

**MASTER**

**De 'centrale' library Ghent  
transformation of a former industrial building**

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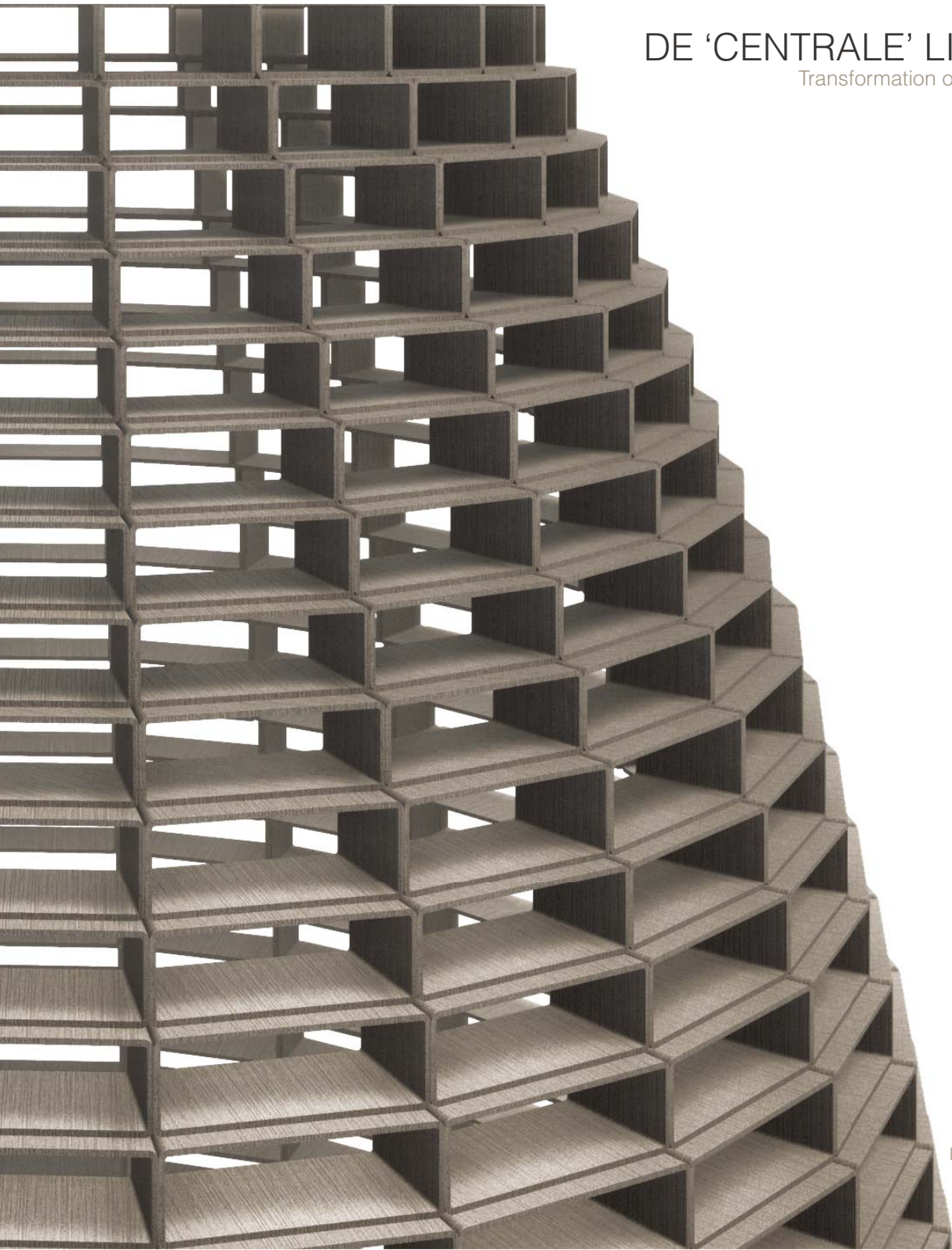
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# DE 'CENTRALE' LIBRARY GHENT

Transformation of a former industrial building

CELIL SAHIN

Eindhoven University of Technology





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COLOFON

*Title*

De 'Centrale' library Ghent  
Transformation of a former industrial building

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Architectural Design and Engineering (ADE)

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## ACKNOWLEDGEMENTS AND PREFACE

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This thesis is written as part of the master program Architecture, Building and Planning (ABP) and is the result of the graduation studio 'De Centrale Gent', started in February 2018 under the guidance of prof. ir. Juliette Bekkering, Sjef van Hoof arch. AvB, ir. arch. Barbara Kuit and Zeeshan Ahmed (PhD-student).

Upon seeing the presented title of the graduation studio 'De Centrale Gent', I was immediately interested. It was, therefore, my first choice for the graduation assignment. I am glad that I have been able to take part in this graduation studio.

This thesis is divided into 2 main sections; The research and the design.

The research section can be divided in four main sections. In the first section, the research of city Ghent will present the extensive analysis where the important points are explained. Afterward, the area where the building the 'Middendruk Centrale' is located is zoomed in and analyzed with the same points. Based on this, a master plan has been developed which serves as a guideline for the design. The main function of the existing building, the public library will be explained extensively with case studies that have been made. Lastly, the starting points, principles and assumptions of the innovative technique 3DCP is included in this section.

The second section entails the design, which the existing buildings are extensively analyzed, the concepts are developed, and the design comes into its own. The entire research in the first section is an important guideline for the design. The third section discusses the fabrication of 3DCP. The preparations, models and the implementation of the part that will be made for the design. After that, the final section will conclude the thesis and present answers to the research question. In addition, implications for further research will be discussed and recommendation will be given. Individual reflection on the entire graduation process will also be included.

I would like to thank prof. ir. Juliette Bekkering, Sjef van Hoof arch. AvB, ir. arch. Barbara Kuit and Zeeshan Ahmed very much for their support, the inspirations they gave me and all the valuable feedback I received during this graduation process. In addition, I would like to thank the members of the lab regarding to 3DCP for their collaboration and time to help me and my fellow students for their comments and feedback. Finally, I would like to thank my family for their support, patience and the motivational words that helped me to finish this graduation project.

I wish you much pleasure in reading my thesis.

Celil Sahin





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## ABSTRACT

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Nowadays, trend in historical cities are showing that the importance of historical industrial area is being rediscovered. This project seeks to take the step in the revitalization of the existing industrial building 'Middendruk Centrale' which is right next to the power plant 'De Centrale', in the district of Ham in city Ghent in Belgium. This industrial area is an example of the earliest industrial architecture for energy production in the region.

The idea behind this revitalization will be to take a current structure and adapt that structure to implement the new function, namely public library and integrating the application of a new innovative technique, using 3D concrete printing (3DCP). Elements of the design will result in actual concrete printed parts.

Transformation can be a successful way of revitalizing buildings. To be succesful, the project need to carefully consider its surrounding context as well as the significance of the existing structure, and its meaning and symbolism to the community. Therefore, this project will seek to maintain the integrity of both the existing and the new structure and its relation to the surrounding context. All of these programs will play a vital role in the success of the new function. In addition, in the process of developing a design for the existing industrial building, this research serves as an starting model for transforming an industrial function into a public function.

**Keywords:** revitalization, industrial building, transformation, public library, 3DCP

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## INTRODUCTION

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In the process of transforming an industrial building, retaining the entire historical façade with minimal adjustment and its existing structure is critical in building restoration. Because of a building's historic and traditional identity, proper preservation has to be made to keep the image of its original architecture.

Therefore, the transformation of the 'Middendruk Centrale' has to be carefully planned to respect its own urban context and to preserve its qualities for future generations in city Ghent.

The specific building for this project is significant to the community in that the building has played an important role in the history of the Ghent community. Currently, the old parts of the power plant are designated as cultural heritage. Nowadays the docks in the city are being developed into a modern residential area. The monumental power plant, which has always been in the periphery of the city, will now be surrounded by the old city, the central station, a number of forgotten residential areas and the new city district at the dock.

Part of the power station is still in use. A small part of the old building has been used as a theatre; a large part of the complex is not used. This part is not sufficiently related to the society and needs to be reused. The city believes that the revitalization of the power plant can aid in the rejuvenation and modernization of the area.

Because of the building's scale and its current urban context, and to support its preservation and maintenance, this project proposes a public library with meeting places which will help to bring life to the city at all hours of the day. Moreover, these programs help the city to provide a recreational place for the public in Ghent.

The goal of the research is to revitalize (transform) the existing industrial building which can play a significant role in the renewal and modernization of the area.

This study serves to resurrect a part of the power plant building by integrating innovative techniques, using 3D printing and new functions into the building. Elements of the design will result in the actual 3D concrete printed parts. This structure will become a drawing point for the city and will help bring life to the district.

The research is guided by the following research question:

- How can the revitalization of an industrial building play a significant role in the renewal and regeneration of urban areas?
- How to implement a new function to the existing structure by using an innovative technique such as 3DCP?

The research question is further broken into three sub-questions, which will help to give an answer:

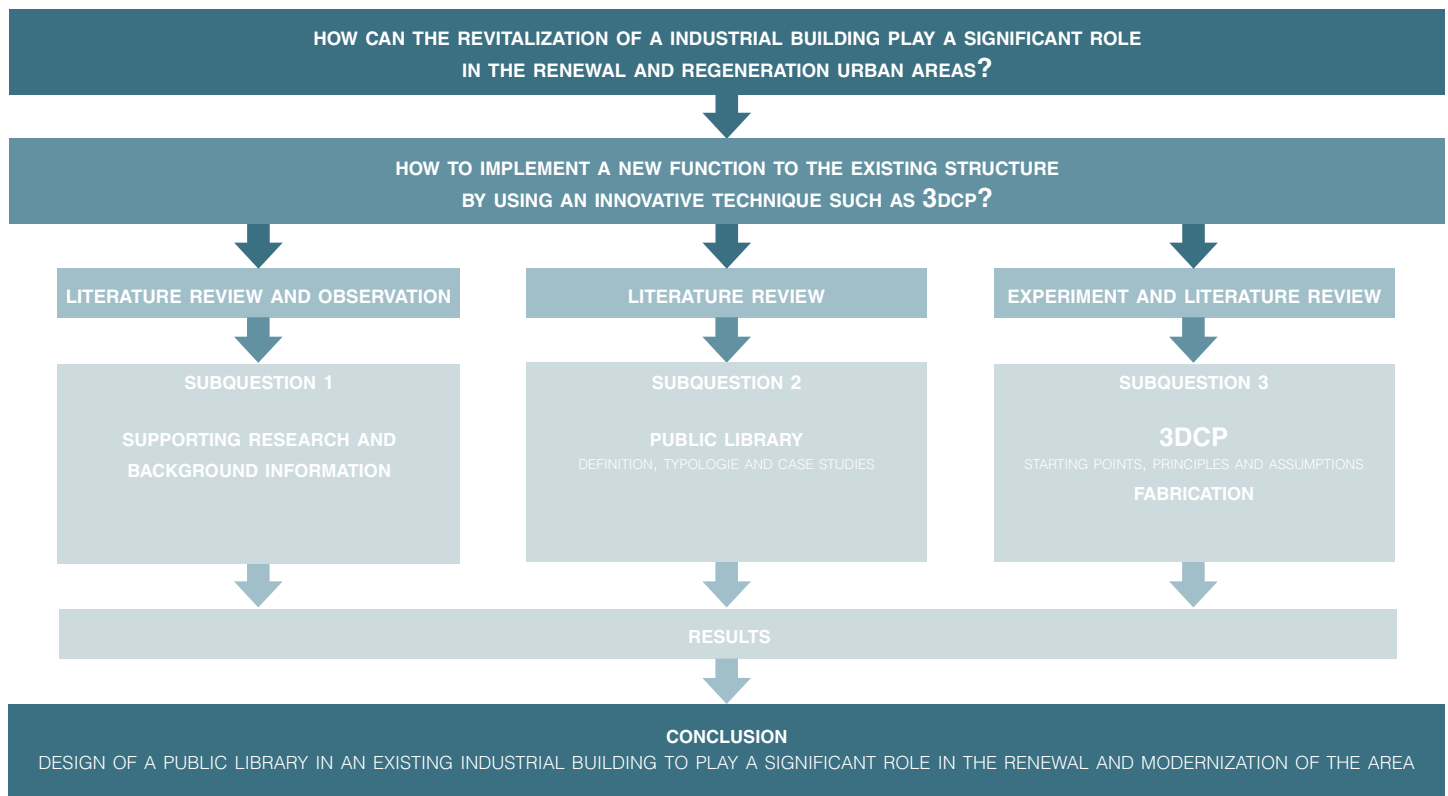
- (1) What are the properties of the city of Ghent and its district Ham?
- (2) What does a public library mean?
- (3) What role does the innovative technique 3DCP play in this?

This thesis is divided into 4 main sections. In the first section, the research of city Ghent will present the extensive analysis where the important points are explained such as the historical development, natural structure, functions and infrastructure. Afterward, the area where the building the 'Middendruk Centrale' is located is zoomed in and analyzed with the same points. Based on this, a master plan has been developed which serves as a guideline for the

design. The main function of the existing building, the public library will be explained extensively with case studies that have been made. Lastly, the starting points, principles and assumptions of the innovative technique 3DCP is included in this section.

research question. In addition, implications for further research will be discussed and recommendation will be given. Individual reflection on the entire graduation process will also be included.

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**fig.0.1** The structure of the research

RESEARCH

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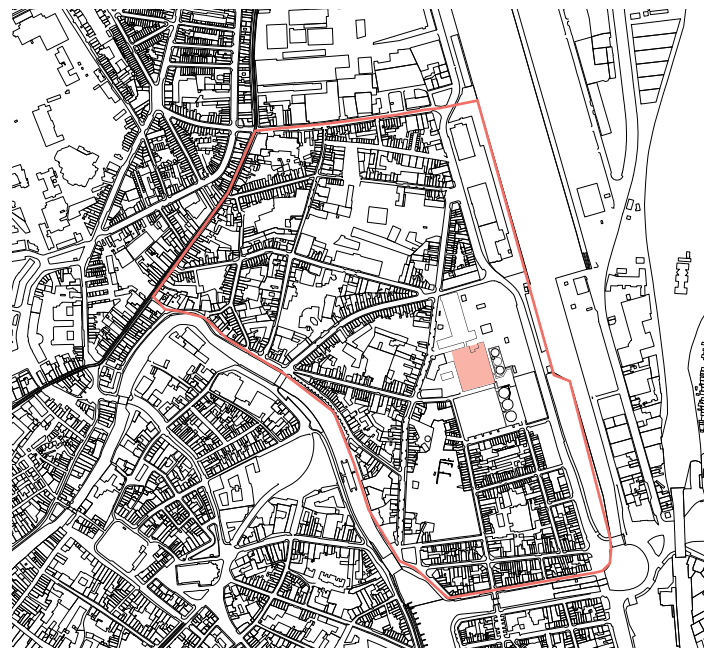
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## 1. SITE ANALYSES

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As a start point the city of Ghent was visited, in order to get familiar with the atmosphere, the plans of the local municipality and the historical context of the city. This visit to the city was the inspiration, the beginning of an extended research and to perform analysis on the city and the district Ham. The district where the famous power plant “De Centrale” with its characteristic chimney is located. In order to understand the context of this district and the connection with the city, theoretical research and analysis are done in different themes, which are divided into five different groups. Not only to understand the historical context, but also the contemporary situation and the future visions from the municipality of Ghent. This is because the harbor area close to the district is under development, to become an important new area in the city. Therefore, the district will form a connection between the historical city center and the new area. In order to define the characteristics of this district, its development and its architectural quality, research has been done on two scale levels. Starting with the largest scale level, chapter 1.1, the city of Ghent itself. To understand the relation of the district with the context of a city, the following themes are researched: historical development (1.1.1), social and demographic background (1.1.2), natural structures (1.1.3), infrastructure (1.1.4), visions of Ghent (1.1.5) and Oma- Masterplan (1.1.6).

In addition, the other level is researched which is focused on the district itself. This level, chapter 1.2 consists of the building block where the power plant ‘Centrale’ is located with the other related buildings such as the ‘Middendruk Centrale’. The following themes are researched: historical development (1.2.1), social and demographic background (1.2.2), function (1.2.3) and natural structures (1.2.4). Based on the analyses the base for the concept is formed to develop the master plan. This master plan is described in chapter 1.3 of this thesis.



**fig.1.01** District Ham and the 'Middendruk Centrale'



© google

16.000 ha.  
± 260.000  
2<sup>nd</sup> largest city

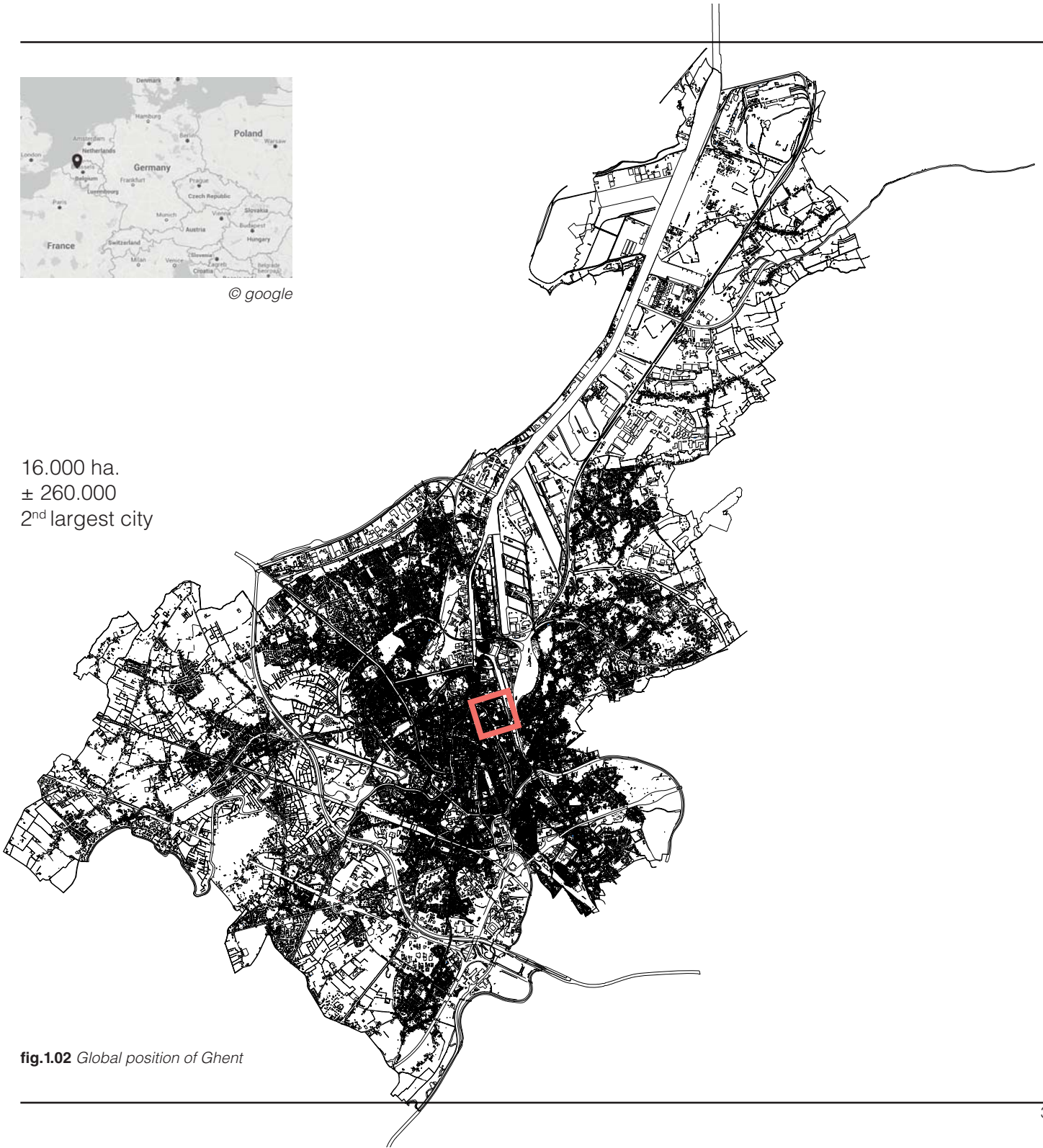


fig.1.02 Global position of Ghent

Population x 1.000

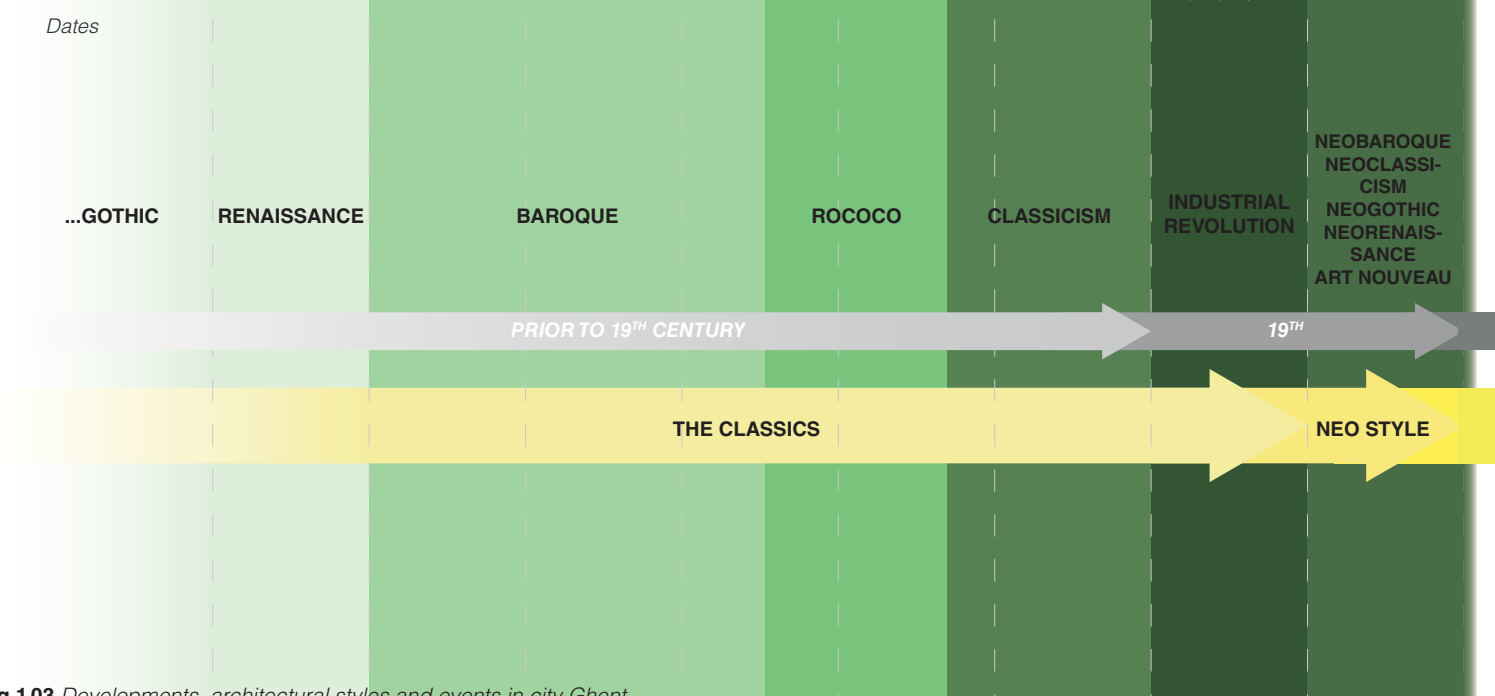
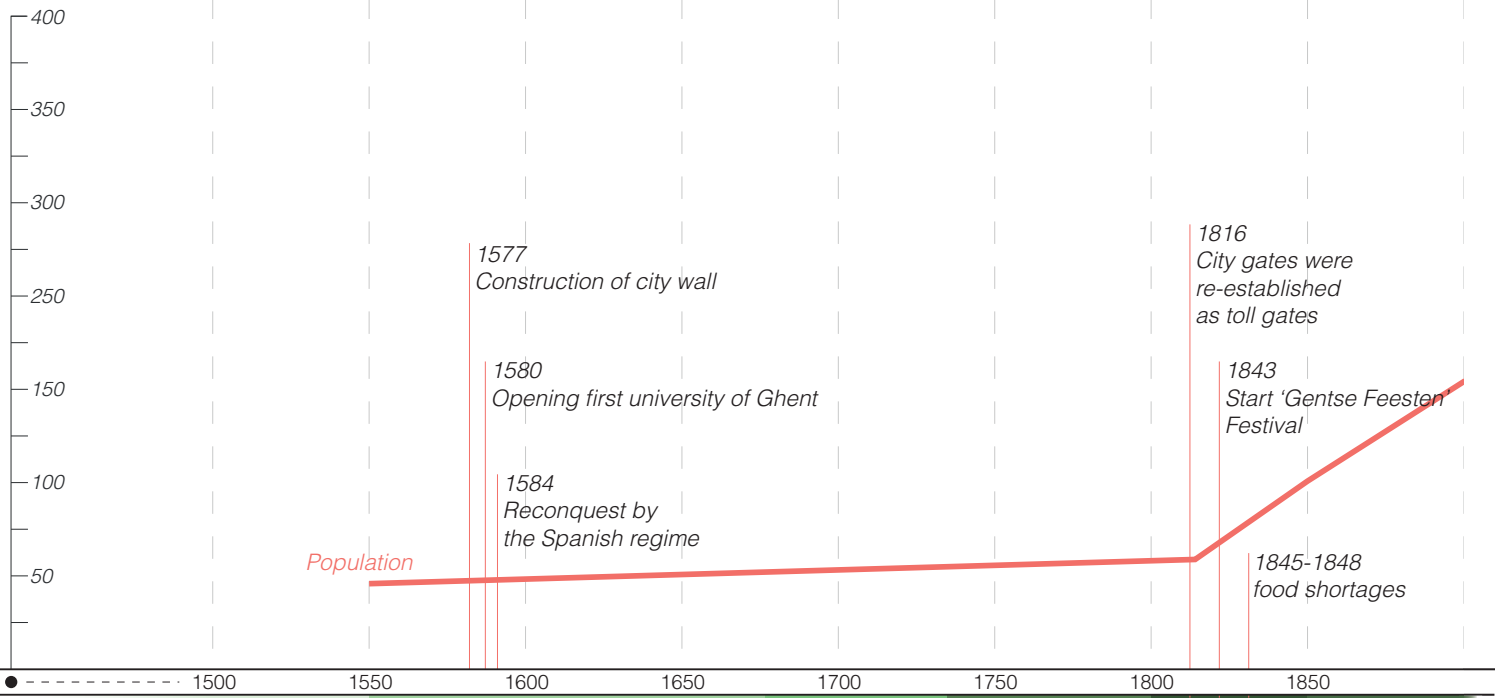
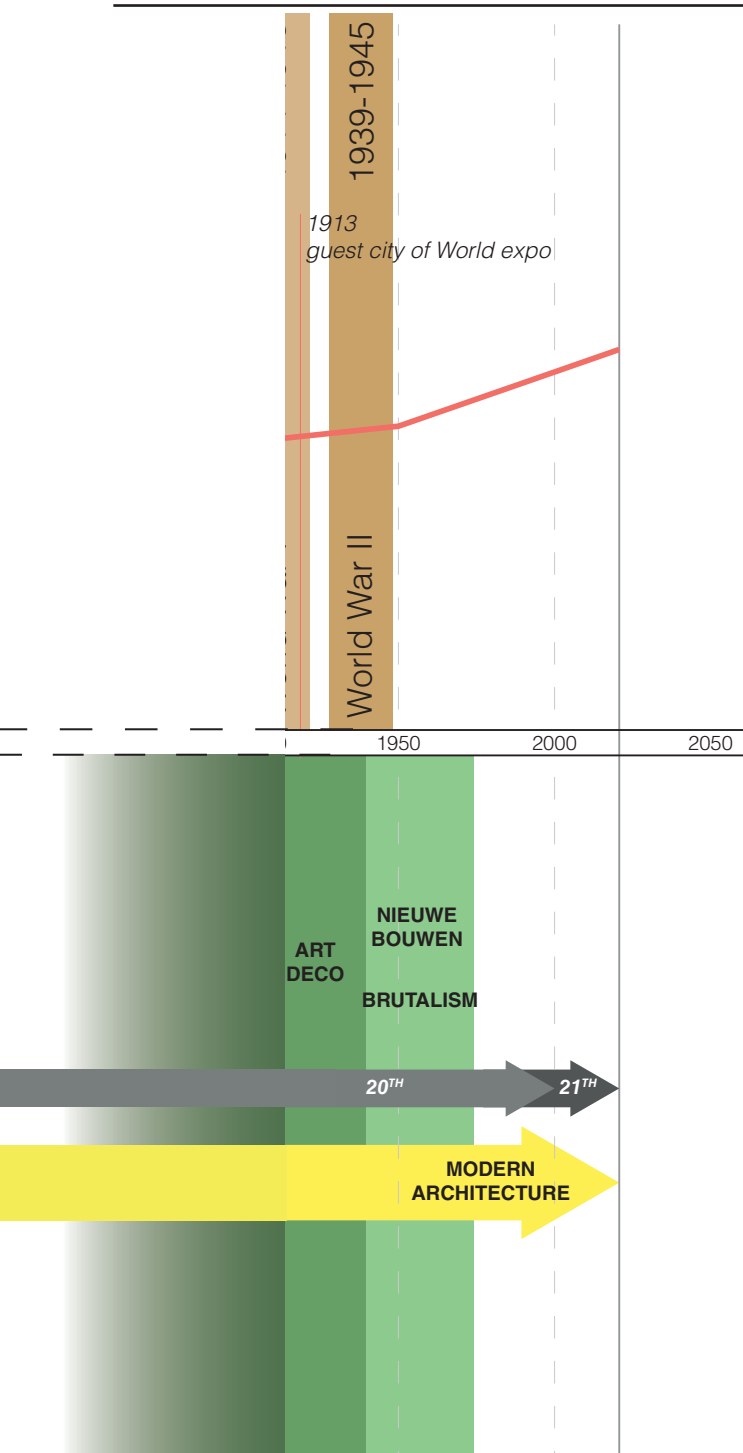


fig.1.03 Developments, architectural styles and events in city Ghent

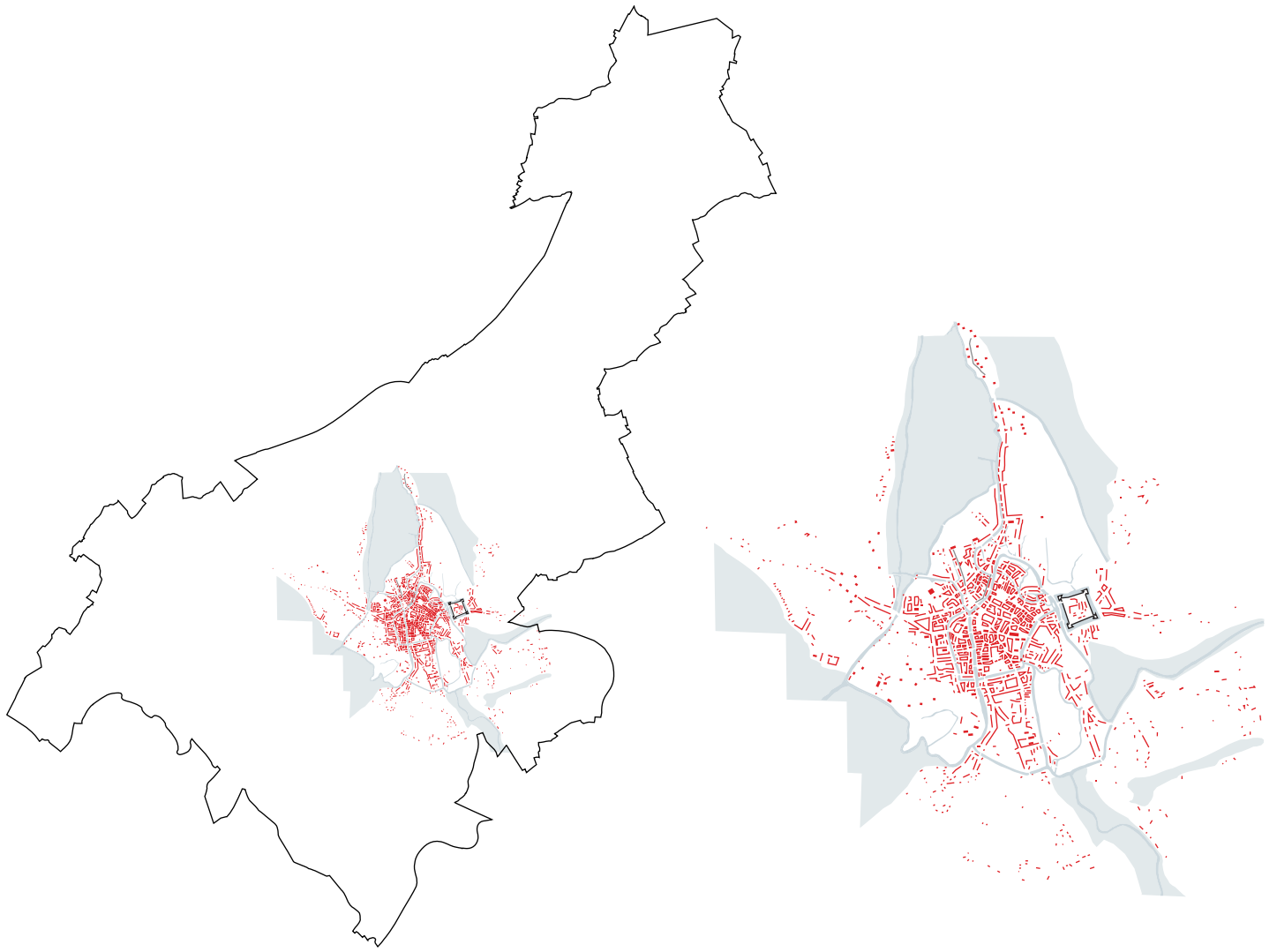


## 1.1 CITY GHENT

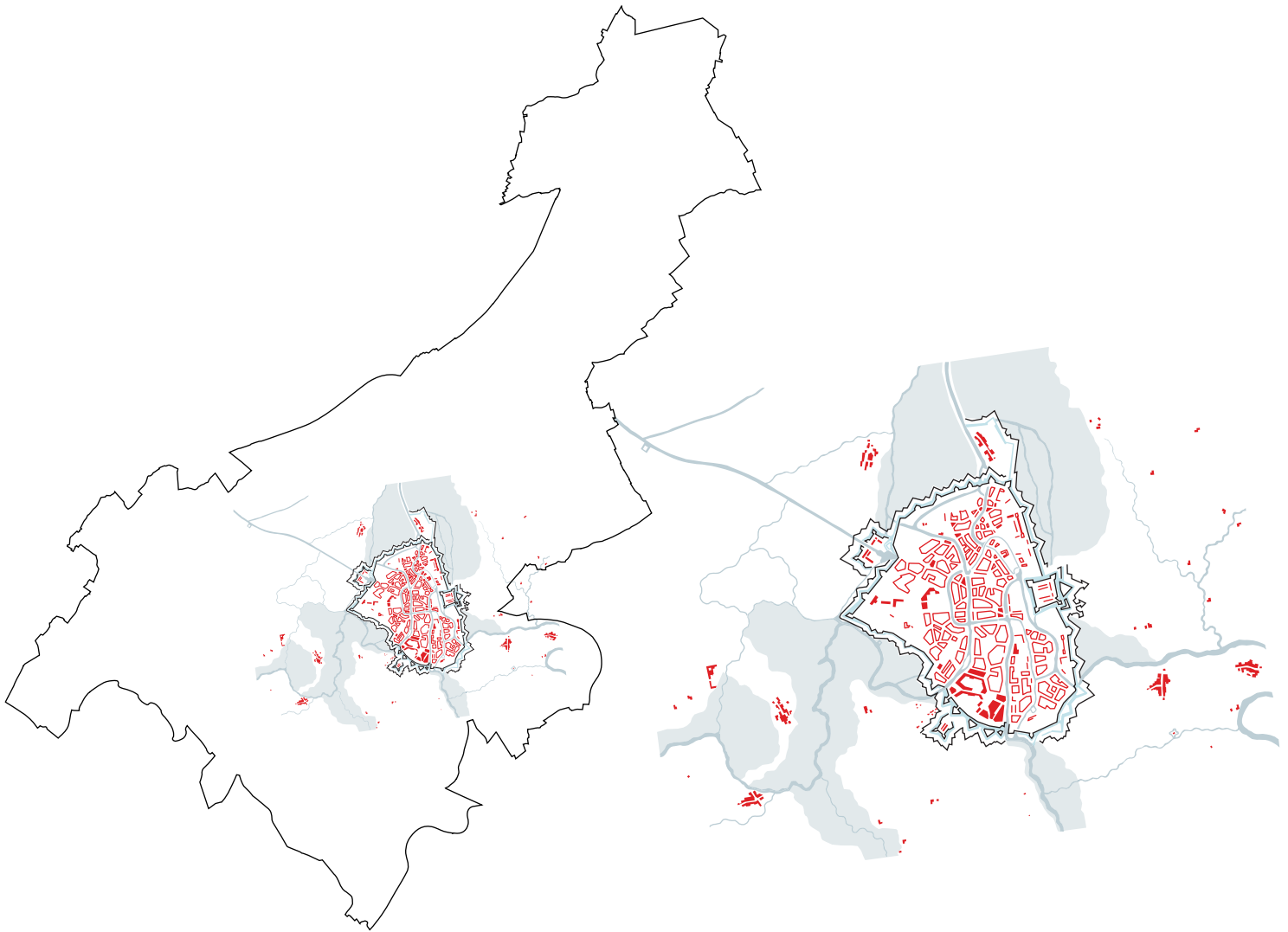
### 1.1.1 Historical development

Gothic architectural style developed from Roman architecture in the 12th century. This trend has also come into the city of Ghent. A revolution that replaces the walls with small openings with an architecture with support points, between walls or large openings (windows). After the 15th century, the Renaissance followed, where proportion and harmony were very important, such as the city hall and the University of Ghent (Boussauw, 2014). After the Renaissance, the Baroque mastered architecture in the Catholic regions during the 17th and 18th centuries. Baroque emphasizes the building itself, focusing on mutual relationships and form. The Rococo, which emerged in the early 17th century, is a period from the end of the Baroque. It is primarily furniture and interior design, characterized by colors such as white and pastel colors. The Classicism is a Protestant counterpart of the Baroque. This architecture is an expression of the then classic Roman civilization. The columns and pilasters are applied as pure as possible. The industrial revolution began at the beginning of the 18th century (Belgiumview.com, 2018). The transition to new manufacturing processes. This transition included going from production to machines, the development of machine tools and the rise of the factory system. Many factories have been opened in the city of Ghent. The Industrial Revolution also led to an unprecedented rise in the rate of population growth (Van Osta, 2016). After this revolution came the Neo-styles early 1850 with the Art Nouveau architecture that was known as functional aspects to embellish. And in the early 20th century Modern architecture is in power with architectural styles such as 'Nieuwe Bouwen'. The emphasis was on the functional aspects of the building. The lifespan and the usage needs to be determined the design.

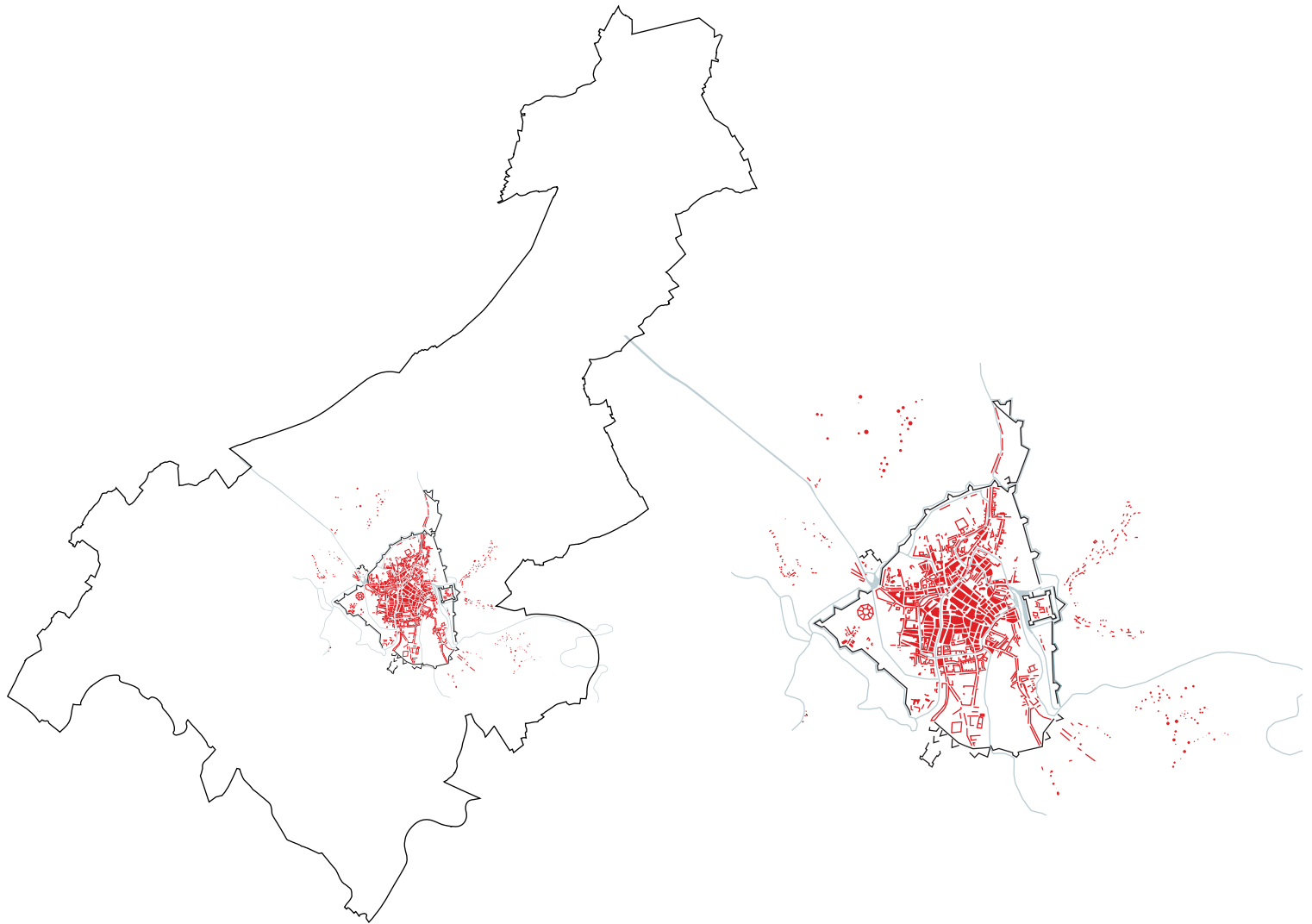




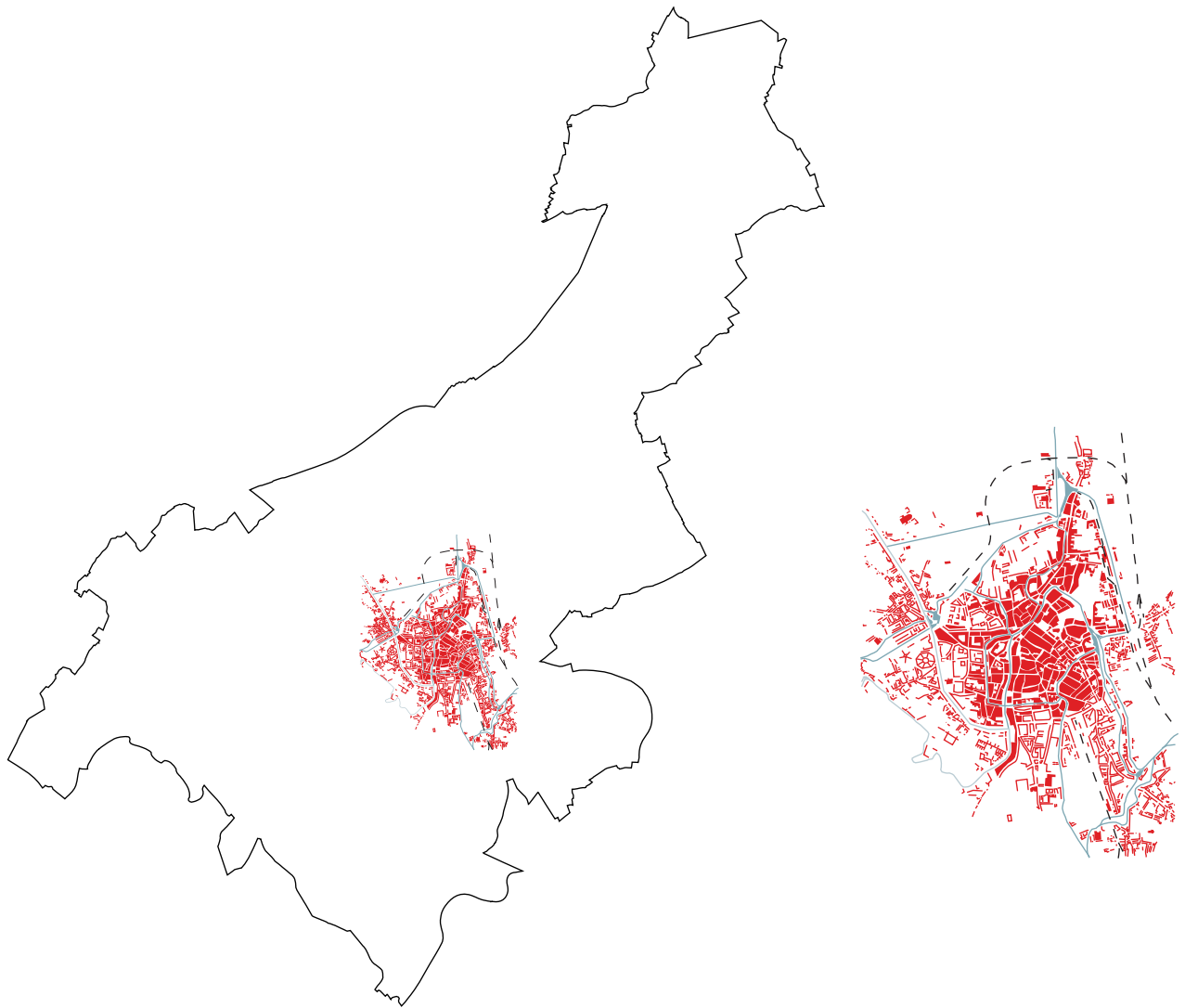
**fig.1.04** Ghent 1559 - construction of the city wall



**fig.1.05** Ghent 1678 - city wall is being expanded



**fig.1.06** Ghent 1777 - a clear boundary line has been created



**fig.1.07** Ghent 1877 - city gates were re-established as toll gates

---

### 1.1.2 Social and demographic background

Ghent in its current dimension is the result of municipal mergers (figure 1.08) in the years 1964-65 (Desteldonk, Mendonk, Sint-Krui-Winkel and Terdonk) and 1977 (Afsnee, Drongen, Gentbrugge, Ledeborg, Mariakerke, Oostakker, Sint-Amandsberg, Sint-Denijs-Westrem, Wondelgem and Zwijnaarde). These added municipalities now surround the inner city of Ghent and give the municipality its whimsical pear shape with a narrow northern part along the canal to Terneuzen. Since that year it can be observed that the total number of inhabitants rose from 246.171 to 259.570 in 2017, similar to a percentual rise of 5,4 percent (Bogaert et al., 1983).

It makes sense to divide the population of Ghent between 1977-2017 in Belgian and non-Belgian people. In this period the number of Belgian people are decreasing from 233.530 in 1977 to 223.028 in 2017 (-4,5%), while on the other hand the number of non-Belgian people are increasing from 12.641 in 1977 to 36.542 in 2017 (+189,1%). Even though the bar chart on page 12 (figure 1.09) only has a period ranging from 2009-2017, it still clearly present how on all four scale levels the Belgian population stays somewhat stable whereas the non-Belgian population is increasing.

Looking more closely at these charts reveals where the majority of the non-Belgian people is choosing to live. On the level of Ghent the percentage of non-Belgian people is the lowest of all four levels. Moving towards scale levels two and three suggests that non-Belgian people tend to be living more towards the city center. Ultimately this has an impact on the quality of life, which can be experienced either as positive or negative. A slight drop in the percentage of non-Belgian people is visible in the statistical sector A62 (Ham), perhaps since this area of the Sluizeken-Tolhuis-Ham neighborhood is the least connected to

the city center. Exact percentages of 2017 can be seen on the next page in figure 1.10. This is further prove of the fact that non-Belgian people tend to be living close to the city center.

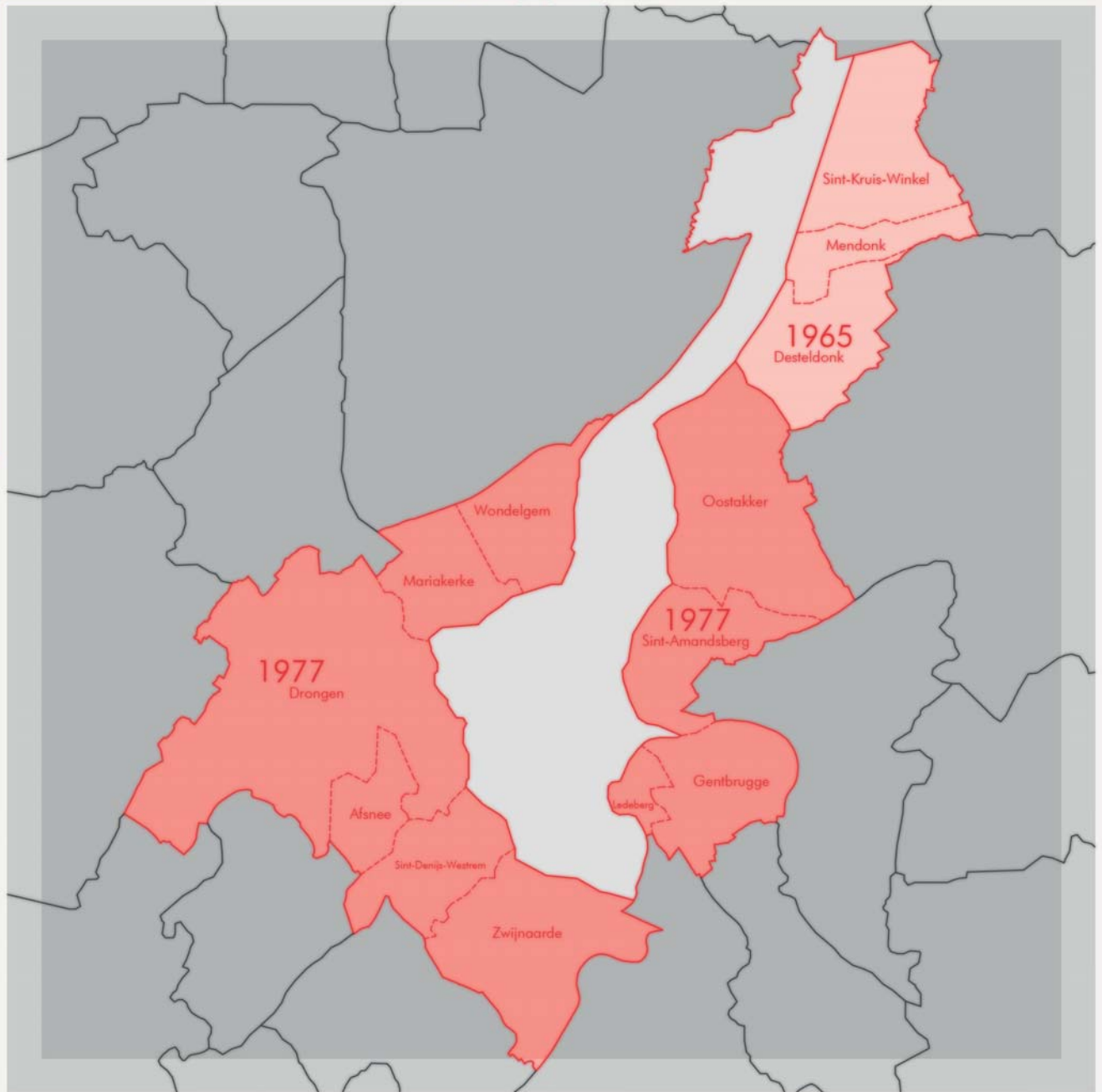


fig.1.08 Municipal mergers Ghent

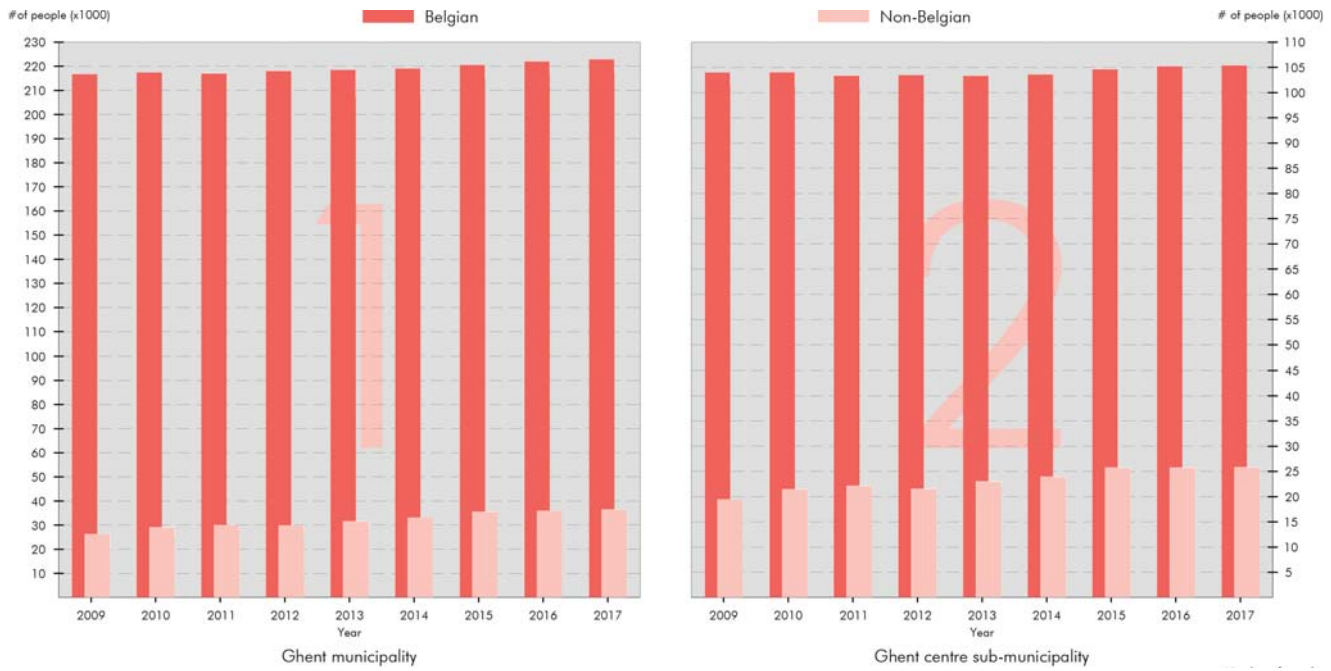


fig.1.09 Municipal growth

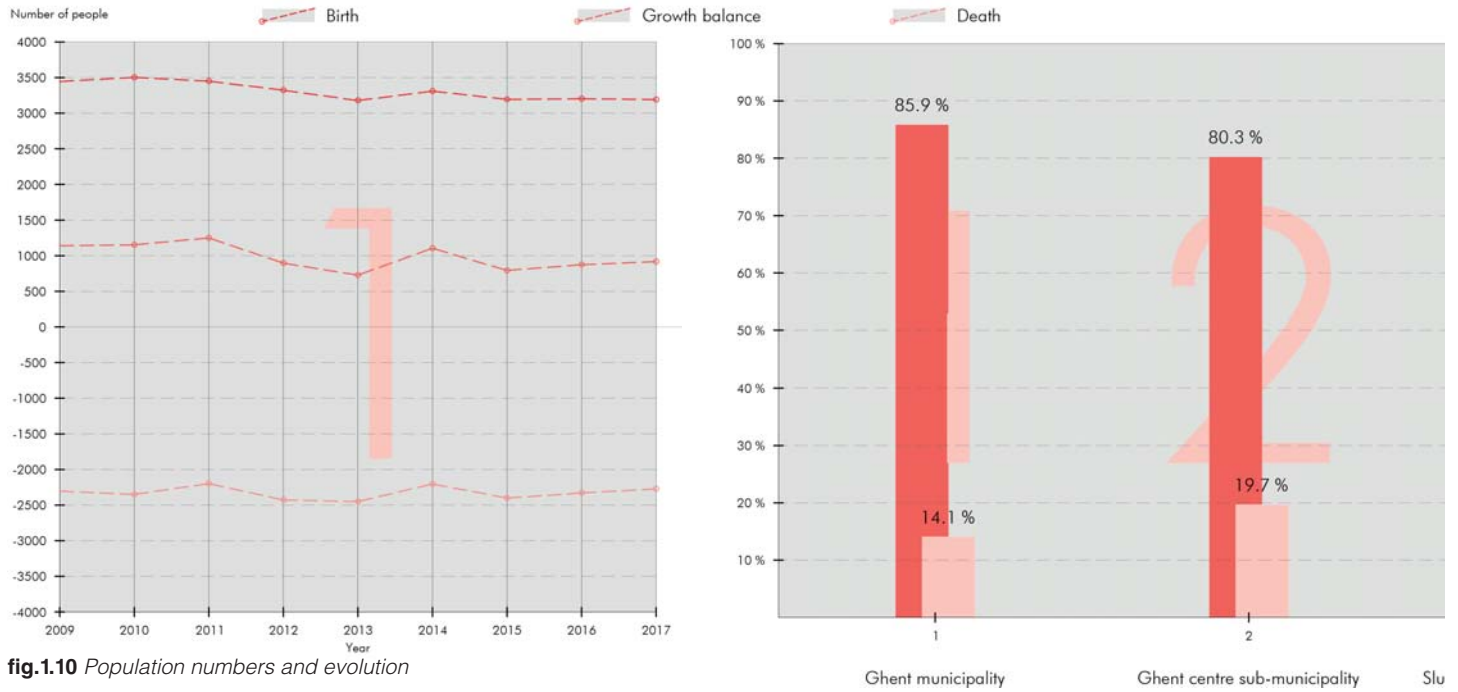


fig.1.10 Population numbers and evolution

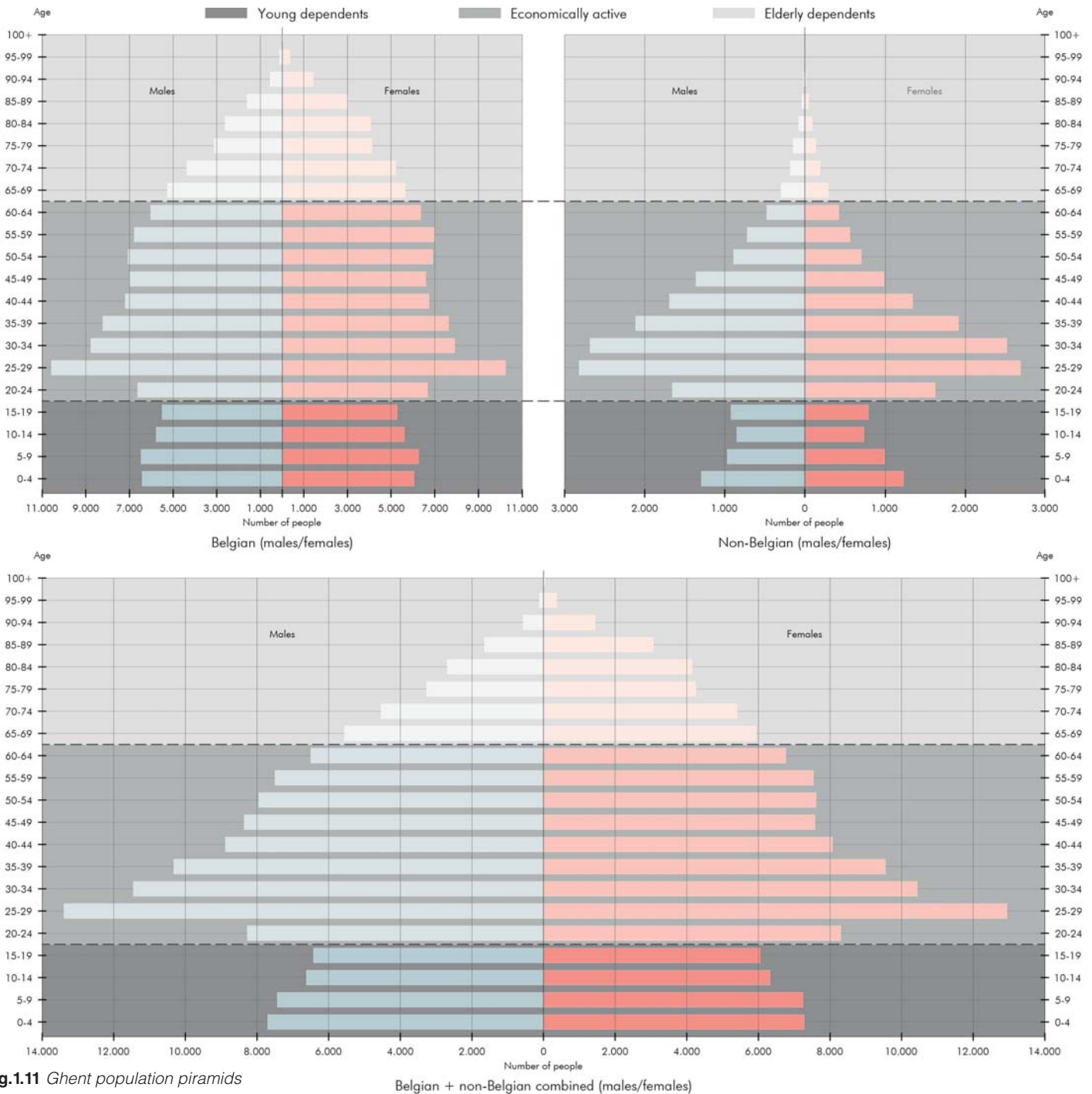


fig.1.11 Ghent population pyramids



Increasingly multicultural cities are nothing new anymore, as cities throughout the world have become multicultural gathering places and hotspots. Slowly and steadily it becomes more and more accepted, and cities acknowledge the fact of a growing diversity, striving to use it as a beneficial aspect. It is at this cross section where cultures meet and new innovative ideas can be exchanged/generated. It comes as no surprise that one of the city's slogans (figure 1.12) is: "Iedereen anders, allemaal Gent", meaning "Everyone different, all Ghent". The city is becoming the common denominator, the shared grounds on which we all live. The city is becoming more than a vernacular place, rather it is developing into a global hub.

The image on the right page (figure 1.13) underlines this story, as it showcases how widespread the population already is when divided into the continents of origin. The amount of people originating from Africa and America have the least percentages of people, 10- and 5% respectively, but together this 15% is quite a big part of the population. The amount of people originating from Asia almost doubles this percentage, at around 25% last year, accounting for 1/4 of the foreign population of Ghent. These relatively high percentages from both Asia and Africa are mostly due to the high number of people originating from the Maghreb countries and Turkey. One remaining is a group of around 60% of foreign people coming from other countries in Europe, mostly originating from the Netherlands and eastern European countries such as Bulgaria and Slovakia.



fig.1.12 City's slogan: Everyone different, all Ghent. © Municipality Ghent



fig.1.13 Foreign inhabitants of Ghent, origin according to continent

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### 1.1.3 Natural structures

Ghent's industrial developments had a major impact on the presence and transformation of water structures and green areas in Ghent. Although the waterways have played an increasingly important role and have been expanded for industrial and commercial purposes, the recreation possibilities and the presence of green structures have decreased considerably. Currently, there is a great interest in expanding water and greenery as natural structures and thus adding recreational opportunities to the city.

The city of Ghent originated in the area of the confluence of the Leie and the Scheldt. In particular through the flourishing textile industry, Ghent has become one of the largest cities in Europe. Due to the growing trade in the city, there was also a growing need to build new waterways or to improve existing waterways in order to connect Ghent with its trade areas. The plot area for which a new master plan has been developed, is located along the Handelsdock. This dock is one of the oldest docks of the port of Ghent. Due to the growth of the ships and the shift of port activities to the north of the city, the Handelsdock became useless as an important port area of the city. However, the channel was still used for the supply and discharge of cooling water from the power plant. Currently, the area around the merchant dock is in full development and plans are being made to transform this old port area into a residential area. Due to its central location near the city and the proximity of Ghent-Dampoort station, the area has enormous potential. The water and green structures around this area offer opportunities for recreation and park areas.



**fig.1.14** *Water and green together in a canal Ghent.*  
© Photo: Dimitris Kamaras

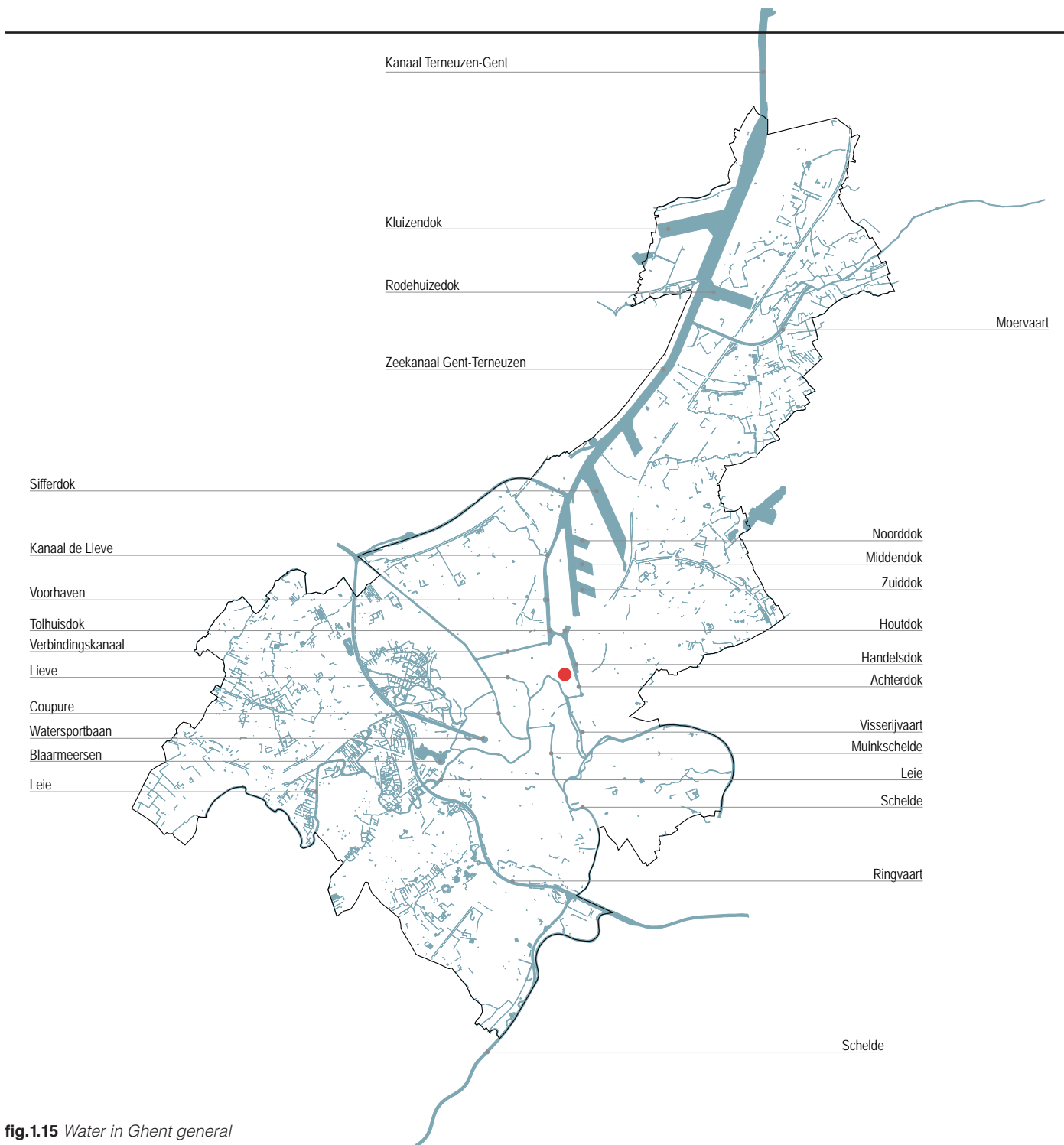


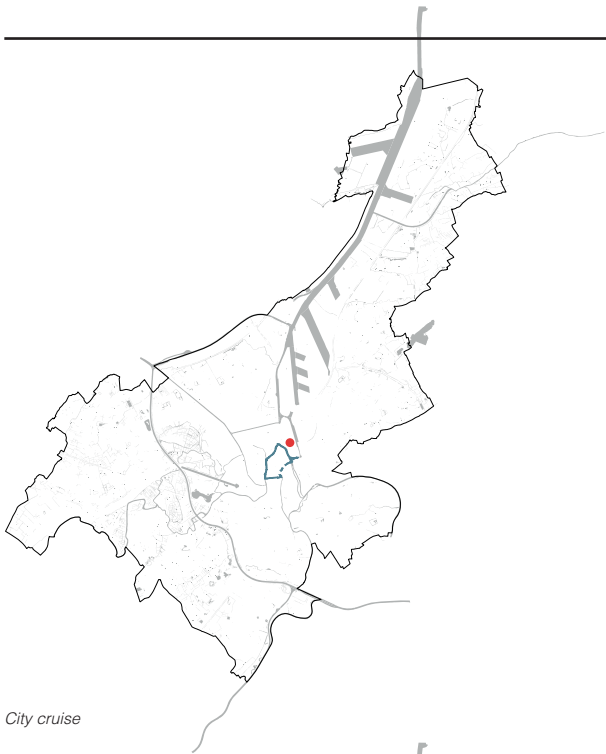
fig.1.15 Water in Ghent general

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In addition to the major waterways that connect Ghent with trade areas, there are also several small waterways in the south of the city, which offer many opportunities for recreation, nature, city cruises and water sports. The waterways, which have a particular function as trade routes, cross the city from north to south. Recreational and sports areas are mainly located outside the city center and in the south of the city. Due to the growth of the industry, many nature and recreational areas have been lost, but the municipality has plans to expand these areas along all waterways.



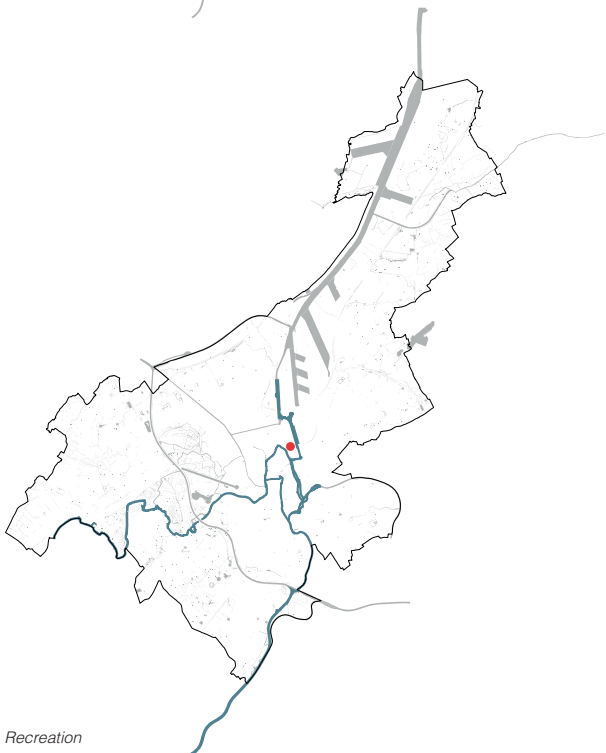
**fig.1.16** Functions of waterways



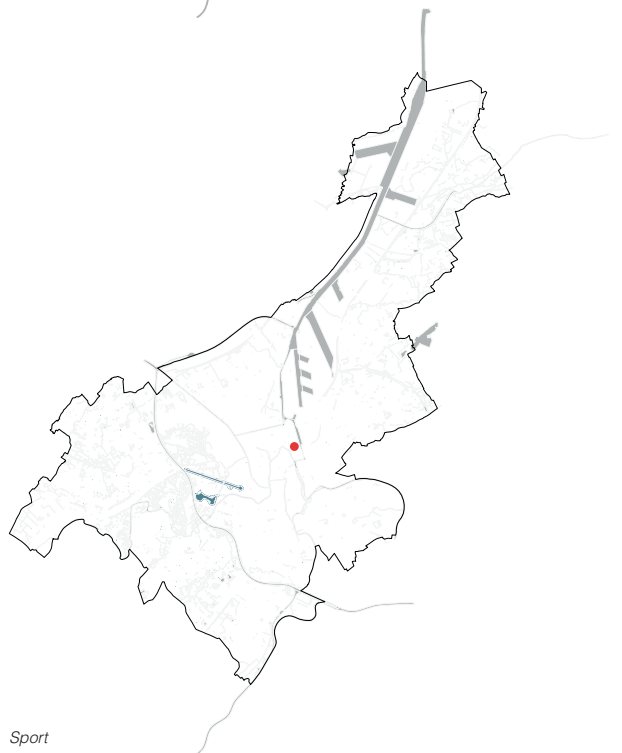
*City cruise*



*Nature*



*Recreation*



*Sport*



The height differences in Ghent are very limited, namely around the water the topographical heights are a little lower. Around the center of Ghent and around the plot areas the height increase.

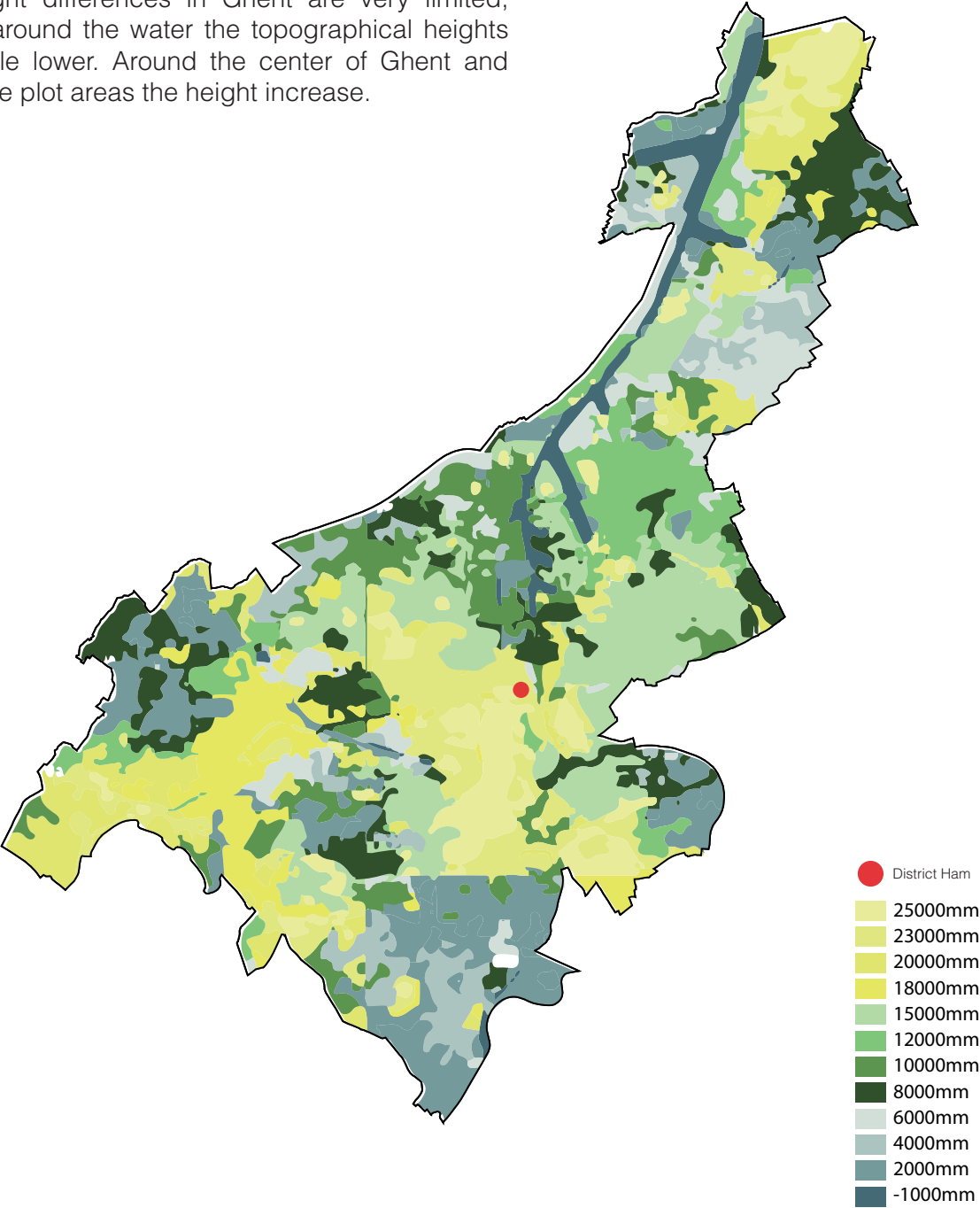
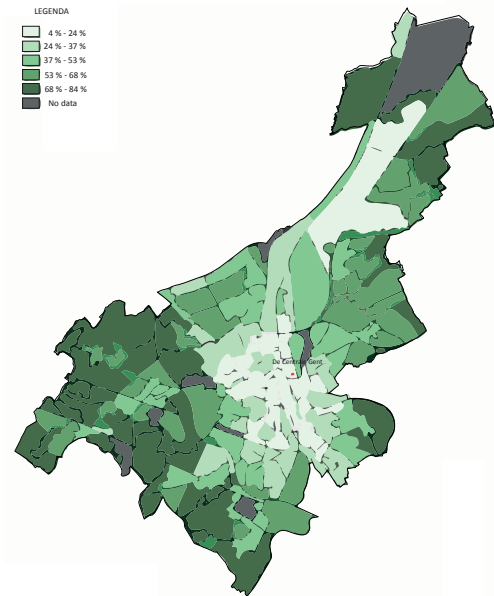
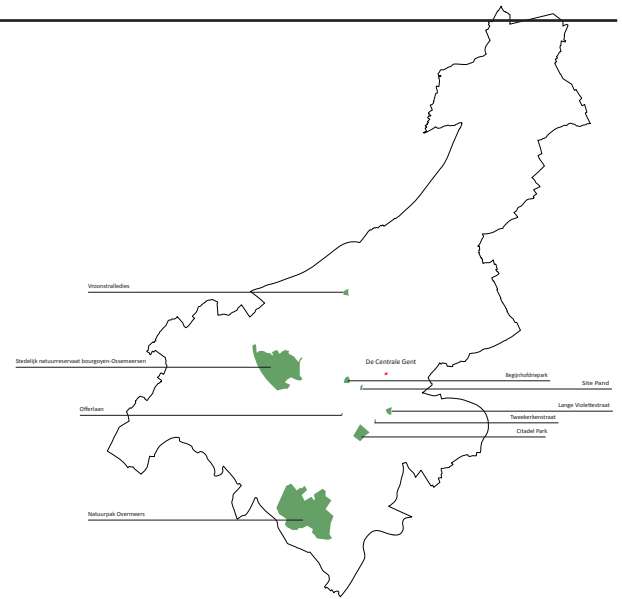


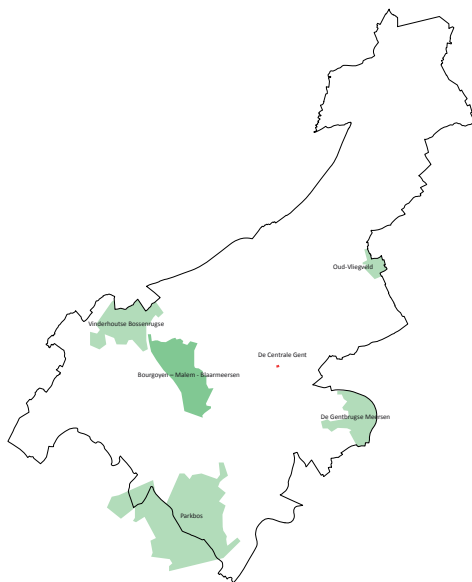
fig.1.17 Topography



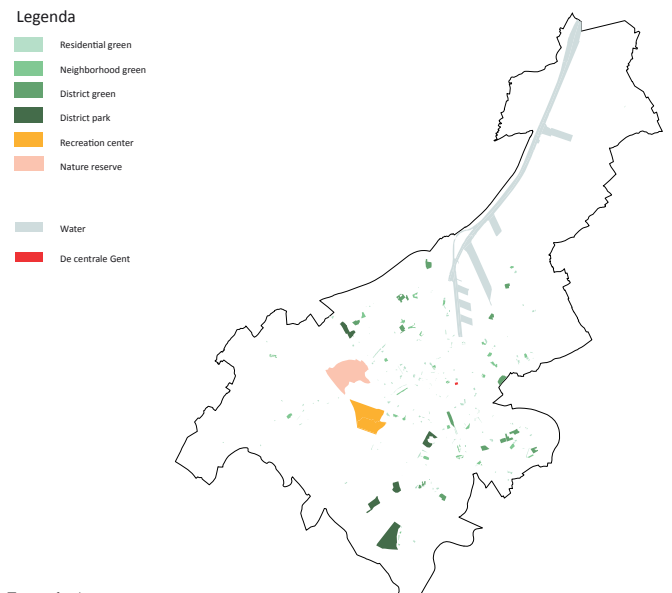
Average percentage amount of green in a 100-meter buffer around a residential area



Protecting culture historical landscapes



Four green poles



Type of urban green

fig.1.18 Nature in Ghent



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#### 1.1.4 Infrastructure

The city of Ghent is known because of its extensive waterways, connected to the cities harbor. This harbor, the second largest of Belgium, and these canals, are the results of Ghent being an important industrial city in Europe. Besides these characteristics of an industrial city, Ghent has varying infrastructural elements, which mark the city. These infrastructural elements are the results of the historical development of the city. Within this historical development, three periods have left their biggest footprint on the city. (1) the Middle Ages, the current city centre. (2) the 19th century city expansion, resulting from the industrial revolution. (3) the 20th century city expansion. However multiple elements of these historical periods have marked the city's infrastructure in a positive way, certain elements are now considered as problematic. Based on a policy analysis of the municipality of Ghent these problematic aspects are researched. At first the city's infrastructural characteristics of the mentioned historical periods are analyzed. Furthermore the current infrastructure in the city of Ghent is analyzed. Combined with the policy analyses varying conclusions are drawn, which infrastructural elements in the city must be improved, and which must be remained.



**fig.1.19b** Map of the Middle Ages Ghent



**fig.1.19a** Streetview of the Middle Ages Ghent

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### Middle Ages Ghent

The city of Ghent was founded on the intersection of two rivers, the Leie and the Schelde. However the military centre of the town was located on the intersection of the Leie and the smaller river, the Lieve. Besides these natural waterways, waterways have been channeled for military purposes throughout centuries. Besides the military purposes these waterways were also used for transportation of goods. The character of a trading town, made Ghent the second largest city in Northern Europe during the 13th century. As the city systematically extended in the 13th and 14th century, new waterways were channeled in order to consequently surround the city for security. The street system in the Middle Ages was based on a checkerboard pattern with many trading squares, such as the Korenmarkt (figure 1.20) and the Botermarkt.



**fig.1.20** Korenmarkt. © out.be

This street system developed in an organic way, which is recognizable by the varying dimensions of public areas. The character of an important trading city is recognizable by certain traffic roads which connected different parts of the city, and connected Ghent to other European cities.

### 19th century Ghent

The industrial revolution in Ghent was caused by the development of the textile industry. The well structured waterways made Ghent very accessible. The water connection between Ghent and the Dutch harbor Terneuzen was one of the most important developments for of the city (Stad Gent, 2002). It was also in this period century the harbor docks were built. Because of the wide spreading of industrial buildings in the city, Ghent was in this period called the Manchester of the European mainland. However because of a toll system, for transport of goods in and out the city, all new buildings were built inside the original military walls. These building blocks were constructed past old existing country lanes. An important factor for the city's development in this period was the construction of the railroads in Belgium in 1835. The train line connecting the city of Brussel with Oostende, past Ghent. In 1837 the first train station, Station Gent-Zuid, opened.

Closing the toll gates in 1860 was the beginning of a further and more extended development of the city. Around 1870 the city urbanized in a more systematic way. In this neighborhood a train station was built in 1873, which was mostly used for the transportation of goods. The new street systems are characterized by a hierarchy of wide and narrow street sections. These streets were orientated around a square. It was also in this period most of the roads were built, which nowadays form the inner-city ring road. These roads were designed as wide boulevards and were partly built on the location of the original ramparts, which were demolished and filled up in 1860.

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### 20th century Ghent

The 20th century knows different periods which left a specific footprint on the infrastructure of Ghent. The beginning of the 20th century before the first world war, the so called Belle Epoque, is characterized by a strong improvement of the public transport in the city. The public transport system of tramlines and railroads extended even more in the period after the first war, the Inter bellum. After the war, the period 1945-1960 is defined by suburbanization. It was also in this period the first highway in Belgium, between Brussel and Oostende was completed. Besides the extension of the public transport and the car roads, also the digging of a ring canal, which connected all the city's waterways was started in 1950. The further development of the harbor in the Northern part of the city resulted in a shifting of employment and industry. Since the 1960's the increase of car owning resulted not only in more highways, such as the E3 motorway from Kortrijk to Antwerp, also the problem of car parking arose. In the 1970's and 80's large scaled parking facilities were built. Since 1982 the tram system was more extended, in order to connect also new suburban areas to the city centre. In the 1990's a mobility plan was introduced to reduce the amount of cars in the inner city and increase the amount of bicycle lanes and pedestrian zones.



### Current Ghent

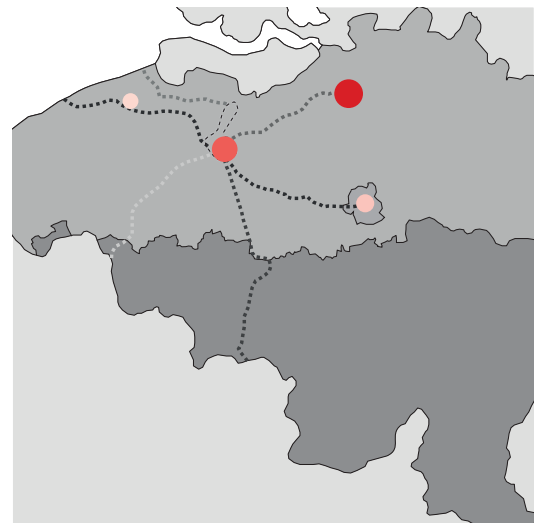
Based on the historical development of the infrastructure in Ghent, the current situation is further analysed. These analysis are focused on the following topics; (1) car roads and parking (2) bicycle lanes. By analyzing the current situation, certain problems have come to light. Based on these problems a direction for future developments is formulated.

### (1) Car roads and parking

The Belgium road system is divided into four different categories. (1) The main roads, connecting Belgium cities and connecting cities on an international level. Figure 1.22 on the next page shows the six largest cities in Belgium and the main roads which connect them to Ghent. All routes leading to Ghent are all via other Belgium cities, which is clearly visible in figures 1.21 and 1.22. (2) The primary roads, which connected the different regions Vlaanderen, Wallonië and Région de Bruxelles-Capitale. The outer-city ring road R4 is also categorized as a primary road. (3) The secondary roads connected cities within the same province. Ghent is located in the province East – Flanders. (4) The local roads within a certain town, which are none of the other categories of roads. As an example of a local road, the inner-city ring road R40 is indicated. For the Main/Primary/Secondary roads a good flow of traffic is the most important, and must be improved where needed. Besides that the accessibility of the city centre is very important. However as described above, the city of Ghent is coping with a car and parking problem since the 1960's. Therefore good deviation of cars in the city centre is important. Within the city centre multiple parking garages are built over the years.



 Province East Flanders  
 Gent




















 Vlaanderen	 N9
 Wallonie	 N60
 Région de Bruxelles-Capitale	 N70
 Antwerpen	 N49
 Gent	 R4
 Charleroi	 N43
 Luik	 Local Roads
 Brussel	 Secondary N-roads
 Brugge	

fig.1.21 Roads in Ghent

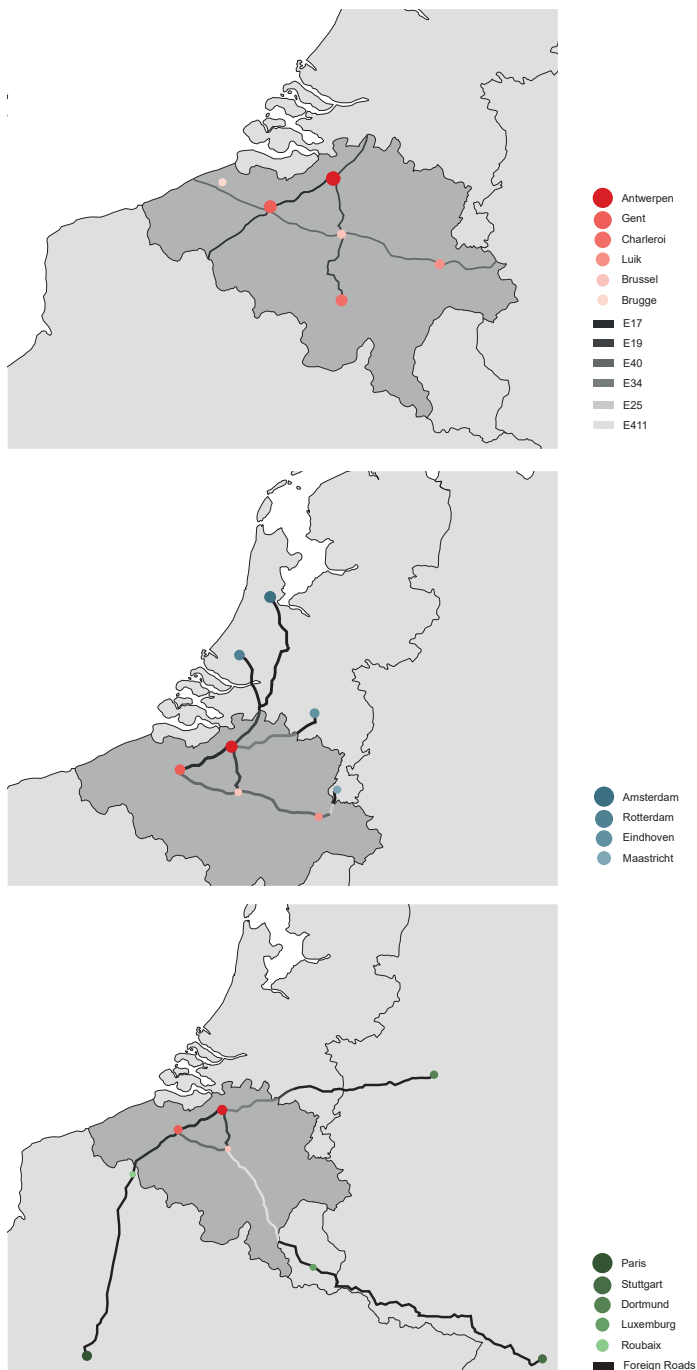


fig.1.22 Roads in Ghent towards other countries

## (2) Bicycle lanes

The municipality of Ghent has the use of bicycles as a main transportation mode very high on the agenda. This because the resident of Ghent often use cars as main transportation mode. Therefore the city, and especially the city centre, is overwhelmed by cars. By the stimulating bicycle use in combination with increasing car free zones in the city centre, this problem is attempt to be solved. However a problem with the current traffic situation is that it is very unsafe. In order to stimulate the bicycle use, this aspect of safety is very important. Mainly the crossing with heavy car roads are currently defined as unsafe. Also the missing out of bicycle lanes and a clear deviation of car and bicycle lanes is as problem. Besides the element of safety, also the accessibility is a key-element in the municipalities policy strategy. All important buildings must be safely reachable by bicycle. Important buildings are mainly schools, theatres, university-buildings and churches. Important routings are the connection between east and west, the routing towards the university campus, the Flora route and the Leiepromenade route. New to develop routings are, Westerspoor route, The Flanders expo route, the Drongen station route and a routing which connect all the villages around Ghent. On the map next page figure 1.23, an indication of these important buildings is schematized. Besides that all the current bicycle lanes are indicated. The municipality distinguishes primary (red) and secondary (yellow) bicycle roads. The primary bicycle roads mainly follow the prominent roads in the street, which connect the different city parts. These primary lanes are connected by secondary lanes, or so-called local lanes.



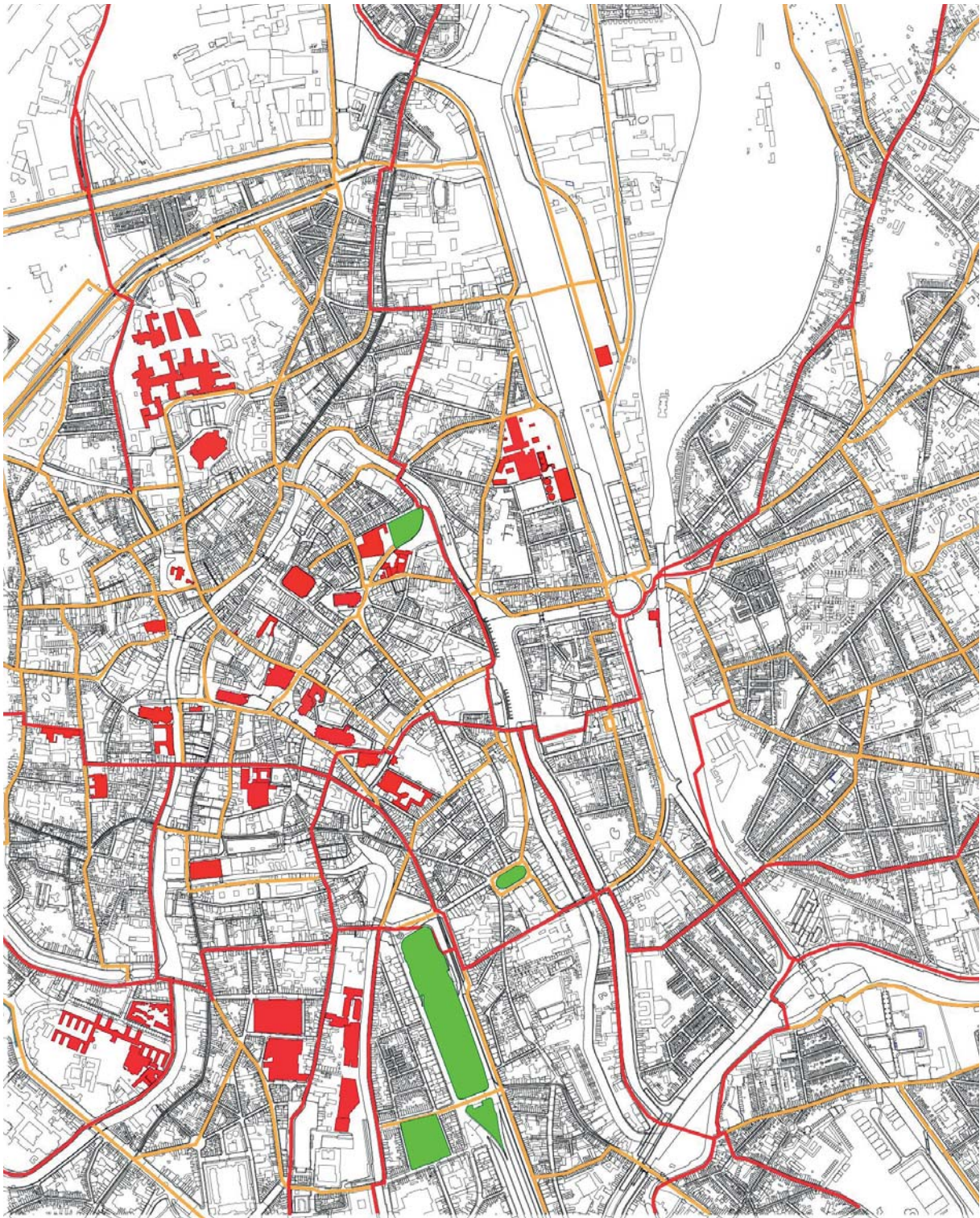


fig. 1.23 Map of bicycle roads

### 1.1.5 Visions of Ghent

In concrete terms, the Spatial Structure Plan Ghent (Teerlinck, 2017) addresses a number of questions. Where can additional houses be built? How can urban renewal in the 19th century city belt be continued? Where do new business areas come? How can it be ensured that Ghent remains easily accessible and that public transport becomes better? How is it possible to get more green in the city?



fig.1.24 Spatial development strategy 2030 of city Ghent



Smart densification - Interweave facilities such as mobility, living and working in the right way



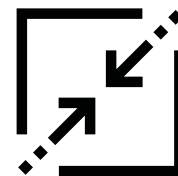
Bicycle urbanism - Cyclists get a prominent place in new developments



Water in and around the city for cooling (binding element, multifunctional role, diverse and uniform)



Human-oriented plan development



Compacting urban space instead of expanding city borders (e.g. new dwelling typologies)

fig.1.25 5x Spearheads





**fig.1.26** The 6x spatial and societal challenges



The Northern strategic zone consists of various project areas: the Dampoort site, the Afrikalaan and the Seahaven / Dampoort marshalling yard. The Old Docks project and the Dampoort project are already presented as a strategic project in the 2003 Spatial Structure Plan of Ghent. The Oude Dokken project is now under construction. Project Dampoort and Afrikalaan are still in the research phase.

The realization of the canal Oude Dokken creates a completely new urban space. These developments also create opportunities for the surrounding neighbourhoods, in first instance for the Dampoort station, which can further develop towards a future-oriented high-quality public transport hub. Redesigning the public space tailored to the pedestrians and cyclists is therefore important: redesigning Antwerp Square, creating a close-knit bicycle network as a link between the various neighborhoods, the scenic and functional better use of water resources, greening the environment and

improving the crossings of barriers.

Two areas are important links to increase the cohesion of the neighbourhoods. In the first instance, the area around the Afrikalaan has a whole range of possibilities. There is a planning process for this. The municipality structures the relatively organically grown and diverse business area through a stronger green approach of the whole with readable bicycle relations towards the city center and the site Oude Dokken. Through interweaving with housing and optimal use of space a mixed economic zone will arise.

The main idea is to develop a spatial-economic vision for this area in which the quality of life in the neighborhood will be taken into account, the infrastructural and economic development and the possibilities for cross connections for cyclists and pedestrians about the area that now forms a barrier between old Sint-Amandsberg and the city center.



fig.1.27 Important bicycle paths and urban junctions. © Spatial Structure Plan of Ghent



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### 1.1.6 OMA- Masterplan

OMA architects also has plans for the docks in Ghent which will be realized in the future. Below the description about the master plan of OMA architects:

“Our project is focused on developing the area as part of the inner city. It is important that the canal zone with its perspectives toward the historical city will not be closed or blocked, but rather opened. The Belgian coast is a good example of how these kinds of border buildings, with only one direction, create a neglected backside.

In our proposal, the area is considered as a whole and is developed based on generating perspectives open to the historical inner city. By emphasizing direct visual connections, the site will have a strong ‘Ghent’ character. The concurrent geometric parcelling, straight on the canal, results in opening strategic zones and thereby deterring a backside condition.

As the waterfront is the key amenity to the site, it was important to establish the first phase of the plan and the position towards the waterfront thus creating a strong connection inclusive of the entire area without creating a backside condition. However, the plan keeps enough flexibility so that future developments are not impeded.

The banding varied between open space, built space and canals. By developing some bands as a park, the perspectives remain open and provide a more enjoyable climate for the people who don’t live at the waterfront. The variation of the width of the bands creates a very simple but strong means to give a rich spectrum of possibilities without causing problems of flexibility. Each band could have different atmospheric qualities through the use of materials and building typologies.

The design is not based on a ‘tabula rasa’. We take care to not wipe out the existing industrial patterning and keep a group of existing industrial buildings, thereby retaining the character of the historical port of Ghent. The strategy of layering of the bands is based on the existing parcel ensuring the plan works with the site, not against it and in this way, the site will have from the beginning a ‘historical center’. The high chimneys are specifically chosen as important high points to be maintained because they create high points similar to towers of the inner city.” (OMA, n.d.).

*“With this plan, we offer a different model of urban development to Flanders, a development that positions the growth in the inner city, instead of the outskirts. Both areas will profit from the confrontation between the complementary qualities of the historical and the modern inner city.”*

*Rem Koolhaas, OMA.*

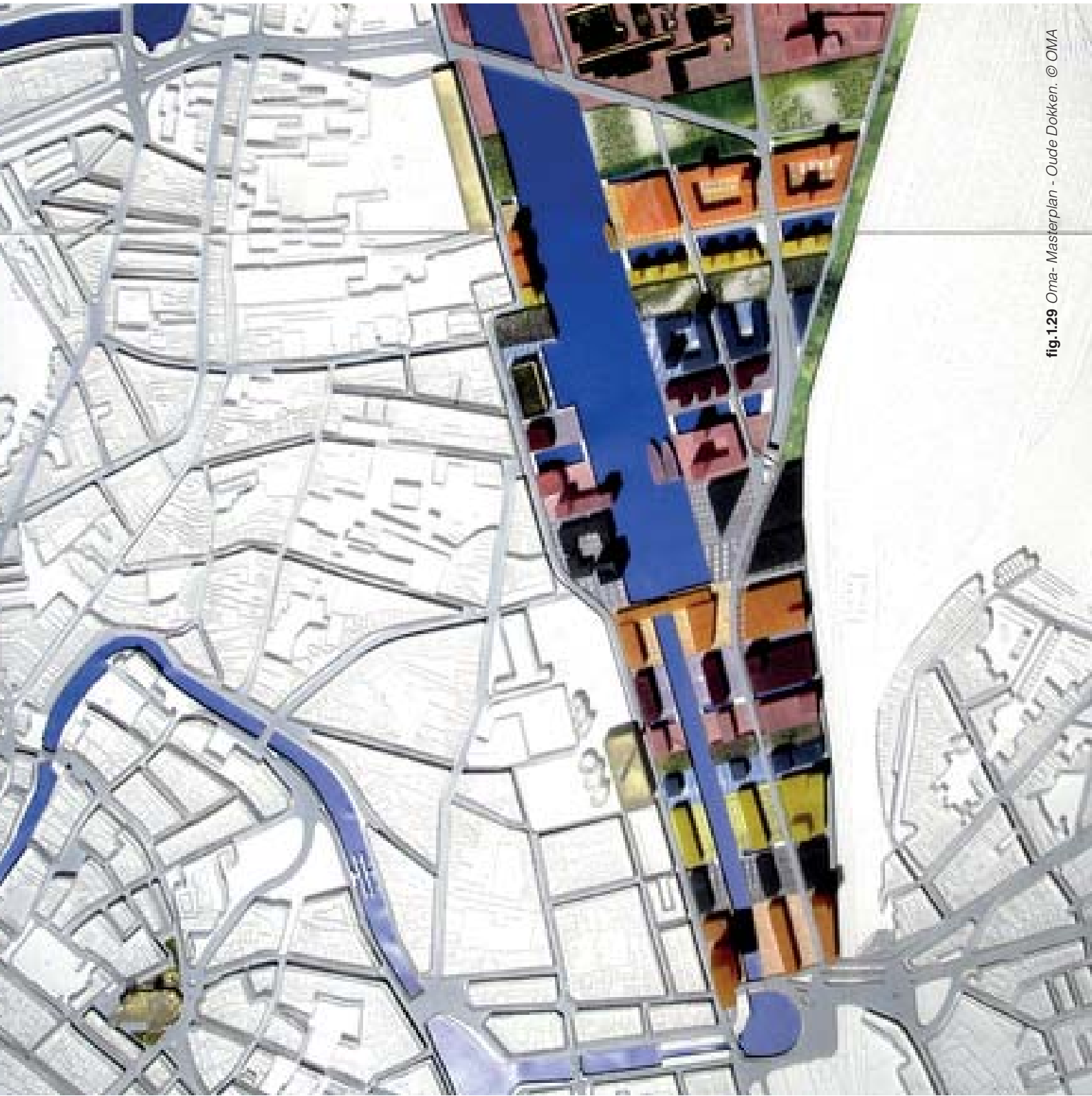


fig.1.29 Oma- Masterplan - Oude Dokken. © OMA

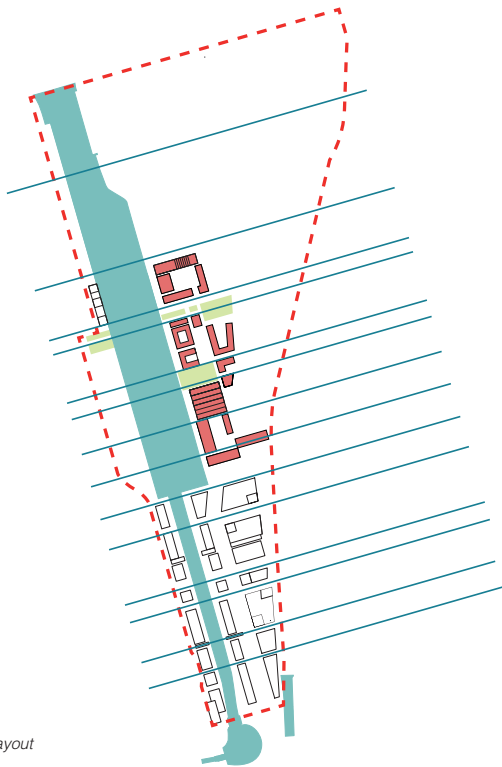




**fig.1.30** Impression neighbourhood OMA- Masterplan - Oude Dokken. © OMA



**fig.1.31** Impression Handelsdok. © OMA



Structured layout

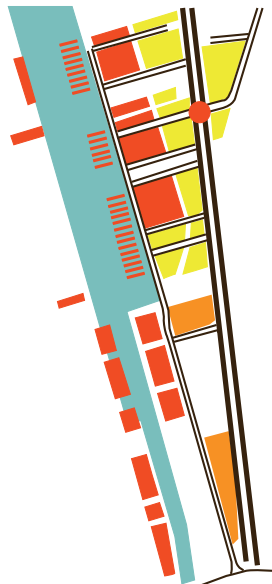


Main bike roads | current situation

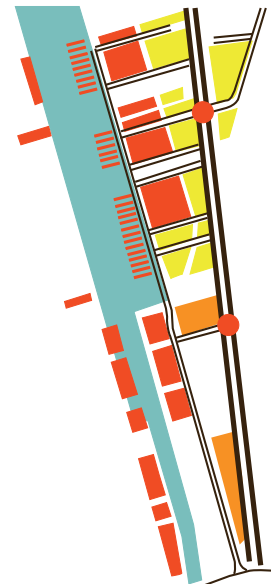
- primary bike road
- secondary bike road
- bike access project



New development within existing infrastructure network



New development - Variant 1



New development - Variant 2

fig.1.32 Schemes and drawings OMA- Masterplan. © OMA

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1.2 DISTRICT HAM

1.2.1 Historical development

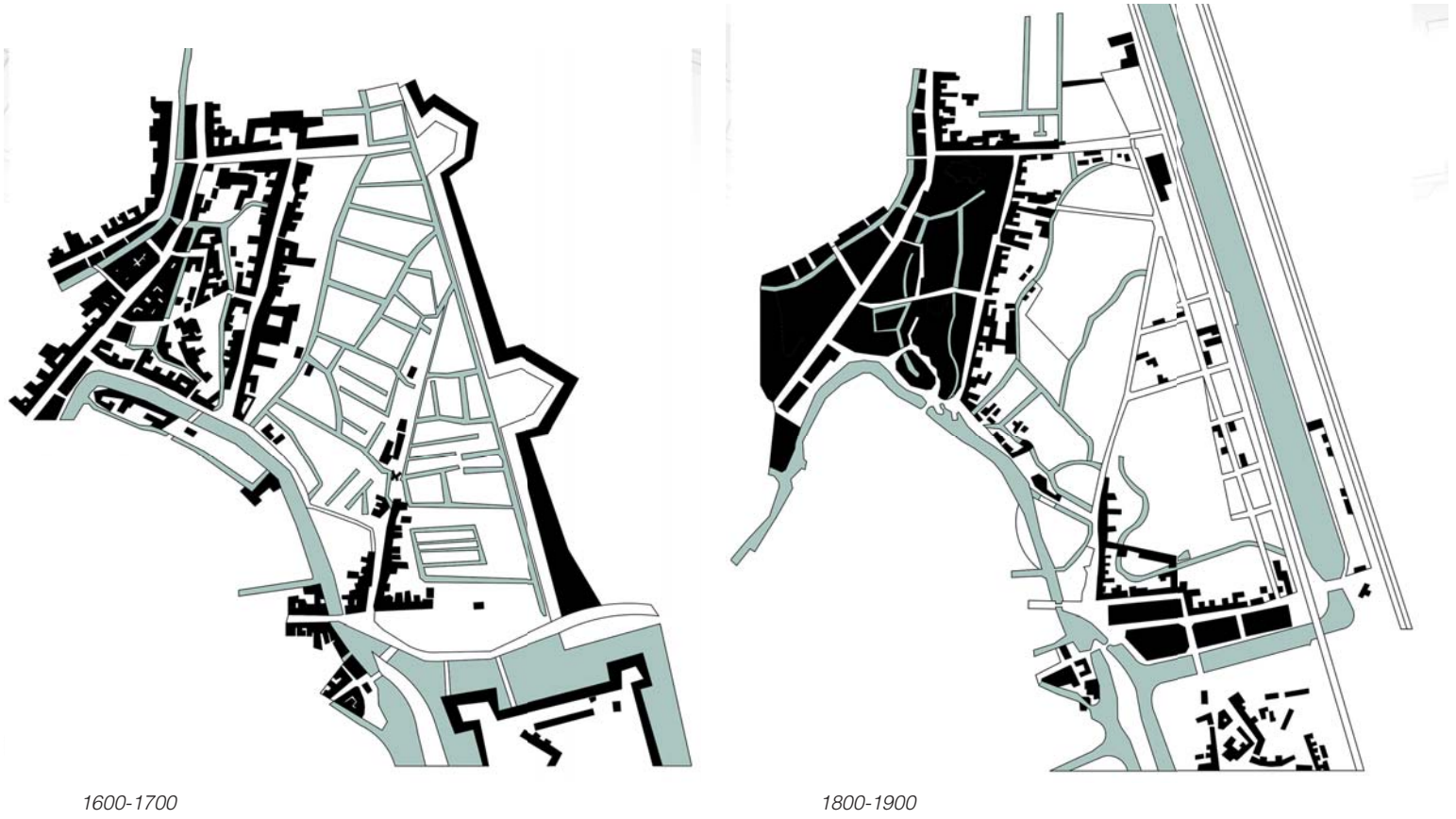
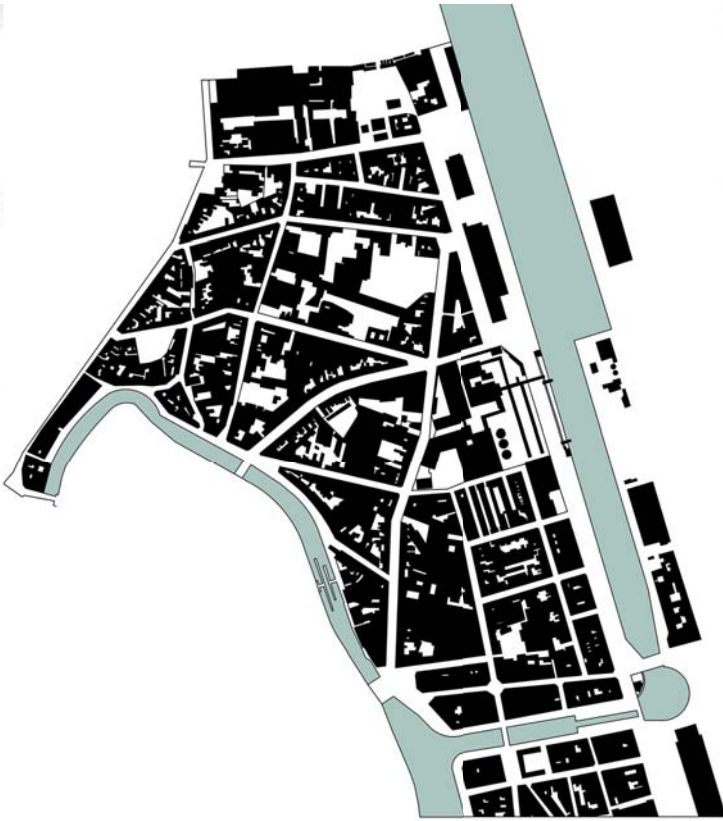
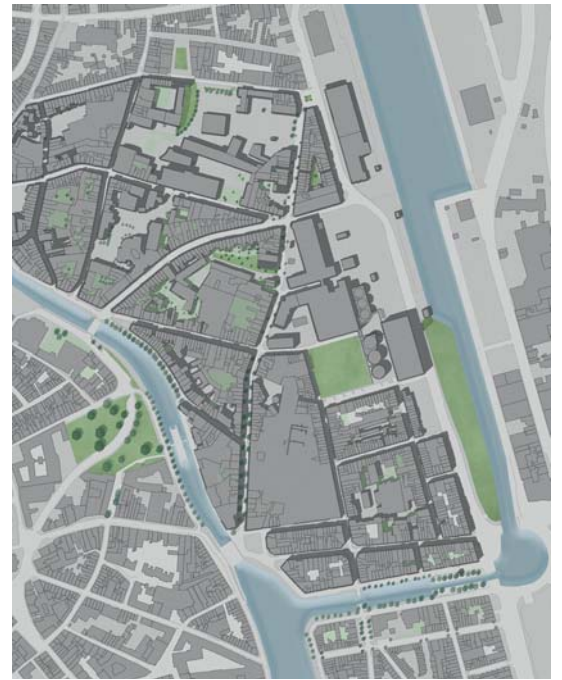


fig.1.33 The development of district Sluizeken-Tolhuis-Ham





1950-1980



2018

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### 1.2.2 Social and demographic background

From the Municipality of Ghent (Stad Gent, 2018) below a short description about the neighborhood:

The Sluizeken-Tolhuis-Ham area covers the northern districts of medieval Ghent (figure 1.34). They were marshy grounds cut through numerous 'Leie-arms' and canals.

During the 13th century, a number of suburbs had grown outside the large 'Leideboch'. They were not subject to the jurisdiction of the Ghentian aldermen, which caused unpleasant conditions.

In 1300 the city magistrate succeeded, among other things, in attaching the 'Briel' and the 'Muide' to the city area. This expansion of territory gave rise to the construction of the second city wall, with in this area the 'Spitaalpoort' (the later 'Dampoort') and the 'Muidepoort'. The power of this area was the 'Schipgracht' or 'Moere', an old northern 'Leie-arm' (now 'Tolhuislaan'), together with the road to the 'Vier Ambachten' and the 'Zeeschelde' (now 'Sleepstraat, Sint-Salvatorstraat, Voormuide, Meulestedesteenweg'). That is where skippers, shipyards, dockworkers traditionally determined the character of the district.

In the late 18th and 19th centuries, the food and clothing industries, metallurgy and port-related activities caused an overpopulation of the poorest population group. The area therefore also had the largest concentration of visitors from all over Ghent.

At the beginning of the 20th century and also after the World WAR II much has been remediated. The watercourses have disappeared and the historic urban fabric has changed considerably due to all sorts of projects.

Today there are important "country brands", as traces of the past. Just think of the parish church of 'Heilige Kerst', the chimney of the SPE-center, the striking façade of the old ACEC-building at Dok-Noord, the 'Schipperhuis' and the 'Schipperkapel', the primary school Dr. Jean Herrel in the Sleepstraat, the director house Voortman at Vogelenzang, the Hortus Thiery (now the Garden of Kina), the "blue crane of Kesteleyn".

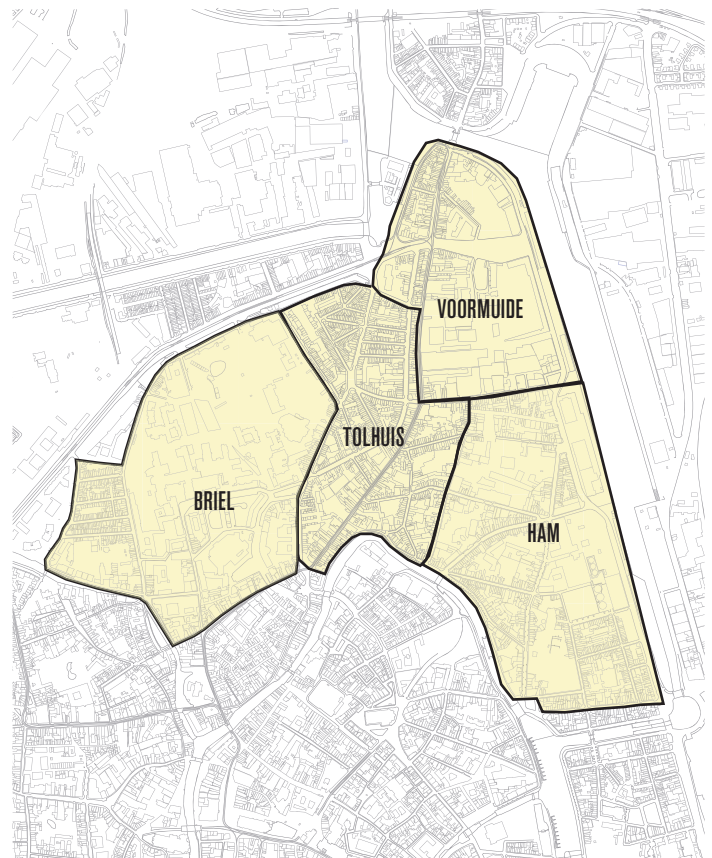


fig.1.34 District Sluizeken-Tolhuis-Ham

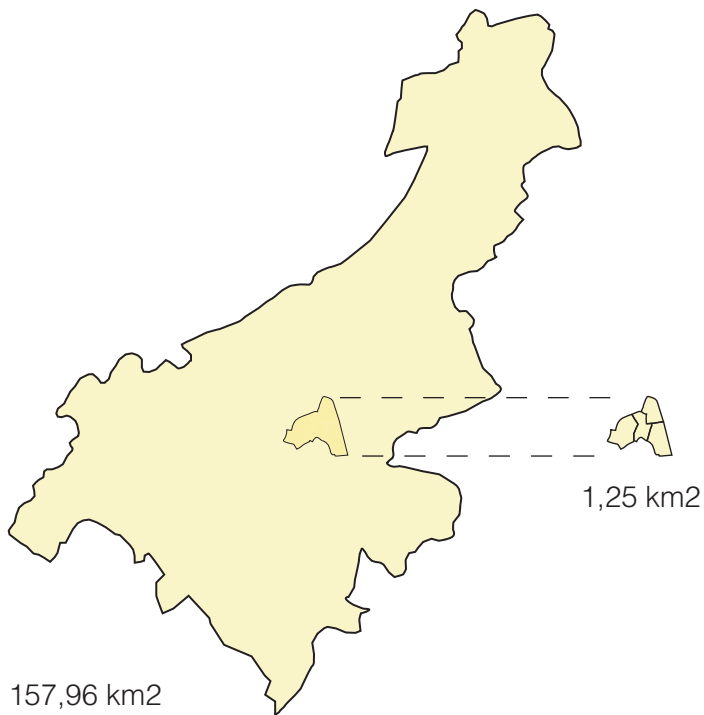


fig.1.35 Surface - Ghent vs District

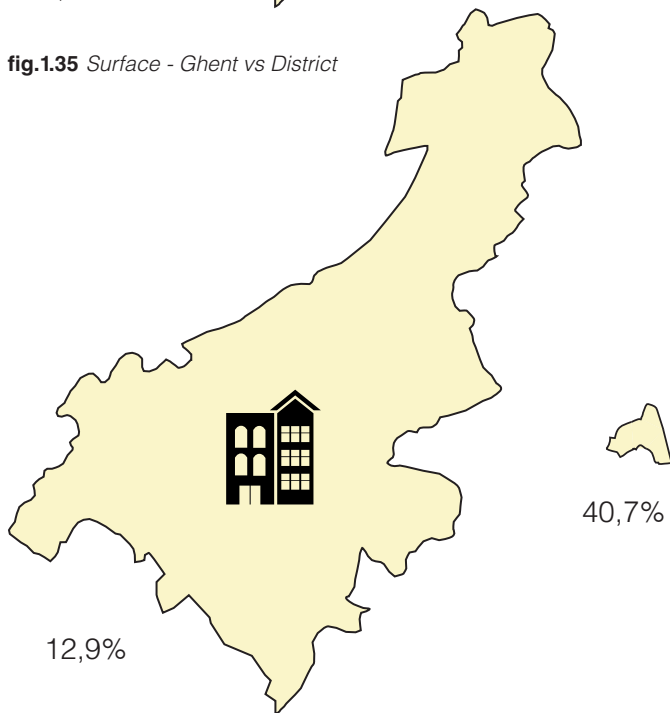
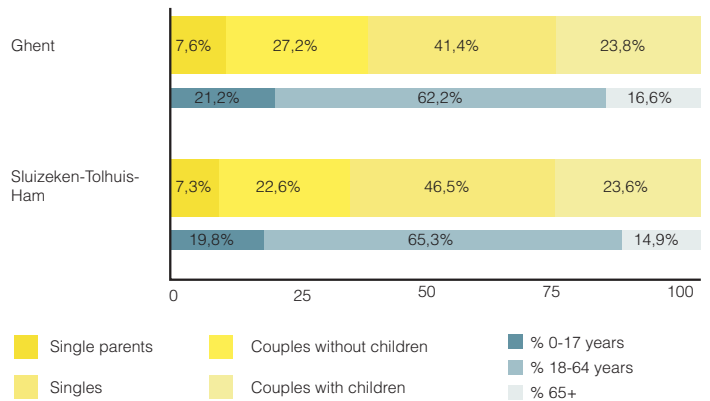
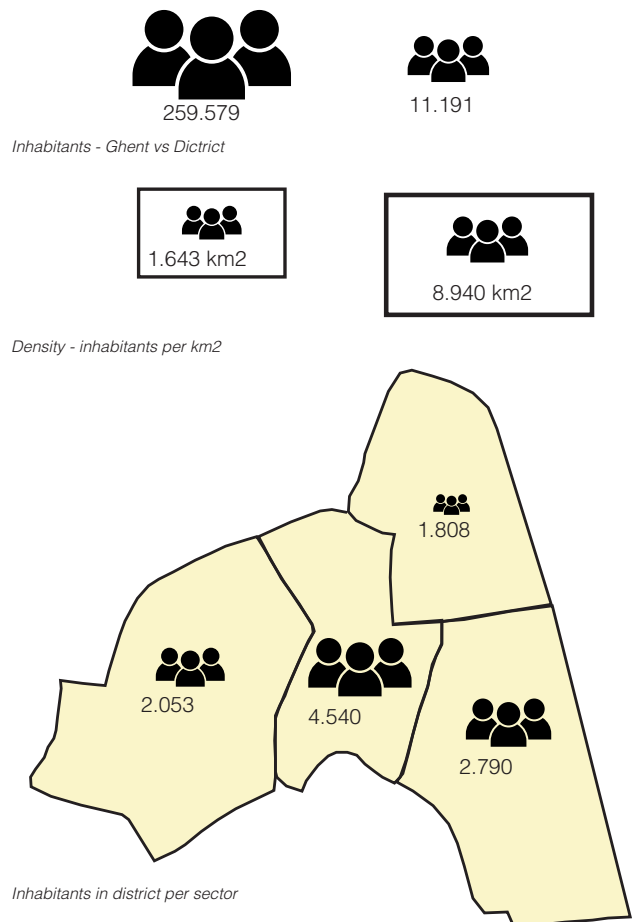
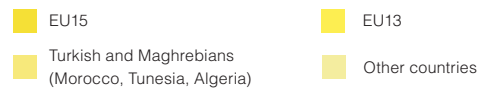
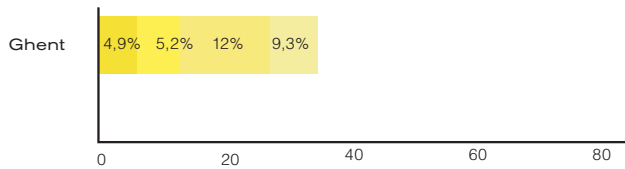
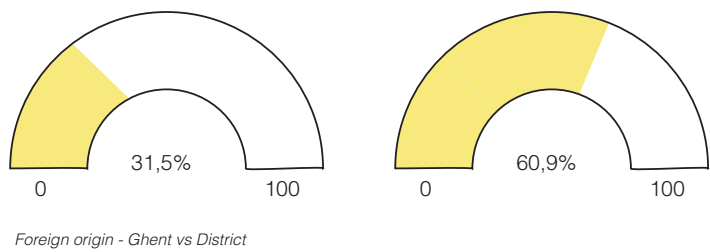
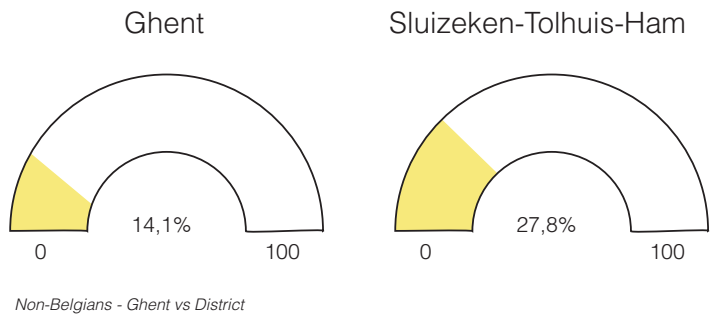


fig.1.36 Site coverage ratio - Ghent vs District



Families and Ages - Ghent vs District

fig.1.37 Population © Gent.buurtmonitor.be



Foreign origin in 2015 (detail) - Ghent vs District

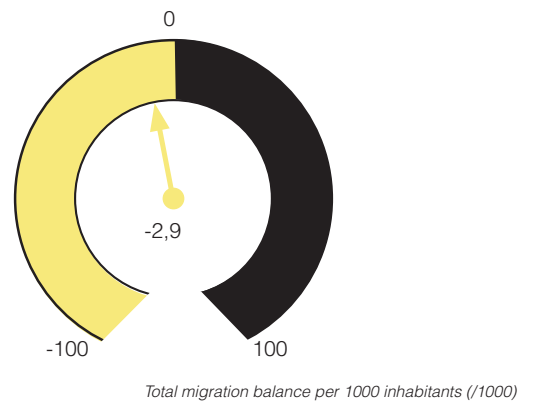
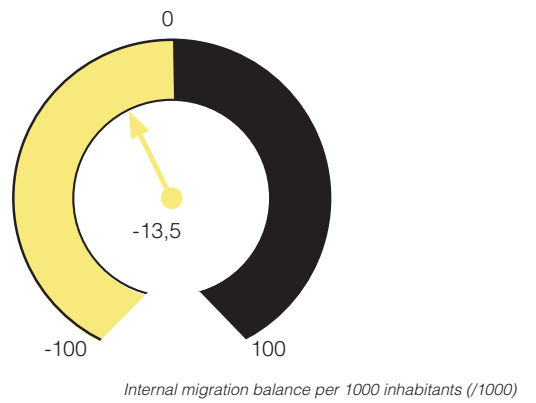
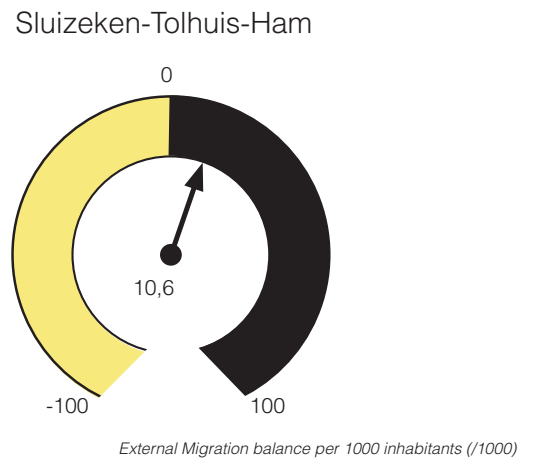


fig.1.38 Nationality

fig.1.39 Relocation

Ghent

Sluizeken-Tolhuis-Ham



3.178

Number of births per year



160



2.274

Number of deaths per year



197

fig... Natural growth

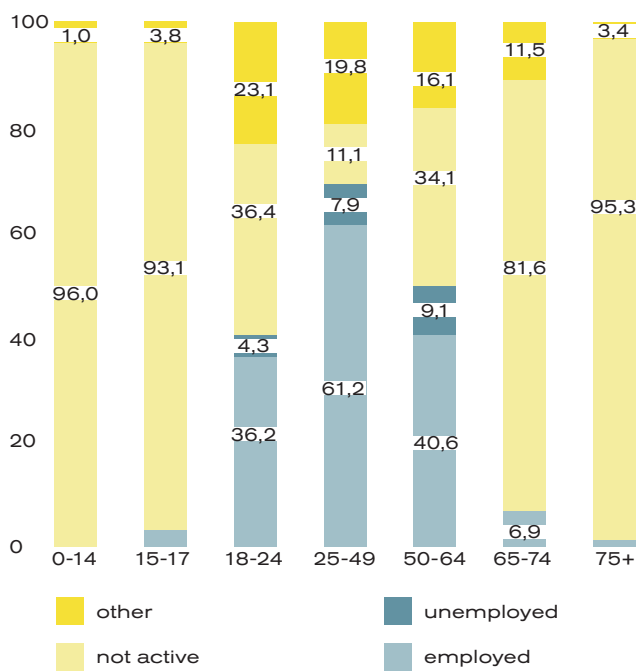


fig.1.40 Inhabitants (age and socio-economic position - 2015)

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### 1.2.3 Function

This chapter gives a brief overview of function distribution in Ghent, it focuses particularly on a district Ham. This chapter focuses on location and versatility of the functions in this area. The map on figure 1.41 presents the general structure of the building blocks around the complex of the power plant 'De Centrale' with all the functions. 'De Centrale' is situated in the heart of the masterplan area bordered by the streets: Sluizeken, Tolkhuis, and Ham. It is situated between the Old Dock (Handeldok and Achterdok) and the old city Ghent. In the direct neighbourhood of this area are situated Old Docks, which are currently being redeveloped according to the master plan proposed by OMA. The analysed area is mostly residential.

Majority of the buildings in Ghent are residential. Residential buildings are grouped in large parameter blocks with an industrial infill inside the block. The blocks consist of two or three story high row houses with private housing (figure 1.42 on page 44). The area is quite densely built with narrow housing. In the higher buildings (three or more story) apartment buildings the ground floor is used as a commercial space.

City Ghent is well-known for its rich educational offer. The city has a plenty of High Schools and Primary Schools which can be seen in figure 1.43 on page 45. According to the statistics provided by stad.gent.be Ghent has almost 77.000 students which make is the biggest student city in Flanders. There are two universities and four higher Schools such as Ghent University, Higher school Ghent, Art University, KU Leuven, Oddisee and LUCA School of Art.

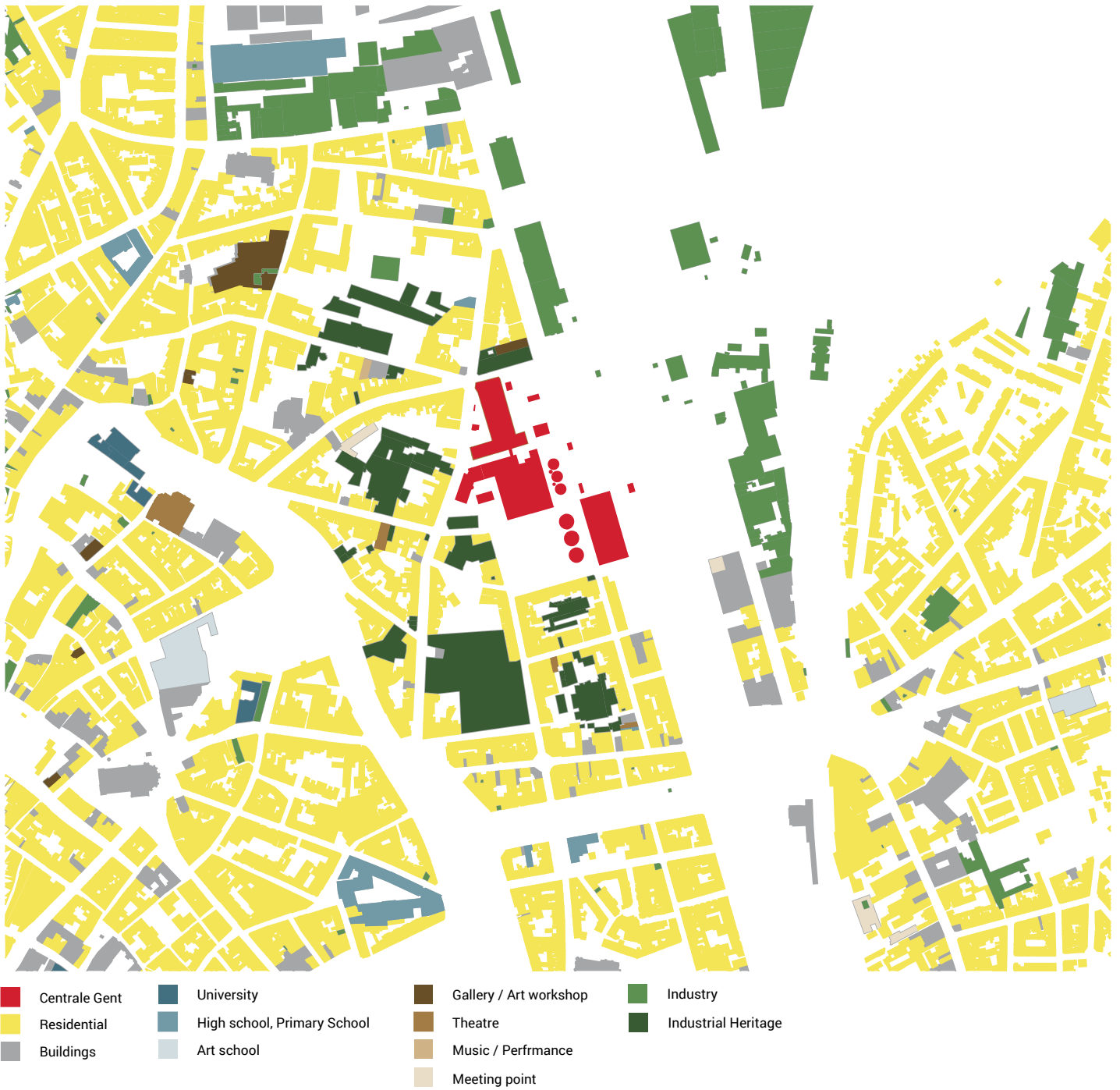
Ghent is part of UNESCO Network of Creative City and as such has plenty to offer in art and culture scene (figure 1.44 on page 46). There are plenty of art galleries such as RIOT, Galery of Tatjana Pieters,

Kristof De Clercq Gallery, Vlask and many others. Ghent is also Unesco City of Music since 2009. It has many concert halls such as De Centrale, Handelbeurs, MIRY, Logos Tetrahedron to mention only the main ones. What is important in Ghent is the fact that the professional art institution and extensively co-operating with the schools of the art active in the city.

Ghent has a large industrial site in the north relatively close to the center (figure 1.45 on page 47). In the former industrial area, technical buildings were located around the Old Docks area which is now being redeveloped. In the north, the beginning of the industrial zone works like a fringe belt. The residential function and industrial function does not mix with each other.

The valuable past is invisible in the structure of the blocks. Inner courtyard of large-scale residential blocks is filled with old industrial buildings which are typical for a Belgium context. Currently, many of this buildings are being transformed into cultural and community functions. Anyway, many of this building is still waiting to be transformed (figure 1.46 on page 48).

The buildings in Ghent can be analyzed different height categories. The building height in the category 6 to 12 meters consists mainly of residential buildings, this category of building height in combination with the residential purpose of it occurs both in the inner city as in the transition zone where the master plan is located. The last and highest building category of 27+ meters there just two results, the powerplant 'De Centrale' and the associated buildings, such as the 'Middendruk Centrale', which plays an important role within the area and the Sint-Jacobskerk in the city center. This building hights are translated into a map in figure 1.47 on page 49.



**fig.1.41** Map of functions in the district





fig.1.42 Residential



fig.1.43 School



fig.1.44 Art



fig.1.45 *Industry*



fig.1.46 *Industrial Heritage*





fig.1.47 Building hight



1.2.4 Natural structures

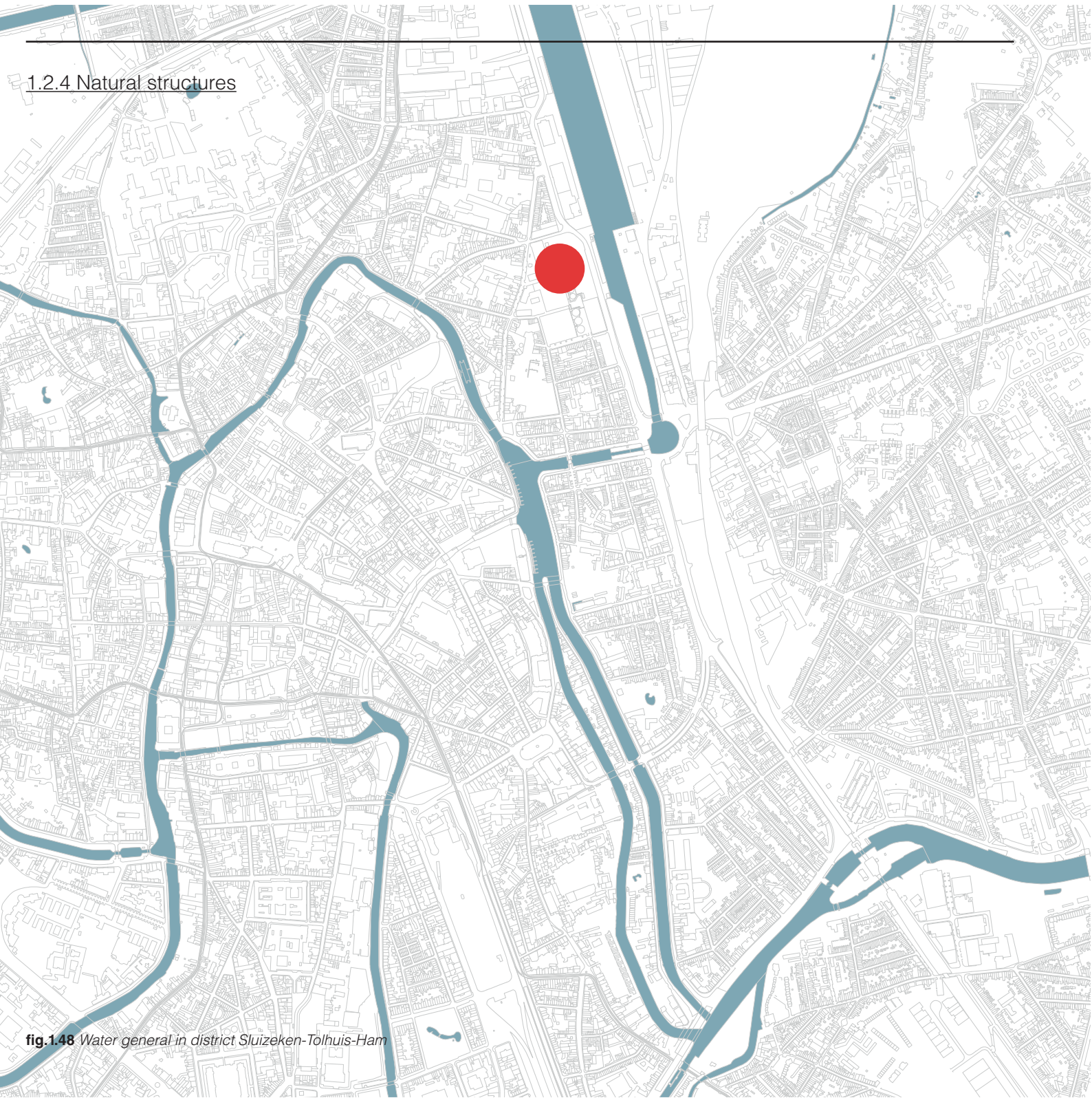


fig.1.48 Water general in district Sluizeken-Tolhuis-Ham



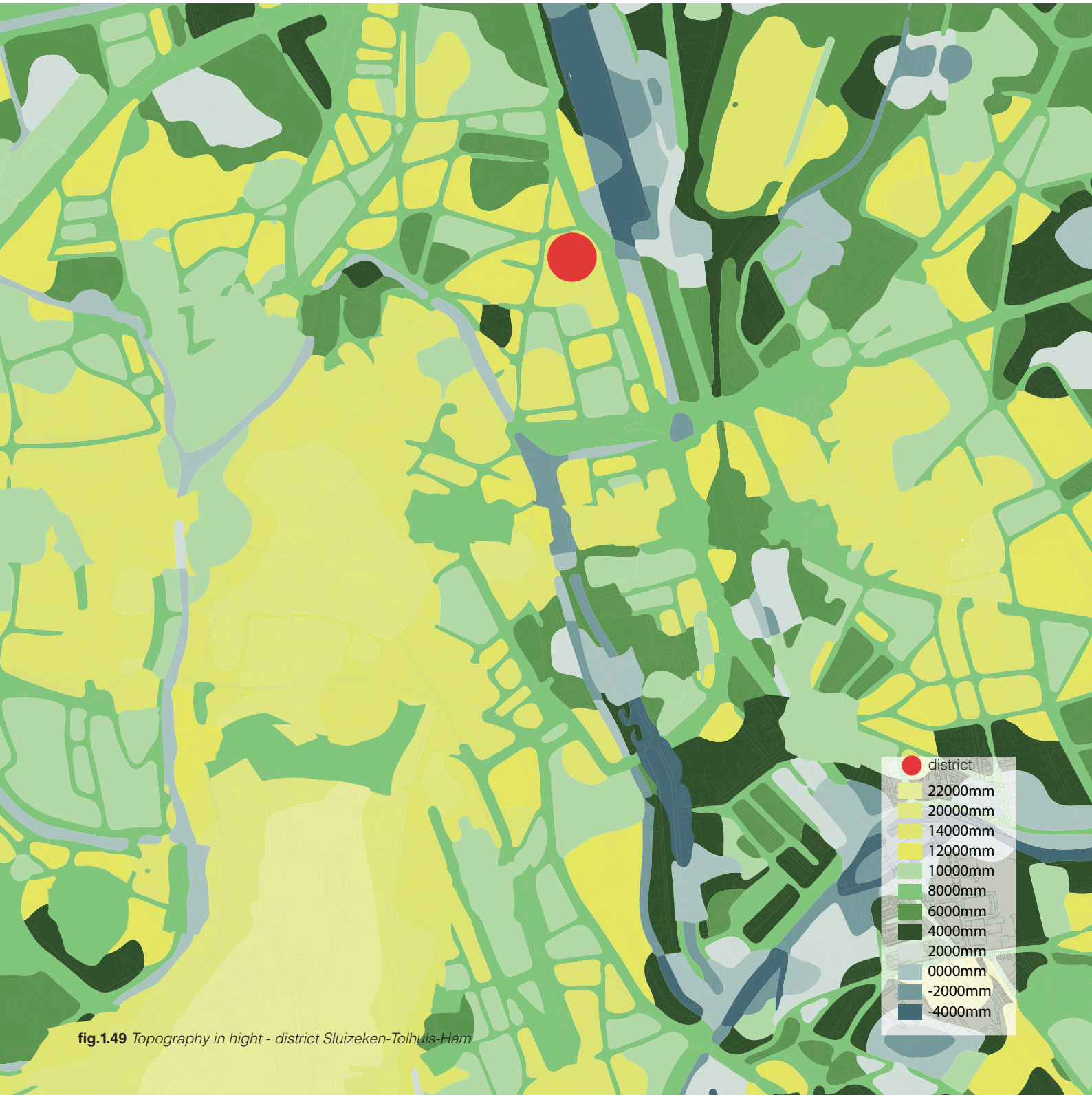


fig.1.49 Topography in hight - district Sluizeken-Tolhuis-Ham

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### 1.3 MASTERPLAN

#### 1.3.1 Findings research and analyses

The research and analyses done on the different scale levels; city, neighborhood, building, block and building, lead to several conclusions. These conclusion where the start point for the development of the concept of the Masterplan, on the neighbourhood, Sluizeken-Tolhuis-Ham can function in the future as a natural connection between the new OMA- masterplan in the harbour area and the historical city. Besides that the municipality pointed out several aspects to develop, these points were included in the analyses and were taken into account during the design of the master plan. Aspects such as the amount of greenery in the area and the stimulation of bicycle use instead of cars.

Looking at the results of the research and analyses it can be concluded that the amount of greenery is limited in the neighborhood. Certain blocks are close to already existing parks and public green zones, however the areas are not large enough to fulfill to the requirements of the municipality. Therefore the amount of greenery needs to be enlarged. And other problem recognized as a result of the analyses is the architectural quality of the buildings blocks. In all the different building blocks monumental buildings are located. However because of the variety of buildings in the blocks, the architectural quality is limited in certain blocks. Another large problem was the quality of the interior of the blocks. Besides that the connection of the these interior spaces with the rest of the neighborhood is missing in many cases. This is also caused by the different building heights inside the blocks and outside the blocks. Another thing which is recognized is that the typology of the neighborhoods varies from the new to develop harbor area, and also of the typology of the historical city centre.

This unbalanced situation was taken into account during the design of the Masterplan. Furthermore several infrastructural problems were recognized. One is the dominance of cars in the area. Not only the car road, but also the amount of street parking spots, which define the character of the streets. Also the limited amount of bicycle lanes, does not meet the policy of the municipality. On the other hand, the neighborhood is for pedestrians not very inviting, in contrast with the historical city center which is very pedestrian orientated. Finally the variety of functions in the neighborhood is limited, and the amount of cultural programs is small. Because the municipality want to attract tourist and locals to the new to develop area, to free the city center, the amount and variety of functions in the neighborhood is important.

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### 1.3.2 Concept Final Masterplan

The concept for the master plan is based on the implementation of a diagonal Boulevard in the existing context. This diagonal is introduced to break with the different street typologies. (1) The organic street typology in the historical city center and partly in the neighborhood. (2) The orthogonal street typology in the new to developed harbor area. The concept is by breaking both typologies, the two diverse areas are connected. Instead of connecting in a natural way, the two areas are connected in a strong and direct way. As this boulevard functions as a boundary between the two areas, it also functions as a central passage through the neighborhood. By implementing a variety of functions located close to the boulevard, liveliness is created. The functions are also introduced to attract tourist and locals to the neighborhood, and to the new to developed harbor area.

The orientation of the boulevard is based on two main spots in the area. (1) The Dampoort-station, a station which is expected to grow in amount of users, and is close to the harbor area. (2) The Heilige Kerst Church, a sixteenth century church. By connecting these two locations with the diagonal boulevard, people arriving at the station can directly discover the neighborhood. As the diagonal is crossing different building blocks, these blocks are opened up. The interior spaces transform in appearance and quality, therefore a new identity is introduced to the neighborhood. Because the diagonal cuts through different buildings, these buildings have to be recovered. With the use of 3D-concrete printing, the “wounds” are “healed”. Therefore the boulevard can also be seen as a “concrete-boulevard”.

An important aspect of the master plan is the shifting in infrastructure. The amount of car roads in the neighborhood are reduced. By introducing a ring-road with one connecting diagonal, the neighborhood is transformed to a car free zone. The amount of street-parking is also reduced, and parking areas are moved to the outsides of the neighborhood. This has a positive effect on the character of the streets. The greater amount of streets, and the boulevard, are pedestrian zones. Besides that, new bicycle routes are introduced which connect with the bicycle routes in the OMA- master plan, in the harbor area. The existing bus line, and new to developed tram line, follow the same routing as the car-ring road, around the neighborhood, connected with the city center.





fig.1.50 Final Masterplan



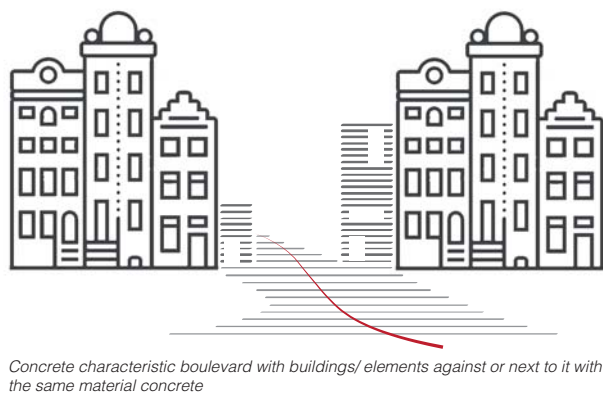
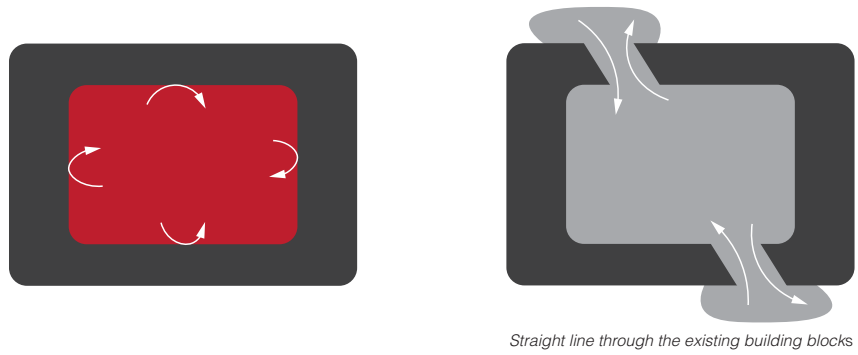
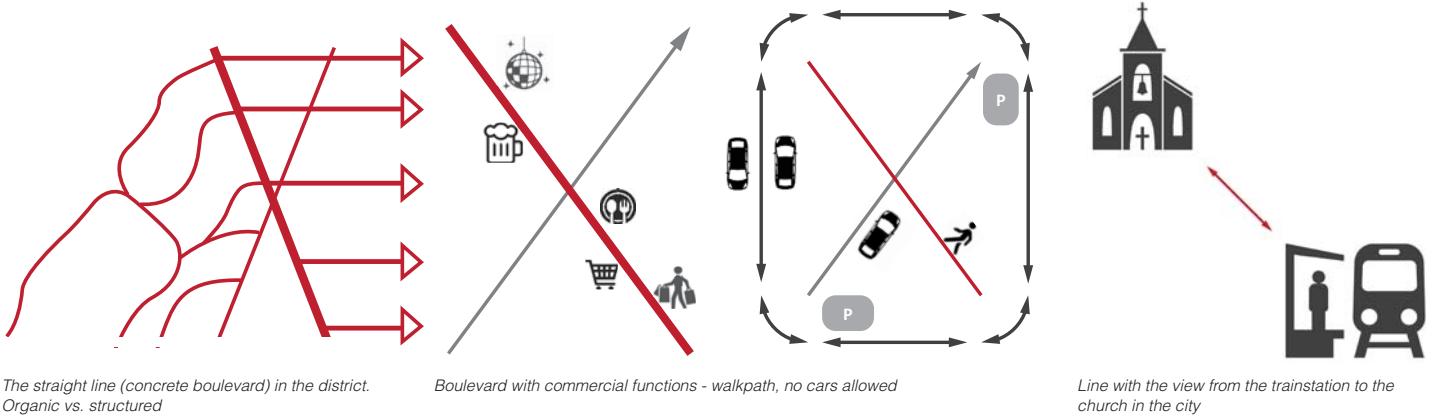
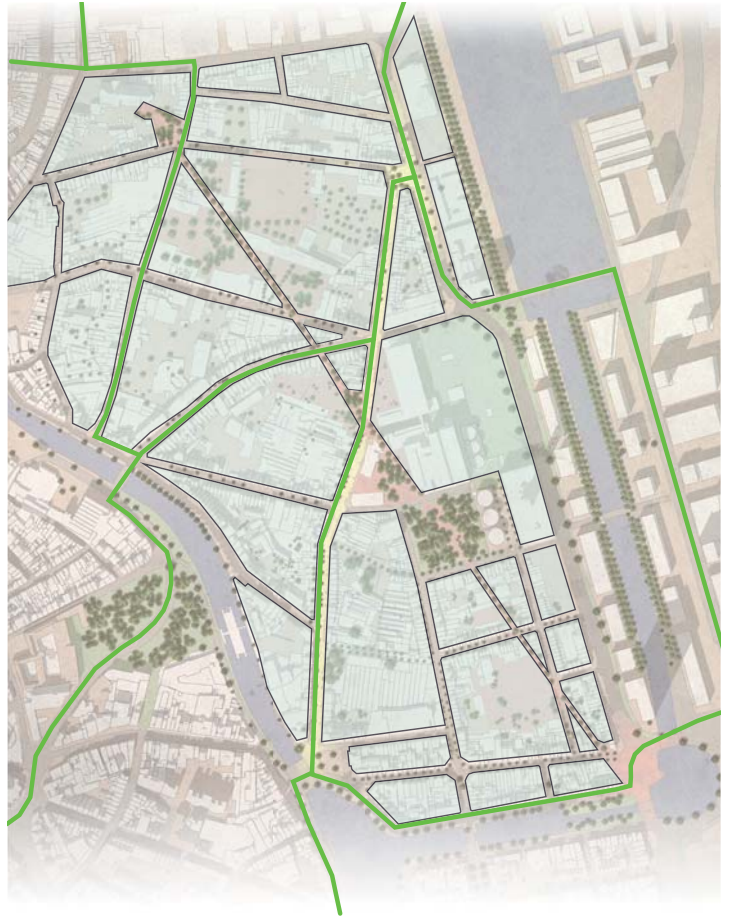


fig.1.51 Conceptual diagrams

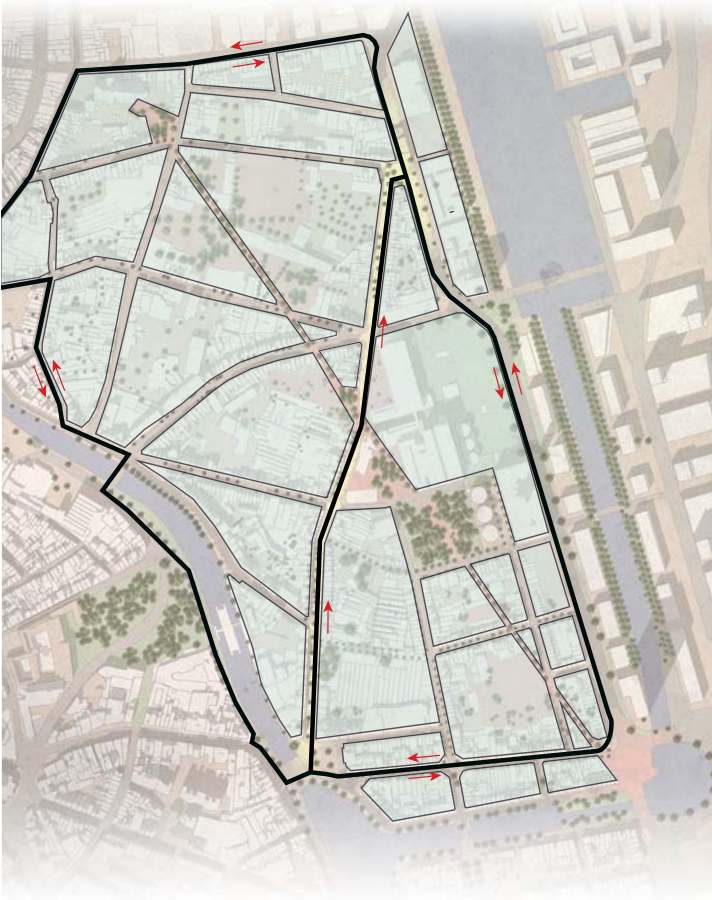


*Pedestrian paths*

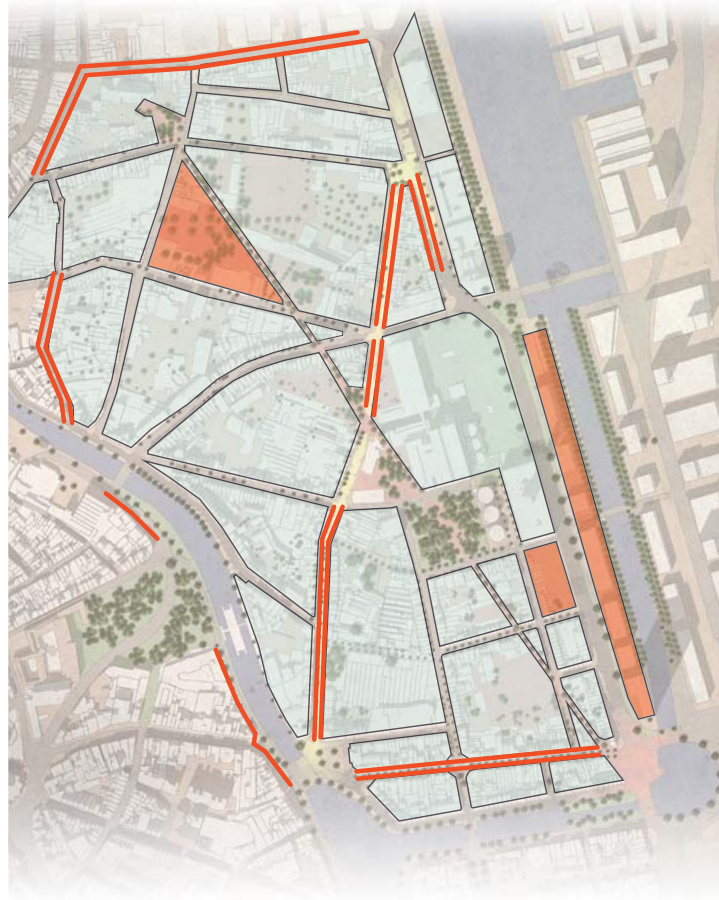


*Bicycle lanes*

**fig.1.52** *Infrastructural diagrams*

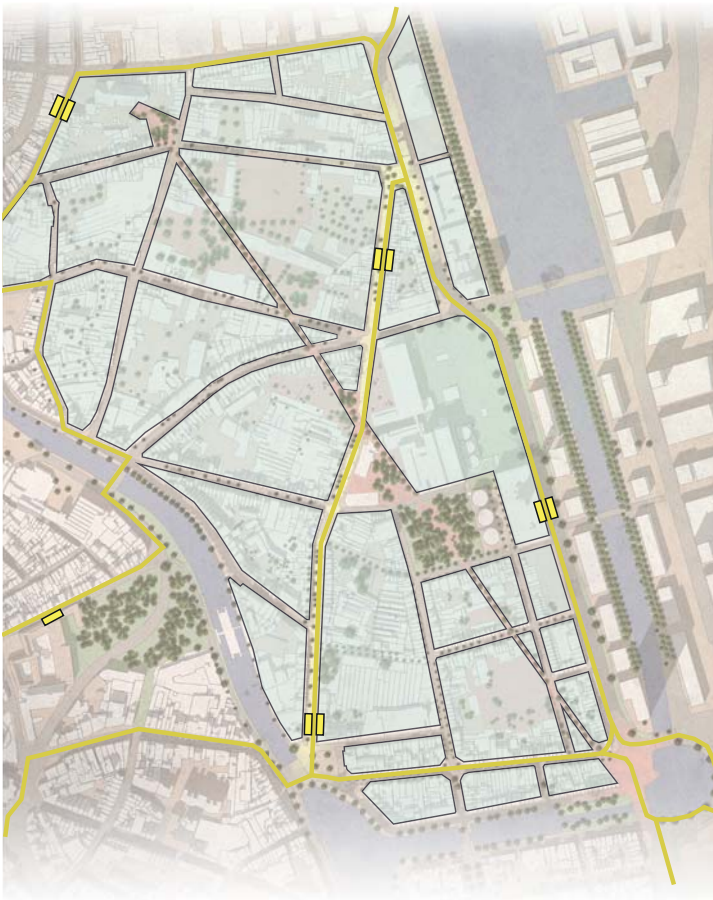


Car roads

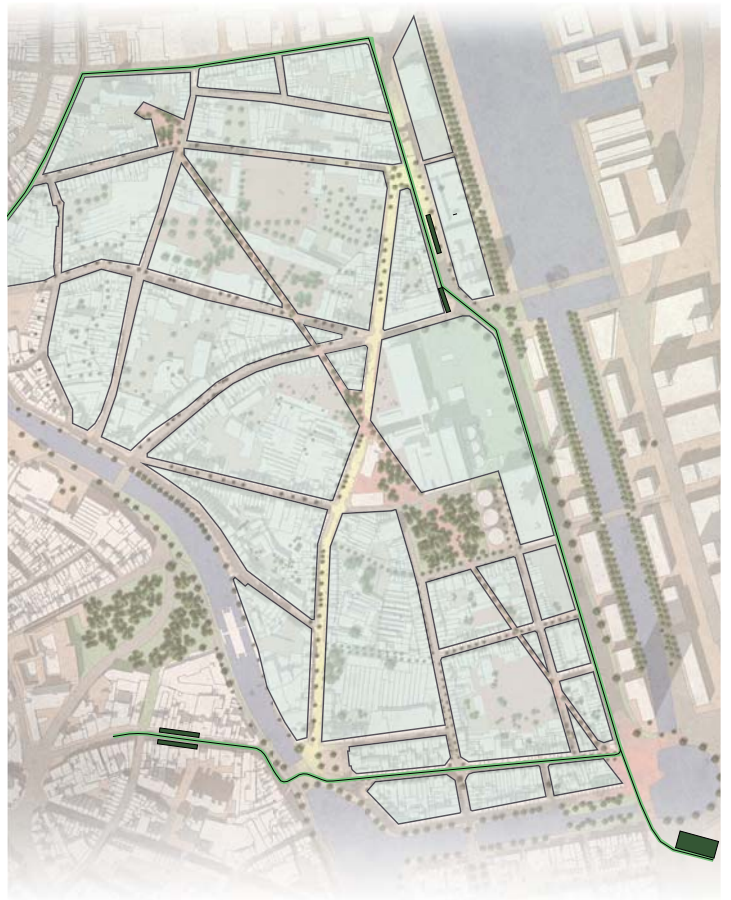


Parking areas

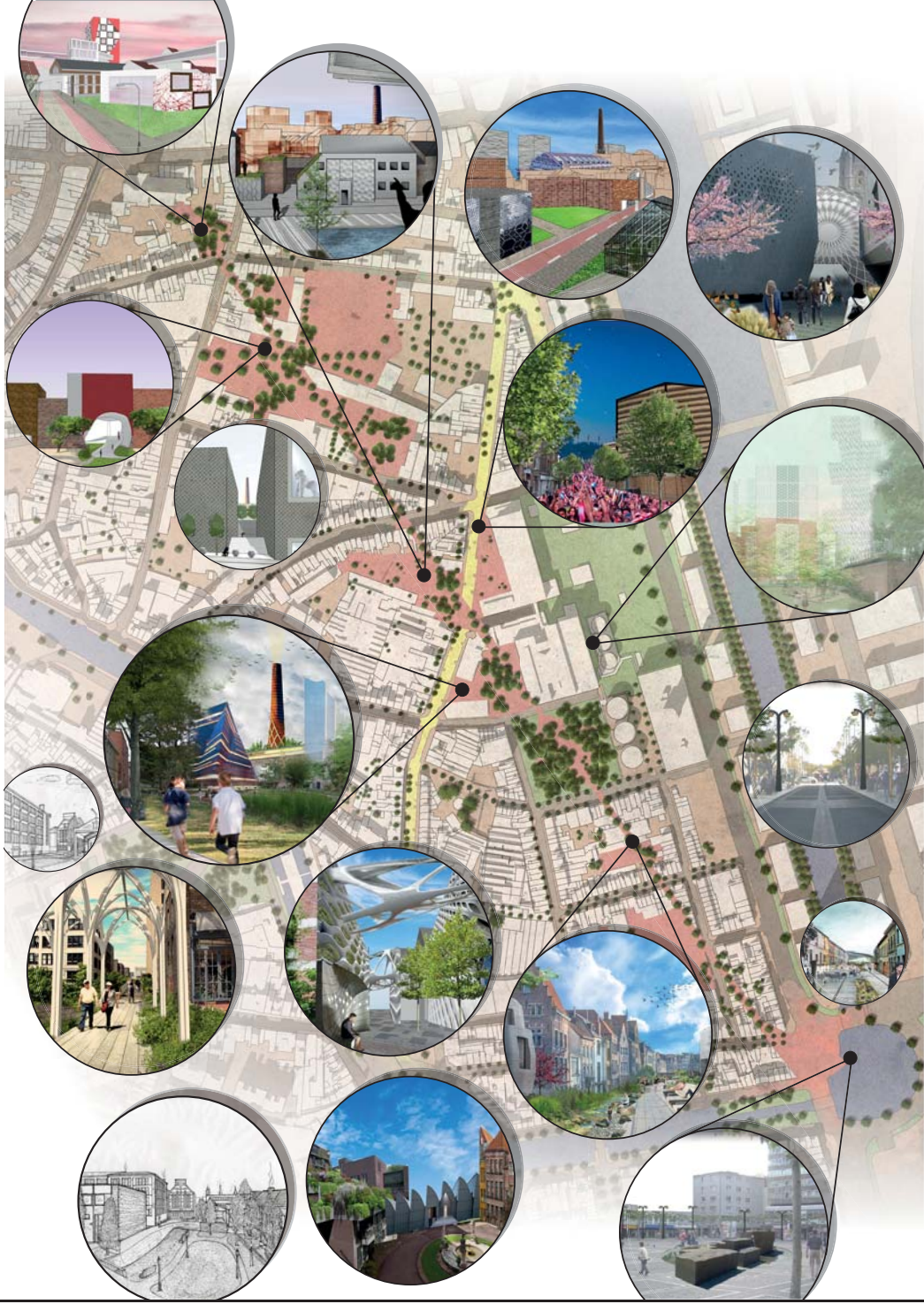




*Bus lines*



*Tram lines*



59 **fig. 1.53** Atmosphere impressions - Masterplan



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## 2. PUBLIC LIBRARY

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### 2.1 DEFINITION

According to UNESCO Public Library Manifesto 1949 which was revised in 1972, a public library is:

*“A public institution or establishment charged with the care of collection of books and the duty of making them accessible to those who require the use of them.”*

Assistant Professor Dr. Jyotsna Gupta from the Kurukshetra University did an extensive research on the meaning of the public library, a brief description of this below:

“This definition describes two main functions of a public library:

- 1) the care of a collection of books means protection and preservation of collection.
- 2) to make them accessible in real sense so that the right person can get right information at the right time.”

“In other words, a public library is a social institution established by law, financed by public fund, open for all without any discrimination, for general and free diffusion of knowledge and information in the community.” (Gupta, 2011).

### 2.2 TYPES OF LIBRARIES

There are different types of public libraries. The four main types are: (1) public libraries (for general public), (2) academic libraries (school libraries, college and university libraries and research libraries), (3) special libraries (industries and governmental agencies) and (4) national libraries (documents of and about a nation) (Issa, 2009).



fig.2.1 Different libraries in Ghent

### 2.3 WHY PUBLIC LIBRARY

A library has become much more today than only collection of books and knowledge. In addition, it also has a social function as a meeting place. A public library is often described in this sense as 'city living' or 'urban living room'.

From this idea I chose to design a public library on an existing industrial building. I assume the themes which are identified in the Masterplan and choose the building which is right next the famous power plant 'De Centrale'. I will explain later about the existing building in the chapter Design.

Due to insufficient social services in this district and many unemployed inhabitants, it is important to include the social aspect in the design in which both social and urban level are taken into account to stimulate the socialization of the visitors.

The themes which are identified in the Masterplan shows that this building can play a important role in its centrally located context. Both from the city and from the district. With its direct environment such as the cultural and educational theme, I chose to design a public library. This library is more than just a library; "the urban 'livingroom' for the district and the city, a place to stay". Due to its centered location in its district, the building will try involve everyone in the city, which spreads the feeling of ownership and to be a place of recognition.

### 2.4 USE OF PUBLIC LIBRARY

The potential of a public library in the digital age lies in the need for access to information, the need for physical spaces where meeting and communication can take place and the importance of social integration.

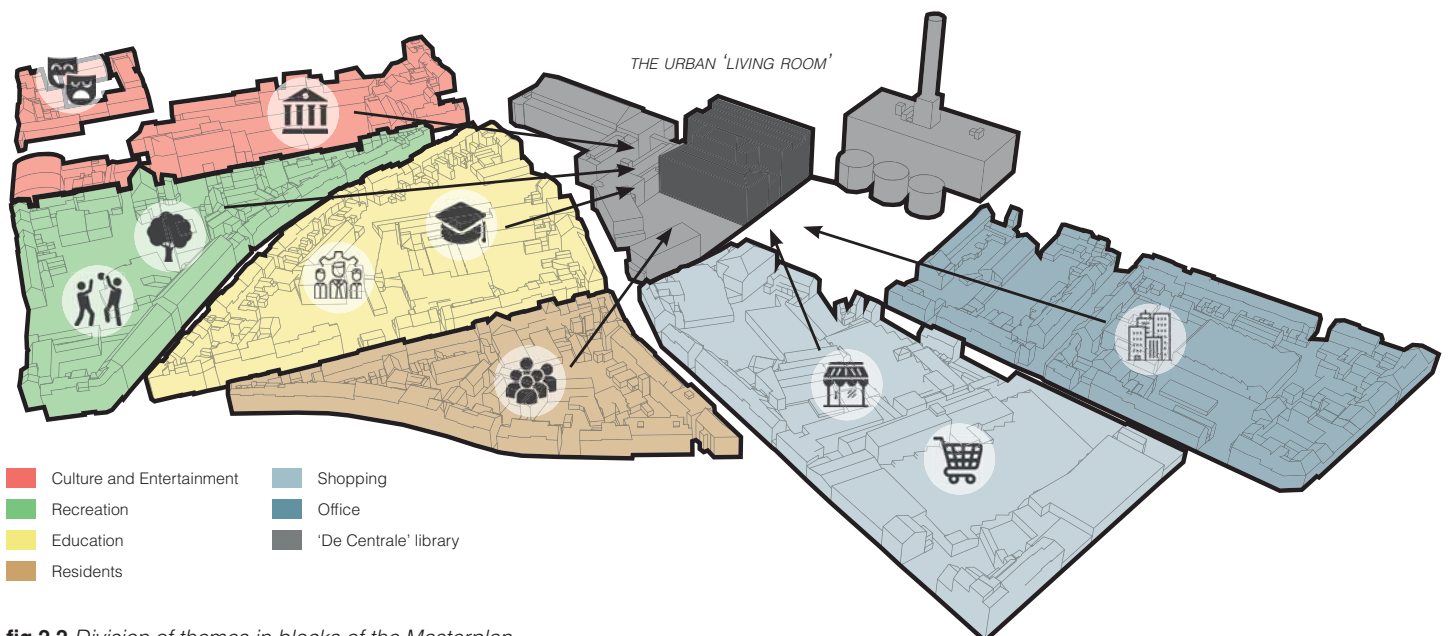


fig.2.2 Division of themes in blocks of the Masterplan

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Apart from the virtual library, the user clearly still needs a counterpart in the real world; a public place where people can meet and appeal to all their senses. Public libraries provide people with the opportunity to pursue a wide range of interests and activities.

The following paragraphs 2.4.1, 2.4.2 and 2.4.3 below are taken from the research of Gemma John (2016) and explores what I also consider to be the main reasons why people use public libraries – which can be summarised as a place to *meet, learn, and read*.

#### 2.4.1 Meeting

“Today, people can access information online, at a click of a button, which has led to declining visitor numbers, and might even throw into question the value of the library as a physical space. Nevertheless, new technology makes people more ‘mobile’, and people are seeking new spaces in which to work and play. Individuals are attracted to the public library as a neutral ‘free’ space to carry out their business, do their studies, or to hang out with friends or families”.

This is how the library has reinvented itself. “It’s the third space. People have home, they have work, and they need something in the middle”, explains the Adult Services Manager at Halifax Central Library. “We noticed that people want space to do their own thing, but they also like sitting with other people. It’s what draws people to coffee shops... People love watching other people,” she explained.

“Public libraries have become global destinations, hosting festivals, conferences, and events to attract people. They are places where individuals meet new friends to explore ideas and share interests across social and intellectual boundaries” (John, 2016).

#### 2.4.2 Reading

“If we respond to the community, then we will remain relevant to them. If we are relevant to them then the public library service is going to survive. What does it mean to be relevant?” asked a Branch Manager in Seattle.

“While public libraries were initially designed to provide everyone with access to printed books, at a time when print books were expensive to purchase, their role has evolved over the years. As print books have become cheaper, public libraries have been filling up with them. Today, librarians are of the opinion that it would be better to remove the open stacks to enable patrons to be more ‘active’.

The staff in libraries argue that weeding is a way of making more popular items visible to patrons. But, it has come as a surprise to patrons who still consider the public library as a place to browse books. When you take out nearly a third of a collection, the shelves look empty. ‘So we removed the shelves,’ said the Deputy Chief Executive Officer of Calgary Public Library. The result is that there are fewer books on the shelves and fewer open stacks on the floor.

Public libraries have provided access to material online, lending tablets and e-magazines and e-books. As the Director of Engagement and Special Projects at Chicago Public Library explained, “digital access is increasing, but circulation of books is not decreasing, it’s actually increasing. The pressure to keep the book is enormous – people who are “hard core” users still want bestsellers, and they want them now.” Patrons want to borrow the latest publication by their favourite author. They also want to be able to read the book online; they not only expect the library collection to be up-to-date, but they expect the library to make it available in physical and digital form” (John, 2016).

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### 2.4.3 Learning

“Increasingly, public libraries are supporting early literacy thorough ‘play’. Devon Hamilton, a Play Consultant, working with Calgary Public Library, explains that play is important. “We are beginning to realise that children’s lives have been overprogrammed” – so they do not have the chance for spontaneous and ‘free’ play.

Public libraries are committed to promoting early learning literacy. They take activities associated with early learning literacy to individuals living at a distance from the library building (often in rural areas). In addition, it take their services to patrons in outlying areas using mobile or pop-up libraries. For example, Delft Library Concept Center uses ‘vindplaats’ (a finding place) which are ‘book shelves on wheels’ that it lends to nearby schools.

For teenagers, public libraries organise classes to help them improve their digital skills and for adults, public libraries continue to offer basic education services. It provides space for individuals from the community college to tutor adults” (John, 2016).

### 2.5 STRUCTURAL VISION MUNICIPALITY GHENT

The municipality of Ghent also has preferences regarding a new public library. From this, objectives and points of attention are pointed out for the new public library in Ghent city. Below the text is taken from the concept note of director-librarian Luc Bauwens in 2005:

The main 10 theses about a new public library in Ghent from the concept note of director/ librarian Luc Bauwens in 2005:

The new library must:

- (1) Besides library and reference library, also be an experience library and meeting place.
- (2) Broaden its services for the local population to Flemish assignments, certainly with regard to the storage function.
- (3) Strengthen the information mediation and provide (even) more depth.
- (4) In addition to the (lively) sitting areas, also have closed (quiet) study rooms.
- (5) Because the digitization of culture and information will, in general terms, increase, a large computer space will be needed.
- (6) In terms of general structure, a threefold and integrated library like the current library, but with more space in the themed room for culture and information market and meeting functions.
- (7) Be fully automated.
- (8) To realize the foregoing, offering sufficient space overall.



(9) A landmark, clearly visible from the urban environment.

(10) In everything, including in architecture and design, customer-friendly and truly public, accessible to everyone.

The key points in the concept note are: experience, meeting, mediation, study, self-service, publicity, and this in a mix of tradition (internally positioned, reliable, well-organized) and innovation (external and experience-oriented).

The traditional library is turned in, inviting for its reliability (quality) and clarity (disclosure). It gives access to culture and information through the indirect path of the various media.

The new library respects the internalized tradition but adds the contemporary dimension of the mediation, the experience and the encounter, the direct access to culture and information. It is not only passively public but also active, it invites to taste culture and information through participation and interaction. The challenge is to harmoniously combine the traditional and the new library.



fig.2.3 The old city library of Ghent. © municipality of Ghent

## 2.6 THE OLD CITY LIBRARY

The old library of city Ghent was opened in 1992 and is located at 'Woodrow Wilsonplein'. It was the public most visited urban building in the city of Ghent with over 800,000 visitors per year. Over the past 20 years, the number of readers has increased from 23,000 to 80,000 (stad Gent, 2018). Due to this success, the building became too small, both for the public and for the staff. A lot of staff members from the municipality has already statement about the need for expansion or completely one.

The solution to this problem from the point of view of the city of Ghent is to move the public library to a new building, to provide all wishes and needs. My design will also play a role in this and take account of this problem.



fig.2.4 Entrance. © municipality of Ghent

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### *2.7 CASE STUDY*

In order to set up a program and critically exploring the design principles for the public library in the existing building that I have chosen, on the next pages four existing similar projects around the world have been selected, large public libraries from 25.000 to 50.000m<sup>2</sup> and analyzed extensively to compare: (2.7.1) Seattle library, (2.7.2) Utrecht University library, (2.7.3) Prague Technical library and (2.7.4) Library of Birmingham. Text description of each project are provided by the sources which can be found in the text.

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### 2.7.1 Seattle public library

FUNCTION: PUBLIC LIBRARY  
LOCATION: SEATTLE, WASHINGTON, USA, 2004  
AREA: 38.300 M<sup>2</sup>  
ARCHITECTS: OMA + LMN ARCHITECTS

The desing of OMA and LMN's opened in 2004 as an 11-floor, 38.300m<sup>2</sup> public library in Seattle, Wachington, USA.

The innovative feature 'book spiral' on levels 6-9 displays the entire collection in a continuous rus in the spiral shape with a 15m high living room, positioned in a distinctive diamond-shaped glass and steel skin ("Seattle Central Library in the USA, Designed by Rem Koolhaas - Verdict Designbuild", 2018).

One of the vision of OMA architects was to redefine the library as no longer dedicated to books but as more a information center, where all collections and media can be presented. "In an age where information can be accessed anywhere, it is the simultaneity of all media and the professionalism of their presentation and interaction that will make the library new" (Koolhaas & LMN Architects, 1999).

The famous architectural concept 'form to follow function' are applied in five platform areas. Each platrom is a programmatic cluster for maximum use, because of their unique size, purpose, circulation, flexibility and structure. The spaces inbetween these platforms serves as trading floors.

The interior has been described as maximum of natural light and space, inspiring users to read and borrow digital books (online texts and multimedia).

Floor level three offers various functions where the function 'Living Room' is tried to maintain. The 'Living

Room' (public space) consists of a teen centre, shop, coffee bar, auditorium, the Library Equal Access Project and spaces to read or study ("Seattle Central Library in the USA, Designed by Rem Koolhaas - Verdict Designbuild", 2018).

On level five the 'Mixing Chamger' offers customer help centre with public computers. The 'Seattle Room' on level ten offers the city's history and services. This historical level also offers reading room with a panoramic view over the city. ("Seattle Central Library", 2018). Nowadays, the library welcomes about two million visitors a year.



**fig.2.5** View of the library from the 4th street side. The children's section is on this level, on the left side. Photo © Darren Bradley



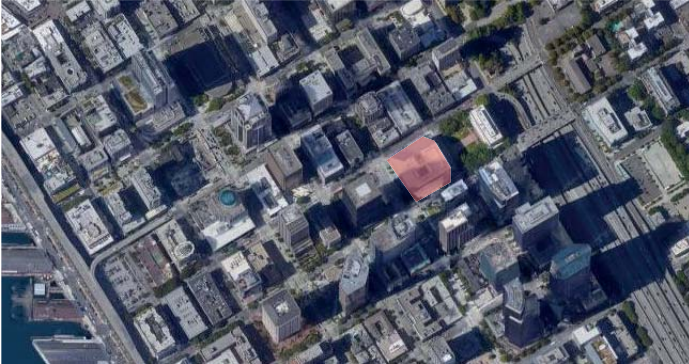


fig.2.6 Site plan. © google.com/maps



fig.2.9 Entrance "arcade" is an extension of the building's exoskeleton, and creates a seamless transition between the building and street. Photo © Darren Bradley



fig.2.7 View from the 5th Avenue side, with the understated main entrance. Photo © Darren Bradley



fig.2.10 The "arcade" from the street. © oma.eu



fig.2.11 Structural system on façade. Photo © Philippe Ruault



fig.2.8 Parti. © oma.eu

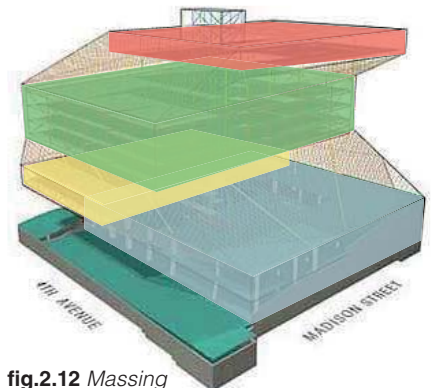
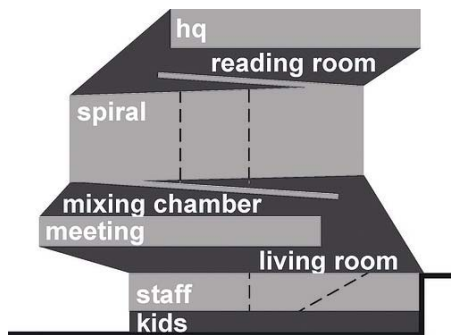
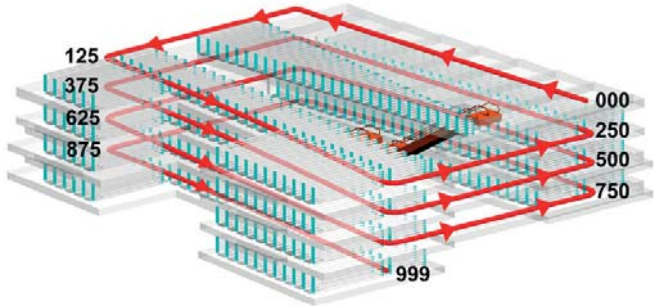
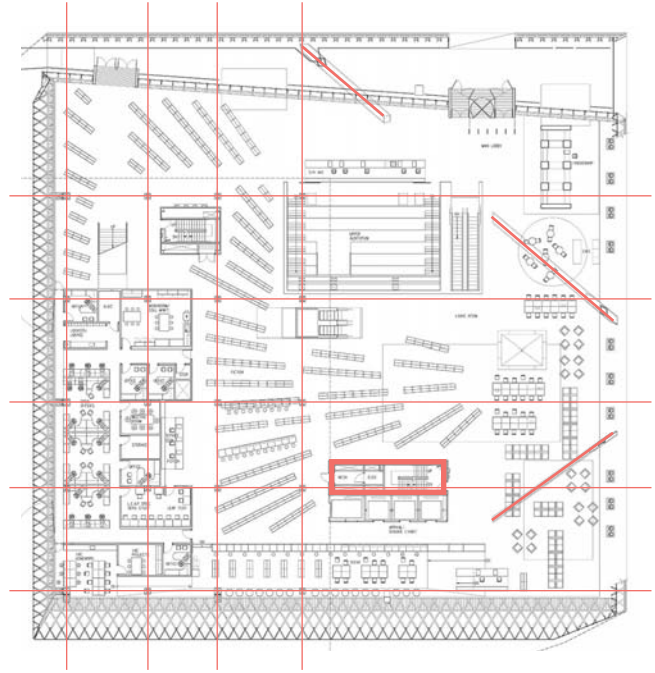


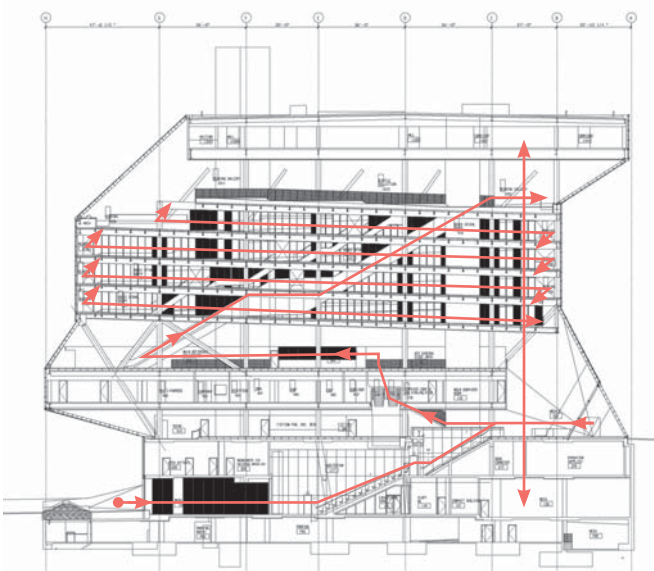
fig.2.12 Massing



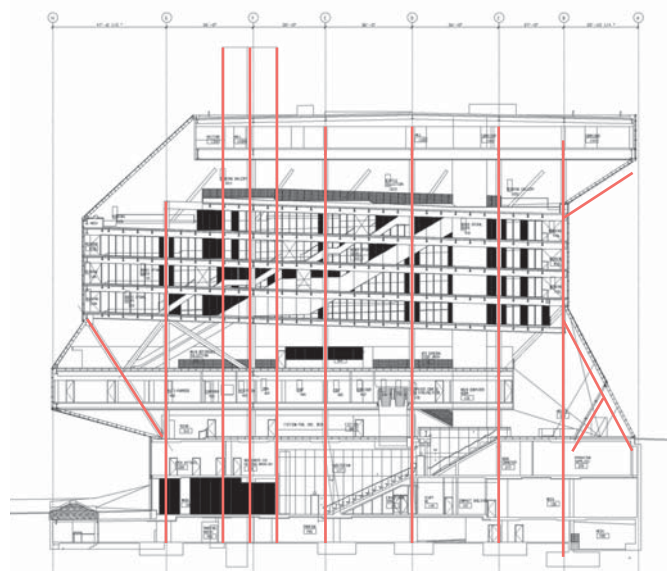
**fig.2.13** The spiral inclined allowed a continuous row of books that make them "easy to navigate". © oma.eu



**fig.2.15** 3<sup>d</sup> floor in grid with the structure



**fig.2.14** Circulation



**fig.2.16** Grid/ Structure



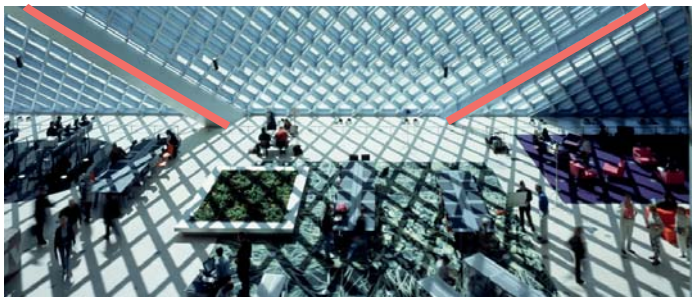
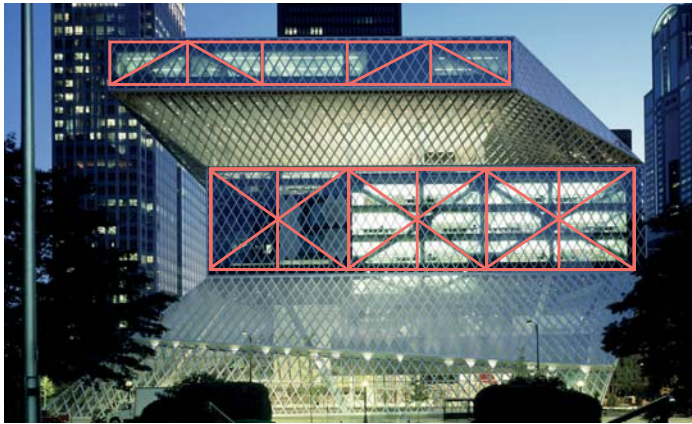


fig.2.17 Structure exterior vs interior. © oma.eu

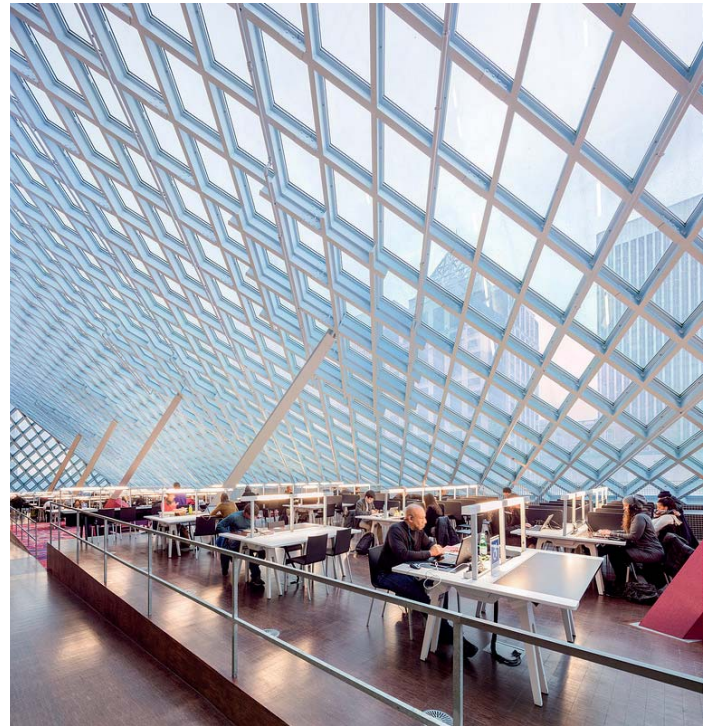


fig.2.19 The 10<sup>th</sup> floor reading room with the glass ceiling has plenty of natural light, and great views. Photo © Darren Bradley

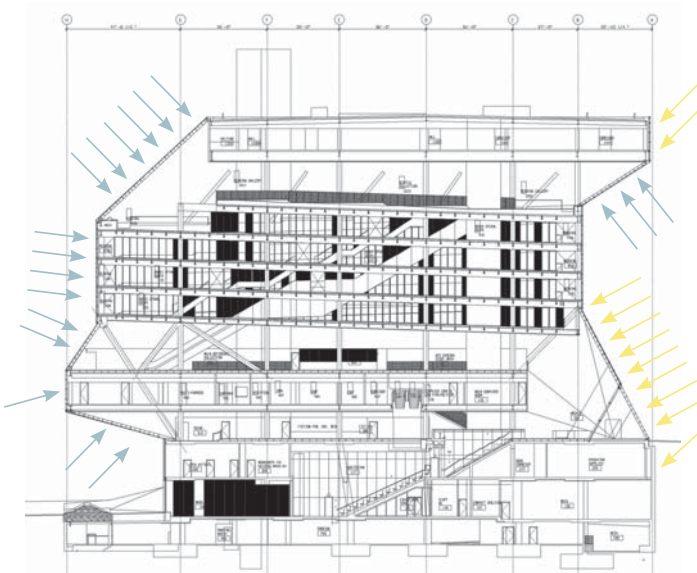


fig.2.18 Light → Direct sun light → Defused light

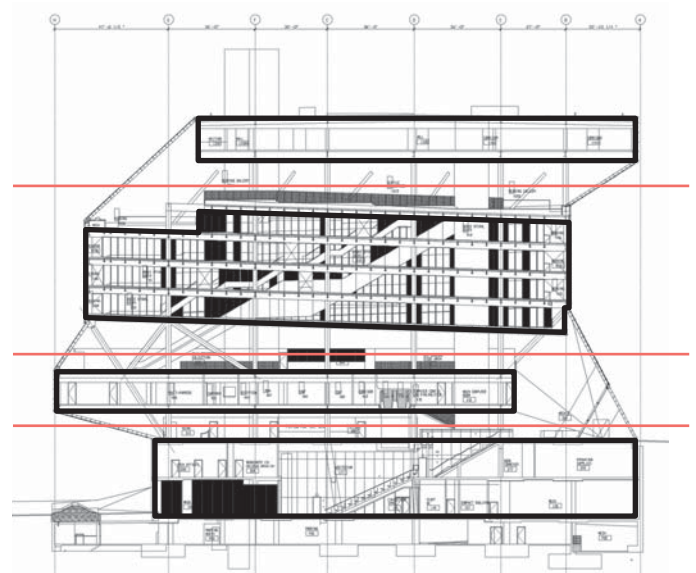


fig.2.20 Balance/ Hierarchy



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## 2.7.2 Utrecht university library

FUNCTION: ACADEMIC LIBRARY  
LOCATION: UTRECHT, NL, 2004  
AREA: 36.250 M<sup>2</sup>  
ARCHITECTS: WIEL ARETS ARCHITECTS (WAA)

For the university in Utrecht, WAA architects designed a library where on the one hand working totally concentrated in silence, on the other hand, it is also a meeting place, with as stimulation the atmosphere that radiates the building. This 8-floor building is approximately 36x100 meters and is 30 meters high. The building facilitates both the group and independent study of students with 1.300 seats, 500 parking spaces, 560-student workstations, 300 librarian workstations, and an auditorium within its interior. Below, the text description provided by the architects

“The concrete book archives, which seem to float, conduct the space that is connected by stairs and ramps. Where the library’s black concrete surfaces are imprinted with the papyrus relief, book stacks are to be found behind, as the library does not have one central book depot, and instead utilizes multiple stacks dispersed throughout each level, which seem to float like black storm clouds throughout the main space. When totaled, these stacks house more than 4.2 million books. Between these black painted concrete structures are the public spaces, such as reading rooms and workplaces. To be able to provide this space with dimmed daylight, a glass façade, equipped with a screen print, is stretched around the concrete structure like a human skin. By extending the façade around the parking garage, which stands as a separate volume next to the library, a patio garden is created between the two buildings.” (Arets, 2018).

“Based on the idea of WAA that silent communication

is of great importance for the building, creating an atmosphere which emphasis is put on a feeling of comfort. This thought was essential in making a black interior. The light and shiny floor provide sufficient reflection of the natural and artificial light to illuminate the 4.2 million books on open shelves. The long white tables offer the opportunity to read a book or to use a computer. The workplaces are divided in the interior in such a way that the student determines the degree of communication by choosing a workplace. Absorption versus confrontation, concentrated working versus communicating, is the essence of the design plan.” (“Wiel Arets Architects | Universiteitsbibliotheek Utrecht”, 2018).

The most important part of the interior is the ‘routing’. From this, besides the workplaces, there are also other programs such as a café, a foyer, an auditorium, and rubber-covered receptions. Together with the extra added shops, they break the mono-functionality of the library program.



**fig.2.21** View of the library from the road side. The cafe on the left bottom and the bridge as a connection of two volumes of the library. © wielaretsarchitects.com



**fig.2.22** Site plan. © google.com/maps



**fig.2.25** View from the road side, with the main entrance in the plinth. The façade is covered with an abstracted image of fossilized papyrus printed on concrete panels, which are equal in size to the fritted glass panels. © archilovers.com



**fig.2.23** The library at night with the printed glass and concrete panels. The light from inside to outside. © wielaretsarchitects.com



**fig.2.26** Abstracted image of fossilized papyrus printed on concrete glass panels. © wielaretsarchitects.com



**fig.2.24** Exterior view of two separate volumes connected by the stretched façade. © bluffton.edu



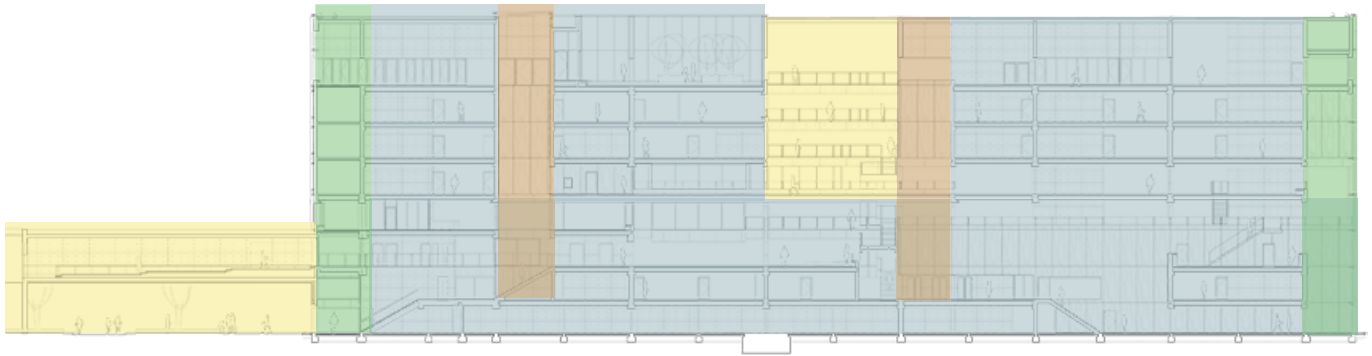


fig.2.27 Massing

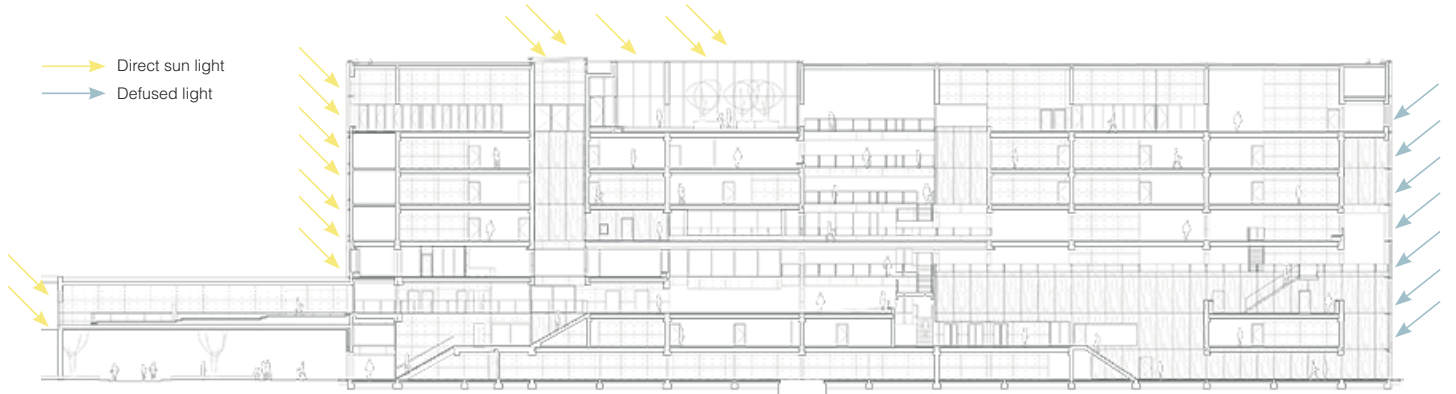
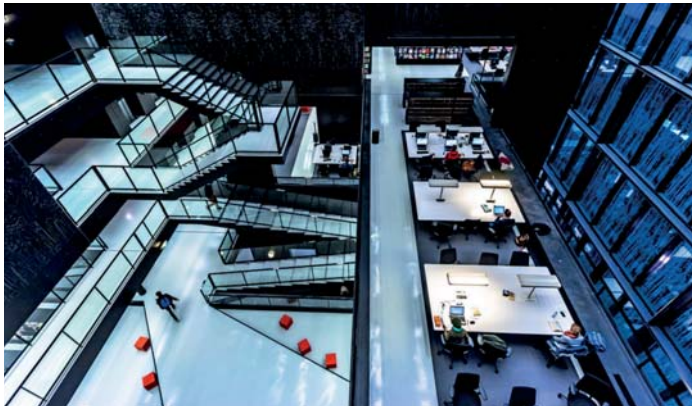


fig.2.28 Light



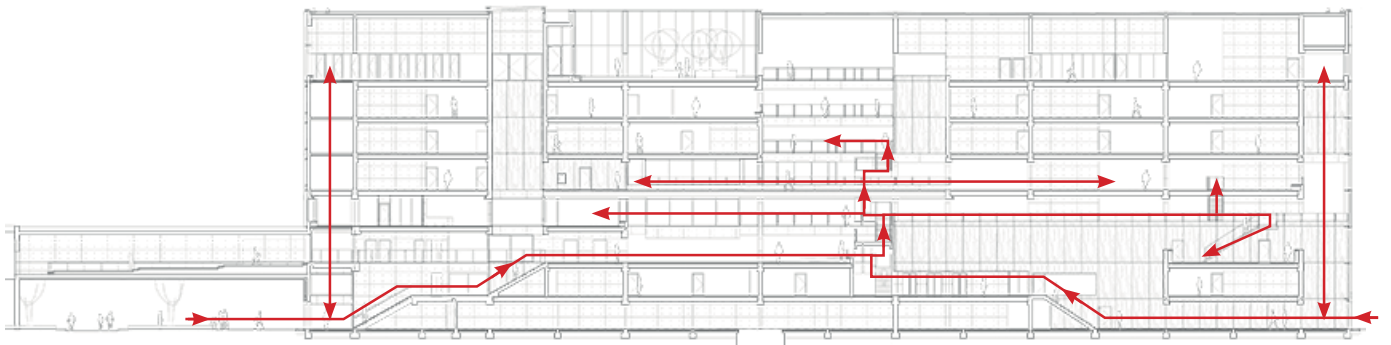
fig.2.29 Grid in section



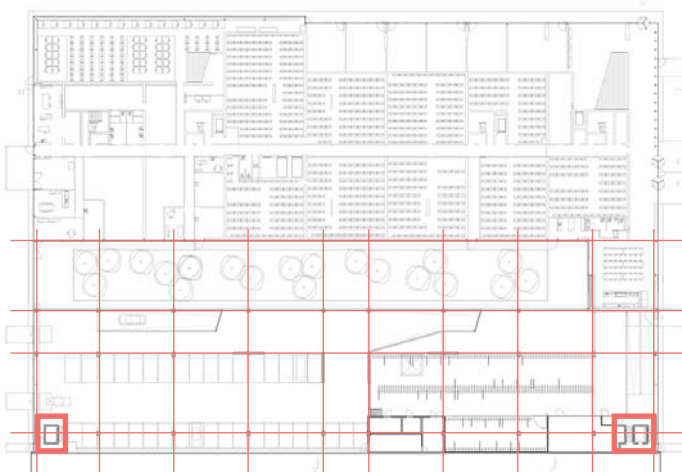
**fig.2.30** Auditorium within its cavernous interior. White surfaces denote circulation, while all black surfaces denote areas of study or contemplation. Photo © Maria Globetrotter



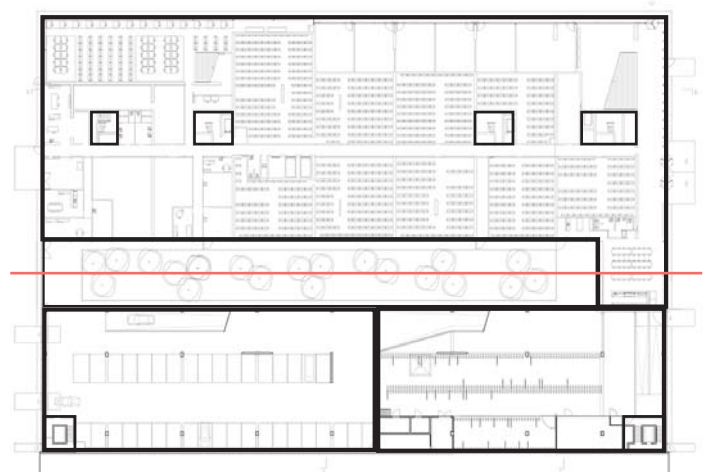
**fig.2.31** Black book stacks in contrast with glossy white polyurethane finished floors. Photo © Maria Globetrotter



**fig.2.32** Circulation



**fig.2.33** Grid/ Structure in floorplan



**fig.2.34** Balance/ Hierarchy

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### 2.7.3 Library of birmingham

FUNCTION: PUBLIC LIBRARY  
LOCATION: BIRMINGHAM, UK, 2013  
AREA: 35.000 M<sup>2</sup>  
ARCHITECT: MECANOO ARCHITECTS

“The Library of Birmingham (LoB) consists of a new-build library of 29.000m<sup>2</sup>; renovation and integration and newly build of the Repertory Theatre (4.519 m<sup>2</sup> newly build + 1.852 m<sup>2</sup> refurbishment); as well as public realm works for the historic Centenary Square including a recessed circular performance space in the square which engages the public with the library programme via a public entertainment venue. In the first year the LoB welcomed over 10.000 visitors per day.

LoB is more than just a building, Mecanoo’s design transforms the largest public square in the heart of the city into one with three distinct realms: monumental, cultural and entertainment that unites people of all ages and backgrounds. These palazzos form an urban narrative of important periods in the history of the city; The Repertory Theatre (REP), a 1960s concrete building, the Library of Birmingham, designed in 2009 and Baskerville House, a listed sandstone building designed in 1936. The busiest pedestrian route in the city, what Mecanoo calls the red line, leads pedestrians into Centenary Square.

A cantilevered volume not only provides shelter at the entrance, but also serves as a grand balcony with a discovery garden. The circular courtyard cut out of the square is a protected outdoor space that invites daylight deep into the building.

Visitors move from one floor to the next through interconnected and overlapping rotundas that provide natural light and ventilation. Ever-changing vistas

unfold through the delicate filigree skin of interlocking circles, inspired by the tradition of metalwork in this former industrial city.” (“Library of Birmingham”, 2018).



fig.2.35 Bird-view LoB in the city. Photo © Christian Richters



fig.2.36 The Repertory Theatre (REP) from 1960, The Library of Birmingham (LoB) and Baskerville House from 1936. © morrisroe.co.uk





**fig.2.37** Site plan. © google.com/maps



**fig.2.40** LoB is a sharp contrast with its predecessor's Brutalist concrete form. © dezeen.com



**fig.2.38** Entrance with the with a sunken amphitheatre. The Discovery Garden overlooks Centenary Square, and is the most public of the three terraces. © Mecanoo



**fig.2.41** Inside the open amphitheatre with the façade of LoB. A circular motif runs through the entire design. Photo © Christian Richters



**fig.2.39** "The building is an ode to the circle: an archetypal form that embodies universality, infinity, unity and timelessness". © Mecanoo



**fig.2.42** The façade with the delicate filigree skin is inspired by the artisan tradition of this once industrial city. © Mecanoo - © Lucy Wang

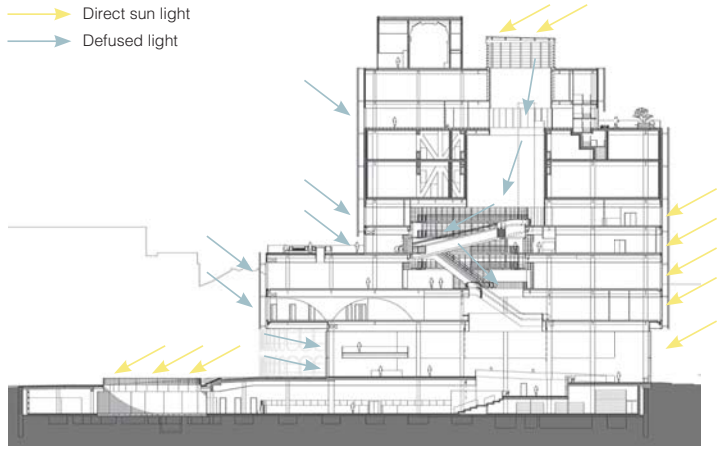


fig.2.43 Light

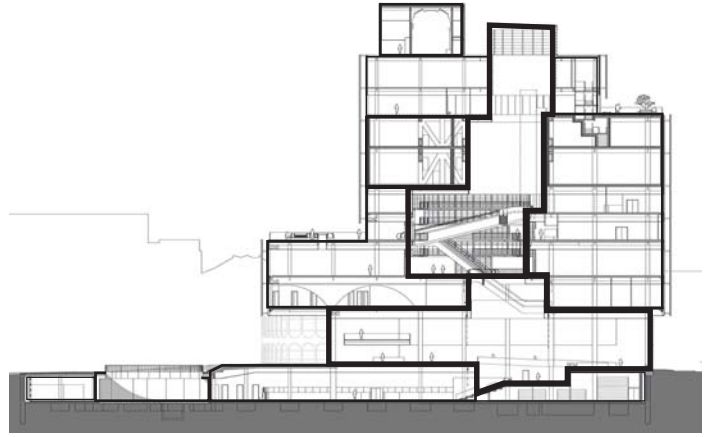


fig.2.46 Hierarchy



fig.2.44 Program



fig.2.47 Parti © Frost Landscapes

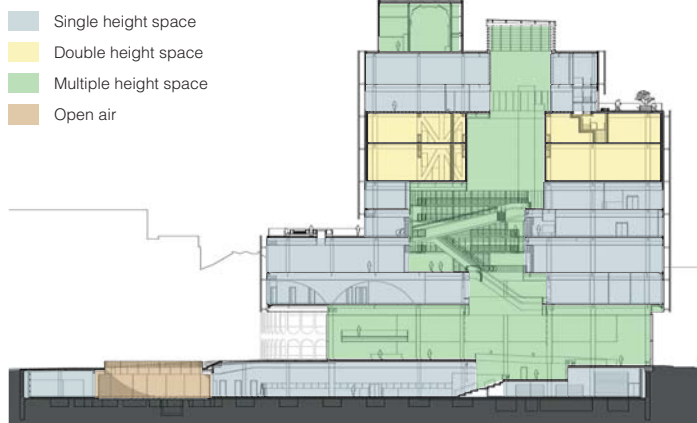


fig.2.45 Massing

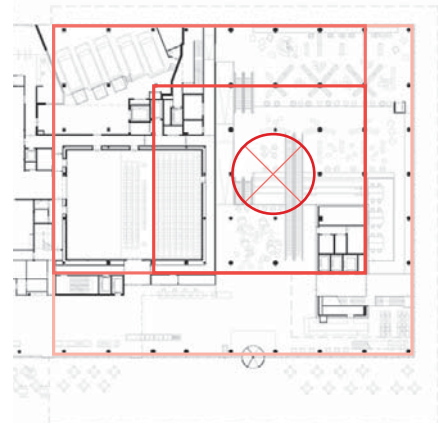


fig.2.48 Geometry/ Parti in floor plan





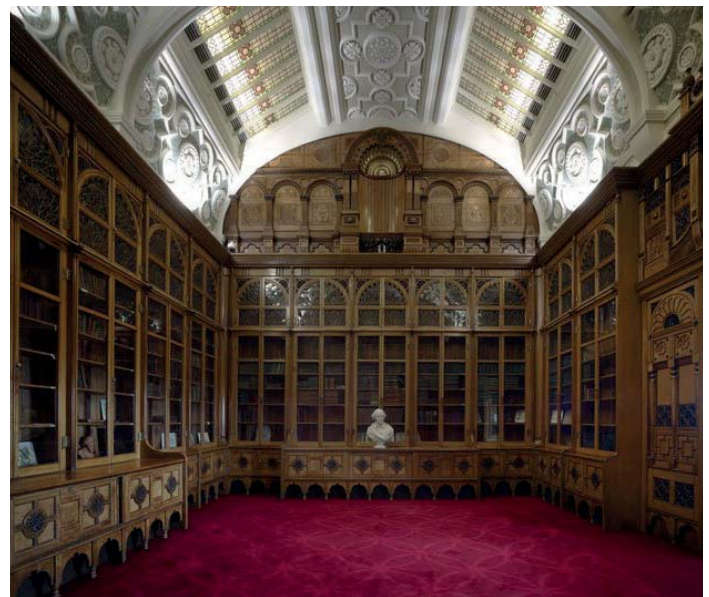
**fig.2.49** Reading (left) and Children's performance space (right).  
© Mecanoo



**fig.2.51** The rotundas (atrium) play an important role in the routing through the library and provide natural light and ventilation.  
© Mecanoo



**fig.2.50** Geometry in façade. © Mecanoo



**fig.2.52** The rooftop rotunda houses the Shakespeare Memorial Room, designed in 1882. © Mecanoo

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## 2.7.4 Prague technical library

FUNCTION: SCIENCE AND TECHNOLOGY LITERATURE  
LOCATION: PRAGUE, CZ, 2009  
AREA: 51.434 M<sup>2</sup>  
ARCHITECT: PROJEKTIL ARCHITEKTI

Below the description of the building, from the website of The National Library of Technology (NTK):

“The National Library of Technology is the largest and the oldest library of science and technology literature in the Czech Republic, with a collection of over 1.5 million volumes. Construction of the current building began in 2006, and it opened to the public on 2009. Its primary function is to provide specialized information resources and services to students, teachers, and researchers in the fields of engineering and applied sciences, as well as to educate members of the general public interested in technical information” (knihovna, 2018).

“In the technical campus, NTK provides around 1300 places to study for students and scholars with around 560 places to relax. The library offers team and individual study rooms, classrooms, self services regard to printing and a special study room whenever the library is closed. in addition, the library serves as a social and cultural center, with lectures, guided tours and exhibitions” (knihovna, 2018).

The building is an meeting place voor everyone and has three underground and six above ground floors.

Rose Etherington from [dezeen.com](http://dezeen.com) describes the organization as follows:

“On the ground floor and the second floor there is the main entry to the library and all complementary facilities – conference hall, exhibition hall, cafeteria, bookshop and cloak room. All of them are around the

entry hall which is the main place for meeting people not just from the library but from the whole university campus. That is the reason why the building has not one but four entrances to all sides. The idea was to give to the campus, not just a library, but a needed public place as well; where all the students could meet together.

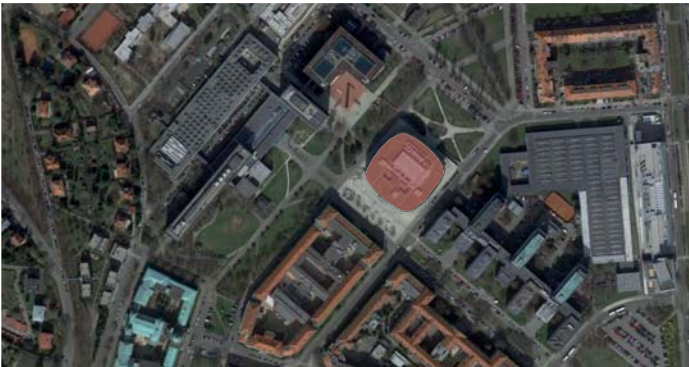
The visitors then follow up to the second floor and the atrium hall with the main desk. The atrium is naturally lit through the skylight and it is the main space of the whole building. Then the library floors follow from third to sixth. The setup is similar. On the north side of the floor there is the administration section. In the public part there are the study places and study rooms of different sizes next to the façade, followed by book shelves in the darker part of the floor and finally an info desk and other study places around the atrium with natural light.

The interior is very open and friendly to express the openness and friendliness of the contemporary institution. The main elements are the power-colored floor and the orientation of all lighting which point to the very middle point of the building. In every room you are sure about your position. Some furniture was developed especially for the library to give visitors a free-minded feeling. They are movable so the students can build their own constellations from them. The main principle of interior design is about collaboartion and reciprocal influence.” (Etherington, 2018).



**fig.2.53** Panoramic view of NTK and the city. © [norakaucuk.com.tr](http://norakaucuk.com.tr)





**fig.2.54** Site plan. © google.com/maps



**fig.2.57** Site plan. © google.com/maps



**fig.2.55** One of the entrances with measures which shows how tall/wide the building is to get a real sense and understanding how tall/high 21m actually is. © dezeen.com



**fig.2.58** Wrapped in glass rain screen channel system that creates soft glow and dimensional feel of the façade. © apodesign.com

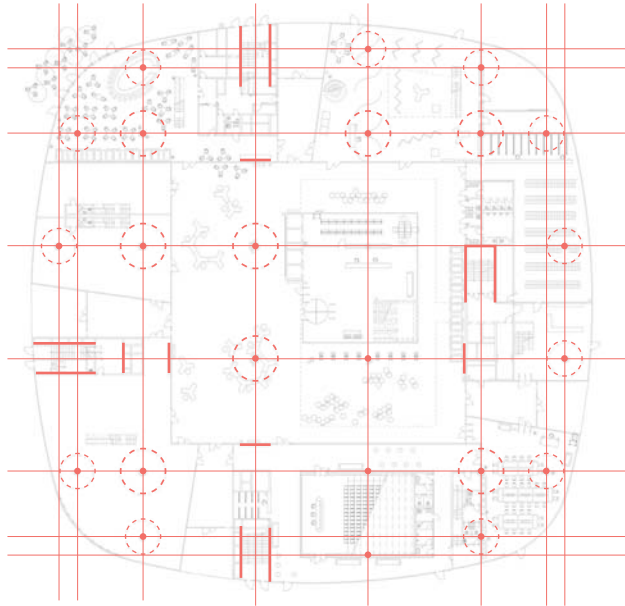


**fig.2.56** "The building in its context which involves the historical urbanistic plans for the whole area as well as its present significance". © Rose Etherington

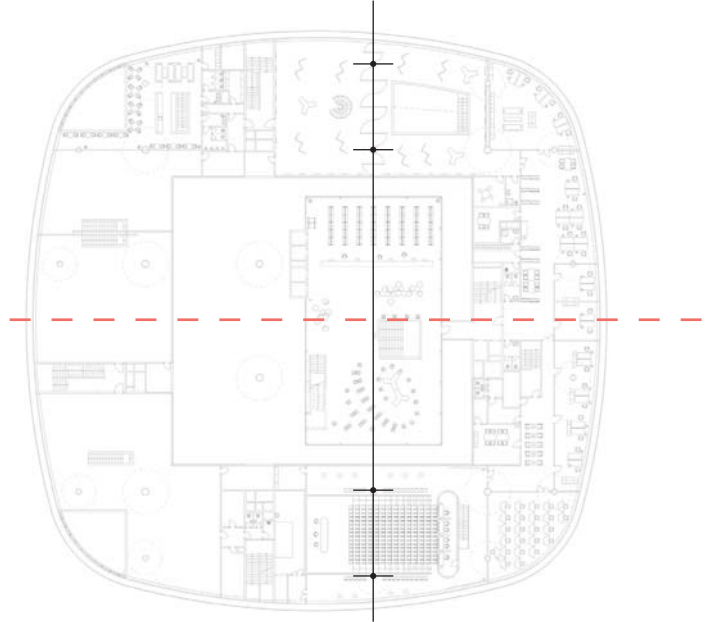


**fig.2.59** The entrance NTK 1 in the evening. The play of light from the linear lines strengthened the floors of the building. © dezeen.com

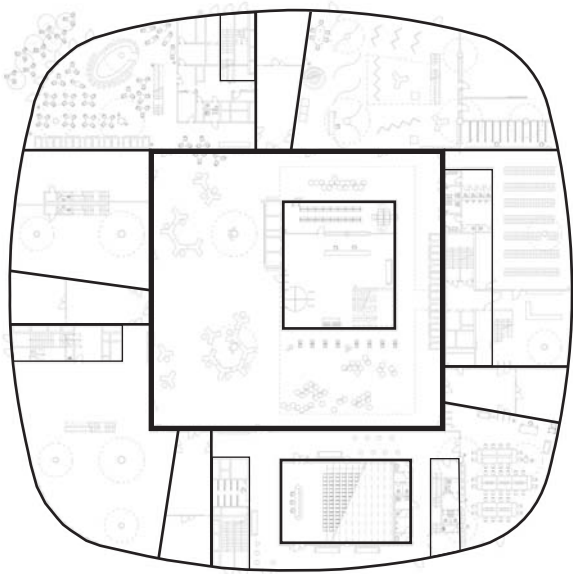




**fig.2.60** Grid/ Structure - 1st floor

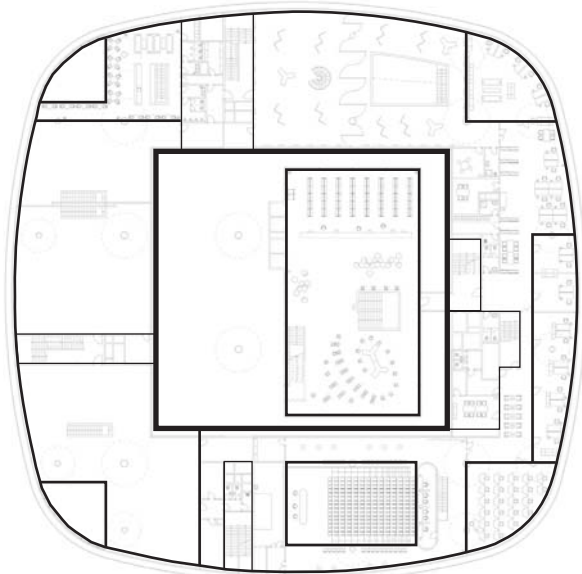


**fig.2.62** Symmetry/ Balance - 2nd floor



**fig.2.61** Hierarchy floorplans

1st floor



2nd floor



**fig.2.63** 1st floor Library entrance with a café, the Municipal Library branch, Balling conference hall, the After Hours Reading Room (to study at night and when the library is closed), and Gallery NTK. © techlib.cz

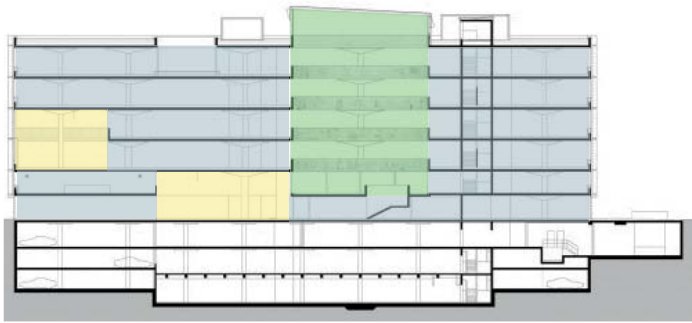
1- entrance, 2 - lobby, 3 - library entrance, 4 - conference hall, 5 - exhibition, 6 - cafe, 7 - study room, 8 - staff entry, 9 - cloakroom, 10 - city library, 11 - bookshop, 12 - main library, 13 - administration



**fig.2.64** Program floorplans © dezeen.com

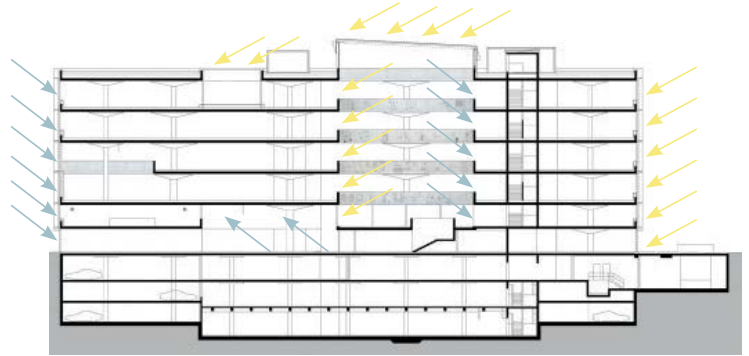
1st floor

2nd floor



Single height space Multiple height space  
Double height space

fig.2.65 Massing



Direct sun light  
Defused light

fig.2.67 Light

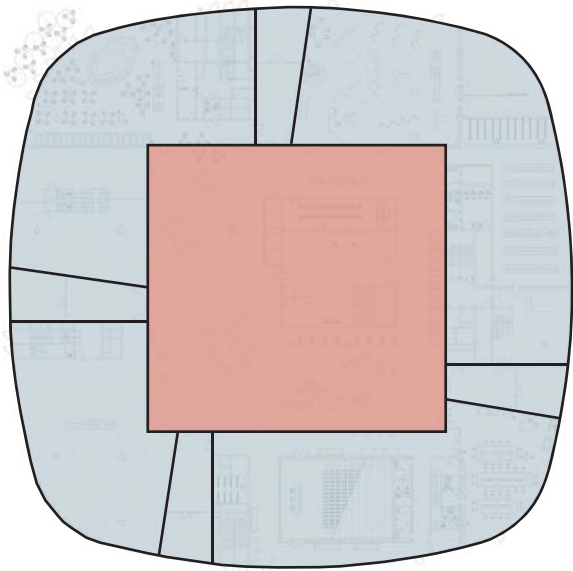


fig.2.66 Geometry - 1st floor



fig.2.68 All lighting points towards the centre of the building to help with orientation and the concrete interiors have brightly-coloured flooring. Photo © Andrea Lhotakova





**fig.2.69** Library area with the storeys are arranged around a central atrium. © apodesign.com



**fig.2.71** Atrium study with the illustrations on the railings. The power-colored floor and the orientation of all lighting which point to the very middle point of the building. Photo © Petr Vocelka



**fig.2.70** Effect of natural light inside the atrium through the glass rain screens on the façade. © Rose Etherington



**fig.2.72** The conference hall in the colors black and white on the first floor. © Rose Etherington

2.8 COMPARISON





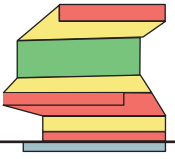
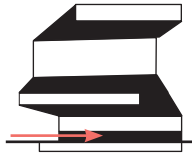












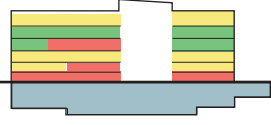






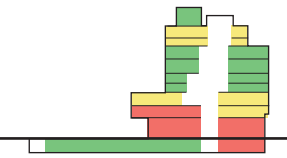
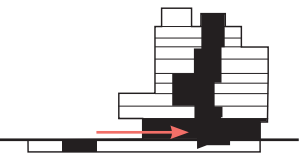





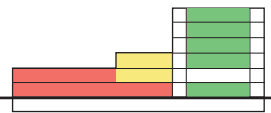
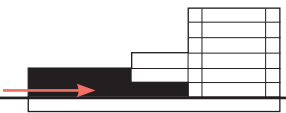
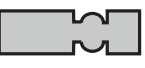




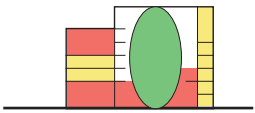
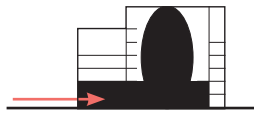
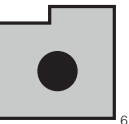

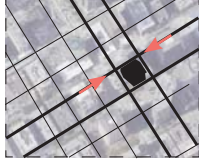







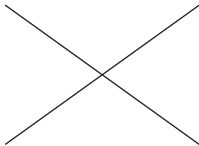


BUILDING	SIZE			AVERAGE NUMBER OF VISITORS/ DAY	NUMBER OF BOOKS (# x 100.000)		NUMBER OF PCs (# x 100)	ORGANIZATION		VOID AND ENTRANCE	VOID AND FUNCTIONS	floor level #
	height (m)	length (m)	width (m)		area (m <sup>2</sup> )	MEETING (LOUD)		STUDY (SILENT)	PARKING			
SEATTLE LIBRARY 	56	73	70	38300	 7500	 10	 4				3	
UTRECHT UNIVERSITY LIBRARY 	30	100	36	36250	 5000	 42	 5				6	
PRAGUE TECHNICAL LIBRARY 	21	70	70	51434	 2500	 11	 3				3	
LIBRARY OF BIRMINGHAM 	60	57	68	35000	 10000	 8	 3				7	
OLD LIBRARY OF GHENT 	30	103	22	8000	 3500	 4	 1				1	
'CENTRALE' LIBRARY GHENT 	35	60	65	20000	 5000	 8	 2				6	

fig.2.73 Scheme comparisons of different public libraries versus the new 'Centrale' library building



SOLID/ FUNCTIONS	CONTEXT AND ENTRANCE
	
	
	
	
	
	

n/a

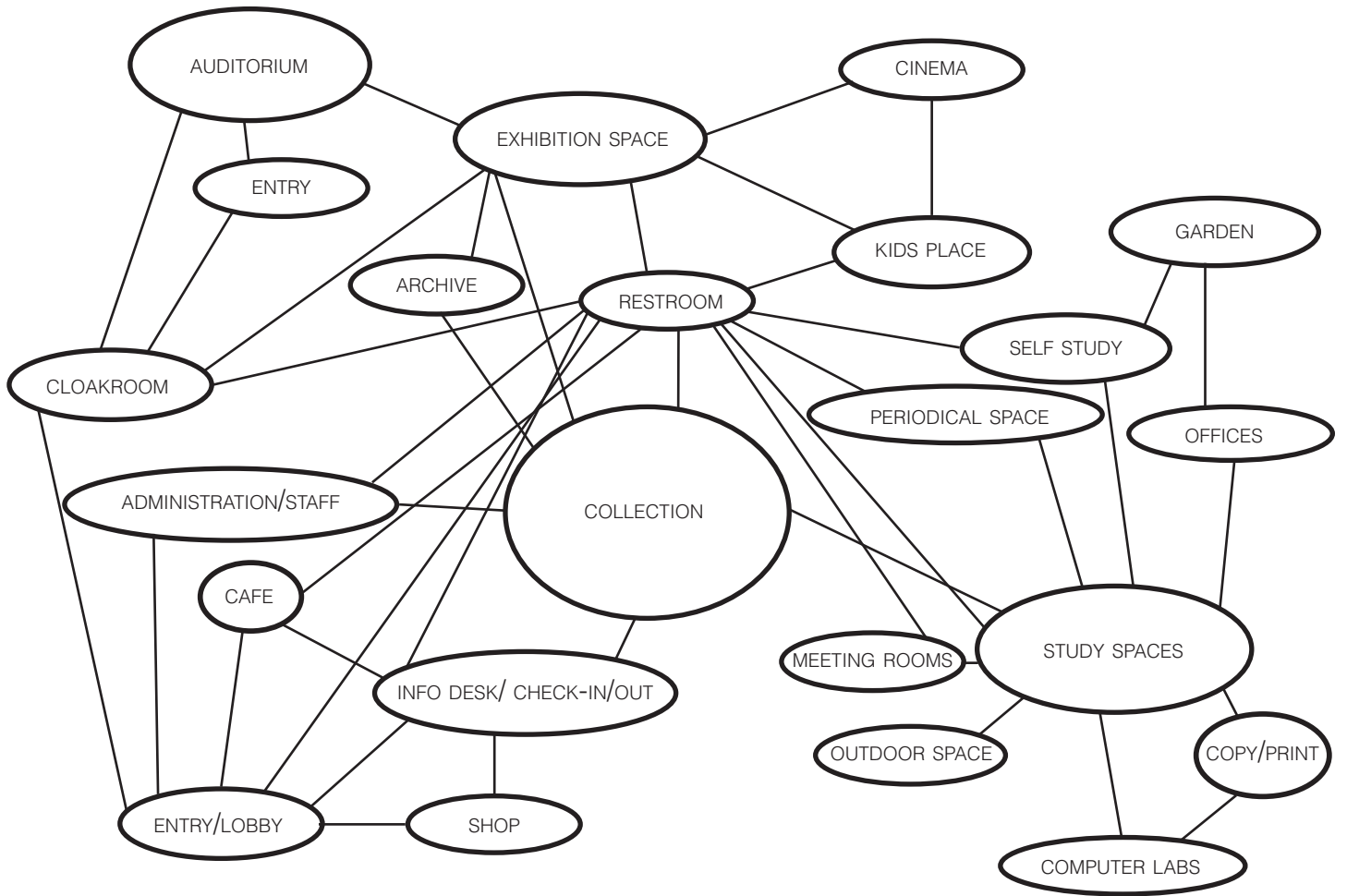
© google.com/maps

The chosen projects in the case studies have a lot in common with each other. For example, the surfaces of the buildings are about the same size and the average number of visitors is almost the same. It is striking that the access is located on a busy and important street or road where many people come. This creates an inviting building. The void on the inside of the buildings is mostly in the center of the building because the libraries are organized 'centrally'. This means that the transition starts from the 'center' of the building and ended in the other areas. This gives a clear and simple layout which ensures a smooth circulation within the building. It starts from the street and goes to the inside through the entrance in the direction of the void of the building.

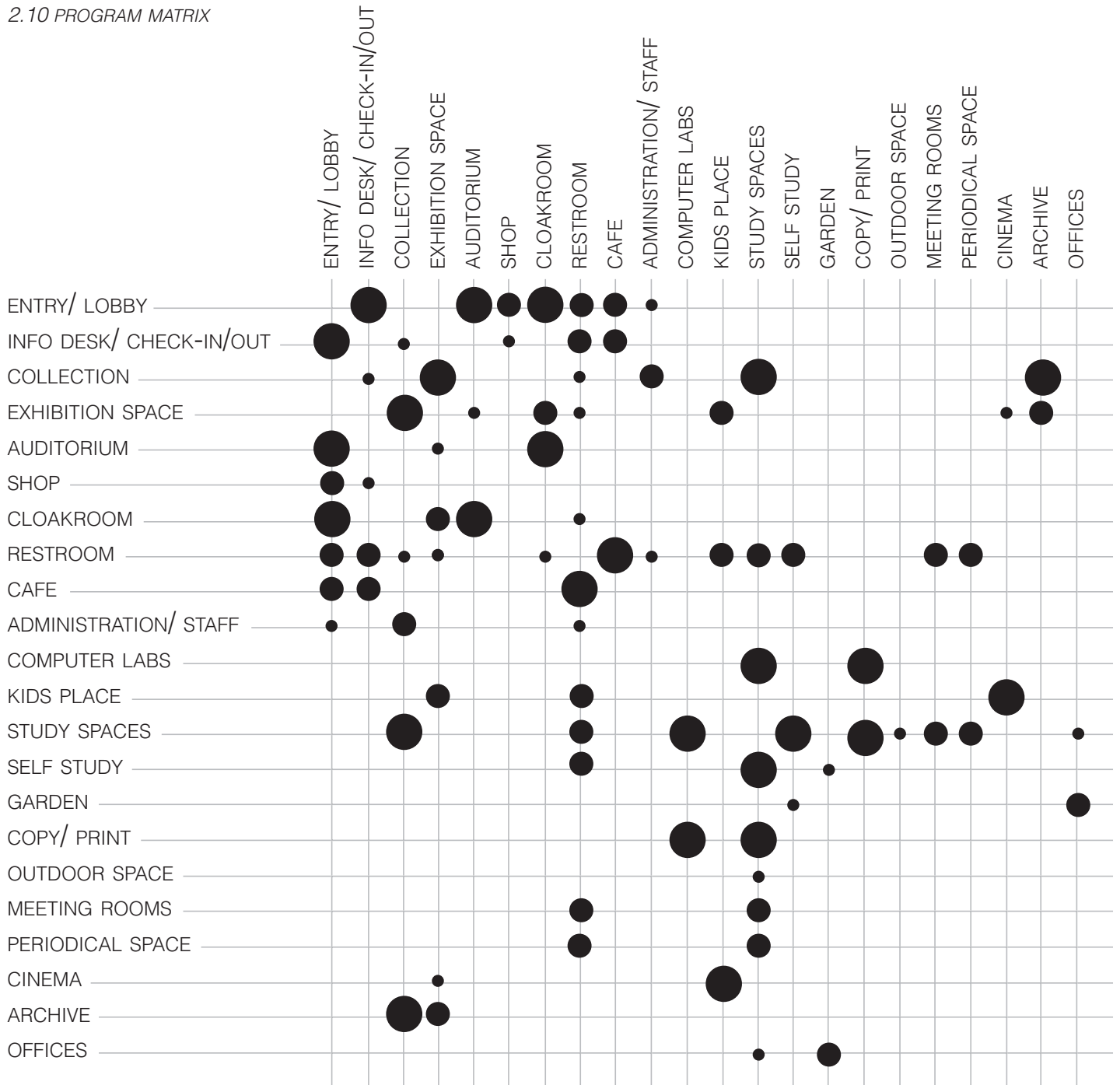
The organization is diverse in all the chosen libraries and are not clustered. The functions are spread out in the building so that the visitors can understand and experience the building. In addition, various spaces can be found in the library. On the following pages, a bubble diagram (2.9) and a program matrix (2.10) has been made to clearly indicate which spaces are connected to each other and their sizes (bubble diagram). Further, in the program matrix, the spaces are assessed by three different dots (levels) which indicates the need and the most applicable spaces with each other.

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2.9 BUBBLE DIAGRAM



2.10 PROGRAM MATRIX



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### 2.11 KEY FEATURES

Remarkable, from the structural vision of municipality Ghent in chapter 2.5, the case studies in chapter 2.7 and the comparisons in chapter 2.8, shows that there are a number of architectural features that returns in all public libraries: (1) the collection itself, (2) public meeting spaces within the building and (3) the circulation. All these key features could be called the 'organization'. The organization of a public library must work very well to be able to function successfully, just like the chosen projects. It must be readable and clear so that you as a visitor know exactly where you need to be. A clear layout can be a solution here.

#### 2.11.1 Collection

The collection consists mainly of books, but also magazines, newspapers, and journals are included. In addition to needlework, you also have digital sources by using the computer.

#### 2.11.2 Public meeting spaces

This is a broad understanding which in short could be summarized as a public function with the aim of meeting in different ways. For instance; spaces where exhibitions are, spaces where people work together or cafes and shops, which is also in almost all public libraries.

#### 2.11.3 Circulation

How do you get to a certain place in the building? The way of moving through the building is an important factor. In the case studies in chapter 2.7, you quickly notice that there is a clear circulation. It must remain attractive for the visitors which are moving around the whole building. It must be a kind of amusement when the visitor walks through the building.

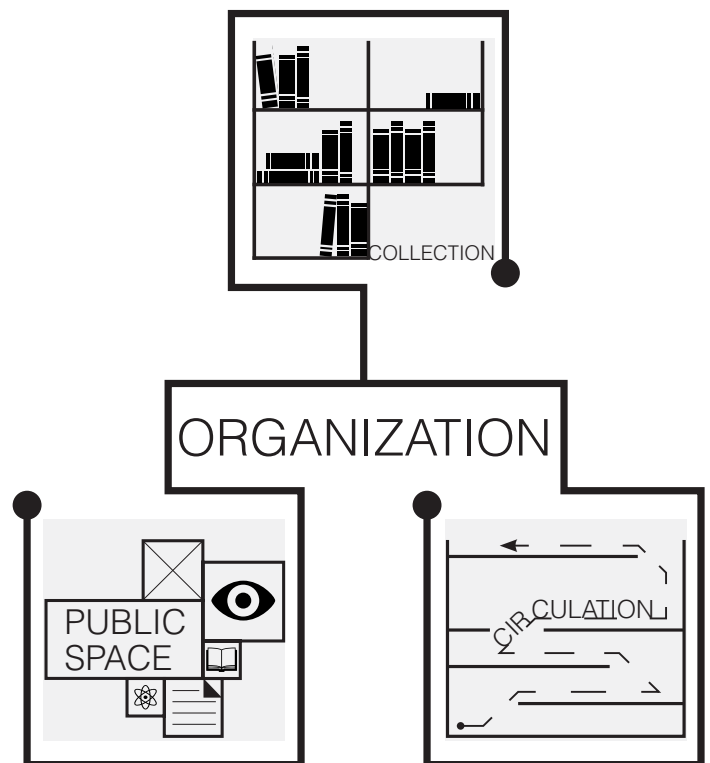
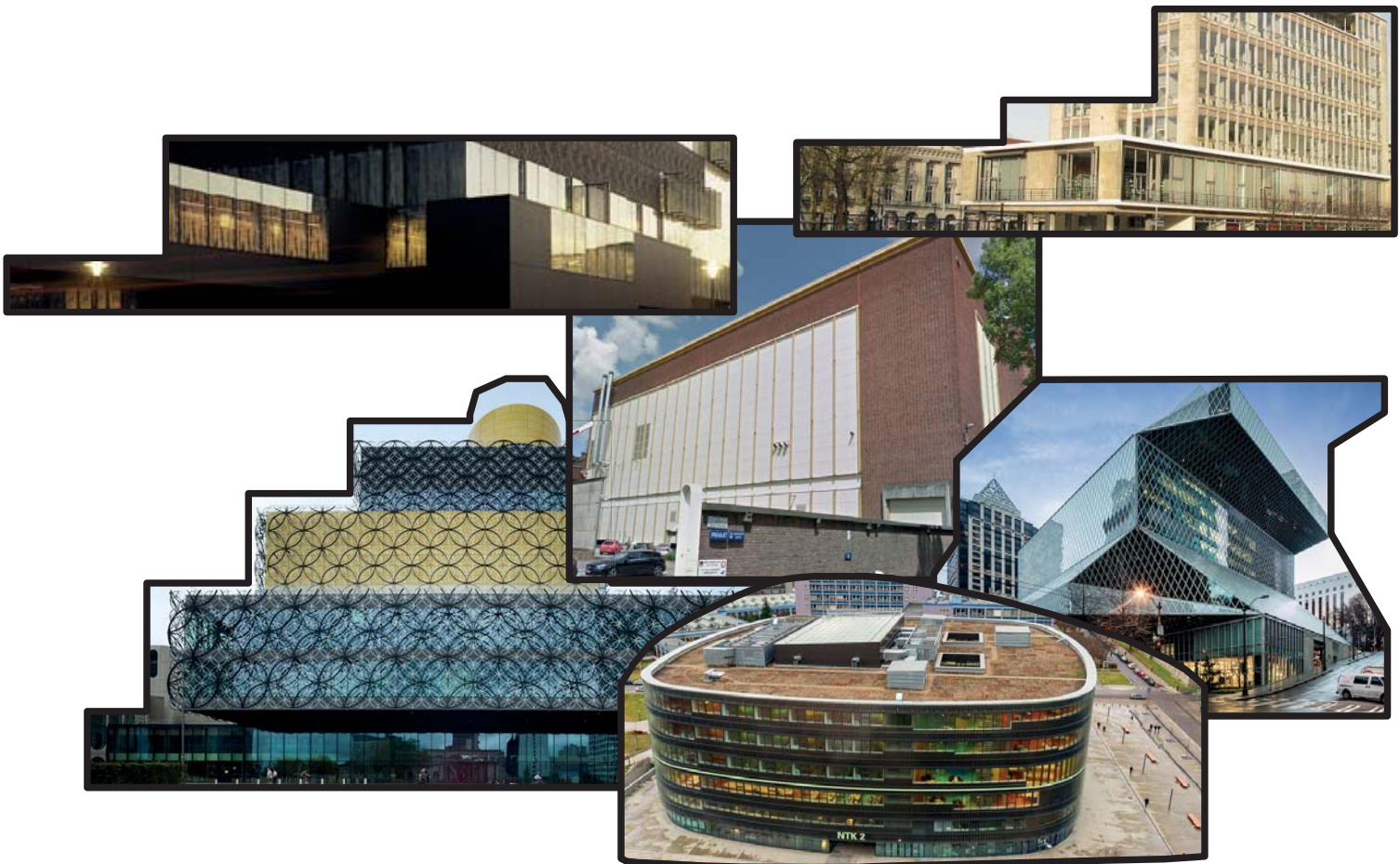


fig.2.74 Scheme of key features of public library



**fig.2.75** Collection of the chosen libraries vs. the 'Centrale' library Ghent



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### 3. 3D CONCRETE PRINTING

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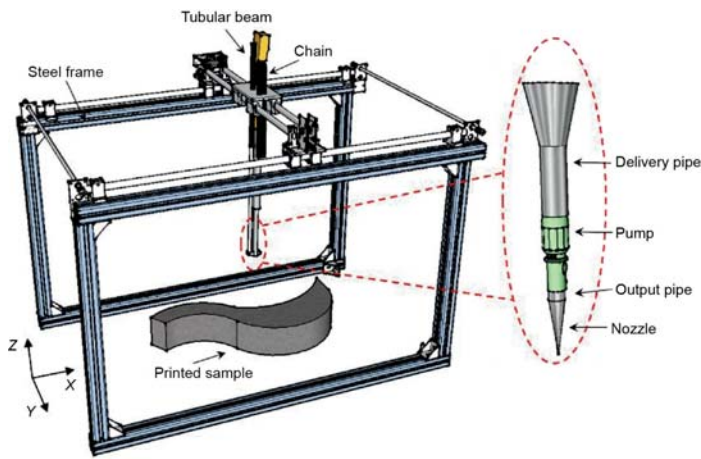
The first part of this graduation studio was about the new innovative technique of 3D concrete printing (3DCP). This technique is a largescale construction process. Continue on this, on the concrete printer, the print head used for the extrusion of cement mortar is mounted on an overhead crane. Printing nozzle moves along a pre-programmed path and continually extrudes concrete materials. This technique is also based on the extrusion of cement mortar, but this method has a smaller resolution of deposition, results in better controlling of complex geometries (Lim S, et al. 2012). Concrete printing has the potential to produce highly customized building components. figure 3.1 illustrates the operation process of concrete printing. Printing head installed in a tubular steel beam can freely move in X, Y and Z directions. Fresh concrete is firstly delivered to a pump through the delivery pipe. Then concrete material is delivered smoothly to the printing nozzle, which is in different size and form available, with the help of the pump. Finally, concrete filaments are extruded out from the nozzle to continually trace out the cross-section of structural components.

3DCP deposits concrete mixture through a nozzle to build structural components without the use of formwork and subsequent vibration. A research team at Eindhoven University of Technology (TU/e) has already unveiled their massive concrete 3D printer to the public. The printer is made of a four-axis gantry robot and features a print bed of 9.0 m×4.5 m×3 m (figure 3.3). It also has its own mixing pump, with the entire printer controlled by a numeric controller (O'Neal, 2016).

In the first week, you were asked about your first thought about 3DCP. After searching for information about this topic, I thought this technique could provide some solutions for the building process. The advantages of this technique are less use of concrete

during printing and much profit in hours of work. However, you are limited to a pre-set surface (space) to carry out your print. During printing, you quickly discover that it is a rehearsal of a certain shape (structure of layers) like in figure 3.4. This ensures that the specific form is converted from 2D to 3D shape. Understanding this whole procedure and basing a design on this technique is complicated and has a different way of thinking to design that I am used to. The way of concrete printing in your mind during the design process, unfortunately, gives me limits to be really free to design. In the first time, I do not see a whole building printed in 3D concrete, but it has the potential to print part of the building like elements such as walls, columns. Using these elements will reduce time and labor during the building process.

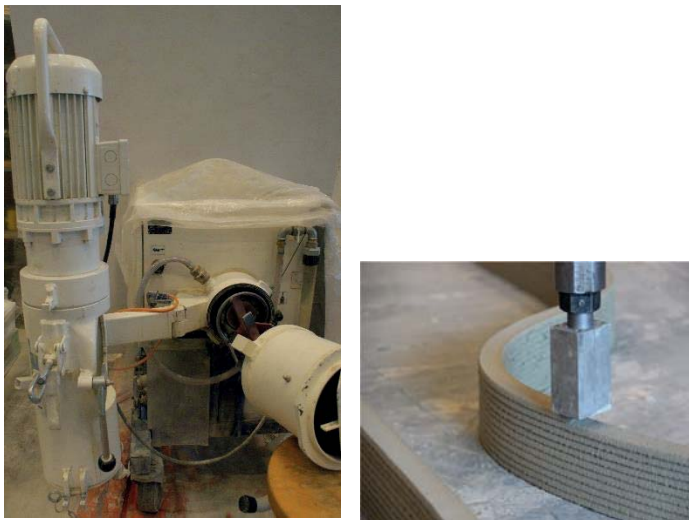
In this study about 3DCP, five subgroups of three or four students each focused on improving possibilities for 3D concrete prints in relation to architecture. Each group has focused on a different aspect like 'Transition, Joint, Fractale, Scaffolders and Assembling'. Each of the studies are directly related to each other when used for the realization of architectural design. I participated in the group which has the subject 'Assembling'. I will explain this further in the following pages with the individual follow-up steps. In the end, these chapters gived us the opportunity to achieve our goal which is 'investigating the creation of a family of interlocking elements that can be connected to a computational design with the aid of a robotic arm'.



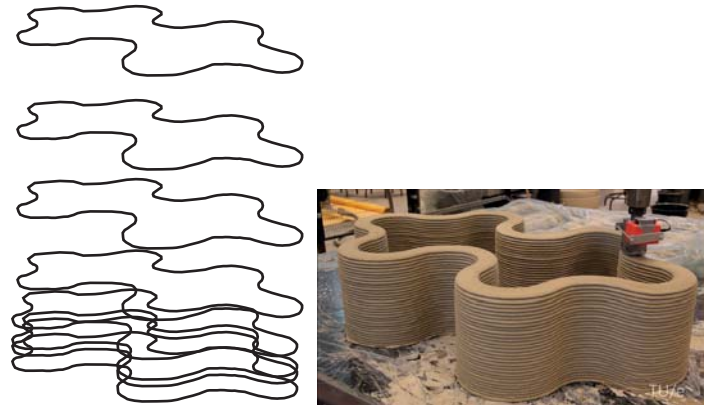
**fig.3.1** Schematic of concrete printing. © GuoWei et al.



**fig.3.3** 3DCP at TU/e made of a four-axis gantry robot and features a print bed of 9.0m × 4.5m × 3m with its own mixing pump and controlled by a numeric controller. © Photo by Doomen



**fig.3.2** Mixing pump and a random nozzle for printing concrete. © Photo by Doomen



**fig.3.4** Structure of layers - rehearsal of a certain shape. © TU/e

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### 3.1 ASSEMBLING

Interpretation and definition of Assembling according to our group within the 3DCP topic; Combining a flexible family of elements to create a composition. In order to have a maximum design freedom it should be possible to assemble and disassemble cells from an object.

3D concrete printing (3DCP) provides a great freedom in form and diversity of products. The complexity in 'building blocks' also raises the question in which way a variety of components can be connected through a smart and innovative way. By introducing assembling it is possible to increase design freedom. This results in the possibility to infinitely extend assemblies. In contrast, a complexity in design arises. The human mind and physical limitations are surpassed by this design strategy. This research within the 3DCP topic aims to investigate the creation of a family of elements that can be connected to a computational design with the aid of a robotic arm.

By assuming a basic shape, it is possible to provide a logic where later choices can be based on. The design freedom of assembling creates a complexity. The result is a large amount of specific elements that needs to be assembled in a precise way. This fact introduces the need for a new building method in the form of a programmed ABB robotic arm. This robotic arm makes it possible to place objects at a specific location with precise coordinates using his gripper, which provides the possibility to grab and release objects. The specifications of the gripper are aligned to the characteristics of the basic shape. However, these parties of elements (basic shapes) offer the possibility to create a system in which individual components are connected to a dry connection. The components are connected to each other by stacking on top of each other. Therefore, A script provides the request for an stacking structure. A whole that meets

the established guidelines and can also be built.

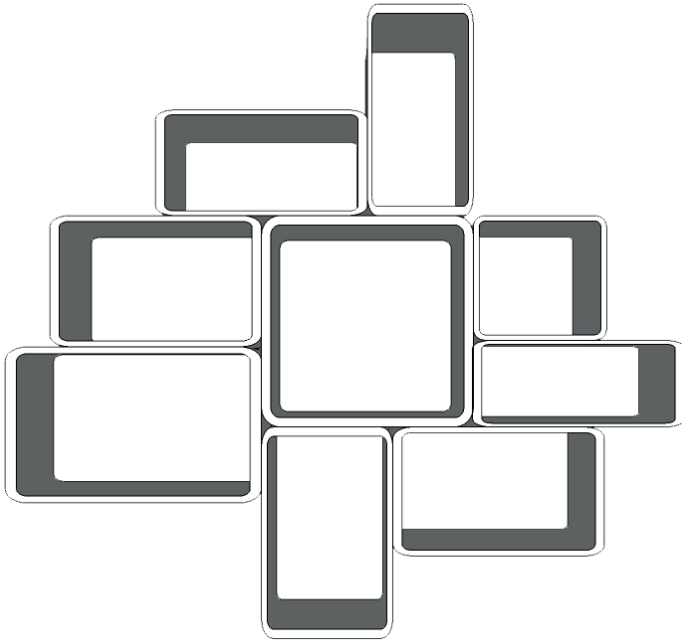
#### 3.1.1 Basic shape

One of the assumptions for the design is the development of a basic component, a cell. This result gives the possibility for multiplication of the design logic and offers the possibility for up or down scaling in other applications.

The development of the discrete shape is an iterative process. A process that depends on many factors whereby close collaboration with other research group is essential (e.g. curving). Studies have been made of various shapes taking into account the capacities, limits and possibilities of the 3DCP. From this, the basic shape has been further developed.

To find the right shape to use as a cell different possibilities are researched. Searching for the right shape it is important to keep in mind the possibilities of the 3DCP and of the material. These requirements has to be on one line otherwise it can give failures.

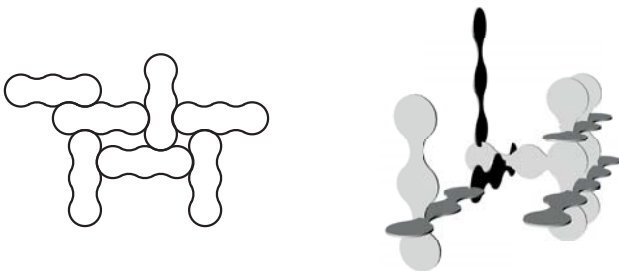
First, curved shapes have been used as an example (figure 3.6). As seen in the example there are difficulties in when you try to go 3D. The curved sides doesn't give the support to each other. Secondly, the hexagon shape is used (figure 3.7). The main problem of this shape is how the forces are going within this shape. Concrete can not handle the forces which go threw the hexagon shape. At last, combining the limits of the 3DCP and concrete quadrangle shapes are used for the design (figure 3.5). This shape is also used in different groups within the project.



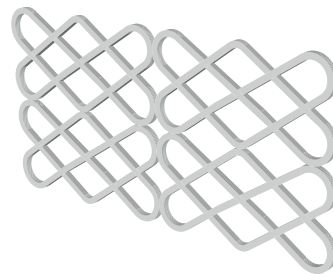
**fig.3.5** *Quadrangle shape. This shape has 4 face which could be different from each other. Every angle is curved and can vary in different sizes and setup. The assembling of these complex shapes can be applied in different ways. For example, the joints of the joinery group could be used. This shape is printable by the 3DCP and is assumed for the design.*



**fig.3.7** *Hexagon shape*



**fig.3.6** *Curved shapes - circle*





### 3.1.2 Cell to elements

Complexity origins in simplicity. A basic cell which has a quadrangle shape offers the desired structural and visual performances. Complex elements can be created from the cell. The logic is found in a coherent 'family' of five interlocking elements like in figure 3.10. These five elements offer a great freedom in form that is also expandable. Each element has been elaborated with consideration of structural logic and mutual connection.

### 3.1.3 Robotic arm

The introduction of a robotic arm is a necessity for a design with complex shapes. By developing family of elements, optimal structures can be developed. A robotic arm and gripper offers a solution in the assembly of these structures. A pre-programmed system which can be applied by the robotic arm to assembly.

First, looking at the properties of the ABB robot (figure 3.8). The robot of TU/e has a capacity of lifting 125 kg. If the gripper is strong enough it will be possible to lift 125 kg otherwise it will be less. At the end of this theme the aim is to decide on a gripper. This will be designed or put together from existing ones.

Secondly, it is important to know how the robot is going to work, for example stack on top of each other (figure 3.9). This depends on how the element is printed and how it is going to be assembled. If the form needs to be turned to be assembled than the gripper needs to be capable to do this. Otherwise there will be a second machine which will position it in right way and the robot has only lift it in y-direction.

Thirth, when stacking precision is important. There has to be no contact with the elements next to it. Looking from different ways of grabbing it the gripper will get a shape. It can also give a combination of

different ways of grabbing. There are a lot of ways the grab but in principle there are grabbing from outside, inside and vacuum.

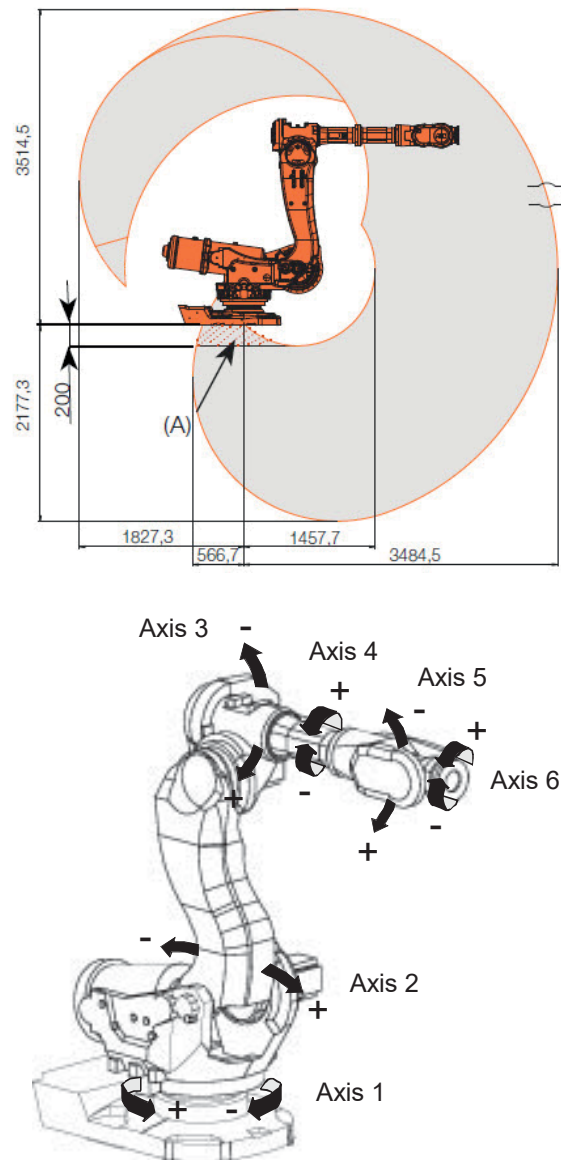
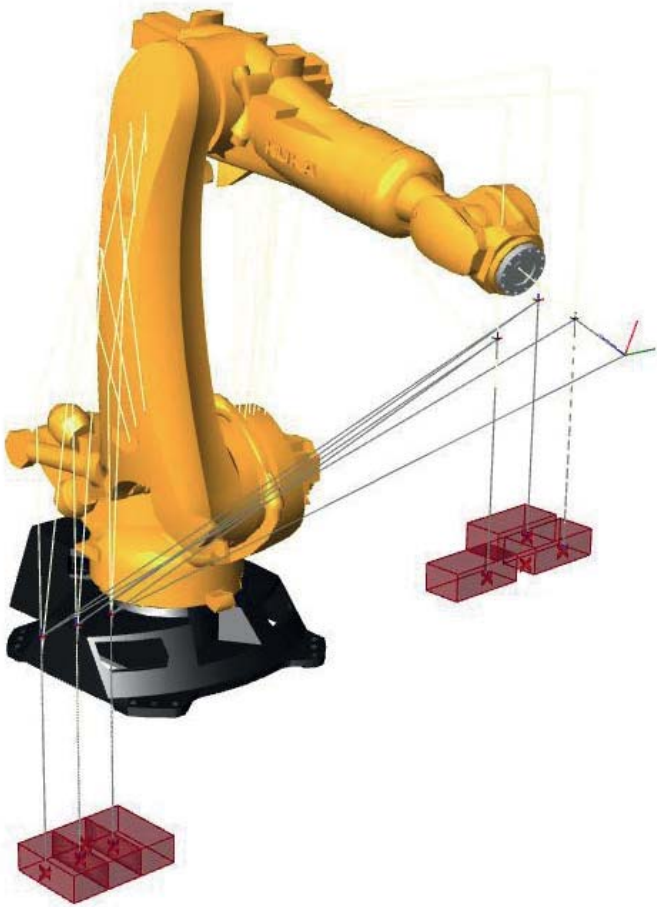
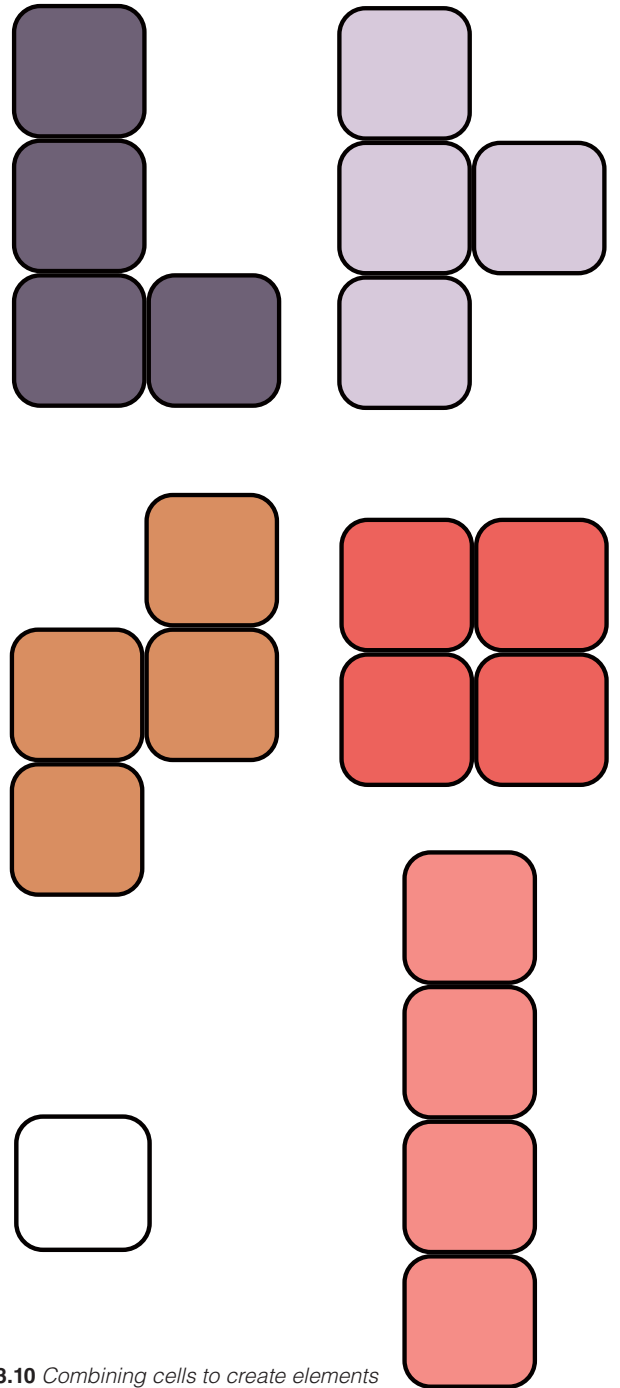


fig.3.8 The robotic arm type IRB6650 in TU/e - © abb.com



**fig.3.9** *The robotic arm stacking elements on top of each other*



**fig.3.10** *Combining cells to create elements*

### 3.1.4 Script

In this example of the sofa below which has been divided into voxels, the script combined squares into elements which interlocks (figure 3.11). The rules in the script makes these elements. For the human mind it can be very difficult to make it. The complexity can be achieved by using a script (Tan et al., 2018). Important part of this are the rules you give it so it can be build.

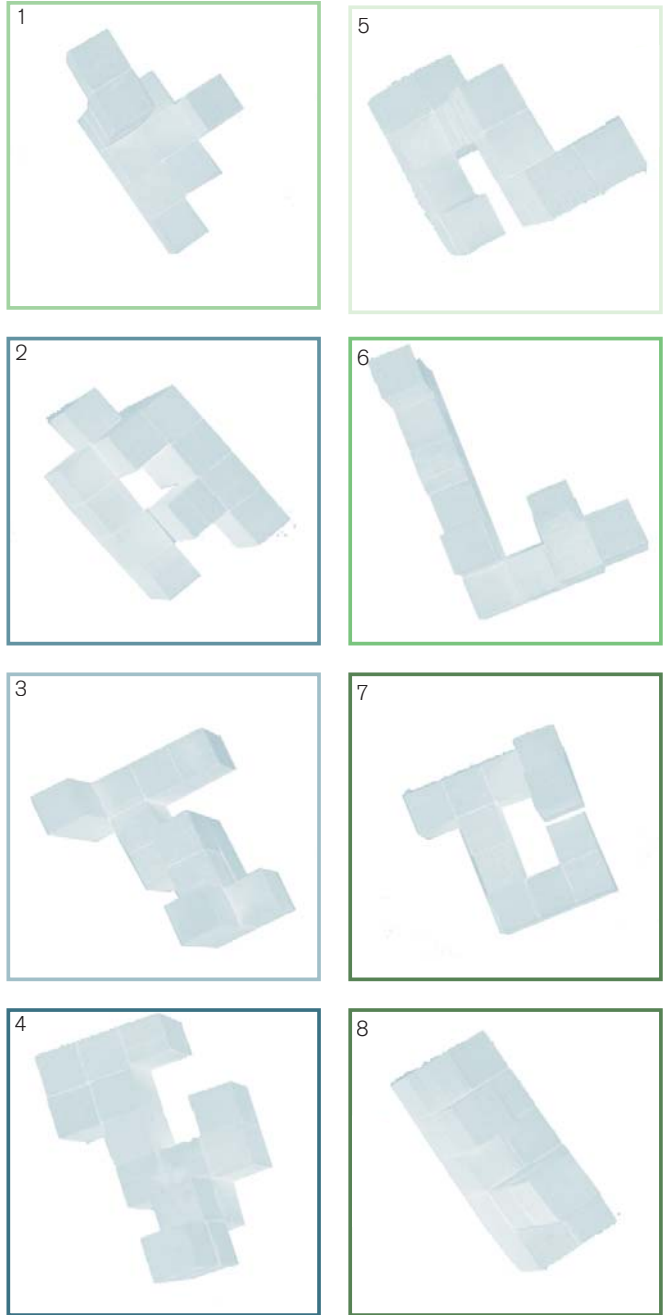
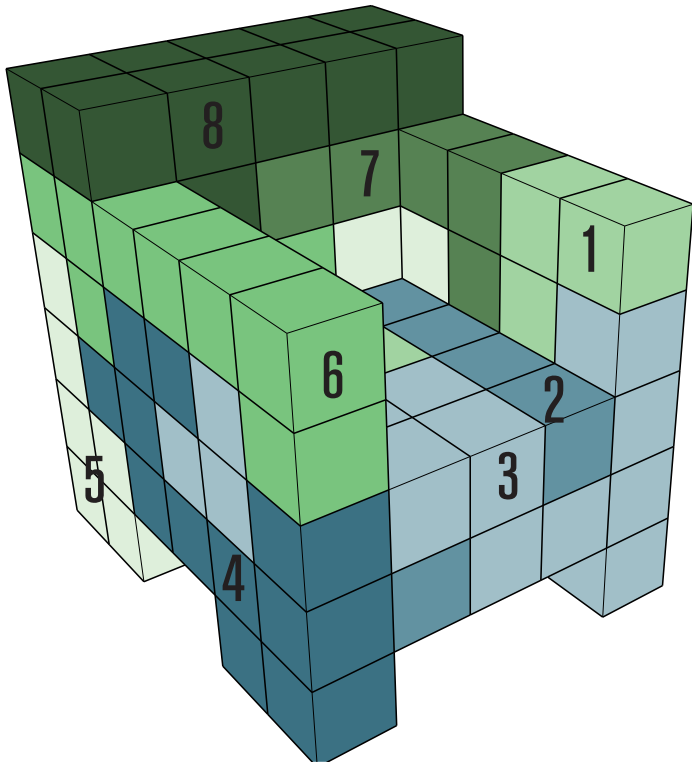


fig.3.11 The sofa divided into voxels

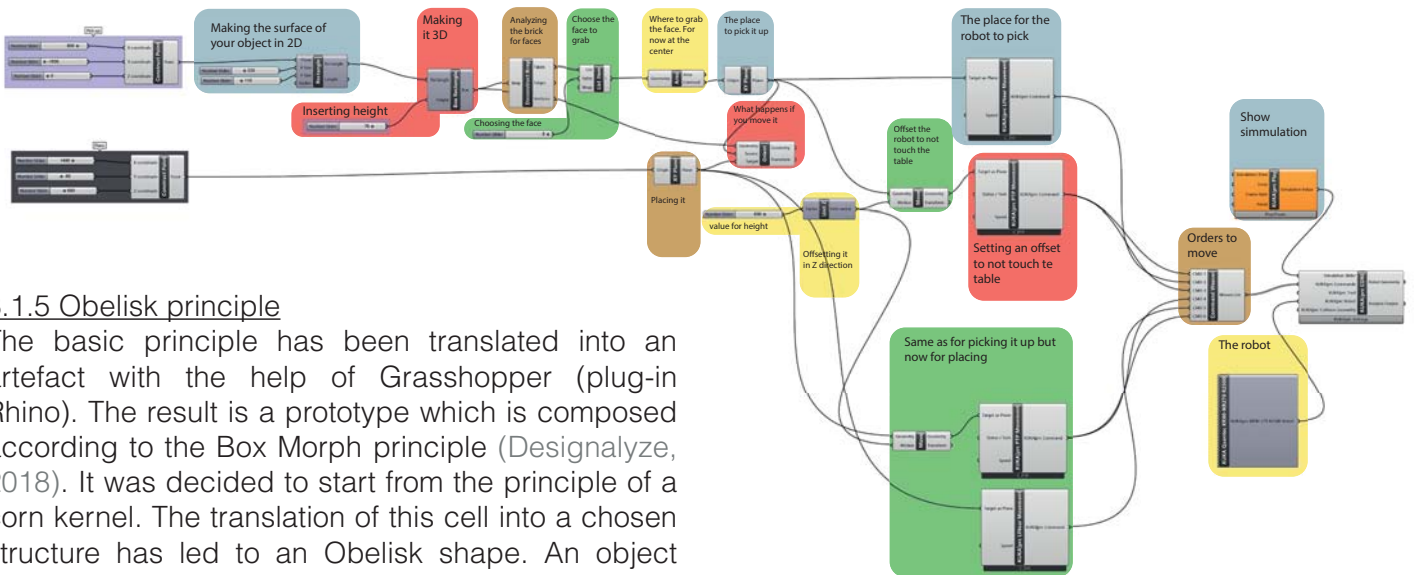


fig.3.12 The script to generate and build the design

### 3.1.5 Obelisk principle

The basic principle has been translated into an artefact with the help of Grasshopper (plug-in Rhino). The result is a prototype which is composed according to the Box Morph principle (Designalyze, 2018). It was decided to start from the principle of a corn kernel. The translation of this cell into a chosen structure has led to an Obelisk shape. An object that tries to test the limits of the research in different ways. The obelisk makes it possible to investigate the maximum cantilever and bending angle. In addition, it is an investigation into the sequence, typology and reinterpretation of architectural styles. The parametric model gives the opportunity to investigate the influence of different parameters. For example, it can be varied in the spherical shape, radius, number of elements and the position of elements.

The typology of the obelisk is related to the Art-Deco art movement, a widely used architectural style in the city of Ghent. Art Deco is characterized as a decorative style with simple geometric patterns, tight design, strict vertical lines, abstraction, embracing technology and a monolithic appearance. It has been tried to translate and reinterpret these design themes into the Obelisk. The result is an artefact which is entirely conceived from the themes of 3DCP and robotic assembling. An object which consists out of 121 different elements with the same principles. This principle is applied in the design which will be explained in the chapter Design and will be further elaborately explained in chapter 4.4 Helix tower.

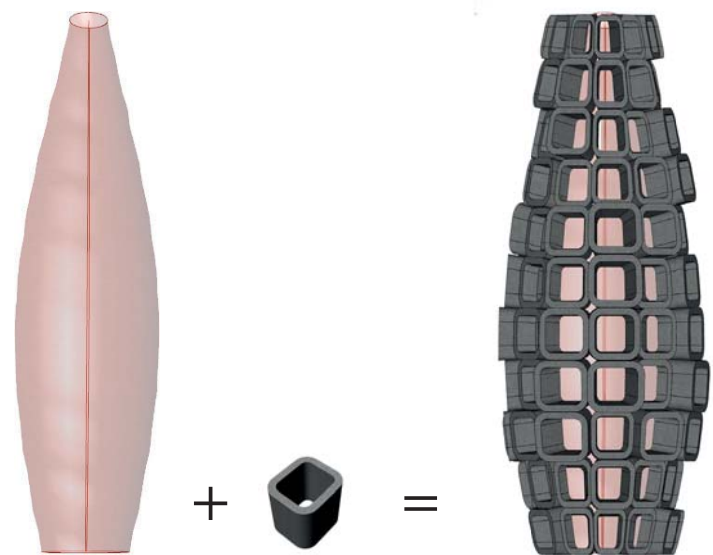


fig.3.13 The basic shape + quadrangle shape (cell) = design (the Obelisk)



THE DESIGN

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## 1. THE EXISTING BUILDING 'MIDDENDRUK CENTRALE'



fig.1.1 Timeline of the powerplant 'De Centrale' and its immediate environment. © edfluminus.edf.com

### 1.1 HISTORY

According to the local energy company EDF Luminus, currently located in the 'Middendruk Centrale' in the district of the powerplant 'De Centrale', says the following about the area: "The power plant was built in the 1920s in the center of Ghent. Under the direction of the City of Ghent, the construction of the diesel hall began in the late 1960s. The high chimney of this building has since been a characteristic element of the Ghent skyline.

After 'De Centrale' area in the district Ham was integrated into the EDF Luminus production park and connected to the national grid, the diesel generators increasingly served as a peak power plant, as an emergency unit that was in service for a limited number of hours. In 1993, the coal-fired units were demolished and replaced by a STEG (the steam and gas turbine) unit (EDF Luminus, 2019).

Thirteen years later, two additional peak units on natural gas were hired. In 2006 two diesel generators were demolished and the third remained operational as an emergency center during the renovation works. This was taken out of service when commissioning the new gas turbines. Over the years, the plant has been modified and improved. The existing infrastructure was always safeguarded and reused in an optimal way.

#### 1.1.1 'De Centrale' today

The area of 'De Centrale' in district Ham today consists of gas turbines that are able to meet specific needs for electricity. Since 1993, the steam and gas turbine unit (STEG), replaced the old coal infrastructure. They continuously produced steam and electricity. The steam was earned back as heat, so it could be delivered to a few hospitals, residential areas and buildings.



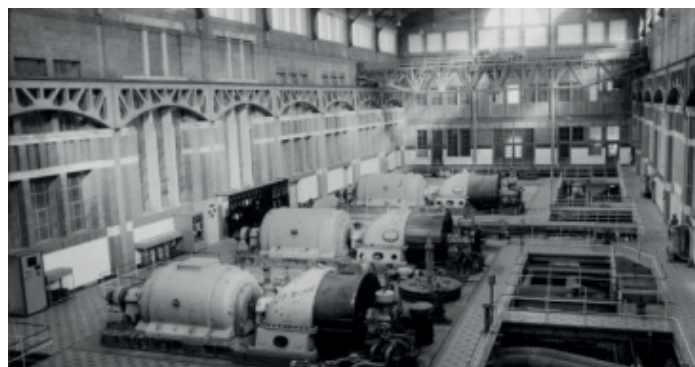
**fig.1.2** The 'Middendruk Centrale' in 1960s against the power plant 'De Centrale' with its unique chimney. © edfluminus.edf.com

The current gas turbines are starting during peak times (mainly during the day during the week, rarely at night or during the weekend). Since electricity cannot be stored, the power plant must be able to produce energy at times when many families use light at the same time or prepare the food.

### 1.1.2 Center for culture

Currently, a part of the 'De Centrale', with its art deco-style front building and the protected turbine hall, is a center for world cultures, with numerous intercultural events, performances (figure 1.4), exhibitions and training activities. After an exclusive visit of this historic building where I could see both the old part with the protected turbine hall (figure 1.3) and the current plant. Interestingly, the machine at that time remained intact and have been classified as monuments. Absolutely not to be missed is the shelter under the central. It was built in 1924 for the staff and is the best-preserved bomb shelter in the country. The unique machines are still in place in the turbine hall, while in the other rooms

various cultural activities are performed such as performances, courses relating to art, culture and music (Industrieelerfgoed.be, 2019). A place where artists, the public and partners can meet each other.



**fig.1.3** The turbine hall with the protected machines in the old part of 'De Centrale' - early 1920 and nowadays 2018. © herita.be



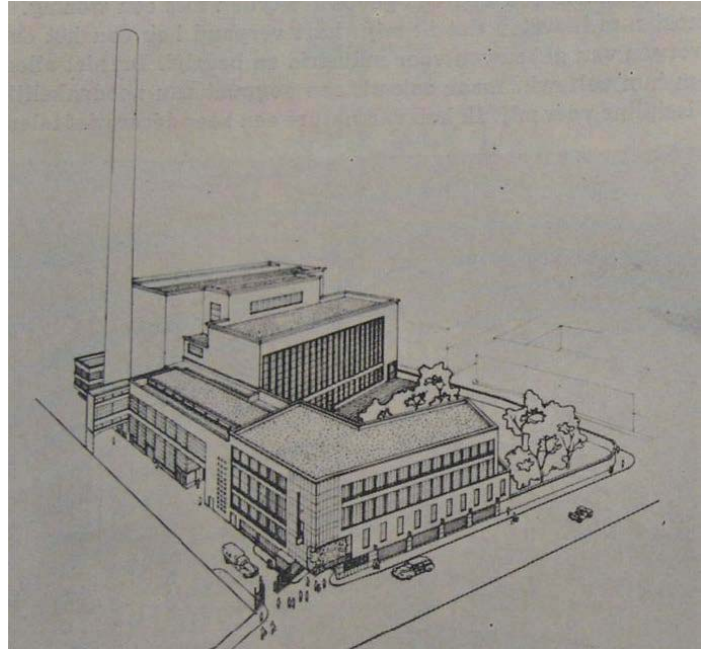
**fig.1.4** Performance space for cultural activities which is right behind the protected turbine hall. © kapowow.files.wordpress.com



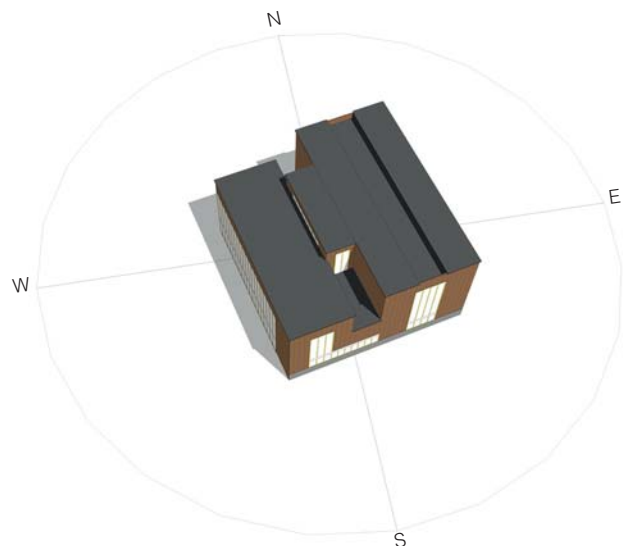
## 1.2 EXTERIOR - MEASUREMENTS

The current 'Middendruk Centrale', located right next to the power plant 'De Centrale', is still used by the energy company EDF Luminus. As previously mentioned in the paragraph 1.1.1, they produce electricity. I chose this building to tackle and revive it as a public library. His current function could be moved to the then 'De Centrale' building, where it will once again have its own function just as in the history. This existing industrial building 'Middendruk Centrale' has, from its history, a number of special architectural features which unfortunately can no longer be seen anymore. For example, in the 1960s the building was designed with many windows in the façades and a special chimney against it that has unfortunately been demolished over time (figure 1.2 on the previous page and figure 1.5). In addition, offices have also been added later against the building, which is still in tact. With this, the new builded offices provides a private square and closes with its immediate environment (figure 1.5).

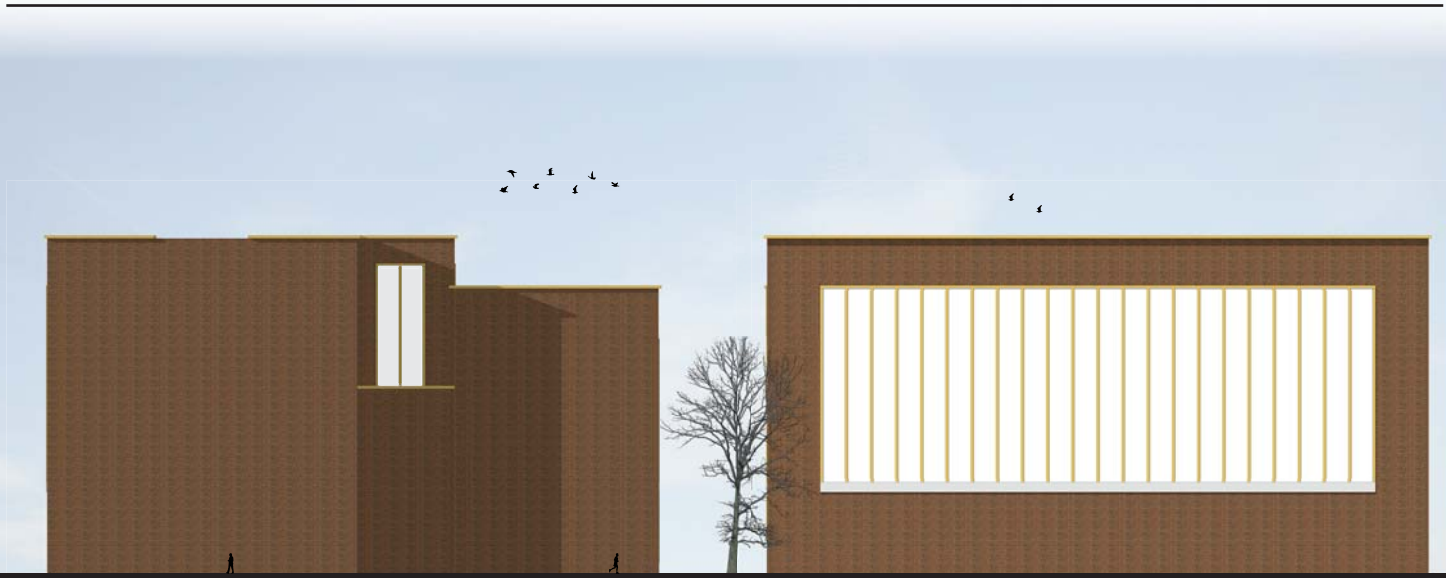
The windows are currently mainly closed with little natural light is coming in. This because of the current function as an energy producer in the building. A cube-shaped building of 65x60x35 meters where the entire façade is closed on all sides. The total floor area of this is approximately 7500 square meters, which means that there is only one floor level and entirely an open space on the inside. However, these openings are still clearly visible like in the drawings of the existing situation in figure 1.7 through the closed white stone blocks that contrast with the special applied brick structure that comes back from its history. This whole picture nevertheless creates a challenge to recover this quality and to restore its value by making openings again.



**fig.1.5** A sketch of the 'Middendruk Centrale' with the offices on the front, which creates an inner square and a second entrance. © stad Gent



**fig.1.6** The orientation within its current context



North view

East view



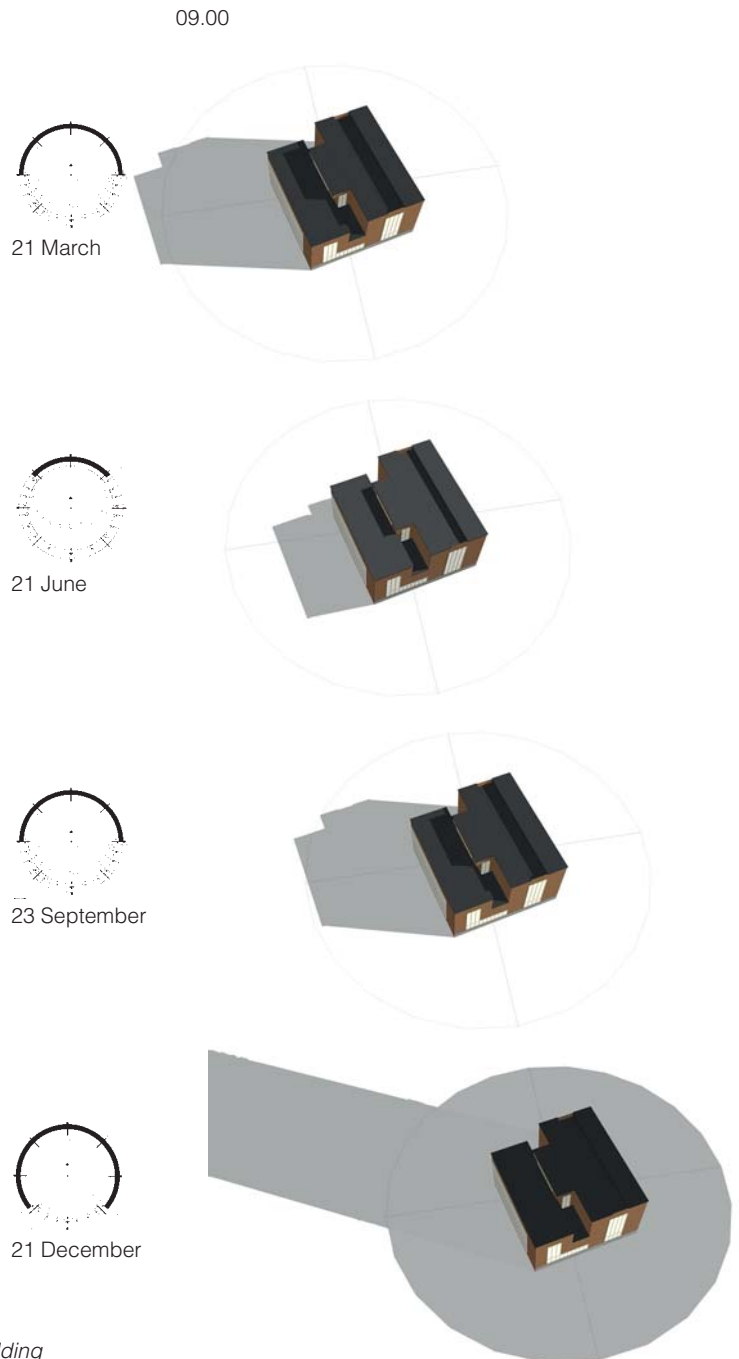
South view

West view

**fig.1.7** The existing façades of the cube shaped industrial building of 65x60x35m with the closed white blocks in contrast with the historical bricks

### 1.3 NATURAL LIGHT

Because of its central location within the district, the natural light through sunlight on the building has been studied. The openings in the façades that were designed have a strong relationship with natural light. This study in figure 1.8 has been made in four different months at different times of the year when the sunlight reaches its highest point to see which façades capture a lot of sunlight. For example, on the façades where the opening is placed, are the most natural light through sunlight, which is currently closed with white stone blocks. These are the façades on the East, South, and Westside. The least light incident is on the North façade where almost no openings have been placed. Especially on the East and West façades are large areas that offers the potential to make a transparent façade, so that natural light enters the building.



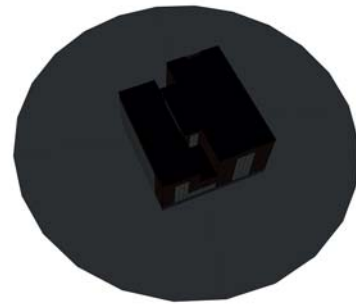
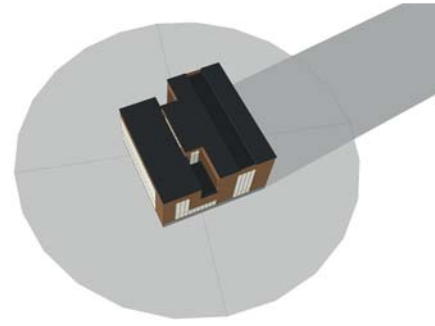
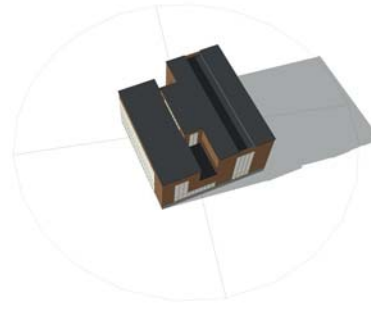
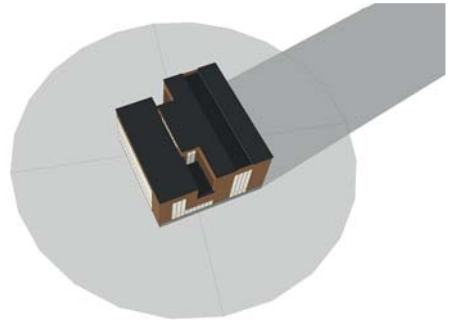
**fig.1.8** Scheme of natural light through skylight vs. the orientation of the building on different moments of the year

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12.00

15.00

18.00





### 1.3.1 Smart windows

Department of Chemical Engineering and Chemistry from Eindhoven University of Technology has developed a new technology related to windows, called 'Peer+' which is currently being taken over by the Merck company. It is also called the liquid-crystal-window technology (Merck, 2016). This new innovative system will be applied to the building. A brief description from the research of the department:

"The windows Peer+ plans to make three settings: dark, diffuse and light. In the dark and diffuse settings, the incoming light is used to generate energy. Teun Wagenaar is one of the company's founders. The main advantage of this technology, in his view, is that the product can be used on a large scale. "It is an excellent way to make buildings greener," he says. The façades of big buildings can easily have 1,000 m<sup>2</sup> or exposed glass. The amount of energy you can save on air conditioning and lights in such a building is tremendous. Plus, you can generate electricity at the same time. This application could greatly reduce carbon emissions."

3 different modes	Dark	Bright	Privacy
Visual Light Transmittance	± 35 %	± 70 %	± 30 %
Maximum energy generating efficiency	50W/ m <sup>2</sup>	25W/ m <sup>2</sup>	60W/ m <sup>2</sup>

fig.1.9 Technical specifications of the three settings of Peer+ technology. © Peer+ smart energy glass

Characteristics of the system, Peer+'s Smart Energy Glass is:

- switchable smart glass (dark/bright/privacy)
- windows delivered in any desired color
- autonomous power supply (integrated solar cells)
- Wireless Installation
- energy generated within the glass will power the switching and the remote control receiver
- changes opacity
- filters sunlight
- reduces energy costs of solar over-exposure
- generates electricity from the blocked sunlight

The operation of this system is as follows: Firstly, the incident solar radiation enters glass. Within the glass there is an active SEG layer that switches the state (opacity) of the glass (figure 1.10). From that, the SEG layer scatters the light to the edges of the window and photovoltaic cells capture the energy (Merck, 2016).

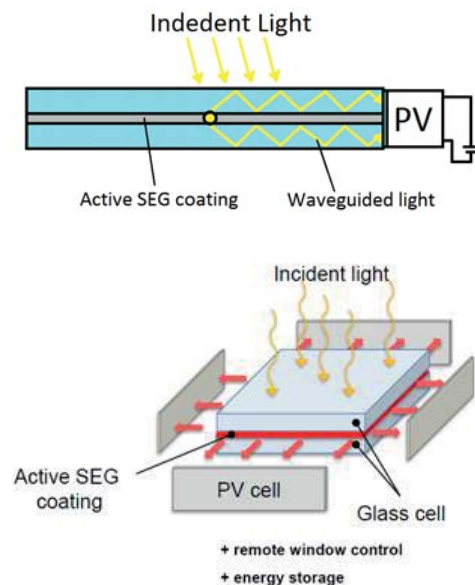
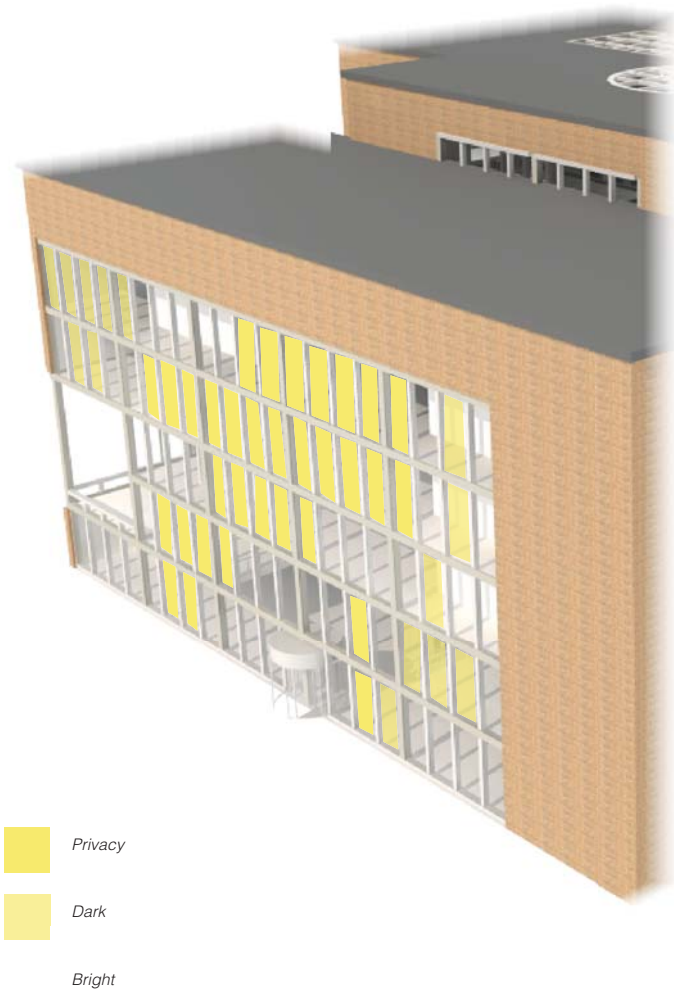


fig.1.10 Operation of the Peer+ system. © Peer+ smart energy glass



**fig.1.11** *The system Peer+ applied to the façades. On the basis of the entry of sunlight, the smart windows work, which creates a play of window surfaces and exudes a special effect both from the outside and inside the building.*

#### 1.4 QUALITIES

By carefully analyzing the building, some qualities of the building emerge, which is retained. Therefore, the structure of the building will be accepted and keep the neutral pattern/ hierarchy in the façades. There are also spatial qualities within this structure. The one floor level building gives the maximum spatiality in the building (figure 1.12 and 1.15). These characteristic and spatial spaces will be respected. The building is set up in a Grid- structure. This structure can clearly be seen based on the columns that are systematically and very strict placed. Based on this, the grids are easy to set out like in figure 1.13.

In addition, the entire building can be split programmatically into three parts. This strategy can be seen both on the floor plans and on the sections (figure 1.12 and 1.13). The tripartition is shown in 3 different colors in figure 1.16. The blue part (front) which lies on the concrete boulevard on the Westside, the brown color as the middle part and the green part at the back, the east façade looking over the water to the OMA- masterplan. From the first part of the building on the front which is the Westside, the heights start low and end high which can be linked to the Masterplan where in the city section the old city center is low and runs through the district Ham and ends high in the OMA- masterplan (figure 1.14). The intermediate part (brown), plays an important role in the interaction with the parts, the blue (front) and the green on the East side.

The front part, which is against the new concrete boulevard from the Masterplan, is the most important part of the building and could, therefore, serve as the main function. The parts behind it could support this main function. This building with its special qualities offers opportunities and architectural possibilities within the new Masterplan in the first section (research) from chapter 1.3 on page 52.

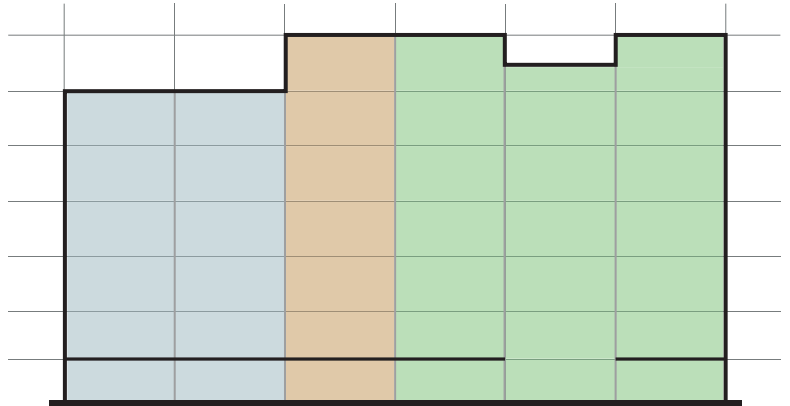


fig.1.12 Section - spaciousness

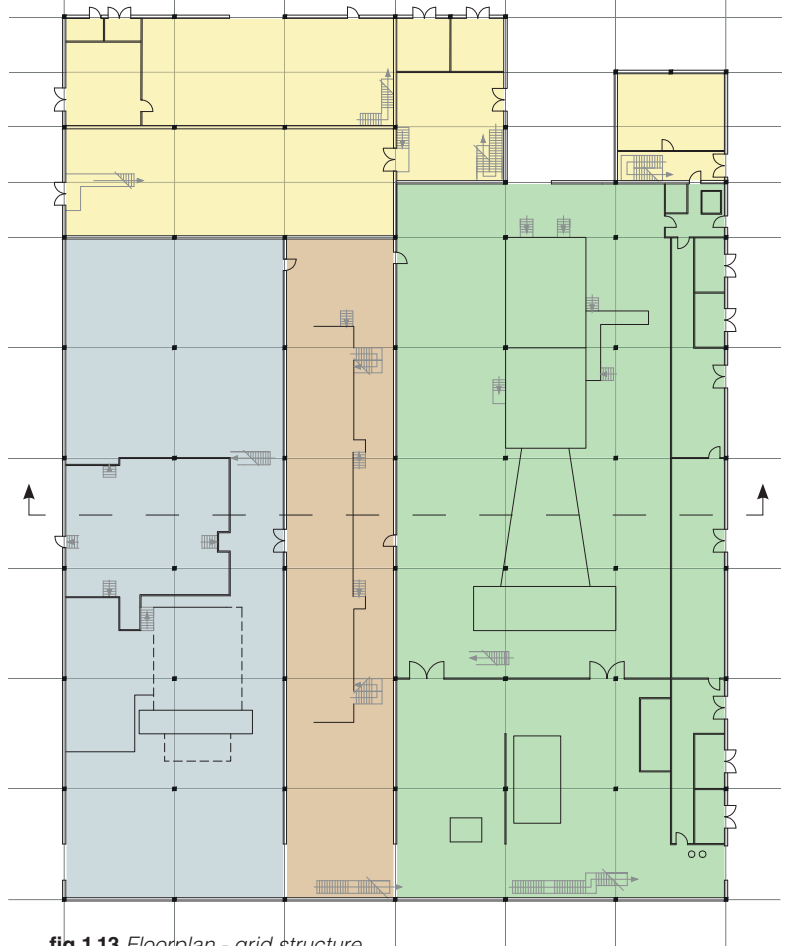
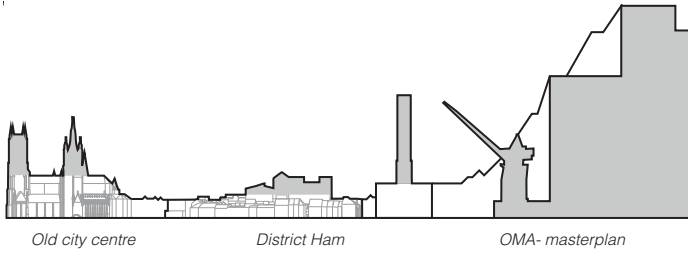
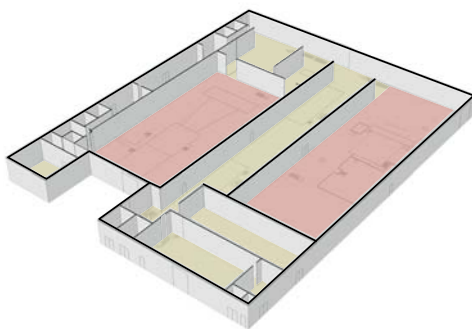
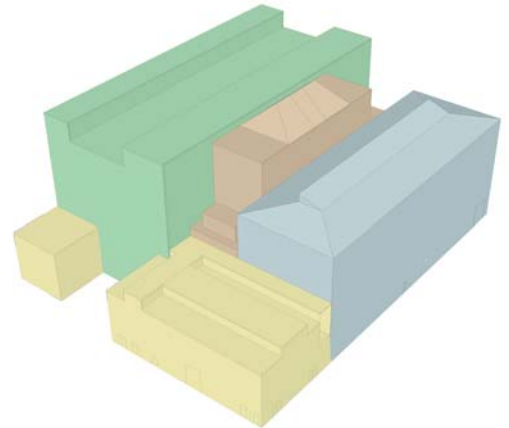
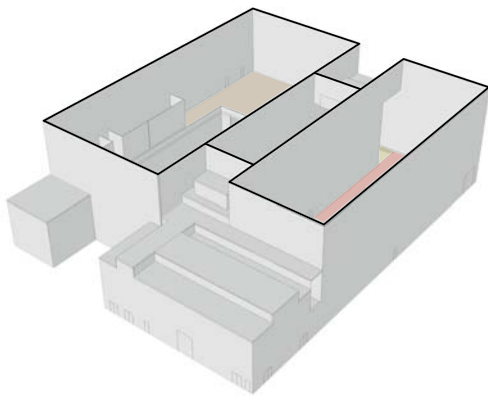
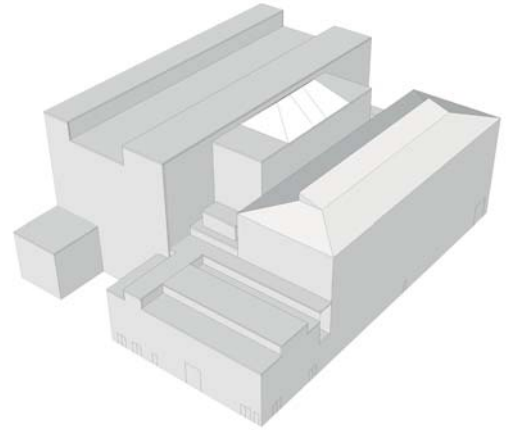


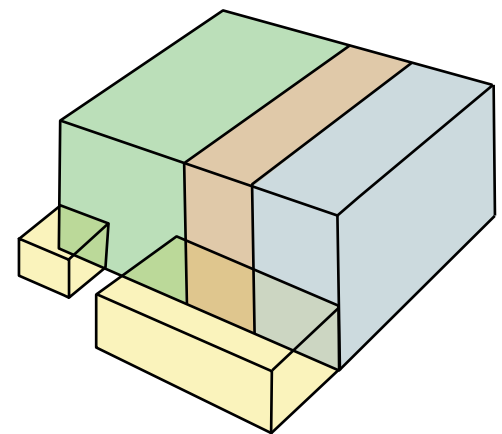
fig.1.13 Floorplan - grid structure



**fig.1.14** Ghent city profile - Expansion in volumes



**fig.1.15** Exploded view - 1 floor level



**fig.1.16** Tripartition



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## 2. CONCEPT

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As mentioned before in the first section, from the research in chapter 2.11, the key features are the collection itself, public meeting spaces and the circulation, in other words the 'organization' of the building (figure 2.1). Together with the unique qualities, the cube-shaped building has the potential to serve as a public domain.

The existing grid structure can help designing the layout of the program and also the circulation of the building to create a centrally focused point. There are number of aspect which play an important role in the architecture for an optimal circulation such as natural light, access, routing, context, space, function and dimensions.

To emphasize the experience and perception of the large-scale building, the Grid- structure has been retained and a grid has been set up. With the help of this a central focus point has emerged that is exactly in the middle (center) of the building to create a clear and calm circulation (figure 2.3). This central point will be situated in the middle part and will work as a serving element that has been explained as a brown color in the previous chapter 1.4. From this, the other spaces are directly connected and there will be a routing around this central point. In addition, in the middle part, the transition (staircase and elevators) will take place, along with the restrooms in order to realize a strong concept (figure 2.4). To give this central point an architectural value, the most important part of a public library will come, namely the collection which will be the 'book tower' (Helix tower) in the design. This tower will serve within its organization both as an art and as a leading component within the building. Furthermore, this thesis will explain in detail about the concrete made Helix tower together with the new design starting from chapter 4.

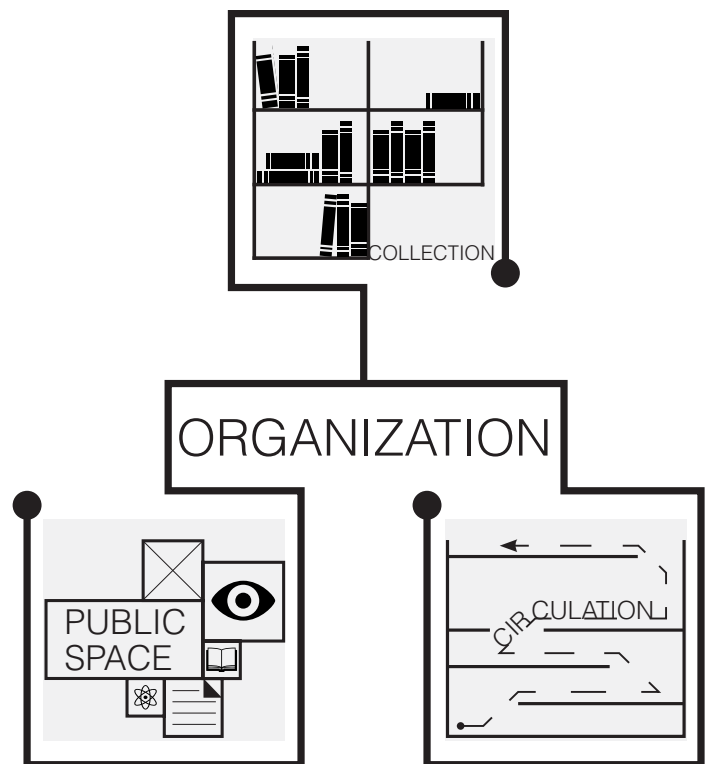
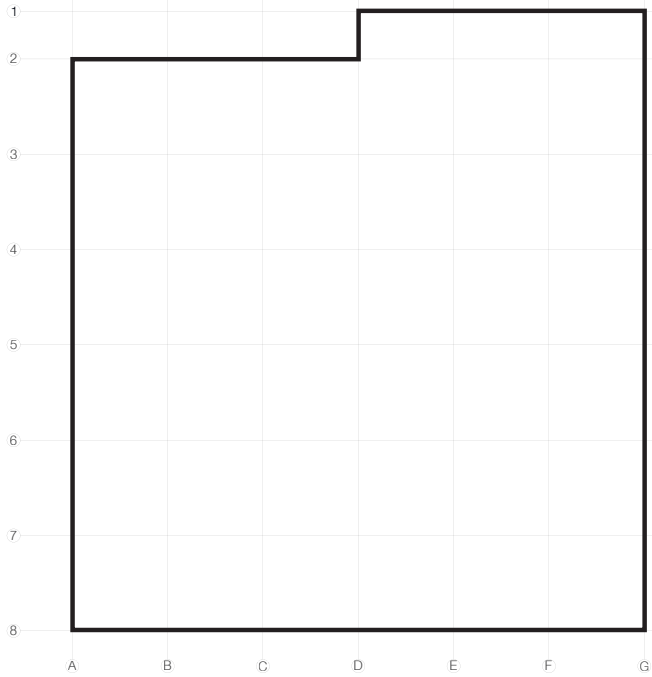
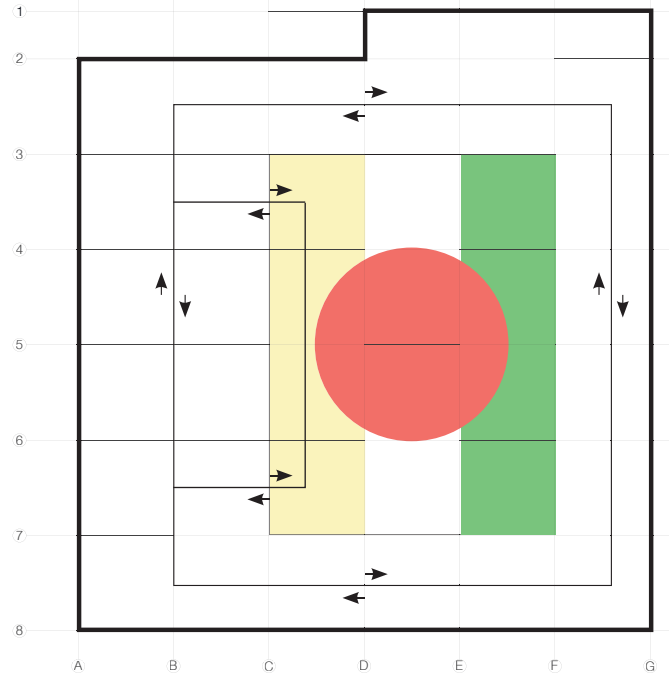


fig.2.1 Scheme of key features public library

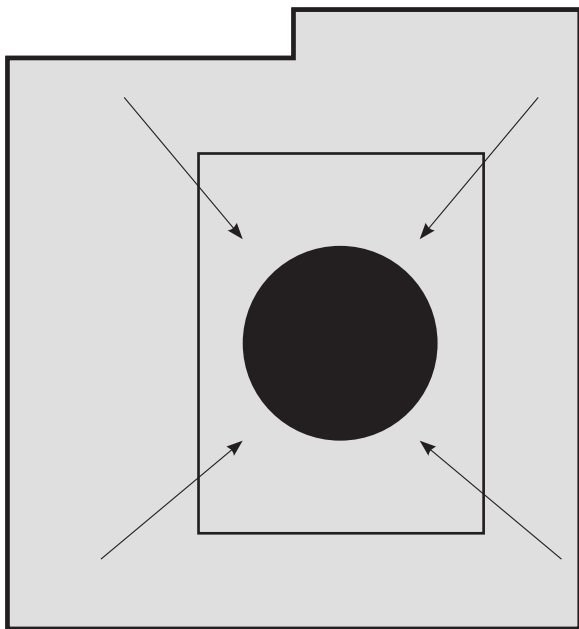


**fig.2.2** Grid- structure



Transition space (staircase, elevators and restrooms)
  Indoor garden
  Helix tower

**fig.2.4** Organization



**fig.2.3** Central focused point

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### 3. URBAN CONTEXT

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The aim is regarding its environment; Creating an urban 'living room' for the city. An urban place to meet, read and learn. In connection with the Masterplan in the first section of the research in chapter 1.3, the building contributes to the height's strategy, starting low from the street side (concrete boulevard) and ending high towards the OMA- masterplan, just like the current old city centre which starts low and through the district Ham (middle), end high at the OMA- masterplan opposite the water (figure 3.2 and 3.3). In addition, the district will work as a hinge between the old city centre and OMA- masterplan (figure 3.1).

#### 3.1 Square

The front side (West façade) of the building, which is the new concrete boulevard from the Masterplan, is the most important part of the building. To put extra emphasis on the main entrance there is a square at the front of the library. This square is an open public square with a hard surface. On the square there are seating options but also works of art from the origin of the library. The grand café will also function outside on the square (outside terrace), to give visitors the opportunity to rest or to enjoy the surroundings. Because of its surfaces, this square can also serve as a local public market just in front of the library.

#### 3.2 Approach

The building can be reached in different ways. There is a new parking spot at the rear of the building that offers plenty of space for visitors with the car. Not only for the library but also for the entire district. A smart strategy to unconsciously invite visitors to the library. Also, for pedestrians coming from the city center or from the train station where the concrete boulevard starts and continue next to the library towards the church where it ends, the library is easy to reach, by following the path. In addition, the building has two entrances, a main entrance on the concrete boulevard,

on the open new square and a second entrance on the north side for visitors who come exceptionally for the auditorium and exhibition outside the working hours (in the evenings). However, a distinction has been made in materializing the path. For example, the terrain of the library has been materialized differently (street tiles), while the boulevard is made of concrete.

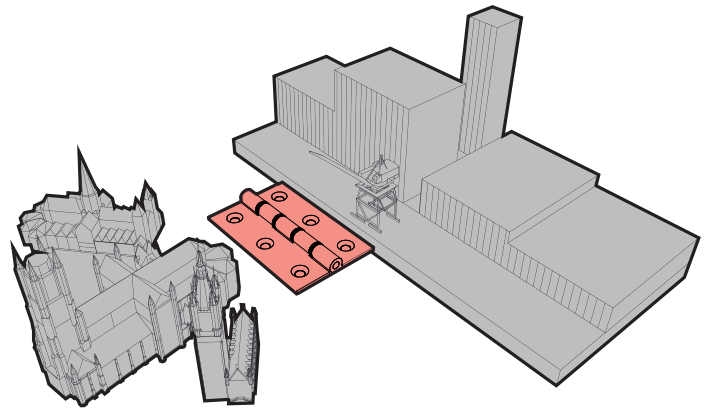


fig.3.1 District Ham as a hinge between the old city centre and OMA- masterplan



fig.3.2 City section. Starting low - ending high

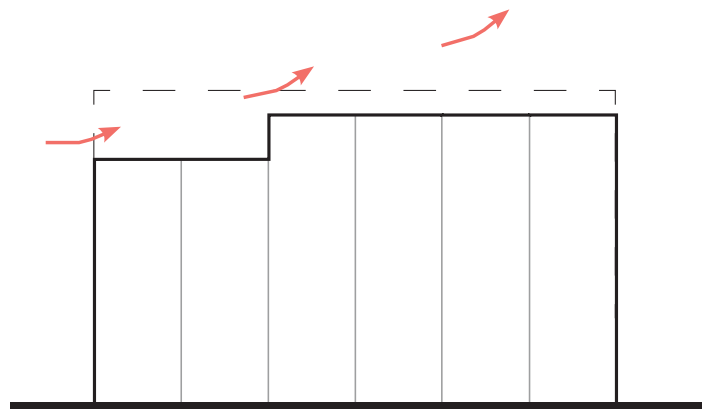
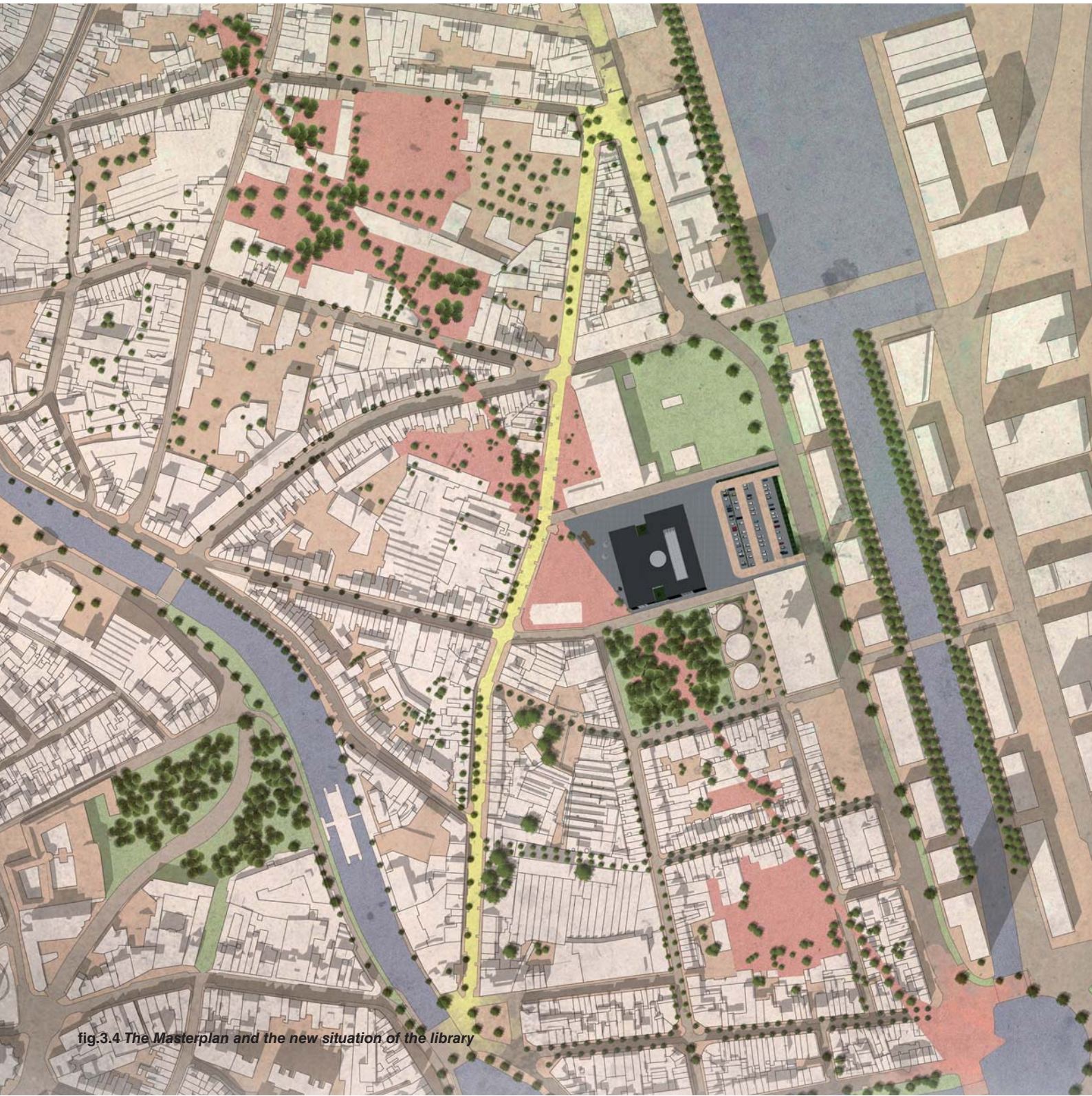


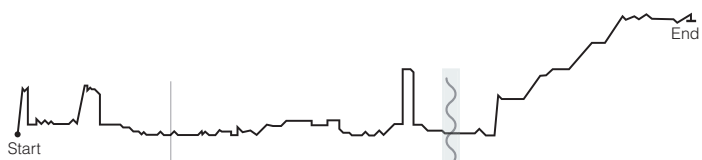
fig.3.3 Building section. Starting low - ending high





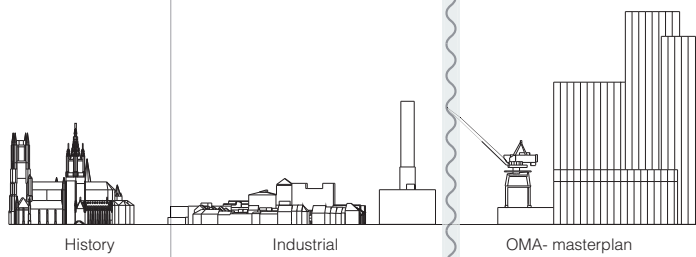
**fig.3.4** *The Masterplan and the new situation of the library*



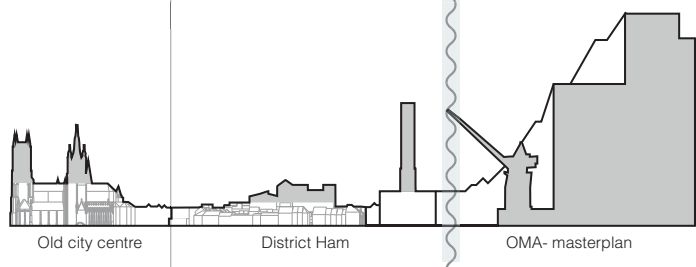


**fig.3.5** Heart beating city

On the next page in figure 3.8, the map shows the following layers which is been made regarding to the new situation in the Masterplan of the public library; pedestrians, bicycle lanes, car roads, parking spots and squares.



**fig.3.6** City vocabulary



**fig.3.7** Ghent city profile section - Expansion in volumes

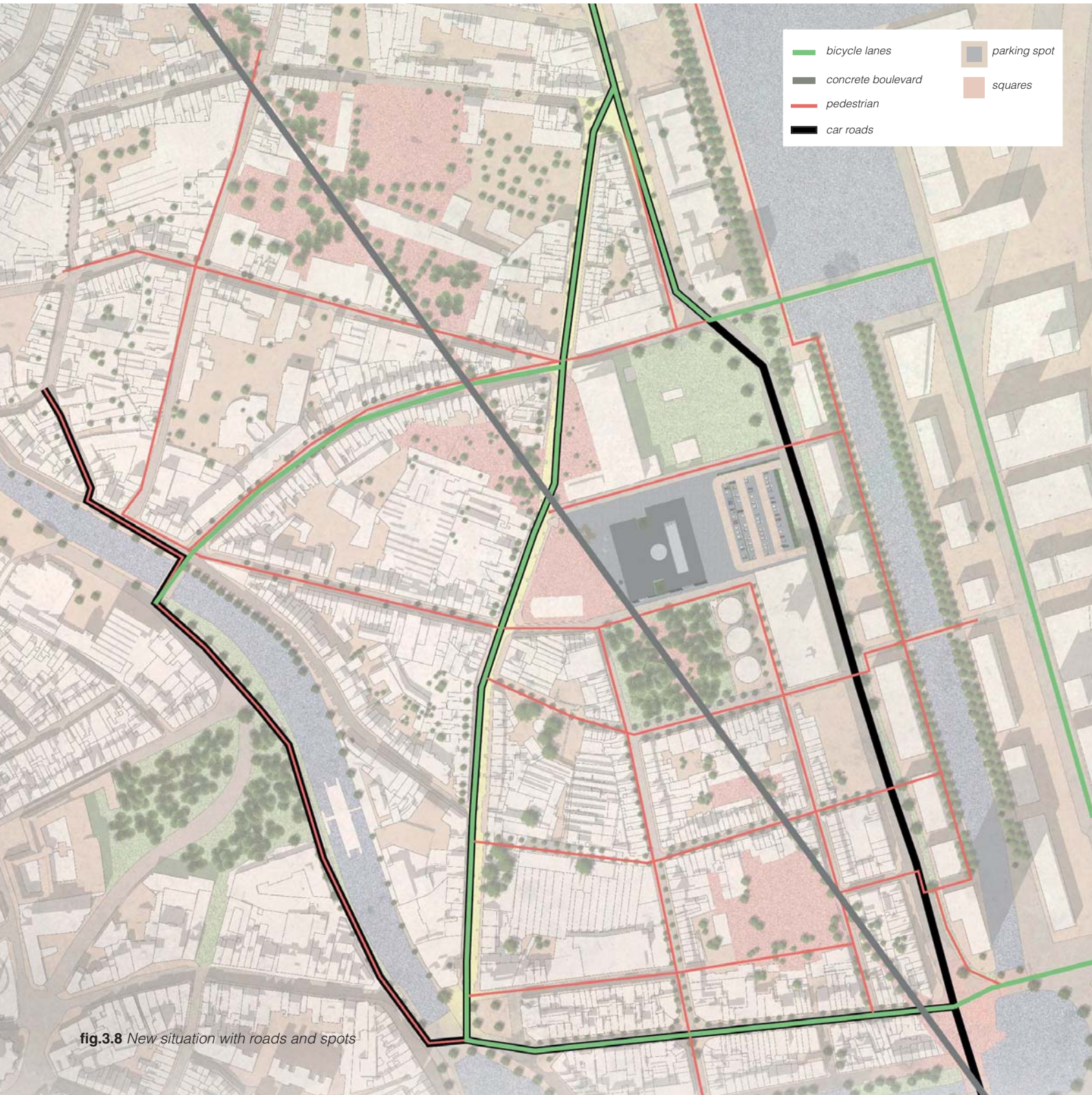


fig.3.8 New situation with roads and spots



fig.3.9 Aerial view from the Dampoort trainstation to the Church. © google.com/maps





fig.3.10 Aerial view from the Church to the Dampoort trainstation. © google.com/maps





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## 4. ARCHITECTURAL DESIGN

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### 4.1 ELEVATIONS

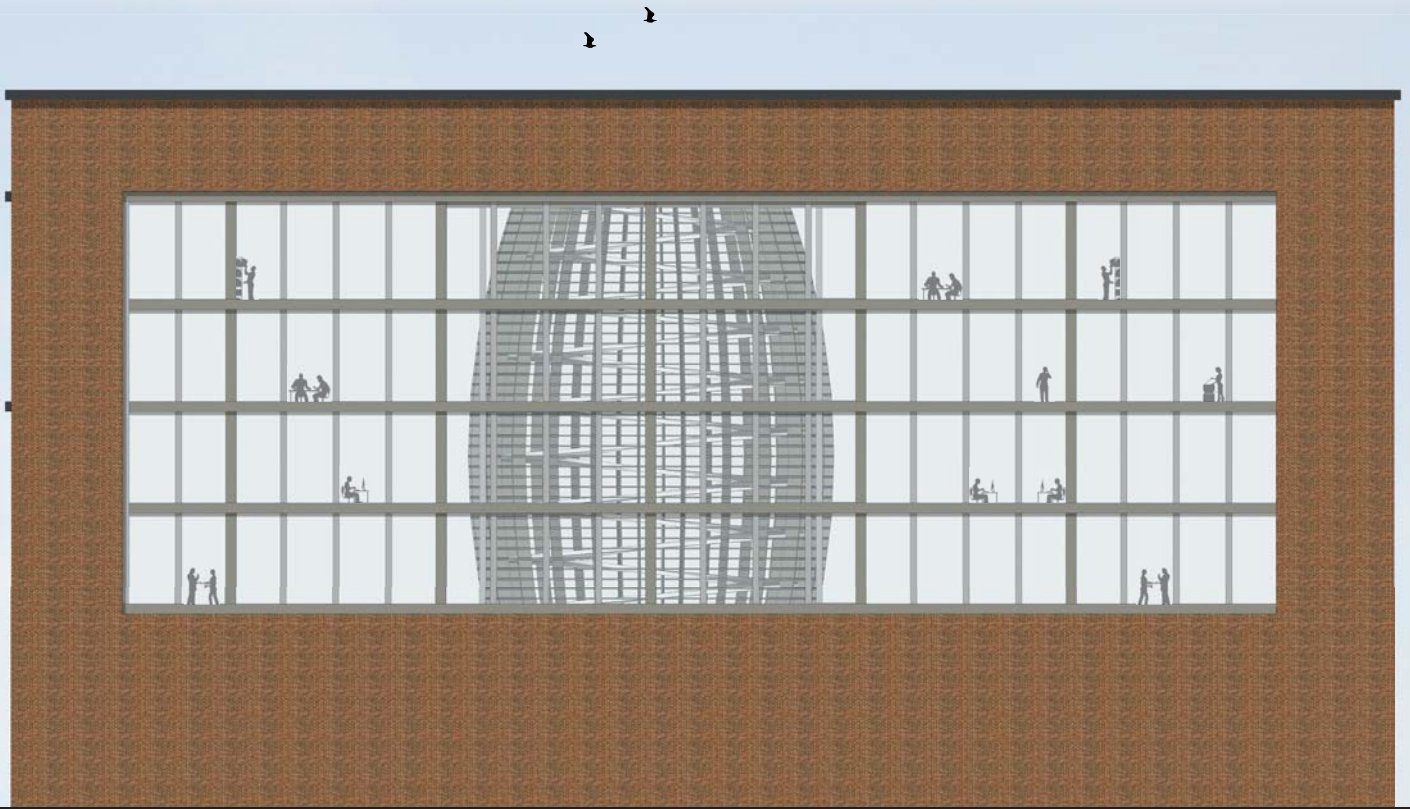
#### 4.1.1 Façade

Local adjustments will be made in the existing façades. These adjustments are restored using curtain wall system with a neutral pattern as it comes from its history. This quality will come back to life and get its value back. In addition, the transparent parts

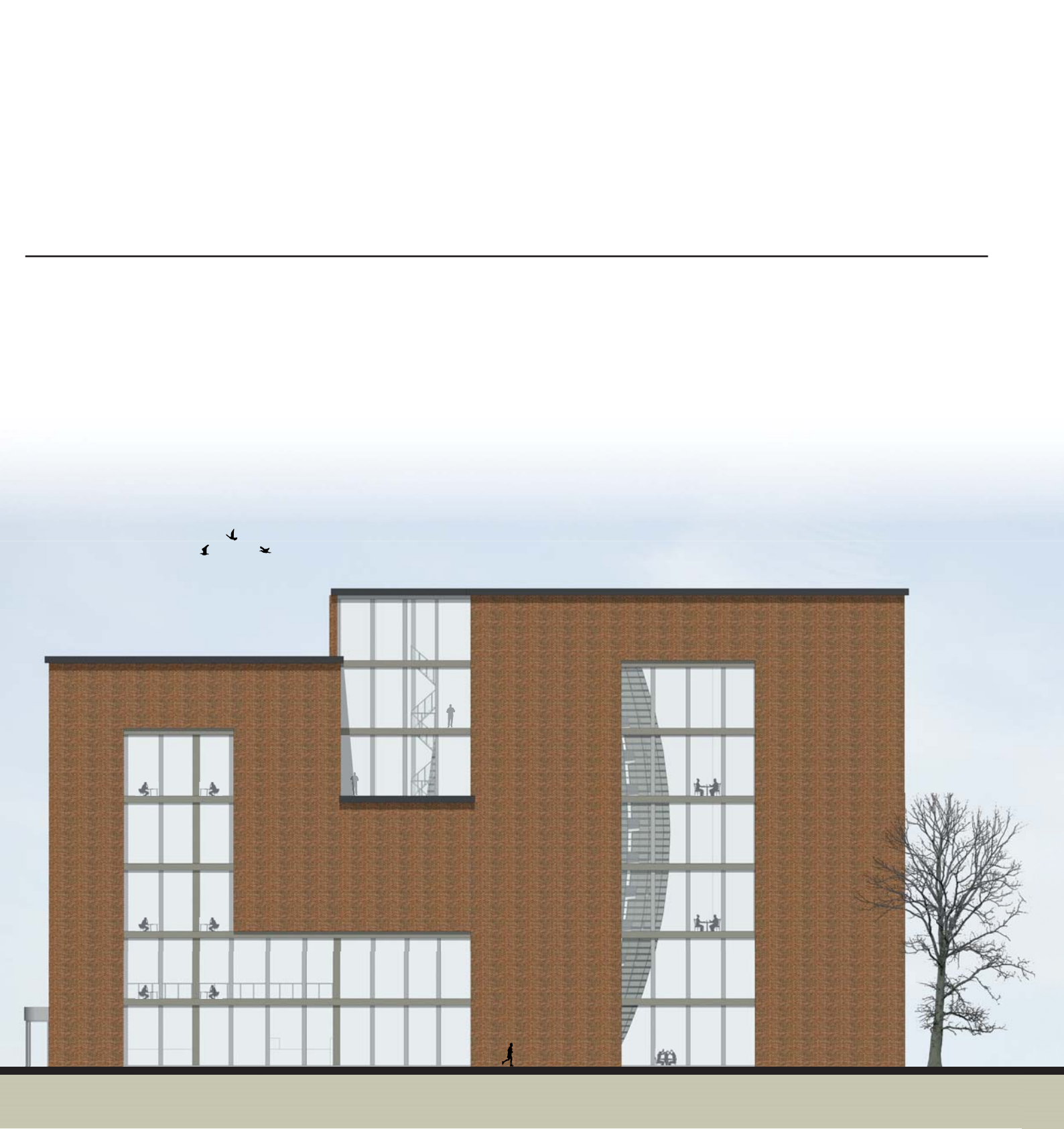
ensure a readable building, both from the outside and inside thanks to the natural light. From this, the Helix tower (book tower) can be clearly seen.



fig.4.1 North view



**fig.4.2** *East view*



**fig.4.3** *South view*





**fig.4.4** *West view*



4.1.2 Detail curtain wall system

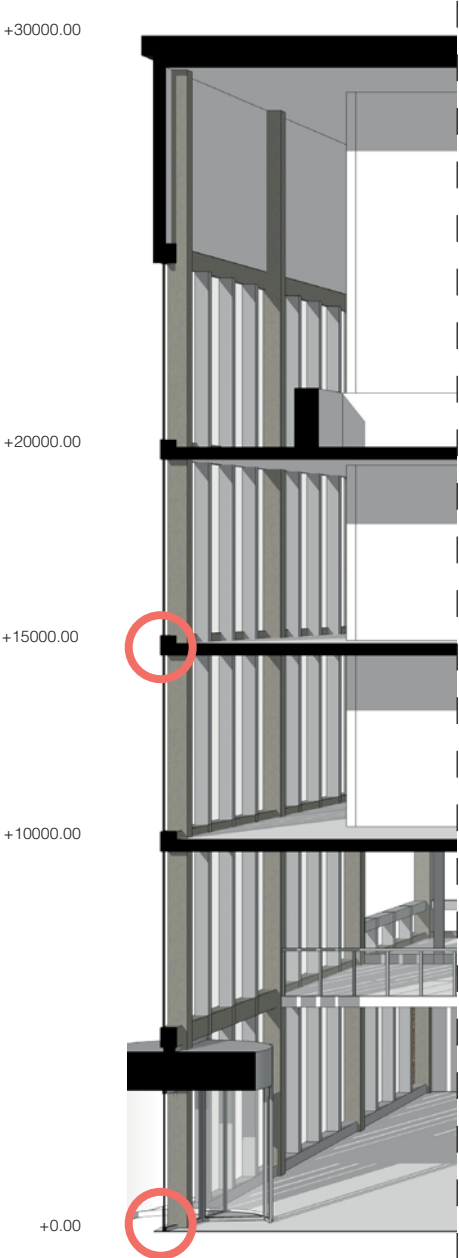


fig.4.5 Total view of the section with curtain wall system

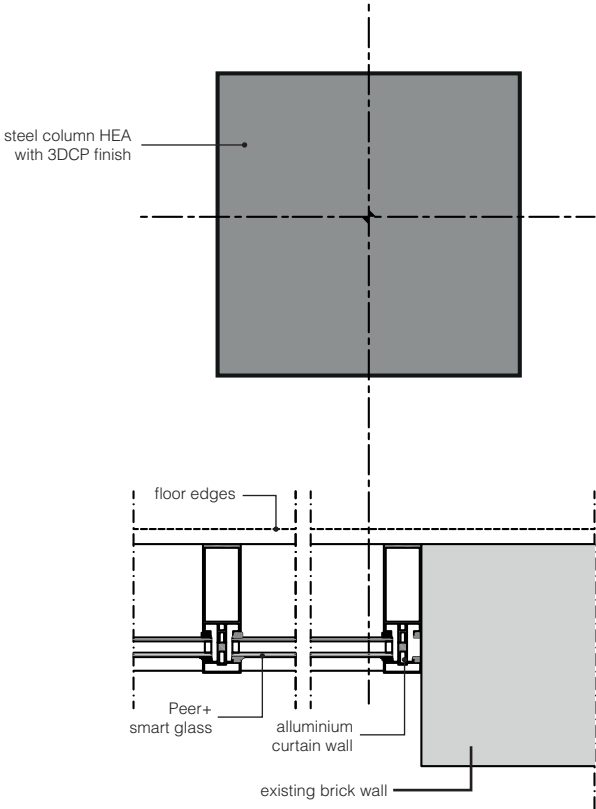


fig.4.6 Horizontal section of the curtain wall system. scale 1:10

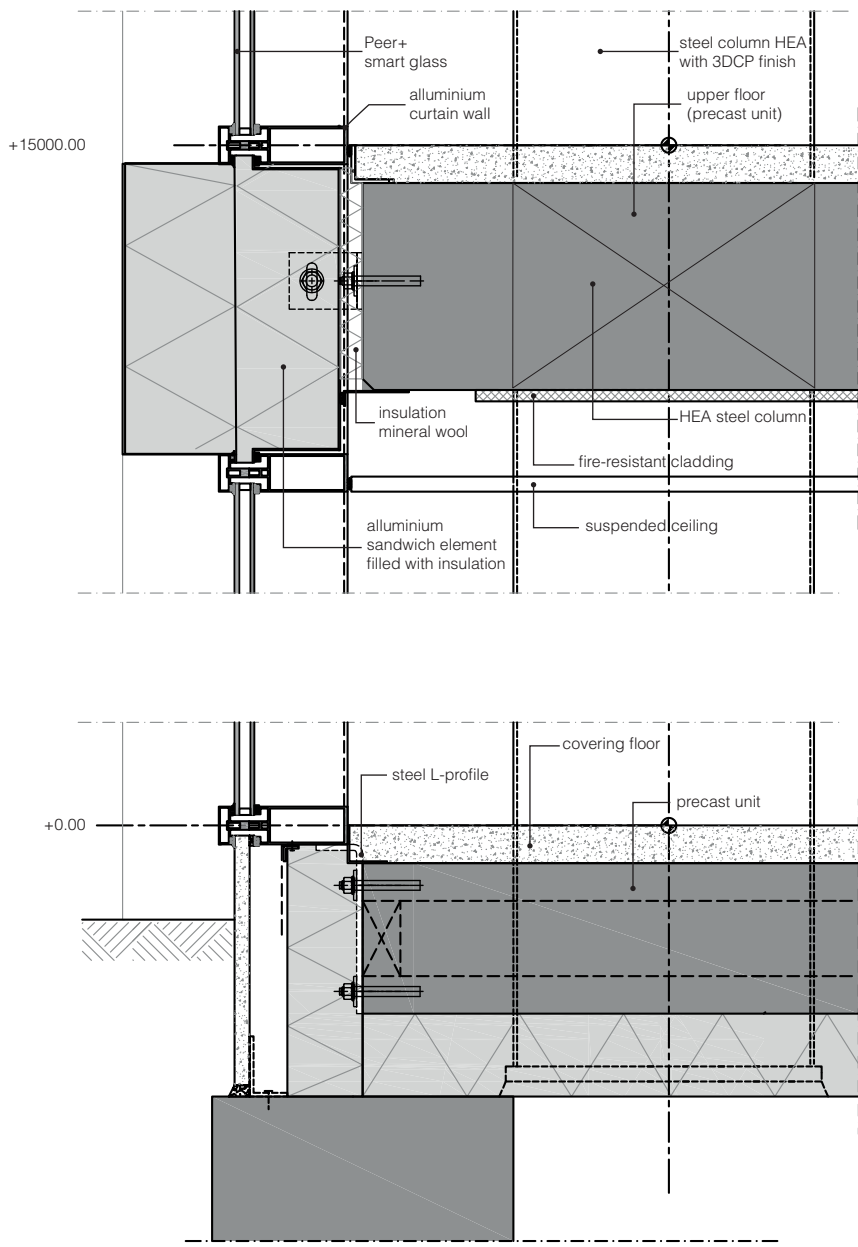


fig.4.7 Vertical section of the curtain wall system. scale 1:10

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## 4.2 PLANS

### 4.2.1 Exploded view

From the main entrance, the visitor enters the lobby in the library where the info desk is placed. Incidentally, it is a public library and it means that it is accessible to everyone. From the lobby, the visitor, on the one hand, has the choice to visit the shop with local stuff or the grand café and on the other hand to enter the Helix tower (book tower). The last choice is the most obvious choice because of the striking shape of the tower in the open space, which stands alone with the 3D printed concrete blocks that are stacked on top of each other to get that unique shape. All these aspects stimulate the visitor to be the first look in the tower and possibly choose a book and later choose a place to sit and read on the floors above. In addition, on the ground floor, you also have other functions such as an auditorium for lectures, a separate kid's place with a cinema, the closed archive and the open space for exhibitions of artworks etc.

On the second floor, there is a separate department for journals and magazines (periodical space). This space is located on the west side of the building, which looks out to the square and the concrete boulevard. On this side, there is also an outdoor space in the corner of the building. This outdoor space is partly from the grand cafe on the ground floor, and partly publicly accessible to rest, sit and enjoy the view of the historic city.

From the third floor till the last floor level on the west side, there are meeting rooms, open study places and individual spaces for studying, reading or coming together. These functions are enhanced by placing copy/print corners so that every visitor can easily print or copy.

The centrally located Helix tower is the heart of the building. Everything revolves around this artwork. Just next to the tower are the staircases where the elevators and toilets are located. These are also the vertical transition spaces for the whole building. Each floor level has a restroom for men and women. Further to the east side, the offices are placed, which starts from the 3rd floor to the last floor. The complete east side of the library is the office complex meant for starters as a target group. These spaces can be rented out or used as meeting rooms. The offices look towards the water to the OMA- master Plan. Between these offices and the Helix tower, there is also an inner garden, which is completely an open space from the 3rd floor to the roof. A special space where a part of the Helix tower also goes through it. This inner garden is open to the public, where visitors and business people unconsciously meet each other.

The existing flat roof of the library has two new openings of glass, one round-shaped glass roof just above the Helix tower, and one complete over the inner garden. These transparent parts provide open and light spaces with sufficient natural light. Especially the roof above the Helix tower gives the effect like if you are walking to the 'heaven', because of the spiral ramp inside the tower that starts from the ground floor and goes up and ends on the last floor. This spiral ramp is accessible on every floor level from the staircases. On the following pages the floor plans can be seen to give a clear picture of the library.

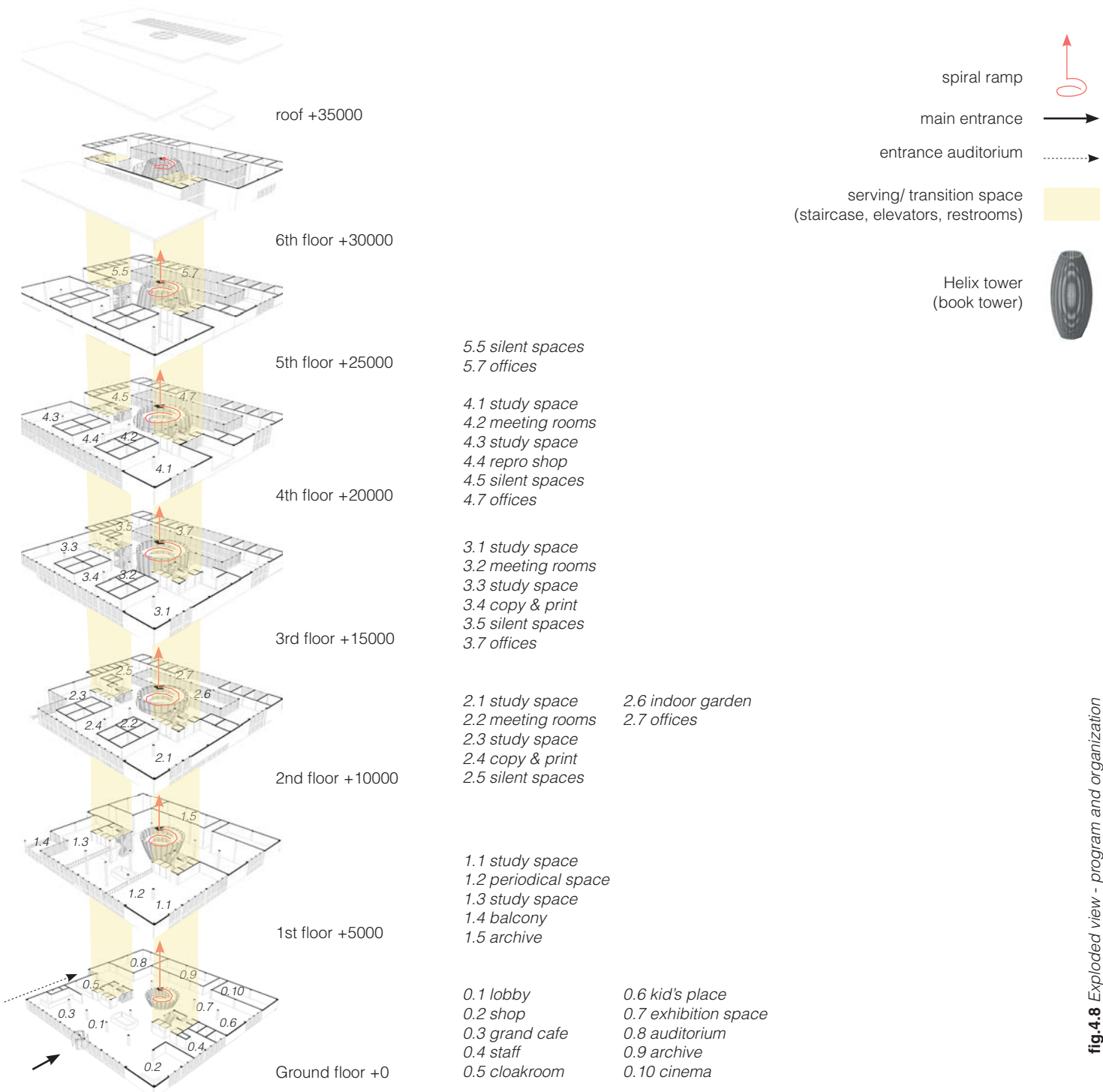


fig.4.8 Exploded view - program and organization





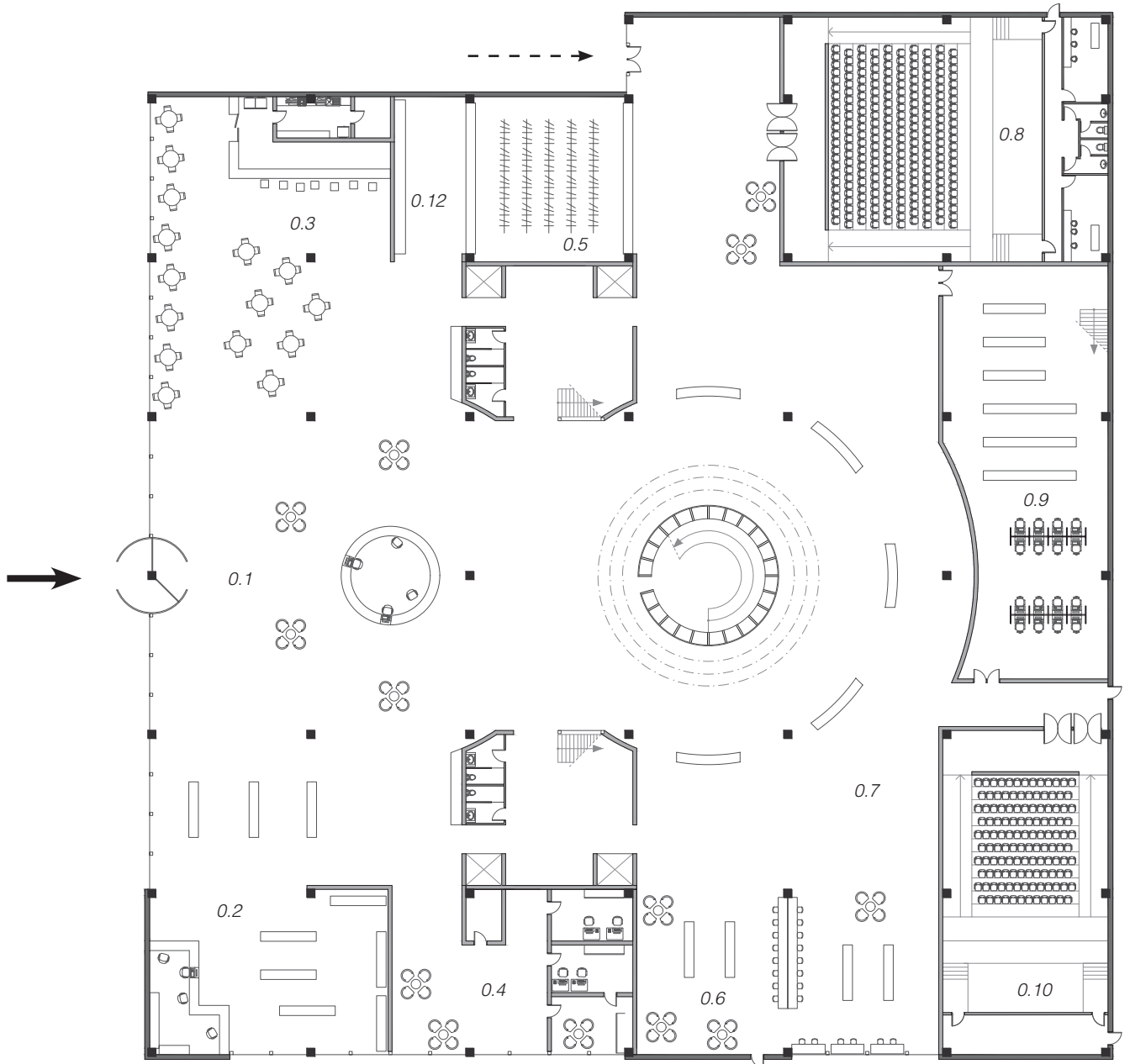
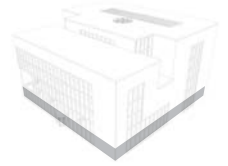
**fig.4.8a** *Art-impression - The West façade with the main entrance on the square against the concrete boulevard. Because of the contrast between the materials in surfaces between the library and the concrete boulevard, the library receives the attention*



**fig.4.8b** *Art-impression - View from the park to the south façade of the library. The building is back in its history. His own value recovered and open to the public*

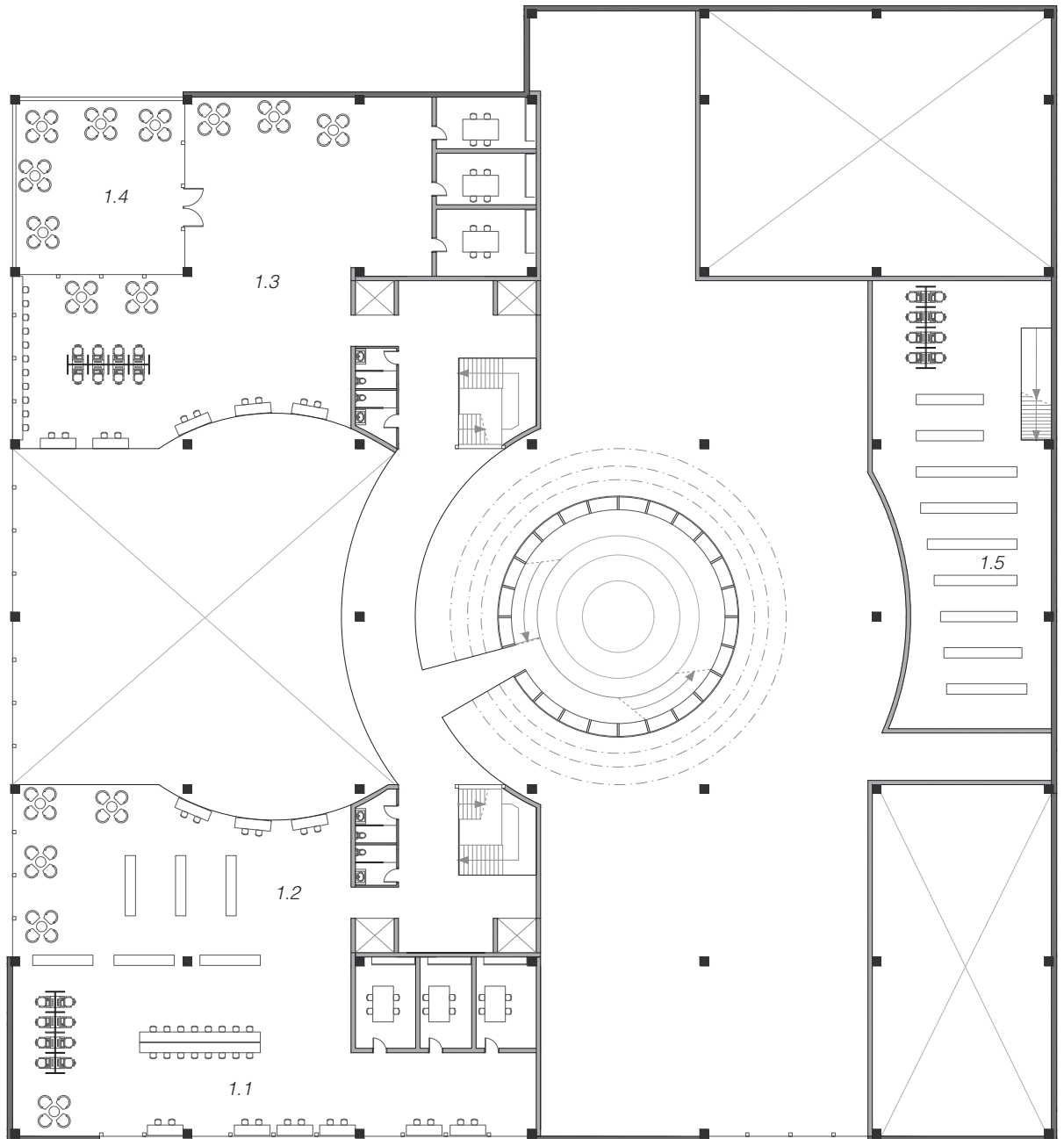
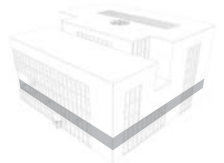
**fig.4.9** Ground floor +0  
scale 1:400

- |                |                      |              |
|----------------|----------------------|--------------|
| 0.1 lobby      | 0.6 kid's place      | 0.12 lockers |
| 0.2 shop       | 0.7 exhibition space |              |
| 0.3 grand cafe | 0.8 auditorium       |              |
| 0.4 staff      | 0.9 archive          |              |
| 0.5 cloakroom  | 0.10 cinema          |              |



**fig.4.10** 1<sup>st</sup> floor +5000  
scale 1:400

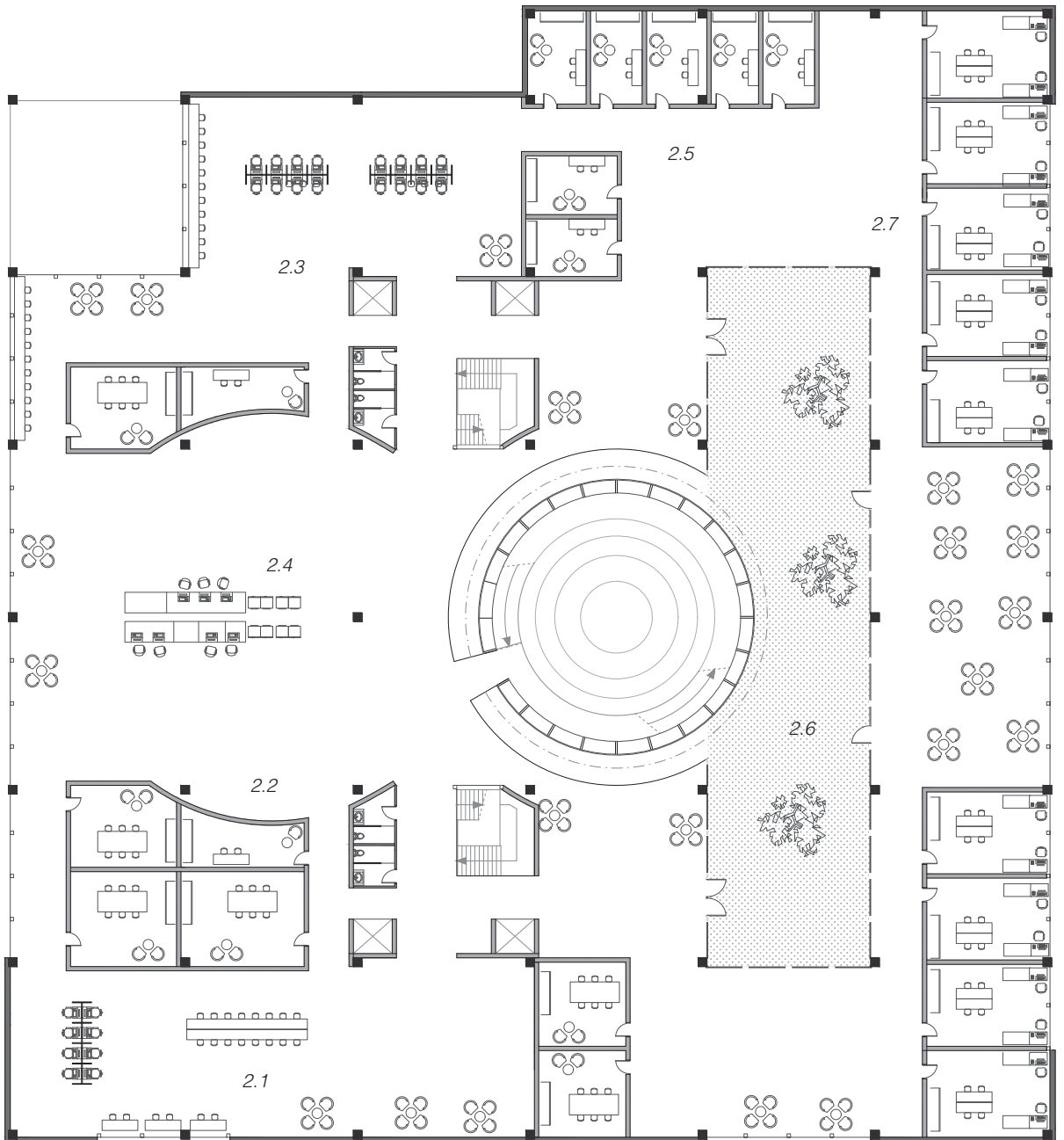
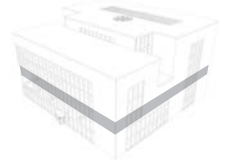
- 1.1 study space
- 1.2 periodical space
- 1.3 study space
- 1.4 balcony
- 1.5 archive





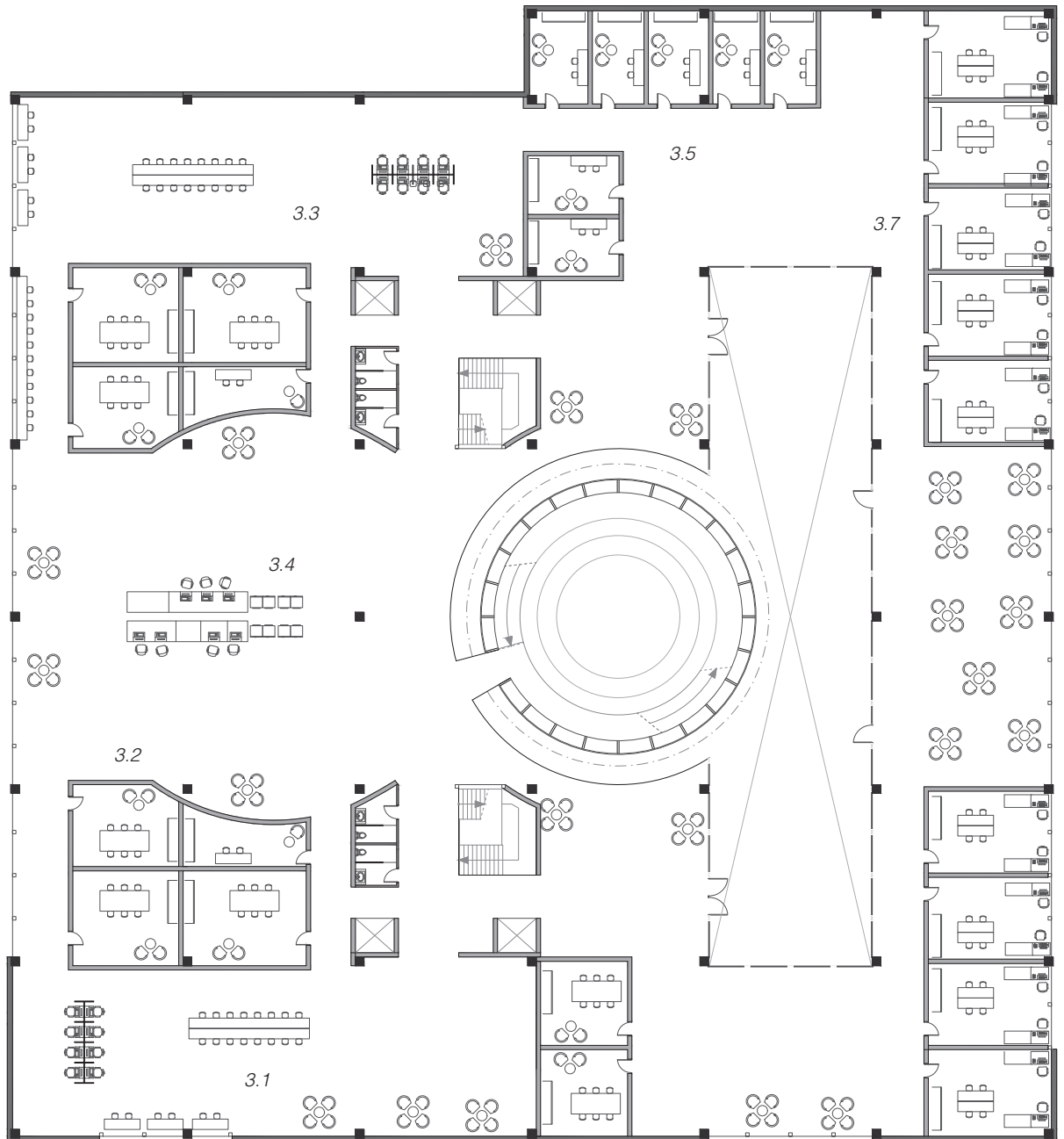
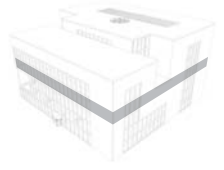
**fig.4.11** 2<sup>nd</sup> floor +10000  
scale 1:400

- 2.1 study space
- 2.2 meeting rooms
- 2.3 study space
- 2.4 copy & print
- 2.5 silent spaces
- 2.6 indoor garden
- 2.7 offices



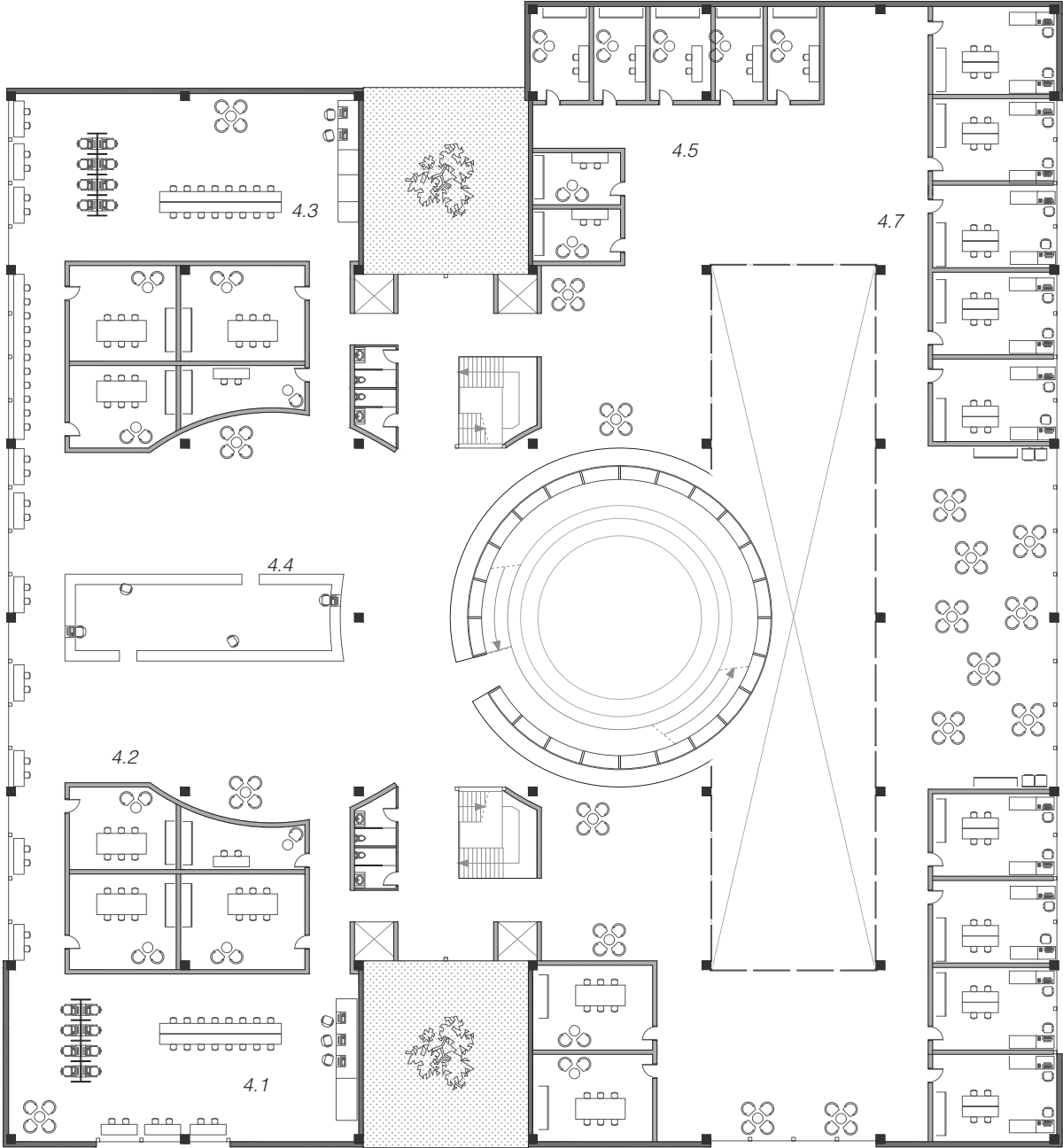
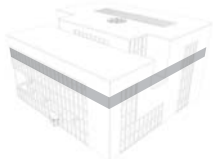
**fig.4.12** 3<sup>rd</sup> floor +15000  
scale 1:400

- 3.1 study space
- 3.2 meeting rooms
- 3.3 study space
- 3.4 copy & print
- 3.5 silent spaces
- 3.7 offices



**fig.4.13** 4<sup>th</sup> floor +20000  
scale 1:400

- 4.1 study space
- 4.2 meeting rooms
- 4.3 study space
- 4.4 repro shop
- 4.5 silent spaces
- 4.7 offices



**fig.4.14** 5<sup>th</sup> floor +25000  
scale 1:400

- 5.2 meeting rooms
- 5.5 silent spaces
- 5.7 offices

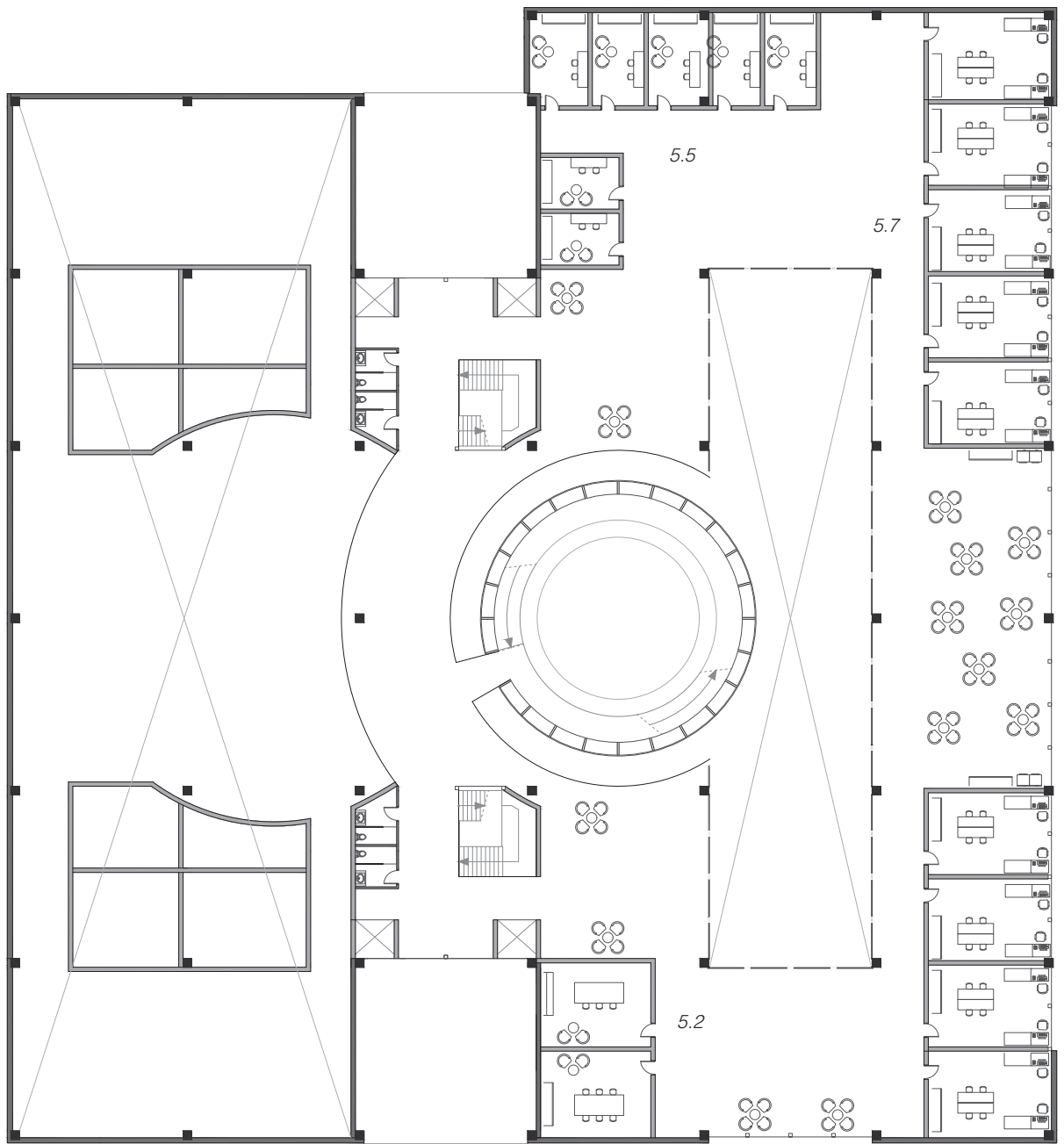
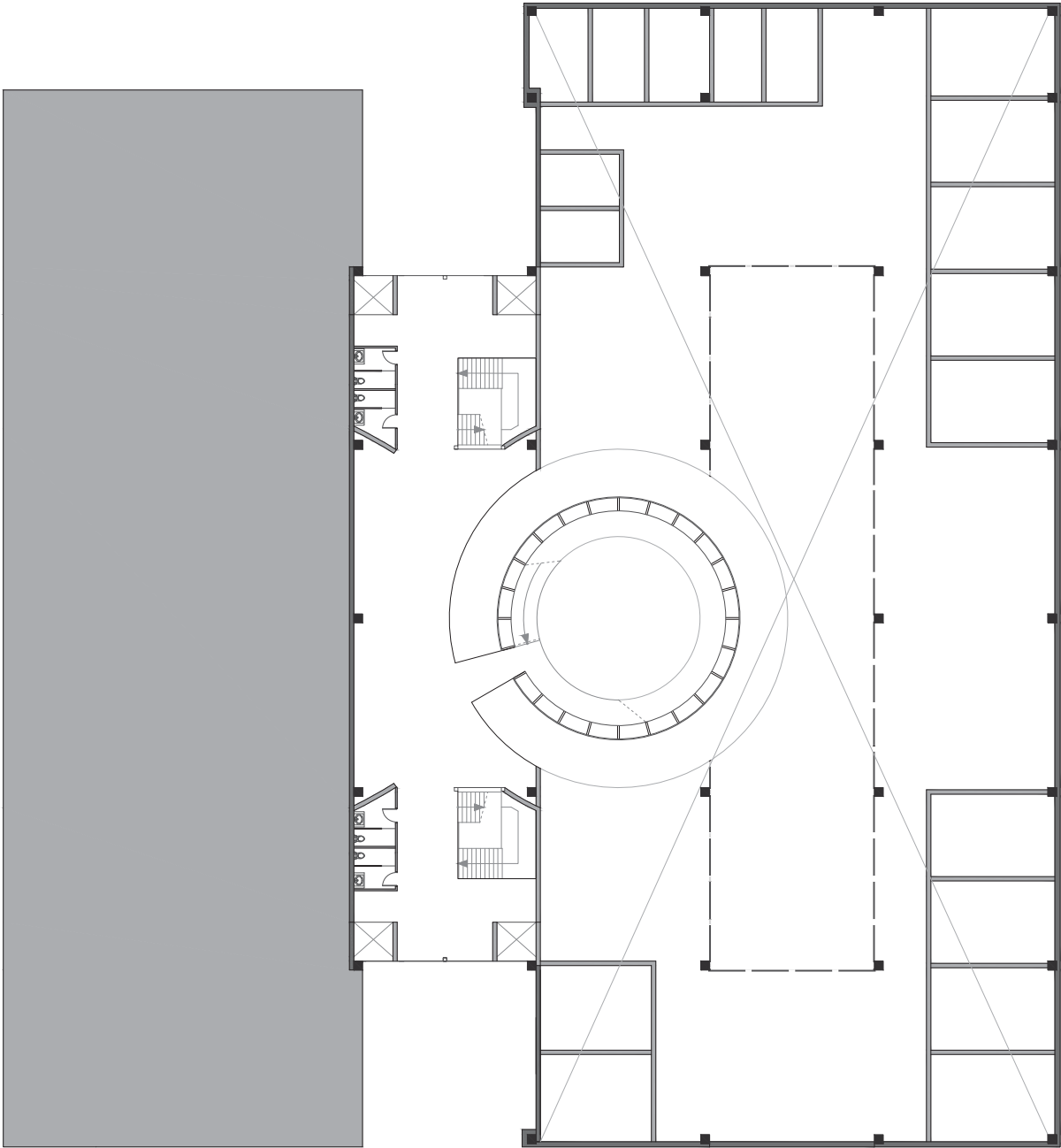
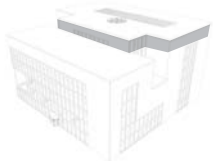
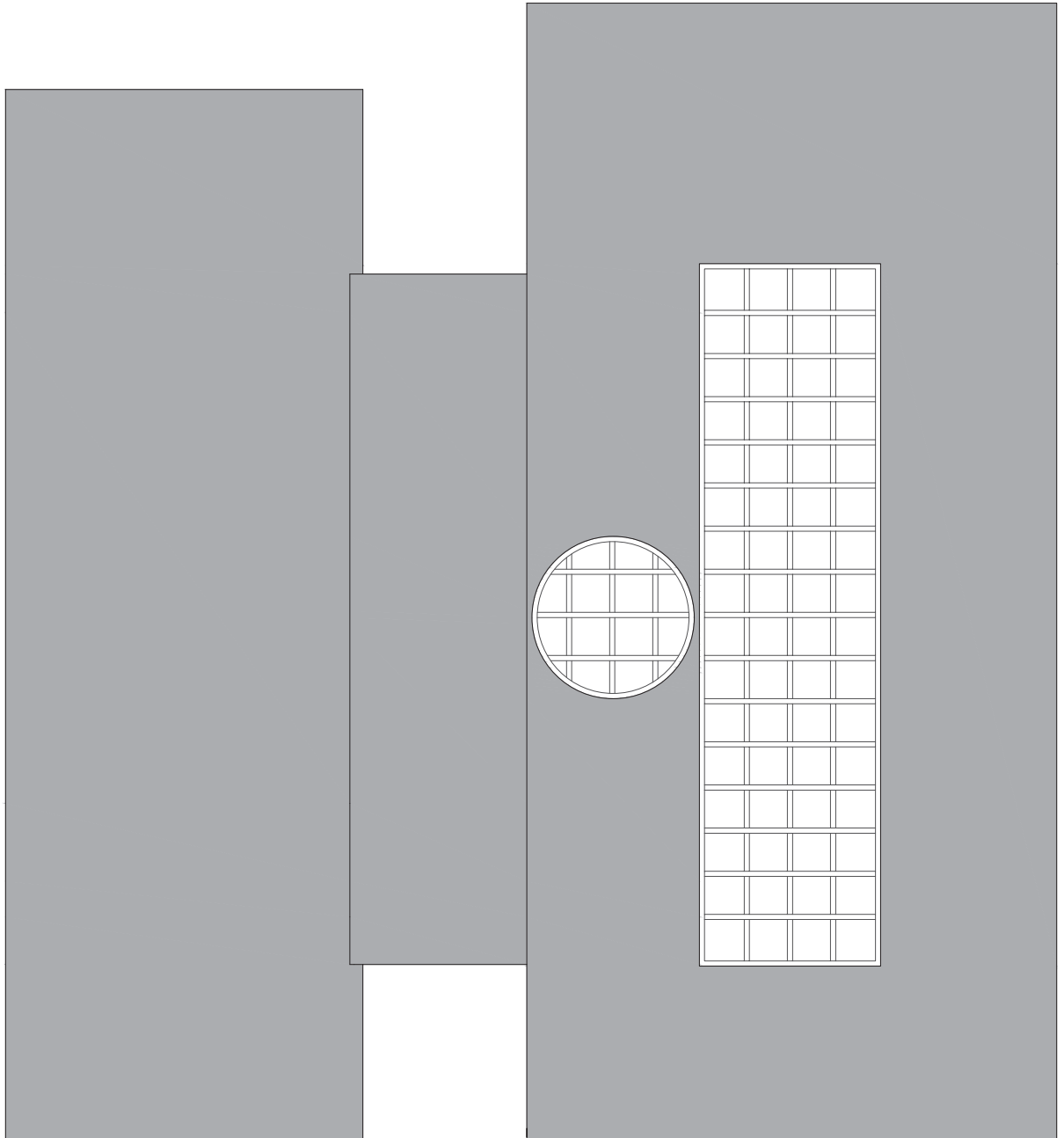
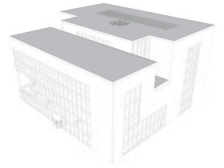




fig.4.15 6<sup>th</sup> floor +30000  
scale 1:400



**fig.4.16** roof +35000  
scale 1:400



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#### 4.3 SECTIONS

The two sections (figure 4.17 and 4.18) that were taken from the center of the building where the Helix tower is centrally positioned. A large-scale building where the spaces here are also taken on a large scale in order to get a clear spatial atmosphere with the Helix tower that stands separate from the building on its own. The two transition spaces on both sides are accessible on each floor, which lead you to enter the

Helix tower. The tower is hereby accessible on every floor on the ramp on the inside (figure 4.19 on the next page). This way every visitor can be at any floor level, grabbing a book from the tower and choosing a place to study, sit or learn. The main circulation is therefore centrally located in the building. The other rooms are easy to reach because of their spaciousness due to sufficient natural light and dimensions.



fig.4.17 Section A-A

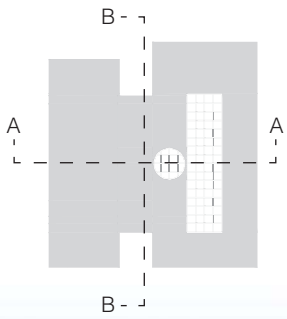


fig.4.18 Section B-B

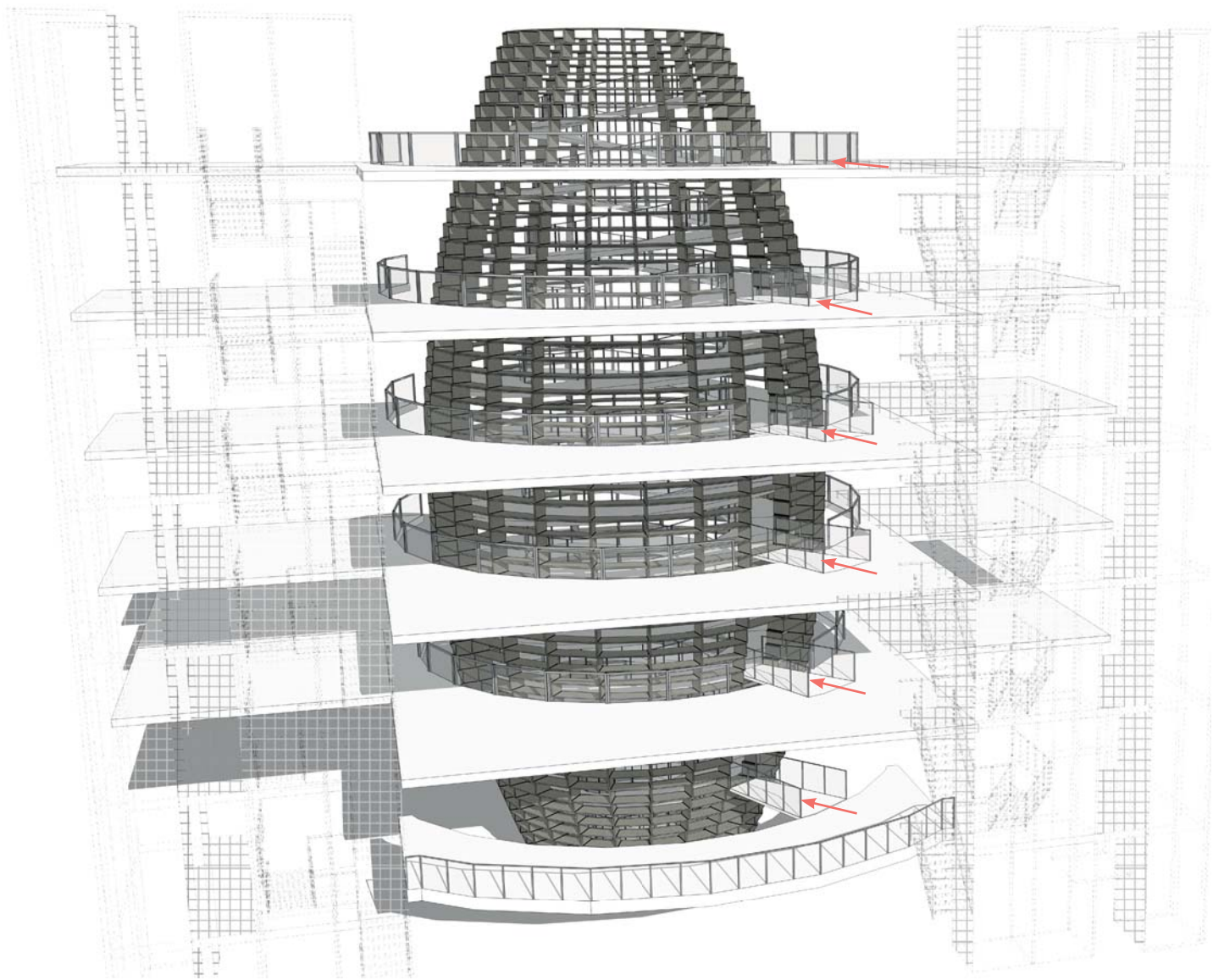








**fig.4.18a** *Art-Impression - Lobby in connection with café and the Helix tower*



**fig.4.19** The helix tower connected with bridges on each floor level of 5 meter high. The ramp connects very well with the floors regarding to the height. These bridges are accessible from the transition space in between the staircases and elevators.

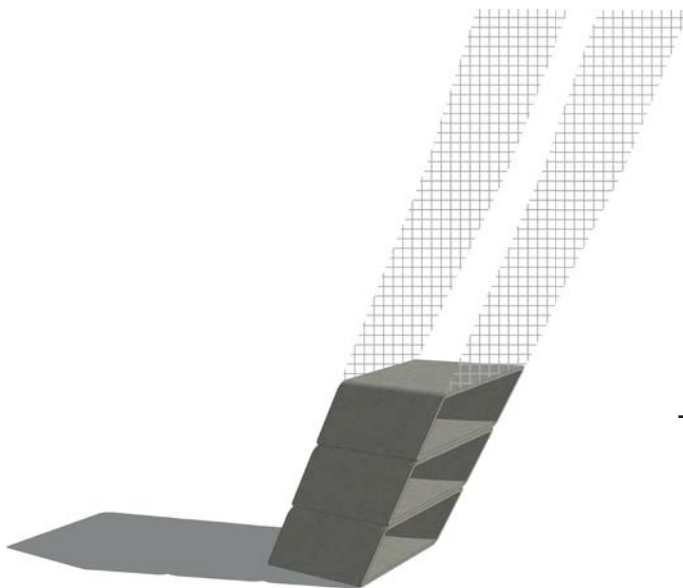
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#### 4.4 HELIX TOWER

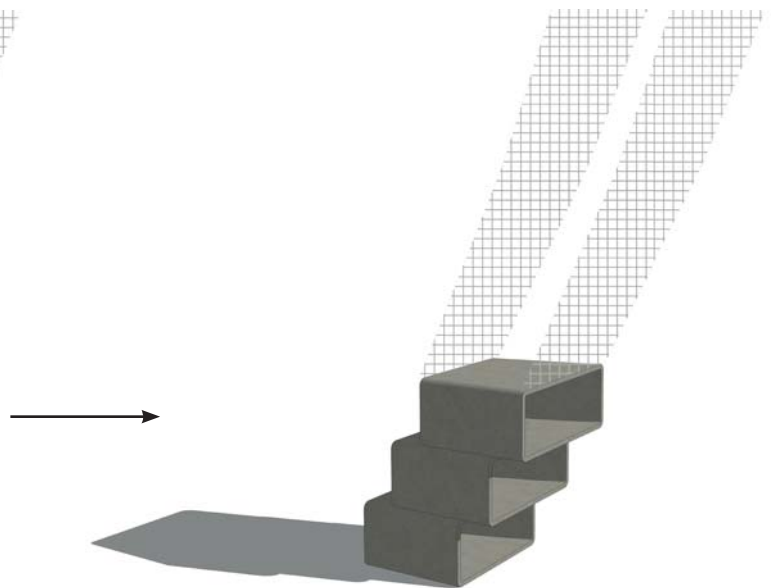
As mentioned earlier, the Helix tower is made of concrete. But not the most usual concrete, but the new innovative technique 3D concrete printing (3DCP). In chapter 3 in the research, the Obelisk method is explained and this method is also applied to the Helix Tower. The free form of the tower is caused by a script. Based on the script, the following step-by-step plan has been implemented from the form to arrive the final result in figure 4.22 on the next page; (1) after determining the shape on the basis of the radius of the bottom, center, and top, the obelisk method is applied, whereby the dimensions of the quadrangle shape or block (in this case a bookshelf) are determined on the basis of the shape of the tower (2). These are further divided over the entire form (3). After the distribution, the blocks are integrated into the tower (4). These blocks have curved faces following the shape of the tower. The ability to print out in concrete can only be done once the entire model has

been transformed and has been translated into the G code to print the blocks identically (5). This would be impossible to do with the human hand and the mold, because of its various dimensions. The curved blocks which are calculated need to be converted to straight faces blocks so that it can be printed (figure 4.20 and 4.21). And finally, when all blocks are printed and stacked in order in a spiral-shaped sequence, the spiral-shaped slope can be calculated and applied to the inside of the tower (6).

On the following pages, technical aspects can be seen where diagrams have been made in chapter 4.4.1 to show the construction with a technical detail 1:20 of the concrete ramp against the tower on the inside in figure 4.26 on page 142.

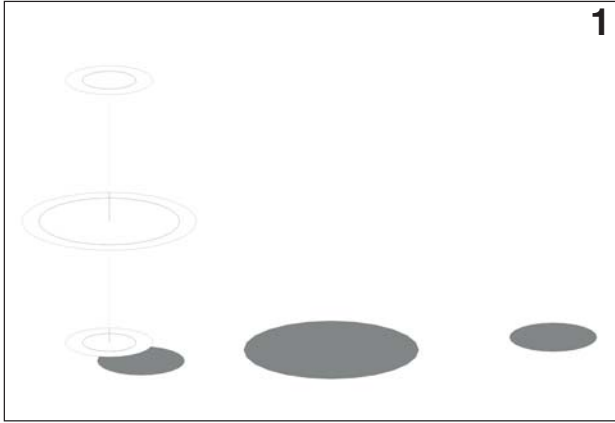


**fig.4.20** *Quadrangle shape with curved faces following the shape*

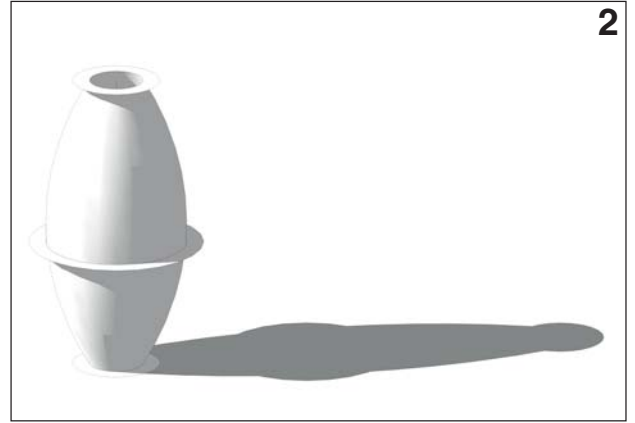


**fig.4.21** *Quadrangle shape with straight faces following the obelisk shape*

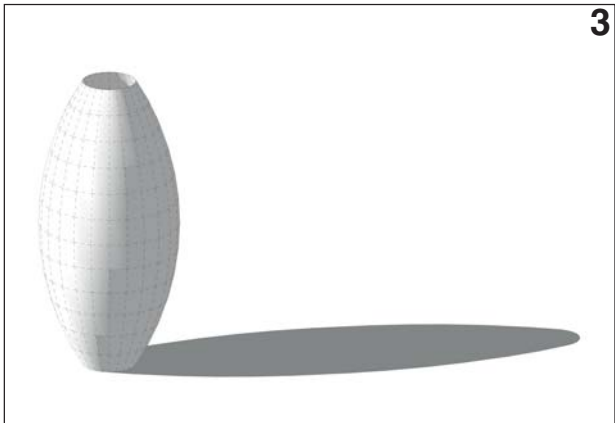




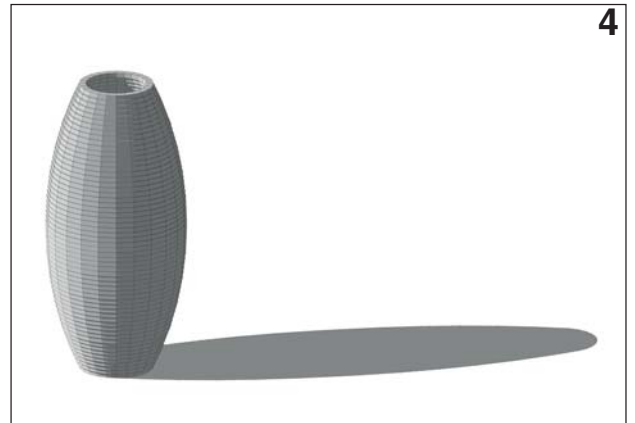
Radius from bottom - center - top



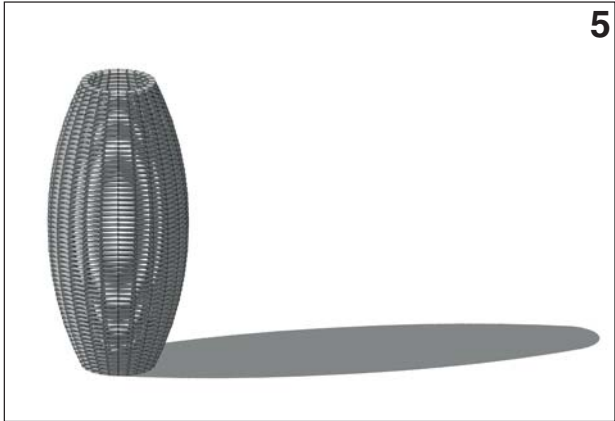
The obelisk principle



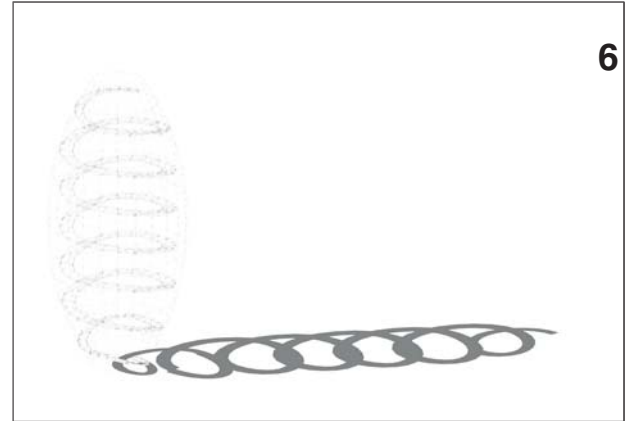
Partition quadrangle shapes



intergration obelisk shape + quadrangle shapes



Transforming quadrangle shapes into 3d concrete printable shapes

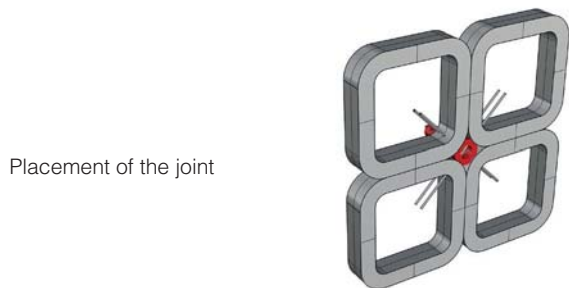


Adding inside ramp fit to the shape

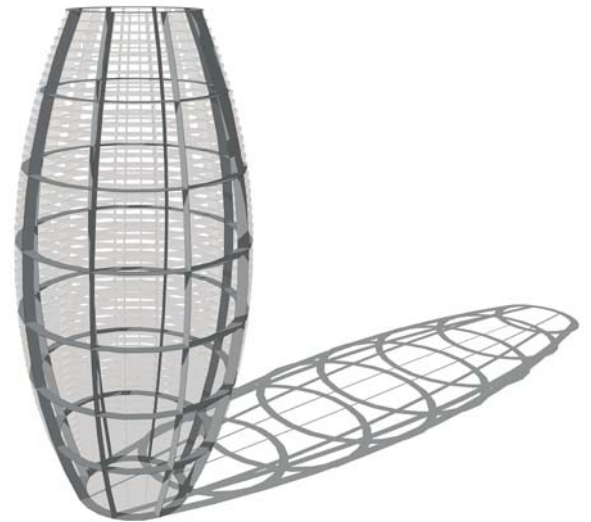
**fig.4.22** The step-by-step plan of the Obelisk method to reach the final design of the Helix tower

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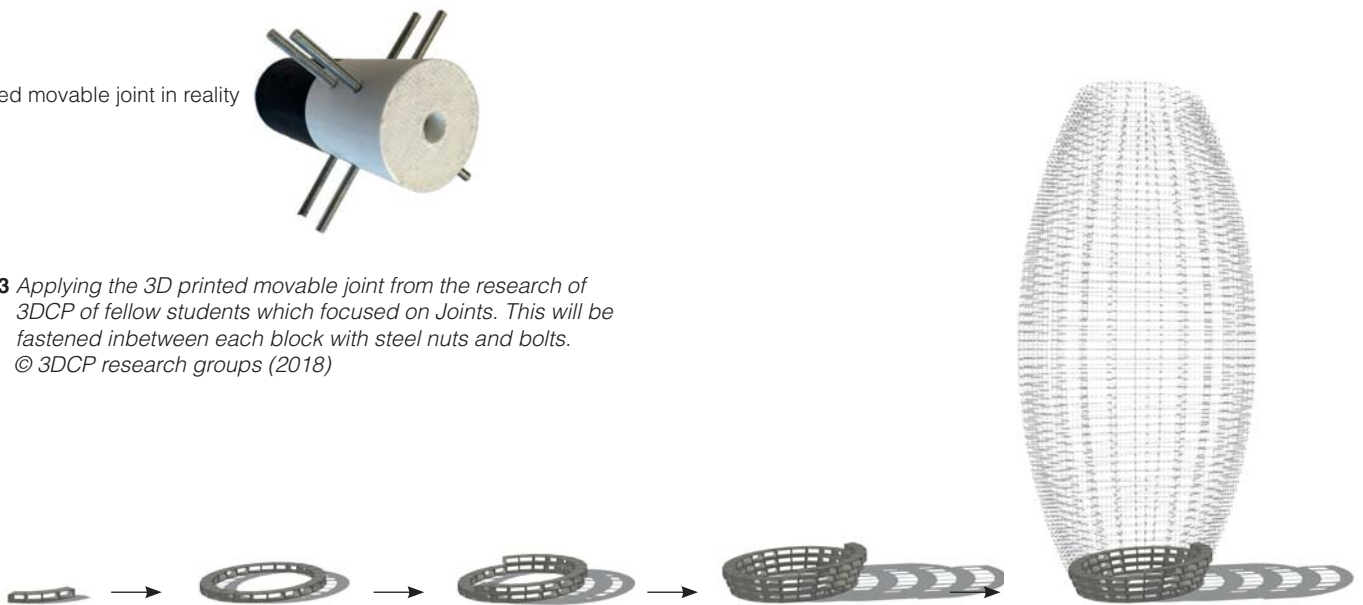
#### 4.4.1 Construction



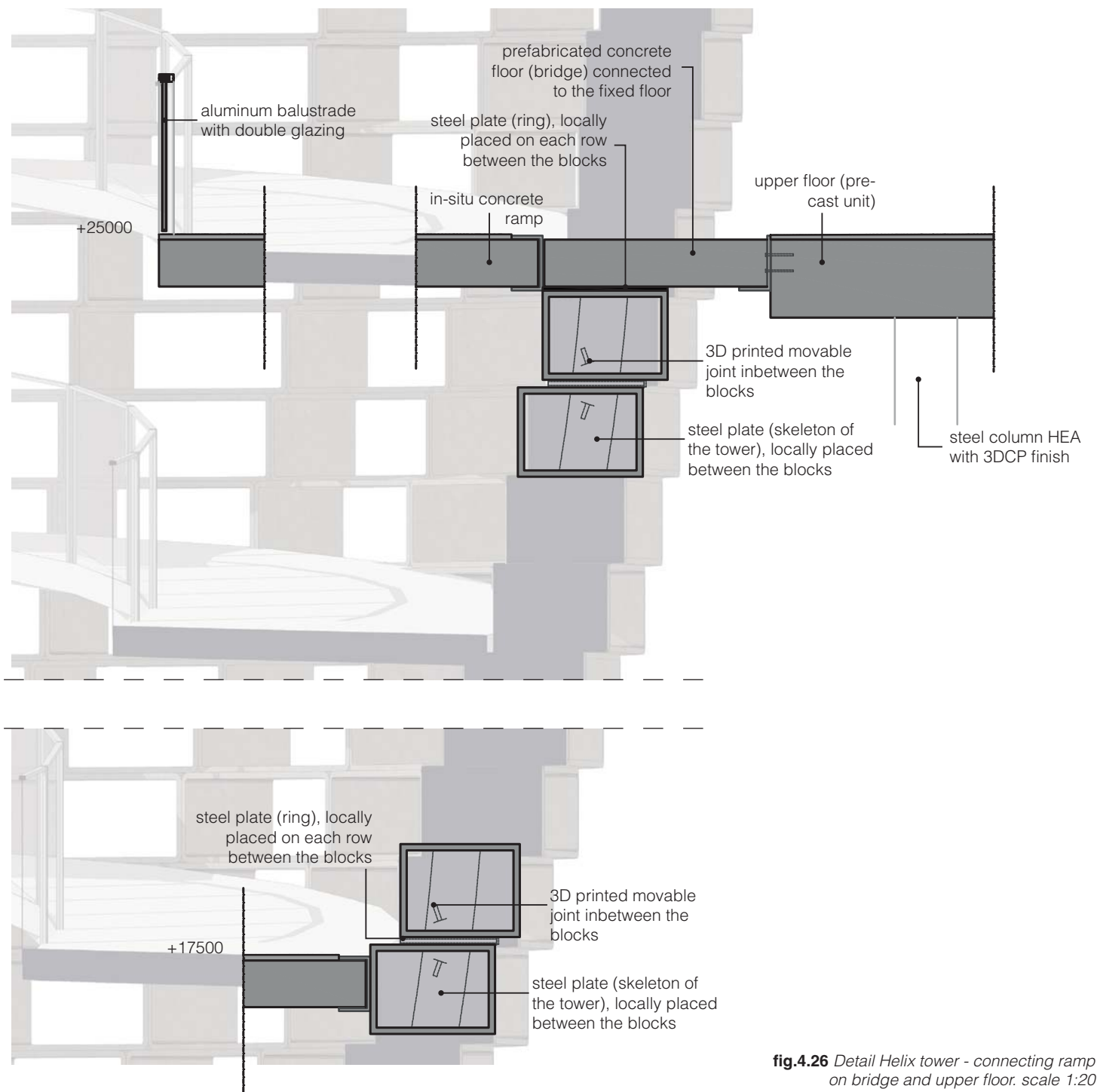
**fig.4.23** Applying the 3D printed movable joint from the research of 3DCP of fellow students which focused on Joints. This will be fastened inbetween each block with steel nuts and bolts.  
© 3DCP research groups (2018)



**fig.4.25** Steel plate (skeleton of the tower), locally placed both horizontally on each row and vertically between the blocks. This skeleton will provide stability



**fig.4.24** The spiral-shaped sequence to stack the blocks in order to achieve the end result.



**fig.4.26** Detail Helix tower - connecting ramp on bridge and upper floor. scale 1:20



**fig.4.27** Art-Impression - Inside the Helix tower (book tower) with the collections in the shelves (3DCP blocks). A well-functioning cohesion of materials such as steel and concrete, which creates an industrial appearance. A special experience for the visitors



FABRICATION

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## 1. PRINTED ELEMENT

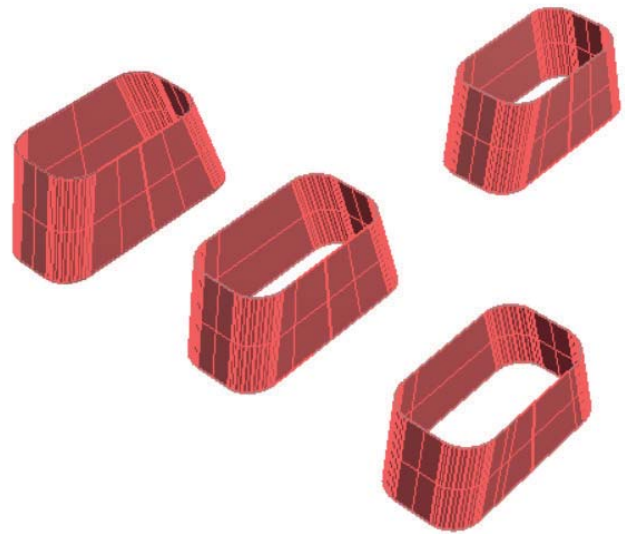
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During the process of designing the book tower, I also gained practical experience with the 3D concrete printer in the TU/ e lab. A few tests performed to print the blocks (bookshelves). For these types of 'small' objects, the lab has purchased a new pump to test if it can be printed. Unfortunately, we concluded in the lab that the small pump is not suitable because of the insufficient supply of concrete to the nozzle. Another option was to use the former pump with a smaller nozzle because the motor is more powerful and much more concrete comes out at the nozzle.

With these experiences, I started to print out the blocks. Making the block ready for the 3d concrete printer is also a very impressive and difficult process. Unfortunately, my first experience was not as I had expected. After printing about 20 layers (20cm) it fell, because of the curve in the block. Together with the employees of the lab, we looked at a possible solution for this and we used empty boxes (which also comes from a research team of fellow students about curves on 3DCP) and filling material to fill this box layer by layer during printing. With this principle, we finally succeeded in printing a number of these blocks (bookshelf) and to my surprise, I can say that the Helix tower could actually be built. However, the robotic arm will be used, because it is impossible to lift and stack with man's strength. In this chapter photos of this special process are shown with the final results of the blocks.



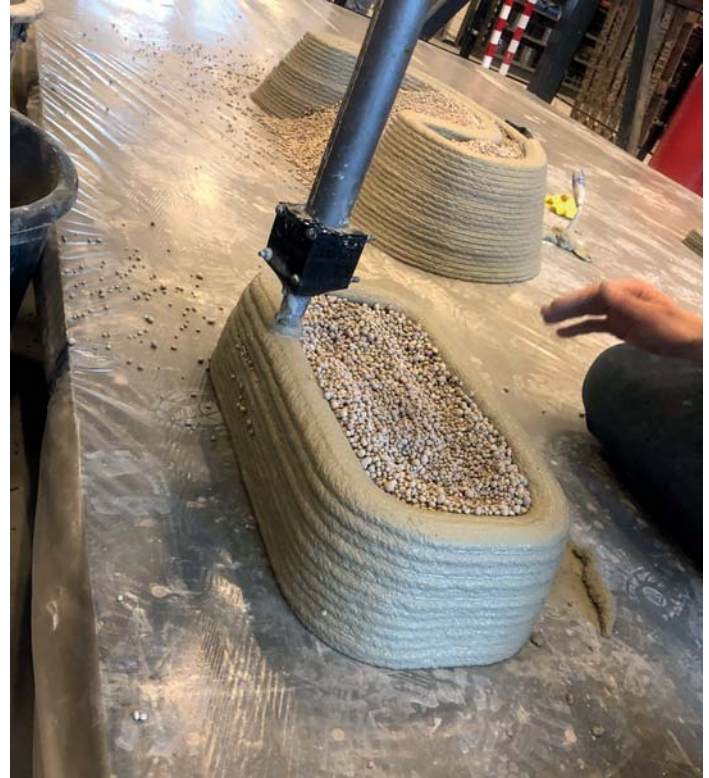
**fig.1.1** The 'new' pump in the lab - not succeeded.



**fig.1.2** Preparation bookshelves - making the blocks ready to print with the help of software Rhino, which generates G code for the concrete printer to understand how to print the blocks.



**fig.1.3** Preparation concrete printer in the lab. Checking the amount of concrete coming out of the nozzle and its speed.



**fig.1.5** Succeeded without using a box - the sizes of the blocks have been changed with only 15 layers instead of 25 layers. This was achieved with the help of filling on the inside.



**fig.1.4** Failed test - after filling layer by layer on the inside of the block without using the box, it fell after having printed about 20 layers.





**fig.1.6** Printing and filling it up layer by layer - in order to still be able to print several layers at once, and to achieve the actual height of the blocks, a box has been placed around the block where the inside and around the block is filled layer by layer. This filling keeps the curve and will not fall over.



**fig.1.7** Bookshelves for the Helix tower are printed - after having printed it, it is time to let it dry in the box with the filling material on the inside. When the concrete has become dry and hard, the box can be taken out and cleaned.



**fig.1.8** *The final result - after hardening and cleaning, the blocks are ready to be stacked to become a special tower. However, there are still filling materials on the inside of the blocks that have entered in the concrete, during printing and are hardened. These are not / difficult to clean. I also think that the structure of the filling material has an aesthetic value in the blocks, these therefore remain. A special process that I eventually became happy at the end.*



## CONCLUSION

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The goal of the research is to revitalizing (transforming) the existing industrial building which can play a significant role in the renewal and modernization of the area.

This study serves to resurrect a part of the power plant building by integrating innovative technique, using 3D printing and new functions into the building. Elements of the design will result in the actual 3D concrete printed parts. This structure will become a drawing point for the city and will help bring life to the district.

The research question to accomplish this goal is:

- How can the revitalization of an industrial building play a significant role in the renewal and regeneration of urban areas?
- How to implement a new function to the existing structure by using innovative technology such as 3DCP?

The sub-questions have been answered and used a basis for designing a public library in the existing industrial building 'Middendruk Centrale'. The sub-questions were mainly about the properties of the city Ghent and the district to understand the context very well. In addition, the meaning of the function, public library and the role which the new innovative technique 3DCP would play a role in it.

In the first section of the thesis, the research part can be concluded that the amount of a few aspects are limited, such as the greenery in the district, the certain blocks are closed, and the areas are not large enough to fulfill the requirements of the municipality. Therefore, greenery needs to be enlarged and make it more an open area. Another issue recognized is the architectural qualities of the buildings in the district. In mostly all building blocks are protected monuments

which needs more attention. This unbalanced situation is largely solved with the new Masterplan in many aspects as mentioned before, such as; infrastructure, social demographics and backgrounds and variety of functions in the district to attract visitors.

The concept of the new Masterplan is based on the implementation of a diagonal boulevard in its existing context. The boulevard will break the street typologies (organic street in the city center and the orthogonal street in the OMA- Masterplan). The district will work as a hinge and break these two typologies. The new boulevard made of concrete will function as a central passage through the neighborhood. By implementing a variety of functions located close to the boulevard, liveliness will be created. My design plays an important role in here which is located against this new straight, direct boulevard.

Because of the social problems in the neighborhood and less variety of functions, these aspects give a bleak picture of the neighborhood, while the area is open to innovation and modernization, which is also mentioned by the municipality. Especially the area where the power plant 'The Central' is located in a special and unique area with a lot of historical value. This area got my attention and helped to revitalize this area within the neighborhood. For example, I chose not to revitalize 'De Centrale' directly, but a building that has no added value regarding the problems mentioned above. Because of its scale and location, revitalizing, through the transformation of the 'Middendruk Centrale' would make a positive contribution and could mean more for society than it is now. Placing a public function such as a public library will have a major impact on the social factor within the neighborhood. One of the visions of the municipality of Ghent is to have more space and more social functions in the city. This new design for the 'Middendruk Centrale' is intended not only for

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residents of the neighborhood but also for tourists and visitors outside this district. To create the best possible transition from the city center to the OMA-master plan, and to invite visitors, this public library will be a meeting place. The library will be more than just a collection of books. An urban 'living room' where people can meet each other. Unconsciously these visitors come into contact with each other. The design is therefore architecturally open and spatial to stimulate these aspects.

After having researched the meaning of public library, I quickly found out that the function itself does not represent much and that it mainly concerns the organization such as circulation, public spaces, and the collection which play an important role. The design offers that organization of circulation and public spaces. Because of the large scale of the building, I also wanted to use this spaciousness quality and so the Helix tower (book tower) was created. The collection is also well organized, just like the circulation and public spaces. The choice has been made to realize this in coherence with the new innovative technique 3DCP. Using the research on the subject of 'assembling'. This technique introduces many possibilities in the field of architecture. A book tower complete in 3d printed elements. It sounds very challenging, new and exciting. This has been realized and well-filled within the building as a public library.

This Helix tower is centrally positioned to gain extra emphasis. From this central location, the organization is built up and connected to the other functions. There are various functions within the building that also attract various visitors into the building. A completely public-accessible building for young and old.

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This building, which first stood as a large block in the neighborhood, with little influence in its surroundings, has been brought back to life through this transformation. This will also be an added value for the neighborhood to bring the district and the city back to life.



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### *1. PROPOSALS FOR FURTHER RESEARCH*

This thesis is based on an existing location where the problems have been thoroughly investigated at both the city and neighborhood level. After that, these problems have been tried to solve. A way to tackle (finding solutions) a neighborhood within a city. To do a more thorough investigation, to do case studies on the reference project of cities where it is already working fine.

The design is applied in an existing building where you have some limitations, such as dimensions and shape. Replacing the existing into a completely new public library could be an option and see how it will work at city and district level.

The new innovative technique 3DCP is generally not yet known in the architecture world. More and more there are many stories coming about it. This thesis has taken a step to see what the potential is and what it can mean in architecture. Within this subject, many aspects are still unknown what can be investigated. Especially in the field of construction. In constructive terms, further research could be done for exact numbers in the field of stability. In this thesis, just one part has been studied, namely assembling in terms of 3DCP.

### *2. REFLECTION*

This graduation studio introduced the new innovative technique 3DCP together with a city like Ghent. A completely new experience within my study. I had never been in Ghent and worked with the 3DCP in an architectural project. In general, the first part which is the research of Ghent (city and district) and 3DCP went well and resulted in a strong basis for the design. During the process of designing, you often encounter things that you think you can do and want to change because you want it differently. This took a lot of energy and time. Making variations and continuously changing.

Starting a design from the research about 3DCP was difficult in the beginning because you need to take 3DCP into account for designing. Therefore, it was a challenge for me that I had to go for it. The nice part was, that we had an existing location to do the research. I did many architectural projects where the location already was spotted to do the research.

My passion for transformation has also returned to this studio. I challenged myself to transform an industrial building into a public library. I learned a lot and have been tested for this project. Perhaps the design of a new building would not have cost as much energy as a transformation project. However, this did ensure that I could get the best out of myself and prove myself which is within my abilities. In general, I can look positively back to the graduation studio.



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