“SNUG AS A BUG IN AN INSTITUTE”

Building characteristics influencing transformation possibilities
INTRODUCTION
This report is part of the Heritage and Housing graduation studio. The main theme of this studio is housing in the historic inner city. And the main area of investigation for this theme is the Binnengasthuis area in the centre of Amsterdam. This area is located in the medieval part of Amsterdam and originated as two adjoining monastic complexes (see fig. Figure 1). After the Alteration the monasteries change into two “gasthuizen” or hospices. These two hospices later evolved into the Binnengasthuis hospital (see fig. 2). The evolution of the hospital, particularly in the 19th century and the early 20th century has greatly influenced the current expression of the complex (see fig. Figure 3). Most of the hospital buildings from this period are still present in the current situation. However since the 1980’s some changes have taken place, a social housing block is introduced in the area, two buildings have been demolished and two modern extensions to the existing have been made. Since the completion the AMC the Binnengasthuis has lost the function of hospital and is now used by the University of Amsterdam, the UvA (see fig. 4).

In the following chapters the research question, goal and methodology will be discussed further.

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1 Eeghen, Meischke, & Stichting Viering 400-jarig bestaan van het Binnengasthuis, 1981, pp. 55, 57
2 Rijksdienst voor het Cultureel Erfgoed, 2004a
1 PROBLEM STATEMENT

The UvA is currently reorganising all their educational locations, including the Binnengasthuis area. Here the amount of used square meters is more than halved, from 140,990 m² to app. 68,000 m². This will result in vacant buildings which can be reused for new functions. The need to re-use is these, in nature, institutional buildings is not only relevant on the Binnengasthuis area but in the whole inner city of Amsterdam. On multiple locations institutional buildings become vacant and are in search of new users and functions. For example the recently vacated Paleis van Justitie and Prinsengracht hospital. Considering the always present demand for housing re-use of these buildings for a housing function seems an obvious solution. However the housing typologies used are all based on new build housing projects. And on the other hand the buildings to be transformed are not designed for a use as housing. This leads to a conflict between the housing type on one side and the existing building on the other side.

In common practice, especially when building new, one would first decide on the housing types and sizes and then create a suitable building. However in the case of re-use the building is already available. This leads to a conflict between the housing type on one side and the existing building on the other side. To solve this conflict the design has to be approached from the starting point of the existing building. This leads to very different solutions for different buildings. Determining the building characteristics which influence the housing design possibilities will give a better idea of the housing potential of a building.

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1 Demmers, 10-10-2014
2 Zijistra, 2011, p. 2
3 Leupen & Moolij, 2008, p. 9
4 Leupen & Moolij, 2008, p. 9
The above explained hypothesis of the influence of building characteristics on housing retrofitting possibilities has led to the following research question:

"Which existing building characteristics influence the housing retrofitting possibilities?"

This research will focus on existing institutional buildings from the late 19th and early 20th century. To better determine the differences in their housing possibilities a specific target group is chosen. In Amsterdam the city centre is now merely occupied by single households or couples. However there is a considerable group of families which also want to live in the city centre but are now pushed towards the suburbs because the city centre houses do not fulfil their demands. Using this very demanding target group for the research will guarantee that different solutions for different buildings will occur. This research question will be answered by a combination of theoretical research and research by design.

2.1 THEORETICAL RESEARCH

In the theoretical research the influence of a single building characteristic is further investigated. The characteristic chosen is the structural system of the building. Because according to Brand the structure a building has the longest live span of all building elements. And moreover the structure of the building determines the possibilities for change of the other elements. At the base of this research is the following research question:

"What structural system characteristics of existing buildings influence the single family housing typology retrofitting possibilities?"

To answer this main research question several sub-questions have been formulated:

1. How can the structural systems be typified?
   In order to use the structural typology of an existing building as a main decisive character in the process of retrofitting for housing it is important to develop a clear definition of the structural typologies

2. What are the adaptation possibilities of each structural type?
   Each structural typology will have some degree of adaptation possibilities. These possibilities will influence the housing possibilities and will thus have to be researched

3. What are the spatial needs of single family housing typologies?
   Each housing typology has specific spatial characteristics, which make this typology unique. These spatial characteristics can be

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1 Karsten, Reijndorp, & van der Zwaard, 2006, p. 10
2 Brand, 1994
3 Leupen, 2002, pp. 31,33
translated to spatial needs which have to be met in order to create this specific housing type.

The structural system adaptation possibilities on the one hand and the housing type spatial needs on the other hand are combined in the buildings of the Binnengasthuis area as a case study. From this case study the structural system characteristics which influence the housing typology retrofitting possibilities can be derived.

2.2 DESIGN RESEARCH

With the base of the theoretical research the research by design will further investigate the influential building characteristics. Unlike the theoretical research this is not limited to the building structural system. By comparing the family housing possibilities of existing buildings with very different characteristics the influential characteristics will become clear. Also the conclusions of the theoretical research can be put to the test.

2.3 GOAL

The main goal is to create a first overview of influential building characteristics for family housing retrofitting possibilities in institutional buildings of the late 19th and early 20th century.
The method of the research can be divided in a theoretical and a design part. The both parts are linked but have separate methods. These methods will be discussed separately.

3.1 THEORETICAL RESEARCH

In the theoretical research the influence of the structural system characteristics on housing retrofitting possibilities is investigated. In this report the three above mentioned sub-questions will be answered. The method for this can be divided in three parts according to subject. The first part will focus on the research on the structural systems, both their typology and the adaptation possibilities. Secondly housing typologies and their spatial requirements will be researched. And finally the third part focuses on the implementation of the knowledge of the first two parts on the Binnengasthuis area. The method of each part is further elaborated on below and is also shown in Figure 1.

Part 1: Structural system typologies

1. Find definitions of structural typologies in literature as a base for the final definition
2. From literature determine the structural systems commonly used in building construction in the Netherlands
3. Separate these structural systems in types and if necessary sub-types based on common characteristics which will influence the possible housing typologies
4. For each structural type define the alteration possibilities

Part 2: Housing typologies spatial requirements

1. Define the housing typologies which are to be researched in the following steps
2. Define the spatial needs these housing typologies based on literature and possibly case studies

Part 3: Case study, the Binnengasthuis area

1. Choose a set of representative buildings of the binnengasthuis area, representing different construction types and times.
2. Determine the structural systems of the chosen buildings. The following aspects will be researched:
   - Foundation
   - Load bearing elements
   - Floor structure
   - Stability elements
3. In this research a combination of archive sources and on site observations will be used.
4. Typify the structural systems of the buildings using the types defined in the general research
5. Relate the structural system of the buildings to the housing typology spatial needs
6. From this relation derive (structural) characteristics of the
buildings which influence the housing typology retrofitting possibilities.

3.2 DESIGN RESEARCH

In the design research part the influential characteristics are further researched. Not only focussed on structural characteristics but also involving other potentially influential characteristics. In this design research process four steps can be distinguished.

1. Choose a representative set of buildings (3 or 4). All the buildings have to apply to certain predefined criteria being:
   - Build in the late 19th or early 20th century
   - Originally intended and designed for institutional use
   - Located in the city centre of Amsterdam
   - Being a more or less singular object, so not a complex with a lot of later additions
   - The original fabric of the building is largely intact
And finally it is preferable that the placement of housing in these buildings is a semi realistic assignment. Buildings which will most certainly never lose their original function are thus also excluded.

On the other hand it is important that the buildings differ as much as possible in characteristics such as shape, size, structure and other potentially influential characteristics

2. Analyse all the chosen buildings, and determine also the valuable elements of the existing building fabric.

3. Based on the analysis develop a design for family housing possibilities for each building. These design solutions will be the one which really fit the existing fabric of the building. So no big forced changes, it is important to find the solutions closest to the original building and its characteristics.

4. Compare the design solutions for the different buildings to answer the following questions:
   - Do the solutions differ, and if yes what are the major differences?
   - Is it possible to relate these differences to the difference in a specific characteristic between the buildings?
   - What is it about this characteristic which really influences this difference?
This process is shown schematically in Figure 2

The steps 2, 3 and 4 can be repeated in a iterative process on increasing detail and elaboration levels (this is also reflected in the planning in Figure 4). Depending on the amount of difference between the design solutions for the multiple buildings the set can remain the same or be decreased in the case of little differences (see Figure 3).
INTRODUCTION

Housing typology retrofitting possibilities

Influential building structure characteristics

Part 1 Structure
- Literature
- Historic development
  Structural typologies
  Structural possibilities

Part 2 Housing
- Access to the house
- Configuration of the house
  Housing needs

Part 3 Case study
- Binnengasthuis Buildings
  Architectural, historical and monumental values

Housing typology retrofitting possibilities

Fig. 5: Scheme of the method of the theoretical research

Late 19th early 20th century institutional buildings in Amsterdam

1. Analysis & Value Assessment
2. Family inner city housing requirements
3. Design possibilities/options/concepts

Feedback, why do the design possibilities differ?

Possible influential building characteristics:
- Structure
- Size
- Facade
- Monumental value
- Location

Fig. 6: Scheme of the method of the design research
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1.1 DEFINITION OF THE STRUCTURAL TYPOLOGIES

As already mentioned in the introduction, the structure of a building is one of the levels of a building typology. This structure is the combination of elements which carry the loads to the ground and take care of the stability of the building. The load bearing elements can be divided in two groups: one with a vertical orientation, such as walls, and one with a horizontal orientation, like floors.

Although the structure of each building will be different to respond to the local conditions, it is possible to abstract these systems to a select set of types. In literature multiple sets of types have been defined already. Quatremere de Quincy defines 2 main types of structure, a monolithic and a framework structure. These types are related to the two types of primitive structures, the trulli as example of a complete monolithic structure and the primitive hut as example for the frame structure. A third type can be added as a transition from monolith to framework, a diaphragm structure. These types can be used both for the horizontal bearing elements and the vertical bearing elements separately. The combination of different types for horizontal and vertical elements will result in new types. These types can be used to typify the vertical bearing elements, and a part of the floor systems but do not mention the third aspect of the structure, stability.

To be able to fully investigate the possibilities of each type, it is important that the typologies used cover all the influential elements, which include stability elements. Before researching the possibilities of the structural types they will first have to be supplemented to be able to typify each building structure.

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1 Leupen & Mooij, 2008, p. 215
2 Leupen & Mooij, 2008, p. 215
3 Van Amerongen, Bukker, Bonebakker, & Jellema, 1998, p. 3
4 Leupen & Mooij, 2008, p. 215
1.1.1 HISTORIC DEVELOPMENT OF BUILDING STRUCTURES IN THE NETHERLANDS

To create a workable definition of the structural typologies it is important that the majority of the buildings in the Netherlands can be typified with it. To find these structural typologies a research into the historic development of building structures in the Netherlands is carried out. For each structure discussed the typologies for vertical and horizontal bearing elements as well as stability are identified. Combining all these types will result in a more complete set of structural typologies.

The first wooden houses

The first wooden house (4th century BCE) was based on a grid of columns. Across these columns connecting beams were placed. These beams supported the roof. Stability was provided by the columns which were slammed in the ground and thus had a non-hinging connection at their base (see fig. 6 and fig. 7).

This type evolved in the subsequent centuries. The row of columns in the centre was substituted by a horizontal connection between the two lower columns. The stability was still provided by the connection between the columns and the soil. However, due to the moist soil the columns quickly deteriorated. To prohibit this deterioration a stone piece was placed under the column. This resulted in a hinged connection between the column and the soil. To provide stability bracings are added in both directions to the supporting frame. Allow for more daylight in the house the two lower aisles at the side of the building were removed from the 2nd century CE (see fig. 8 and fig. 9).

The first stone houses

After the roman age stone and brick were not used for building construction anymore. From 900 CE onwards the use of natural stone for building returned to the building industry. In housing construction stone was mostly used to build fortified houses. After the re-invention of brick in the 12th century it became much more affordable to build a stone house. The fortified houses traditionally consist of a tower later complemented with a rectangular block. The brick or stone walls are all equally supporting and also provide stability. The floors of the building are added in a wooden beam system (see fig. 10).

5 Zantkuijl, 1994, pp. 4-5
6 Zantkuijl, 1994, pp. 10-11
The first city houses

The wooden one aisle house was the base for the first city houses. After city fires in the 15th century city councils obliged the use of stone or brick for the side facades. At first the stone wall was erected between the wooden frames, not intended to play any structural role. During time the brick wall replaces the wooden columns as supporting structure. Resulting in 2 monolith walls supporting the beams and frames (see fig. 11 and fig. 12).

The system of these first city houses and the system of the stone houses remains in use for a long period of time for all types of buildings, not only housing. The industrial revolution in England can be considered as a turning point in this slow evolution. New types of buildings were needed requiring new structural systems and new structural materials.

19th century the introduction of new building materials

Iron was introduced for the use of structural building elements in England in the end of the 18th century. At first this material was used for the new industrial buildings needed. The new material has very different properties than for example the brick which was most used at that time. These properties demanded a different structural type when using cast iron. A typical iron factory building structure would consist of cast iron columns supporting wooden or wrought iron beams. In-between the beams a stone vaulted ceiling was placed. Stability was provided by the brick exterior walls in both directions. The factory buildings were not the only new building type making use of iron structures. The large spans which were possible with iron structures made them very suitable for the emerging railway stations.

The use of iron in Dutch building construction emerged much later; only around 1840 the first iron structures were introduced. Wrought iron beams where commonly used for floor constructions from 1875. They would either be used to support smaller wooden beams and a wooden floor or vaulted ceilings, consisting of brick or concrete, would be applied between the beams. These vaulted ceilings where mostly used in factories as they are much more fire save than the wooden floors. Similar to the developments in England the large span properties of iron structures did not go unnoticed in the Netherlands. Multiple railway stations but also large factory halls made use of iron frames to provide for the large span roofs.

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7 Zantkuijl, 1994, p. 21
8 Leupen, 2002, p. 50
9 Oosterhoff, Arends, Van Eldik, & Nieuwmeijer, 1988, p. 1
10 Oosterhoff et al., 1988, p. 1
11 Leupen, 2002, pp. 53-54
12 Oosterhoff et al., 1988, p. 5
13 Oosterhoff et al., 1988, p. 7
14 Oosterhoff et al., 1988, p. 18
15 Bot, 2009, p. 314

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![fig. 11: Structure of a medieval city house](image1)

![fig. 12: Structural typology of the first city houses](image2)

![fig. 13: Structural typology of the first iron factory buildings](image3)

![fig. 14: An example of early iron factory buildings, the Nash Building in Omaha. The iron columns and wooden floors are clearly visible](image4)

![fig. 15: An example of the large railway station platform roofs, in this case the station of ’s Hertogenbosch. The iron frames are clearly visible](image5)
These roofs where either supported by brick masonry walls or iron columns, leading to the first complete iron building structures\(^{16}\)(see fig. 15).

In contrast to these large span full iron structures the iron factory building structure was still very dependent on the brick outer walls, mainly for stability. The first complete iron office buildings, which were now no longer dependant on their façade for stability, were realised in Chicago in 1888, but came into use in the Netherlands from the 1920’s\(^{17}\). For stability either moment connections or bracings were used\(^{18}\). This iron skeleton structure was carried out in steel from the 1900’s onwards\(^{19}\).

The cast iron structure was at first thought to be very fire save since iron does not burn. However it does lose its strength when exposed to high temperatures. This implies that the iron skeleton has to be protected from fire to keep the building save. At first this was done using ceramic elements, but also plain concrete could be used to cover the iron\(^{20}\)(see fig. 17).

This combination of iron and concrete was one of the reasons that in the end of the 19\(^{th}\) century the reinforced concrete was developed\(^{21}\). The use of reinforced concrete was developed in the second half of the 19th century. The inventor, Monier, only used the reinforcement for the concrete to stay in the desired shape. He used this system to produce concrete flower pots (see fig. 18). Hennebique introduced the first use of reinforced concrete in a structural way with his in 1892 patented integrated building system.

This system was revolutionary since it consisted of one monolithic unity of columns, beams and slabs(see fig. 19 and fig. 20). Before than concrete elements like floor slabs were not structurally integrated with their supporting beams or columns\(^{22}\). These reinforced concrete systems where mostly used for industrial and public buildings in which the big span and small dimensions of the structural elements where important for the use of the buildings\(^{23}\).

\textbf{20\(^{th}\) century further development of the concrete structures}

In the 20\(^{th}\) century the reinforced concrete structures for industrial and public buildings developed further. New systems are developed such as the mushroom column to support a flat floor slab, which emerged in the USA in 1914. This system was further developed

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\(^{16}\) Oosterhoff et al., 1988, pp. 14-15
\(^{17}\) Oosterhoff et al., 1988, p. 19
\(^{18}\) Friedman, 2010, p. 68
\(^{19}\) Bot, 2009, p. 312
\(^{20}\) Leupen, 2002, pp. 60-62
\(^{21}\) Oosterhoff et al., 1988, p. 23
\(^{22}\) Heinemann, 2013, pp. 40-41
\(^{23}\) Heinemann, 2013, p. 44
into a system with only columns and flat floor slabs. Next to the development for utilitarian use experiments were carried out to use reinforced concrete for housing construction. One of the early examples is the completely casted concrete house in Santpoort which was realised in 1911 (see fig. 21). The further development of the knowledge about the use of reinforced concrete in building construction lead to an increase of use in the 1920’s and from the 1930’s onwards concrete is one of the common building materials. During the first half of the 20th century more knowledge on reinforced concrete was gained and led to standardisation rules. Experimentation with concrete for mass housing took place, for example in Betondorp (see fig. 22).

After the Second World War concrete was one of the materials used widely in the reconstruction. Combined with the great need of housing after the Second World War a big amount of new, patented, housing systems emerge. These systems can be divided in three groups:

1. Stacking systems, characterised by wall and floor constructions which consist of small element that are put together by hand on site;
2. Cast systems, characterised by wall and floor constructions which are cast on the building site with standardised formworks;
3. Pre-cast element systems, characterised by wall and floor constructions which consist of large pre-cast elements put together with help of a crane.

Within these groups various systems have been developed. However different systems using a different building technique can still result in the same structural typology. For example a wall build-up out of big blocks, pre-cast elements or cast at the site will all function as a diaphragm independent from their system type. The systems commonly used in Netherlands will be grouped and discussed per structural type. In total six groups can be identified. First of all the systems which use diaphragm wall as vertical bearing element, which can be further divided based on their floor system and finally theirs stability elements will be discussed.

The first examples are the so called Muwi or Pronto systems which are still very similar to the traditional building practice. Their load bearing walls are built up out of smaller hollow concrete blocks which are later filled with concrete to form a solid diaphragm. The floors consist of small prefabricated beams which are placed on the walls. Between the beams lightweight concrete filling elements are placed. The beams and floor elements are connected by a small layer of concrete. Stability is provided by shear walls in both directions, the bearing walls and some additional wall perpendicular to them.

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24 Oosterhoff et al., 1988, p. 35
25 Oosterhoff et al., 1988, p. 13
26 Heinemann, 2013, pp. 48-50
27 Andeweg, 2013, p. 1
28 Priemus & Van Elk, 1970
connected horizontally by the stiff floor\(^{29}\) (see fig. 23, fig. 24 and fig. 25).

The second group uses larger elements for both walls and floors. These elements are generally pre-cast. The loadbearing walls either consist of one or two large elements connected with cement joints, they form the load bearing diaphragms. The floors consist of large pre-cast elements connected by reinforced cement joints. Stability is provided by shear walls, also consisting of one or two big pre-cast elements, placed perpendicular to the load bearing walls\(^{30}\) (see fig. 26).

Instead of using pre cast elements the third group of systems uses cast in-situ elements. The wall and floor can either be cast in separate cycles or simultaneously using a tunnel formwork. The standardisation of the wall and floor size ensures that the formworks can be used multiple times. By casting the walls and floors on site it is possible to connect them in such a way that only this connection is able to provide the stability for the building\(^{31}\) (see fig. 27 and fig. 28).

However when using the separate formworks for walls and floors it is also possible to cast shear walls together with the other walls to provide stability\(^{32}\) (see fig. 29).

All the groups discussed above use diaphragm walls as vertical bearing elements. The last group use columns as loadbearing elements.

The use of columns as vertical bearing elements is most common in utilitarian type of buildings. The combination of columns and a flat concrete slab floor is commonly used. The stability can either be provided by the connection of column and floor, like in the case of the mushroom columns, or by a core of shear walls in both directions\(^{33}\) (see fig. 30).

However columns systems were not solely used in utilitarian buildings, mass housing structural systems using columns has also exist, though have never really flourished. These systems make use of hollow sectioned portals which are joined on site by filling them with concrete. On top of these portals large pre-cast element floor slabs are placed, joined by reinforced cement joints or a small layer of concrete. Stability is ensured by the house separating walls, which where casted on site under the portals, and shear walls, casted perpendicular to the portals\(^{33}\) (see fig. 31 and fig. 32).
Conclusion

Although the main goal of this short historical study was to identify the structural typologies which will be used in the following paragraphs some interesting trends become visible when combining the above described historical developments in one graph the overall development. First of all it shows the dramatic increase of structural systems with the introduction of both iron and reinforced concrete in the building industry. Where the development of the systems was relatively slow until the 19th century afterwards the new systems rapidly succeed each other. This introduction of new structural materials also started the trend of separation of the structural systems for housing and those for commercial functions. This is closely related to the material properties of iron and concrete. They provide for larger spans and less columns, making larger rooms possible. In the case of housing this increase of size is not very necessary, since dwelling room sizes are relatively small compared to for example large warehouses or factory halls. The third somewhat less obvious trend is the movement from 3d frame based structures, such as the first wooden houses, to almost complete monolith structures, such as the concrete tunnel framework systems, in housing construction. This influences the stability measures which are necessary. In the case of a 3d frame the stability is not automatically provided by the horizontal and vertical bearing elements, however in the case of a complete monolithic structure the bearing elements also provide stability. In a way this movement from 3d frame to monolith is a movement from the separation of structural functions to an integrated situation.
fig. 33: Scheme of the historic development of the structural systems
1.1.2 TYPOLOGICAL ELEMENTS

From the previous historical analysis the structural typologies can be identified. As already mentioned the structural typologies can be divided in three main groups each taking care of one aspect. First of all the vertical bearing elements, taking care of the transportation of the vertical loads to the foundation. The second group, horizontal bearing elements, transports the vertical loads to the vertical elements. But also plays a part in stability as it transfers the horizontal loads to the stability elements. These stability elements from the third group. The following typologies have been identified in these three groups:

**Vertical bearing elements**
- Columns
- Diaphragms
- Monolith

**Horizontal bearing elements**
- Beams
- Large elements
- Monolith

**Stability elements**
- Fixed foundation
- Fixed connection
- Bracing
- Stability walls

The vertical and horizontal element groups both contain three members. In both groups a frame, monolithic and an in-between type can be identified. The in-between types are the diaphragm walls and large element floors. The stability element group shows a more diverse collection of types. Although the bracing and fixed connection types are in a way connected, one can say that the first examples of fixed connections were actually very small and strong bracings. The type of stability walls in two directions is closely related to the monolithic structure, since this already incorporates the walls in both directions. The fixed foundation however is the odd one out since it is the only typology which concerns the foundation of the building. All other typologies are independent from the foundation.
1.2 ADAPTATION POSSIBILITIES

The adaptation possibilities of a structural system are determined both by the possibilities of each element and the collaboration of the separate elements as a whole structure. However since the amount of theoretically possible structural systems based on the typologies is 36 the typological elements will be discussed separately. This makes it possible to combine the elements in every combination which is needed. However this element based approach has the risk of losing contact with the context of the other structural elements and the building. To overcome this the relation between the structural elements is sympathized and further explained in the conclusion of each group of structural elements. Also the influence of the adaptation possibilities on the other structural elements is mentioned here.

For each element the commonly used systems will be further discussed and following from this the intervention possibilities will be investigated. These interventions can be grouped in two groups.

First of all the interventions needed to comply with the current regulations. This will be interventions to strengthen the structure to be able to bear the new loads. In general it can be noted that the structure can be strengthened in three ways. First of all by strengthening the existing structural members, this type strengthening will be discussed for each type. Is has to be taken in to account though that the strengthening of some structural members can cause a change in the division of the load between the different structural members. This might lead to a different behaviour of the structure. Secondly an addition structural framework can take over the loads of the existing structure; this however will have a high visual impact. And finally complete replacement of the structural members is also an option, the significant loss of historic material will have to be considered though. Next to the strengthening the interventions which will alter the structural elements in a spatial way, for example making holes in walls or alterations in the floor plan or façade, will be discussed.

The typological elements will be discussed in the three groups as defined in the previous paragraph. Within each group each type will be discussed separately, and if necessary this will be further divided in the different materials used. After all the elements of one group have been dealt with they will be compared and some conclusions for each group can be made. Finally, after all the types have been discussed, overall conclusions concerning the several systems will be drawn.

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34 Theodossopoulos, 2012, p. 8
35 Gold & Martin, 1999, p. 65; Wheeler & Hutchinson, 1998, p. 4
36 Gold & Martin, 1999, p. 68; Verhoef, 1999, p. 25
1.2.1 VERTICAL BEARING ELEMENTS

Column

A structure with columns as its vertical bearing elements can consist of several materials. As already mentioned in the historic overview historic wood constructions used wooden columns as bearing elements. With the introduction of iron, steel and concrete new possibilities for the column structure appeared.

The techniques used to strengthen these columns are similar even though the properties of the several materials differ. All the techniques are based on the strategy of adding geometry to the column. This can be done using several materials. First of all the original material of the column can be added once more, by bolting or bonding the materials together. In the case of concrete columns the concrete can be casted around the existing column. The steel framing used in strengthening the steel column can also be applied to concrete and wooden columns, either bolting it or bonding it with epoxy resins onto the column. An alternative for the steel are fibre reinforced polymer materials which can be bonded to the columns using epoxy resins. The choice of strengthening material is dependent on the failure mechanism which it should prevent. For example in the case of failure of the original material due to high compression forces adding a material with high compression strength is a good choice. However in this case wrapping the column in FRP, which has a high tension strength, can restrain the column and thus create extra bearing capacity. It must be noted that some of the strengthening materials will greatly influence the appearance of the elements.

Regardless of the material of the columns this structural type has maximal spatial freedom. Because the bearing elements are not integrated with walls or facades these can easily be adapted without altering the structure itself. The spatial alteration possibilities are now not limited by the structure itself but by other aspects as for example the possibilities to sound and fire proof a dividing wall added to the column structure. Enlarging this freedom by removing a column however will cause major structural problems. The loads carried by the column will have to be diverted to the neighbouring columns by adding a beam.

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37 Gold & Martin, 1999, p. 60; McCaig & Ridout, 2012, pp. 304-310
38 Theodossopoulos, 2012, p. 113
39 Van Amerongen et al., 1998, p. 8
40 Leupen, 2002, p. 33
41 Gold & Martin, 1999, p. 74
Diaphragm

The diaphragm structure uses two parallel walls as main vertical load bearing elements. These walls where historically built up out of brick masonry. In the 20th century concrete replaced the brick masonry as main material for diaphragm walls. The diaphragm walls are traditionally the side walls of a single house, however also front and back facades functioning as bearing walls are possible.

Both the brick masonry and the reinforced concrete used in these walls have the favourable material property of high pressure strength. Still strengthening of the walls is sometimes necessary. In the case of a brick masonry wall cracks can occur when overloaded. Depending on the cause of overloading and the size of the crack it can be left as it is or repaired with a mortar. Removing or neutralizing the cause is obviously a requirement. Actual strengthening of the wall can be done by adding geometry to take the extra loads. This geometry will have to be carefully joined with the existing wall to make sure the new wall will function as one element. The materials used to add this geometry are usually the same as the original material of the wall. By adding this material any aesthetic features of the wall finish will disappear, and the original material will become invisible. If the loss of wall finish is an issue treating the structural issue of the wall in an integrated building way is possible. By strengthening other walls and redirecting the high loads to those walls the wall finish can be spared on this particular location.

All diaphragm structures are characterised by a high degree of spatial freedom parallel to the walls and a very low freedom and flexibility in the direction perpendicular to the walls. In the case of bearing side walls this freedom results in a wide range of possibilities for alterations of the facades. In the case of bearing facades the possibilities will be rather in alterations in the floor plan. Enlarging rooms in the width of the building is, in contrast to building with bearing side walls, relatively easy.

If necessary alterations in the bearing walls are, to a certain extent, possible. Small holes for example for service ducts, up to 75mm, are easily made and will not affect the load bearing capacity of the wall. Bigger holes like windows and doors require a lintel to divert the loads of the remaining wall above the hole. This lintel has to be placed without wall losing its bearing capacities. There are two possibilities to accomplish this. First of all the traditional method which uses shoring, the part of the wall above the new hole by placing

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42 Van Amerongen et al., 1998, p. 6
43 Ashurst, 1988, p. 50
44 Theodossopoulos, 2012, p. 123
45 Gold & Martin, 1999, p. 72
46 Theodossopoulos, 2012, pp. 123-124
47 Van Amerongen et al., 1998, pp. 6-7
48 Gold & Martin, 1999, p. 77
49 Van Amerongen et al., 1998, p. 52
small beams through the wall. These beams are supported by and temporary structure, and are at that moment supporting the wall. The hole can now be made and the lintel can be added. After this the temporary support structure can be removed again. The second method does not involve a temporary structure. It involves the sandwiching of the inner part of the wall by two halves of a double channel lintel. Part of the wall section is removed to place the two steel sections of the lintel. The two lintels are bolted together through the remaining wall creating a combined lintel\(^50\)(see fig. 41). The width of the openings which can be created with both systems is dependent on the force which will be transferred to the remaining wall part next to the hole\(^51\). Adding only a lintel is possible if the wall does not also function as stability element, since the lintel is not capable of transferring lateral loads. If adding a hole in a wall with lateral loads a complete stiff framework will have to be made inside the hole. This can be done using both above explained methods\(^52\)(see fig. 42). In the case of a concrete wall also the present reinforcements need to diverted. This is usually done by steel plate bonding to the edges of the hole\(^53\).

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50 Friedman & Oppenheimer, 1997, pp. 163-164  
51 Van Amerongen et al., 1998, p. 52  
52 Friedman & Oppenheimer, 1997, pp. 164-167  
53 Gold & Martin, 1999, p. 77
Monolith

The monolithic bearing element structure is characterised by bearing walls in all directions\(^{54}\). The monolith structure was used in the first stone buildings in the Netherlands, as discussed in the paragraph on the historic development of the building structures. For the bearing walls of those stone buildings either natural stone or brick masonry was used\(^{55}\). More recently also concrete has been used for these monolith structures\(^{56}\).

As already mentioned at the section on diaphragm walls the load-bearing walls can be strengthened by adding additional geometry in the same material as the original wall\(^{57}\). Any cracks in brick masonry walls which occurred due to overloading can be filled with a mortar in necessary\(^{58}\).

The monolithic bearing wall structure leaves little alteration freedom. Spatial rearrangements are only possible within the framework of the bearing walls\(^{59}\). Small alterations to the existing bearing walls are possible though. These alterations are similar to those of the diaphragm bearing wall. Small holes to provide for example services do not affect the wall load bearing capacities\(^{60}\). Larger holes will need a lintel to support the part of the wall above the cut out. Care has to be taken to assure the remaining wall is capable of bearing the new loads. In the case of a reinforced concrete wall the reinforcement has to be diverted around the hole\(^{61}\).

Conclusion

After discussing all the vertical bearing element types separately comparing them on both the strengthening and the spatial alteration possibilities will show the differences and similarities between the three systems. Placing the strengthening and adaptation possibilities in the greater context of the whole building will give an idea of the influence of them on other building parts and structural elements.

The strengthening of all the vertical bearing element types generally takes place by adding geometry. This geometry is usually the same material as the existing structure. The choice of added material and technique is highly dependent on the predicted failure mechanism. This failure mechanism is highly dependent on other structural interventions in the building. A strong bond between the original structure and the added material has to ensure that the new element will function as a single element. In the case of columns an increase in strength can also be accomplished by covering the exterior of the column in a material with a high tension strength.

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54 Leupen & Mooij, 2008, p. 250
55 Zantkuijl, 1994, pp. 10-11
56 Van Amerongen et al., 1998, p. 119
57 Gold & Martin, 1999, p. 72
58 Ashurst, 1988, p. 50
59 Van Amerongen et al., 1998, p. 119
60 Gold & Martin, 1999, p. 77
61 Gold & Martin, 1999, p. 77
The need for strengthening is not always generated by the imposed load on the floors. Interventions in the entire structure can result in the need to strengthen its vertical members. For example, the removal of a floor leads to a higher unconnected length of the vertical bearing elements. Because of this buckling can appear. This leads to the necessity to strengthen the elements, even though the total load on the structure has not changed or was even lowered.

In contrast to the strengthening options the spatial alteration possibilities greatly differ between the different types. Especially the alteration possibilities of façade and floor plan differ, while each type does provide a degree of freedom for services such as ducts. The degree of freedom in floor plans and facades is related to the degree of integration of the load bearing elements and the dividing elements such as internal walls and facades. The column structure shows the complete disengagement of these two aspects. And resulting from this is a high degree of alteration freedom in both the façade and the floor plan. On the other hand, monolith structures show a maximal degree of integration of bearing and separating elements. And this results in little spatial alteration possibilities. Facades can be altered a bit but cannot change drastically and only between the bearing walls some degree of floor plan freedom exists. The diaphragm type can actually be considered as an intermediate step between the column type on the one hand and the monolith type on the other hand. In the direction parallel to the diaphragms the degree of freedom resembles the freedom found in the column type. In the perpendicular direction however the degree of freedom is much lower, similar to the monolithic structures.

The influence of integration is not limited to the integration of separating and bearing functions. Integration of stability and vertical bearing functions in the walls of both monolithic and diaphragm structures leads to more complicated methods of making voids in the walls. The need to transfer not only the vertical but also the lateral loads around the new void sets higher standards for execution of the work.
1.2.2 HORIZONTAL BEARING ELEMENTS

Beam

The beam floor type can be divided further on base of the material of the beams. For each material other strengthening options and spatial alterations are possible. They will be discussed separately before drawing conclusions on the options of the beam system in general.

Wood

Traditional wooden floors consist of a layer of wooden beams spanning usually in the shortest direction and a layer of floor board on top spanning the other direction. Or two layers of beams can be present, a lower layer of big beams (moerbalken) and a second layer of smaller beams in the other direction with on top of them again the floorboards. To prevent dust to transfer through the floor to the room below also double floorboards in both directions have been used.

The need of strengthening can be either local, for example at a decayed part of a single beam, or universal, when the used beams do not have the sufficient profile and strength to support the imposed loads.

Local strengthening or replacements can be done in wood, steel or with the use of epoxy resin bonding. In wood the common solution is to add a new member bolted to the decayed beam to provide supplementary strength (see fig. 48). In steel the solution is similar, adding a steel plate bolted to the decayed beam section. Both solutions are reversible, however they are both very visible in an exposed beam layer. A second option using steel is to add the plate in the centre of the beam, by cutting a slot in the decayed beam and sliding in the steel plate which is then attached to the beam using bolts (see fig. 49). This results in a less visible intervention. The third possible material is an epoxy resin. The epoxy resins can be used as consolidants, adhesives and as a replacement of the original material. Advantages are the low structural and fabric disruption of the solution and the high strength of the material. However the compatibility of the epoxy repair is still unclear and since the material has only been available for about 30 years the long-term performance is still unknown. And finally an epoxy resin repair or strengthening is not reversible.

Universal strengthening the existing floor structure can be done using both wood and steel. The stiffness of the floor structure can be increased by fixing new timber or steel plates in perpendicular to the beam direction (see fig. 50). Connecting all the beams creates a

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62 Zantkuilj, 1994, p. 38
63 McCaig & Ridout, 2012, pp. 304-308
64 Wheeler & Hutchinson, 1998, p. 3
65 McCaig & Ridout, 2012, pp. 308-310
66 McCaig & Ridout, 2012, p. 311
67 Wheeler & Hutchinson, 1998, p. 4
diaphragm structure which increases the stiffness. Strengthening the beams while not altering the structural system is also possible using steel plates. Just as strengthening a small part of a beam they can also strengthen the whole beam, and can be either placed on the exterior of the beam, or in the centre.

The main spatial alteration concerning floors is the removal of part of the floor to create either a void or space for vertical connections. The size of the void determines the degree of alterations necessary. A void which is smaller than the distance between two beams can be made without any structural alterations. The only addition may be a framing around the void, possibly connected to the original beams. When the required void is too big to be placed between the beams a trimming is required. In a timber floor structure retrofitting a trimming is similar to adding a trimming in a new floor. However additional support will be necessary during the installation of the trimming. The strength of the remaining beams, especially the beams joined with the trimming beams, will have to be assessed since the load division between the beams can be altered by the trimming. Finally voids which span the entire width of the floor and thus imply the removal of complete beams. For the load bearing capacity of the remaining floor this has little implications. Before adding any of the above mentioned voids though it is important to assess the structural function of the floor. Does the floor only support the weight imposed on it and its own weight or does it also play a role in the support of lateral forces. If the floor supports or transfers the lateral forces it is important that the added voids do not compromise the stiffness of the entire floor.

Iron

The historically used iron beam floors consisted of a layer of wrought iron beams which either supported a layer of wooden beams and wooden floorboards or were connected by brick or concrete vaulted ceilings (see fig. 52 and fig. 53). Strengthening of the existing elements can be carried out with multiple techniques and materials. Traditionally strength is added by adding iron strips to the existing structure. The additional material is welded to the historic beam thus creating a new complex beam with a bigger section, and consequently higher strength, than the original beam (see fig. 54). New techniques involve the use of carbon fibre reinforced polymers (CFRP). Carbon fibre reinforced polymers have a much higher stiffness than the used iron beams. By adding a layer of CFRP to the iron beam the stiffness, and thus load bearing capacities, will increase. The CFRP reinforcement layers are attached to the iron beams using epoxy resins. To ensure maximal

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68 McCaig & Ridout, 2012, pp. 304-309
69 Van Amerongen et al., 1998, pp. 146-147
70 Bot, 2009, pp. 313-314
71 Verhoef, 1999, p. 58
72 Moy, 2014, p. 417
bonding a vacuum application technique is commonly used. Both the strengthening options will ensure the preservation of the original materials; however they are both not reversible.

Similar to the timber floor systems the spatial alterations of the floor system will concern all types of voids, smaller for services, larger for stairs, or even removing a whole section of the floor system to create a void space. Removing a part of the floor between two iron beams will not need any structural alterations. Possibly a framing is needed to cover the cut sides of the vaulted ceilings. However adding a trimming in an iron beam floor is considerably more difficult than in a timber floor, the iron beams are not as easy to connect or trim. Removing a complete section of the floor is probably easier, since there is no need for trimming or joining the iron beams. However as with the timber floor the diaphragm action of the floor system might be altered, which can have consequences for the building stability.

Concrete

The concrete beam floors considered here are the combination floor systems, for example used in the Muwi system, which consist of small pre-stressed concrete beams with between these beams a light concrete filling element and finished with a cast in-situ concrete layer on top, possibly reinforced, connecting the beams with the infill.

The increasing the geometry of the section can be done using concrete but also steel plates or fibre composite elements can be used. To increasing the geometry with concrete is only possible in the depth of the beam, since increasing the width also implies radical changes to the filling elements. This increase in depth will decrease the free floor height, and can also affect the position of services. Increasing the geometry with steel plates glued or bolted to the existing beam will not have such big influence on the construction height. Since the steel plate has a much greater tension strength than the concrete.

Next to steel plates bonded to the concrete beam fibre-reinforced polymers are used as an alternative strengthening material. Both of the materials are bound to the concrete using epoxy resins. The advantages of fibre-reinforced polymers are the low added weight and necessary section compared to both steel and concrete added geometry.

Similar to the timber floor systems the spatial alterations of the floor system will concern all types of voids, smaller for services, larger for stairs, or even removing a whole section of the floor system to create a void space. Creating a void solely in the filling elements is similar to creating a hole in the previously discussed concrete vaulted ceilings. Since the filling elements are not reinforced removing a part of the

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73 Mustafa & Moy, 2011, p. 1048
74 Gold & Martin, 1999, p. 65
75 Roberts & Haji-Kazemi, 1989, p. 21
76 Belarbi & Acun, 2013, p. 2
element does not harm the structural integrity of the floor. Creating a void which would be of such a size that the beams will have to be trimmed the intervention becomes considerably more difficult. Mainly because the trimming of the beams requires a connection between the trimmed beams and the remaining beams. Installing this connection is in principle similar to installing a trimming beam in a timber floor, however in this connection also the removed reinforcement has to be compensated\textsuperscript{77}. Obviously when dimensioning the void taking care that the void sides will not cut the filling element but removing them in their entire width will minimise the difficulty of the trimming works. Removing entire lengths of beams and filling elements will avoid these trimming problems completely. But it will alter the diaphragm action of the floor, which will have consequences for the building stability\textsuperscript{78}.

\textsuperscript{77} Friedman & Oppenheimer, 1997, p. 111; Gold & Martin, 1999, p. 75
\textsuperscript{78} Gold & Martin, 1999, p. 76
Large elements

A large element floor consists of large pre-cast concrete elements which are placed next to each other and joined by cement joints. A concrete hollow-core slab is an example of this type of floor. As shown in the paragraph concerning the historic development of building structures the large element type is only carried out in concrete.

Contrasting to the strengthening of the concrete beams adding geometry in concrete to the floor slab is not possible. Bonding steel strips or fibre reinforced polymers are used to strengthen the floor slab though. Both materials are bonded to the concrete using epoxy resins. The strengthening of the slab is based on the tension strength of the added material. This is much higher than the tension strength of the concrete slab. By bonding this material to the slab the stiffness of the slab increases resulting in smaller deflections and tensions in the concrete slab. To generate a similar result the steel plate will have to be thicker than the fibre reinforced polymer material, since the polymer has greater tension strength than the steel. This bonding strategy can be used locally to support a part of a floor slab but will be impractical when the complete floor needs to be strengthened.

The possibilities for creating openings in the floor slabs are largely dependent on the reinforcement of the slab. Small holes which will not cut through any reinforcement elements are always possible. Larger openings in the slab will require a trimming to redirect the reinforcement around the void. Removing a length of the slab is relatively easy, since the reinforcement will not have to be redirected, however a trimming beam supporting the new end of the slab will have to be inserted. When removing the complete floor slab a trimming beam is not necessary but extra attention will have to be paid to the diaphragm action of the floor. If the floor is part of the stability system of the building this diaphragm action will have to be taken over by other structural members.

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79 Gold & Martin, 1999, pp. 65-66
80 Gold & Martin, 1999, pp. 75-76
Monolith

Monolith concrete floors are, as earlier mentioned in the historic overview, either large pre-cast concrete elements or cast on site, combinations which consist of large precast elements with integrated reinforcement which are connected by a second concrete layer cast on site are also possible.

Similar to strengthening large floor elements by adding geometry to the existing section adding concrete geometry is not possible. Geometry can be added only by bonding steel plates or fibre reinforced polymer materials to the floor slab with the use of an epoxy resin\(^{81}\). This bonding strategy can be used locally to support a part of the floor but will be impractical when the complete floor needs to be strengthened.

The possibilities for creating openings in the floor slabs are largely dependent on the reinforcement of the slab. The amount and main direction of the reinforcement is greatly determined by span directions and size. Small holes which will not cut through any reinforcement elements are always possible. Larger holes will need a reinforcement trimming to divert the cut through reinforcement\(^{82}\). The size of possible openings with a trimming however is not unlimited. Generally a maximum of 10 to 12% of the total floor slab can be opened without compromising the structural integrity of the slab\(^{83}\). Bigger openings require additional structural measures to support the remaining slab\(^{84}\).

Conclusion

After discussing all the horizontal bearing element types and their materials separately comparing them on both the strengthening and the spatial alteration possibilities will show the differences and similarities between the three systems. Placing the interventions on the structural type in the greater context of the building will give an idea about the influence of them on other building parts and vice-versa.

Between the different floor types some similarities in the strengthening techniques can be identified. All the types can be strengthened by adding geometry to the current section if the floor. The material of this geometry differs for the different materials of the floors themselves. Materials which are commonly used are steel or iron and carbon fibre reinforced polymers, they are bonded to the existing materials with an epoxy resin or, when possible, also can be bolted. The degree to which the materials can be added is dependent on the size of the floor elements. Larger elements can only be locally strengthened by steel or CFRP strips. Next to these common materials the same material as the existing structure can also be used to

\(^{81}\) Gold & Martin, 1999, pp. 65-66  
\(^{82}\) Gold & Martin, 1999, p. 75  
\(^{83}\) Bhatti, Lin, & Idelin Molinas Vega, 1996, p. 149  
\(^{84}\) Gold & Martin, 1999, p. 75
add geometry.

The spatial alteration possibilities are not only connected to the structural type of the floors but also to the material used. The ease with which additional supporting elements can be added in the original floor construction largely determines the spatial alteration possibilities of each type and material. All the systems provide a certain degree of freedom for small holes to provide for example service ducts. However when creating bigger voids, for example for stairs or for actual voids in the floor plan, the differences between the systems become clearer. Adding trimming elements is much easier in a timber beam floor system than in an iron beam floor or concrete floor systems. Removing the entire length of a beam or slab does not require a trimming and thus can be considered easier in the case of iron and concrete systems.

However when considering the floor in the greater context of the building the spatial interventions can influence the functioning of the entire structural system. In the case of floor systems this is the case when the floor also plays a role in the stability system. Creating holes in the floor weakens the diaphragmatic integrity of the slab. If this is compromised, for example by too big or too many voids, the floor will not be able to transfer the lateral loads to the stability elements. This leads to the transfer of these loads to other members, which can become overloaded due to this. The weakened diaphragmatic action of the floor in this way influences the structural integrity of the whole building.
1.2.3 STABILITY ELEMENTS

Unlike the vertical and horizontal bearing elements, the stability elements provide for the horizontal load transfers and are not necessarily affected by an added vertical floor load. Thus, they will not have to be strengthened in the case of floor loads higher than designed. However, the current regulations ask for more stability measures than the historic regulations did. This could be a reason to strengthen the existing stability elements or take additional stability measures. So similar to the vertical and horizontal bearing elements, for each stability element type, the strengthening possibilities and the influence of the element on spatial alterations will be discussed.

Fixed foundation

Providing stability by fixing the columns in the foundation is not very common. This is due to the fact that creating a fully fixed connection is very difficult. However, there are some buildings which use this type of stability system; the first wooden houses are an early example of that. Since the strength of this stability system is largely dependent on the connection between the columns and the earth, strengthening this connection is a possibility to increase the stability. This is also possible for existing foundations by injecting grout or chemical materials into the earth surrounding the columns.

The spatial alteration possibilities of the fixed columns are equal to the spatial alteration possibilities of columns as vertical bearing elements. A high degree of freedom in alterations is present in both directions. The only impossibility is removing the columns themselves.

Fixed connection

The fixed connection between vertical and horizontal bearing elements was introduced as a stability element with the introduction of iron and concrete structures. The fixed connection demands a more difficult connection between the bearing elements. In iron structures, the joint can be strengthened by welding strips onto the joint to create more moment bearing capacity. In concrete, the joints are reinforced by adding additional concrete and reinforcement or bonding carbon fibre-reinforced polymers.

The fixed connections only add some more volume to the joints between the vertical and horizontal bearing elements. In this sense, they will provide the full range spatial alteration possibilities. Alterations to the joints themselves will reduce the moment bearing capacity of the joints drastically.
Bracings

Bracings as stability element where introduced in the early wooden houses as an alternative for the fixed foundation of the columns. The bracings can take several shapes, from the wooden corner pieces in the wooden houses to the modern steel and iron bracing diagonals. The strengthening techniques are dependent on the material of the bracing. The techniques for wooden bracings are identical to the techniques used for wooden columns. Wood, steel or CFRP materials are added to the original section to provide additional geometry. Wood and steel can be bolted to the original element, making the intervention reversible. CRFP and steel plates can also be bonded to the wood with an epoxy resin. This epoxy resin can also be used separately to increase the bond, and with it the strength, of the wooden member itself. The steel or iron bracings generally do not lack the strength but are just not well designed. Altering the structure to overcome this design flaw is usually sufficient to strengthen the structure.

Depending on the size of the bracings the location of the bracings can have a big influence on the spatial alteration possibilities. In the case of floor height bracings the degree of freedom concerning the floor plan can be defined as small since moving them is difficult and they will always close of the space between the two vertical elements in-between which they are placed. The small wooden bracings provide a much higher degree of freedom since they are only present close to the ceiling they will not close of the space.

Stability walls

As an alternative for the visible bracing the stability wall was introduced. This wall is placed perpendicular to the main direction of the vertical structural elements, in the case of columns the walls will be placed in both directions. The wall can be considered as a diaphragm which functions as a bracing. The advantage of a wall was that it could be integrated to the designed floor plan or facade and thus would be almost invisible. Both brick and concrete have been used for this type of wall. For both brick and concrete walls CRFP are used to increase their shear capacity. The CRFP material has a high tension strength they are added to the surface of the wall as a network of diagonals, realizing actually a sort of bracings. In the case of concrete walls a second possibility is the increase of geometry of the wall by adding an extra layer of concrete and reinforcement.

The integration of the stability wall in the floor plan or façade lowers the spatial alteration possibilities of the system. The wall itself cannot be altered or removed without adding a new stability system first. The spatial potential of the system will largely depend on the

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92 McCaig & Ridout, 2012, pp. 304-318
93 Verhoef, 1999, p. 62
94 Verhoef & Wittmann, 2000, pp. 108-109
95 Gold & Martin, 1999, p. 72
size and placement of the stability walls.

**Conclusion**

After the several stability system types have been discussed separately, comparing them on both the strengthening and the spatial alteration possibilities will show the differences and similarities between the types.

The strengthening of the stability elements is, with the exception of the fixed foundation and the iron or steel bracings, generally based on the addition of geometry to the element. Wood, steel or iron, concrete and CFRP are used for this purpose. They are bonded to the elements either by bolting, in the case of wood and steel, or by an epoxy resin, in the case of CFRP and also steel. Concrete is bonded to the material in the casting process.

When comparing the spatial alteration possibilities of the different stability type an interesting pattern becomes visible. The systems which do not integrate the structural function with a dividing function, like the fixed foundation and connection but also the small bracings, provide a high degree of spatial freedom. Whereas the systems which integrate the structural function with a dividing function in either floor plan or façade, like the large bracings and stability walls, have a much lower degree of spatial freedom.

Important to realise when altering the stability elements is that they do not provide the stability all by themselves. The stability elements are dependent on the horizontal, and sometimes vertical, bearing elements to transfer the horizontal loads to them. Interventions in the stability elements should thus be developed in close relation with the interventions in particularly the horizontal bearing elements.
1.3 CONCLUSION

The two previous paragraphs an attempt has been made to answer the first two sub-questions (see introduction) which both regard the structural systems of existing buildings. The goal of this chapter was to define the adaptation possibilities of the structure of the existing building. To make this theory applicable to the majority of the existing buildings is was decided to typify their structure and determine the possibilities for each type. Defining the right typologies for this type of research was crucial in this process. The structural typology should at least describe all the tasks of a structural system, namely the transfer of the loads to the foundation or ground and the providing of stability. Unfortunately the scarce structural types which were defined in literature did not take into account this stability aspect. Also they were incomplete with regard to the typifying of floors. To develop typological system which was able to describe the majority of the existing structures a historical investigation was carried out. Of each buildings structure encountered the structural typology was described. This lead to a typological system with three groups each taking care of an aspect of the structural system. These three groups were defined as vertical bearing elements, horizontal bearing elements and stability elements.

Each building can be typified using one typology of each of these groups. This leads to the theoretical possibility of 36 different types of structural systems. To lower the amount of investigation the structural possibilities are researched per type in each group. These can be combined to the possibilities of the structural system. Taking into account the other structural elements when planning an intervention is of utmost importance and will often be decisive. However the possibilities of each type give an indication.

Between the different structural typologies and their groups several interesting similarities appear when investigating both their strengthening techniques and spatial freedom. Strengthening is commonly done by adding geometry to the existing structure. The materials used are dependent on the material of the structure. Commonly wood, iron, steel, concrete and carbon fibre reinforced polymers are used. An alternative strategy is to not strengthen the actual structural members but introduce an additional load bearing structure. And finally replacement of the structure can also lead to stronger structure, however all the historic material will be lost.

The spatial possibilities of a structure appear to be closely related to the degree of integration supporting and dividing functions in the structural system. Typologies which only supply support and do not integrate any dividing function, for example the column typology, have a high degree of spatial alteration freedom. Whereas the typologies which closely integrate the both functions, like the monolithic types, only remain with a small spatial alteration freedom. This is especially clear in the vertical bearing and stability elements. In the
case of the horizontal bearing types the division is obvious since it is inherent to a floor system to integrate supporting and dividing functions. However in the comparison between a beam floor and a monolithic floor the difference is visible. In a beam floor the beams main function is support and the floorboards take care of the dividing aspects, while a monolithic floor combines both in one slab. Additionally in the case of the horizontal bearing elements the used materials also largely determine the spatial freedom.

Combining these conclusions about spatial freedom with the historic development of the structural systems several interesting statements can made. First of all the trend of housing construction from 3d frameworks to almost monolithic structures might maximize the building effectivity when newly built, but is has drastically decreased the spatial alteration possibilities for the future. In the case of commercial buildings the opposite trend has been visible, and one can say the spatial freedom has increased with time.
fig. 75: Scheme showing the influence of the structural integration on the spatial freedom
The knowledge about structural adaptation possibilities on the one hand and housing typology spatial needs on the other hand will come together in this chapter. The buildings of the Binnengasthuis complex will be typified using the structural typologies defined in chapter 3. Their structural system will be at the base of the definition of the possible housing types. By doing this the method developed in the previous chapters can be tested. Furthermore a first insight in the decisive characteristics of an existing building structure with regards to the housing possibilities can be developed. The amount of information on the various buildings greatly varies, leading to more elaborate analyses of some buildings and shorter ones of other buildings.

2.1 SITE DESCRIPTION

Before going into the separate buildings a description of the Binnengasthuis area will place them in their context. As already mentioned in the Introduction the Binnengasthuis area is located in the medieval part of the Amsterdam historic city centre and originated from two monastic complexes which evolved into the Binnengasthuis hospital. The monastic urban structure was long still visible in the hospital lay-out. Some of the buildings of the monasteries were still in use for the hospital in the beginning of the 19th century, while it had been in use for the hospital since 1579 (see Figure 106 and Figure 107). In the beginning of the 19th century the Binnengasthuis were all in a bad state and in no way able to comply with the “modern” medical standards. From the mid 19th century, simultaneous with the emergence of big modern hospitals in Rotterdam and Utrecht, big plans for a completely new hospital building are made. The first, of 1847, was too small for the likes of the hospital board (see Figure 108). For the second design, of 1862, they got the permission to use a more space to be able to provide enough hospital beds. This design projected one big hospital building based on the conventional corridor system. The scale of the buildings was enormous compared to the small scale of the surrounding historic inner city (see Figure 109). The design was received very positive by the hospital board; however it proved to be impossible to buy the required parcels making it impossible to execute the plan. A third plan was made based on the more modern pavilion system, but was also never realised (see Figure 110). Eventually it was decided to improve the hospital bit by bit.

This step by step development of the new hospital has greatly formed the current appearance of the site. The small scale approach makes it impossible to plan one big hospital building so instead several smaller buildings were built each housing a specific part of the hospital. These separate buildings lead to a pavilion like appearance of the site. However in a true pavilion hospital all the buildings would

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1 Eeghen et al., 1981, p. 105
2 Eeghen et al., 1981, pp. 114-122
have been connected, in the case of the Binnengasthuis this did not happen leading to multiple independent buildings (see Figure 111). Within these buildings the two movements in hospital design, the corridor and the pavilion system are also visible. The first buildings, the maternity clinic and the women’s hospital, both use the corridor system to access the hospital rooms. The building of the New Clinic however uses a pavilion type with two wings. The later added second surgical clinic and nurses house again uses the “old-fashioned” corridor lay-out. But in contrast to the other buildings it is placed around a private inner courtyard a bit like the historic layout of the hospital wings. The last building added by the hospital is the administration and children hospital building in the beginning of the 20th century. When the hospital left the Binnengasthuis area and moved to the modern AMC the area came in use by the University of Amsterdam (UvA). In the 1980’s a social housing block is placed literally in the area, completely changing the appearance and structure of the site. Also the UvA demolished the children hospital part of the administration building replacing it with a modern information building. Next to this they covered the courtyard of the new clinic to function as an atrium (see Figure 112).

The current urban structure of the Binnengasthuis is still characterised by the step by step renewal approach of the hospital. The buildings are placed separately in the surrounding public space. Because of this there is not much of a relationship between the buildings and their surroundings, making it feel like a “left-over” space. The remaining courtyards however can be considered as the pearls of this area and have the possibility of really improving the quality of the area.

3 Nijhof, 2014, p. 50
2.2 BUILDING DESCRIPTIONS

2.2.1 KRAAMVROUWENKLINIEK

The “Kraamvrouwenkliniek” is located in the West corner of the Binnengasthuis area. The building was erected in 1868-1870 after a design by A.N. Godefroy. It was part of the Binnengasthuis hospital, and functioned as a maternity clinic. The structure of the building consists of brick walls and wooden floors. The spanning direction of the floors is solely defined by the shortest distances possible. This leads to a system with bearing walls in multiple directions. It is unclear if the walls which do not bear any of the floor beams still are part of the structural system, for example for stability. The lay-out of the original bearing walls is still completely intact in the current building. The only minor structural change made is the removal of part of a bearing wall on the ground floor. The location of this change is marked in Figure 116.

Using the structural typologies of the theoretical research the “Kraamvrouwenkliniek” can be categorised. The monolithic brick walls provide vertical bearing capacity; the wooden beam floors the horizontal. The stability is provided by stability walls in both directions, this obviously is inherent to the monolithic system which is characterised by bearing walls in both directions. Based on the research also the spatial possibilities of this structural system can be defined (see Figure 115). The system has little spatial freedom in the horizontal plane, due to the monolithic walls. In the vertical direction however the wooden beam floor has a great spatial freedom. The stability is already provided by the monolithic wall and does not influence the spatial possibilities any further.

1 Rijksdienst voor het Cultureel Erfgoed, 2004b
2 VVRH Architecten, 2003

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**Figures:**
- **83:** Location of the Kraamvrouwenkliniek in the Binnengasthuis area.
- **84:** Bearing elements of the Kraamvrouwenkliniek:
  1. Wooden beam floor
  2. Brick monolithic walls
- **85:** Structural typology of the Kraamvrouwenkliniek and the resulting spatial possibilities.
- **86:** Plan (1:500) showing the Bearing elements and floor spans of the Kraamvrouwenkliniek:
  1. Location of the structural change on the ground floor.
2.2.2 VROUWENVERBAND

The building of the "Vrouwenverband" is located east of the "Kraamvrouwenkliniek". It was erected in 1874-1877 after an earlier design by A.N. Godefroy, adapted by B. de Greef. The building was designed as a women’s hospital building for the Binnengasthuis\(^3\). The structure of the "Vrouwenverband" is similar to the structure of the "Kraamvrouwenkliniek", brick walls and wooden floors. Also here the floors span in different directions throughout the building and it is unclear if and how the non-floor bearing walls contribute to the structural system. The main lay-out of the building is still similar to the original design: some internal (not bearing) walls have been added and removed though. On the ground floor a bigger intervention has removed part of a bearing wall\(^4\). The location of this change is marked in figure XX.

The structural system of the "Vrouwenverband" can be typified as monolithic walls, (wooden) beam floors, and stability walls. The stability walls are incorporated in the monolithic walls of the vertical bearing elements. These monolithic vertical bearing elements leave little spatial freedom in the horizontal plane. The beam floors however provide a high degree of freedom in the vertical direction.

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3 Rijksdienst voor het Cultureel Erfgoed, 2004c
4 Universiteit van Amsterdam, 2003b
2.2.3 KLINISCH ZIEKENHUIS

The “Klinisch ziekenhuis” is located in the North East part of the Binnen-
gasthuis area. This hospital clinic was built in 1888-1890 after a design by H. Leguyt. The structure of the hospital consists of brick walls and floors of wrought iron beams and brick vaults. In the 2 wings a clear structural system is visible. In the hospital rooms the beams span between the facades. In the service areas, half way the wings, smaller rooms are situated and the beams span in the perpendicular direction. The connecting building is also comprised out of smaller rooms where the beams span between the dividing walls. In the current situation though these dividing walls have been removed completely, they are most probably replaced by a frame (see fig. 94).

The hospital’s structural system can be typified as diaphragm walls with beam floors. Stability is provided by the change in direction of the diaphragms, which is part of the stability wall type (see fig. 93). The diaphragm walls leave spatial freedom in one direction. Depending on their orientation this is either in the façade (smaller service rooms) or parallel to it (hospital rooms). The floor system provides fewer possibilities than the previously discussed wooden beam floors but still leaves a moderate spatial freedom, preferably in the direction of the floor beams.

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5 Rijksdienst voor het Cultureel Erfgoed, 2004d
6 Universiteit van Amsterdam, 2003a
2.2.4 TWEEDE CHIRURGISCHE KLINIEK

The “Tweede chirurgische kliniek” is located in the south of the Binnen gasthuis area. Together with the “Zusterhuis” it was built in 1897-1900 after a design by F.M.W. Poggenbeek. The building consists of two wings placed in a 80° angle connected by a smaller building part. The connection part mainly houses supportive functions and the big main staircase is also located here. The wings consist of hospital rooms on one side connected by a corridor. On the north wing a lecture room is added to the main volume of the wing. At the ends of both wings secondary staircases are placed.

Combining the foundation drawings with the floor plans an idea about the bearing structure can be developed. Based on the directions floor beams and the size of the foundation the loadbearing walls can be derived. A plan showing the loadbearing walls and the floor spans can be found in fig. 97. Striking is the change in direction of the floor beams from the corridor to the hospital rooms. This arrangement leads to a great amount of loadbearing walls in two directions, and thus also ensures the easy transfer of lateral loads to the foundation. And because the façade of the hospital rooms is not load bearing it was possible to make large windows here and also use the special cavity walls. Together with the cavity wall between the rooms and the corridor the facade cavity played an important role in the ventilation of the rooms.

fig. 95: Location of the Tweede chirurgische kliniek in the Binnen gasthuis area

fig. 96: Bearing elements of the Tweede chirurgische kliniek
1. Wrought iron beam and brick vaulted ceilings
2. Brick diaphragm walls

fig. 97: Plan (1:100) showing the bearing elements and floor spans of the Tweede chirurgische kliniek
1. Location of bearing wall removals on the third floor

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7 Rijksdienst voor het Cultureel Erfgoed, 2004e
8 Naus, 2014, p. 30
function as loadbearing wall. However the loads on this wall are only generated by the load on the corridor floors, and since the span of these is only small the loads will not be very high. These small loads made the cavity wall and also the high amount of façade openings on the other side of the corridor possible. The difference in span direction and length between the corridor and the rooms is also visible in the placement of the floor beams. In the corridors, with the short spans, the beams are placed quite far apart. While in the rooms, with the large spans, the beams are placed much closer together (Figure 144 and Figure 145). This solution makes it possible to keep the same floor structure height at all places while not wasting expensive material. The walls supporting the room floors bear the highest loads and thus do not contain any cavities. On the top floor however three of these walls have been replaced by steel frames in later renovations (for the exact placement see fig. 97). Because the walls did not only function a vertical bearing element but also as stability walls the frames had to be able to transfer the lateral loads. This is done by making a fixed connection between the inserted columns and beam (lintel) (see Figure 146).

More in detail the structure and materials of the floors can be further examined. The floors consist of wrought iron profiled beams with brick vaulted ceilings which span between them (see Figure 147). The top of the floor is covered with a wooden boarding, which is in poor condition in some places (Figure 148). The structure of the roof is different from the floor structure, as can be seen in the section (Figure 150). At

9 Van den Berg, 1982
some parts a steep roof is in place, here a traditional wooden structure is used in the support. The majority of the building however is equipped with flat, or actually slightly sloping, roofs. At the facades connected to these roofs detailed wall anchors are placed (see Figure 149). These are the only wall anchors of the building, and they are mainly present on the inner courtyard facades. If their function would have been to keep the facades joined they would show on both facades and most probably also on every floor level, not only on the top. This is why it seems more probable that they are somehow connected to the roof structure. Possibly this roof structure exerts horizontal loads to the facades, thus needing a wall anchor to compensate for them (see Figure 150).

With this structural information on both building and detail level a structural analysis of the whole building can be made. In this analysis both the transfer of vertical as well as lateral loads is examined. This analysis is visible in figure xx.

Concluding, the structure of the “Tweede chirurgische kliniek” can be typified as diaphragm walls with beam floors. The stability is provided by the change in direction of the diaphragms between the corridor and the adjacent rooms, this can be categorised as the stability wall type. The diaphragm walls leave spatial freedom in one direction. Depending on their orientation this is either in the façade (in the case of the rooms) or parallel to it (in the corridor). The floor system provides a moderate spatial freedom (see Figure 151).

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**fig. 101:** Beneath the plaster layer the brick vaults are clearly visible

**fig. 102:** The top layer of the floor seems to be wood, but is not in very good condition

**fig. 103:** At the top of the walls the special wall anchors are visible.

**fig. 104:** The structural function of the wall anchor further explained. The anchors give a counter force to the outward horizontal forces exerted by the roof

**fig. 105:** Structural typology of the Tweede chirurgische kliniek and the resulting spatial possibilities
2.2.5 ZUSTERHUIS

The "Zusterhuis" is located on the South border of the Binnengasthuis area. It was built together with the "Tweede chirurgische kliniek" in 1897-1900 as housing for nurses. However during construction the amount of nurses employed in the hospital increased and an addition to the nurses building connecting it to the "Tweede chirurgische kliniek" was built in 1900-1901. Both parts were designed by F.M.W. Poggenbeek and form an architectural unity. Identical to the clinic the structure of the nurses building consists of brick walls and wrought iron and brick floors. In this case the bearing walls are all placed as diaphragms in the façade and parallel to it. Stability is provided by a couple of stability walls perpendicular to the facades.

The structure of the nurses building can be typified by bearing diaphragm brick walls with an iron beam floor and brick stability walls. The diaphragm walls parallel to and in the façade leave spatial freedom parallel to the facades. The only limitations in this direction are the stability walls. The wrought iron floor system provides a moderate vertical freedom due to the difficult placement of trimmings.

10 Rijksdienst voor het Cultureel Erfgoed, 2004

fig. 106: Location of the Zusterhuis in the Binnengasthuis area

fig. 107: Bearing elements of the Zusterhuis
1. Wrought iron beam and brick vaulted ceilings
2. Brick diaphragm walls

fig. 108: Structural typology of the Zusterhuis and the resulting spatial possibilities

fig. 109: Plan (1:500) showing the bearing elements and floor spans of the Nurses House
2.2.6 ADMINISTRATIE GEBOUW

The administration building is located between the "Vrouwenverband" and the "Klinisch ziekenhuis". When built in 1913-1914, after a design of J.M. van der Mey, it was connected to a children's hospital which was located south of the administration building. This part of the building has been demolished in 1991, and has been replaced by an extension of the administration building designed by T. Bosch11. The structural systems of the historic administration building and the modern extension are very different and will be discussed separately.

The structure of the historic administration building consists of brick walls and concrete floors. They form an almost monolithic structure. At the location of the interior corridor part of the supporting walls have been replaced with columns. The stability is provided by the bearing walls in both directions (see Figure 168). This leads to the following structural typologies; monolithic walls, monolithic floor; stability walls. The spatial freedom of these monolithic typologies is very limited; however the addition of the columns in the interior provides some interior spatial freedom (see Figure 167).

The modern addition to the administration building has a completely different structure. It consists of concrete columns and floors. It is unclear how stability is provided in this system, possibilities are a fixed connection between floor and column or a fixed foundation of some of the columns. The vertical and horizontal bearing elements can be typified as respectively columns and monolithic floor. The use of columns provides maximal spatial freedom in the horizontal plane; the monolithic floors however do not provide much freedom in the vertical direction (see Figure 167).

11 Rijksdienst voor het Cultureel Erfgoed, 2004f
2.3 CONCLUSION

Combining the analysis of the previously discussed buildings an overview of the structural typologies present on the binnengasthuis area can be created. This overview is graphically represented in Figure 181. The site shows a great diversity in structural systems, from almost complete monoliths to column or beam structures. For each structural system the degree of spatial freedom has been determined based on the theoretical research. The spatial freedom can be divided in a horizontal freedom, resulting from vertical bearing elements, and a vertical, resulting from horizontal bearing elements. The both directions are collected for the buildings on site and are represented in Figure 182 and Figure 183.
fig. 116: Horizontal spatial freedom of the structures on the Binnengasthuis complex

fig. 117: Vertical spatial freedom of the structures on the Binnengasthuis complex
## 1 STARTING POINTS

### 1.1 BUILDING CHOICE
- **1.1.1 CONSTRAINTS**
- **1.1.2 BUILDINGS**
- **1.1.3 CHARACTERISTICS**

### 1.2 PROGRAM
- **1.2.1 REQUIREMENTS**

### 1.3 GENERAL DESIGN STARTING POINTS

## 2 KONINKLIJK INSTITUUT VOOR DE TROPEN

### 2.1 VALUE ASSESSMENT

### 2.2 DWELLING CONFIGURATION

### 2.3 PRIVATE OUTDOOR SPACES

### 2.4 TRANSFORM-ABILITY

## 3 VROUWENVERBAND

### 3.1 VALUE ASSESSMENT

### 3.2 DWELLING CONFIGURATION

### 3.3 PRIVATE OUTDOOR SPACES

### 3.4 FLOORPLANS

### 3.5 FAÇADE

### 3.6 DETAILING

## 4 KLINISCH ZIEKENHUIS

### 4.1 VALUE ASSESSMENT

### 4.2 DWELLING CONFIGURATION

### 4.3 PRIVATE OUTDOOR SPACES

### 4.4 FLOORPLANS

### 4.5 FAÇADE

### 4.6 DETAILING
In this third part of the report the design research phase will be discussed. As mentioned in the methodology chapter in the introduction part the design phase is an important part of the research. In the design phase the conclusions of the theoretical research, as developed in the previous part, will be tested by putting them into practice. Secondly, and most importantly, the design and the design process itself are actually an ongoing investigation into the influential characteristics on which this research is aimed.

Before starting the design some starting points are set. These starting points are necessary to be able to fully compare the multiple designs, and draw valid conclusions. These starting points can be divided in three parts.

The first part comprises the choice of buildings for the design. It is important to use multiple buildings which have on one side some similarities, to make it possible to compare the design solutions for the different buildings. On the other hand the buildings have to differ on a substantial amount of characteristics, to make it possible to find the influential characteristics in the comparison.

The second part is the program. The program is the same for the multiple buildings. In this way interference of the comparison between the buildings by changes in the program is cancelled out. Finally, the last part comprises some design starting points to make sure the designs remain comparable.

All these starting points are discussed in the first chapter.

These starting points are the foundation of the conceptual design phase. Several design directions within these constraints are explored in a conceptual and sketchy way. The results of this process are described the second chapter. Following the conceptual stage two designs are worked out in a more detailed manner. This design will be discussed in chapter three.
1 STARTING POINTS

1.1 BUILDING CHOICE

The choice of the right case-study buildings for the research is essential. It is important that they are similar enough to be able to compare the design solutions. But also they should differ in as much characteristics as possible to minimize the chance of overlooking an influential characteristic in the final comparison. The scope of the research already gives an indication of the similarities necessary.

1.1.1 CONSTRAINTS

As already mentioned in the introduction chapter the focus of this research is solely on late 19th and early 20th century institutional buildings in the city centre of Amsterdam. So buildings chosen should be from this specific time period and should have an institutional character, at least at the time of erection. Additionally it is important that the original fabric of the buildings is largely intact, since it is impossible to research the effects of the original building design when it has been drastically altered.

The Binnengasthuis area hosts a large group of this type of buildings and since this is also the main location of the studio it is obvious that at least part of the building set is located in this area. However to cancel out the effect of the specific location it is important to add at least one building outside the Binnengasthuis area. For this search more constraints are added, based on the characteristics of the Binnengasthuis buildings. All the buildings on the Binnengasthuis all have the pavilion like characteristic of being an (almost) free-standing building. This results in the constraint that the buildings all have to be free-standing, singular objects in the urban fabric. Additionally it would increase the usability of the research if the transformation of the proposed building is a semi-realistic assignment. In the Binnengasthuis this is the case, since the UvA has decided to more than halve the m² of the inner city campus.

In summary, the above mentioned leads to the following list of constraints:
1. Build in the late 19th or early 20th century.
2. Originally intended and designed for institutional use.
3. Located in the city centre of Amsterdam.
4. A singular object.
5. The original fabric of the building is largely intact.
6. A semi-realistic assignment.
1.1.2 BUILDINGS

A survey of the buildings in Amsterdam which meet the first three constraints lead to the map shown in fig. 1. This group is still relatively large and can obviously not be examined in total. A realistic assignment is found in the case of the Koninklijk Instituut voor de Tropen. Due to budget cuts by the government the institute was forced to sell its large book collection and is now searching for a new function for the library\(^2\). This building also meets the constraints of the singular object and the intact original fabric. In this case even a large part of the interior is still intact.

Next to the Koninklijk Instituut voor de Tropen two buildings of the binnengasthuis will be added to the set. Since the constraints where determined based on the general characteristics of the Binnengasthuis buildings all the buildings more or less meet the constraints. So to make a choice an additional constraint has to be added. Since the goal of the design research is also the test the conclusions of the theory it is best to create a building set with as much difference in structure as possible.

The structure of the Koninklijk Instituut voor de Tropen consists out of concrete monolithic floors and brick monolith walls, so at least another building with this combination is undesirable. In an optimal situation the other two buildings have structural systems using either diaphragm walls or columns and either beam or large element floors. However as already mentioned in the analysis in the theory part the Binnengasthuis does not contain buildings of the right age (late 19th, early 20th century) with either a column structure or

\(^2\) Heijmans, 2013
large element floors. So instead the maximal diversity offered by the Binnengasthuis will have to be used.

Within the Binnengasthuis two groups of buildings can be distinguished by their structural system. The first uses monolithic brick walls and wooden beam floors, for example the Vrouwenverband and the Kraamkliniek. The second group has diaphragm walls and iron beam floors, for example the Klinisch Ziekenhuis and Tweede Chirurgische Kliniek.

Of each group one building is chosen. From the first group the Vrouwenverband is chosen, it is currently being transformed and thus forms a quite realistic assignment. From the second group the Klinisch Ziekenhuis is chosen. In contrast to the Tweede Chirurgische Kliniek it uses the facades as bearing walls. This results in interior spaces which have a lot of potential for change. This very adaptable space is also in great contrast with the difficult to adapt space in the Vrouwenverband due to the monolithic wall system. This contrast between the buildings is just what was necessary in the chosen set of buildings.

1.1.3 CHARACTERISTICS

As already mentioned the buildings should differ on as much characteristics as possible to make sure no influential characteristics are overlooked. To make sure this is the case in the chosen set of three buildings (Koninklijk Instituut voor de Tropen or KIT, Klinisch Ziekenhuis and Vrouwenverband) is analysed on multiple “basic” characteristics.

Shape

First of all the general shape of the buildings is analysed. The Vrouwenverband and the Klinisch Ziekenhuis clearly represent the two trends in hospital buildings in the late 19th century. The Vrouwenverband is of the “conservative” type and can best be characterised as a compact block like shape. While the Klinisch Ziekenhuis is of the “progressive” pavilion hospital type and is characterised by the two long wings for the ill (pavilions), connected by a smaller wing containing educational spaces. The KIT is best characterised as a collage shape. Each department of the institute has its own building volume which together form the KIT.

Access

The contrast between the “conservative” design of the Vrouwenverband and the “progressive” Klinisch Ziekenhuis is also visible in the access systems of both buildings. The Vrouwenverband uses the traditional corridor system with rooms on one side. The vertical access is provided by a single large staircase. In the Klinisch Ziekenhuis the pavilion idea is visible in the access system. The two wings each have a central core for supporting rooms and vertical access. The traditional corridor has been abandoned so the large hospital rooms are directly connected to the core, thus minimizing the actual
corridor length. The design of the KIT much more resembles a common office layout. A large staircase at one end connects to a central corridor on each floor with rooms on both sides.

**Monumentality**

The monumentality of a building is not a standard aspect to analyse, however when dealing with monumental buildings such as the chosen three buildings it is important. Instinctively one can imagine the influence of monumentality on the adaptation possibilities of the building. A monumental building element is less likely to be changed in the adaptation process compared to a non-descript part.

In the case of both buildings of the Binnengasthuis the monumentality is concentrated in the facades of the buildings. The interior was mainly designed as functional and is quite plain, and due to the change of function from hospital to university many original interior elements have disappeared. In the Vrouwenverband the monumentality concentrates in the North façade. This façade was the “image” towards the city and was thus designed as the representative and monumental façade. The other façades were apparently thought of as less important since they all have a very plain appearance. The pavilion thought of the Klinisch Ziekenhuis meant that the building does not have a clear front façade. All the facades of the Klinisch Ziekenhuis have a similar monumental appearance and decoration.

The KIT however was originally designed as monumental in both exterior and interior. Even the door handles and window openers were specifically designed for the KIT. Additionally the building is still used by the KIT.
and has thus not seen a lot of major changes. Because of this a large amount of the original interior elements are still intact and in place. In this case the monumentality is thus both on the exterior and the interior.

**Orientation of the rooms**

The office like function an lay-out of the KIT has resulted in the typical office rooms with a single sided orientation. The hospital rooms show a larger diversity in orientation. In the case of the Vrouwenverband single side oriented rooms are present next to the corridor. At the corridor ends the rooms have a triple sided orientation. Although the windows on the long side of the room are placed well above eye level so they provide for daylight but it is not able to look outside. The wings of the Klinisch Ziekenhuis are characterised by their two-sided orientation. By removing the corridor from the wings the rooms now connect to both facades and thus a two-sided orientation is created.

**Room size**

The difference is room size between offices and hospitals becomes really clear when analysing the average room size of the three buildings. The smaller size of a standard office compared to the larger hospital rooms results in the KIT having the lowest average room size of about 28 m². However the large amount of smaller supporting rooms in the Vrouwenverband and the relatively small hospital rooms leads to an average size of only 31 m². The large open-plan hospital wings of the Klinisch Ziekenhuis lead to a high room size average of 72 m². This is more than twice the size of the Vrouwenverband.

**Floor height**

The tradition of high floor heights in hospitals is still visible in both Binnengasthuis buildings. However the buildings are already affected by the trend of a continuous lowering of the floor height. The Vrouwenverband, as oldest of the three buildings has het highest floor height. In the Klinisch Ziekenhuis is already a little bit lower. The KIT has the lowest floor height. However this could also be due to the office like function.

**Structure**

The difference in structure was one of the main reasons to choose these three buildings. As already mentioned the KIT consists out of concrete monolithic floors and brick monolith walls. And the Vrouwenverband also has the monolithic brick walls but has a wooden beam floor. The Klinisch Ziekenhuis on the other hand has diaphragm walls and iron beam floors.
## Buildings

<table>
<thead>
<tr>
<th>Koninklijk Instituut voor de Tropen</th>
<th>Buildings</th>
</tr>
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<tbody>
<tr>
<td>Shape: Collage</td>
<td>Access: Inner corridor, Corner staircase</td>
</tr>
<tr>
<td>Monumentality: Facades &amp; interior</td>
<td>Orientation: Single sided</td>
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<tr>
<td>Room size: 28 m²</td>
<td>Floor height: 4,4 m to 3 m</td>
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<td>Structure: Brick monolith &amp; Concrete monolith</td>
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<table>
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<th>Klinisch Ziekenhuis</th>
<th>Buildings</th>
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<td>Access: Cores, Central staircase</td>
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<td>Monumentality: Facades</td>
<td>Orientation: Double</td>
</tr>
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<td>Room size: 72 m²</td>
<td>Floor height: 4,7 m to 4,6 m</td>
</tr>
<tr>
<td>Structure: Brick diaphragm &amp; Iron beam</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Vrouwenverband</th>
<th>Buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shape: Block</td>
<td>Access: Corridor, Central staircase</td>
</tr>
<tr>
<td>Monumentality: Single facade</td>
<td>Orientation: Single &amp; triple sided</td>
</tr>
<tr>
<td>Room size: 31 m²</td>
<td>Floor height: 5,1 m to 4,6 m</td>
</tr>
<tr>
<td>Structure: Brick monolith &amp; Wooden beam</td>
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</tbody>
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*Fig. 7: Diagram showing the different characteristics of the buildings*
1.2 PROGRAM

The basis of this studio is housing in heritage. So a program which includes housing is obvious. This still leaves many options, but for the sake of the research it seems best to choose a housing target group which is demanding and will really push to the boundaries of the adaptation possibilities. For it is in the conflict between the program demands and the building characteristics influential characteristics can be derived.

This demanding group was found in the shape families. Contradictory to the current belief that all young families prefer a house in the suburbs recent research shows that part of the families prefer the inner city over the suburbs. However they do have high demands for this inner city living area. And one of them is the need for a quiet place with the hectic city live around the corner. These locations are hard to come by and especially combined with houses in the right price category. When the family cannot find the desired dwelling in the inner city they eventually reluctantly move to the suburbs, resulting in an inner city with almost no inhabitants younger than 18 years. In the case of the historic inner city of Amsterdam this results in only 6.5% citizens under 18, whereas in the whole of Amsterdam, including the suburbs, the same age group represents 18.2% of the inhabitants. Due to the low amount of families in the inner city their wishes are not considered by the urban planners, because they are convinced that families do not belong in the inner city. This leads to a downward spiral for these families; they do not see their needs represented in the local policies, discouraging them even more, leading to more families moving to the suburbs.

Both the Binnengasthuis and the KIT can provide the much wanted quiet living area with the busy city around the corner. And thus also seem very suitable for these families.

1.2.1 REQUIREMENTS

Families dwelling in the inner city have different requirements regarding their house and environment than families in suburbs. A recent study into family dwelling in inner cities resulted in some important points to keep in mind when designing for this specific group.

First of all it is important to create enough rooms for all the family members to withdraw in. A house with the possibility to add or split rooms to increase the total amount of rooms is considered optimal in this regard. The house has the ability to grow along with the family.

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3 Gemeente Amsterdam, 2013, p. 22
4 Karsten, Reijndorp, & van der Zwaard, 2006, p. 10
5 Stadsdeel Centrum, 2012, p. 20
6 Karsten et al., 2006, p. 10
7 Liesker, Atteveld, Ming Lam, & Fäustle, 2013, p. 5

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living in it, making it “future proof”\(^8\). Secondly a lot of attentions goes out to the well-being of the children, and especially to their play spaces. Creating a wide hallway makes it possible to also use it as indoor playing area. And a corridor can also function as outdoor playing space close to home. Finally keeping parked cars of the street creates a nice and save street playing area\(^9\).

Finally the limited amount of square meters of the inner city house creates a need for smart, space saving solutions. Creating multifunctional space an efficient and usable storage space or areas is a must\(^10\).

These requirements resulted in a basic list of necessary rooms and square meters for a traditional family of four (see fig. 11). In total the dwelling should be approximately 100 m\(^2\) in size.

### STARTING POINTS

To assure the designs for all three buildings will be relevant to the research some final design starting points have been fixed.

Most important is the fact that the designs should not fundamentally change the building. Nowadays almost any intervention thinkable is also conceivable, but these drastic interventions will not be a good source to find the existing building characteristics influencing them. Instead it is better to create designs which stay in touch with the original building fabric. In this way it is much easier to find the spots were the design needs and existing building compete. These are the interesting spots were eventually results and conclusions originate.

\(^8\) Liesker et al., 2013, pp. 149,153,155

\(^9\) Liesker et al., 2013, pp. 151,161,163

\(^10\) Liesker et al., 2013, pp. 157,159
2.1 VALUE ASSESSMENT

The building of the KIT was specifically designed for this institute, at the time only focussed on the Dutch overseas colonies, in the 1910’s. However because of WWI and the big recession afterwards the building was only finished in 1926. Despite the delays a building was created which was designed to the very detail of for example the doorknobs. Every detail is specifically designed for the institute. And also all the rooms are fitted with a custom panelling and build-in cabinets. The central and public parts of the building were designed with an extravagance and exquisiteness which is unique in the Netherlands.

A large part of this special interior is still present in the building, and still in the original condition. Besides the interior also the exterior is almost unchanged, apart from some small additions on the museum side.

The intact interior and exterior of the building is considered as historically valuable, both in an architectural historical way as in relation to the Dutch colonial history.

2.2 DWELLING CONFIGURATION

The structure of the KIT is based on brick walls and concrete floors. Based on the theoretical research it seems logic to create single floor apartments since it is difficult to vertically connect through the concrete floors. The original floor plans have a central corridor with offices at both sides. Also the collage like composition of volumes is also visible in the floor plans which can easily be divided in the multiple building parts. These different building parts sometimes have different sections and floor levels corresponding with the spatial needs of the original function.

The average size of the rooms is about 28 m², which is by far not enough to fit the 100 m² programme. Additionally the floor height of approximately 3,0 m up to 4,4 m is insufficient for the creation of in between floors.

Here we already encounter the first influential characteristic. The floor height is decisive when it comes to the possibility to create an in-between floor. Based on the Dutch building legislation the height will have to be at least 2x2,6m + “the thickness of the new floor” to be able to create two residential rooms above each other. When creating utility rooms, such as bathrooms, the acceptable height is 2,3m so the absolute minimal height in which an in-between floor is possible is 2x2,3m + “the thickness of the new floor”. See also the paragraph on Floor height in the Characteristics part.
fig. 15: One of the original interior design sketches of the architect Van Nieukerken and the current state of the same room.

fig. 16: Facade painting showing the different building parts

fig. 17: Current state of the facades
For the dwelling configuration multiple concepts were tested. In the first concept the current access routes through the building are maintained. The 100m² houses are realised by connecting multiple smaller rooms on a single side of the corridor. However sometimes there are not enough adjoining offices to create a 100 m² group, resulting 22 dwellings smaller than 90m² with the smallest being 57m².

By removing a part of the routes it is possible to create more dwellings which meet the 100m² requirement.

In the configuration of the dwellings care is taken that the dwellings are all part of a single building volume. This is done for two reasons, first of all to maintain the feeling of the building volumes which are visible on the outside also on the inside. Secondly because not all the parts have the same section differences in floor height in a single dwelling are prevented. Now only 8 dwellings of less than 90m² remain, with the smallest dwelling being 75 m². This can be reduced to 6 dwellings if we allow some of the dwellings to cross the building part borders.

Finally one can adapt both the original routing and create dwellings which can be part of multiple building volumes. This results in some funny shaped dwellings, but reduces the amount of dwellings of less than 90m² to 5. However this reduction is "small" compared to the large impact on the historic building structure. So the third concept is preferred above this most efficient one.

fig. 18: The 4 dwelling configuration concepts
2.3 PRIVATE OUTDOOR SPACES

Because of the historic value of the existing facades it is undesirable to add balconies or other outdoor spaces. The building currently has a collection of roof terraces which could be used by the inhabitants. Furthermore the building is located practically inside the Oosterpark. This unique setting can perhaps provide even more quality as outdoor space than an ordinary balcony. By creating more private zones close to the building dissipating into the public zones of the Oosterpark a pleasant outdoor space can be created for the inhabitants. However the newly created dwellings will not meet the Dutch building legislation which demands a private outdoor space adjoining to each dwelling.

2.4 TRANSFORM-ABILITY

While making the concept designs for this building it becomes clear that it is difficult to drastically transform a building with so much historic valuable content. The created dwellings will all have to deal with the original elements still present. And the most monumental rooms such as the Great Hall and areas were already excluded from the configuration concepts. Some of the rooms are so specifically designed for their function that transformation is undesirable or even impossible. And secondly the demands of the new housing function sometimes cannot do justice to the original monumentality. As is the case for example in with the original panelling which cannot fully be kept in a transformation.

Here a new influential characteristic comes to the surface. A building or building parts, both exterior such as facades and interior such as the original panelling, can be so valuable that it is of the utmost importance to maintain it. A change of function can possibly endanger this, and is thus not desirable. See also the paragraph on Value of building(parts) in the Characteristics part.

Concluding we can state that a transformation of the KIT to dwellings is possible, of course, but not desirable. Also it will take a very clever design to really give a stage to the existing monumental elements. Because the current research also consists of two other buildings the KIT has not been further developed.
3 VROUWENVERBAND

3.1 VALUE ASSESSMENT

The Vrouwenverband is characterised by the contrast between the monumental and representative character of the front, city faced, façade and the plain back façade. These facades show the still very relevant struggle of institutes between keeping up appearance and keeping down the costs. The compromise made tells something about the stand of the hospital board. The choice was to keep up the appearance to the outside world (the city) and reduce cost and appearance on the facades facing into the hospital area. This contrast is still very visible and is telling about the origins of the building. In this way the contrast between the ornamented north façade and the plain south façade can be considered a historical value. This contrast should be maintained and also influence the possibilities to change elements in the façade. The monumental side should change as less as possible while larger changes are possible on the plain back facades.

The Vrouwenverband is located on a unique spot in Amsterdam. On the one side it is located at a traditional Amsterdam canal with views on other canals. On the other side it is located to a public square. Both sides have great opportunities, but neither of them is exploited in the current situation. The new design is an opportunity to change this and create a strong connection with the canal and improve the quality of the square.

3.2 DWELLING CONFIGURATION

The first configuration which comes to mind is just using the existing hospital room layout for the dwellings, so one hospital room is one house. The original access routes can be maintained, and the large size of the corridor also provides a playing area for kids as well as storage for eg. buggy’s. However the average size of the dwellings in this case is 86m² which is a lot smaller than 100 m² necessary. Because of the limited floor height, between 4,6 and 5,1 m, it is impossible to make a fully functional in-between floor to increase the square meters.

To create larger dwellings it is possible to connect the hospital vertically. The wooden beam floor system provides full vertical flexibility, as explained in the theory part. By doing so the original corridor structure can be maintained on at least one of the floors. Also the large corridor is now used by twice as many dwellings creating a more effective use of the space.

But the vertical freedom of the wooden beam floors can even be exploited more by creating a fully vertical design. By creating a complex stacking of dwellings almost all of them can be provided with the much wanted front door on street level. Only the attic houses will need the central staircase to provide access to the house. Because the corridor is now not in use for the access of dwellings it can also
fig. 24: Dwelling configuration concept 1, maintaining the original structure of the building and use the former hospital rooms as dwellings.

fig. 25: Dwelling configuration concept 2, maintaining part the original structure of the building and create vertical connections between the hospital rooms to enlarge the dwellings.

fig. 26: Dwelling configuration concept 3, creating vertical houses with front doors on street level.
be used as dwelling space, thus creating a more space effective design. Also an interesting research case is created. The vertical houses can function as a test for the conclusions of the theory. Specifically the conclusion that the wooden floors provide a large vertical freedom. In the design the limitations of this freedom can explored. And thus this third configuration concept is chose to be further developed into a final design.

### 3.3 PRIVATE OUTDOOR SPACES

Each dwelling needs a private outdoor space of some kind. For the Vrouwenverband multiple concepts have been explored. First of all the possibility of roof terraces, they have almost no impact on the historical façade, and the roof is most of the time not very visible from the street. However not all the dwellings will probably have access to the roof. A second option is the traditional (front) garden on street level. When creating ground bound dwellings this type of ground bound outdoor space is a great option to spare the original building. But the tight location of the building and the orientation to the north of part of the possible gardens makes this option inconceivable.

Finally adding balconies is an option. In the case of the Vrouwenverband these balconies can be added to the three “plain” facades but not to the monumental north façade, as already mentioned in the value assessment.

To make sure every dwelling will be provided with a qualitative private outdoor space the option of balconies on the plain facades is developed further in the final design.

### 3.4 FLOORPLANS

The vertical oriented dwelling configuration was developed further into actual dwelling floorplans. In the configuration one can distinguish 3 different dwelling types. First of all the 2 story dwellings on the south side, secondly the three story dwellings with entrance at the North side of the building, and finally the 4 “penthouses” located in the attic. These types all have specific qualities. The attic houses benefit from the beautiful roof construction which is visible throughout the entire attic. The three story houses on the North side have a unique view onto the typical Amsterdam canals. And finally the two story houses have a close relation with the street. This relation is only beneficial in the case of the three dwellings which are located on the edge of the square. The three dwellings on the west side of...
the building face a blind wall and a small alley-like street. Here possibility of a close relation with the street is anything but alluring. The quality of these three houses will have to be in the house itself, since the surroundings do not provide it.

In the above mentioned case the surroundings influence the future dwelling plan. In the case of the houses on located on the square a strong relation with the surroundings can be considered a quality. Whereas in the other case the same relation would be displaced, since a view on a blind wall only devalues the dwelling. See also the paragraph on Context/Surroundings in the Characteristics part.

This thus results in eventually 4 housing types with each a different focus and quality. The floorplans of each dwelling will be discussed separately.

**Canal houses**

The Canal Houses are located on the north side of the building. They all consist of 3 storeys. Additionally because the first floor has a height of 5.1 m here an in-between floor is created dividing the height in a 2.6 m room below it and a 2.3 m room above it. To be able to optimally enjoy the unique view on the canals the living rooms are placed on either the first or second floor. On the ground floor the entrances are placed. In some cases the entrance area is accompanied by a room which can function as a home-office or as an additional bedroom. On the remaining floors the bedrooms and bathrooms are situated.
In all these houses the rooms are really spread out in vertical direction. In a conventional house a corridor might connect the multiple rooms to give it the feel of one home. In these vertical units the staircase will be the obvious connector. However, this connection is further strengthened by the design of the specific dwelling interior. For example, in the case of the two corner houses a single connecting element is introduced. This box contains all supporting functions such as bathrooms, kitchen and storage. By giving this box a uniform and recognisable design the relation between the several floors is emphasised.

**Introvert houses**

The three dwellings with view on the blind wall have been designed as introvert houses. These houses have an internal focus point instead of a focus on the surroundings. This focus point consists of a small patio, or introvert garden, and the central staircase with adjoining voids. The entrance of the dwelling is on the ground floor through the introvert garden. Directly connected to the entrance and the garden is the central staircase and focus point. To the left is the large kitchen and dining. Connected from here and facing the garden is the second bedroom. Going up the staircase to the first floor one passes an in-between floor with a bathroom. On the first floor a living and work/play area is located. On top of the living room an in-between floor is created, similar to the one in the canal houses. On this floor the main bedroom with en-suite bathroom and walk-in closet is located. In the case of the corner dwelling two bedrooms can be created on the in-between floor. This difference occurs because the corner dwelling also has windows on the left side of the dwelling, whereas the other two just have windows on the front side.
Square houses
The three houses adjacent to the square are designed to create optimal relation with the square as this is their main quality. The dwellings have a small private garden at the edge of the square. Adjacent to this garden with two large double doors opening into it is a family kitchen and dining. In practice these garden doors will probably be used as the “front door” by the inhabitants. However on the other side of the house a formal entrance is also present. In this entrance hall also a separate toilet is placed. Between the family kitchen and the formal entrance the living room is located. From here the stairs go up to give access to a roof terrace and go up further to the first floor. Here also an in-between floor is placed. On both the first and in-between floor bedrooms and bathrooms are located. On the first floor we once again see the extra possibilities of the corner house in comparison to the terraced houses.

Attic houses
The attic houses are the only four houses in the complex which are designed as apartments instead of ground bound houses. The four
dwellings are reached via the large central staircase which is brought back. The dwellings are based on a corridor with all the bedrooms and bathroom attached to it and which ends in the living room with kitchen. This corridor is extra wide to make it also usable as playing area for the children. Because of the height of the attic floor a second fire escape route is obligatory for these apartments. It has been realised with an outdoor staircase on the east and west façade. Attached to the staircase are the balconies which provide these dwellings with private outdoor space.

3.5 FAÇADE

The previously discussed floor plans will also affect the current façade at multiple locations. On the ground floor doors are added and the voids for the stairs in both the introvert house and the square house ask for a different window, especially in combination with the doors to the roof terrace of the square houses. And the living rooms on the second floor are in need of balconies to provide for some private outdoor space.

One can meet all these requirements easily; however the interventions are diverse and scattered throughout the façade. In order to keep the image of the building intact it is important to create a façade composition which is in line with the essence of the original façade. In this case an old picture if the façade shows how the now considered plain façade is somehow also very elegant. This elegance is created by the curved windows with the masonry arc on top, and also by the elegance of the window frame detailing. The façade feels like a unity because of the repetition in both the vertical and horizontal direction.

In the new design these qualities reappear. The curves of the window frames are reintroduced by the curved balconies on the second floor, and also reappear in the newly added doors on the ground floor. The replaced window frames are made of modern materials but still carry the elegant and profiled detailing of the old ones, and are even slimmer. The same “improved” window frames are used to reinstate the façade of the large staircase and create a real entrance. The unity of the façade is now created by the row of balconies in the horizontal direction and by the long windows in the vertical direction.

The confrontation between the needs of the spaces inside the building and the appearance of the façade on the outside can be considered as an influential element. Compromises will have to be made on both sides to create a qualitative solution. See also the paragraph on Tension between demands and aesthetics in the Characteristics part.
fig. 45: Floor plan 1:500 of the attic houses

fig. 46: South facade 1:500

fig. 47: Facade fragment 1:100
3.6 DETAILING

The proposed façade changes have been partly worked out in a 1:20 façade fragment and a few 1:5 details. The façade fragment is located on the south façade of one of the introvert houses with a canal house and attic house on top of it.

One of the main detailing issues was the insulation. The façade is a monolithic brick wall so the only possibilities are to insulate either on the outside or on the inside. Since exterior insulation will harm the valuable facades inside insulation is the only option. Insulating the roof on the inside creates the risk of losing the sight of the roof trusses. But because the trusses are placed at a small offset from the roof panelling insulation can be placed in-between. The purlins however are directly connected to the roof panels and thus for a thermal bridge. They are packed in insulation to solve this and are thus now out of sight. Furthermore the existing windows remaining will have to be insulated. Unfortunately the frames are not thick enough to place double glazing so as an alternative a second layer of glass is placed at the inside of the window creating a double layer of windows. This layer also provides insulation. Also the framing of the windows will disappear under the insulation layer. Most of the framing was not original anymore, but is gives a monumental feeling to the building interior. The framing is restored on top of the insulation layer. The original windows will be equipped with a profiled frame while the new ones will get a sleek new frame. And finally the ground floor is insulated at the bottom to prevent the cold to come up.

Next to the insulation ventilation is an important issue. The current
fig. 50: The 1:20 facade fragment, now rescaled to fit the page
windows are not equipped with a vent and the only ventilation option is opening the window itself. This is not acceptable for modern housing purposes so a different solution will have to be found. But whereas normally one would simply put a rectangular vent on top of the window frame, in the case of a curved frame this is not possible. To overcome this issue an innovative design was made using a newly introduced keystone as a smart ventilation opening invisible on the outside. On the interior the vent is integrated in the new framing.

Because of the orientation of the façade sunscreens are necessary to prevent the rooms from overheating in summer. These sunscreens are placed on the inside to keep the exterior appearance intact. The sunscreens have been integrated into the design of the new interior framing.

As already mentioned the new window frames and balcony are based on the existing elements of the façade. The profiling of the original window frames comes back in the profiled strips on the new aluminium window frames. And also the colour of the window frames is similar both the new and the old ones are white.

The curved shape of the balcony is derived from the curved shape of the windows. The balcony is designed to stay in the elegant feeling of the façade. It has a thicker edge of C-beams which is the load bearing part; in-between are slim balusters for the elegant touch. The balcony is painted in a dark grey colour which matches the dark colours of the brickwork. The balcony is attached to the existing façade in an almost invisible manner using chemical anchors to connect the C-beams to the masonry by doing so on different heights the moment is better transferred into the façade. The dark grey of the C-beams comes back in the structural connection and support in the long window of the introvert house.
4.1 VALUE ASSESSMENT

The Klinisch ziekenhuis is an example of the at the time innovative trend of pavilion hospitals design. This resonates in the large hospital “halls” and the lack of corridors. Also it results in a façade design with all equally decorated facades. There is no clear front façade only a small increase of decoration shows the main entrances. In this pavilion lay-out the two healthcare wings were connected by a wing dedicated to healthcare education. The Binnengasthuis was one of the first hospitals to combine education and healthcare, and the combination of them in a single building is extra special. The Klinisch ziekenhuis has a certain historical and scientific value as a step in the development of the hospital typology but also as an early example of the combination of healthcare and education, an academic hospital avant-la-lettre. The special lecture hall at the centre of the educational wing is a symbol for this connection between education and healthcare and is thus of high historic value. Because of this it is important to keep the lecture hall publicly accessible. And for this reason it will not be transformed to housing but can be used for a more public function.

Some of the recent interventions by the university have strongly compromised the visibility of the values and features of the buildings. The atrium building has compromised the pavilion lay-out of the building. And the addition of long corridors in the centre of the hospital “halls” does not do justice to the innovative (at that time) spacious lay-out of the wards. All these additions will be removed to be able to show the building values and features again. And it is important that the new designs also draw the attention to these values or even enhance them.

4.2 DWELLING CONFIGURATION

The spacious wings without any separating walls potentially give a lot of opportunities for transformation. However a single ward is already 180m² which is almost twice the size of the program for a single dwelling. Splitting them in at least two is thus unavoidable. But this can be done in many ways. First of all they can be split in the length creating two shallow apartments. In this case the historic access structure with the cores can be used to access all dwellings. But these shallow apartments would be less than 4m deep, which is impractical in many ways. So finding different ways to split the room is necessary.

This need to split is an interesting contrast to the need to combine several rooms in both the Vrouwenverband and the KIT. Apparently the size of the original rooms in relation to the size of the program has an influence on the necessary interventions. See also the paragraph on Size of the rooms in the Characteristics part.
Two main options have been developed for this. First of all it is possible to add new vertical access cores halfway each wing. From here the two halves can be accessed. These cores could also be more extreme, and be actual cuts in the building, creating the possibility of combining the vertical core with loggias. In both options valuable area in the wings is lost to circulation leading to dwellings of less than 90m². The second option does not have this disadvantage. By creating a new access core on the south and using the existing one on the north side of the building all dwellings can be accessed without losing space in the wings. Simultaneously the new access core on the south closes of the court for the public, creating a common internal garden. In this case the dwellings are all at least 100m².

Vertically oriented dwellings are also possible. The iron beam floor is not as flexible as the wooden floor of the Vrouwenverband but is still flexible enough to create vertical connections between the beams. The dwellings will be narrow, and only have a single window on each façade on each level. But still they are at least 128 m², because of the amount of existing floors. This is big enough for the program, but actually can be considered too big. The extra square meters will also mean a higher price which is unaffordable for the families. The solution with the addition of a access core on the south is the most space efficient and also the least impacting on the original structure and is thus worked out further.

### 4.3 PRIVATE OUTDOOR SPACES

As already mentioned in the previous paragraph one of the dwelling configuration concepts had possibility of creating loggias as private outdoor spaces. Next to this it is also a possibility to add balconies to the existing façade. Although it is important to keep in mind that at least a part of the facades should remain in the original state to make sure this image is preserved. And similar to the Vrouwenverband here also the possibility of roof terraces is present. And finally the dwellings on the ground floor have the possibility of creating small private gardens in the courtyard. Next to these private gardens a communal garden can be realised in the courtyard. The loggia option is not valid anymore since a different dwelling configuration concept is chosen. However the other three are all continued on in the final design.

### 4.4 FLOORPLANS

In the dwelling plan it is important to make sure that the spaciousness of the original wards will remain visible in the apartments, and the current poky feeling of the spaces has to be avoided. To realise this part of the spaces is concentrated in a single block like element. The element contains the kitchen, bathroom, toilet and storage. On top of the block a study or additional bedroom is created. Although because of the limited floor height of 4,7 m this room is not officially residential space. The block is lower than the total floor height and thus does not touch the ceiling. By doing so the special characteristic of the free spanning
fig. 58: Dwelling configuration concepts based on splitting the wings in two and adding new access routes

fig. 59: Dwelling configuration concept based on all vertical housing

fig. 60: Floor plans 1:1000 of the Souterrain, Bel Etage (First floor is the same) and attic

fig. 61: Floor plans 1:200 of a single unit. Showing the box on floor level and on the in-between floor height.
floors is shown, the block makes clear that is is not here to provide additional support to the floor. Next to the room on top of the block two traditional bedrooms are created either by splitting a single bay of the ward in two rooms or by using the rooms available at the service core. Splitting precisely into two is however to always possible. In the case of the utmost North West apartment the three windows in the end wall prevent an equal split.

To create a division between corridor and the living area ad glass wall connects the box on two places to the façade and also closes the gap between box and ceiling.

In the case of the attic and souterrain apartments the floor height is not sufficient to create the entire block. So here variants of the block are integrated in the design. In the attic the block also contains the kitchen, bathroom, toilet and storage; it just does not have the second level. In the souterrain the floors are not free spanning so a supporting wall is present in the centre of the space. On one side of the wall the bedrooms and bathroom are located. The other side is used by the kitchen and living room. The block actually wraps around part of this supporting wall and encloses the kitchen on one side and build in storage at the other side. In the souterrain only 4 dwellings are realised compared to the eight on the floors above. This leaves space for bicycle storage boxes for each apartment.

The private outdoor spaces have been realised in three different ways. On the souterrain level the apartments will have a small private garden in the courtyard. On the first and second floor the dwellings will be equipped with balconies. And the attic houses will have the roof terraces.

The new connection element which provides access to the south dwellings is placed on bay to the back from the original façade. By doing so the façade shows its subordinate attitude towards the existing. Also it gives passers by a clue of what the facades on the inside of the court look like because the first bay is visible to them. The corridor is placed exactly between the first and second window. In this way no window has to be sacrificed as front door. Since each dwelling has only six windows each of them is essential. Secondly if the intervention were to be reversed it is easier to restore a piece of masonry than remake an entire window.

This influence of the amount and placement of the windows on the possibility to split large rooms is one of the influential characteristics. In this case it is still possible to split the room, albeit not equally, in the case of a single window any split is ruled out. See also the paragraph on Façade openings in the Characteristics part.

fig. 62: Close up of the splitting issue in the North West corner (1:200)

fig. 63: Façade openings as influential characteristic

fig. 64: Section 1:200
4.5 FAÇADE

In this case there are two main additions to the façade. First of all the new addition which provides access to the south side dwellings and secondly the addition of the balconies. In both cases new and old coexist parallel to each other. The new addition needs to be fitting, but does certainly not have to be invisible.

A single language has been developed for both elements. The language is based on the façade characteristics of the building but is clearly a modern interpretation of it. And it also clearly shows the difference in function between the addition and the existing. Were the function of the existing is shelter, which is in line with the closed character, the function of the new element is purely access. Shelter is not necessary and thus a very closed design to resemble the existing would be illogic. The new elements are designed as light and see through, but still mark a clear border between the public area at the street side and the common area at the court side.

The new connecting part consists of a steel framework with precast concrete floor elements for the access routes. Connected to the steel frame is a denser framework of thin steel balusters. On this frame a pattern of small wooden slats is placed. This pattern is based on the original façade. The basic pattern is based on the cross bond of the existing brickwork. The natural stone elements reoccur as thick wooden strips recreating the so characteristic horizontal façade lines. Similar to the existing façade this façade also has open and closed parts in the pattern, resembling the windows. At the very top of the façade the pattern changes to give the impression of a cornice. The entrance in the centre of the façade protrudes from the façade and is also higher. By doing so the entrance is
A similar method of emphasis is used in the existing building. The access cores protrude from the wings and are higher. The balconies are designed with a fence in a similar style as the façade. The pattern returns, but now the balusters are only 1,2m high. In the placement of the balconies the earlier tension between floorplan and façade aesthetics was present again. The balconies and roof terraces of two adjoining dwellings are always placed in the two adjoining bays in the centre of the wing. By concentrating the interventions in these bays the repetition of the bays stayed intact and the original design of the bays remains visible.

When placing the balconies on these locations a new issue arose. The decorative arches above the windows end above the level of the next floor. Placing the balconies on floor level would result in a cut-off of the top of the arch. These arches are one of the characteristic façade elements of the building and really make the façade, cutting them off is not an option. By placing the balcony on the level of the windowsill both the arches as the window can be maintained.

In both the design of the new additions as the placement of the balconies the influence of characteristic façade elements is unmistakable. See also the paragraph on Characteristic façade elements in the Characteristics part.
4.6 DETAILING

The new additions have been worked out in a 1:20 fragment and a few 1:5 details. The 1:20 fragment is located on the south west corner of the court. Here the existing building and new addition meet. In this case the insulating of the current structure is much easier and has less impact because of the presence of a cavity. This cavity can be filled with insulating material, thus creating an insulated wall without the need to add insulation material on the inside. The roof obviously does not have a cavity and is thus insulated at the inside. Because of the space between roof truss and roof paneling it is possible to insulate while still keeping the trusses visible. The purlins however are directly connected to the paneling and would form a large thermal bridge. Because of this the purlins are covered in the insulation. The ease in insulating which is present in the facades is also present in the detailing of the window frames. The current window frames are thick enough to accommodate common double glazing. By replacing all the glazing for double glazing and insulating the cavity wall most of the insulation problems are solved. The only difficulty is the souterrain floor. This is a vaulted brickwork structure and cannot be insulated from the bottom the only insulation option is putting an insulation layer between the current floor and the sand cement screed floor.

With regards to ventilation these square windows do not have the shape issue. However there probably is a steel lintel which will have to be replaced in case on the installment of a vent. But in this case the original detailing of the building also provided another solution for both ventilation and heating and cooling. Right under the current windows small recesses

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**fig. 70:** Detail 1:5(now 1:10) of the existing window frame, showing the insulation measures; cavity fill and double glazing.

**fig. 71:** Detail 1:5(now 1:20) of the balcony. Both the connection of the balcony and the climarad system connected to the historic ventilation openings.
in the masonry are visible. Originally these were ventilation openings for the cavity. Nowadays they are closed but by reopening them and connecting them to a climarad system on the inside both ventilation and heating can be provided.

The structure of the new balconies consists of a solid framework of C-beams connected to the façade on multiple heights to create maximal moment transferral. The balusters are placed in front of the steel structure. And a concrete balcony floor is placed on top of the structure. This concrete is necessary to make sure the balcony is leak proof, and prevent that a spillage on a second floor balcony will not lead to a wet situation on the first floor balcony below it. To level the balcony floor with the window sill a wooden deck is added on top of the concrete floor.

The differences in both insulation and ventilation possibilities of both the Vrouwenverband and the Klinisch ziekenhuis shows the influence of original detailing. See also the paragraph on Detailing in the Characteristics part.

fig. 72: Detailing as influential characteristic

fig. 73: Section detail 1:5(now 1:10) of the “façade” of the new addition.
fig. 74: The 1:20 facade fragment, now rescaled to fit the page
CHARACTERISTICS
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INTRODUCTION

In the theory and design parts a total of 12 influential characteristics have been recognised. Each of them is only mentioned once in the complete story of the design, to prevent endless repetitions. However they are visible on much more places than the single spot in the design were it was first mentioned. To show this and also learn a little bit more about the influence of the specific characteristic they will be discussed separately in this part of the report. And will be illustrated by multiple examples.
1 CHARACTERISTICS

1.1 CONTEXT AND SURROUNDINGS

In the case of the Vrouwenverband the context a big influence on the eventual floor plans of the different dwelling types. The diversity of the surrounding area created the need for very diverse dwelling types and floor plans. The view on the canals from the dwellings located on North side was a reason to locate their living rooms on the first and second floor to optimally enjoy the unique view. While the view on a blind wall at the south west corner of the building was an incentive to design an introvert house.

In the Klinisch ziekenhuis a large part of the context of the dwellings is actually formed by the inner court. This court is the main focus point of all the dwellings. Because this court is part of the design assignment it is possible to create a qualitative court. Making it also a pleasant view from the dwelling perspective.

1.2 FAÇADE SURFACE/FLOOR SURFACE

The amount of façade surface in relation to the floor surface behind it is influential on the possibilities to create residential area’s (rooms). This is mainly due to daylight penetration issues. Especially dwellings which are relatively deep +- 7m and have only one façade have a lot of dark spaces at the back of the house which are not useable as living areas. Also the actual amount of façade openings in the façade can determine the maximal possible amount of rooms connected to this façade. With only one window one can never create two rooms on this same façade on the same floor.

This is very clear when comparing the corner and terraced houses of the same type in the Vrouwenverband. The second façade of the corner dwellings gives the possibility to create a second bedroom, whereas the terraced, single side oriented dwellings can only be given a single room. Creating more rooms is practically impossible because they also only have one window left.

In the Klinisch ziekenhuis all the dwellings are at least two sided oriented. But still face this limitation of the amount of façade openings in relation to the floor surface. With only 6 windows the creation of more than 6 rooms is impossible. And considering that the living room and kitchen already need multiple windows there are not much left. The shortage in windows was also the reason to use the window of the hallway also as window for the room on top of the block.

1.3 SIZE OF THE ROOMS

The size of the rooms determines the need to either connect several rooms or split them up. In the case of both the KIT and the Vrouwenverband the average room size is lower than the size of the program. And in both designs we see the need to connect several rooms to create a right size dwelling. This connection can be an issue when one needs to break down supporting walls, but in the case of the KIT the issue was also a difference in floor level of some of the rooms. In the Klinisch ziekenhuis there was the need to split the hospital wards
since they were practically twice the size of the proposed program. This splitting can lead to the need for new access routes because now the one dwelling will block the access to the other one. But besides these very practical issues the difference in room size also lead to a difference in spaciousness of the designs. In the case of the Vrouwenverband this need to divide in small rooms is also visible in the design while dwellings with the same amount of rooms and space in the Klinisch ziekenhuis feel much more airy and spacious. So poky buildings seem to lead to design solutions which cannot shake off this poky feel, while spacious buildings seem to keep the spacious feeling even though there is not much more space left than in the poky dwellings.

1.4 TENSION BETWEEN DEMANDS AND AESTHETICS

When transforming the existing building changes in the functions on the inside might also demand changes in the façade, such as balconies. But these changes must always be in accordance with the pursued façade image. These two perspectives on the same intervention can cause a certain tension. This tension is visible in both designs. In the Vrouwenverband it was caused by the need for balconies and new types of windows and doors. From the perspective of the internal function the balconies had to be a reasonable size, to make them also functional. And the existing windows had to be replaced by new windows of two stories high. The placement of these windows was different on the left and right of the entrance and the rhythm was not regular. These interventions led to a very fragmented façade design. While from the façade perspective it was important to recreate the elegant and plain atmosphere of the historic façade. In a compromise between the two the balconies were reduced in size and placed in each bay to create a repeating image. The shape of the balconies changed from square to curved to keep the elegant image. The longer windows remain, because they are indispensable for the dwellings, but are placed in a regular rhythm and symmetrical on the both sides of the entrance.

In the Klinisch ziekenhuis the tension raised when placing the balconies. Preferably the balconies are always located adjacent to the living room. However in the case of the south and north east corner dwellings this would mean that the balconies could not be placed adjacent to the inner court. While from an aesthetics perspective it is preferred to concentrate the interventions on the inner court to preserve the exterior image of the building. And furthermore it would be preferable to concentrate the interventions in a small group of bays. In this case the aesthetics were dominant in the decision and the balconies were concentrated on 4 spots on the inner court. For the south and northeast dwellings this means that the balconies are now connected to a bedroom instead of the living room.
1.5 FAÇADE OPENINGS

The amount and placement of the windows in the existing rooms influences the possibilities of transformation for this room. A space with a single window cannot be split into two rooms, for one of them would get no daylight and fresh air. A space with for example three windows can never be used for more than three rooms. This is also visible in the designs for both buildings.

In the Vrouwenverband it is visible in the canal houses. Were the dwellings in the central part of the building have a single window and it is for example impossible to create two smaller child bedrooms. While in the corner dwellings two windows are present and it is possible to create two bedrooms on a single floor.

In the Klinisch ziekenhuis a façade with three windows prevented an equal split into two bedrooms.

1.6 FLOOR HEIGHT

According to the Dutch building legislation the floor height of residential rooms is 2.6 m. To be able to split the height in two residential rooms the it will have to be at least 2x2,6m + “the thickness of the new floor” high. When creating utility rooms, such as bathrooms, the acceptable height is 2,3m so the absolute minimal height in which an in-between floor is possible is 2x2,3m + “the thickness of the new floor”.

This is a reoccurring issue in all three buildings. In the KIT the floor height was only between 4,4m and 3m. In this case it is not possible to create any of the above described in-between floors. In the Vrouwenverband the first floor is 5,1 m high so a residential room and a utility room can be placed above each other and 20cm remains for the thickness of the floor. But the other floors are about 4,7/4,6 m high so it is not possible to superimpose two rooms. Even utility rooms are difficult since it would leave less than 10cm for the floor thickness. In some of the designs this is resolved by placing a storage room and a bathroom on top of each other. There is no requirement for the height of indoor storage so it can be lower than 2.3 m.

In the Klinisch ziekenhuis the Bel Etage and first floor are both 4.7 m high. In this case the in-between floor is only realised in the block. Here the utility rooms are placed underneath so still about 2.2 m of free height remains above it. Obviously the room on top of the block will not officially be counted as a room because of this limited floor height. However this does not mean that the space is not useful for the inhabitants.

1.7 VALUE OF BUILDING (PARTS)

Sometimes an entire building or parts of a building are so valuable for society or for science that transforming them would detract from this value. In the case of the KIT this lead to the conclusion that the building is such an amazing and unique piece of art and architecture that a transformation to dwellings would not do justice to the building. In the case of the Klinisch ziekenhuis this applied to the central
wing and in particular the lecture room. It is of such a high value that it should remain open to public and is thus not transformed into housing.

1.8 CHARACTERISTIC FAÇADE ELEMENTS
The characteristic façade elements influence the design in two ways. First of all the conservation of important façade elements can lead to changes in the proposed interventions. Which was the case with the balconies and arches of the Klinisch ziekenhuis. On the other hand the façade elements influence the design of the interventions. In the Klinisch ziekenhuis they inspired the pattern and size of the new addition. In the Vrouwenverband the influential characteristics were the brick arches, which return in the curved balconies and in the newly added windows.

1.9 MONUMENTALITY OF THE FAÇADE
A monumental façade is less likely to be altered by new intervention than a plain façade. The monumentality makes the façade more special and creates the need to conserve this image. In the Vrouwenverband this lead to a design which minimized the need for interventions on the north façade and concentrated the larger transformations on the plain south façade.

1.10 WINDOW SHAPE
The shape of the window influences the transformation possibilities. Especially in the case of the need to add ventilation openings on top of the window. This was the case in the Vrouwenverband were the curved top of the window made it impossible to add a conventional ventilation opening. This does not mean that it is not possible to add ventilation openings, it just need more design thought and will probably not be a common factory made solution. In the Vrouwenverband the solution was found in the design of a ventilation keystone, which went along with the curved shape of the window.

1.11 DETAILING
The existing detailing of the building can greatly influence the design, mainly the insulation possibilities are influenced by it. The difference in detailing on multiple points leads to very different insulation possibilities. In the Klinisch ziekenhuis a cavity was present, making it possible to insulate the façade without adding thickness to the walls. Also the detailing of the window frames allowed replacement of the glazing for double glazing. And finally the detailing of the roof structure had the opportunity of insulating without losing sight on the roof trusses. So due to the detailing insulating the Klinisch ziekenhuis was of relatively low impact on both the building interior and exterior.

While in the Vrouwenverband the detailing lead to very different insulation methods. The monolithic brick wall could only be insulated by adding insulation material on the interior. Due to this space is lost.
in the dwellings. Additionally the window detailing did not allow for the replacement of the glazing for double glazing. So a different solution using an additional window placed behind the original window to create the necessary insulation. But the buildings do not differ on all detail points. The similar detailing of the roof structure here also gave the opportunity of insulating without losing sight of the roof trusses.

1.12 STRUCTURE
In the theoretical research the influence of the structure was determined as follows; the more integration between structural elements and separating elements the less possibilities to change it. In the designs of the Vrouwenverband and Klinisch ziekenhuis this hypothesis is put to the test. The vertical dwellings of the Vrouwenverband formed the test case for the statement that wooden floor systems provide the most, or maybe even infinite vertical freedom. When looking at the design one can see that the freedom is certainly not infinite. It is limited by:
• Total height of the vertical connection
• The floor space on each level
• The height difference between the levels
• Fire safety regulations
And additionally the creation of vertically oriented ground bound houses also leads to a loss of usable façade. Front doors are located on the façade instead of the darker interior in the case of a corridor system. The front door and hallway behind it now take a place at the façade which could also have been used for a room. And in the case of the Vrouwenverband both façade surface and windows were already in short supply in some of the dwellings.
Finally the change of the main direction of the spaces from horizontal to vertical also leads to a change in repetition of the facade elements from vertically to horizontally.
The apartments of the Klinisch ziekenhuis formed a testcase for the presumed horizontal freedom of spaces with bearing facades. This freedom to place new walls wherever you want is certainly present but limited by:
• The amount of windows
• The depth of the space
CONCLUSION
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INTRODUCTION

In this final part of the report the research is finished with a conclusion. Furthermore a list of recommendations is presented. These recommendations are possibilities to deepen or broaden this research in multiple directions, and to further strengthen the conclusions.
1 CONCLUSION

1.1 INFLUENTIAL CHARACTERISTICS

In the previous part the results of the research were discussed in the form of the following twelve influential characteristics.

1. Context and surroundings
2. Façade surface/floor surface
3. Size of the rooms
4. Tension between demands and aesthetics
5. Façade openings
6. Floor height
7. Value of building(parts)
8. Characteristic façade elements
9. Monumentality of the façade
10. Window shape
11. Detailing
12. Structure

The collection of characteristics applies to a very broad field design elements, from urban, in the case of context, to detail, in the case of detailing. Some characteristics are more related to design choices, such as the tension between demands and aesthetics, while others are more related to technology, like the window shape. Finally there is also a group of characteristics which are mostly concerned with the value of the building is different ways.

1.2 INTERVENTION STRATEGY/POSITION

When comparing the type of interventions in both designs it is interesting to see that both designs use very different intervention strategies. In the Vrouwenverband the interventions and existing building parts are interwoven with each other. While in the case of the Klinisch ziekenhuis they merely exist next to each other, but almost never "touch". Has this difference in strategy occurred because of their difference in characteristics or is it merely the merit of the designer? As always it is a compromise, I believe. On the one hand the starting points and program force the design in a certain way. The choice for vertical dwellings in the Vrouwenverband versus the apartments in the Klinisch ziekenhuis already causes a difference in interventions necessary to comply with these starting points. On the other hand the spaciousness and detailing of the Klinisch ziekenhuis made it possible to minimize the influence of the transformation on the façade, while in the Vrouwenverband large interventions were indispensable due to detailing and room sizes for example.
2 CONCLUSION

This research is a first step to explore this new field of research in building transformation. This research has raised some new questions, and also some have remained unanswered. The question unanswered is the influence of the access system on the design. Because in the design of the Vrouwenverband the original access system was completely changed it is not possible to see whether it would influence the design. It is recommended to do a second design study keeping the access routes intact.

A new question which rose in the final part of the research has already been mentioned in the previous chapter. It is still not clear if the combination of characteristics in a specific building also influences the very base of the design, the intervention strategy. It is recommended to extend the design research in a broad way. By analysing design solutions of different architects in and for different programs (all on late 19th early 20th century institutional buildings) one can get a better idea of the influence of either building of architect.

It would also be interesting to broaden the research in to different building types. Are these characteristics also valid for modern monuments for example?

And finally for the usability of the research in the design field I feel it would be a great contribution if an inventory is made of examples for each characteristic and how different architects have dealt with them in their design proposals.
3 REFLECTION

In this chapter I will reflect upon the process, products and planning of my entire graduation process. This will be done in multiple steps. First of all I will introduce my chosen subject and position it in relation to the studio theme. Next the chosen method for the research will be explained and related to the studio line of methodology. Finally I will reflect upon how well both the research and the proposed method have worked out, both in products as well as planning and also the final results.

3.1 CHOSEN SUBJECT

At the beginning of the studio all students chose a housing related theme to start their research with and were all assigned the same design location; the Binnengasthuis Area. Every student was to research housing in historic inner cities, in particular focussed on their chosen theme and the given location, Amsterdam. In my case the chosen subject was “The Type: System” which I interpreted as types of structural systems (see Figure 1). Based on this theme I started my literature research into the housing adaptation / transformation possibilities of structural systems. For this research I formulated the following research question: “What structural system characteristics of existing buildings influence the single family housing typology retrofitting possibilities?”.

However a focus solely on structure for the entire project did not really do justice to my fascination of why buildings are transformed in a certain way. So I decided to broaden my research to all the building characteristics which influence the transformation of existing buildings into housing. This lead to the following research question: “Which existing building characteristics influence the housing retrofitting possibilities?”. The structural system is incorporated in this research as one of the influential building characteristics. In this research the focus would be on late 19th and early 20th century institutional buildings, located in the Amsterdam city centre. By doing so the Binnengasthuis became one of the main research locations, because if the high concentration of late 19th / early 20th century institutional buildings right in the middle of the Amsterdam city centre. And thus relating the project to the studio location.

There is a second reason to choose for this specific group of buildings. In Amsterdam quite a reasonable group of this type of building is present in the city centre (see Figure 2). And one or more of these buildings are probably to be found in the historic centre of any medium to large city. This means that my research will also be applicable and valuable in cities other than Amsterdam. And in the case of Amsterdam also some of these buildings have lost their “institutional” function recently or are about to. For example the Paleis van Justitie and the Prinsengracht Ziekenhuis. But also on the Binnengasthuis changes in use will occur in the near future since the UvA has decided to more than halve their m²’s here¹.

¹ Demmers, 10-10-2014
fig. 2: Late 19th-early 20th century institutional buildings in Amsterdam
REFLECTION

Since the theme of the studio is Housing and Heritage the research also contains a housing specific element. In the scope I have stated to only focus on the transformation of these buildings to family housing. The choice for family housing was based on multiple researches which showed the wish of families to either stay in or return to the inner city.

3.2 CHOSEN METHOD

The graduation projects of Heritage and Architecture generally consider of three main parts: literature research, site analysis and design. As already mentioned above each student chose a theme to easily and quickly get started with the research. Your research question was supposed to be in the direction of this theme. And also in the analysis each student focussed on his or her specific theme. Eventually the design phase would be a continuation of this research direction.

In my case I stayed with my theme in both the literature research and the analysis phases but instead of deepening this theme in my design I have broadened it. The original theme however is still part of the design phase but in a smaller amount (see Figure 3). In this sense I have stepped away slightly from the methodological framework of the studio. I feel though that the broadening of the research has led to a far more interesting and relevant project. Also it made the design really part of the research which results into one cohesive project.

To research the influential building characteristics in the design phase asked for a specific research by design methodology. I chose to make a design for the same target group, families, in buildings with very different characteristics. By comparing the designs and the conflicts and problems which arose in the design process of both of them I would be able to find the influential building characteristics (see Figure 4). When I made my selection however I did not know which characteristics would be important so I tried to find two buildings which were different on as many characteristics as possible. But both of them still have a lot of similarities unfortunately. This is mainly related to the fact that they are both located on the binnengasthuis area and thus have both been built as hospital buildings and are now both in use by the UvA. I tried to overcome this by including a third building outside the Binnengasthuis area, but in the Amsterdam city centre which was also late 19th early 20th century and again had different characteristics compared to the two buildings of the Binnengasthuis (see Figure 5). After the conceptual design phase however I chose to leave this building out of the investigation because I felt it would not be possible to make a satisfactory design for three buildings in the remaining time.

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2 Gemeente Amsterdam, 2013; Karsten, Reijndorp, & van der Zwaard, 2006
**Part 1 Theory**
Focus on **structure** as influential characteristic

**Part 2 Design**
Compare design solutions for buildings with very different characteristics
&
Put theory conclusions to the test

### Influential building characteristics

**fig. 3:** Scheme showing how both the theoretical research and the design research contribute to the final results

**Late 19\textsuperscript{th} early 20\textsuperscript{th} century institutional buildings in Amsterdam** + **Analysis & Value Assessment** + **Family inner city housing requirements** = **Design possibilities/options/concepts**

1.
2.
3.

Feedback, why do the design possibilities differ?

**Theoretical research**

Possible influential building characteristics:
- Structure
- Size
- Facade
- Monumental value
- Location

**fig. 4:** The research by design method, using multiple buildings with different characteristics
In this graduation project the design is very clearly part of the research. Actually the main elements of the conclusions of the research originate in the design phase rather than the literature research (see Figure 6). But designing for research instead of for a specific aesthetic or design goal is difficult. The direction of the research gives no clue to which design direction should be chosen. This led to a research result which is not bound to any design direction and thus easily for others to use, which I consider as a quality of the research. But for my own process it made it more difficult. It took me a long time to find the design direction which lies closest to my heart. And even then the design process itself was not easy. A recurring issue was when to let building characteristics influence or decide your design and when to add your own touch. Because I was searching for influential characteristics, I tended to let the building decide for me. However, this could also lead to conflicts between for example the interventions needed based on what fits best with the interior of the building and those of the façade. It was up to me as designer to reconcile these conflicts.
the new entrance and access element at the front of the court. This results also in two end products with a different focus. In the Vrouwenverband the focus was on smart and effective floor plans. In the Klinisch Ziekenhuis the focus was much more on the façade. Also the choice to make a design for two buildings leads to a lower degree of elaboration for each building. And considering the time it took me to work on these two buildings I am very glad that I decided to leave the third building out. Because I feel it would have led to an insufficient degree of elaboration of all three of the buildings just because of a lack of time.

The lower degree of elaboration per building is something that I found hard to accept. It is in my nature to work things to “perfection”, or at least make sure that everything is right in the design. This attitude has led me to deviate from the original planning more than once. When I was not yet happy with the design in a certain phase I could get stuck in it instead of accepting it and continuing to the next phase or building. Continuing would have been much more profitable for the research, since for the research the actual design did not really matter as long as there was one.

fig. 6: Scheme showing the relation between design and theory during the process and how the results are determined.
3.4 RESULTS

When looking at the result of the research I am glad that I chose this method of two buildings. It has led to a substantial list of influential characteristics. These characteristics are all related to one or more corners of the Heritage and Architecture triangle. And each corner; Design, Technology and Cultural Value; is represented in the list by one or more characteristics. Also they range from more urban related to very detailed characteristics. For me this shows that I have been able to conduct this research on different scale levels and in different directions. And that the list is reasonably complete.

This list of characteristics could possibly be used as a sort of checklist/quick scan for a building which is to be transformed. Taking a close look at all the aspects on the list could give an indication about where conflicts will arise and measures need to be taken. However the list is not a step by step working method, it only states important points. How to deal with them is often highly personal, and completely dependent on the specific designer and assignment.
fig. 7: A selection of results showing the diversity in H&A theme and scale
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