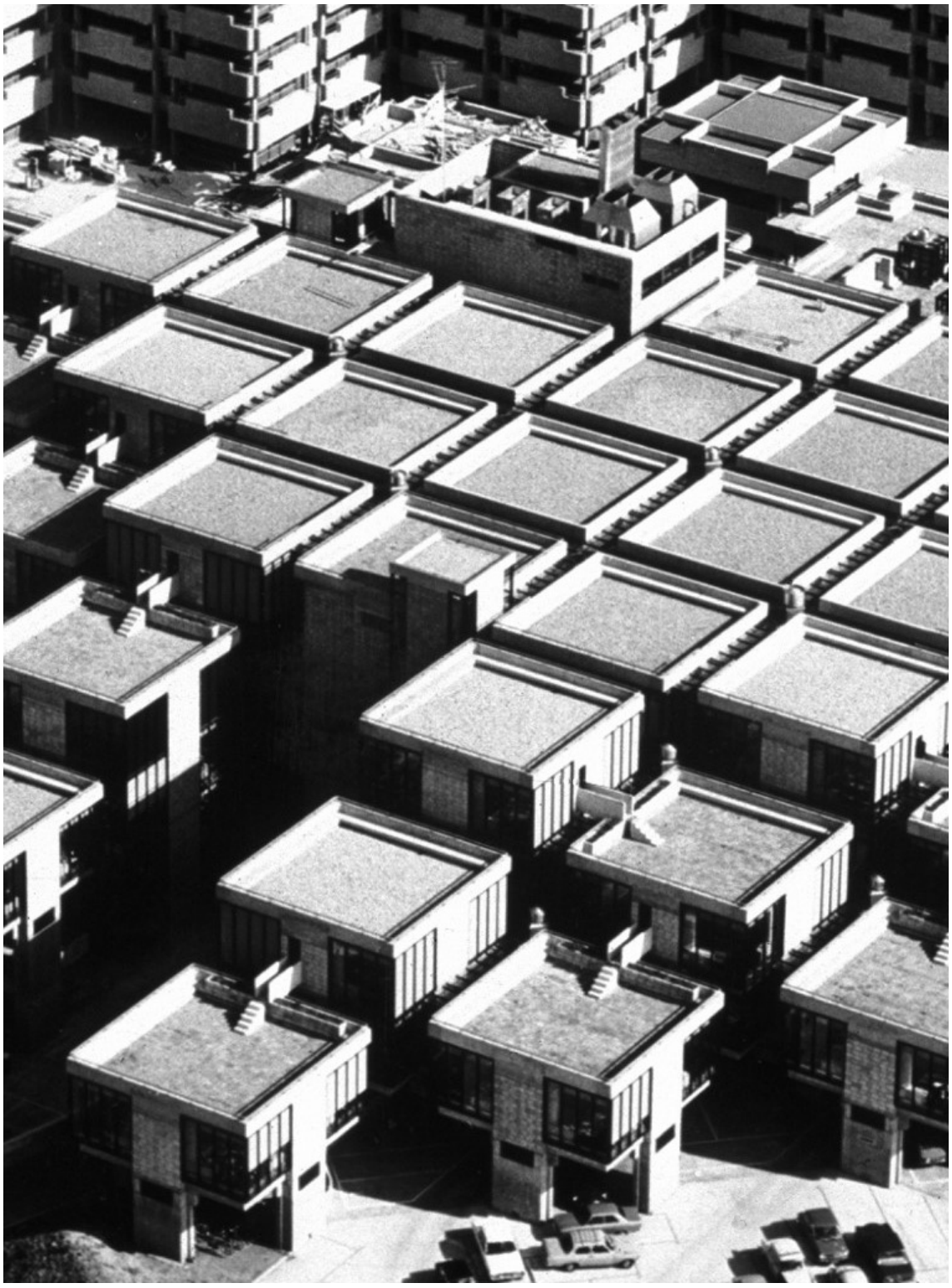
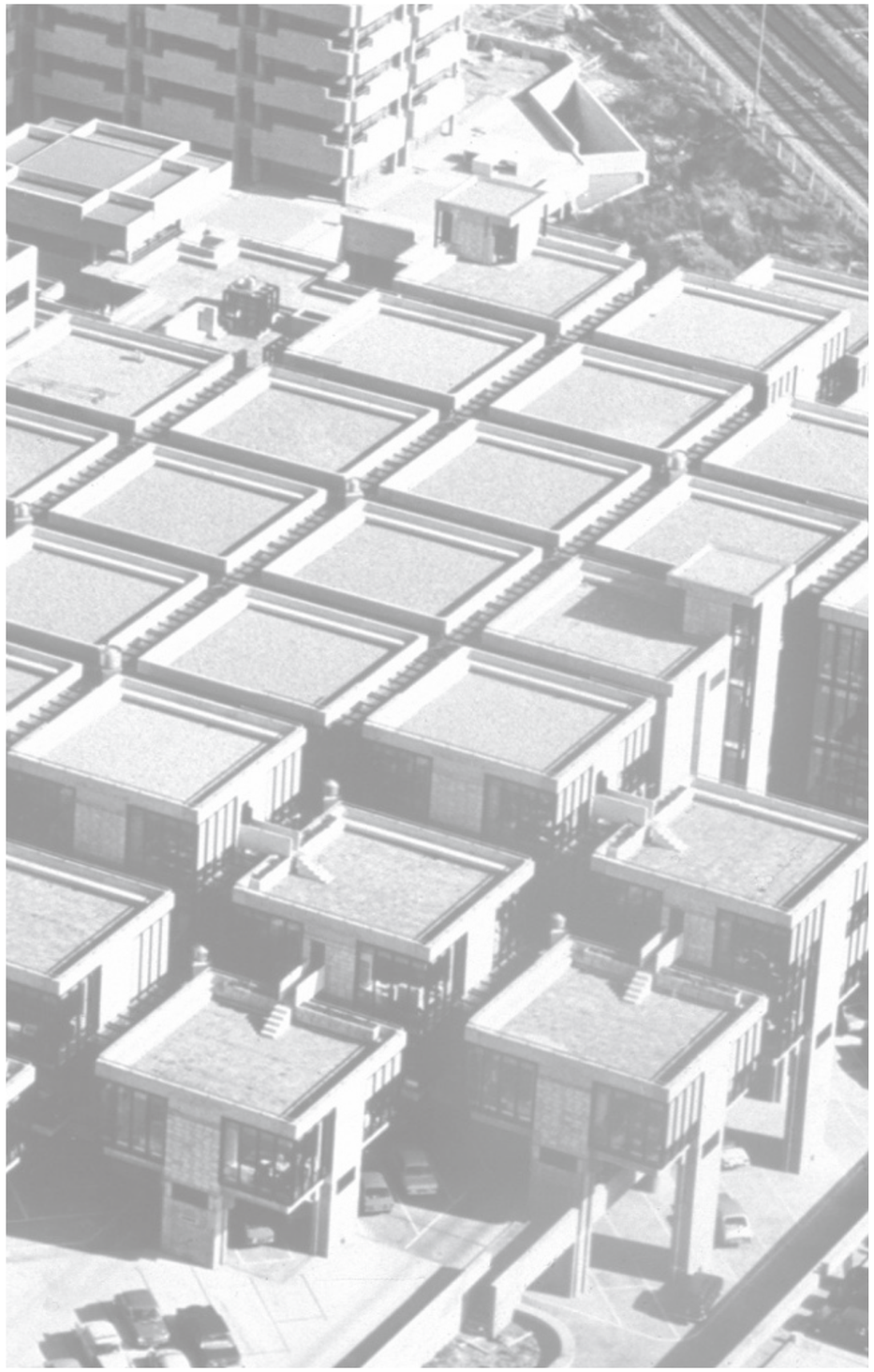
Revitalizing Centraal Beheer

Discovering the future potential of Structuralism, by redesigning Centraal Beheer and revitalize its inherent concepts



1. Research



Revitalizing Centraal Beheer

Discovering the future potential of Structuralism, by redesigning Centraal Beheer and revitalize its inherent concepts

MSc Architecture, Urbanism & Building Sciences
Track: Architecture
Studio: Heritage & Architecture: The Future of Structuralism
Delft University of Technology
Dirk Gevers
4523180
d.gevers@student.tudelft.nl

3rd July 2018

1st supervisor: Ir. L.G.K. Spoormans
2nd supervisor: Ir. F.W.A. Koopman
3rd supervisor: Dr.I. Nevzgodin
External examiner: Prof.dr.ir. H.J. Visscher

Content

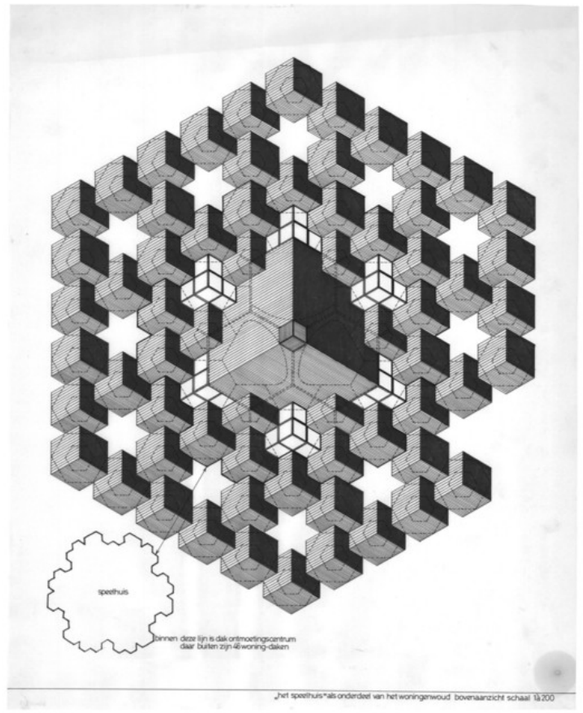
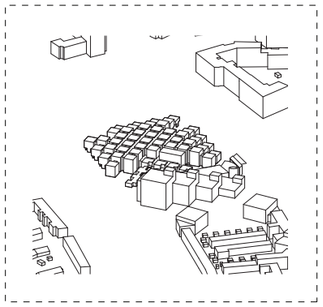


Fig 1. Piet Blom, the Speelhuis Theatre and Cube Houses, c. 1974.

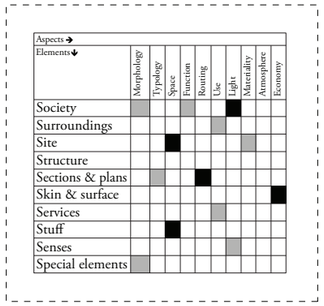
1. Introduction

This booklet describes the beforehand research and redesign of the Centraal Beheer office building from 1972 by Herman Hertzberger in Apeldoorn. The building is design according the Structuralist paradigm which '*represents a human, social architecture that can interact, grow and adapt. Starting in 1959, Structuralism became a very influential movement in The Netherlands. But what happened ever since? Some of the Structuralist buildings became icons, but many are facing drastic transformation or demolition. Despite the design of open structures, flexible for the future by extrapolation or adaptation, the buildings show shortcomings in indoor climate, aesthetic appearance and programmatic possibilities*' (Heritage & Architecture Fall Semester, 2017). The studio, and therefore this project, aims on researching the future value of Structuralist buildings by making a redesign of an existing Structuralist building that functions as a case study.

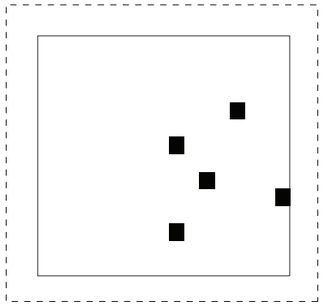
This booklet elaborates on the in depth and all-scaled analysis on the building and its context, depicting the most important heritage values, transform these values into a framework that sets the starting points for the re-design.



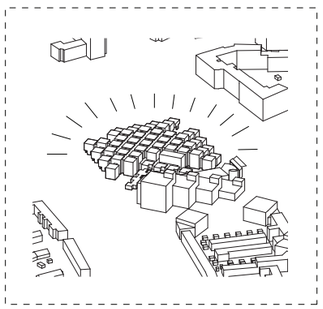
Analysis
Of the original building and its context from an architectonic, cultural-historical and technological angle.



Value Assessment
Prioritizes only the cultural - historical, architectural and technical values relating to Structuralism, in order to formulate starting points for a meaningful redesign.



Transformation framework
Addresses the key values that are fundamental for discovering the potential of Structuralism that determine the design approach and sets starting points for the design.

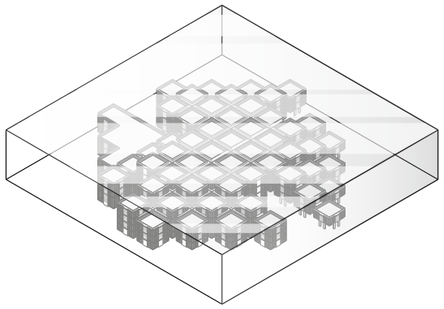


Design
A design that revitalizes the values relating to Structuralism and exposes Structuralism's future potential.

Fig 2. Research methodology

2. Methodology

In order to respond to the studio's aim the most directly, which is trying to discover the future potential of Structuralist buildings, it is essential to give priority on the inherent characteristics that make the Centraal Beheer building a Structuralist building. Also, Structuralist buildings can be seen as modern and specific buildings which were based on revolutionary and conceptual ideas that were supposed to change, and did change, the perception of architecture. They are buildings that, as one of the first, took into account the notion of time and were directed at the future. Therefore, they also demand a specific approach that acts on these strong, conceptual intentions. Compared to more historical, heritage projects where the emphasis is on freezing and enclosing heritage values, I believe Structuralism has the inherent capacity of continuing its legacy. Although the buildings show a very strong and recognizable formal language, most of them were designed from the inside out, starting from the human perspective and the perspective of (future) use. I believe ignoring all these great concepts and ambitions would be disrespectful, freezing and enclosing them would be a missed opportunity.



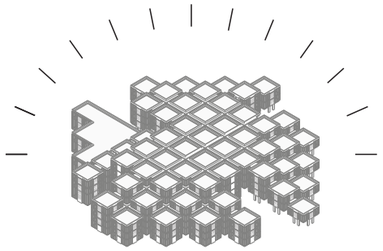


Fig 3. Revitalizing instead of freezing

The result can be seen as a facelift of Structuralism, instead of merely freezing and enclosing it's original concepts.

Fig 4. City of Apeldoorn

3. Urban analysis

This analysis seeks for a broader understanding on how the urban context surrounding Centraal Beheer has developed. It places the realization of Centraal Beheer in a timeline of urban developments, offering insights on how the building relates to its urban context, where and when it was constructed.

Fig 5. Apeldoorn in 1842

Setting

For the historical development of Apeldoorn, the landscape has been very decisive. Even the current structure of the city is still relating to this (Bet, Hinterthür, & van Meijel, 2009, p.13).

Apeldoorn existed on the scenic transition of high to low subsoil. The eastern low part consisted of the wet and low-lying river basin of the IJssel with shallow lakes and swamps. The western higher was formed by the landscape of the Veluwe and was dry and barren. The higher levels were used for arable and livestock farming (Bet, Hinterthür, & van Meijel, 2009, p.13).

A settlement originated on a high part of subsoil between the streams the Grift on the south side and the Badhuisspreng on the north side. The settlement developed along two crossing, continuous routes from north to south and east to west. The name of Apeldoorn - which most likely means 'by a water' - appears for the first time in a document of 792/793. That water was the Grift, the most important vein of the village. During the middle ages, Apeldoorn was primarily an agricultural neighbourhood and for many centuries to come, Apeldoorn was an isolated, poor and bare area (Bet, Hinterthür, & van Meijel, 2009, p.17).

A church, dedicated to Maria, was built in the twelfth century on the south part of the historical core. The stand-alone church formed the heart of the small settlement which developed further as a small village due to its location at the intersection of important trade routes. The village had a central, caring function for passing travellers and traders (Bet, Hinterthür, & van Meijel, 2009, p.17).

Besides agriculture and trade, the royal castle Het Oude Loo from 1439 and the royal palace Het Loo from 1685, contributed to the further development of Apeldoorn. Because of the royal presence, wealthy families started to descend in Apeldoorn. Between the palace Het Loo and the village, they built large country houses and villas (Bet, Hinterthür, & van Meijel, 2009, p.23).

Despite all this, Apeldoorn remained being a small and modest village. On the north side, a new church was constructed in 1842, so the core of the village was laid out between the two church centres. Loose buildings stretched out along the main routes and parts of the water streams and the edges of higher parts of subsoil. The densest building concentration (core) was on the Dorpsstraat, the central street through the historical core (Bet, Hinterthür, & van Meijel, 2009, p.23).

Fig 6. Apeldoorn in 1898

In the second half of the 19th century, Apeldoorn transformed gradually from an agricultural village into a villa-village with corresponding facilities (Fig. 2). The green, forest-like environment, the royal presence and the improved infrastructure were attractive factors for the wealthy to settle in Apeldoorn. At that time, the municipality considered it their primary task to maintain and expand the attractive and green character of the villa-village. Spacious living in a green environment remained until far into the twentieth century the central theme in the north-western extensions (Bet, Hinterthür, & van Meijel, 2009, p.23).

Especially the middle class benefited from the arrival of the wealthy. Detached houses were built by entrepeneurs in the area 'Apeldoornse Enk', in which Centraal Beheer would be built later, along with new shops in the Hoofdstraat which developed into a shopping district. Also, the green, forest-like environment, the royal palace het Loo, the villas, the parks and the shops made Apeldoorn an interesting destination for tourists. This led to the construction of a large number of lodges, pensions, hotels and restaurants in the village (Bet, Hinterthür, & van Meijel, 2009, p.23).

The accessibility of the village improved in the nineteenth century significantly because Apeldoorn was linked with the national network of streets and water-/railways. The real growth occurred in the second half of the 19th century as a result of extending the canal in south direction and the construction of railways towards Zutphen (1876), Hattem en Dieren (1886) en Deventer (1891). The improved and newly constructed streets and water-/railways broke the isolation of Apeldoorn and became attractive for businesses to settle. The new infrastructure was also an important economic catalyst for the industrial development of Apeldoorn. The home-bound industry made more and more place for industrial (large) companies (Bet, Hinterthür, & van Meijel, 2009, p.27).

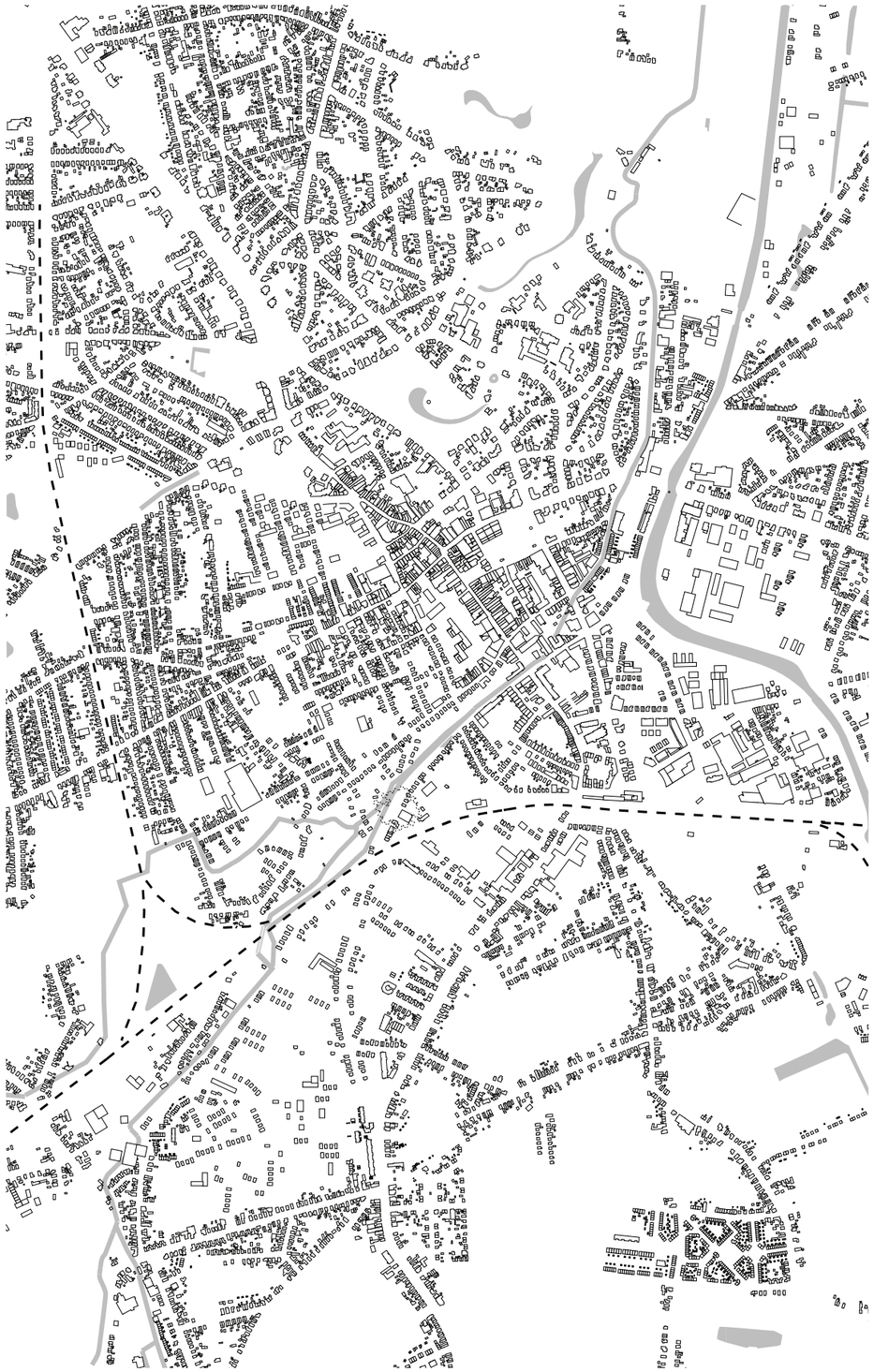


Fig 7. Apeldoorn in 1933

Spatially, the empty land between the strips of buildings was filled up in the end of the 19th and the beginning of the 20th century (Fig. 3). Because the agricultural settlement of Apeldoorn is not bounded by any fortifications, there was space for expansion on the surrounding farmland. There was no need to build compact. The 'loose' building pattern consists mainly of detached and semi-detached buildings in rows of varying lengths, with gaps and indoor areas (Bet, Hinterthür, & van Meijel, 2009, p.29).

Fig 8. Apeldoorn in 1966

In the twentieth century Apeldoorn grew from a village to a town. Until then, Apeldoorn was mainly built without planning, in the form of highly diffused linear building strips and incidental, small-scale street plans. In order to lead the turbulent growth of becoming a town, a series expansion plans were drawn up, in accordance to the Structuurplan from 1950/1962. Multiple versions of this plan turned out to be too ambitious and also the Second World War stopped a further development and change of those plans. After the Second World War, Apeldoorn was one of the fastest growing cities of the Netherlands. All around the historical core, new neighbourhoods were constructed, in accordance to the Structuurplan from 1950/1962 (Bet, Hinterthür, & van Meijel, 2009, p.33).

Fig 9. Apeldoorn in 2016

The new construction of neighbourhood's all around the historical core ended in the 70s. Besides this, multiple redevelopments took place on the periphery of the city centre, in which scale enlargement was the central theme. The historical core itself became denser. Around the city centre, a continuing route was created, therefore the city centre lost its function as crossing route for car traffic (Bet, Hinterthür, & van Meijel, 2009, p.37).

To conclude, the historical development can be categorized into a number of important stadia. The scenic and rural subsoil, the royal touch, the green and open villa parks, the new street and water-/ railways, the industrialization, the metropolitan visions and the final city formation, all still connected and visible in the current city structure.

On January 1, 2017, the city counted 141.107 inhabitants, and is the 12th biggest city of the Netherlands (Fig. 17). The current character of the city is mainly determined by its green character and city parks. Also characteristic are the 'Apeldoornse huisjes' structure, the structure of the Apeldoorn dwellings, with many monumental and detached houses and relatively little high rise. With approximately 100,000 jobs, Apeldoorn is an important employment center in central and eastern Netherlands. However, nowadays Apeldoorn is still struggling with being regarded as a large village that is looking for their own urban identity (Herpoel, 2013, p.93)

Fig 10. Surroundings and site in 1842

Site

Taking a closer look, towards the surroundings of the site, it becomes clear that the Driehuizerspreng (1 in Fig. 6) and de Grift (2 in Fig. 6) both, traditionally have been important structural elements in the area, which was called the 'Apeldoornse Enk'. These old streams (especially de Grift) have been of great importance to the spatial and economic development of Apeldoorn and for the area surrounding Centraal Beheer in particular.

Fig 11. Surroundings and site in 1872

Along the flowing water of the streams, there were various forms of industry, located in a green and rural setting. The first water mill for grain and oil in Apeldoorn dates from 1335 and was in the area from the current Centraal Beheer office. Later, in the 19th century, there were farmhouses, paper/ water mills and laundries.

Fig 12. Surroundings and site in 1898

The rise of small industrial companies, partly due to the arrival of the railway Amersfoort-Apeldoorn and the track to Zwolle (via Het Loo) in the 19th century, laid the foundation for the further urbanization of the former Apeldoornse Enk to a residential area named Brinkhorst. The green character was largely lost. De Driehuizerspreng largely disappeared during the course of time (CODA Apeldoorn, 2003, p.5). Streams and roads (like the Brinklaan) were cut off.

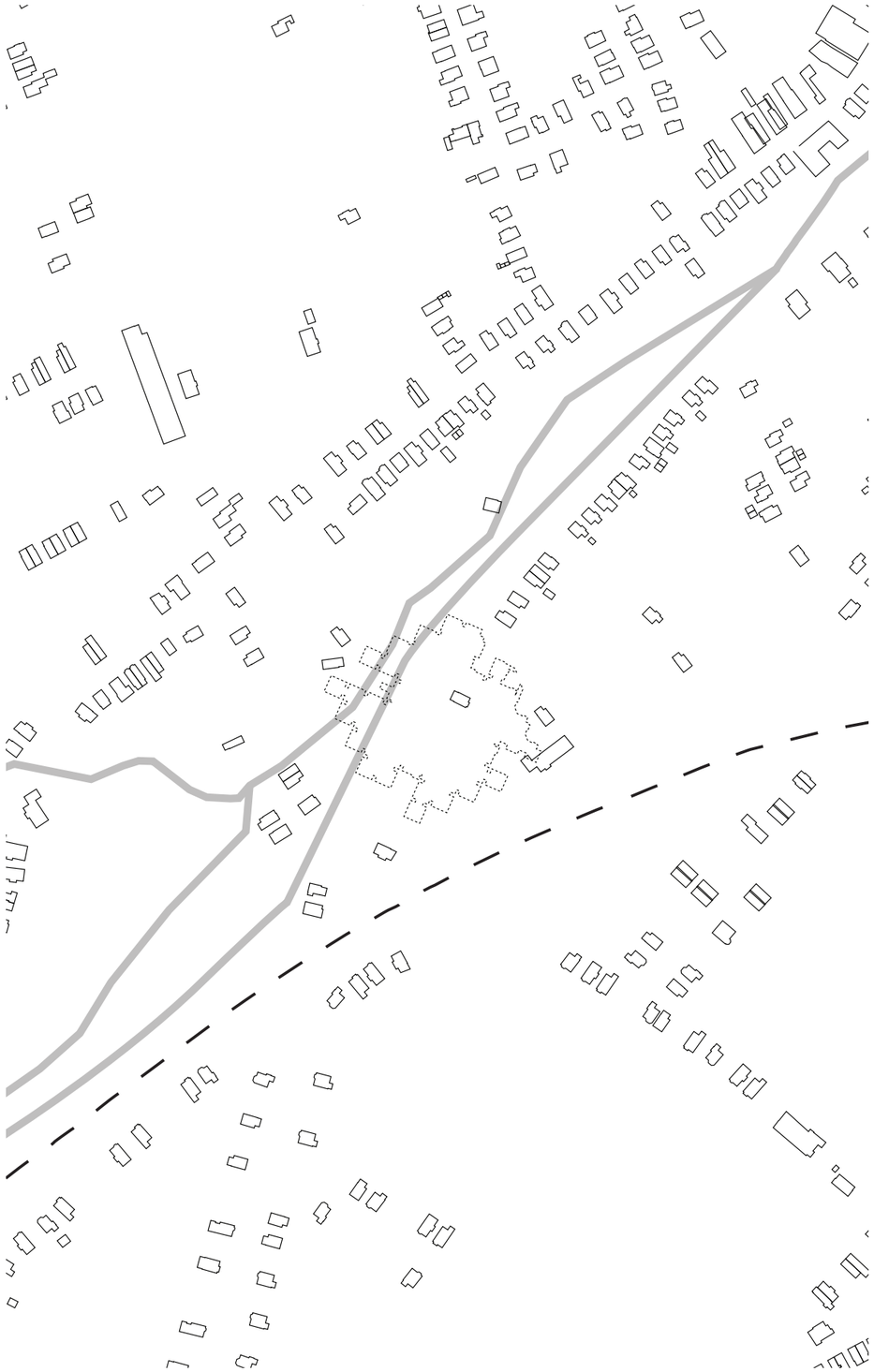


Fig 13. Surroundings and site in 1907

Existing and new roads were filled up with (semi) detached (workers) homes. This structure has maintained until the 1960s (CODA Apeldoorn, 2003, p.7).

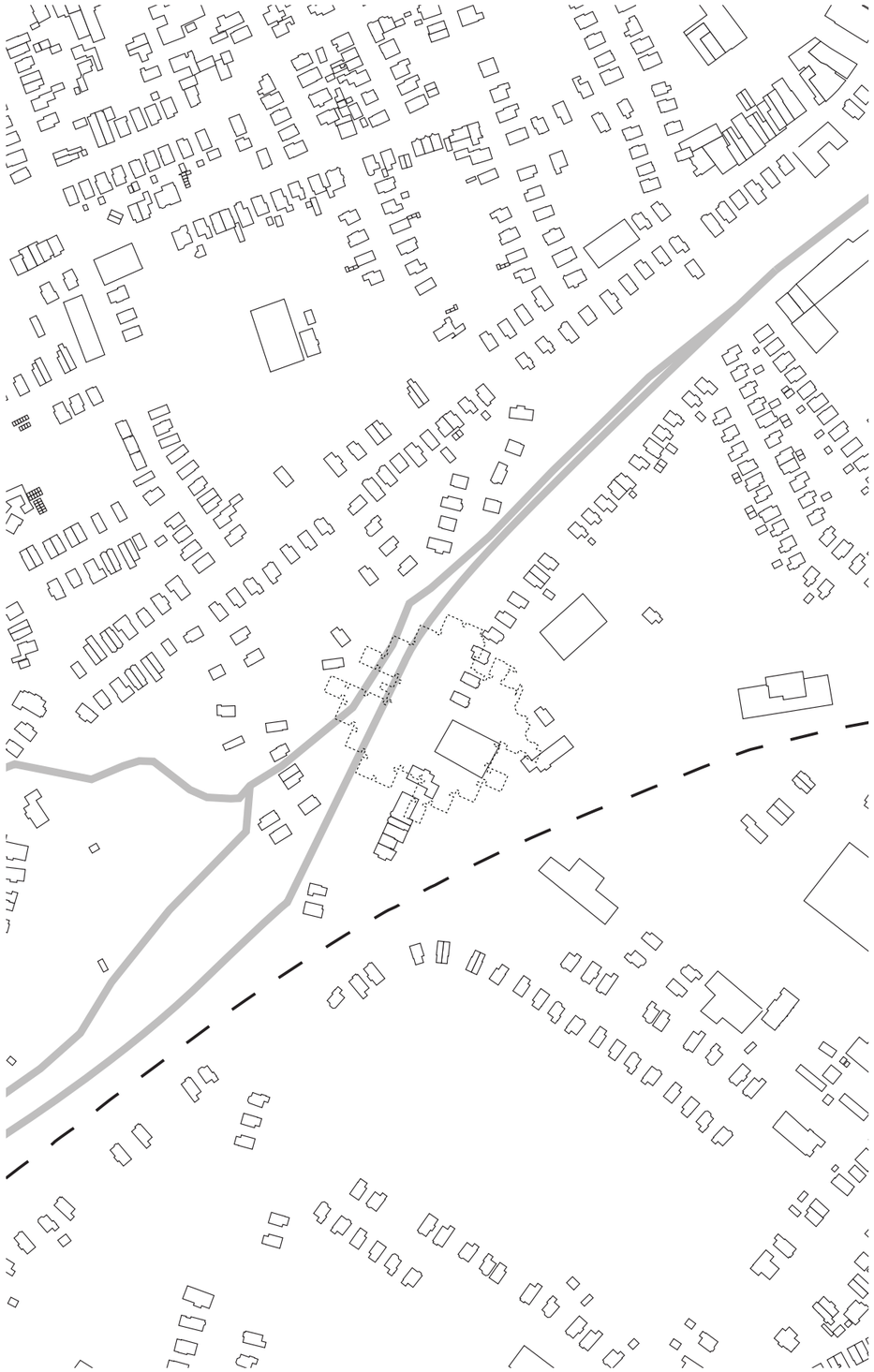


Fig 14. Surroundings and site in 1966

As the industry flourished, workers residences were constructed along the existing urban tissues, making the site becoming more dense and becoming more and more part of the city centre.

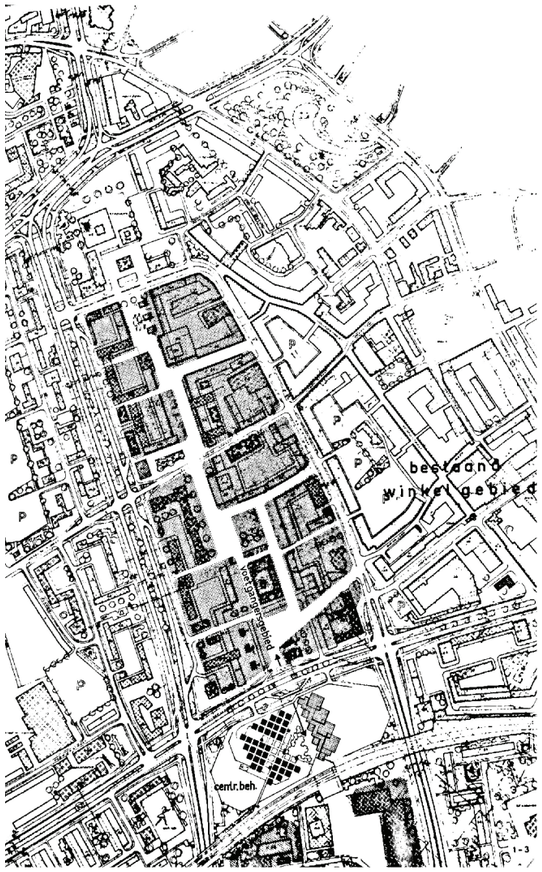


Fig 15. Centrum and City plan from 1966

The most influential version of the Structuurplan for a renewed and modern city centre was the sketch plan 'Centrum en City' from 1964 by the design of Ir. D. Delver, head of the Urban Planning Service (FIg 4.). In the plan, the idea of Apeldoorn being the 'second writing desk of the Netherlands' was elaborated. The plan presented a compact, modern city with high rise buildings, a shopping area, an office area and new wide infrastructure. However, the hope that many government agencies would, under the pressure of the decentralization policy, settle in Apeldoorn, was no longer there in the seventies. Therefore, the plan was only executed for a small bit. In terms of the infrastructure, only the W. Druckerstraat, the Prins Willem Alexanderlaan (PWA-laan), the Princes Beatrixlaan and the Koning Stadhouderlaan were realised. Regarding the buildings, only Centraal Beheer, the Brinklaanflat, the former Stadskantoor, the theatre Orpheus and the flats next to the Loolaan were built (Bet, Hinterthür, & van Meijel, 2009, p.33).

The space required for the Centrum en City plan was acquired by joining the eastern part of Brinkhorst to the historic city centre. The expansion of the centre in the western direction became considerable and desirable because of the low density of buildings and the lack of historical, high-valued buildings. From the late 1960s, a careful start was made with the implementation of this ambitious Sketch Plan, of which the PWA-laan and the Centraal Beheer building were the first. The PWA-laan (1 in Fig. 12) crosses the southern part of Brinkhorst in the east-west direction and connects the postwar extension neighbourhoods on the West directly with the city centre. The aim of the PWA-laan at the end of the sixties was to replace the narrow and curved Waterloseweg as a connecting road, as well as to ease motorized traffic on the Asselsestraat (CODA Apeldoorn, 2003, p.7).

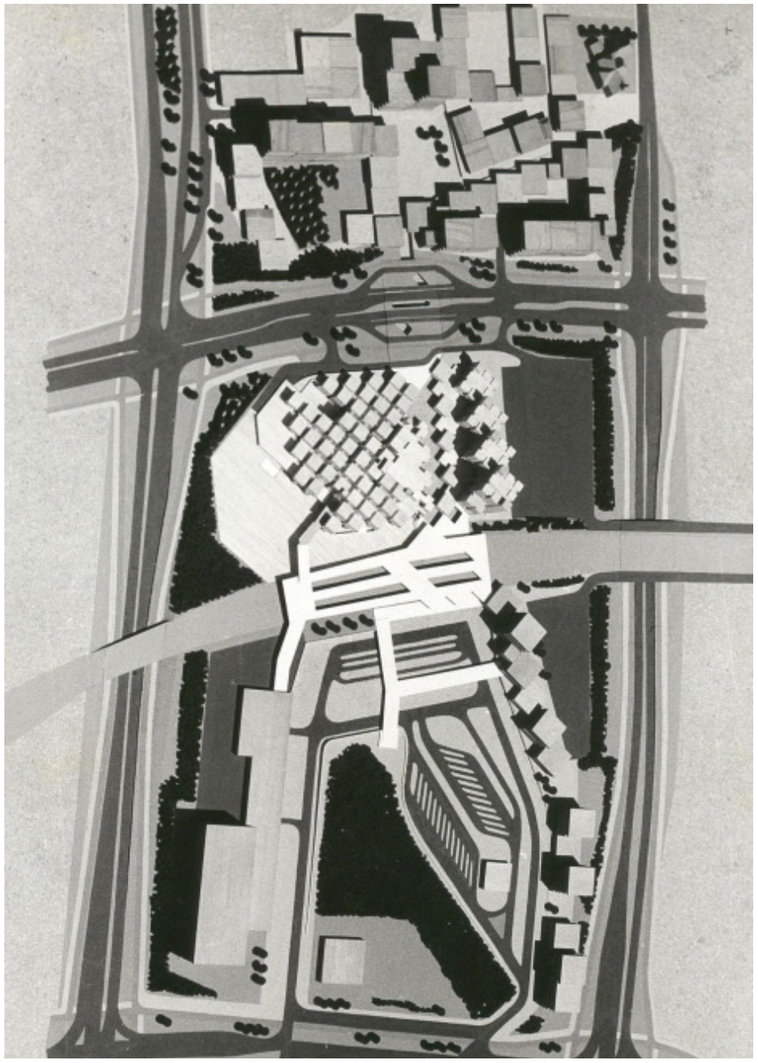


Fig 16. Model of Centraal Beheer, anchored in its urban context

As described before, the site used to be characterized as a rural landscape, with mills, farmhouses and laundries. Straight through the site, the Grift stream flowed, the most important economic vein during the early history of Apeldoorn. But then, the Centraal Beheer was built and was supposed to play a crucial role in the development of Apeldoorn becoming an important metropole (CODA Apeldoorn, 2003, p.7).

Around the time Hertzberger was commissioned to build Centraal Beheer, the Apeldoorn municipality was developing ideas for a pedestrian area, together with an extra train station (Fig. 14). This was music to Hertzberger's ears, since he was already thinking on how this building could be linked to the city centre. He felt the station could use a renewal, and even more, this way Apeldoorn can show and prove that it's a real city. So, Hertzberger proposes to move the station in the western direction, and positions it directly across the Centraal Beheer building. He even made a design for the station itself, composed out of the same cubic modules as Centraal Beheer, and containing a partially underground pedestrian area that connects the station, through the Centraal Beheer building, with the city centre. The owners of Centraal Beheer were surprisingly positive on the idea making their office publicly accessible. This all was the way for Hertzberger, to anchor the building in its urban context, and to create an urban appearance that would put Apeldoorn on the map (Herpoel, 2013, p.93).

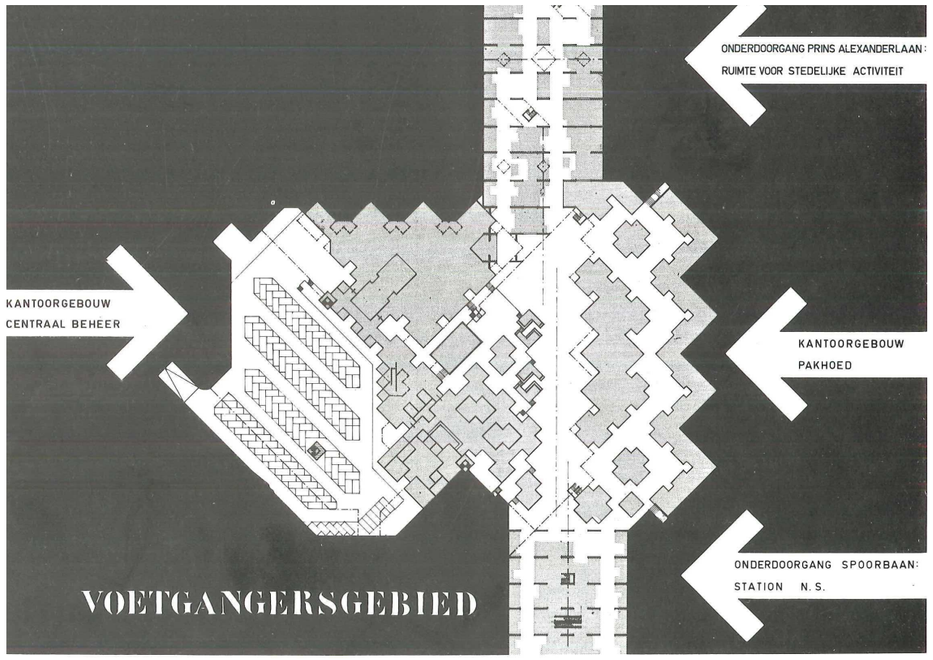


Fig 17. The planned pedestrian area, running trough Centraal Beheer

The partially open pedestrian area in the elongated, city centre would be extended, and form the spinal cord of the new city centre. By making a tunnel that goes underneath the PWA-laan that opens up between the Centraal Beheer and Pakhoed buildings it would be possible to directly walk from the station to the city centre. The Centraal Beheer building and the adjacent Pakhoed building would be open towards this pedestrian area, and also contain public, urban functions such as a shops, café's, a bank etc. A pleasant space, designed from the human scale that can be seen as an extension of the city centre (Fig. 15). The Centraal Beheer building would really contribute to the urban life of people in Apeldoorn. The only remnant of this vision is the dead-end walkway that starts at the Centraal Beheer building (Herpoel, 2013, p.93).

The tunnel part of the pedestrian area, can also be seen as a structuralism design (Fig. 16). It was designed as a permanent, compelling structure, with temporary, diverse and free infills. To prevent this tunnel from being a scary place, Hertzberger wanted to create crowded places, in which for example markets, shops, rehearsal spaces and theatre would be accommodated. Also this tunnel has never been realised (de Vries, 2008, p.53).

Hertzberger saw Centraal Beheer as an extension of the city, and as a little city itself. The buildings contained streets that would be publicly accessible, and accommodate restaurants and shops. People would be able to easily make a shortcut while going from one place to the other, by simply passing through the building (de Vries, 2008, p.52).

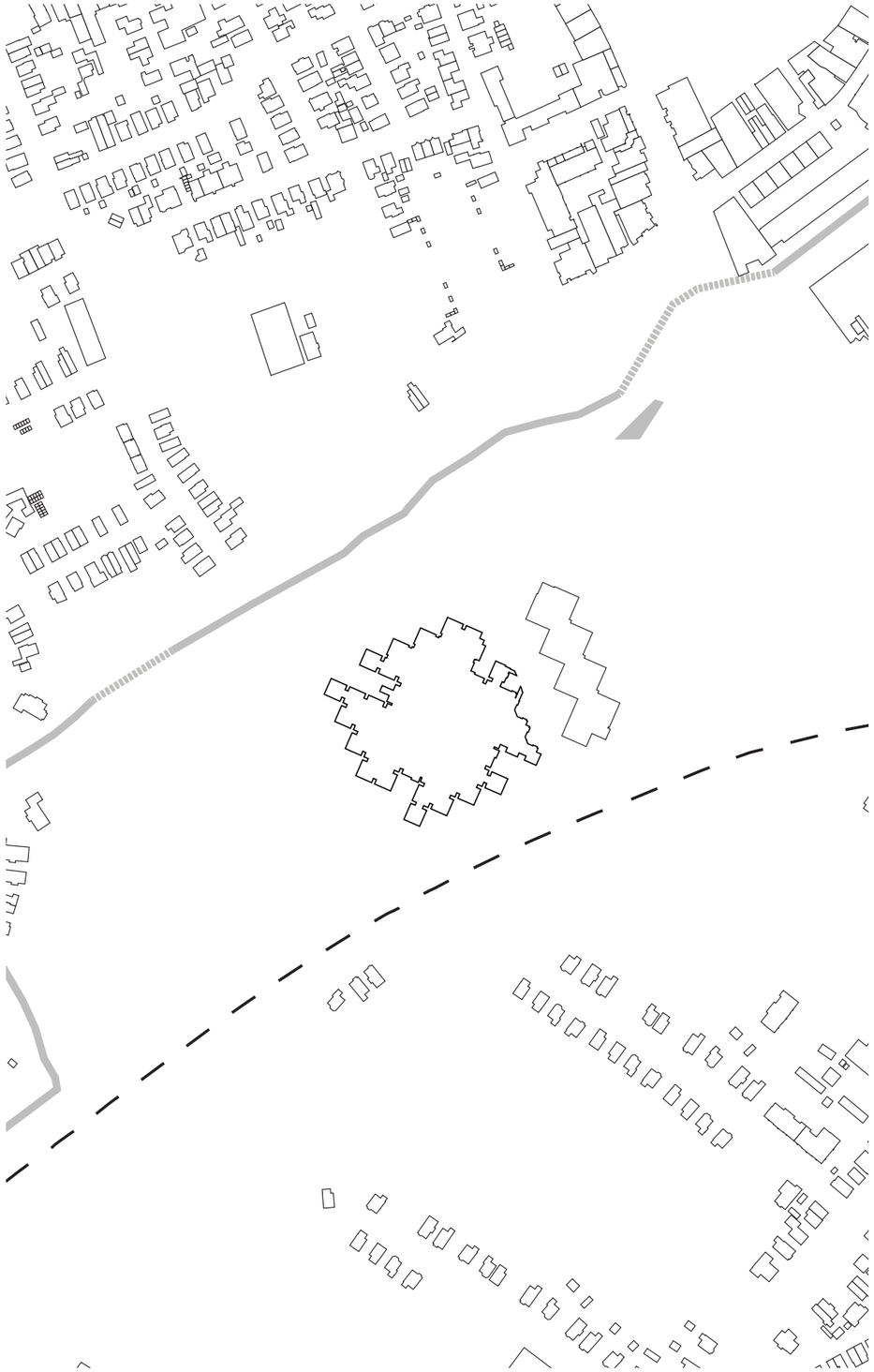


Fig 18. Surroundings and site in 1975

Centraal Beheer a few years after its completion. Aside from the Pakhoed building right next to Centraal Beheer and some bigger buildings towards the city centre, it is evident that Centraal Beheer as an exceptional stamp in its urban contex.

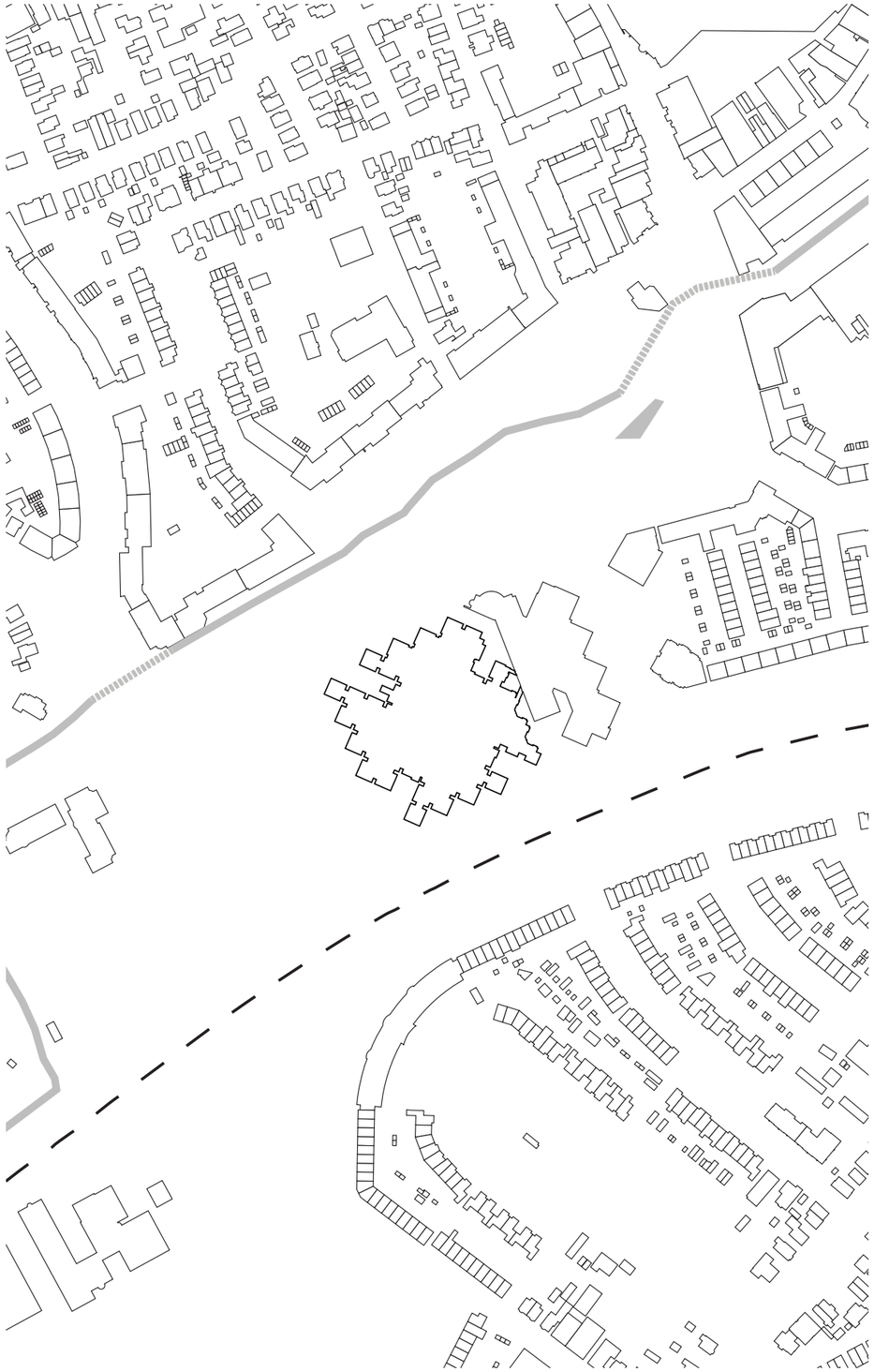


Fig 19. Surroundings and site in 2003

Since the expected companies and municipal organizations didnt settle in Apeldoorn, the cleared out space was filled up by mainly housing and some shops / small offices. This results in Centraal Beheer maintaining being an exceptional stamp in its urban context. The analogy with an island or fortress is therefore simply made.

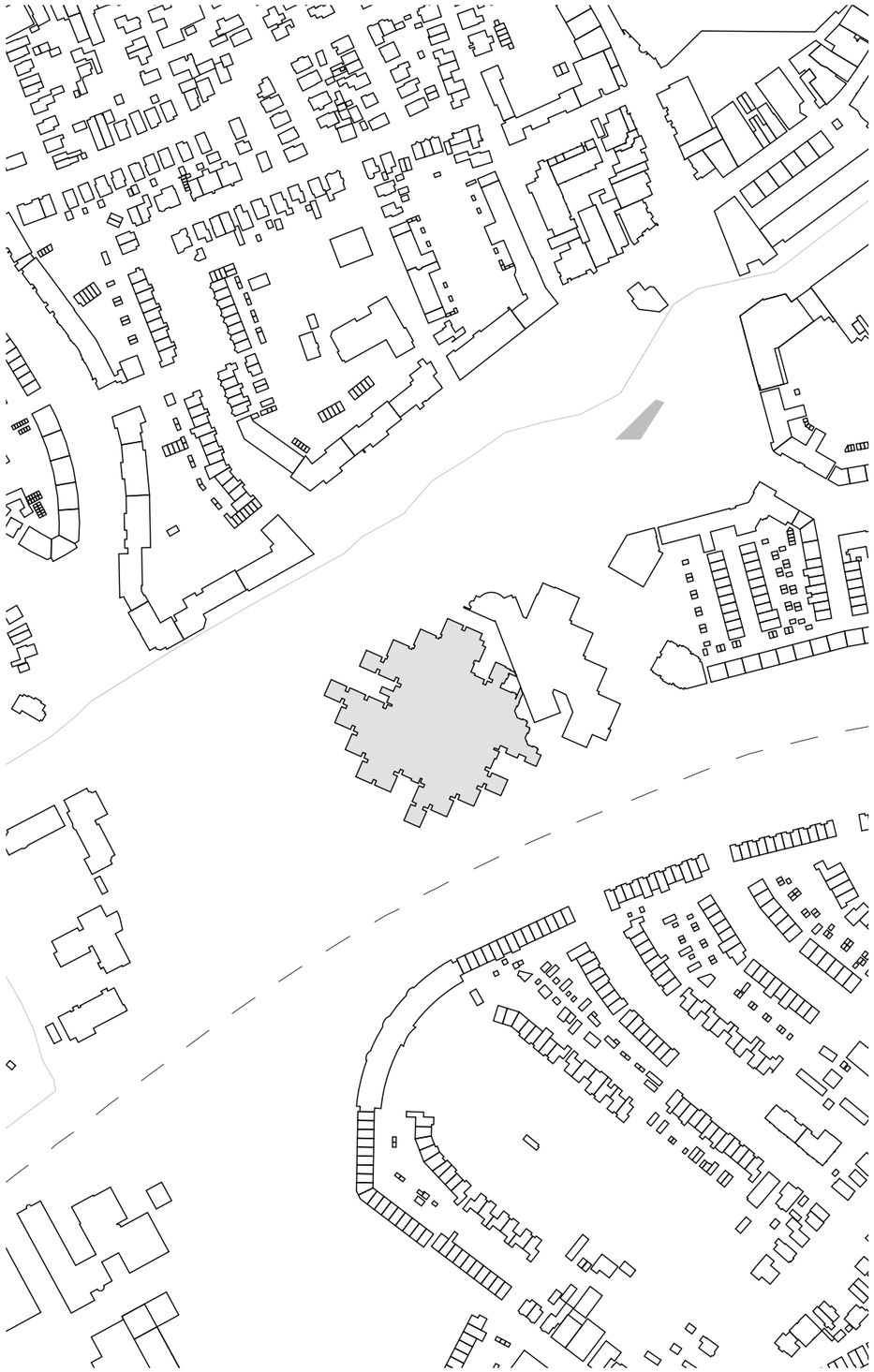


Fig 20. Surroundings and site in 2008

Fig. X shows the resulting mixture of urban tissues. On the north east the linear historic core which is the densest. On the north west and south east the late 19th and early 20th century linear strips, organized along long roads. Around Centraal Beheer a more planned structure with slabs and open blocks. On the south west there is a scattered, almost regular urban tissue. What is clearly visible is that Centraal Beheer, in terms of surface, is the biggest building of its surroundings, located in the most open area. Fig. 19 shows that the height of Centraal Beheer is corresponding with its adjacent buildings, except the Pakhoed building, right next to Centraal Beheer.

Centraal Beheer behaves autonomously in its urban context, because of its form, and the orientation of its grid structure. However, these are also the reasons Centraal Beheer strongly relates to the Pakhoed towers. Besides this, the building is mainly surrounded by smaller slabs, that all have different orientations. Centraal Beheer can be seen as an exceptional ‘stamp’.

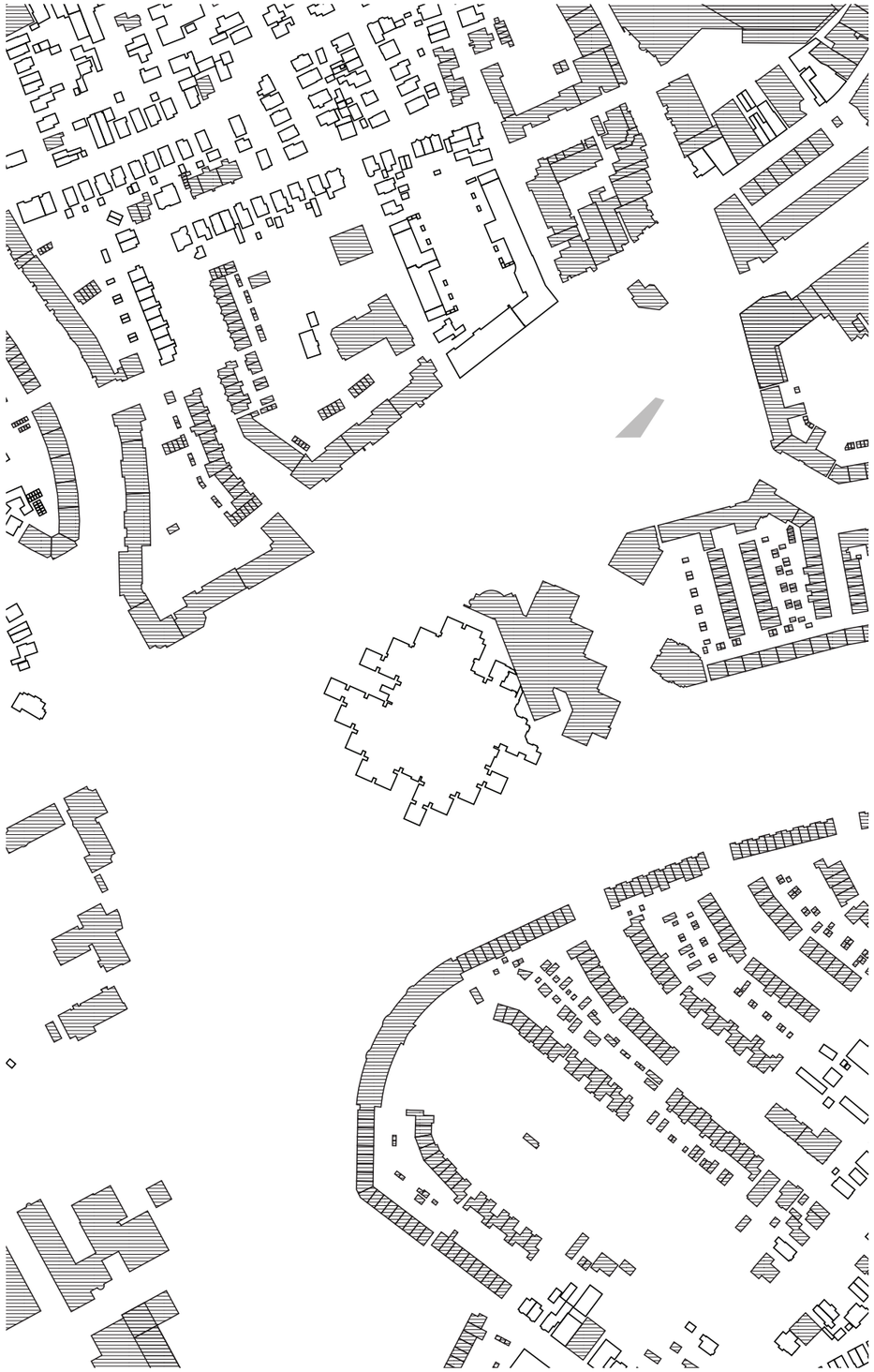


Fig 21. Buildings < 1975 and > 1975

Building dates

Fig X. shows all the buildings built before 1975 and all the buildings built after 1975, almost the same time Centraal Beheer was constructed. It is evident that Centraal Beheer can be seen as the center of these >1975 developments, surrounded by modern buildings, which are again surrounded by < 1975 buildings.

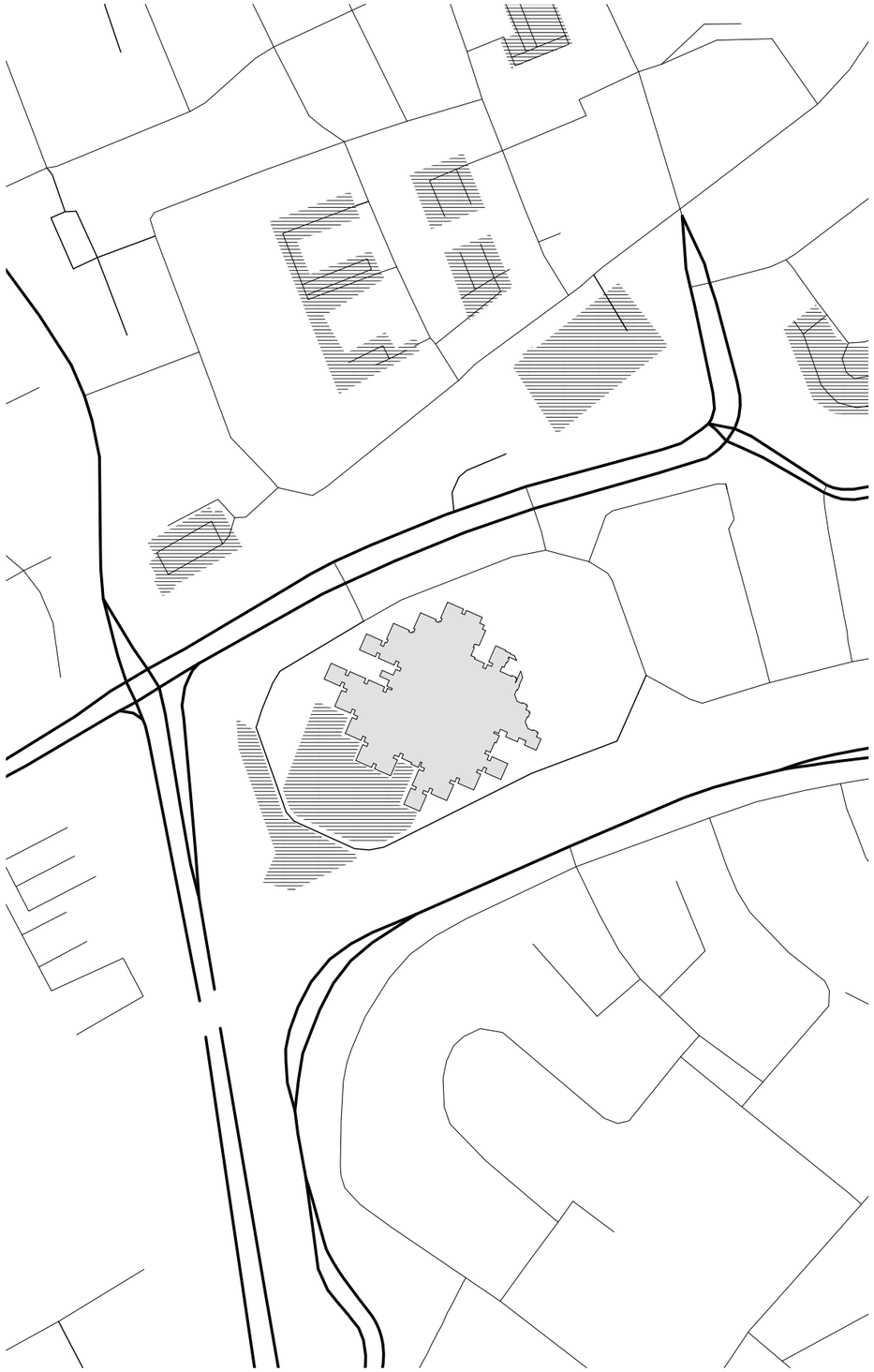


Fig 22. Infrastruture

Infrastructure

Fig X. shows how Centraal Beheer is enclosed by large scale infrastructure in the form of two highways and a railroad, the first interventions according the Centrum and City plan. The site and the building are very well accessible, because of the surrounding infrastructure and the multiple entrances. From the station, a 9 minute walk or a 6 minute bus drive brings you to the Centraal Beheer building. The site already contains a parking area that visually dominates the main entrance of the building. Although, the surrounding infrastructure makes the site isolated, like an island in the city, and gives the building an introvert character.

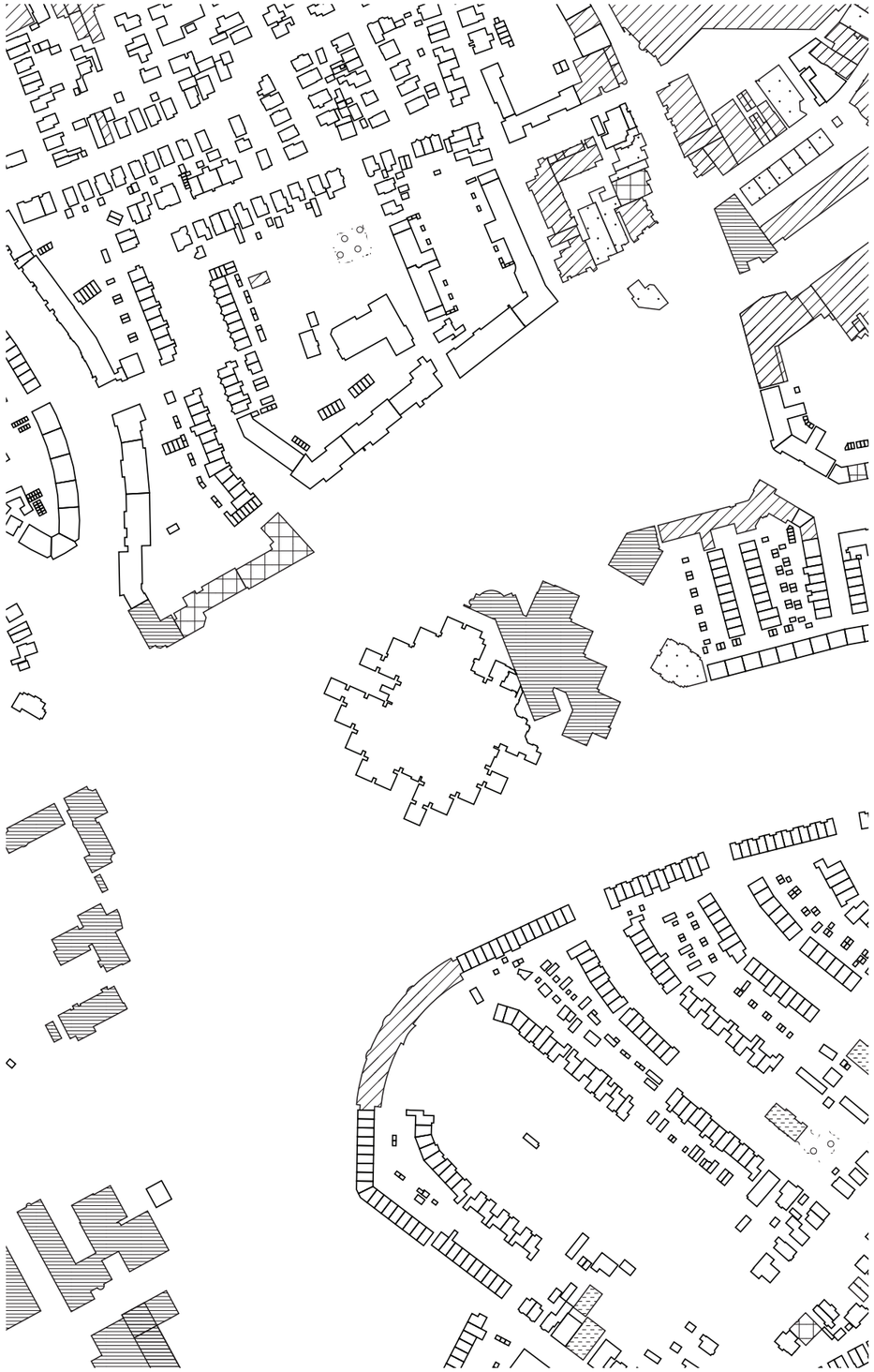


Fig 23. Programs

Programs

Fig X. shows that the area is clearly dominated by a housing program. Because of its peripheral position in the city center, Centraal Beheer lies next to other functions besides housing, with some exceptions on the south side of the railroad track. The building is closely surrounded by offices and some shops.

Fig 24. Green and water

Green and water

Fig. X. shows that the building is surrounded by green. This green mainly consists of grass, bushes and trees that are long, narrow strips, located next to the highways and railroad. The Brinkpark is the only green public space surrounding the site, indicated between the dotted lines. It is an unintended result of the unfinished city formation and therefore still refers to the former 'Apeldoornse Brink'. The historical Grift stream is still present in the area, altough hardly recognizable. The historical Grift stream is still present in the area.

Fig. X. shows how the trees give the building a green décor, however, they do make the building a lot more invisible, especially on the west side, where trees stand on a grass hill that results from the tunnel underneath the railroad track. All this closes the building of from its context and and givesthe building an introvert character.

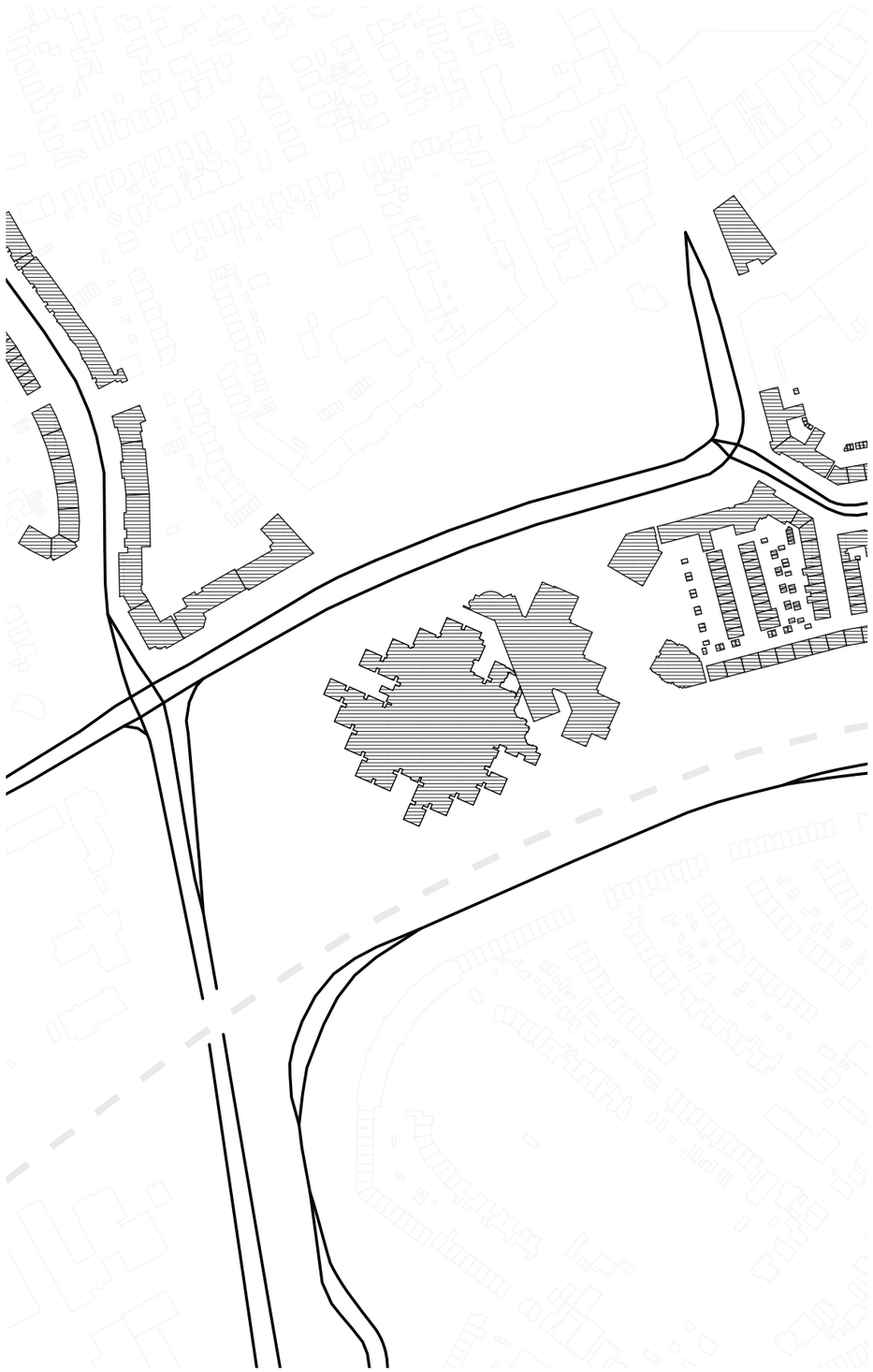


Fig 25. Realizations of the City and Centre plan

Realizations of the City and Centre plan

Fig. X. shows the remnants of the failed Centrum and City plan. These remnants are the Princes Beatrixlaan, the former Stadskantoor, the theatre Orpheus, the Prins-Willemalexanderlaan, the Koning Stadhouderlaan, the Brinklaanflat, the Pakhoed building and Centraal Beheer. Also, after failure of the plan, the gaps created were filled with elongated, collective housing projects as on either side of the Wilhelmina Druckerstraat and south of the Kalverstraat.

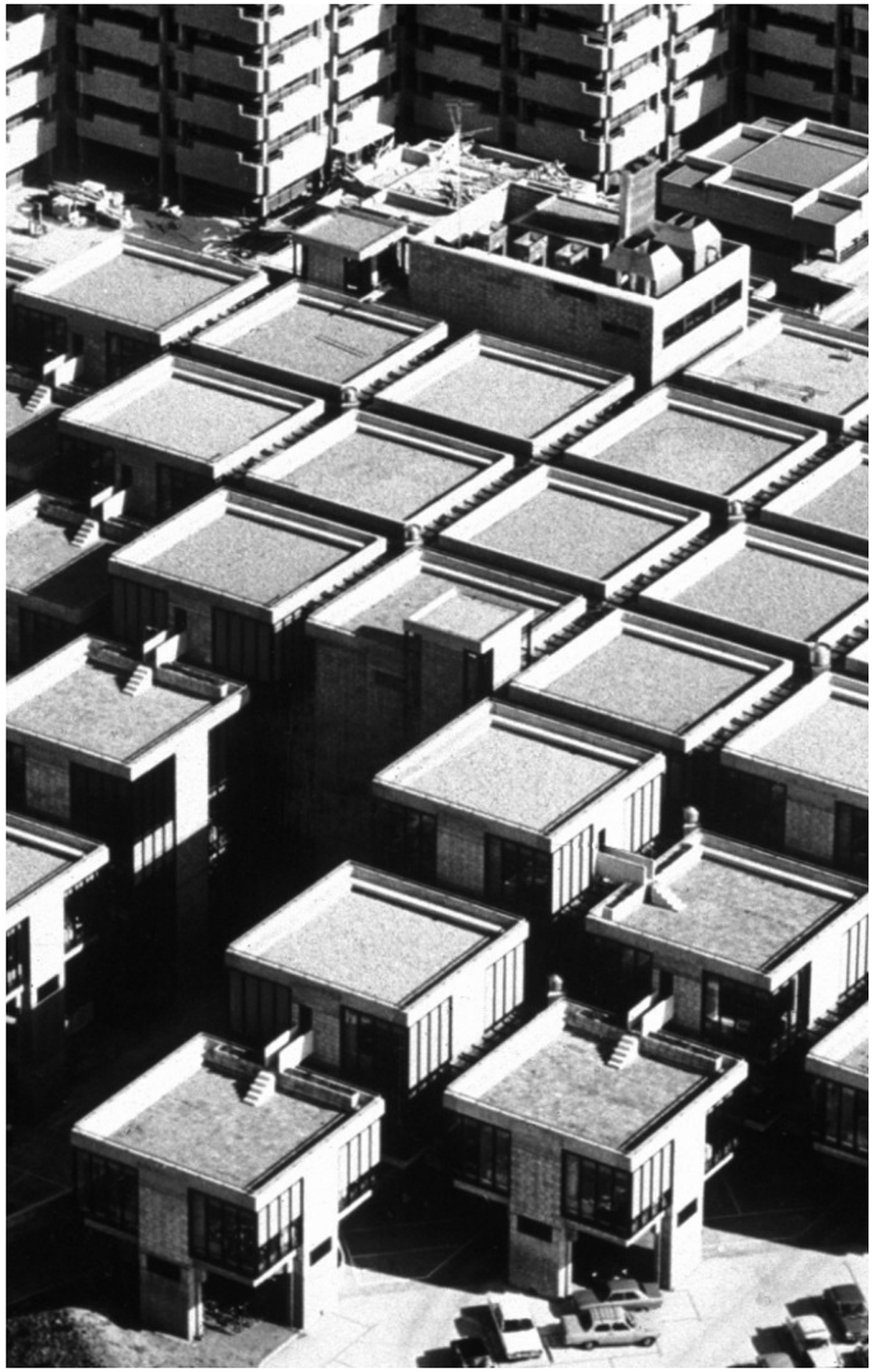


Fig 26. Centraal Beheer aerial photo

4. Building analysis

This chapter analyzes the existing building from an architectonic, cultural-historical and technological angle.

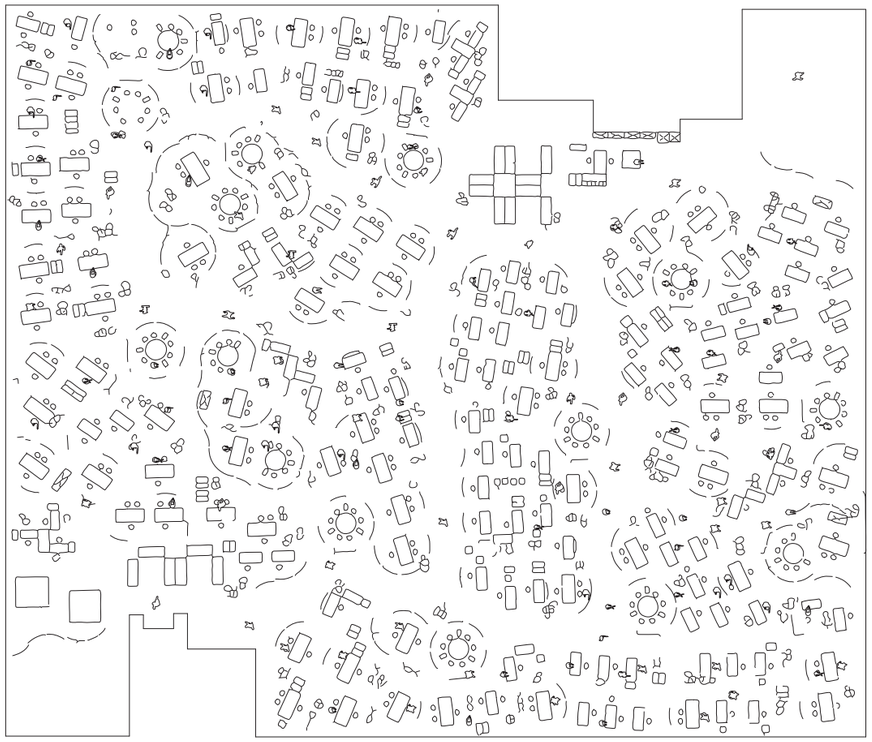


Fig. 27. Herman Hertzberger's interpretation on the office gardens

Space plan

Altough Structuralist architects consider structure as the essential part to achieve their architectural idea, in the case of Centraal Beheer, the design of the space plan deserves the attention first.

The conceptual development of the space plan was supported by defining the positive aspects of the, then widely applied, office organisations: the traditional cabin system and de very large office spaces or so called 'office gardens'. Hertzberger stated that the benefits of the second mentioned organisation, compared to the traditional one, are obvious. The first benefit is flexibility, the office can easily absorb changes from the company's organisation. The second one is ensuring better contacts between the employees, because they are all working in the same space. The third benefit is creating a sense of belonging. No separation by compartmentation creates a feeling of 'togetherness'. The final advantage is that the office becomes an anti-hierarchical organisation, what makes it more democratic and brings people of different ranks closer together (Hertzberger, 1970, pp. 1-16).

However, Hertzberger believes these 'office gardens' do have some accompanying challenges, which were confirmed by the experience of the Centraal Beheer staff. These issues were: preventing noise disturbance, the presence of enough natural daylight, having enough outside views and how to climate such a large space. Even though these issues could be solved by technical means, there is still the risk of massification: of always being surrounded by people and never having the opportunity of withdrawal, and of: the danger of becoming too dense, since there are no impediments to stop this. Hertzberger's proposal of the space plan for Centraal Beheer can be seen as a 'big articulated space', reacting on the aforementioned challenges.

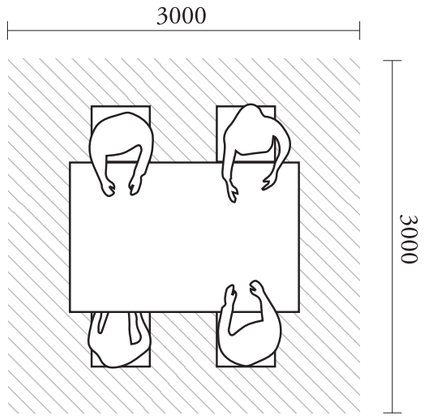


Fig. X. Development of the space plan: singular 'building block'

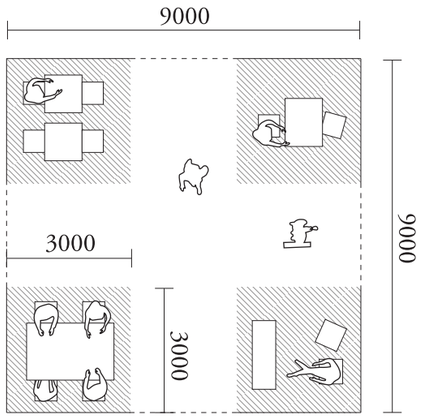


Fig. X. Development of the space plan': one working 'island'

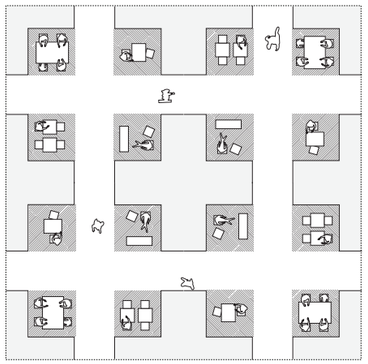


Fig. 28. Development of the space plan: four working 'isalands' and voids

The space plan starts with the idea that work, as well as recreational activities, happens in small collectives, instead of individually. Therefore, the entire design can be based on the singular 'building block' of a 3x3m square, or working zone, that corresponds with the amount of space max. 4 employees would need to do their work, collectively. These working zones were called 'interpretable zones' which means they can absorb changes and accommodate different office-related infills. One working 'island' of 9x9m contains 4 of these working zones and an in-between circulation zone that connects them. The circulation zone runs over 'bridges' that connect the different working islands, coinciding with the infrastructure of the services. They both form the basic, permanent structure, or skeleton of the building. The spaces between the working islands are open, designed as voids. These stimulate spatial and visual cohesion between the working islands and therefore between employees. The open working islands are not only connected with each other in horizontal terms, but also in vertical terms. This creates a strong feeling of togetherness and gives the office the allure of a coherent community. Also, the danger of the working spaces becoming too dense, is hereby solved.

Interpretable zone's

Permanent structure

Voids

Fig. 29. Primary 'building block' of 3 x 3 m

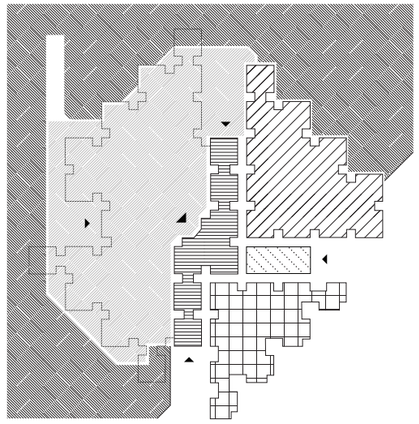


Fig. 30. Space plan: level -1

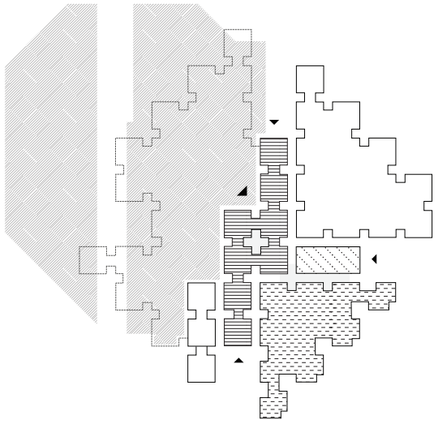


Fig. 31. Space plan: level 0

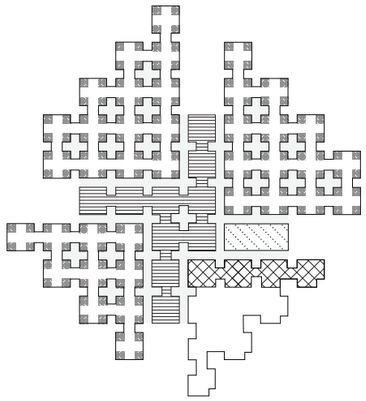


Fig. 32. Space plan: level 1

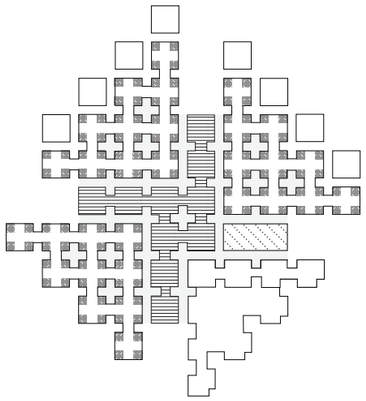


Fig. 33. Space plan: level 2

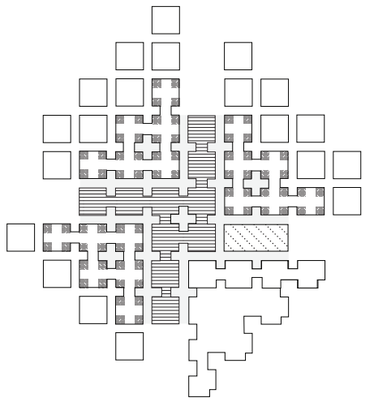


Fig. 34. Space plan: level 3

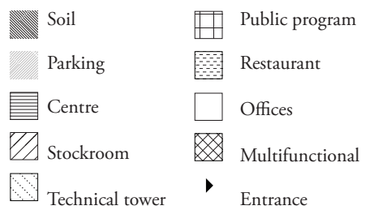


Fig. 35. Legend

The working islands, surrounded by voids, are multiplied to together form a 'quadrant'. The building has 4 quadrants. 3 of them were office quadrants and 1 was called the service quadrant and contained multiple programs such as a restaurant, nursery, barber, recreation rooms etc. The 4 quadrant were interconnected by 'the centre'. Here, the social character of the building is the strongest since it contained all the other programs aside from offices, such as coffee corners, seats, toilets and boudoirs meant for female and male employees to change their clothes, to do their make-up or to wash their hands. The initial idea was to make the centre on the ground floor publicly accessible, supported with small public programs. Random people could literally take a shortcut by going right through the building. The programmatic layout of the centre applies for the 1st up to the 3rd floor, with an exception on the 1st floor, where an art gallery runs through the centre, to get employees more acquainted with art and a possibility to express themselves by allowing them to exhibit their own work. Also, the working quadrants become smaller every floor. A technical tower, in which all the installations and services are accommodated, runs through every floor of the building.

The basement and ground floor have a slightly distinctive programmatic organisation, compared to the levels above. 2 of the 4 quadrants are occupied on both floors by outdoor parking levels. On the basement floor, the centre contains an entrance area with a reception, library, laboratory, doctor, waiting rooms and a boudoir. One of the quadrants was assigned as a stockroom and the other quadrants would contain a public program that was directed at the pedestrian route adjacent to the building, which was never realised and became office spaces later on.

The layout of the buildings resembles the layout of a city in two ways. Firstly, Hertzberger makes a clear distinction between the 'streets', or circulation zones that people use to move themselves, and the 'buildings' programmed zones, that people use for all sorts of activities. Secondly, Hertzberger considers the primary structure, along with the infrastructure of the services, as the permanent structure of the building. This primary structure is filled in with interpretable and more temporary zones. Here the analogy can be made with f.i. a grid-structured city where the grid remains constant and the infills of the plots change over time.

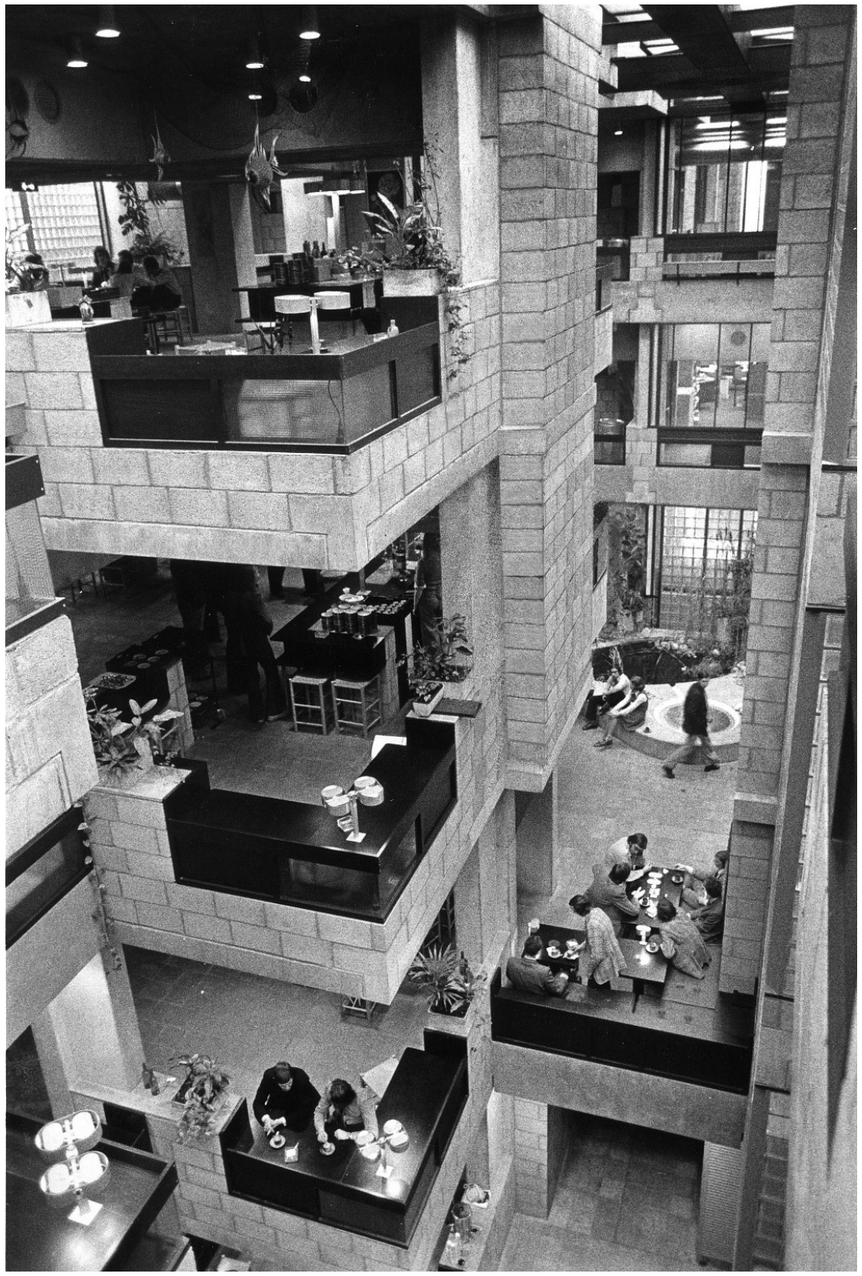


Fig. 36. Void in 'Centre'

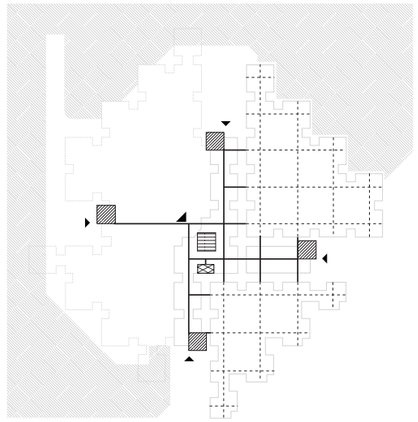


Fig. 37. Circulation: level -1

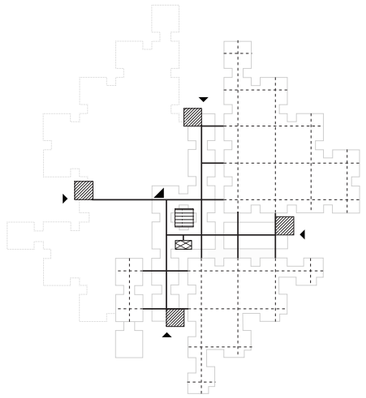


Fig. 38. Circulation: level 0

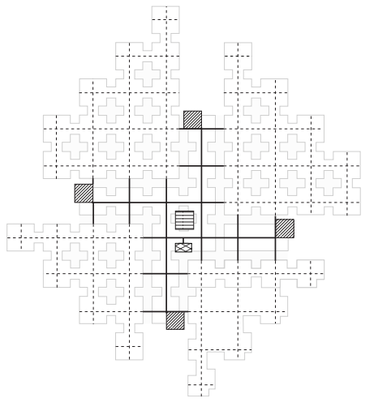


Fig. 39. Circulation: level 1

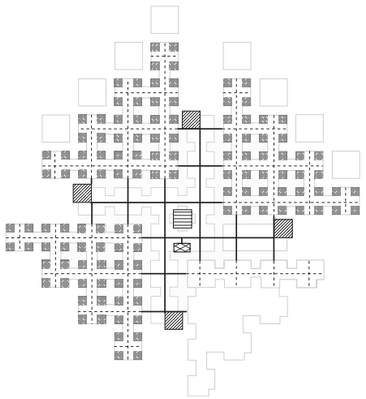


Fig. 40. Circulation: level 2

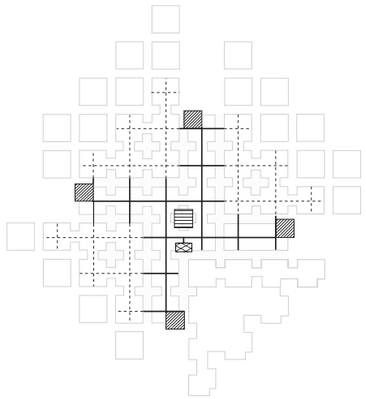


Fig. 41. Circulation: level 3

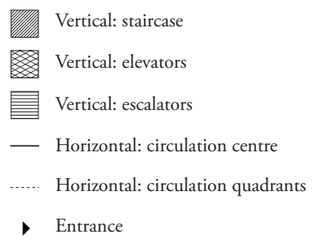


Fig. 42. Legend

The space plan starts with the idea that work, as well as recreational activities, happens in small collectives, instead of individually. Therefore, the entire design can be based on the singular 'building block' of a 3x3m square, or working zone, that corresponds with the amount of space max. 4 employees would need to do their work, collectively. These working zones were called 'interpretable zones' which means they can absorb changes and accommodate different office-related infills. One working 'island' of 9x9m contains 4 of these working zones and an in-between circulation zone that connects them. The circulation zone runs over 'bridges' that connect the different working islands, coinciding with the infrastructure of the services. They both form the basic, permanent structure, or skeleton of the building. The spaces between the working islands are open, designed as voids. These stimulate spatial and visual cohesion between the working islands and therefore between employees. The open working islands are not only connected with each other in horizontal terms, but also in vertical terms. This creates a strong feeling of togetherness and gives the office the allure of a coherent community. Also, the danger of the working spaces becoming too dense, is hereby solved.

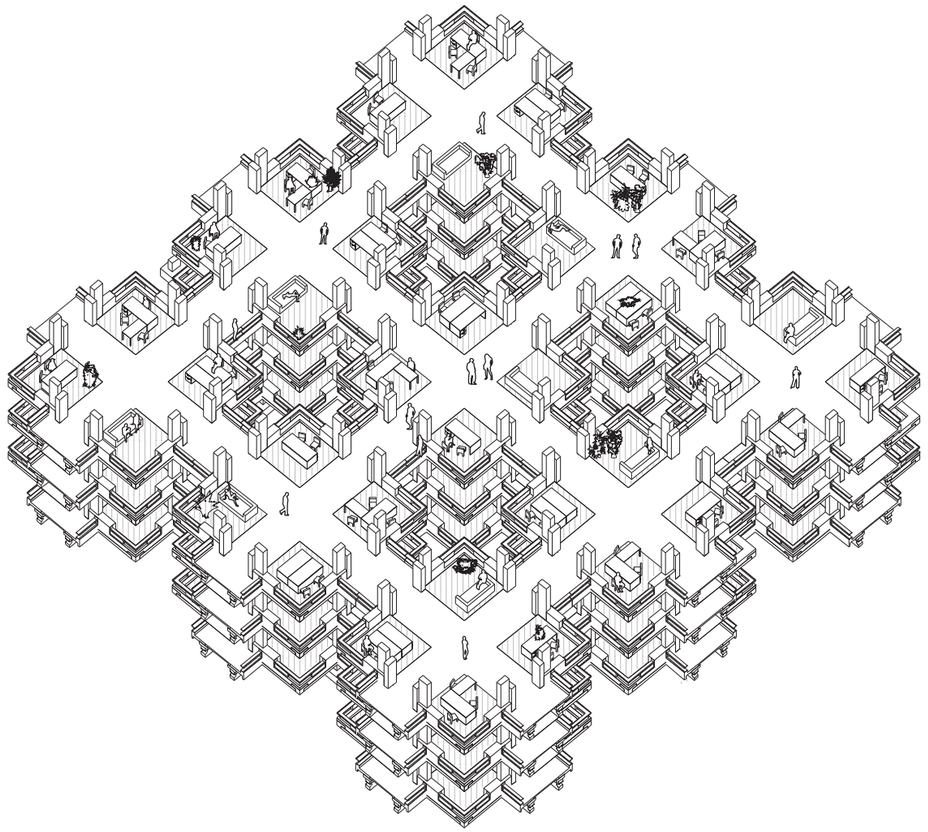


Fig. 43. Structure and space: plan

By repeating the equal programmatic and spatial plan of the single module, to construct the entire building (with a few exceptions mentioned before), the result are democratic relationships and an almost anti-hierarchical building. Almost, because a hierarchy is present between the modules located on the periphery and the ones located in the core of the building. This results in differences between their accessibility, amount of daylight, views and the level of privacy. These contrasts, together with the differing height of voids and changing materiality in the interior (explained further in X. Surfaces), still bring a dynamic rhythm in the strongly repetitive and labyrinth-like building.

As described in X. Structure, the structure plays a crucial role in how the space is articulated and perceived. The floors can be experienced as a single, open space in which the columns are positioned as concrete trees, indicating the islands with accompanying voids. Therefore, the building manages be an open structure in which community live can enter, blurring the borders between public and private, building and street.

In the 80s, the attitude of the corporation and the employees changed in the sense that representativeness and customer service had more priority than the previous informal and open working environment. Not only did the employees wear suits, instead of shirts and jeans, also partition walls, extra stairs and bridges and different materiality were introduced in the building.

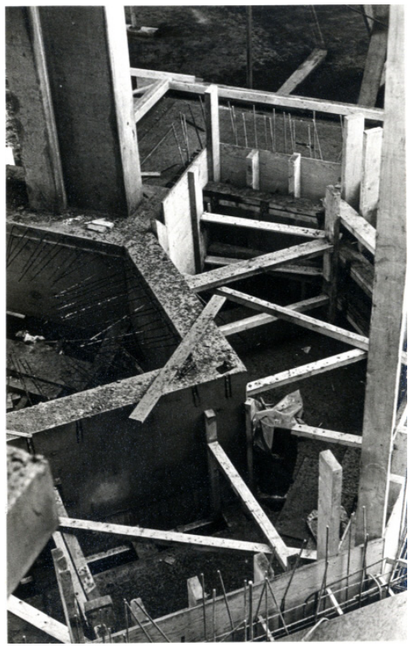


Fig. 44. Centraal Beheer during construction, 1970

Structure

Dutch Structuralist architects, including Herman Hertzberger, consider structure as the essential part to achieve their architectural idea. This is because this structure functions as the fundamental principle for architecture and will serve as the 'order' that allows and stimulates 'freedom'. In other words the structure is a regulation that encourages free interpretation, and a way of binding diverse 'individuals' as a 'whole' (space, p.27). The structure is the rule for the ordering of space, and constitutes the system from which the configuration of this project emerges. In words of the architect, "a clear spatial structure or infrastructure promises durability and because of it, makes more space in which to capitalize on the need for change. This gives rise to space for time, and space for the unexpected" (time, p.43). The structure of Centraal Beheer can be seen as a repetitive system, specifically developed for this project only.

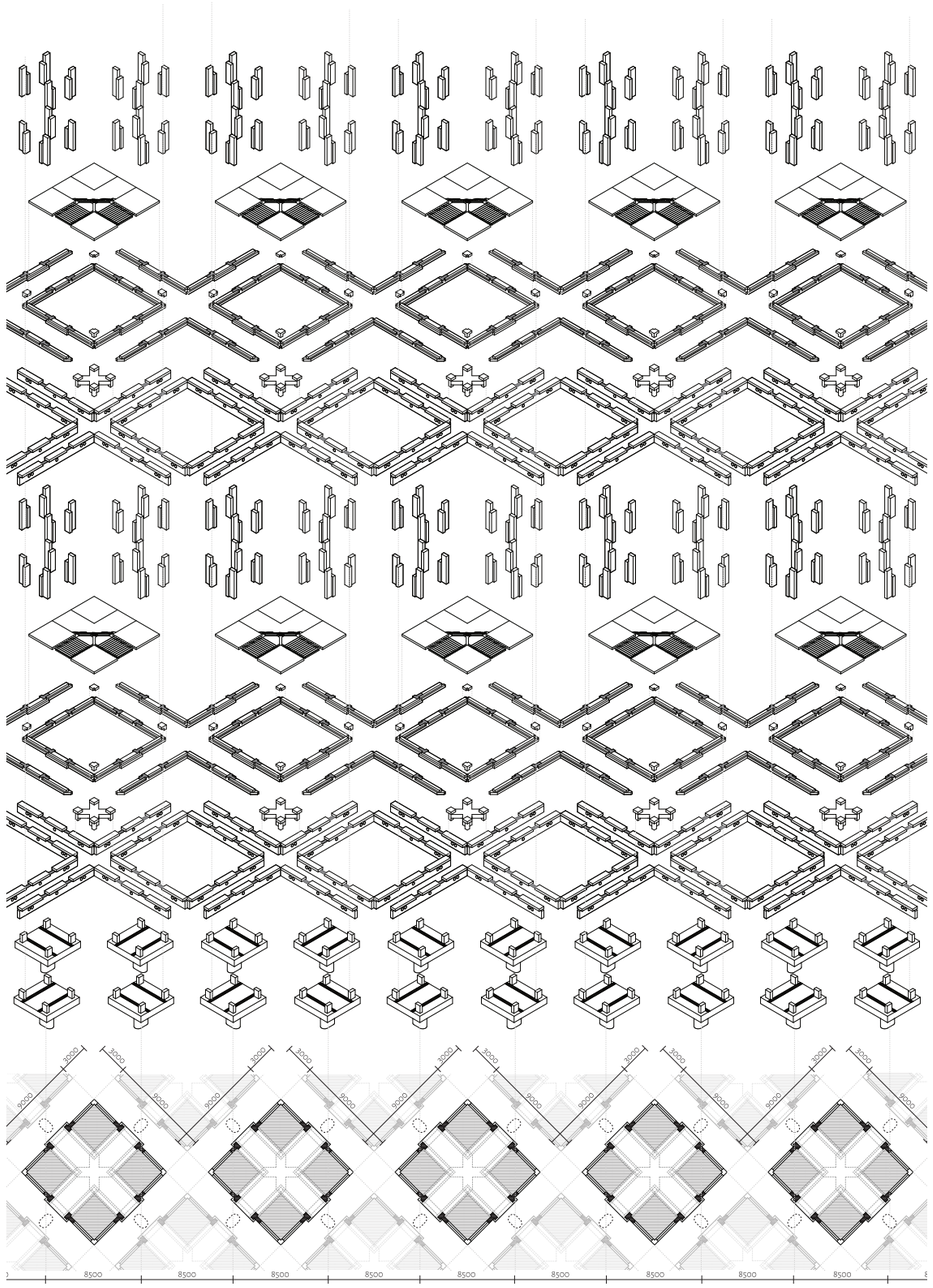


Fig. 45. Exploded structure from a row of modules

The structure of the building contains the basis of two grids. The first grid is that of the parking levels. This grid differs from the main grid that constitutes the levels above, because the pattern of parking spaces could not fit within the main grid (time, p.46). The mushroom-like parking columns each support a group of 4 columns from the main grid, therefore the parking grid is rotated 45 degrees compared to the main grid. The mushroom-like parking columns, as well as the basement floor on which one of the parking levels is situated, the basement walls and the ground floor are constructed in in-situ concrete. A cross strip foundation is used to support the basement structure. The mushroom-like columns are located at the center of the concrete bars.

The concrete structure of the modules is based on a 9x9m grid that is interconnected with the structure of its surrounding modules. The group of 4 prefabricated columns, supported by the mushroom-like columns, support 2 cantilevering, prefabricated, 'primary' beams, aligned with the circulation space and services between and within 2 modules. These all together are called the 'permanent structure' of the building and is interconnecting with the adjacent modules. By multiplying the group of 4 columns and 2 beams by 4 and rotate them 90 degrees each, the interconnected structure exists. This structure is connected in the centre by pouring an in-situ cross structure between the cantilevering endings of the primary beams. By doing this, the structure becomes stable.

Then, a square of 4 cantilevering, prefabricated, secondary beams are placed with their centre-point on top of the primary beams, to form the structure of the module's island. These a connected by pouring, in-situ, a concrete corner joint.

Prefabricated floor elements are placed on the primary beams and in the secondary beams. On the floors placed on the primary beams, the remaining space is filled with in-situ concrete, to match the level of the 4 other floor elements. Steel reinforcements on top of the primary beams connects the structure with the in-situ floor. By doing this, the floors will have a stabilizing function.

The floors for circulation between the modules, are constructed by assembling prefabricated floor and balustrade elements, which are afterwards also filled up with in-situ concrete.

The sequence of building a single module is hereby finished and continued by again placing the group of 4 prefabricated columns on top of the secondary beams. In case a module is not interconnecting on all 4 sides with an adjacent module, the primary beams are shorter. In this situation it was necessary to temporarily support the cantilevering, primary beams until the in-situ floor is poured.

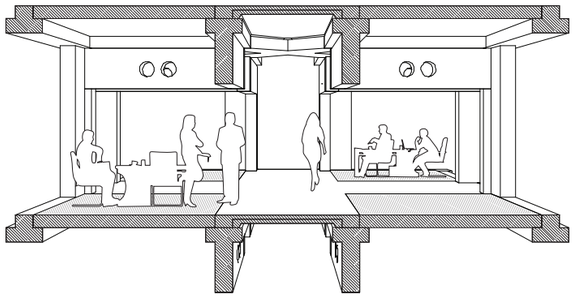


Fig. 46. Structure and space: perspective

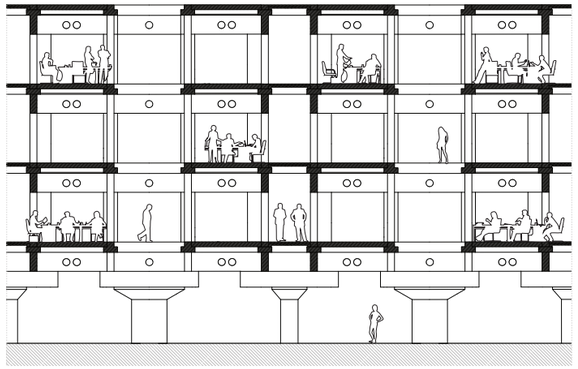


Fig. 47. Structure and space: section

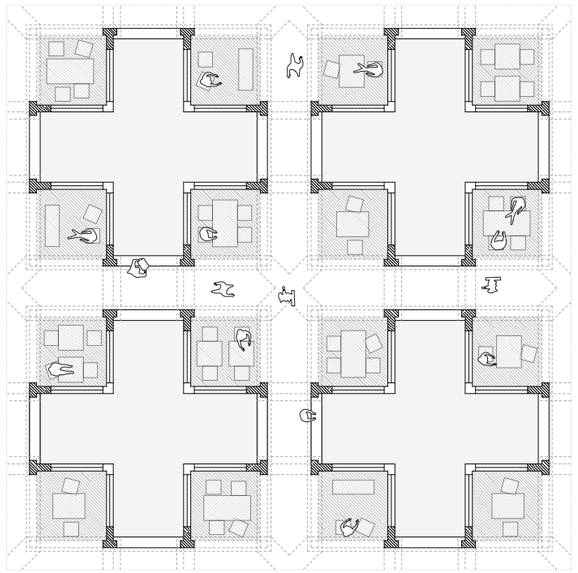


Fig. 48. Structure and space: plan

The design of the structure derived from the space plan of the building and strongly dominates the architecture of the interior. It starts from the layout of a single island, which is divided in 4 working zones and the intersecting circulation zones. This layout corresponds with the structural 9x9m grid. The primary beams and the columns define the transition between the circulation and working zones. This applies not only in terms of the horizontal arrangement, the space is also defined by the height of structural elements, since the primary beams are significantly higher, resulting in a narrower circulation zone. The secondary beams enclose the working zones. Aside from the office program, a bathroom, cafeteria, machinery, restaurant etc. could be placed within the 9x9 module.

The repetitive design of the structure resembles the idea of a democratic office with no hierarchy. A rigid system that is equal everywhere, creating order that is needed for individual freedom and interpretation of the workers. Working zones are in direct contact with each other, horizontally due to the absence of interior walls and vertically due to the open voids between 4 working islands. This openness is strengthened by the cantilevering, secondary beam and the position of the columns at 2 corners of a single working island.

The columns and primary beams are over-dimensioned, which means their dimensions exceed the required dimensions to meet the load bearing capacity. Therefore, they both strongly dominate the interior of the building. This over-dimensioning is due to two reasons. Firstly, due to prefabrication, and the architectural concept of having no-hierarchy, it was best to use a single element with the same dimensions throughout the entire project. Secondly, the space between the two primary beams had to be high enough to be able to contain the amount of infrastructure regarding the different services for heating, cooling and ventilation.

Interpretable zone's

Permanent structure

Voids

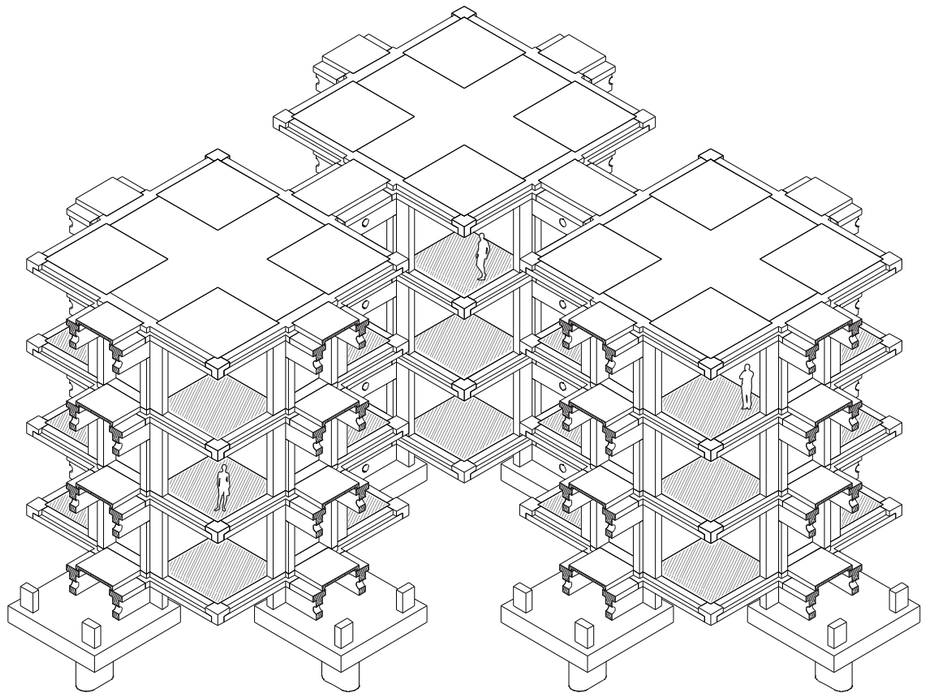


Fig. 49. Structure of 3 modules

As mentioned before, the overall structure consists of prefabricated and in situ construction techniques. One of the first reason to choose a prefabricated structure had to do with its costs, since the structure is a repetition of the same structural elements. Another reason is related with material quality. Processing the elements at the factory is easier than at site because in the factory you can always dumped the material in the same place. The idea that the factory quality would been higher than the quality of one site-based construction played a part in the decision-making process for this building. Most of all, the choice of prefabrication was the relatively short available construction time. It was found that the prefabricated elements could already been produced before the work could be started at the building site so that at the start of assembly could be sufficient elements to make this assembly undisturbed and the delivery time satisfied (time, p.45).

The choice of carrying out certain elements with in-situ concrete is because these elements can connect the different prefabricated structural elements, which results in a strong, coherent and stable structure, by protruding reinforcement from the prefabricated elements.

Fig. 50. Exterior view

Skin

In his lecture in and about the Centraal Beheer building on 08-09-2017, Herman Hertzberger proudly told it was great that the NAI (Dutch Architecture Institute) mainly showed photos of the interior of Centraal Beheer, when showcasing icons of Dutch Architecture on their website. According to Hertzberger, the exterior facade design derived from inner spatial and structural organisation, and can be considered as the least important architectural element of the building (time, p.40). The question of whether Hertzberger also took this position during the design of Centraal Beheer, is answered by looking at 'Een werkplaats voor duizend mensen: nieuwbouw hoofdkantoor apeldoorn' (1970). In this explanatory document about the design, Hertzberger strongly emphasizes its anchoring in the urban setting, the structure and the internal space plan. Hardly any attention is paid to the external architectural expression of the skin. However, the skin of the building does have multiple architectural values that either relate to the concepts of Structuralism, or to general accepted architectural and technical qualities.

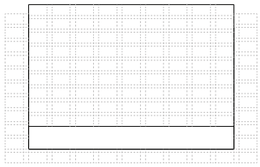


Fig. 51. Building's volume with parallel grid

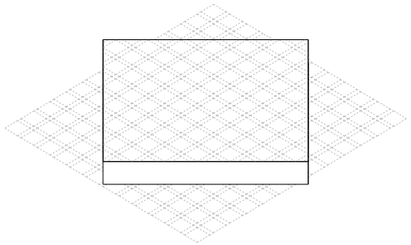


Fig. 52. Turning the grid 45 degrees

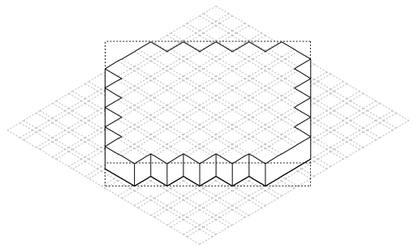


Fig. 53. Increase of the external building envelope

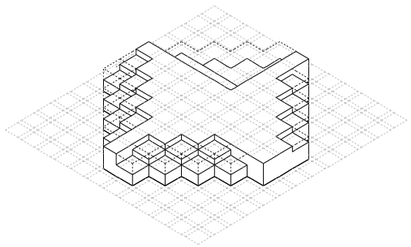


Fig. 54. Enlargement of peripheral modules

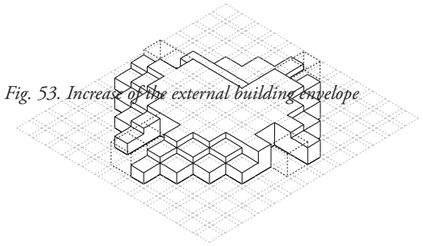


Fig. 55. Removal of modules for entrances/daylight

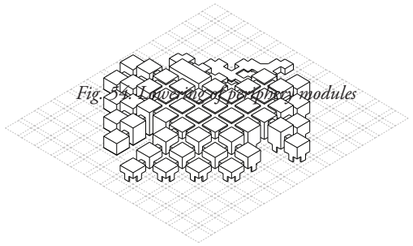


Fig. 56. Addition of vertical skylights and horizontal, sunken windows

On an abstract level, the skin of the building can be seen as a grid, which is altered in different ways. First, the grid is rotated 45 degrees, what results in an increase of the external building envelope. This means that multiple modules can benefit from natural daylight. For the same reason, the modules on the periphery are lowered, providing the access of daylight to the adjacent, higher modules. Each module seeks to relate to the human scale, in terms of its dimension. To mark the entrances and again create the accessibility of natural daylight, some modules on the corners of the volume are removed. The modules that are located more towards the core of this volume receive natural daylight thanks to the addition of skylights and sunken windows (social, p.31). All these adaptations make the cubist layout more legible, resulting in the iconic appearance of the building. Not only iconic for Structuralists architecture, but also for the Centraal Beheer's company image. The multiplication of the single, relatively small module that together form the final, large building, is done with such portions so that the whole is read as a collection of elements (such as a necklace). According to Hertzberger: 'This makes it easier to accept deviations as well as expansion or contraction and still view the whole as a unified entity without it resulting in an unfinished or heterogeneous picture' (insert volume, p.19). This Structuralist principle strongly dominates the composition of the building. This theme has been implemented, in terms of all the architectural features of the single building module.

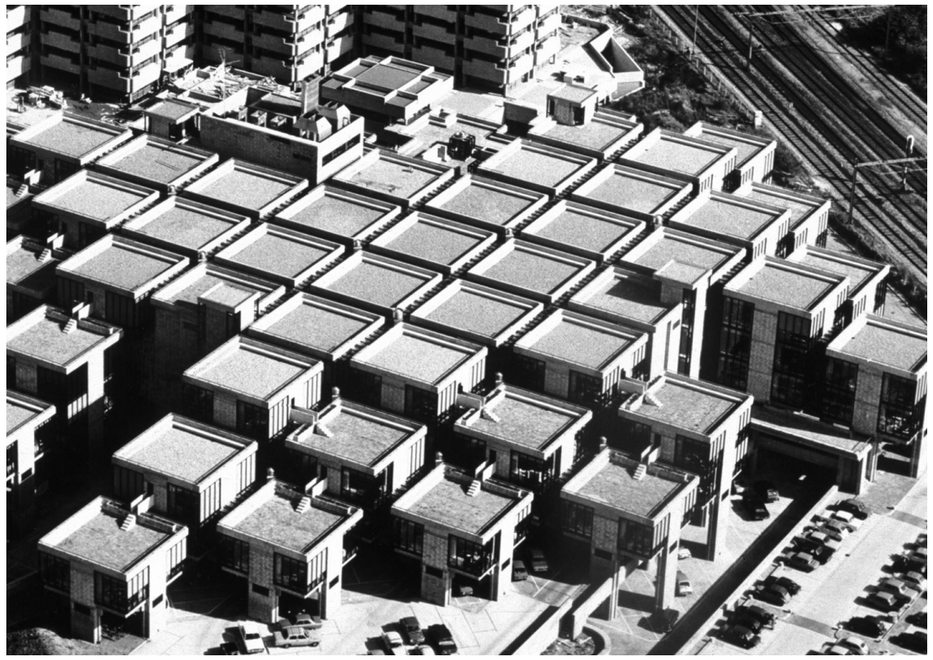


Fig. 57. Skin shown on aerial photo

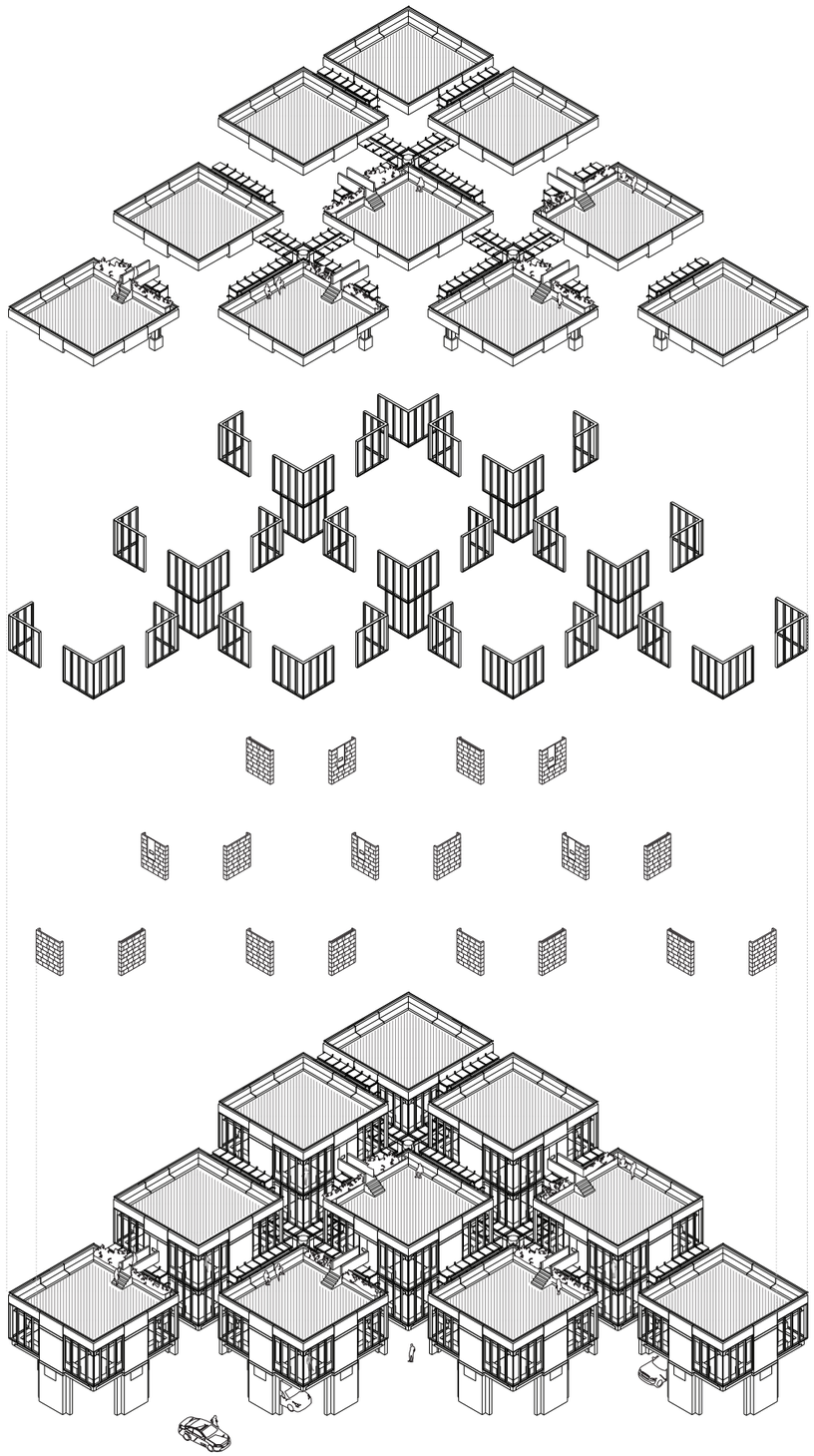


Fig. 58. Different layers of skin

Looking closer, the skin contains many openings and transparent parts, leading to abundant and different contacts with the both, the inside and outside atmospheres. This is achieved by, first, the appliance of large, glass vertical openings in the facade, adjacent to the working places. Secondly, the ability to enter roof terraces and thirdly by skylights that run through all de towers of which the building is constituted. This all leads to fading boundaries between inside and outside, what breaks through the usual isolation of office life, but also strengthens the idea of an office as open structure, interacting with its environment (social, p.31). One more environmental connection is made by the design of the skylights. Namely, these also contain the drainage system, for water coming from the roofs and terraces. The visible presence of water in both, horizontal but also vertical sense, is an important architectural feature of the skin.

Fig. 59. Environmental interactions

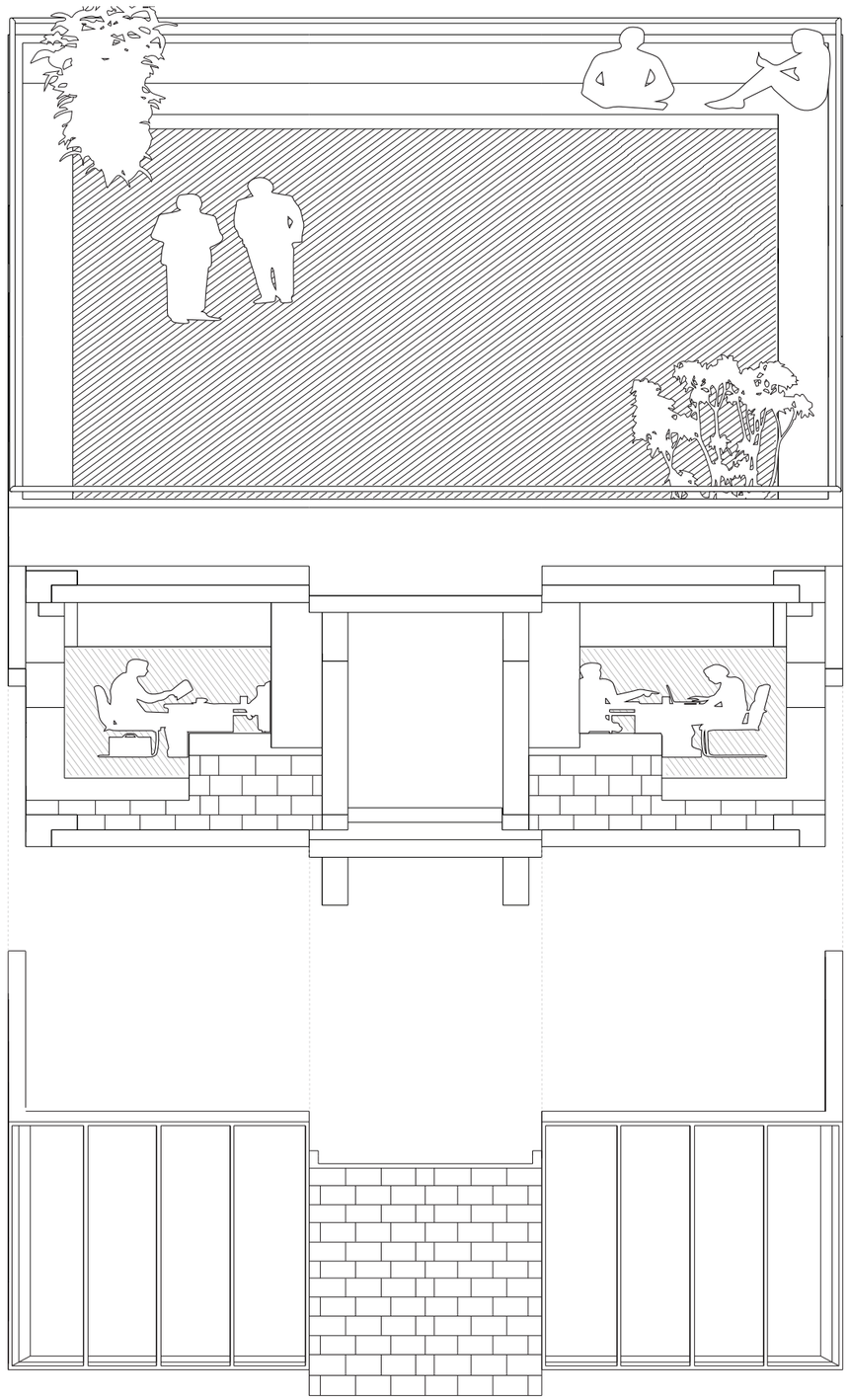


Fig. 60. Skin and structure

Hertzberger's statement on how the exterior facade design derived from inner spatial and structural organisation becomes visible while looking at the modular design of the skin. Firstly, glass openings are applied only next to the working 'islands' within the 9x9m module. The wall made out of concrete blocks, relates to the internal circulation space. Secondly, the concrete floor slabs are visible in the exterior that, together with the horizontal window division. All these aspects, clearly reveal the internal organisation.

The skin of the building goes hand in hand with the overall modular layout. As an efficient building kit, it cooperated with the prefabricated elements of the structure. The glass curtain wall is divided horizontally in 2 equal parts and vertically in 8 equal parts, altogether with a 90 degree corner in the middle. This curtain wall element can be assembled on any corner of the single module. The bottom, horizontal frame is constructed on a balustrade of concrete blocks, the middle, horizontal frame is constructed on the secondary, concrete beam and the top, horizontal frame is constructed on the concrete slab that ends the module. The entire curtain wall slightly cantilevers out of the structure. On the contrary, the exterior, concrete blocks can be seen as a filling, between the secondary, concrete beams. In the façade, no type of insulation was applied.

Fig. 61. Closed versus open

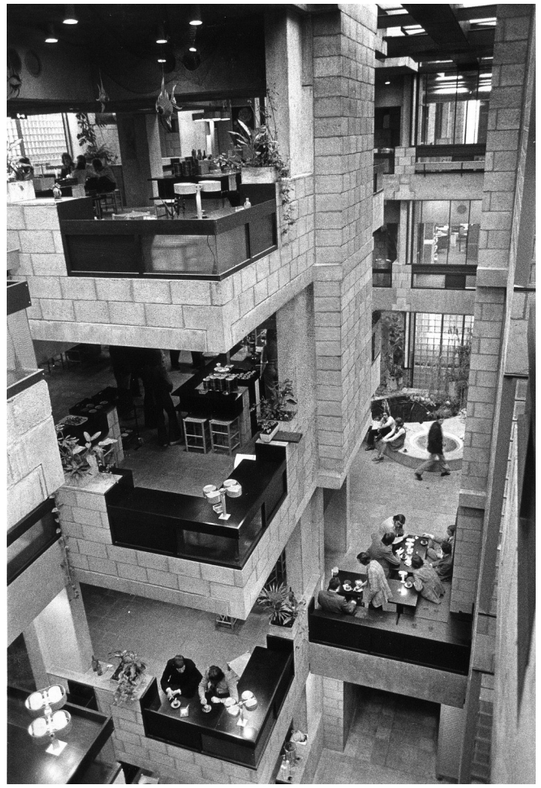


Fig. 62. Interior surfaces

Surfaces

The building knows a limited range of interior materials. What they all have in common, is that they are defined by the building's structure. Due to their location and detailing, they also can be perceived as 'infills' in the permanent structure that are honest in their expression and tectonics. The Structuralist vision, which is recognized by Hertzberger, on user participation is that they must be able to appropriate and express their (working) spaces, in order for an individual not to fall in the anonymity of the crowd. Therefore, the interior surfaces of Centraal Beheer can be seen as a canvasses, open for individual interpretation.

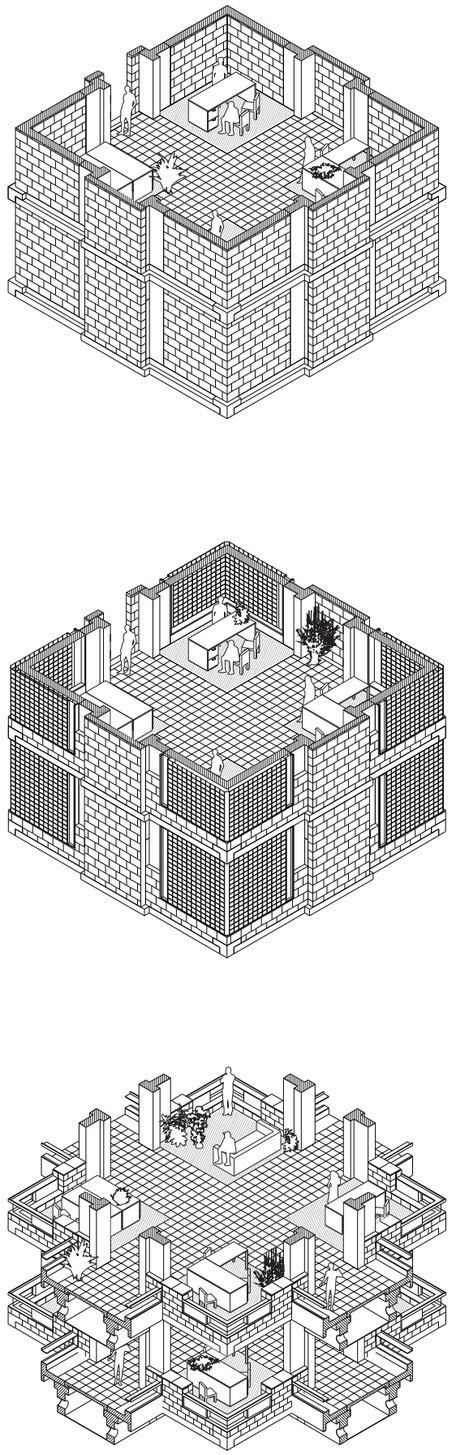


Fig. 63. Different interior surfaces

Aside from the bare, rough concrete of which the columns and beams have been poured, the interior is dominated by the use of concrete blocks. These blocks are deployed between the two columns, at the intersection of the centre and the quadrants and zones that contained services such as staircases, toilets and the technical tower. The zones that required a higher level of privacy, are shielded by the same concrete blocks, such as meeting rooms. To conclude, walls made out of concrete blocks were applied at locations were closedness, in terms of visibility and sound, was desired. Also, throughout the whole building, concrete blocks are applied as balustrade next to the voids, but also next to the buildings envelope, the curtain wall. This vertical safety barrier is in the case of the voids, finished with a timber frame that can be seen as an extension of the desk and therefore working zone.

Also at the intersection of the centre and the quadrants, but on the corners of the islands adjacent to the working zones, glass brick were applied. Their application is based on the same reasons as the concrete blocks, but because the glass bricks shield a working zone, daylight and visibility was still desirable.

Both, the walls made out of concrete blocks and the walls made out of glass bricks, are submissive to the building's structure. The position and detailing, compared to the columns and beams, can be perceived as infills, totally respecting the structural layout of the building as a whole.

Parallel to the permanent structure of the building (the primary beams and services), a pattern of floor toppings is placed on the concrete floors. A distinction has been made between the working and circulation zones. The working zones make use of a wooden oak floor topping, while the circulation zones are led by brick floor tiles. This means, a warm and smooth surface for places to stay, interact or work and a rough, exterior like surface for places to walk through. The centre, only contains bare concrete-like materials, to strengthen the effect of being in an exterior street.

With Centraal Beheer leaving the building, the canvases were erased. The honest exposed, bare and rough materiality was supposed to stimulate customization by the users and it did. Allowing every single user to personalize their space is, again, a principle for the democratic way of working Hertzberger envisioned. Now, the blank building is waiting for users that can revitalize the building.

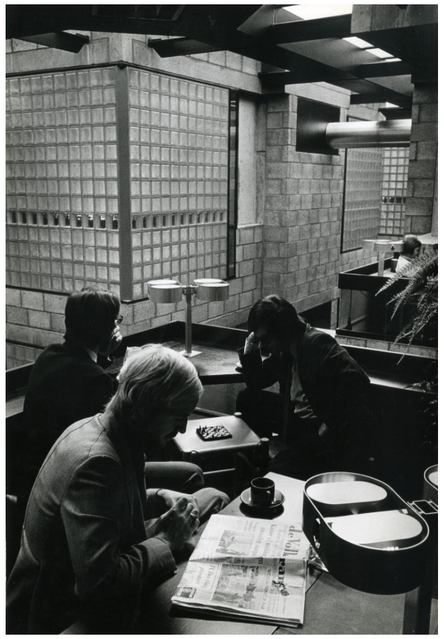


Fig. 64. Surfaces shielding of office quadrant from 'centre'

Fig. 65. Rough materiality resembling an outdoor street

Fig. 66. Working zone interpreted by employee

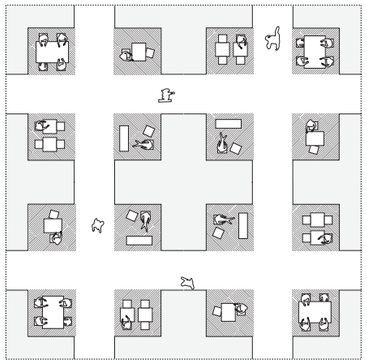


Fig. 67. Core-aspect 1: Open for internal changes

Fig. 68. Core-aspect 2: Open for individual interpretation

Fig. 69. Core-aspect 3: Open for social interaction

5. Value assessment

In order to respond to the studio's aim the most directly, which is trying to discover the future potential of Structuralist buildings, it is essential to give priority on the inherent characteristics that make the Centraal Beheer building a Structuralist building. Summarizing the information gathered from the analysis, Centraal Beheer can be seen as an open structure, consisting of neutral cells that are combined by an intelligent system. An open structure that is open to interaction with the outside world.

To convert the large amount of information into manageable parts, I depicted three core-characteristics or core-aspects of which I think capture the essence of the Structuralist paradigm in the Centraal Beheer building. Namely that Centraal Beheer can be seen as an open structure, that is *1. Open for internal changes*, 2. *Open for individual interpretation* and *3. Open for social interaction*.

1. Open for internal changes

This meant, the capability of absorbing different office-related arrangements within a 3x3m zone, which Hertzberger called 'the interpretable zone' that was the 'basic building block' of the entire complex. This concept saw the building not as a finished object, but more as a continuity. It took into account that changes will occur during the life span of the office and that a building should be able to absorb such changes.

2. Open for individual interpretation

Centraal Beheer was designed as a canvas, unfinished and open for individual interpretation and customization by the offices employees. By intensively decorating their own working places, a sense of belonging was send out to the employees, enhancing the community feeling. The individual identity was not lost in the structure, on the contrary, it was strongly expressed.

3. Open for social interaction

A concept that is part of the building's DNA. The building breathes openness, both, physically as conceptually. This openness stimulates social and visual interaction and perceiving its users as one community, instead of separate individuals. The openness is also non-hierarchical, making sure the building treats every employee the same way. All of this was structured in such a way that the building resembles a small city, with interior streets accompanied with small squares, places for meeting.

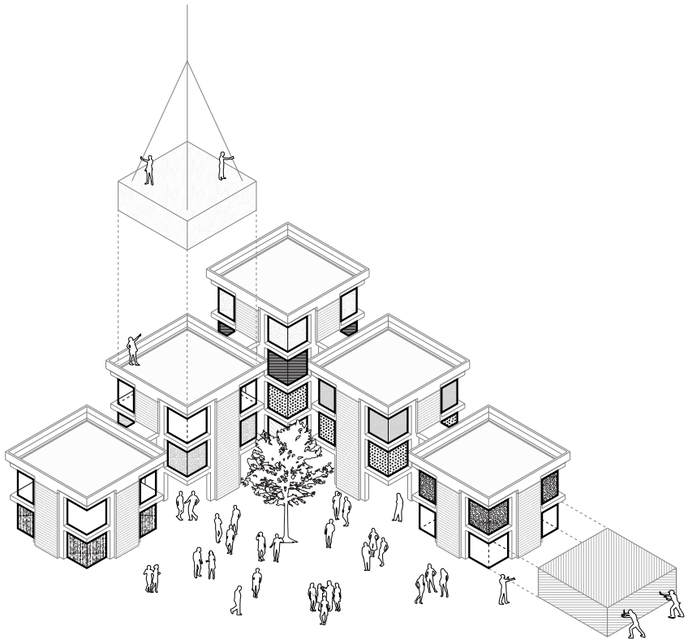


Fig. 70. Revitalizing core-aspect 1: Open for internal changes

6. Transformation framework

The next step is juxtaposing the before mentioned 3 core-aspects to the contemporary, societal situation and see if these have to and can be manipulated in a way that they become relevant again, or if they need to be optimized or reinterpreted.

1. Open for internal changes

Nowadays, societal changes occur even more often and drastic than before. This leads me to the decision of reinterpreting this concept and expand it in a way that the building is able to accommodate any program, at any given time. The small interpretable 3x3m zone needs to be enlarged to a more feasable size, leading to the notion that each island of 9x9m will become the interpretable zone and creating the option of linking multiple islands together in the case a larger program is being added. This results in, again, an open structure in which any program can be added, removed, grow or shrink.

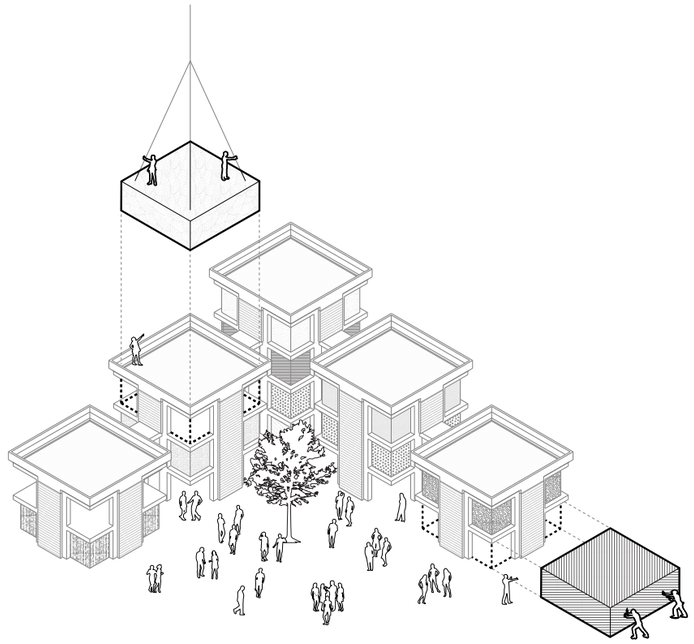


Fig. 71. Revitalizing core-aspect 2: Open for individual interpretation

2. Open for individual interpretation

Personal expression and freedom of choice have always been important values for mankind. In terms of the built environment, Modernism has proven its failure in its attempt to architecturally engineer society. The book ‘Spatial Agency: Other Ways of Doing Architecture’ (Awan, Schneider, Till, 2011) refers to an understanding of design that takes into account other spatial agencies than that of the architect and both define the architectural project beyond the articulation of a perfected image. Something that is acknowledged by Tom Avermaete in The Agency of Structuralism (Avermaete, v.d. Heuvel, 2013). He claims that that ‘people these days are more aware of their spatial agency than they were in the 70s’ 7. So the building is seen as a canvas, unfinished and open for individual interpretation which means users can come up with own initiatives, self design and built their programs.

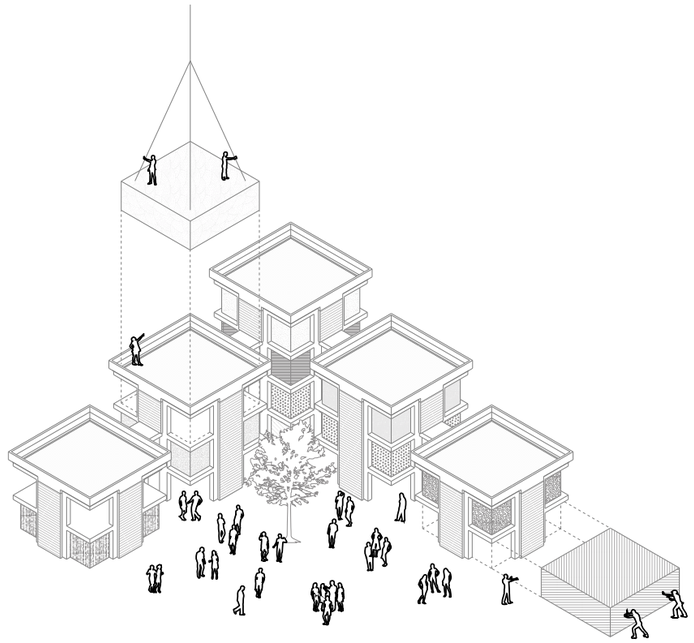


Fig. 72. Revitalizing core-aspect 3: Open for social interaction

3. Open for social interaction

With the pressure on public space due to urbanization and privatization, and the increasing influence of digital media on our social behaviour, the demand for spaces that stimulate direct social interaction is increasing. Due to unforeseen developments in the surrounding, urban context and the fact that the building was used by a single organisation which moved out, these concepts need to be respectively optimized and reinterpreted according its new intended use. Therefore, the urban contrasts will need to be restored. The 'building as a city' concept will be optimized, stimulating social interactions and the emergence of communities.

Sources

Avermaete, T., & v.d. Heuvel, D. (2013). The Agency of Structuralism. Volume #35: Everything under Control, 3-7.

Benjamin, W. (2003). The Arcades Project. Cambridge: Harvard University Press.

Bet, E., Hinterthür, H., & van Meijel, L. (2009). Binnenstad Apeldoorn; cultuurhistorishe en ruimtelijke analyse. Amsterdam: Topaz Architecten.

Brand, S. (1994). How Buildings Learn. New York: Viking press.

CODA Apeldoorn. (2003). Cultuurhistorische analyse, locaties PWA-laan. Apeldoorn: CODA Apeldoorn.

de Vries, A. (2008). Centraal Beheer, van kantoor naar leefgemeenschap voor kunstenaars. Eindhoven: TU Eindhoven.

Eliot, T. (1943). Four Quartets. New York: Harcourt.

Gemeente Apeldoorn. (2009). Regieplan Binnenstad, Structuurvisie voor de binnenstad van Apeldoorn. Apeldoorn: Gemeente Apeldoorn.

Gemeente Apeldoorn. (2013). Structuurvisie 2030. Apeldoorn: Gemeente Apeldoorn.

Gornicka, G. (2008). Lighting at work : environmental study of direct effects of lighting level and spectrum on psychophysiological variables. Eindhoven: TU Eindhoven.

Grijalba, J. (2013). Architectural Draughtmanship. Madrid: Springer.

Herpoel, C. (2013). Centraal Beheer, uitgedoofd paradigma voor het nieuwe landschapskantoor? Gent: Universiteit Gent.

Hertzberger, H. (1970). Een werkplaats voor duizend mensen: nieuwbouw hoofdkantoor apeldoorn. Amsterdam: Centraal Beheer.

Hertzberger, H. (1971). Kantoorgebouw ‘Centraal Beheer’ Apeldoorn: bouwkundig ontwerp. Delft: TH Delft, Afdeling der Bouwkunde.

Hertzberger, H. (2016). Lessons for students in architecture. Rotterdam: Nai010.

Jürgenhake, B. (2016). De gevel – een intermediair element tussen buiten en binnen. Delft: TU Delft.

Kuipers, M., & de Jonge, W. (2017). Designing from Heritage, Strategies for Conservation and Conversion. Delft: TU Delft.

Magee, G. (2010). The Hegel Dictionary. London: A&C Black.

Monumenten Advies Bureau. (2008). Monumentenbeschrijving Prins Willem Alexanderlaan 651. Apeldoorn: Gemeente Apeldoorn.

Roorda, R. (2010). Architecture in crisis. Delft: TU Delft.

Ruby, I., & Ruby, A. (2001). Naïve Architecture: Notes on the work of Lacaton & Vassal. Barcelona: Editorial Gustavo Gili.

Strauven, F. (1998). Aldo van Eyck : the shape of relativity. Amsterdam: Architectura & Natura Press.

unknown. (unknown). Heritage & Architecture. Opgehaald van TU Delft: https://www.tudelft.nl/en/education/programmes/masters/architecture-urbanism-and-building-sciences/msc-architecture-urbanism-and-building-sciences/master-tracks/architecture/programme/studios/heritage-architecture/

unknown. (unknown). Heritage & Design. Opgehaald van TU Delft: https://www.tudelft.nl/en/architecture-and-the-built-environment/about-the-faculty/departments/architectural-engineering-and-technology/organisation/chairs/heritage-design/

unknown. (unknown). Track: Architecture. Opgehaald van TU Delft: https://www.tudelft.nl/onderwijs/opleidingen/masters/aubs/msc-architecture-urbanism-and-building-sciences/master-tracks/architecture/

Valena, T., Avermaete, T., & Vrachliotis, G. (2011). Structuralism Reloaded, Rule-Based Design in Architecture and Urbanism. Stuttgart: Edition Axel Menges.

Zijlstra, H. (2017). AR3AR142 Heritage & Design Analyses. Delft: TU Delft.

Cover photo Retrieved from https://www.ahh.nl/
Figure 1. Retrieved from https://www.archdaily.com
Figure 2 – 3. Self made figure
Figure 4. Retrieved from GoogleEarth
Figure 5 – 14. Self made figure
Figure 15. Retrieved from Hertzberger, H. (1970). Een werkplaats voor duizend mensen: nieuwbouw hoofdkantoor apeldoorn. Amsterdam: Centraal Beheer, p.2.
Figure 16. Retrieved from: https://www.geheugenvanapeldoorn.nl
Figure 17. Retrieved from Hertzberger, H. (1970). Een werkplaats voor duizend mensen: nieuwbouw hoofdkantoor apeldoorn. Amsterdam: Centraal Beheer, p.3.
Figure 18 – 25. Retrieved from https://www.ahh.nl/
Figure 26-28. Self made figure
Figure 29. Retrieved from https://www.ahh.nl/
Figure 30 – 35. Self made figure
Figure 36. Retrieved from https://www.ahh.nl/
Figure 37 – 43. Self made figure
Figure 44. Retrieved from: https://www.geheugenvanapeldoorn.nl
Figure 45 – 49. Self made figure
Figure 50. Retrieved from: www.flickr.com
Figure 50 – 56. Self made figure
Figure 57. Retrieved from https://www.ahh.nl/
Figure 58. Self made figure
Figure 59. Retrieved from: https://i.pinimg.com/
Figure 60. Self made figure
Figure 61. Retrieved from ajbuildingslibrary.co.uk
Figure 62. Retrieved from https://www.ahh.nl/
Figure 63. Self made figure
Figure 64 – 65. Retrieved from https://www.ahh.nl/
Figure 66. Retrieved from: https://i.pinimg.com/
Figure 67. Self made figure
Figure 68. Retrieved from: https://i.pinimg.com/
Figure 69. Retrieved from https://www.ahh.nl/
Figure 70 – 72. Self made figure