DESIGN FLEXIBILITY WITHIN THE INDUSTRIAL BUILDING METHODS IN THE NETHERLANDS

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Abstract

The purpose of this study is to determine the most suitable Dutch industrial construction method for creating unique corner buildings. These can enhance the visual and physical appeal of common monotonous and rectangular industrial build residential blocks. By compiling a collection of active industrial builders in the Netherlands with as many different applied construction systems as possible, all options are considered. Subsequent desk research was conducted on the architectural qualities of corner buildings and how they can bring added value within their environment. Three case studies were then selected in Rotterdam Centrum and the analysis of these formed the basis for a list of criteria that the newly chosen industrial construction method must meet. The list of criteria revealed an overlapping theme of the construction methodologies; its dimensions (1D, 2D, and 3D), which is also a prominent factor within the construction methods and therefore easily led to a choice. The most suitable construction method, a combination of 1D and 2D, was further investigated on constructive limits that will be applicable during the design with the method.

KEYWORDS: *Industrial building, prefabrication, housing, corner buildings.*

I. INTRODUCTION

1.1 Problem statement

The Netherlands sets out to solve its housing crisis for a large part with industrial build houses from factories. These houses can be produced within sheltered circumstances, with no dependency on whether to keep building and are made to fit seamlessly when parts or modules are brought to the site (Ministerie van Algemene Zaken, 2022). These building advantages come however with architectural limitations (Smith et al., n.d.). The building design becomes repetitive and efficiency driven. This is of great influence on the buildings in which we must live and walk past every day. There are mainly 5 challenges to overcome for industrial building methods for housing according to Frits Palmboom, an urban planner who was assigned to study the matter by the Ministry of Internal Affairs.

Firstly, responding to the irregularities of the urban and village fabric. Within the Netherlands, this is often not rectangular, and because of the employed building methods in industrial buildings, other forms are often difficult. Second, consistency with public space. This means relation to the surroundings of the building through architecture. This is normally done through well-thought-out transitions from public to private, as well as eyes on the street from homes. This is hard to do for industrial-produced buildings because of the rigid layouts that are not easy to alter. Third, combining building flows. This means different designs accustomed to different living styles; family homes, apartments, and flex housing. Fourth, variation and 'main form'. The creation of housing in a 'main form' designed on an urban scale happens more often nowadays instead of the old method; putting all the separately designed buildings next to each other, a method visible in most of the old city centers of the Netherlands. The challenge lies in creating a unique identity for houses within a larger, comprehensively designed context. Finally, a call to overcome the above challenges by occasionally not opting for industrial construction methods but in the traditional way (Palmboom, n.d.).

This research explores what industrial building methods are used in the Netherlands to create prefabricated homes which help solve the housing crisis. The most suitable method or a combination of those will be further researched to create the overarching theme of the five challenges mentioned above by Palmboom: a unique corner building within a prefab residential block. To do so, the research question and sub-questions have been formulated in the next paragraph.

1.2 Research Questions

"Which existing industrial housing construction method is most suitable for creating corner buildings that can be designed to seamlessly integrate with existing urban spaces?"

Sub Q1. What are the primary methods employed in industrial housing construction?

Sub Q2. What architectural qualities do corner buildings possess that elevate their value within the urban landscape and which structural needs are connected to these qualities?

Sub Q3. Which building method scores best when the methods from sub-question 1 are tested against the criteria from sub-question 2?

Sub Q4: What are the specifications of the best scoring building method and which design rules apply?

1.3 Methods

This research paper is divided into five parts. The first part involves identifying Dutch industrial builders and their methods. Through desk research, a broad variety of building methods has been selected. Following this, the building methods have been categorized and labeled according to the methods applied. This part answers sub-question 1.

The second part is a study of the qualities of corner buildings that make these buildings valuable for the urban surroundings going beyond designing only for its inhabitants. This is achieved through literature reviews on corner buildings and their values, and three case studies from locations in Rotterdam. The findings from the literature study form the basis for analyzing the case studies. From existing buildings, constructive requirements can then be established based on architectural qualities.

Subsequently, the methods found in Part One are evaluated based on the criteria from Part Two. From this, the highest-scoring construction method is selected. In the last part, this construction method is further specified and the applicable limits for building a corner house using this method are investigated.

II. DUTCH INDUSTRIAL BUILDING METHODS

This part answers Sub Q1. What are the primary methods employed in industrial housing construction? A combination of builders was selected for this study. This collection was created by the supply of concept builders in the Netherlands. Additions were made on the recommendation of experts by experience and notable construction methods. On the most overarching categorization of construction methods; the dimensions 1D, 2D, or 3D, the builders were categorized first. In this way, while the research only works with construction methods used in the Netherlands, the results are not limited by the conversions resulting from market strategic choices of builders in which they decide which machines to fill their factories with. In the collection of builders, an equal distribution of dimensions in the construction methods was sought so that each method is represented in approximately equal proportions. Although the collection should be expanded, that is not possible for this research given the timeframe it has.

Looking at Appendix 1 we see all the different methods employed by the Dutch builders. They are categorized using the book PREFAB, categories varying from structure and skin options to grids and methods (Smith et al., n.d.). While at a first glance it would seem, the Dutch builders have certain preferences, there is actually a great variety in the methods. The building systems are devided in: structure, skin, services, and space. Within the first columns of this categories there is little variety, but also the options are very limited. For the structure, both solid and frame structures are used, but within the frame structure category, the methods are limited to shear wall and brace framing. The skins are exclusively nonbearing, multilayered and all possible options for opacity are given. Services are compacted selectively, or this remains unknown. The interiors (space) are either fixed or demountable. Moving on to materials, in this case only used for the construction, we see three available options almost in any given combination: wood, steel, and concrete. For methods all the possible options are employed: machining, molding, and fabrication. The products brought to the site are either made to order or engineered to order. Class, open or closed discusses whether the work together with other contractors or third parties, both open and closed systems are found. At last, the grid seems always axial while the height differs quite a lot, from 2 stories to 17 stories. This showcases a great variety in building methods and therefore a need for further research into all these building method combinations.

The next step would be to determine the design freedom these industrial building methods offer in a specific situation, the corner building. But to do so it must first be clear which architectural qualities a corner building should have. This is researched in the next chapter.

III. ADDED VALUE THROUGH ARCHITECTURE FOR THE URBAN ENVIRONMENT

Adding value through architecture for the urban environment means that the architecture transcends the architecture itself and connects in such a way to its surroundings that these are improved by it. In this research, the surroundings of the building will be a relatively dense urban fabric, for it became clear in the problem statement that a densification task awaits the Netherlands. This dense urban fabric also offers the often the non-rectangular, weird, shaped plots that need can be filled in with residential blocks s but need 'special' corners, as Palmboom describes them (Palmboom, n.d.).
A quote from the study; The Topological Relations of Corner Buildings at Street Junctions, describes clearly why; '*The concept is also simple in that it posits that the corner building has an essential role in unifying the urban fabric and ordering the internal and external topologies of the "urban theatre".'* (Herriott, 2016).
The paper however also states that very limited research is done on corner buildings. While there are extensive works about urban space, like Lynch's Image Of The City, Krier's Urban Space, Cuthbert's Designing Cities, and Marshall's Streets and Patterns in which all of the corner buildings are not mentioned (to a great extent). The paper of Herriot is therefore much referenced and mentions four architectural considerations for good corner designing:
1) Architects and clients need to engage with the limitations imposed by conventional corner building designs. There's a paradox between the meticulous attention given to small-scale craftsmanship and the lack of concern for how buildings fit together within street blocks.
2) new build areas could be conceived with conjoined facades and fully integrated corner designs, with a reference to architect Rob Kier's project: Potsdam Kirchsteighfield, which consists of large building blocks but with architecturally defined corners. But when talking about densifying an existing Scandinavian postwar neighborhood he suggests adding "material, textural and volumetric variation to what can be rather uniform and characterless areas."
3) Corners offer great possibilities for creating landmarks, making them memorable buildings so they help people orientate themselves within the city.

4) Integration of different functions. Capitalizing the four approaches a corner building often integrates more functions and makes the building accessible for more people and therefore has more relation with the urban fabric (Herriott, 2016).

In addition to this, the paper by Milena Krklješ, dives into the relationship between public spaces and built-in corner buildings of modernist architecture. She suggests that the corner buildings' design and shape should be influenced by the public spaces nearby. This should be done through:
1) Urban Integration: The corner building should contribute to the urban block, influencing the overall urban definition and geometry by considering the interrelationship between buildings and public spaces.
2) Defined Interrelationship: It should have a clearly defined relationship with various public spaces such as squares, streets, boulevards, and parks, improving the overall structure of the urban blocks and creating quality environmental micro-spaces.
3) Internal Organization Influence: The internal organization of space within the corner building influences its geometry and application of morphological elements, often shaped by vertical communications, residential units, and business offices where facades meet.
4) Morphological Elements: Effective use of balconies, galleries, terraces, sculptures, reliefs, or other elements can shape and define the corner building's interaction with adjacent public spaces.
5) Symmetry/Asymmetry: Façade symmetry is often present on buildings located at prominent corners or those facing open public spaces, with more dominant and developed features on the main facade.
6) Impact on City Image: Corner buildings' geometries and their relation to surrounding public spaces directly influence the city's image, spatial, and psychological character, reflecting social, symbolic, and cultural values within the urban context.(Krkljes et al., 2009)

With all the above criteria in mind, a collection of three buildings has been made. The search area of the case studies has been the city center of Rotterdam. The province of Zuid-Holland, in which Rotterdam lies, takes on the largest number of houses to be built to tackle the housing crisis in the Netherlands (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2022). In addition to this, Rotterdam as a building area has been a personal favorite of mine because of its vibrant architectural history and the opportunities to make positive improvements through architecture in disadvantaged or troubled neighborhoods, which has gone wrong quite a few times in Rotterdam (Arjan van Veelen, 2022).
A building period has been added as a selection criterion, all buildings were built between 1900 and 1913. This led to the analysis of the following corner buildings:
Westkruiskade 1 seen in figure 1, Van Vollenhovenstraat 62, as seen in figure 2, and Spoorsingel 1, viseble in figure 3.

Figure 1 Westkruiskade 1 (Google, 2023)

Figure 2 Van Vollenhovenstraat 62 (Authors own archive, 2023)

Figure 3 Spoorsingel 1 (GoogleMaps)

All the buildings show architectural emphasis on their corners in different ways. This among other qualities must be possible with the industrial building method that is to be chosen. To determine which constructional capabilities the industrial building method must possess to achieve the architectural freedom needed, the corner buildings have been assessed. This has been done by reviewing the blueprints of the buildings, which are visible in Appendix 2, on subjects deemed important with earlier named qualities of a building in mind. These review drawings are visible in Appendix 3. The most important qualities are the shape of the building, the free space available within the building, max free height possible, and different options for the façade. The needed structural capabilities that come with these qualities have been listed during the assessment, which are visible in the first three tables in Appendix 4.

After this, the information on the three different corner buildings was assembled into a single list of qualities, or criteria, for the new industrial building method. The type of structure and materials used is not mentioned. This is because the best-suited industrial construction method to the current architectural qualities is to be chosen, therefore there is no point in examining the structures used themselves.
This matrix, in addition to the earlier mentioned values of corner buildings, forms the answer to sub-question 2.

IV. THE OPPORTUNITIES FOR CREATING VALUE WITH THE AVAILABLE METHODS

This chapter covers sub-question 3; 'Which building method scores best when the methods from sub-question 1 are tested against the criteria from sub-question 2?'
This is done by studying the named building methods from Chapter 2 and putting their capabilities in a table that covers the same criteria as in the last table of Appendix 4.
The most important aspects of the building methods from Chapter 2 are listed in Table 1 below. The methods have been ordered by the most overarching factor in building, their dimension.
For the different industrial building methods employed in the Netherlands the books 'Manual to Multistory Timber Construction', 'Modern Concrete Construction Manual', and 'PREFAB ARCHITECTURE' have been used to learn about their capabilities and to try to fill out the table in Appendix 5.

Table 1 Collected building industrial methods in the Netherlands.

nr	Dimension	System	Material
1	1D	Brace frame	Wood/Steel
2	1D/2D	Brace frame	Wood/Steel
3	2D	Solid structure	Wood
4	2D	Solid structure	Concrete
5	2D/3D	Solid structure/ Braceframe	Wood
6	3D	Shear wall	Wood
7	3D	Solid structure	Concrete/wood

However, after this attempt, it became clear that there was a lot of repetition in the outcomes. This is mainly so in the layout and openings section. For the layouts, each floor or story is covered separately with the different shapes it should be able to be. This made for a cluttered whole. An attempt to fill it in led to having to examine all the different shapes as floor plans and circuits while the results could not be properly put on the table. Thinking the problem lay with the table itself, it was rearranged, allowing more space for the different shapes of layouts. This table is visible in Appendix 6.

This table made it clear through the repetition within itself once again, that being able to create different shapes as a layout is one of the most important signs of flexibility in architectural design according to this study. The same repetition in the table is found in the facade openings. The possibilities to create shapes and openings are related to one another.
Since being able to be free in creating shapes carries the most weight, the assessment method can be changed. This is because the dimensions differ for each industrial building method and have a great influence on the freedom to create shapes. For the next part a supporting visualization of these limitations has been made which can be found in Appendix 7.

If we assume that every shape is created at the extreme of its constructive possibilities, the shape can only grow by making a pattern with the same shape. Because some shapes do not become a large variant of themselves when they are multiplied, some construction methods cannot be used for certain shapes as being the main shape if the goal is design freedom within the shape. A circle or a shape with five corners, like the pentagon, are examples. Variants in which the supporting structure depends on walls (2D and 3D variants) can no longer be arranged freely other than the shape they create, and this limits the possibilities of design to such an extent that it can be assessed as not suitable. Therefore, the following can be said about the dimensions (1D, 2D and 3D) of the construction method:

With 1D, any shape can be created and expanded how one wants and great spans are achievable because of the columns and beams. Space within the structure is "freely divisible but of course, the columns and beams are of great influence.
With a 1D/2D combination, there are still a lot of possibilities. The columns are connected by the 2D floors and ceilings. Creating a multiple of a certain shape is only possible if a circuit of these modules creates that multiple itself. This is the case with triangles and squares, but not, for example, with pentagons. The space remains freely divisible within a multiple of shapes because, as in 1D, there are only columns to reckon with.
From 2D on, the freedom of shape deteriorates rapidly. Here the floors, ceilings, and walls are made of solid material and are also load-bearing. This leaves one free in the shapes to create, but you are bound to make the load-bearing lines in walls as well, which can quickly create undesirable spaces.
The 3D consists of complete modules connected. In this case, freedom is the least and there is no chance of freedom in form without completely reinventing the module for each project and different shape.

1D/2D seems the best scoring method because it allows the prefabrication of a structural 2D element while there is only a small sacrifice in freedom of design.
Table 1 shows Dutch industrial construction methods for 1D and 1D/2D are mainly performed in Wood and steel. This sounds logical if we consider the following aspects of building with wood in dense areas. Building with wood allows for a lightweight construction in comparison to concrete or traditional building. Cross Laminated Timber (CLT) is 450 kg/m3 while concrete is 2400kg/m3 and masonry is 1600 kg/m3 (Blok.R, 2015). In dense urban areas, it is crucial to limit noise, traffic, and other disturbances. Lightweight building (construction) means a lighter foundation and lighter or lesser transport of materials.
The next chapter further discusses the industrial building method and its material in more detail.

V. SPECIFYING THE CONSTRUCTION AND DESIGN LIMITS

This chapter answers Sub Q4: What are the specifications of the best scoring building method and which design rules apply? To answer this question the options within a 1D/2D method of wood and steel must be further researched and choices need to be made. With the requirements in mind from Appendix 4 for the building, such as a minimum of 5 stories, choices are made within the options of building with the 1D/2D method. These options involve the vertical load-bearing system, the type of flooring, and the non-structural walls of the building.
For the columns only two options are available. The performance material is glued laminated timber (glulam), and solid construction timber. Glulam is preferred because of its greater span compared to solid construction timber.

For the ceiling/floors, the options are Dowel laminated timber, box ceilings, CLT, Laminated veneer lumber slabs (LVL), and Composite timber slacks. Because they need to be rigid to function well in the brace frame construction, Dowel Laminated timber, box ceilings, and Composite timber slacks are not well suited. While LVL has good structural threats, CLT is the more consistent material in different constructional situations and therefore preferred because of the design freedom this will offer (Kaufmann et al., n.d.).

The last part to choose a construction for is the non-loadbearing walls. These will make up the facade and interior walls. A great influence on this choice is the ability to dissipate horizontal forces within a wooden construction. Because rigid joints like the spider or pillar are not enough for this construction material (Arends et al., n.d.). The relatively low demand for the total height (five stories), and the fact that Timber-frame buildings in the Netherlands can reach heights of 6 layers, there is no expected need for a concrete structure to dissipate the horizontal forces (Het Houtblad, 2021).
However, because of the relatively weak link between columns and floors and the absence of a concrete core the strongest option out of wood is preferred for the interior walls. In Figure 4 the different options are ranked and visible how CLT has the best qualities for these demands.

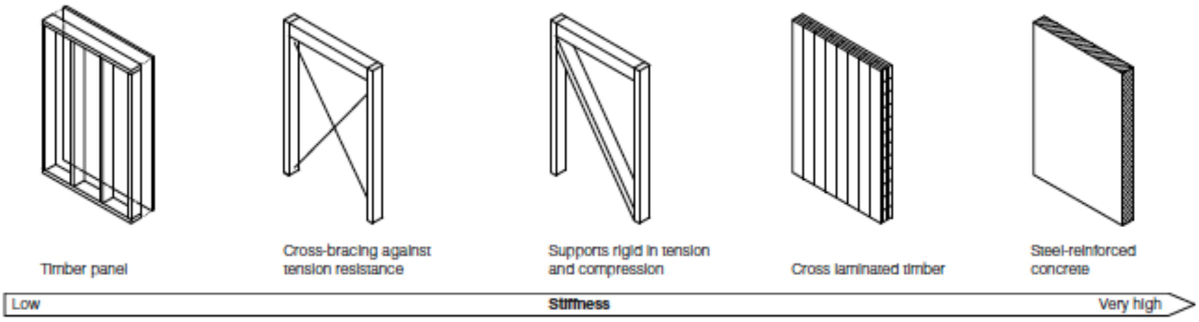

Figure 4 Stiffness of wall structures (Smith et al., n.d.)

The options for joints between both are limited, but sufficient. Rothoblaas has come up with two variations based on the principle of the famous Brock Commons Tallwood House, as seen in figure 5. First, they made the Rothoblaas Pillar, which is the same principle as used in the Brock Commons House. This variant, visible in figure 6, is very slender in design and allows a grid of 3,5 by 7 meters. Second, the company developed the Rothoblaas Spider, visable in figure 7, with structural problems in slab-to-pillar concrete constructions as inspiration. This joint solution can, because of the added range from its screws around the column, allow a larger grid of 7 by 7 meters.

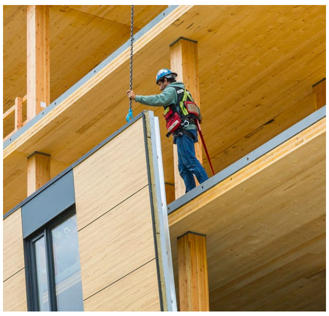

*Figure 5 Brock Commons construction (*Think Wood*, 2022)*

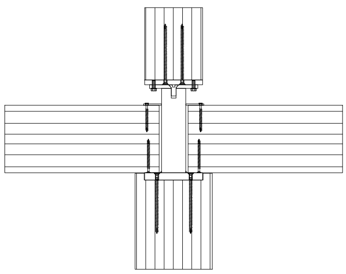

Figure 6 Rothoblaas Pillar (Rothoblaas, 2023)

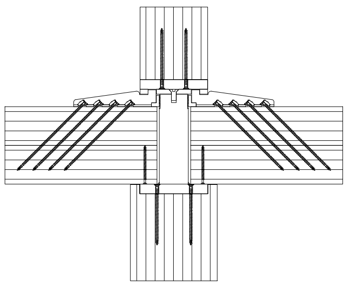

Figure 7 Rothoblaas Spider (Rothoblaas, 2023)

As with all prefabricated building methods in the Netherlands, the first limits are those of transportation. The law allows 3.5-meter-wide objects to be transported with a permanent license. The effective length of a carrier is 12 meters, objects can be stacked on this carrier until 4 meters high. This means you could

transport 10 floors of LxWxH 12x3.5x0.4m at once. Exceptions can be made when objects need to have larger dimensions. The length is then allowed to be 22 meters, but placed diagonally over a truck so it is no longer stackable. Boarder than 3.5 but slimmer than 4.5 meters are allowed, but for every load a license is needed. When loads are broader than 4.5 meters it is only allowed to carry them to the nearest harbor and continue transport by boat (RDW, 2012).
While the Glulam column structure will be very project-dependent because of efficiency the following aspects are known about it;
The grid cannot be much more apart from each other than 6 by 6 meters. The maximum height due to the load-carrying capacity of a column is 5 meters (Arends et al., n.d.). However, the biggest column available is 7,3 meters high and 266x350mm in section (APA, 2009).
For the CLT floor slabs the maximum span width is 7,7 meters. If this span width is to be reached the slab will be 300mm thick. The maximum producible length is 16 meters.

VI. CONCLUSION

This study aimed to identify an optimal Dutch industrial construction method for designing distinctive corner buildings within prefabricated residential blocks.

The research surveyed a diverse range of construction methods in the Netherlands, reflecting variations across dimensions and support structures, detailed in Appendix 1. Corner buildings play a significant role in defining urban blocks, establishing relationships with public spaces, and featuring design elements like balconies and symmetrical facades. These qualities influence the city's image and social character within its fabric. Detailed architectural criteria in Appendix 4 highlight the importance of building shape, available space, maximum height and span, and facade options. Among the methods examined, the 1D/2D approach emerged as a strong contender, offering structural depth while maintaining design flexibility. The study pinpointed key specifications within this method, favoring Glulam columns for their spanning capacity, and CLT for ceilings/floors and non-loadbearing walls due to their reliability and ability to handle horizontal forces—Rothoblaas joint solutions provided feasible grid configurations. Transportation regulations impacted component dimensions and stacking, influencing logistical considerations.

This research contributes to breaking the monotony of prefabricated construction methods in the Netherlands, providing avenues for unique and recognizable architectural links within efficient and cost-conscious construction processes.

VII. DISCUSSION

The course of the research deviated from the initial plan. The intention was to gather information about each construction method regarding design freedom by filling in a table. It was anticipated that filling in the table would index all the positive and negative aspects of the selected industrial construction methods in the Netherlands. However, due to excessive repetition in the table and a shortage of time to revise it, this goal wasn't achieved. Consequently, a quicker decision was made to choose a suitable construction method based on the 1D/2D/3D dimensions. As a result, less knowledge was acquired about other construction methods, which could have significant value. This might serve as a basis for future research, with more in-depth exploration into the design freedom of the remaining industrial construction methods.

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8.2 FIGURES

Figure 1. Westkruiskade 1; Google. (2023, March). *Westkruiskade 1*. www.google.com/maps. Retrieved December 19, 2023, from https://www.google.com/maps/@51.9209669,4.4709371,3a,75y,272.43h,94.17t/data=!3m6!1e1!3m4!1sh2B9wiFj2NCHwaozHLIRGA!2e0!7i16384!8i8192?entry=ttu

Figure 2. Vollenhovenstraat 62: Catharinus Veenema (2023, Dec.) Vollenhovenstraat 62.

Figure 3. Spoorsingel 1: Google. (2021, September). *Spoorsingel 1*. www.google.com/maps. Retrieved December 18, 2023, from https://www.google.com/maps/@51.9287735,4.466728,3a,75y,179.28h,78.91t/data=!3m7!1e1!3m5!1sMbdK3RF08i6zggm-3cc5XQ!2e0!5s20210901T000000!7i16384!8i8192?entry=ttu

Figure 4. Stiffnes of wallstructure: Smith, R. E., Timberlake, J., & Smith, F. (n.d.). PREFAB ARCHITECTURE. www.itac.utah.edu

Figure 5. Brock Commons construction: *Think Wood* (By Acton Ostry Architects). (2022, September 16). https://www.thinkwood.com/construction-projects/brock-commons-tallwood-house

Figure 6. Rothoblaas Pillar: Rothoblaas. (2023a). *Rothoblaas Pillar*. www.rothoblaas.com. https://www.rothoblaas.com/products/fastening/clt-floor-column-connections/pillar

Figure 7. Rothoblaas Spider: Rothoblaas. (2023b). *Rothoblaas Spider*. www.Rothoblaas.com. https://www.rothoblaas.com/products/fastening/clt-floor-column-connections/spider

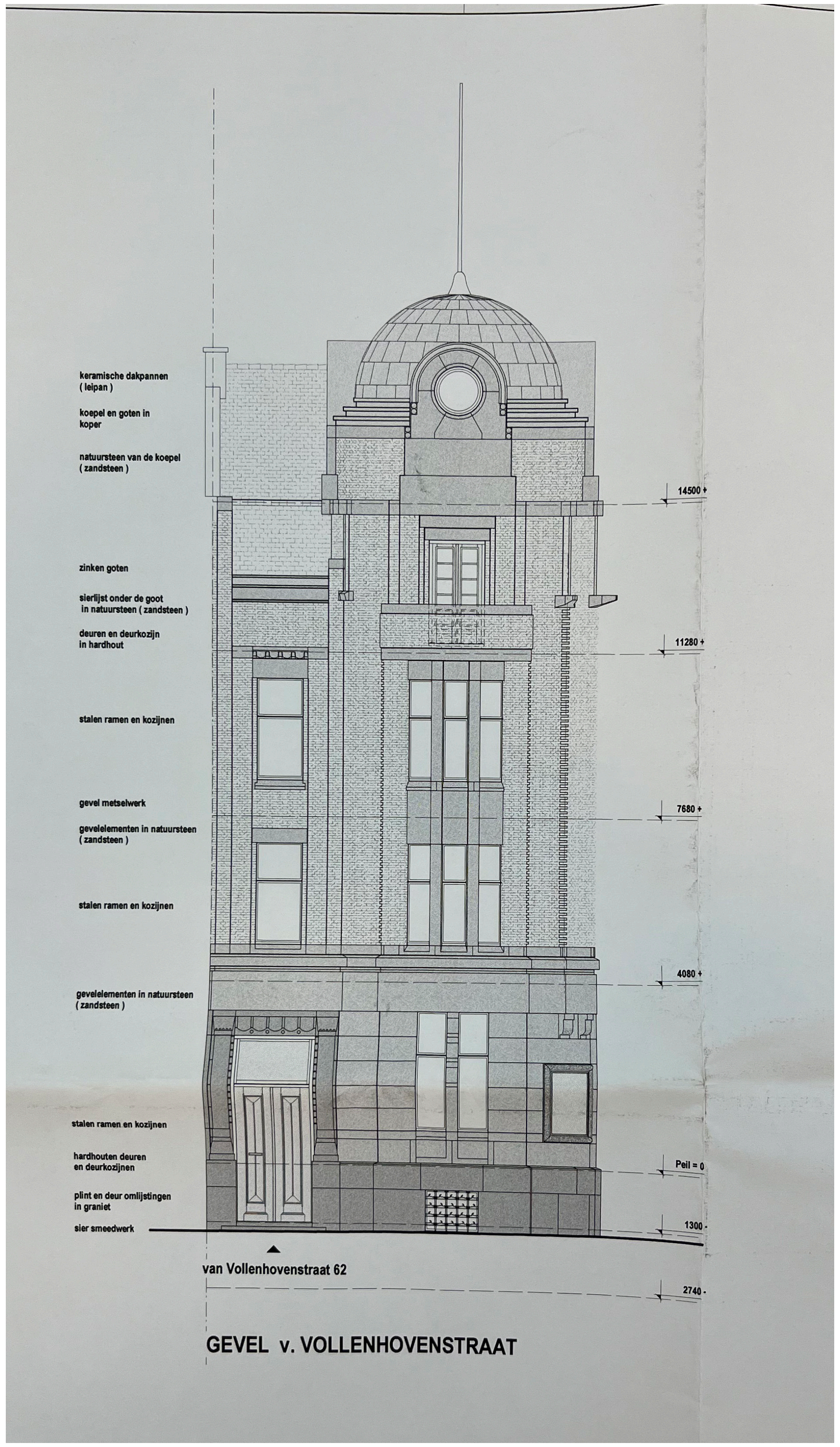
APPENDIX 1.

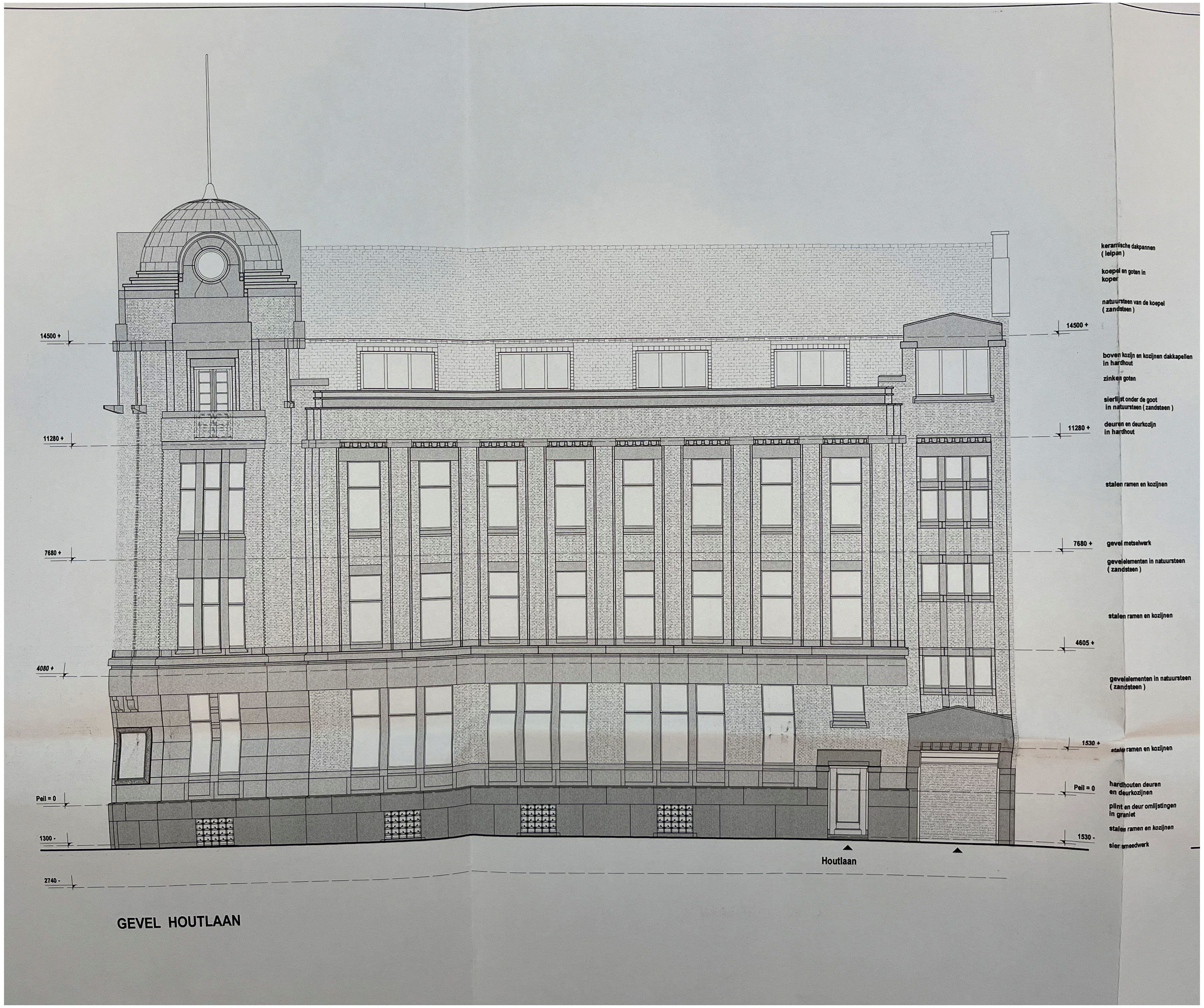
Building methods

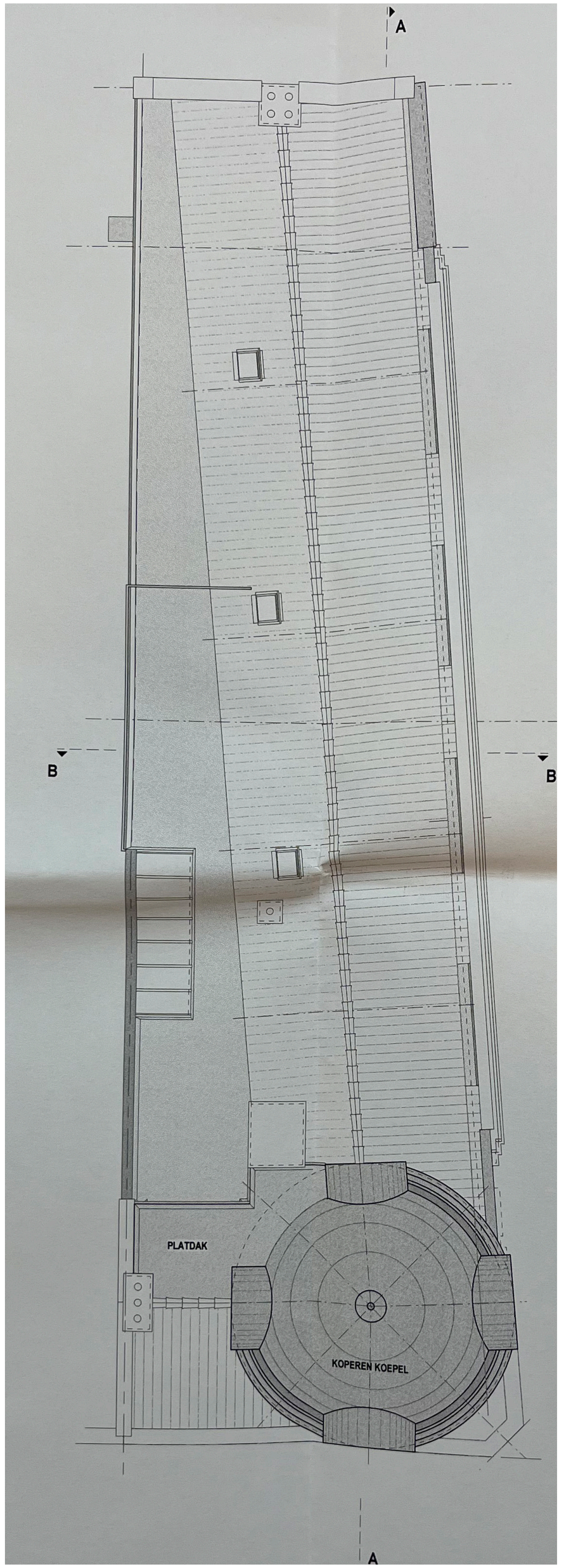
Dimension	**System**						**Material**	**Method**	**Product**	**Class**	**Grid**	**Height**	**Builder**
	Structure	Skin 1	2.	3.	Services	Space							
1D	Brace frame	Non bearing	Multi Layered	All options possible	unknown	Demountable	Wood/Steel	Machineing/Fabrication	Made to order	Open	Axial	5 stories	Circle wood
1D/2D	Brace frame	Non bearing	Multi Layered	All options possible	unknown	Demountable	Wood/Steel	Machineing/Fabrication	Engineerd to order	Open	Axial	unknown	De groot vroomshoop
2D	Solid structure	Non bearing	Multi Layered	All options possible	unknown	Fixed	Wood	Machineing/Fabrication	Engineerd to order	Closed	Axial	2 stories	Unbrick
2D	Solid structure	Non bearing	Multi Layered	All options possible	unknown	Fixed	Concrete	Molding/fabrication	Engineerd to order	Closed	Axial	14 stories	Van wijnen
2D/3D	Solid structure/ Braceframe	Unknown	Multi Layered	All options possible	selective	unknown	Wood	Machineing/Fabrication	Engineerd to order	unknown	Axial	6 stories	Aemsen
3D	Shear wall	Non bearing	Multi Layered	All options possible	selective	Fixed	Wood	Machineing/Fabrication	Engineerd to order	Closed	Axial	4 Stories	HEM
3D	Solid structure	Non bearing	Multi Layered	All options possible	selective	Fixed	Concrete/wood	All	Engineerd to order	Open	Axial	17 stories	Moos

Appendix 2.

Vollenhovenstraat 62



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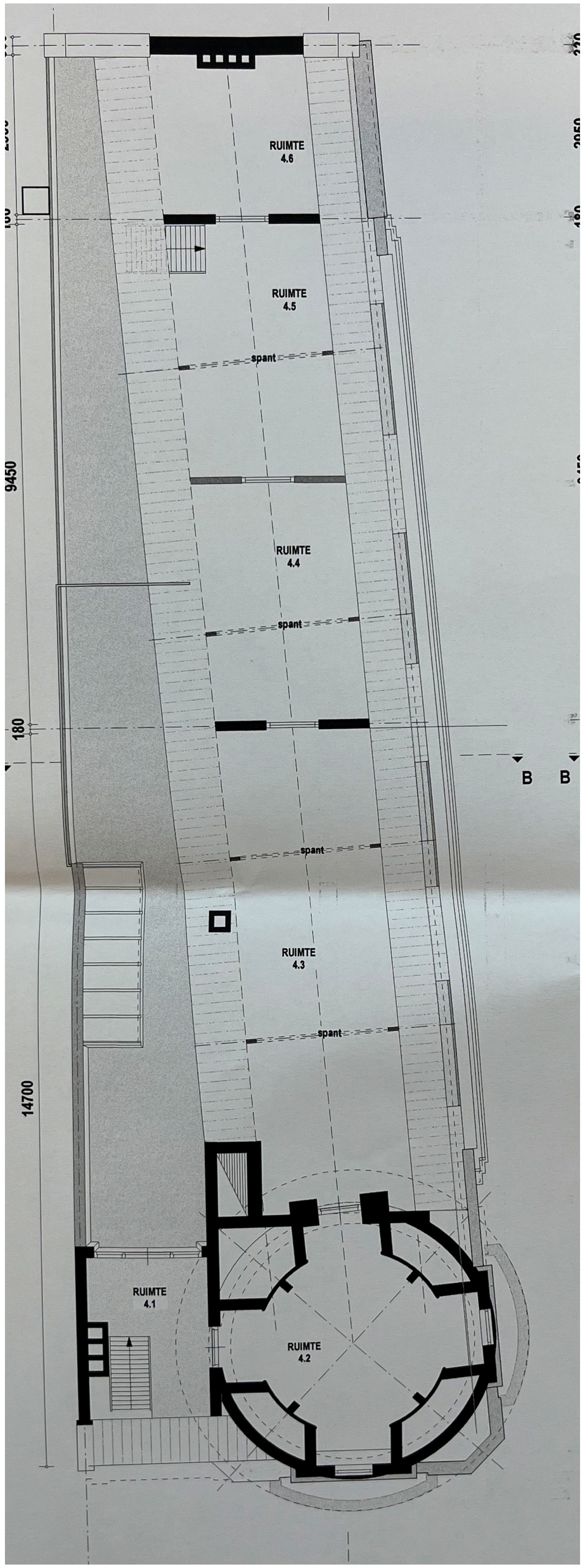
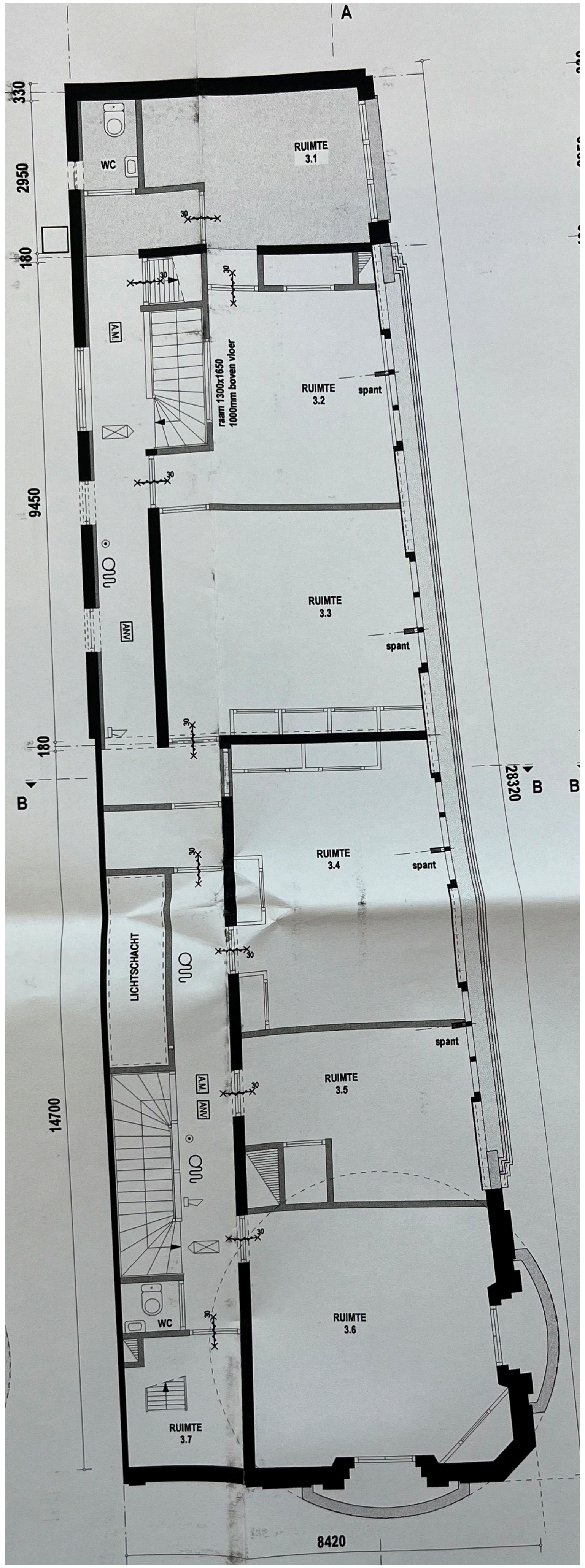
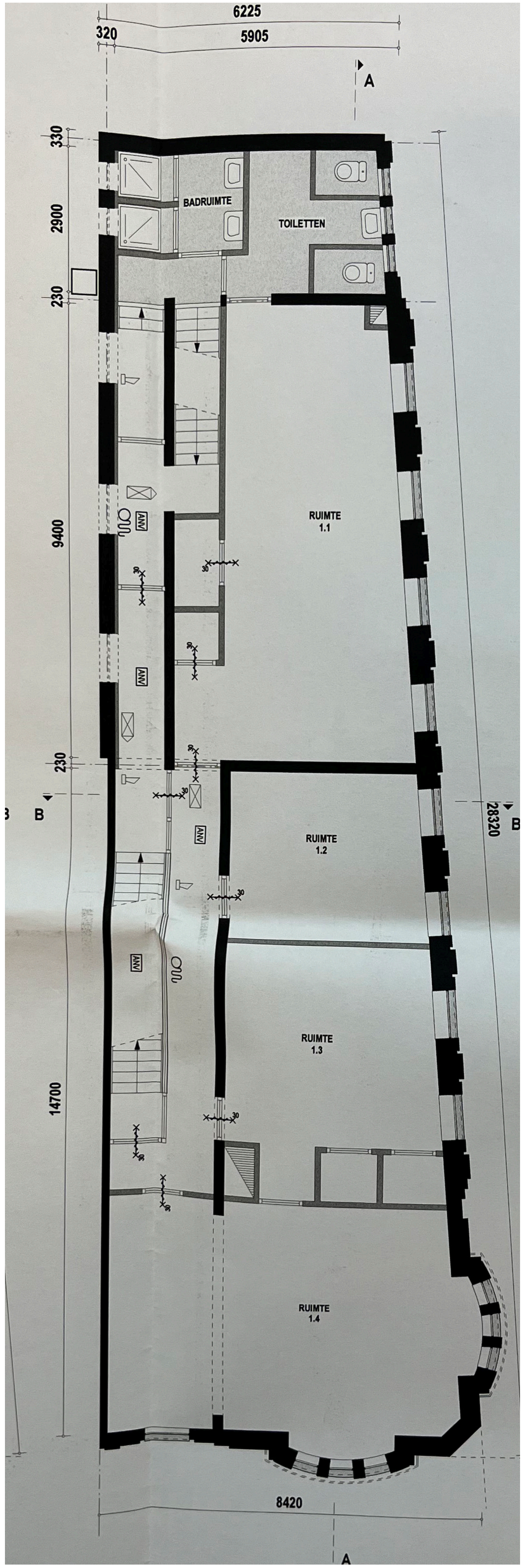
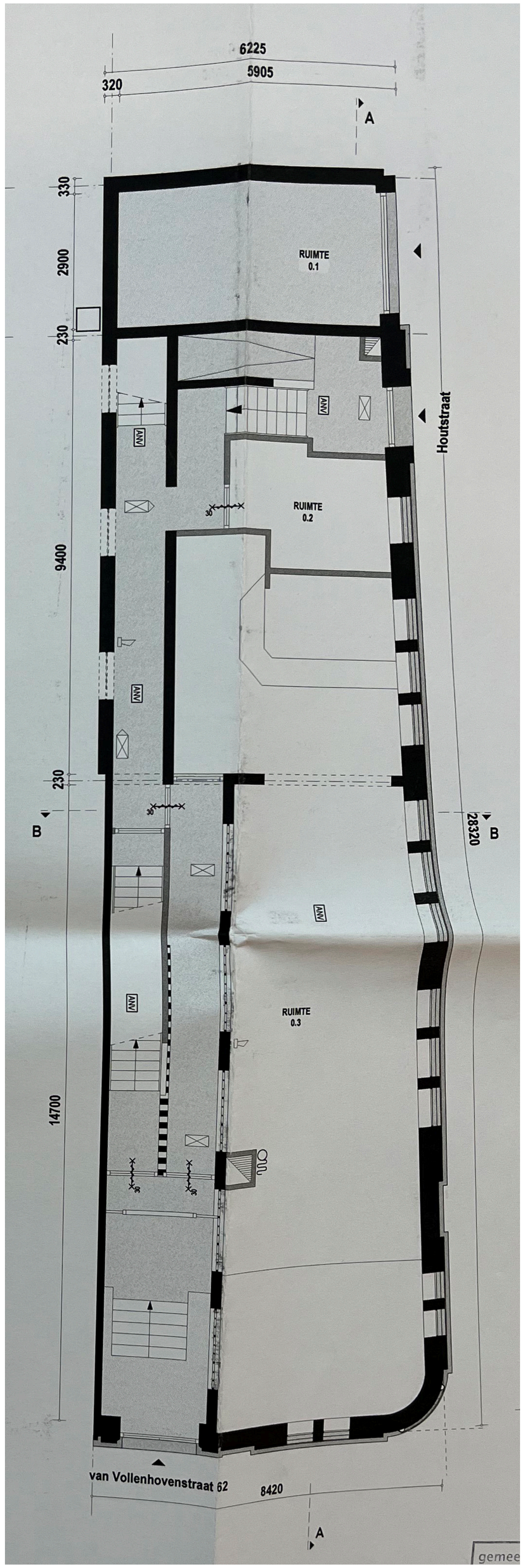
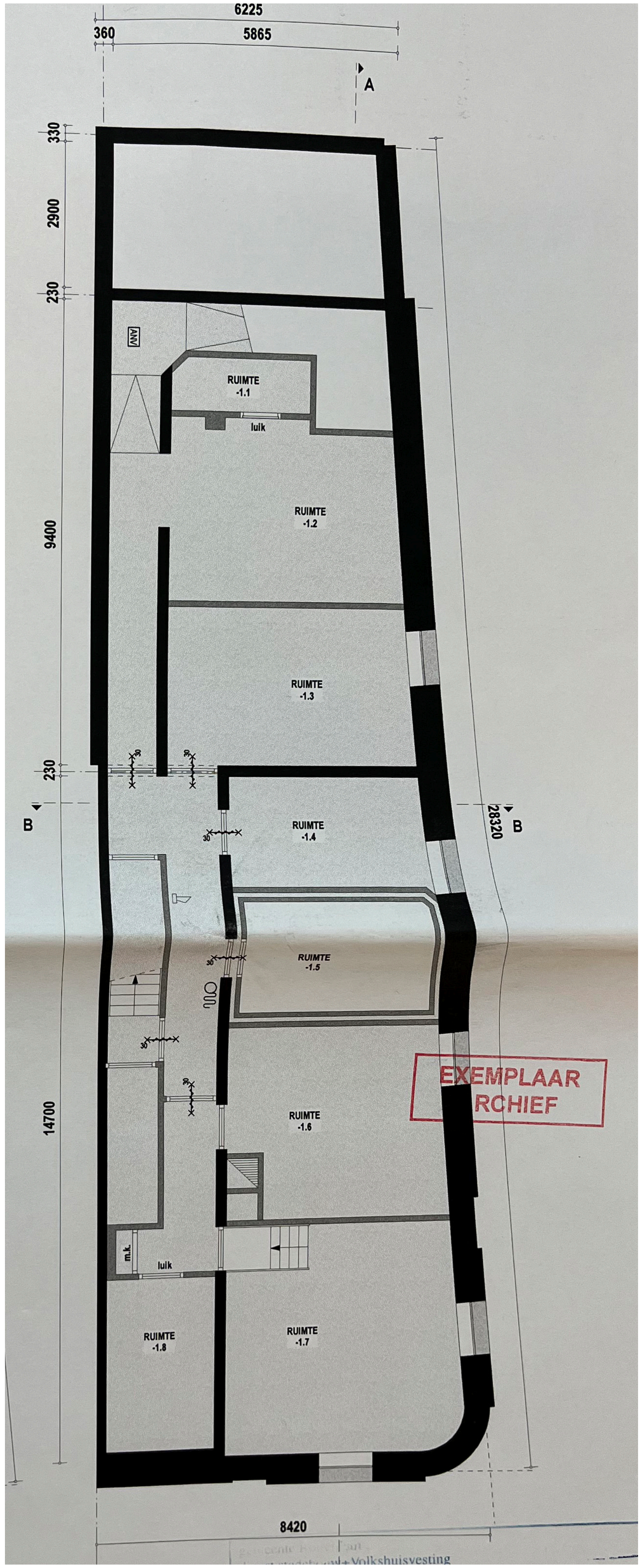

RUIMTE 4.6
RUIMTE 4.5
spant
9450
RUIMTE 4.4
spant
180
B
B
spant
RUIMTE 4.3
spant
14700
RUIMTE 4.1
RUIMTE 4.2

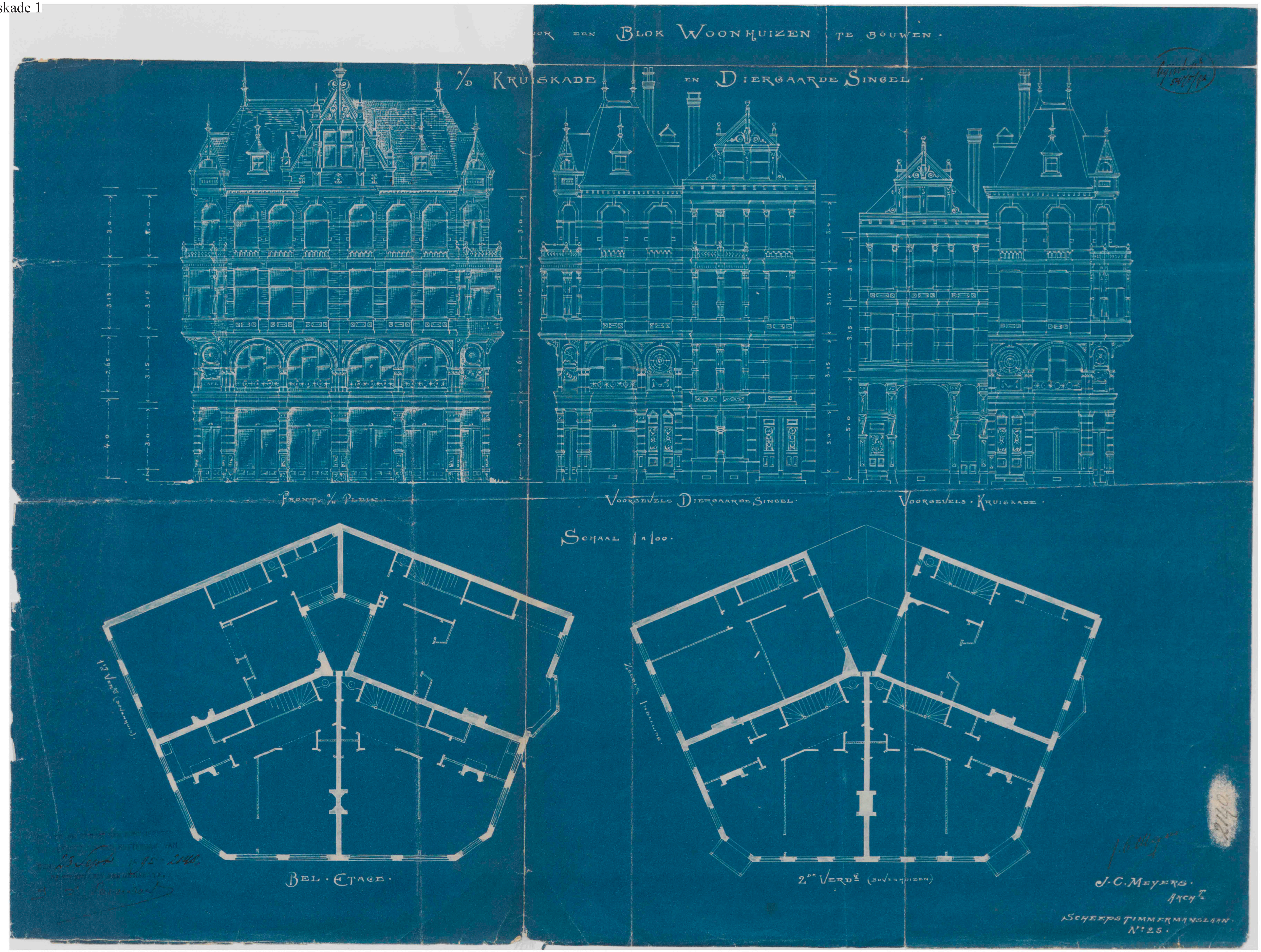

A
330
2950
WC
RUIMTE 3.1
180
raam 1300x1650
1000mm boven vloer
RUIMTE 3.2
spant
9450
RUIMTE 3.3
spant
180
B
28320
B
B
RUIMTE 3.4
spant
LICHTSCHACHT
spant
RUIMTE 3.5
14700
WC
RUIMTE 3.6
RUIMTE 3.7
8420

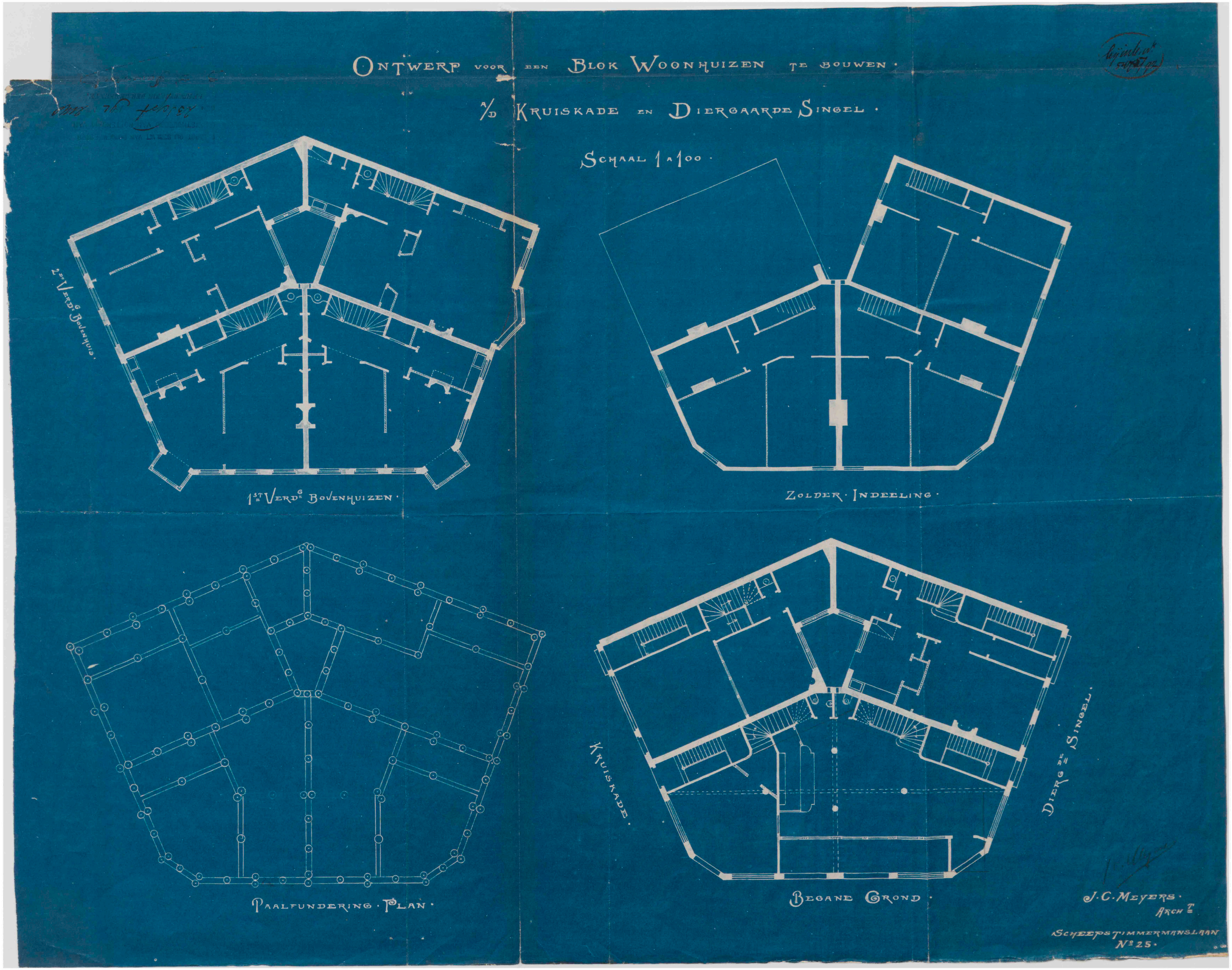

6225
320
5905
A
330
2900
230
9400
230
14700
B
28320
BADRUIMTE
TOILETTEN
RUIMTE 1.1
RUIMTE 1.2
RUIMTE 1.3
RUIMTE 1.4
8420

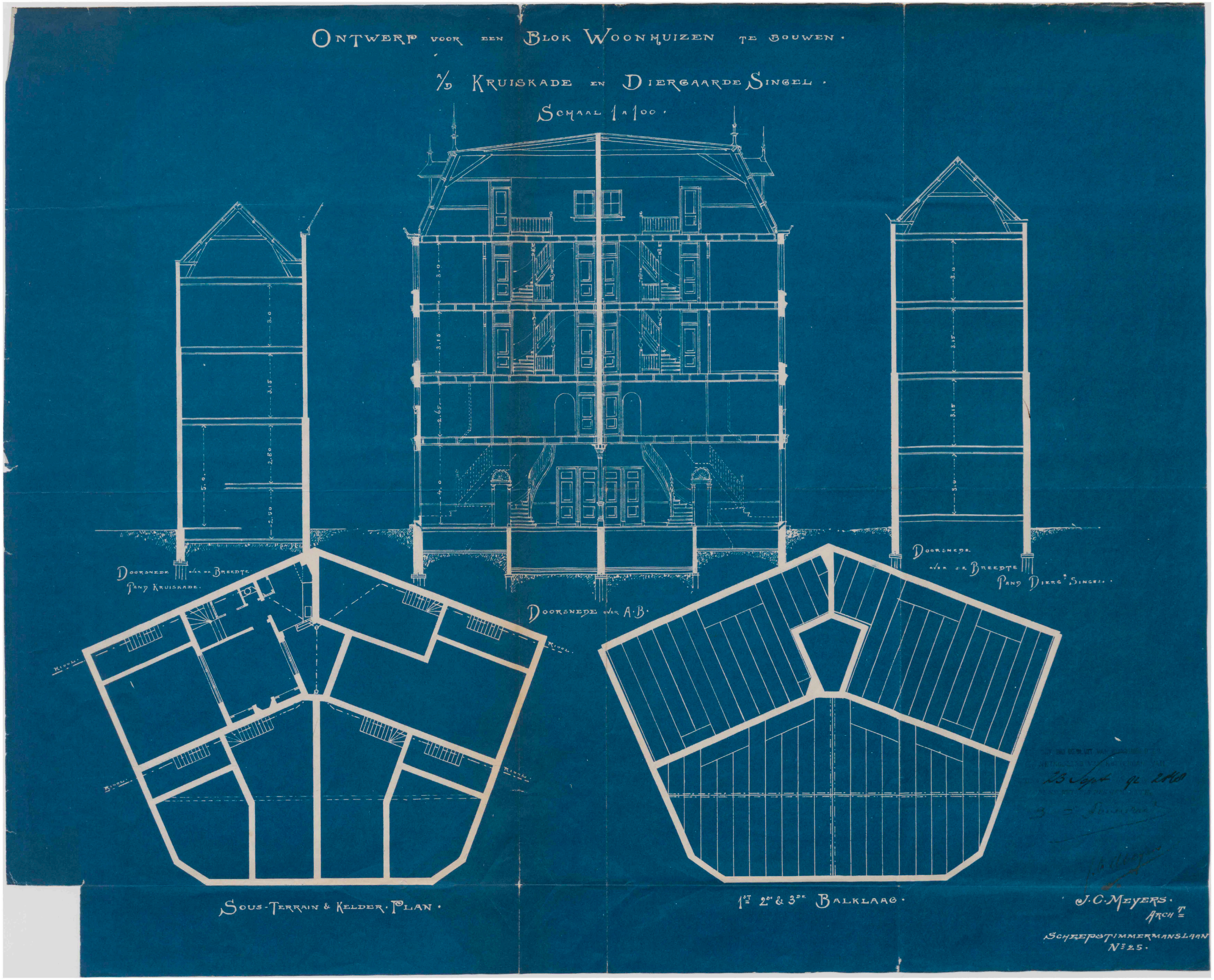

6225
320
5905
A
330
2900
230
9400
230
14700
B
28320
Houtstraat
RUIMTE 0.1
RUIMTE 0.2
RUIMTE 0.3
van Vollenhovenstraat 62
8420


6225
360
5865
A
330
2900
230
9400
230
14700
B
28320
RUIMTE -1.1
luik
RUIMTE -1.2
RUIMTE -1.3
RUIMTE -1.4
RUIMTE -1.5
RUIMTE -1.6
m.k.
luik
RUIMTE -1.7
RUIMTE -1.8
EXEMPLAAR
RCHIEF
8420

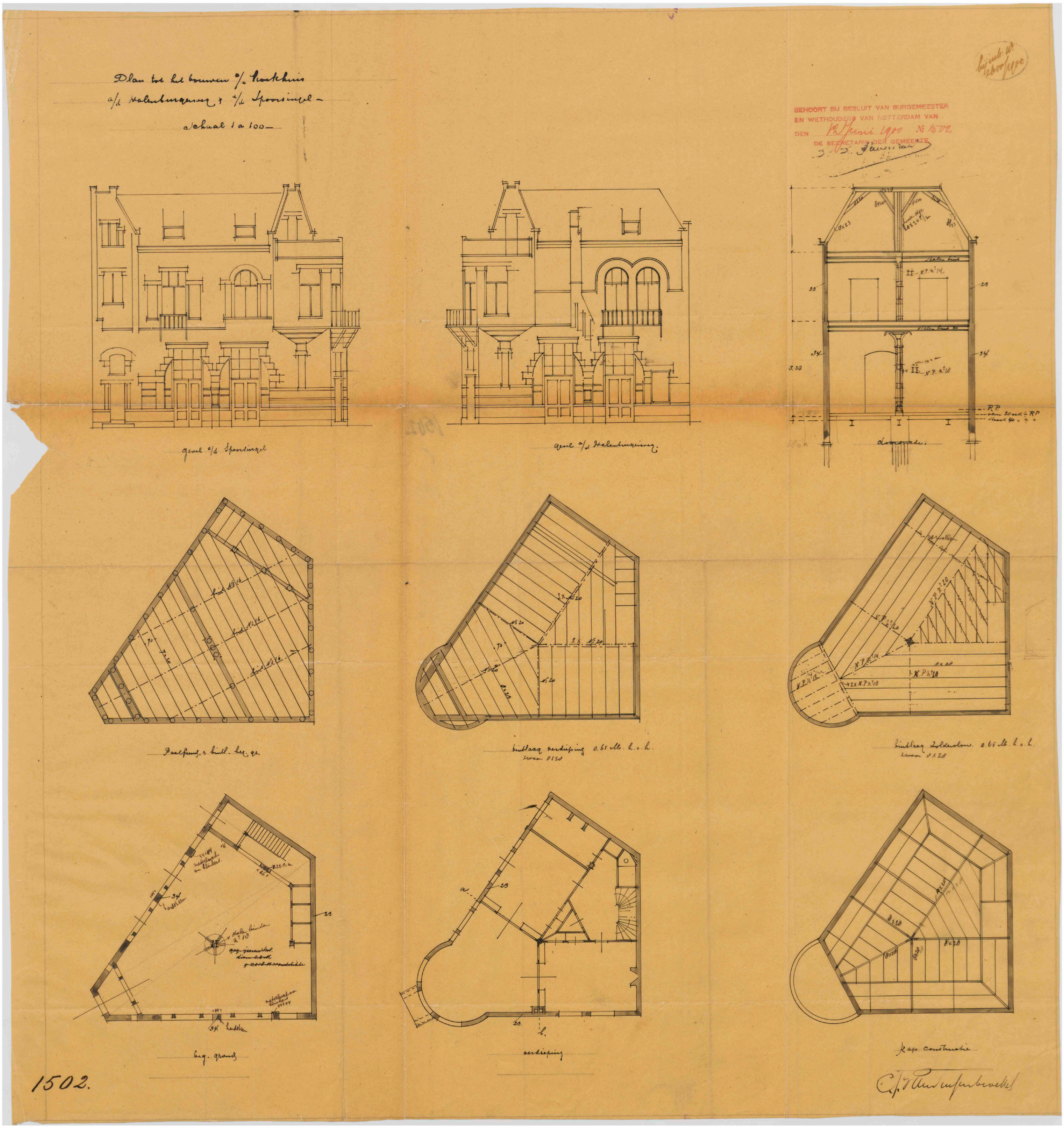
Westkruiskade 1



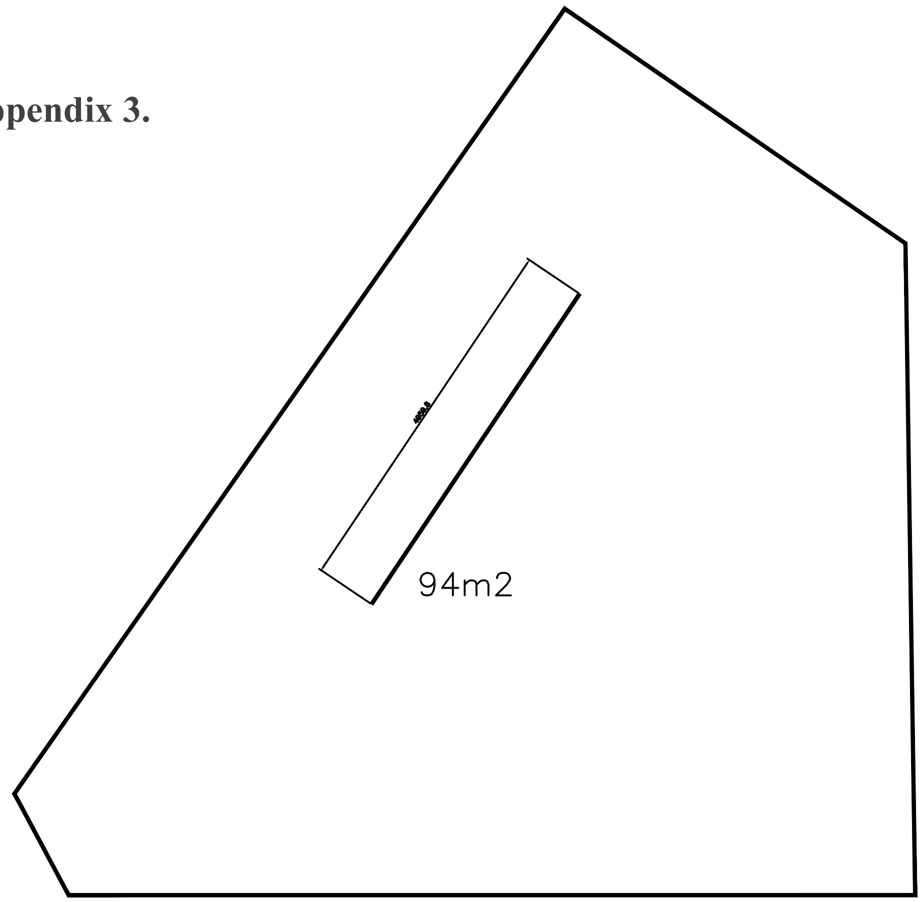

Ontwerp voor een Blok Woonhuizen te bouwen ·
a/d Kruiskade en Diergaarde Singel ·
Schaal 1 a 100 ·
2de Verdg Bovenhuis.
1ste Verdg Bovenhuizen ·
Zolder · Indeeling ·
Paalfundering · Plan ·
Kruiskade ·
Diergde Singel ·
Begane Grond ·
J. C. Meyers · Archt
Scheepstimmermanslaan N° 25 ·


Ontwerp voor een Blok Woonhuizen te bouwen.
a/d Kruiskade en Diergaarde Singel.
Schaal 1 a 100.
Doorsnede over de Breedte
Pand Kruiskade.
Doorsnede over A-B.
Doorsnede over de Breedte
Pand Dierg.e Singel.
Riool
Sous-Terrain & Kelder-Plan.
1e 2e & 3e Balklaag.
23 Sept 92 2860
J.C. Meyers.
Arch.t
Scheepstimmermanslaan
N.o 25.

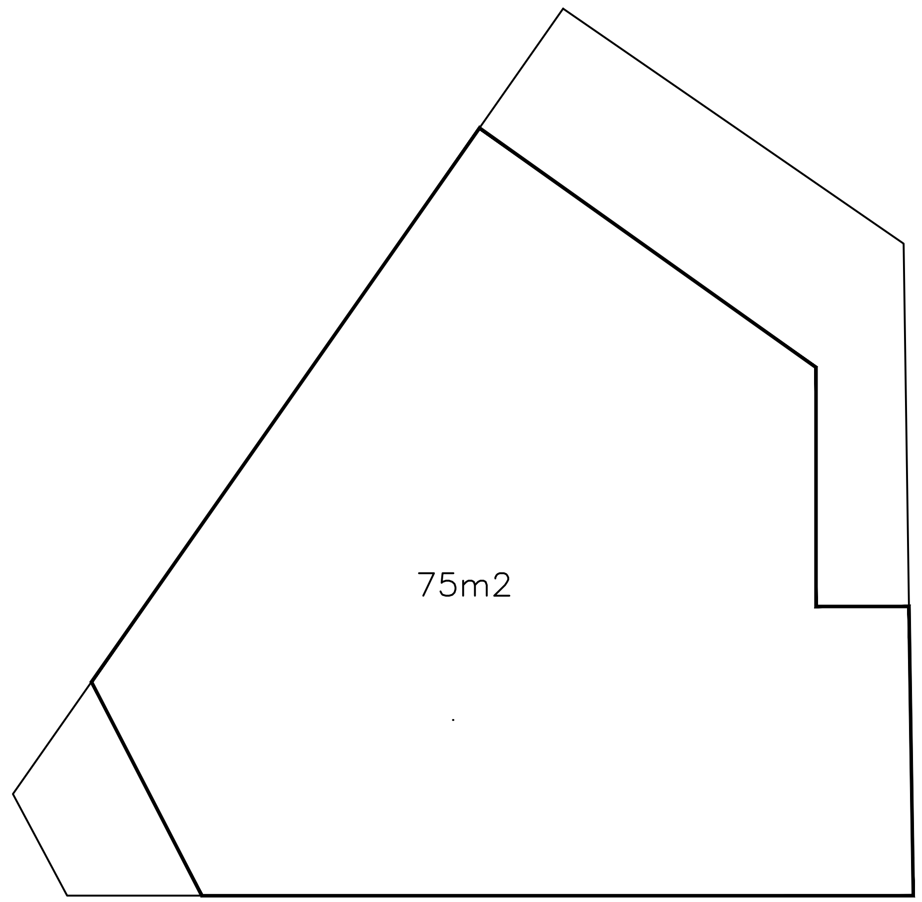
Spoorsingel 1



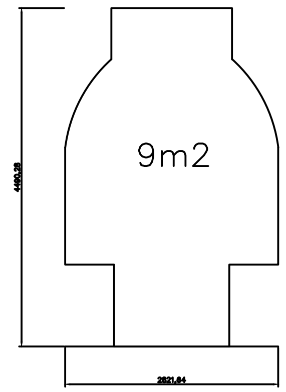
Appendix 3.



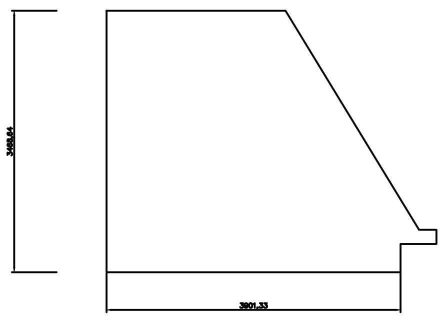
Ground floor
overall



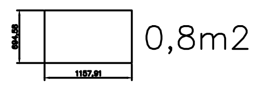
Ground floor
free space



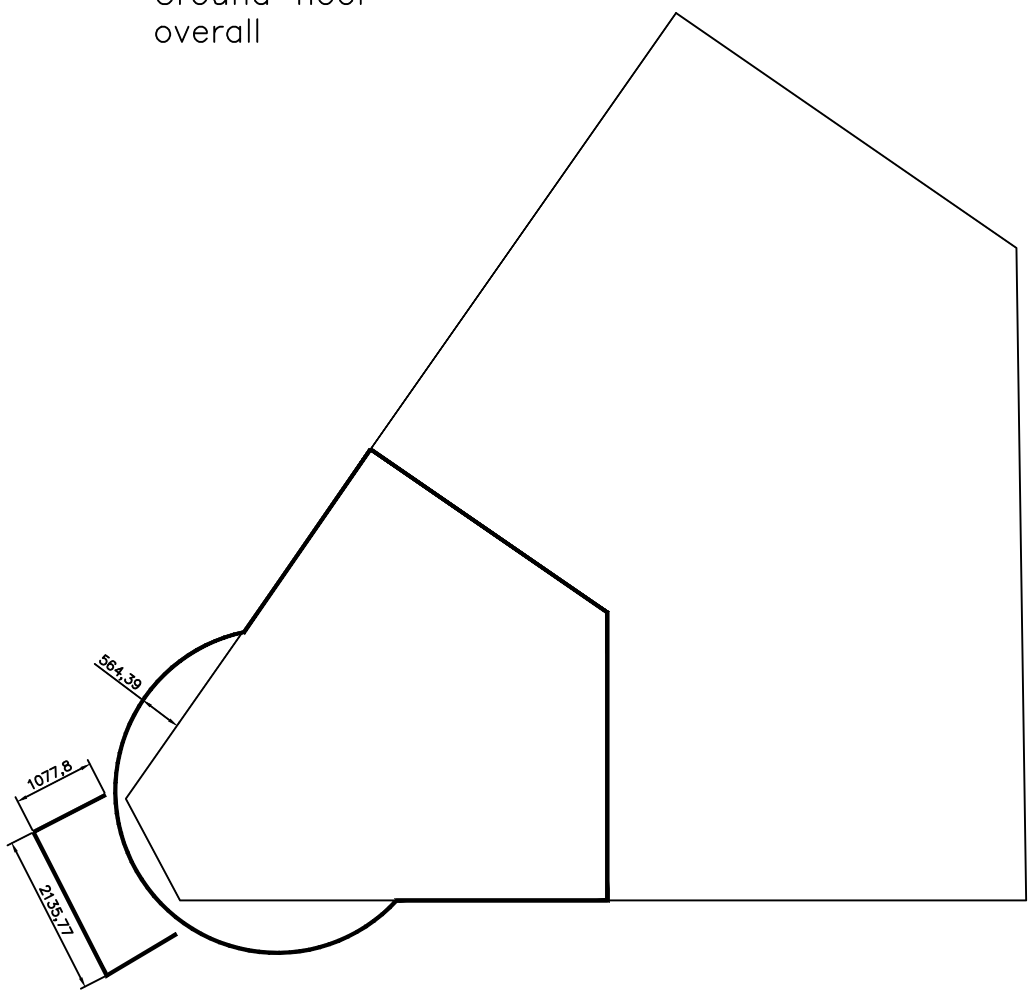
Largest opening:
window



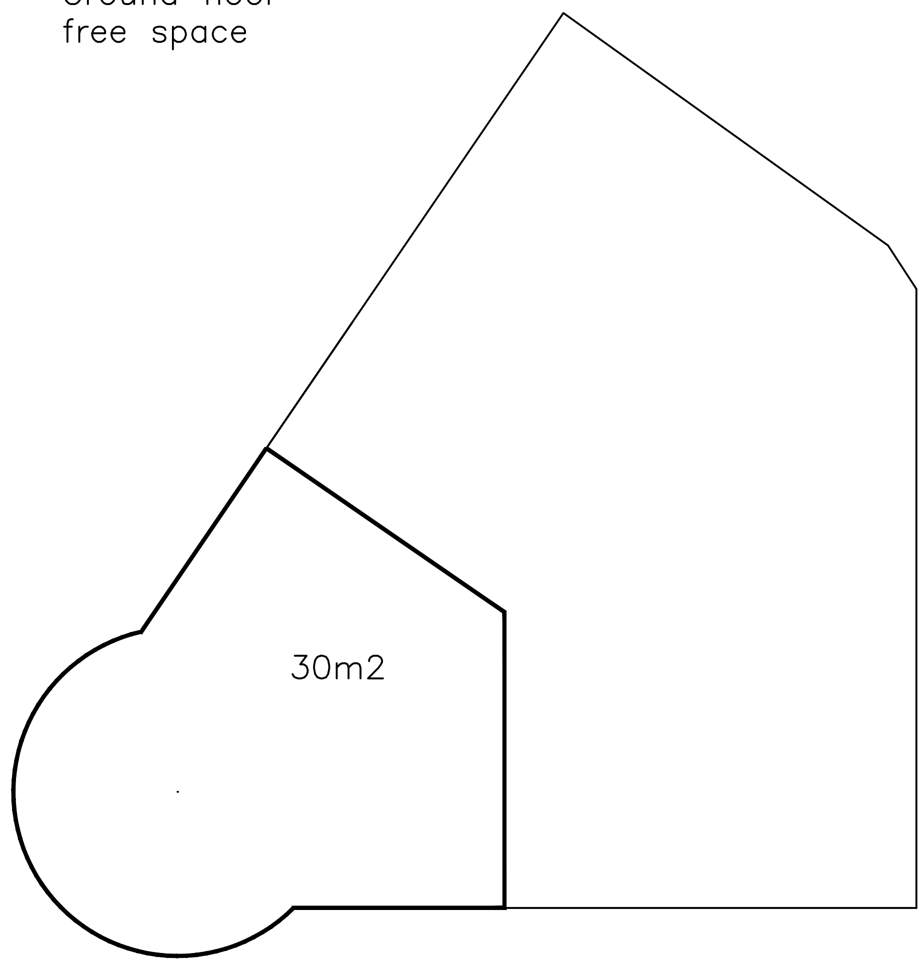
Roof
height and max
freespan



Roof
opening
dormer



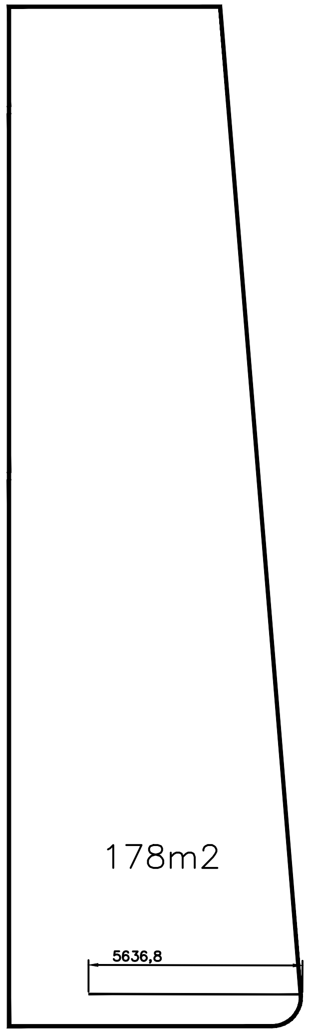
First floor
cantilevers



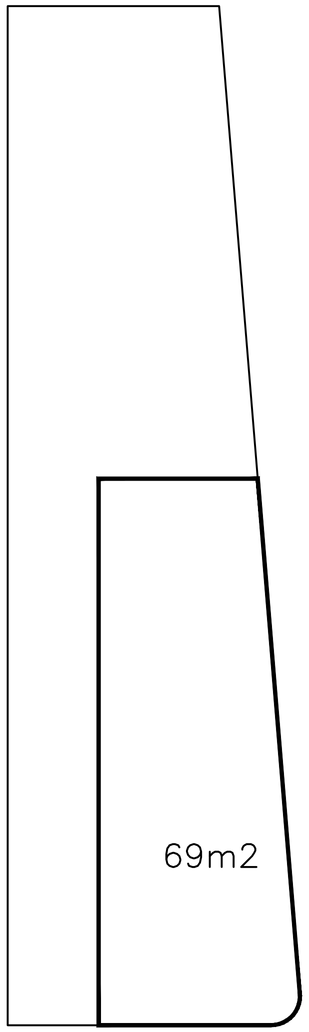
First floor
free space

Corner building analysis

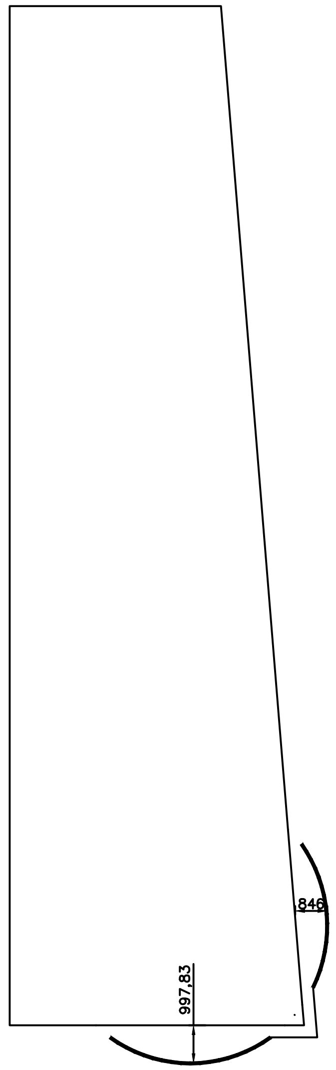
Adres: Spoorsingel 1 Rotterdam
Date: 20-12-2023
Paper size: A3
Scale: 1:100
Drawn by: Catharinus Veenema



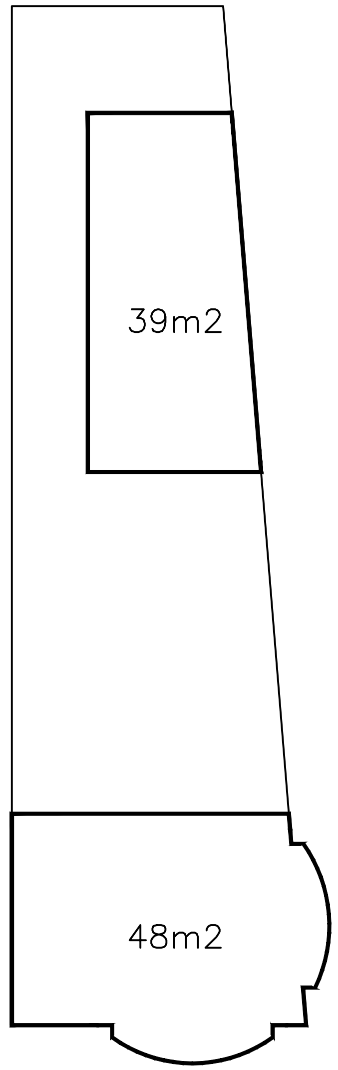
Ground floor
overall



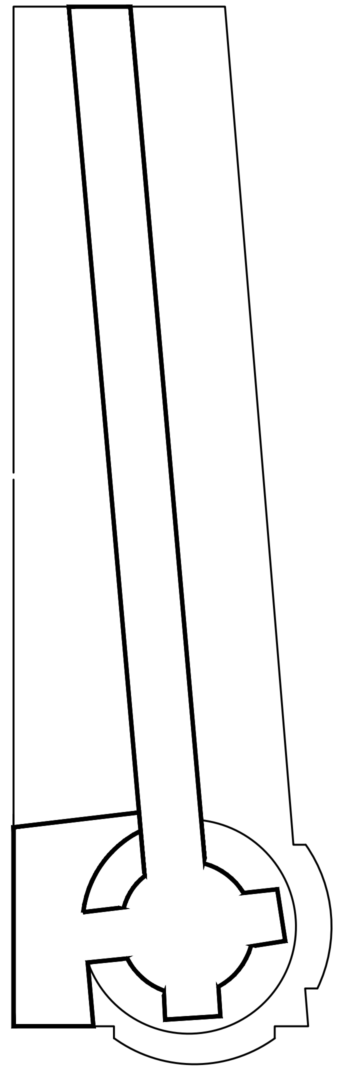
Ground floor
free space

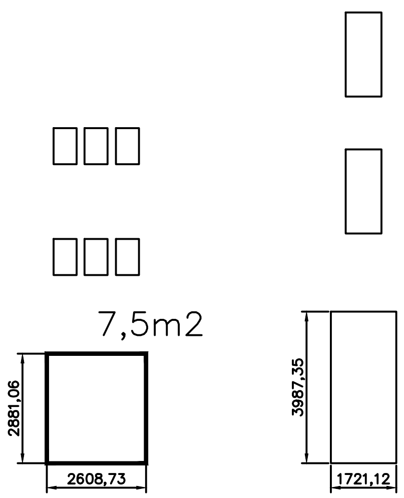


First/second floor
cantilevers

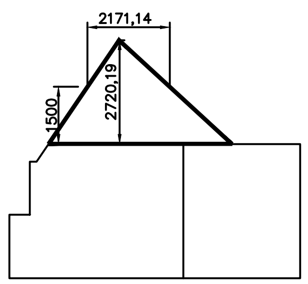


First/second floor
free space

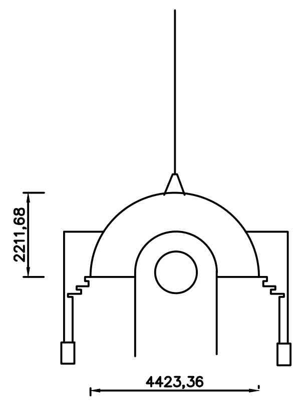




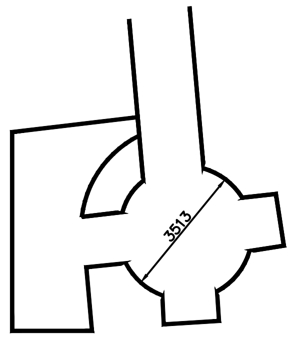
Largest
opening: gargae door



Roof 1
heigt and max freespan



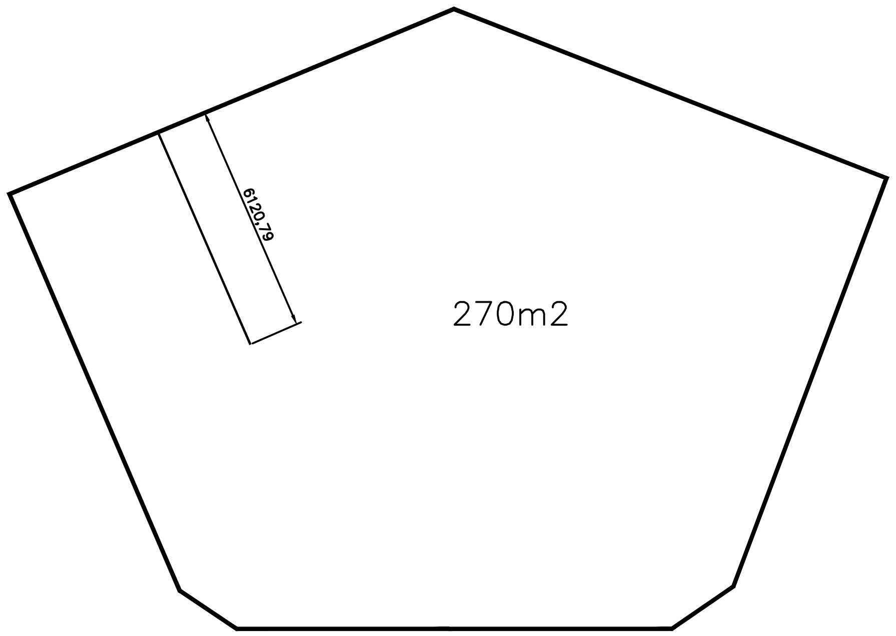
Roof 2
heigt and max freespan



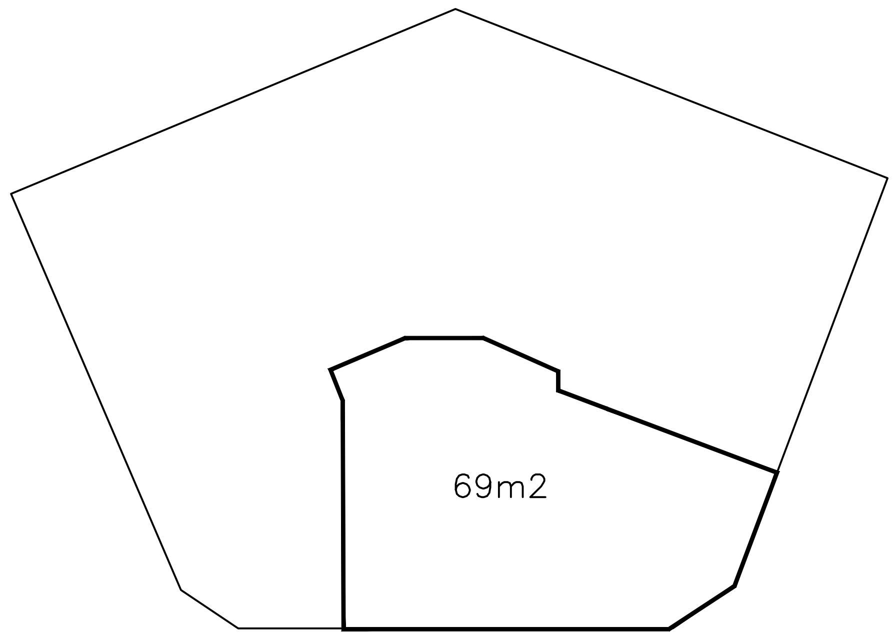
Roof 2
heigt and max freespan

Corner building analysis

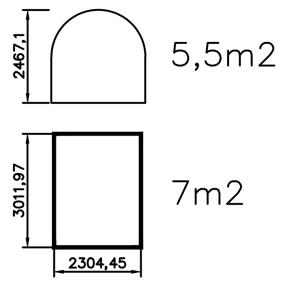
Adres: Vollenhovenstraat 62
Date: 20-12-2023
Paper size: A3
Scale: 1:100
Drawn by: Catharinus Veenema



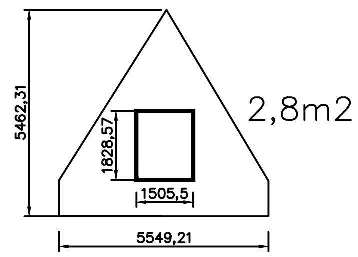
Ground floor
overall



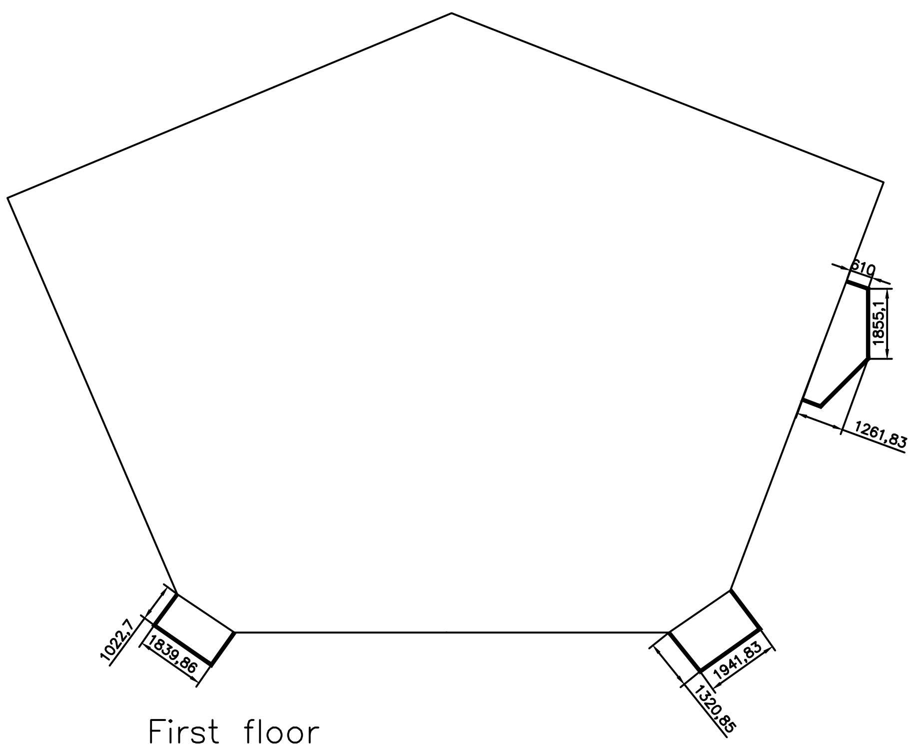
Ground floor
free space



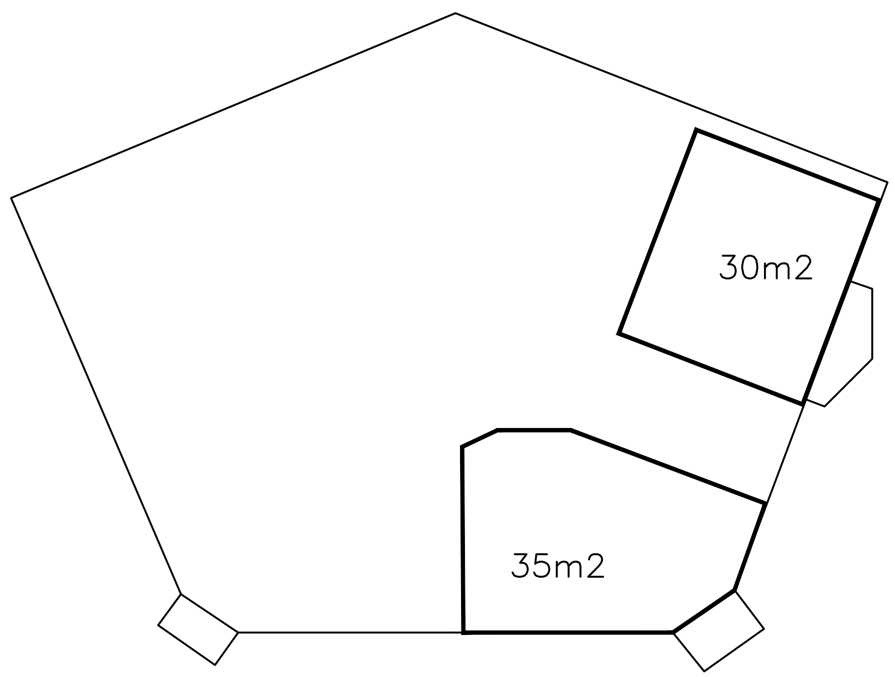
Largest
opening: window



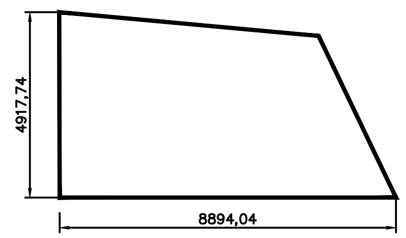
Roof
opening dormer



First floor
cantilevers



First floor
free space



Roof
heigt and max
freespan

Corner building analysis

Adres: Westkruiskade 1
Date: 20-12-2023
Paper size: A3
Scale: 1:200
Drawn by: Catharinus Veenema

APPENDIX 4.

Vollenhovenstraat 62

structural needs casestudies

building part	specifictation	measured va	amount / shape	units
Section	n/a	free height	3,5	m
		free span	5,64	m
		floor thicknes	0,6	m
Layout	grnd floor	shape	rectangle	-
		free space sha	rectangle	-
		free space	69	m2
		total space	178	m2
	1st floor	shape	rectangle	-
		free space sha	rectangle	-
		free space	48	m2
		total space	184	m2
	-	shape	rectangle	-
		free space sha	rectangle	-
		free space	48	m2
		total space	184	m2
	-	shape	rectangle	-
		free space sha	rectangle	-
		free space	48	m2
		total space	178	m2
	attic	shape	triangle	-
		free space sha	triangle / circle	-
		free space	14	m2
		total space	61	m2
Facade	opening	kind	front door	-
		shape	regtancular	-
		area	6,9	m2
	cntlvr 1	kind	baywindow	-
		shape	circular	-
		length	>1	m
	cntlvr 2	kind	baywindow	-
		shape	circular	-
		length	>1	m
Roof	1st	shape	saddle cap / flatroof	-
		dormers	no	-
		openings	2,8	m2
		height	2,7	m
		max free spa	2,1	m
	2d	shape	dome	-
		dormers	no	-
		openings	circle	-
		height	2,2	m
		max free spa	4,4	m
	3d	shape	-	-
		dormers	-	-
		openings	-	m2
		height	-	m
		max free spa	-	m
Special notes	n/a	single window in the vertical forces remittance		

Westkruiskade

structural needs casestudies

building part	specifictation	measured value	amount / shape	units
Section	n/a	free height	5	m
		free span	5	m
		floor thickness	0,58	m
Layout	grnd floor	shape	pentagon	-
		free space shape	triangle	-
		free space	75	m2
		total space	270	m2
	1st floor	shape	triangle / circle	-
		free space shape	triangle / circle	-
		free space	30	m2
		total space	270	m2
	-	shape	-	-
		free space shape	-	-
		free space	-	m2
		total space	-	m2
	-	shape	-	-
		free space shape	-	-
		free space	-	m2
		total space	-	m2
	attic	shape	triangle / circle	-
		free space shape	triangle / circle	-
		free space	35	m2
		total space	97,5	m2
Facade	opening	kind	window	-
		shape	regtancular	-
		area	7	m2
	cntlvr 1	kind	baywindow	-
		shape	regtancular	-
		length	1,3	m
	cntlvr 2	kind	balcony	-
		shape	triangle / pentagon	-
		length	1,3	m
Roof	1st	shape	hipped roof	-
		dormers	yess	-
		openings	2,8	m2
		height	4,9	m
		max free span	8,8	m
	2d	shape	-	-
		dormers	-	-
		openings	-	-
		height	-	m
		max free span	-	m
	3d	shape	-	-
		dormers	-	-
		openings	-	m2
		height	-	m
		max free span	-	m
Special notes	n/a	symmetrical building with also a		
		single point for weight remittance		

Spoorsingel 1

structural needs casestudies

building part	specifictation	measured va	amount / shape	units
Section	n/a	free height	4,72	m
		free span	5	m
		floor thicknes	0,58	m
Layout	grnd floor	shape	kite/triangle/pentagon	-
		free space sha	kite/triangle/pentagon	-
		free space	75	m2
		total space	94	m2
	1st floor	shape	triangle / circle	-
		free space sha	triangle / circle	-
		free space	30	m2
		total space	97,5	m2
	2d floor	shape	triangle/rectangle/circle	-
		free space sha	triangle/rectangle/circle	-
		free space	48	m2
		total space	184	m2
	-	shape	-	-
		free space sha	-	-
		free space	-	m2
		total space	-	m2
	attic	shape	triangle /circle	-
		free space sha	triangle / circle	-
		free space	30	m2
		total space	97,5	m2
Facade	opening	kind	front door/window	-
		shape	regtancular / reliefarch	-
		area	9	m2
	cntlvr 1	kind	baywindow	-
		shape	regtancular/circular	-
		length	>1	m
	cntlvr 2	kind	balcony	-
		shape	triangle / pentagon	-
		length	1,1	m
Roof	1st	shape	-	-
		dormers	-	-
		openings	-	m2
		height	-	m
		max free spa	-	m
	2d	shape	-	-
		dormers	-	-
		openings	-	-
		height	-	m
		max free spa	-	m
	3d	shape	gableroof	-
		dormers	yess	-
		openings	0,8	m2
		height	3,5	m
		max free spa	3,9	m
Special notes	n/a	one very central beam		
		one setback at hight away from load bearing wall		

Overall Demands

structural needs casestudies

building part	specifictation	measured value	amount / shape	units
Section	n/a	free height	5	m
		free span	6,1	m
		floor thickness	0,6	m
Layadfhaldkfjout	grnd floor	shape	kite/triangle/pentagon	-
		free space shape	kite/triangle/pentagon	-
		free space	75	m2
		total space	270	m2
	1st floor	shape	triangle/rectangle/circle	-
		free space shape	triangle/rectangle/circle	-
		free space	48	m2
		total space	270	m2
	2d floor	shape	triangle/rectangle/circle	-
		free space shape	triangle/rectangle/circle	-
		free space	48	m2
		total space	184	m2
	3d floor	shape	rectangle	-
		free space shape	rectangle	-
		free space	48	m2
		total space	178	m2
	attic	shape	triangle	-
		free space shape	triangle / circle	-
		free space	14	m2
		total space	61	m2
Facade	opening	kind	front door/window	-
		shape	regtancular / reliefarch	-
		area	9	m2
	cntlvr 1	kind	baywindow	-
		shape	regtancular/circular	-
		length	1,3	m
	cntlvr 2	kind	balcony	-
		shape	triangle / pentagon	-
		length	1,3	m
Roof	1st	shape	saddle cap / flatroof	-
		dormers	yes	-
		openings	2,8	m2
		height	4,9	m
		max free span	8,8	m
	2d	shape	dome	-
		dormers	no	-
		openings	circle	-
		height	2,2	m
		max free span	3,5	m
	3d	shape	gableroof	-
		dormers	yess	-
		openings	0,8	m2
		height	3,5	m
		max free span	3,9	m
Special notes	n/a	symmetrical building with also a		-
		single point for weight remittance		-
		single window in the vertical forces remittar		-
		one very central beam		-
		one setback at hight away from load bearin		-

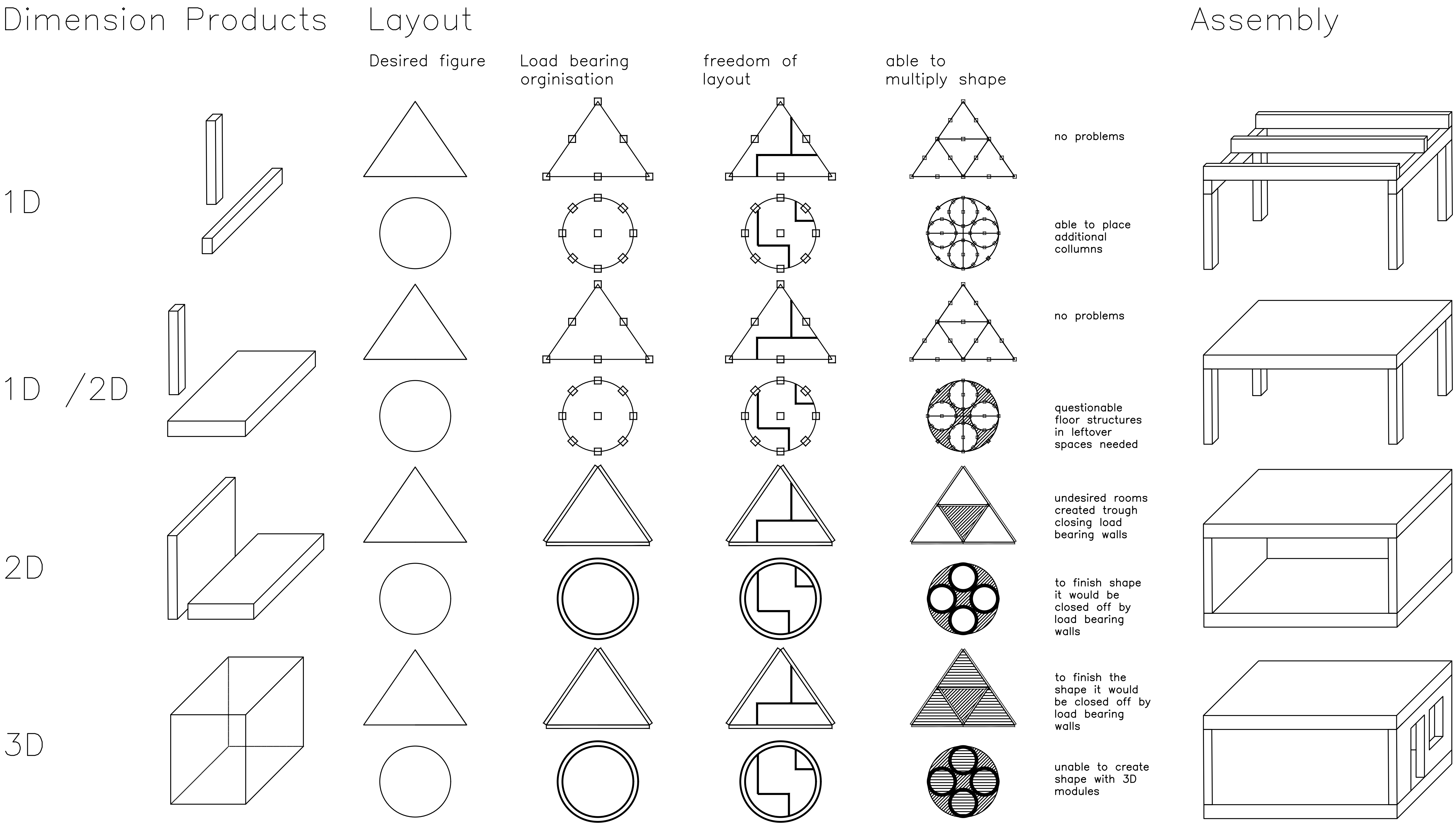
APPENDIX 5.

Overall Demands					1			2			3		4		5	
structural needs casestudies					1D braceframe wood/steel			1D/2D braceframe wood/steel			2D solid structure wood		2D Solid structure concrete		2D/3D Solid strcuture / brace frame wood	
building part	**specifictation**	**measured value**	**amount / shape**	**units**	**amount / shape**	**units**	**source**	**amount / shape**	**units**	**source**	-					
Section	n/a	free height	5	m	10.97	m	https://www.dim	10.97	m	same	-					
		free span	6,1	m	>30	m	glulam handbook	>30x 6	m	https://www.lami	-					
		floor thickness	0,6	m	>0,6	m	page 116 manua	>0,6	m	manual multi sto	-					
Layadfhaldkfjout	grnd floor	shape	kite/triangle/pentagon	-	possible	-	free placement of	some possible	-	triangle possible	-					
		free space shape	kite/triangle/pentagon	-	possible	-	free placement of	some possible	-	all possible	-					
		free space	75	m2	380	m2	30x30x30 surfac	61	m2	triangle, kite and	-					
		total space	270	m2	n/a	-	enlarging the sha	244	m2	triangle repeatab	-					
	1st floor	shape	triangle/rectangle/circle	-	possible	-	free placement of	possible	-	triangle and recta	-					
		free space shape	triangle/rectangle/circle	-	possible	-	free placement of	possible	-	all possible	-					
		free space	48	m2	380	m2	30x30x30 surfac	61 driehoek / 42,41 circle	m2		-					
		total space	270	m2	n/a	m2	attaching to the a	n/a	m2		-					
	2d floor	shape	triangle/rectangle/circle	-	possible	-	free placement of	possible	-		-					
		free space shape	triangle/rectangle/circle	-	possible	-	free placement of	possible	-		-					
		free space	48	m2	380	m2	30x30x30 surfac	61 driehoek / 42,41 circle	m2		-					
		total space	184	m2	380	m2	30x30x30 surfac	n/a	m2		-					
	3d floor	shape	rectangle	-	possible	-	free placement of	possible	-		-					
		free space shape	rectangle	-	possible	-	free placement of	possible	-		-					
		free space	48	m2	380	m2	30x30x30 surfac	>30x 6= 180	m2		-					
		total space	178	m2	n/a	m2	attaching to the a	>30x 6= 180	m2		-					
	attic	shape	triangle	-	possible	-	free placement of	-	-		-					
		free space shape	triangle / circle	-	possible	-	free placement of	-	-		-					
		free space	14	m2	380	m2	30x30x30 surfac	-	m2		-					
		total space	61	m2	n/a	m2	attaching to the a	-	m2		-					
Facade	opening	kind	front door/window	-	all possible	-	no carrying walls	-	-		-					
		shape	regtancular / reliefarch	-	all possible	-	no carrying walls	-	-		-					
		area	9	m2	300	m2	free hight * free	-	m2		-					
	cntlvr 1	kind	baywindow	-	cantilever 25% of s	-	chrome-extensio	-	-		-					
		shape	regtancular/circular	-	possible	-	n/a	-	-		-					
		length	1,3	m	7,5	m	30x0.25	-	m		-					
	cntlvr 2	kind	balcony	-	cantilever 25% of s	-	chrome-extensio	-	-		-					
		shape	triangle / pentagon	-	possible	-	n/a	-	-		-					
		length	1,3	m	7,5	m	30x0.25	-	m		-					
Roof	1st	shape	saddle cap / flatroof	-	possible	-	any given roof ca	-	-		-					
		dormers	yes	-	possible	-	any given roof ca	-	-		-					
		openings	2,8	m2	300	m2	any given roof ca	-	m2		-					
		height	4,9	m	10,96	m	any given roof ca	-	m		-					
		max free span	8,8	m	30	m	any given roof ca	-	m		-					
	2d	shape	dome	-	possible	-	any given roof ca	-	-		-					
		dormers	no	-	possible	-	any given roof ca	-	-		-					
		openings	circle	-	300	m2	any given roof ca	-	m2		-					
		height	2,2	m	10,96	m	any given roof ca	-	m		-					
		max free span	3,5	m	30	m	any given roof ca	-	m		-					
	3d	shape	gableroof	-	possible	-	any given roof ca	-	-		-					
		dormers	yess	-	possible	-	any given roof ca	-	-		-					
		openings	0,8	m2	300	m2	any given roof ca	-	m2		-					
		height	3,5	m	10,96	m	any given roof ca	-	m		-					
		max free span	3,9	m	30	m	any given roof ca	-	m		-					
Special notes	n/a	symmetrical building with also a		-	very suitable with this building method to create the san			-			-					
		single point for weight remittance		-				-			-					
		single window in the vertical forces remittan		-	can be hard force remittance is on corner			-			-					
		one very central beam		-	very well possible			-			-					
		one setback at hight away from load bearing		-	very well possible			-			-					

APPENDIX 6.

Overall Demands				
structural needs casestudies				
building part	specifictation	measured value	amount / shape	units
Section	n/a	free height	5	m
		free span	6,1	m
		floor thickness	0,6	m
		stories	4	-
Layout	n/a	free space	75	m2
		total space	270	m2
	rectangle	free space within shape		
		able to create pattern	yess	-
		pattern repeatable	no	
	circle	free space within shape		
		able to create pattern	yess	-
		pattern repeatable	no	
	triangle	free space within shape		
		able to create pattern	yess	-
		pattern repeatable	no	
	pentagon	free space within shape		
		able to create pattern	yess	-
		pattern repeatable	no	
	kite	free space within shape		
		able to create pattern	yess	-
		pattern repeatable	no	
Facade	opening	kind	front door/window	-
		shape	regtancular / reliefarch	-
		area	9	m2
	cntlvr 1	kind	baywindow	-
		shape	regtancular/circular	-
		length	1,3	m
	cntlvr 2	kind	balcony	-
		shape	triangle / pentagon	-
		length	1,3	m
Roof	1st	shape	saddle cap / flatroof	-
		dormers	yes	-
		openings	2,8	m2
		height	4,9	m
		max free span	8,8	m
	2d	shape	dome	-
		dormers	no	-
		openings	circle	-
		height	2,2	m
		max free span	3,5	m
	3d	shape	gableroof	-
		dormers	yess	-
		openings	0,8	m2
		height	3,5	m
		max free span	3,9	m
Special notes	n/a	symmetrical building with also a		-
		single point for weight remittance		-
		single window in the vertical forces remittance		-
		one very central beam		-
		one setback at hight away from load bearing wall		-

Appendix 7.


Dimension Products
Layout
Assembly
Desired figure
Load bearing orginisation
freedom of layout
able to multiply shape
1D
1D /2D
2D
3D
no problems
able to place additional collumns
no problems
questionable floor structures in leftover spaces needed
undesired rooms created trough closing load bearing walls
to finish shape it would be closed off by load bearing walls
to finish the shape it would be closed off by load bearing walls
unable to create shape with 3D modules