converting office space

using modular prefab architecture to convert vacant office buildings

+ MSc graduation thesis
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MSc graduation thesis - P5 report

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+ | preface

In front of you, you will find the research paper that was an essential part of my graduation project for my MSc in Architecture followed at the ExploreLAB studio at the Faculty of Architecture of the Technical University in Delft. The final result, besides this paper, is the design for a conversion of a vacant office building in Rotterdam according to a concept that followed from this research. A special thanks goes out to my instructors at the faculty; Hilde Remøy who helped me conduct this research, Ype Cuperus for the technical advice, Robert Nottrot for the advice on design and the Veldacademie in Rotterdam for practical guidance.

Ferdi Koornneef
April 2012

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1 | introduction

figure 1.1.1 vacant office space (stichthage, the hague) | f.p. koornneef (2011)

1.1 problem statement

1.1.1 office vacancy

6.795.000 m2 - this is the amount of vacant office space in the Netherlands. Currently, with a total stock of 48.195.000 m2, this means 14,1 percent of the total office floor area in the Netherlands is vacant (DTZ, 2012). This amount does not yet take 'hidden' vacancy into account, which is the part of office space that is not in use in buildings rented by companies and organizations, good for another estimated 2.000.000 m2.

Structural vacancy

Most of the vacant office stock of today is defined as structurally vacant, meaning that the building has been vacant for more than three years (Hek, 2004). This type of vacancy is different from frictional vacancy and vacancy caused by (seasonal) conjuncture, which are not always considered as a negative development.

In a balanced office market, the quantitative demand and supply of office space will not differ significantly. But if the economy shows fast growth, the office market will show signs of shortage, while during an economic recession some excess vacancy will be seen (Keeris, 2007). Vacancy as a result of this mismatch on the office market is a natural phenomenon and equals 3% to 8% of the total supply of the office market (Wheaton 1999; Tse and Webb 2003). Considered healthy, this type of vacancy is called *frictional vacancy*, caused by friction between supply and demand. However, in an unbalanced market, vacancy can rise substantially, caused by a significant mismatch between the demand and supply of available office space. In markets with continuous high levels of vacancy, structural vacancy will occur, as can be seen in figure 1.1.3.

Overcapacity

According to the EIB, the Economical Institute of the Dutch Building industry, the structural problem really shows when the current vacant stock is confronted with the future demand for office space. This shows how the current market is able to take up vacant office space in the future. Careful forecasts from data from 2009 already show an overcapacity of 4.000.000 m2 of office space (EIB, 2011 - *see figure 1.1.3*), meaning that there will be no more future demand for almost 70% of the vacant office stock.

Kantoorbanen 2.265.500 2010 t.o.v. 2009 ↓ 0,8%	**Aanbod** 7.561.000 m² 2011 t.o.v. 2010 ↑ 5,7%	**Voorraad** 48.195.000 m² 2011 t.o.v. 2010 ↑ 3,0%
Opname 1.341.000 m² 2011 t.o.v. 2010 ↑ 9,4%	**Leegstand** 14,1% (6.795.000 m²) 2011 t.o.v. 2010 ↑ 0,2%	**Huurprijs*** € 141 per m²/ jaar 2011 t.o.v. 2010 ↓ 1,5% *Excl. evt. incentives

figure 1.1.2 fact sheet office property market (2011 vs. 2010) | from: DTZ (2012)

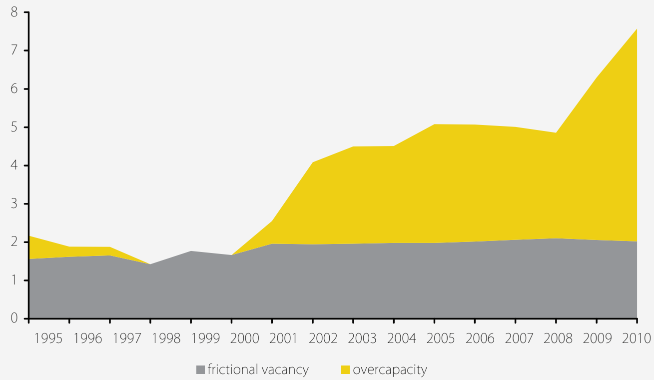

figure 1.1.3 frictional vacancy and overcapacity indicate structural vacancy | from: EIB (2010)

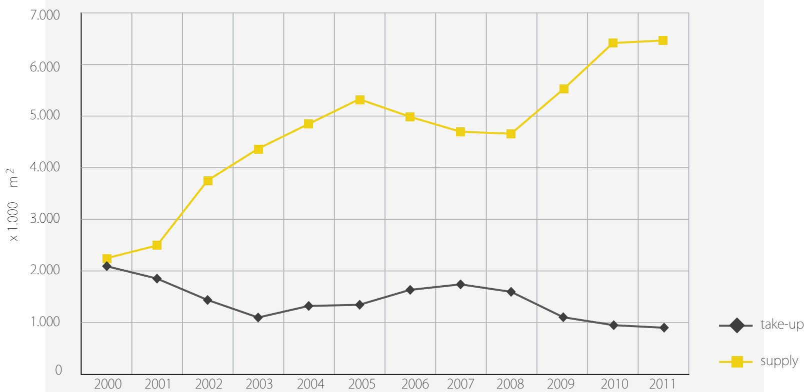

figure 1.1.4 development of supply and market take-up | from: Dynamis (2011)

Prospects are that this amount will only increase further (by 2010 the overcapacity is already an estimated 5.500.000 m2 - *see figure 1.1.3*).

Fact is, there are too many office buildings. This has several reasons, but is mainly because the office market is not perfectly functioning and transparent. Offices are heterogeneous investment goods, transactions are complicated. This adds up to the fact the market is highly adaptive, making it a market of 'bubbles' driven by short-term demand, not overlooking long-term consequences. So-called 'overshooting' is followed by 'undershooting' (EIB, 2010).

Hog cycle

Responding to short-term demand is natural, but the real estate market is slow – because of the simple fact that it takes some time for a building to be completed. This especially makes the office market vulnerable. A study from Brounen and Eicholtz (2004) showed the relationship between lagged employment growth and new supply of office space. This phenomenon, characteristic for the office market, is referred to as the 'hog cycle'. The growth of the office space supply shows a cyclic behavior that lags 2 to 3 years behind of economic cycles and office space demand, which is registered as office space absorption (Remøy, 2010).

As a result, there is always the possibility that an office building upon completion will not find a tenant. This is what happened in the last 10 years – the office market was 'overshooting'. While the market take-up was stagnating, the supply grew (*see figure 1.1.4*).

Changing office market

To explain this further, we have to go back in recent history. In 2008, The Netherlands had around 43.5 million square meters of office space, in 1995 this was 32.9 million square meters and in the 1980's this was 'only' 20.0 million square meters (SBR, 2009). In 30 years the office stock doubled, which is not strange, considering growth of the participating working population throughout the years and employment growth in office environments. The growth of the office stock concentrated in the Randstad, but cities lacked space for offices in their centers, so mono-functional office areas were being built along city borders. With the automobile becoming the most important means of transportation, these locations were easily accessible and

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figure 1.1.5 collage vacant office buildings (DTZ Zadelhoff database), f.p. koornneef (2011)

located along highways. Because of high demand, most of these office buildings became interesting investments for an anonymous tenant market. In comparison: in the city centers roughly half of the office buildings is still owned by its user (SBR, 2009).

Optimistic market

If we look back, the office market was also characterized by high vacancy in periods of economic downfall, such as the mid 1980's and 1990's. But when the economy recovered, the vacant office stock was taken up again. In the beginning of the 21st century this changed. After the burst of the 'Internet-bubble' in 2000, the demand for offices dropped: many IT-companies went out of business and after 9/11 this development continued; the economical downturn caused the office market to reach vacancy levels of 15 percent.

In the aftermath of the 'Internet-bubble' offices were still being completed between 2001 and 2004 – but now with no tenants to move in. When the economy started to recover in 2004, the demand for office buildings regained. Tenants preferred the newly-built office buildings over the dated ones and left their former offices behind, vacant. The 'hog cycle' started over: the real estate market was signaled by the economical upturn and started design- and development phases for construction of new office buildings. Local governments earned extra money selling greenfields and were willing to work along. And not without a reason: both in 2006 and in 2007 the take-up was 1.8 million square meters, which was 30 percent above the long-term average, according to DTZ (2008).

On a side note, this take-up was served with 1.4 million square meters of newly built office space, leaving vacant office space behind. This went on until 2008; the financial crisis hit, resulting in the collapse of financial institutions, bank bailouts and downturns in stock markets all around the world. Again, the demand for office space dropped, but office buildings were still under construction and being completed until today. Newer buildings attract new tenants, who, on their turn, leave dated office buildings behind, resulting in the current total vacancy level of 6.795.000 m2 (DTZ, 2012). Although vacancy levels have been high in times of economical downturn, like now, this time the vacancy is different and harder to overcome - especially when we consider the current prospects.

	extent (x 1.000) 2000	cumulative growth 1950 - 2000	(in %) 2000 - 2050
Australia	14.356	113,6	21,5
Canada	16.912	174,3	15,9
France	36.320	41,3	-8,1
Germany	53.035	23,8	-27,9
Italy	37.137	30,7	-34,3
Japan	82.200	84,3	-35,6
The Netherlands	10.244	74,2	-13,8
Spain	25.802	53,4	-41,1
United Kingdom	35.888	14,1	-16,2
United States	174.872	83,1	28,8
Average (Europe)	486.766	60,4	-4,4
Average (World)	3.482.774	152,6	53,4

figure 1.1.6 cumulative growth of the working population between 1950 - 2050 (United Nations world population prospects database) - working population is defined as the national population between 18 - 64 years old. | adapted from Brounen & Eichholtz (2004).

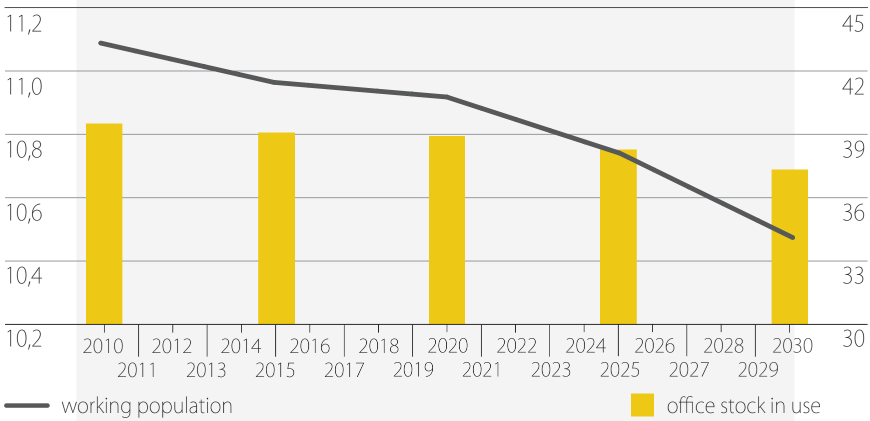

figure 1.1.7 frictional vacancy and overcapacity indicate structural vacancy | from: EIB (2010)

Declining working population

The office market in The Netherlands has always characterized itself as a market of growth. The working population has shown a steady growth and office employment increased according to economic conjuncture. Until now; if we look at the demographic development of The Netherlands (and Europe as a whole), we can only conclude that the office market has changed into a market of replacement (SBR, 2010). The working population in The Netherlands in the next 40 years will shrink with 13,8 %; in Europe in general this percentage will be 4,4% (*see figure 1.1.6*).

Less people working, means less people need a physical workplace – so there will be less demand for office space and an increasing part of the already built office stock in the next 40 years will become redundant (*see figure 1.1.7*). The working population rate is a good tool to estimate the demand for future office space, but there is another recent development that needs to be taken into account. It is clear to say that not the entire working population is working in an office environment, but that part that does, is in the middle of a changing working environment.

Changing working environment

The ongoing globalization forces white-collar activities (such as ICT-departments and call centers) to move to low-wage countries. The stereo-type office job, sitting in your cubicle behind your desk, talking on the telephone and working on a desktop computer belongs to the past. Influenced by the Internet and new mobile technology, our working environment changed and is becoming more mobile. Also referred to as 'Het Nieuwe Werken', office jobs are moving from their static location of the office building out into the 'flexible'. This can be your own home, your favourite coffee bar or one of the 'flex'-working places in your office.

In a recent report '*What users want. The influence of Het Nieuwe Werken on the office environmen*t' (2011) CBRE concludes that 'Het Nieuwe Werken' will require 15% less office space (equivalent of 6.000.000 m2) in the future, because of space efficiency (on a side note, that is if companies decide to swith to 'Het Nieuwe Werken', otherwise it will be defined as hidden vacancy). If a company decides to swith to 'Het Nieuwe Werken', occupancy rates of office space will decrease, because employees will be working at home or part-time. On top of the current vacancy levels this will contribute to a total vacancy (partly hidden) of around 13.000.000 m2 office space in the near future: the current vacant office stock doubled.

1.1.2 consequences

Private problem becomes public

First of all, a vacant office building is financially unprofitable for its owner: without a tenant, an office building is almost worth nothing. This adds up to the costs of maintaining a vacant building, such as property taxes, service contracts and energy costs. This shows: vacant buildings deteriorate faster, because of overdue maintainance. In areas with high vacancy rates, there is less livelyhood and without the 'eyes on the street' (essential for urban quality according to Jane Jacobs in her book 'Death and life of great American cities' (BNA Onderzoek & TU Delft, 2011)), there is less public surveillance, which leads to graffiti, further deterioration and vandalism. A financial problem for the owner is now becoming a problem in the public realm: indirectly, this further depreciates the property value of the vacant office building, making the problem worse.

Waste of usable space

Beside the financial consequences, vacant office space is above all a waste of usable space. From a recent report[1] from the SCP (Dutch Social Cultural Planning office) it turns out that the Dutch citizen does not understand why new offices are being built while there is that much vacancy on the office market. This, in combination with a shortage in affordable housing (*so why not use the space?*), makes it even harder to understand.

Market attitude

Although the office market already moved from a supply-driven to a mostly demand-driven market, how is it possible that offices are still being added to the stock, neglecting vacancy? The answer to this question is one from a financial character: although we are in a difficult financial climate, a new office building is still a solid investment. That is, only if you can find a tenant who is willing to sign a contract for a

1 Rapport *Burgerspectieven 2011-2012* | from: www.vng.nl (visited december 2011)

long term. Why this is, is explained with the following example:

A random company rents 10.000 m2 from investor A for 15 years. After 15 years the office building becomes outdated, the contractual agreement is running to an end and the company wants a new office environment. Although the company does not necessarily need an entirely new building, but more a refitted office environment, it does not want to move twice (in-and-out during the refitting procedure of the existing building), because this is cost and time inefficient. In stead, the company rather moves into a new office at once.

This is where investor B (or the same investor A) moves in: he offers an entirely new up-to-date building on another location for the same rental price as the company paid, only if the company signs a contract for (another) 15 years. The choice is easily made: now the company only has to move once, into a brand new building according to the companies needs and it keeps paying the same rental price. Investor A now has a vacant building left (from which he already earned back his investment plus yield from the first contract) and puts the office building back on the market, hoping to find a new tenant (but in the meanwhile adding to the vacant office stock).

Above example shows the dynamics of the office market in a simplified way, but it signifies how it is possible that new office buildings are still being built.

Depreciation?

Now the office market changed and new tenants are hard to find, the market attitude moves to that of 'damage control': the tendency is to protect investments in this financial climate and slowly depreciate on office portfolios. Immediate depreciation of the value of the entire vacant office stock will result in large financial losses for all parties involved and could have major influence on the, already unstable, economy. In april 2011, the Dutch National Bank published their half-annual report 'Financial Stability in The Netherlands', that stated that the commercial real estate market is still fragile, with structural vacancy on the office market as one of the main reasons. For the recovery of financial stability in The Netherlands '*it is essential that stakeholders can trust each other and that financial losses are not covered up*'.

DTZ recently stated that a depreciation of a large part of the vacant office stock is necessary, claiming that it the office market is currently overvalued by 10 billion euros (Vastgoedmarkt, January 2012). In DTZ's report is concluded that '*more transparancy in real estate valuation is necessary now the real estate market is under pressure. Insights into incentives and more transparancy in ground politics will contribute.*'

1.1.3 measures

In overview, there are basically four ways to deal with the structural office vacancy as it is today (NVM Business, 2010).

1. Further commercial exploitation (lowering of rents)
2. Renovation (office renewal)
3. Conversion (new function)
4. Demolishment (withdrawal from the market)

But how does each stakeholder on the office market respond to structural vacancy? To identify which measures are taken by which stakeholder, the following overview can be made:

Investors

Investors do not always see office vacancy as a problem. Depreciation of their office portfolio or a drastic strategy change is therefore not a priority. This is mostly because only a part of their office portfolio is vacant, the other part still generates an 'acceptable' yield. If an investor decides to depreciate and restructure a vacant office building, he faces the so-called *prisoner's dilemma*: if he is the first owner to take his loss, the other surrounding owners can benefit from the quality improvement of the restructured office building (and its surrounding area) and maybe attract the tenant the owner was looking for in the first place (EIB, 2011).

Financial institutions

A lot of office investments have been financed with loan capital from (international) financial institutions. That the risks on loan capital were not always correctly valued, is proved by the credit crisis which started in 2007. With vacant offices in their portfolios and thus less money coming in, it has become harder for investors to pay off loan capital and interest.

Because financial institutions are still recovering from the credit crisis, they do not have the financial position to be able to depreciate their loan capital on real estate. In this situation, financial institutions and investors will both not benefit from depreciation. This difficult financial position also restricts new financial means for redevelopment or conversion of vacant office buildings.

Project developers

Contributing to the oversupply on the office market, project developers have facilitated the growing need of investors to invest in offces after 2002 (EIB, 2011). Because investors were willing to pay more for a new office with a tenant in comparison to the costs (ground and construction) of a new office an incentive was created. By using the incentive to save on housing costs, it became a rational choice for a tenant to move to a new building (similar to the example given on page 17).

Now this situation has changed, most (office) developers are challenged to come up with creative solutions for the future and have to take measures and change their development strategies. Area redevelopment, conversion projects, sustainable and zero-emission office buildings are becoming more and more the new norm in project development. But the success of these projects is always dependent on the willingness of the different stakeholders involved.

(Local) government

First it needs to be noted that the government (and local governments in particular) is partly responsible for the office vacancy as it is today. This is because over the last decades, local governments have been generous selling greenfields (new grounds for development) for office development. According to Neprom (the Association of Dutch Project Developers), all local governments in The Netherlands together still have enough plans at their disposal to add an office stock the size of the current vacancy (EIB, 2011). It is highly unlikely that these plans will ever be realized, but it signifies the ambitions of local governments to expand.

This is explainable: by bringing more office organizations within local borders, more jobs are created (often followed by a growth in population), which can function as an impuls for the local economy. The revenues from selling greenfields for office locations were used to fill in gaps for other ground developments. In this way, local governments started competing against each other to bring new office developments within their local borders. But by being generous in selling greenfields, developers were not triggered to redevelop the existing stock. This way, it was possible that more buildings were being added, while demand was stagnating. Also here it involves a *prisoner's dilemma*: if a municipality decides to be strict in granting land, other municipilaties, being more generous selling land, could benefit.

For the future, it is therefore important that local governments make agreements on a regional level in regards to selling greenfields, to prevent the vacancy problem becoming worse.

Awaiting attitude

What is clear from the position of most stakeholders in the office market is that they are hesistant to respond. This awaiting attitude is partly due to the current financial climate, but has more to do with the *prisoner's dilemma* that plays: no one wants to be the first to take his loss. But in the end, the problem is inevidable: almost 70% of the current vacant office stock will become redundant (EIB, 2011) and if nothing is done, worthless.

Looking back on the current office market, its stakeholders and the four measures (*further commercial exploitation, renovation, conversion* and *demolishment*) mentioned at the beginning of this chapter, a few things can be said: Looking at the office market in general, further commercial exploitation (for example by lowering rents) is a possibility to make the office market more competitive and dynamic, but does not cope with the fact that in the end there will always be an oversupply of office buildings. For renovation a similar explanation: renovating vacant office buildings will not change anything about the oversupply - it only puts the problem in a new jacket.

Two options remain: conversion or demolishment. Demolishment is, in financial terms, depreciating the vacant office building to the price of the ground it stands on. The building is demolished and the ground is sold to another investor (or back to the local government). Conversion on the other hand also requires a significant depreciation of the value of the office building, but you still have a building left which, after conversion, can function for years to come.

1.1.4 conversion

The SEV (2007) sums up the advantages for conversion over demolishment: structurally vacant office buildings can be purchased relatively cheap, the time to redevelop is shorter than new-built and conversion of a former office building is better for the environment than to build something entirely new. It is sustainable: by reusing most of the building, there is less waste and existing building material is used for years to come. Since sustainability is becoming more important in real estate development, it is more likely that we have to look into opportunities to convert vacant office buildings. But where do we start?

figure 1.2.1 demolishment former PTT-kantoor | from: wikipedia (2011)

1.2 project goal

Although conversion is often named as a solution for a part of the vacant office stock, it is hardly ever put into practice. The awaiting attitude of most stakeholders on the market is not helping. To come up with solutions, all stakeholders have to work together. If placed in a broader perspective, a shift is happening in the real estate market: from a market driven by supply, to a market mostly driven by demand, from a market characterized by growth to a market of replacement. Learnings from the real estate 'bubbles' make the highly adaptive and speculative character of the real estate market subject to change.

Position of the architect

Enter the architect: his position in the building process, right between investors, developers, the government, the public realm and the contractor makes him the ideal mediator: '*(...) As a practioner, an architect coordinates a team of professionals (...) Typically, the interests of some team members will compete with the interests of others. An architect must know enough about each discipline to negotiate and synthesize competing demands while honoring the needs of the client and the integrity of the entire project.*' (lesson 21 from *101 Things I Learned in Architecture School* by Matthew Frederick, 2007).

This is the time where the architect must anticipate, overview the issue and respond. And the solution should not solely be architectural, but must also take financial, regulatory and technical consequences into account. The idea of the unsolicited architect, responding to the market, is therefore key in this thesis project.

Project goal

This paper therefore aims to explore and map the difficulties and opportunities on the vacant office market with conversion as solution and find an adequate answer to the following question, that also entails the project goal:

Conversion of vacant office buildings is hard: how can the architect contribute?

1

1.3 design of research

Research introduction

By starting this paper with a thorough introduction about the office market in general and the vacancy problem in specific, a clear impression is made of how the office market dynamics work. The focus from this part on will be more aimed towards the actual conversion of office buildings and how the architect can contribute in this process by means of design.

Research questions

Main research question:
By means of design, what can the architect contribute to make conversion projects more feasible on a large scale?

To give an answer to the main research question, subquestions need to be answered first. The focus of these subquestions all lie in the same field of research: mapping the building characteristics of office buildings in general and office vacancy in specific and subsequently its potential for conversion. The research can therefore be divided into two parts: **design research** and **conversion potential**.

Design research

- *What shaped the (Dutch) office building?*
- *What are the most important characteristics of (vacant) office buildings?*
- *Can the vacant office stock be typologically described?*

The goal of the design research is to find more specific information on the vacant office stock in The Netherlands on the level of the building (structure, façade, etc.). For the first question, related to the history of the office building, literature research will need to be conducted. To find an answer to the other two questions, a database will be consulted. At the department Real Estate and Housing at the Technical University of Delft sufficient information is available: a database with information about 200 vacant office buildings, all located in and around Amsterdam (database dates from 2008). Used for the PhD-research of H.T. Remøy, this database includes (besides different descriptions of characteristics of every building) plans, cross

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sections and other construction drawings. Although this database does not contain much technical information about the buildings, construction drawings will be used additionally. From this database useful information will be extracted, such as grid sizes, elevations, floor depths, construction methods and building materials.

Conversion potential

- *What are the most common difficulties encountered in conversion projects?*
- *Which building characteristics can be identified as opportunities for conversion?*

The findings from the first part of the research will be used as a guideline through the second part of the research. Both parts will together lead to an answer to the main research question, the conclusion to this research paper.

Important to note is that the subquestions only focus on the level of the building; the location characteristics of office vacancy are not taken into account.

Design project

The final result of this project, besides this research paper, will be the design for a conversion of an existing (and vacant) office building. The lessons learned from this research will help design the conversion of the building. Because additional research was conducted to help define the conversion concept, an extra chapter will be added after the concluding chapters.

2 | design research

figure 2.1.1 '*Casa degli officiali*' - Uffizi, architect Giorgio Vasari | Firenze, Italy

2.1 office architecture history

To get a better understanding about the building characteristics of office vacancy, it is important to know how time and culture shaped the physical appearance of the (Dutch) office building and how this evolved to the office building of today. From the international precedents and architectural movements that influenced the Dutch office, this chapter will subsequently zoom in on office buildings in the Netherlands and its most important building characteristics.

Origin of the office

Until the invention of the press around 1450, nothing more than a standing table in the corner of a warehouse or living room was needed to do 'office work', which only entailed writing or copying (by rewriting) letters by hand. The tables used for this work were called '*comptoirs*' in French, which comes from the verb '*compter*' meaning counting or calculating (derived from '*compter*' is the Dutch word for office, '*kantoor*'). On the other hand, the English (and also French) word '*office*' refers to the Latin word '*officium*' which means task or duty (de Gunst & de Jong, 1989). This word was first used by theoretics from the 15th century to describe buildings in which klerks worked and this brings us to the first building that can be ascribed to the office as a building typology: the world-famous *Uffizi* in Firenze in Italy built between 1560 and 1571.

Pevsner, author of 'History of building types' (Pevsner, 1989), claims otherwise: he does not recognize the office as a building typology until the mid 1900s (in his respect, the Uffizi as a building is ascribed to the typology of a governmental building). Because of the upcoming industrialization in the 1900s, the need for administration and archiving grew. To facilitate this growing need, buildings that Pevsner's regards as the first offices were designed. Three buildings, built between 1830 and 1860 in Liverpool and London and designed by architect C.R. Cockerell for Sun Assurance, were the first that can be described according to the typology of the office building (see figure 2.1.2 - next page). From this moment on, driven by the economy, the office as a building typology is becoming more common.

Characteristics through time

Already in the second half of the 19th century an important aspect that characterizes

figure 2.1.2 Sun Assurance building, architect C.R. Cockerell | London, England

figure 2.1.3 Sears & Roebuck order department around 1913 | Chicago, USA

the office market of today shows: the difference between an office built for its owner and user, and the office built for an anonymous tenant market (de Gunst & de Jong, 1989). Other aspects that shaped the appearance of the office buildings as a typology were the use of the building over time and the technological development that influenced the construction of office buildings.

Use of office buildings

The use of the office building changed drastically in the beginning of the 20th century under influence of industrial efficiency. Based on the assembly line of Henry Ford for cars, introduced in 1908, Frederick Taylor developed a similar vision on administrative work, that was adopted worldwide as a standard for office work. Hierarchy, rationality, division of labour, precision and supervision were the most important features and shaped the design of the office (Remøy, 2007). Large open floor plans with rows of desks (almost as assembly lines) characterized the office of that time (see figure 2.1.3: *Notice that there were only women working behind the typewriters - entirely according to Taylorism; women were by then cheaper labour and regarded as being more precise in office work than men, so more efficient*).

Technological development

Technological developments, such as the application of steel (former cast-iron) in construction, made it possible to make larger spans and lighter constructions. To provide enough natural light for office workers in these large spaces, façades were mostly designed out of glass to maximize incoming daylight (curtain-wall façades are already being used). The introduction of the (electrically driven) elevator made it easier to stack office floors. Together with an increasing building density and higher land prices in cities, it was desirable to build closer to other buildings, resulting in higher buildings. The desire for prefabricated building systems to build faster grew coherent. Important to note is that this development almost exclusively occured in the United States, with the cities of New York and Chicago as frontrunners, but it sets an example for the rest of the world.

Office buildings that signify the technological, but also architectural development of the office building are the Wainwright Building by Louis H. Sullivan built in 1891 (figure 2.1.4) and the Larkin Building by Frank Lloyd Wright built in 1904

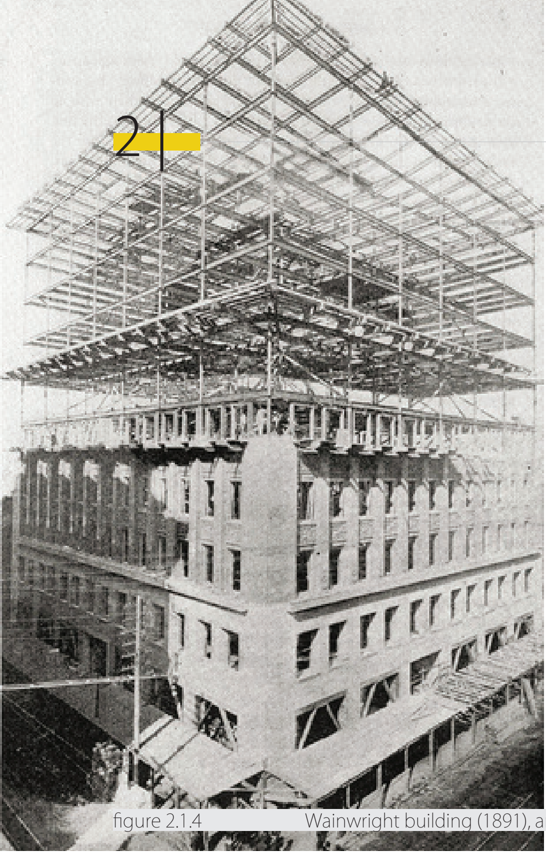


figure 2.1.4 Wainwright building (1891), architect Louis H. Sullivan | Saint Louis, USA

figure 2.1.5 Larking building (1904), architect Frank Lloyd Wright | Buffalo, NY - USA

(figure 2.1.5). The design of the Wainwright building was ahead of its time: the use of a steel structure and the vertical formal language by the composition of the windows was unique for that time. The Larkin Building, demolished in 1950, was characterized by its sober appereance, but also its lay-out plan: the office floors were placed along an atrium, catching light from above with vertical transportation placed in the corners of the building. It was also noted for many innovations, such as mechanical ventilation and built-in office furniture.

If we look back, the technological development in office construction around that time is impressive. At the end of the 19th century a building of around 16 floors was considered high, in 1931 the Empire State Building was completed: with a height of 375 meters, 102 stories and build within 1 year and 45 days, it still is the highest building in Manhattan today.

Expansion of office organizations

After the Second World War the service sector grows significantly, both in the United States as in Europe and a service economy flourishes. Technological innovations in the office environment, such as telecommunication, office machines and computers result in an expansion of office organizations world-wide. As a result, offices are growing larger (and higher) to house employees. The office buildings around the 1950's and 1960's therefore show a more and more functional character: concrete (based on Corbusier's Domino-plan) or steel structures closed off by curtain-wall façades (de Gunst & de Jong, 1989).

In the field of office architecture, the United States is still leading. Artificial lighting and mechanical ventilation make it possible to make office buildings deeper. European office architecture is influenced by the appearance and curtain-wall façades of the American office building, but the lay-out plans are not followed - the deep and open floorplans do not comply with European office culture (Remøy, 2007). The façade of the office is getting the most attention and studies are conducted how façade grid sizes inform the floor plans of the spaces behind the façade. Examples of this type of office architecture are designed by the influential architect Mies van der Rohe, with the Seagram Building (New York) (see figure 2.1.6), One Charles Center (Baltimore) and IBM Plaza (Chicago) as frontrunners.

figure 2.1.6 Seagram Building (1958), architect Ludwig Mies van der Rohe | New York - USA

The 60's movement

As a reaction to the sober functionality of the after-war period, the ideological ideas of the sixties changed office architecture. Architects started thinking more about the organizational structures and how hierarchy was translated in the design. The focus in the design moved to unobstructed communication between employees making a new type of office environment possible: the office landscape (or *Bürolandschaft*, developed by a team of consultants, know as the Quickborner team in Germany in 1963). Although this not directly influenced the appearance of the building from the outside, it changed the inside and the organizational character of office environments, but only for a brief moment of time (de Gunst & de Jong, 1989)

The office landscape had its concerns: the open floor plan made it hard to concentrate and employees complained about privacy and not having the ability to look outside (Remøy, 2007). Quickly, new mixed floor plan arrangements emerge: office landscapes combined with cell offices or only cell offices along a long corridor on both sides.

Office buildings as investments

Around the same time, office buildings were discovered as interesting investment products (see chapter 1.1). Because office organizations were growing and technology (for example telecommunication and transportation) allowed to have offices in different places, office space for an anonymous tenant market becomes more rule than exception (and still is) (Remøy, 2007). This development continues, causing the design (grid sizes, façades) of office buildings to become standardized.

1970's and 1980's

The energy crisis in 1973 throws the economy back, but leads to more attention for insulation and climate control of office buildings (Remøy, 2007) to save energy. Curtain-wall façades are better insulated, double glazing is applied and mechanical ventilation is introduced to become the norm in office climate control. Climate façades and windows prevent façades to be opened manually.

When the economy picks up in the 1980's, demand for smaller, flexible office space grows further. Insight into owning your own office changed permanently, the tenant office becomes the new standard.

1965

1969

1978

1985

1988

1992

figure 2.1.7 (American) office environments from 1965 - 1992, from: hermanmiller.com

After 1985

From 1985 onwards the introduction of the computer in the office environment has changed the way people work in offices. This also had his influence on the design of the office. Since large archives and cabinets were less needed, the desire to sit close to the façade and have the abilitiy to look outside, grew. Under influence of new workspace dimensions, buildings became more narrow.

Computers required new installations, such as cabling and extra cooling. Cabling was placed along the façade in a cable duct, underneath so-called 'computer-floors" (raised floor system with cabling underneath) or in the lowered systemized ceiling. The lowered ceiling was also used for ducts for mechanical ventilation and air-conditioning, to improve the indoor climate.

After 2000

With the introduction of mobile technology, such as the mobile phone, laptop, internet and e-mail, the employee has become less dependant on the office building: 'Het Nieuwe Werken' (*new working attitude*) is changing the way employees use their office. Shared or flexible workspaces have become the norm. At the same time, more people work from their own homes or at different places during the week. For the appearance or outside of the office building not much has changed because of this development; the change can be seen more clear in office interiors. 'Flex' workspaces, spaces to concentrate on your work, spaces for casual encounters or lounge areas, open office landscapes with meeting rooms as defined elements - a wide range of different spaces is possible.

What can be said about the outside of the office building is that there is a trend to move to mixed-use and more innercity areas. Activity around the office is becoming more important: in your coffee break you can go down to the lunchroom down the street or go to fitness after work, located in the plinth of the same building. Monofunctional office-areas are therefore becoming more in decline.

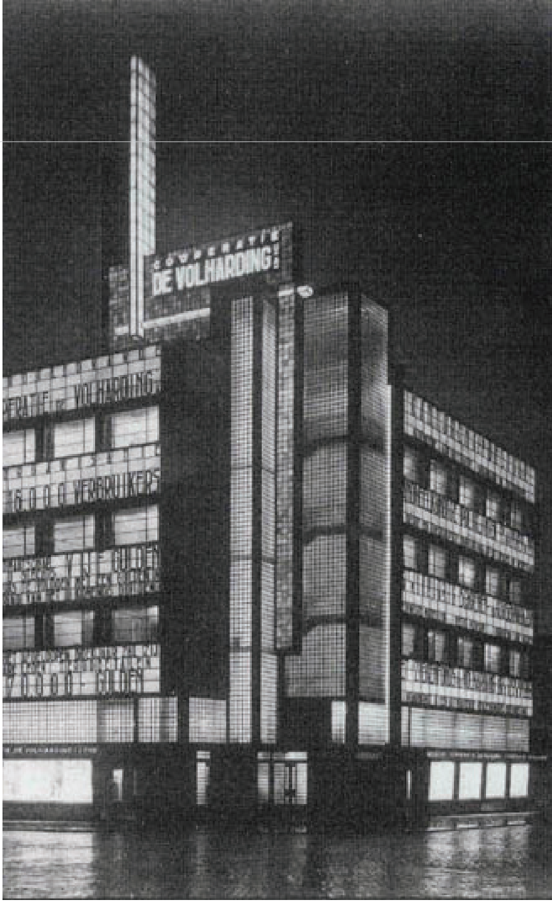


figure 2.2.1 (left) Witte Huis (1898), architect W. Molenbroek | Rotterdam

figure 2.2.2 (right) De Volharding (1928), architects Buys & Lürsen| The Hague

figure 2.2.3 Van Nelle factory and office (1930), architect Brinkman & Van der Vlugt | Rotterdam

2.2 office architecture in the netherlands

The reason why this chapter only focuses on The Netherlands, is because the *'Dutch office buildings are above all very Dutch. From the outside, these buildings may be similar to those abroad. A closer look, however, reveals that office buildings in The Netherlands are different from offices elsewhere, particularly from those in the UK and the US.'* (Meel, 2000).

Office building types

This chapter will only analyze the office building that can be described as the administrational office, where office work is the main activity and where the public does not play any role (de Gunst & de Jong, 1989). The other two types of offices, namely the public office and the clientele office, are different. The public office is accessible for the public, where office employees behind counters assist. These offices are mainly situated on ground-level and are mostly operated by banks or governmental institutions. The higher levels of these buildings are often administational and are organized according to the administrational office type. The clientele office is also accessible for the public, even on several floors, but are more in a private setting (examples are offices for accountants, lawyers or consultants in a smaller organization). Although we are in the middle of a changing working environment, as described in chapter 1.1, where the distinction in type of office can not be so clearly made, the office buildings that are vacant today have all been designed according to these standard types and are thus relevant.

History overview

In overview, the history of the Dutch (administrational) office can be roughly divided into five periods, excluding the buildings that were not originally designed as an office.

First generation offices in The Netherlands (pre-1945)

The first generation of office buildings date from before 1945. Without exception these office buildings were all designed in commission of its owner-user. Important to note is the attention for design; the architecture of these buildings is mostly unique and extensively decorated with sculptural elements.

The international (office) architecture movement has had its influence on

figure 2.2.4 Groothandelsgebouw (1952), architects W. van Tijen en H.A. Maaskant | Rotterdam

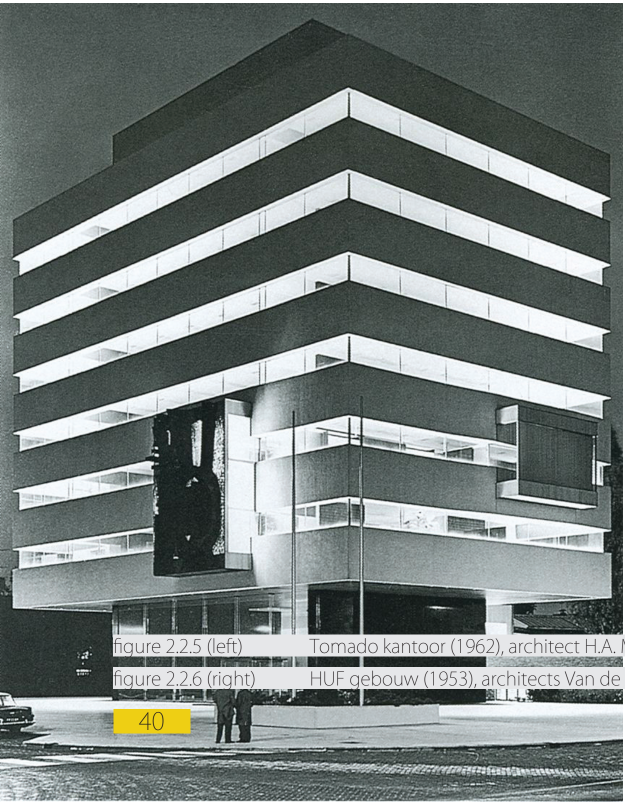


figure 2.2.5 (left) Tomado kantoor (1962), architect H.A. Maaskant | Dordrecht

figure 2.2.6 (right) HUF gebouw (1953), architects Van de Broek & Bakema | Rotterdam most of these buildings, but are hard to compare. An example: the 'WItte Huis' (or White House) in Rotterdam, built in 1898, had eleven floors and reached a height of 43 meters and was designed according to the 'American spirit' (*figure 2.2.1*). For 30 years, this building was the highest in the Nederlands; the competitive attitude that helped built the 'booming cities' in the United States did not have any followers here.

Other office buildings from before 1945 in the Netherlands that have had influence on Dutch architecture in general and office design in specific are 'De Volharding' in The Hague by architects Buys and Lürsen, built in 1928 and the Van Nelle office (and factory) by Brinkman & Van der Vlugt in Rotterdam, built in 1930. Both were built according to 'Het Nieuwe Bouwen' ('a new way of constructing'), which was adopted from international precedents, like Bauhaus. Light, air and space were important aspects in the design and new techniques (steel, concrete and curtain-wall façades) were used in construction. Although these buildings had its followers, it took some time before 'Het Nieuwe Bouwen' was widly adopted in The Netherlands, but this changes after World War II.

Second generation offices in The Netherlands (1945 – 1965)

The international style is introduced; straight lines and box-shaped, sober buildings. Important architects in this after-war period were Maaskant, Van de Broek & Bakema and Oud, strongly influenced by the international architecture movement (see figure 2.2.4 - 2.2.6). The individual expression of the architect is less important, although design commissions are still mostly coming from owner-users (Reuser, 2005). In the end, the building, above all, had to be functional (Functionalism).

Innovations in the construction industry in the 1950's, such as the first generation curtain-wall façades of steel without any interruption of thermal bridges, insulated glass, air-conditioning, artificial lighting, rubber sealants and prefabricated elements change the architecture of office buildings further. In line with the architectural movement of Europe and the United States (see chapter 2.1), steel, glass and concrete are now widly used in construction. In the beginning of the 1960's prefab (non-load bearing) façade elements are further developed. Also the size of glass window increase further, giving daylight more chance to enter the deepening office spaces.

figure 2.2.7 Centraal Beheer office (1979), architect H. Hertzberger | Apeldoorn

Third generation offices in The Netherlands (1965 – 1975)

Between 1965 and 1975 the office market changes; the growth of the service economy exploded and the office emerged as a new market. Office buildings became interesting investments for an anonymous tenant market (Kohnstamm & Regterschot, 1994) in a growing market, leading up to the current situation with 64 % of the total office space in the Netherlands being rental offices (Bak, 2005).

New construction methods made it possible to connect floors directly to its supporting columns with spans up to 9 meters. As a result, load bearing beams were not essential anymore. This allowed ceilings not to be interrupted by beams creating a higher and more open (continuous) office space. Furthermore, this decreased the construction height of the different floors substantially.

The tenant market demanded flexible, standard office space - resulting in a standardization in office design. In line with the international movement, the façade is becoming more important in the design. Floor plans were open, with concrete cores placed in the middle or on the side of the building. This allowed office tenants to determine their own floor plans by placing flexible wall systems and to bring in their own furniture. Façade grid sizes were based on the spaces behind the façade. In this way, the width of offices spaces within the building could be determined by placing an inner wall against the window frame of the façade.

The 60's movement (see chapter 2.1) changed the office environment from hierarchical cell office structures to open office landscapes. But when in the 1970's it turned out that for many organizations the office landscape was too radical, architects started experimented with new lay-outs and variants of the office landscape, resulting in the team office, of which Herman Hertzberger's building for Centraal Beheer (design from 1972) is the most significant example (see figure 2.2.7). This design combined the two (so far known) office lay-outs into a new concept for office space and was revolutionary for its time, not only on the inside, but also on the outside with its terrace-stacked 9 x 9 meter cubicles.

Next to architectural 'innovation' in the office environment, the building industry also come up with new materials and products which influence the appearance of the office building, such as the introduction of prefab, isolated sandwich panels, the second generation curtain-wall façade systems (this time without thermal bridges) and thermal insulation of façade becomes the standard.

In stead of steel, only aluminum profiles are now being used and developments in the glass industry allow insulating and sun reflecting glazing to be used more often. This (brown or blue-tinted) sunreflecting glazing was popular, because with this kind of glazing it was not necessary to use sun screens, while incoming daylight was optimized.

Fourth generation offices in The Netherlands (1975 – 1982)

Influenced by the energy crisis of 1973 and its aftermath, most of the office buildings turn out to be highly energy inefficient (and therefore expensive in use). More effort is put into the design of office buildings to reduce the exploitation costs for energy use, such as lightning and HVAC-systems. Also, the climate façade is introduced.

Fifth generation offices in The Netherlands (1982 – now)

After the energy crisis and an economical downturn in the beginning of the 1980's, the growth of the economy in 1982/1983 signifies a new era in office development. The office for several tenants becomes less attractive and there is more attention for the individual user. Outside expression and office identity are becoming more important. For exposure of corporate identities sight locations along highways are popular and monofunctional office areas (or 'office parks'), located along city borders, are being erected. For the outside of the office building this means that, although standard dimensions are still the basis grid for the inner structure, the façade is more expressive (although it is still a repetition of façade elements).

From 1987 more attention goes out to the quality of the environment and this development continues to be the trend today. Under influence of 'Het Nieuwe Werken' the office user prefers to work in a vibrant (mixed-use) area, causing monofunctional office areas to be left vacant.

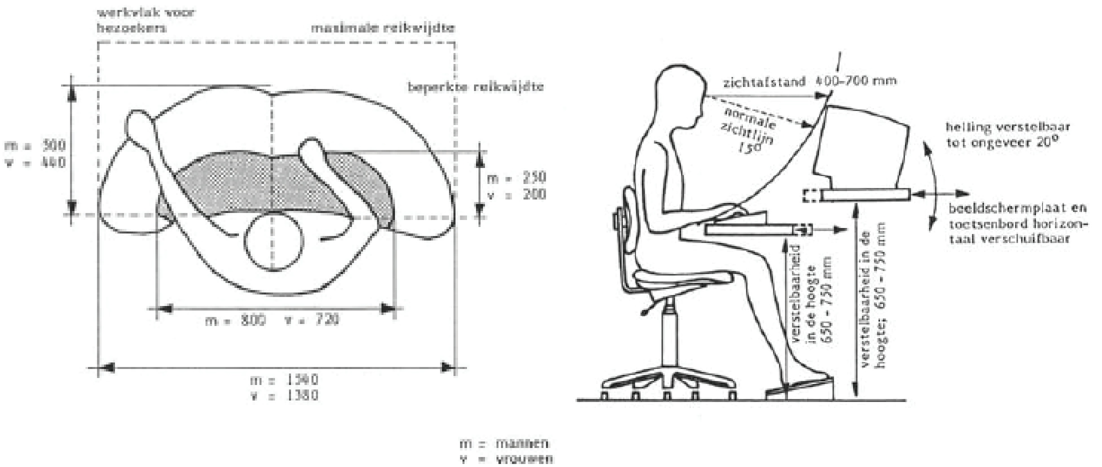


figure 2.3.1 Workplace dimension schemes, adapted from: de Gunst & de Jong, 1989.

Office space dimensions	Existing office building	New office building
Width (window module)	1.8 m	1.8 m
Total surface	8.0 m² *	10.0 m² *
Height	2.1 m	2.4 m

*These m² can be spread over several spaces

figure 2.3.2 ARBO-regulations for office space, adapted from: Meel, 2000.

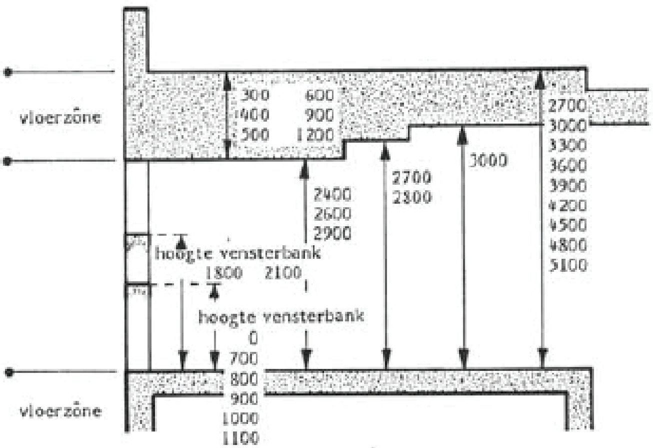


figure 2.3.3 Cross sectional options, adapted from: de Gunst & de Jong, 1989.

2.3 office building characteristics

In previous chapters the history of the office architecture gives us an idea of how the office building is shaped to what it is today. International precedents have had their influence on the architecture of office buildings, but as mentioned in the previous chapter, innovations in the (Dutch) building industry have had their influence too.

What can also be concluded from the previous chapter is that the office building for a tenant market became highly standardized to accomodate different office organizations. If standard, what are the corresponding building characteristics? This chapter will give an overview of those characteristics, focusing on three parts of the building, that are most interesting keeping conversion in mind. These three parts are: *standard dimensions*, *construction* (floors, columns, beams) and *façade*. Important to note is that this chapter will only focus on the Dutch office building.

2.3.1 standard dimensions

'In the majority of office buildings nobody is sitting more than 7 meter from a window. (Meel, 2000). In comparison to international standards, this difference is remarkable. If you look at it economically, a shallow floor plan tends to be less efficient than a deeper floor plan: for a similar amount of space you have to build a more expensive façade.

To explain this, Dutch building regulations are important: In The Netherlands we have extensive health and safety regulations for the design of office workplaces. The most important are the ARBO-regulations. These determine various aspects of the physical working environment. The most important of these are regulations stipulating the dimensions of workplaces and those governing access to daylight. ARBO-regulations prescribe that a workplace should compromise at least 7 m2. This concerns the basic space needed for a desk and a chair. For other features such as the entrance to the workplace, a filing cabinet or a conference table more space is required.

Furthermore, Dutch law prescribes that an enclosed office space should be at least 8 m2. In new office buildings this minimum is 10 m2 (see figure 2.3.2). In literature the average square meters per employee as a rule of thumb for office design differs significantly: ranging from 9.3 m2 to 25 m2 (de Gunst & de Jong, 1989) or 24 m2 (Meel, 2000). Although this number includes all other space needed, such as space needed for routing, fire escapes and sanitary units, there is no strict guideline. De Gunst & de Jong discuss this issue in their book '*Planning and design of office buildings*' (1989): first of all is there the fundamental question whether the client wishes to control the indoor climate. Mechanical ventilation allows deeper floor plans (up to 50 meters), which is for instance demonstrated in the design of Herman Hertzberger's office for Centraal Beheer in Apeldoorn. The design of the building further determines (for instance by a large void in the middle of the building) whether sufficient daylight - according to ARBO-regulations - can penetrate into the building. If the client chooses to let employees regulate the climate themselves, the tendency will be to choose for a shallow floorplan with direct access to the façade (which can be opened). If this is the issue, buildings will not be deeper than 12 meters.

If we zoom in further to a single office space for one employee the maximum depth, based on sufficient daylight, should be between 4.4 and 5.5 meters (de Gunst & de Jong, 1989). With the minimum space (10 m2) per workplace for new office buildings according to ARBO-regulations taken into account (see figure 2.3.2), the width of the room should be around 1.8 meters to 2.3 meters.

Meel (2000) further concludes that in the Netherlands open office plans are rare. The narrow floor plans of Dutch office buildings mostly have a cellular layout, since the rejection of the office landscape in the mid-1970s (see Chapter 2.1 and 2.2), so Dutch office organizations choose to accommodate their employees in rooms rather than in open office plans. These cellular layouts have since then been highly standardized. Most office buildings currently tend to be based on an office module of 1.8 x 5.4 meters. Employees can get an office of one module (1.8 m x 5.4 m = 9.7 m2), two modules (3.6 m x 5.4 m = 19.4 m2), three modules (5.4 m x 5.4 m = 29.1 m2) etc. Research has shown that this type of module is not that efficient from a space planning point of view. De Gunst & de Jong (1989) see the 2.4 m (or rather 2.7 m) module, based on the minimum width of one office room for one person, as the most ideal module. The load-bearing structure and placement of the columns is therefore always according to a multiple of 2.4 or 2.7 meters. This is in some way coherent with the 5.4 meter (2 x 2.7 m) module Meel refers to.

Another crucial factor for this level of standardization is that the building industry uses similar sizes for the production of building products such as prefabricated floor slabs, ceilings and HVAC units. The most common window module used in offices, 1.8 meters in width, corresponds with the module size Meel (2000) mentioned. What can be concluded is that the 1.8 meter basis for the office grid over the years has become the standard as a combined result of ARBO-regulations, space requirements, daylight optimalization and efficiency in the building industry.

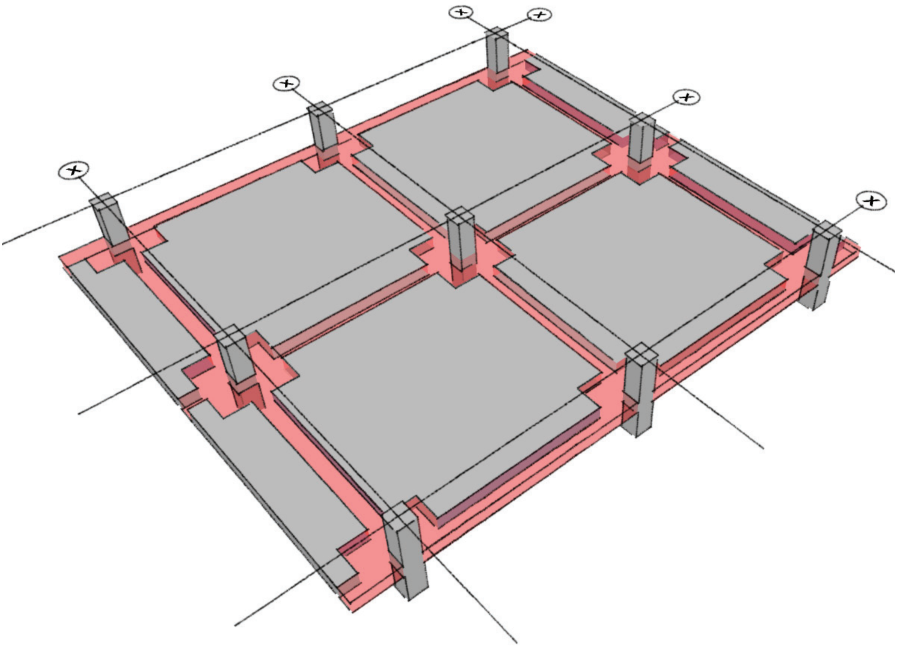
2.3.2 construction

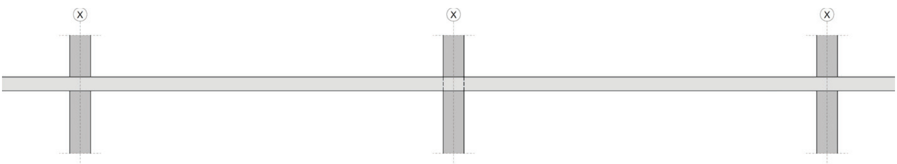
The standard dimensions of an office building and its construction are either the result of floor plan demands, but vice versa the floor plan demands are limited by what the construction allows. In general, the desirable flexibility of the office demands free spans as large as possible, keeping cost-efficiency in mind. The most applied material for floors, beams and columns is reinforced concrete, in-situ, precast or prefab. If steel is used, this is carefully 'wrapped' in concrete for fire retardancy.

From a functional and economical point of view, the building industry in general uses a standard grid for the dimensions of the load-bearing construction. This grid is partly the result of optimal values from a constructive point of view for the chosen material (in this case, mostly concrete) and partly the result of functionality on the construction site (de Gunst & de Jong, 1989). In non-Anglo-Saxon countries this grid is based on a 0.3 meter unit, from which the grid is subsequently a multiple of this unit. This is coherent with the 1.8 meter (6 x 0.3) basis of the office grid.

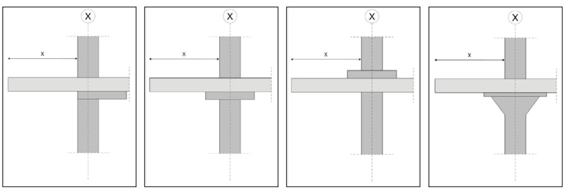
Other MSc-graduates from the Technical University of Delft (W. Kok & P. van Luijn, 2012) have made an overview of which construction types can be identified in office construction between 1950-1990. Combined with information from Jellema 3 (2004) this gives a good idea what different construction methods have been applied in office construction. See the overview on the following pages.

+ concrete flat slabs — pages 48-49
+ cassette slabs — pages 50-51
+ ribbed slabs — pages 52-53
+ precast concrete panel floor slab — pages 54-57
+ hollow core slab & double t-slab — pages 58-59





+ typical floor cross section



+ floor to column connections

figure 2.3.4 Concrete flat slab, from: W. Kok & P. van Luijn, 2012 & Jellema 3, 2004.

Concrete flat slabs

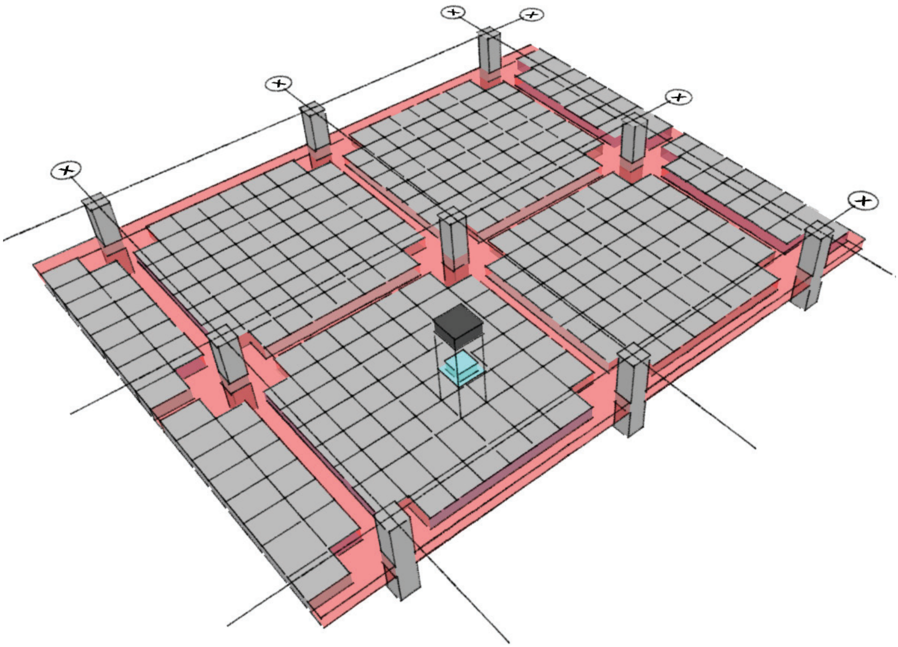
Flat slabs are reinforced in-situ concrete slabs which are point-supported. Linear supporting by beams or walls occurs only occasionally and only at the edges.

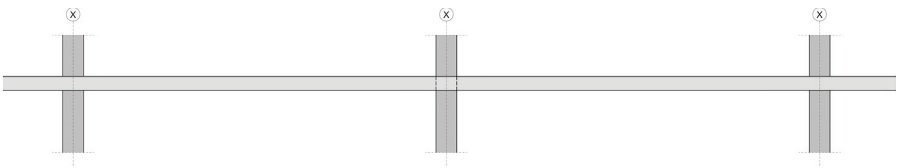
_Connections

The rigid (bending stiff) connection between columns and floor are reinforced to cope with large moment and shear forces. This reinforcement can have several forms, but generally it is called a mushroom floor because of the thickened column plate, heading or both (sometimes even literally shaped organically in the shape of a mushroom). Mushroom floors have a regular grid size (column distance), that is not too different from a square grid, for optimal work of forces. When no column plate or heading is applied, the floor slab needs to be considerably thicker to make a rigid connection with the column. In some cases the so-called Geilinger column header is used and when raised floors (for installations) are used, the column plate is placed on top of the floor (Jellema 3, 2004). Over time, these floor slabs are subject to deformation: the floor slabs will start 'hanging' between the columns. With these type of floors it is therefore not possible to place stone walls (masonry, concrete, sand-lime bricks) on top (Remøy, 2007), because there is the risk of cracks.

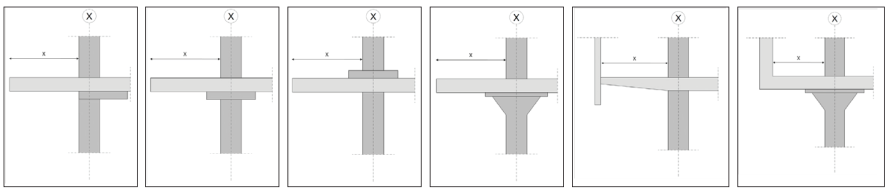
_Adjustments

If adjustments are needed to the floors, options are limited. The floor slabs span to both sides and are sometimes pre-strained. Conceiled underneath the gridlines are heavily reinforced (hidden) beams which cannot be perforated. When adding load to the floor structure, it is important to know if the rigid connections between columns and floor are strong enough. When the contact area is too small, it is possible that the column is punched through the floor slabs. Cracks and deformation around the column base can also be the result of adding load. The floor edges are often cantilevering outside the structure. The dimension of the cantilever is at least as large as the diameter of the column and a maximum 1/4 to 1/3 of the floor span (Kok & van Luijn, 2012).





+ typical floor cross section



+ floor to column connections

figure 2.3.5 Cassette slabs, from: W. Kok & P. van Luijn, 2012 & Jellema 3, 2004.

Cassette slabs

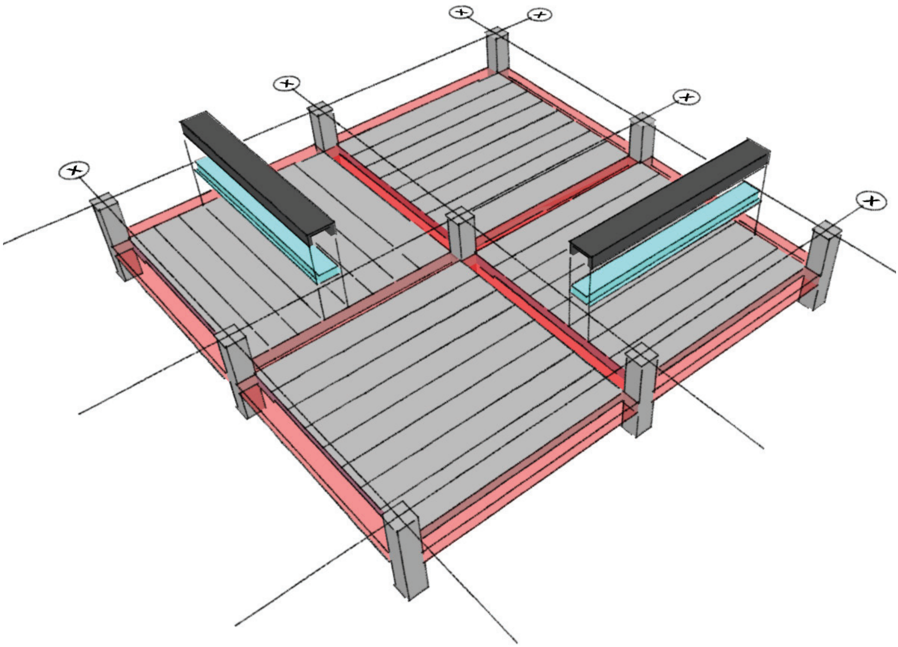
The ribs in cassette floors are usually spanning in two directions according to an orthogonal grid pattern. The ribs can be considered as hidden beams, placed along a square grid for an optimized load-bearing scheme. The cassette slabs require less material, but can make larger spans possible.

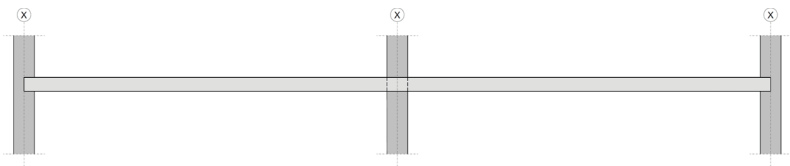
_Connections

Around the columns the cassettes are left out and reinforced, to cope with negative bending moments and shear forces. At the floor edges (along the façade) large moments, shear forces and deformations will occur, this is why ribs on the edge are thicker.

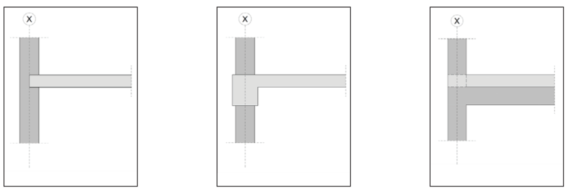
_Adjustments

The ribs are perfectly suited for inner wall connections in two directions and soundproof connections are easily made: the cassettes can be filled with sound-absorbing material (Kok & van Luijn, 2012). Floors with inner openings can be considered as a concrete flat slab. They carry the load not in two directions but only in one direction, parallel to the openings.





+ typical floor cross section



+ floor to column connections

figure 2.3.6 Ribbed slabs, from: W. Kok & P. van Luijn, 2012 & Jellema 3, 2004.

Ribbed slabs

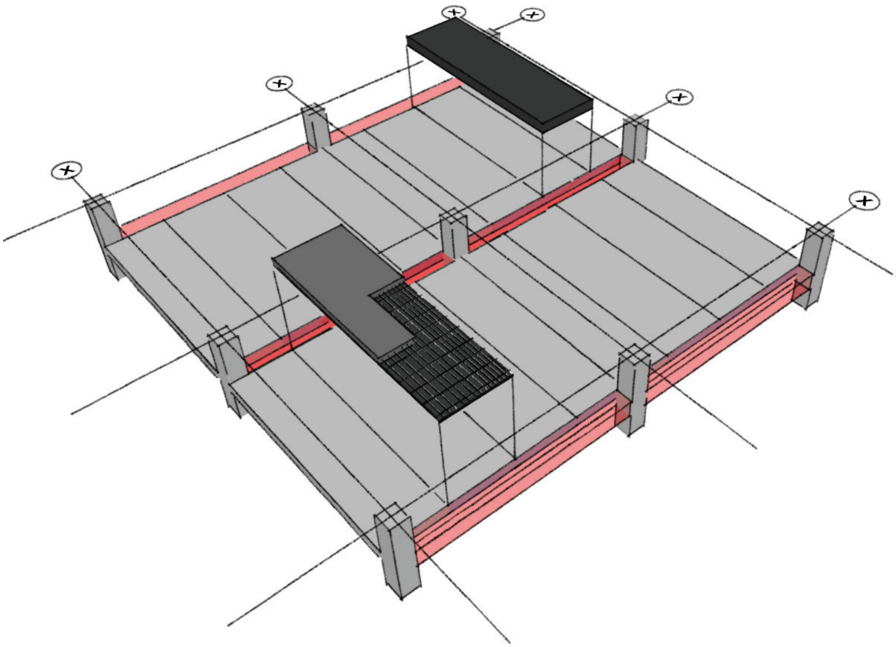
Ribbed slabs only span in one direction. The floors are made with standard molds, which are made of different materials (board, steel, plastic). They were often applied in office construction in the United States and Germany and also in the Netherlands, but not that often.

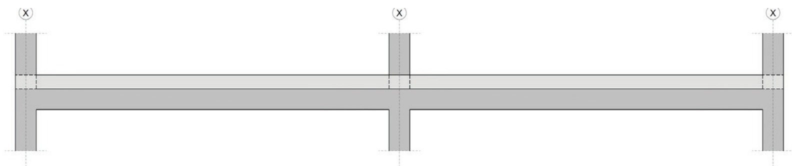
_Connections

The ribbed slabs are mostly applied in linear structures. The ribs have a center distance of 0.9 or 1.2 meters and are resting on hidden beams which have the same height as the ribs (Kok & van Luijn, 2012). No reinforced column head is needed.

_Adjustments

Openings can be made between the ribs, as long as they are parallel to the other ribs and from beam to beam. To create larger openings an extra load-bearing structure is needed.





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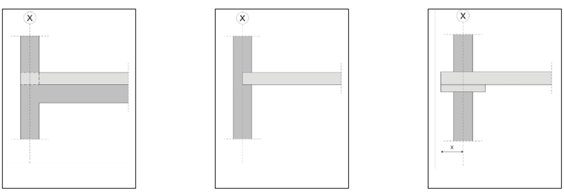


+ floor to column connections

figure 2.3.7 Precast concrete panel floor slabs, from: W. Kok & P. van Luijn, 2012 & Jellema 3, 2004.

Precast concrete panel floor slab (longitudinal direction)

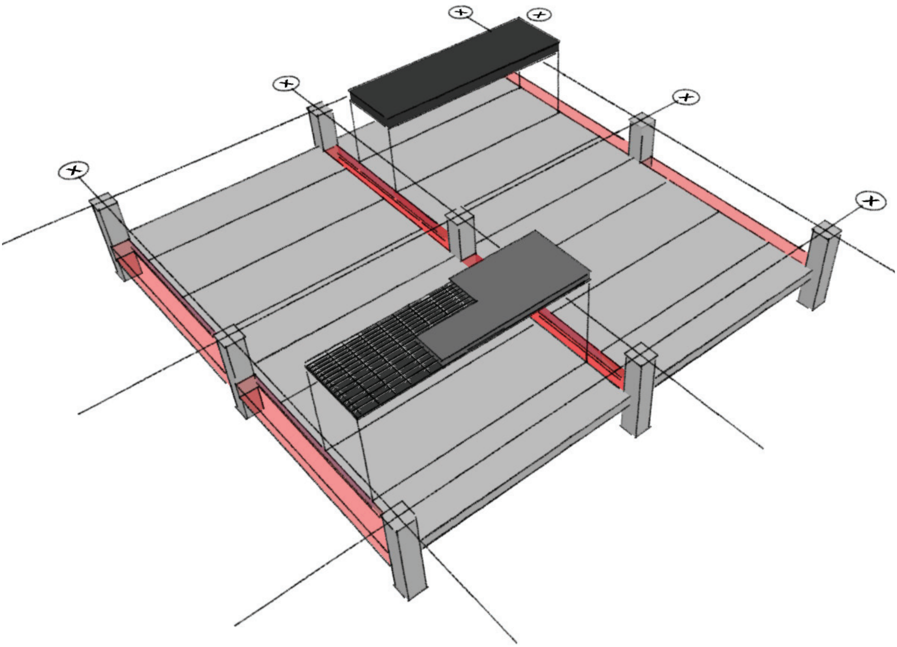
The slabs are partially prefabricated, to avoid formwork on the construction site: a prefabricated thin shell of 50/80 mm concrete with reinforcement or pre stressed steel is used, finished with structural concrete poured in-situ. These floor slabs are rigid, but are relatively thin. In terms of structural behavior, the filigree slabs can be compared to entirely in-situ concrete slabs.

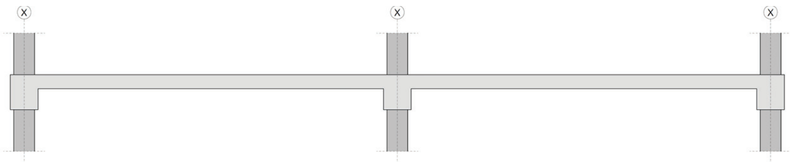
_Connections

Precast concrete panel floor slabs are often placed on widened strip zones on the columns. These are flat beams, which are created by floor slabs with a small thickness and can vary in height. The load transfer is basically linear (Kok & van Luijn, 2012). The pre-stressed slabs for the heavy strip zone are laid towards the strip. These strips can have a width of 1200 mm. In the other direction the normal precast concrete panels are placed above the strips and after placing, the whole floor can be poured in-situ. There are two edge combinations possible at the floor edges along façade: the heavy strip zone with overhang and the edge beam placed on columns.

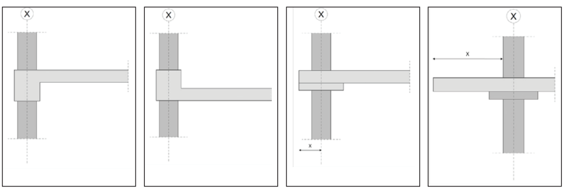
_Adjustments

Because the concrete panels are prefabricated and are relatively light, sizes of the concrete panels are only limited by transport. Sizes up to 3 by 9 meters are possible and floor openings are already included (and extra reinforcement is added around the floor opening) (Jellema 3, 2004). Also cantilevering is possible when the reinforcement is carefully calculated and placed. These carefully placed reinforcements also make adjustments for floor openings difficult.





+ typical floor cross section



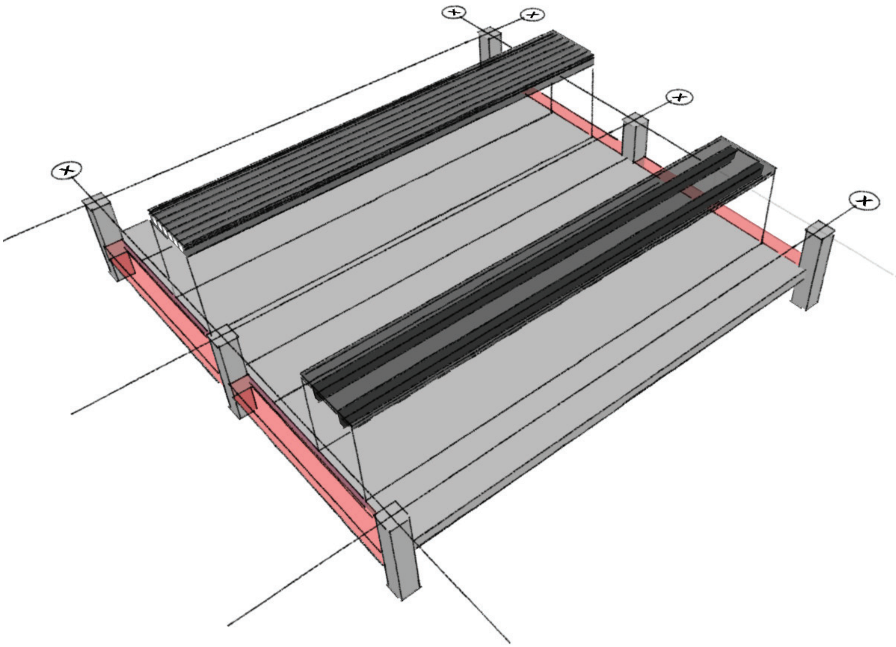
+ floor to column connections

figure 2.3.8 Precast concrete panel floor slabs, from: W. Kok & P. van Luijn, 2012 & Jellema 3, 2004.

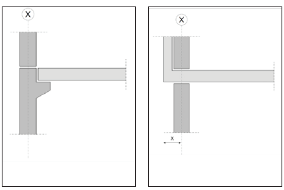
Precast concrete panel floor slab + tubes (cross directional)

To make precast concrete panel floor slabs even lighter, tubes were placed before structural concrete was poured over it. The tubes created internal openings in the concrete slab and with these openings, it was possible to reduce the total weight of the floor. In large spans this reduction was the most effective. There are several variations of which material was applied and how. Polystyrene blocks in different shapes, impregnated cardboard tubes or ribbed steel sheets, as long as it was light and working together with the in-situ concrete. With concrete blocks, the tubes are placed in their positions and attached to anchors. This avoids floating of the tubes during the pouring of the concrete. With this principle it is possible to make edge beams and the floor at once to let it function as one rigid disk.

The floors mostly spanned from grid line to grid line. Later, these distances became larger because the tube floors were prefabricated and pre-stressed. This development stood at the basis of floors that are now known as hollow core slabs (see next page).



+ typical floor cross section



+ floor to column connections

figure 2.3.9 Hollow core & double T-slab, from: W. Kok & P. van Luijn, 2012 & Jellema 3, 2004.

Hollow core slabs

From the year 1990 on, hollow core slabs were often used in office construction. Floor spans were now possible from façade to façade without columns placed in between. Span distances are usually between 12 and 14 meters. Because hollow core slabs are pre-stressed and consisting of high-quality concrete, the thickness of slabs is minimized. The hollow core made a weight reduction, in comparison to in-situ concrete, possible of 50 %. The hollow core slab became a standardized product with a nominal width of 1200 mm.

_Connections

Hollow core slabs are connected together by welding, or connected by reinforcement and a constructive layer of concrete on top, to create a rigid disk.

_Adjustments

Hollow core slabs are only provided with pre-stressed reinforcement, there is no steel reinforcement in the concrete present. Therefore, when making openings in the floor, caution is needed. For large openings, the floor should have a secondary structure made of steel beams (or the entire slab has to be taken out). The slabs cannot be cantilevered without using a reinforced and constructive layer on top (Jellema 3, 2004).

Double T-slab

The double-T slab can reach very large spans, standard plates are delivered to over 20 meters. In recent years, the TT-floor is often exchanged for hollow core slabs to minimize the floor thickness. The openings at the bottom between the ribs are often an objection for connecting inner walls. Physical barriers have to be made between the openings to prevent transfer of sound and fire. TT-plates have a nominal width of 1.80 or 2.40 meters, with the ribs on a center to center distance of 0.90 or 1.20 meters. The flange or shell thickness is made very thin, about 50 mm. If the plates are provided with a constructive layer than the shell thickness is about 80 mm. This is only needed when the plates have a constructive function and play an important role in the constructive stiffness of the building.

For exact numbers, there is not enough information available of which type of floor construction is the most common in office construction in The Netherlands.

Constructive loads

Constructive loads on office buildings in specific and buildings in general can be divided into three groups: *permanent*, *variable* and *special* loads . The permanent load is the weight of the building and all its components. Variable loads are not-permanent loads such as persons, furniture and goods, but also external forces such as wind, temperature, rain and snow. Special loads are caused by accidental external forces, such as fire, collision or changes in the ground it stands on.

Permanent loads are different for every office building, depending on which construction, façade and building material is applied. The variable loads are more general: building regulations require all buildings to be calculated according to specific loads depending on the use of the building. These regulations have somewhat changed over the years, but loads used to be estimated higher, making constructions of older buildings often overdimensioned. With conversion in mind, it is therefore interesting to know what variable loads were used to dimension office buildings. In TGB 1972 (or NEN 3850), the regulations that were in place from 1972 until 1992 (when TGB 1990 or NEN 6702 was introduced), the following variable loads (distributed and concentrated) were used:

distributed loads	TGB 1972 / NEN 3850	TGB 1990 / NEN 6702
- floors	2.0 kN/m2	2.5 - 3.5 kN/m2
- stairs, balconies, galleries, etc.	2.5 kN/m2	3.0 kN/m2
concentrated loads		
- hallways	3.0 kN/m2 (0.5 x 0.5 m2)	
- balconies	5.0 kN/m2	
- galleries	5.0 kN/m2	

If a flexible interior for the office building was desirable (especially in the office tenancy market), distributed loads of 5.0 kN/m2 were used as guideline. Large archives required distributed loads up to 10 kN/m2 (de Gunst & de Jong, 1989).

2.3.3 façade

At the Technical University of Delft extensive research has been conducted into the Dutch office façade by T. Ebbert, in his dissertation '*Re-Face: refurbishment strategies for the technical improvement of office façades*' from February 2010. For his dissertation he analyzed 115 office buildings with a total of just over of 500.000 m2 of façade surface (or 1.000.000 m2 GFA). In his dissertation, he acknowledges five main façade construction principles used in Dutch office construction, based on where the thermal separation is placed in relation to the load-bearing structure: inside, along inside, in line with, along outside and outside. From here Ebbert breaks it down in form (planar, skeleton, parapet + window, unitized or stick system) and then how the façade is layered.

What can be concluded from his analysis is that in The Netherlands many construction types have been applied in office construction. Although not all types became very common, the office building shows a great variety of façade structures. The most common façade is the skeleton structure in line with the load-bearing structure (type 3.2 - see next page), good for 20 % of all façade systems (predominately constructed in the 1950's and 1960's - after-war period). The second most common construction is the prefabricated suspended parapet combined with windows, good for 16 % of the total stock. Together with other (unitized and stick-) curtain-wall systems, they are together good for a total of 44 % of the total market, by far the most common. For more information see figure 2.3.10 on the next page.

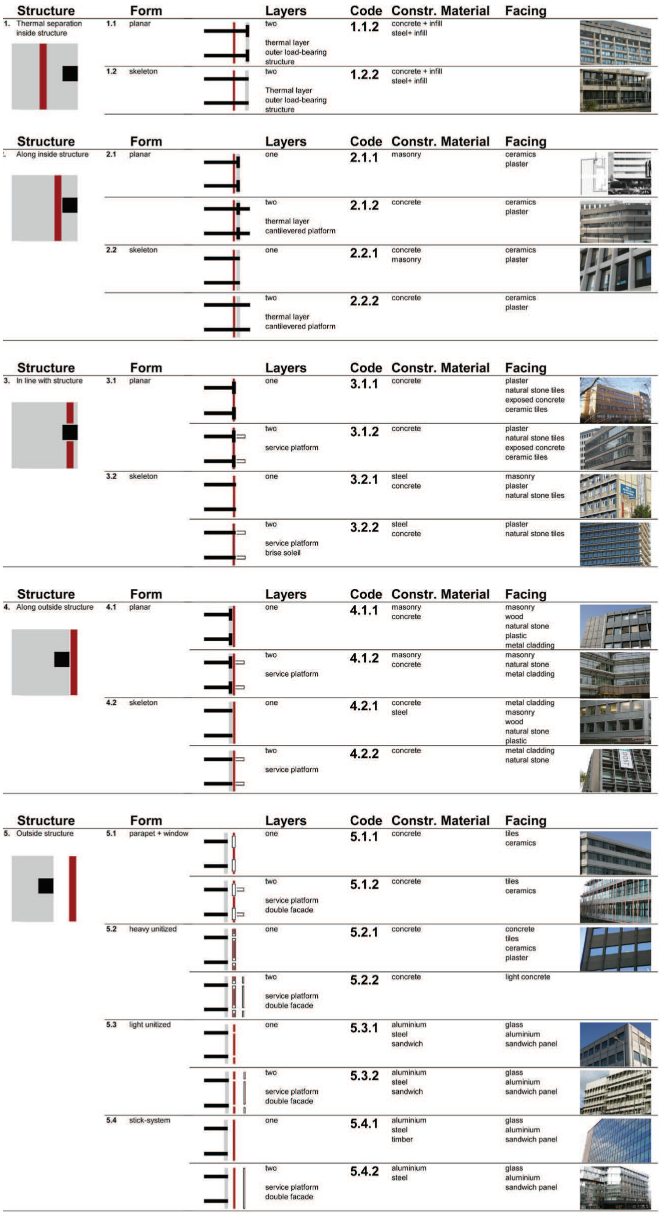
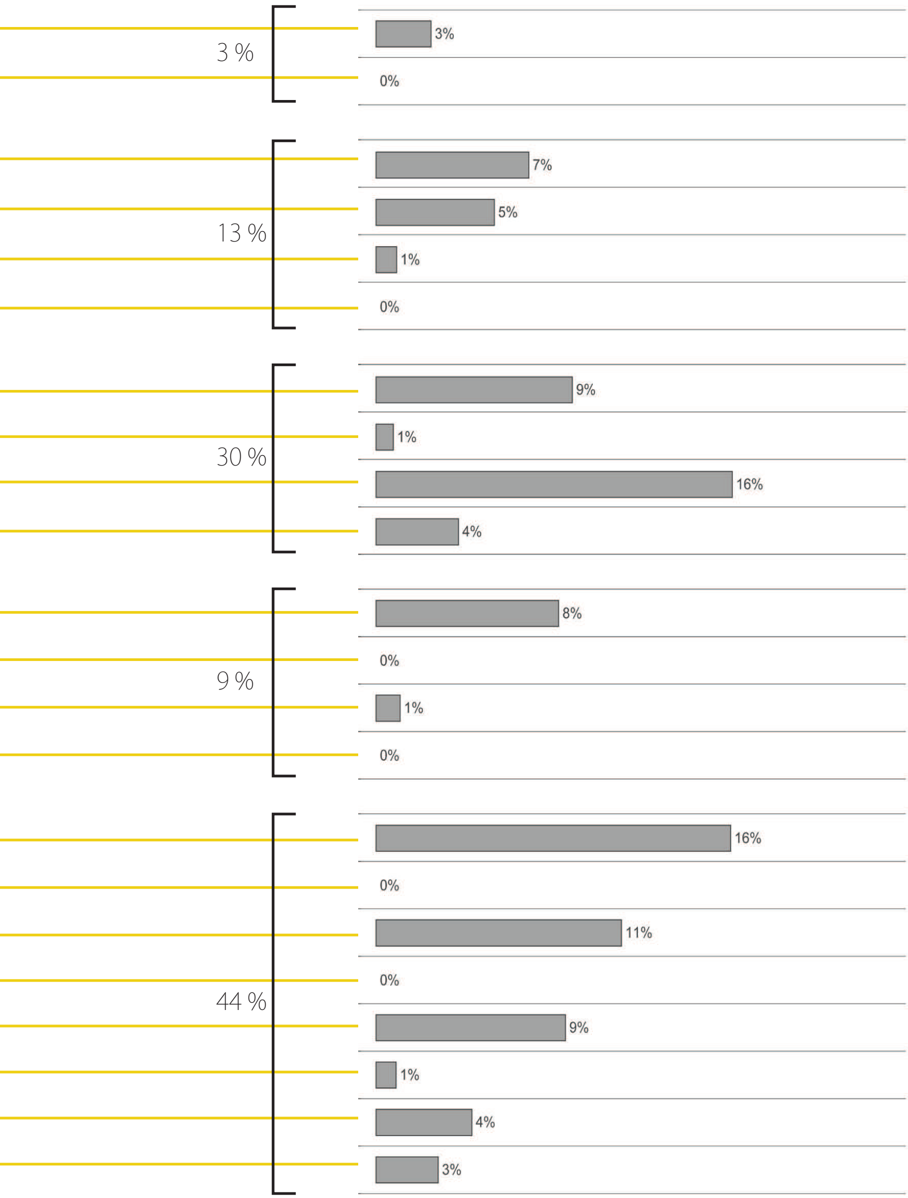


figure 2.3.10 Façade construction principles and ratio, adapted from: T. Ebbert (2010).


3 %
3%
0%
13 %
7%
5%
1%
0%
30 %
9%
1%
16%
4%
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16%
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1%
4%
3%

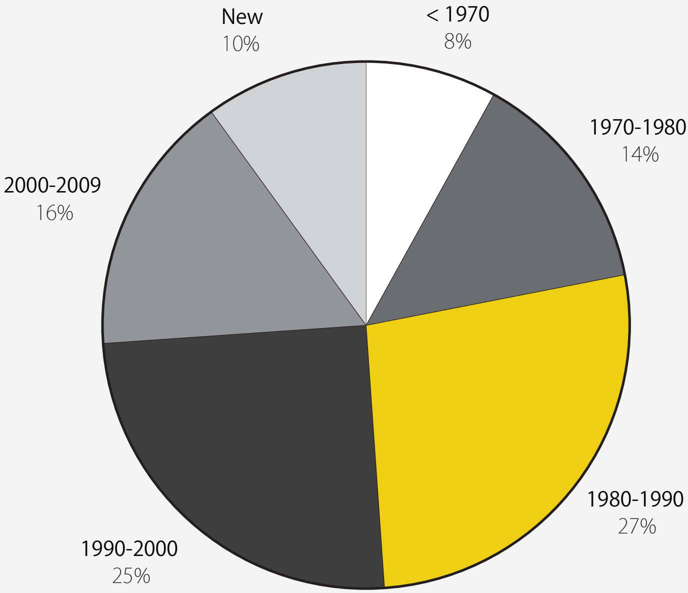


figure 1.2.1 office vacancy in construction years | from: *rapportage kantorenleegstand*, EIB (2010)

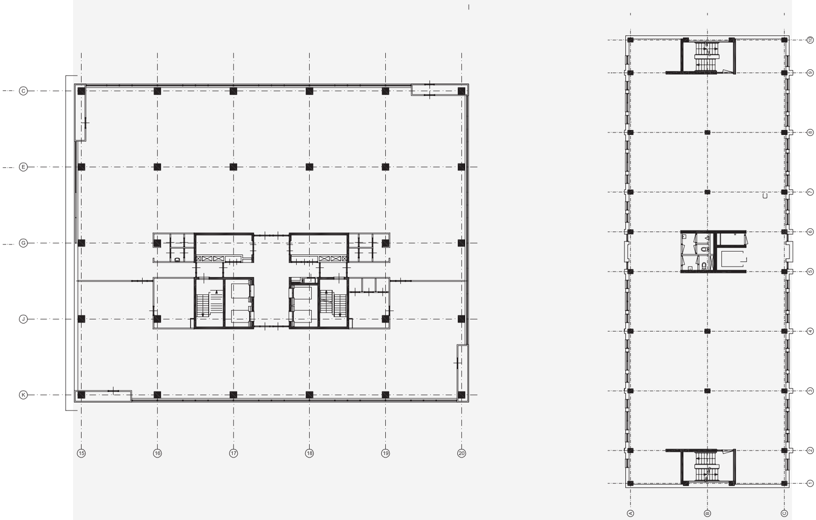


figure 1.2.2 standard office building plans | h. remøy (2007)

2.4 vacant office building characteristics

In the previous chapters the characteristics of office buildings in general have been analyzed, but what does this say about the office buildings that are vacant today? As is shown, the Dutch office building is built with a great variety of construction types and façade structures. How does this relate to the office building that is vacant? In other words, can the vacant stock be typologically described?

Construction year

Looking at the characteristics of the current office vacancy in the Netherlands, two-third of the total vacant office stock has been built between 1970 and 2000 (see figure 1.2.1). Statistics show us that this share is still increasing, while the share of vacant office buildings built after 2000 (including new buildings) is decreasing. This is coherent with the tendency for tenants on the office market to look for better qualitative, cheaper and thus newer buildings (Remøy, 2007). Although exact numbers are not available, the structural vacancy rate is therefore higher in outdated office buildings built before 1990. This high rate also indicates the difficulty these buildings will ever find a new user or purpose. With conversion in mind, these are the most interesting to analyze.

Shape

If we look further into the appearance of vacant office buildings from before 1990 (excluding some historical examples built before 1970) most buildings are designed according to a standard typology of a simple rectangular shape. This standard typology can be subdivided into two main groups. The first one is the high-rise building, consisting of several floors supported by columns, stabilized by a concrete core in the middle which contains the vertical infrastructure of the building. The second is the more low-rise office building, stretched, containing several stabilizing walls (Remøy, 2007). Also here, the vertical infrastructure is placed in the center of the building in a stabilizing concrete core.

Other building characteristics will follow from findings from the database research.

egorie	Straatnaam	Huisnummer		Aanpasbaar volgens concept	Reden	Gevelstramien		Extra	Gebouwna
1	Amstelplein	6	8	ja		5.4			Mondriaan
6	Anthony Fokkerweg	1	1	ja		5.4	7.2	stramien verschilt	Westhagh
9	Arent Janszoon Ernststraat	199	199	ja		5.4	7.2		
19	Burgemeester Stramanweg	102	103	ja		5.4	7.7	idem	Londen
18	Burgemeester Stramanweg	104	106	ja		5.4	7.7	idem	Parijs
20	Contactweg	60	66	ja		5.4	7.2		
41	[illegible]	199	215	ja		5.4		complex	Ganzenpo
46	Gelderlandplein	75	75	ja		5.4	7.2		De Veldert
53	H.J.E. Wenckebachweg	90	100	ja		5.4	7.2		Mediamax
50	H.J.E. Wenckebachweg	200	200	ja		5.4		complex	Pecoma
61	Hessenbergweg	109	119	ja		5.4	7.2		
77	Hogehilweg	15	15	ja		5.4			California
79	Hogehilweg	19	19	ja		5.4			Texas Buil
111	Karspeldreef	14	14	ja		5.4			Corner Off
124	Laan Nieuwer Amstel	3	3	ja		5.4			
148	Overschiestraat	63	63	ja		5.4	7.2	idem	Kwadraat
147	Overschiestraat	65	65	ja		5.4	7.2	idem	Kwadraat
160	Paasheuvelweg	8	8	ja		5.4			
172	Postjesweg	175	175	ja	bedrijfshal + kantoor	5.4			Postjeswe
178	Rembrandtplein	33	43	ja		5.4		complex	Gouden H
197	T.H.K. van Lohuizenlaan	196	198	ja		5.4	7.2		
211	Wibautstraat	135	139	ja		5.4		gesloten achtergevel	Delphi
48	Grote Bickerstraat	74	74	ja		5.5		extra	
99	Joan Muyskenweg	40	48	ja		5.5	4.58		Ankesteyn
55	Haaksbergweg	3	73	ja		6.0		ovaal	Dreef Tore
65	Hettenheuvelweg	4	6	ja		6.0	7.2		
64	Hettenheuvelweg	16	16	ja		6.0	7.2		Mercurius
67	Hettenheuvelweg	41	43	ja	showroom	6.0			Deltac
63	Hettenheuvelweg	45	47	ja	showroom	6.0			Läser/Brid
78	Hogehilweg	4	4	ja		6.0			
70	Hogehilweg	8	8	ja		6.0			Keynes
72	Hogehilweg	10	10	ja		6.0			Smith Buil
81	Hogehilweg	12	12	ja		6.0			Castor
80	Hogehilweg	14	14	ja		6.0			Pollux
73	Hogehilweg	16	16	ja		6.0			
76	Hogehilweg	17	17	ja		6.0			Florida
75	Hogehilweg	18	18	ja		6.0			Prismatriu
122	Kuiperbergweg	50	50	ja		6.0			
150	Overschiestraat	184	184	ja		6.0			Autumn
169	Pilotenstraat	6	6	ja		6.0			De Piloot
40	Egelenburg	150	150	ja		6.04		extra	
226	Zwaansvliet	20	20	ja		6.5	6.33		Noordholl
163	Paasheuvelweg	5	5	ja		6.55	4.75	idem	
162	Paasheuvelweg	14	14	ja		6.55	4.75	idem	
5	Anthony Fokkerweg	61	61	ja		6.6			
129	Maassluisstraat	2	2	ja		6.7	7.5		
207	Weesperplein	8	8	ja		6.9			Weespers
115	Klaprozenweg	75	75	ja		7.0			NDSM
201	Van Boshuizenstraat	12	12	ja		7.0			
212	Wibautstraat	133	133	ja		7.0			
24	De Boelelaan	32	32	ja		7.1			
3	Anderlechtlaan	175	175	ja		7.2		ideaal	Sloterzoor
7	Apollolaan	150	150	ja		7.2		custom	
17	Burgemeester Stramanweg	101	101	ja		7.2		ideaal	Tridion
34	De Klencke	4	6	ja		7.2			Officia II
35	De Ruijterkade	6	6	ja		7.2	5.4		Hooge Hu
45	Gatwickstraat	1	1	ja		7.2			Gatwick
47	Gondel	1	1	ja		7.2		extra	
60	Herikerbergweg	2	36	ja		7.2	14.4	recent	Minerva
83	Hoogoorddreef	5	5	ja		7.2		idem	Atlas - Azi
82	Hoogoorddreef	9	9	ja		7.2		idem	Atlas - Afri
84	Hoogoorddreef	54	58	ja		7.2			Europlaza
100	Joop Geesinkweg	125	125	ja	bedrijfshal + kantoor	7.2		extra	
102	Joop Geesinkweg	201	224	ja		7.2			A'dammiu
103	Joop Geesinkweg	701	799	ja		7.2	5.4	idem	Koningsgra
104	Joop Geesinkweg	801	899	ja		7.2	5.4	idem	Koningsgra
106	Jozef Israelskade	46	48	ja		7.2	5.4		Office Cen
108	Kabelweg	21	21	ja		7.2	5.4		Einstein
123	La Guardiaweg	116	162	ja		7.2			La Guardia
126	Laarderhoogtweg	7	19	ja		7.2	5.4		Sinus
137	Naritaweg	12	12	ja		7.2	3.6		High Tech
145	Ottho Heldringstraat	5	5	ja		7.2			
146	Overschiestraat	59	59	ja		7.2			De Coener
158	Paasheuvelweg	33	33	ja		7.2			Royal Tele
165	Piet Heinkade	55	55	ja		7.2			IJ-toren
171	Poeldijkstraat	4	4	ja		7.2			Heemsted
191	Startbaan	8a	8a	ja		7.2			
193	Strawinskylaan	1	1755	ja		7.2	5.4		WTC toren
196	Teleportboulevard	110	110	ja		7.2		brede gevelelementen	Tauro Busi
224	Zekeringstraat	38	40	ja		7.2		idem	Parthénon
225	Zekeringstraat	42	42	ja		7.2		idem	Alpha Busi
220	Zekeringstraat	44	44	ja		7.2		idem	Alpha Busi
221	Zekeringstraat	46	46	ja		7.2		idem	Alpha Busi
222	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]	Alpha Busi
223	Zekeringstraat	50	50	ja		7.2		idem	Alpha Busi
117	Wilhelminaplein	11	11	ja		7.5		extra	Amsterdar
141	Noordhollandstraat	71	71	ja		7.5			Noordholl
195	Stroombaan	4	4	ja		7.5	7.1		
204	Vijzelgracht	50	50	ja		7.5		complex	Noortse B
210	Wibautstraat	224	224	ja		10.5			Renaultge
132	Nachtwachtlaan	20	20	ja		10.8	8.9		Ringpark

figure 2.4.1 Office vacancy database, F.P. Koornneef (2011).

2.4.1 database research

Just like in chapter 2.3, the main characteristics are analyzed from the database, the same as earlier mentioned (*standard dimensions*, *construction* and *façade*). With information from 200 vacant office buildings (dating from 2008), it should be possible to get a good idea about the building characteristics of the total vacant office stock in the Netherlands.

Although it is arguable if vacant office buildings in Amsterdam are a good representation for the total vacant office stock, the total floor area of all vacant office buildings in the database together is 1.780.000 m2 and therefore represents 3.7 % of the total office space of 48.195.000 m2 in the Netherlands (DTZ, 2012). On the next page an overview of the most important findings can be found.

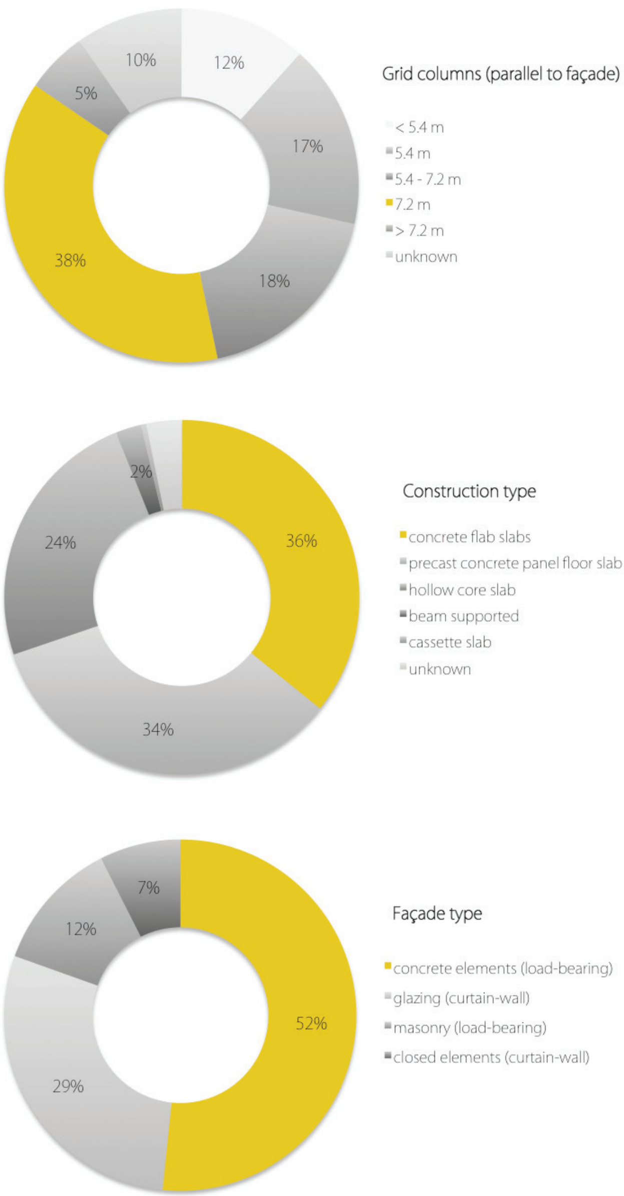


figure 2.4.2 Statistics office vacancy database (grid, construction, façade), F.P. Koornneef (2011).

Standard dimensions

In the database the dimensions between columns have been described in two ways: parallel to the façade and perpendicular to the façade. For this research, the dimension parallel to the façade is the most interesting, because it is the most determining for the façade. Moreover, the dimension perpendicular to the façade is in most buildings the same as the dimension parallel, so together they form a square grid for optimal work of forces.

From the analysis it is noticeable that 7.2 meter as a grid for the columns is most common, in 38 % of all buildings (*see figure 2.4.2*). In 17 % of the cases this is 5.4 meter, the other grid sizes are scattered: grids less than 5.4 (12 %), between 5.4 and 7.2 (18 %) and larger than 7.2 (5 %), the rest is unknown.

Construction

In almost all office building the construction consists of columns supporting floors (through beams or hidden beams). Two floor construction types stand out: the concrete flat slab (in-situ) and the precast concrete panel floor slab (covered with in-situ poured concrete). Both are good for 70 % of all applied construction floors (*see figure 2.4.2*). Information on what loads are used for calculation are not available.

Façade

Although the database does not provide in information as extensive as the studies from Ebbert (2010) - see chapter 2.3.3 - it gives a good idea what type of façades are used in general. By far the most applied type of façade is the façade consisting of (load-bearing) concrete elements (52 %). If we compare this with the results of Ebbert (see figure 2.3.10) the load-bearing elements (both concrete and masonry) most probably fall under codes 1.0 - 4.0 (and are not all load-bearing as found in the database). Futhermore, 36 % of the façades are curtain-wall, either glazing (29 %) or closed elements (7 %) - consistent with code 5.0 façades from Ebbert.

In overview

From the database it is hard to conclude that one specific combination of characteristics is the most common. Office buildings with grid sizes of 7.2 meter for example cannot be directly associated with a specific type of construction or façade.

3 | conversion potential

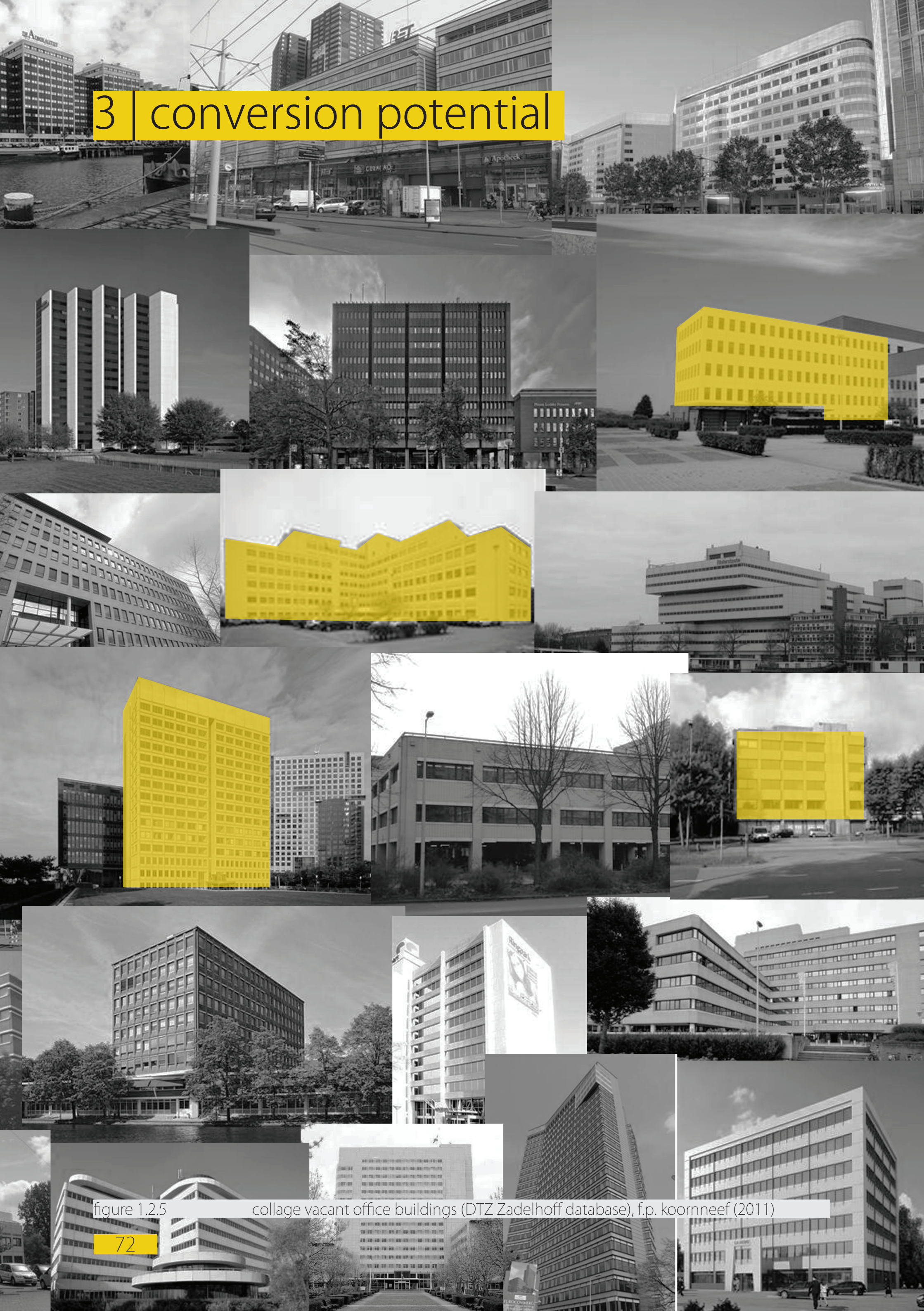


figure 1.2.5 collage vacant office buildings (DTZ Zadelhoff database), f.p. koornneef (2011)

3.1 conversion as solution

Conversion over demolishment

The consequences of office vacancy are clear: a private problem of the owner is becoming a problem in the public realm, affecting the urban quality. Furthermore, it is a waste of usable space and without the (inevitable) depreciation of the value of the current office stock the financial problems will only become worse.

The situation on the office market and the suggested measures that can be taken to deal with structural office vacancy (further commercial exploitation, renovation, conversion or demolishment) (NVM Business, 2010) only leave out two most probable options for the buildings that will never find a new tenant (70% of the current vacancy, according to EIB (2011): conversion or demolishment. Demolishment is depreciating the office buiding to its land price, while the office building that is being demolished is still a well-functioning structure - a waste of usable space. That leaves conversion as the most desirable measure to cope with structural vacancy, but conversion projects are scarcely carried out - why is this?

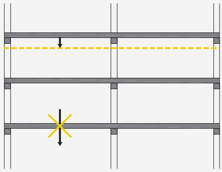
Mapping difficulties and opportunities

To get a better grip on this issue, this chapter will therefore focus on mapping the most general difficulties in conversion projects, but also opportunities for future conversion projects. The chapters will be subdivided in three main topics: building characteristics, conversion costs and legislation concerning conversion. Research from the department of Real Estate & Housing of the Technical University of Delft, but also other research institutes of the Dutch building industry (where already significant research has been done into conversion of vacant office buildings) will be consulted. As said, for this research the location specifications are not taken into account.

office façades

> façade physically outdated
> unattractive for converted function
> closed curtain-wall system

construction as obstruction



> load-bearing beams: lower ceilings
> steel reinforcement restricts floor openings
> not sufficient sound insulation

conversion costs

> not sufficient knowledge
> high risks / unexpected costs

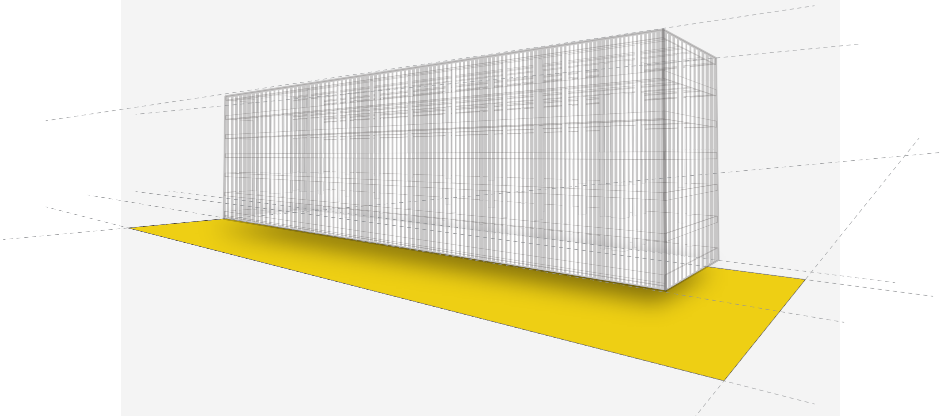


figure 3.2.1 conversion difficulties | f.p. koornneef (2011)

3.2 difficulties

Before looking into the difficulties faced in conversion of office buildings, there are a few things that make conversion of buildings in general difficult and are therefore important to mention.

Conversion is different from new-built and requires a different approach: the organization of the building process is complicated, because of the many parties involved and Dutch building regulations requiring a higher standard than the existing situation. This adds up to the fact that conversion in technically complex and existing building conditions make a project harder to estimate, with many unforseen complications. Other complications that specifically apply to conversion of office buildings are described below.

3.2.1 building characteristics

The most common difficulties when converting office space to dwellings are according to the SBR (Knowledge Platform Dutch building industry) in their publication '*Transformatiewijzer: van kantoor naar woonruimte*' (2009) the following:

+ (Insufficient parking)
+ Planological co-operation
+ Sound insulation façade
+ Inefficient office plans
+ Façade (opening windows and ability to ventilate)
+ Exterior space (balconies, loggias)
+ Fire-safety demands
+ Sound insulation between dwellings

Insufficient parking is placed between parentheses, because this is not within the scope of this research. Insufficient parking is a difficulty that needs to be solved on (or outside) the location of the office building. Planological co-operation on the other hand, will be discussed in chapter 3.2.3. The other difficulties SBR defines, can basically be brought down in two categories: the façade and inner walls.

Façade

Why the façade is in most cases a difficulty for conversion, can be easily explained looking at the building physics: façades of office buildings do not meet the requirements for other functions, such as housing. Because most office buildings are equipped with HVAC-systems, the façades are not designed to ventilate naturally, which is required in housing. Same goes for an office function: new office tenants most likely wants to move into an energy-efficient building with modern amenities, but the façade does not meet current energy-efficiency demands. Regulations concerning daylighting require a glass surface of 5% of the total occupied floor space for office buildings, but this is less than the demand for (for example) housing, which is 10%. (Remøy, 2007) - so adjustments need to be made (1 - *see figure 3.2.2*). To add exterior spaces to the different floors, the façade either requires a setback (2) or an auxiliary construction for a canterlevering balcony (3), but in both cases new façade elements are needed to make the add exterior space accessible. This adds up to the fact that in most cases the existing office façade is unattractive for its converted function.

When an office building is up for conversion, the façade will therefore most likely need replacement or strong adjustments to stretch its lifetime. Hidden defects encountered during construction, such as asbestos or deviating construction drawings, make conversion also hard.

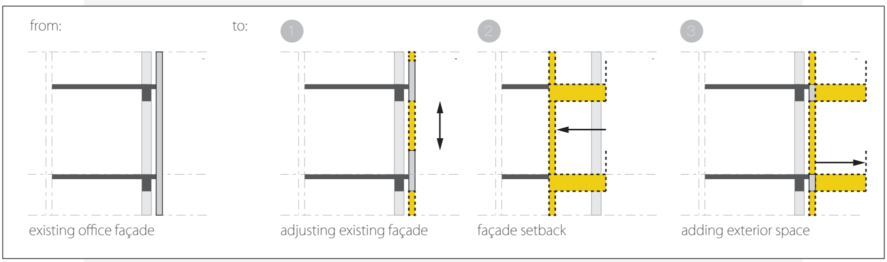


figure 3.2.2 adjusting the existing office façade | f.p. koornneef (2012)

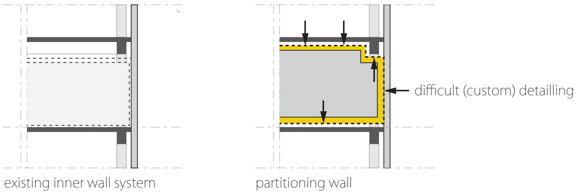


figure 3.2.3 adding inner (partitioning) walls | f.p. koornneef (2012)

Inner walls

As became clear in chapter 2.3 is that there is a great variety of façades and construction types. This has its influence on the possibilities for a new lay-out. Most offices are designed with an open floor plan with a lowered systemized ceiling and a flexible wall system placed between the floor and the lowered ceiling. If sound insulating and fire-retardant partition walls need to be placed the construction and façade can cause difficulties in detailling, as is made clear in figure 3.2.3. With cassette or ribbed floor slabs, the connection between wall and ceiling will be even more problematic. In most cases, the concrete non-rigid floors in the construction are not suited for erecting brick or limestone walls (Remøy, 2007).

Construction

What the SBR (2009) does not mention in their publication is the construction as a difficulty in conversion, especially into housing. The former office floors are not sufficiently insulated for housing and the steel reinforcement in the floor construction restricts openings in the floor (see also chapter 2.3.2). These floor openings are essential; for housing each appartment needs its own vertical service shaft for drainage and other installations.

Furthermore, the building structure mostly consists of columns that support several load-bearing beams, which on their term support the floors. When adding installations to the building, the horizontal ducts will have to be placed underneath the load-bearing beams. Because the load-bearing beams already restrict the clearance between floor and ceiling, the ducts underneath will require the ceilings to be placed even lower. The minimum ceiling height of 2.6 meter required in new-built housing (Bouwbesluit 2003) can therefore not always be realized.

3.2.2 conversion costs

First of all, the book amount of vacant office buildings is often appreciated too high (*see chapter 1.1.3 - investors*) and this makes the acquisition costs, before conversion can even start, high. Even if the value of the vacant office building is depreciated, the converted function generates lower revenues in comparison to its former office function (although this is becoming less of an issue, since investors realize their office buildings will not find a new tenant).

Conversion costs and (financial) risks have been mapped extensively to get a better grip on conversion. From research into the building costs of several conversion projects, it turned out that the difficulties found in the different building characteristics of the office building (namely the façade and inner walls) are also responsible for the highest building costs (Mackay, 2007).

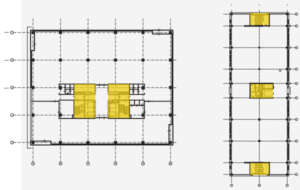
The façade, as mentioned on the previous page, often needs replacement or large adjustments, but is also the most expensive part of a building. Inner walls are high cost generators because of the unit-dividing properties that Dutch building regulations require. Because floor heights of office buildings are often higher between the load-bearing beams than that of a normal apartment, you often need up to 20% more material to reach the ceiling. Joining an inner wall to the floor, ceiling or existing curtain-wall façade is problematic: the walls need to insulate sound and require a certain fire retardancy. Working with the existing curtain-wall façade system, this requires difficult (and thus expensive) construction details.

In his research, Mackay (2007) concludes from his case studies (of solely office conversion projects) that in most cases the final costs are higher than originally estimated, simply because there is not enough knowledge available to precisely estimate the costs of conversion projects – every conversion is custom work.

3.2.3 legislation

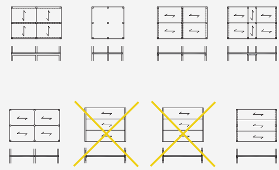
Dutch building regulations are strict: a converted office building needs to meet the same requirements as new-built housing, according to *Bouwbesluit 2003* (in 2012, implementation is planned for new building regulations that should make conversion easier – planned for April 2012 (SBR, 2011)). On the scale of the building building regulations can therefore impede renovation or conversion of vacant office buildings. To meet quality and safety demands, conversion often requires adjustments to the existing building, making it less financially feasible and thus unattractive for conversion.

standard office dimensions



> rectangular shaped building
> grid size: 5.4 or 7.2 meters

basic building structure



> over-dimensioned (300 kg/m2)
> open floor plan + vertical transport

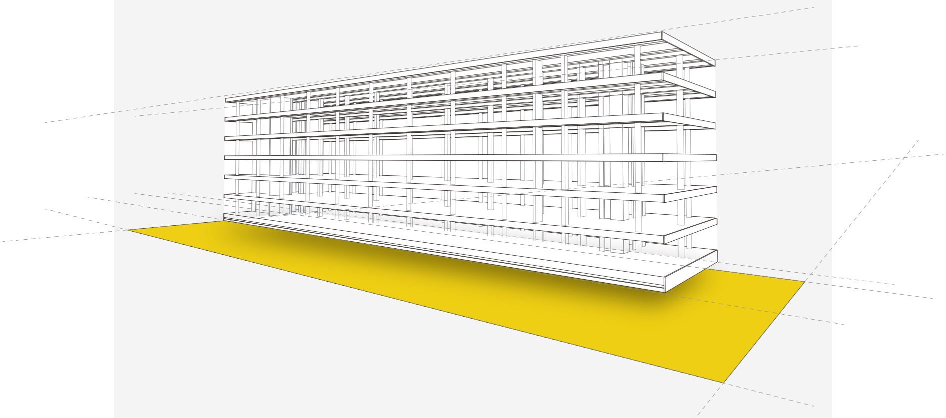


figure 3.3.1

3.3 opportunities

3.3.1 building characteristics

For conversion of vacant office buildings on a large scale the building characteristics mentioned in chapter 2.4 are promising: if multiple buildings have similar features in grid sizes, construction and façades, it should be possible to apply similar techniques to convert more efficiently.

Grid size

As said, most office buildings have been built according to a simple office typology: a rectangular shaped, high- or lowrise building with concrete floors, supported by columns and stabilized by thick concrete cores. Grid sizes are standardized and are either 7.2 meter (38 %) or 5.4 meter (17 %), always a multiple of 1.8 meter, the standard for office design - see chapter 2.3.1.

Construction

The basic building structure is, in most cases, over-dimensioned and calculated according to variable loads ranging from 200 kg/m2 up to 500 kg/m2 - see chapter 2.3.2 (without computers, office buildings used to contain heavy file cabinets and desks with tons of paper work - loads that do not apply now). In comparison, housing is calculated according to variable loads of 175 kg/m2, making it possible to add weight to the basic building structure.

The height clearance between the concrete poured in-situ or precast concrete panel floors (in 70 % of all - vacant - office buildings - see chapter 2.4.1), supported by (lowered or hidden) beams, is larger than that of a normal house, because space was needed for installations above the lowered ceiling. This height difference can be used to add extra quality to the converted space, but extra insulation between the floors will always be needed when converting.

To change the office environment over time, offices are designed with an open floor plan to accomodate change for a tenant market. All the supporting functions, such as the vertical transportation, service areas and shafts, are placed along or within the concrete cores. The vertical transportation, including elevators, stairs and fire escapes, is often sufficient for the converted function, so does not need any large adjustments.

Façade

In most cases the façade has been separately designed from the building's basic structure and can thus be separated from the structure and is not load-bearing. With curtain-wall façades (applied in 44 % of all office façades - see chapter 2.3.3) this separation is even more evident. The façade is suspended to the building's structure with fixings, meaning it would not be much effort to remove the façade without any large adjustments to the building's structure.

3.3.2 conversion costs

In the first place, an office conversion project is more feasible when the office building is already owned property (van der Voordt, 2007). If so, the value of the building can silently be depreciated and high acquisition costs are left out.

Only one problem remains: the office market is a special 'line of business' in the real estate market and different from housing, retail or mixed use development. When it comes to conversion to other functions, office building owners do not have enough expertise to redevelop their own building. The growing problem of office vacancy could be the call for office owners to change their strategy.

The highest cost generators in conversion projects, namely the façade and the inner walls, are also an indication that the building industry will need to think of more innovative techniques to make conversion more feasible.

3.3.3 legislation

Research from another MSc-graduate student from the Technical University Delft showed that initiated office conversion projects that stranded, were not impeded by legislation issues, but primarily by other external factors (Buenting, 2012).

With the introduction of *Bouwbesluit 2012* regulations concerning conversion will change. At first, it differed from municipality to municipality if it was allowed to deviate from building requirements for new-built, only after review. New building regulations however, *Bouwbesluit 2012*, demand this deviation to be regulated nationally. If the deviation is granted, the conversion should not reduce the building below the level of quality of the existing building and the minimum level for existing buildings in general (Scharphof, 2011).

Furthermore, now the office vacancy problem shows, municipalities are becoming more cooperative when it comes to conversion. Every major city in The Netherlands today has its own ‘vacancy taskforce’, resulting in mitigating zoning laws and other regulations.

4 | conclusion & recommendations

4.1 conclusion

In the beginning of 2012, office vacancy in The Netherlands has reached emerging levels: 6.795.000 m2 (or 14.1 %) of the total office stock is vacant. Prospects indicate that, although some of the vacant office space could be taken up again, for almost 70% of the currently vacant office space there will not be any future demand.

The consequences are clear: in areas with high vacancy rates, there in less livelyhood, resulting in vandalism and deterioration, affecting the urban quality. Next to this, it is a waste of usable space. Depreciation of the vacant office stock is inevidable and will result in large financial losses, but is difficult in the current financial climate.

The measures that are currently taken to deal with office vacancy are not changing much on a large scale and the awaiting attitude of stakeholders on the office market is not working along. Conversion of the vacant office stock is the most effective and sustainable way to cope with vacancy, but is hardly put into practice.

The goal of this project was therefore to find out how the architect, by means of design, can contribute to make conversion projects more feasible on a large scale. To give an adequate answer to the main research question, the research was split up in two parts: the design research and conversion potential.

Design research

The design of the Dutch office building has been greatly influenced by the international and technological development of the office environment. From the moment office buildings were discovererd as interesting investments for an anonymous tenant market in the 1970's, the office building becomes more standardized to accomodate the changing office user.

The building characteristics of the standardized office building are therefore a combined result of ARBO-regulations, space requirements, daylight optimalization and efficiency in the building industry. The standard office grid is based on a multiple of 1.8 meter, with 7.2 meter as the most common grid for the construction (38 %) in vacant office buildings. The façade is in 44 % of all office buildings a curtain-wall façade, suspended to the building's structure. The construction is calculated according to variable loads ranging from 200-350 kg/m2, with 500 kg/m2 as variable load if a flexible office interior was desirable (as it was in most tenant offices).
As can be concluded from the great variety of construction and façade types

that were applied in Dutch office architecture, it is hard to say that one specific combination of characteristics is the most common in vacant office buildings. Office buildings with grid sizes of 7.2 meter (for example) cannot be directly associated with a specific type of construction or façade. With the available information it is therefore not possible to describe the vacant office stock in specific typologies.

Conversion potential

Conversion of buildings in general is difficult: the building process is different from new-built and existing building conditions make a project harder to estimate and technically complex, with many unforseen complications. In office conversion projects the most common difficulties are the façade and the inner walls, both also the highest cost generators. Next to this, the construction of office buildings often restricts floor openings and the load-bearing beams limit the floor to ceiling clearance, specified by legislation.

But there are also opportunities: the highly standardized office building offers similar situations in grid sizes, construction and façades and thus the opportunity to apply similar techniques to convert more efficiently. The basic building structure is often overdimensioned, is designed with an open floor plan and contains the necessary vertical transport and is therefore valuable for conversion.

As long as the (inevidable) depreciation on the vacant office stock will not be made, it will be hard to make conversion projects feasible. Office conversion projects are more feasible when the office building is already owned property, so the value of the building can silently be depreciated and high acquisition costs are left out. Although in the current market office owners do not have enough expertise to redevelop their own buildings, the current vacancy levels might call for change.

Conclusion

This research will be concluded with an answer to the main research question:
By means of design, what can the architect contribute to make conversion projects more feasible on a large scale?

Although vacant office buildings show a great variety of construction and façade types, a lot of opportunities lie in the standardization of office design: the 1.8 grid, standard rectangular shapes, non load-bearing façades and overdimensioned constructions. The architect should benefit from the opportunities of this standardization: by devising smart systematic elements that are based on standard office dimensions he can make conversion of office buildings on a larger scale possible. But to really contribute, it is essential for an architect that he is familiar with the opportunities and difficulties faced in office conversion projects, as been described in this research paper. For example, special attention needs to go out to the design of the façade and the placement of inner walls, the highest cost generators in conversion projects. Also, the possibilities of the construction need to be known in an early stage of the design process as well as the possibilities when it comes to building regulations.

What can be said, is that this research paper contains information that could help architects to devise new ways to make conversion projects of vacant office buildings on a large scale more feasible. That is, at least, the intention of the design project that will follow from this research (see next chapters).

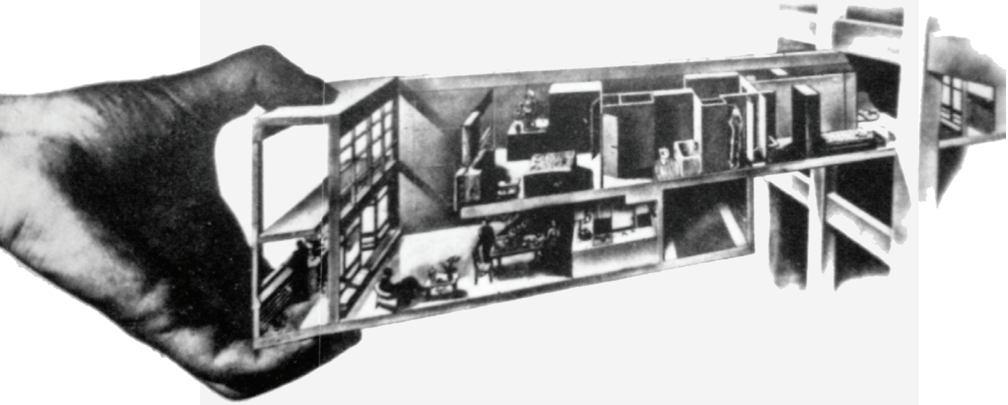


figure 4.2.1 Concept drawing of Corbusier's Unité Habitation in Marseille | from: Wikipedia (2011)

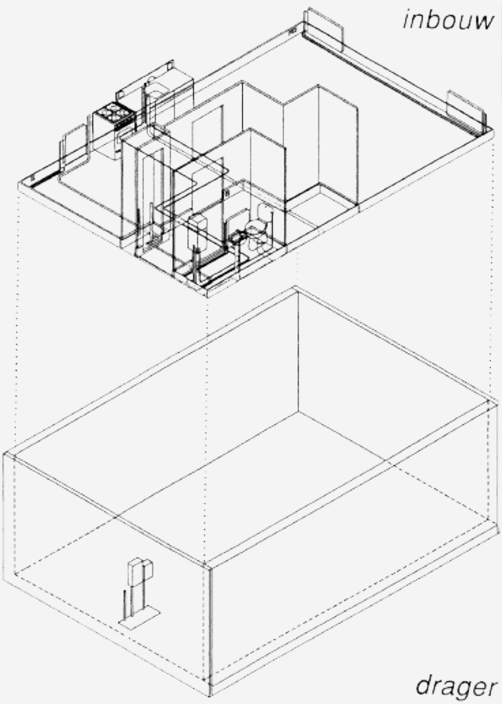


figure 4.2.2 *Drager-inbouw* (support-infill) system by N.J. Habraken | from: Cement (1992)

4.2 recommendations

Further research

What this research could not prove, was if the vacant office stock could be described in certain typologies, based on its architecture, construction and façade. There was sufficient information available on office façades (for example: *Re-Face* (2010) from Th. Ebbert), but exact numbers on what type of construction was applied, were missing. For further research and mapping the opportunities for conversion, this could be interesting to look into.

What was not the aim of this research, but should not be neglected, is the location of the vacant office stock. Research has been conducted into what the specifications of the location say about the vacancy levels (and vice versa), but what do the building characteristics of the vacant office building say about the location (and vice versa)?

Design project

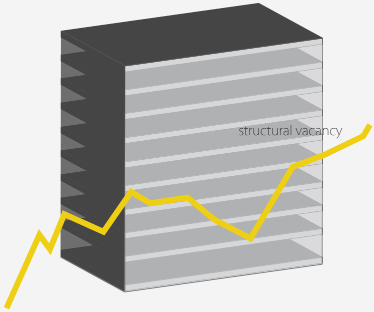
The findings from this research paper have been used to help design the conversion of an existing and vacant office building, while keeping in mind that it should also be applicable on other office buildings. For further development of the conversion concept, additional research was needed, which will be elaborated on in the next chapter. But before this will be explained, it is important to know what stood at the basis of this project, the most important recommendation at the end of this research.

Buillding as support

What became clear during the research was that the office building is highly standardized. When up for conversion, difficulties are mostly found in the façade and inner walls. The building basic structure on the other hand, is often overdimensioned and still contains the needed vertical transport and can therefore be reused. As said, the architect should benefit from this information.

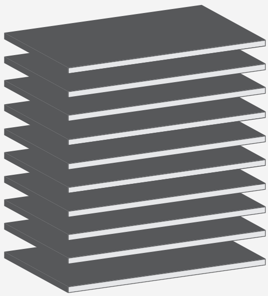
The idea that came forth, was that for future conversion projects, the office building should be seen rather as a 'support' that needs new infill. This idea is similar to the method Corbusier illustrated for his Unité Habitation in Marseille (*see figure 4.2.1*), or what N.J. Habraken wrote down in his book '*Supports, an alternative to mass housing*' from 1962 (English edition - 1972). In this book, Habraken proposes the separation of 'support' (or base building) from the 'infill' (or interior) in residential

1.



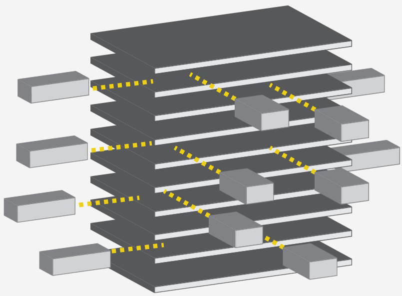
standard 1970-1990s office

2.



prepare building as support

3.



deployment of modular prefab architecture

figure 4.2.3 Initial concept diagrams conversion concept | f.p.koornneef (2011) construction (*see figure 4.2.2*) - this way inhabitants could play a more participative role in the design process. Until some extent, this can also be applied on office conversion projects, with the structure of the office building as 'support' and seperate 'infill' to accomodate a new function of the building.

Converting using modular prefab architecture

Imagine that the office building is prepared as a support and the (outdated) façade is stripped, what about the infill? How are we able to control the construction costs needed for the adjustments of the existing building, the costs that are so hard to estimate? Modular prefab architecture offers a solution: by deploying modular and prefab elements, costs are more controllable, the technical details are not building-specific and the building process is faster in comparison to the traditional one.

This method also has some extra benefits; while the existing office building is being stripped, construction of modular units can start which in a later phase will be placed into the existing structure: it is similar to shoving drawers (the infill) into an open closet-frame (the support). Hypothetically, within a short amount of time it should be possible to convert an office building efficiently and cost effective.

On the longer term, these modular prefab elements can be reused and deployed on different locations. Suppose you want the building to be converted back to an office after several years, remove the units and add a new façade. And then there is the flexibility in programming the converted office building: the units can function as a living-unit, a working-unit or as a hotel room.

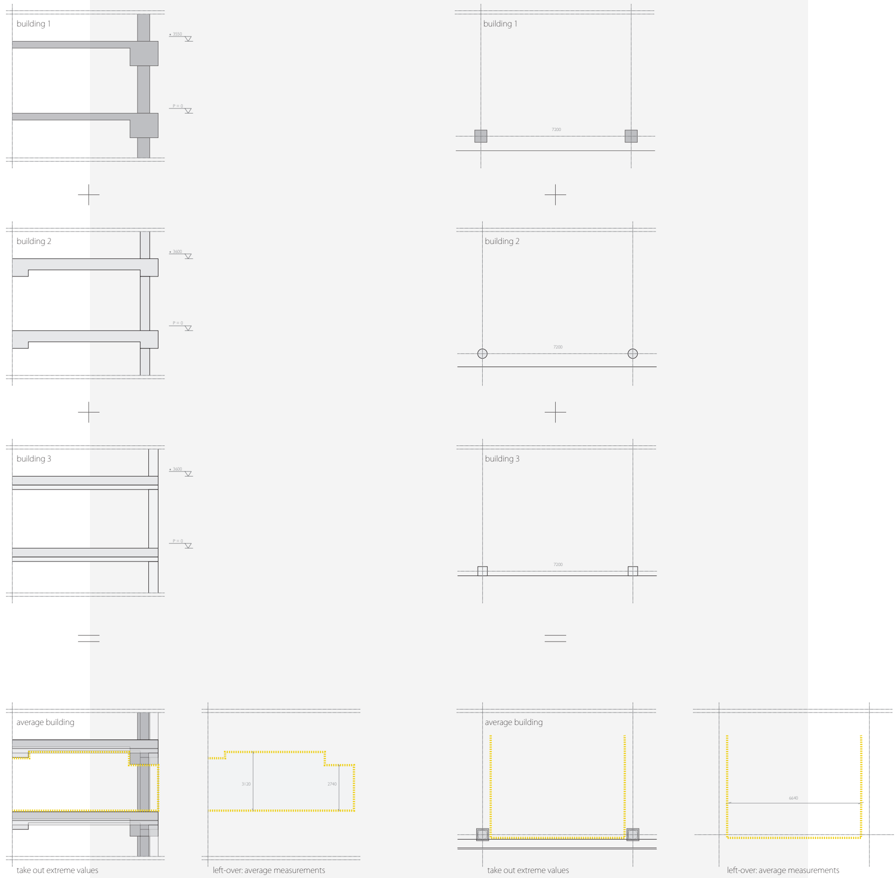


figure 4.3.1 Overlay method | f.p.koornneef (2011)

4.3 additional research

For the conversion concept to evolve, it required to further dive into the building characteristics that, until now, were only described statistically and generically.
It was important to get more 'tangible' information; the design margins for the conversion concept. In chapter 2.3 and 2.4 is identified what construction types and façade constructions are applied in office construction (in general and vacant office buildings in specific)., but what is the consequence for the floor plan and cross sections of the office building? For example, if the modular prefab architecture would be deployed from the outside of the building and 'shoved' into the structure, what would be the minimum height clearance?

To get a better grip on this issue, the building's basic structure is analyzed by overlaying floor plans and cross sections (*see figure 4.3.1*) from the office vacancy database.

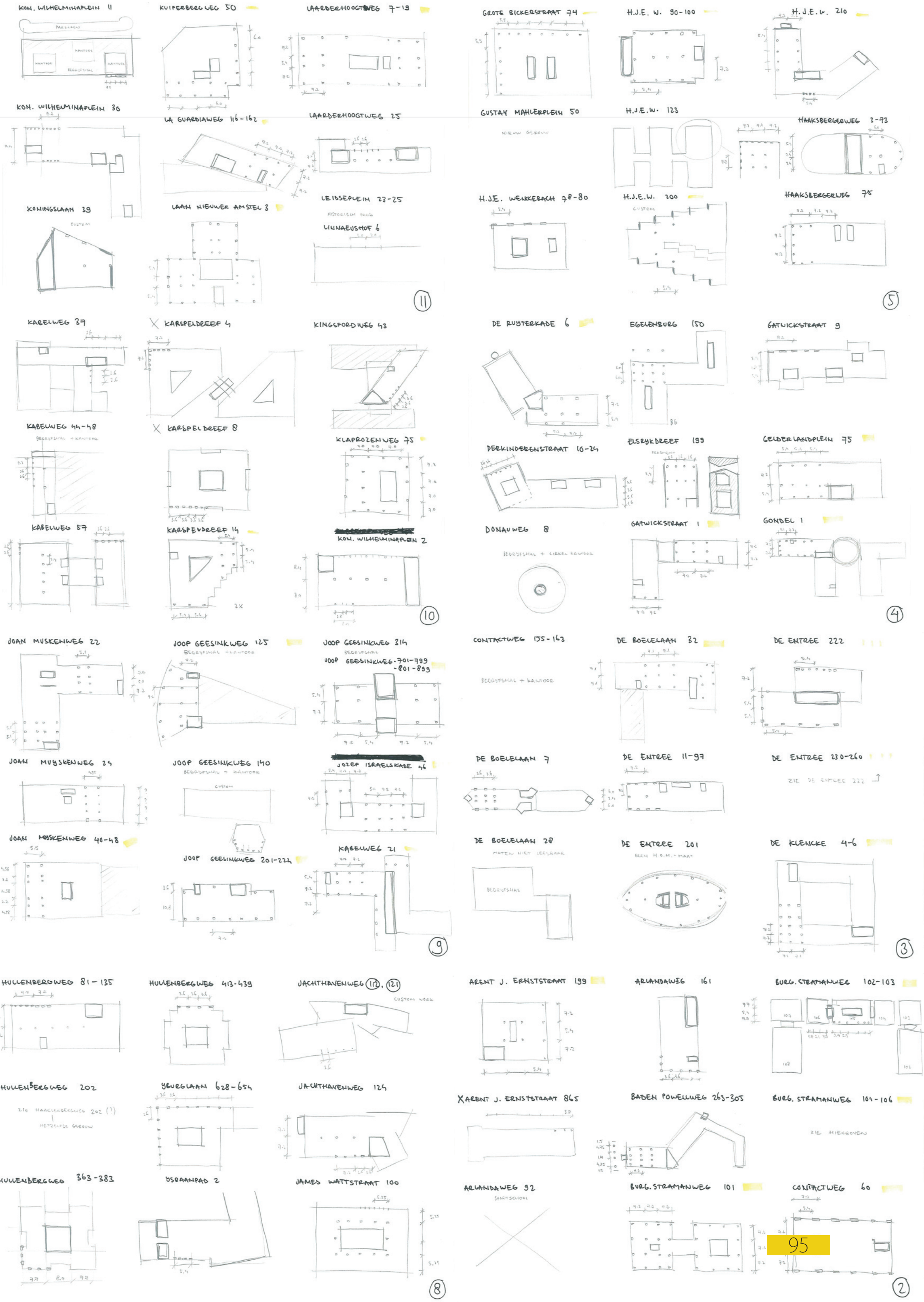
Criteria

Before the construction drawings could be overlayed, it was important to make a selection out of the 200 buildings from the vacant office database. By setting up a list of criteria, it was possible to 'test' the buildings on their ability to be converted according to the conversion concept.

- façade: needs to be non load-bearing and should be easily removable;
- grid structure columns: between 5.4 and 7.2 m;
- no structural parapets in the façade (free clearance from outside);
- rectangular shaped building (not too complex).

Because not all of this information can be read from the excel database, it was necessary to analyze all 200 construction drawings. To make a quick scan, simple sketches were made to analyze the construction drawings in a simplified manner (see next page for the total overview of all scanned drawings).

figure 4.3.2 Office lay-out sketches, adapted from database | f.p.koornneef (2011)


KON. WILHELMINAPLEIN 11
KUIPERBERGWEG 50
LAARDERHOOGTWEG 7-19
GROTE BICKERSSTRAAT 74
H.J.E. W. 90-100
H.J.E. W. 210
KON. WILHELMINAPLEIN 30
LA GUARDIAWEG 116-162
LAARDERHOOGTWEG 25
GUSTAV MAHLERPLEIN 50
H.J.E.W. 123
HAAKSBERGERWEG 1-73
KONINGSLAAN 39
LAAN NIEUWER AMSTEL 3
LEIDSEPLEIN 23-25
LINNAEUSHOF 6
H.J.E. WENKEBACH 78-80
H.J.E.W. 200
HAAKSBERGERWEG 75
11
5
KARELWEG 37
KARSPELDREEF 4
KINGSFORDWEG 43
DE RUYTERKADE 6
EGELENBURG 150
GATWICKSTRAAT 9
KABELWEG 44-48
KARSPELDREEF 8
KLAPROZENWEG 75
DERKINDERENSTRAAT 10-24
ELSRIJKDREEF 199
GELDERLANDPLEIN 75
KABELWEG 57
KARSPELDREEF 14
KON. WILHELMINAPLEIN 2
DONAUWEG 8
GATWICKSTRAAT 1
GONDEL 1
10
4
JOAN MUSKENWEG 22
JOOP GEESINKWEG 125
JOOP GEESINKWEG 314
JOOP GEESINKWEG 701-799 - 801-899
CONTACTWEG 135-163
DE BOELELAAN 32
DE ENTREE 222
JOAN MUYSKENWEG 24
JOOP GEESINKWEG 140
JOZEF ISRAELSKADE 46
DE BOELELAAN 7
DE ENTREE 11-97
DE ENTREE 230-260
JOAN MUSKENWEG 40-48
JOOP GEESINKWEG 201-224
KABELWEG 21
DE BOELELAAN 28
DE ENTREE 201
DE KLENCKE 4-6
9
3
HULLENBERGWEG 81-135
HULLENBERGWEG 413-439
JACHTHAVENWEG 119, 121
ARENT J. ERNSTSTRAAT 199
ARLANDAWEG 161
BURG. STRAMANWEG 102-103
HULLENBERGWEG 202
IJBURGLAAN 628-654
JACHTHAVENWEG 124
ARENT J. ERNSTSTRAAT 865
BADEN POWELLWEG 263-305
BURG. STRAMANWEG 104-106
HULLENBERGWEG 363-383
IJSBAANPAD 2
JAMES WATTSTRAAT 100
ARLANDAWEG 92
BURG. STRAMANWEG 101
CONTACTWEG 60
8
2

Maatcategorie		Straatnaam	Huisnummer		Aanpasbaar volgens concept	Ingevoerd AutoCAD	Reden
1	1	Anthony Fokkerweg	1	1	ja	onbekend	
2	3	Apollolaan	150	150	ja	onbekend	
3	3	De Ruijterkade	6	6	ja	onbekend	geen doorsnede
4	2	Egelenburg	150	150	ja	onbekend	geen doorsnede
5	2	Haaksbergweg	3	73	ja	onbekend	geen doorsnede
6	2	Hogehilweg	14	14	ja	onbekend	
7	3	Hoogoorddreef	5	5	ja	onbekend	geen doorsnede
8	3	Hoogoorddreef	9	9	ja	onbekend	geen doorsnede
9	3	La Guardiaweg	116	162	ja	onbekend	geen doorsnede
10	1	Rembrandtplein	33	43	ja	onbekend	geen doorsnede
11	2	Weesperplein	8	8	ja	onbekend	geen doorsnede
1	1	Contactweg	60	66	ja	ongeschikt	
2	1	Elsrijkdreef	199	215	ja	ongeschikt	recentelijk gebouwd
3	1	H.J.E. Wenckebachweg	200	200	ja	ongeschikt	te complex
4	1	Hessenbergweg	109	119	ja	ongeschikt	dragende bakstenen gevel
5	2	Hettenheuvelweg	41	43	ja	ongeschikt	laagbouw (bedrijfshal)
6	2	Hettenheuvelweg	45	47	ja	ongeschikt	laagbouw (bedrijfshal)
7	2	Hogehilweg	16	16	ja	ongeschikt	laagbouw (bedrijfshal)
8	2	Hogehilweg	18	18	ja	ongeschikt	constructieve balk vloerrand
9	3	Jozef Israelskade	46	48	ja	ongeschikt	recentelijk gebouwd / baksteen
10	4	Koningin Wilhelminaplein	11	11	ja	ongeschikt	veilingcomplex
11	1	Laan Nieuwer Amstel	3	3	ja	ongeschikt	bevat al woningen
12	4	Nachtwachtlaan	20	20	ja	ongeschikt	
13	3	Naritaweg	12	12	ja	ongeschikt	
14	4	Noordhollandstraat	71	71	ja	ongeschikt	
15	1	Overschiestraat	63	63	ja	ongeschikt	
16	1	Overschiestraat	65	65	ja	ongeschikt	
17	3	Paasheuvelweg	33	33	ja	ongeschikt	laagbouw (verschillende verdiepingen)
18	3	Poeldijkstraat	4	4	ja	ongeschikt	dragend prefab gevelelement
19	1	Postjesweg	175	175	ja	ongeschikt	geen kantoorpand
20	3	Teleportboulevard	110	110	ja	ongeschikt	dragende bakstenen gevel
21	4	Vijzelgracht	50	50	ja	ongeschikt	te complex
22	1	Wibautstraat	135	139	ja	ongeschikt	dragende gevelkolommen
23	2	Wibautstraat	133	133	ja	ongeschikt	i.h.w. gestorte borstwering
24	4	Wibautstraat	224	224	ja	ongeschikt	stramienmaat 10500
25	3	Zekeringstraat	38	40	ja	ongeschikt	dragende bakstenen gevel
1	1	Amstelplein	6	8	ja	x	
2	3	Anderlechtlaan	175	175	ja	x	
3	2	Anthony Fokkerweg	61	61	ja	x	
4	1	Arent Janszoon Ernststraat	199	199	ja	x	
5	1	Burgemeester Stramanweg	102	103	ja	x	
6	1	Burgemeester Stramanweg	104	106	ja	x	
7	3	Burgemeester Stramanweg	101	101	ja	x	
8	2	De Boelelaan	32	32	ja	x	
9	3	De Klencke	4	6	ja	x	
10	3	Gatwickstraat	1	1	ja	x	
11	1	Gelderlandplein	75	75	ja	x	
12	3	Gondel	1	1	ja	x	
13	2	Grote Bickerstraat	74	74	ja	x	
14	1	H.J.E. Wenckebachweg	90	100	ja	x	
15	3	Herikerbergweg	2	36	ja	x	
16	2	Hettenheuvelweg	4	6	ja	x	idem
17	2	Hettenheuvelweg	16	16	ja	x	idem
18	1	Hogehilweg	4	4	ja	x	idem
19	1	Hogehilweg	8	8	ja	x	idem
20	2	Hogehilweg	10	10	ja	x	idem
21	2	Hogehilweg	12	12	ja	x	idem
22	2	Hogehilweg	15	15	ja	x	
23	2	Hogehilweg	17	17	ja	x	
24	2	Hogehilweg	19	19	ja	x	idem
25	3	Hoogoorddreef	54	58	ja	x	
26	2	Joan Muyskenweg	40	48	ja	x	
27	3	Joop Geesinkweg	125	125	ja	x	deels bedrijfshal
28	3	Joop Geesinkweg	201	224	ja	x	deels bedrijfshal
29	3	Joop Geesinkweg	701	799	ja	x	
30	3	Joop Geesinkweg	801	899	ja	x	
31	3	Kabelweg	21	21	ja	x	
32	1	Karspeldreef	14	14	ja	x	
33	2	Klaprozenweg	75	75	ja	x	
34	2	Kuiperbergweg	50	50	ja	x	
35	3	Laarderhoogtweg	7	19	ja	x	
36	2	Maassluisstraat	2	2	ja	x	
37	3	Ottho Heldringstraat	5	5	ja	x	
38	2	Overschiestraat	184	184	ja	x	
39	3	Overschiestraat	59	59	ja	x	
40	1	Paasheuvelweg	8	8	ja	x	
41	2	Paasheuvelweg	5	5	ja	x	
42	2	Paasheuvelweg	14	14	ja	x	idem aan 8
43	3	Piet Heinkade	55	55	ja	x	
44	2	Pilotenstraat	6	6	ja	x	
45	3	Startbaan	8a	8a	ja	x	
46	3	Strawinskylaan	1	1755	ja	x	WTC
47	4	Stroombaan	4	4	ja	x	
48	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
49	2	Van Boshuizenstraat	12	12	ja	x	
50	3	Zekeringstraat	42	42	ja	x	
51	3	Zekeringstraat	44	44	ja	x	idem
52	3	Zekeringstraat	46	46	ja	x	idem
53	3	Zekeringstraat	48	48	ja	x	idem
54	3	Zekeringstraat	50	50	ja	x	idem
55	2	Zwaansvliet	20	20	ja	x	

figure 4.3.3 Final selection of 55 office buildings | f.p.koornneef (2011)

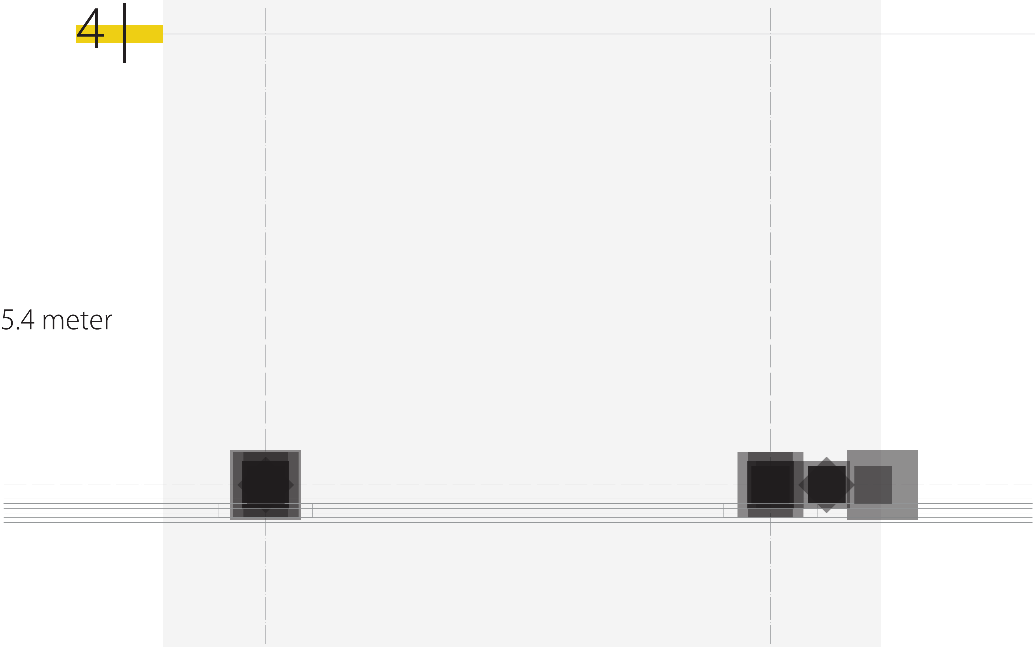
Results

From the drawings on the previous page a shortlist was made of 91 office buildings (out of 200 buildings) that met the criteria mentioned earlier. The next step was to overlay the detailled drawings from this selection in AutoCAD. Because not all buildings from this selection had cross sectional drawings in the database, 11 buildings had to be marked as 'unknown'. From 25 buildings it turned out that after a second, more detailled, look the building was not able to be converted according to the initial conversion concept. Reasons were structural parapets restricting clearance, load-bearing masonry walls or building shapes that were too complex. These buildings were therefore marked 'unfit'.

In the end, 55 office buildings (out of 200 = 27.5 %) were approved and drawn in AutoCAD, according to the method earlier described. Furthermore, the 55 office buildings were separated, based on their grid size (either 5.4 meter or 7.2 meter). The result of all 55 drawings overlayed can be seen on page 98-99.

After this was done, the drawings were optimized by maximizing the clearance between columns and floors. Due to this optimalization, 33 buildings still met the criteria, 20 buildings with a grid of 7.2 meter, 13 with a grid of 5.4 meter. The result of this optimization can be seen on page 100-101. What should be noted is that some of the buildings that were approved had the same construction drawings, but different adress numbers. These buildings are most likely part of a collection of separate, but similar office buildings located in a so-called 'office park', so this does not interfere with the total numbers.

5.4 meter



plan

7.2 meter

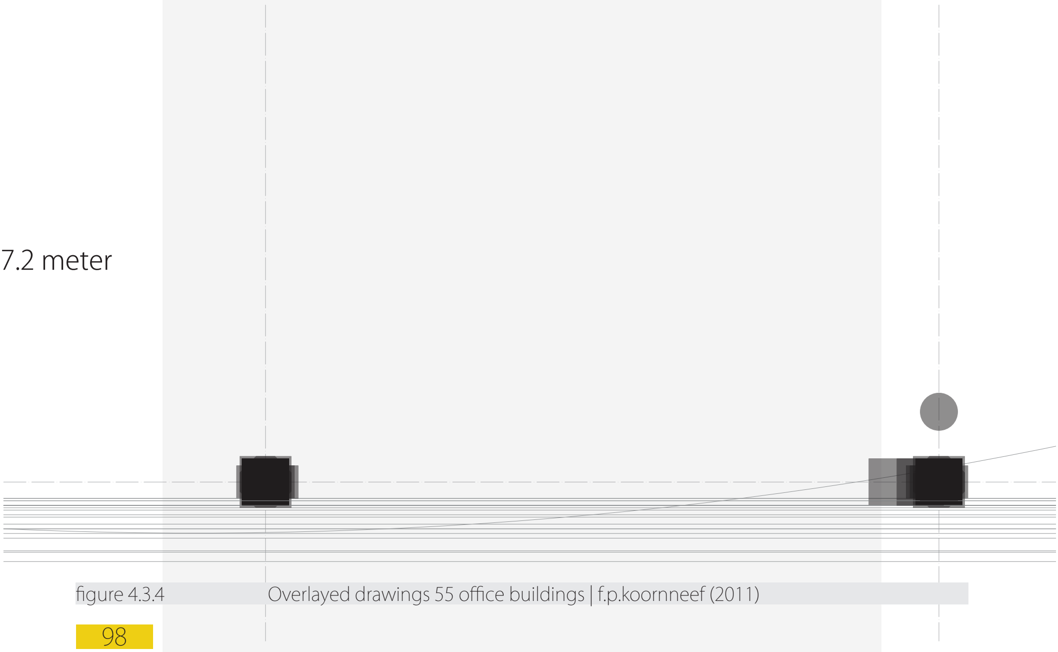
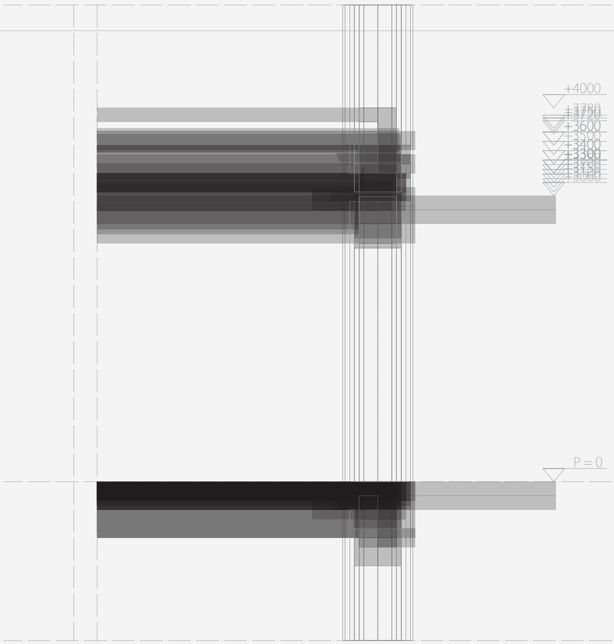
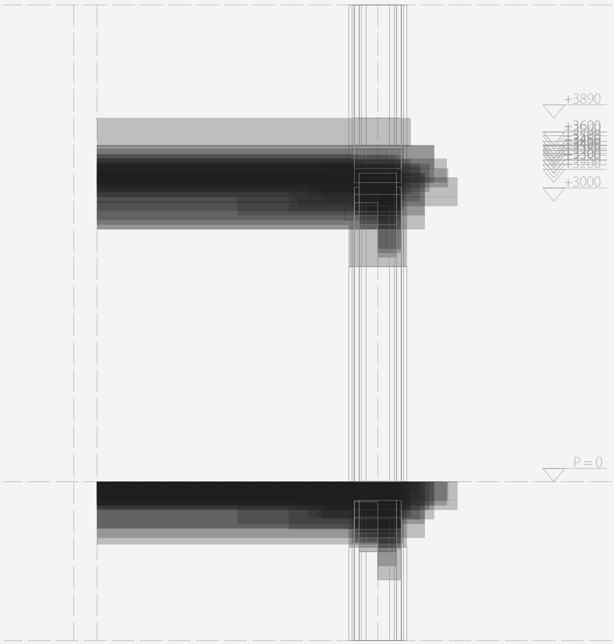


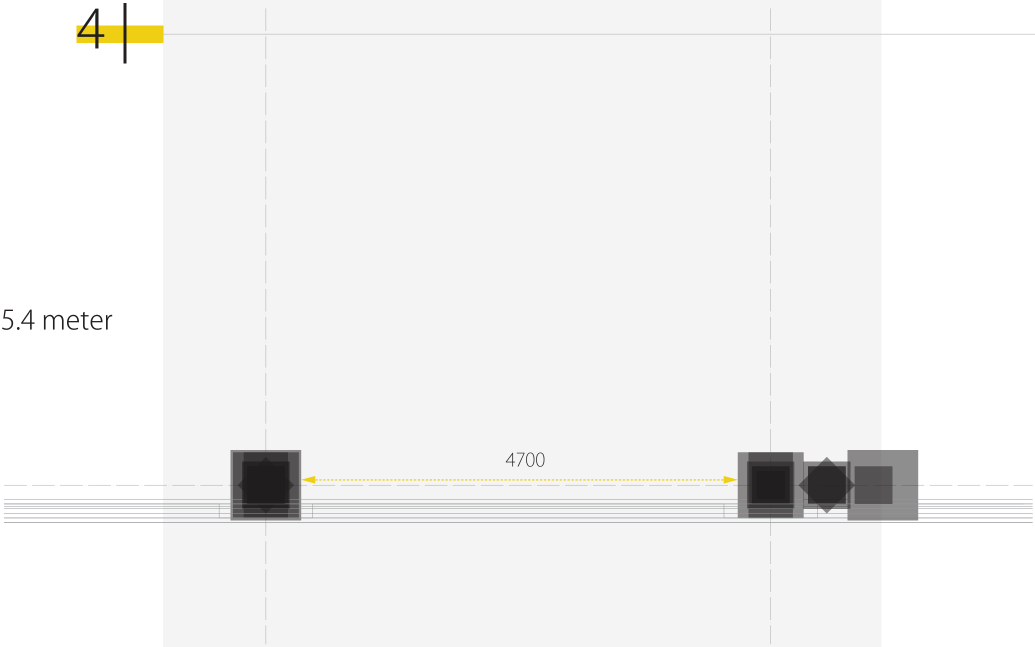
figure 4.3.4 Overlayed drawings 55 office buildings | f.p.koornneef (2011)



cross section



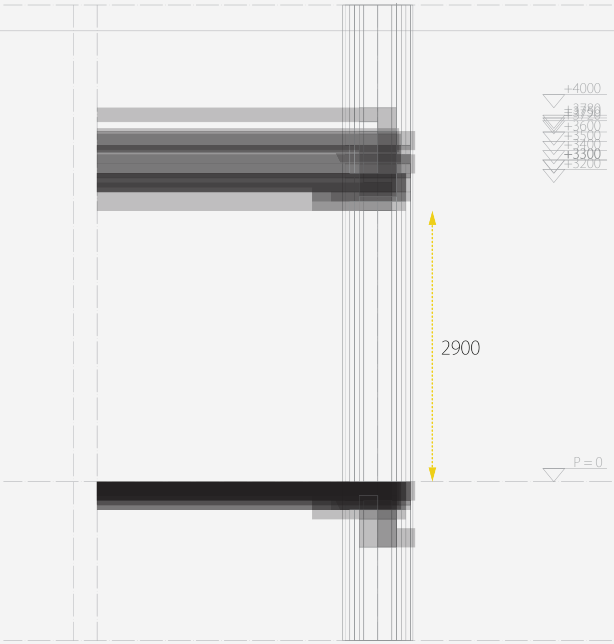
5.4 meter



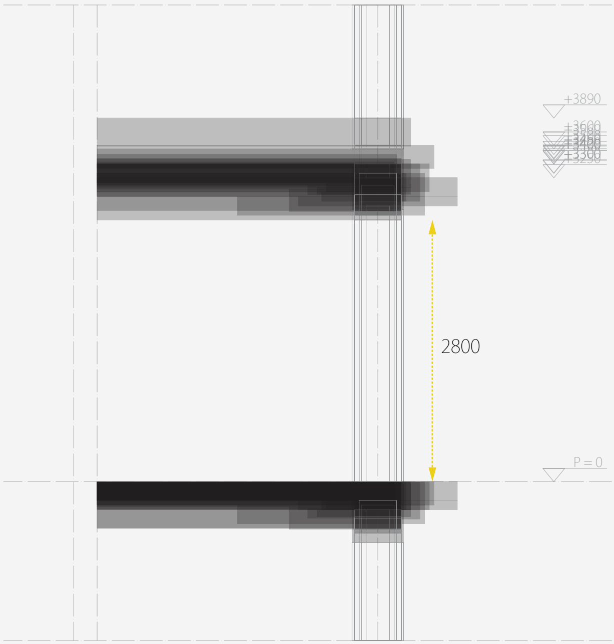
plan

7.2 meter

figure 4.3.5 Overlayed drawings 33 office buildings - after optimalization | f.p.koornneef (2011)



cross section



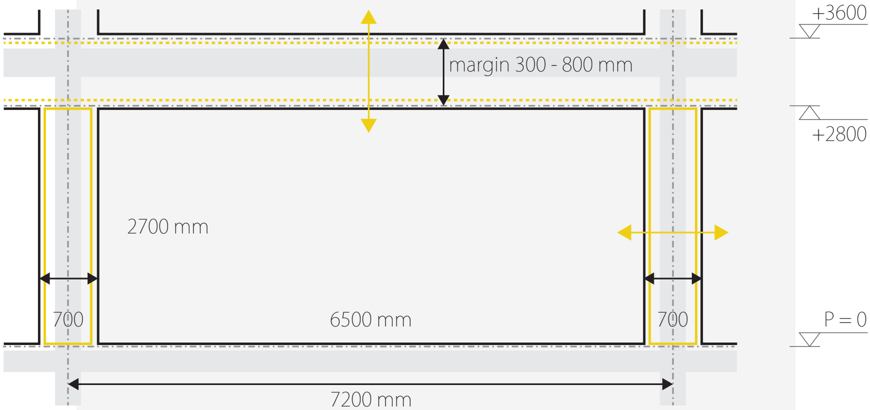


figure 4.3.6 Designing within margins - final result | f.p.koornneef (2011)

Designing within margins

The 33 buildings that remained after optimalization provide the information needed to start designing, within the margins determined by the overlayed drawings. Because the final design project that will follow from this research is an office building with a 7.2 meter grid, the corresponding margins are the most interesting. The result is illustrated in figure 4.3.6 will be leading in the design phase of the modular prefab conversion concept.

What can be concluded after this analysis is that the design that will follow from this research will be applicable on 20 out of a total of 200 vacant office buildings (in Amsterdam). On a larger scale, this indicates the potential of converting 10 % of the total vacant office stock with the proposed conversion concept.

+ | bibliography

literature

- Bak, R.L. (2005). Kantoren in cijfers 2005. NVM, Zeist.
- BNA Onderzoek & TU Delft (2011). Zorg voor Leegstand, BNA Onderzoek in samenwerking met Faculteit Bouwkunde TU Delft.
- Brounen, D. & Eicholtz, P.M.A. (2004) Vastgoedmarkt kraakt onder demografische druk, verschenen in: ESB - 89e jaargang, nr. 4430.
- Buenting, L. (2012). MSc-thesis: Obstakels voor transformatie Juridische knelpunten en oplossingsrichtingen. TU Delft.
- CB Richard Ellis (2011). What users want. De invloed van het Nieuwe Werken op de kantooromgeving, CB Richard Ellis, Amsterdam.
- DNB (2011). Overview of Financial Stability 2011, DNB, Amsterdam.
- DTZ Zadelhoff v.o.f. (2012). Factsheet Kantorenmarkt 2012. DTZ Zadelhoff, Utrecht.
- DTZ Zadelhoff v.o.f. (2008). Cijfers in perspectief 2008. DTZ Zadelhoff, Utrecht.
- Ebbert, T. (2010). Proefschrift - Re-face: refurbishment strategies for the technical improvement of office façades. Faculty of Architecture, TU Delft.
- EIB - Zuidema, M.V., Elp, M. van (2010). Eindrapport: Kantorenleegstand – Probleemanalyse en oplossingsrichtingen. Economisch Instituut voor de Bouw, Amsterdam.
- Gunst, D.D. de & T. de Jong (1982), Typologie van gebouwen. Handleiding bij het ontwerpen van bedrijfsgebouwen, Delft: Afdeling der Bouwkunde th Delft.
- Hek, M., J. Kamstra & R.P. Geraedts (2004), Herbestemmingswijzer. Herbestemming van bestaand vastgoed, Delft: Publikatieburo Bouwkunde.
- Kohnstamm, P.P. & L.J. Regterschot (1994), De manager als bouwheer. De rol van de bestuurder bij de realisatie van nieuwe huisvesting, Den Haag: Ten Hagen en Stam.
- Kok, W., van Luijn, P. (2012). MSc-thesis: Transformation 'office to dwelling' and 'dwelling to user'. TU Delft.
- Mackay, R. (2008). Bouwkosten van transformatieprojecten. Faculty of Architecture, TU Delft.
- Meel, J. van (2000). The European Office: office design and national context. 010 Publishers, Rotterdam.
- NVM Business (2010) Structurele leegstand van kantoren, Nieuwegein: NVM Data & Research.
- Remøy, H. (2007). Typologie en transformatie - Transformatie van kantoorgebouwen. 010 Publishers, Rotterdam.

- Remøy, H. (2010). Out of Office: a study on the cause of office vacancy and transformation as a means to cope and prevent. Faculty of Architecture, Technical University Delft.
- Reuser, B. (2005). Calendarium Naoorlogse kantoorgebouwen. Rotterdam.
- SBR (2009). Transformatiewijzer: van kantoor naar woonruimte – perspectief, financiën en regelgeving. SBR, Rotterdam.
- SCP (2011). Rapport Burgerspectieven 2011-2012, from: www.vng.nl (visited december 2011).
- Spiering, T.G.M. e.a. (2004). Jellema 3 - Draagstructuur. ThiemeMeulenhoff, Utrecht/Zutphen.
- Van der Voordt, T., Geraedts, R., Remøy, H., Oudijk, C. (2007). Transformatie van kantoorgebouwen: Thema's, actoren, instrumenten en projecten. 010 Publishers, Rotterdam.