is different in combination of context, stakeholders, and organisation. Adaptable architecture is an approach towards more user empowerment in the design of the built environment. At M4H the adaptability of the project is implemented at building and human scale. This is the use of a cooperative which focusses on the needs of the residents in general. The design of the

6| Conclusion

dwellings in which spaces can vary in use. Combining working and living at the same floor levels. Make the possibility to completely change all modular elements of the building. Realising shared open and indoor spaces for people to meet and share goods. The requirements of the users need to be clear, and the building needs to be able to adapt with them if this changes. The architect provides the guidelines in which the user is free to adjust to its own daily activities.

7| Bibliography

Acharya, L. (2013). Flexible Architecture for the Dynamic Societies [Master's thesis]. Faculty of Humanities, Social Sciences and Education. University of Tromso.

ANA architecten (2014). Learning from Multifunk. BNA onderzoek

ANA Architecten. (2020). Het Schetsblok [Brochure]. https://www.ana.nl/portfolio-item/het-schetsblok/

Asselbergs, T., Jonkman, A. & Spoormans, L. (2020). Open Bouwen voor een hernieuwbare woningvoorraad. Ruimte + Wonen, 2/2020, 16-25.

BNA. (2014). Flexibel bouwen voor de toekomst. Schooldomein

Boucsein, B, & Seidel, T. (2015). Open Building as a Principle of Cooperative Housing. ETH Zurich. https://www.research-collection.ethz.ch/handle/20.500.11850/110106

Brand, S. (1994). How Buildings Learn. What happens after they're built. Penguin Books.

Brand, S. (1997d). How Buildings Learn, Unreal Estate. [Video]. Youtube. https://www.youtube.com/watch?v=PuP-MF7lOe4&list=PLqTJSIweddBDwOtFOnFL2tPXvhlBBTDkB&index=5

Brand, S. (1997e). How Buildings Learn, The Romance of Maintenance. [Video]. Youtube. https://www.youtube.com/watch?v=nWsASJ-CnvI&list=PLqTJSIweddBDwOtFOnFL2tPXvhlBBTDkB&index=6

Brand, S. (1997f). How Buildings Learn, Shearing Layers. [Video]. Youtube. https://www.youtube.com/watch?v=485R4xst-DU&list=PLqTJSIweddBDwOtFOnFL2tPXvhlBBTDkB&index=7

Cuperus, Y. (2001). An Introduction to Open Building. Delft University of Technology

Dankers, B. (2013). Kansen van bouwen met woningconcepten. Keuzemogelijkheden door een efficiënt ontwerpproces. [Master's thesis, Delft University of TechnologyTechnische] https:/xxx.

De Architect (2016, September 8). ARC16: PATCH22 – FRANTZEN et al. De Architect. https://www.dearchitect.nl/116048/arc16-patch22-frantzen-et-al-2

DELVA. (2019). M4H – Toekomst in de maak – Rotterdam. Retrieved January 15, 2023, from https://delva.la/projecten/m4h/

Duffy, F. (1990). Measuring Building Performance.

EUmiesaward. (2022a). The Sketchblock. https://www.miesarch.com/work/4287

Frantzen, T. (2016a). Patch22. Retrieved January 4, 2023, from https://www.frantzen.nl/NE/index1.html

Frantzen, T. (2020, November 9). Open Building NOW! Lecture by Tom Frantzen [Video]. Youtube. https://www.youtube.com/watch?v=1Bina57y_CY&t=2896s

Genevro, R. (2009). A Walk with Frank Duffy. Urban Omnibus. https://urbanomnibus.net/2009/07/a-walk-with-frank-duffy/

Genosschenschaft Kalkbreite (2012). Das Zollhaus [Brochure]. https://www.kalkbreite.net/zollhaus/

Habraken, J. (1961). De dragers en de mensen. Scheltema & Holkema.

Hannema, K. (October 26, 2016b). Woon-werkgebouw Patch22. ArchitectuurNL. https://www.architectuur.nl/project/woon-werkgebouw-patch22/

Hochbauten, Stadt Zurich Amt fur. (2014). Wettbewerbsprogramm Neubau Wohn- und Gewerbeuberbauung Zollhaus.

7| Bibliography

Hoogstraten, D. (2011). Baas in eigen huis. DASH, 4-19.

Jacobs, J. (1961). Death and Life of Great American Cities. Modern Library.

Kai, Y., K. (2022b). Adaptability and Flexibility in Architecture Concepts & Theories Applied in Residential Architecture to Achieve Adaptability. Taylors University Malaysia. https://www.researchgate.net/publication/357866253

Kendall, S. & Teicher, J. (2000). Residential Open Building. Taylor & Francis Group

Khatibi, M. (2022c). A socio-spatial approach to the first legal hall dwelling setting in Switzerland: the case study of Hallenwohnen in Zurich. Journal of Housing and the Built Environment. https://doi.org/10.1007/s10901-022-09980-y

Kischkel, J. (October 6th, 2022d). Typologies for a changing society – challenges for old and new cooperatives. Symposium Cooperative Conditions/ learning from Vienna, Zurich, and Munich.

Leijten, P. (2021). Flexible housing for the amateur. Flexible building concepts explored in the age of the amateur [Master's thesis, Delft University of Technology]. http://resolver.tudelft.nl/uuid:e2447d0c-c625-4b83-8de8-09c01983031c

Lengkeek, A. & Kuenzli, P. (2022). Operatie wooncoöperatie. Uit de wooncrisis door gemeenschappelijk bezit. Trancity*valiz.

Leupen, B. (2002). Kader en generieke ruimte: Een onderzoek naar de veranderbare woning op basis van het permanente. Delft University of Technology.
http://resolver.tudelft.nl/uuid:cba125d6-aa1f-47b5-a021-9a35f53a46ee

Luscuere, P. (Ed.) (2018). Circulariteit: Op weg naar 2050? TU Delft Open. https://books.bk.tudelft.nl/index.php/press/catalog/book/isbn.9789463660549

Nakib, F. (2010). Toward an Adaptable Architecture. Guidelines to integrate Adaptability in the Building. Ecole Polytechnique d'Architecture et d'Urbanisme-EPAU
https://www.researchgate.net/publication/260277772_Toward_an_Adaptable_Architecture_Guidelines_to_Integrate_Adaptability_in_the_Building

Novy, J. (2022e). Getting back into the "business of making things:. On the promise and perils of the "productive city". European Journal of Spatial Development, 19(2), 1-12. 10.5281/zenodo.6511439

Openbuilding.co. (2020). Het Schetsblok. ANA Architecten. https://www.openbuilding.co/schetsblok-ana

Patch22 (2016c). The architect as developer. https://patch22.nl/

Schmidt III, R. & Austin, S. (2016). Adaptable Architecture. theory and practice. Routledge.

Schneider, T. & Till, S. (2005a). Flexible housing: opportunities and limits. Cambridge University Press. https://doi.org/10.1017/S1359135505000199

Schneider, T. & Till, S. (2005b). Flexible housing: the means to the end. Cambridge University Press. https://doi.org/10.1017/S1359135505000345

Schneider, T. & Till, S. (2007). Flexible housing. Elsevier Inc.
Schuler, T. A. (2018). Patch22's Timber Structure Faces the Weather. Architectmagazine.
https://www.architectmagazine.com/technology/architectural-detail/patch22s-timber-structure-faces-the-weather_o

Struharik, D. (2019). Bauhaus and the Beginning of Mass Housing: How Residential Open Building Reacts to Changes in Society. Brno University of Technology Faculty of Architecture. DOI: 10.24427/aea-2019-vol11-no3-04

Van der Werf, F. (1993). Open Ontwerpen. Uitgeverij 010.

Westerman, R. (2021). Modulare Wohnturme mit Wechselnder Aussicht. Modulart. https://www.modulart.ch/modulare-wohntuerme-mit-wechselnder-aussicht/

Zuidema, R. (2015). Open Building as the basis for Circular Economy Buildings. ETH Zurich. https://doi.org/10.3929/ethz-a-010578376

4Winden. (2021). 2021 ... de aanhouder wint! https://4winden.nl/2021-de-aanhouder-wint/

8| Glossary

Adaptability
Capacity of a building to effectively accommodate the evolving demands of its users and environment, thus maximizing value through life.

Adaptability type
Classification of a particular change objective which relates to a subset of approaches and methods under the theme of adaptability.

Adjustable
Change of task.

Moveable
Change of location.

Flexibility
Technical methods to realise adaptability.

Infill
Composition of flexible indoor spaces in a carrier.

Support
Composition of spaces formed by fixed structures.

User empowerment
The capability of the user to make customisations that effect the users experience or outcomes.