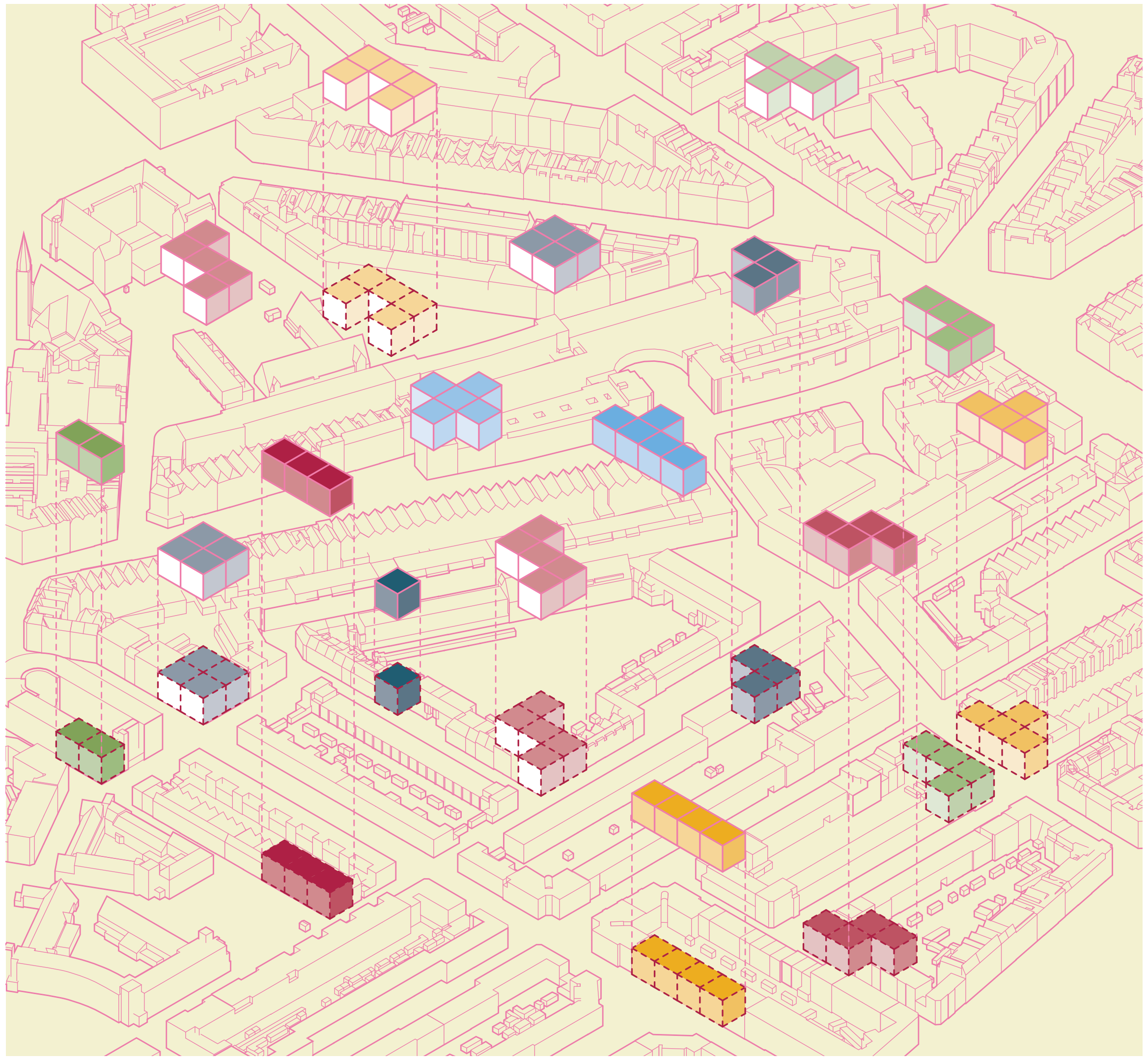
SPONGE HOUSING - create flexibility to adapt to changing housing densities



ABSTRACT

An ever-changing modern society imposes new challenges for city development, namely how the built environment can be designed for a changing population and urban housing density. This article argues that current large-scale top-down demolition and construction strategies for densification are not the most efficient and sustainable approaches. Alternatively, a proposal for a more flexible system, consisting of small-scale interventions, is put forward, with the goal of creating resilient neighbourhoods that can adapt to different dwelling densities. This article takes the neighbourhood of Hillesluis in Rotterdam South as the research subject to explore possible densification strategies. Afterwards, a new housing model of 'Sponge housing' is proposed that can self-regulate the number and size of houses , creating a system capable of having flexible densities.

INTRODUCTION

1.1 Definitions

The concept of density is widely used both in the planning and design process to describe the relationship between a particular area and the number of entities in that area. These entities can be dwelling, population, services or floor space (M. B. Pont. and P. Haupt., 2012). In this article, urban density represents built-up area density, which is defined mainly by FSI (floor space index) and GSI (ground space index).

Dilution and densification refer to the decrease and increase of dwelling densities in a certain area. There are different strategies to change the residential density at different scales. The demolition and merging of homes proposed by the local government will lead to a decrease in dwelling numbers, these are strategies of dilution. The construction of new houses within the existing urban area results in a higher number of housing units, which is the strategy of densification.

The top down approaches initiated by the government are defined as large-scale or macro-scale while the interventions that take place at architecture level are defined as small-scale or micro-scale.

1.2 The Current Housing Situation in Rotterdam

The city of Rotterdam is currently in the process of urban renewal and urban growth. 31.4% of Rotterdam's housing stock was built before 1945, while in Amsterdam this value is 19% (Gemeente Rotterdam, 2018). These pre-war houses are now considered as low-quality. For this reason, among others, the housing vision of Rotterdam aims to improve the existing housing stock and living environment through renovation and demolition (Woonvisie Rotterdam, 2016).

Located in the south of Rotterdam, Feijenoord is identified as a multicultural but less developed area compared to the northern part of the city. Similarly, there is a large amount of pre-war housing used to accommodate the harbour workers in Feijenoord. Besides, it has a higher population density of 11567 people/km2 compared to the Rotterdam central area of 8732 people/km2 (Statistics Netherlands, 2020). The housing density is however similar in the two areas. This indicates that the housing stock in Feijenoord does not correspond with its population density, which is shown in the higher number of overcrowded houses in Feijenoord.

1.3 The Current Government Strategy in Rotterdam South

To solve the housing issue mentioned above, the National Program Rotterdam Zuid (NPRZ) was launched to improve the area over 20 years until 2030. It is clearly demonstrated in the plan that there will be interventions in the housing stock in this area which mainly consists of social housing and small houses. On one hand, to improve the housing quality in terms of variety and ensure a more differentiated housing stock, the local government aims to create houses suitable for local social risers and attract more affluent inhabitants (Gemeente Rotterdam, 2020). The strategies include converting social housing into privately rented housing and stimulating the merging of homes to create larger living spaces. This will result in the renovation of 1,000 houses and the merging of 5,000 homes up until 2031 in the Rotterdam South area (NPRZ Implementation Plan, 2019). Besides, demolition and new construction of 4,000 dwellings in total is another approach to improve private housing stock. On the other hand, there also exists the need for more homes as the population will continuously grow in Rotterdam according to the forecast (Gemeente Rotterdam, n.d.). The local government thus also envisions new housing development to accommodate the increasing population. Between 2018 and 2031, there will be 16.500 new houses added in the south of Rotterdam.

1.4 Problem Statement: A Static Housing Model

It can be observed that currently the housing vision initiated by the government ends with proposing general numbers of houses applied in a large area. Afterwards, the top down interventions attempt to improve the housing quality through dilution and increase housing quantity through densification. According to the government report, in 2015, 110 homes are demolished for every 100 new homes built, while in Amsterdam there are 2 to 12 houses demolished for every 100 new homes (Gemeente Rotterdam, 2018). It is argued that these large-scale interventions are not the most sustainable way to solve the housing issue. Besides, the articulation of the processes of dilution and densification as separate approaches to change residential density indicates that the current housing model is not flexible enough and cannot accommodate changing densities. Moreover, starting from policy (city) scale, both processes of dilution and densification may overlook negative effects brought to the neighbourhoods. For instance, the dilution process of demolishing social housing and merging homes in one neighbourhood may result in gentrification by displacing lower income residents (Kleinhans, 2019) who are forced to move to other neighbourhoods (figure. 1.1). The design at a neighbourhood scale is missing and its place, there exists a potential for a more flexible and democratic housing system.

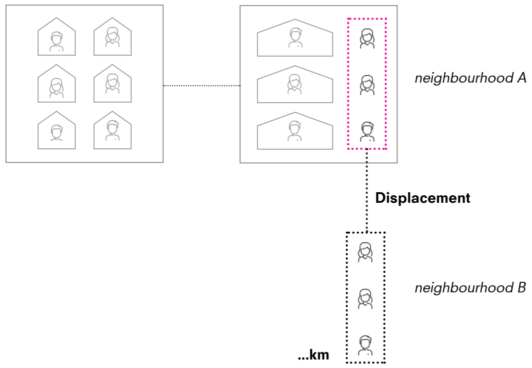


fig. 1.1: Process of displacement

To sum up, the current housing model characterized by large-scale interventions is argued a being too static to adapt to the ever-changing housing demand. Alternatively, a more flexible system consisting of small-scale interventions is needed to create resilient neighbourhoods.

1.5 Research Question: A Dynamic Housing Model

Contrary to the existing static housing system, a dynamic housing model initiated at a neighbourhood level is proposed l that can adapt to changing residential densities through dilution and densification at a small scale. The following research question will be explored in the following chapters: *How can a flexible architectural model be designed to both dilute and densify a neighbourhood, resulting in a housing system that is able to regulate its own density?*

MAIN PART

2.1 Hillesluis as The Research Neighbourhood

Hillesluis located in the Feijenoord area is chosen as the neighborhood scale site. It is one of the 15 target neighbourhoods in the National Program Rotterdam Zuid (NPRZ) in need of improving its housing conditions. Hillesluis was developed into a residential area for workers from harbors and factories ever since the 20th century and 71% of housing stock was constructed before 1945, which is much higher than the Rotterdam average of 31.4%. There are currently around 5,000 homes in Hillusluis. The local government aims to merge 200 to 300 houses to create more single-family houses before 2030. At the same time, there are plans to add 500 new houses within the neighbourhood. Also, considering that Hillesluis is defined as a lively urban living area (Stadsontwikkeling Gemeente Rotterdam, 2018) and many new developments are envisioned around the area, more people are expected to be attracted to live in this neighbourhood.

2.2 Proposal in Two Scales

Given that the population will be growing in Hillesluis, the current primary issue, at an urban scale, is how to densify by increasing built areas for more houses. Based on the forecast of population, the maximum dwelling numbers within the next 15 years will be defined as the capacity of each building block within the neighbourhood (pink solid line in figure. 2.1). It might need to be densified again after 15 years if the population keeps growing. The long-term issue, at a building scale, is that resident numbers may fluctuate (black solid curve in figure. 2.1). The problem then becomes how to make the added new housing flexible to change its residential density through strategies of dilution and densification.

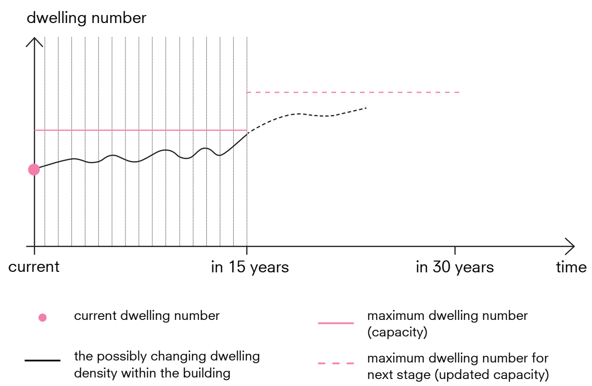


fig. 2.1: Anticipated density variations

2.3 Literature Review: Urban Density Study

Studies on urban density from Pont and Haupt (2012) is reviewed in this part to develop strategies of densification at an urban scale. Historically, the use of density is limited for statistical purposes as it is considered to poorly reflect the spatial qualities of a certain area. However, Pont and Haupt argue that there exist relationships between density and urban form (2012). Here, instead of defining a specific urban form derived from different densities, their research uncovers a more general correlation between urban form and density. They propose that at a certain place and time, certain conditions defined by density in combination with other constraints, such as building regulations, limit the potential possibilities for urban forms. Pont and Haupt developed a diagram to illustrate this relationship between density and urban form (2009). Spacemate is created by relating four main variables, FSI (floor space index), GSI (ground space index), OSR (open space ratio) and L (layers), which are often used to define the urban density, see (Figure. 2.2.). Spacemate can be used to illustrate the relationship between these variables. This diagram argues that not only changes in FSI, but also GSI, OSR and L can affect the change of density. It also shows that the change in the values of all four variables results in the change of building typologies.

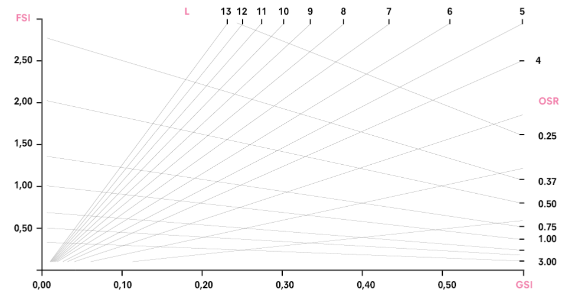


fig. 2.2: The Spacemate diagram (Pont and Haupt, 2009)

2.4 *Spacemate* in Hillesluis: Densification at Urban Scale

To understand the urban density in Hillesluis, it is important to firstly picture the densities of general housing typologies so that they can be compared. In the book Spacematrix: space, density and urban form (2012), three basic types: the pavilion, the street and the court are used to represent a range of morphological patterns of different building types. Inspired by this, in this article, urban residential buildings are categorized into five main types: pavilion, strip, open block, closed block and tower. Examples of these types are studied in terms of density variables and marked in the Spacemate diagram (Figure. 2.3). It can be observed that a certain type of residential building is located in a certain area in this diagram. Pavilion and strip building types are less dense than block types, and closed blocks can achieve high densities with high FSI and GSI.

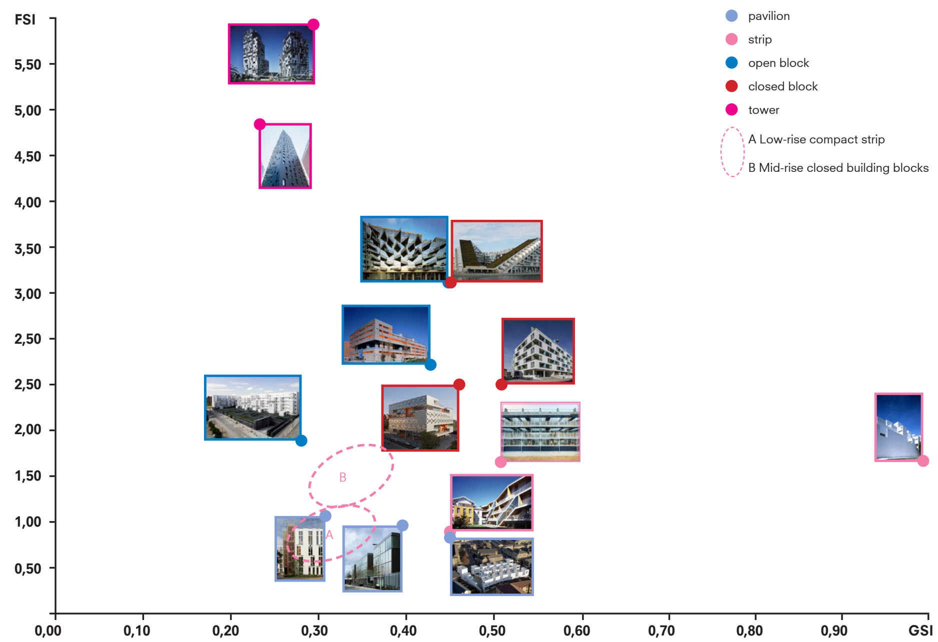


fig. 2.3: The Spacemate diagram with different urban housing types marked.

In Hillesluis, the urban housing types are mainly strip and closed building blocks composed of different building typologies, including row house, porch house and flats. The urban housing densities in Hillesluis are also marked in the Spacemate diagram (figure. 1). They are similar with pavilion and strip types but less dense compared to the open block type due to comparatively low heights.

By mapping and analyzing different urban residential building types in the Spacemate diagram, some transformation strategies of increasing densities can be developed, for instance, adding more floors and taking up more ground areas. These strategies are assumed to be applicable for all the building blocks in the Hillesluis neighborhood. However, when applying it to a specific building block, there are some other factors that limit the use of certain strategies. For example, limitations on building heights derived from urban rules are also crucial for considering the sunlight exposure for the surrounding buildings. Besides, factors such as the size of the block may also affect the implementation of certain transformation strategies. If some closed building blocks are small with only private gardens in the courtyard, the strategy of horizontal extension becomes limited.

After analyzing the building blocks and possible transformation approaches, one typical block is chosen for this thesis project to explore specific densification strategies at an urban scale (figure. 2.4). This block has some other attributes, one of which is that a park is located to its eastern side. This provides the opportunities to create houses of higher value on this side and more public programs on the ground floor.

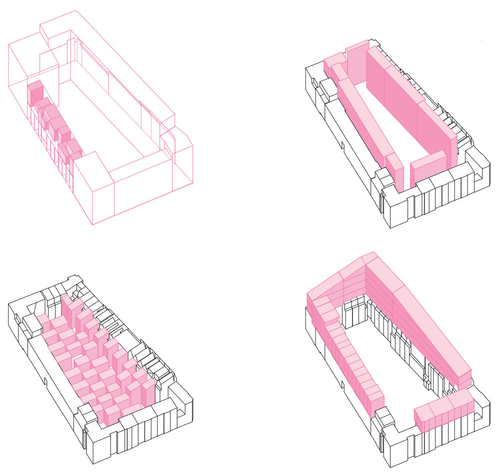


fig. 2.4: Different densification strategies

2.5 Strategies For Dilution And Densification at Building Scale

2.5.1 Unit size and unit number

After developing densification strategies with the help of the Spacemate diagram, possible dilution and densification strategies at the building scale need to be identified. The residential density within one building is determined by living unit number and size. The process of densification can be adding living space for an increasing number of dwellers (Figure. 2.5). Dilution, on the other hand, refers to creating more living space for a smaller number of people. It can also be achieved by reducing the number of residents by adding other programs (Figure. 2.6).

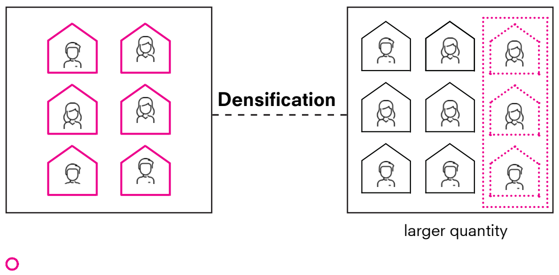


fig. 2.5: Densification process

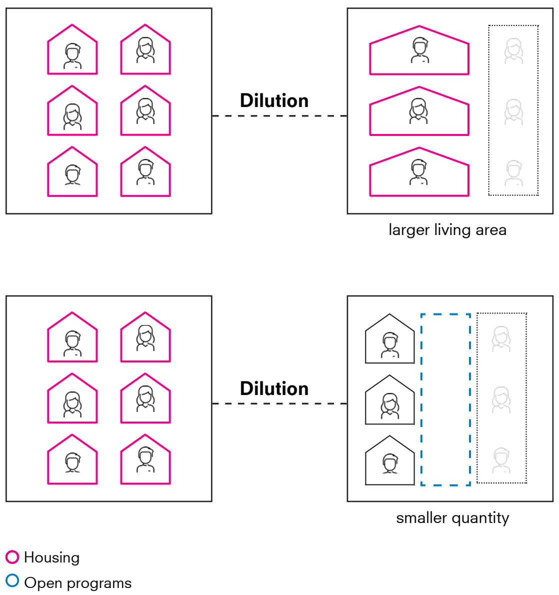


fig. 2.6: Dilution process

Compared to the urban density, the residential density in one built-up area is more related to the unit size. For example, both projects of A and B belong to the pavilion type in terms of urban density and B is comparatively more densely built with a higher GSI (figure. 2.7). However, A has a much higher residential density than B as the main user group in A is students, each unit occupies a smaller space compared to the case in B which mainly accommodates families.

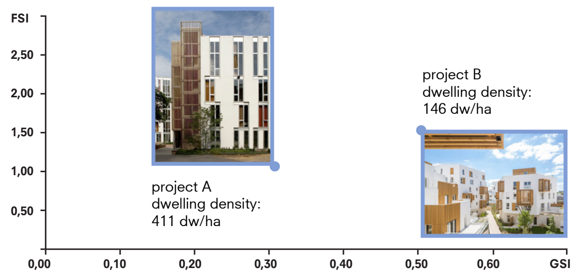


fig. 2.7: Urban density and dwelling density

There have been some spatial explorations in terms of changing unit numbers by changing unit sizes within the building. The Open Building approach is one of such examples. By firstly creating the support structure or the 'base building', the separated user-responsive infill level is changeable (Kendall and Teicher, 2000). The basic units defined by the structure can be combined or subdivided and dwelling numbers and sizes can be changed, adapting to the users needs. Superloft is a contemporary example based on Open Building principles. It uses modular design with prefabrication methods to create various loft types that are flexible to change (figure. 2.8).

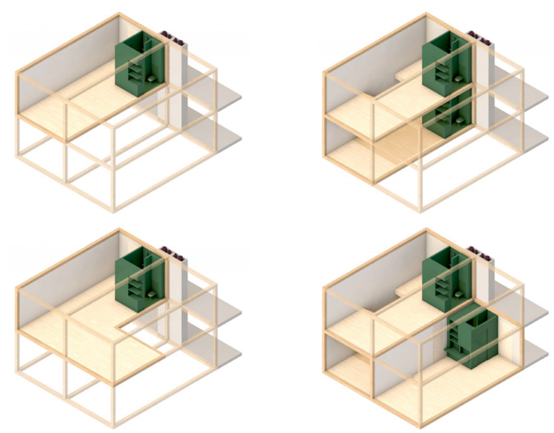


fig. 2.8: Changeble living units (Superloft, n.d.)

2.5.2 Organization and circulation system

Different types of urban form have different ways of organizing living units. The pavilion type tends to have more compact and centralized circulation systems to save space for living units (figure. 2.9). The strip type constrained by its linear form is more likely to have long corridors for the access of individual units (figure. 2.10). In this way, each unit in the strip type has more circulation space compared to the pavilion type. This can be concluded from the comparison of program percentage. The strip type has a higher portion of circulation space which is around 15% out of its total built area, while in the case of the pavilion type, the percentage is under 10% (refer to appendix).

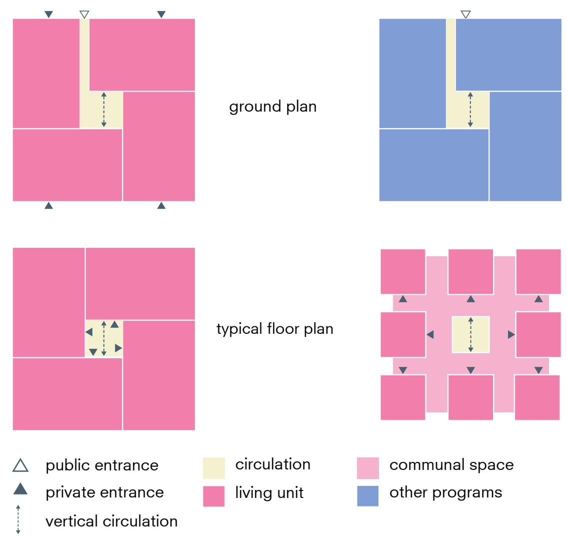


fig. 2.9: Centralized circulation system

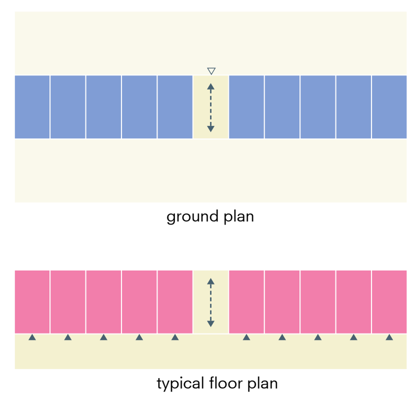


fig. 2.10: Corridor circulation

The closed building block type can be seen as a combination of the pavilion type and strip type in terms of its circulation system. The percentages of circulation space vary drastically between different projects (refer to appendix). This shows that different types of circulation system can be used to achieve different residential densities. Besides, the proportion of communal space can also be very different depending on the user group, for example, the student group can have more shared facilities and common room space with smaller living units. This can inspire other strategies of changing residential densities. One possibility is to transform communal space into living units to accommodate more dwellings.

2.5.3 A conceptual framework example

Combining the study above, one example acting as the conceptual framework of the building can be developed (figure. 2.11). The support structure of a 6-meter grid is firstly defined and the circulation core is located in the center. At the initial stage, there are many communal spaces and the basic living unit is 36m2. When densifying, the communal spaces can be transformed to create more individual rooms. When diluting, 2 or 3 basic units can be combined to make a larger living space for one household.

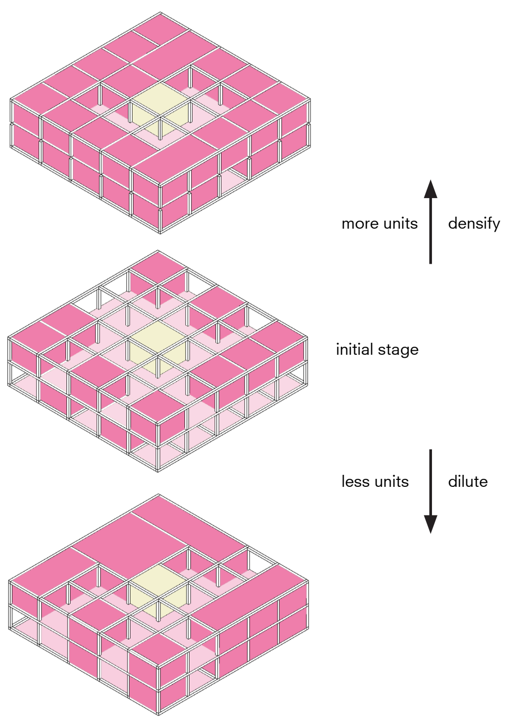


fig. 2.11: Densification and dilution strategies within framework

CONCLUSION

3.1 Sponge Housing as The New Housing Model

As discussed in the first section in this article, the current housing model is static and inflexible, relying on macro-scale top-down approaches to improve housing quality and achieve a desired housing quantity. This thesis project explores and proposes an alternative to this, by creating a dynamic housing model that can be applied in the neighbourhood level and adapt to different dwelling densities through micro-scale interventions. Using the tool of the Spacemate diagram, urban housing typologies in Hillesluis in terms of density and form are analysed. The strategies of densification developed from the analysis are applicable to all building blocks in the neighbourhood but in different ways according to the specific condition. These densification strategies are based on the existing building block, which avoids large scale demolition and construction. After increasing the capacity to accommodate more living units, the new housing can achieve different residential densities through small scale interventions within the building. This flexible housing system performs like a sponge to either 'absorb' or 'release' dwellers.

3.2 Meaning of Application / Global Relevance

Historically the concept of density is used in either a descriptive way to describe a built environment or prescriptive way to impose constraints in urban planning (2012). Accordingly, Pont and Haupt argue that the density study through Spacemate can bridge the gap between macro-scale urban planning and micro-scale project-based intervention (2012). After engaging Spacemate in neighbourhood analysis, the study in this article takes one step further to explore how the density can be changed on an architectural level, relating the abstract density concept with a physical spatial organization.

This thesis project provides one possibility of upgrading the urban residential area through adding houses that can adapt to different dwelling densities. And as it is a design proposal beginning from the neighbourhood scale, it can have a wider significance. Despite this, the project explores ways of achieving urban densification in a more flexible manner in case the housing needs to change. This is considered meaningful and useful as urban compaction and densification have taken an important position in the Netherlands and other countries to limit urban sprawl and acquire sustainable urban developments (Nabielek, 2012).

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APPENDIX I: DESIGN BRIEF

1.1 Ambition

The initial project ambition is to create a flexible housing system that can adapt to different housing densities as an alternative to current static housing model, which relies on large interventions of demolition and construction to achieve certain residential densities. To visualize this, the diagram in the figure 1 shows housing and other programs within a pre-defined framework. Overtime, the sizes and numbers of houses can be changed by combining two units or subdividing one unit depending on the density requirement. The users are defined by researching about the Hillusluis neighborhood data, which is composed of 44% single households, 16% and 23% living together without and with children respectively and 13% single parent family. Different user groups under these categories are further defined as students and young expats for single households, different family sizes such as nuclear families for living together with children. Besides, the average living area per person under the conditions of these categories in Rotterdam is considered to conclude the range of total living spaces for each type of household.

Considering Hillesluis has a high percentage of social housing stock owned by different housing corporations and it is one of the target neighborhoods in National Program in Rotterdam South (NPRZ), the development type for this project is assumed to be a collaboration between the government and housing corporations to improve the residential area. Every 15 years, based on the forecast of population, it will be decided by the government whether densification or dilution is needed in the neighborhood. And the housing corporations will choose to add or remove building volumes accordingly.

As the strategies of changing densities are derived from the analysis on the neighborhood level, though the final project is located in one typical housing block, it can also be applied in other housing blocks to have a wider impact. The diagram in the figure 2 shows this idea of urban ambition that different frameworks can be employed around the neighborhood as needed. In terms of programs, in addition to housing programs, other supporting public programs, such as parking and care facilities, will be added in different density situations. It is also imagined when residence density is high, all living units share a central courtyard. When it is low, each household may have their own back gardens.

To achieve this flexible housing model, modular design combined with prefabricated wooden construction is considered to be applied. In addition to offer time and cost efficiency, prefabricated wood elements are sustainable and energy efficient.

fig. 1:project ambition

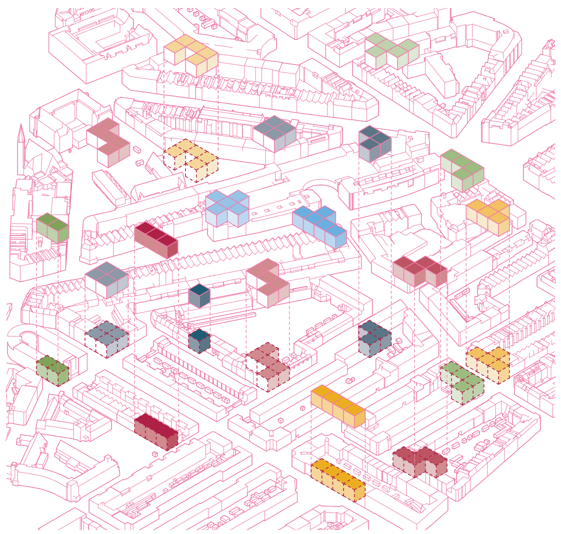


fig. 2: urban ambition

1.2 Site

The analysis of current housing starts from the neighborhood scale and the strategies evolved from the analysis are thus applicable around the neighborhood with necessary alterations. This project aims to develop a flexible system that can adapt to different needs, therefore, a building block with more attributes is selected as the 'site' to add to the complexity and diversity to the scheme. The site chosen is located at the eastern edge of Hillesluis with a park to its eastern side (figure. 3). This provides the opportunities to create houses of higher value with an attractive view to the greenery in this side. Besides, the routes cross the park from the convergent zone to the art academy is considered an important strip in the future vision of Feijenpoort site. Responding to this, the programs in the eastern side can be more public and mixed on the ground floor to create activities and stimulate vitality.

Most houses in the Hilleesluis neighborhood were built before 2000, some of them have higher historical values. There are four main approaches (figure. 4), three of which is to keep the parameter of the block, the valuable façade (or the entire building depending on the foundation condition) and part of the structures (if they were built after 2000 and are still stable). Those with little value and small living space are suggested to be demolished. These approaches can be applied in all building block but also editable accordingly.

In terms of urban rules, there are restrictions of building heights for each block. While the coverage is allowed to reach 70%, the maximum heights have more limitations. In the block chosen as the site, the eastern part is allowed to build upward to 20 meters while the western part is limited to 10 meters (figure. 5). By analyzing the sunlight access for the surrounding housing blocks (figure. 6), it is argued that the western and northern parts can be built higher (figure. 7).

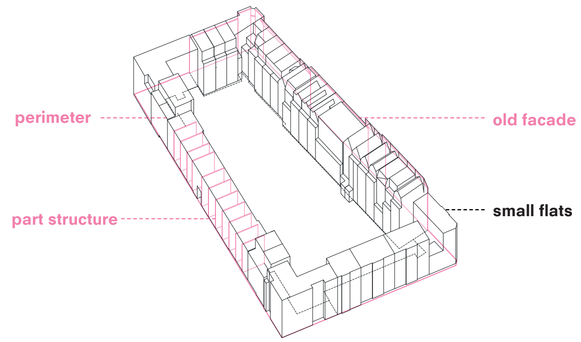


fig. 4: strategies to the existing building

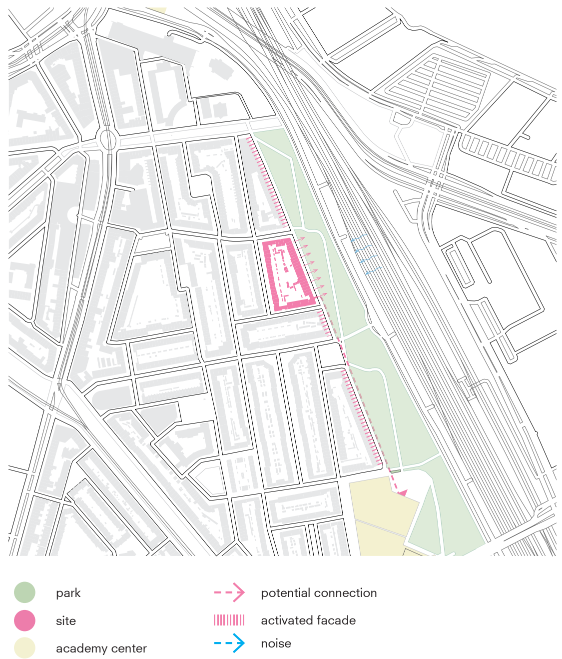
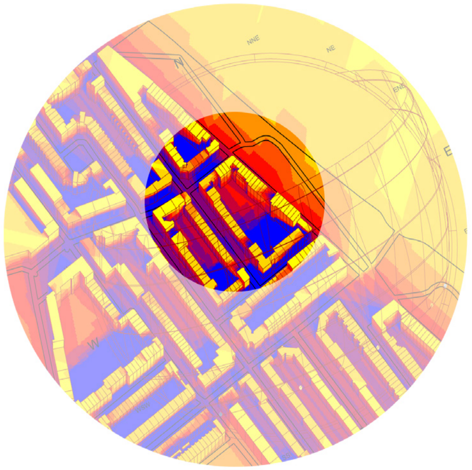


fig: 3: site potential

fig. 5: urban rules



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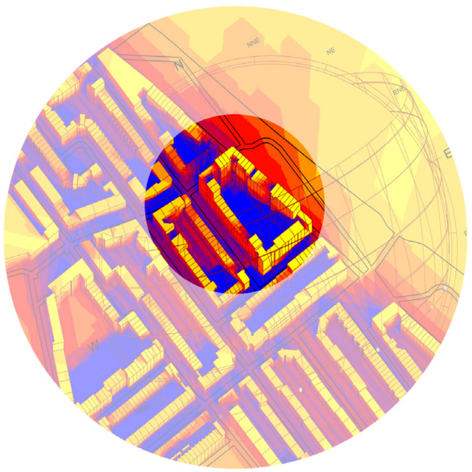
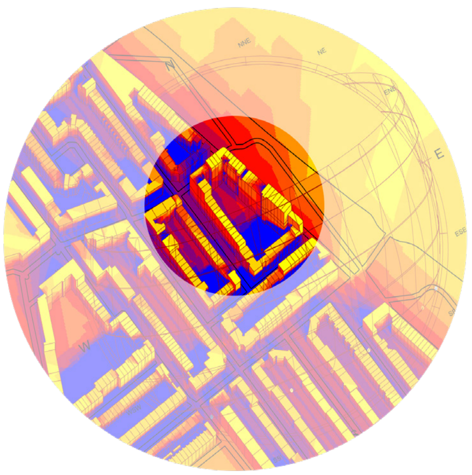


doubled height on four sides



doubled height excludes south side

fig. 6: sunlight testing

fig. 7: adjusted urban rules

1.3 Program

This project envisions a complex housing scheme providing different kinds of living units supported with other public programs including parking, care facilities and small business.

In addition to the research into projects in terms of programs, the typologies of urban housing are also important to develop the possible strategies for densification and dilution. Continuing with the urban housing types identified in the Spacemate diagram, three main typologies of pavilion, strip and closed building block are studied in terms of access, circulation and organization of units.

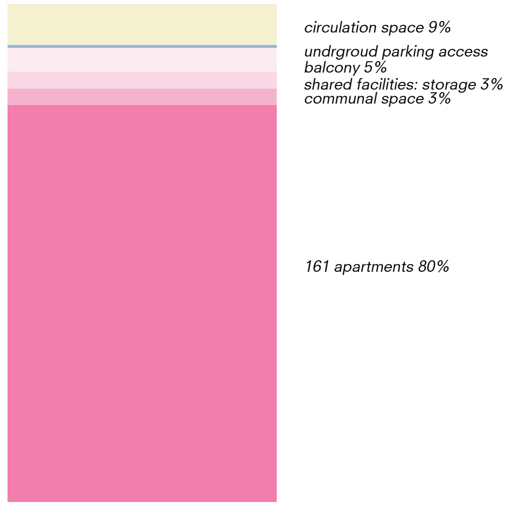
For the benchmarking, instead of an exact percentage, different programs all have a range of percentages that can adapt to certain residential density.

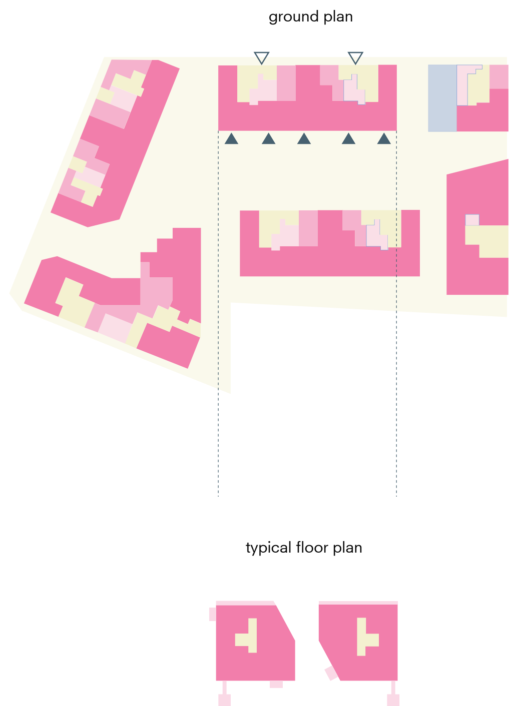
There will be different unit types in this housing scheme, including row house, apartment and penthouse (figure. 8). Each type has different sizes and accommodate different kinds of user groups. Some typology studies are also done to see the possibilities of placing different types in a vertical way (figure. 9).

Besides, considering this project will provide inclusive living available to the old and disabled group. There will be special space requirements for these groups in terms dimensions (figure. 10).

Location: Paris, France
Architect: Brenac & Gonzalez & Associés
Completed in 2005
Plot area: 10,790 m2
Floor area: 18,330 m2
Dwelling: 161

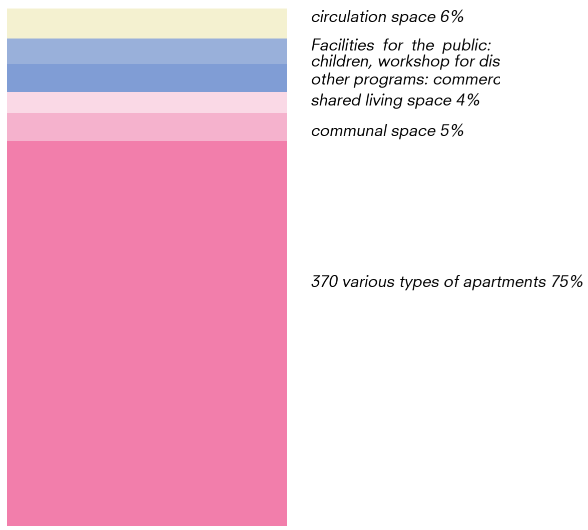
Density: 146 dw/ha

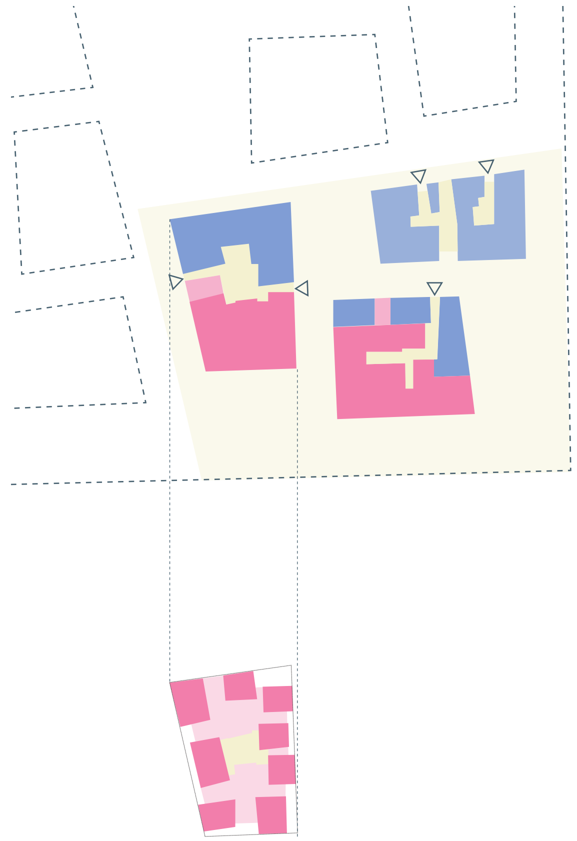




Location: Zurich, Switzerland
Architect: Duplex Architekten
Completed in 2015
Plot area:40,000 m2
Floor area: 60,000 m2
Dwelling: 370

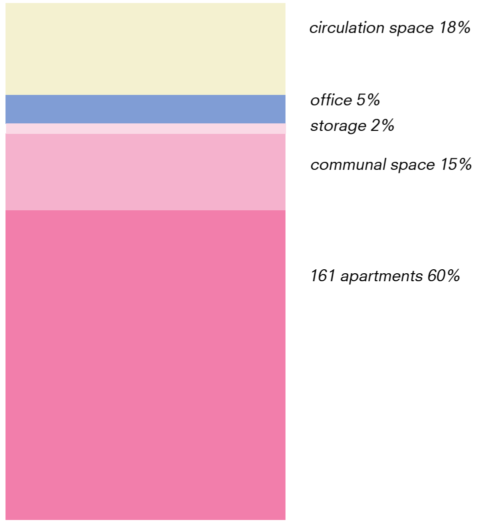
Density: 93 dw/ha

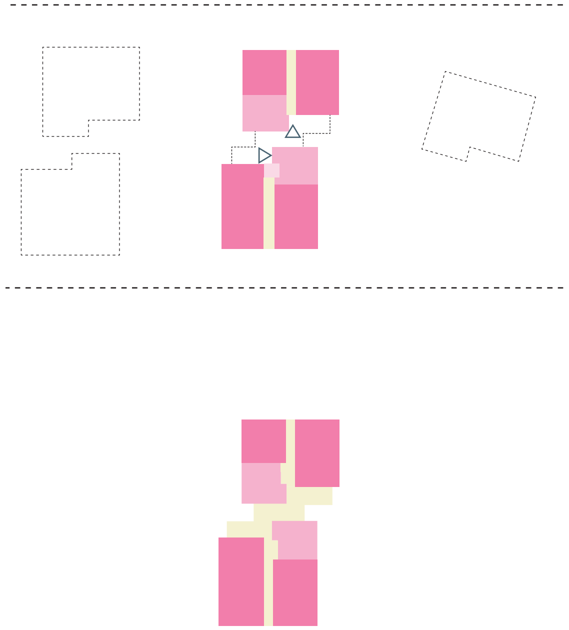




Location: London, UK
Architect: Haworth Tompkins
Completed in 2004
Plot area: 4,934m2
Floor area: 5,324 m2
Dwelling: 203

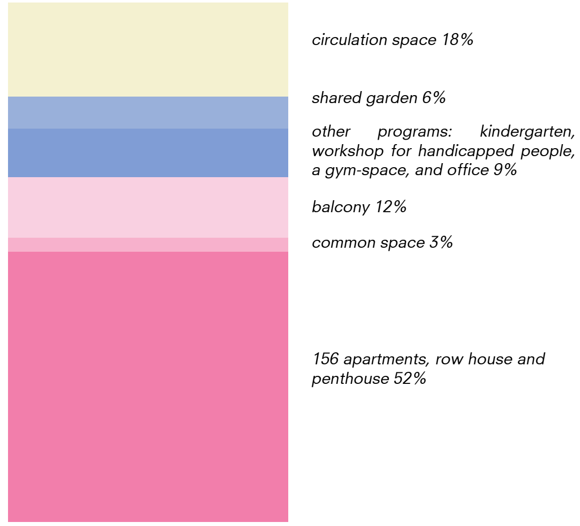
Density: 411 dw/ha

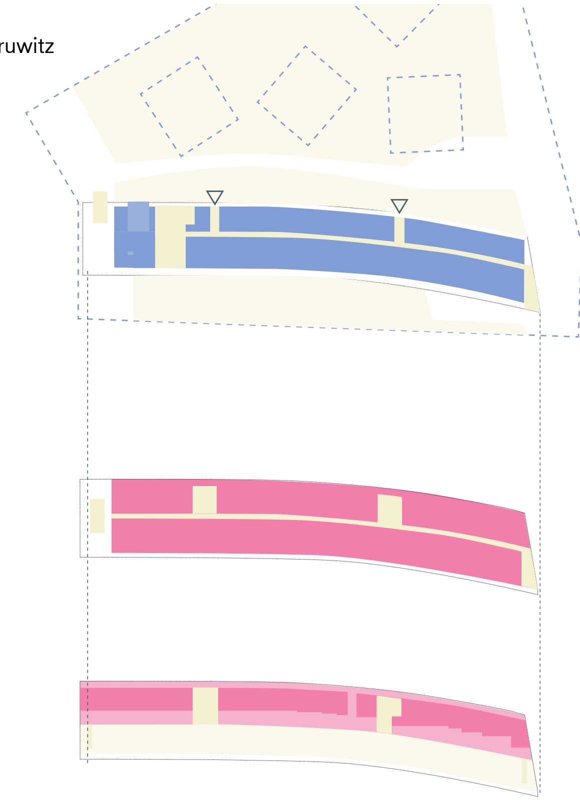




Location: Vienna, Austria
Architect: StudioVlayStreeruwitz
Completed in 2019
Plot area: 34,000 m2
Floor area: 13,850 m2
Dwelling: 156

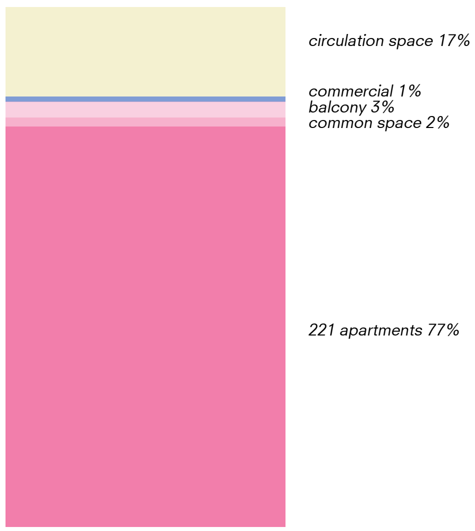
Density: 176 dw/ha

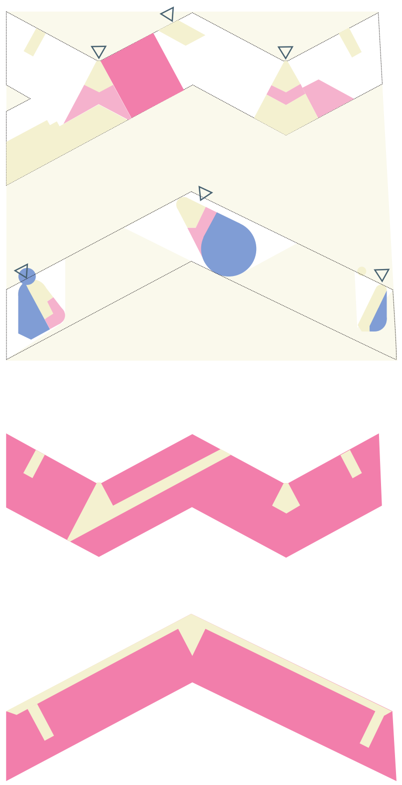




Location: Copenhaguen, Denmark
Architect: BIG. JDS (PLOT)
Completed in 2005
Plot area: 8,027 m2
Floor area: 25,000 m2
Dwelling: 221

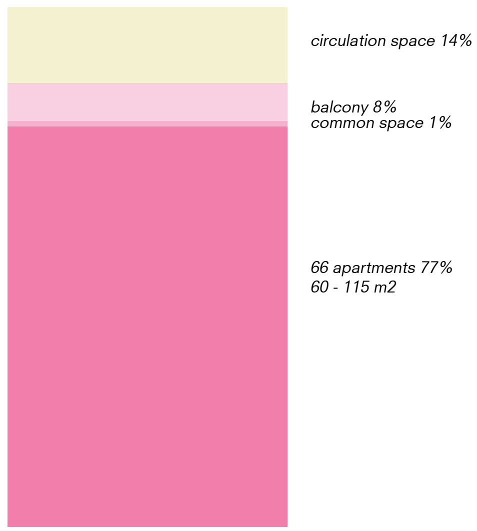
Density: 275 dw/ha

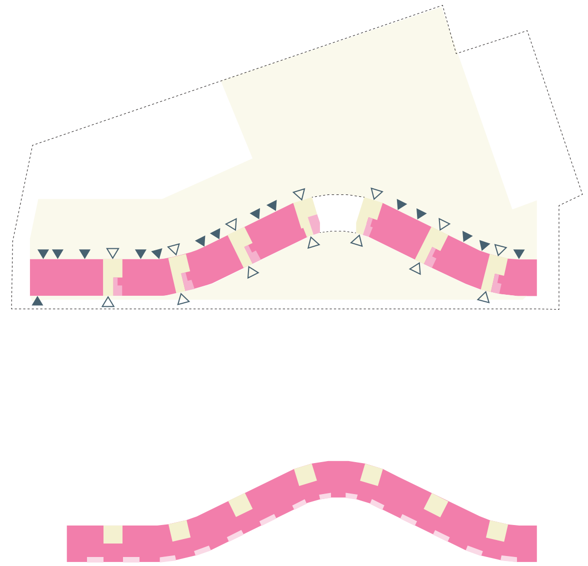




Location: Copenhaguen, Denmark
Architect: BIG
Completed in 2018
Plot area: 3,950 m2
Floor area: 6,800 m2
Dwelling: 66

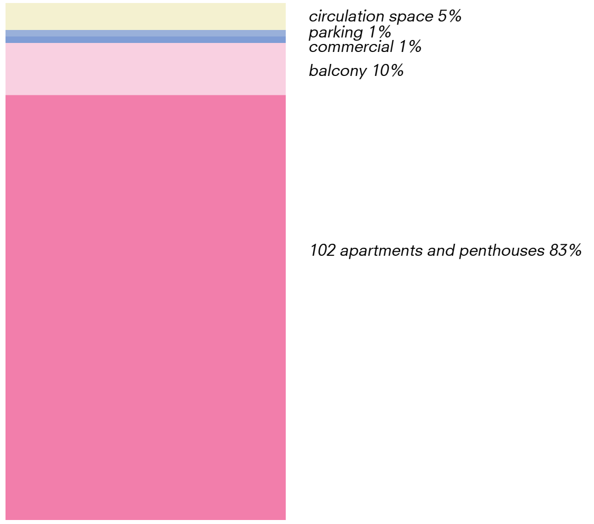
Density: 165 dw/ha

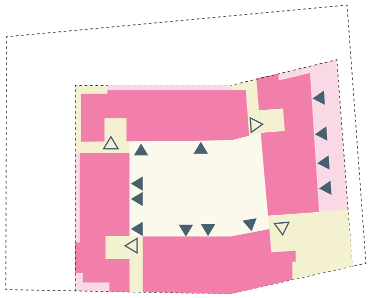


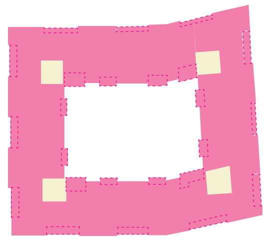


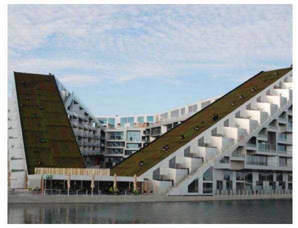
Location: Copenhagen, Denmark
Architect: C.F. Moller
Completed in 2006
Plot area: 4,397 m2
Floor area:11,000 m2
Dwelling: 102

Density: 232 dw/ha



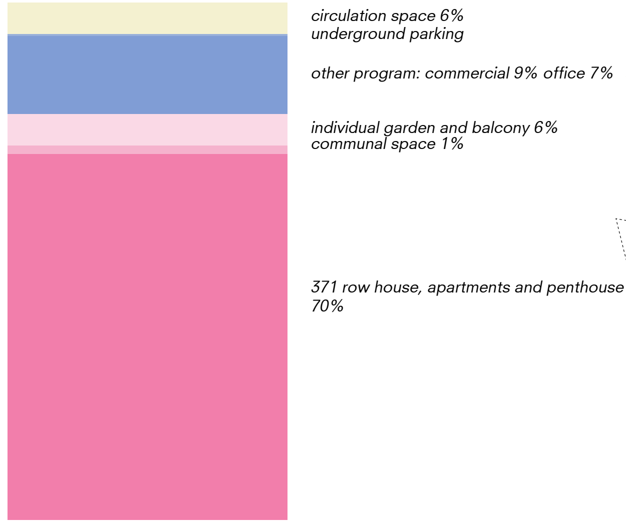


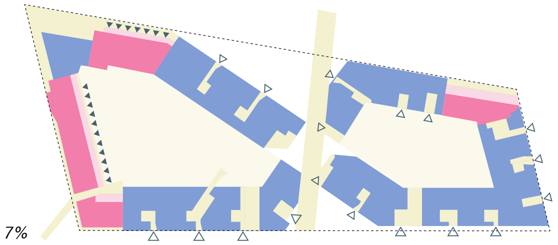


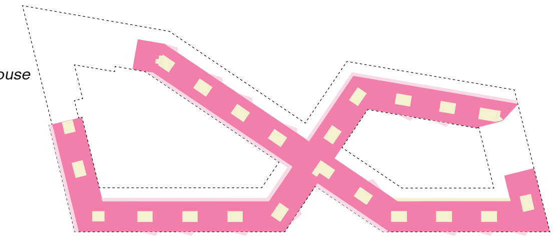


Location: Copenhagen, Denmark
Architect: BIG
Completed in 2010
Plot area: 18,299 m2
Floor area: 61,000 m2
Dwelling: 471

Density: 257 dw/ha

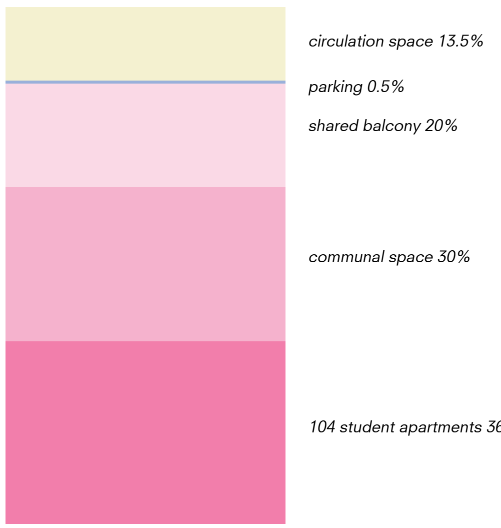


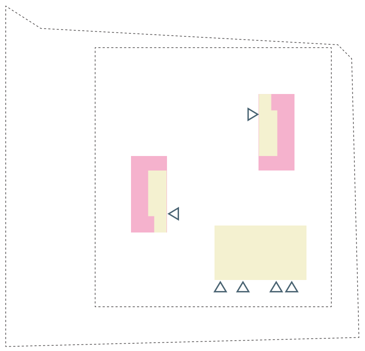


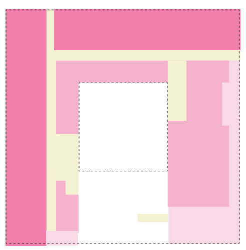


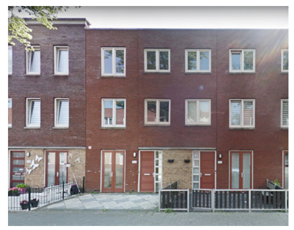
Location: Copenhagen, Denmark
Architect: AART
Completed in 2006
Plot area: 2,495 m2
Floor area: 6,950 m2
Dwelling: 107

Density: 429 dw/ha



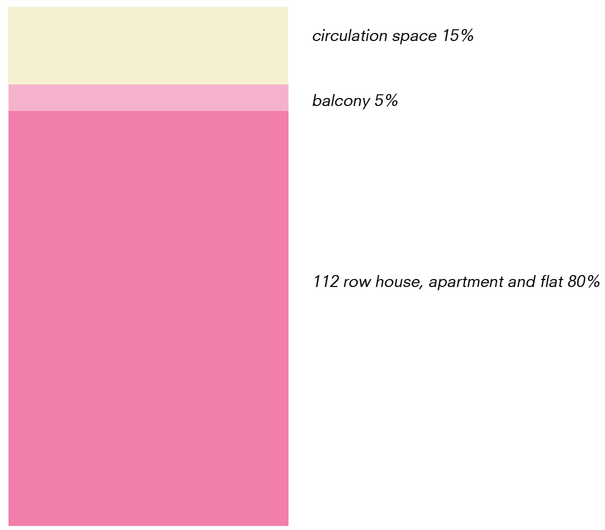


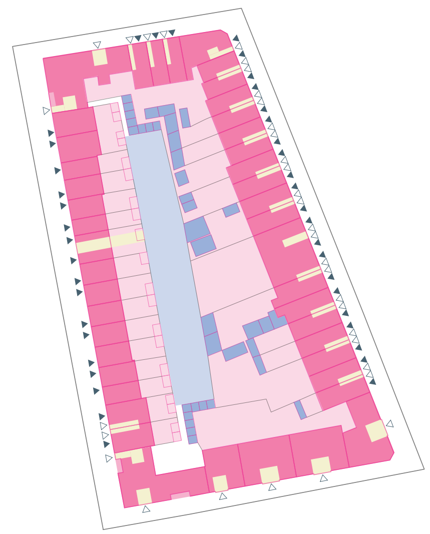




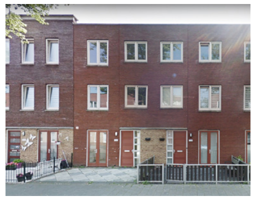
Location: Hillesluis, Rotterdam
Plot area: 9,080 m2
Floor area: 3,274 m2
Dwelling: 112

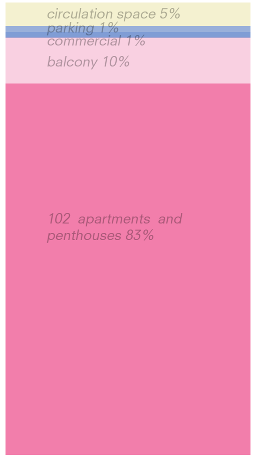
Density: 123 dw/ha

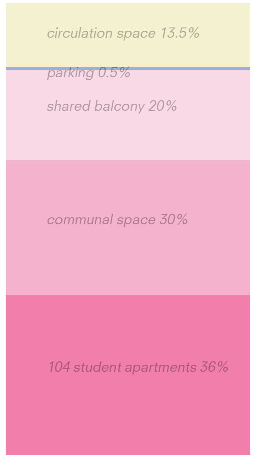


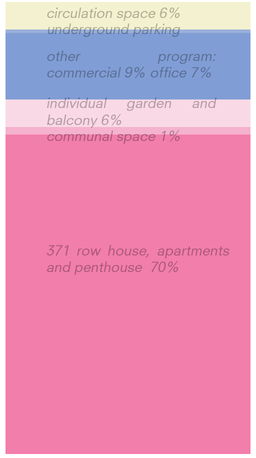


SPONGE HOUSING









Location: Denmark
Architect: C.F. Moller
Completed in 2006
Plot area: 4,397 m2
Floor area:11,000 m2
Dwelling: 102

Density: 232 dw/ha

Location: Denmark
Architect: AART
Completed in 2006
Plot area: 2,495 m2
Floor area: 6,950 m2
Dwelling: 107

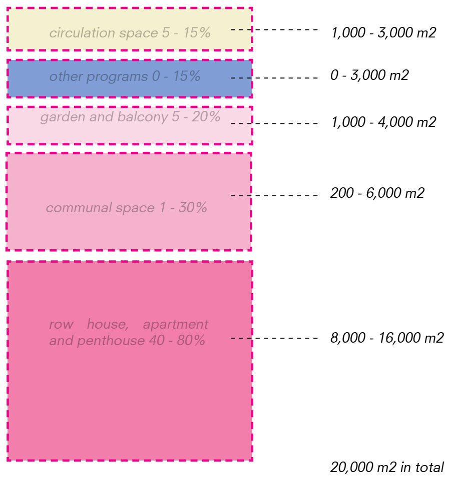
Density: 429 dw/ha

Location: Denmark
Architect: BIG
Completed in 2010
Plot area: 18,299 m2
Floor area: 61,000 m2
Dwelling: 471

Density: 257 dw/ha

Location: Hillesluis, Rotterdam
Plot area: 9,080 m2
Floor area: 3,274 m2
Dwelling: 112

Density: 123 dw/ha



Sponge housing

Plot area: 9,080 m2
Dwelling: 80 - 200
Density: ~ dw/ha

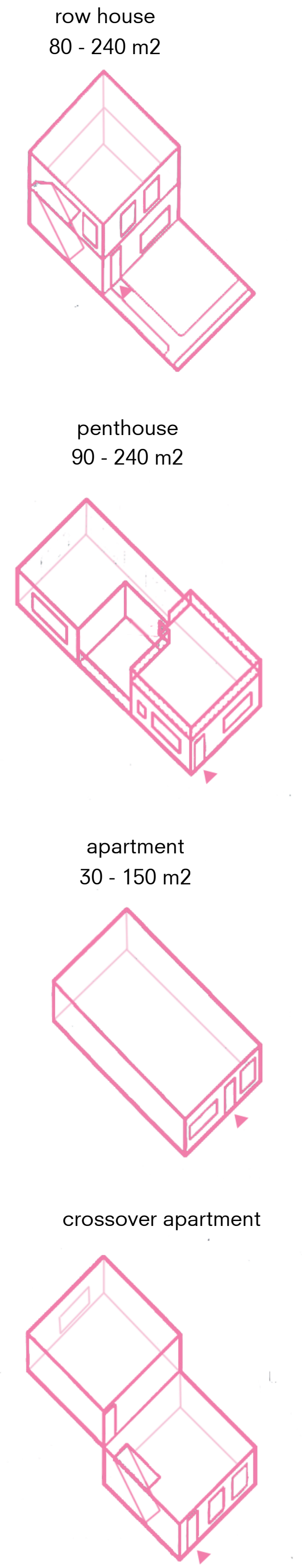


fig. 8: unit types

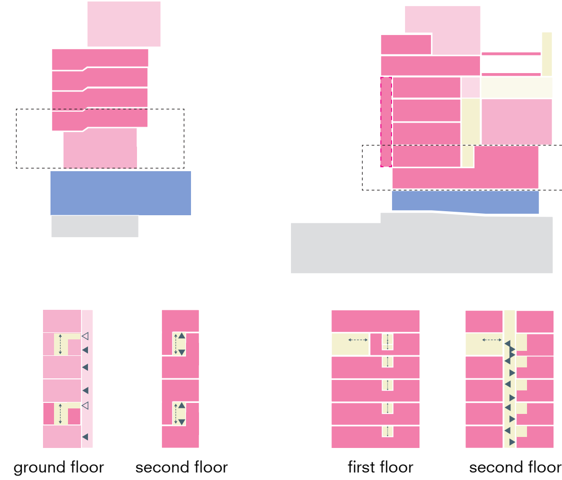
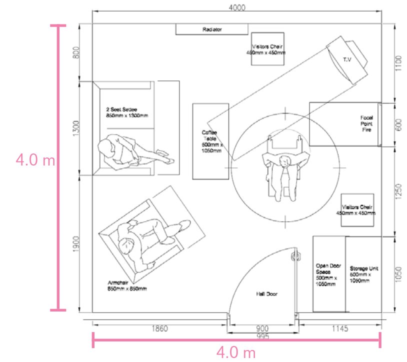
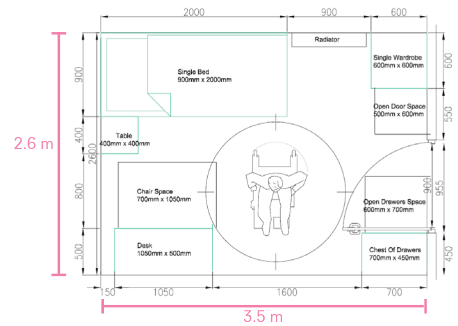


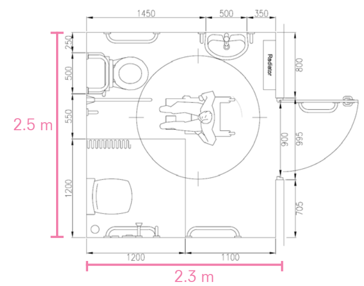
fig. 9: typology study in section



lounge 1-3 perpon



single bedroom



shower room

fig. 10: space requirements
(Wheelchair homes design guidelines)

APPENDIX 2: MSC4 TIMELINE

	RESEARCH	DESIGN
CONCEPT	> site analysis > program analysis > analyses of the ambition > analyses the site vision	> massing options > programmatic options > design options > revise design vision
P 2.5		
DESIGN	> functional research > reference research > structure research > reference research	> develop plans > develop sections > develop facades
P 3.0		
MATERIAL	> research on materials > research on structural systems > research on facades	> developing materials > developing form details > develop facades > integrating individual work into the vision
P 4.0		
FINAL	> finalizing research	> finalizing design brief
P 5.0		