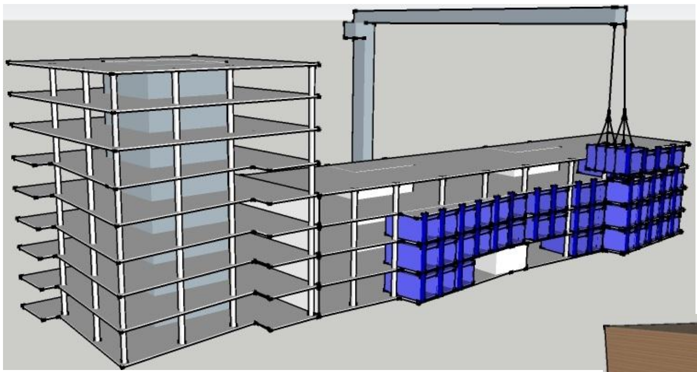
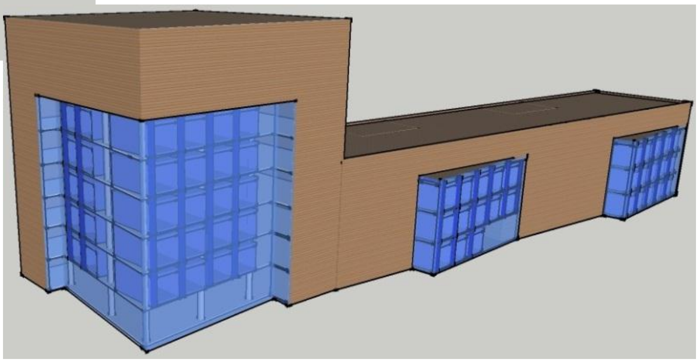
Master thesis

Hotels for vacant offices

A design and study in applying modular room elements and the development of a general calculation tool for transformation projects from vacant offices to hotels





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Preface

This master thesis is the result of eight months of hard work and enthusiasm. The thesis is the final hurdle in the master program Building Technology and Physics at the faculty of Civil Engineering and Geosciences at the Delft University of Technology and the last step in becoming an actual engineer.

Transformation from structurally vacant office buildings to hotels in Amsterdam is the central topic of the report. The thesis is built up in three major parts. The first part is a literature study in the current vacant office market and the current demands in the hotel market in the region Amsterdam. The second part is the development of a new transformation method with the creation and design of modular room elements. The final part is a calculation tool developed for transformation projects of vacant offices to hotels. With this tool the current vacant office buildings can be mapped and compared in their suitability to transform.

In this part I would also like to express my gratitude towards a number of people who helped me very much during the course of this thesis. In the first place I would like to say thanks to my family who always supported and motivated me. I also would like to thank the committee which motivated me with every meeting we had and I felt their support along the entire thesis. Philip Koppels I would like to thank because of the help I received from him getting information about the structural vacancy in Amsterdam and also in obtaining detailed information about said buildings.

The master thesis is the final part of my Master studies at the Delft University of Technology. The followed program and the studies in general gave me the knowledge, skill and understanding to prepare me for a life as an engineer in practice. I look forward of being in the field and feel confident of being an engineer.

Niko Divendal — Delft, February 2013

Summary

The current building stock for offices is very large, and is too large for the demand out of the market. The reason for this goes back to around 2000; one after another building was erected by municipalities and developers. Following these fast and large amounts of erections of office buildings were a number of crises that followed each other up, such as the internet crisis, the financial crisis and the euro crisis. Also new forms of working such as working (partly) from home, called teleworking and flex working, and the stabilization of the working force took effect and made a large part of the office buildings obsolete. However, the building of new offices didn't stop.

Currently there is a total vacancy of 14.1% in the Netherlands, which is equal to 6.795.000 m^2 of office space. DTZ Zadelhoff, a real estate advisor, has calculated a quarter of this number to be hopeless and unable to fulfill the function of office anymore. On the other side, the municipality of Amsterdam is demanding a large amount of hotels. In order to maintain their European and Worldwide position and fulfilling their wish for an "Amsterdam Topstad" Amsterdam needs around 9000 new hotel rooms until the year 2015. This number is later lowered to 7500 new hotel rooms until the year 2015.

Transformation of current vacant office buildings in Amsterdam to hotels could be a solution to a number of vacant office buildings. While transforming may seem like a good and easy solution, there are reasons it's not that often used. The setbacks include financial and technical aspects. Technical aspects include the state and the dimensions of the current structure and the higher demands in a new function. The financial aspects, currently the ones that make any transformation very difficult, are major setbacks; the developer value a building in a different way than investors do, which creates a difference in "building value" and a second setback is the financial insecurity of the transformation itself.

The Master thesis is the result of researching the supply of vacant office buildings in Amsterdam and brings that together with the demand for hotel rooms. This will be done in two parts, the first being a modular room solution and the second one being a calculation tool to compare vacant office buildings to each other in their potential to transform to a hotel.

The first handed solution in order to bring the vacant office supply with the hotel demand together is the design of the modular rooms. These are timber frame rooms with a low weight and a fixed price that can benefit the transformation into a hotel. The building speed will increase, fewer handlings on the building site will benefit risk management and the fixed price of the units will take away financial insecurity of transformation projects. These advantages will benefit the (mainly financial) feasibility of the project becoming more advantageous than using a general method of transformation with or without the change in façade.

The downsides to the modular element method lie in the transport and assembly of the units. These large elements need to be transported via road transport and hoisted with cranes; larger rooms will be transported separately and assembled on site. Also the fact that using this solution implies that the façade needs to be replaced is a large financial factor. The set sizes of the elements make the solution somewhat inflexible and sensitive to loss of space.

The Transformation Performance Coefficient is a calculation tool that will bring the current state and location of the building together with the future demands of the hotel. By adding a score to each of the 69 characteristics a coefficient will result from the program that can be used to compare

different buildings on their potential to transform to a hotel function. Each choice of a characteristic is scored with a 0,3, 0,6 or 1,0. Each characteristic, however, has the same weight as opposed to the other characteristics making each characteristic of the same importance. The score itself is open to interpretation.

The downsides of the tool are that the tool needs a second layer of scoring making one characteristic (such as the location of the hotel) more important than the other (such as the floor height) that are now of the same importance and that the program doesn't take connections between characteristics into account. An example of this is that when the choice is made for a 5 star hotel the location is even more important than with a 2 star hotel.

In summary we can say that both solutions are a solution in order to bring the vacant office market together with the hotel market. A fast and cost effectively building method has been designed in the sense of the modular elements. Future recommendations concerning this solution lie in the indicators of transformation projects being used, which are hard to predict, exact numbers can only be obtained by application of the method or studying a large number of transformation projects. We can say, with more certainty that the assumed hypothesis of prefabrication being better than working on site is true. A modular room method is proven to be better than general methods, especially when applying a new façade. The TPC calculation tool is a solution which has the right boundaries but needs to be more detailed. The skeleton of the program and the idea of the thesis of comparing buildings on their transformability to hotels are there, but the detailing and the quality of the outcome or results of the program need to be considered. Recommendations for the calculation tool lie in the extended calculation of correlation between characteristics and the difference in importance of the characteristics.

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1 Introduction

The first chapter will be an introductive chapter where the motive for the master thesis is made clear and the relevance and the purpose of the studies are discussed. The delineations of the thesis are made clear and the research methods are elaborated upon. In the first section, 1.1 the motive for the Master thesis is made clear. Section 1.2 will discuss the relevance of the subject from a number of angles. Section 1.3 will make the purpose of the study clear, with the delineations of the thesis in section 1.4. The research methods that were used are elaborated upon in 1.5.

1.1 Motive Master thesis

The current building stock for offices is very large, and is too large for the demand out of the market. The reason for this goes back to about ten years ago; before that time there couldn't be enough office buildings. One after another were erected by municipalities and developers, especially along the major highways. Developers and investors immediately started building. That was up until around 2001/2002.

Following the fast and large amounts of erections of office buildings were a number of crises that followed each other up, such as the internet crisis, the financial crisis and the euro crisis. Also new forms of working such as working (partly) from home, called teleworking and flex working, and the stabilization of the working force took effect and made a large part of the office buildings obsolete. The building of new offices didn't stop; businesses are not waiting for the currently vacant offices, largely from the same building time and the same type, but want their own (unique) building. This does not help the current vacancy either.

Currently there is a total vacancy of 14.1% in the Netherlands, which is equal to 6.795.000 m^2 of office space. DTZ Zadelhoff, a real estate advisor, has calculated a quarter of this number to be hopeless and unable to fulfill the function of office anymore.

On the other side, the municipality of Amsterdam is demanding a large amount of hotels. In order to maintain their European and Worldwide position and fulfilling their wish for an "Amsterdam Topstad" Amsterdam needs around 9000 new hotel rooms until the year 2015. This number is later lowered to 7500 new hotel rooms until the year 2015.

Transformation of current vacant office buildings in Amsterdam to hotels could be a solution to a number of vacant office buildings that may be otherwise demolished. Transformation is not a new concept, but is not largely used. However, the awareness for maintaining the buildings that are already there instead of demolishing, out of a durability point of view, is largely gaining ground.

While transforming may seem like a good and easy solution, there are reasons it's not that often used. The setbacks include financial and technical aspects. Technical aspects include the state and the dimensions of the current structure and the higher demands in a new function. The financial aspect, currently the one that makes any transformation very difficult, is a major setback; the developer value a building in a different way than investors do, which creates a difference in "building value".

The Master thesis will research the supply of vacant office buildings in Amsterdam and bring that together with the demand for hotel rooms in the capital. Of importance will be to create a solution for the technical setbacks in transformation projects.

1.2 Relevance

This section will elaborate on the relevance of this thesis from a number of angles. The social, scientific and personal relevance will be discussed.

1.2.1 Social relevance

Vacant buildings influence the street view of the area. When a building is (structurally) vacant it's influencing the value of that building, but also the value of the buildings surrounding and the value of the entire area. It also is not generating any income for the owner and thus not fulfilling its intended function, it has become useless. Currently vacant office buildings are a social problem and need to be addressed.

Transformation will give the building and the area new life. As opposed to demolition and new building, transformation has the advantage of keeping a part of the building, which is more sustainable and better for the environment; its building time is shorter than with building a new building and the buildings will keep their emotional and cultural value.

At the same time another social problem is addressed and dealt with. The municipality of Amsterdam is asking for a large number of hotel rooms within the city limits. This can be done by transforming the vacant office buildings into hotels.

1.2.2 Scientific relevance

The thesis will address building and location specific characteristics in order to create a solution for both technical setbacks and a computational model. In order to tackle the technical setbacks of transformation projects there will be made a design of prefabricated hotel units. The goal of this is to create less invasive, fast built, sustainable and from a building physics point of view good adaptable design, units.

A computational model or quantification method is a method to see in a glance whether or not a transformation is feasible. The idea behind this is that every building and location can be calculated upon and the program will tell whether or not it's feasible to transform the vacant building into a hotel.

1.2.3 Environmental relevance

In transformation projects the current building is left standing, meaning that the amount of demolition is up to the point that an owner or a builder can add a new function to the building. The amount of demolition varies but the structure is almost always left intact. The more of the building is left standing, the less waste there is. Demolition, transport and processing the large amounts of construction debris are large environmental assessments.

Transformation is a more sustainable and durable solution than demolishing the entire building and constructing a new building. Even if from the old building only the construction is kept and the building is totally stripped transformation is still a more sustainable solution.

1.2.4 Personal motive

My personal opinion and motive for this thesis has a number of aspects. The first aspect being that in my view transformation is almost always better than demolition. Keeping the positive characteristics, which is not always the façade itself but can also be a certain shape or size of a building, of current buildings and in this way respecting of what is already there is a very important point in my view. Restoration and renovation also fit into this view, but transformation is focusing on changing the function, which is more addressing the actual problem of current structurally vacant building, they are not needed anymore in their current function.

The second aspect being that I personally have a preference for prefabrication. Prefabrication brings a lot of advantages, such as a high building speed, fewer nuisances at the building site, more sustainability, flexibility at the end of its life, guarantied quality because of production at controlled conditions and easy to create burglary proof and fire proof units. Prefabrication takes away uncertainties during the building and is in my view a very good solution.

1.3 Purpose of the study

1.3.1 Goal Master thesis

The goal of the study will be broken up in three parts. The first part will be a literature study which will make clear what the current state of (structurally) vacant offices in Amsterdam is; what the market demand for hotels is and what the technical aspects of buildings of certain time periods are. The goal here is to gain knowledge and insight and at the same time proof the actual worth of the thesis, to proof that the study has a function.

The second part will be a design of prefabricated hotel units. This part will focus on creating a complete design where the main focus is on the building physics. All interior demands will have to be met in order to make the design technically feasible. The goal here is to create a fast-to-build solution for transformation from offices to hotels.

The third and last part of the thesis will be to create a computational method for transformation projects from office to hotel. The computational method will be a performance coefficient and will make clear whether or not a certain vacant building in a certain location is suitable to function as a hotel in the next life.

The main goal of the thesis is to bring the supply of the vacant office buildings in Amsterdam together with the demand of hotel rooms and to create an everywhere-to-use solution in the form of prefab rooms and a performance coefficient for transformation to hotels.

1.3.2 Hypothesis

During the course of this master thesis there is a hypothesis formulated that will have to be proven true in order to make the solution of the second and third part of the thesis useful. The hypothesis is:

"Using prefabricated elements during a transformation project is better than creating and executing work on site."

This can be explained by risk management and financial feasibility. The general assumption is that the more handlings on a building site itself, the more risk there is during a project. More handlings equal more room for mistakes that have to be solved in a limited time (during the building). This problem solving under the pressure of time is not always beneficial for projects. By taking a lot of handlings away from the building site and into a more controllable and secluded area, such as a factory, the risks can be lowered. Prefabricated elements are generally more expensive than separate building materials, namely due to transport and assembly, but are far easier to place and will save a lot on labor hours. Because of the lowering of the risks, unforeseen costs will also be lowered by a lot. These two reasons are assumed to make the hypothesis true.

The hypothesis is proven true if from the master thesis a conclusion can be drawn that the handed solution is financially more beneficial than using separate materials. This conclusion can be drawn by using a case study. For the risk management part, we can conclude that the hypothesis is true if the design is technically feasible. From this feasibility we can conclude that if it's possible, the handed solution is easier to carry out than using a different transformation method.

1.3.3 End product

Out of the thesis there will be two main end products; the first one being a complete design of prefabricated hotel rooms, focusing on building physics and integration with office buildings. These hotel rooms have to meet certain requirements and need to be usable in a lot of vacant offices, therefore need to be flexible and focus needs to be on building characteristics.

The second end product is a performance coefficient in the form of a web application. The purpose of this is to immediately see and judge whether or not a vacant office building is suitable to transform to a hotel. Different solutions, such as the solution of this thesis, can be applied into this performance coefficient and in this way evaluated.

1.4 Delineations of the thesis

To do the thesis within the timeframe it's important to set delineations. The products of the thesis will consist of results of a literature study, a design for prefab hotel rooms and a web application of a computational method for transformations. There have been made delineations in location and function.

Amsterdam
Out of all the major cities in the Netherlands Amsterdam has the highest vacancy rate. Amsterdam is of particular interest because of the high demand for hotel rooms within the next coming years, thus combining the supply of vacant offices and the demand for hotel rooms. The municipality of Amsterdam has a clear vision to be one of the leading capitals in Europe ("Amsterdam Topstad").

Hotels
Together with the high amount of structural vacancy in the capital there is a high demand of hotels. In the years from 2009 up until 2015 there is a need for a total of 7500 extra hotel rooms. A solution for this problem could lie in prefabricated hotel rooms.

1.5 Research methods

Although this thesis not being only a literature thesis, but also a practical one because of the design, we can still indicate a number of research methods.

Literature study
The literature study forms the basis of the thesis. In the study there is a research to the supply side of vacant offices in Amsterdam and the demand side of hotel rooms. These two factors are put together and after that there is a research into certain building characteristics of vacant buildings and to set the first boundaries in determining whether or not a building is transformable into a hotel.

Case study
Case studies into several projects will be done within the literature study. There will be looked at hotel transformations and at computational methods. These will be used as reference projects.

On the other side, both the design and the performance coefficient created in the thesis will be applied to a number of existing buildings to prove their validation. The design and performance coefficient are only valid when they can be applied to the practice and acquire reasonable results.

Programming
The performance coefficient that is created in the thesis will be programmed as a web application. The programming method that will be used is Java. Digitalization of the performance coefficient is done in order to make it available in practice.

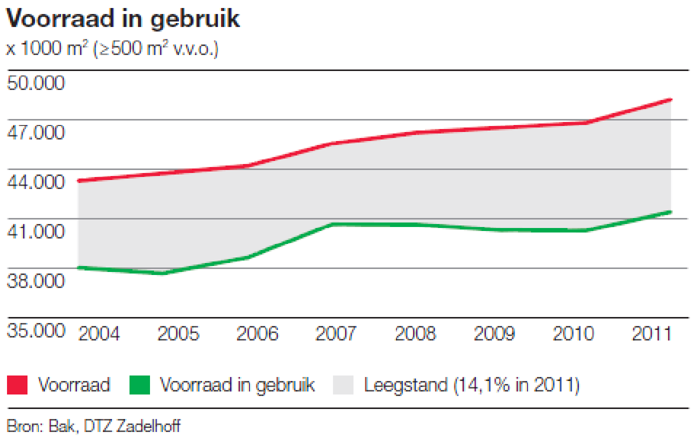
2 Literature Study

In this chapter the results and findings are discussed of the literature study in office vacancy and hotel demand in Amsterdam. In section 2.1 the background of vacancy in general and in Amsterdam is discussed. In section 2.2 the market demands for hotels are discussed and cross referenced with the available vacant office stock in section 2.3. 2.4 gives reference projects for hotel transformations out of vacant office buildings. Section 2.5 discusses the background of the use of calculation methods in relation to transformation projects which has reference calculation methods mentioned in section 2.6. The final section, 2.7, will address building characteristics such as the structure through the years from the Second World War up until now.

2.1 Background vacancy Amsterdam

2.1.1 Introduction

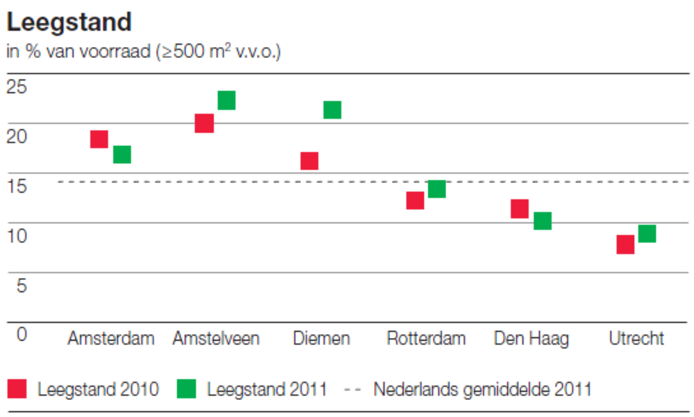
The Dutch building stock went booming after the Second World War. Buildings of all sorts were erected throughout the Netherlands, a lot of them office buildings. This went on till even today. In the year 2011 the supply in office space grew with 7.561.000 m^2 (5.7% growth from 2010 to 2011) to a total of 48.195.000 m^2 as can be seen in figure 1.1 (DTZ, 2012).



Source: DTZ Zadelhoff *Figure 2.1 – Building stock in use*

What is a modern day problem with all these office buildings is that a lot of them are vacant now. In the Netherlands we have a vacancy rate of office buildings of 14.1 % (DTZ, 2012). This is expressed in a total number of 6.795.000 m^2 of office space that is vacant in the Netherlands.

If we look more closely to the area the Master Thesis focuses on, we can see that the vacancy rate in Amsterdam in 2011 is 17.4% which is higher than the national average. It is lower than in 2010 by 1.1%. This can also be seen in figure 1.2 where the situation in Amsterdam is laid next to other major cities in the Netherlands and the national average (DTZ, 2012).



Source: DTZ Zadelhoff *Figure 2.2 – Vacancy different cities*

In order to deal with this high amount of vacant office space there can be done several things. To deal with the vacancy there is the possibility of selling the space, to maintain it the way it is, to renovate, to temporarily transform, to transform or to demolish the building.

The focus of the Master thesis is in the lines of temporary transformation. To transform or to reallocate temporarily will generate an income for the owner of the building, while maintaining flexibility in use. The downside of this is that the functional change is only temporarily and the relatively high costs of transforming twice. (Hek, M et al., 2004).

If we look a little more closely in the current building stock we can see a number of things. The vacancy of the office building stock consists for almost half (49%) of buildings from 1960-1980. More than a quarter (29%) is from after 2000. The reasons for these vacancy rates are discussed in the next section. (DTZ, 2012)

2.1.2 The social consequences of (structural) vacancy

In this section two important questions will be answered in relation to the social consequences of the structural vacancy and transformation as a solution. These questions are as follows:

1) *Why is structural vacancy socially unacceptable?*

2) *Why is transformation more socially acceptable than demolition?*

Structural vacancy and vacancy in general mainly has a consequence for the owner of a building. When he has a (office) building, which is not rented out, he loses money because he has no income and the value of the building will diminish in time of vacancy. But this is an ownership problem and not a social problem. What is a social problem is that vacant buildings have a negative influence on the surroundings. Because the owner isn't getting any income he is most likely not going to spend money on maintenance, buildings of these kind are deteriorating. (Remøy, 2011d).

Also in the vicinity of the vacant building there is less liveliness and the urban quality is getting lower. In relation to the low supervision there is bound to be acts of vandalism, graffiti and pollution which will create a feeling of social insecurity for the local residents. A structural vacant building will come in a negative spiral and will take the neighborhood with it (Remøy, 2010). Vacant buildings are thus not only a problem for the owner and users, but are also a social problem.

Transformation as a solution has a number of advantages over other solutions, such as consolidation, reuse as an office or demolition. Consolidation and unadapt reuse are, due to the high number of structural vacant office buildings, not a solution, they are bound to stay vacant and not generate the desired effect. Transformation into a different function will be more feasible because it will provide for a demand, such as housing or hotels (Voordt, 2007).

The advantages opposed to the demolition of a building are that there is the possibility to gain savings on building time and building costs because the construction of the building will be unharmed and the residents are already accustomed to the building. In cases of appealing buildings in the form of architecture, cultural and historical value or emotional value a transformation keeps the identity of the neighborhood intact while at the same time providing a new function.

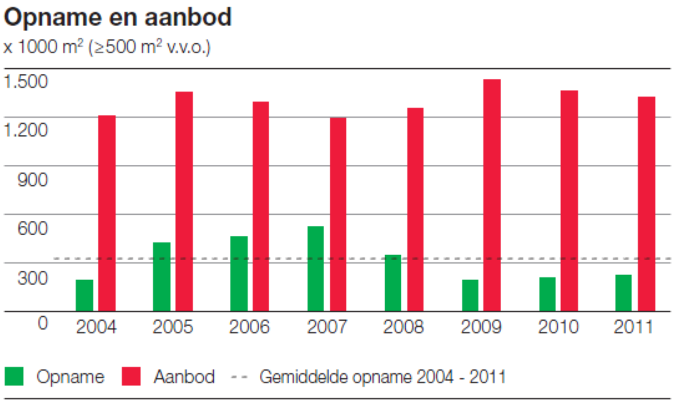
Transformation is an exemplary solution of sustainability. The structures of the buildings are not demolished but intact, resulting in less demolition waste and the current building materials are used for a longer time. Sustainability is a key aspect in transformation projects and is viewed as a very important aspect in the previous years and the years to come. The social acceptance of transformation projects is higher than the acceptance of demolition.

2.1.3 The reasons for the vacancy rate

In order to address the problem of the high vacancy rate in office buildings in the Netherlands we have to look at the reasons behind this. What is causing these high vacancy rates and how will this change or go on in the future? This part will deal with a number of reasons behind the high vacancy rate.

Discrepancy supply and demand

The reason for the high vacancy rate is a discrepancy between the offer of office buildings and the demand of them. DTZ Zadelhoff has done research in this discrepancy and the offer of new office space is fluctuating over the past years, with a peak in 2005, a low in 2007 and another peak in 2009. The demand for office space however is fluctuating less, with only a peak in 2007. The demand for office space is lowering over the years 2007-2011 while the offer was increasing till 2009 and lowering very little over the years 2009-2011.



Source: DTZ Zadelhoff

Figure 2.3 – Supply and demand

The Cobweb model

The Cobweb model is a theoretical model described by the American economist Mordecai Ezekiel in the 1930's. The model describes the cyclical dynamics of demand and supply as a result of the delay in which the producers respond to a price change. In other words, the model describes the constant movements of supply and demand of a general good, in the case of the first model, hogs and the way the market reacts on that by altering the price and quantities. This can be seen in the figure, which is an example of the Cobweb model. (Chiarella, 1988)

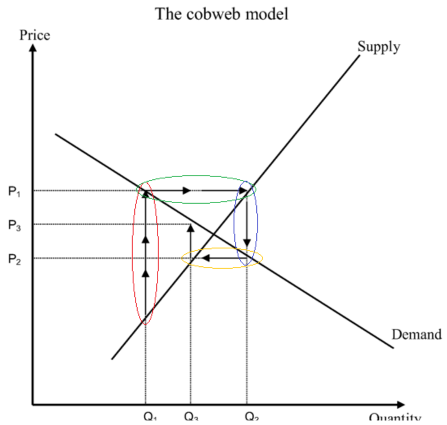


Figure 2.4 – Cobweb Model

The model works as follows, when there is a low supply of a product, the price goes up, and this can be seen in the red part of the figure. When the prices are at this high point, producers will see this as an opportunity to produce and earn more, so the quantity becomes higher (green part). After this, when there is a lot of supply, the prices will fall, in order to sell the entire stock (blue part). The next phase is that when the demand is lower again, producers will stop producing, or lower their production (yellow part). These phases will follow each other up until there is equilibrium at the intersection point of the supply line and the demand line.

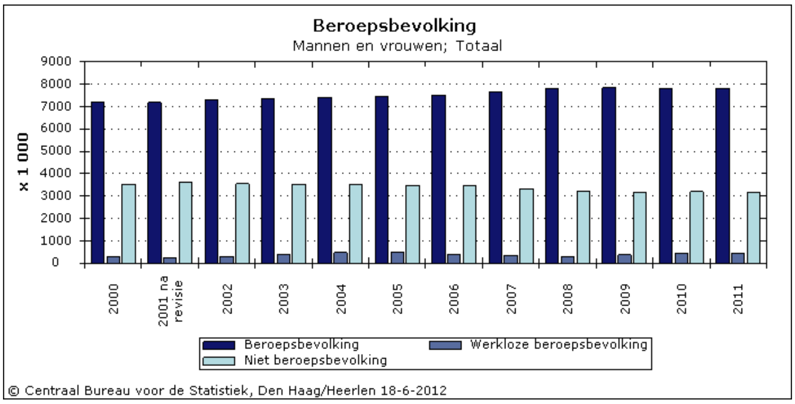
This model can be applied to the office market in the Netherland. Around the year 2000, there was a large demand for office space because of the strong economic phase the country was going through and the internet bubble. In this time there were a lot of new office buildings being erected but 2 years later the demand suddenly dropped drastically because the internet bubble shattered and the economy imploded (DTZ, 2010). The supply was, and still is, high, while the demand was at a low point, this causes a lot of vacant office buildings that nobody is waiting for. (Soeter & Koppels, 2008)

Demographic changes

What is happening in the Netherlands is that the labor force is aging. While the total labor force is somewhat stabilized along the past couple of years, the group is consisting of a lot of people which are at a higher age. We can see this at the figures obtained by Statline from the CBS (Centraal Bureau Statistiek (Central bureau of statistics)). In the upper figure we see the total labor force nationwide from 2000 to 2011. The second figure is of Amsterdam, where we can see that the same lines are noticeable. What we see in both figures is that the total labor force was at a high point in 2009 and was decreasing is 2010 and stabilizing in 2011. This in itself is not a problem.

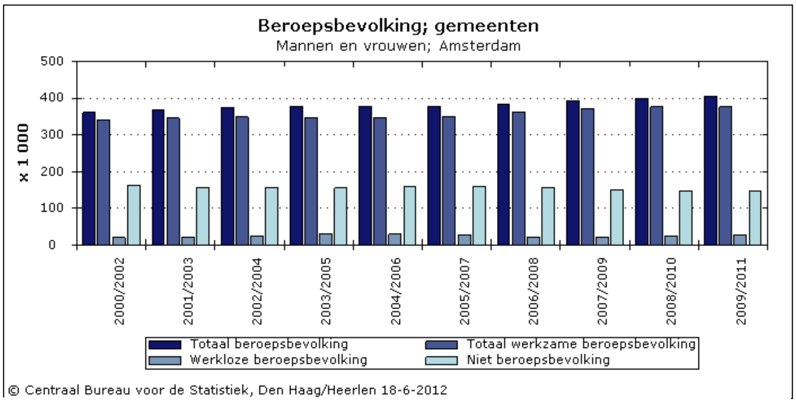
The problem with the stabilizing labor force is that the group with the age of 55 to 65 is explosively increased over the last couple of years. This is due to a baby boom after the Second World War. This group is going out of the labor force while the group with the age of 15 to 25 is decreasing. This would mean that the total labor force will decrease in the next couple of years. This is also concluded in the studies of Neuteboom and Brounen in 2006.

The problem with this is that in the next couple of years a large part of the labor force will retire, while the total population is increasing,



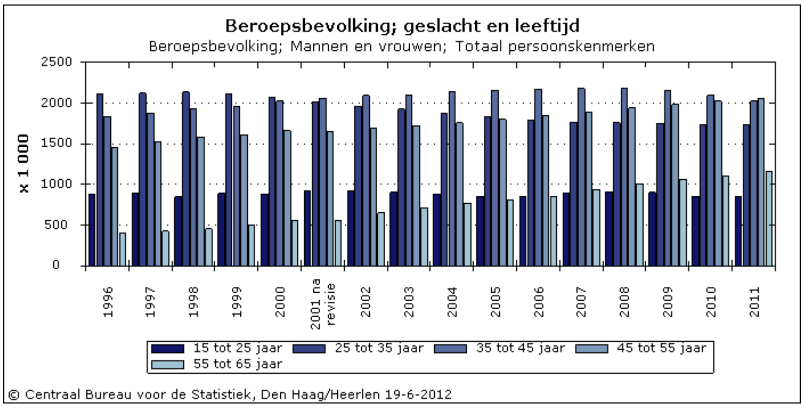
Source: CBS

Figure 2.5 – Working force Netherlands



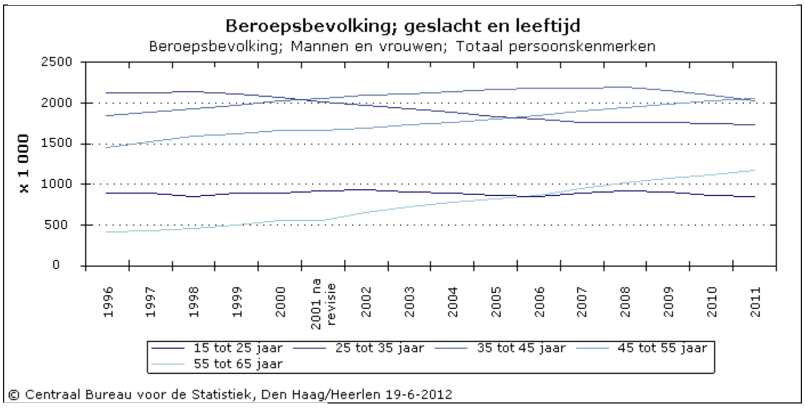
Source: CBS

Figure 2.6 – Working force in Amsterdam



Source: CBS

Figure 2.7 – Working force by age



Source: CBS

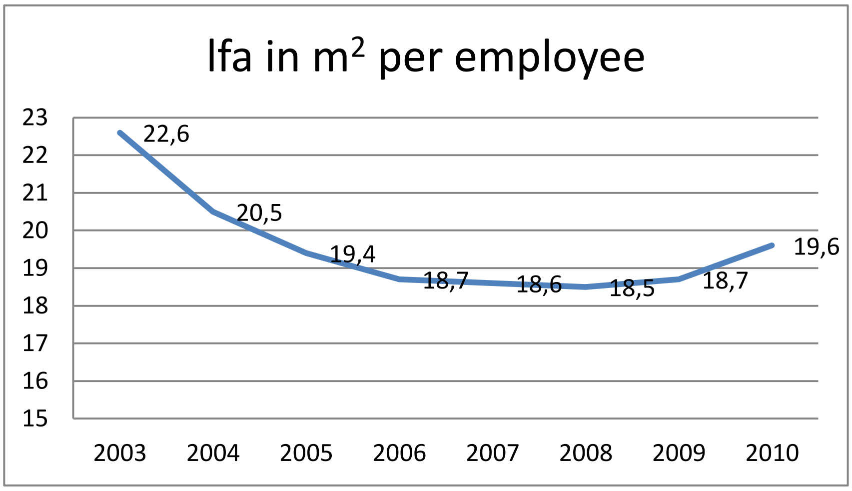
Figure 2.8 – Working force by age

resulting in a smaller labor force taking care of the entire population. For the office market this would be a problem since the demand for office space is decreasing due to the shrinkage of the labor force.

Teleworking and flexible working

With the technology being increasingly important over the years 2003 to 2008 the number of workers actually working at the office is decreased. This is due to working at home (teleworking) via an internet connection or home office and working at different times than the "normal" working hours of 9.00 to 17.00 (flexible working). In both cases the number of people actually using an office space at the same time is decreased and thus the demand for office space is decreased.

These flexible methods of working, called "Het Nieuwe Werken", translated as The New World of Work, are contributing to the vacancy rate of office space. Office spaces are in this case characterized as flexible working space, with impersonalized working spots for all employees to work. The decrease is noticeable from 2003 to 2006 and from 2006 to 2010 the office space per employee has stabilized and somewhat increased. We can see this from the figure made based on data from the NFC Index.



Source: NFC Index

Figure 2.9 – lfa in m² per employee

The increase in 2010 is a sign that office vacancy is increasing. While in the years 2003 through 2008 the lfa per employee has decreased because of new ways of working (Het Nieuwe Werken, or New World of Work) as described above, the increase in the last years is because of employers not able to sell their empty offices. The problem is that the office space is the same, due to long term office lease contracts, but they do not have that many employees, so they have more space per employee. In the years before the lfa decreased as a result of employers demand. They did not need so many office spaces because of new working methods. What's different with the years before is that it's harder to sell or sublease the surplus office space (NFC, 2011).

From growth market to replacement market

The current office market is a replacement market, while it used to be a growth market. A growth market is a market in which there is a high demand for, for instance, office spaces. In this case there are a lot of new office buildings being built whenever there is a demand. In the times when the demand is low and the supply is high the growth market stops and the replacement market starts. The current office buildings are being transformed into something with a higher demand, such as residences and hotels. (Gelinck, 2007)

2.1.4 Structural vacancy

When talking about vacancy of office spaces there can be made a division in vacancy types, not all types of vacancy are undesirable. Research by Keeris (2007) shows a division in vacancy in different groups and within the groups a level of degree.

Different forms of vacancy		*Problematic*	*Transformation*
Group 1	**Accepted vacancy**	**Not**	**Irrelevant**
Initial vacancy Vacancy in first year after completion		No	Irrelevant
Natural, normal vacancy Normal rate of vacancy for a given category and type of property within the submarket		No	Irrelevant
Mutation vacancy Vacancy after tenant leaves and new tenant enters		No	Irrelevant
Frictional vacancy Vacancy after tenant leaves and no new tenant enters, till max 1 year after end of rental contract		No	Irrelevant
Group 2	**Problematic vacancy**	**Limited**	**Barely relevant**
Long-term vacancy Vacancy where frictional vacancy turns into, till max 2 year after end of latest rental contract		Insufficient, alternatives first	Potentially relevant
Operational vacancy Specific long-term vacancy due to a to low performance level of the building		Insufficient, alternatives first	Potentially relevant
Group 3	**Dramatic vacancy**	**High**	**Possibly relevant**
Structural vacancy – Lacking in opportunities Vacancy after 3 years of frictional and long-term vacancy without short term perspective on rental		Possibly, alternatives first	Potentially relevant
Structural vacancy – Hopeless Vacancy after 2 years of long-term vacancy without short term perspective on rental, building doesn't comply with demand		Very	Focus on transformation and redevelopment
Locational vacancy Structural hopeless vacancy due to not being able to comply with locational demands		Very	Focus on transformation and redevelopment

Table 2.1 – Vacancy types

The vacancy that is worrying are the types of vacancy in group 3, the structural vacancy. This is the type of vacancy the thesis is aiming at and is seen as the most relevant group. Structural vacancy is also described as:

"The buildings that are vacant for 2 or more years and built before 1990 and the buildings that are vacant for 3 or more years and built after 1990." (DTZ, 2008)

2.2 Market demand hotels

In the last section we have seen that there is a large supply of vacant office space in the Netherlands and thus in Amsterdam. This is the supply side of the thesis. On the demand side for Amsterdam there is chosen for hotels. This chapter will elaborate on the reason for the choice of hotels, the current numbers of hotels in Amsterdam and the thresholds in a transformation from office to hotel.

2.2.1 Demand for hotels

In Amsterdam there is a great need for hotels. Amsterdam has made it into a target to be an international business location as well as a tourism and conference center, this is translated into the phrase "Amsterdam Topstad". Enough hotel rooms are a basic requirement for obtaining and maintaining this target. (Horwath HTL, 2011)

In the years before 1997 Amsterdam had a shortage of hotel rooms. The years after 1997 were years where the supply increased but not at a fast enough rate. With the 2001 recession both the growth in supply and demand tailed off, since during a recession no one wants to create hotels, but on the other and, fewer people are travelling, so the need for hotel rooms also decreases. However, from 2004 onwards the demand for hotel rooms increased again and the average room occupancy rate indicated there was still a need for more hotel rooms in Amsterdam. (Horwath HTL, 2011) The average room occupancy rate indicates the number of hotel rooms that are being used at any given time. If this number is too high it indicates that there are too few hotel rooms, and peak moments during the year can't be dealt with. The number was 81% in 2007 and is 72% in 2011. (Gemeente Amsterdam, 2012a)

In order to deal with the annual growth projected by the city of Amsterdam of 4% in overnight stays until 2015 there is a demand for 9000 new hotel rooms in Amsterdam. This number is lowered in 2012 and expected to be at 7500 (alderman of economics C. Gehrels). When looked at the number of hotels opened from 2005 till 2007 the projected number of new rooms is only half of that, 4500 and opened in the years 2011 and 2012 till June are another 2600 new rooms. From these numbers we can conclude that a number of hotel rooms are still needed in the years until 2015. This conclusion is also being made in the Nota Hotelbeleid 2007-2010 which is made by Horwarth HTL from Hilversum. Two very important conclusions which also intersect with the scope of this thesis are:

Conclusion 4:

- *The College of Mayor and Aldermen has entered into a hotel agreement with the city districts in order to jointly achieve the target of 9,000 new hotel rooms in 2015* **(later 7500)**. *In the light of the existing hotel density in the city center, a separate agreement has been made with this district. They have stated the intention to generate plans for 1,000 new hotel rooms before 2010 (on top of already existing plans). As part of this initiative, at least two unique top hotels will be realized, of such a level that Amsterdam would fall short were they not established in the city center.*

Conclusion 5b:

- *The City of Amsterdam will further research two potential quick-fix solutions:*
  a. (…)
  b. Redeveloping vacant office buildings into hotels: Amsterdam will explore whether suitable vacant offices can be converted, in cooperation with owners and city districts.

2.2.2 Current hotel stock and segmentation

When looking at a demand for hotels in the area of Amsterdam it is important to see what is already there and what is being developed at the moment. In order to do so this section will elaborate on the current hotel stock and the developments within Amsterdam.

Amsterdam has a total of 375 hotels if we only look to the definite borders of the city. The metropolis area of Amsterdam has 575 hotels; this is the area that also includes the adjacent areas, directly next to Amsterdam. The 375 hotels are divided into categories based on luxury; this is called the "Nederlandse Hotel Classificatie" (NHC) which is a standardization classification. The classification as given by the branch organization is shown in the table (Bedrijfschap Horeca en Catering, 2012).

Classification	Description	Minimum room size
1 star	Simple hotels with standardized facilities. A clean environment and a hospitable service are obliged. Room with bed and washbasin. Minimal requirement to be called hotel.	--
2 stars	Functionally decorated simple to middle class hotel. Beverages are available and faxing possibilities. Rooms as with 1 star en at least half of the rooms has an own shower, toilet and color TV.	--
3 stars	Comfortably decorated middle class hotel. Separate reception, luggage service to rooms. All rooms own shower and toilet, writing table and chair, phone with land line, color TV and radio. Non-smoking rooms must be available.	17 m^2
4 stars	Very comfortably decorated, first class hotel. Bar and lounge with service. Room service and laundry service. PC with internet on request. 2 luxury chairs, a safe in the room, extra connections for PC, a hair dryer in the room, as well as a luggage rack and a minibar.	22 m^2
5 stars	Luxury hotel with very high standards of facilities. Reception and janitor 24 hour service, valet parking, permanent luggage service. Bar and restaurant obliged, a minibar in every room and 24 hour room service. Individually regulated air conditioning per room. Own parking garage and own shuttle service, kiosk.	26 m^2 + at least two suites of 50 m^2

Table 2.2 – Star classifications as given by the NHC

The total of 375 hotels is divided into the number of hotels shown below. This is the number of hotels in 2011 and is obtained from the O+S (Bureau Onderzoek en Statistiek; meaning bureau for research and statistics) from the municipality of Amsterdam.

	Hotels				Total
	5 stars	**4 stars**	**3 stars**	**rest + hostels**	
Amsterdam	12	52	97	214	375

Table 2.3 – Number of hotels per star category in Amsterdam

What is important when talking about hotels is not the number of hotels, but the number of rooms. The number of rooms is constantly developing, new rooms and hotels are added to the market and hotels and rooms are discarded from the market. From 2001 to 2011 there was an addition of 5450 rooms. From 2009 to 2011 there were 1237 new hotel rooms in 2011 and until May 2012 there were another 2600 new rooms (C. Gehrels, 20th June 2012), together this is around half of the needed 7500 rooms in 2015. We can see from the table in which category each hotel is and the total amount of hotel rooms. The graph gives a more visual picture of the table. It should be noted that the drop in 5 star hotel rooms in 2007 and the related rise in 4 star hotel rooms is due to the fact that there was a change in classification system. The "Benelux Hotel Classificatie" went to the "Nederlandse Hotel Classificatie" which has stricter requirements for 5 star hotels. A number of 5 star hotels thus came into a 4 star rating. (Bedrijfschap Horeca en Catering, 2012).

Rooms	5 stars	4 stars	3 stars	rest + hostels	total hotels
2001	4162	3888	4837	3832	16719
2002	4159	3899	5255	3843	17156
2003	4138	4058	5316	3888	17400
2004	4328	3941	5411	4048	17728
2005	4287	3997	5763	3907	17954
2006	4268	4385	5770	3943	18366
2007	4440	4814	5917	4229	19400
2007 2)	2202	6653	6208	4337	19400
2008	2822	6386	6013	4535	19756
2009	2809	7000	6402	4721	20932
2010	2574	7708	6708	4757	21747
2011	2983	7996	6542	4648	22169

Table 2.4 – Number of hotel rooms per star category in Amsterdam

What we can see from this is that in every category there is a constant rise in hotel rooms with a short low point in 2007/2008 and for 5 star hotel rooms in 2010. The 4 star hotel rooms are increasing the fastest and the 1+2 star hotel rooms and the 3 star hotel rooms are increasing very slowly.

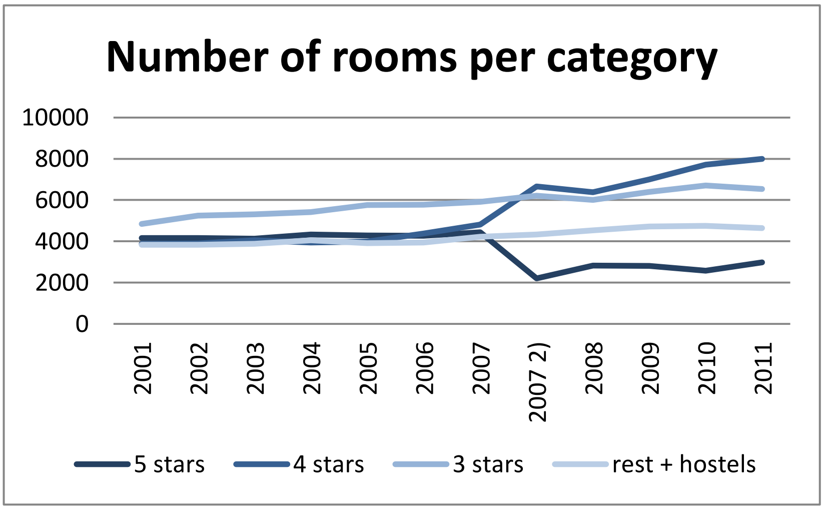


Figure 2.10 – Number of rooms per category

It is safe to say that the focus of adding hotel rooms should be in the 1, 2 and 3 stars category. However, the growth expectance of the hotel market, as researched by Horwath HTL (2011) and published in the Nota Hotelbeleid 2007-2010 is a 4% annual growth rate until 2015 with not many differences along the categories. We can see that from the table. The growth rates are calculated with a large number of variables that include variables such as the type of guests, their origin, the classification preference of people from certain countries, the number of guests in the past and the reason for travelling. The method of calculation of Horwath HTL is not elaborated upon in the thesis.

	Segmentation				Annual growth		
	Business	**Leisure**	**Total**		**Business**	**Leisure**	**Total**
0-2 stars	12%	88%	100%		3,5%	4,5%	4,4%
3 stars	36%	64%	100%		3,5%	4,5%	4,1%
4 stars	59%	41%	100%		3,5%	4,5%	3,9%
5 stars	72%	28%	100%		3,5%	4,5%	3,8%
Total	***46%***	***54%***	***100%***		***3,5%***	***4,5%***	***4,0%***

Table 2.5 – Segmentation and growth of hotel market Amsterdam

With the growth rates as seen above we can say that any solution of the hotel problem should be along all categories.

Segmentation hotel market

Segmentation of the hotel market is clearly visible in Amsterdam. The current hotel stock can be arranged according to their NHC classification and to the target group they're aiming at. The higher star classifications are often used by business travelers and the other classifications by tourists. What seems to be a very important key aspect is the location. In a report of Deloitte (2006) there has been stated that 97% of the touristic and 93% of the business guests make their choice of hotels based on location. With the segmentation in class and type of guests there can be made a distinction of a number of hotels, the two most important for cities being discussed here:

Business travel hotels – These hotels are mainly for guests traveling on business trips. The locations of these hotels are particularly important since traveling distance between hotel and office should be as short as possible. Also, within the hotels it's recommended to have certain business-oriented facilities, such as Wi-Fi-connectivity, free local calls, auditoriums and meeting rooms/conference rooms.

Touristic hotels – These kinds of hotels focus on guests staying to see the attractions in the surroundings. The location of these hotels should be close or in the touristic attraction and is recommended to have a number of facilities in order to be successful, such as family rooms, a swimming pool, a gym and a restaurant. This type is a very broad type of hotel types and can be narrowed down to family hotels, youth hotels, luxury hotels and budget hotels.

An important note to make is that hotel brands are very important in terms of success rate. Hotel brands mostly have an efficient cost reduction policy and generally have a higher RevPAR, which is the revenue per available room (Tensen, 2011). Different hotel brands aim for different segments of the market, such as Crowne Plaze (aiming at business travelers) and Travelodge (aiming at beach vacations). There are also hotel brands that aim for more than one segment, such as Hilton Hotels and Best Western International.

Any segmentation can be done on a lot of variables that can be divided into four main categories:

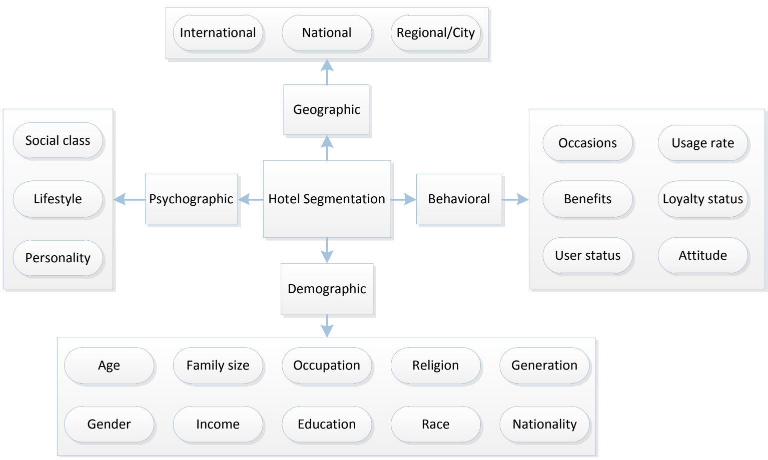


Figure 2.11 – Segmentation of hotel market

geographic, demographic, psychographic and behavioral segmentation, each of them consisting on a number of aspects. The aspects are mentioned but not worked out, since the level of detail this brings is not within the scope of the thesis.

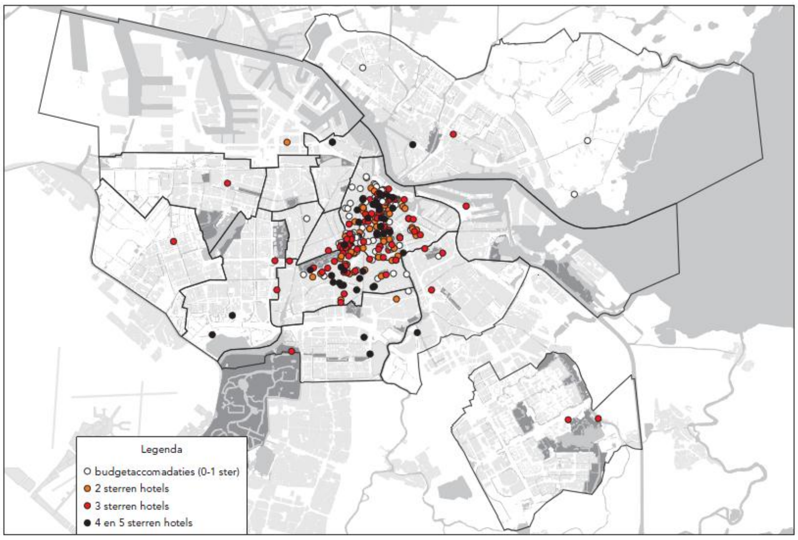
2.2.3 Potential locations hotels

Now that we know how many hotels there are and in what category to place them, the locations of these hotels are also of importance. The location of hotels is a critical point in the success of a hotel business. This brings a problem; there are no available good spots to create a hotel anymore in the city of Amsterdam. Hotel entrepreneurs are eager to start a business in Amsterdam but can't find a suitable location. A suitable location needs to satisfy a number of criteria (Horwath HTL, 2011):

- Hotel development is allowed by the municipality
- Ground/location is available on short term
- Accessibility or visibility from Schiphol and the local freeway
- Public transport to the city center on walking distance
- Local businesses act as demand generators (business hotels next to businesses)
- Experience local environment on walking distance
- Parking possibilities

These criteria are not go/no go criteria, meaning an entire plan will not get shot down when one of these criteria is not met. For instance, when a hotel is within the city center, a prime location, the parking possibilities are of lesser importance, unless of course the hotel plans include a state of the art 5 star hotel.

In order to see where the current hotels are located and where the new hotels are being developed we have two maps of Amsterdam.

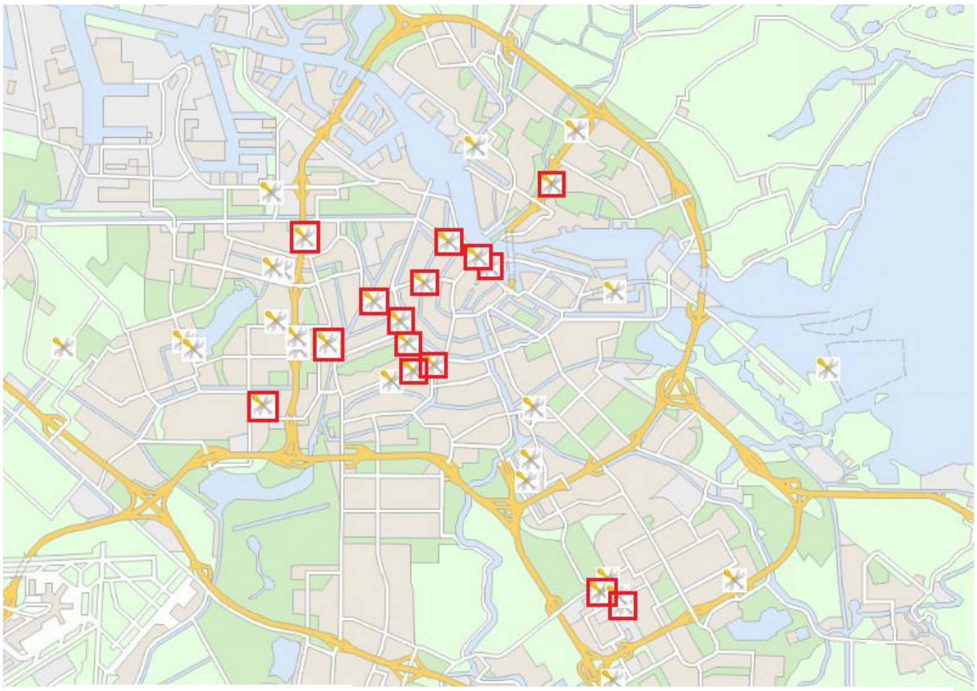


Source: Amsterdam O+S

Figure 2.12 – Current locations hotels

On the first map, from the O+S of the municipality of Amsterdam we can see the spread of hotels in Amsterdam. We can clearly see that most of the hotels are in the center of Amsterdam and in "Zuid" a very good area of Amsterdam. The second map shows us all the hotels under development and highlighted which ones are the transformations.

Now that we know what an area needs to have in terms of criteria to maintain a successful hotel, we can outline the potential locations for hotels. From the research of Horwath HTL (2011) the following areas are outlined with the reasons of potential.



Source: Hotelloods

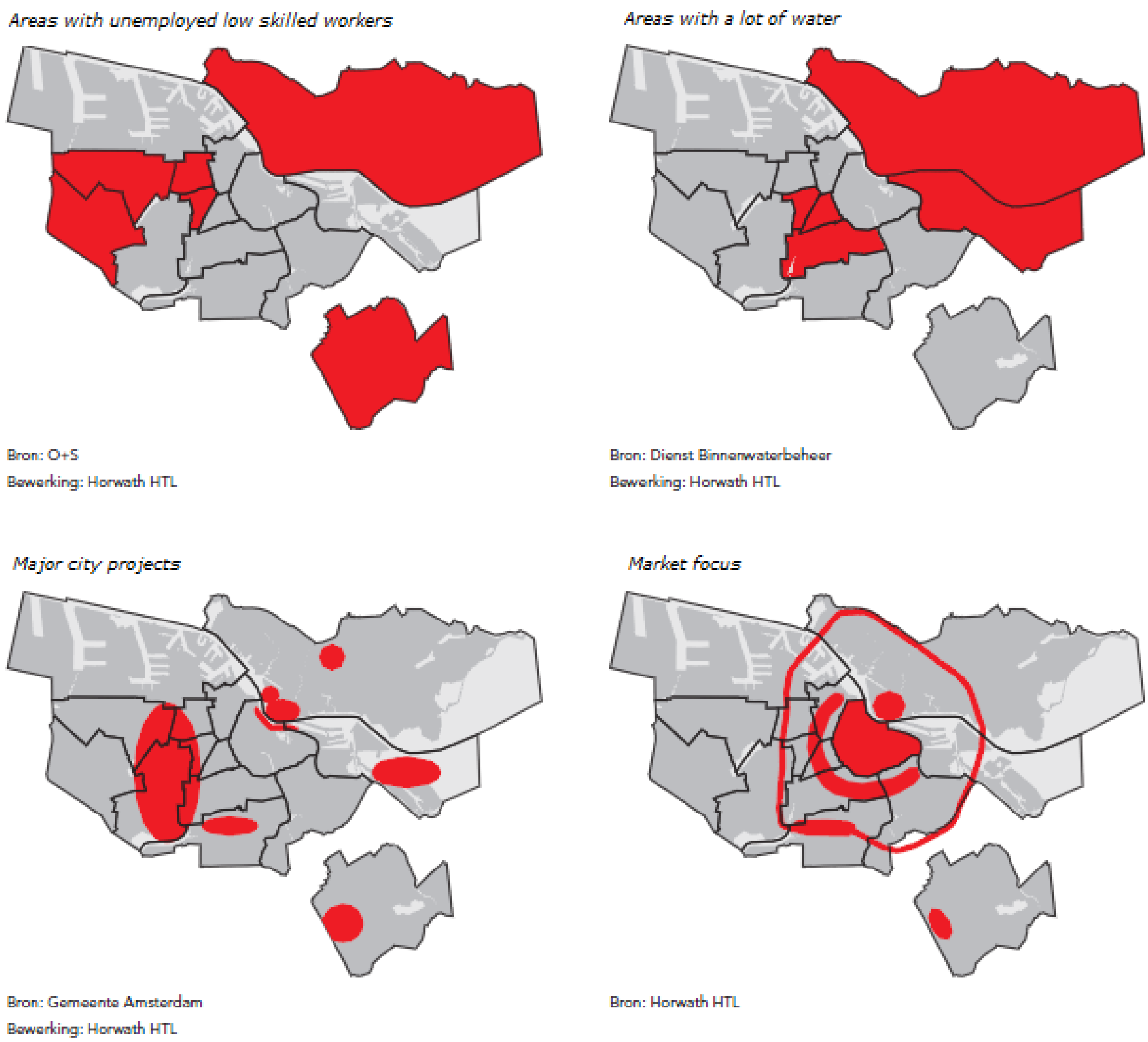
Figure 2.13 – Hotels under development (red are transformations)

Areas with unemployed low skilled workers – These areas house more unemployed low skilled workers than other areas and thus have more benefit with the jobs hotels create. Working in hotels is more low skilled labor than high skilled labor.

Areas with a lot of water – These areas are suitable for hotels on water (Horwath HTL, 2011), but also bring a suitable and nice environment to be experience, one of the criteria mentioned before.

Major city projects – Major city projects will expect to give a potential area for hotels. These major city projects are being realized by the city and not by a district and with a "building envelope". In this building envelope there is a mentioning of functions and their surfaces and is less strict than a list of requirements usually worked with. This gives the municipality the freedom to emphasize the hotel market and get the major city project developers involved into the hotel sector. (Horwath HTL, 2011)

Market focus – The areas with the highest potential as seen by the hotel market. These areas are the highest potential areas to realize a hotel. It includes the city center, a ring around it and next to the highway (good accessibility/visibility).



Source: Horwath HTL

Figure 2.14 – High potential locations hotel

The locations where the current hotels are, are now known and in addition to that the high potential locations to start a hotel business. As stated before, Amsterdam is in need of 7500 new hotel rooms within the scope of 2009 till 2015. From 2012 to 2015 there is still a need of around 3000 new hotel rooms. In section 2.3 the current office vacancy stock is discussed and cross referenced with the potential areas for hotels in this section.

2.2.4 Hotel requirements

As already mentioned in section 2.2.2 and 2.2.3 each hotel has to meet certain requirements and certain criteria in order to be able to get and stay into the hotel business. If requirements or criteria are not met than there is a high risk of failure of the hotel.

Requirements to open a hotel are to meet the requirements of at least a one star classification in the "Nederlandse Hotel Classificatie". These requirements are stated in a shorter form in the table in section 2.2.2 and come from the branch organization. Each star category has a separate list of requirements in the hotel standards list. For the one star level they are all obligatory, for the higher stars there is a division between obligatory requirements and optional requirements. For these star levels there have to be met a total score based on the obligatory + optional requirements. (Bedrijfschap Horeca en Catering, 2012)

The criteria location-wise in order to have a successful hotel are discussed in section 2.2.3 and include the following criteria:

- Hotel development is allowed by the municipality
- Ground/location is available on short term
- Accessibility or visibility from Schiphol and the local freeway
- Public transport to the city center on walking distance
- Local businesses act as demand generators (business hotels next to businesses)
- Experience local environment on walking distance
- Parking possibilities

The next section will elaborate more on the criteria and the thresholds they bring.

2.2.5 Thresholds in hotel transformation

The reason not every empty office building is transformed into hotels, or hotels are popping up in every corner of Amsterdam is because of a number of thresholds. There are juridical, financial, organizational and technical thresholds.

Juridical – Transformations are only feasible if legally possible. To be legally possible any transformation needs to be in accordance with the zoning plan described by the municipality and the building code.

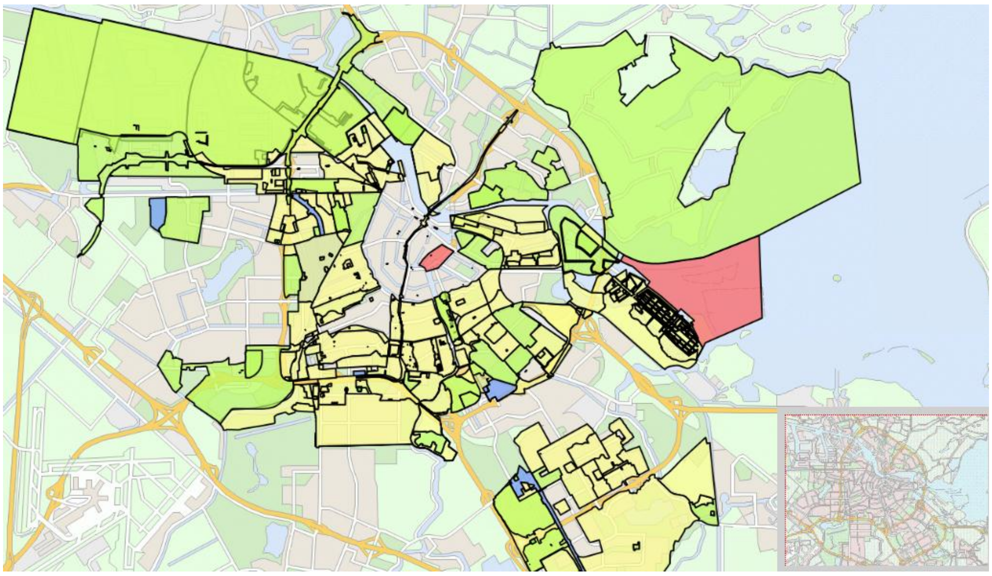
Financial – The costs and benefits of a transformation from a vacant office function to a hotel function is very important. The feasibility depends on the financial aspects, since this is a key point to convince an owner or municipality to change functions instead of leaving the building as it is.

Technical – The technical possibilities of the current building need to be clear in order to change functions. New functions, hotels, have different technical requirements than office functions. These are described in the building code.

Functional – Functional thresholds include building characteristics such as lay-out of the building, position of staircases and usability of the basement.

Juridical

In Amsterdam there are a lot of zoning plans, every district has different zones in which there has been made a planning. These zones all have different sizes and different functions. A map is given with



Source: Gemeente Amsterdam

Figure 2.15 – Zoning plans Amsterdam

different zones and different zoning plans of the municipality of Amsterdam. The different colors don't necessarily mean irrevocable planning. What's also the case in this figure is that it's not complete yet. Every part of Amsterdam has a zoning plan, but in the figure not every part has a color. The colorless parts also have a zoning plan but they are not accessible at this time. (Gemeente Amsterdam, 2012b).

All zoning plans are made into a digital model, called IMRO. The different colors are the different versions of IMRO, the 2003 version being red, 2006 being yellow and the 2008 version being green. All these zoning plans are accessible, but not all of them are reversible or adaptable. When looking at the vacant buildings in section 2.4 the zoning plans are also of very high importance.

The building code is the second legal aspect that has to be taken in account. All building in the Netherlands have to meet the requirements that are in the building code. All transformations have to apply to NEN8700 which is called "Assessment of existing structures in case of reconstruction and disapproval - Basic Rules". This norm has a number of requirements and demands to the transformation. Together with this norm there should also be accounted for the difference in all sorts of requirements that are different for offices and hotels, such as ventilation, floor heights, fire protection and so on.

Financial

Financial feasibility is often the reason the transformation is not applied in practice. Two worlds collide over the same building, each having calculated their own value for the building. The owner of a building is calculating the value of his building in residual land or building lease value while the investor (who buys the building and transforms it) is calculating the value of a building on future expectations. A large amount of transformation studies to specific building end with the conclusion that it's not feasible because the two values are too far apart (Gelinck, 2007).

A transformation can be seen as giving up the current function of the vacant building, to give up the reason it was meant to be built. This on one side is a huge threshold since the owner of the building is not keen on changing functions, due to the insecurity it holds. The insecurity comes from the financial point of view, the (fictive) financial security in the current state versus financial insecurity in the new state. Meaning that in the current situation an owner of a vacant office building has rent of €507 (Gemeente Amsterdam 2012a) per m^2 per year in Amsterdam, a total value of the building and a value of the lot. When the function changes these values change, especially the rent per m^2 and the total value of the building. Value of the lot of the building is not changing.

However, when the building is vacant, or parts of the building are vacant, the rent per m^2 is only applicable in theory, meaning it's not the actually money gained from rent, since there is no tenant. In this case the owner is losing money, but still has a certain building value in his financial books based on the rent per m^2 and the building and lot values. There is a difference between the financial value in the books and the actual value in practice. (Hek, M. et al., 2004)

The reason an owner doesn't want to apply the transformation is because the value of the building and the rent per m^2 with the new function is lower than with the current function. Not taking into consideration that with the new function he will get rent and actual money in his pocket. With the adding of a function where there is a demand for of course, such as residential or hotels. The reason the rent per m^2 is lower is because of the difference in floor area. With offices the calculation is done with the lfa, which also includes the surfaces from the hallways, the staircases and the storages, hotels are calculated per room. Hotel rooms in Amsterdam have a certain room occupancy rate and an average room rate. This can be translated into a value per m^2.

If we do an example calculation of a hotel in Amsterdam we could use the following numbers. A room is on average €124 and has an average occupancy rate of 72% in 2011 (Gemeente Amsterdam, 2012a). We assume a 15% housing costs where the budget for transformations, renovations and so on come from (Van Spronsen & Partners, 2010). If we assume that a 3 star hotel is taking over the vacant office building with a 17 m^2 room size than we can say that the income of a hotel is equal to:

$$0{,}15 \cdot \frac{€124 \cdot 72\% \cdot 365}{17} = €288\ per\ m^2 per\ year$$

However, as just mentioned, the number calculated above for hotel rooms, have a different meaning than the ones of offices. With the lfa all surface areas from staircases, hallways and storages are also calculated and sold as €507 per m^2 per year. With the hotel surface area only the rooms count towards this number and not the hallways, entrance lobbies and all other parts of the hotel. This will account for a large difference; differences from 20% to 40% are not unusual (Gelink, 2007).

A budget for transformation can be obtained by the difference between the current value (total m^2 lfa x price per m^2) and the value after transforming (total m^2 rooms x price per m^2). In order to compete with new constructions there are a number of possibilities listed (Gelink, 2007). These are divided into two categories, one only the building or project and the other the area oriented approach.

	Building level	Area level
Increase revenue	Adding a number of floors on top of the building, this is possible due to the higher calculated floor loads for offices as opposed to hotels	When adding floors is not a possibility sometimes there is a possibility for generating income in the area
	Creating a unique concept can act as a booster or igniter for the building or area	Tackling a number of partly vacant buildings can lead to one whole vacant building available for a change in function
Save expenses	Investors sometimes have more ties with area than financial, e.g. pension fund local company	Deployment of capital from investors to reduce capital costs for municipal warranty
	Maintain building parts, such as façade and staircases	Reduce book values based on cash flows from temporary operations
	Building code offers room for creative solutions and exemptions	Value loss of one building can be compensated with profit from another building
	Temporary transformations	
Agreement investor, developer & municipality	Agreements between parties in risk management often translate to lower costs and in higher selling prices	Right to build new offices connect to remittance for vacant buildings
	Tax-friendly delivery; connect the moment of delivery to the delivery to the new buyer	
Subsidies	Subsidy for functions needed by the municipality is often negotiable or available	Location based subsidies are also often available

Table 2.6 – Possibilities to compete with new constructions

A different option to make transformations feasible is the scope of this Master thesis; to use prefabricated units with low costs and to apply them into vacant office buildings, thus changing the function and generate income. Chapter 3 will elaborate further into this and into financial numbers when a number of buildings are chosen for the design phase.

Technical

Technical feasibility is highly dependent on the building itself and the characteristics of the building. A number of characteristics are summarized here. (Remøy, H., Jong, P. de, 2011a) What needs to be noted is that each of the characteristics is increasing the potential of the transformation and the lack of a single requirement doesn't make the transformation impossible.

No load bearing façades – The façade's primary function is to divide the inside with the outside and to be the face of the building. The façade is built up in a way that it meets the requirements and demands of the function the building holds. When the function (and thus the requirements) changes, especially with structural vacant buildings, there might be a higher need to change the façade as well. If the façade is load bearing it can't be changed, this is an unwanted situation.

Good technical state of the construction – The construction itself, all columns, beams and floors need to be in a good technical state in order to span another 20 or 30 years of service. With a new function there could be a new demand for a certain lifetime.

No pre-spanned prefab floors – Pre-spanned prefab floors pose a problem when transforming the building into a new function. Usually there is a need for more perforations in the floor, for sewage pipes, elevators and staircases. When a perforation is made in a pre-spanned prefab floor it loses strength.

Removable and/or adaptable façades – Removable or adaptable façades make it very easy to change the façade. For a new function the higher (or different) demands can be met with a new façade that can replace the old one.

Possible reuse or refit of installations and shafts – The installations in structurally vacant office buildings are assumed to be outdated and are only usable for the office function. However, there are opportunities to reuse or refit a part of the installations. Whether or not this is possible is very dependent on the building, what kind of installations there are present and in what state they are.

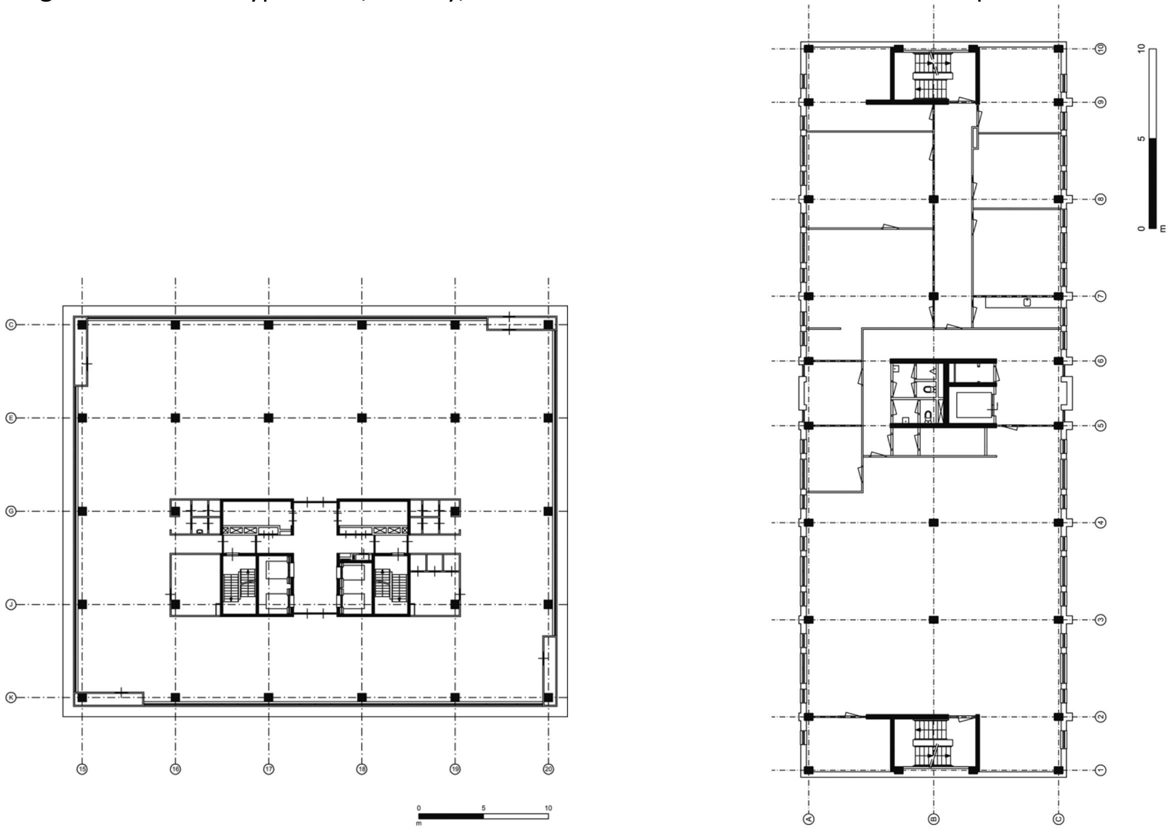
Possibility for horizontal extension – Horizontal extension meaning there is a possibility to add building parts in the horizontal direction. This can only be done if the municipality agrees and there is enough room for it.

Possibility for vertical extension – Vertical extension meaning there is a possibility to add building parts on top of the current building. This will result in more floor area that generates more income.

No integration of structure and installations – Integration between structure and installations will become very problematic. Installations, as described above, are assumed to be outdated and not in a good condition, so there is a need to remove this. The structure has to be maintained the way it is. When there is a integration between something to remove and something to maintain it's either impossible to divide or very costly.

Functional

Functional feasibility include among others, the structural grid of the building, the layout and the usability of basements. These building specific requirements increase the potential of the transformation and all buildings should be categorized with these functional aspects.
Structural grid – There are two main types of structural layouts, the central core tower type and the single corridor slab type. Each, usually, have standardized measurements of multiples of 1.8m.



Source: Remøy, H., Jong, P. de, 2011

Figure 2.16 – *Typical floor plans*

Position of entrances, stairways and elevators – These differ from the single corridor type to the central core type. With the single corridor there usually is a central elevator and two corridors along the length of the building to two extra staircases. The central core type has a corridor along the core and two staircases and elevators are all within the core.

Daylight admission – the daylight admission is different for office functions than it is for hotel functions. For hotel functions there are no specific demands for daylight admission (BRIS, 2012).

Possibility of attaching interior walls to the façade – In the design phase there will be made prefabricated hotel rooms for use in vacant office buildings. The type and extent of prefabrication may ask for a sound insulated attachment or connection of the interior walls with the current or new façade.

Basement usable for storage or parking – As seen in section 2.2.4 there is a need for parking possibilities and when a hotel for higher star categories are being developed extra room for additional functions. The possibility to use the basement for parking or a different function could be a very positive outcome.

2.3 Vacant office buildings Amsterdam

This section is about the current vacant office building stock in Amsterdam. In the first part all characteristics of the buildings will be compared which will be discussed and after that filled in as much as possible in the entire list of vacant office buildings. The second part will be a summary of how many buildings are actually structurally vacant and what part we can use for a hotel function based on the location and characteristics.

2.3.1 Characteristics

Not all buildings from the vacant office list of Amsterdam are usable for hotels. A lot of buildings are not in a location in which the hotel can be successful or have the needed characteristics to be converted into a hotel. The vacant office buildings list is filtered using a number of criteria, a number of which were also mentioned in the sections before.

The general characteristics are the first scan; this will define if there is structural vacancy and if there should be a solution in transformation. If the first scan meets the criteria of transformation as a solution than a second scan can be done in the form of location characteristics. The location characteristics will decide whether or not a vacant office building is in such a location that the expectation is that it will succeed, in other words a potential area for hotel. If this second scan shows that a structural vacant building is in a high potential area the final scan can be done in the form of building characteristics, this will prove that an exact building is suitable for transformation to a hotel function.

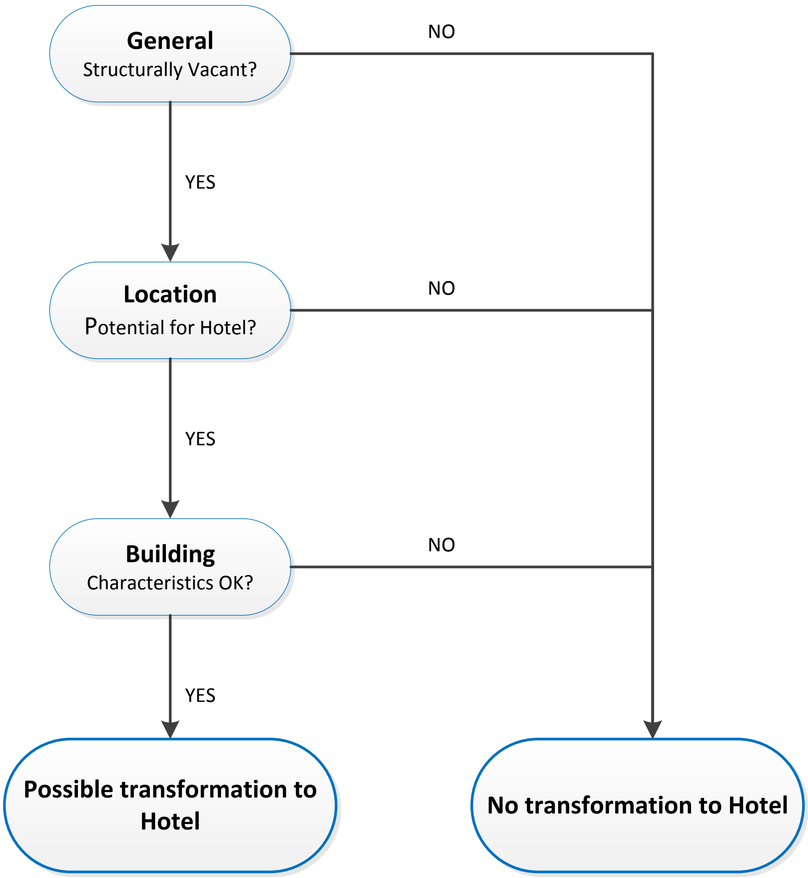


Figure 2.17 – Steps through characteristics to decide if transformation is feasible

General

General characteristics are the input of the first scan of the vacant building stock of Amsterdam and include building information, such as the year the building was completed, the number of years it's vacant and the percentage vacancy of the building.

The year of completion plays a role in the first scan of looking at suitability of buildings. Buildings need to have a certain state of the construction and need to span another lifetime with a different function. What is also of importance is that through time different methods of constructing an office building were being used. This will be elaborated upon in section 2.7 at the building specific characteristics.

The year of completion also comes back at the definition of structural vacancy and deciding whether or not the building is eligible for transformation.

The number of years that a building is vacant is important to identify if the building is structurally vacant and is eligible for transformation. Different types of vacancy were discussed in section 2.1.3 and concluded from there was the definition of structural vacancy, which is:

"The buildings that are vacant for 2 or more years and built before 1990 and the buildings that are vacant for 3 or more years and built after 1990." (DTZ, 2008)

The percentage of the building that is vacant is used in order to find out which part of the building are usable and whether or not the building is usable at all. It might be the case that any hotel owner wishes to have the building solely for him and not share it.

The last general characteristic is the gfa of the current office situation. This decides what value the building or part of the building has at this moment and if transformed, what the new value will be. All buildings will be described according to these general characteristics and from this the structurally vacant buildings can be extracted.

Location

As described in section 2.2.3 a number of locations for hotels are particularly interesting. These include areas with unemployed low skilled workers, areas with lots of water, major city projects and the tourist attractions like the city center.

The unemployed low skilled workers are the workers that are needed in hotels. Areas where these people are available have a higher potential than areas where they don't live. The water-rich environments have a higher potential for hotels because of the planning of hotels on water, but in the same matter, give a higher visual attraction for hotels on land.

Major city projects are large projects with multiple functions spanning a larger area of the city in question. The difference with smaller projects is that the city is realizing the projects and not a district. The use of so-called building envelopes, which give direction as to how many m2 will be used for each function, make the project less strict than if the project was carried out with a list of requirements, which is in general more extensive.

The areas that attract the most tourists, or are most convenient for tourists, are the city center and the most visible areas from the major freeway, the A10. These areas give the highest visibility and accessibility in the city of Amsterdam. All the potential locations can also be seen in figure 2.13 in section 2.2.3; a smaller version of this picture is given here. All red parts are the potential locations.

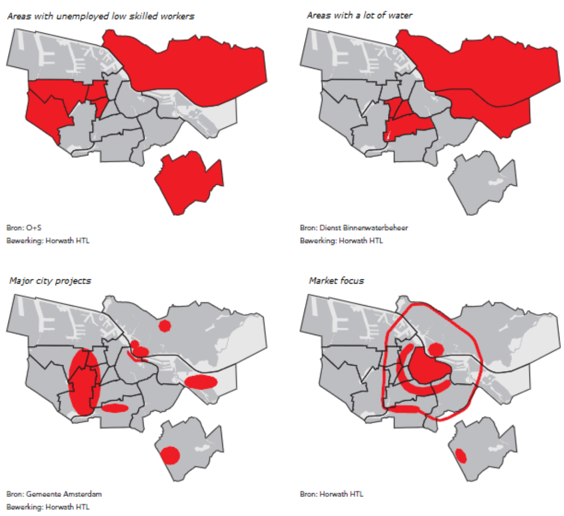


Figure 2.18 – High potential location hotels

All structurally vacant office buildings will be cross-referenced with the high potential areas as described here. They will be given a score of 1 if it's present in one of the high potential areas.

Building

The building characteristics scan is a more thorough scan and the final step in concluding whether or not a building is suitable for transformation to a hotel. Building characteristics include among others the type of grid, type of material, type of façade, placing of the columns and the usability of the basement.

What is very different and important to acknowledge with the building characteristics is that it very much depends on interpretation. In a building there can be columns in the façade and the basement can't be used, but it still can be feasible to transform this building to a hotel. The positive and negative sides to the characteristics will be described without concluding whether or not a criterion is a go/no go criterion.

Structural grid – As mentioned in section 2.2.4 there are in general, two types of structural grids, the central core type and the single corridor type. Characteristic about the central core type is that it has a central core with a structural grid of columns. The typical depth from façade to core is 9m, but differs from 7.2 to 12m. The single corridor type consists of a single corridor of 1.8m with office space of 5.4m deep on one side and 7.2m deep on the other, giving it a total depth of 14.4m. The construction consists mostly of load bearing outer walls and hollow core slabs (Remøy, H., Jong, P. de, 2011). What is found in the same research and literature is that the standard floor to floor height of both type of offices are 3.6m and 4.5m in the plinth.

Material – The material of the building is important to know when transforming the building. Different building materials ask for different approaches, lifespans and solutions. Therefore a division is made into structural materials concrete, steel or timber. The latter is assumed not being used as often for office buildings, but mentioned for completeness.

Plan – There is a distinction between open plan offices and plans with interior walls. Interior walls need to be accounted for and need to be demolished before a transformation can take place, or the transformation needs to fit in with the interior walls.

Façade – The façade of any office building can be either load bearing or non-load bearing. This is an important difference since the load bearing façade is not transformable. A load bearing façade would imply that removing or altering the façade will mean (partial) collapse of the structure. The structure needs to be intact for a transformation. Transforming the interior without changing the façade will not solve problems, since the façade is assumed to be old and not meeting standards of a different function than it currently has. From a transformation point of view it is safe to say that load bearing façades are harder to transform and non-load bearing façades can be more feasible to transform. Load bearing façades were becoming increasingly popular in the 1980's (Bennenk et al., 2010). When the façade is non-load bearing than it becomes increasingly attractive to transform when the façade is easily adaptable, replaceable or even better demountable.

Columns and floors – Buildings from the 1960's and 1970's form the biggest part of the vacant office buildings (Remøy, 2011b). Columns and floors were designed in two very distinctive ways in the early 70's; a floor which rests on columns inside and with an edge beam along the façade and a floor which rests on columns inside and a cantilever along the façade. The downside to this is that the floors are rigid and there can't be heavy walls placed on top of these. However, the designed floor load for offices is 3 kN/m^2 and for hotels it's lower than that. This does give opportunities to transform.

Columns are also almost always designed on a grid of multiples of 1.8m; grids of 5.4m and 7.2m are common (Remøy, 2007). The possible problem with floors is that floors in these times were pre- or post-tensioned reinforced floors and that they are of a too low mass. This poses problems for vertical transport of vents, ducts, elevators, and so on and the low mass for sound insulation. Problems with the vertical transport through pre- or post-tensioned reinforced floors are not insurmountable and for sound insulation reasons a lowered ceiling can be applied (Remøy, 2007).

Installations – The most important installations in office buildings consist of the elevators, mechanical ventilation and heating. The elevators can and are preferably reused in the new function while the mechanical ventilation and possibly heating are probably all demolished from the building and new installations will be required. Sanitary is also a key aspect, since most office buildings have a central location for sanitary and a kitchen close to the core, in a new function there will be a need for more sanitary than one per floor. Additions and replacement of installations is necessary in a transformation.

Entrance position – The entrance per floor of a building plays a role in the horizontal transport of a building. With the central core grid the entrance is in the core, the middle of the building, with the single corridor grid there are multiple entrances along the length of the floor.

Basement usability – In order to meet criteria as in section 2.2.2 such as a parking garage, extra storage space or secondary functions of a hotel the basement can play a big role. When the basement is already of big enough proportions to serve as a parking garage this can have a positive effect on the feasibility of a hotel transformation, although the regulations regarding parking garages are very strict.

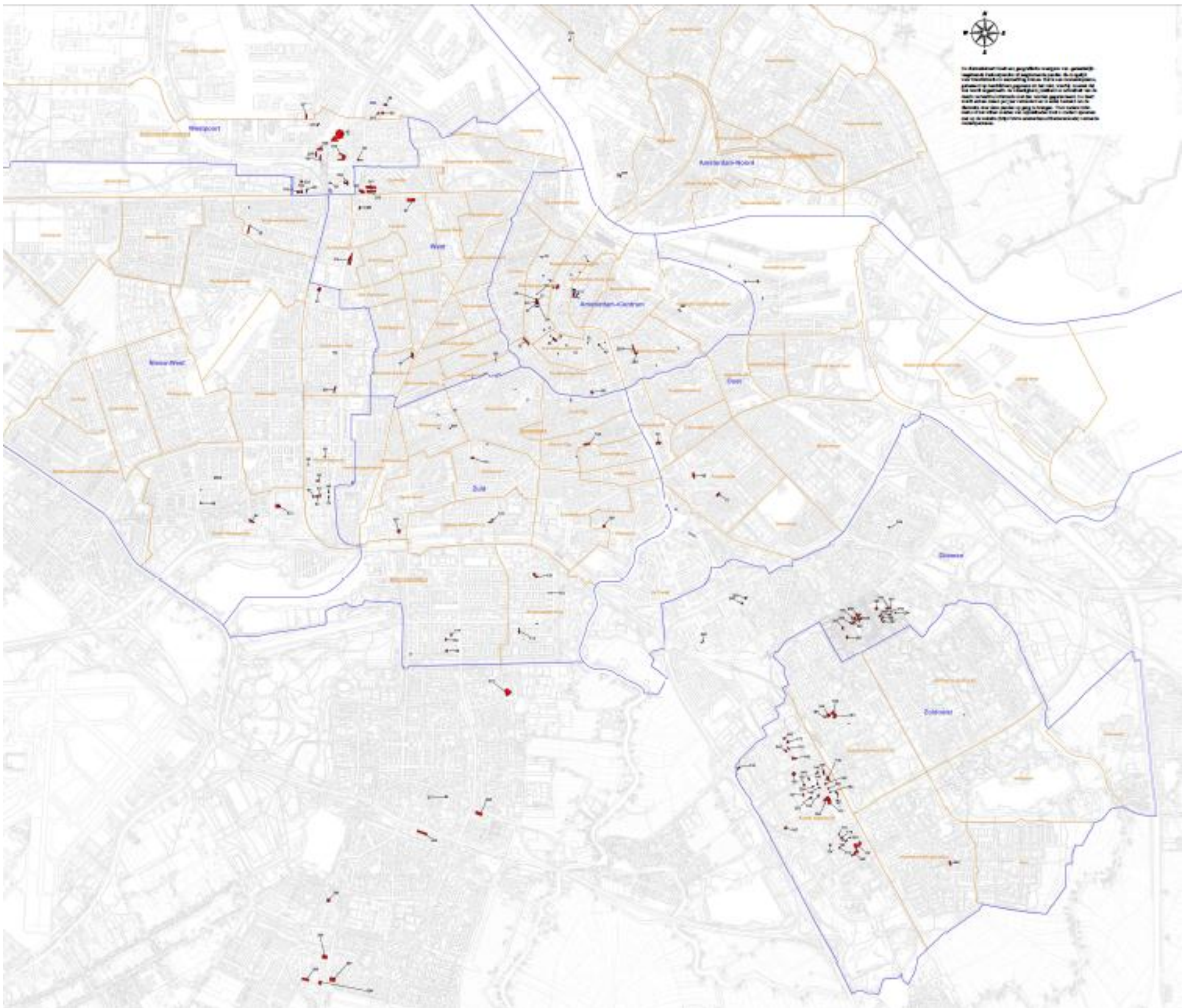
In order to summarize the above building characteristics we can use an adapted table as used by Remøy (Remøy, 2007).

	Stimulating	Obstructive
Structure	Grid size 5.4m or 7.2m High ceilings Columns, open-plan space	Local lower ceiling height due to beams Grid construction
Floors	Calculated for high floor loads	Pre- or posttensioned reinforcement Too low total mass, for sound insulation Fire resistance needs to be higher
Façade	Grid size 1.8m	Keeping load bearing façade very difficult New façade very costly
Installations	More elevators than necessary	Stairwells and elevators take a lot of space Insufficient escape routes

Table 2.7 – Summary building characteristics

2.3.2 Usable vacant office buildings Amsterdam for hotels

In this section the results of the findings in the study to the vacant building stock of Amsterdam is discussed. That will be done in the same order as the previous section; first a discussion and results of the general characteristics, then the same for the location characteristics, and as far as possible for the building characteristics.



Source: Gemeente Amsterdam Kantoremonitor BV

Figure 2.19 – Current locations vacant office space

To begin with there is a total of 140 buildings in Amsterdam that are currently vacant. These can be seen in the figure. The first step to determine is to whether or not these are structurally vacant or not. Out of 140 vacant office buildings there are 115 structurally vacant, meaning they are 3 or more years vacant if built before 1990 or 2 or more years vacant if built after 1990.

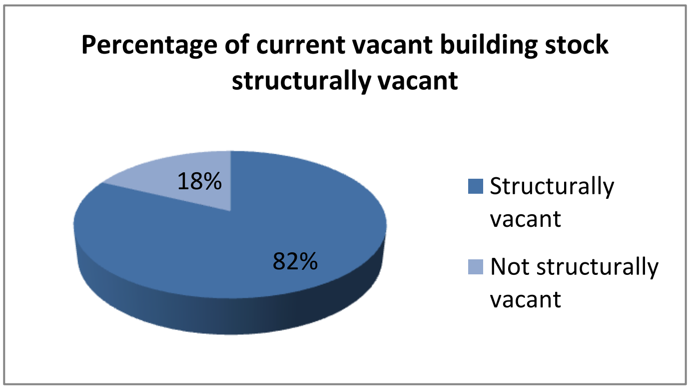


Figure 2.20 – Structural vacant office space

As we can see from the figures above, in Amsterdam there is a total of 82% of the buildings structurally vacant with a total surface area of almost 700.000 m^2. This would mean that on basis of type of vacancy we can already exclude 18% of the total current vacant building stock.

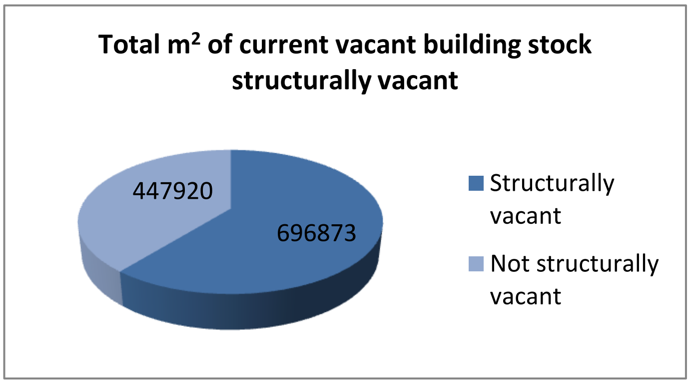


Figure 2.21 – Structural vacant office space

When we look at the correct location for the hotel business, the so called high potential locations we find the following figure (2.20). What we see here is that buildings that satisfy either high potential area criterion is expressed as a percentage of the total structurally vacant office building stock. There are buildings that satisfy more than one criterion and the top bar is the total number of buildings that satisfy one or more criteria. There are a total of 72 buildings out of the 115 structurally vacant buildings that satisfy either one or more criteria.

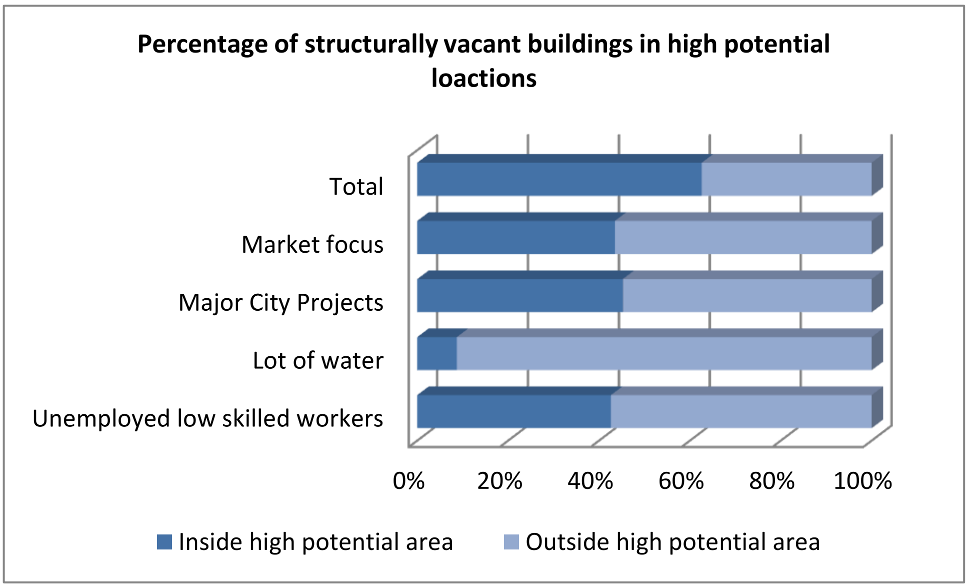


Figure 2.22 – Structural vacant office space by location

2.4 Reference projects hotel conversions

Transforming vacant office space into hotel rooms is a concept worked out a number of times. The idea behind this was always to bring the supply of vacant offices together with the demand for hotel rooms. Projects of this kind are mostly in the vicinity of tourist attraction such as Amsterdam and the surrounding municipalities. Two recent hotel conversion projects will be discussed here, the Holiday Inn Express directly next to the train station Sloterdijk in Amsterdam and the Ramada Apollo Hotel next to the Rembrandtpark in Amsterdam.

2.4.1 Holiday Inn Express Sloterdijk

The Holiday Inn Express Hotel at the station of Sloterdijk is a hotel opened in 2011 in a vacant office building. It holds 254 rooms and 2 conference rooms big enough for 8 people. The developer of the project is the Dutch Hotel Group which is a partnership between TVHG Budget Groep Beheer and Interstate Hotel & Resorts. The hotel relies for a large part on the location, which is directly next to the train station Sloterdijk. From here it's a very fast and easy step to go to both Schiphol and Amsterdam Central.

Figure 2.23 – Holiday Inn Express Sloterdijk

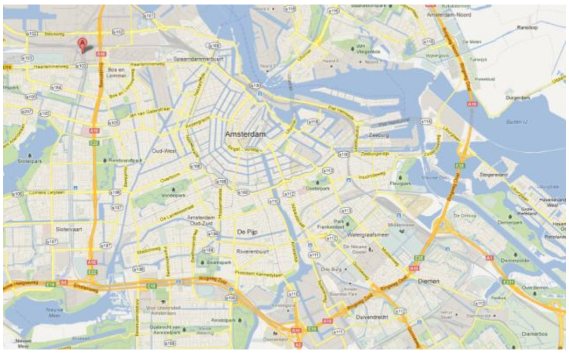


Figure 2.24 – Location Holiday Inn Express

2.4.2 Ramada Apollo Hotel

The Ramada Apollo Hotel has just opened in March 2012 and is 3 star hotel near the Rembrandtpark just outside the center of Amsterdam. The 18 story building holds 446 rooms, 2 restaurants, 6 meeting rooms and a skybar. The building has been transformed by bouwgroep BAM and the owner of the building is Pronam Property Investments.

Figure 2.25 – Ramada Apollo Hotel

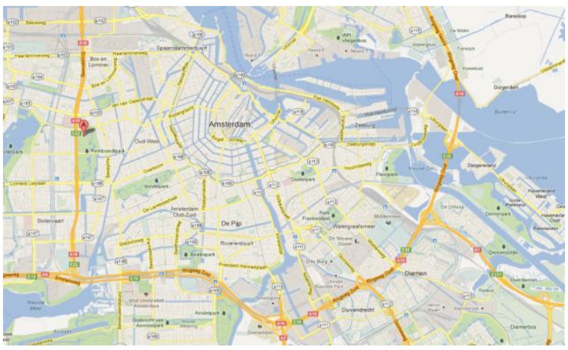


Figure 2.26 – Location Ramada Apollo Hotel

2.5 Calculation methods transformation projects

2.5.1 Introduction

Presented in the sections before is a solution to the vacancy problem, transformation. However, transformation is still not widely used or an attractive solution, because the uncertainties it comes with. Financial, functional, technical, juridical, and organizational problems have to be dealt with in order to make a transformation feasible.

To deal with these problems and uncertainties a number of calculation methods have been developed to gain insight into the feasibility of transformation projects. These methods will all be discussed in the next section (2.6). A quantification method for feasibility of transformation projects can help to speed up and simplify the decision making process making the feasibility directly clear to all parties.

The master thesis will present a new calculation method inspired by the current available computational methods, the method for calculating an Energy Performance Coefficient (EPC) and will be adapted to fit transformation from an office function to a hotel function. A number of expected criteria need to be fulfilled for the calculation method to be successful. These will be discussed in the following section.

2.5.2 Criteria in a Renovation Performance Coefficient

A calculation method for transformation projects needs to fulfill a number of criteria. A number of general criteria are given here. In chapter 4 where the actual Renovation Performance Coefficient (RPC) is developed and explained, elaboration will be upon the criteria with sub-criteria.

With the criteria there is a basis in which to work; from there the development can start. Chapter 4 will elaborate on this topic and discuss the exact criteria and the resulting Renovation Performance Coefficient.

When developing a calculation tool it should give a possibility to:

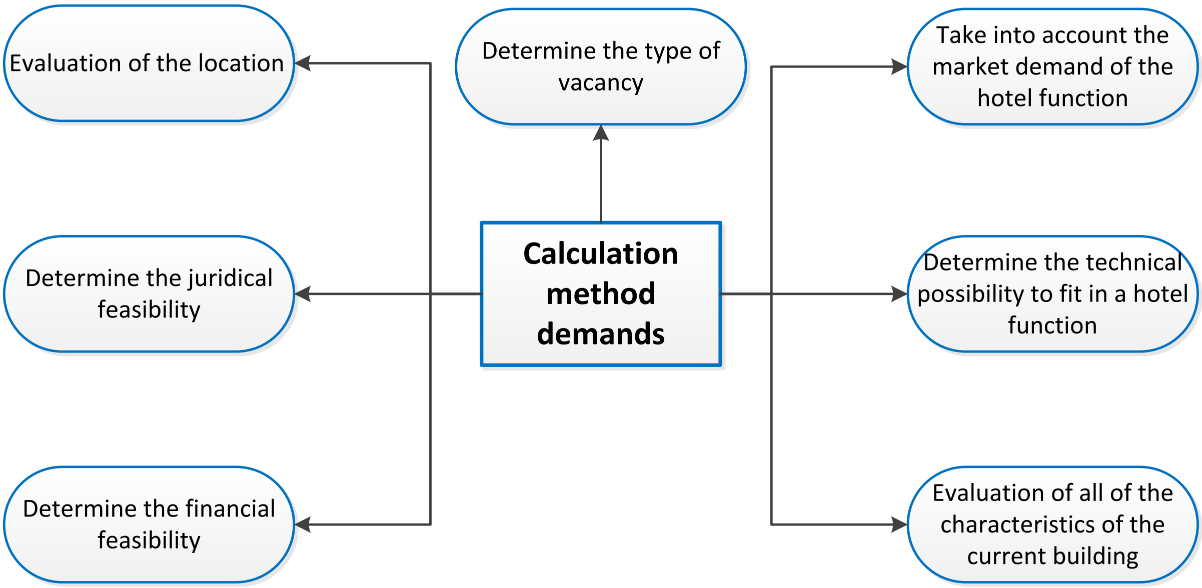


Figure 2.27 – Criteria for calculation method transformation projects

Determine the type of vacancy – The type of vacancy is important for the chance of a successful transformation; longer vacancy gives a higher chance the owner will transform his building.

Evaluation of the location – High potential location, attractive to tourists or business travelers will result in a higher success rate for a transformation to a hotel.

Evaluation of all of the characteristics of the current building – General characteristics of the current building will give a clear first feasibility of the transformation.

Determine the juridical feasibility – Every transformation or building needs to comply with the zoning plans and the building decree.

Determine the financial feasibility – The financial feasibility will be expressed in a positive or negative budget; the current value versus the new value and the cost of the transformation.

Determine the technical possibility to fit a hotel function – Technical specifications of the current building make it possible or impossible to transform to a hotel.

Take into account the market demand of the hotel function – The local market demand of any zone is determining the success of a hotel function in a given location.

With the demands being stated, the calculation method needs to fulfill a number of performance demands as well:

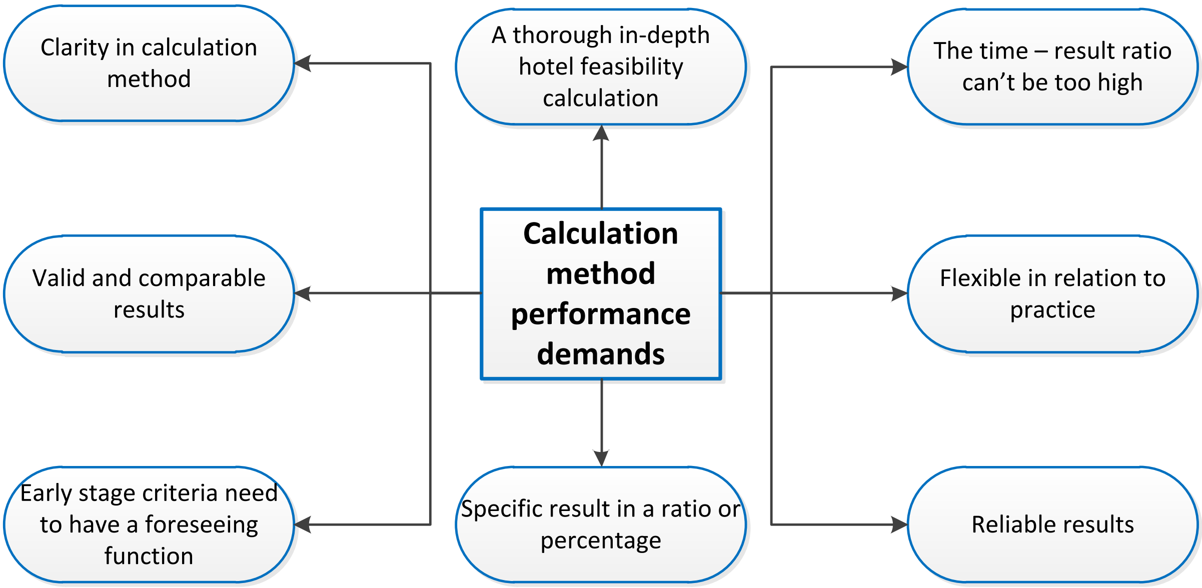


Figure 2.28– Performance demands for calculation method transformation projects

A thorough in-depth hotel feasibility calculation – Results of the calculation should be that it's clear whether or not a building should be transformed to a hotel.

The time – result ratio can't be too high – The time spend on the total calculation should be in relation to the detail of the result; one shouldn't work for days to get a maybe/maybe not answer.

Flexible in relation to practice – In practice no two buildings, nor two situations are exactly the same; certain flexibility in calculation should be held.

Clarity in calculation method – The calculation itself needs to be clear and understandable.

Specific result in a ratio or percentage – The result should be a ratio or percentage from which one can immediately say that the transformation is feasible, costly or unfeasible.

Reliable results – Results from the calculation method should be reliable; it should be able to work as a standard in transformation practice.

Valid and comparable results – Plausible results should follow from the calculation and they should be comparable with other calculations.

Early stage criteria need to have a foreseeing function – Early stage, general, criteria should be able to say in an early stage of the calculation whether or not the transformation is likely/unlikely to succeed or in between.

The first guidelines to make a computational model for transformation projects from office to hotel are stated above. In the following section there will be a discussion of a number of existing calculation methods for transformation projects.

2.6 Reference projects computational models

In order to develop a calculation method for the feasibility of transformation projects there should be studied what other computational models include and what is available in the market. Also important is which models are used in the market and what their specifications are. In this chapter there will be elaborated upon a number of calculation methods for transformation projects.

2.6.1 EPC

The Energy Performance Coefficient is the only computational model discussed that is not specifically for transformation projects. It's a program which is a certified and widely used calculation method for the energy performance of buildings.

The way it works

All new buildings need to satisfy certain energy efficiency demands, which are expressed in an Energy Performance Coefficient (EPC); the lower the outcome of an EPC the better the energy efficiency of the building. For dwellings an EPC of 0.6 or lower is required, for offices 1.5 and for hotels 1.9.

In order to gain a result there are two types of EPC programs, one for dwellings called EPW and one for utility buildings called EPU. The idea behind both programs is the same. All characteristics of a building to be designed or already there are filled in a number of pages.

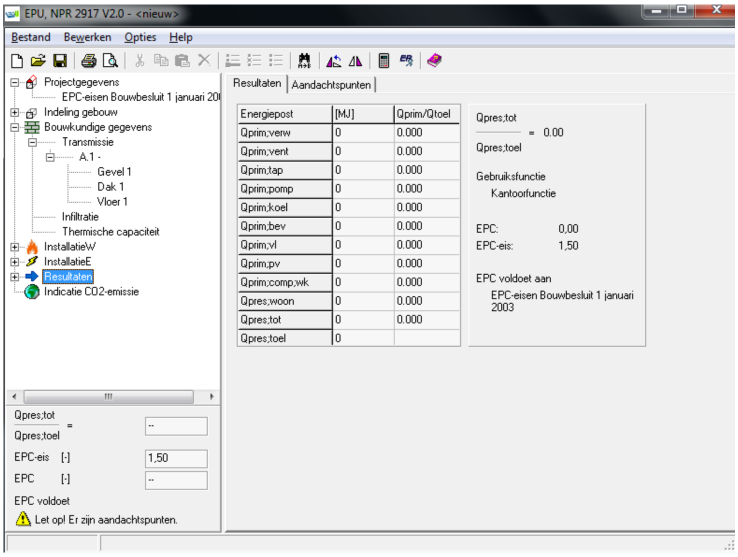


Figure 2.29 – Window from EPC calculation program

Examples of characteristics to be filled in are floor areas, façade areas and orientation, installation types, such as heating, ventilation, cooling and even PV cells. Total lighting watts are also an important aspect in the modeling.

The current method of EPW and EPU will be changed in July 2012 into a new norm called the EPN (NEN7120). The new program works in the same way but is different because of the higher level of detail of climate data and is up to date with the new techniques in installations.

Function	EPC
Residential	
a mobile home	1.3
b other residential	0.6
Meeting	2.0
Cell	
a in building of cells	1.8
b other cell function	1.8
Health care	
a with bed area	2.6
b other health care function	1
Industrial	-
Office	1.1
Lodging	
A in building of lodges	1.8
B other lodging function	1.4
Education	1.3
Sport	1.8
Retail	2.6

Table 2.8 – EPC demands

Results out of the program

Out of the program there follows a coefficient which has to be lower than a certain demand made by the government. The coefficient is based on all energy consumed by all filled in installations and divided by a certain base value depending on the filled in characteristics of the building such as orientation of the glass areas and the surface areas; the lower the coefficient, the better.

2.6.2 Leegstandsrisicometer

The "leegstandsrisicometer", which will be translated as vacancy risk indicator, is an indicator developed by Geraerdts and Van der Voort at the TU Delft and is answering the question whether or not a vacant building or soon-to-be vacant building can maintain his function, with or without renovation. (Geraerdts, R.P., et al., 2007a)

The way it works

The program is divided into 3 clear steps, from the bigger picture to detailed characteristics; the first step being the one with veto criteria. If one of these three veto criteria are met (answer is = "yes") the building has a high chance of being vacant. If all three of the veto criteria are positive (answer = "no") than the second step can be made. The second step has more detailed aspects.

Step	Action	Level	Result
1	Assessment market supply with veto criteria	Location Building	Quick selection of offices; further research necessary or not
2	Assessment market supply with detailed criteria	Location Building	Detailed judgment about the vacancy risk
3	Determine vacancy risk	Location Building	Vacancy risk of the building

Table 2.9 – Steps in vacancy risk indicator

There are 23 location characteristics and 37 building characteristics in the second step which all can be filled in with a certain score; 0, 1, 2 or 3. In this way a number of characteristics can be left out of the results; the characteristics that viewed unimportant by the user filling in the indicator. The score is based on correcting ability. When a certain aspect is not correctable, the score is 1; when an aspect is limited correctable, the score is 2 and when it's easily correctable the score is 3.

Results out of the program

The final step is the results of the vacancy risk meter. All detailed aspects that are answered with "yes" will be multiplied with the given score (1, 2 or 3) and all added up together per type of characteristic. Also a default weighing factor is added to the final step which is 5 for location aspects and 3 for building aspects. These can be changed by the user. The reason that this is done is to make the location aspects of the same importance as the building aspects.
Out of 23 location aspects there can be a maximum score of 23 x 3 = 69.
Out of 37 building aspects there can be a maximum score of 37 x 3 = 111.

This implies that there can be scored more points with the building aspects, making it more important than the location aspects. In order to make this 1 on 1, the default weighing is added, making the scores 345 (location) vs. 333 (building).

Vacancy risk score	Vacancy risk class
Location + Building = 0 – 136	1 = Very suitable for preservation as an office
Location + Building = 137 – 272	2 = Suitable for preservation as an office
Location + Building = 273 – 408	3 = Limited suitable for preservation as an office
Location + Building = 409 – 544	4 = Barely suitable for preservation as an office
Location + Building = 545 – 678	5 = Not suitable for preservation as an office

Table 2.10 – Vacancy risk classes

2.6.3 Transformatiepotentiemeter

The "transformatiepotentiemeter", which will be translated as transformation potential indicator, is an indicator developed by Geraerdts and Van der Voort at the TU Delft and is viewed as the follow-up of the vacancy risk indicator in the section before. The transformation potential indicator is used to determine whether or not a certain vacant building or soon-to-be vacant building is eligible for transformation to a residential function. (Geraerdts, R.P., et al., 2007b)

The way it works

This program is working in rather the same way as the vacancy risk indicator (2.6.2), with a number of steps towards a result. The transformation potential meter is a more extensive version of the vacancy risk indicator and pointed more towards transformation to residences rather than saying the preservation of the current function is not suitable.

The transformation potential indicator is divided into 4 steps, with 2 additional, optional, steps. The first step of the indicator is step 0, where a local market supply analysis is done to gain insight in the local office vacancy. The second step is step 1, which is a step with 8 veto criteria. When either of the 8 veto criteria is answered with a "yes" than further investigation in transforming the particular building is not necessary. If all vet criteria are answered positively, with a "no" than the third step can be made.

Step	Action	Level	Result
0	Assessment market supply vacant offices	Stock	Insight location vacant offices
1	Quick Scan: first exploration; assessment building with veto criteria	Location Building	Quick selection offices; further research necessary or not
2	Quick Scan: Feasibility scan; assessment building with detailed criteria	Location Building	Judgment about the transformation potential office
3	Quick Scan: Determination transformation potential class	Location Building	Transformation class office building; transformation potential building
	Further steps (optional)		
4	Scan financial feasibility	Building	Insight in financial feasibility
5	Checklist risks planning	Location Building	Transformation plan

Table 2.11 – Steps in transformation potential indicator

The third step is the one with more detailed criteria. These detailed criteria include 23 criteria following location characteristics and 28 criteria following building characteristics. There is no score to be filled in with this indicator, just a "yes" or a "no" is sufficient.

Results out of the program

The final step is the results of the transformation potential indicator and all detailed aspects that are answered with a "yes" are added together for each type of characteristic. Again the same weighing factor is used as with the vacancy risk indicator, 5 for location aspects and 3 for building aspects. However, this doesn't even out both types, it makes the location aspects more important.

Out of 23 location aspects there can be a maximum score of 23 x 5= 115.
Out of 28 building aspects there can be a maximum score of 28 x 3 = 84.

Vacancy risk score	Vacancy risk class
Location + Building = 0 – 40	1 = Very suitable for transformation
Location + Building = 41 – 80	2 = Suitable for transformation
Location + Building = 81 – 120	3 = Limited suitable for transformation
Location + Building = 121 –160	4 = Barely suitable for transformation
Location + Building = 161 – 199	5 = Not suitable for transformation

Table 2.12 – Vacancy risk classes

2.6.4 Herbestemmingswijzer

The "herbestemmingswijzer", which will be translated to reallocation guide, is developed by Hek as a Master Thesis at the TU Delft and shows which functions and in what combination they are applicable in an existing building. (Hek, M. et al., 2004)

The way it works

The program is made of several phases and within the phases there will be worked from a general to a detailed manner. It consists of 4 phases, the function selection, the function combination, the layout plan and the financial test.

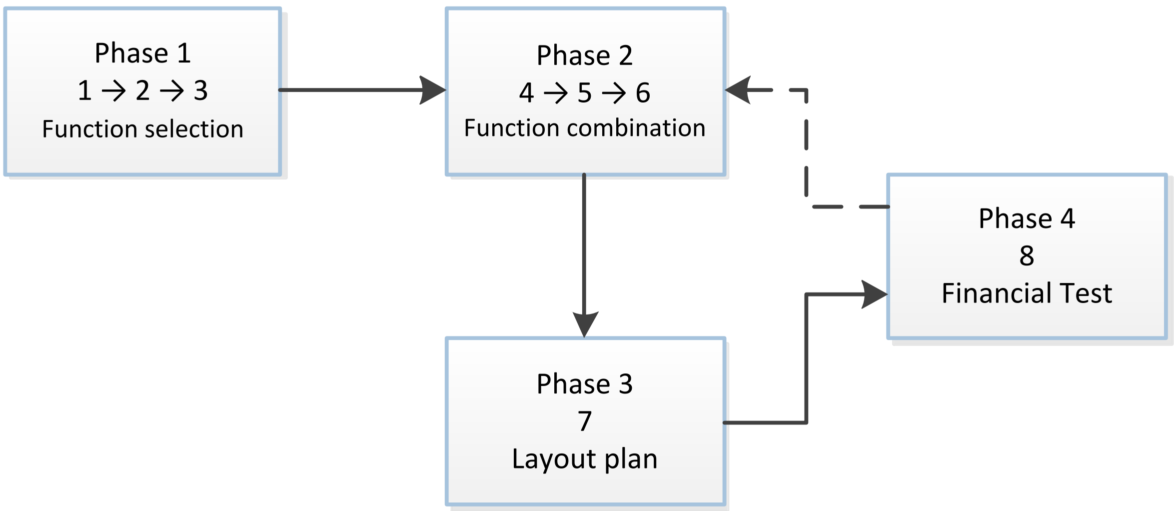


Figure 2.30 – Steps in reallocation guide

The first phase, the function selection phase, there is a systematically progress to select the most suitable functions from a large list of possible functions. The judgment of suitability will be based on location, social, technical, financial and procedural feasibility.

The second phase, the function combination phase, include the combining, adapting and positioning of the functions within the building. Functions will be reviewed on the basis of combined use.

The third phase, the layout plan phase, is the phase where out of the functional combinations from the second phase a number of variants will be made and the surface area divisions, relations and positioning of the different functions will be determined.

The final phase, the financial test phase, is the phase where the feasibility will be determined through a financial test including all the functions of the previous phases. After all these phases are walked through a result will come out of the reallocation guide indicating which function, or combination of functions is best suited at a certain vacant building.

Results out of the program

After all steps in the guide are followed the result is a function or combination of functions best suited in a specific location and certain building. The size of the different functions will follow from the functional layout of the building and the financial feasibility. (Hofmans et al., 2007)

2.6.5 ABT QuickScan

The ABT-Quickscan is developed by a company named ABT (ABT-Consult) and is a more technical approach to transformation projects. The scan doesn't deal with the current market or market changes but focusses mainly on the technical feasibility of a function in a building. The financial feasibility will be dealt with in a final step of the scan.

The way it works

The ABT-Quickscan analyzes six different aspects of a building in the current situation. These are as in figure 2.31 is also shown: the indoors, installations, location, entrances, load bearing structure and the building envelope. With the indoors the finishing on the inside of the building is meant, this can have an effect on, for example, fire safety in the current state. All these six aspects are than assessed on 3 criteria; condition, quality and regulations.

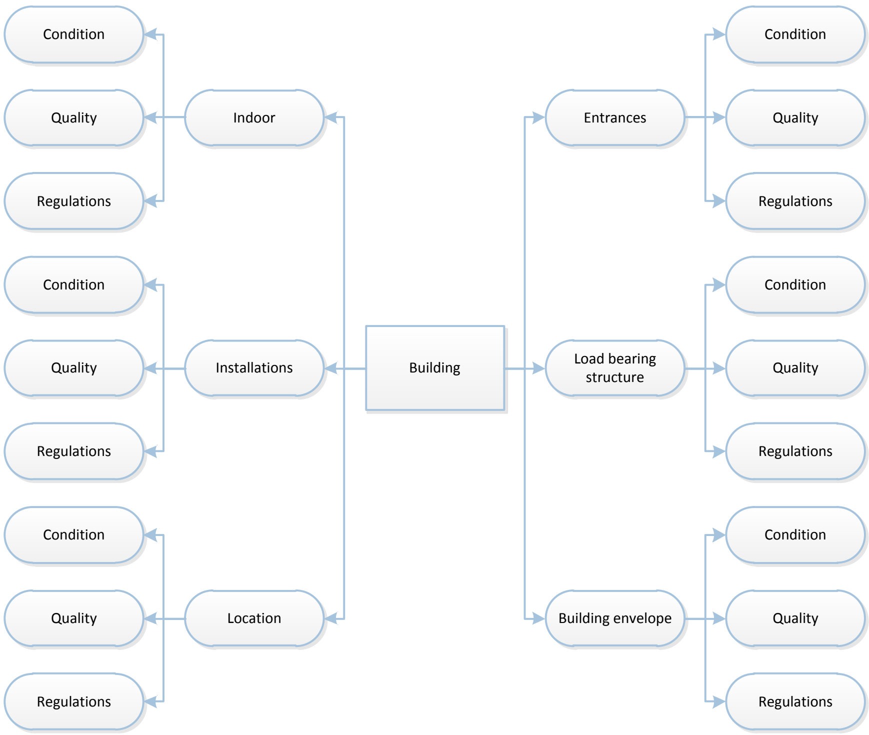


Figure 2.31 – Analysis in ABT-Quickscan

The condition focuses on the current condition of the building, what parts can still be used for another lifetime and what parts need to be replaced. The quality focuses on the possibility to transform, the architectural and cultural value and the emotional value of the building. Regulations are the only aspect that looks to the new function and in what degree the current building already meets criteria of the building decree.

The first step was to measure the current situation as described above; the second step is to value all aspects on transformation. This is done by a functional analysis with 10 possible functions: Residential function, meeting function, cell function, health care function, and industrial function, office function, lodging function, education function, sport function and retail function. These are the functions also used in the Dutch building decree. Each of these will get a value based on a five point scale, so the function to transform to is made clear.

After these steps a financial feasibility is calculated based on the Dutch norm NEN2631. In this norm the financial feasibility is based on the necessary interventions and from there a number of expenditure is given.

Results out of the program

Out of the program follows a score list for each of the 10 functions described above and with the highest score follows the best function to transform to. It will look like in the figure below (Hofmans et al., 2007). After the technical feasibility and the best function to transform to a financial feasibility based on the interventions will show a total picture of the transformation.

Functional Analysis	Excellent	Good	Reasonable	Moderate	Bad
Function	**1**	**2**	**3**	**4**	**5**
Residential function				4	
Meeting function			3		
Cell function					5
Health care function		2			
Industrial function	1				
Office function		2			
Lodging function			3		
Education function			3		
Sport function		2			
Retail function	1				

Table 2.13 – Score list ABT-Quickscan

2.6.6 Cultuurhistorische waardemeter

The cultural and historical value indicator is a tool developed as a master thesis by Van Beers at the TU Delft in 2004. With the tool the historical and cultural value of (parts of) a building is determined (Beers, 2007).

The way it works

The Dutch governmental department of heritage preservation (RDMZ) has made a list of five criteria in order to assess the cultural and historical value of buildings. Each criterion consists of a number of aspects. The cultural and historical value indicator consists of 40 basic components based on the criteria of the RDMZ divided into five criteria.

Criteria	RDMZ	Cultural and historical value indicator
1	Cultural and historical	Landscape
2	Architectural	Urban development
3	Ensemble	Architectural
4	Flawlessness/Recognizable	Social/Cultural
5	Rarity	Historical

Table 2.14 – Selection criteria RDMZ and Cultural and historical value indicator

With the calculation tool the first step will be to score each of the 40 aspects in the list and with that score a weighing based on the importance as viewed by the user. The user has an influence in the importance of each of the aspects. After the scoring has been done also the flawlessness and the rarity have to be accounted for in the tool. A certain score for these two aspects are also added to the equation and all four scores (score of aspect, importance, flawlessness and rarity) will be multiplied with each other to get a total value of each aspect.

The total list of aspects will be added to a matrix of 10 terrain factors and 32 building elements. These factors and elements consist of parts of the terrain, such as public space, nearby water and parks and of elements of the building, such as the roof construction, the façade and the floors. By adding this matrix to the 40 aspects it will become visible where the cultural and historical factors are. All terrain elements and building elements can also be connected to each other if they have a relation with each other in the "roof of the matrix". This is the second step of the tool.

The strength of each relation within the matrix can be shown by adding a factor 1, 3 or 9 to the equation. In the program this is done by adding a color to the cell; yellow is the factor 1, blue is 3 and red is 9. This is the third step and the last one before the results roll out of the program.

Results out of the program

With the scores of the first step and the factors of relation of the third step a total score can be calculated. There is a total score per terrain factor, which is the addition of each aspect score multiplied by 1, 3 or 9 and adding all those scores together per factor. The

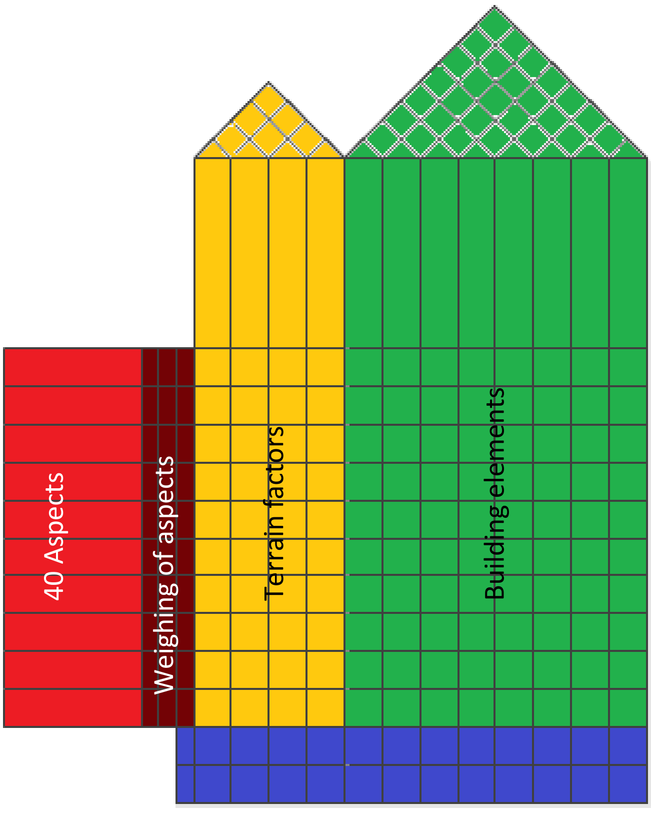


Figure 2.32 – Cultural and historical value indicator

same is done for the building elements. In this way there can be immediately seen which terrain factor or building element is important for the cultural and historical value of the building.

2.6.7 Transformatiemeter voor kerkgebouwen

This tool, the transformation indicator for church buildings, has been developed by Van der Vlist at the TU Delft as a Master thesis and is a tool that focuses mainly on the transformation of churches into other functions (Vlist, 2007).

The way it works

The transformation indicator for church buildings is divided into 5 steps, numbered from 0 to 4. The 5 steps are; the function assessment (0), the building assessment (1), the location assessment (2), financial assessment (3) and the final representation (4). The final representation is a graph with 4 axles; two building axles, a location axle and a financial axle.

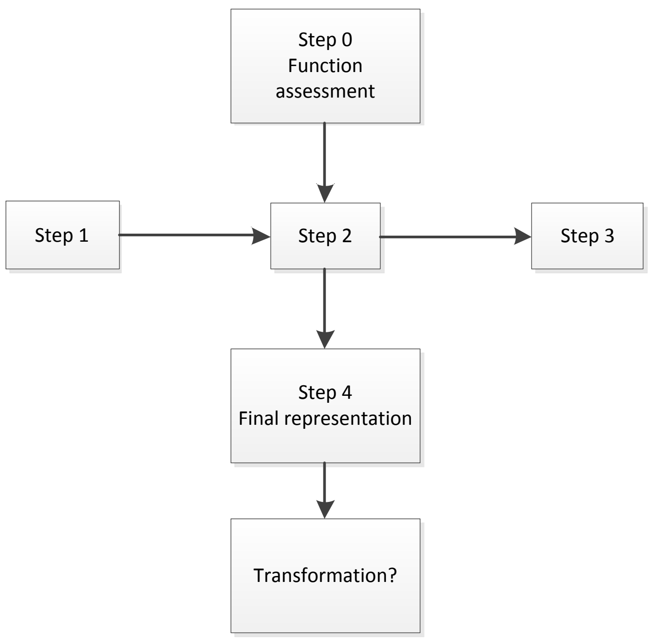


Figure 2.33 – Step by step program

The first step, the function assessment, goes into detail on which function to use in the current church building. In the second step, the building assessment, there will be a distinction into three types of monuments. Each church building will fit into one of these monumental types. The three types are described as; National monument/municipal monument (RM & GM), potential monuments (GM) and others (O). This first axle of the final representation is the one with the types of monuments.

The second axle is one that has the total amount of rentable floor area on it. This is the second outcome of the building assessment. A calculation is done in order to view the total rentable floor area. The third step, the location assessment, is also the third axle in the final representation, and goes into detail in the area that the church is in. Although, as with the function step, not clearly stating how one should choose or calculate, it does offer a series of aspects such as types of residences in the area, demographics and average transaction value per m^2 of nearby buildings.

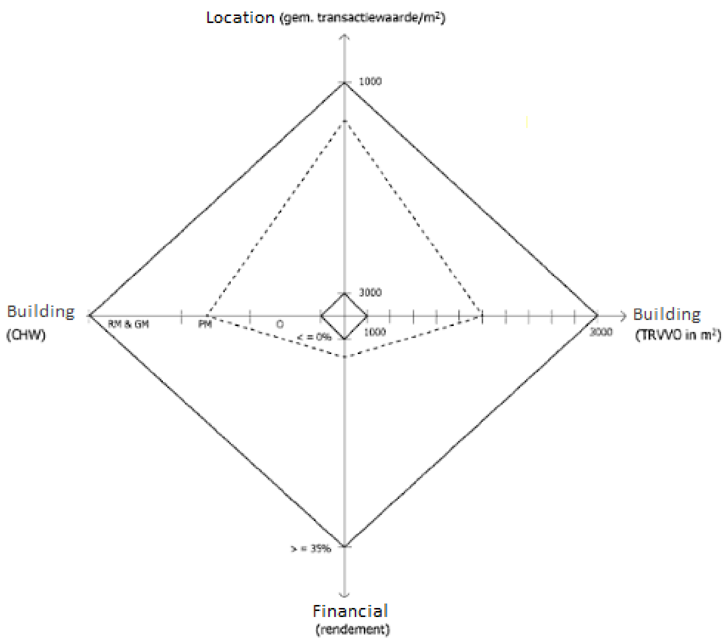


Figure 2.34 – Outcome in 4 axles

The financial assessment is done through a number of factors such as building costs, acquisition costs, subsidies and rental or selling. Out of these factors comes a financial efficiency between 0 and 35%, which makes up for the fourth and final axle of the final representation.

Results out of the program

Out of the previous steps all axles can be filled in and with these four axles the figure arises as in figure 2.34. There will be a maximum and a minimum transformation potential viewed as the dotted line (maximum) and the solid line (minimum. The bigger the figure, the higher the potential is to transform from a church to a different function.

2.6.8 Geloof in Transformatie

Another tool for the transformation from churches to other functions is developed by B.J. Schrieken as a Master Thesis at the TU Delft. The title of his program is “Believe in Transformation”. The focus of his program is making sure all different actors in a transformation project get the same vision. (Schrieken, 2007)

The way it works

The program uses a step by step plan in order to select the best possible function to change a church into, according to the market, location and building properties. The main scope of the step by step program is to work in a systematic way and to give structure in the decision making process. The church will then be assessed by veto criteria coming from the municipality, the market, the church itself, the location and the building properties.

The first phase is a problem definition phase, where the reason for transformation is made clear, the policy is determined by the church and the municipality and a decision making team is formed. These are all steps that can save a lot of time if done in an early stage.

The second step of the program is the analyzing of the building itself. Aspects that are treated here include functional analysis of the building, veto criteria, analyzing new functions, determining the cultural historical value of the building and to make a decision based on the analysis. The veto criteria include criteria based on church policy, the municipality, building and location aspects and the demand out of the market. Analyzing new functions will be done by examining 19 different functions on 47 aspects and giving each function a score, multiplying it with a weighing factor.

Nineteen different functions	
1 Reuse as church	11 Mourning center
2 Reuse as mosque	12 Retail
3 Student housing	13 Large scale retail
4 Youth housing	14 Restaurant
5 Family housing	15 Children day care
6 Elderly housing	16 Disco
7 Small offices	17 Medical center
8 Large offices	18 Gymnasium
9 Library	19 Storage/warehouse
10 Theatre/cinema	

Table 2.15 – Nineteen different functions

$$\left(W_a + CF_{tech} \cdot CF_{time} \cdot (5 - W_a)\right) \cdot W_e$$

In this formula:
W_a = valuation of each aspect (0 – 5)
CF_{tech} = correctional factor for technical possibilities (0; 0.5; 1)

CF_{time} = correctional factor for time (0; 0.5; 1)
W_e = Weighing factor of each aspect (0 – 3)

The next step in the second phase is to determine the cultural and historical value of the building by examining 17 different aspects, scoring them and multiplying them with a weighing factor. This step is done twice, once for the current function and once for each of the new functions. A final number coming out of the process is the conservation factor, which is the cultural historical value in the new function divided by the cultural historical value in the old function.

The third phase is the further development phase, which consists of contract formation, final design and specifications, permit procedures, construction preparation and realization. Within the program itself this is only indicative and theoretical. These are steps that are only descriptive and are not telling in what way the different steps should be taken.

Results out of the program

What comes from the calculations in the second phase, with a series of scores and factor is a table with functions and there calculated transformation potential and conservation factors. An example out of the work of Schrieken is given her and is the result of an analysis of the H Annakerk of Breda.

H. Annakerk	Transformation potential	Conservation factor
1 Theatre/cinema	79.9	83%
2 Student housing	79.6	67%
3 Library	Veto	
4 Youth housing	78.2	67%
5 Small scale offices	77.6	72%
6 Restaurant	Veto	

Table 2.16 – Analysis H. Annakerk in Breda

2.6.9 INKOS

INKOS (INstrument voor Kosten en Opbrengsten Simulatie (Instrument for Costs and Revenues Simulation)) is a calculation tool developed by Bijleveld at the TU Delft. The program uses functions and surface areas in order to make the financial consequences clear (Bijleveld, 2007).

The way it works

The program has two major phases, drawing and calculating. The first part consists of drawing the surface areas of the building. These will be the digital images of the transformation program and will act as a writing pad for the fitting of the functions. The functions will be fitted in the surface areas by adding a function to a certain amount of m^2 on the digital image. What follows is a visual representation of surface areas with different functions, each having their own characteristics.

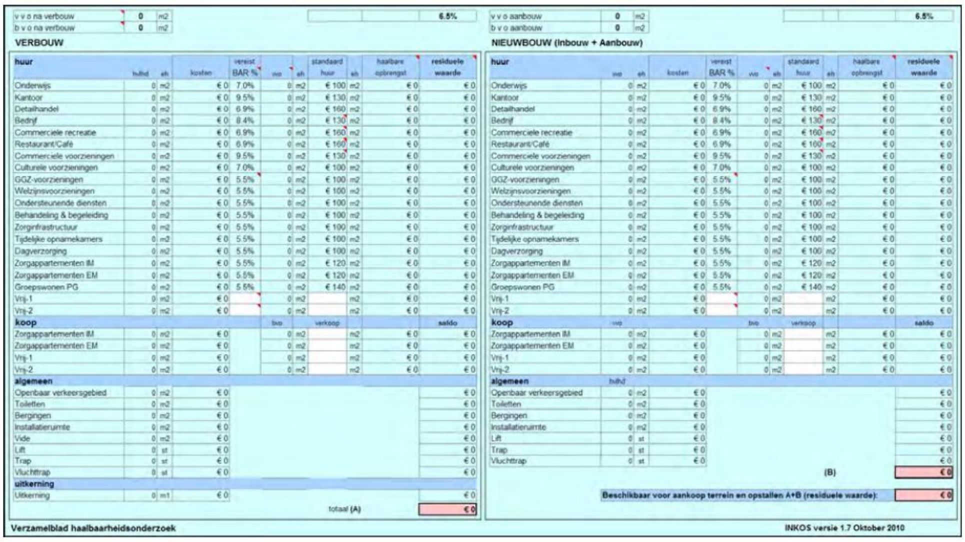
Source: Remøy, H.2011d

Figure 2.35 – "Drawing" part of INKOS

The second phase of the INKOS is the calculation part. Each function has its own characteristics and is coupled to an Excel sheet. In order to calculate, all information made in the first phase is extracted to the Excel sheet. All surface areas will be provided with a cost per m^2 that is dependent on the level of transformation and the quality level desired in the new function. The quality level also has an influence on the revenues gained afterwards.

Results out of the program

Out of the program comes a total list of functions and for the functions desired after the transformation there is a cost and revenues calculation in the list. These cost calculation are dependent on built-in numbers for renovation, environment fees and other costs.



Source: Remøy, H.2011d

Figure 2.36 – "Calculating" part of INKOS

The revenues are calculated by certain BAR percentage (rental revenues divided by the total investment), the surface area and the desired rent per m^2. From the total revenues and the total costs one can conclude whether or not the transformation should take place.

2.6.10 BBN Rekentool transformatie

The BBN Rekentool transformatie (BBN calculation tool transformation projects) is a calculation tool developed by BBN Adviseurs voor gebouw & gebied (Dutch building advisors company). The tool gives the financial consequences for transformation projects from offices to apartments by using a number of characteristics. (BBN, 2012)

The way it works

The program is a web application that uses 7 steps to gain a financial picture of a transformation projects. The 7 steps consist of building, façade, roof and stairs, outside space, outfitting, installations, taxes and additional costs. Each of the 7 steps consists of a small number of input, which can be a size (e.g. building/façade) or a yes/no choice (e.g. façade/roof/installations) or a limited choice (e.g. outside space/outfitting).

Figure 2.37 – 7 Steps of the BBN Rekentool transformatie

The results of the program are updated in real-time by changing the values of input in the aforementioned steps. In this way it's made clear what the financial impact is of each decision and whether or not the project is financially feasible.

Results out of the program

Out of the program comes a table with a number of financial costs and benefits along with a visual representation of the build-up of the costs of the transformation project. The total result is shown in either a positive or negative value.

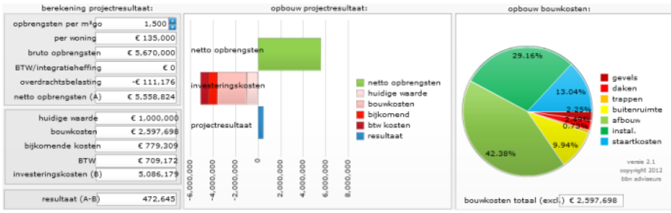


Figure 2.38 – *Results out of the BBN Rekentool transformatie*

2.6.11 Summary

Now that nine calculation tools have been researched a more clear understanding is achieved in terms of how programs to determine transformation feasibility work. One program, the EPC, is not a transformation tool but an energy performance tool. This program addresses different aspects than the other programs on will not be in the same summarized table as the rest. A number of aspects occurred in more than one program. Aspects such as location based criteria and veto criteria. The table will give a summary of the most important aspects and whether they are in the tool or not.

Veto criteria – Veto criteria are particularly important because they offer a conclusion in a very early stage. In any quick scan a lot of buildings can be written off on basis of veto criteria and these criteria thus prevent a lot of extra work in buildings that won't be feasible to transform.

Location based criteria – A second scan of criteria usually involves location based criteria. The location of any building can determine the success of the new function. Residences in the middle of an office area or a hotel far away from any touristic attractions are doomed to fail. Also the direct location such as the presence of green and the visual attraction are key aspects.

Building based criteria – Within a second scan not only the location is of importance, but also the building itself. Building based criteria usually go in to detail in the state of the building, the type of structure and façade and so on. These are also very important criteria since any new function has to compete with new buildings and needs to have a second lengthy life.

Financial based criteria – The reason a lot of transformation projects fail is not because of the technical feasibility, but because of the financial feasibility. When a developer, an owner or an investor can't make money from a transformation, it will not happen. Finances are of the utmost importance. However, for transformation projects it's still very hard to put exact numbers on, since the method is not widely used yet, there are more cases of demolition and new buildings than there are of transformations. Financial numbers are thus usually estimates.

Changing into specific function – A transformation happens from an old to a new function. Some programs only handle a number of possible new functions, some a lot of possibilities and others only say if a transformation is feasible without a mentioning of a new function. The feasibility however, does depend on the new function. An example could be a location that is unsuitable for hotels because it's too far from an attraction, but is suitable for housing since there are already a lot of residences there together with other functions such as retail.

Results in terms of (percentage, coefficient, recommendation, financial) – A result of a calculation program can have many forms. It can be a percentage, a coefficient or just a recommendation. Recommendations are the most open to interpretation and are the least solid. However, with percentages and coefficients one needs to realize that they are as exact as the number put into the equation. When a “vague” number such as scores that are open to debate are entered, one can’t expect very accurate and 100% true results.

	Veto criteria	Location based criteria	Building based criteria	Financial based criteria	Changing into specific function	Results in terms of
“Leegstandsriscometer”	Yes	Yes	Yes	No	No	Coefficient
“Transformatie-potentiemeter”	Yes	Yes	Yes	Yes	1 (residential)	Coefficient
“Herbestemmingswijzer”	Yes	Yes	Yes	Yes	900	Recommendation
“ABT-Quickscan”	No	Yes	Yes	No	11	Recommendation
“Cultuurhistorische waardemeter”	No	Yes	Yes	No	No	Percentage
“Transformatiemeter voor kerkgebouwen”	No	Yes	Yes	Yes	No	Recommendation
“Geloof in transformatie”	Yes	No	No	No	19	Percentage
“INKOS”	No	No	No	Yes	18	Financial
“BBN Rekentool transformatie”	No	No	Yes	Yes	1 (residential)	Financial

Table 2.17 – Summary calculation tools

To conclude the section of the calculation tools we can say that: “With any calculation tool one needs to be open to interpretation, needs to have a clear understanding of what he is filling in and should expect the following results to be viewed as recommendations instead of pure and final answers.”

2.7 Building characteristics through time

Buildings, or rather the way of building, changes continually. As stated before, transformation happens with older office buildings, mainly from the 1980's. A view into the differences between eras in building typology will prove helpful in designing a solution that is applicable in most building types. Differences in structure, floors and façades are discussed and shortly described and are based on the research of Kok and Luijn in 2012. Also the building code specifically for transformation projects is briefly discussed and a summary will conclude the section.

2.7.1 Structure types

In time a number of structural types can be assigned to each era. In each timeframe there were made a lot of buildings in a particular way, such as load bearing in two directions and in one direction. With structural types we mean the way the loads are transferred to the ground, through columns or the façade.

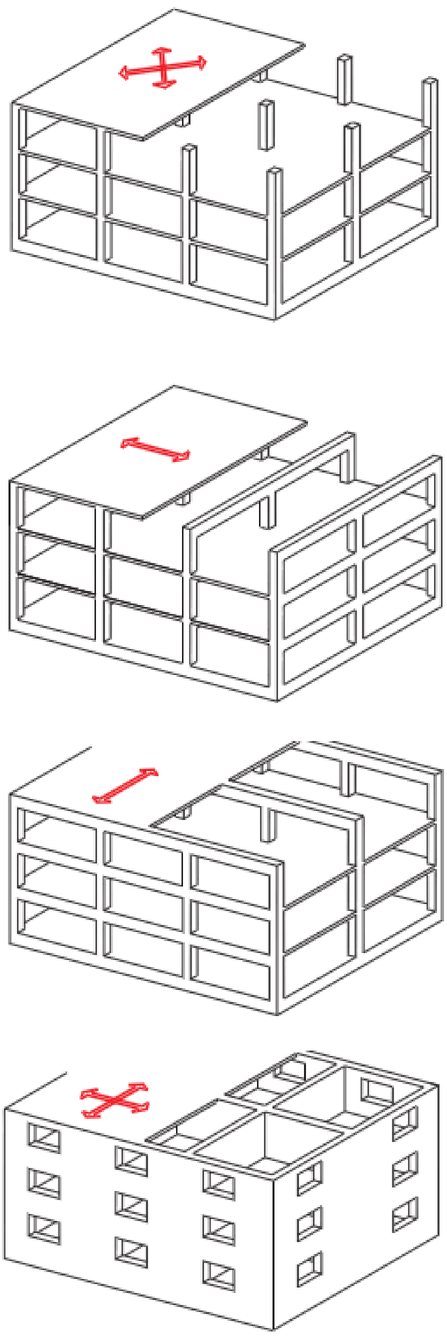
1950-1960 – During this time the load bearing was done in two directions, the structure consisting of floors and columns. These columns could be either from steel, concrete or brick (Giebeler, 2005).

1960-1970 – In the 1960's the use of beams become more applicable. This opened up possibilities to change the load bearing to one direction. Shear walls also made an upcoming during these times.

1970-1980 – The use of two directional support systems is in this time very popular again. The height of the floor structure is low and taller buildings are braced with cores. Beams are not used that much anymore and buildings had a square grid with the use of concrete parapets.

1980-1990 – During this time there were 3 main structural systems often used. These were a structure with façade beams and beams on columns, point supported floors with cassette floors without beams and columns with hidden floor beams.

1990-present – The final era in the time span is the times from the 1990's up until around now, not including the latest innovations. There are 3 main structural systems often used. A full prefab system with a load-bearing façade is one of them. The other systems are a precast structure of columns, beams and floors and a structure with load bearing façade and shear walls (Giebeler, 2005).



Source: Jellema 9, 2004

Figure 2.39 – *Various structural systems*

2.7.2 Floors

As with the structural systems, also the floors changed and altered over time. The typical function of a floor slab is to bear all the loads from each floor and distribute it to the columns and beams. Different floor slabs make sure this happens and evolution of the slabs happened in the form of carrying capacity and reduction of the weight.

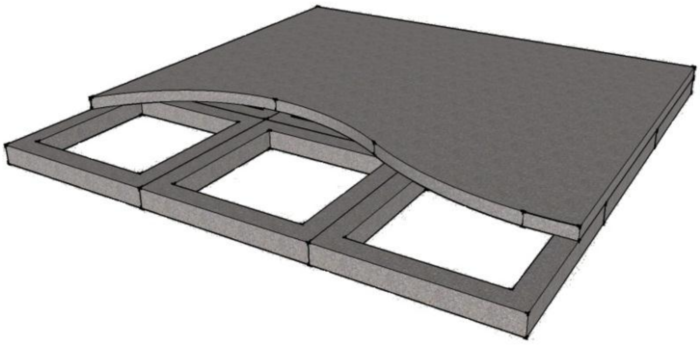


Figure 2.40 – *Cassette slab floor*

1950-1960 – During the 1950's there was made use of two types of floors, the in-situ concrete slab and the coffered cassette slab. Both were, at that time, easy to use floor systems that could carry loads in two directions (Jellema 3, 2004).

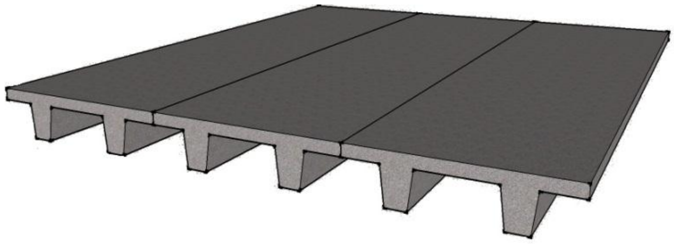


Figure 2.41 – *Ribbed slab floor*

1960-1970 – Different kinds of floors could now be used because of the load bearing in one direction. Next to the in-situ concrete slab that was still used there could be made use of the ribbed slab which gave extra strength in one direction (Jellema 3, 2004).

1970-1980 – In the 1970's the same floor systems were used as in the 1950's and 1960's. There weren't any large structural differences in the floor type area.

1980-1990 – A number of floor systems were used in the 1980's, among them are filigree floor slabs, cassette floor slabs, ribbed floor slabs and the hollow core slabs. The hollow core slabs were developed to save weight without losing carrying capacity. As we've seen with the structural system, this was also the time that hidden floor beams were used to carry certain floor types.

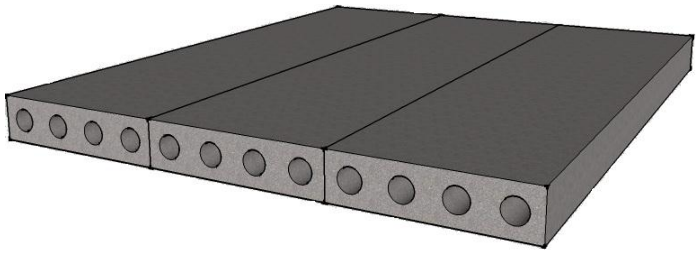


Figure 2.42 – *Hollow core slab*

1990-present – In the 1990's and present time there are used a number of floor types, which consist of hollow core slabs, filigree floor slabs and double T-slabs. All these floor types are prefabricated and thus are fast to assemble at the building site without any concrete drying time (Jellema 3, 2004).

Other floor types that will be encountered often in office buildings are wide slab floors, in situ floors and VZA-floors (translated as "prestressed without attachment" floors). Wide slab floors are semi-prefab floors where a prefabricated 50mm thick concrete shell is covered on site with a 150-200mm thick in-situ concrete layer. In situ floors are floors poured on site in (wooden) molds.

Advantages of in situ floors as opposed to prefab floors are that the transport is easier, since concrete in a paste-like form is easier to transport than whole prefab elements. Disadvantages are that in situ floors are a time-consuming process and ask for a lot of work on site. VZA-floors are floors comparable to in-situ floors, but with a difference; cables are first placed in the mold, before pouring concrete, after the pouring and drying of the concrete the cables are brought under tension and anchored.

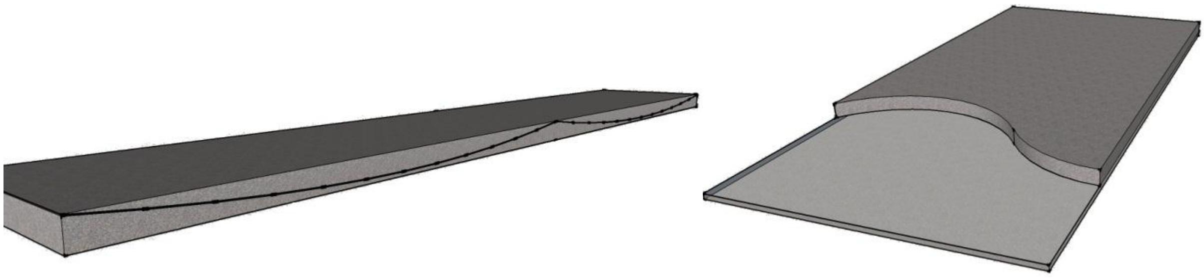


Figure 2.43 – VZA floor (left) and wide slab floor (right)

2.7.3 Façades

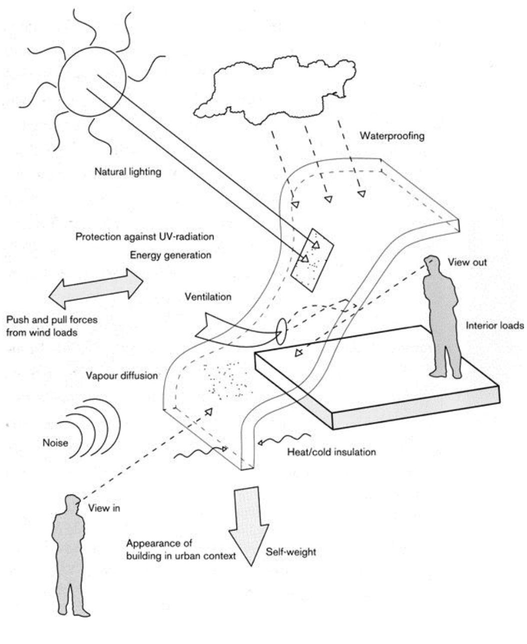
Façades are the face of the building, the architectural expression the building gives. The façade changed a lot from the 1950's to nowadays. In short it went from steel curtain walls to insulated sandwich panels to glass façades and "smart" façades in the present (Knaack, 2007).

1950-1960 – In the 1950's the façades were not thermally insulated and usually consisted of steel curtain walls. This gave an indoor climate that will not satisfy today's requirements and in case of transformation will need to be changed.

1960-1970 – Columns in the façade were used very often in these times and completed a total structural system of columns; columns were used inside and in the façade. Beams were introduced in these times, but only perpendicular on the façade. The use of prefabricated elements for the façade was also introduced; these were lightweight elements with no structural purpose. Another development in the 1960's was the need to increase the daylight admission of a room, which resulted in the use of larger glass panes in the façade.

1970-1980 – Awareness grew in these times in relation to the necessity of thermal insulation and a curtain walls were developed with the use of aluminum and thermal bridge breaks. Also with glass there were developments, such as double glazing and sun reflective glazing. Climate façades were also slowly coming up (Knaack, 2007).

1980-1990 – During the 1980's load bearing façades become increasingly used; they consisted of prefabricated elements assembled on the building site. Load bearing façades are not the same as columns in the façade; the load is directly on the façade and is transported to the ground through these façade elements. Closed façades in order to keep the indoor generated heat inside lead to sick building syndrome and the wishes to have operable windows or other openings in the façade became more important.



Source: Knaack, 2007

Figure 2.44 – Functions of a façade

1990-present – The number of façade types in the present are very large and a study in itself. The general view of a façade is that it's the separation of the indoor space from the outdoor world. The functions of the façade in the present are best described by figure 2.35. Innovation is a key aspect in the current façade industry and designing with an eye on energy (re)use and sustainability became increasingly important (Knaack, 2007).

2.7.4 Building decree

Every building in the Netherlands has to comply with the regulations and requirements of the Dutch Building Decree. The building decree consists of a large amount of regulations divided into norms, quality certificates, Dutch practice guidelines (NPR's) and Dutch technical agreements (NTR's).


Nederlandse norm

NEN 8700
(nl)

Beoordeling van de constructieve veiligheid van een bestaand bouwwerk bij verbouw en afkeuren - Grondslagen

Assessment of existing structures in case of reconstruction and disapproval - Basic Rules

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Figure 2.45 – *NEN 8700*

Norms are a very large part of the building decree and hold all calculation and determination methods in order to meet certain regulations or requirements of the building decree. The use of these norms in order to comply with the building decree is not obliged but gives a method to do so. These norms are being developed and given out by the Dutch Standardization Institute (NEN).

For transformation projects there is a norm called the NEN8700, which handles the basic rules of the assessment of the structural safety of existing structures in case of renovation and disapproval. The norm holds the principles, application rules and the determination methods from where an assessment can be obtained if the structure is sufficiently safe and useful. In short, the norm holds the safety standards in renovation projects and the principles of the assessment of the structural safety.

The norm does not describe detailed methods of determination of the safety standards of an existing structure, but only gives the tools for that, the principles. Detailed elaborations, such as strength classes of timber and the conversion of cube compressive strength to cylinder compressive strength of concrete, are in different norms and documents in the same NEN 8700 series (NEN 8700, 2011).

2.7.5 Summary

The development of structures, floors and façades through the years 1950 until now will be summarized in the table. What needs to be noted and learned from this section is that each development doesn't necessarily means that every building is built with this new development. In other words, when a certain floor system is assigned to a certain time period it doesn't mean all buildings from that time used this floor system, only that the system is used more often in this time period. For every transformation it is thus very important to look at the specific building and not to just assume a certain structural system when it's built in a certain year.

	Structural system	Floor type	Façade type
1950-1960	• Columns • Load bearing in two directions	• In-situ • Cassette slab	• Steel curtain walls • Not insulated
1960-1970	• Beams • Sheer walls • Load bearing in one direction	• In-situ • Ribbed slab	• Columns in façade • Prefabricated elements in façade • Larger glass panes
1970-1980	• Less beams • Load bearing in two directions	• In-situ • Ribbed slab	• Use of thermal insulation • Aluminum curtain walls • Double/sun reflective glazing
1980-1990	• Façade beams and beams on columns • Point supported floors with cassette floors without beams • Columns with hidden beams	• Filigree slab • Cassette slab • Ribbed slab • Hollow core slab	• Load bearing façades • Closed façades
1990-present	• Full prefab system with a load-bearing façade • Precast structure of columns, beams and floors • Structure with load bearing façade and shear walls	• Hollow core slab • Filigree slab • Double T-slab	• Large diversity • Sustainability • Energy (re)use

Table 2.18 – Summary structural developments

3 Modular hotel

In this chapter the process and results of a design for a modular hotel is explained. The modular hotel is a hotel which will be built with a high level of prefabrication. The first section will give a number of reasons for the choice of a modular hotel. The advantages of this design will be discussed in the section 3.2. Three design variants will be discussed in 3.3 and the elaboration of the final design is in 3.4. A discussion of transportation and assembly of the modular units is elaborated upon in section 3.5 and lastly, a number of case studies are discussed in 3.6.

3.1 Introduction

From chapter 2.2 a number of aspects became clear that make transformation projects less feasible than demolition of structurally vacant office buildings. These aspects include financial, juridical, functional and technical aspects. In order to minimalize the negative side of the aspects, in other words, making it financially, juridical, functionally and technically more feasible, a plan of modular buildings is made so the feasibility increases. An explanation for every aspect is given here.

Financial

As discussed in chapter 2.2 the financial thresholds include the difference in value given to a building by the different parties, the financial insecurity of a function transformation for the owner and the different lettable floor area (lfa) calculations between functions.

In order to deal with these three thresholds a solution is necessary that gives a clear cost picture to lower the insecurity for the owner together with minimizing the risks and maximizing the number of rooms that can be rented out. The costs of a solution should be clear from the start and a solid number, meaning it won't fluctuate during construction. This can be achieved by fewer acts on the building site and modular building.

These solutions will also minimize the risks for the owner, since modular building is mostly prefabricated and as such fewer acts on the building site are necessary, fewer minor (or major) adaptations of materials during construction are necessary and the building speed will be higher. If any of these requirements wouldn't be met insecurities would be higher since any adaptation on the building site can slow the project down and eventually cost money, more time will be mean more money lost.

Juridical

Juridical thresholds are thresholds such as the building decree and the zoning plans as given by the municipality. These can be best described as rules that prevent unsafe and unwanted functions. In order to increase the feasibility of a transformation project the first step is to fulfill the laws and rules from the building decree. The second step is a step much more open to interpretation and it's to be in line with the zoning plans.

The zoning plans don't always have room or have a limited availability for hotel functions. With a solution that makes temporarily adjusted buildings available and of lower risk could help negotiations and feasibility. Also a concept of modular building could have different functions within them.

Functional

The functional feasibility depends on the functional state of the vacant office building. Functional aspects are the structural grid of the building, the current layout of interior walls and the usability of basements. The structural grid is often of standardized measurements of multiples of 1.8m. Columns, if used, are mostly in 5.4m or 7.2m grids. The two structural layouts, the central core tower type and the single corridor slab type, both should be addressed in any solution if looking at transformation.

Any solution for transformation, including modular building, should be able to adapt to the functional parameters of a given building. Grid sizes, places of entrance, stairways and elevators should make no difference in the given solution. The admission of daylight, as described in chapter 2.2 should be accounted for in the (new) façade.

Modular building can be adapted to any building but to a certain degree. When adapting the modular element to make it fit to a different building, one should be aware that making it comply with every building will make the variants of the modular elements to diverse, thus forgetting the true idea of modular building, the prefabricated modular parts that are the same. Adaptation of modular element should thus be within size and level of finishing boundaries.

Technical

The technical feasibility depends on the characteristics and state of the current vacant building. These characteristics include, load bearing façades, technical state of the construction, floor type, removable/adaptable façades, the possible reuse or refit of installations and shafts, the possibility for horizontal or vertical extension and the lack of an integration between structure and installations.

Each of these characteristics has an influence on the transformation potential, and as such, any solution should lower the influence of any of these characteristics. Some characteristics, such as the technical state of the current building, will make modular building elements less feasible, since a lot of extra work has to be done to make the building in a better state, before applying the modular elements. Load bearing façades should be (temporarily) removed in order to place the modular elements.

On the positive side, the floor type won't matter, together with the reuse and refit of installations and shafts, since all vertical and horizontal transport will be done within these modular elements. Integration between structure and installations will prove to be either a bad thing (interior walls which need to be demolished with water pipes) or won't be a bad thing (floors with water pipes or sanitary pipes) since these won't be altered. Also, the floors, which are designed for an office function, have a certain design load which is a lot higher than the design load for a hotel function. This will give room to add the modular elements.

From the above we can conclude that any solution for modular transformation from office space to hotel rooms will meet certain requirements following each of the four given aspects. These requirements will be dealt with in the following section 3.2, where all requirements and parameters of the modular hotel rooms design will be dealt with.

3.2 Requirements modular hotel

The requirements for the design of the modular hotel are divided into two parts. The first part is the requirements that are following from the vacant building; these result from the aspects discussed in 3.1. The second part of requirements follow from the hotel sector itself, the requirements they impose to hotel rooms, hallways, lobbies and so on. Both set of requirements will be addressed in this chapter.

3.2.1 Requirements following from vacant building

From the previous chapter and 3.1 we can extract a number of boundary conditions that any given solution needs to satisfy, in this case a modular system. These boundary conditions, following the state of the vacant building, will be the outline of the design and will give boundaries to a solution.

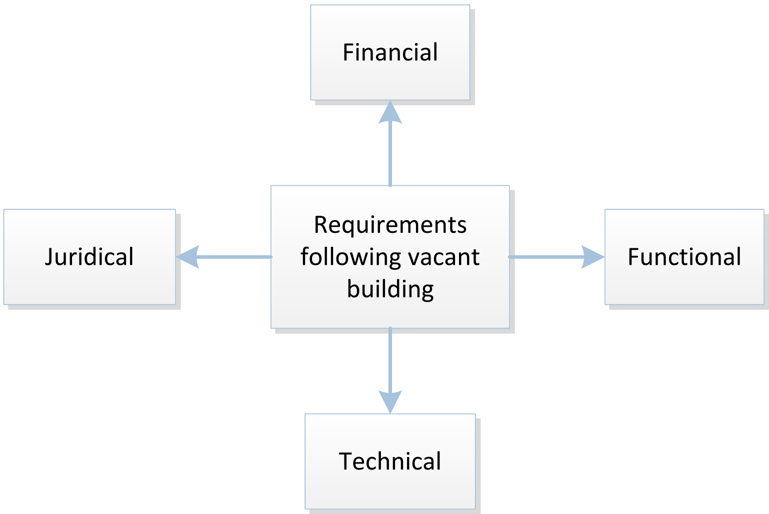


Figure 3.1 – Aspects of requirements following vacant building

From a financial point of view there is a need to keep the costs and risk low and maintain a low insecurity level. From this we can say that elements should be low-cost, easy to assemble and to place and prefabricate as much as possible. Keeping the building speed high is also important from this point of view. Prefabricating is assumed to be of less risk, since elements are fabricated off-site and having fewer adjustments on-site and adding positively on the building speed. Adjustments on-site are assumed to be of higher risk, since faults can have a negative impact on the building speed and need to be handled with some imagination and won't always result in a cost efficient manner.

Requirements following the juridical aspects will follow from the building decree and zoning plans. The zoning plans are a region and municipal specific plans which differ from municipality to municipality. The main thing here is the building decree, which will give the outlines of the design in the field of building physics and structure. These requirements will be elaborated upon in 3.2.3.

The functional point of view will result in the adjustability to different building grids and that any solution needs to be adaptable to a large amount of different floor plans. Following this, a modular solution for hotel rooms needs to be of different sizes as to fit in different building grids.

Technical aspects as mentioned in the previous chapter and in 3.1 will result in requirements making the modular elements lightweight, making the vertical and horizontal transport partly within these elements and will limit the number of buildings because of the presence of load bearing façades. The lightweight requirement will follow from the added load bearing weight of the element on the floor. Hotel functions have a lower design floor load than offices and this difference will be the modular element weight. A second very important reason to limit the weight (and sizes) is due to transport of the modular elements to the building site.

The horizontal transport within the elements of water, air, electrical and sanitary will have to be partly within the element (prefabricated) and partly exterior (outside the element) and the vertical transport outside the element within the façade. This latter will limit any problems with vertical floor penetrations within the building.

Vacant building	
Aspect	**Requirement**
Financial	Low-cost elements
	Easy to assemble
	Easy to place
	Prefabricate as much as possible
Juridical	In accordance with building decree
	In accordance with zoning plans
Functional	Adjustable to different building grids
	Adaptable to different floor plans
Technical	Lightweight elements
	Horizontal transport building services within elements
	Vertical transport building services on the façade side
	Sanitary waste system

Table 3.1 – Requirements following vacant building

3.2.2 Requirements following from hotel sector

The vacant office building is not the only part given boundary conditions for a modular hotel room solution. The hotel sector and hotel owners also provide a list of requirements. This section will give a number of requirements without going into too much detail for a specific hotel company. One can imagine that every hotel chain has different requirements for his own hotels. Requirements given her are based upon the NHC star class as mentioned on page 13 and the segmentation of the hotel market in business and touristic hotels as mentioned on page 15.

Every star level has different requirements for the room itself and for the hotel in general. For the room itself what is important in the design phase is to know what functionalities a room in a certain star level requires. These are listed in the NHC requirements. Baths, sinks and water closets per room or per floor need to be accounted for, as well as lighting, electricity, TV cables and air conditioning. Each of these requirements is required on certain levels and the outline for these need to be inserted in the room design.

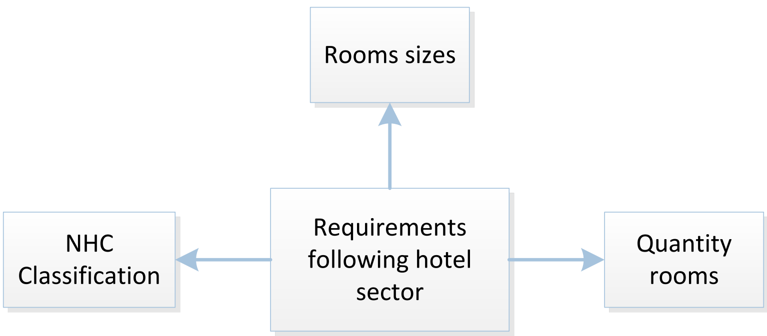


Figure 3.2 – Aspects of requirements following hotel sector

The key factor in rooms of different star category is the size of the room. For 1 and 2 star rooms there are no requirements for the size, however, for 3 to 5 star rooms there are minimum floor area sizes that need to be designed for. For 3 star rooms the minimum floor area is 17m^2, for 4 star rooms it's 22m^2 and for 5 star rooms it's 26m^2 (Bedrijfschap Horeca en Catering, 2012).

From the hotel sector it's assumed that there is a need for maximizing the number of rooms. More rooms mean more income since hotels get their income not from floor area rent, like an owner of an office building, but from the room rentals. Together with the minimum sizes required per star level and the structural grid of the vacant building, there shouldn't be too much "empty space". In other words, a lot of available space per floor should be taken up by the modular hotel rooms.

For the hotel rooms it should be possible for different levels of finishing, as different star levels require a different look and different hotel chains have different wishes for the finishing and extras in each room. Modular hotel rooms should leave room for a different finishing on floors, walls and ceilings.

A hotel doesn't only consist of hotel rooms, also different areas need to be created, such as a lobby, a breakfast area or a restaurant, meeting rooms and so on. All these different functions within the hotel also need to be in a modular hotel. There are a number of options here, one is to design for each hotel different, hence giving up on the idea of total prefab or create a single solution that works for rooms and other functionalities in the hotel.

Hotel sector	
Aspect	**Requirement**
NHC Classification	Electrical and lighting in room
	TV, Internet cables in room
	Wet cells per room, per floor
Room size	1 and 2 star rooms no requirement
	17m^2 for 3 stars
	22m^2 for 4 stars
	26m^2 for 5 stars
Quantity rooms	Maximizing number of rooms

Table 3.2 – Requirements following hotel sector

3.2.3 Requirements following from building decree

Every building in the Netherlands has to comply with the Dutch building decree. The Dutch building decree gives a lot of requirements and minimum rules that a building has to comply with. Attached to the building decree are the Dutch norms (NEN) or in some cases Eurocodes. These norms give a more detailed view of the requirements and rules that a building has to comply with and also gives examples of how to satisfy certain criteria (BRIS, 2012)

The building decree gives minimum requirements to all sorts of aspects, but the four most important ones are discussed here. The strength of the current building needs to be sufficient to carry the load of the modular rooms, there should be enough fire protection between rooms, both horizontal and vertical, the acoustic insulation should be sufficient between rooms, also both horizontal and vertical and the building physics and installations need a place within the rooms.

The strength of the current building in a remodeling or transformation project is handled within the norm NEN8700 titled the "*Assessment of existing structures in case of reconstruction and disapproval – Basic Rules*". The most important part of this norm is the function in which one can calculate the current strength of the office building. The outcome of this function will give the adjusted value of the current strength of floors, columns and so on.

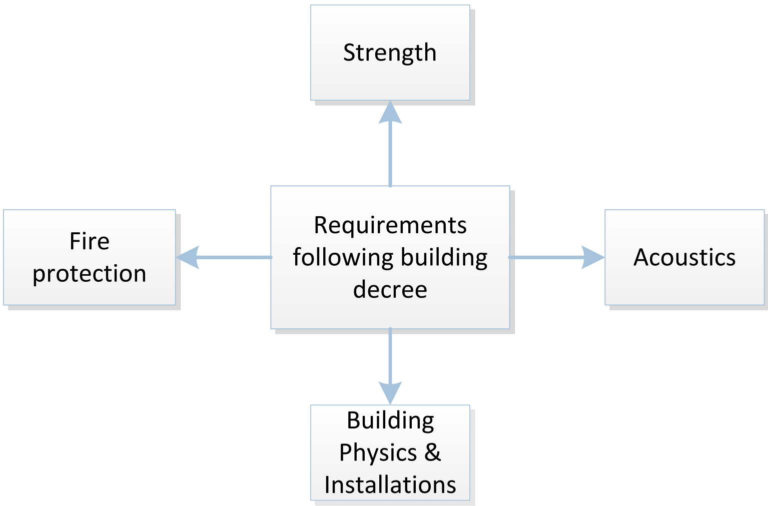


Figure 3.3 – Aspects of requirements following building decree

Acoustics are handled in the building decree by means of sound insulation and reverberation time. Building acoustics are discussed in the norm NEN5077 titled *"Noise control in buildings – Determination methods for performances concerning airborne sound insulation of façades, airborne sound insulation, impact sound insulation, sound levels caused by technical services and reverberant time"*. For acoustics the sound insulation in two directions should be determined, horizontal between the rooms and vertical between the rooms. A concrete floor slab generally does not meet requirements of sound insulation.

The sound insulation from the outside to the inside has no requirement for lodging functions according to the building decree in case of a renovation. However, a demand for sound insulation for new dwellings can be up to a maximum of 35dB(A). Sound insulation between rooms also has no requirement for lodging functions according to the building decree in case of renovation. For new buildings however there are two demands for lodging functions, the characteristic airborne noise level difference can't be smaller than 52dB and the contact noise level can't be bigger than 59dB. The reverberation time is the same for new buildings and renovated buildings and should be 0,5 s for hotel rooms (BRIS, 2012)

The fire protection of a building is expressed in minutes before reaching a structural unsafe situation. In case of buildings with the highest floor between 5m and 13m above ground, the structural safety should be maintained for 30 minutes; for buildings with floors higher than 13m this number is 60 minutes. The calculation of this fire protection time is done with NEN6069 titled *"Testing and classification of resistance to fire of building products and building elements"*. In order to not exclusively aim at low rise buildings with a modular hotel room solution the aim is for a 60 minute fire resistance in vertical and horizontal direction.

For building physics and installations a large number of requirements can be mentioned out of the building decree and out of common sense. Not every aspect will be discussed in detail. Every room however needs to be a healthy and comfortable environment by means of heating, cooling and ventilation. The use of natural ventilation is, with an eye on health, a preferred method. The minimum value of ventilation in a room is $12dm^3/s$ per person and $14dm^3/s$ for a bathroom unit. Heating is done through water, since mechanical ventilation may not be necessary because of the natural ventilation and cooling is done through an air conditioning unit.

Sanitary and electrical cables are also a part of the installations. The sanitary makes use of different pipes and have minimum sizes for draining units. Also the wet parts, shower, sink and water closet need to have an inlet and drain of water. The minimum size for a water closet drain is 110 mm, for a sink and a shower 50 mm.

Building decree	
Aspect	**Requirement**
Strength	NEN8700
Acoustics	NEN5077
	Sound insulation outside to inside 35dB(A)
	Airborne noise level difference between rooms >52dB
	Contact noise level between rooms <59dB
	Reverberation time 0,5s
Fire protection	NEN6069
	Highest floor >5m & <13m, 30 minutes
	Highest floor >13m, 60 minutes
Building physics and installations	Heating with water (radiators)
	Cooling with air conditioning (if necessary)
	Natural ventilation (12dm^3/s per person)
	Mechanical exhaust air from bathroom (14dm^3/s)
	Sanitary water closet needs drain 110mm
	Sanitary shower needs drain 50mm
	Sanitary sink needs drain 50mm
	Water pipes for sanitary in floor

Table 3.3 – Requirements following building decree

3.2.4 Requirements based on transportation

Modular hotel rooms need to be transported from the factory to the building site, preferably by road. Since this solution needs to compete with general renovation techniques and should be appealing to an owner of a building it should be low-cost. Also in transportation the same line should be seen, any form of special transport will cost extra and waiting for an exemption by the RDW (Dutch government service for road traffic) will slow the building speed. A solution would be to adjust the modular elements to normal road transportation sizes or to make the elements separate, as in the first variant and transport can be done in the form of flat packages.

For transportation by road in the Netherlands a number of maximum values are determined. These values will determine what parts can be prefabricated and what parts need to be handled on site. The maximum length of transport is determined by the turning radius of the vehicle and is 22,00m for a truck + trailer combination and thus won't give restrictions to the modular elements (RDW, 2009b).

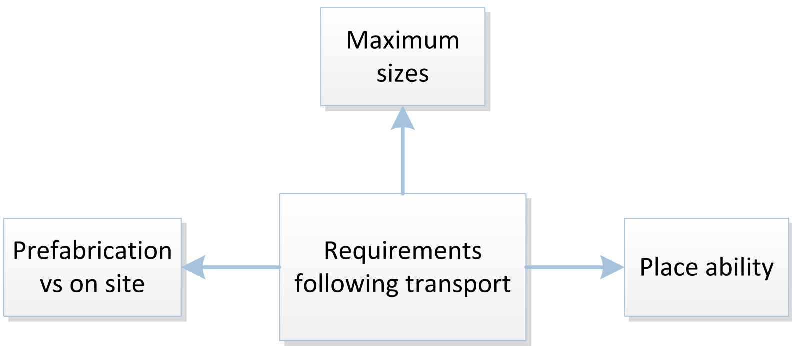


Figure 3.4 – Aspects of requirements following transport

The maximum road transportation width of an indivisible load is 3,00m. The maximum width is determined by the lane width of the roadway. Transport of indivisible loads of up to 4,50m can be done in special transport options. The maximum height for all types of vehicles is 4,00m. For higher heights there is a possibility to search for diversion routes where viaducts and tunnels can be avoided. For transports with a height higher than 4,50m special transports come into effect (RDW, 2009a).

Concluding from the maximum road transportation sizes the sizes for the modular hotel rooms can be determined. The modular elements should not exceed 22,00m in length, 3,00m in width and 4,00m in height. This will mean that a single room fitting into a grid size of 5,4m will have to be divided into two separate elements.

This applies to the second and third variant as described in section 3.3. When using the first variant there can be an application of flat boxes with different elements which in turn will be assembled together on the building site. The same maximum sizes apply to these "boxes", however the benefit from this is that there won't be a transportation of air.

For road transportation not only the size of the elements are important, but also the weight and the place ability. Road transportation puts maximum weight requirements per axle for every road transport. The maximum weight carried by a tandem axle vehicle is 19.000 kg (RDW, 2009b), so every (half) element should not exceed this weight. For place ability reasons cranes will be used to put the elements into place. Mobile cranes are in different models, with lifting capacities from 35.000 kg to 650.000 kg (Peinemann, 2012).

Road transport	
Aspect	**Requirement**
Length	22,00 m
Width	3,00 m
Height	4,00 m
Maximum weight transport	19.000 kg
Maximum weight lifting	35.000 kg – 650.000 kg

Table 3.4 – Requirements following transportation

3.2.5 Total requirements modular hotel rooms

Now that requirements are clear for each aspect and from what angle we can summarize them here and use them in the following design sections. All designs will be made according and in compliance to these requirements.

Requirements modular hotel solution	
Aspect	**Requirement**
General	Low-cost elements
	Easy to assemble
	Easy to place
	Prefabricate as much as possible
	In accordance with building decree
	In accordance with zoning plans
	Adjustable to different building grids
	Adaptable to different floor plans
	Lightweight elements

	Horizontal transport building services within elements
	Vertical transport building services on the façade side
NHC Classification	Electrical and lighting in room
	TV, Internet cables in room
	Wet cells per room, per floor
Room size	1 and 2 star rooms no requirement
	$17m^2$ for 3 stars
	$22m^2$ for 4 stars
	$26m^2$ for 5 stars
	Maximizing number of rooms
Strength	NEN8700
Acoustics	NEN5077
	Sound insulation outside to inside 35dB(A)
	Airborne noise level difference between rooms >52dB
	Contact noise level between rooms <59dB
	Reverberation time 0,5s
Fire protection	NEN6069
	Highest floor >5m & <13m, 30 minutes
	Highest floor >13m, 60 minutes
Heating	Heating with water (radiators)
	Vertical transport through façade
Cooling	Cooling with air conditioning (if necessary)
Ventilation	Natural ventilation ($12dm^3$/s per person)
	Mechanical exhaust air from bathroom ($14dm^3$/s)
Sanitary	Sanitary water closet needs drain 110mm
	Sanitary shower needs drain 50mm
	Sanitary sink needs drain 50mm
	Water pipes for sanitary in floor
	Vertical transport through façade
Drinking water	3 pipes, hot, cold and drain
	Vertical transport through façade
Energy	Electricity in room before placing
	Vertical transport through façade
Length	22,00 m
Width	3,00 m
Height	4,00 m
Maximum weight transport	19.000 kg
Maximum weight lifting	35.000 kg – 650.000 kg

Table 3.5 – Requirements

3.3 Design variants

From the requirements three different variants of modular building are being discussed in this section. Each will be given a number of positive and negative aspects and a choice will be made at the end of the section. In order to clearly explain the variants we use a fictive model of columns and floors to represent a building.

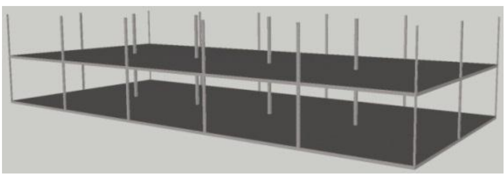


Figure 3.5 – Fictive model of building

3.3.1 Variant 1: Everything separate

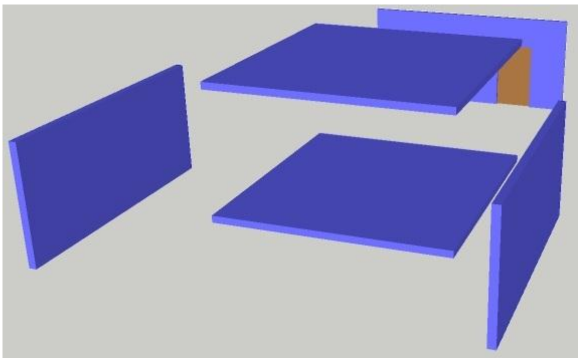


Figure 3.6 – Exploded view Variant 1

The first variant is the one with the least amount of prefabrication. Floors, ceilings and walls are all individually prefabricated and separately placed on site. Every part will be connected to each other on site and will be demountable at the end of use.

Positive points for this variant is that it's easy to transport, since every floor, ceiling and wall unit in itself is not that large, and can be transported in any direction (on its side for instance) and it's adjustable to a lot of different building grids. The walls are separate and thus can be placed on any location in the building, as long as a floor unit can fit in too. There is also a possibility to make rooms of different sizes depending on the wishes of the client.

What is negative about this variant is that there is a low amount of prefabrication and still a lot of work on site; this doesn't contribute to the building speed and low risk that is required for the modular room project to succeed. Also, building services, such as ventilation ducts, sanitary and so on are harder to already place before the units go into the building, so these handlings also have to be done after the modular units are already placed (even more handlings on site).

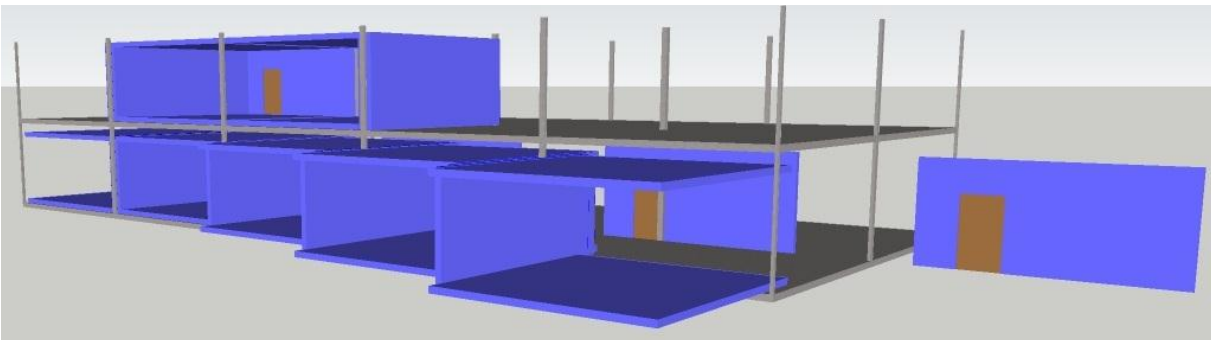
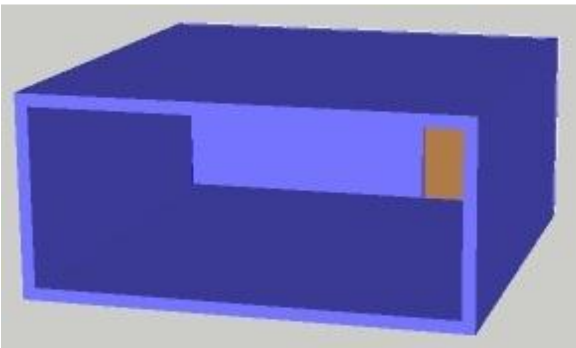


Figure 3.7 – Variant 1 in fictive building model

Variant 1	
Positive	*Easy transportation due to limited size*
	Adjustable to any grid and room size
Negative	*Lot of work on site brings lower building speed and higher risk*
	Building services can't be placed beforehand

Table 3.6 – Positive and negative aspects Variant 1

3.3.2 Variant 2: Room without façade



The second variant is one of larger proportions, the walls, floor and ceilings are prefabricated and mounted together, giving a complete room as a modular element. The mounting will be done off site and a complete room will be delivered to the building site.
What's positive about this variant is that it brings a

Figure 3.8 – Exploded view Variant 2

fair amount of prefabrication with it, giving a complete room as a building unit that can be placed in the building in one piece, thus limiting the work on site and lowering the risk, also contributing positively to the building speed. Also, horizontal ducts, pipes and electrical wires can already be placed beforehand as well as the sink, water closet and shower.

A negative point for this variant is the total size of the element, making it difficult to transport, rooms with bigger widths than 3,00m need to be transported in two pieces and placed together and connected on site. The adjustability to different grids is also a problem, since walls can't be moved in relation to the floors, connections have already been made. A solution for this would be to design within a catalogue with different room sizes the client can choose from, based on his building.

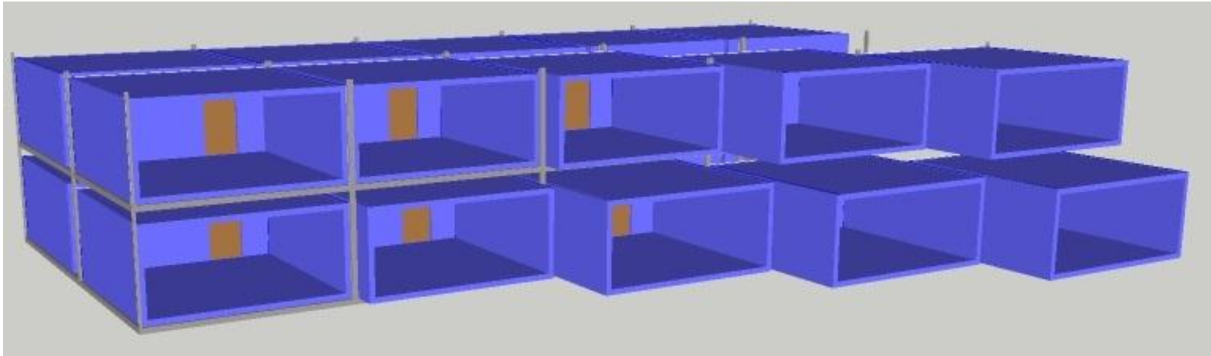


Figure 3.9 – Variant 2 in fictive building model

Variant 2	
Positive	*Prefabrication, building speed, lower risk*
	Building services and wet cells can be placed beforehand
Negative	*Size for transportation*
	Adjustability to different structural grids

Table 3.7 – Positive and negative aspects Variant 2

3.3.3 Variant 3: Room with façade

The third variant is the largest and the one with the most prefabrication. As with variant 2 the walls, ceiling and floors are prefabricated and mounted together. In addition to this also the façade is attached to the room and will be delivered as a whole. The total modular element can be placed in the building and the façade will be attached to the floors of the vacant building.

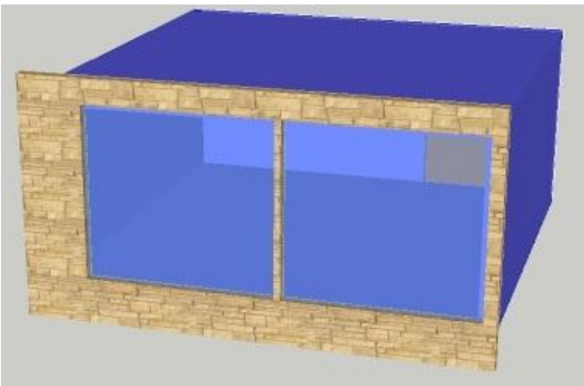


Figure 3.10 – Exploded view Variant 3

The positive side is that this variant offers a completely prefabricated solution where almost no handlings on site are necessary. The building speed can be maximized and everything in the room, except finishing layers on walls, floors and ceiling, is immediately ready.

On the downside of this variant are a number of things; the size of the total element is very large and together with façade makes it very hard to divide in two parts, the vertical transport of pipes will still have to be done after placing, the adjustability to different grid sizes asks for a same solution as in variant 2 and last but not least, the façade element attached to the room will have to fit in to different widths and heights of already existing structural grids. All these negative sides make this last variant very difficult and thus also the pricing will become problematic.

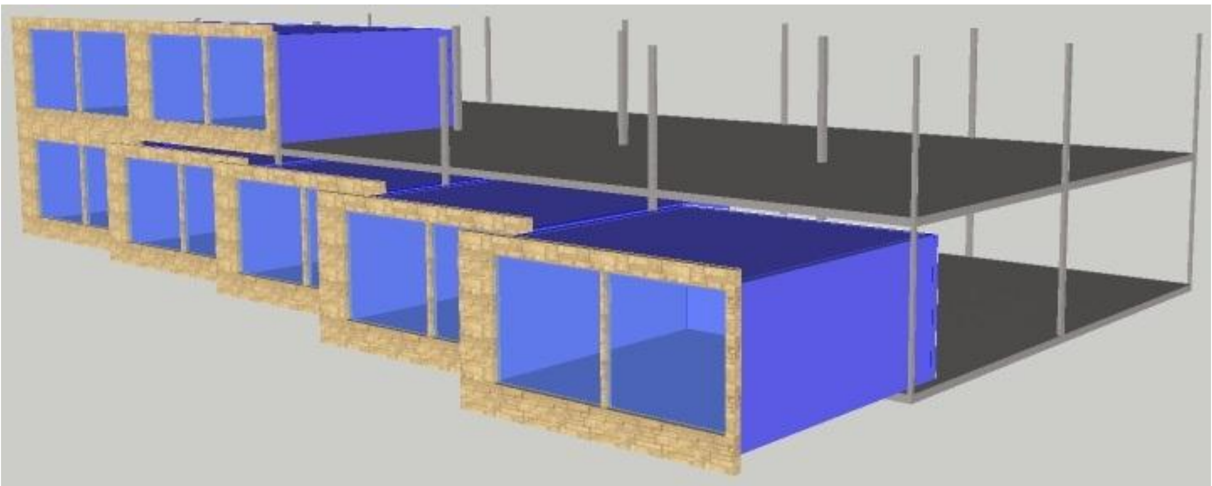


Figure 3.11 – Variant 3 in fictive building model

Variant 3	
Positive	*Prefabrication, building speed*
	Building services and wet cells can be placed beforehand
Negative	*Size for transportation*
	Façade element will have to fit in different grids
	Adjustability to different structural grids

Table 3.8 – Positive and negative aspects Variant 3

3.3.4 Choice for modular room

The choice for a variant is dependent on the factors as given in section 3.2 and the resulting positive and negative points. From this a MCA (Multi Criteria Analysis) can be set up in which each variant reaches a certain score. A number of requirements are more important than the other.

MCA	Variant			
	Factor	**1**	**2**	**3**
Low cost	3	3	2	1
Assembly of elements on site	2	1	2	2
Placing of elements on site	2	1	3	1
Amount of prefabrication	4	1	3	3
Adjustable to building grids	1	3	2	2
Adjustable to floor plans	1	3	2	2
Lightweight	1	3	2	1
Prefabrication of building services	1	0	2	2
Prefabrication of wet cells	1	0	2	2
Maximum sizes for transport	2	3	2	1
Total score		***32***	***42***	***32***

Table 3.9 – MCA

More specific requirements such as fire protection and sound insulation are left out of the MCA, since the solutions are not comparable by these detailed requirements. Each variant gets a score from 0 to 3 (poor to good).

When looking at the MCA and the scores each variant reaches it is clear that variant 2 is the best to choose. Variant 2 becomes a catalogue of a number of room sizes, with a number of modular façades that the client can choose from, giving the client freedom to choose. Horizontal transport of air, heat and other building services can be already installed in the room and the vertical transport can be added after placing. The heating method and the cooling method as well as placing drinking water tanks on top of the building or down under the building are all design freedoms the client can still choose from.

3.4 Modular hotel design

In this section the modular design of the hotel is elaborated upon. The modular design is based upon a catalogue; it will feature several types of rooms of different sizes and different finishing levels. The catalogue itself will be in appendix B. The largest part of this section will be taken up by the modular rooms themselves, but in section 3.4.4 the rest of the design catalogue is discussed, meaning the different façade types and the hallway units.

The first part of section 3.4 will consist of the design itself and the materials used, the second part will go into depth in the build-up of the walls, floors and ceilings. The third part will elaborate upon the installations and building services within the modular room unit and the last part will handle the different façade units and the hallway units. Resulting from this chapter will be a total picture of a modular room.

The choice of only designing these parts (rooms, façade and hallways) is a conscious decision and is done to keep a balance between modular prefabrication and uniquely designing. Rooms, hallways and façades are repetitive units inside a building, while a restaurant, a conference room or a swimming pool are unique items in a hotel building. Designing a modular or prefabricated unit for these unique items would be purposeless, since the client than only has one option for one unique item. The more sensible solution would be to design unique items within a hotel different every time and keep the concept of modular building to repetitive items.

3.4.1 Design of modular room and use of materials

The modular rooms need to satisfy a number of needs and requirements as given in section 3.2. One of the requirements was that of weight, which is assumed to be the key requirement when using a vacant building for the modular rooms. A second requirement was the one to design a low-cost solution. Extracted from the previous is to use one of the 3 widely used materials (concrete, steel, wood). Since these are assumed to give better prices than materials which are less common to use as a building material. From the two requirements the choice is to use timber, since it's lightweight and low cost.

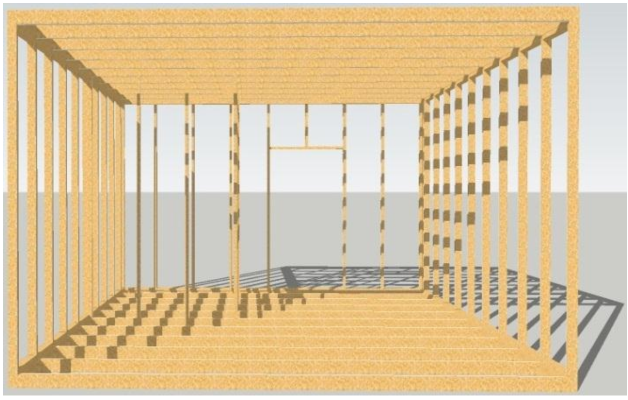


Figure 3.12 – Total timber frame

The design of the room will be built up as a timber frame. The lightweight structure can be of different widths and lengths as can be seen in the catalogue. The timber frame will consist of 3 walls (one with a door), a floor and a ceiling. The fourth wall will be open and will be connected to the façade.

For sound insulation reasons the timber frame walls will be fitted with rock wool insulation which also gives a certain fire protection. The timber frame walls will also be cladded with plasterboard. The finishing of the plasterboard will be done after placing the room element in the building. Details of the build-up of the wall can be found in section 3.4.2.

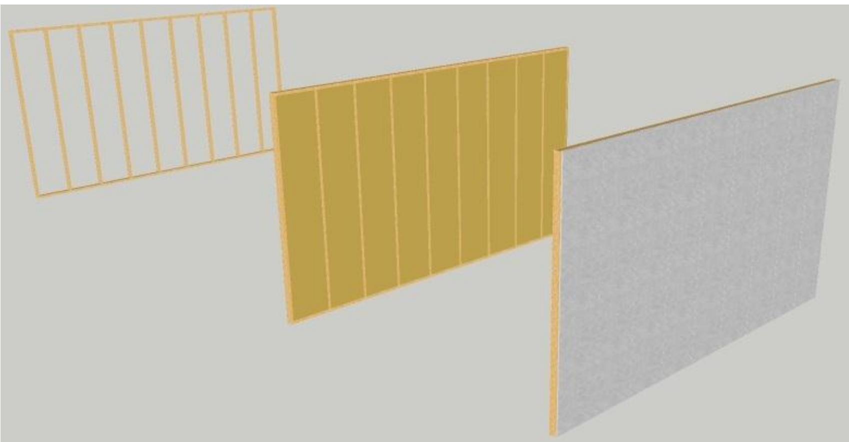


Figure 3.13 – Build-up timber frame wall

The floor is built up with timber beams with sizes of 120x50 and a center to center distance of 600 mm which will line up the beams of the floor with the “columns” in the walls. On top and underneath the floor beams there will be OSB (Oriented Strand Board) plating. The top floor will be a gypsum anhydrite and the finishing on top of that will be done after the placing of the element. Underneath the floor there will be a mineral wool with a high compression which will give the desirable sound insulation.

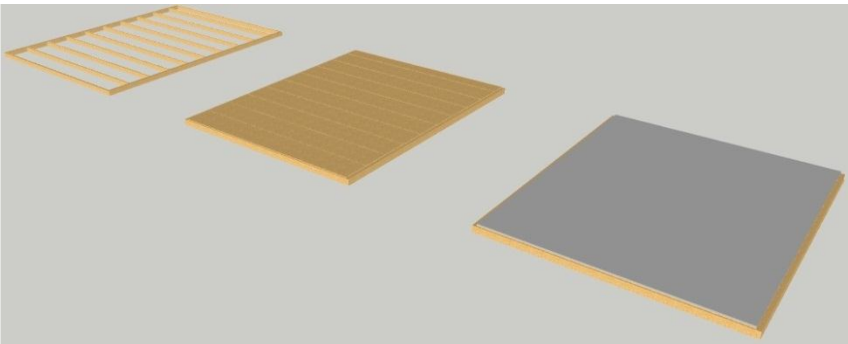


Figure 3.14 – Build-up timber frame floor

The ceiling will be built up in a similar way as the floor, with beams between the walls. This is mainly done to keep a same production process and to keep the total strength of the room. Both sides will be cladded with OSB but not the gypsum anhydrite. On the inside plasterboard will be added and the finishing will be done after placing the room.

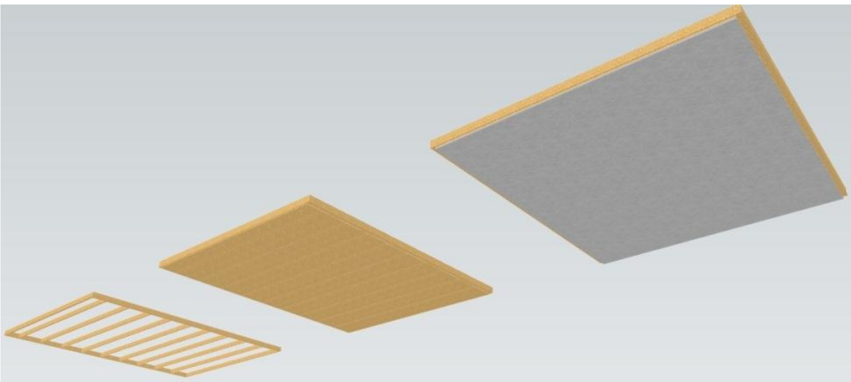


Figure 3.15 – Build-up timber frame ceiling

In the appendix there is a total list of materials in the modular room element and per size the total weight and cost. These can be found in appendix C.

3.4.2 Detailing of floors, walls and ceiling

The floors, walls and ceiling have been designed in the previous section and in will be elaborated upon in this section with details of connections and details of build-up of the separate elements. A larger amount of details can be found in appendix D, where also the different room sizes have their floor plans and technical drawings. For each element (wall, floor and ceiling) their specific requirements are discussed and a design with detailed drawings will be given.

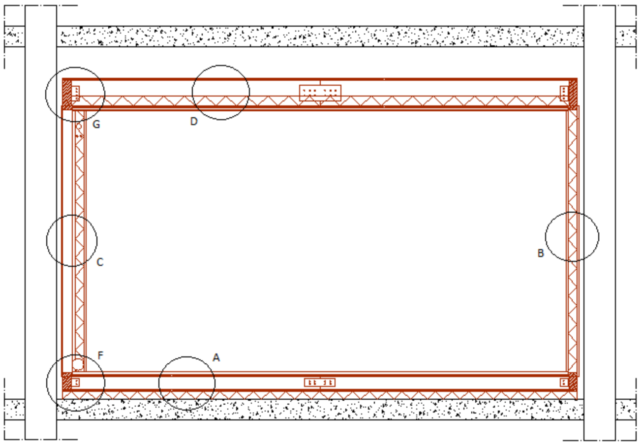


Figure 3.16 – Overview modular room including details

Floors

The floor of the modular hotel room will have a number of functions. It will be to walk upon within the room, but since it will be placed on top of an already existing load bearing floor it won't have to be able to carry loads after placement. However, during the transportation and placement of the rooms it will have to carry its own weight and the weight of the already prefabricated top floor and walls. Two other very important requirements are necessary for floors and that's acoustic insulation and fire protection.

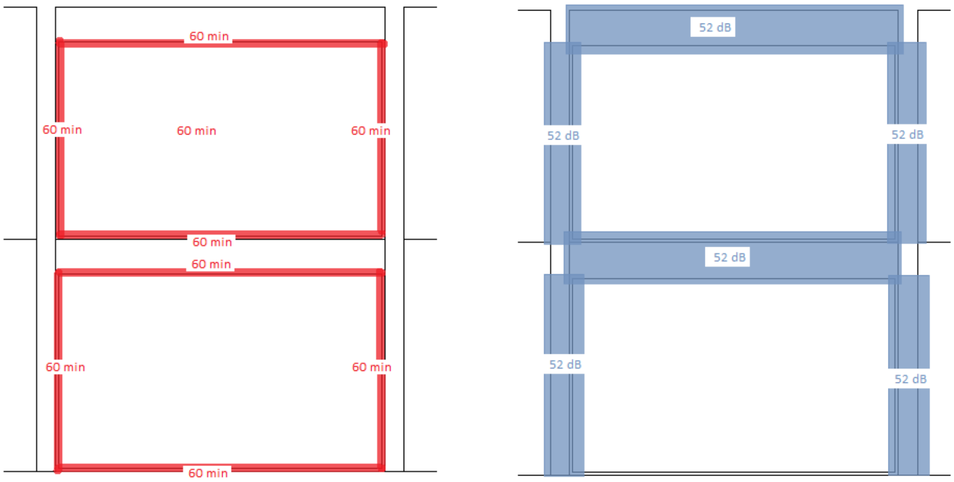


Figure 3.17 – Fire protection (red) and sound insulation (blue) from room to room in side view

The floor will be built-up from top to bottom as follows:

- Top floor finishing (after placement)
- Top floor of gypsum anhydrite 30mm
- OSB plating 18mm
- Floor beams (125x55mm) 600mm apart (span of 2500 mm e.g. room type 4A)
- OSB plating 18mm
- Mineral wool with a high compression 80mm
- Current floor

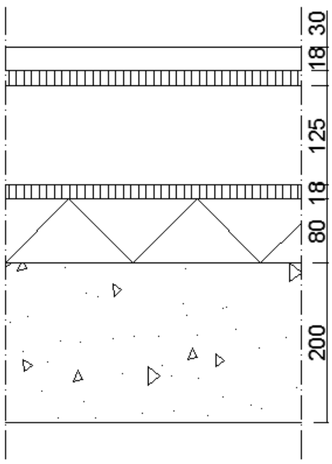


Figure 3.18 – Detail A: Build-up timber frame floor

The mineral wool will be placed on the current floor of the vacant building and on top of this the modular room will be placed. The mineral wool will act as a dampener for sound and will increase the fire resistance of the total floor. The total floor build-up will need to have a sound insulation of 52 dB as specified in section 3.2 and a preferred fire protection of 60 min.

Walls

The walls also have a number of characteristics. Their primary function is to divide the spaces, making a border between rooms. The other functions a wall has to fulfill is to separate outside from inside (façade) and to acoustically insulate between rooms. Also fire protection is a key factor. The size of the wall is determined by looking at reference walls and the requirements as determined in section 3.2.

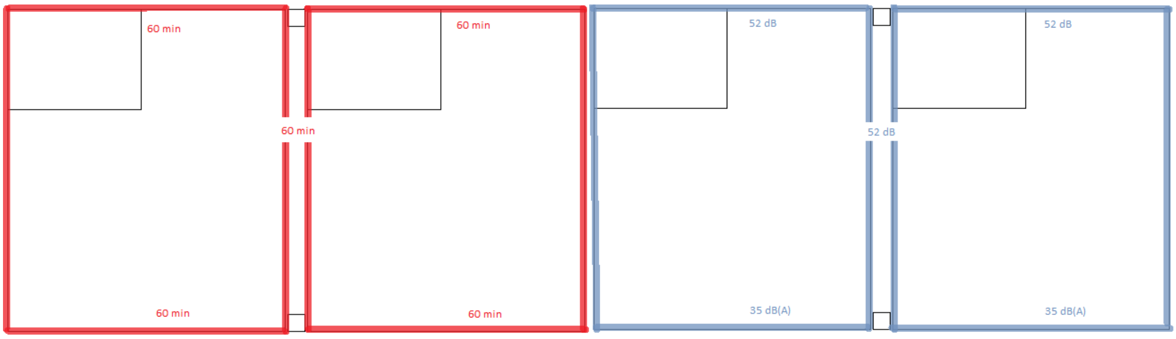


Figure 3.19 – *Fire protection (red) and sound insulation (blue) from room to room in top view*

There are two types of walls; one is thicker than the other. The thicker one will be used for the wall going from the bathroom to the façade. This will hold the horizontal pipes and drains going from the bathroom to the vertical shaft in the façade. The second type of wall is the thinner wall and will be used for the wall with the entrance and the other wall going to the façade.

The height of the thinner wall is lower than 3000mm and when referring to Fermacell insulating walls (Fermacell, 2012a) a thickness of rock wool of 70mm is necessary with non-load bearing walls. This will give an air-borne sound insulation of 47 dB per wall. The layer is extended to 90 mm, as will be made clear in section 3.4.3. The build-up of the wall from outside to inside will be:

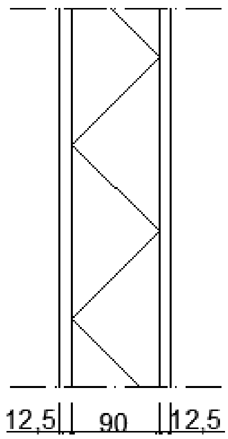
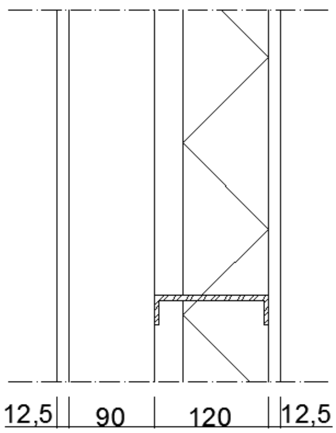


Figure 3.20 – *Detail B: Build-up thinner timber frame wall*

- Plasterwork (gypsum) 12,5mm
- Timber framework 90x40mm
- Rock Wool (90mm)
- Plasterwork (gypsum) 12,5mm
- Finishing (after placement)

The thicker timber wall has the same height but has a different build-up. It will consist of extra aluminum U-profiles to hang the plasterwork at a distance from the timber framework. The cavity that results from there will be used for the horizontal pipes, ducts and sanitary drains. The build-up of the wall from outside to inside will be:



- Plasterwork (gypsum) 12,5mm
- Timber framework 90x40mm

Figure 3.21 – *Detail C: Build-up thicker timber frame wall*

- Aluminum U-profiles 120x30mm
- Rock Wool (90mm)
- Plasterwork (gypsum) 12,5mm
- Finishing (after placement)

Ceiling

The ceiling of the modular room is in build-up a lot like the floor. The same timber elements are used for the ceiling as for the floor. This is done because of the simplicity of the modular elements and the stability of the element as a whole. Between the ceiling of the element and the actual floor of the vacant building there will be a leftover space. This space is also necessary when placing the element, so there is room for lifting handlings of the modular element and placing it.

The ceiling will be built-up from top to bottom as follows:

- OSB plating 18mm
- Beams (250x55mm) 600mm apart (span of 5000 mm e.g. room type 4A)
- Rock Wool (100mm)
- OSB plating 18mm
- Double Fermacell FirePanel A1 15mm (Fermacell, 2012b)
- Finishing (after placement)

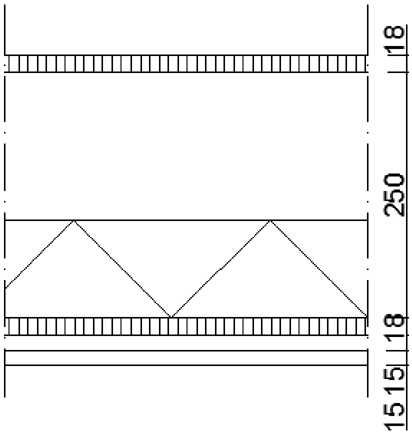


Figure 3.22 – Detail D: Build-up timber frame ceiling

The ceiling will need to have a fire protection value of at least 60 min. As seen before, there is a cavity between the modular element and the structural floor above. When fire gets in this cavity it can spread very quick through the floor and will pose a very dangerous situation for the rest of the building. With this build-up the ceiling will have a fire protection of 90 min, since the design is based on a similar design of Fermacell (Fermacell, 2012b). Together with the floor and the walls the modular room is made into a single fire compartment.

Both the floors and ceiling have different spans for the different room types and thus different sizes. Because the larger rooms will be separated and constructed in multiple parts the floor beam sizes are also different from the ceiling beam sizes. This is explained in section 3.5 where the transportation and assembly is discussed. Appendix F holds the calculations for all floor and ceiling beam sizes.

Wall to wall connection

The connection between the wall on the side and the wall with the entry will need to be done in such a manner that they will be sufficiently sound insulated and sufficiently fire protected. This will result in connections with air-tight closures.

Floor wall connection

For the connection between the floor and the wall the same applies as to with the wall to wall connection. The connection needs to be sufficiently sound insulated and fire protected. The floor will have floor beams and an edge beam. On top of the edge beam will be the mounting of the walls.

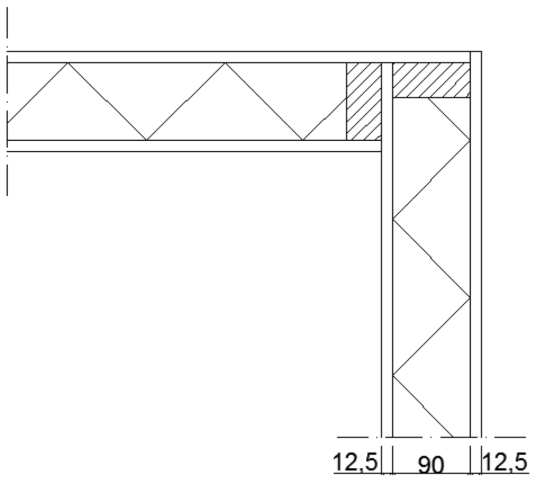


Figure 3.23 – Detail E: Wall-wall connection top view

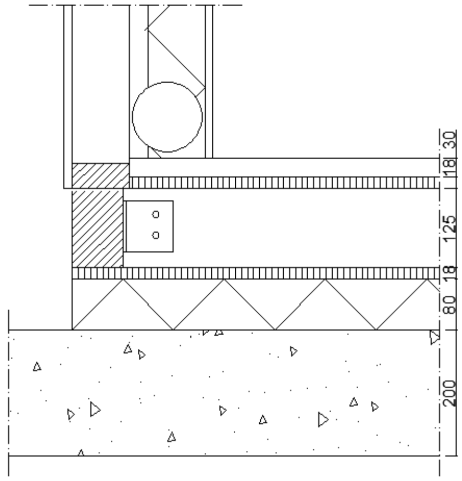


Figure 3.24 – Detail F: Floor-wall connection

Ceiling wall connection

The ceiling to wall connection is very similar to the floor to wall connection. The ceiling has the same build-up as the floor, only inverted. The connection between the ceiling and floor needs to meet the same requirements as the other connections in case of sound insulation and fire protection.

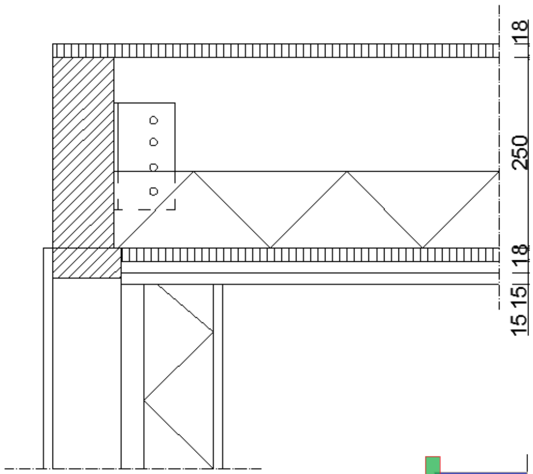


Figure 3.25 – Detail G: Floor-ceiling connection

Floor façade connection

The floor also has a connection to the fourth wall, the façade. This connection also needs to have an air-tight connection so the outside will be parted from the inside. What is also of particular importance with these connections is the fire protection in vertical direction, the heat from the fire may not go through this end-of-the-floor part of the building to the room above. There are a number of thresholds when designing a façade for this concept. One of them is the number of horizontal connections to the façade. There are the already available floors, which are in every building, and added to that are the new floor of the modular hotel room and the ceiling of the modular hotel room.

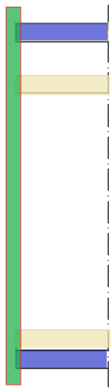


Figure 3.26 – Schematic view existing floors (blue), new floor and ceiling (brown) and new façade (green)

In order to fulfill the desired fire protection and sound insulation the most important thing is to create an air-tight barrier between the already existing floors and the façade. The new modular hotel room will be connected to the façade but the demands for these connections don't have to be so high, since the most important part (floor to floor) is sufficiently safe.

A second threshold is the type of façade. Within the scope of the Master thesis one façade type will be discussed and worked out for reference. However, the façade and the modular unit are separate elements and the owner or client may desire a different façade, the possibility for a different façade is present.

Ceiling façade connection

The same applies to the ceiling-façade connection as with the floor to façade connection. There has to be sufficient fire resistance and sound insulation between the different stories of the building. Vertical transport of fire is very important because of the rapid progress of fire when not properly contained.

The details are in a larger size in appendix D, along with the sizes of walls, floors and ceilings of different modular room sizes.

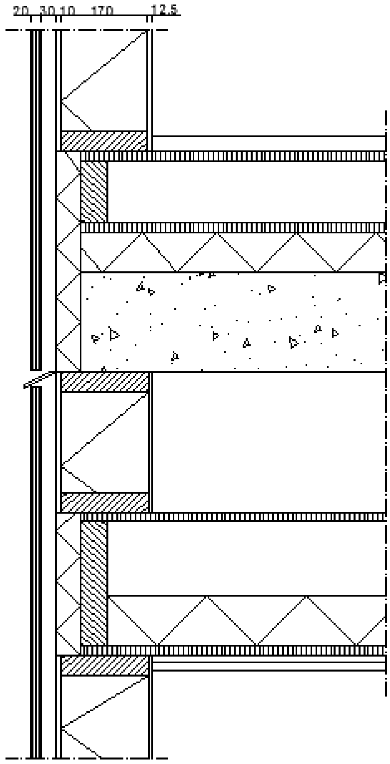


Figure 3.27 – *Detail H: Floor/Ceiling-façade connection*

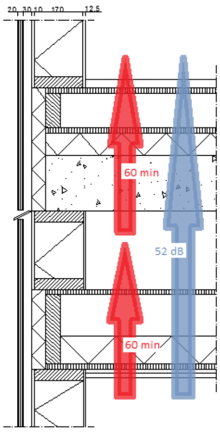


Figure 3.28 – *Floor/Ceiling-façade connection with fire protection and sound insulation requirements*

3.4.3 Installations and building services in the modular room

The timber frame isn't the only thing prefabricated on the modular hotel room unit. The aim is to do as much work off site as technically possible. This will include also adding pipes, ducts and drains for all installations and services within the room. Transport of air, fresh water and grey water can be divided into two directions, vertical and horizontal. Both directions will be designed for and elaborated upon in this section.

There are a number of services and installations in a building that need to enter and service the room. Each service needs to be generated or congregated at a central or local place and distributed to the rooms. The following table gives the necessity of horizontal and vertical distribution and the place of generating or congregation (either central or per room).

	(De)centralized?	Horizontal	Vertical
Ventilation air	Decentralized	Yes	No
Heating	Centralized	Yes/No	Yes
Cooling	Decentralized	No	No
Electricity	Centralized	Yes	Yes
Sanitary Inlet	Centralized	Yes	Yes
Sanitary Outlet	Centralized	Yes	Yes
Drinking water	Centralized	Yes	Yes

Table 3.10 – *Building service centralization or decentralization*

For each centrally generated or congregated service the owner or client is free to choose the way of generating or congregating. This will ensure that the client is not limited in what type of building service he can choose, but still giving a certain amount of prefabrication and modular building. As stated before, the horizontal pipes, ducts and drains will be prefabricated and already present in the modular room. The vertical pipes and drains will not, these will be located on the outside of each room, at the side of the façade. There will be a small box designed which will hold all vertical transport.

Vertical transport

The vertical transport will be as mentioned be done in the façade. A vertical transport shaft (box) will be designed at the façade side of the modular room element. The way this is build up is figuratively expressed here. The brown part represents the room itself, the blue represents the façade and the green part is representing the vertical shaft.

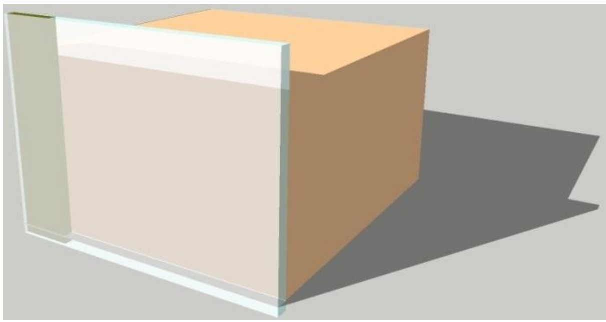


Figure 3.29 – Location vertical shaft

The vertical shaft will be within the façade and will be attached to the wall of the modular room element. All water pipes, sanitary drains and other vertical transport will be vertically transported through this element. Three of the four "walls" of the vertical box will be attached to the element before placing the room in the building, the outside "wall" will be left open so the vertical pipes and ducts can be placed and later accessed if necessary.

The build-up of the vertical box will be with a different timber strength class. This will ensure higher fire safety which will be a critical point when designing a vertical shaft. The "walls" of the vertical shaft will have a 60 min fire safety to ensure the fire can't easily go through the shaft. On top of that, all pipes, ducts and drains will have to be fitted with a closure system to ensure the same level of protection against fire.

The "walls" will be designed with D50 timber with a density of 650 kg/m^3. According to NEN6073 the burning speed of timber with a density larger than 600 kg/m^3 will be 0.45mm/min. Since the "walls" of the vertical shaft won't have a structural function the thickness of the wall can be designed by multiplying the burning speed with the required fire protection, making the walls at least 27 mm thick. The walls will be overdesigned and will be 35 mm thick to ensure sufficient protection.

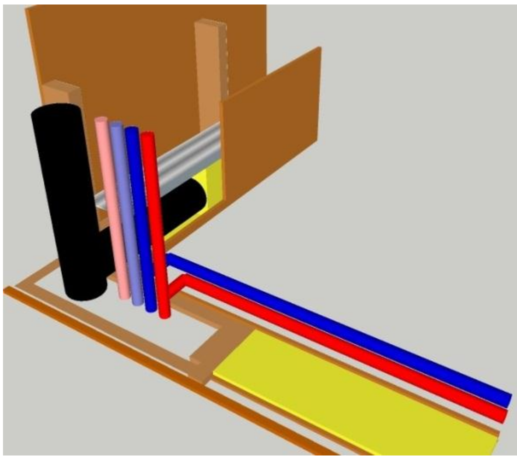


Figure 3.30 – 3D vertical shaft

The inside of the vertical shaft needs to be totally filled with rock wool. This is necessary due to the insulation of the room; the vertical shaft will otherwise be a thermal bridge. The R-value of the designed façade is equal to R_f = 4,96 m^{2}K/W and of the vertical shaft it is equal to R_{vs} = 3,81 m^{2}K/W.

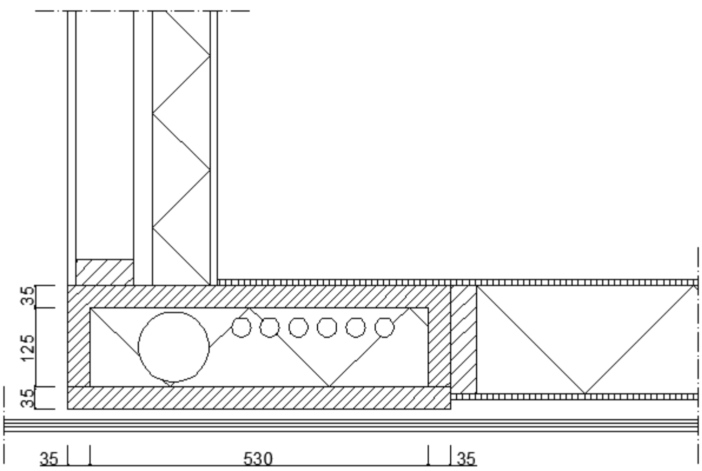


Figure 3.31 – Detail I: Vertical shaft

The detail as shown here is in full scale in appendix D; the calculation of the R value of the façade and the vertical shaft is in appendix E.

Horizontal transport

Horizontal transport will be done in two separate ways. One of them is through the wall perpendicular to the vertical shaft through the wall. This wall can also be seen in figure 3.30, above. The wall has a cavity, as mentioned in section 3.4.2 in which the sanitary pipes will be designed. This sanitary drain will have a connection with the vertical drain slightly above the floor level of the modular room. Within the wall there is also room for hot and cold water pipes which flow to the bathroom and a ventilation shaft for the exhaust air out of the bathroom.

The ventilation shaft will be in the wall near the ceiling and will have a circular shape with a diameter of 50mm, which will be sufficient for the 14dm^3/s of mechanical exhaust air that is demanded for bathrooms in the building decree. The following function will make that clear where 4 m/s is the air speed in ventilation shafts directly connected to a room.

$$A = \frac{q_v}{v} = \frac{14\ dm^3/s}{4\ m/s} = \frac{0{,}014\ m^3/s}{4\ m/s} = 0{,}0035\ m^2 = 3500\ mm^2$$

A 50 mm diameter circular ventilation shaft will be able to create a flow of 31 dm^3/s with an air speed of 4m/s. Even if the air speed is lowered to 3 m/s, the requirements will still be met. As mentioned in section 3.2 the sanitary drain will have a diameter of at least 110mm. This will fit in the cavity of the wall.

What is very important is that both the ventilation shaft and the sanitary drain, together with other pipes will be on the inside of the wall and within the insulation. The insulation will therefore need to be made thicker to compensate for this, both for fire resistance and sound insulation. This is the reason that instead of 70mm there is an insulation layer of 90mm within the wall.

The hot and cold water will also be designed in the wall near the ceiling, under the ventilation shaft. The location for the water pipes will make sure there is water pressure when used in the bath or sink, water coming from above, and won't be in the way of the ventilation shaft which will have its suction from the ceiling.

The second method of horizontal transportation will not be done through the wall, but from the vertical shaft will immediately exit the shaft and continue along the façade, this will apply to the hot water of the heating and the return water, but also to TV and internet cables, which can be put away in the plinths. Electricity cables and lighting will go through the walls, but all cables of these sizes won't have problems of stowing away in the walls.

All horizontal cables, pipes, ducts and drains will be prefabricated and added to the modular hotel room unit before placing. After placement the vertical pipes, ducts and drains can be attached to the horizontal pipes from within the vertical shaft. Electricity will have to be done by a certified electrician since connections have to be made on site. The alternative is to leave all smaller cables for after placement, however, this can be more time-consuming.

3.4.4 Façade and hallway units

Not only the rooms themselves will be prefabricated and brought on site as a whole. There will also be handed solutions for the façade and the hallways. The reason for this is to make a complete floor of a hotel consisting of modular elements, which is the design idea of this thesis. For a client applying this solution there is no necessity to apply either the façade or the hallway units, making him free to choose for a different façade. However, the advantage of selecting a predesigned façade is that the costs are more constant since a lot of detailing work has already been done. There is a certain degree of certainty that the façade will work.

Façades

For the façade there are three different types designed where a client can choose from. All three façades are based on a timber frame wall with an outside plate or wall that gives the façade its face. The reason for using a timber frame in all three occasions is that it's in line with the rest of the modular building in terms of production process. All modular elements are constructed in timber, so there is no reason to alter the production process in order to create a façade. A timber based façade can hold the same façade cladding as a concrete wall, albeit in lesser amounts due to the restrictions in strength.

Timber plate façade

The first type of façade consists of a timber frame wall which will be placed in between the modular hotel room unit and the current floors; this will make the façade as airtight as possible. On the outside of the façade there will be timber plating; this will give the building a durable wooden look and homely, warm feel. The detail as seen in section 3.4.2 figure 3.26 is given here again to show the way the façade is built up.

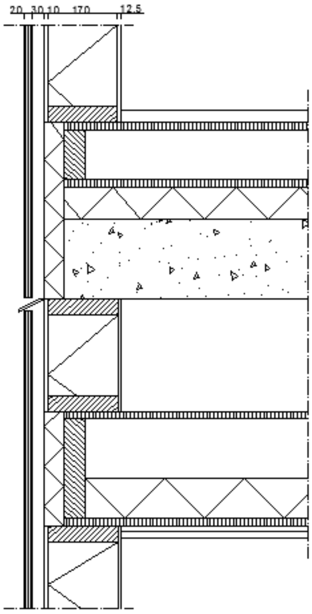


Figure 3.32 – Detail H: Timber plate façade

Brick façade

The second type of façade is one with a brick cladding on the outside. The façade is again one of a timber frame, but this time the wooden plating on the outside is substituted by a thin layer of brickwork that gives the building a feel of Dutch typical masonry homes and strength. The detail for this has similarities with the first type of façade, namely because of the timber frame giving the façade its strength.

Aluminum cladding façade

The third type of façade is one that gives a more futuristic and clean look to a building. The aluminum cladding will be placed on the outside instead of the wooden plating, while again the interior of the façade will consist of a timber frame. The futuristic or clean look may be appealing to owners who want their building to really stand out of the rest.

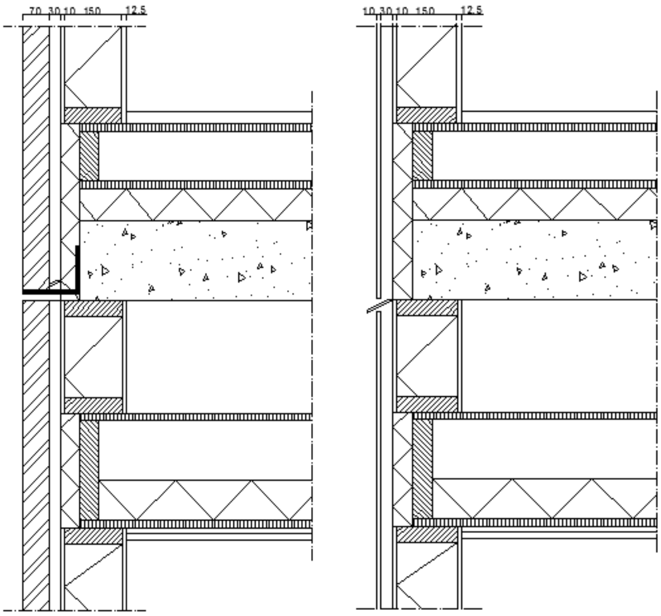


Figure 3.33 – Detail J and K: Brick façade (left) and aluminum façade

All temperature resistances, or R-values, are calculated in appendix E and a summary table is given here. All façades have a temperature resistance of around 5m^2K/W, even making them good for new buildings and not only for transformation projects.

Façade	R-value (m^2K/W)
Timber plate façade	4,96
Brick façade	5,00
Aluminum cladding façade	4,89

Table 3.11 – R-values façade units

Hallway units
The hallway units are the smallest part of the modular building. The hallway units will only consist of a timber frame floor, with an OSB plate and a top floor of gypsum anhydrite. The build-up is the same as the floors of the modular rooms, making it easier in the production process. The hallway units will come in 4 different sizes, 2 different widths and 2 different lengths, making them applicable in a number of situations.

The benefit of using these floors is that they are easily placed and not much work has to be done after placing; only applying a top layer as wished by the client and to cut the OSB plates so they fit the situation. The OSB plates will be designed with an overhang of 50mm on each side which can be sawn or cut to match the situation on the floor. This will make sure that the floor will connect properly to each other and to the rooms.

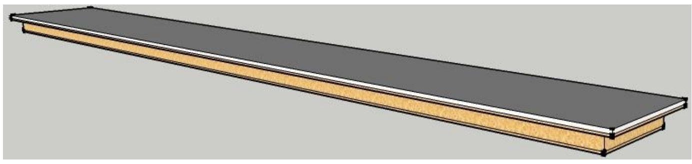


Figure 3.34 – Hallway unit 1A (7,2 x 0,8m)

The top layers may consist of a carpet, laminate or even stone. The hallway units can be placed before the modular units or afterwards, however, before placing the hallway units there should be a mineral wool applied to the existing floor for the same reasons as it's placed under the modular room units.

The hallway units, together with the modular rooms will make for a total modular hotel floor which is comparable to an easy puzzle. Different pieces will be placed next to each other and form a whole hotel floor.

3.4.5 Fire protection

In the previous sections we already have seen that the design of the modular room has to comply with a number of characteristics. One of the most important ones is fire protection. With the design of section 3.4 the focus was to make the modular room a single fire compartment, so that if a fire occurs within the room the spread to the rest of the building is limited. Working with cavities above the modular room makes it particularly important to make the ceiling sufficiently fire proof. When smoke or fire reaches the cavity it can spread very quick, as was also seen in the Schiphol-fires (NOS, 2009).

There are two main types than can be described of how a fire starts, being a fire that starts within the room (for any reason) and a fire that starts because of short circuiting (within a wall). For both types the fire should be contained within the room and the time before the fire leaves the compartment should be at least 60 min. In this time the people will be able to evacuate and the fire department can do their job.

Situation	Start of fire	Solution to contain
1	During a fire inside a room	Floor, walls, ceiling 60 min fire protection
2	During short circuit	Within the room: situation 1 Within the wall: using non-combustible materials around electrical wiring

Table 3.12 – Fire situations and solutions

The fire that starts within the room must be contained within the room. For this reason, the floor, walls and ceiling have to be fitted with sufficient fire protection to make the fire protection 60 min. The floor has mineral wool underneath, the walls contain rock wool and the ceiling contains rock wool together with fire panels. From reference designs of Fermacell (Fermacell, 2012a; Fermacell, 2012b) we know that the fire protection of the walls and ceiling are sufficient. The floor is assumed sufficient because of the build-up of the old and the new floor together and referencing them with sufficiently fire protected structures.

A fire that occurs due to short circuiting of electrical equipment or wires can be placed at two locations, inside the room or inside the wall (where electrical wires will go through). Fire due to short circuiting has to comply to a number of flaws in order to occur, but there are enough references of buildings destroyed by fire due to short circuiting that it does need attention (Faculty of Architecture, Delft (Nu.nl, 2008)).

In the situation the short circuiting happens inside the room the fire should be contained within the room, in other words, the first starting point of fire will occur, as seen above. When the short circuiting happens within the walls due to bad electrical wiring, the fire should not go outside the wall, however for all fires the same three elements are necessary to occur; oxygen, heat and fuel (or combustible material). Oxygen is available, together with the heat from the electricity so the way to contain fire in this part of the room is to make sure there are no combustible materials available. The electrical wires will run in the wall between the rock wool and the plasterwork. The rock wool is not combustible (Euroclass A1) and the plasterwork is difficult to combust (Euroclass A2).

What should also be noted is that short circuiting occurs when water meets the electrical wiring. As the water pipes are situated higher than the electrical wiring the situation that leaking water will go to the electrical wires should also be noted. The solution here is to make sure that even in the event of leaks the water can't reach the electrical wires. All pipes and wires are surrounded by rock wool for insulation, but even if it wouldn't the electrical wires should be double insulated, in other words, using a different material around the wires to make sure that water can't reach the wires. This does have to be checked and carried out with care, but since the electrical wiring will be done off-site it's possible to maintain a certain quality level.

3.4.5 Total room picture

A cross section of the total room, including floor, ceiling, walls, ducts and pipes, is given here. This is the total picture of a room, as designed and will give a clear view of the total room. The room, as given here is one of type 4A (see catalogue).

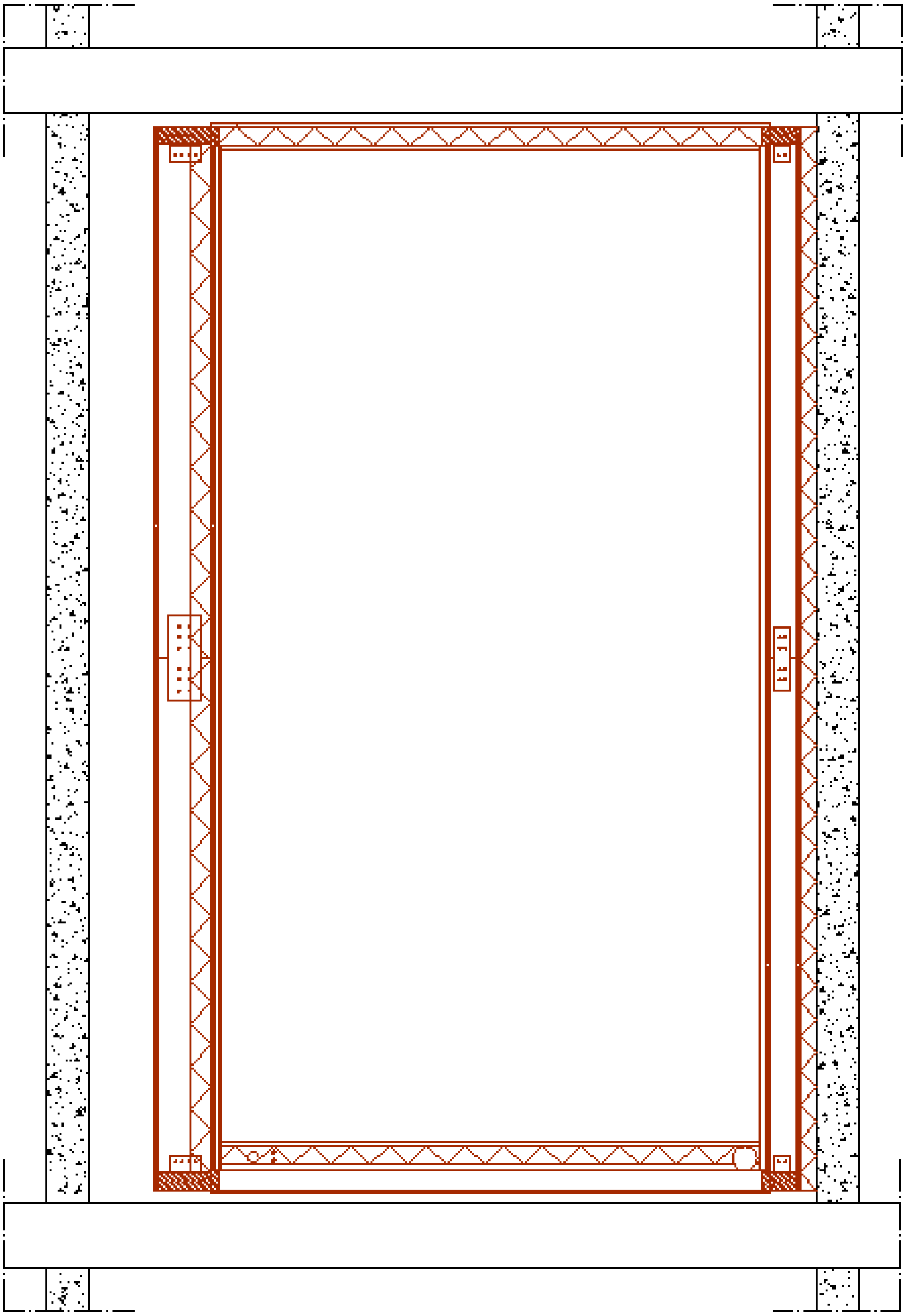


Figure 3.35 – Total room picture

3.5 Transportation and assembly

A lot of important issues have already been tackled in this chapter, such as the sizes and adaptability to different building grids of vacant buildings, the necessary surface areas per star class and the different needs and adaptability in finishing levels, without losing sight of the building services, a complete package with a façade and maintaining a certain level in prefabrication hence not losing sight of the concept.

3.5.1 Size and hoisting restrictions

A very important factor is the transport of the modular units to any given building site. This will restrict the solution in a number of ways, the most important being the size of the elements and in lesser amount the weight. As seen in section 3.2 the maximum sizes of a modular element has to be 22x3x4m (lwh). The length of 22,00m and the height of 4,00m will be easily maintained and won't put restrictions to the modular elements.

The size restriction will come from the 3,00m of maximum width that has to be complied with in order to make use of normal transport trucks and without using special transport which will add to the costs. In order to comply with these measures a number of rooms, the ones with a width higher than 3,0m will be divided into two parts. The largest room will be divided into 3 parts.

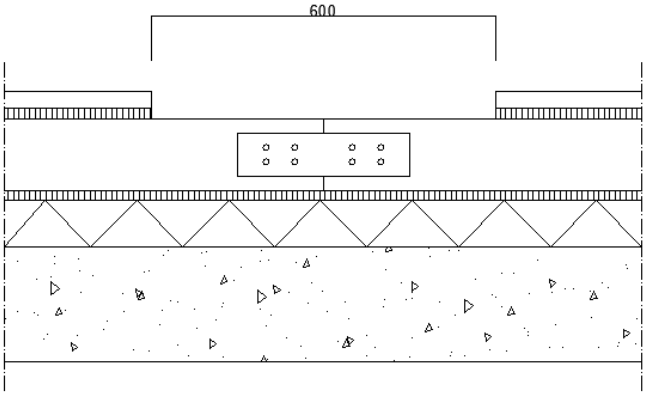


Figure 3.36 – Opening in floors for connection

After placing each part of the room they will be connected to each other at every ceiling beam and every floor beam, this can also be seen in figure 3.35 and in the details in appendix D. In order to connect the beams to each other, the end part of the OSB and top floor will be left open as can be seen in figure 3.36 and 3.37.

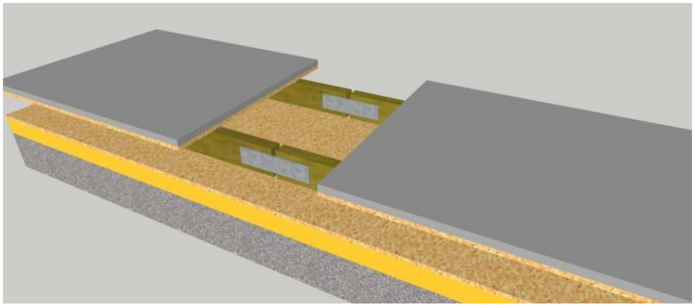


Figure 3.36 – 3D resemblance of opening in floors for connection

A second part of transportation influencing the design is the size of the floor beams and ceiling beams. The floor beams have no structural purpose after placement but during hoisting they need to carry their own weight, the same applies to the ceiling beams, but these do serve a structural purpose after placement and connection. The ceiling beams need to span the width of the room and carry their own weight. These ceiling beams are not determined by hoisting, but by their end state, spanning the entire length of the room.

In résumé, the floor beams are calculated for their use during hoisting, and the ceiling beams are calculated for their use during the end state. The calculations themselves can be found in appendix F.

During hoisting half of the room can be made into a mechanical scheme, which will make the force distribution more clear. The values of forces are all from the own weight of the timber frame and prefab elements, since no variable forces are applied yet. What can be seen during hoisting is that if no measures are taken to make the "half"-room stronger it will probably breaks during the hoisting. For this reason there are metal tie rods used during the hoisting of the modular room.

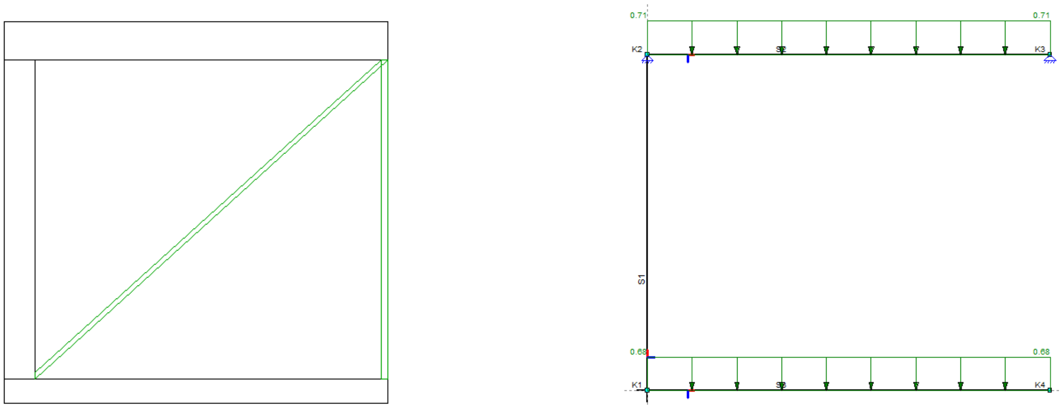


Figure 3.37 – Hoisting of the "half"-room with tie-rods (left) and mechanical scheme (right)

The tie rods will be connected to the end part of the floor, which is already left "floorless" as seen in on the previous page, and at the floor/wall connection, which can be seen in figure 3.38. Small rectangular pieces will be left out of the floor, so the temporary tie rods can be connected to each floor beam. This will ensure structural strength during hoisting and placing of the modular units.

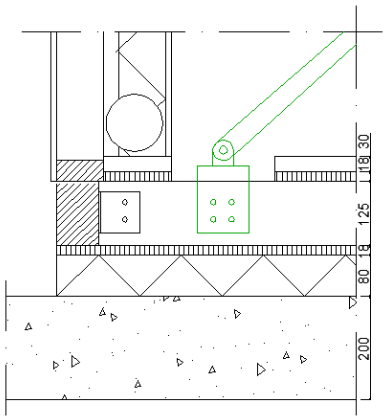


Figure 3.38 – Temporary hoist connection to the floor beams

Out of the calculation of floor beams under its own weight during hoisting follow the sizes of the floor beams for every type of room. The same happens for the ceiling beams during the end state. A table on the basis of timber beams calculations of all floor and ceiling beams sizes is given here to show the various sizes.

Room	Beams in ceiling			Beams in floor			Columns in Wall	
	span (m)	b (mm)	h (mm)	span (m)	b (mm)	h (mm)	b (mm)	d (mm)
1A	6,8	55	340	3,0	55	150	90	40
2A	3,4	55	170	1,7	55	85	90	40
2B	3,4	55	170	1,7	55	85	90	40
3A	2,5	55	125	2,5	55	125	90	40
3B	2,5	55	125	2,5	55	125	90	40
4A	5,0	55	250	2,5	55	125	90	40
5A	3,4	55	170	1,7	55	85	90	40
5B	3,4	55	170	1,7	55	85	90	40
6A	2,5	55	125	2,5	55	125	90	40
6B	2,5	55	125	2,5	55	125	90	40
7A	5,0	55	250	2,5	55	125	90	40

Table 3.13 – Floor and ceiling beams sizes

The size of the total modular unit and the hoisting of the unit are not the only thing that limits the design of the modular hotel room unit. The weight is of importance for both transport and hoisting. As seen in section 3.2 the maximum weight during transport is 19.000 kg and during lifting anywhere up to 650.000 kg. The maximum lifting capacity is not posing any restrictions since for every capacity there is a type of crane up to 650.000 kg lifting capacity.

The weight of any modular unit, or half unit, is restricted by two parameters:

- Maximum load bearing of current floors: NEN8700 formula

$$F_t = F_{t_0}(1 + \frac{1-\psi_0}{9}\ln\left(\frac{t}{t_0}\right))$$

F_t = The extreme value of the adapted variable uniformly distributed load at the reference period corresponding to the chosen remaining life span.
F_{t_0} = The extreme value of the adapted variable uniformly distributed load at the base reference period.
ψ_0 =The factor value ψ_0 which can be derived from tables in NEN8700.
t = The reference period that corresponds to the chosen remaining life span.
t_0 = The base reference period.

The maximum load bearing of current floors is dependent on the current state of the building and the current state of the floors. Carrying capacity should always be taken into account and this formula is applied to the carrying capacity of structural elements in transformation projects, in other words, the carrying capacity after a certain life span.

- Maximum transport weight: 19.000 kg

The maximum transport weight is a more solid number since there is a number given by the Dutch government service for road traffic and is equal to 19.000 kg (RDW, 2009b). Every (half) modular unit won't exceed this weight limit as can be seen in table 3.13.

	Weight (kg)	Weight part unit (kg)	Weight (kN)
Room			
1A	8938	4069	87,68
2A	5395	5395	52,93
2B	5395	5395	52,93
3A	3196	3196	31,36
3B	3646	3196	35,77
4A	5628	2814	55,21
5A	4336	4336	42,54
5B	4336	4336	42,54
6A	4078	4078	40,01
6B	4528	4528	44,42
7A	7045	3523	69,11

Table 3.14 – Weight of modular units

3.5.2 Assembly steps

For the assembly and placing of the elements there has been made a step by step program which will be shown in this section. This step by step plan is covering everything on the building site from vacant building to new modular hotel building.

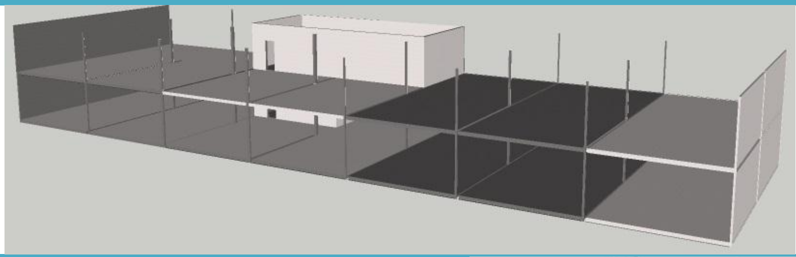
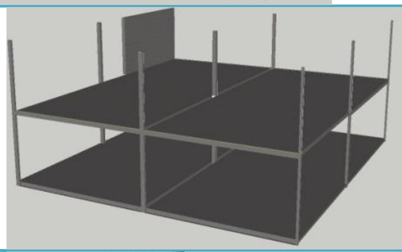
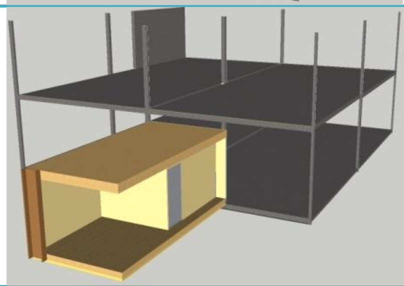
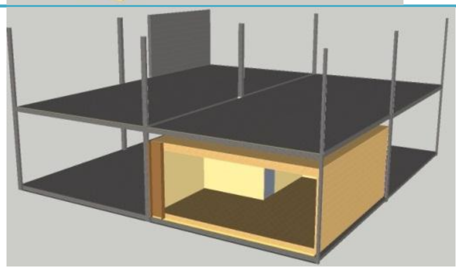
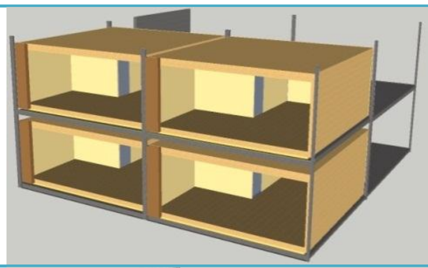
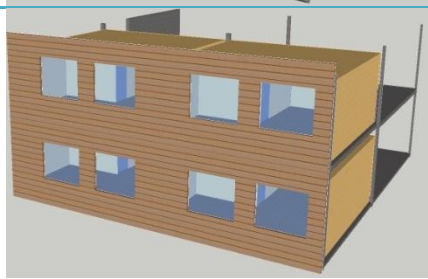
Step	Explanation	Picture
		
1	***Demolition*** The demolition of the current vacant building will include stripping the building completely and leaving only the columns, floors and other structural elements	
2	***Hoisting and placing (part) element*** The modular element or part of the element can be hoisted up and placed on top of the mineral wool, after this the different parts can be attached to each other.	
3	***Place left over parts*** All hoisting equipment can be removed from the elements and all savings due to hoisting equipment in floor and ceiling can be filled.	
4	***Connect vertical transport*** All vertical pipes and ducts will be attached to their horizontal counterparts, which will already be there. After this, the vertical transport can be attached to the floor above and below.	
5	***Close vertical shaft*** After all pipes and ducts are attached to each other the vertical shaft can be filled with rock wool and be closed.	
6	***Place façade*** The façade can then be placed in front of the building and the vertical shaft.	
7	***Finishing inside*** After the closing of the room, the finishing inside can start, all floors, walls and ceilings will be finished with a top layer as wished by the client and all furniture can be placed. Before this all electrical wires should be connected.	

Table 3.15 – Step by step program

3.5.3 Load bearing façades

The situation of vacant office buildings up until now was almost always based on a column and floor structure without load bearing façades. However, in practice one can and will come across buildings with load bearing façades. In these cases the solution should still be applicable.

The difference between the non-loadbearing façades and the loadbearing façades is that the façade should be detached from the building and that it's more difficult to detach load bearing elements. When applying the modular elements to a building with a load bearing façade the solution is to first temporarily support the floors on the façade side. This can be done with temporary columns and beams.

As can also be seen in the total room picture in the section 3.4.5, there is room between the ceiling of the modular element and the concrete floor. After the placing of the modular rooms a new load bearing façade can be placed in front of the rooms. The space under the concrete floor is sufficient to place an edge beam (~300mm). After the placing of the new load bearing façade the temporary columns can be removed.

Step	Explanation
1	**Placing temporary support** Temporary support mainly consists of columns and beams behind the façade to temporarily support the floors while detaching the façade.
2	**Removing façade** The old load bearing façade will be removed as is done in the first step of the regular step by step plan, demolishing it from the building.
3	**Placing elements** The placing of elements will be done in the same matter as is done in step 2 to 6 of the previous assembly step program.
4	**Placing new load bearing façade** The new façade can be placed, this has to be a load bearing façade, since it's undesirable to change the initial force distribution of the building itself, this is the same step as step 7 of the assembly step program.
5	**Removing temporary support** In between step 7 and 8 of the assembly step program the temporary support structure can be removed.

Table 3.16 – Different steps with load bearing façade

3.6 Case study

All sections in the design phase until this one where only theoretical sections, but no link has been made to the actual practice. In the form of a case study this will be done in this section. From a building out of appendix A there will be made a design of a hotel using the modular elements as designed before. The building will be Trivium, in the Derkinderenstraat in Amsterdam Nieuw-West, which will be converted into a 3 star class hotel.

The case study will be built up as follows; an overview of the building will be given, along with its location and floor plan. After this the modular elements will be fitted in the floor plan and the maximum floor loads will be calculated. Along these calculations and fitting in of the elements also the feasibility of the step by step program will be determined and the financial feasibility of using the modular elements against "general" transformation into a hotel.

3.6.1 Derkinderenstraat 10-24

The building Trivium at the Derkinderenstraat in the Nieuw-West part of Amsterdam is a building which has a total vacant gross floor area of 9160 m^2 and is vacant for over 5 years, making it structurally vacant.

As seen in the photo and floor plans, the building consists of two parts, a tower and a longer low-rise part. Travelling from this location to the center of Amsterdam is 20 min with public transport and to Schiphol is 15 min as the location of this building is close to an intercity train station.

Figure 3.39 – *Trivium, Derkinderenstraat 10-24, Amsterdam*

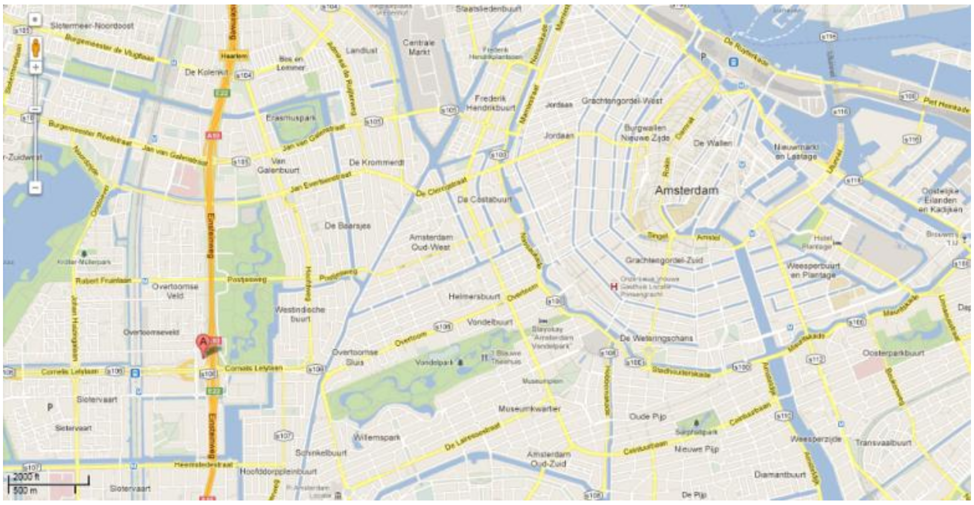


Figure 3.40 – *Location Trivium*

The left part of the floor plan is the tower and the right part is the low-rise part. We can already establish from this that the tower gets its stability from a central core along with a load bearing façade. The low rise part is carried in the same way, with a central core and a load bearing façade.

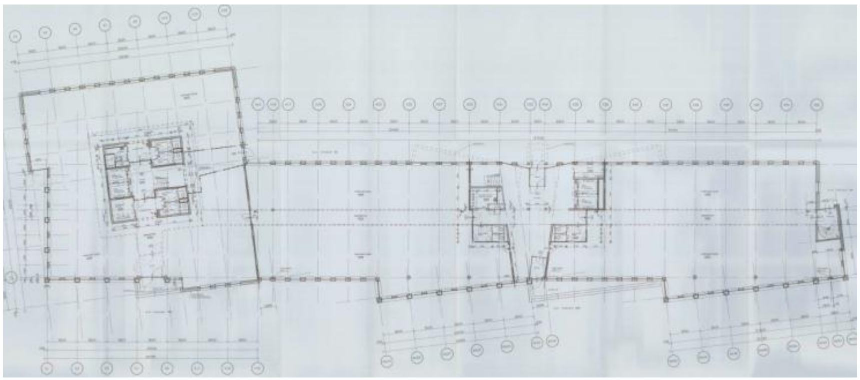


Figure 3.41 – Floor plan ground floor Trivium

3.6.2 Fitting of elements

The first part of the determination of feasibility for transformation to a hotel using the modular elements is to fit in these elements into the Trivium-building. For this, floor plans will be used for each floor and modular elements will be added to that floor. Modular elements of the type 5A/B will be used for this project giving rooms of sufficient size which are able to fit with the grid size of 3,6m of this building.

The two parts of the building, the tower and low-rise will each get a number of hotel rooms, which will be seen in the table (3.17), all floor plans with the modular rooms will be in larger size in appendix H.

The ground floor will only have rooms in the low-rise part; the section in the tower will be used as an entry and hotel lobby, a central entry around the central core of the tower. The low-rise part consists of 4 floors of hotel rooms (floors 0, 1, 2 and 3) and the tower will be made with 6 floors of rooms (floors 1, 2, 3, 4, 5 and 6). The seventh floor of the tower will be used for a restaurant or "other" functions. The eight floor of the tower and the fourth of the low-rise will be used for technical rooms, as in the current situation.

	Tower			Low-rise		
Floor	**Function**	**Rooms**	**Floor Area (m^2)**	**Function**	**Rooms**	**Floor Area (m^2)**
0	Lobby		570	Hotel	27	1000
1	Hotel	15	570	Hotel	30	1000
2	Hotel	15	570	Hotel	30	1000
3	Hotel	15	570	Hotel	31	980
4	Hotel	15	570	Technical		250
5	Hotel	15	570			
6	Hotel	18	650			
7	Restaurant/other		650			
8	Technical		210			
Total		**93**	**4930**		**118**	**4230**

Table 3.17 – Number of rooms and total floor area per floor

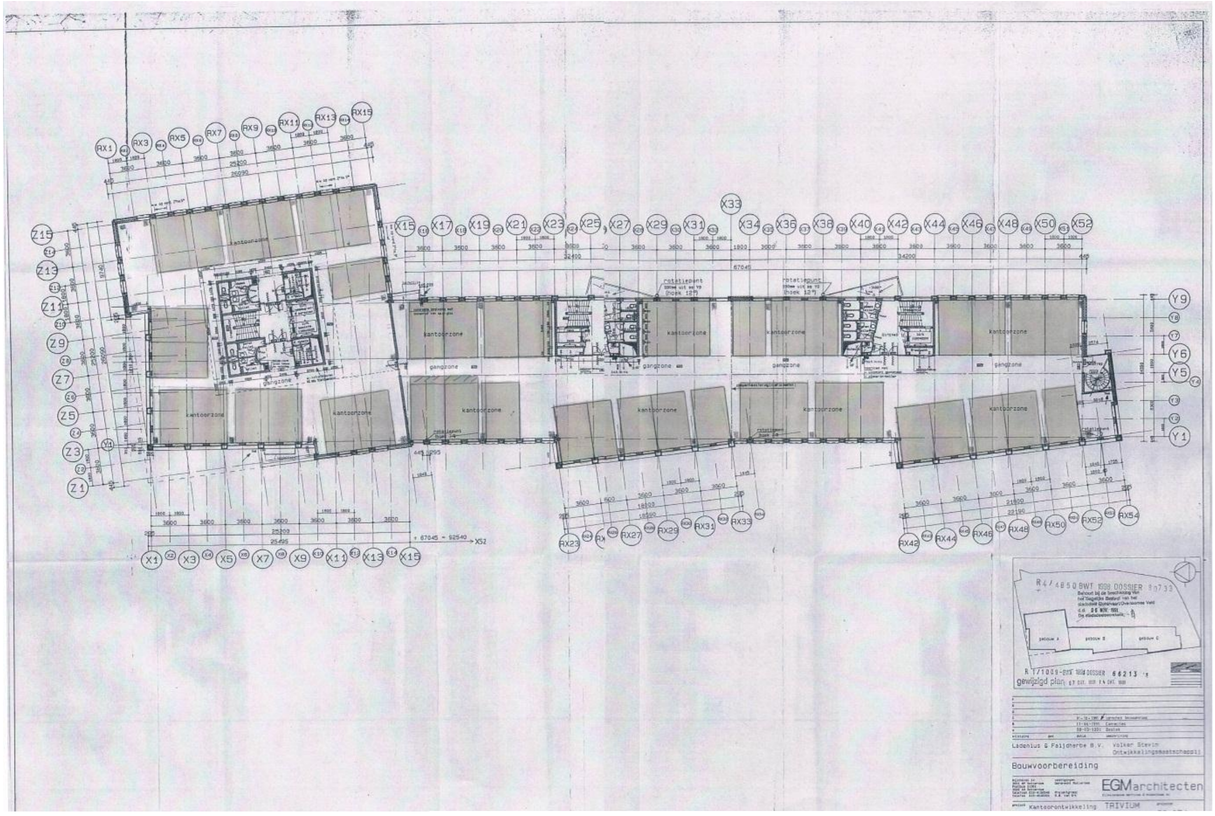


Figure 3.42 – Floor plan first and second floor Trivium with modular rooms

As an indication, the floor plan of the first (and second) floor will be shown here, all the other floor plans will be in the appendix H. All modular room elements are placed in such a way that the new to place columns can be placed at a distance of 7.2m of each other. This has to be done to maintain the structure, as the load bearing façade will be demolished. We can also see from the floor plan that all rooms can be placed in the floors and that two conclusions can already be drawn:

Using modular hotel rooms is possible for this project; however there is a certain amount of lost space due to the inflexibility of the modular elements

Using modular floor elements as described in section 3.4.4 will be very difficult due to the different angles of placing of the rooms.

3.6.3 Structural feasibility

The scope of this part is to determine whether or not the new elements inside the current floors will be possible, construction wise. The carrying capacity of the floors, as designed will be determined and will be adapted with the formula in NEN8700. This will give a capacity of the floor and whether or not the elements, with their known weight may be placed.

The formula of NEN8700 has already been explained in section 3.5.1 and will be given here:

$$F_t = F_{t_0}(1 + \frac{1-\psi_0}{9}\ln\left(\frac{t}{t_0}\right))$$

What is of importance within the formula is that the carrying capacity of the current floors needs to be determined. This will be done through calculations with the drawings that are available, since no calculations could have been retrieved.

The floors of this building are hollow core slabs with a number of heavier beams. Forces are thus distributed into one direction and along the beams will be carried to the core and façade. This can be seen in the detail given and the visual representation of the load distribution.

The modular elements will be placed parallel to the beams and will cause an extra force on the floor. The extra force and the force that is applied theoretically for hotel floors according to the building decree added together should not exceed the carrying capacity of the concrete floor with beams. All modular elements will be of the type 5A/B.

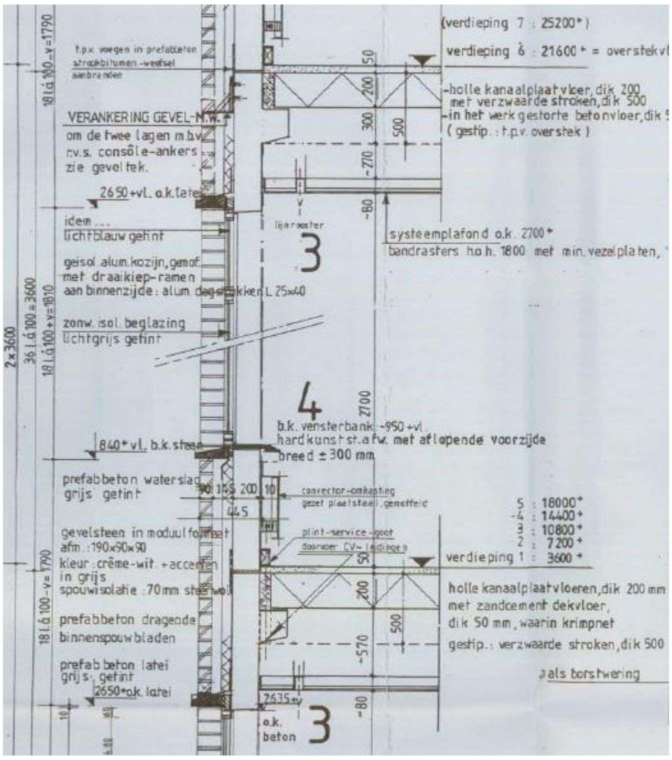


Figure 3.43 – Detail of connection façade to floor

The complete calculation can be found in appendix G and the results of the calculation will be discussed here. After the placement of the modular elements as in 3.6.2 we can calculate the total weight that's on each floor. From this we can say what the floor load per square meter is and thus if the structural floor will have sufficient carrying capacity.

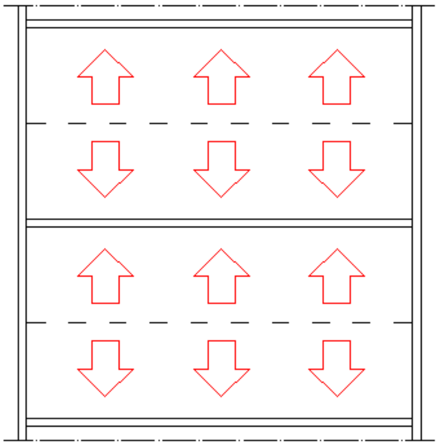


Figure 3.44 – Force distribution floors

The total weight per floor is shown in the following table and is for each floor of the tower and for the low-rise. All forces are the permanent forces of the rooms and are not calculated by the total weight and total floor area, but with only the weight of a room. This is done because if the total weight and the total floor area are divided by each other the average force is lower than the actual force of a room. This is because the floor areas where no modular room is, is also taken into the calculation and thus lowers the average force. The variable forces should be added to these values.

The total weight per floor is given in the table (3.18) together with the number of rooms and the force of the modular rooms per square meter. Although the number of rooms may differ per floor, this doesn't make the modular room any heavier and as such the force per square meter is the same for every floor.

Permanent Force	Tower			Low-rise		
Floor	Number of rooms	Total weight (kg)	Force (kN/m^2)	Number of rooms	Total weight (kg)	Force (kN/m^2)
0				27	118800	2,24
1	15	66000	2,24	30	132000	2,24
2	15	66000	2,24	30	132000	2,24
3	15	66000	2,24	31	136400	2,24
4	15	66000	2,24			
5	15	66000	2,24			
6	18	79200	2,24			
7						
8						

Table 3.18 – Total weight of rooms and force per floor

The carrying capacity of the floors is calculated in appendix G and is equal to 11,91kN/m^2 and after the calculation with the factor from NEN8700 is equal to 11,76kN/m^2. The force per square meter of the rooms is calculated per floor and the variable force for hotel room functions is taken equal to that of residential functions; 1,75kN/m^2.

The total force of permanent and variable loads should never exceed 11,76kN/m^2 and the calculation for each floor should be done by taking the permanent force and the variable force together. From table 3.19 we can see that the permanent load and the variable load together for any floor will proof that the floor is sufficiently strong.

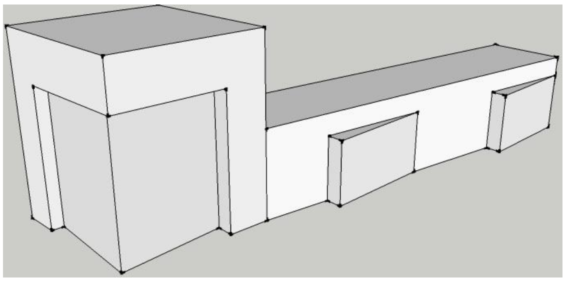
Total force	Tower			Low-rise		
Floor	Permanent	Variable	Total	Permanent	Variable	Total
BGT	2,24	1,75	3,98	2,24	1,75	3,98
factor	1,2	1,5		1,2	1,5	
UGT	2,69	2,63	5,31	2,69	2,63	5,31

Table 3.19 – Total permanent and variable load per floor

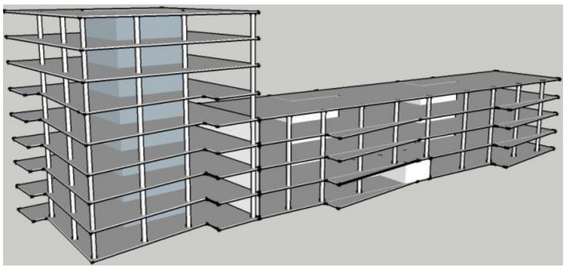
After placing two rooms in every 7,2m grid, each of room type 5A/B, the total force on each floor will not exceed the carrying capacity of the current floors. This will mean that there is a possibility, structurally, to use the type of solution as described in this chapter.

3.6.4 Carrying out the step by step program

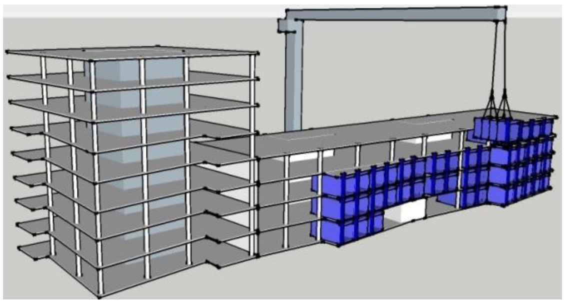
The step by step program as designed in in section 3.5.2 and 3.5.3 will be applied to the Trivium building and will be explained in a series of figures. For the step by step program the steps will be followed including those of the load bearing façade.



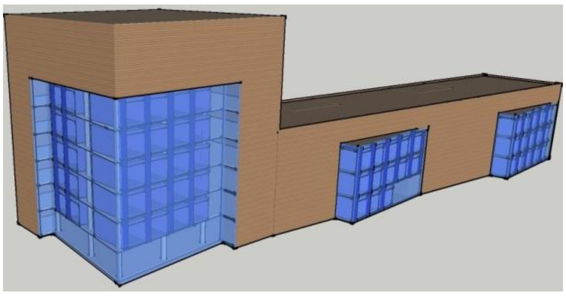
The Trivium building with no details as it is today (0).



The placing of the columns will be done near the load bearing façade and will make sure the structure holds during the placing of the elements and the current façade and the interior will be demolished (1).



The modular elements will be placed into the building (2, 3) and all vertical transport can be connected to each other (4, 5). In some cases a corner has to be made since not all rooms are directly above each other.



The new load bearing façade will be placed in front of the modular elements (6).
After this the temporary columns can be demolished and the finishing can be done (7).

Figure 3.45 – Step by step program Trivium

3.6.5 Financial feasibility

The most important type of feasibility after the structural feasibility is the financial feasibility. After the question "*Is it possible?*" there is the question "*Is it affordable?*". To answer the second question the building costs of the transformation project of Trivium in a "general" way is compared to a transformation with the modular element hotel.

There are a number of steps to be taken to reach financial numbers so there can be a comparison. In the first place the costs of partial demolition is calculated, the costs to demolish the façade and the costs to demolish the inside parts. After that the transformation project will be directed into three directions:

- "General" transformation, keeping the old façade
- "General" transformation, with a new façade
- Modular room transformation, with a new façade

All costs will be applied to the building Trivium at the Derkinderenstraat in Nieuw-West in Amsterdam. The total financial feasibility will also be dependent of whether or not the building should be transformed in the first place. This will give a general budget for a transformation project. The money it represents as an office functions will be laid next to the value of the same building as a hotel.

Transformation budget

The transformation budget will come from the room price, the occupancy rate and the housing costs of hotel businesses. This is already partially dealt with in section 2.2.5. The average room price of a 3 star hotel in Amsterdam is €124 and has an average occupancy rate of 72% in 2011 (Gemeente Amsterdam, 2012a). With a given possible turnover it is assumed 15% can be allocated to housing cost (Van Spronsen & Partners, 2010).

$$0{,}15 \cdot \frac{€124 \cdot 72\% \cdot 365}{17} = €288\, per\; m^2 per\; year$$

With 211 total rooms this will give the following calculation:

$$0{,}15 \cdot 211 \cdot €124 \cdot 72\% \cdot 365 \approx €1.000.000\, per\; year$$

A BAR of 8% is assumed for this building, which in the western part of the Netherlands is a fair number. If this value is then divided by the total floor area (gFA) we get a value per square meter which is usable for transformation.

$$\frac{0{,}15 \cdot 211 \cdot €124 \cdot 72\% \cdot 365}{9160} = €112{,}60\, per\; m^2\; per\; year$$

$$\frac{€112{,}60}{8\%} \approx €1400\, per\; m^2$$

The question is what this number represents, comparing to other transformation projects. The total possible investment per m^2 for this building is around €1400, resulting in a total possible investment of roughly €12.800.000. The investment consists of 4 types of costs; the acquisition costs, the building costs, the user facilities and the additional costs. Adding all these together gives a minimum investment (P. De Jong).

The total minimum possible investment is clear (€12.800.000), but we want to know the building cost in order to say something about the transformation methods. With newly built hotels the investment would relate to the building cost with a factor 2. However, with transformation projects this relation is absent and relations between investment and building cost are dependent on different factors (Mackay, 2008). We assume the lower the percentage in relation to the total possible investment the better, since the least of money is spend in that way.

We do know that normal transformations from office to dwellings range from €300-€800 per m^2 for low quality transformation to high quality transformation (Gelink, 2007). These are solely building costs and for new buildings these would result in investments of €600-€1900 per m^2.

When looking at conclusions drawn from a number of 12 reference projects done by Mackay a certain minimum, maximum and average building cost per section is given (Mackay, 2008). If we accept the average numbers and adding them all together, giving a building cost of €750 per m^2 we would have a more solid number. However, this number is also an inaccurate one, taking into account the standard deviation given in the same conclusion. The numbers of the different reference projects are far apart and are too inaccurate to draw conclusions.

In order to do calculations and not doing a whole side thesis project, an estimate has to be made of building cost of this particular building to a hotel function. Taking into account the numbers given by Mackay and Gelink and looking at the reference projects of Mackay, an assumption is made for the building cost of €600 per m^2.

In calculations following only the building costs are considered, the method of using prefabricated modular elements is assumed to only have influence on the building costs. In comparing the different transformation methods with each other the acquisition costs, the user facilities and the additional costs are considered equal to each other and thus the same for all methods. The building costs are the differentiating factor.

Demolition costs

For the demolition costs there will be a division between the costs to demolish the inside part (all parts inside the building) and to demolish the façade. This is done because in "general" transformation projects the façade won't always have to be demolished. The demolition of the old façade and the building of a new façade will have a large financial impact and may be a financial deal breaker in some projects.

The demolition costs of the inside parts, meaning all inside walls (not structural), finishing, vents, ducts, pipes, and so on will cost €8,00 per m^2 gFA (Archidat, 2012).

The demolition of the inside parts and the façade together, so only the hull will remain, is equal to €24,00 per m^2 gFA (Calcsoft, 2012) and as such the extra costs for demolishing the façade is equal to €16,00 per m^2.

For the Trivium building this will mean that the following demolition costs can be calculated. All costs are excluding taxes.

	Demolition					
gFA (m^2)	**Inside**		**Façade**		**Total**	
9160	€8	€73.200	€16	€146.560	€24	€219.840

Table 3.20 – Demolition costs

"General" transformation, keeping the old façade

A general transformation from an office function to a hotel function will cost a certain amount of money, which can be simplified to a general number per square meter just like the demolition costs. For this number we are assuming a value that is close to the transformation of dwellings as stated prior. The assumption for a transformation from office to a 3 star hotel is €600 per m^2.

The total costs of this transformation together with the demolition of the inside parts of the office building Trivium, will result in the following costs. All costs are excluding taxes.

	General transformation, keeping the old façade					
gFA (m^2)	**Demolition**		**Building**		**Total**	
9160	€8	€73.200	€600	€5.496.000	€608	€5.569.200

Table 3.21 – Costs general transformation, keeping the old façade

The total building costs are €5.569.200. As seen above, the budget for the transformation is €12.800.000. The building costs are represented as 44% of the total possible investment. Except the building cost, the acquiring costs, user facilities and additional costs are deducted from the total possible investment.

"General" transformation, with a new façade

The same general transformation as above will be applied here; however, in this calculation two extra costs will be calculated. The façade needs to be demolished and rebuild. The demolition costs for façade, together with the inside parts is already given, but the façade rebuilding costs isn't. For this we can again assume a certain number per 2 of façade, being 270 per m^2. This is an average value found for new façades in the BBN transformatietool (BBN, 2012) and CasaData (CasaData, 2012).

The total costs of this transformation together with the demolition of the inside parts of the office building Trivium and the build-up of a new façade, will result in the following costs. All costs are excluding taxes. The façade has a total surface area of 4600 m^2.

	General transformation, with a new façade						
gFA (m^2)	**Demolition**		**Building**		**Façade**		**Total**
9160	€24	€219.840	€600	€5.496.000	€270	€1.242.000	€6.957.840

Table 3.22 – Costs general transformation, with a new façade

The total building costs are €6.957.840. The total investment of the transformation project is again €12.800.000. The building costs are thus represented as 54% of the total possible investment. Except the building cost, also the acquiring costs, user facilities and additional costs are deducted from the total possible investment.

Modular room transformation, with a new façade

The final calculation is that of the modular elements as designed in the Master thesis. For this a more extensive calculation is needed; the calculation of the cost to build one element of the type 5A/B. The build-up of the costs can be seen in the following table and the source of the values can also be checked in the table.

	Surface (m^2)	Cost per m^2	Total cost (€)	Source
Walls	36,5	130	4.745	*CasaData*
Ceiling	19,0	140	2.856	*CasaData + assumption for extra costs*
Floor	18,6	140	2.611	*CasaData*
Bathroom			1000	*Assumption*
Assembly			800	*Assumption*
Finishing	74,2	10	742	*Thesis Naber*
Total			**12.754**	

Table 3.23 – Build-up of production costs modular room

Every modular element of the type 5A/B costs €12.754 to make, in order to make it profitable the elements should be at least €13.000. All other modular element costs and prices can be found in appendix I and in the catalogue (appendix A). This price will be multiplied by the number of rooms and to compare the price with the other "general" transformation methods it will be divided by the total surface.

$$211 \cdot €13.000 = €2.743.000$$

$$\frac{€2.743.000}{9160} = €299{,}45\ per\ m^2 \approx €300\ per\ m^2$$

The following table will make clear what the total costs are and whether or not the project will become more feasible than using the "general" transformation methods.

	Modular room transformation, with a new façade						
gFA (m^2)	**Demolition**		**Building**		**Façade**		**Total**
9160	€24	€219.840	€300	€2.743.000	€270	€1.242.000	€4.204.840

Table 3.24 – Costs modular room transformation, with a new façade

The total costs of using the modular element solution and applying that to the Trivium building is €4.204.840. This time, the building costs represent 33% of the total possible investment.

Type	Possible investment	Demolition costs	Building costs	Façade costs	Total building costs	Percentage of investment
General, keep façade	€12.800.000	€73.200	€5.496.000	€0	€5.569.200	44%
General, new façade	€12.800.000	€219.840	€5.496.000	€1.242.000	€6.957.840	54%
Modular	€12.800.000	€219.840	€2.743.000	€1.242.000	€4.204.840	33%

Table 3.25 – Comparison different transformation methods after the first year

From the final result we can conclude that the modular element solution is a lot cheaper than using a general transformation method and applying a new façade. The solution is more on the same level as a general transformation and keeping the façade and per m^2 is even cheaper than using the general methods.

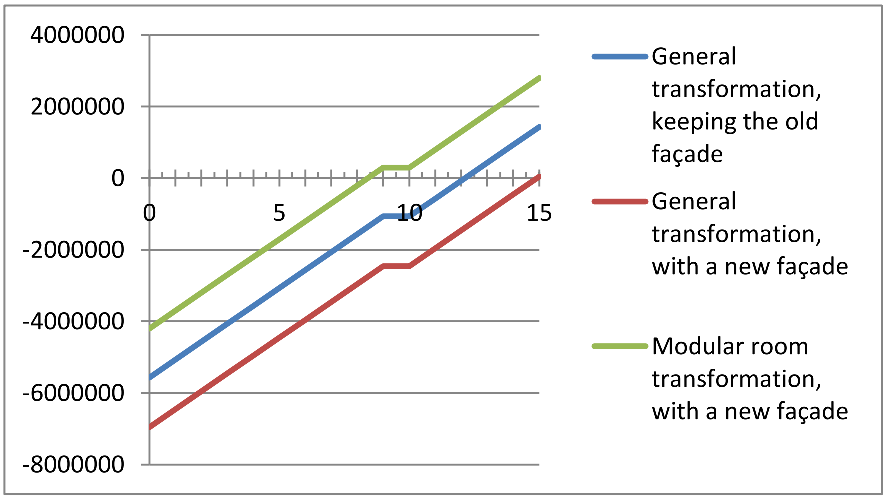


Figure 3.46 – Payback time of building cost

If we again only consider the building cost and assume the acquisition costs, the user facilities and the additional costs to be the same in each case, then we can create the following graph for the payback time of the building cost. From the yearly income we can calculate after how many years they are paid back, by calculating the payback time. With a given yearly turnover and the assumption that 15% can be allocated to housing cost we get a yearly income of €1.000.000. Yearly maintenance and other costs are assumed at €100.000. We assume that from the €900.000 remaining €500.000 will contribute to the payback time of the building cost. After 10 years there is an extensive maintenance projected which is assumed to cost €1.000.000, €500.000 is assumed to influence the building cost part.

We can see that for the modular room method the payback time of the building cost is the fastest, within 9 years. After that the general method follows, with keeping the façade (12 years) and the longest payback time is with the general method and adding a new façade, which takes 15 years to pay back the initial building cost.

What should be kept in mind is that these are payback times of only the building cost, not for the acquisition costs, the user facilities and the additional costs, which are the same in each case but can make the payback time more than twice as long. When all costs are known the payback time will be more accurate. The graph and calculation above show the influence of using each method of transformation on the payback time.

3.7 Conclusion total feasibility modular hotel

In the previous chapter the modular hotel rooms are designed and theoretically tested on feasibility. From the requirements a number of variants were created and after that a design was created of a number of modular room elements with different sizes.

Feasibility is, as stated in the hypothesis is chapter 1, dependent on the structural feasibility and the financial feasibility. Feasibility was tested by the use of a single building as a case study. Both types of feasibility are dealt with in the previous sections 3.6.3 and 3.6.5. From the structural feasibility we have determined that all elements are likely to fit in a number of building grids, but two important conclusions were drawn from this part; the use of the method will create a certain amount of lost space and the placing of floor elements may be difficult due to different angles of the rooms.

From the structural part also the conclusion was drawn that in this case, and assumed in more cases, the structure of the office building will be sufficiently strong in order to house the new function of a hotel. The floors, columns and beams are of a sufficient strength to carry the loads of the new function.

The financial feasibility study proved that solid and exact numbers for transformation projects are very difficult to give and the numbers as calculated are with a certain margin of error. However, the calculation is by far not useless at all, because it does show that the method of modular room method is likely to be a cheaper solution than using general transformation methods. What does need to be said about the modular room element financial calculation is that it only covers the rooms themselves and it doesn’t take into account the rest of the hotel, such as the lobby and restaurant. The difference with the general method is however large enough to cover such a difference and it also takes a new façade into account.

The final remark is that the use of a single case study may only be the start and is not enough to conclude that the method is 100% feasible or unfeasible.

4 Transformation Performance Coefficient

In this chapter the design and elaboration of a calculation tool called the Transformation Performance Coefficient is discussed. The Transformation Performance Coefficient (TPC) is a calculation tool specific for transformation projects from office functions to hotels. After the introduction in section 4.1 the outline of this tool will be discussed in section 4.2. The parameters and the score given to each parameter will be discussed in section 4.3. The last section, 4.4, will be the appliance of the calculation tool on a case study; this will be done on the same building as the case study in chapter 3.

4.1 Introduction

The transformation performance coefficient is a calculation tool developed in this Master thesis to gain insight and to visualize the potential to transform a vacant office building into a hotel. The program uses a number of parameters in which choices can be made. Out of the tool will come a series of coefficients in which the TPC is the most important. The TPC will be a coefficient (between 0 and 1) where one can immediately see whether or not the transformation will be a good decision.

The transformation tool will, in an ideal situation, be used in the same matter as an Energy Performance Coefficient, which is added to every building. In the same way buildings can be compared to each other in transformation potential. The calculation tool can be carried out for every vacant building and the coefficient resulting from this can be compared to other vacant buildings, thus gaining insight in the transformation potential of buildings.

The Transformation Potential Coefficient (TPC) is a calculation tool which needs to add something to the currently existing calculation tools (see section 2.6) for transformation or renovation projects. The TPC is more inspired and based on the way of working of the EPC (Energy Performance Coefficient) where a number of parameters are filled in and results will come out of the tool in the form of coefficients that can be compared to other projects.

What also is the case with the TPC is that the parameters to be filled should not be vague or very open to interpretation. All parameters have a set number of choices and won't leave a lot of room for discussion or interpretation, which will benefit the clarity of the results. All in all, the TPC will be a method that can be used to quickly see the potential to transform a building, without using a lot of figures, connections and interpretation. The elaboration on the program will be done in the section 4.2 and 4.3.

The coefficient is loosely based on the same principles as the EPC, the energy performance coefficient, which is calculated a lot in practice to show the energy performance of a building. The same principle is the ultimate goal of this calculation, "*To create a coefficient which in practice will be added to any vacant office building to show the feasibility of transformation to a hotel function*".

The TPC is only applicable for transformation to hotel functions. This is done because of the total scope of the Master Thesis, focusing on the transformation from office to hotels in general. Developing a general performance coefficient for any transformation would be an extensive task which goes further than the problem handled in this thesis. However, a transformation performance coefficient for other functions could be seen in a subsequent study.

4.2 Outline TPC calculation tool

In this section the outline of the calculation tool will be discussed. The first part will handle the overall outline; what the TPC calculation tool can do. The second part will give the input versus results; the results the calculation tool will produce and with what type of calculations. The last part will go more into detail on the results following the calculation tool.

4.2.1 Working of the TPC Calculation tool

For the calculation tool the principle of past-present-future is used. This current building (which is built in the past) is transformed in a certain way on a certain location (in the present) into a new function (the future). Parameters that represent the past are mainly in the first (out of four) parts, named the building parameters. The present is described in a number of parameters that influence the type of transformation and the location the building is currently in. The parameters that represent the future are in the third (out of four) parts, which is called "hotel". These parameters handle the type of hotel and a number of characteristics of the future hotel.

The calculation can also be divided into an input in the form of parameters, a calculation method, which will be discussed in this part and in 4.2.2, and an output in the form of a number of coefficients.

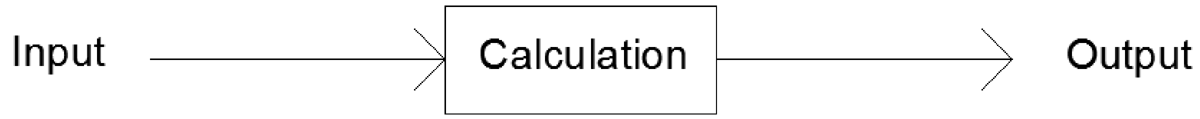


Figure 4.1 –Simplified program structure

Input

The input of the calculation tool will be a series of variables in the form of characteristics, each working with a dropdown menu with a set number of choices or an open choice that involves a number.

All these input variables will be divided into tabs and sub tabs, each representing a certain characteristic. This can also be seen in the figure. The larger tabs are the Building tab, the Location tab and the Hotel tab. A user should have all information available at the start or at least be able to make certain assumptions.

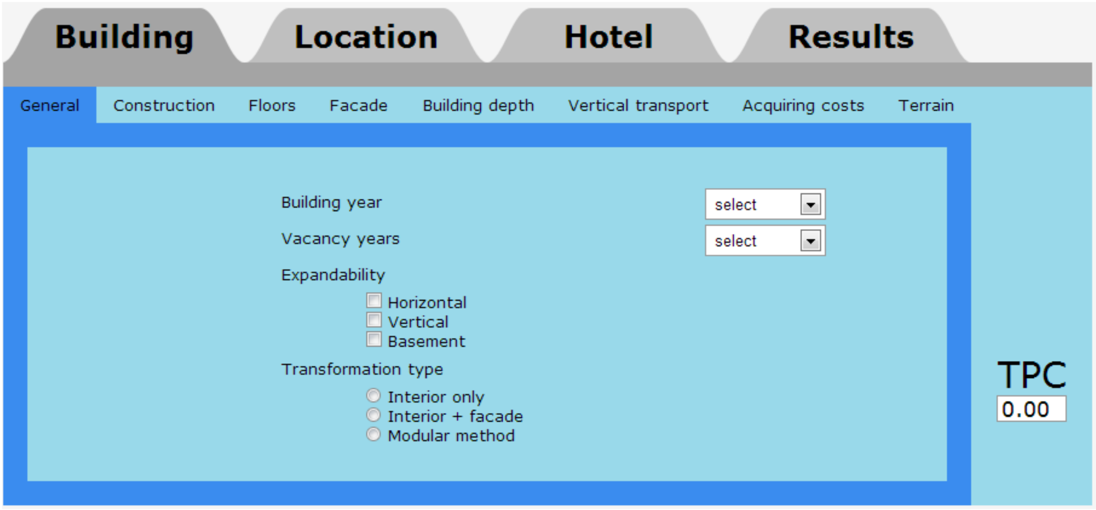


Figure 4.2 – Transformation Potential Coefficient: Tabs and sub tabs

There is no quick scan method and detailed method involved in the calculation tool. The lack of a quick scan method is done because the calculation of a certain coefficient asks for a certain degree of detail in the calculation, otherwise the coefficient would lose its importance. Quick scans work with a limited amount of input and are less thorough than extended calculations. The purpose of the TPC is to give an exact number in order to express the feasibility of a transformation project to a hotel making a quick scan an obsolete step in the process.

Lacking a quick scan in the method does, however, pose some problems that should be taken into account. There are a number of parameters that should be favorable and if not met the calculation shouldn´t be done, since these are characteristics that can´t be changed or leave room for improvement. In a way, this can be seen as a first scan or quick scan and the following characteristics should be met before starting the TPC calculation tool.

Characteristic	Information
There should be a demand for hotel(s)	Municipality/research
The hotel function should fit in with current zoning plans	Municipality
No severe health danger(s) can be in the close vicinity	Location
There is no willingness to sell or transform the current building	Owner
There is no hotel entrepreneur that wishes to take on the project	

Table 4.1 – Veto characteristics

Calculation

In order to come from the input to the results there has to be a sort of calculation. The goal of the calculation is to show immediately how feasible a project is. This will be done with a coefficient which will show how feasible a project is. The coefficient is, as seen before, loosely based on the same principles as the EPC, the energy performance coefficient, which is calculated a lot in practice to show the energy performance of a building. The coefficient calculated in the TPC is, however, a number between 0 and 1, where 1 is the best and 0 the worst.

To come to a coefficient between 0 and 1 every choice will get a score. For every parameter there are a number of choices, mostly 3 and each of them will get a 0.3 (bad), 0.6 (mediocre) or 1 (good) score. All scores will be added together and divided by the total number of parameters. When a field is left blank, so no choice has been made, the score will be 0 and is thus disadvantageous.

A number of parameters have a financial and/or durable effect on the project. These parameters will also get a score based on financial feasibility or durability. This is done in the same matter as the scores. 0.3 is bad for financial feasibility, in other words a lot of investments are necessary. 0.3 is also bad for durability, which can be explained as everything needed to replace is bad, everything that can be saved on a building will be beneficial for durability.

Financial and durability, as well as the TPC for each tab, also get an own TPC in order to make the results more clear and cut the result in smaller pieces to see where improvements can be made. This will be explained in the output section.

Output

The output will consist of several coefficients and numbers. The most important output will be the TPC itself; however there are more detailed derivatives of the TPC, called the $TPC_{building}$, $TPC_{location}$, TPC_{hotel}, $TPC_{financial}$ and the $TPC_{durability}$. Each of these derivatives will give a detailed picture of the improvement possibilities and what part(s) of a project will contribute to the feasibility or the failure.

The other outputs will be a financial calculation of the first year and the payback time of the project. The first will be a number in Euros and the second will be in full years and rounded up to whole years. With these numbers the financial base can be expressed, it will act as a financial quick scan and will show whether or not the project is assumed to be feasible.

We can say that there is a quick output and a detailed output. The quick output is the total TPC, the coefficient it's all about. The detailed output is are all the other factors which are supporting the TPC and are there to see why a project is left behind in feasibility and if there is improvement possible.

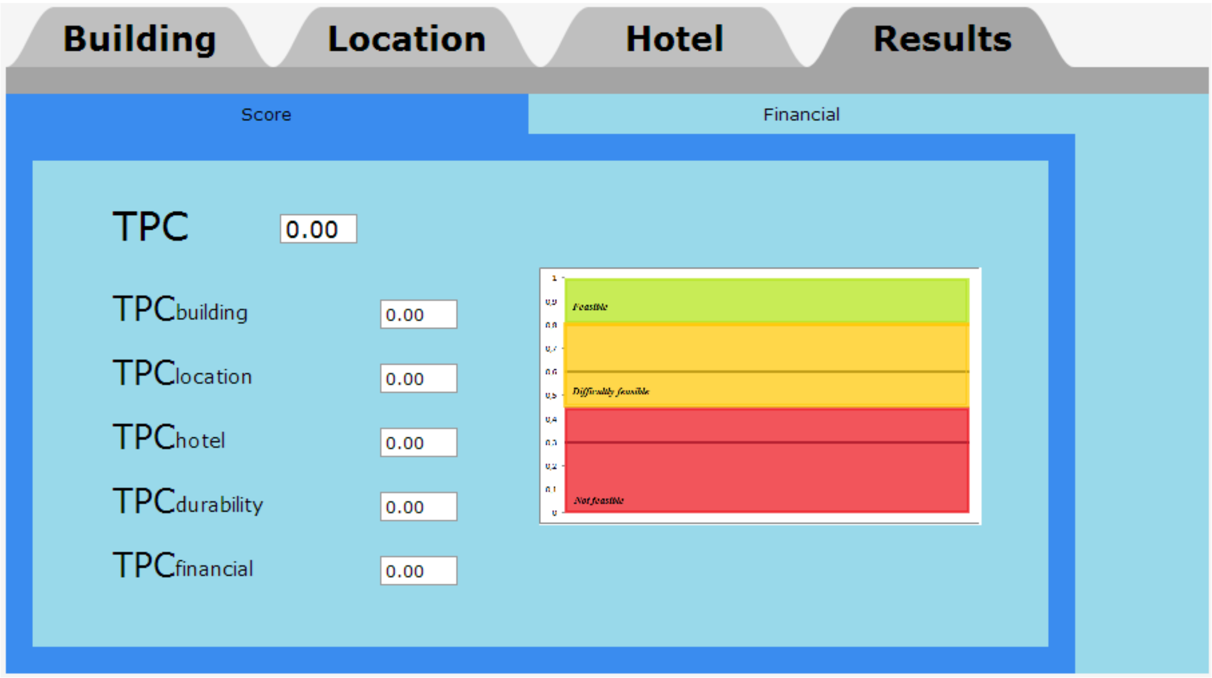


Figure 4.3 – Transformation Potential Coefficient: Output/results

4.2.2 Results of the TPC

As seen in the previous section the results of the TPC have a certain degree of detail. In this section each derivative of the TPC will be explained and the calculation for each will be given. This is done to enhance the understanding of the Transformation Performance Coefficient and to gain insight in the numbers leading up to the TPC.

Transformation Performance Coefficient
The total Transformation Performance Coefficient, or TPC, is the main outcome of the calculation tool. This number is assumed to have a status such that different projects can be compared to each other. The coefficient is the number that ties all characteristics to each other and forms the total performance coefficient of a project. With this number a conclusion can be drawn whether or not a project is feasible.

The TPC is calculated by adding all scores (from every choice made in the calculation) and dividing them by the total number of characteristics, which is 69. This will give a number between 0 and 1 and will represent the Transformation Performance Coefficient. From this number a general conclusion can be drawn whether or not a project is feasible to carry out and transform to a hotel. The calculation for the TPC is as follows.

$$TPC_{building} = \frac{Sum\ score\ "Building" + "Location" + "Hotel"}{Total\ "Building" + "Location" + "Hotel"\ (69)}$$

$TPC_{building}$

From the different tabs in the program come different derivatives of the TPC. The first of those is the $TPC_{building}$. This includes all characteristics that are filled in the "building" tab. Under the building tab all building characteristics are handled and the total score will be divided by the total number of characteristics. In this case there are 29 characteristics, 21 of them have a financial score tied to them and 10 have a durability score tied. For the $TPC_{building}$ the calculation is:

$$TPC_{building} = \frac{Sum\ score\ "Building"}{Total\ "Building"\ (29)}$$

$TPC_{location}$

The $TPC_{location}$ is very similar to the $TPC_{building}$, but gets the results from the tab "location". The 25 location characteristics, including 3 that have a financial score tied to them, are handled in the $TPC_{location}$. The calculation method is the same as with the $TPC_{building}$.

$$TPC_{location} = \frac{Sum\ score\ "Location"}{Total\ "Location"\ (25)}$$

TPC_{hotel}

For the TPC_{hotel} the same applies as to the $TPC_{building}$ and $TPC_{location}$. The scores of the "hotel" tab are all added together and divided by the total number of characteristics. In this case there are 15 characteristics that influence the total score and all of them have a financial score tied to them. There are also 6 characteristics that influence the durability. The TPC_{hotel} function is similar to the $TPC_{building}$ and $TPC_{location}$.

$$TPC_{hotel} = \frac{Sum\ score\ "Hotel"}{Total\ "Hotel"\ (15)}$$

$TPC_{financial}$

The $TPC_{financial}$ works in the same matter as the previous derivatives of the TPC, but also has a difference. The financial scores are, as mentioned before, tied to characteristics. This means that the user doesn't have to add financial numbers himself to the equation, but financial scores are derived from the characteristics that influence financial feasibility.

From the aforementioned TPC derivatives we know that there are 21 characteristics from the "building" tab, 3 from the "location" tab and 15 from the "hotel" tab, which results in a total of 39 characteristics with a financial effect. The calculation for the $TPC_{financial}$ is as follows.

$$TPC_{financial} = \frac{Sum\ score\ financial\ ("Building" + "Location" + "Hotel")}{Total\ financial\ ("Building" + "Location" + "Hotel")\ (39)}$$

$TPC_{durability}$
The durability derivative, the TPCdurability, is a coefficient that is comparable to the financial TPC with regards to the method of calculation. However, the parts of the calculation that has durability scores tied to the characteristics are the "building" and the "hotel" part, which has 10 and 6 characteristics that affect the durability. The calculation will then be as follows.

$$TPC_{durability} = \frac{Sum\ score\ durability\ ("Building" + "Hotel")}{Total\ durability\ ("Building" + "Hotel")\ (16)}$$

Financial calculations
The financial costs are the first calculation that won't involve coefficients, but exact numbers in the form of currency (Euros €). A number of characteristics have a financial currency attached to them, such as the transformation type and the price per room. From this the tool will do a series of calculations involving financial feasibility. The projected total costs will be calculated, as well as the projected budget per m^2, the projected total revenue per year usable for housing costs and the projected total possible investment.

The following functions will define each of the calculations. The calculations done here are the same as done in section 3.6.5.

$$Projected\ Total\ Costs = TransformationType \cdot gFA + NewFacade \cdot FacadeSurface$$

$$Projected\ Total\ Revenue\ per\ year = \#Rooms \cdot \%HousingCosts \cdot PricePerRoom \cdot OccupancyRate \cdot 365\ days$$

$$Projected\ Budget\ per\ m^2 = \frac{\left(\frac{Projected\ Total\ Revenue\ per\ year}{gFA}\right)}{BAR}$$

$$Projected\ Total\ possbile\ investment = Projected\ Budget\ per\ m^2 \cdot gFA$$

4.2.3 Discussion of results

From the previous section we already saw that we define bad (0.3), mediocre (0.6) and good (1.0) for the scores. For the feasibility (the TPC) we define numbers which are in between these scores. So not feasible will be from 0 to halfway bad and mediocre, difficultly feasible will be from halfway bad and mediocre to halfway mediocre and good. Everything above this is feasible. For a better understanding the following graph and table are presented.

Figure 4.4 –Feasibility from TPC

The feasibility definitions seem to be very strict or difficult to obtain. For instance, in order to come to a "feasible" result, out of 69 parameters at least 35 need to have a score of 1,0 and the rest 0,6. However, these projects do get a certain status of being feasible to transform, without encountering problems. It is therefore viable that the score to meet this degree of feasibility has to be high. Everything underneath that is definitely not unfeasible or impossible to transform, but do need more investing to become feasible. In the lowest segment there are so many problems in the current building that it's categorized as not feasible.

Boundaries	Feasibility
0.00-0.45	Not feasible
0.45-0.80	Difficultly feasible
0.80-1.00	Feasible

Table 4.2 – Feasibility from TPC

For the financial results we can say that they are strictly indicative and do not give exact financial numbers. As studies before (Gelink, 2007), (Mackay, 2008) proved that giving exact general financial numbers for transformation projects is very hard and those number are dependent on a lot of factors. This also means that calculating with these inaccurate numbers gives inaccurate results and thus giving more general and indicative financial results.

4.3 Detailed parameters TPC calculation tool

In this section all parameters that can be filled in in the TPC calculation tool will be discussed and elaborated upon. All choice possibilities and consequences will be dealt with in this section, which is built up in 3 parts analog to the calculation tool; the Building part, the Location part and the Hotel part. All scores will also be in Appendix J.

4.3.1 Building

In this first part all the parameters from the Building tab of the TPC calculation tool will be briefly discussed along with the scores each choice receives. The building tab accounts for all parameters that can be appointed to on or around the building. These are characteristics that mostly can be viewed on site or from documentation available for a building.

General
General characteristics are characteristics that are found in documentation and give general information about the building itself and the form of transformation that is being carried out, such as the building year, the number of vacancy years and the floor area.

Building year
The building year is divided into two options, buildings prior to 1970 get a score of 0,6 as they are assumed to be in a lesser structural state, since they are at the end of their intended lifespan, and thus less feasible to last another lifetime; buildings after 1970, which get a score of 1,0. For durability these factors are the same.

Vacancy years
The number of years the vacancy of a building is lasting is expressed in this parameter. If a building is vacant between 0 and 3 years the score is 0,3 since structural vacancy doesn't apply here. For buildings vacant between 3 and 5 years the score is 0,6 and buildings vacant for longer than 5 years the score is 1,0. The number of vacancy years also has a financial consequence and the financial feasibility scores are the same as the general scores.

Expandability
The expandability is divided into three parts, horizontal expandability, vertical expandability and the usability of the basement. For each positive answer in the expandability characteristic the score is 0,333, ultimately getting a score of 1,0 for this parameter. The financial scores are the same as the general scores.

Transformation type
The transformation type is a 3 point choice of the type of transformation which will be used in the project. The parameter is describing the type in a general way and doesn't influence the score; it only brings financial numbers such as price per m^2 to the financial calculation. The choices are Interior only, Interior + façade, and the use of the modular method. The choice here does influence the façade options in a later tab and costs per m^2 for transformation, façade and demolition can be filled in for each choice.

Gross floor area
The total gross floor area is the total area of vacant office space in m^2. No scores are assigned to this parameter; the floor area will only be used in financial calculations.

Façade surface area
The façade surface area is the total area of façade m^2. No scores are assigned to this parameter; the façade surface area will only be used in financial calculations.

		Score	Financial	Durability
Building year	<1970	0,6		0,6
	>1970	1		1
Vacancy years	0-3	0,3	0,3	
	3-5	0,6	0,6	
	5-...	1	1	
Expandability	Horizontal	0,333	0,333	
	Vertical	0,333	0,333	
	Basement	0,333	0,333	
Transformation type	Interior only			
	Interior only luxurious			
	Interior + façade			
	Interior luxurious + façade			
	Modular method			
Gross Floor Area (m2)	m^2			
Façade surface area (m2)	m^2			

Table 4.3 – Outtake from TPC Building tab

Construction

The construction part gives characteristics that are found on site or on drawings, handling the total structure of the current building and the possibilities to transform.

Structure

The structure itself handles a number of parameters divided into 5 parts.

Grid size

The grid size of the building is very important, a smaller grid size means more columns and beams and less room to alter the inside space. Larger grid sizes give more room to transform and are thus rewarded higher. Grid sizes smaller than 5400 mm are scored with 0,6 and larger sizes with 1,0.

Floor height

The floor height plays a big role in the possibilities to transform buildings. When the floor height is too low certain criteria of the building decree won't be met. Floor heights smaller than 3000 mm are scored 0,6 and larger than 3000 mm 1,0.

Type

The type of structure gives a number of general structural types where most of the buildings can be divided in. The choices are Beams/Columns, Columns or a Mesh structure. The mesh structure gives the least possibility to transform (score 0,3), the beams and columns are a better structure (score 0,6) and the columns are the easiest structure to transform (score 1,0).

State

The state of the structure will give insight in how much needs to be done to make the structure last another building lifetime. This is done in 3 degrees, replace certain elements, renovate the structure or do nothing. The first option gives the lowest score (0,3), the second the middle score (0,6) and a good structure gives a score of (1,0). Financial and durability scores are in this case the same as the general scores.

Foundation

The foundation of the building is important since any type of altering creates a change in forces. Also the vertical expandability is highly dependent on the state of the foundation.

State

The state of the foundation is the expressed in 3 choices; replace certain elements, renovate the foundation/make it stronger or do nothing. The replacing and renovating options each give the lowest score (0,3) and a good structure gives a score of (1,0). This is because renovating a foundation is difficult to do. Financial and durability scores are in this case the same as the general scores.

Interior walls

The interior walls are very important in transformation projects; they define the interior and the possibility to alter or remove these walls has a positive influence on feasibility. If walls are fixed then this results in fewer options in the new function and thus contributing negatively on feasibility.

Type

The type of wall will contribute in the demolition. Some materials are easier to demolish out of the building than others. Glass is the easiest (score 1,0), light walls such as timber, gypsum and aluminum/steel are a little more difficult to demolish (score 0,6) and the heavier walls of stone or load bearing walls are difficult to demolish (score 0,3). The financial scores are the same as the general scores. Out of a durability point of view timber walls are the easiest to demolish (1,0), stone and gypsum are second (0,6) and glass and aluminum are the worst (0,3). These numbers follow from the usability after demolition.

Fixed establishment
Whether or not the interior walls are fixed plays a key role in the feasibility study. Fixed walls influence the feasibility negatively since extra effort needs to be put in to make room for a new function. Fixed walls get a score of 0,3 and non-fixed walls get a score of 1,0. A building has fixed walls if these walls create spaces smaller than $100m^2$ or in non-rectangular shapes.

Ceilings
Ceilings have an influence on the usable height of floors and thus have an influence on the feasibility. For the same reasons as with the floors, the height between the floors is of importance.

Type
For ceilings only the type of ceilings is considered. Lowered ceilings can either be solid (score 0,3) which makes them hard to demolish, suspended (score 0,6) which is easier to demolish or non-existent (score 1,0) in which case nothing has to be done. Financial scores are the same as general scores.

Floors
The floors themselves are subdivided into a new section. From the previous only the height between floors was considered, in this case the floors themselves are elaborated upon.

Roof
The roof can be considered as a floor. The roof can be outdated in accordance to the new function and needs to be altered or replaced, in which case more money makes the project less feasible.

State
The state of the roof is of importance here, which is subdivided into three categories. Replacing the roof is the worst scenario (score 0,3), renovating the roof is less bad (score 0,6) and leaving the roof as it is because it's good enough is the best scenario (score 1,0). When categorizing the roof three parts should be considered, structural, environmental and functional. Functional meaning that the roof is still carrying out its primary function, dividing the outside from the inside. Structural means that the roof is still in structural sound condition and can keep its function for another building lifetime. Environmental means that the roof has a certain energy performance that is in accordance to demands in the building decree as well as demands of the project developer. The durability scores are again the same. The financial scores are only different in that renovating (0,3) costs more than demolition (0,6).

Floors
As mentioned, the floor height is already considered. In this section the floors themselves and their properties are considered.

Sound Insulation
The sound insulation of the floors is important in an early stage. When the sound insulation is not sufficient the floors need to have a solution in order to comply with regulations in this area. The sound insulation in the current state is of importance and the parameter is divided into three ranges. A sound insulation of 0 to 30 dB is bad and will get a score of 0,3, a sound insulation between 30 and 50 dB is normal but in most cases will need upgrading for a new

function so a score of 0,6 is given here. Any sound insulation value of higher than 50 dB is good and will be given a score of 1,0. The financial scores are the same as the general scores.

Fire protection

Fire protection of floors is very important and has to comply with very strict regulations. A fire protection of 30 minutes is often not sufficient in new functions and is given the score of 0,6. Any higher number, such as 60 or 120 minutes is given the score of 1,0. Also form a financial point of view.

Carrying capacity

In new functions often the floor load is lower than that of office functions. However, this is not a certainty and thus the current carrying capacity of floors is of importance. When the carrying capacity is lower than 150 kg/m^2 the score is 0,3, if it's between 150 and 300 kg/m^2 the score is 0,6 and anything above 300 kg/m^2 gets a score of 1,0. These scores are for the general score and the financial score.

Façade

The façade can be a large and costly part of a transformation project. A number of characteristics can determine whether or not the current façade is sufficient for a new lifetime or needs to be replaced.

R-value

The current R-value plays a role in the decision to keep, renovate or demolish a façade. This choice has a consequence for the financial feasibility and the durability of the building. The scores in general are divided in three parts; an R-value between 0 and 2 m^{2}K/W is given a score of 0,3, a R-value between 2 and 4 m^{2}K/W is given a score of 0,6 and higher than 4 m^{2}K/W is a score of 1,0. For financial and durability reasons the any R-value between 0 and 4 m^{2}K/W will get a score of 0,6 since in this R-value range extra measures need to be taken in the same amount, such as extra layers of insulation.

Load bearing

When a façade is load bearing it becomes more difficult to change the façade. This will result in a lower feasibility resulting in a score of 0,6. When a façade isn't load bearing the score is 1,0.

State

The state of the current façade is deciding whether or not to change the façade. A façade in a bad state needs to be replaced in order to make the building more appealing. For this reason replacing the façade is the worst solution (score 0,3), renovating is a better solution (score 0,6) and leaving the façade as it is because it meets the requirements is the best (1,0). For financial scores again the replacing is switched with the renovation.

Daylight admission

Daylight admission from the current façade is a key aspect when designing for a new function. All location in the building should receive sufficient sunlight and for this reason the façade needs to let enough sunlight through. The daylight admission is divided into 3 ranges; 0 to 5% receives 0,3 score, 5-10% a 0,6 score and anything above that gets a 1,0 score.

Building depth

Buildings which are too deep are usually very dark and buildings which aren't deep enough aren't very functional, so a certain depth is ideal. This will also be considered in the feasibility for transformation.

Depth
The building depth is ideally around 14m. Three ranges are defined, 0 to 11m and 17 or more meters building depth will get a score of 0,6, between 12 and 16m the score will be 1,0.

Vertical transport
The vertical transport of both installations and people will be considered here. A number of vertical transport points are available in the current state; in this part will be considered whether or not this is sufficient.

Installations
The installations available in the current situation have a certain state and an amount of vertical penetrations. These two influence the transformation potential of the building since transport pipes in a good state can be used again and if there are sufficient penetrations there won't have to be a creation of new shafts.

State
The state of the current vertical transport is important. When in a bad state they need to be replaced in order fulfill their function. For this reason replacing the vertical transport is the worst solution (score 0,3), renovating is a better solution (score 0,6) and leaving it as it is, because it meets the requirements, is the best (1,0). For financial scores again the replacing is switched with the renovation. Durability scores are the same as the general scores.

Amount
In any new function there are a number of vertical shafts necessary; the amount differs per projects. For this reason when a building has sufficient vertical penetrations for installations it gets a score of 1,0, when adding one vertical shaft a score of 0,6 is used and adding more than one vertical shaft gets a score of 0,3. The same scores are applied to the financial scores.

People transport
Besides the installations that need transporting through the building also the people need to be transported from each floor to another. Vertical transport of people considers two methods for this, via stairs and via elevators.

Stairs
The number of staircases is considered here. Three ranges of numbers of staircases are the choices, from 0 to 1 staircase gets a score of 0,6 and 2 or more staircases gets a score of 1,0. The same scores apply to financial scores.

Elevators
For the elevators the same typology exists as with the stairs. Three ranges of numbers of elevators are the choices, from 0 to 2 elevators gets a score of 0,6 and 3 or more elevators gets a score of 1,0. The same scores apply to financial scores.

Acquiring costs
Acquiring costs play a role for the financial feasibility. For this reason it's also considered important for the general feasibility. Two aspects are handled, the building value and the percentage of the building that is vacant.

Building value
The building value is the value that is the current value of the total building. This will play a role in the acquiring costs of the building, the initial investment. Three ranges are considered here; when a building is valued between 0 and €1.000.000 the score will be 1,0. Cheaper buildings are easier to sell, assuming the state of the building itself is adequate. Building valued between €1.000.001 and €5.000.000 get a score of 0,6 and buildings value €5.000.001 or more get a score of 0,3. The same scores apply to the financial scores.

Percentage vacant
The percentage that a building is vacant can make the project less feasible. If just half the building is vacant, an owner will be less eager to sell that half and transform it to a hotel. The more of a building is vacant, the better. When a building is from 0 to 50% vacant the score will be 0,3, from 51 to 80% the score will be 0,6 and between 81 and 100% vacant will get a score of 1,0.

Terrain
The terrain parameters express the way the building is viewed within its direct environment and the energy performance of the building.

Recognition
The recognition of the building is basically the popularity of a building; the way the building is viewed and to what extend the recognition of the building is. In order to express this there are 4 options to choose from; “no recognition”, the building is generally viewed as not special or redundant (score 1,0), “neighborhood”, the building is a sort of landmark for the neighborhood (score 0,6), “local”, the building is a landmark for the city or town and people will object doing extensive transformation (score 0,3) and “rural”, the building is a nationwide landmark which will make transformation difficult (score 0,0).

Entrance
The entrance of a building can either be inviting to enter the building or be a very obscure and repellent entrance. When the entrance is already inviting a score of 0,6 is given and when an obscure entrance is found a score of 1,0 is given, increasing the potential to transform.

Energy Performance
The energy performance of a building is represented in an EPC (Energy Performance Coefficient). This coefficient has been increasingly stricter over the years resulting in lower energy performing buildings in earlier years and better performing building is later years. For this parameter 3 choices are given; a “bad” is any EPC higher than 1,70 (Score 0,3), a “mediocre” EPC is an EPC between 1,00 and 1,70 (score 0,6) and a “good” EPC is an EPC lower than 1,00 (score 1,0). Financial and durability scores are the same as the general scores.

4.3.2 Location

In the second part all the parameters from the Location tab of the TPC calculation tool will be briefly discussed along with the scores each choice receives. The location tab accounts for all parameters that can be appointed to the location where the building is in. These are characteristics that mostly can be viewed on different maps or from research in the neighborhood of the building.

Geographic
The geographic location of a hotel plays a role in the success rate of that hotel. Starting a hotel in locations that aren't touristic attractive are bound to fail.

Nationwide location
From a geographic point of view the first parameter is to determine in what part of the Netherlands the hotel will be situated.

Within Netherlands
A hotel needs to be in a place with a certain touristic attraction, this can either be a city or the countryside. In what part of the Netherlands the hotel will be situated in will give a certain chance on success. Hotels in west are assumed to have the biggest success rate since the western part of the Netherlands seems to be the most touristic attractive (score 1,0). The east and south part of the Netherlands come on a second place, these parts offer less touristic attractions and are more of a countryside hotel (score 0,6). The northern part of the Netherlands receives the lowest score (0,3).

Part of City
After the location nationwide the location within a city or town is of importance. The part of a city which has the most touristic attraction is the city center. For countryside hotels this can also be read or altered to another touristic attraction, such as a place of serenity or peace.

Center
Whether or not the hotel is in a city center is handled in this parameter; if the answer is yes then the score is 1,0. If the hotel isn't in the city center then the score will be 0,6.

Distance to center (km)
The second important parameter is the distance to the center. When a hotel is outside of a city center the distance to that center is of importance. The further away, the worse it is for feasibility. For this reason 3 ranges of distances are scored; from 0 to 10 km is scored with 1,0, from 10 to 20 km is scored 0,6 and any distance above 20 km is scored with 0,3.

Hotel
The hotel itself gets an own tab, however, the location of the vacant office building, which will be transformed into a hotel, is of importance if looking at competition. This is more a location of the current building type of parameter than a more detailed hotel parameter.

Competition (within same star class)
When a lot of the same star class hotels are in the vicinity of the transformed hotel the chances of success are lowered because of the competition. When the supply is too high for the demand the prices, and thus the income, has to be lowered (see also section 2.1.3 "The cobweb model").

Distance to closest competitive hotel (km)
First we define on what distance the closest hotel within the same star class (competition) is located. This is done by defining 3 ranges of distances; if there's a competitive hotel between 0 and 5 km the score is 0,3, if a competitive hotel is between 5 and 15 km the score is 0,6 and if the competition is 15 or more kilometers away the score is 1,0. Financial scores are the same as the general scores.

Number of hotels within 2 km
Secondly we define the number of competitive hotels in the vicinity of the transformed building within the same star class. If there are between 0 and 5 hotels within 5 km the score

will be 1,0, if there are between 6 and 10 hotels in this vicinity the score will be 0,6 and in the case of 11 or more hotels the score is 0,3. The financial scores are the same as the general scores.

Accessibility

How to get to the hotel and whether or not it's an easy route to there is important for tourists who aren't familiar with the surroundings. The hotel should therefore be easily accessible by car and public transport.

Car

By car the hotel should be accessible by being close to a major freeway. From a major freeway the route to a hotel should be easy and short so tourists won't be lost on the way to there. Also the parking possibilities should be considered.

Distance to major freeway (km)

As mentioned, the distance from a major freeway to the hotel should be a short as possible. The shorter route is clearer and less prone to errors than a longer route. The distance is measured in km of roadway and if the route is between 0 and 5 km the score is 1,0, between 6 and 10 km the score is 0,6 and if the route is more than 11 km the score is 0,3.

Parking possibilities

There should be sufficient parking possibilities on or around the premises of the hotel in relation to the number of rooms/number of guests. If there is sufficient parking then the score is 1,0, if not, the score is 0,6. The scores for financial feasibility are the same as the general score. If no parking is available new parking should be created, costing money.

Public transport

The car is not the only way of travel to a hotel. A lot of guests are dependent on the public transport system. When visiting they most likely take a bus or train from an "entry to the country", which can be a major train station such as Amsterdam Central station or Den Haag HS, or an airport, such as Schiphol. On day to day basis people will make smaller trips in the city which can be done by using the bus or tram. All these public transport facilities are considered.

Distance to bus/tram (m)

The distance to a bus or tram station should be within reasonable walking distance. The bus or tram is assumed to be used on a daily basis to go to each tourist attraction a tourist desires. For this reason the bus or tram stop should be within 500 m to get a score of 1,0, between 500 and 1000 m for a score of 0,6 and more than 1000 m away from the hotel to get a score of 0,3.

Distance to train station (m)

A train station should be on a reasonable walking distance as well. Ideally, coming from an "entry to the country" and arriving at the train station, guests should be able to walk to their hotel with their luggage. For this reason the train station should be within 500 m to get a score of 1,0, between 500 and 1000 m for a score of 0,6 and more than 1000 m away from the hotel to get a score of 0,3.

Distance to airport (km)

The distance to an airport, where most guests are arriving from, should be a reasonable distance to cover with public transport, such as a train or a bus. If the hotel is within 20 km of the airport a score of 1,0 is given, if it's between 21 and 50 km a score of 0,6 is give and if the hotel is further than 51 km away from the airport a score of 0,3 is given.

Facilities

For hotels to succeed their location should ideally lie in the middle of a lively part of the city with restaurants, shops, recreation and touristic attractions. In this part we consider the number of restaurants in the vicinity of the hotel and the presence of supermarkets, shops, recreation and touristic attractions.

Number of restaurants within 1 km

The number of restaurants within 1 km gives the guests options on where to eat. Lively locations with more restaurants are more likely to succeed. When there are 0 to 10 restaurants within a 1km radius the score is 0,3, between 11 and 20 restaurants is scored 0,6 and more than 21 restaurants is scored 1,0.

Grocery possibilities within 1 km

Guests may like to make their own meals during the day or do their own grocery shopping. When there are grocery possibilities within 1 km the score is 1,0, if not the score is 0,6.

Shopping possibilities within 5 km

A good reason to go to visit a city is to do shopping. Shopping possibilities in the vicinity of the hotel, within 5 km is for this reason score 1,0. If no shopping possibilities within this radius exist the score is 0,6.

Recreation possibilities within 1 km

Guests of a hotel may desire for recreation facilities such as a swimming pool, a park or a health spa to spend the day. If 1 or more of such recreation facilities exist within 1 km the score is 1,0, otherwise the score is 0,6.

Touristic attractions within 1 km

Touristic attractions may be a reason, other than business, for guests to come to a city. When a hotel is situated close to touristic attractions, such as the city center or museums, they are more likely to succeed. If the hotel is within 1 km of a touristic attraction the score is 1,0, otherwise the score is 0,6.

Public safety

The public safety of the neighborhood is of importance for the secure feeling visitors to the city need to have. When a hotel is in a neighborhood with a high crime rate the secure feeling is lower and the overall experience will be negative, creating a small life span for the hotel. Public safety is somewhat simplified in two measures, the first being vandalism and the second is the crime rate in the area.

Vandalism

Vandalism is split into two parts, the first being vandalism in the neighborhood and the second is the graffiti in the area. To measure vandalism there is more room for interpretation.

Vandalism in vicinity (1km)

When vandalism is discovered within a certain radius of 1 km of the planned hotel the problems are assumed to be in the total neighborhood. When this is the case the score is 0,6 and when there is no discovery of vandalism within the vicinity the score is 1,0.

Graffiti on (surrounding) building(s)

Graffiti on the building itself or surrounding buildings create a feeling of insecurity, as if the people rule this part of the city instead of the normal authorities. When graffiti is seen the score is lowered from 1,0 to 0,6.

Crime rate

The crime rate of the area is of importance to get a view in what kind of neighborhood the planned hotel will be in. Safety during the dark hours is of importance here, since tourists make an easy prey for criminals.

Offenses per 1000 habitants

The crime rate is expressed in offenses per 1000 habitants. The mean crime rate for Amsterdam is 170 and for the Netherlands around 90 offenses per 1000 habitants (CBS, 2007). For each area more detailed number could be available. When the crime rate is between 0 and 100 the score is 1,0, between 100 and 200 the score is 0,6 and when the crime rate exceeds 200 the score is 0,3.

Environmental nuisance

The environmental nuisance is important in selecting a location for a planned hotel. When constant nuisance is at this location the hotel is likely to be out of business very quick. The influences are categorized in two parts, environmental and man influenced. The environmental nuisance part is based on the Leegstandsrisicometer of Van der Voordt and Geraerdts (Geraerdts, R.P., et al., 2007a).

Environmental

The environmental influences are those that are influenced with nature, such as wind and light. These natural effects are influenced by the surroundings of a planned hotel.

Unpleasant shadow from adjacent buildings

The breaking of the light entering a building, thus creating a building in the shade, by another building is unwanted. This will make the building a dark one without sufficient entering of natural light. When during more than 50% of the daytime there is an unwanted shadow by another building the score will be lowered from 1,0 to 0,6.

Wind nuisance

The surrounding buildings or the shape of the city may cause wind nuisance on the planned hotel building. When a study or trial shows that there is wind nuisance during more than 50 days a year the score is lowered from 1,0 to 0,6.

Man influenced

The man influenced environmental nuisance is not influenced with nature, but with manmade problems such as sound and odor.

Odor nuisance

The odor nuisance can have many causes, such as factories or a dump site nearby. When planning for a hotel a study proves that during more than 100 days per year there is an odor nuisance the score will be lowered from 1,0 to 0,6.

Noise nuisance

Also noise nuisance is a manmade problem that will hinder guests in a hotel. Noise nuisance can come, among others, from busy streets, highways or factories. When the noise nuisance is present during more than 2 hours per day the score will be lowered from 1,0 to 0,6.

Visual quality environment

The visual quality of the environment can be an appealing factor for guests to choose for a hotel. The visual quality also gives a positive feeling to the experience of the guest and will likely enhance the chance for success of the hotel.

Direct surroundings

The direct surroundings have a large impact on the visual quality of the area of the planned hotel. The typology of the surroundings and the appearance of the street play an important role.

Type

The typology of the street can be divided into 4 types; industrial, office district, residential or a city center. Each of these brings a certain feel to the area and either increases or decreases the positive feeling of the hotel guests. An industrial area decreases this feeling and will score 0,3, an office district won't increase the positive feeling either and will score 0,6. A residential area gives a more homely feel and the city center a more lively feel and will both score 1,0.

Appearance street

The general appearance of the street will give the first impressions to hotel guests and is the first surrounding the guests are in. The appearance of the street is divided into 3 types; urban, green/rural or non-consistent. An urban appearance will score 0,6, a green/rural appearance will score 1,0 and the non-consistent appearance will score 0,3.

Green

Green in the neighborhood will give a positive feeling to hotel guests, either directly around the hotel (appearance street) or in the vicinity of the hotel. The distance to the nearest park is therefore important.

Distance to nearest park (km)

The distance to the nearest park is important since green enhances the positive feel of hotel guests, even when not directly visible from the hotel. When a park is within 1 km the score is 1,0, when the park is between 1 and 5 km the score is 0,6 and when a park is further than 6 km away from the hotel the score is 0,3.

4.3.3 Hotel

In the third tab all the parameters from the Hotel tab of the TPC calculation tool will be briefly discussed along with the scores each choice receives. The hotel tab accounts for all parameters that can be appointed to the hotel itself. These are characteristics that come from the demands of the hotel itself and the technical limits.

Hotel

The hotel part handles a couple of general hotel characteristics. The star class of the hotel is one of them, with the housing costs percentage and the BAR percentage (gross initial yield). The housing costs percentage and the BAR percentage are needed for the financial calculations as well.

Class

The star class for hotels is already mentioned in section 2.2.2 and will have an influence on the general feasibility of the project. When designing cheaper hotels the feasibility is assumed to be better, since there are no restrictions on room size and fewer rules and restrictions to comply with. Therefore, 1, 2 and 3 star hotels get a score of 1,0 and 4 and 5 star hotels get a score of 0,6 and 0,3 respectively. Financial scores are the same as the general scores.

Housing costs (%)

The housing costs percentage is the percentage that with a given possible turnover is assumed to be allocated to housing cost; usually this is between 10% and 18%. A percentage of 0 to 8% is given a score of 0,3, a percentage of 8 to 12% is given a score of 0,6 and a score of 12 to 18% is given a score of 1,0. The financial scores are the same as the general scores.

BAR (%)
The BAR percentage is the gross initial yield. It represents the ratio between the gross market yield for the first year and total investment. With this number a calculation can be made to determine the projected budget per m^2 of floor area. The BAR-percentage is usually around 8%.

Room
The rooms of the hotel also have certain characteristics as desired by the hotel company that will use the building as a hotel. This is divided into two parts, quality and quantity. Quality describes characteristics influencing the quality of the room and quantity describing the number of rooms.

Quality
The quality or the room is divided into two parts that define the quality in a broad manner; the finishing of the room and the price per room.

Finishing
The finishing of the room will have an impact on the financial feasibility and thus the general feasibility. We define three ways of finishing; budget is the cheapest way of finishing (score 1,0), average is a normal way of finishing (score 0,6) and luxurious is a deluxe way of finishing (score 0,3). Financial scores are the same as the general scores.

Price per room (€)
Each room has a certain price per day that it's worth. Three ranges are defined; €10 to €100 are the cheapest rooms and are score 0,6. The rooms that are between €100 and €200 are score 1,0 and the most expensive rooms (€200 and higher) are scored 0,6. These scores are as such because of the assumption that cheaper rooms also are of lower quality. Financial scores are the same as the general scores.

Quantity
The quality or the room is divided into two parts that define the quantity in a broad manner. These two parts are the number of rooms and the occupancy rate.

Number of rooms
The number of rooms define the general income of a hotel and is therefore financially interesting. The general feasibility is also dependent on this. When the number of rooms is between 1 and 100 the score is 0,3, when the number of rooms is between 100 and 300 the score is 0,6 and when there are more than 300 rooms in a hotel the score is 1,0. The financial scores are the same as the general scores.

Occupancy rate (%)
The occupancy rate is the average room occupancy during a year. The percentage is the number of rooms that are rented out during a year. The average number is 72% (Gemeente Amsterdam, 2012a). For occupancy rates lower than 60% the score is 0,3, for occupancy rates between 60% and 80% the score is 0,6 and higher than 80% gets a score of 1,0. Again, the financial scores are the same as the general scores.

Facilities
Facilities in a hotel will bring an extra to the total positive experience of the guests. Two types of facilities are highlighted here, the two most important ones that aren't assumed standard in 2012.

These two are categorized in sport facilities and dining facilities. Facilities such as Wi-Fi, a refrigerator in the room and a bar in the hotel lounge are considered to be standard in a new hotel that is competing with already existing hotels.

Sport
Sport facilities are not obliged or considered standard in a new hotel. However, these facilities can be of added value to any guest and will make the success rate of the hotel higher. There are two sport facilities considered, a gym and a swimming pool.

Gym
A gym is assumed to be of added value to any hotel. Guests wishing not to interrupt their training program when on business trip or holiday will view this as a good solution. When the gym is designed for in the planned hotel the score is 1,0, otherwise the score is 0,6. Financial scores are the same.

Swimming pool
A swimming pool is a great way to relax or unwind from a long day of walking the streets. This is one of the most common extras of a hotel. There is a distinction between an indoor and outdoor pool and whether or not the structure of the current building needs to be changed. What may be expected is that a swimming pool is adding to the feasibility, however, the extra costs for a swimming pool in transformation projects is assumed to lower the feasibility. No swimming pool will make the score 1,0. The other scores can be seen in the table.

		Score	Financial
Gym	Yes	0,6	0,6
	No	1	1
Swimming pool	Inside: Structurally possible	0,6	0,6
	Inside: Structurally impossible	0,3	0,3
	Outside	0,6	0,6
	Inside and Outside: Structurally possible	0,6	0,6
	Inside and Outside: Structurally impossible	0,3	0,3
	None	1,0	1,0

Table 4.4 – Outtake from TPC Hotel tab, Sport

Dining
Dining options in a hotel won't have to be large. It is assumed a most guests will dine outside of the hotel. However, it still has an added value when there are not a lot of restaurants in the neighborhood or when it's a business hotel.

Restaurant
A restaurant in a hotel has an added value in the sense that it's within the hotel and it's the first restaurant guests will come across generating an extra income for the hotel. When a restaurant is designed in the planned hotel the score is 1,0, otherwise the score is 0,6. The financial scores for restaurants are the same as the general scores.

Installations
The installations which will be placed in the new hotel will have a large impact on financial feasibility and on durability. These two aspects make installations also a very important aspect of the general feasibility. Just as in the EPC the installations are divided into two parts, heating systems and lighting systems.

Heating systems
The heating systems are the systems that are generating different sorts of heat, heat for the building itself, heat to create warm drinking water, or cooling the building. Ventilation is also placed among these systems, as well as solar panels which can be used to generate heat and electricity.

Heating of building

The heating of the building can be done on a number of ways. Each heat generation method costs a certain amount of money and from are durability perspective are good or not good. Electrical gets the lowest score (0,3). After that steam powered heat generation, HR boilers and VR boilers are scored (0,6). The best method from the durability perspective are using a heat pump or external heat delivery (1,0). The financial numbers are a little different and can be seen in the table.

		Score	Financial	Durability
Heating of building	Electrical	0,3	0,6	0,3
	HR boiler	0,6	1	0,6
	VR boiler	0,6	1	0,6
	Heat pump	1	0,6	1
	External heat delivery	1	1	1
	Steam powered	0,6	0,3	0,6
Cooling	Heat pump (summer operation)	0,6	0,6	0,6
	Absorption cooling machine	0,6	0,6	0,6
	Cold storage	0,6	0,3	0,6
	Multiple devices	1	1	1
Hot drinking water	Electrical	0,3	0,6	0,3
	HR boiler	0,6	1	0,6
	VR boiler	0,6	1	0,6
	Heat pump	1	0,6	1
	External heat delivery	1	1	1
	Steam powered	0,6	0,3	0,6
Ventilation	Mechanical ventilation with heat exchange	1	0,6	1
	Mechanical ventilation without heat exchange	0,6	0,3	0,6
	Natural ventilation only	1	1	1
Solar panels	No solar panels	0,3	1	0,3
	Solar panels	0,6	0,6	0,6
	PV Cells	1	0,3	1

Table 4.5 – Outtake from TPC Hotel tab, Installations

Cooling

Cooling methods can also be done in multiple ways. The heat pump (0,6) can be used in a summer operation to cool a building; and the absorption cooling machine (0,6) is another central way of cooling. Cold storage in the ground (0,6) can be used to store cold water from the winter and using multiple A/C devices gives the best results (1,0).

Hot drinking water

The drinking water can be heated by the same methods as the general heating of the building. These methods create hot water to heat the building itself, but can also heat the pipes distributing the drinking water. The scores are the same as with the heating of the building.

Ventilation

The ventilation of the building is handled in two distinctive ways, natural or mechanical. Most office buildings rely on mechanical ventilation, but also use natural ventilation. In order to choose one, the user should be aware which method will be used more, will the windows be open every day even in the winter, than natural can be chosen, if the windows remain closed and all ventilation air will be mechanical than mechanical needs to be chosen. Mechanical heating with heat exchange scores 1,0 just like natural ventilation, but financially scores 0,6 as opposed to 1,0 for natural ventilation. Mechanical ventilation without heat exchange scores 0,6.

Solar panels

The use of solar panels is greatly encouraged in the EPC. For the TPC we also encourage the use of these panels with an important difference: the number of m^2 of solar panels is not taken into account. In order to not make users only put 1 m^2 on top of the building to increase the score there is a minimum of 50 m^2 of panels in order to positively fill in this parameter. Other methods of green energy generation can also be added in a later stadium of the program. When using no solar panels at all the score is 0,3, when using solar panels only to generate heat the score is 0,6 and when using PV cells, for both electricity and heat the score is 1,0.

Lighting systems

The lighting system uses a lot of energy per year and being inefficient with the lighting system can create a lot of unnecessary costs. Using energy efficient systems such as motion detectors, time switches and low energy lighting can reduce the power per m^2.

Power per m^2

The lighting system itself is chosen outside of the calculation tool. Only the power per m^2 is necessary for this parameter. Energy efficient types of lighting systems have a lower power per m^2. Low efficient lighting is 8 W/m^2 and lower (score 1,0), a little worse is the lighting between 8 W/m^2 and 14 W/m^2 (score 0,6) and the worst lighting systems are using more than 14 W/m^2 (score 0,3). The durability and financial scores are the same as the general scores.

4.4 Case studies

The case study done in chapter 3 of the Trivium building in the Derkinderenstraat in Amsterdam-West will also be used in this section to fill in the Transformation Performance Coefficient calculation tool. This will be done with the available information, maps and parameters of section 4.3. The first part (4.4.1) will be an assessment of the current building and the filling in of the building tab. The second part (4.4.2) will be an assessment of the location of the building and the filling in of the location tab. For the third part (4.4.3) the desired hotel will be filled in in the hotel tab. After this the results will be discussed in part 4.4.5.

After the elaboration on the Trivium building in the Derkinderenstraat, three other case studies will be handled in the fourth part (4.4.4) which will give more insight into the scoring method of the TPC. These buildings are at the Hullenbergweg in the south-eastern part of Amsterdam outside the city center, the Orlyplein in the northwestern part of Amsterdam, also outside of the city center and the Spuistraat, which is in the center of Amsterdam.

4.4.1 Current building Trivium

The current building has certain characteristics which are viewable in the table. In this section the scope is not to discuss every single choice, because some are obvious and can easily be checked if wanted. All choices are in the table and a couple of them are discussed, being the ones that are based on assumptions.

For our project we do the *modular method* which needs both the gross floor area and the façade surface area also found in section 3.6.5.

The assumption is made that all *columns, floors* and the *foundation* are in a good state, which has been confirmed on site. On site this assumption can also be checked by a professional.

Building			
General		Building year	>1970
		Vacancy years	5-...
		Expandability	
		Transformation type	Modular method
		Gross Floor Area (m2)	9160
		Façade surface area (m2)	4600
Construction	Structure	Grid size (mm)	7600
		Floor to floor height (mm)	>3000
		Type	Columns
		State	Good
	Foundation	State	Good
	Interior walls	Type	None
		Fixed establishment	No
	Ceilings	Type	Lowered
Floors	Roof	State	Good
	Floors	Sound insulation (dB)	0-30
		Fire protection	30 minutes
		Carrying capacity	>300 kg/m2
Facade		R-value	
		Load bearing	Yes
		State	
		Daylight admission (%)	
Building depth		Depth (m)	12-16
Vertical transport	Installations	State	Replace
		Amount	Sufficient available
	People transport	Stairs	2-4
		Elevators	3-6
Acquiring costs		Building value	0-5.000.000
		Percentage vacant	81-100
Terrain		Recognition	None
		Entrance	Obscure
		Energy Performance	Mediocre (1,00>EPC>1,70)

Table 4.6 – Building characteristics case study

The *sound insulation* between floors is only provided by a single concrete slab, so the assumption that the sound insulation is between 0 and 30 dB is made. Also the *fire protection* is kept at 30 minutes for the same reason.

The current façade is assumed to have an *R-value* between 2 and 4 m^2K/W and since it needs to be replaced because of the modular method we choose the replace option for the *state*. The *daylight admission* which it currently has is between 5 and 10%. We assume this with the same rule applied in practice, by dividing the total glass surface by the gross floor area (NEN2057). However, the factor of the R-value and the daylight admission in reality won't play a role, since the façade is replaced anyway.

The *building value* is calculated on a somewhat basic method, by multiplying the total gross floor area (9160 m^2) with the rate of rental, which is €160/m^2 (Funda in business, 2012). Multiplying these gives a building value of €1.465.600.

The $TPC_{building}$ with these characteristics will be 0,84, which is a quite good result even though the entire façade needs to be replaced.

4.4.2 Location Trivium

For the location of the building a number of characteristics are found in maps and other documentation. All these characteristics are summed up in the table and as with the current building a number of the characteristics will be briefly explained.

Location			
Geographic	Nationwide location	Within Netherlands	West
	Part of City	Center	No
		Distance to center (km)	0-10
Hotel	Competition	Distance to closest competitive hotel	0-5
		Number of hotels within 2 km	11-...
Accessibility	Car	Distance to major freeway (km)	0-5
		Parking possibilities	Yes
	Public transport	Distance to bus/tram (m)	0-500
		Distance to train station (m)	0-500
		Distance to airport (km)	0-20
	Facilities	Number of restaurants within 1km	21-...
		Grocery possibilities within 1km	Yes
		Shopping possibilities within 5km	Yes
		Recreation possibilities within 1km	Yes
		Touristic attractions within 1 km	No
Public safety	Vandalism	Vandalism in vicinity (1km)	No
		Graffiti on (surrounding) building(s)	No
	Crime rate	Offenses per 1000 inhabitants	100-200
Environmental nuisance	Environmental	Unpleasant shadow from adjacent buildings	No
		Wind nuisance	No
	Man influenced	Odor nuisance	No
		Noise nuisance	Yes
Visual quality environment	Direct surroundings	Type	Residential
		Appearance street	Urban
	Green	Distance to nearest park (km)	0-1

Table 4.7 – Location characteristics case study

For the public safety aspect, and more in detail the *vandalism* and the graffiti, on site examination proved no signs of vandalism in the vicinity of the building. Signs of vandalism are broken windows, cars without tires, destroyed litter bins and so on. Graffiti also wasn't found on the building itself and buildings nearby.

The *crime rate* in Amsterdam is found to be 170 offenses per 1000 inhabitants, which is higher than the national average of 90 offenses per 1000 inhabitants. (CBS, 2007).

Environmental nuisance is not to be expected in the vicinity; the building is not surrounded by high rise which could give unpleasant shadows and the wind and odor nuisances are not experienced during on site examination. Noise nuisance is to be expected since the building is next to the highway A10.

The maps show the location of the nearby *restaurants* (within 1 km) and the nearby *hotels* (within 2 km). *Shopping possibilities* are within 5 km (city center) and the park at the other side of the highway provides a *recreation possibility*. *Touristic attractions* are a little further away than 1 km.

The location gives a $TPC_{location}$ of 0,90, which is really good. This was to be expected since the location isn't' too far from the center and restaurants and attractions are nearby.

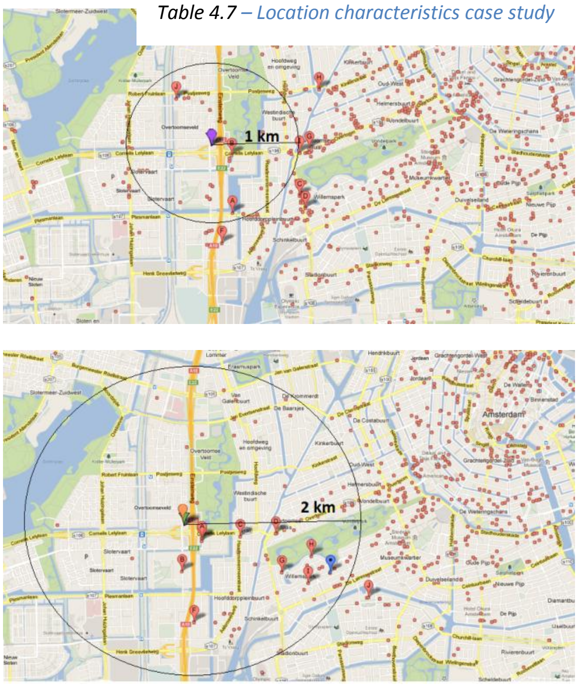


Figure 4.5 – Map with 1 km radius and restaurants (above) and map with 2 km radius and hotels (below)

4.4.3 Hotel Trivium

For the last tab to fill in, the hotel tab, we assume the same hotel as we wished to build in section 3.6. This means a 3 star hotel with an average finishing in the Trivium building. Again, the choices are shown in the table and a few will be discussed briefly.

Hotel			
Hotel		Class	3*
		Housing Costs (%)	15
		BAR (%)	8
Room	Quality	Finishing	Average
		Price per room (EURO)	124
		Room size (m2)	17
	Quantity	Number of rooms	211
		Occupancy rate (%)	72
Facilities	Sport	Gym	No
		Swimming Pool	None
	Dining	Restaurant	Yes
Installations	Heating systems	Heating of building	HR boiler
		Cooling	Multiple devices
		Hot drinking water	HR boiler
		Ventilation	Natural ventilation only
		Solar panels	No solar panels
	Lighting system	Power per m2 (W/m2)	0-8

Table 4.8 – Hotel characteristics case study

The *housing costs*, *BAR*, *price per room*, *number of rooms* and *occupancy rate* are all drawn from section 3.6 were all number already have been explained.

For facilities we assume a *restaurant* on the top floor of the high rise part (section 3.6) and no extra facilities such as a *swimming pool* or a *gym*. In this case the scope is for a simple and plain hotel with not too many (costly) extras.

The installations are all assumptions. In order to create a simple and plain 3 star hotel in a transformation project we assume a HR boiler for *heating* the building and the *warm water*. For the *cooling* a choice is made for air conditioning units per room. *Ventilation* is handled with only natural ventilation, each room has the possibility to open their window and no mechanical ventilation will be present. The use of solar panels is for this project not covered. *Lighting systems* are assumed to be of high efficiency.

Al these parameters together create a TPC_{hotel} of 0,88 which, again, are assumed to be a good result.

The total TPC is equal to 0,84. This result will make the project a feasible transformation from an office building to a hotel function. In the next section (4.5) a discussion will follow on whether or not this number is fair. In this part only the results are mentioned.

As seen in the figure the $TPC_{durability}$ is equal to 0,81 and the $TPC_{financial}$ is equal to 0,82. Also these numbers are very good, making the total feasibility high.

Figure 4.6 – TPC results from calculation tool

Financial numbers show the same results as were found in section 3.6.5, making the TPC calculation tool work in the intended way.

4.4.4 Other case studies

In order to value the results of the Transformation Performance Coefficient multiple case studies are done. In this way the results of each case study can be compared to the other case studies. Buildings that are expected to score low should score low in the TPC and high potential buildings are expected to score high in the TPC.

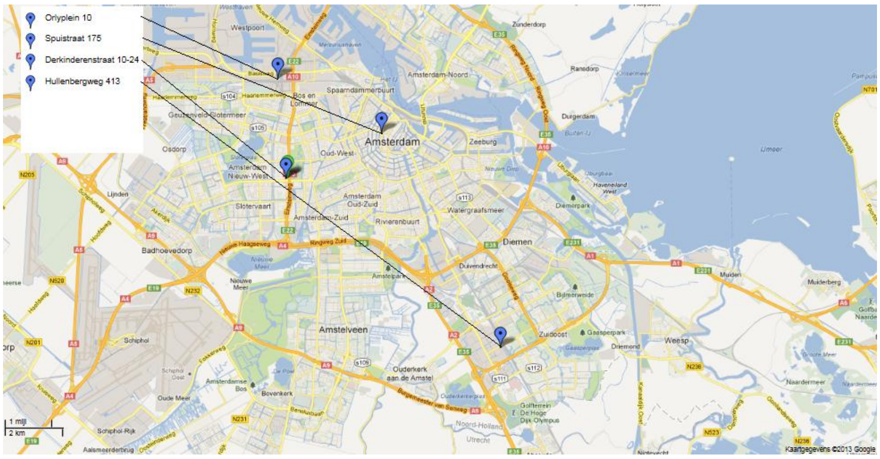


Figure 4.7 – Location vacant buildings case studies

There are three buildings chosen to work out as a case study in this part. The buildings are at the Hullenbergweg in the south-eastern part of Amsterdam outside the city center, the Orlyplein in the northwestern part of Amsterdam, also outside of the city center and the Spuistraat, which is in the center of Amsterdam. The map will show the location of each and the location of the first case study of Trivium.

Hullenbergweg 413-439

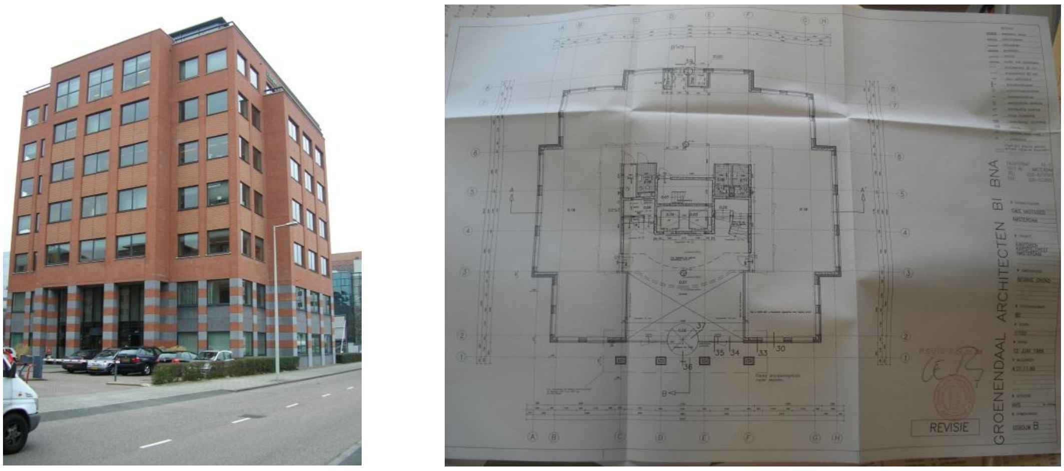


Figure 4.8 – Photo Hullenbergweg 413-439 (left) with floor plan (right)

The building at the Hullenbergweg is an eight story building which is almost completely empty. The floor area is 3496 m^2 and the building is vacant for 3 years, making it structurally vacant as the building is from 1999. The floor plan of every floor except the ground floor and the upper floor are as in the figure above.

Without going in every detail for this case study we will make a number of assumptions.

- No vertical or horizontal expandability.

- Only interior changes, so no modular method will be used in this case. Also no façade changes will be done.
- All structural elements are in a good condition; this may be expected from a building from 1999.
- The building will be transformed to a 3 star hotel.
- Per floor 12 rooms will be designed, making a total of 72 rooms.
- Location factors such as hotels, restaurants and other facilities in the vicinity have been checked with maps, as well as (public) transportation possibilities.
- Hotel factors such as housing costs percentage, BAR percentage and occupancy rate are all left the same as averages of the city of Amsterdam.
- Average room price is €124
- No gym and no swimming pool will be designed.

When all parameters and assumptions are filled in we can extract the following results:

	Result
TPC	0,75
$TPC_{building}$	0,79
$TPC_{location}$	0,72
TPC_{hotel}	0,84
$TPC_{durability}$	0,79
$TPC_{financial}$	0,83
Projected total costs	€ 2.126.000
Projected total revenue usable for housing costs	€ 341.000
Projected budget per m^2	€ 1218
Projected total possible investment	€ 4.257.000

Table 4.9 – Results from TPC Hullenbergweg 413-439

From the results we can conclude that the location is bad (0,72) but the building itself makes the whole score better (0,75). The current state of the building will make sure that transformation will probably be without major changes. Also, the façade can be kept the way it is. However, the location is far from the city center and the lack of facilities and restaurants in the neighborhood will make the total TPC lower.

Orlyplein 10

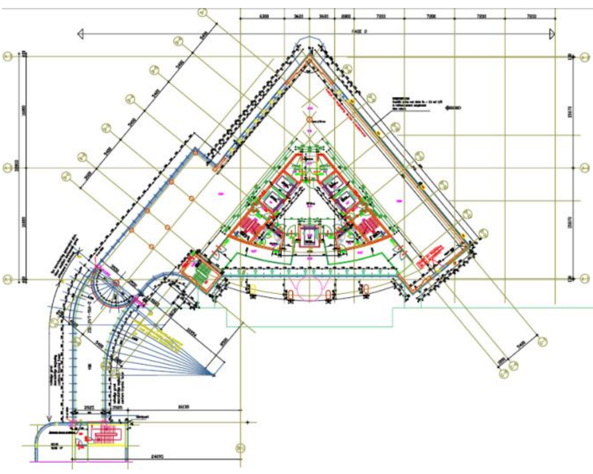


Figure 4.9 – Photo Orlyplein 10 (left) with floor plan (right)

The building at the Orlyplein, the Crystal Tower is a building with 19 usable floors, which is for 78% empty. The total floor area is 18486 m^2 and the building is vacant for 3 years, making it structurally vacant as the building is from 2002. A floor plan of the usable floors is in the figure above.

Again, as with the previous case study, there is a certain amount of detail and we will make a number of assumptions.

- No vertical or horizontal expandability.
- Only interior changes, so no modular method will be used in this case. Also no façade changes will be done.
- All structural elements are in a good condition; this may be expected from a building from 2002.
- The building will be transformed to a 5 star hotel.
- Per floor 10 rooms (on average) will be designed, making a total of 190 rooms.
- Location factors such as hotels, restaurants and other facilities in the vicinity have been checked with maps, as well as (public) transportation possibilities.
- Hotel factors such as housing costs percentage, BAR percentage and occupancy rate are all left the same as averages of the city of Amsterdam.
- Average room price is €200
- A gym and an indoor swimming pool will be designed.

When all parameters and assumptions are filled in we can extract the following results:

	Result
TPC	0,73
$TPC_{building}$	0,76
$TPC_{location}$	0,77
TPC_{hotel}	0,73
$TPC_{durability}$	0,79
$TPC_{financial}$	0,77
Projected total costs	€ 11.239.000
Projected total revenue usable for housing costs	€ 1.498.000
Projected budget per m^2	€ 1013
Projected total possible investment	€ 18.725.000

Table 4.10 – Results from TPC Orlyplein 10

The Transformation Performance Coefficient of this project is low (0,73) as compared to the other case studies. On the whole line (building, location and hotel) the buildings scores around the same numbers. The location itself is fair when looking on site and in the neighborhood. This also follows from the TPC, but not in an alarming way. The distance to the city center is good and the transportation possibilities are very good from this location.

Spuistraat 175

Figure 4.10 – Photo Spuistraat 175

The building at the Spuistraat in the center of Amsterdam Tower is a building with 5 usable floors, which is completely empty. The total floor area is 8300 m^2 and the building is vacant for 4 years, making it structurally vacant as the building is from before 1990. Floor plans are not available making the number of stairs and elevators, as well as the number of rooms, assumptions.

Again, as with the previous case studies, there is a certain amount of detail and we will make a number of assumptions.

- No vertical or horizontal expandability.
- Interior changes and façade changes. Modular method will be used in this case.
- All structural elements need renovation in order to meet the requirements of another lifespan.
- Interior walls are fixed and made of stone.
- Two sets of stairs are assumed to be in the building, and no elevators are present (assumption).
- The building will be transformed to a 4 star hotel.
- Per floor 20 rooms (on average) will be designed, making a total of 80 rooms.
- Location factors such as hotels, restaurants and other facilities in the vicinity have been checked with maps, as well as (public) transportation possibilities.
- Hotel factors such as housing costs percentage, BAR percentage and occupancy rate are all left the same as averages of the city of Amsterdam.
- Average room price is €160
- No gym and no swimming pool will be designed.

When all parameters and assumptions are filled in we can extract the following results:

	Result
TPC	0,73
$TPC_{building}$	0,65
$TPC_{location}$	0,85
TPC_{hotel}	0,81
$TPC_{durability}$	0,63
$TPC_{financial}$	0,65
Projected total costs	€ 3.445.000
Projected total revenue usable for housing costs	€ 505.000
Projected budget per m^2	€ 760
Projected total possible investment	€ 6.307.000

Table 4.11 – Results from TPC Spuistraat 175

From the results we can conclude that the location is very good (0,85) but the building itself makes the whole score lower (0,65). This is because of the current state of the building, which needs a lot of renovating and a new façade in order to bring a certain level of quality.

4.4.5 Discussion of results

From the four case studies handled above result a number of performance coefficients, which are summarized in the table.

	Derkinderen-straat	Hullenberg-weg	Orlyplein	Spuistraat
TPC	0,84	0,75	0,74	0,73
$TPC_{building}$	0,84	0,79	0,76	0,65
$TPC_{location}$	0,90	0,72	0,78	0,85
TPC_{hotel}	0,88	0,84	0,73	0,81
$TPC_{durability}$	0,81	0,79	0,79	0,63
$TPC_{financial}$	0,82	0,83	0,77	0,65
Projected total costs	€4.210.000	€2.126.000	€11.239.000	€3.445.000
Projected total revenue usable for housing costs	€1.031.000	€341.000	€1.498.000	€505.000
Projected budget per m^2	€1407	€1218	€1013	€760
Projected total possible investment	€12.892.000	€4.257.000	€18.725.000	€6.307.000

Table 4.12 – Results from TPC all case studies

From the results we notice a number of things which will be handled briefly here. Reflection and recommendations for the program as a whole will be discussed in the next section (4.5). The first notable is that we can see that every result is within a certain range, between 0,70 and 0,90. This will make the distinction between good and bad very difficult because every number is pretty much the same. Explanations for this are that certain parameters are more likely and more easily met than others so that they are mostly always the case (creating a base score), such as the distance to a city center being less than 10 km is easily met, as opposed to a certain energy performance or sound insulation performance and the calculation method itself, using no weighing factors for more important parameters. The further explanation on this will be done in section 4.5.

What is also notable is that transforming a building to a hotel in the center of Amsterdam doesn't necessarily give a higher TPC. The TPC of the building at the Spuistraat (in the center) is lower than that of the Derkinderenstraat (just outside of the center). This can be explained in a number of ways:

- The building at the Spuistraat is in such a condition that the transformation will be more difficult and costly, resulting in a lower TPC.
- The building at the Spuistraat will be transformed to a 4 star hotel, but without a gym, a swimming pool and parking possibilities; the latter being available at the Derkinderenstraat.
- Although being in the city center, the Spuistraat scores lower than the Derkinderenstraat on location basis. This is because of the lack of green and parks in the neighborhood and because of the high competition within the center. Making the parameter of the location within the center more important through a grading system is a solution here (see section 4.5).

From these case studies we can conclude that the TPC gives results based on the feasibility of the vacant building on transforming to a hotel in the desired way but within a limited range. This limited range does pose some problems, such as not being able to get a clear distinction between good and bad, but solutions shouldn't be sought in the direction of changing the boundaries, but in adjusting the calculation itself. Also, from the case studies there can be said that the highest score doesn't necessarily mean it's the best building, because a number of parameters, which are extra important (façade change, location within center) are not scored as such. As mentioned before, the elaboration on this will be handled in section 4.5.

4.5 Reflection on TPC

In the last section we found several TPC's as a result of completing the TPC calculation tool with parameters found for four case studies in Amsterdam. In this part a reflection and discussion will follow on the results gained and on the Transformation Performance Coefficient calculation tool itself.

The problem with a new calculation tool is that the results may mean nothing; the results give a number and can be interpreted in a number of ways. Why is it good to have a TPC of 0,80 or why is it bad to have a TPC of 0,64? The answer to that question is: it isn't. Because four case studies with one outcome based on one person's view on a number of characteristics on location, building and the hotels in general is not sufficient to create a flawless new calculation tool for transformation projects.

Is the tool completely redundant or useless? No, the tool has positive aspects as well as aspects that need further studies. But the scope of the calculation tool within this Master thesis is to create a tool that will give a single coefficient to each building and to compare these building with each other when transforming them to a hotel function. In this sense the calculation tool was a success, numerous characteristics can be filled in and a score will come out based on the current state of the building, the location of the building and the demands of the hotel market.

Each characteristic that can be filled in is scored in a general way, with 3 types of scores based on "good", "mediocre" or "bad" with the score of 1,0, 0,6 and 0,3 respectively. The choice not to include more levels of score is a conscious choice to not get into detail too fast. However, we immediately come to a first setback aspect of the tool: Each characteristic will score either a 1,0, a 0,6 or a 0,3, without a scientific validation. There is no gradation in between, making each characteristic less objective and of the same importance. The floor height for instance is of the same importance as the location in a city center or changing the façade will have the same impact as a bus station being more than 1 km away. In reality this is not the case, some characteristics are more important than others, a certain gradation between aspects or a second layer of scoring is necessary to come to this.

To create such a second level of scoring and adjusting the first layer of scoring to come to a score more based on reality a number of options are available. A multi criteria analysis based method can be used where all aspects are weighted and scored on importance, a team of experts from different fields (hotel branch, durability experts, real estate experts, engineers experienced with transformation projects, and so on) can create a workgroup and in that way alter the scores to come closer to reality and multiple questionnaires or a Delphi-method where experts in different fields are asked to answer a series of questions in where the importance lies in transformation projects can be used to gain more insight and alter the scores to come closer to reality.

By only changing the scores or creating a second layer of scoring based on importance is not the only downside to this calculation tool. There are a number of aspects or characteristics within the tool that have a relation with each other. Correlation such as "*a 5 star hotel will score lower on a location in an office district than a 2 star hotel*" or "*encountering a grid size smaller than 5400 mm will* *exclude the use of modular elements of 4 or 5 star hotels*". In order to get these relations in a program will be very time consuming, but is the next step when creating a standardized calculation tool. These correlations can be made visible by taking every single characteristic and placing them on two axles, drawing lines between them where relations lie.

The TPC also has limitations in the use of the tool. The Transformation Performance Coefficient calculation tool is, as it name suggests, usable for only transformation projects. Transformation projects are difficult to predict, as different studies prove, especially financially. All results therefore have a certain degree of interpretation. The coefficient itself needs to prove its worth, in other words, at this point a TPC isn't saying much other than what is defined as good and bad. Using the TPC for a large amount of projects after creating the second layer of scoring and the correlation between the characteristics is a step needed to say something about the scores themselves. When after the scoring it turns out almost all buildings are not feasible to transform (according to the tool) apparently the tool is too strict and the boundaries of feasibility in the tool need to be changed.

Another limitation of the calculation tool is that it's only usable for transformation to a hotel. Not actually a limitation since that is what the tool is primarily intended for. Future steps of the development of a TPC may include different TPC's for different functions or choosing a function beforehand altering the last tab (Hotel-tab) into more function-specific characteristics. Within the tool itself choices are also limited, for instance when choosing a method of heating the building or the current type of interior walls. Many more choices can be thought of and need to be applicable in the program, as well as different methods of generating energy. Just as in the EPC only solar panels are added to the calculation tool, where many more methods could be thought of giving the same or even better results.

The same inaccuracy applies to the financial results. Transformation projects are far too different from each other and each building has its own problems encountered when transforming. Gaining indicative numbers for cost of transformation projects is near impossible since there always is a large deviation in these numbers. To create more solid numbers in this matter is to use standardized methods of transformation and/or examination of a large number of transformation projects. Financially transformation projects are too uncertain.

With all the previous remarks and comments the Transformation Performance Coefficient may be viewed as a failure or a program in a very early stage. The latter is preferred as a current view of the program. The scope was to create a program with which we can compare different vacant office buildings to each other in their potential to transform to a hotel function. In this sense the tool is a success, being the total skeleton to this philosophy. Very bold, we can say that a lot of important characteristics are handled, scored and made visible and thus creating a sort of standardized score for each building. The score itself is still open to interpretation and can't possibly be scored and weighted by a single person due to subjectivity and lack of experience in the field. Earlier mentioned methods can be used to enhance the accuracy of the score.

5 Conclusion and reflection

The purpose of the master thesis was to bring the supply of vacant offices together with the demand for hotels in Amsterdam. Any conclusion drawn can be different outside of Amsterdam because of different situations in, among other reasons, hotel demand, vacant office supply and touristic attraction. This was set to be achieved through designing a modular building method to increase feasibility of transformation projects and through the development of a calculation tool creating more insight in the transformability of vacant office buildings. The hypothesis of the study is

"Using prefabricated elements during a transformation project is better than creating and executing work on site."

As mentioned in the introduction the hypothesis is explained by lowering the risks of the transformation project and making it financially less unsure. The following sections will support the hypothesis.

Modular Rooms

The modular room design consists of a timber frame room that is build up in a factory and transported to the building site, where it can be placed in the building as a whole unit. The modular room design has been tested on financial and structural feasibility as well as application possibilities through a case study.

A single case study was carried out after the determination of the financial and structural feasibility. The case study centered on the building Trivium in the western part of Amsterdam. The goal of the case study was to determine whether or not the modular rooms are applicable in practice and are thus an asset to the range of transformation methods. A number of findings from the case study and rest of the thesis are:

- A single case study has shown that the modular room method is a useful solution. The elements are made on a different location than the building site and have a fixed price making the financial insecurity less. The reduction of the amount of actions on the building site reduces the risks during the execution of the project. The increased possibilities for risk management and improved financial feasibility support the hypothesis that prefabrication is better than working on-site.

- The modular room method needs the existing façade to be demolished or temporarily removed leading to increased costs of this method in situations where the façade is still in good shape. However, comparison to other methods of transformation in a single case study, that comprised a necessary refurbishment of the façades, shows that the modular room method is a valuable addition to the currently available methods. In order to make the findings and conclusion stronger more buildings need to be examined as case studies, including studies of floor plans, structural feasibility and financial feasibility.

- Disadvantages of the modular rooms are the necessary transport and the placement; during placement cranes are necessary hoisting the elements into place. Another point that could make users choose for a different method is that the rooms have fixed sizes, meaning that there is no adaption to the building itself, creating inflexibility, resulting in lost space and fewer rooms.

From the design of the modular rooms a number of conclusions can be drawn:

- The modular room elements have proven their worth in a case study and can, in suitable situations, increase the feasibility of transformation projects. Due to the lowering of risks during the execution phase of the project and the lowering of the financial uncertainty as a result of the fixed prices of the elements further support for the hypothesis is found.

- Modular room elements can be used to increase the building speed and simplicity of building. During the execution phase the prefabricated elements only need to be placed in the building as opposed to the traditional way of working in which a lot of materials are used and assembled on site. Possible problems are solved in an earlier stage, and fixed long before the actual construction and manufacturing has started, thus reducing potential failure costs.

- The fixed price is helping in the problem of financial insecurity of transformation projects. Transformation projects generally are financially uncertain projects with a high chance of hidden or added costs. The fixed prices of the modular elements make a large part of the transformation financially clear in an earlier stage.

- The lightweight materials used in the modular rooms reduce the risk that the current load bearing capacity of the structure might become a problem and make the elements relatively cheap.

- In situation where the façade needed refurbishment or replacement, the modular room method is a better solution than general methods with construction mainly on-site. The financial advantages in such situations give further support for the hypothesis.

The method has proved to be valuable in a single case study and is assumed to work in more than one instance. However, with indicators of transformation projects being used which are hard to predict, exact numbers can only be obtained by application of the method or studying a large number of transformation projects.

Recommendations
In order to further develop the method and investigate in which situations it is applicable, more case studies need to be done. These case studies need to follow certain boundary conditions to continue this research:

- Completed transformation projects, where financial numbers are readily available need to be theoretically worked out with the modular rooms method as alternative, so that financial feasibility can be compared.

- The vacant buildings used for additional case studies need to have different characteristics in lay-out, typology and so on in order to extrapolate the conclusions to a reality in which more building types will be found than the two typologies used in this study.

Also in the design of the modular rooms further research can be done:

- Further detailing of the connections, especially the vertical transport connections between rooms. The vertical transport of building services is handled on the outside part of the modular rooms and each room will need to be connected to the room underneath.
- Research into exacter costs of building materials and assembly may change the estimated costs of the modular units..
- Creation of a scale model and a full size model after the further detailing of the connections. The (scale) model will create a visualization of the modular rooms.

Transformation Performance Coefficient

The Transformation Performance Coefficient is a calculation tool designed in this master thesis with the goal to be a tool in which different buildings can easily be compared to one another on the feasibility of transformation to a hotel. For this, the tool scores 69 characteristics with a weight, resulting in a coefficient and general financial numbers. The calculation tool is tested through four case studies.

The case studies were all buildings in Amsterdam, but in different parts of the city and with very different surroundings. From the thesis and the case studies general findings can be drawn:

- The TPC is not proven a watertight or perfect method since the scoring itself is open to interpretation. Each choice within a certain characteristic is scored with a 0,3, 0,6 or 1,0 and each characteristic is of the same importance. Making each characteristic of the same importance is not fully realistic but does at least give comparable results between buildings.
- The outcome of the TPC gives numbers between 0,7 and 0,9 making the interpretation of the results somewhat difficult. Due to the small bandwidth of results the conclusions of transformability of a building can be difficult. The impact of certain choices in the tool may have a bigger or smaller impact on the outcome than may be expected in reality.
- The score itself is open to interpretation and can't be scored and weighted by a single person without the use of a panel of experts. This results in a score that may be considered too biased and subjective and lacks the input of experts.

From the thesis and the case studies a conclusion can be drawn.

- The skeleton or the idea of the thesis is to create a calculation tool that allows comparison of different buildings. The calculation tool does what it is meant to do, weighing different choices and characteristics and ultimately creating a score that enables comparison of buildings.

The tool still needs a second layer of scoring making one characteristic (such as the location of the hotel) more important than the other (such as the floor height) that in the present version are considered of equal importance. A further recommendation on the program is that it doesn't take crosslinks between characteristics into account, which in reality should play a role in scoring. An good example of this is that when the choice is made for a 5 star hotel the location is even more important than with a 2 star hotel. The present tool weighs the location equal for both categories of hotels.

Recommendations
In order to make the solutions to come to a score that has a more robust underpinning the following studies need to address a number of recommendations. These recommendations are in the direction of further developing the calculation tool:

- The transformation performance coefficient needs a second layer of scoring making the characteristics of different importance to each other. A second layer of scoring can be made by a multi criteria analysis and the formation of a panel of experts.

- Relations between a number of characteristics should be explored and the weighing should be adjusted accordingly.

- When weighing each characteristic some characteristics may be more important than others in a single project. For this reason adjustability by the user of the scores per choice in each characteristic should be explored.

- Adding options to the calculation tool such as information blocks per characteristic explaining what consequence each option has and calculation examples within the tool. These options make the tool more user-friendly and self-explanatory.

- Adapting the Transformation Performance Coefficient calculation tool to more than only transformability to hotels. When the tool has been adjusted as above the next step would be to make it applicable to transformation from vacant offices to other functions than only hotels, such as student housing and regular housing.

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