

SDE19 - The Mobble: Onderzoek naar modulaire bouwcomponenten

Ineke Tavernier

Promotoren: prof. dr. Ronald De Meyer, Marc De Kooning

Masterproef ingediend tot het behalen van de academische graad van
Master of Science in de ingenieurswetenschappen: architectuur

Vakgroep Architectuur en Stedenbouw
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Toelating tot bruikleen

“De auteur geeft de toelating deze masterproef voor consultatie beschikbaar te stellen en delen van de masterproef te kopiëren voor persoonlijk gebruik.

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Gent, juni 2018

Een bijzondere dank

Aan Prof. Ronny De Meyer, mijn promotor, voor zijn vertrouwen, belangstelling, tijd, ruimte, bezorgdheid en leerrijke begeleiding.

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Woord vooraf

Deze masterproef handelt over de *Mobble*, de inzending van de Universiteit Gent voor de *Solar Decathlon Europe*-wedstrijd in 2019, in Hongarije. Het doel van deze wedstrijd is studenten uit te dagen om kritisch na te denken over hoe we kunnen bouwen en wonen in de toekomst en om meteen deze ideeën te vertalen in een paviljoen. The *Mobble* staat voor *Modular Building Block* en is een modulaire bouwsteen om grotere gehelen te realiseren. Het paviljoen bestaat uit vijf *Mobbles*.

De *Mobble* heeft een voorontwikkelingsfase en een mogelijke doorontwikkeling. Deze verschillende fases zijn uitgezet in een schema met tijdslijn. De belangrijkste invloeden en beslissingsmomenten worden weergegeven in de tijdslijn en verder gedocumenteerd en toegelicht in de verschillende hoofdstukken.

Door de tijdsdruk en de specifieke opgelegde renovatieproblematiek van de wedstrijd zijn de intrinsieke eigenschappen van de *Mobble* (maatvoering, stapelbaarheid, combinatorische eigenschappen, enz.) voor verdere ontwikkeling vatbaar. Daarenboven wil Vlaams bouwmeester Leo Van Broeck naar voorbeeld van Nederland en Duitsland het concept module-stapelwoningen introduceren in België en een proefproject opstarten in Gent.

Een mogelijke doorontwikkeling wordt aangegeven in de laatste fase van de tijdslijn.

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Abstract

Voor een grotere aanpasbaarheid van gebouwen ontstaat stilaan een groter maatschappelijk draagvlak. ‘Nieuwe’ woonvormen zijn noodzakelijk om te evolueren naar aanpasbaar bouwen. Modulair bouwen levert een potentieel antwoord.

Deze masterproef geeft de zoektocht naar een modulaire bouwcomponent weer waarbij het geheel tot op het niveau van elementair bouwelement uit elkaar kan worden gehaald. Een bouwcomponent die zowel autonoom (als *tiny house*) een bestaansrecht heeft maar ook kan uitgebreid worden tot een gezinswoning, een schakeling van meerdere woningen (*cohousing*) en nieuwe grotere gehelen, zoals appartementsgebouwen.

Binnen deze context wordt de *Solar Decathlon*-wedstrijd aangegrepen om deze ‘nieuwe’ woonvorm verder te ontwikkelen en aan een breed publiek kenbaar te maken. Het doel van deze wedstrijd is studenten uit te dagen om kritisch na te denken over hoe we kunnen bouwen en wonen in de toekomst en om meteen deze ideeën te vertalen in een paviljoen.

Trefwoorden: Modulair bouwen - Solar Decathlon - Aanpasbaar bouwen - The Mobble

Extended Abstract

SDE19 - The Mobble: Onderzoek naar modulaire bouwcomponenten

Introductie

De bevolkingsprognose in Vlaanderen evolueert naar steeds meer alleenstaanden en éénundergezinnen. Het woningbestand is niet gericht op deze steeds groter wordende groep. Bestaande woningen worden te groot en te duur. Er is nood aan ‘nieuwe’ woonvormen. [1]

De stad Gent kampt momenteel met een wachtlijst van 10.000 mensen voor een sociale woning. Vlaams Bouwmeester Leo Van Broeck ziet een toekomst van containerwoningen als mogelijk antwoord hierop. Niet alleen om tegemoet te komen aan de vraag voor sociale huisvesting maar ook als betaalbare opstapwoning voor jonge mensen. [2]

Methodiek

Containers laten fungeren als woning is een mogelijk vertrekpunt naar ‘nieuwe’ woonvormen. Het gebruik van een container als woning heeft een aantal voordelen:

- Standaard transport;
- Beperkte omvang;
- Stapel- en verplaatsbaar.

De container kan bovendien volledig ingericht en afgewerkt worden vooraleer de woning naar de bouwplaats te vervoeren. Dit vereenvoudigt de veiligheidseisen en de bouwomstandigheden op de werf aanzienlijk. Toch hebben wooncontainers beperkingen op het vlak van modulariteit, aanpasbaarheid en ontwerprijheid.

Daarnaast moet de hulp ingeschakeld worden van derden om een container te vervoeren en te bewerken tot woning.

Misschien kan het anders, eenvoudiger. Een belangrijk aspect in deze zoektocht naar ‘nieuwe’ woonvormen is betaalbaarheid. De kosten kunnen gedrukt worden door de bewoner toe te laten zelf zijn woning in elkaar te zetten en door toe te spitsen op het gebruik van gestandaardiseerde bouwelementen.

Aanpasbaar bouwen en goedkoop bouwen vormen de twee belangrijkste uitgangspunten en creëren een andere kijk op de zoektocht naar ‘nieuwe’ woonvormen. Modulair bouwen is een mogelijk antwoord op deze uitgangspunten.

In deze masterproef wordt op zoek gegaan naar een module die zonder veel technische *knowhow* en professioneel gereedschap kan worden opgebouwd. De module vormt de basiscomponent en zal steeds in dezelfde hoedanigheid voorkomen. Deze bouwcomponent heeft autonoom een bestaansrecht als *tiny house*. De modules kunnen geschakeld worden tot een gezinswoning en ook grotere configuraties kunnen worden bekomen, zoals schakelingen met meerdere woningen (cohousing) en nieuwe appartementsgebouwen.

Resultaat

Solar Decathlon

De *Solar Decathlon*-wedstrijd wordt aangegrepen om modulair bouwen als ‘nieuwe’ woonvorm verder te ontwikkelen en aan een breed publiek kenbaar te maken. Midden december 2017 werd de Universiteit Gent geselecteerd om deel te nemen. De wedstrijd gaat door in juli 2019 in Hongarije. Het doel van deze wedstrijd is studenten uit te dagen om kritisch na te denken over hoe we kunnen bouwen en wonen in de toekomst. Deze ideeën worden meteen vertaald in een paviljoen.

Thema: renovatie van appartementsgebouwen

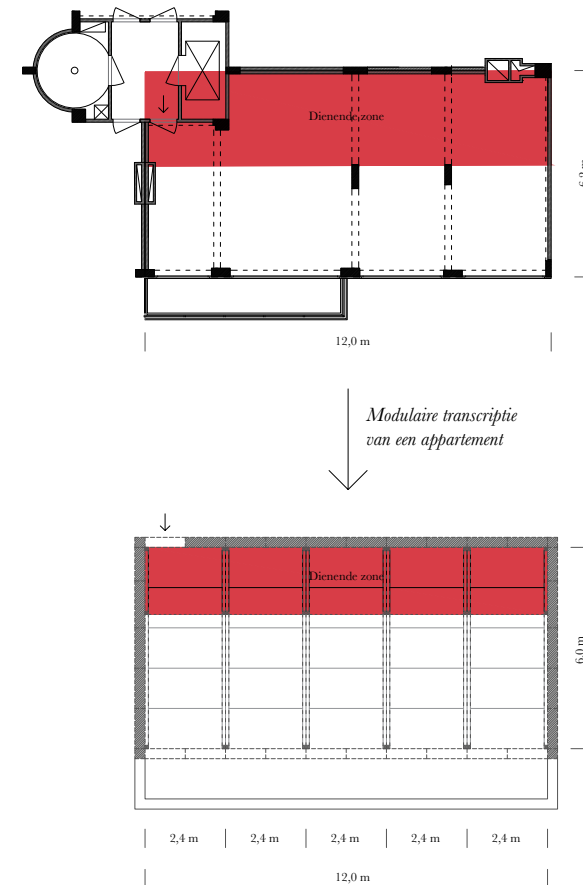
De wedstrijd kadert in een renovatiethematiek gekoppeld aan het land van afkomst van het deelnemend team. *Team Ghent University* legt zich toe op de renovatie van appartementsgebouwen die opgericht zijn door de firma Etrimo. Dit is één van de grote aannemersbedrijven die in de jaren '50 tot '70 de Belgische markt domineerden. Deze onderneming bouwde de ene woontoren na de andere. De appartementsblokken zijn verouderd, energetisch inefficiënt en voldoen niet meer aan de huidige normen inzake brandveiligheid, toegankelijkheid, enz. Daarnaast behoren bijna alle appartementen aan verschillende eigenaars (private eigendom), waardoor totaalrenovatie van een bouwblok moeilijk is. De renovatie is een complex proces dat afgeremd wordt door een aantal praktische, technische, financiële, organisatorische en juridische obstakels.



Figuur 1. Etrimo-gebouwen in Breughelpark, Zellik.

Transcriptie: van appartement naar paviljoen

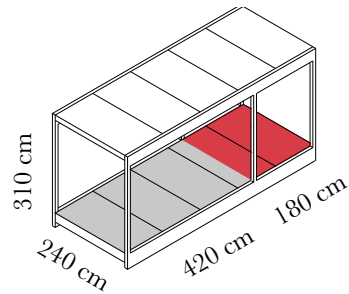
Het vertrekpunt voor de plattegrond van het paviljoen is het meest voorkomende type-appartement uit een appartementsgebouw van de firma Etrimo. Er wordt een modulaire transcriptie gemaakt naar een paviljoen in hout. De geometrie en de daarbijhorende afmetingen worden bijna letterlijk gekopieerd, alsook het gebruik van éenzijdige beglazing, het balkon en de typerende dienende zone, zie rode arcering op de grondplannen hiernaast. Het appartement/paviljoen wordt betreden vanuit de linker bovenhoek.



Figuur 2. Vertaling van appartement naar paviljoen.

Maatschappelijke relevantie

De module is de *Mobble* gedoopt en staat voor *Modular Building Block*.



Figuur 3. Isometrie van de Mobble. Rode arcering is dienende zone, grijze arcering is bediende zone.

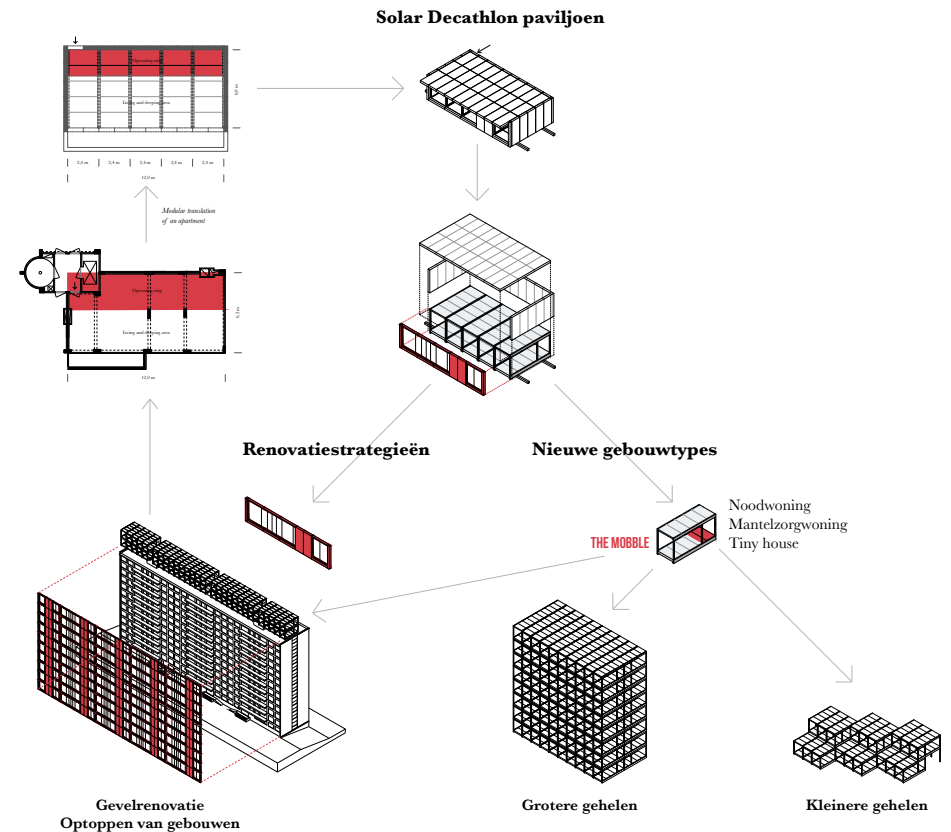
Het paviljoen bestaat uit vijf *Mobbles* en demonstreert verschillende renovatietechnieken en -strategieën. Daarnaast is de *Mobble* zodanig geconcipieerd dat het geheel tot op het niveau van elementair bouwelement uit elkaar kan worden gehaald. Naast het paviljoen is de *Mobble* inzetbaar voor verschillende doeleinden.

Eén *Mobble* kan fungeren als noodwoning, *tiny house*, mantelzorgwoning in de tuin, enz.

Aan de hand van het maatsysteem van de *Mobble* kunnen nieuwe 'intelligente' gehelen worden ontwikkeld. Met 'intelligent' wordt bedoeld dat het gebouw zonder fundamentele aanpassingen een ander programma kan dragen.

Mobbles kunnen ingezet worden als *rooftop apartments*. Door modules op het dak van het te renoveren gebouw te plaatsen kunnen bewoners tijdelijk verhuizen naar deze module-appartementen om dan terug te keren naar hun appartement na de verbouwingen. Daarna zijn de volgende bewoners aan de beurt tot alle

appartementen zijn opgeknapt. De *Mobbles* op het dak worden na de renovatie behouden. Dit is gunstig voor de verdichting van de steden want, na afloop van de renovatie zal het appartementsgebouw meer wooneenheden bevatten.

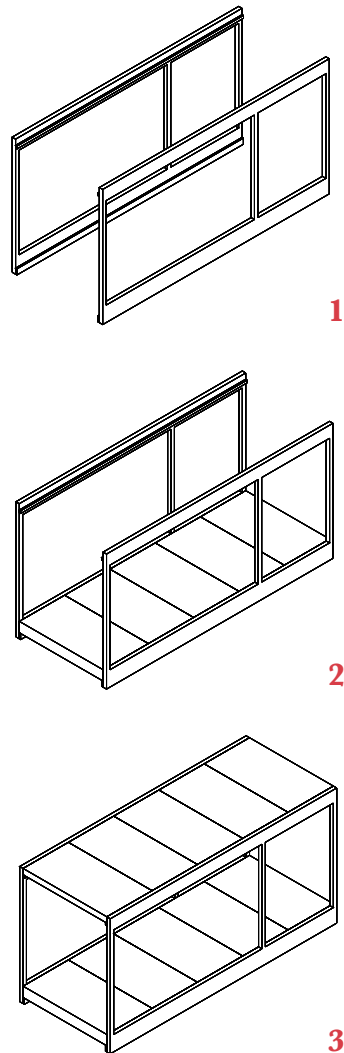


Figuur 4. Schema met de verschillende doeleinden gekoppeld aan het paviljoen.

Opbouw van de Mobble

De *Mobble* wordt opgebouwd uit twee structurele kaders **1**. Een kader wordt gemaakt van een vijf-laagse stapeling van geschrante multiplexschijven, verzaagd uit standaard platen van 1,22m x 2,44m. De twee kaders worden verticaal recht gezet en daartussen komen de vloerpanelen **2** en dakpanelen **3**.

De afmetingen van de *Mobble* zijn: L6,0m x B2,4m x H3,1m. De lengte en breedte zijn veelvoud van 1,2m die gebaseerd zijn op de standaardbreedte van typische sandwichpanelen. Een andere reden voor het gebruik van beperkte afmetingen vloeit voort uit de afmetingen voor normaal transport.

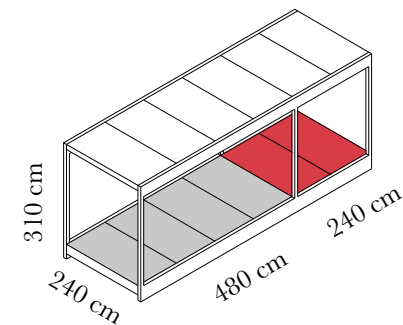


Figuur 5. Opbouw van de Mobble.

Discussie en conclusie

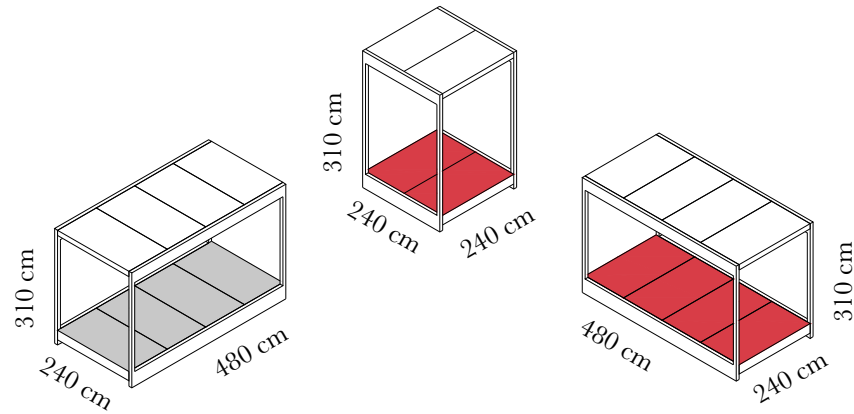
De tussenkomst van de *Solar Decathlon*-wedstrijd heeft het verdere onderzoek naar een modulaire bouwcomponent voorlopig beëindigd. De *Mobble* is niet het eindresultaat van de zoektocht maar een mogelijk tussenpunt voor verder onderzoek. De *Mobble* is tot stand gekomen binnen de wedstrijdregels en de opgelegde renovatieproblematiek van de wedstrijd. Buiten de context van de wedstrijd heeft de *Mobble* als modulaire bouwcomponent ruimte voor verbetering. Niettegenstaande is het vergaand detailleren van de module en het paviljoen een leerrijk zijspoor van het onderzoek geweest om inzichten te verwerven in het ontwikkelen van dergelijke modules.

Een eerste verbetering aan de *Mobble* zou een aanpassing van de afmetingen, rechtstreeks overgenomen van een standaard Etrimo-appartement, kunnen zijn. Voor meer mogelijkheden bij het schakelen is het wellicht interessanter dat de kopse zijde van de module exact drie keer past in de langse zijde. Op die manier kunnen schakelingen 90° roteren.



Figuur 7. Isometrie van de Mobble met aangepaste afmetingen.

Een volgende mogelijke stap is het loskoppelen van de dienende en bediende zone. Hierdoor kunnen de modules t.o.v. elkaar roteren, verkrijgen de bouwcomponenten een autonoom karakter en zijn meer planvarianten mogelijk.



Figuur 6. Isometrie van de losgekoppelde modules.

Hopelijk zet deze masterproef aan tot verder onderzoek en tot ‘intelligent’ ontwerpen en bouwen.

Trefwoorden: Modulair bouwen - Solar Decathlon - Aanpasbaar bouwen - The Mobble

[1] Belga. (2017). Helft van de Belgische huishoudens bestaat uit 1 persoon tegen 2060. *De Redactie*. Geraadpleegd op 15 februari 2018 via <http://deredactie.be/cm/vrtnieuws/binnenland/1.2910510>

[2] Nav. (2018). Vlaams bouwmeester vraagt proefproject met ‘stapelwoningen’. *Netwerk Architecten Vlaanderen*. Geraadpleegd op 30 maart 2018 via <http://www.nav.be/artikel/1299/vlaams-bouwmeester-vraagt-proefproject-met-stapelwoningen/>

Extended Abstract

SDE19 - The Mobble: Research into modular building components

Introduction

The population demography in Flanders is continuously evolving towards singles and one-parent families. The housing stock today, however, is not suitable for this ever-growing group. Existing homes are becoming too big and too expensive and therefore, there is need for ‘new’ types of housing. [1]

The city of Ghent is currently facing a waiting list of over 10,000 people for social homes. Flemish Government Architect Leo Van Broeck states a future of container homes is a possible answer to address this issue, not only to meet the social housing demand, but also as an affordable temporary rental for young people. [2]

Methodology

A possible starting point for these ‘new’ housing types is applying shipping containers for accommodation. The usage of containers has a number of advantages:

- Standard transport;
- Limited scale;
- Stackability and movability;

Furthermore, the containers can be fully equipped and finished before transportation to the construction site, which simplifies the safety requirements

and the construction conditions on site. Nevertheless, residential containers have limitations in terms of modularity, adaptability and design freedom. In addition, help of third parties for transportation and processing has to be enlisted.

However, there are other options. Affordability, for example, is another goal in this search for ‘new’ housing types. Costs can be reduced by allowing the residents to assemble their home themselves and by focusing on the usage of standardised building elements.

Adaptable and cheap building are the two most important aspects in creating a different perspective of the search for ‘new’ living forms. Modular building is a possible answer to this issue.

In this master’s dissertation, a modular component is developed that can be built without much technical know-how and professional tools. The component forms the basic structure and will contain the same capacity. This building component autonomously has a right to exist as a tiny house. The modules can be switched to a family home and larger configurations can also be achieved, such as multi-unit circuits (cohousing) and new apartment buildings.

Results

Solar Decathlon

Within this context, the Solar Decathlon competition is introduced for further developing this new housing type and spreading it to a wide audience. In the middle of December 2017, Ghent University was selected to participate. The competition will continue in July 2019 in Hungary with the aim of challenging students to think critically about how people can build and live in the future and also immediately translating these ideas into a pavilion.

Theme: renovation of apartment buildings

The competition is part of a renovation theme linked to the organising country. Team Ghent University, however, focused on the renovation of apartment buildings set up by the building firm Etrimo. This is one of the large contractors which prevailed the Belgian market from the 1950s to the 1970s and built one residential tower after another. Nowadays, the apartment blocks are outdated, energetically inefficient and no longer meet the current standards regarding fire safety, accessibility, etc. In addition, almost all apartments belong to different owners (private ownership), making total renovation of a building block difficult. The renovation is a complex process that is curbed by a number of practical, technical, financial, organisational and legal obstacles.



Figure 1. Etrimo-buildings in Breughel park, Zellik.

Transcription: from apartment to pavilion

This theme has a major influence on the development of the module. The pavilion for the competition is a conversion from a standard type Etrimo apartment into modules. The dimensions, manner of entry, terrace and the zoning between sleeping and living space on the one hand and the serving area with hallway, bathroom, (technical) storage room and kitchen on the other are all equally important.

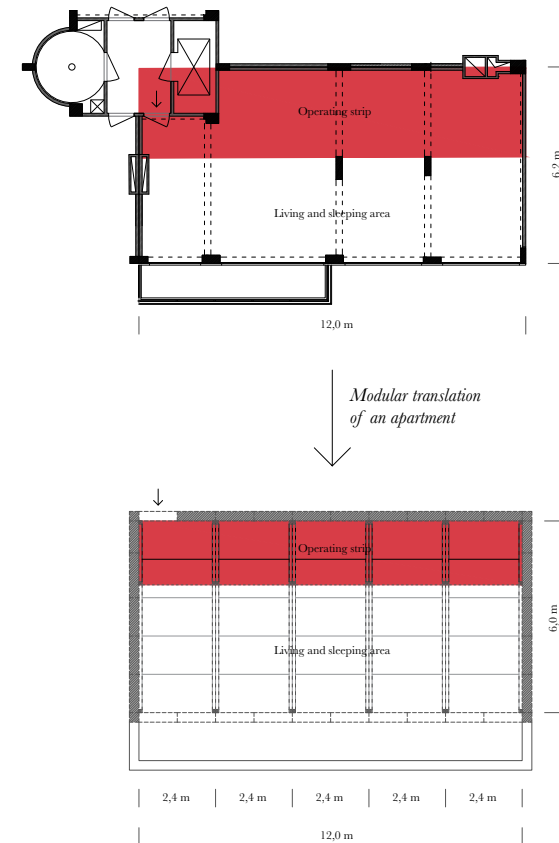


Figure 2. Transcription from apartment to pavilion.

Social relevance

The module is called the Mobble and stands for Modular Building Block.

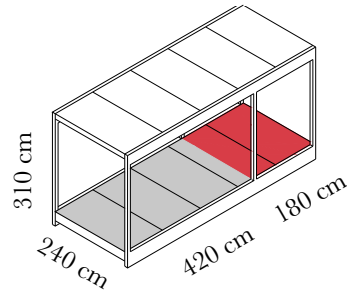


Figure 3. Isometry of the Mobble.

The pavilion consists of five Mobbles and demonstrates various renovation techniques and strategies. In addition, the Mobble is designed in such a way that the whole can be disassembled to the level of elementary building elements. In addition to the pavilion, the Mobble can be used for various purposes.

For example, one Mobble can serve as an emergency home, tiny house, informal care home in the garden, etc.

Depending on the size system of the Mobble, new 'intelligent' units can be developed. 'Intelligent' means that the building can carry another program without fundamental adjustments.

Mobbles can be used as rooftop apartments. By placing modules on the roof of the building to be renovated, residents can temporarily move to these module apartments and then return to their apartment after the renovations are complete. After that, all apartments will be refurbished in turn. The Mobbles on the roof will be retained after the renovation is complete. This is positive for

the densification of the cities because, following the renovation, the apartment building will contain more residential units.

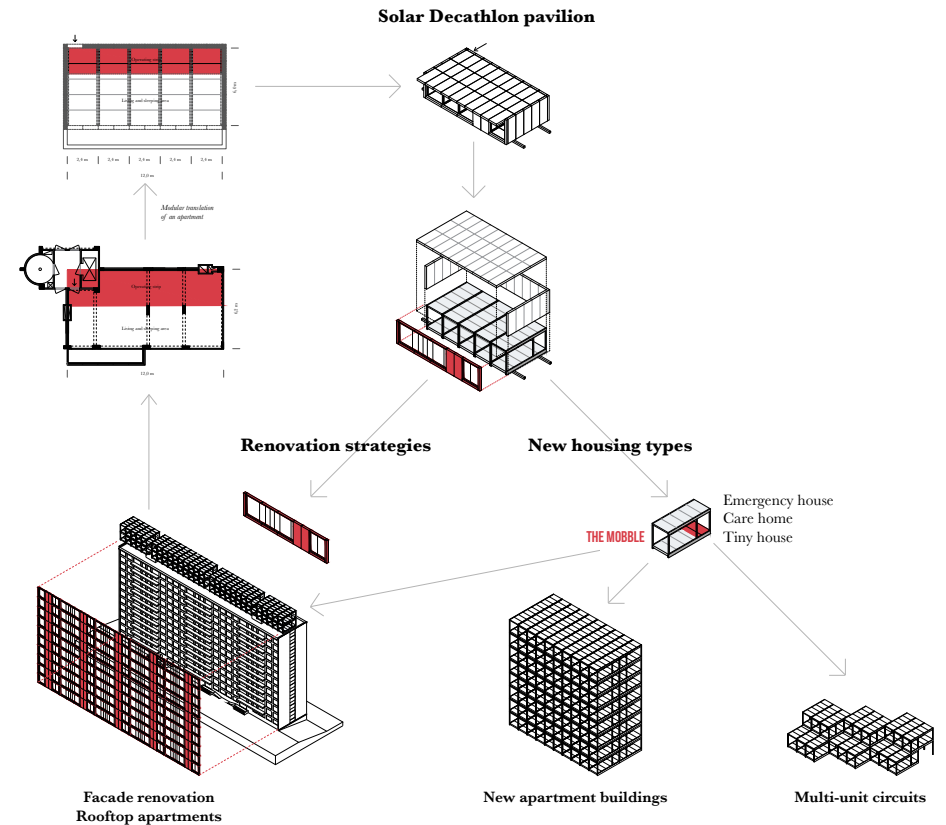


Figure 4. Schedule with the different purposes linked to pavilion.

Build up the Mobble

The Mobble is made up of two structural frameworks **1**. A frame is made of a five-layer stack of perforated plywood disks, cut from standard 1.22m x 2.44m plates. The two frames are set vertically straight and between them are the floor panels **2** and a layer of roof panels **3**.

The dimensions of a Mobble are: L6.0m x W2.4m x H3.1m. The length and width are multiples of 1.2m which are based on the standard width of typical sandwich panels. Another reason for the use of limited dimensions is that they are suitable for normal transport.

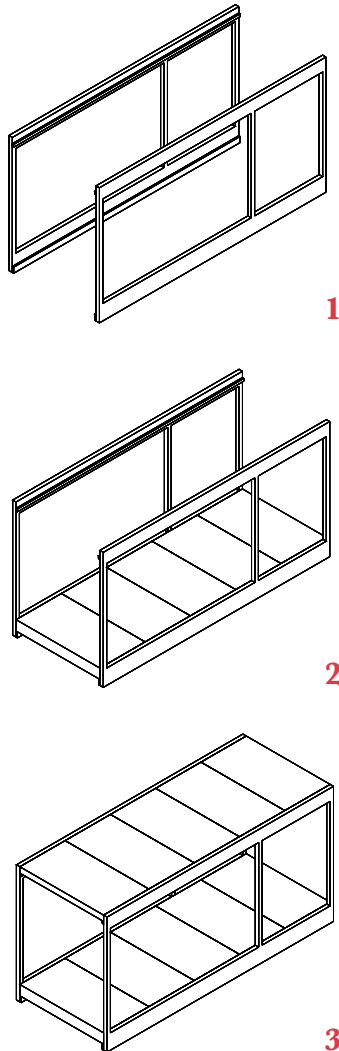


Figure 5. Build up of the Mobble.

Discussion and conclusion

The intervention of the Solar Decathlon competition has prevented further investigation into a modular building component. The Mobble is not the end result of the search, but a possible intermediate point for further research. The Mobble was created within the competition rules and the imposed renovation problems linked to the competition. Outside the context of the competition, the Mobble has room for improvement as a modular building component. Nevertheless, the extensive detailing of the module and the pavilion was an interesting by-product of the study to gain insights into the development of such modules.

An initial improvement to the Mobble could be an adjustment of the dimensions, taken directly from a standard Etrimo apartment. For more options when converting, it may be more interesting that the end of the module fits exactly three times in the longitudinal side. In this way, circuits can rotate 90°.

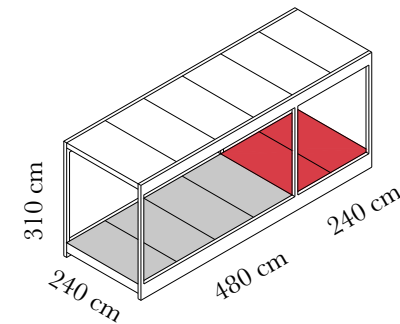


Figure 7. Isometry of the updated Mobble.

A further option is to disconnect the large and small zone. As a result, the modules can rotate with respect to each other, the building components acquire an autonomous character and more plan variants are possible.

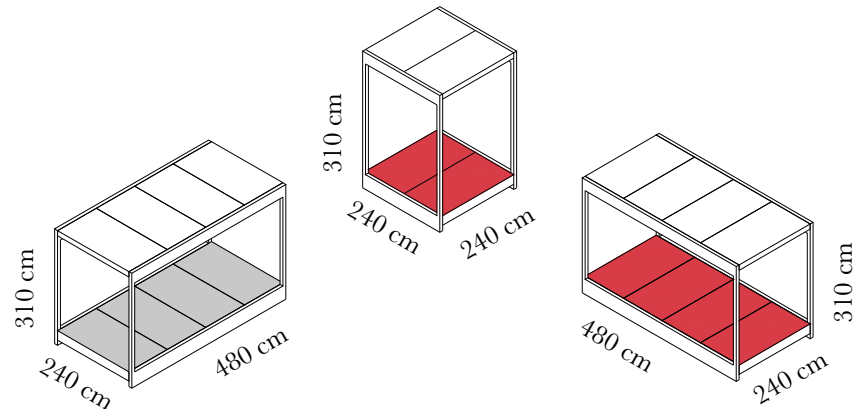


Figure 6. Isometry of the disconnected modules.

Hopefully this master's dissertation will encourage further research, 'intelligent' design and construction.

Trefwoorden: Modular building - Solar Decathlon - Adaptable building - The Mobble

[1] <http://deredactie.be/cm/vrtnieuws/binnenland/1.2910510>

[2] Nav. (2018). Vlaams bouwmeester vraagt proefproject met 'stapelwoningen'. Netwerk Architecten Vlaanderen. Geraadpleegd op 30 maart 2018 via <http://www.nav.be/artikel/1299/vlaams-bouwmeester-vraagt-proefproject-met-stapelwoningen/>

Inhoudstafel

Toelating tot bruikleen

Een bijzondere dank

Woord vooraf

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2.3 Solar Decathlon Europe 2019, Szentendre

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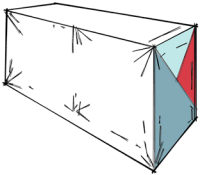
7 Hoofdstuk 7: Huisstijl

8 Hoofdstuk 8: Deliverable #1

8.1 Project Manual

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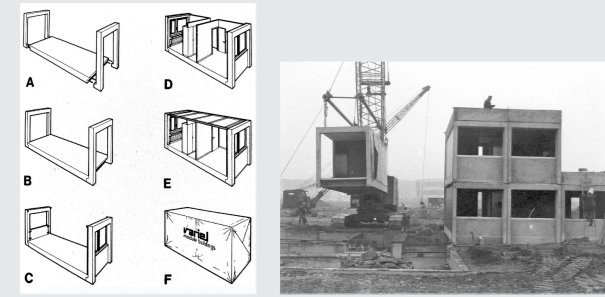
Onderzoek naar modulaire bouwcomponenten

Voorontwikkeling

Variel - Fritz Stucky

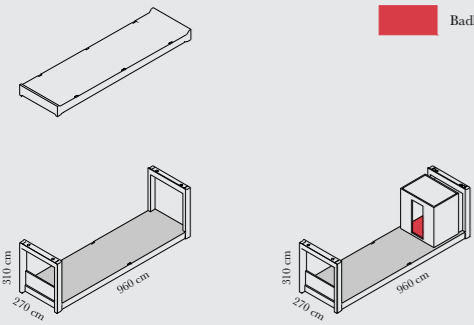
Prefabmodule in beton
1963

Kenmerken

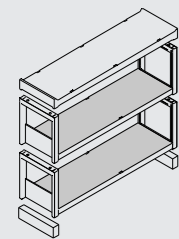


Bouwcomponenten

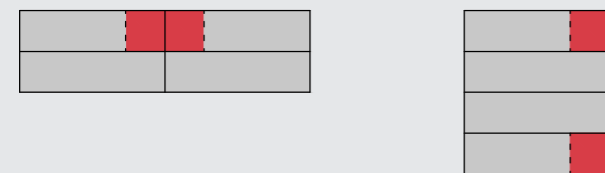
Leefruimte, slaapkamer, keuken
Badkamer



Stapelen



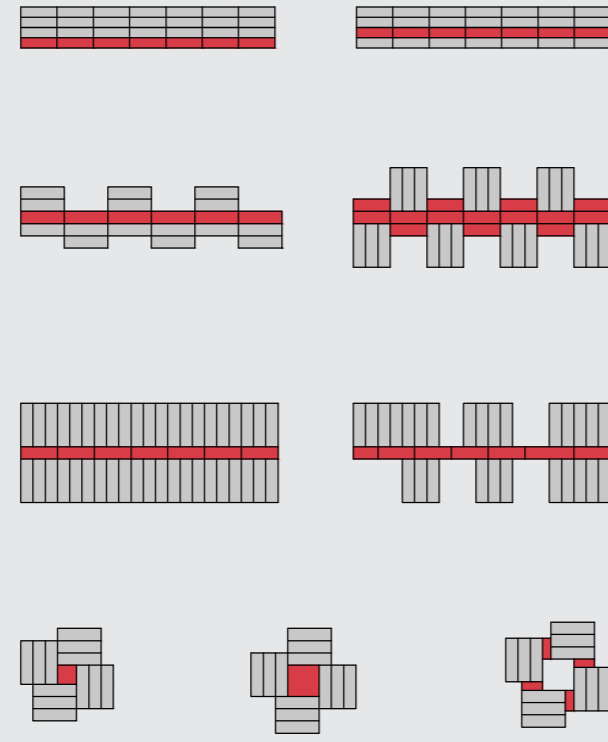
Toegepaste schakelingen door Willy Van Der Meeren aan de VUB
Vrije Universiteit Brussel, 1973



Masterstudio A

Herbruik van Variel met nieuwe dienende zone
Semester 1 - AJ 2016/2017

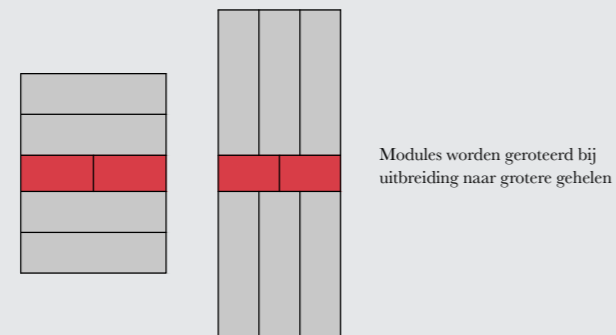
Haalbaarheidsstudie a.d.h. van woonmodellen



Stapelen

Herbruik Varielmodules - Programma: leven, slapen, werken
Nieuwe bedieningszone - Programma: technische ondersteuning

Paviljoen Solar Decathlon wedstrijd - Eenvoudige schakeling

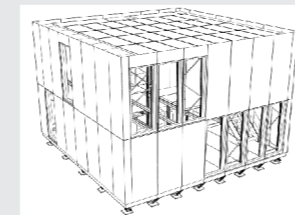


Atelier bouwtechniek

Prefabmodules in hout
Semester 2 - AJ 2016/2017

Invloeden

Denken in bouwelementen
Cfr. E-cube (SD11)



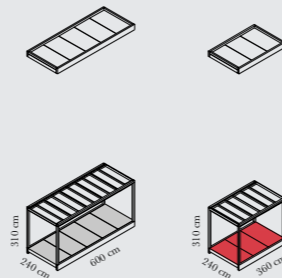
variel

Maakbaar door studenten
Doe-het-zelfprincipe

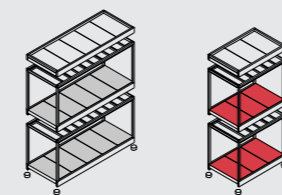


Bouwcomponenten

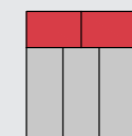
Leefruimte, slaapkamer, keuken
Badkamer, berging, trap



Stapelen



Basisschakeling



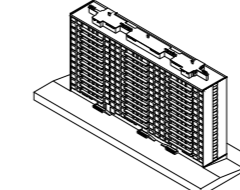
The Mobble

Solar Decathlon Europe 2019

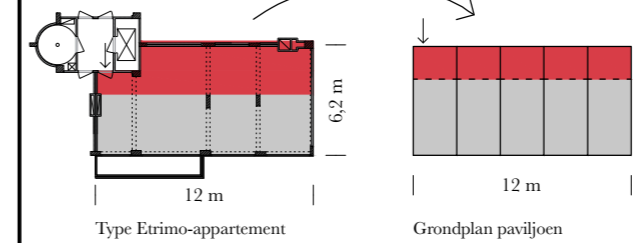
Prefabmodule in hout
Masterproef - AJ 2017/2018

Thematiek wedstrijd

solar decathlon europe
Renovatie van appartementsgebouwen

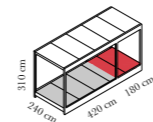


Modulaire transcriptie van een appartement

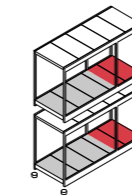


Bouwcomponent

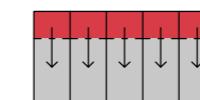
Leefruimte, slaapkamer
+ losse dakelementen
Badkamer, keuken, berging, trap



Stapelen

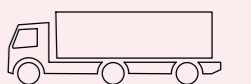
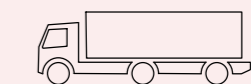


Basisschakeling



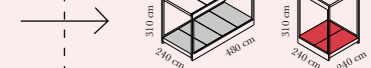
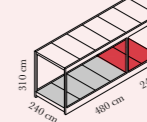
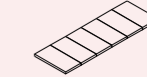
Doorontwikkeling

Kenmerken

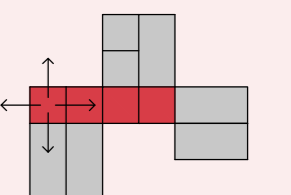
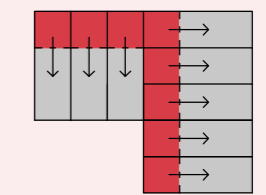
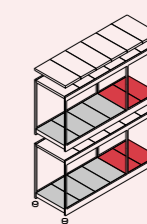


Bouwcomponent

Leefruimte, slaapkamer
Badkamer, keuken, berging, trap



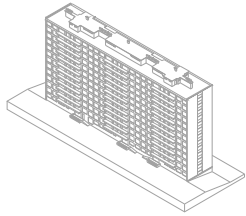
Stapelen



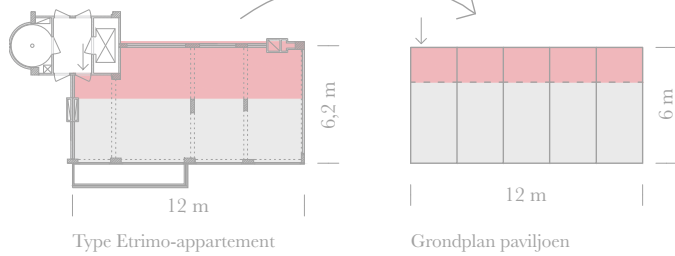
Thematiek wedstrijd

solar
decaathlon
europe

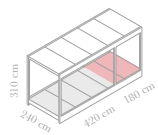
Renovatie van appartements-
gebouwen



Modulaire transcriptie van een appartement



Bouwcomponent

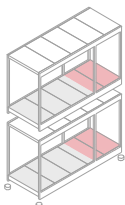


+ losse dakelementen

Leefruimte, slaapkamer

Badkamer, keuken, berging, trap

Stapelen



HOOFDSTUK

Referentiekader

INHOUDSTAFEL

1.1 Voorontwikkeling

Variel - Fritz Stucky

Masterstudio A - Herbruik van Variel

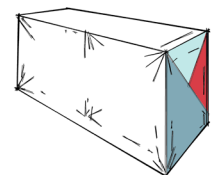
Atelier bouwtechniek - Prefabmodules in hout

1.2 The Mobble

1.3 Doorontwikkeling - Conclusie

WOORD VOORAF

De *Mobble* heeft een voorontwikkelingsfase en een mogelijke doorontwikkeling. De belangrijkste invloeden en beslissingsmomenten worden weergegeven in een schema met tijdslijn en verder gedocumenteerd en toegelicht in dit hoofdstuk.

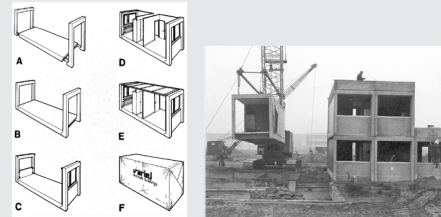


Variel - Fritz Stucky

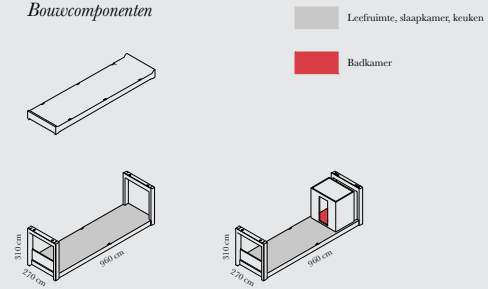
Prefabmodule in beton

1963

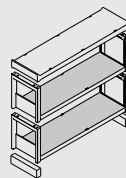
Kenmerken



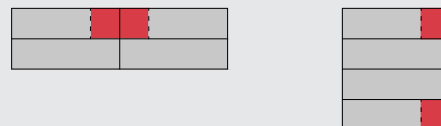
Bouwcomponenten



Stapelen



*Toegepaste schakelingen door Willy Van Der Meeren aan de VUB
Vrije Universiteit Brussel, 1973*



Hoofdstuk 1: Referentiekader

1.1 Voorontwikkeling

1.1.1 Variel - Fritz Stucky

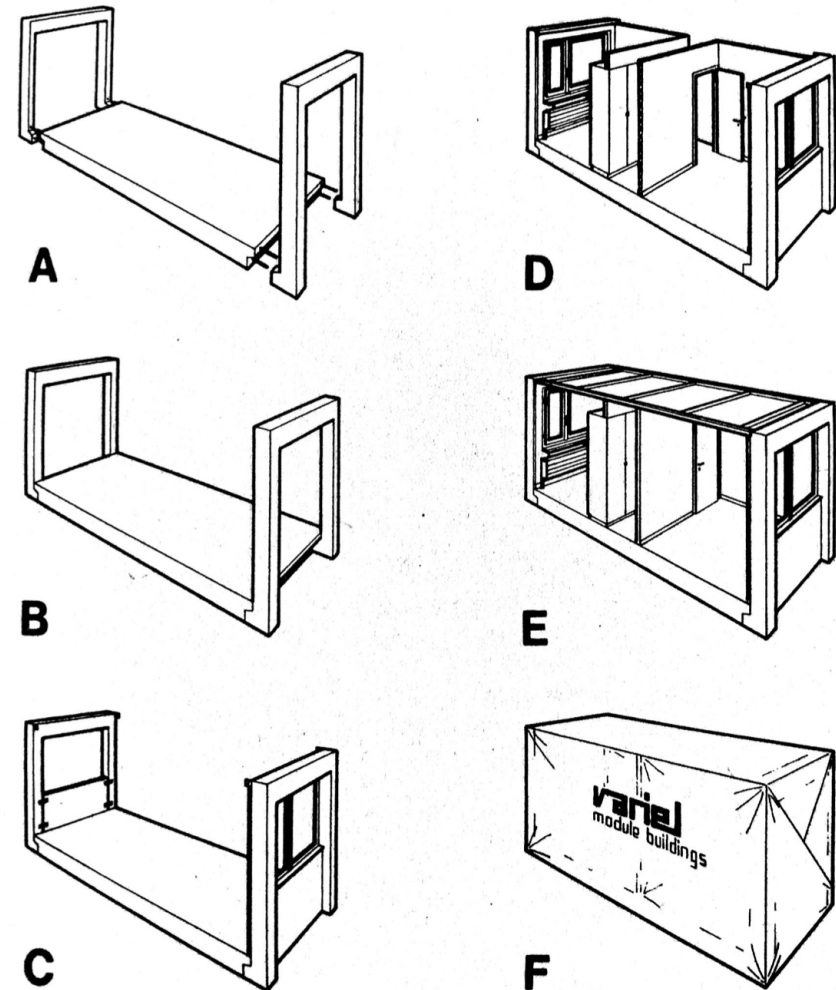
Prefabmodule in beton, 1965

Kenmerken

De Varielmodule is een geprefabriceerde bouweenheid en is ontwikkeld door de Zwitserse architect Fritz Stucky. Hij ontwerpt in 1958 een module (eerst in hout en later in staal) om grotere gehelen zoals woningen, scholen en kantoren op te bouwen. Vijf jaar later is ook een module in beton vervaardigd om in te kunnen spelen op de normen in brandveiligheid.

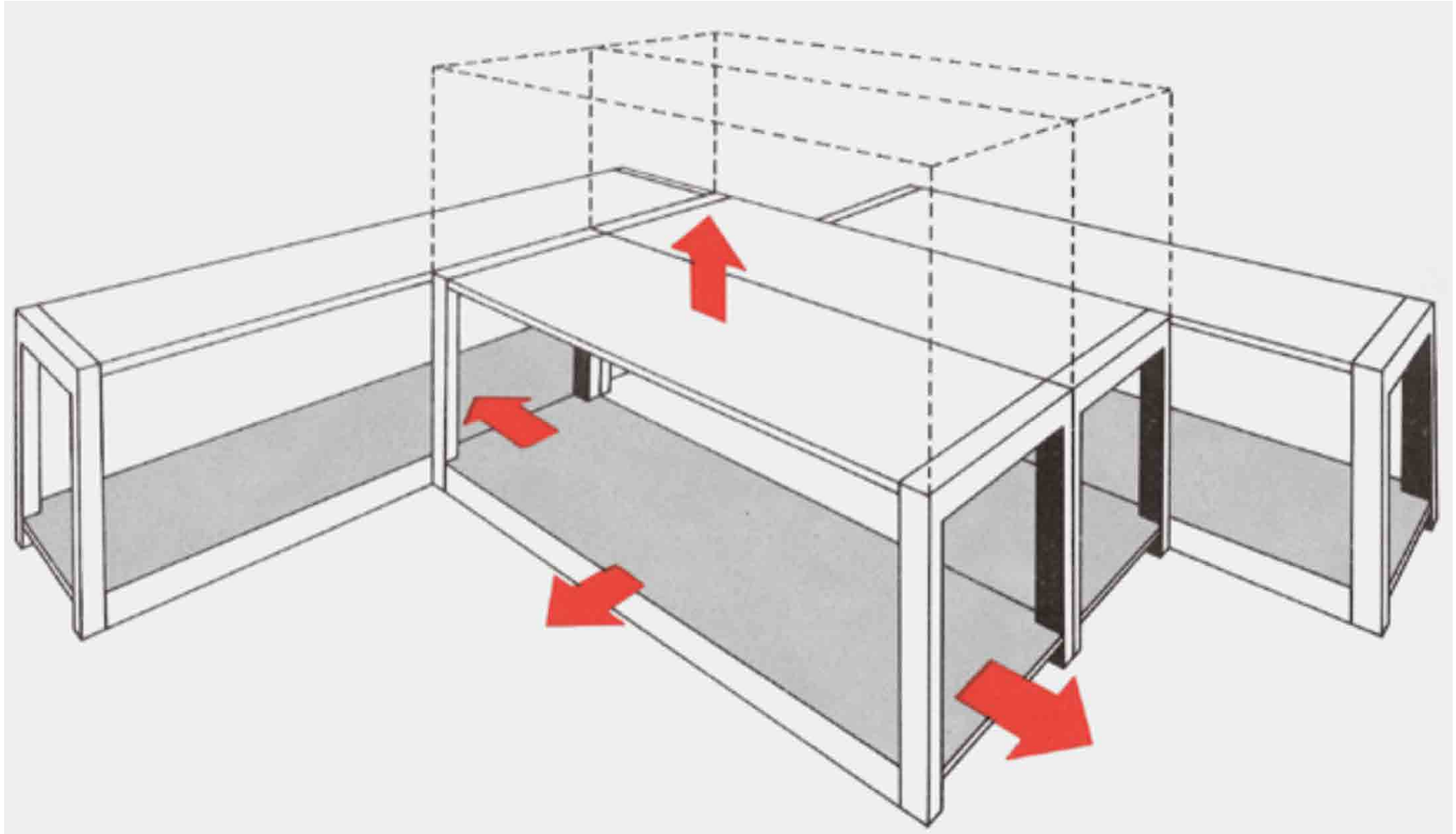
Stapelen met modules staat lijnrecht tegenover de klassieke manier van bouwen, d. i. alle bouwmaterialen naar de bouwplaats transporteren en alles ter plaatse assembleren. De Varielmodules worden in een werkplaats geprefabriceerd, ingericht en naar de bouwplaats vervoerd om daar het gebouw kamer per kamer, i.p.v. steen per steen op te bouwen. De hoge graad van prefabricatie in de productie zorgt voor een snelle en veilige bouwmethode op de werf.¹

De Varielmodule realiseert een open ruimte met vrije overspanning van bijna 10 meter. Varielmodules kunnen horizontaal geschakeld en gestapeld worden. Dit impliceert een grote flexibiliteit en aanpasbaarheid in de plattegrond.



Figuur 1. Opbouw van de Varielmodule. (Archiv Fritz Stucky, Zug)

¹ Jenatsch, G. Kamm, P. Krucker, B. Sieber, H. (2006). *Werk > Serie. Fritz Stucky: Architekt und Unternehmer*. Zürich: gta Verlag



Figuur 2. Uitbreidbaarheid bij de Varielmodule. (Private archive P.D.)



Figuur 3. De Varielmodule.

Toegepaste schakeling door Willy Van Der Meeren

Vrije Universiteit Brussel, 1973

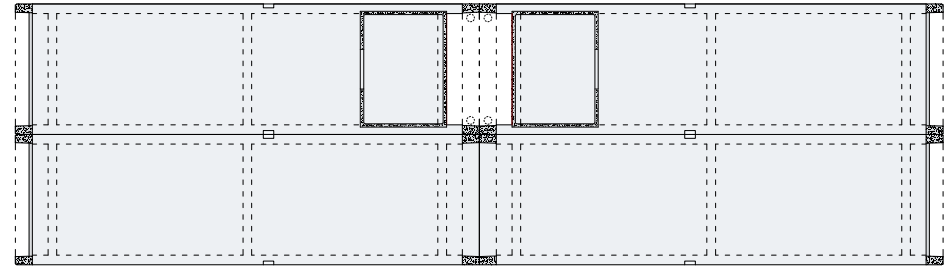
In 1973 heeft Architect Willy Van Der Meeren met de Varielmodules van Fritz Stucky studentenhomes gerealiseerd op de VUB-campus in Etterbeek. Vier modules worden gecombineerd tot een appartement voor vier studenten. Twee verschillende schakelingen zijn gemaakt. Deze schakelingen zijn gegroepeerd in vijf wijken met een eigen kleuraccent op de kopse wandpanelen.²

Een studie over de verschillende Varielmodules, die terug te vinden zijn op de VUB-campus, is reeds gemaakt in het kader van het Bijzonder Vraagstuk *Geschiedenis van de hedendaagse architectuur* in het academiejaar 2016/2017. Deze documenten tonen het werk van Matthias Van Hove en Ineke Tavernier en kunnen worden opgevraagd bij Prof. Mil De Kooning en Prof. Ronny De Meyer.

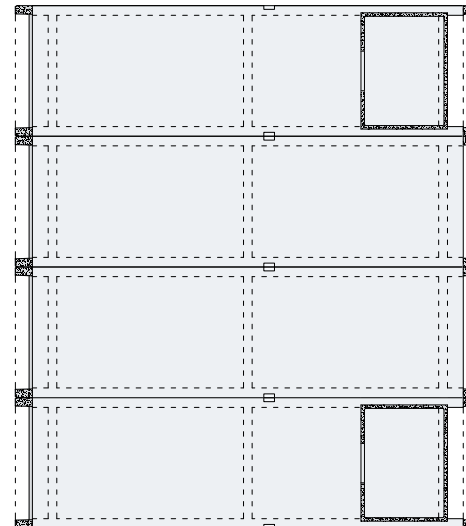


Figuur 4. Opbouw van de studentenhomes op de VUB-campus te Etterbeek (VUB Archiv).

² Van de Voorde, S. Wouters, I. Bertels, I. (2016). *Post-war housing in Brussels. Student homes by Willy Van Der Meeren on the VUB campus in Elsene 1971-1973*. Gent: Graphius Group.



Figuur 5. Schakeling 1 op de VUB-campus.



Figuur 6. Schakeling 2 op de VUB-campus.



Figuur 7. Uitzicht op de studentenhomes op de VUB -campus (VUB Archiv).



Figuur 8. Gebruik van de dakterrassen (VUB Archiv).



Figuur 9. Inplantingsplan van de studentenhomes op de VUB-campus.



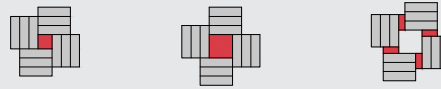
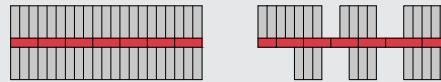
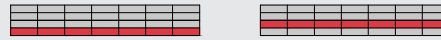
Figuur 10. Varielmodules op de VUB-campus.

Masterstudio A

Herbruik van Variel met nieuwe dienende zone

Semester 1 - AJ 2016/2017

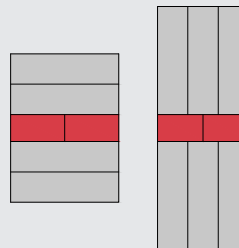
Haalbaarheidsstudie a.d.h. van woonmodellen



Herbruik Varielmodules - Programma: leven, slapen, werken

Nieuwe bedieningszone - Programma: technische ondersteuning

Paviljoen Solar Decathlon wedstrijd - Eenvoudige schakeling



Modules worden geroteerd bij uitbreiding naar grotere gehele

1.1.2 Masterstudio A

Herbruik van Variel met nieuwe dienende zone

Haalbaarheidsstudie a.d.h. van woonmodellen

De Varielmodule is in het kader van Masterstudio A (semester 1 - AJ 2016/2017) als 'intelligente' ruïne bestudeerd. Het opzet van deze studio is om een haalbaarheidsstudie aan de hand van verschillende woonmodellen te maken over de wijze waarop de Varielmodules kunnen worden herbruikt in combinatie met een nieuwe dienende zone. Deze zone bestaat uit transportabele containers die de technische installaties, badkamer, berging en trap bevatten.

Het documenteren van de resultaten van Masterstudio A van Matthias van Hove en Ineke Tavernier valt buiten het kader van deze masterproef maar kan opgevraagd worden bij Prof. Ronny De Meyer.

Paviljoen Solar Decathlon-wedstrijd - Eenvoudige schakeling

In Masterstudio A (AJ 2016/2017) is de *Solar Decathlon*-wedstrijd voor het eerst toegelicht en beslist dat Universiteit Gent zich inschrijft bij de eerstvolgende *Call for Teams*. De *Solar Decathlon* is een internationale studentenwedstrijd waarbij de teams elk een energie-efficiënt paviljoen bouwen.

Meer informatie over deze wedstrijd zie *Hoofdstuk 2: Solar Decathlon*.

Bij het ontwikkelen van woonmodellen met de Varielmodules diende er ook nagedacht te worden over een vereenvoudigde schakeling waaruit men een paviljoen kan filteren. Op dat moment was er nog geen wedstrijd uitgeschreven

maar een onderzoek naar modulaire componenten en het ontwikkelen van schakelingen kon reeds van start gaan.

De keuze om het paviljoen op te bouwen met modules komt voort uit de wedstrijdbeperking om de woning volledig te assembleren, van fundering tot interieur, in een periode van 10 dagen. Dit volgt ook uit de keuze om dit te doen met een beperkte groep studenten.

Atelier bouwtechniek

Prefabmodules in hout

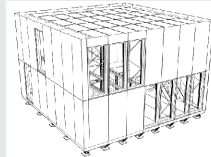
Semester 2 - AJ 2016/2017

Invloeden

variel

Denken in bouwelementen

Cfr. E-cube (SD11)



Maakbaar door studenten

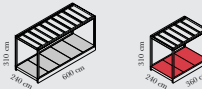
Doe-het-zelfprincipe



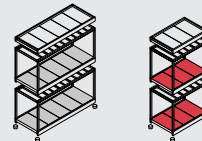
Bouwcomponenten

■ Leefruimte, slaapkamer, keuken

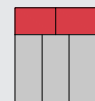
■ Badkamer, berging, trap



Stapelen



Basisschakeling



1.1.3 Atelier bouwtechniek *Prefabmodules in hout*

Inleiding

In het Atelier Architectuurontwerp en Bouwtechniek (semester 2 - AJ 2016/2017) is het opzet om een compacte, lichte module te ontwerpen. De conclusies uit de ontwikkelde woonmodellen uit Masterstudio A en een herinterpretatie van de Varielmodule liggen aan de grondslag van dit ontwerponderzoek. Het ontwerp van een nieuwe module kent een aantal invloeden die verder zijn beschreven.

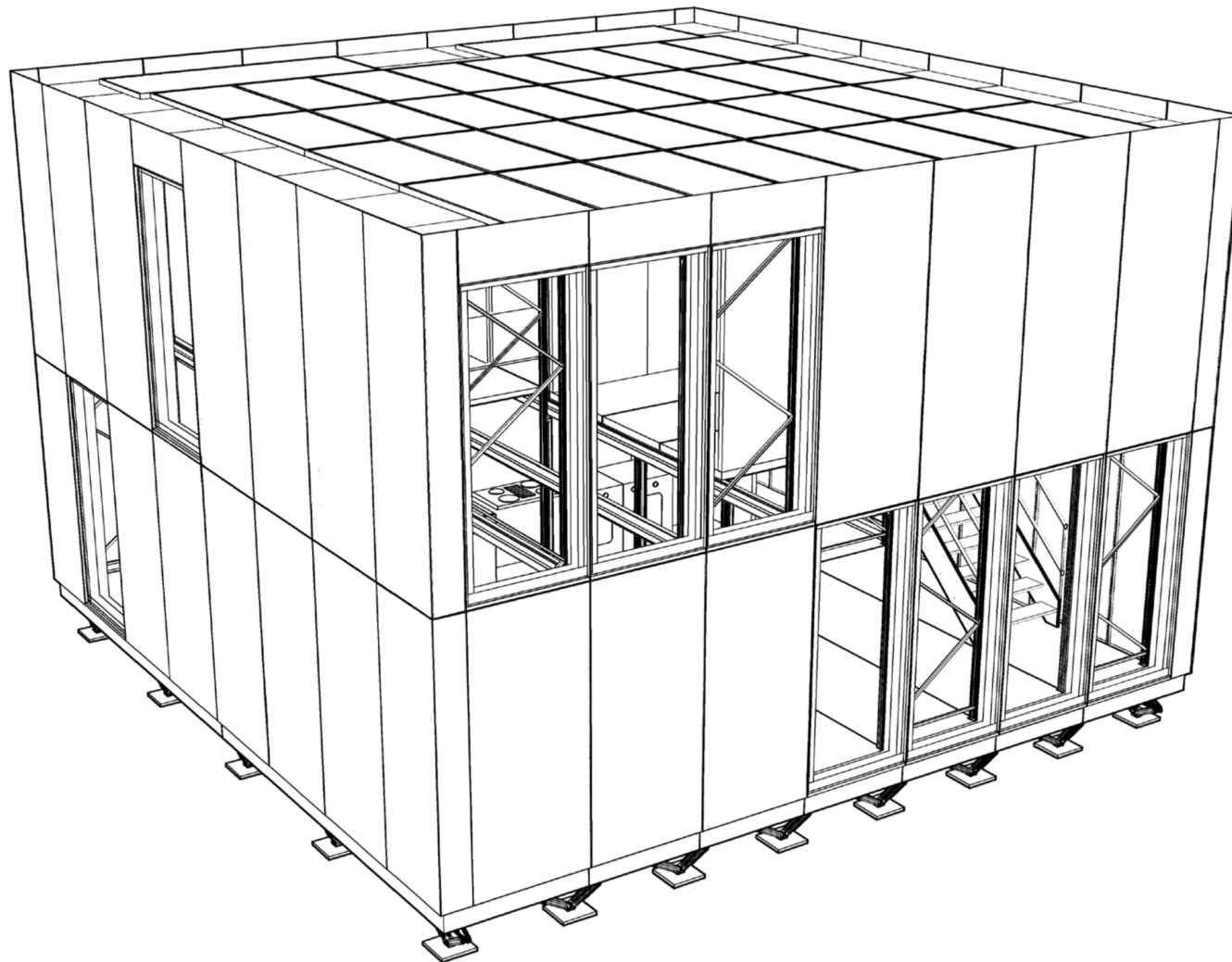
Invloeden

Variel - Onderzoek Masterstudio A

Het onderzoek naar een nieuwe module start bij een evaluatie van de Varielmodule. Het gewicht, het uitzonderlijk transport en de afmetingen maken de Varielmodule vandaag moeilijk handelbaar en moeilijk bruikbaar om er woningen van bescheiden omvang mee te bouwen. Niettegenstaande bevat deze module intrinsieke eigenschappen en concepten om verder te ontwikkelen. Volgende eigenschappen van de Varielmodule zullen worden overgenomen bij het ontwikkelen van een nieuwe modulaire bouwcomponent: volledige prefabricatie (incl. interieur), mogelijkheid tot aanpassen en uitbreiden in drie richtingen.

Bij de overstap van de Varielmodule naar een nieuwe module wordt gekozen voor hout i.p.v. beton. De voorkeur gaat uit naar hout vanwege de eenvoudige bewerkbaarheid van het materiaal door studenten alsook om thermische bruggen (eenvoudiger) te vermijden. De breedte van de module in hout bedraagt 2,40m. Er wordt gerekend met stappen van 1,20 m. De breedte van gevel-, vloer- en dakpanelen is telkens 1,20m.

Bij de Varielmodules die door Van Der Meeren aan de VUB gebruikt zijn, kan men twee soorten van modules met dezelfde afmetingen onderscheiden: een module mét ofwel zonder badkamer cel. Deze tweedeling wordt verder ontwikkeld bij de variant in hout.



Figuur 11. E-cube (De Loof P. J., Rottiers R., van de Walle D., 2011)

Transport

Er dient rekening gehouden te worden gehouden met de maximaal mogelijke afmetingen van het wegtransport. De modules mogen de maximumbreedte van 2,55m niet overschrijden als gevolg van de Europese wetgeving.³

E-cube, Solar Decathlon Washington D.C. 2011

De *E-cube* is de naam van het paviljoen van de deelname aan de *Solar Decathlon*-wedstrijd in Washington in 2011. De *E-cube* vertrekt vanuit een doe-het-zelf-standpunt. In het kader van de competitie moet de student zelf in staat zijn een bescheiden woning op te bouwen in een mum van tijd. De belangrijkste spelregel hiervoor is de beperking van het gewicht van de afzonderlijke elementen. Het denken in bouwelementen wordt meegenomen bij het ontwikkelen van een nieuwe module.⁴

Voor meer informatie over de *E-cube* wordt verwezen naar de masterproef *E-cube, Ontwerp en bouw van een nul-energiewoning* door Pieter Jan De Loof, Ruben Rottiers en Dietwin van de Walle.

Resultaat

De combinatie van Variel (= denken in modules) en de *E-cube* (= denken in bouwelementen) levert een nieuwe kijk op het onderzoek naar een modulaire bouwcomponent.

³ Neele-Vat Logistics. *Toegestane maximummaten en -gewichten*. Geraadpleegd op 9 oktober 2017 via <http://transportbelgie.info/maten-en-gewichten/>

⁴ De Loof, P.J., Rottiers R., van de Walle, D. *E-cube, Ontwerp en bouw van een nul-energiewoning*. Masterproef, 2011.

Er is geopteerd om met twee verschillende modules verder te ontwerpen, die verschillen in lengte en programma. In de lange module (L6,0m) huizen de programma's leven, slapen en werken. De andere module (L3,6m) bevat de badkamer, (technische) berging en trap.

Basisschakeling

Deze units geven door de keuze van hun afmetingen aanleiding om steeds configuraties te maken aan de hand van een vaste schakeling.

De relevantie van dit nieuwe maatsysteem moet worden getoetst. Dit gebeurt aan de hand van simulaties op één- tot vierslaapkamerwoningen alsook op schaal van appartementsgebouwen, cohousing, scholen en kantoren.

Het documenteren van de resultaten van het Atelier Architectuurontwerp en Bouwdetail van Sven De Turck en Ineke Tavernier valt buiten het kader van deze masterproef en kan opgevraagd worden bij Prof. Jan Moens.

Solar Decathlon Europe 2019

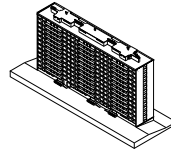
Prefabmodule in hout

Masterproef - AJ 2017/2018

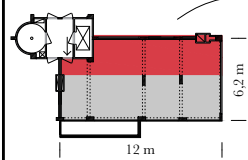
Thematiek wedstrijd



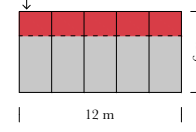
Renovatie van appartementsgebouwen



Modulaire transcriptie van een appartement

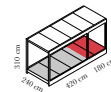


Type Etrimo-appartement



Grondplan paviljoen

Bouwcomponent

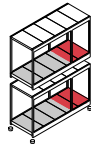


+ losse dakelementen

Leefruimte, slaapkamer

Badkamer, keuken, berging, trap

Stapelen



Basisschakeling



1.2 De Mobble - Solar Decathlon Europe 2019

Prefabmodule in hout

1.2.1 Solar Decathlon-wedstrijd en renovatiethematiek

De *Call for Teams* is gelanceerd op 14 juli 2017. De volgende editie gaat door in de zomer van 2019 in Szentendre, nabij Boedapest (Hongarije). SDE 2019 richt de aandacht op renovatie van appartementsgebouwen. Prof. Nathan Van Den Bossche en Marc De Kooning hebben beslist specifiek in te zetten op de renovatie van appartementen zoals opgericht door Etrimo. Dit is één van de grote aannemersbedrijven die in de jaren '50 tot '70 de Belgische markt domineerden. Deze onderneming bouwde de ene woontoren na de andere.

Meer informatie over de *Solar Decathlon*-wedstrijd zie *Hoofdstuk 2: Solar Decathlon*. Meer informatie over de gekozen thematiek zie *Hoofdstuk 3: Renovatie van Etrimo-appartementsgebouwen*.

1.2.2 Start ontwikkeling paviljoen en application documents

Begin augustus 2017 is gestart met wekelijkse vergaderingen en begeleidingen om de *application documents* (= de kandidatuurstelling om geselecteerd te worden) op te stellen en de *Mobble* te ontwikkelen: een modulaire component die als basis dient voor het paviljoen. Uiteraard wordt hiervoor ook teruggegrepen naar het reeds geleverde werk uit Atelier Architectuurontwerp en Bouwdetail.

De *Mobble* is een modulaire bouwcomponent die zonder technische voorkennis, ervaring of professionele gereedschappen kan worden samengesteld.

Net zoals met Varielmodules verschillende types van gebouwen kunnen gemaakt worden is de *Mobble* inzetbaar voor verschillende doeleinden.

- Het paviljoen, dat bestaat uit vijf *Mobbles*, is een transcriptie van een Etrimo-appartement (= wedstrijdvrage) en laat toe verschillende renovatietechnieken en -strategieën te demonstreren.
- Een *Mobble* kan dienst doen als noodwoning, *tiny house*, mantelzorgwoning in de tuin, enz.
- Aan de hand van het maatsysteem van de *Mobble* kunnen nieuwe 'intelligente' gehelen worden ontwikkeld. Met 'intelligent' wordt bedoeld dat de structuur van het gebouw de tand des tijds kan doorstaan en dat het gebouw zonder fundamentele aanpassingen een ander programma kan dragen.
- *Mobbles* kunnen ingezet worden als *rooftop apartments*. Door modules op het dak van het te renoveren gebouw te plaatsen kunnen bewoners tijdelijk verhuizen naar deze module-appartementen om dan terug te keren naar hun appartement na de verbouwingen. Daarna zijn de volgende bewoners aan de beurt tot alle appartementen zijn aangepakt. De *Mobbles* op het dak worden na de renovatie behouden. Dit is gunstig voor de verdichting van de steden, want na afloop van de renovatie zal het appartementsgebouw meer wooneenheden bevatten.

Meer informatie zie *Hoofdstuk 4: The Mobble*.

Meer informatie zie *Hoofdstuk 5: Selectiedocumenten*.

1.2.3 Technische uitwerking

Varianten op de plattegrond

De maatvoering van de nieuwe module wordt getoetst aan de hand van varianten op de plattegrond van het paviljoen. Hiermee wordt de veelzijdigheid, de aanpasbaarheid en de brede inzetbaarheid van het paviljoen aangetoond.

Meer informatie zie *Hoofdstuk 6: 6.1.1 Varianten op de plattegrond*.

Een gelijkaardig onderzoek op de herindeling van Etrimo-appartementen is reeds gemaakt. Het documenteren van de resultaten van het Bijzonder Vraagstuk *Bouwtechniek* (AJ 2016/2017) van Sara Claerhout, Eva Denys, Hannah De Vidts, Egeleen Romaen en Eline Van Herzele valt buiten het kader van deze masterproef maar kan opgevraagd worden bij Prof. Nathan Van Den Bossche.

In Masterstudio A (AJ 2017/2018) krijgen studenten de opportuniteit om mee in te stappen in het *Solar Decathlon*-verhaal. De opdracht is om aan de hand van het maatsysteem van de *Mobble* grotere gehelen te ontwikkelen en na te gaan wat de relevantie is van het maatsysteem aan de hand van verschillende modellen voor middelhoog- en hoogbouw. Het geleverde werk wordt verzameld en zal tentoongesteld worden in het paviljoen.

Het documenteren van de resultaten van Masterstudio A (AJ 2017/2018) van Bjorn Pieters, Febe Lanckmans en Laura Landuyt valt buiten het kader van deze masterproef maar kan opgevraagd worden bij Prof. Ronny De Meyer.

Detaileren

Meer informatie zie *Hoofdstuk 6: 6.1.2 Ontwerpkeuzes, grondplannen en doorsnedes.*

Uitvoeringstekeningen

Naast het detaileren zijn er ook bundels met uitvoeringstekeningen en stuklijsten opgemaakt om duidelijk weer te geven hoe het paviljoen stap voor stap moet worden opgebouwd. De bouw van het paviljoen wordt gestart begin van volgend academiejaar (2018/2019).

Meer informatie zie *Hoofdstuk 6: 6.2.1 Kader.*

Meer informatie zie *Hoofdstuk 6: 6.2.2 Stuklijst panelen.*

Meer informatie zie *Hoofdstuk 6: 6.2.3 Stuklijst fundering, balkon en helling.*

Meer informatie zie *Hoofdstuk 6: 6.2.4 Steunhaken.*

Meer informatie zie *Hoofdstuk 6: 6.2.5 Buitenschrijnwerk.*

Interieur

Het ontwerp van het interieur is in ontwikkeling. De scheidingswand tussen de dienende zone en de bediende zone bestaat uit schuifpanelen waarop informatie over de *Mobble* en het onderzoek erond grafisch kan worden tentoongesteld. Een link naar het schoolbord is niet veraf. Daarnaast zijn er meubelementen die instaan voor de distributie van de technieken. Deze meubelementen zijn momenteel in ontwikkeling en zullen bestaan uit componenten die een verschaling van de *Mobble* voorstellen.

Tenslotte is reeds een teststuk gemaakt van de *Petite Potence wall lamp* van Jean Prouvé om een stempel te drukken op de tijdsgeest die het paviljoen kenmerkt. De knipoog naar de industriële manier van bouwen van de jaren '50-'70 wordt daardoor in de verf gezet. Deze lamp is gekozen vanwege de zoektocht naar een ultieme, vanzelfsprekende eenvoud. Zo zullen de meubelen ook verwijzen naar de wandmeubelen van Charlotte Perriand.

Meer informatie zie *Hoofdstuk 6: 6.3 Interieur.*

1.2.4 Wedstrijdgerelateerde opdrachten

Binnen het kader van de wedstrijd is het ook belangrijk een logo, naam en beeld te ontwerpen om bekendheid en herkenbaarheid te bedingen. In het logo zit een knipoog naar de Varielmodule die aan de grondslag ligt van de *Mobble*. De doos komt terug op de voorkant van het boek over Variel *Werk > Serie*.

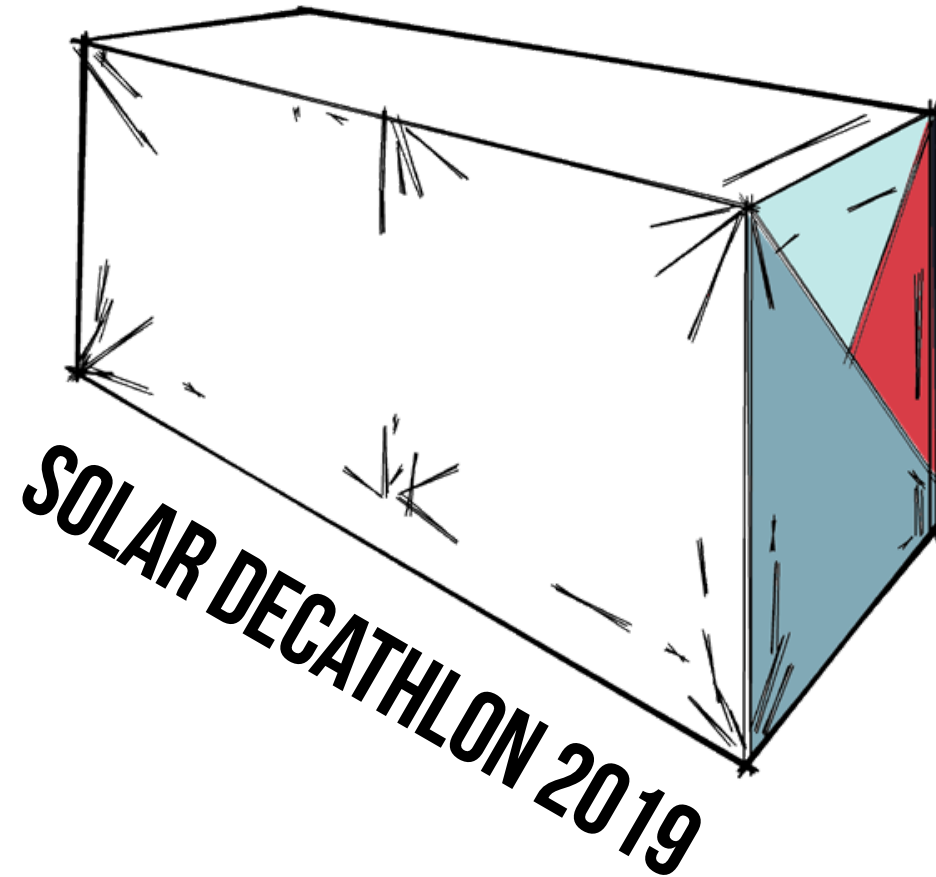
Meer informatie zie *Hoofdstuk 7: Huisstijl*.

Op bepaalde tijdstippen moet elk team een aantal documenten versturen naar de organisatie van de wedstrijd. Dit worden de *deliverables* genoemd. Er zijn in totaal zeven *deliverables* waarvan de eerste reeds op 30 maart 2018 is verzonden.

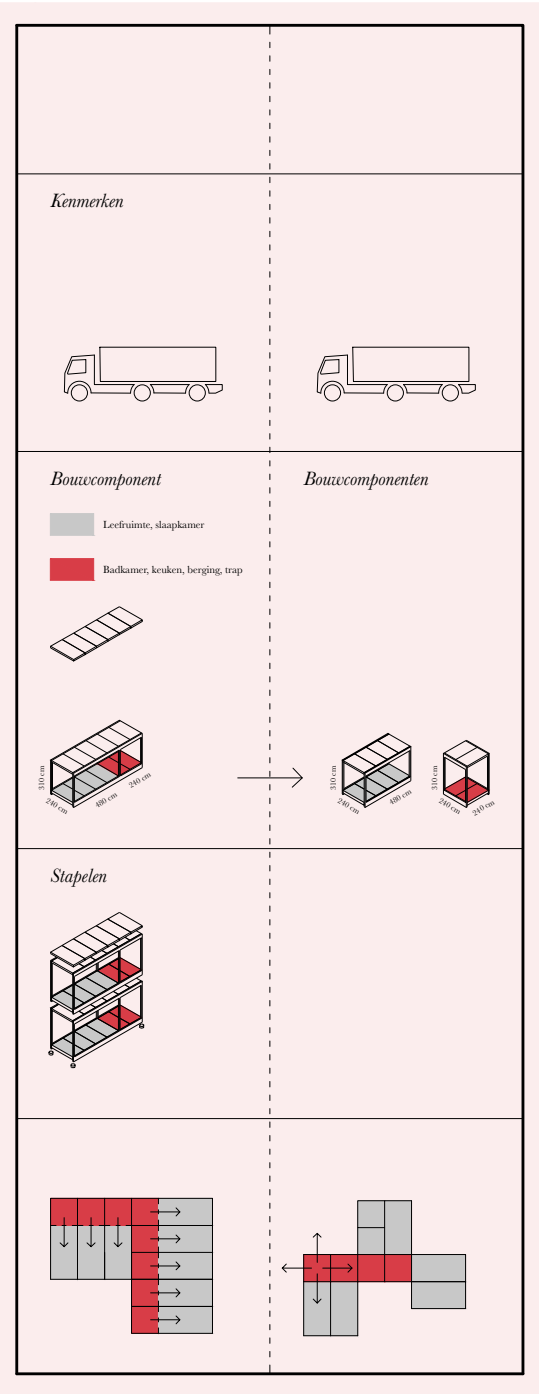
Meer informatie zie *Hoofdstuk 8: Deliverable #1*.

Naast de *deliverables* zijn er nog de online meetings en de workshops. In de tabel rechts is een overzicht te vinden over alle belangrijke momenten in het *Solar Decathlon*-verhaal. De rode streep geeft de stand van zaken weer.

Webinar #1	27/02/2018
Deliverable #1	30/03/2018
Workshop #1	25 - 27/04/2018
Deliverable #2	30/07/2018
Webinar #2	11/09/2018
Deliverable #3	02/11/2018
Workshop #2	3 - 7/12/2018
Deliverable #4	01/03/2019
Deliverable #5	26/04/2019
Deliverable #6	31/05/2019
Truck Arrival	29 - 30/06/2019
Assembly	1 - 10/07/2019
Rest Day	11/07/2019
Opening Ceremonies	12/07/2019
Competition Days	13 - 27/07/2019
Closing Ceremonies	28/07/2019
Extended Exhibition	29/07/2019 - 29/09/2019
Disassembly	30/09/2019 - 05/10/2019
Deliverable #7	25/10/2019



Figuur 13. Logo.



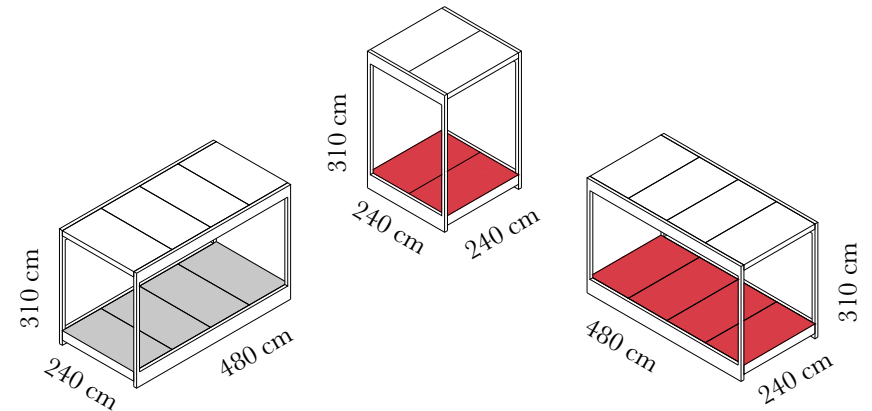
1.3 Doorontwikkeling

De tussenkomst van de *Solar Decathlon*-wedstrijd heeft het verdere onderzoek naar een modulaire bouwcomponent voorlopig beëindigd. De *Mobble* is niet het eindresultaat van de zoektocht maar een mogelijk tussenpunt voor verder onderzoek. De *Mobble* is tot stand gekomen binnen de wedstrijdregels en de opgelegde renovatieproblematiek van de wedstrijd. Buiten de context van de wedstrijd heeft de *Mobble* als modulaire bouwcomponent ruimte voor verbetering. Niettegenstaande is het vergaand detailleren van de module en het paviljoen een leerrijk zijspoor van het onderzoek geweest om inzichten te verwerven in het ontwikkelen van dergelijke modules.

Een eerste verbetering aan de *Mobble* zou een aanpassing van de afmetingen, rechtstreeks overgenomen van een standaard Etrimo-appartement, kunnen zijn. Voor meer mogelijkheden bij het schakelen is het wellicht interessanter dat de kopse zijde van de module exact drie keer past in de langse zijde. Op die manier kunnen schakelingen 90° roteren.

Een volgende mogelijke stap is het loskoppelen van de dienende en bediende zone. Hierdoor kunnen de modules t.o.v. elkaar roteren, verkrijgen de bouwcomponenten een autonoom karakter en zijn meer planvarianten mogelijk.

Hopelijk zet deze masterproef aan tot verder onderzoek en tot ‘intelligent’ ontwerpen en bouwen.



Figuur 14. Isometrie van de losgekoppelde modules.

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Van de Voorde, S. Wouters, I. Bertels, I. (2016). *Post-war housing in Brussels. Student homes by Willy Van Der Meeren on the VUB campus in Elsene 1971-1973*. Gent: Graphius Group.

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Info Transport België

Neele-Vat Logistics. Toegestane maximummaten en -gewichten. Geraadpleegd op 9 oktober 2017 via <http://transportbelgie.info/maten-en-gewichten/>

Studie

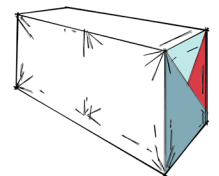
De Loof, PJ., Rottiers R., van de Walle, D. *E-cube, Ontwerp en bouw van een nul-energiewoning*. Masterproef, 2011.

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Brussels, VUB Archive, *Algemene bouwonderneming Van Riel & Van Den Bergh N.V., Dagboek der werken (10.10.1972–14.12.1973)*.

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2

HOOFDSTUK

Solar Decathlon

WOORD VOORAF

Alles wat je moet weten over de *Solar Decathlon*-wedstrijd.

INHOUDSTAFEL

2.1 Wedstrijd

Wat

Doel

Verloop

2.2 Vorige deelnames

E-cube, 2011

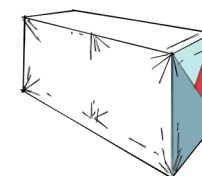
Solatrium, 2013

2.3 *Solar Decathlon Europe* 2019, Szentendre

Europese editie

Opgelegde thematiek wedstrijd

Specifieke thematiek





Figuur 1. Door studenten gebouwde huizen aangedreven door zonne-energie tentoongesteld in Washington D.C. op de Solar Decathlon 2009. (NREL, 2009)

Hoofdstuk 2: Solar Decathlon (SD)

2.1 Wedstrijd

Wat

De *Solar Decathlon* is een internationale studentenwedstrijd op academisch niveau. Hierbij worden universiteiten over heel de wereld uitgedaagd om een duurzaam en energie-efficiënt paviljoen te ontwerpen en te bouwen.

De oorsprong van de *Solar Decathlon*-wedstrijd ligt in de Verenigde Staten in 2002, waar hij toen georganiseerd werd door *The United States Department of Energy*. Sindsdien vond de wedstrijd om de twee jaar plaats in de Verenigde Staten. Ondertussen wordt de *Solar Decathlon* wereldwijd georganiseerd: Europa (2010, 2012, 2014, 2019), China (2013, 2017), Latijns-Amerika (2015) en Afrika (2019).¹

Doel

The United States Department of Energy heeft deze wedstrijd ontwikkeld om mensen bewust te maken van en te informeren over energieverbruik, duurzame en energie-efficiënte technologieën en hernieuwbare energie. Hierbij worden studenten gestimuleerd om creatief te denken en innoverende oplossingen te zoeken.

¹ *The U.S. Department of Energy, About Solar Decathlon. Geraadpleegd op 20 november via <https://www.solardecathlon.gov>*

Verloop

Fase I: Vooronderzoek en ontwikkeling (augustus 2017)

Binnen de door de organisatie opgelegde renovatiethematiek, wordt een maatschappelijk relevante problematiek gekozen, gelinkt aan het land van herkomst van het deelnemend team. Vervolgens kan het onderzoek naar innoverende ideeën en de ontwikkeling van een intelligent ontwerp voor het paviljoen van start gaan.

Selectie (december 2017)

Midden december is bekendgemaakt dat de Universiteit Gent geselecteerd is voor de volgende *Solar Decathlon Europe* in 2019 in Szentendre, Hongarije.

Fase II: Uitwerking (februari 2018 - juni 2018)

In deze fase ligt de focus op de ontwikkeling van het paviljoen. De constructieve architecturale plannen en innoverende technische installaties worden uitgewerkt.

Fase III: Bouwen van het paviljoen (september 2018 - juni 2018)

In de derde fase wordt het definitieve paviljoen opgebouwd en worden de technische installaties ingebouwd. Hierna wordt het paviljoen in componenten uit elkaar gehaald en is het klaar voor transport naar Hongarije.

Fase IV: Transport en opbouw paviljoen (juli 2019)

Tijdens deze fase van de wedstrijd worden de verschillende paviljoenen van elk geselecteerd team in een *Solar Village* geconstrueerd in Hongarije.

Na een opbouwperiode van tien dagen, worden de paviljoenen gedurende een langere periode opengesteld voor het publiek.

Fase V: Wedstrijd (juli 2019)

Elk team wordt tijdens deze periode beoordeeld op basis van tien criteria, waarbij per thema 100 punten kunnen worden verdiend.

De tien beoordelingscriteria zijn:

- Architecture;
- Engineering & Construction;
- Energy efficiency;
- Communication & Social Awareness;
- Neighbourhood Integration & Impact;
- Innovation & Viability;
- Circularity & Sustainability;
- Comfort Conditions;
- House Functioning;
- Energy Balance.

2.2 Vorige deelnames

E-cube, 2011

In 2011 nam de Universiteit Gent voor het eerst deel aan de vijfde editie van de *Solar Decathlon*-wedstrijd, te Washington D.C. (USA). *Team Belgium* verdedigde met de ‘*E-cube*’ (naam van het paviljoen) daarmee ook de Europese eer.

De *E-cube* stelt een kubusvormige woning voor met de nadruk op betaalbaarheid en het ‘doe-het-zelf’-karakter. *Team Belgium* was winnaar van het onderdeel *Affordability*.

Solatrium, 2013

Twee jaar later maakte Universiteit Gent deel uit van het internationale *BEMANY*-team, wat een samenwerking was tussen de UGent en twee Amerikaanse universiteiten: Worcester Polytechnic Institute en Polytechnic Institute of New York University. Dit team deed mee aan de SD in 2013 in Datong (China).

De basispijlers, nl. een op zonne-energie aangedreven huis rond een centraal atrium, verklaren meteen waar de naam *Solatrium* van het paviljoen vandaan komt. Team *BEMANY* eindigde op een mooie achtste plaats.²

² *Horizon, Solar Decathlon. Geraadpleegd op 20 augustus 2017 via <http://www.horizon-ugent.be>*



Figuur 2. Opbouw van de E-cube in Washington D.C. (Toon Vermeir, 2011)



Figuur 4. Solatrium in Datong (Tine Lanssens, 2013)



Figuur 3. E-cube in Washington D.C. (Toon Vermeir, 2011)



Figuur 5. Solatrium in Datong (Tine Lanssens, 2013)



Figuur 6. Etrimo-appartementsgebouw in Breughelpark, Zellik.

2.3 *Solar Decathlon Europe 2019, Szentendre*

Europese editie

Het is de eerste keer dat Universiteit Gent meedoet aan de Europese editie van de *Solar Decathlon*-wedstrijd. Bij de Europese editie (versus Amerikaanse editie) wordt de klemtoon gelegd op een maatschappelijke problematiek in een stedenbouwkundige context die typisch is voor Europa.

Opgelegde thematiek wedstrijd

SDE19 focust op de renovatie van bestaande gebouwen. Teams kunnen één van de volgende onderwerpen kiezen:

- Renovatie van Hongaarse rechthoekige appartementsgebouwen;
- Ontwikkelen van *rooftop apartments*;
- Een renovatieproject dat typisch is voor het land van herkomst.³

Team Ghent University focust op het laatste voorstel.

Specifieke thematiek

De aanpak van *Team Ghent University* viseert de vele, quasi identieke, appartementsgebouwen die onder meer opgetrokken zijn door de firma Etrimo in de jaren '50 - '70 aan de rand van vele Belgische steden. Deze appartementsblokken zijn vandaag aan grondige renovatie toe en dit blijkt een niet zo eenvoudige opdracht te zijn. Universiteit Gent heeft in 2016 een uitgebreid kennis- en onderzoeksplatform opgericht over deze renovatieproblematiek: *Horizon*. (www.horizon-ugent.be)



Figuur 7. Etrimo-appartementsgebouw in Breughelpark, Zellik.

³ EMI. *Call for Teams*. Geraadpleegd op 2 augustus 2017 via <http://solardecathlon.eu>

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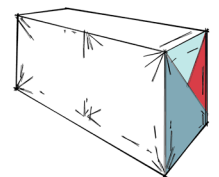
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National Renewable Energy Laboratory (NREL), (2009). *Photo taken by Richard King, Director of the U.S. Department of Energy Solar Decathlon*. Geraadpleegd op 16 november 2017 via https://en.wikipedia.org/wiki/Solar_Decathlon

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HOOFDSTUK

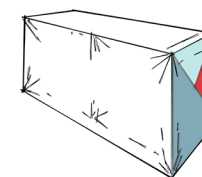
Renovatie van Etrimo- appartement- gebouwen

INHOUDSTAFEL

- 3.1 Voorgeschiedenis
- 3.2 Huidige problemen
- 3.3 Organisatie Etrimo-plattegrond

WOORD VOORAF

Het paviljoen stelt een appartement voor en zal strategieën demonstreren om de appartementsgebouwen, die in de jaren '50 - '70 door de firma Etrimo zijn gebouwd, te renoveren.





Figuur 1. Etrimo-apartmentsgebouwen in Breughelpark, Zellik.

Hoofdstuk 3: Renovatie van Etrimo-appartementsgebouwen

3.1 Voorgeschiedenis

Tijdens de Tweede Wereldoorlog werden vele woningen vernietigd. Samen met de naoorlogse *babyboom* zorgde dit voor een grote woningnood in België. Om deze situatie het hoofd te bieden, werd het repetitieve hoogbouwmodel veelvuldig toegepast.

Deze industriële bouwmethoden maakten het mogelijk om een grote hoeveelheid woningen te realiseren op korte tijd. Vergeleken met de huizen van voor de oorlog vertoonden deze woningen een hele verbetering op het vlak van hygiëne en leefbaarheid.

Eén van de grote aannemersbedrijven die in de jaren '50 tot '70 de Belgische markt domineerden, was de firma Etrimo. Het bouwbedrijf zorgde voor een revolutie binnen de woningbouw door een aantrekkelijke formule aan te bieden volgens een sleutel-op-de-deur-concept. Deze onderneming bouwde woontorens met een minimum aan architecturale kwaliteiten. Door verregaande standaardisatie van zowel woontypologieën, structuur als gebruikte materialen was het mogelijk om op een zeer korte tijd een groot aantal projecten te realiseren.¹

¹ Cleemput, E. en De Pauw, J. *Solar Decathlon: ontwerpend onderzoek naar renovatiestrategieën van Etrimo woontorens. Masterproef, 2015.*

3.2 Huidige problemen

De appartementsblokken zijn verouderd, energetisch inefficiënt en voldoen niet meer aan de huidige normen inzake brandveiligheid, toegankelijkheid, enz. Daarnaast behoren bijna alle appartementen aan verschillende eigenaars (private eigendom), waardoor totaalrenovatie van een bouwblok moeilijk is. De renovatie van deze woningen is een zeer complex proces dat afgeremd wordt door een aantal praktische, technische, financiële, organisatorische en juridische obstakels. Universiteit Gent heeft in 2016 een uitgebreid kennis- en onderzoeksplatform opgericht over deze renovatieproblematiek: Horizon. (www.horizon-ugent.be)

Horizon focust grotendeels op de Etrimo-gebouwen, vanwege de grote aantallen die in België te vinden zijn. Deze woontorens hebben een aantal interessante voordelen, waardoor een grondige renovatie van deze appartementsgebouwen de moeite waard is.

Deze voordelen zijn:

- Groene omgeving;
- Hoge repetitiviteit;
- Voordelen van collectief wonen;
- Betaalbare appartementen;
- Interessante stedelijke locatie;
- Structuur in goede staat (afbreken is geen noodzaak).



Figuur 2. Etrimo-appartementsgebouwen in Breughelpark, Zellik.

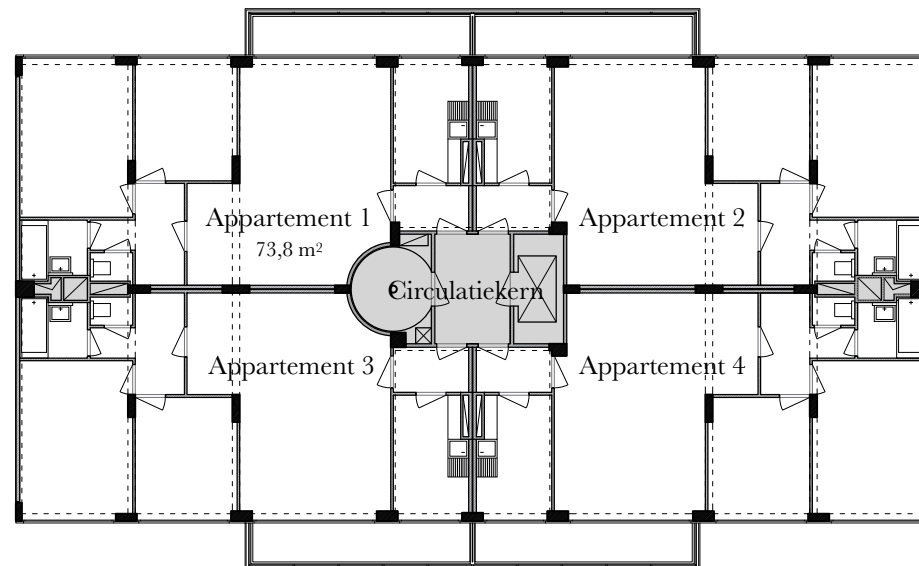
Om de problematiek van deze appartementen volledig te kunnen onderzoeken, is een enquête afgelegd met als doel het achterhalen van de klachten van de inwoners. Deze klachten zijn vertaald in pijnpunten die de bewoners ervaren en waarvoor oplossingen moeten worden gezocht:

Deze pijnpunten zijn:

- Slechte thermische prestaties van de bouwschil;
- Verouderde technische installaties;
- Onvoldoende brandveiligheid;
- Onvoldoende akoestische isolatie;
- Ontoereikende circulatie;
- Geen toegangscontrole.²

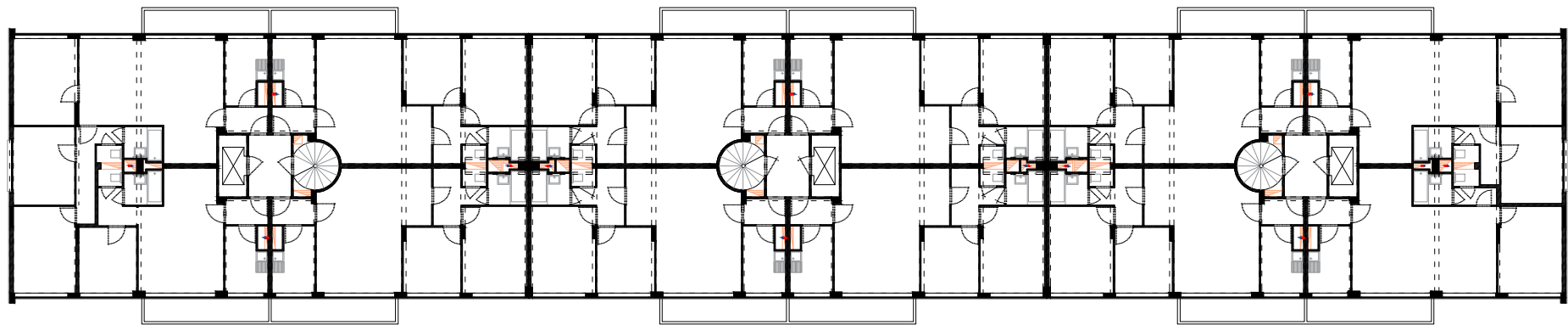
3.3 Organisatie Etrimo-plattegrond

Alle woontorens van de firma Etrimo zijn volgens één principe opgebouwd. Alle appartementen zijn telkens per vier rond een circulatiekern geschikt, hebben een terras en een planindeling die telkens gelijk is (zie afbeelding hieronder). Dit schema wordt horizontaal twee, drie tot vier keer herhaald, afhankelijk van de afmetingen van het beschikbare terrein.



Figuur 3. Schakeling appartementen aan circulatiekern bij Etrimo-appartementsgebouwen.

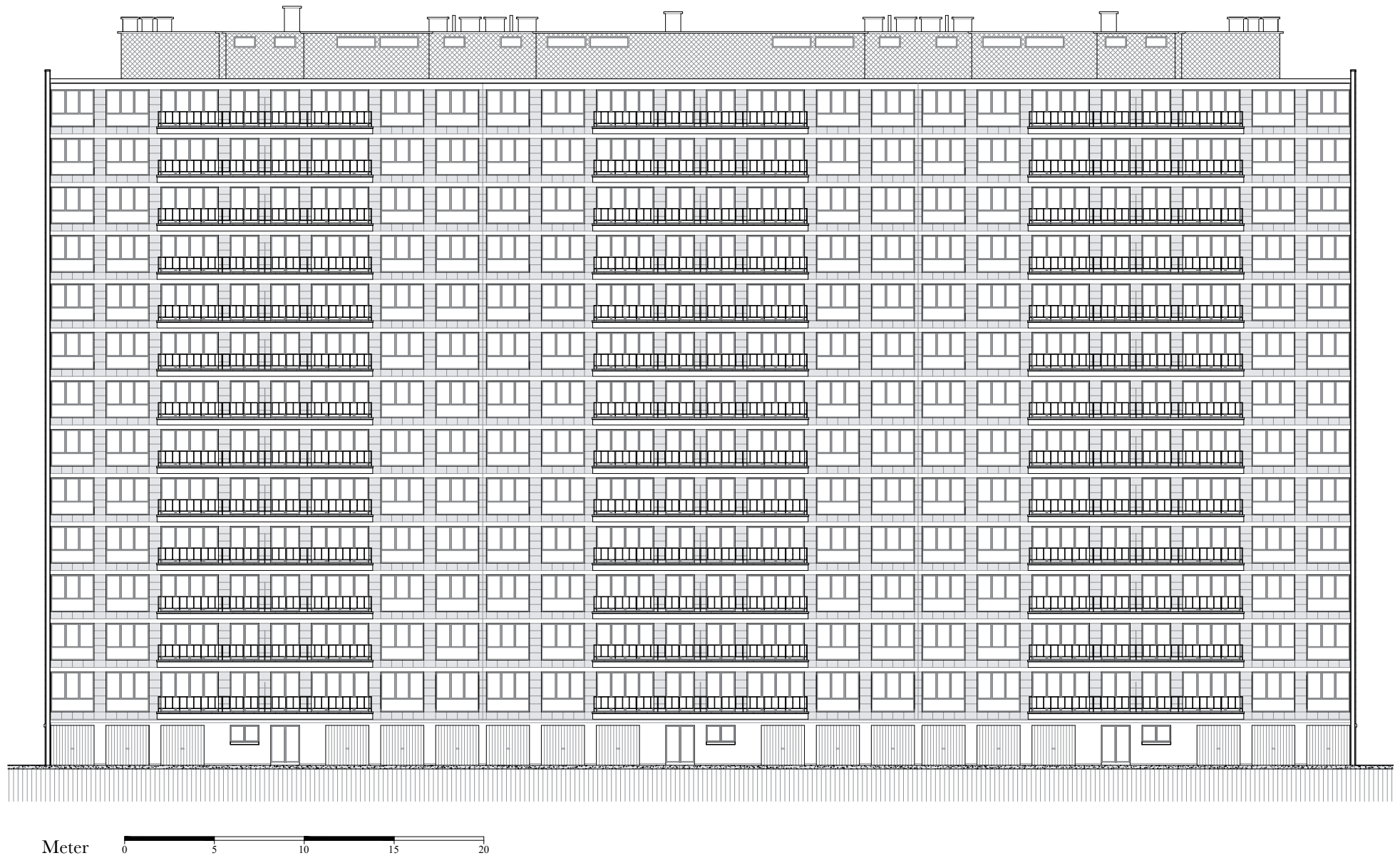
² De Mynck, D. Haalbaarheidsstudie, Residentie II, Breughelpark, Zellik. Masterproef, 2016.



Meter 0 5 10 15 20

Figuur 4. Grondplan van een regulier verdiep van Residentie II, Breughelpark, Zellik.

The new cool is living in a Mobble



Figuur 5. Repetitive gevel van Residentie II, Breughelpark, Zellig

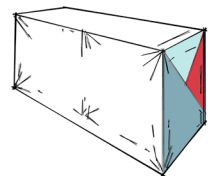
Bibliografische gegevens

Afbeeldingen en tekst zonder verwijzing zijn eigen werk.

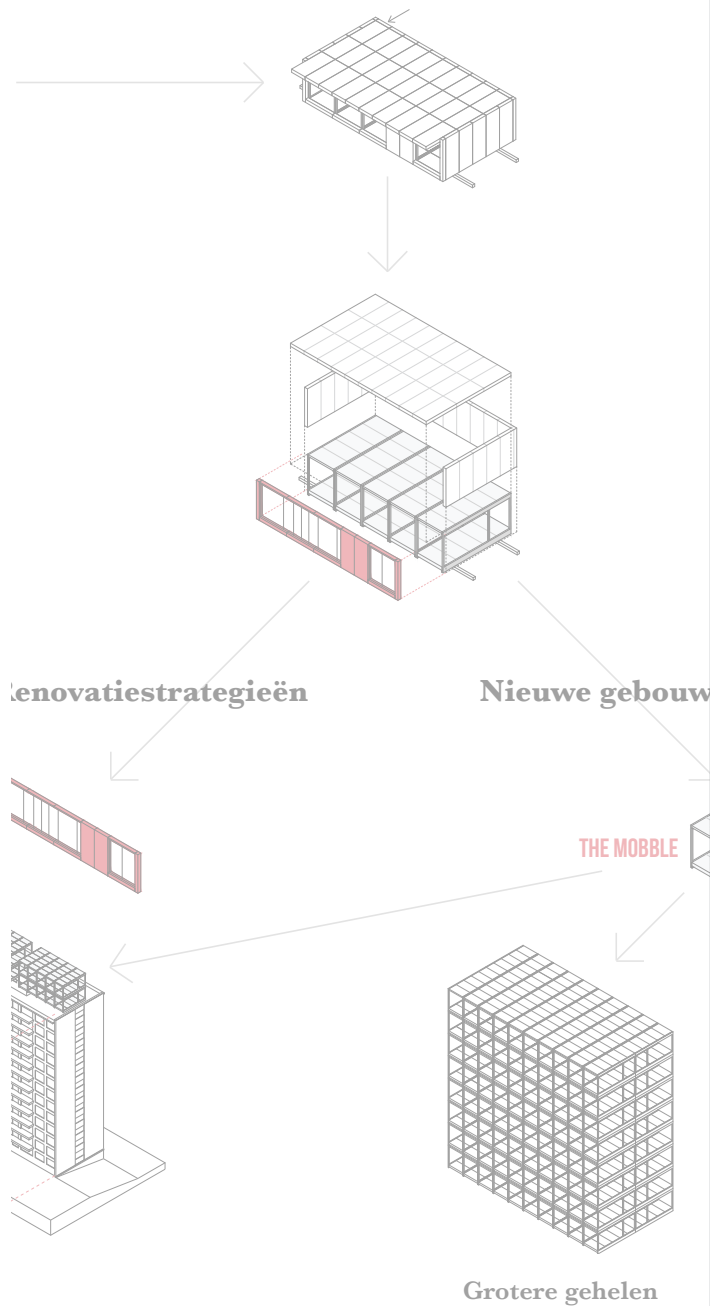
Studie

Cleemput, E. en De Pauw, J. *Solar Decathlon: ontwerpend onderzoek naar renovatiestrategieën van Etrimo woontorens*. Masterproef, 2015.

De Muynck, D. *Haalbaarheidsstudie, Residentie II, Breughelpark, Zellik*. Masterproef, 2016.



Solar Decathlon paviljoen



4

HOOFDSTUK

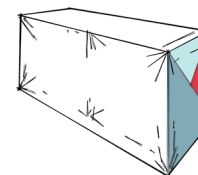
The Mobble

WOORD VOORAF

Mobble is de naam van de modulaire bouwcomponent die ontworpen is voor de *Solar Decathlon*-wedstrijd.

INHOUDSTAFEL

- 4.1 Opbouw van de *Mobble*
- 4.2 Maatschappelijke relevantie
- 4.3 Vertaling: van appartement naar paviljoen
- 4.4 Opbouw van het paviljoen

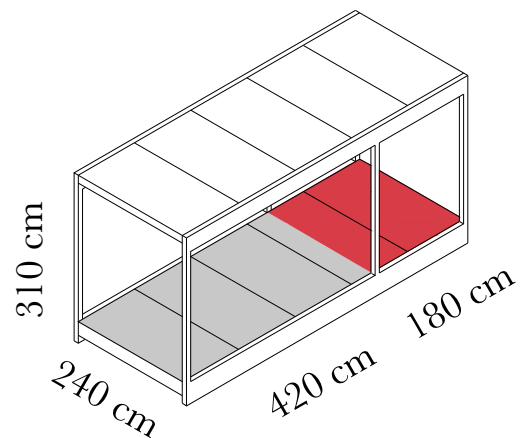


Hoofdstuk 4: The Mobble

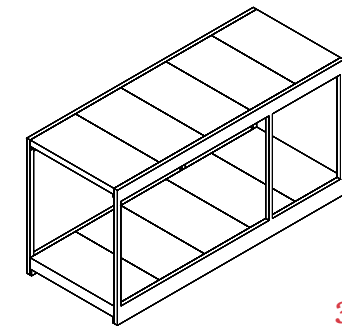
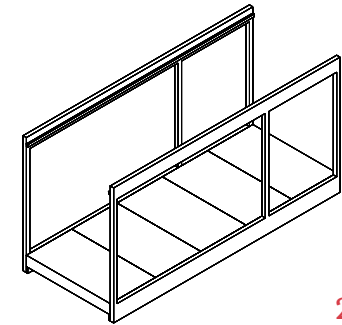
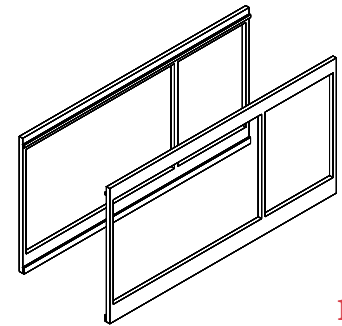
4.1 Opbouw van de Mobble

De *Mobble* is opgebouwd uit twee structurele kaders **1**. De kaders worden verticaal recht gezet en daartussen worden de vloerpanelen **2** en dakpanelen geplaatst **3**.

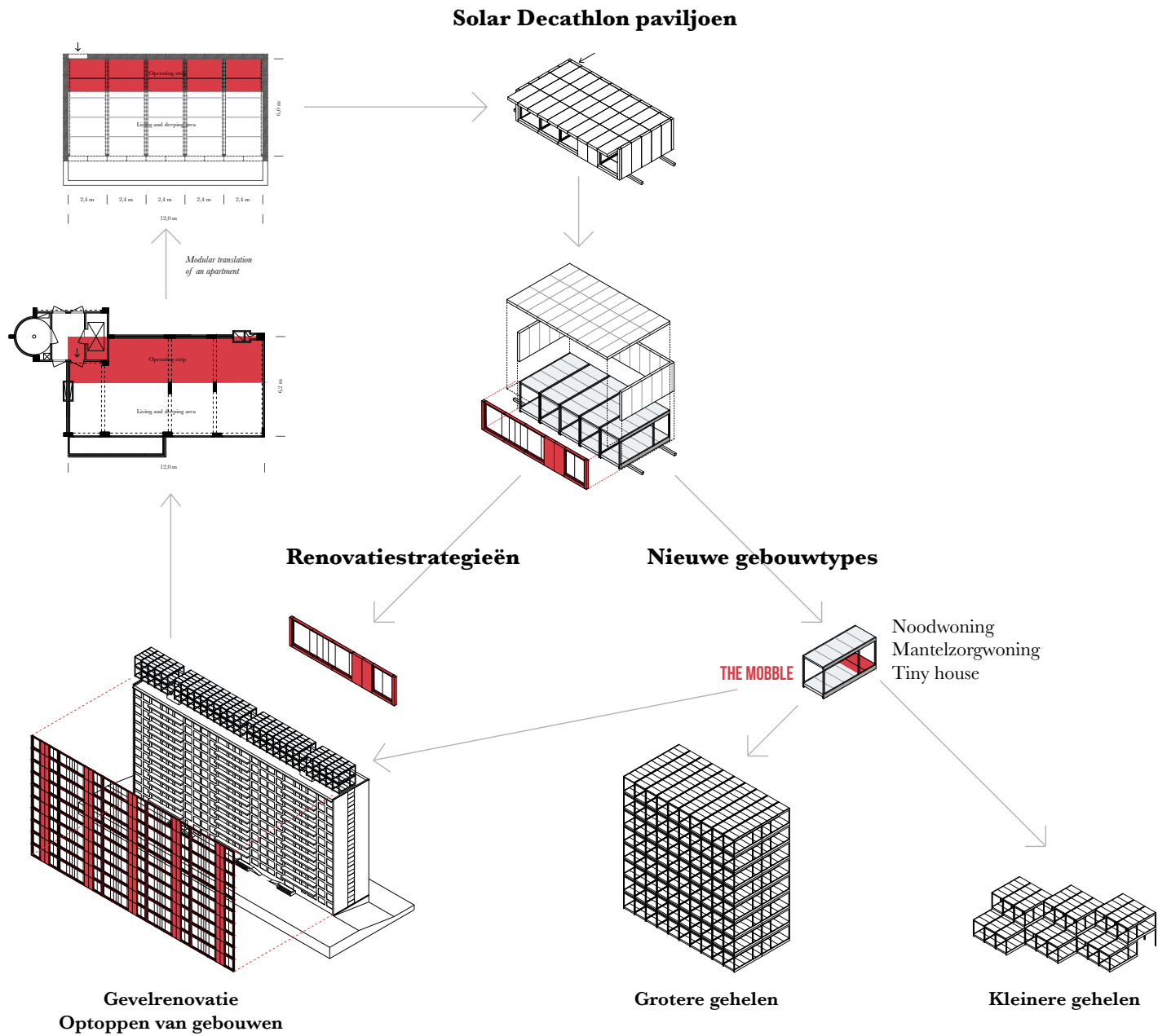
De afmetingen van een *Mobble* zijn: L6,0m x B2,4m x H3,1m. De lengte en breedte zijn veelvoud van 1,2m die gebaseerd zijn op de standaardbreedte van typische sandwichpanelen. Een andere reden voor het gebruik van beperkte afmetingen vloeit voort uit de afmetingen voor normaal transport.



Figuur 1. De Mobble met een dienende (rood) en een bediende (grijs) zone.



Figuur 2. Opbouw van de Mobble.



Figuur 3. Schema met de verschillende doeleinden van het paviljoen.

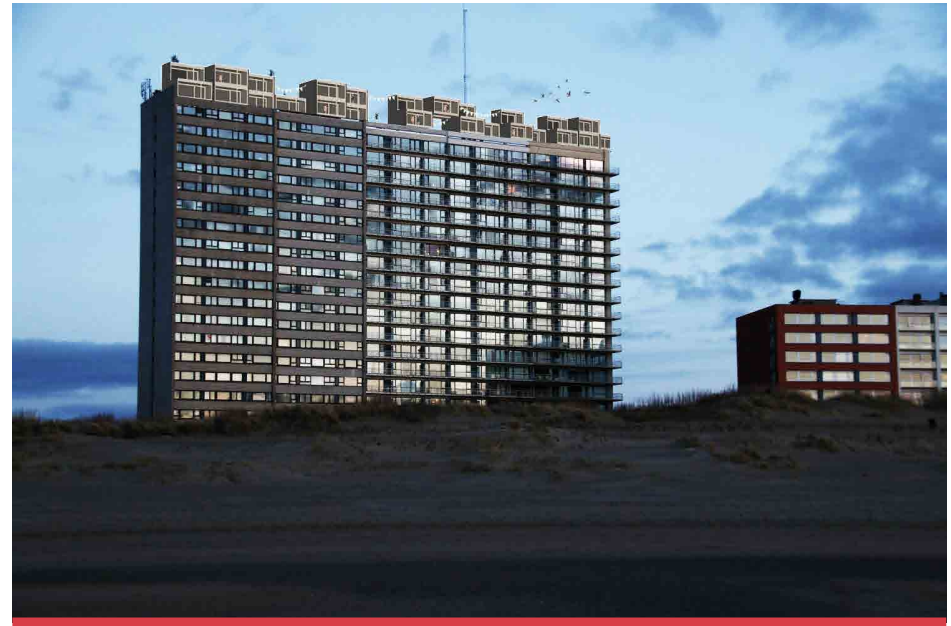
4.2 Maatschappelijke relevantie

Het *Solar Decathlon*-paviljoen kadert in de renovatieproblematiek van de Etrimo-appartementen. Concreet representeert het paviljoen een proefopstelling om renovatiestrategieën voor woontorens te demonstreren aan een breed publiek. De technische installaties worden ondergebracht in een gevelpaneel om het renoveren van de appartementen efficiënter te laten verlopen (zie grondplan pag. 4 - 8).

Een *Mobble* kan fungeren als noodwoning, *tiny house*, een mantelzorgwoning in de tuin, enz.

Aan de hand van het maatsysteem van de *Mobble* kunnen nieuwe ‘intelligente’ gehelen worden ontwikkeld. Met ‘intelligent’ wordt bedoeld dat het gebouw zonder fundamentele aanpassingen een ander programma kan dragen. De modulariteit brengt een hoge flexibiliteit en aanpasbaarheid met zich mee.

Mobbles kunnen ingezet worden als *rooftop apartments*. Door modules op het dak van het te renoveren gebouw te plaatsen kunnen bewoners tijdelijk verhuizen naar deze module-appartementen om dan terug te keren naar hun appartement na de verbouwingen. Daarna zijn de volgende bewoners aan de beurt tot alle appartementen zijn opgeknapt. De *Mobbles* op het dak worden na de renovatie behouden. Dit is gunstig voor de verdichting van de steden want, na afloop van de renovatie zal het appartementsgebouw meer wooneenheden bevatten.

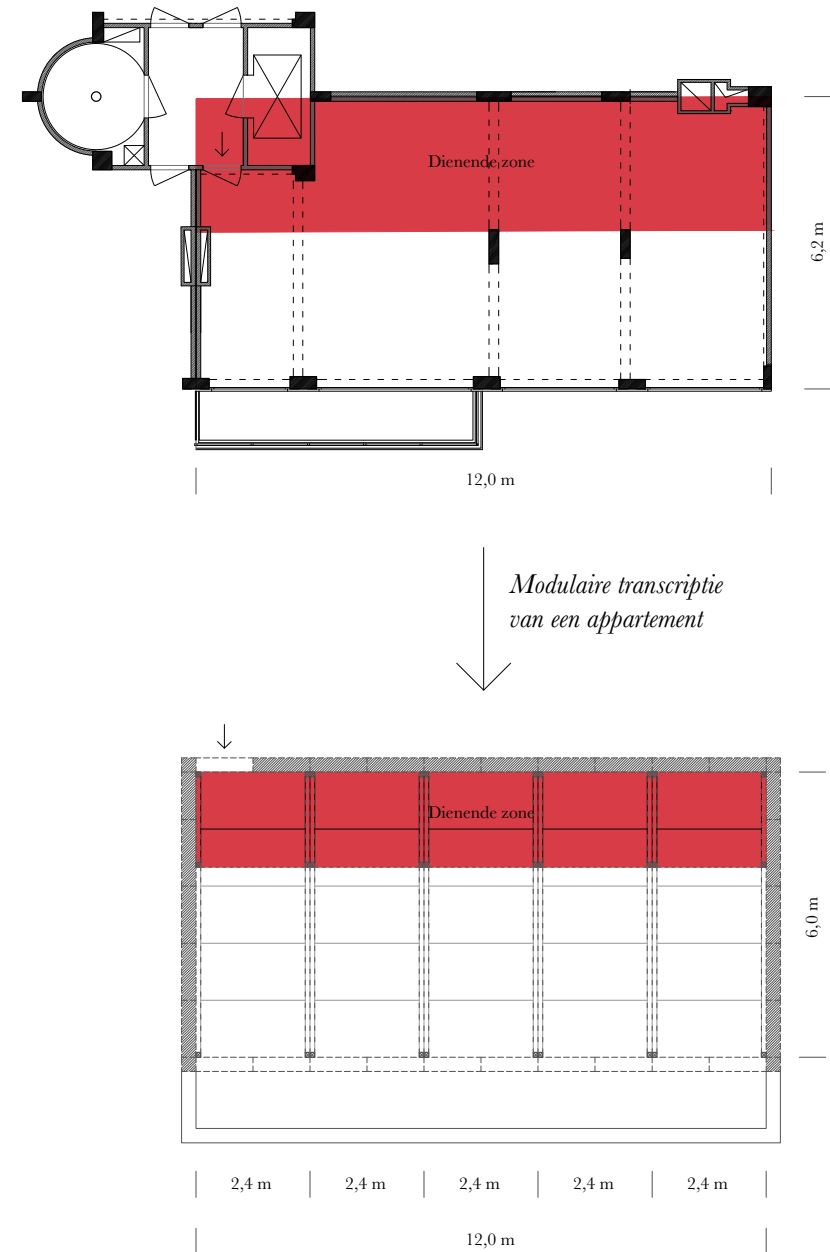


Figuur 4. Conceptuele voorstelling van de Mobbles op een appartementsgebouw.

4.3 Vertaling: van appartement naar paviljoen

Het vertrekpunt voor de plattegrond van het paviljoen is het meest voorkomende type-appartement uit een appartementsgebouw van de firma Etrimo. Er wordt een modulaire transcriptie gemaakt naar een paviljoen in hout.

De geometrie en de daarbijhorende afmetingen worden bijna letterlijk gekopieerd, alsook het gebruik van éézijdige beglazing, het balkon en de typerende dienende zone, zie rode arcering op de grondplannen hiernaast. Het appartement/paviljoen wordt betreden vanuit de linker bovenhoek.



Figuur 5. Modulaire transcriptie van een Etrimo-appartement.

4.4 Opbouw van het paviljoen

Het paviljoen bestaat uit vijf *Mobbles*.

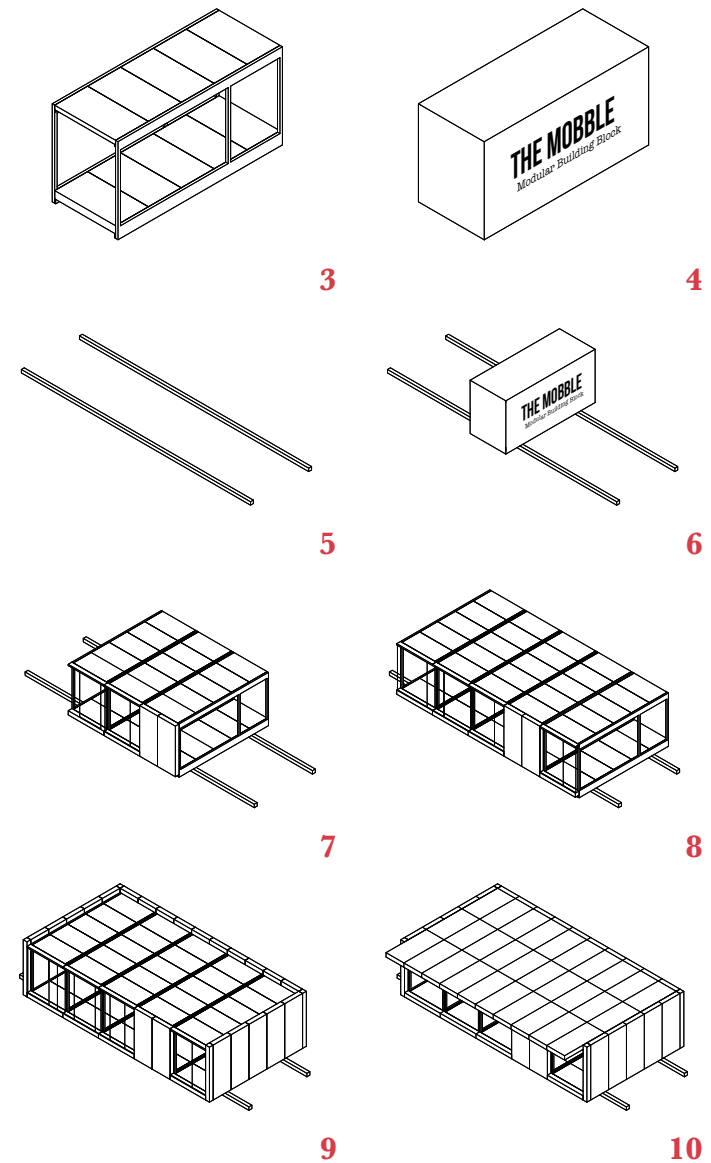
(vervolg 4.1 Opbouw van de *Mobble*)

Als de *Mobble* klaar is **3**, worden de binnenmuren, vaste meubelementen en de technische installaties ingebouwd. Het buitenschrijnwerk en de ramen worden aan de module bevestigd. Enkel nog de module verpakken (beschermzeil) **4** en de *Mobble* is klaar voor transport. De gevelpanelen en de tweede laag dakpanelen worden ter plaatse aangebracht.

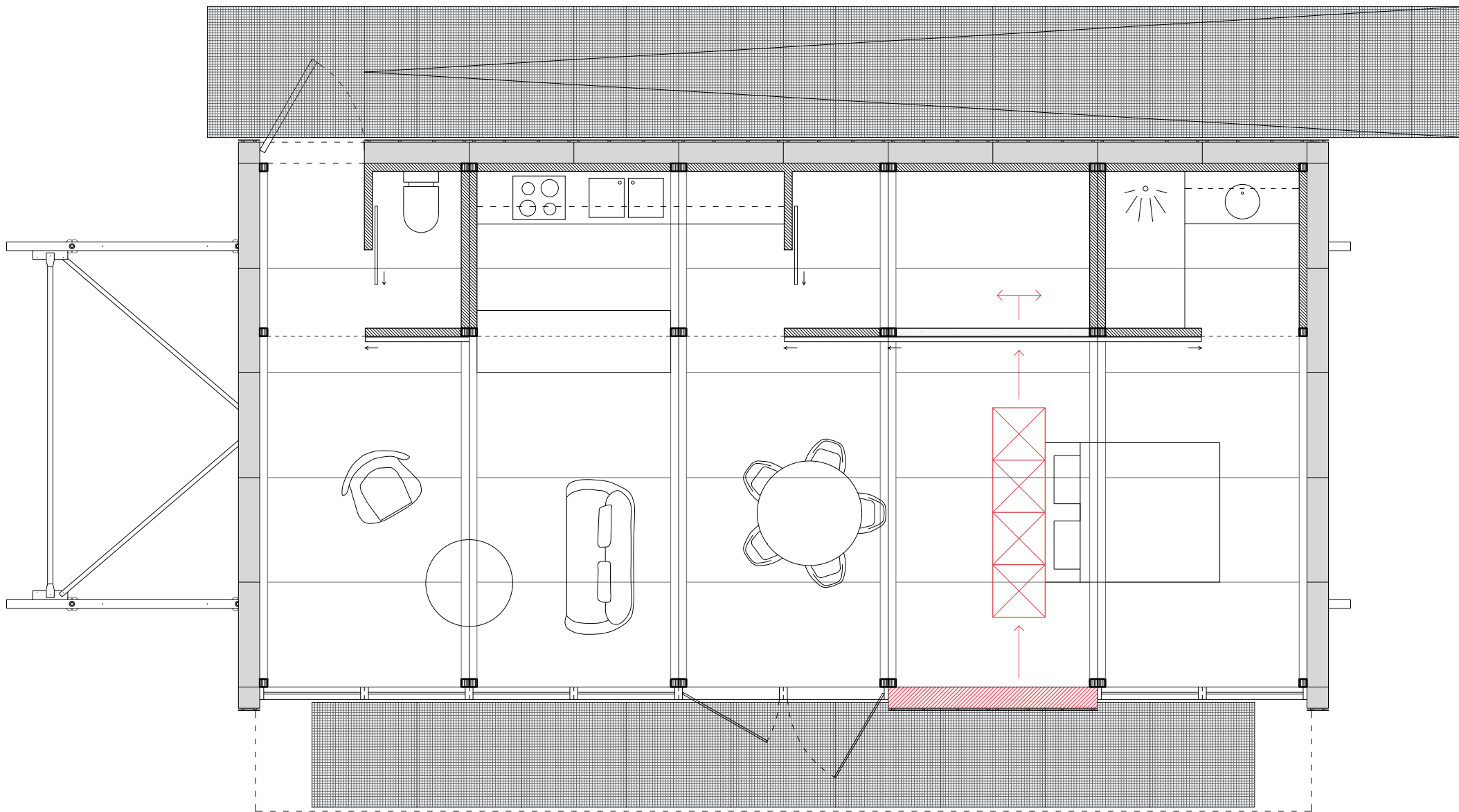
Op de site worden eerst de funderingssporen uitgezet **5**. Als eerste zal de middelste *Mobble* **6** geplaatst worden, vervolgens de twee *Mobbles* **7** die de middelste flankeren en tenslotte de buitenste twee *Mobbles* **8**. Na het plaatsen van de *Mobbles*, worden de gevelpanelen geïnstalleerd **9** en als laatste element de tweede laag dakpanelen **10**.

Het is een eenvoudig bouwconcept dat studenten en doe-het-zelvers in staat stelt zelf de handen uit de mouwen te steken om een eigen paviljoen of woning te bouwen. Een handleiding bij de *Mobble* is in de maak!

De gevel met de ramen bevat één gesloten paneel. Dit paneel bevat de technieken. De technische installaties worden van daaruit verdeeld via een kast naar de technische berging om van daaruit de technieken te laten distribueren in de dienende zone met verlaagd plafond. Zie grondplan volgende pagina.



Figuur 6. Opbouw paviljoen.



Figuur 7. Plattegrond van het paviljoen 1/60 - Verdeling van de technieken: van technisch paneel aan de gevel via kast naar de dienende zone.

solar
decathlon
europe
SZENTENDRE 19
HUNGARY

architecture
engineering & construct
energy efficiency
communication & socia
neighbourhood integrat
innovation & viability
circularity & sustainabil
comfort conditions
house functioning
energy balance

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deadline for submission - 27_10_17

HOOFDSTUK

Selectiedocumenten

INHOUDSTAFEL

5.1 Call for Teams

5.2 Toegestuurde documenten

Application Letter

Technical Volume

Budget

Summary for Public Release

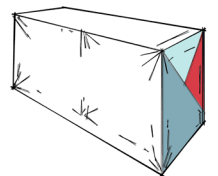
Summary Slide

5.3 Brief met mededeling selectie

5.4 Geselecteerde teams

WOORD VOORAF

Op 14 juli 2017 is de oproep voor een deelname aan SDE19 gelanceerd. Om geselecteerd te worden, zijn een aantal documenten opgemaakt. In dit hoofdstuk zijn deze documenten geordend.



Hoofdstuk 5: Selectiedocumenten

5.1 Call for Teams

Call for Teams en wedstrijdreglement:

<http://solardecathlon.eu/sde19-call-for-teams-documents/>



- architecture
- engineering & construction
- energy efficiency
- communication & social awareness
- neighbourhood integration & impact
- innovation & viability
- circularity & sustainability
- comfort conditions
- house functioning
- energy balance

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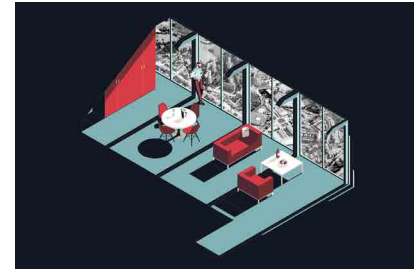
design - p. gary

5.2 Toegestuurde documenten

5.2.1 Application Letter



TEAM GHEENT UNIVERSITY
APPLICATION LETTER



THE MOBBLE

Modular Building Block

FACULTY ADVISOR
Prof. dr. eng. arch. Nathan Van Den Bossche
Nathan.VanDenBossche@UGent.be

STUDENT TEAM LEADERS
info.horizon@UGent.be

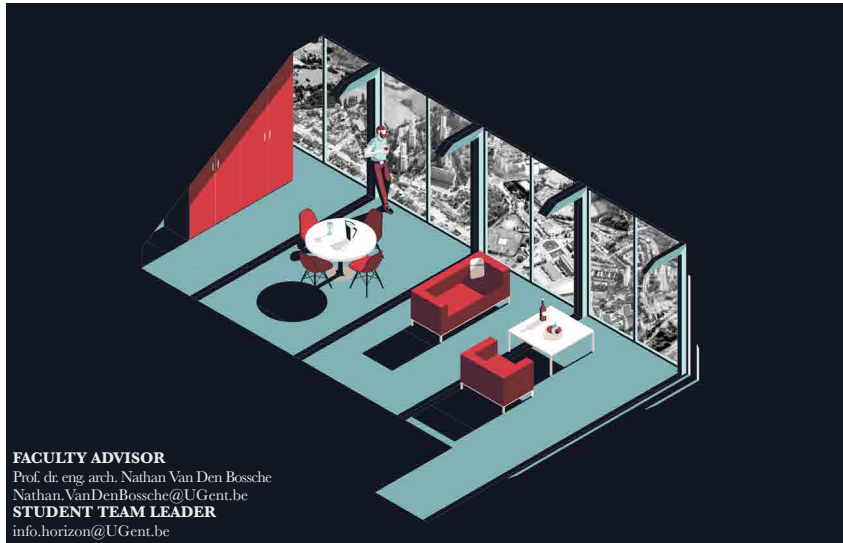
Dear Sir, Madam,

Ghent University aspires to participate in the Solar Decathlon Europe 2019 edition in Szentendre. Please find hereby the full application. Based on our positive experience in two previous editions in Washington and Datong, we are convinced that Ghent University can showcase a number of innovative designs, concepts and systems at the contest, with a strong link to the high-level scientific research at the University.

Prof. Nathan Van Den Bossche, PhD
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Department of Architecture and Urban Planning
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9000 Ghent, Belgium
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5.2.2 *Technical Volume*



FACULTY ADVISOR
Prof. dr. eng. arch. Nathan Van Den Bossche
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STUDENT TEAM LEADER
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2.

2.1. Background

Ghent University¹

Ghent University is one of the top 100 universities in the world and one of the major Belgian universities counting over 41 000 students and 9 000 employees. It is based in Ghent, located in the Dutch-speaking part of Belgium called Flanders, but also has campuses in Courtrai, Ostend, Bruges and even South Korea. Ghent University is an active partner in national and international educational, scientific and industrial cooperation. We are talking about cooperation in research and scientific service, numerous research groups, centers and institutes have been founded over the years, whom several of them are renowned worldwide, in various scientific disciplines. We distinguish ourselves as a socially committed and pluralistic university in a broad international perspective.

The faculty of Engineering and Architecture educates more than 5000 students, and comprises more than 50 research teams, about 1000 researchers, and produces over 700 web of science publications each year. The Research group Building physics, Construction and Services focuses on whole building simulations (energy use, system control algorithms, indoor air quality and comfort), HAM-modeling (thermal optimization, hygrothermal risk analysis, CFD), and weather tightness (watertightness, airtightness, pressure equalization, runoff modeling). The research group currently consists of 4 professors and about 15 researchers. The research projects vary from fundamental to applied, in collaboration with national and international partners from industry and academia. On an international level, these professors are active as subtask leader in 4 Annex projects of the International Energy Agency, are leading 3 interreg projects, are member and coordinator of 2 Horizon projects, and have organized 2 major conferences this year (Indoor Air Conference, 1000+ participants; 14th Durability of Building Materials and Constructions Conference; 300+ participants) and published over 100 journal papers in the last 10 years.

Successes

Ghent University has already participated in two previous Solar Decathlon competitions in 2011 (E-cube, Washington D.C., USA) and 2013 (Solatrium, Datong, China).

E-Cube in Washington D.C., U.S.A. ²



Figure 1. The E-Cube student team

In 2011 team Belgium built a pavilion in Washington D.C., called the E-Cube. This is an affordable Do-It-Yourself-kit for an ecological solar-powered home. It consists of pre-fabricated units and can easily be assembled with the help of an IKEA-like construction manual. The award for most affordable house was won by team Belgium. The E-Cube is rebuilt at the Ostend's Ghent University Science Park Green-Bridge. It is part of the scientific research for new construction and installation concepts for applications in highly energy-efficient buildings. The participation was a major success at the University, boosting team spirit among students, and bringing the solar energy design in the spotlight. For more information: <http://www.solardecathlon.ugent.be/en>

¹ Ghent University (2017). Facts and figures. Retrieved September 2017, from <https://www.ugent.be/en>

² Ghent University (2011). De E-cube. Retrieved September 2017, from <http://www.solardecathlon.ugent.be/en>

Solatrium in Datong, China



Figure 2. Solatrium in Datong

In the summer of 2013 Ghent University was part of the multi-national team BEMANY (Ghent University, Worcester Polytechnic Institute and Polytechnic Institute of New York University) with a house designed around a central atrium, called Solatrium. Concrete tiles made of phase-changing material regulating the inside temperature, were one of the innovative features. Light-weight glass fiber reinforced composite panels made the house easy to transport and assemble with limited use of big machinery. The Solatrium was ranked 8th out of 20 projects in the SD China competition.

Current research³



Figure 3. Horizon logo.

In 2016, the Horizon Knowledge Hub was created at Ghent University. Started as an interdisciplinary knowledge platform supported by 13 professors related to the renovation of apartment buildings, it has evolved into an interdisciplinary project where researchers from different fields and faculties collaborate on challenges of mutual interest.

2.2. Project Goal

The Ghent university Horizon Team aspires to showcase the potential of renovating large scale apartment buildings. Furthermore, renovating the inside of the apartment allows to adopt a new blueprint as design principle, which was developed based on extensive scenario analysis: a minimal set of interventions provide a range of possibilities for various plan configurations, from starters, over young families, up to elderly people. We also add a new angle to the ongoing debate on life-cycle-cost and cradle to cradle. Our design puts more emphasis on re-use on a component scale than recycling on the material scale. The pavilion comprises specific solutions to tackle the technical challenges in renovating large-scale building blocks, the building industry is confronted with. More specifically, prefab panels with vacuum insulation are used for the building envelope; IoT-controlled heating, cooling and ventilation is installed with direct online output of energy use and indoor air quality; and a heat pump driven by building integrated photovoltaics with battery storage finally renders the building extremely energy efficient.

2.3. Impact

Firstly, we want to raise awareness concerning the necessity of a thorough renovation of these building blocks. Renovation of the facade will render the building more energy efficient. But this is just the start. Health issues such as poor indoor air quality, high relative humidities, mould risks and critical legionella concentrations in tap water, are equally important. By consequence, HVAC systems should be intelligent and demand-controlled; domestic hot water production will be controlled, and indoor air quality is a priority... These improvements will ameliorate the overall user comfort. The project aspires to reduce the life cycle cost of a building by providing a straightforward building plan that enables a whole range of different floor plans within the same apartment. Hence, this inherent and engineered flexibility will increase the time between renovations, decrease the life cycle cost, and increase the sustainability.

³ Horizon (2017). About. Retrieved September 2017, from <http://www.horizon-ugent.be>

3. TECHNICAL DESCRIPTION, INNOVATION & IMPACT

3.1. Relevance and outcomes

Problem statement^{4,5}

Massive destructions throughout the second World War resulted in a large housing shortage in Belgium. As from the 50's, the high-rise condominium model was introduced into suburban districts of metropolitan areas such as Brussels, Antwerp and Liege. However, today these high-rise buildings are typically outdated and don't longer meet code requirements in terms of e.g. fire safety, thermal performance and acoustical performance. Furthermore, the discrepancy between the idealized countryside living and the lack of privacy in these buildings have also initiated social segregation and concentration. The majority of these high-rise buildings – mainly constructed between 1950 and 1980 - is in desperate need of a thorough renovation. Nevertheless, complex proprietary structures, high demolition cost as well as some intrinsic qualities (cfr. Figure 4; e.g. location, presence of surrounding green areas and affordability) block large-scale demolition.

In Belgium home-ownership exceeds 80%, and there is a large governmental social housing sector which renders the market for private rental rather small. By consequence, private ownership in apartment blocks introduces several practical, technical, financial, organizational and legal obstructions that hamper thorough renovations.



Figure 4. Advantages and disadvantages of the building blocks.



Figure 5. Overview typical high-rise buildings in Belgium.

⁴ Horizon (2017). Problem statement. Retrieved September 2017, from <http://www.horizon-ugent.be>

⁵ Calle, K., Supervisors: prof. J. Moens, dr. ir. arch. N. Van Den Bossche, ir. arch. S. Mangé. The development of (cost) effective facade renovation in residential highrise.

Case study⁶

Large contractors such as Etrimo and Amelinckx dominated the high-rise market in the 60's and 70's, adopting a low-cost modular building system, copied over and over again in line with typical post-war functionalism and industrial production logic. One of the high-rise buildings by Etrimo which requires a thorough renovation, is Residence II in the Breugelparc, situated close to Brussels. The building consists of three almost identical and adjacent modules, comprising four apartments each, as shown in figure 6. Note that no corridors are present, and only a single spiral staircase for a 14-storey building to evacuate in case of emergency.

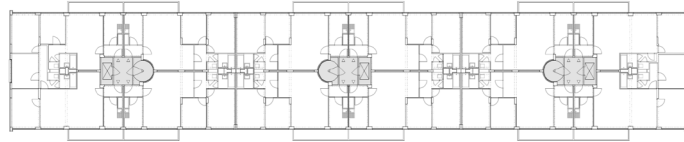


Figure 6. Regular level of a high-rise building.

Concept intention

Ghent University Horizon Team will build a characteristic apartment of the Residence II housing block to address this technical, scientific and societal challenge. Instead of building an exact replica, a more generic reinterpretation is made rendering the concept a more universal nature in line with the international dimension of the competition, simultaneously enabling to display a 3-layered strategic dimension:

- We want to raise awareness concerning the health issues such as poor indoor air quality, high relative humidities, mould risks and critical legionella concentrations in tap water. The communication is mainly oriented towards the general public, but also architects, contractors, building experts and policy makers need to be triggered and informed.
- The pavilion comprises specific solutions to tackle the technical challenges in renovating large-scale building blocks the building industry is confronted with. More specifically, prefab panels with vacuum insulation are used for the building envelope, facade panels will integrate HVAC distribution and production units, IoT-controlled ventilation is installed with direct online output of energy use and indoor air quality, localized heating and cooling is used to create an optimal thermal comfort in a zone close to the users while reducing the overall temperature, and a heat pump driven by building integrated photovoltaics with battery storage finally renders the building extremely energy efficient.
- Finally, the construction concept of the pavilion is based on a modular container, which can be recombined into different configurations. The project aspires to reduce the life cycle cost of a building by providing a straightforward building plan that enables a whole range of different floor plans within the same apartment. Hence, this inherent and engineered flexibility will increase the time between renovations, decrease the life cycle cost, and increase the sustainability.

Pre-design pavilion

The selected case-study, as described above, serves as blueprint for the Solar Decathlon pavilion, adopting the overall geometry with rectangular floor plan, single-sided large windows and balcony (see figure 7). The kitchen, bathroom and storage are situated in a service zone.

Based on the experience from our two previous participations at the Solar Decathlon competitions in Washington and Datong, the Ghent University Horizon Team decided to design and construct a house, using a modular system which we call The Mobble. This standard module with dimensions 2,40 m x 6,00 m x 3,10 m, will be completely prefabricated at Ghent University. Not only the structural frame, but also HVAC systems, electricity, kitchen, bathroom, interior finishing, etc., will be fabricated in advance. Once finished, the modules can easily be transported to Szentendre, with limited installation time on site. Specific tailor-made

⁶ Horizon (2017). Problem statement. Retrieved September 2017, from <http://www.horizon-ugent.be>

solutions have been developed and tested extensively for the structural connections, airtightness, watertightness, and thermal performance and continuity of the building envelope.

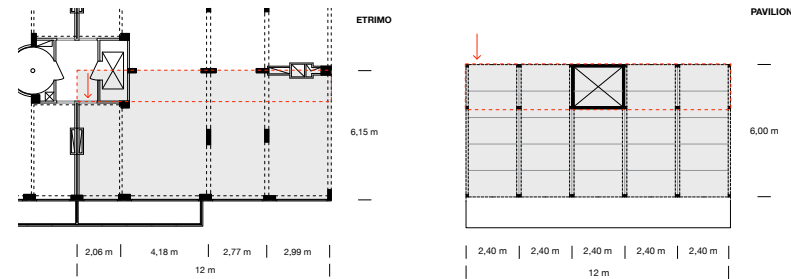


Figure 7. The main principles of the Etrimo apartment and the pavilion.

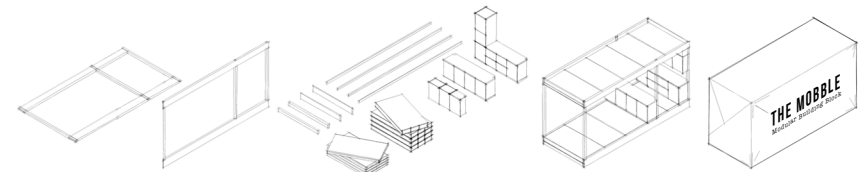


Figure 8. Fabrication process of The Mobble.

Expected outcomes

The Ghent university Horizon Team aspires to showcase the potential of renovating large scale apartment buildings. Detailed engineering of prefab building envelope components allows for a rapid and thorough low-energy renovation with minimal nuisance for owners and tenants. Furthermore, renovating the inside of the apartment allows to adopt a new blueprint as design principle, which was developed based on extensive scenario analysis: a minimal set of interventions provide a range of possibilities. The underlying blueprint allows to reorganize the apartment very easily, which renders it apt for various social configurations, from starters, over young families, up to elderly people. At the same time, the degree of privacy can be adapted accordingly, and the apartment can switch from enclosed spaces up to loft-style. This approach adds a new angle to the ongoing debate on life-cycle-cost and cradle to cradle. Nowadays, sustainability is often conveniently addressed by quantitative LCA, omitting the fact that the envisioned life span is typically not met due to functional or esthetical refurbishment and renovation. Next to that, our design puts more emphasis on re-use on a component scale than recycling on the material scale. Finally, energy efficiency is a prerequisite, but in these types of buildings with complex social mixes, the HVAC systems should be intelligent and demand-controlled as well. Hence, an innovative IoT-approach is required to ensure an optimal trade-off between indoor air quality, comfort, and energy use.

3.2. Feasibility ⁷

201713



Figure 10. The E-Cube in Washington D.C. during the contest week.

We have entered into two Solar Decathlon competition before: Washington in 2011 (E-cube, Team Belgium) and Datong in 2013 (Solatrium, Team BEMANY). In both cases we succeeded in designing, building and operating a fully functional pavilion. The E-cube focused on a simple and adaptable D-I-Y prefab system and was built in 48 hours without help of contractors. The building kit comes with an IKEA-like construction manual. It won the affordability contest. The Solatrium was ranked 8th out of 20 projects in the SD China competition, using passive techniques such as optimal solar design and phase changing materials.



Figure 11. STEAMlab21

In preparation of the next Solar Decathlon Europe competition in 2019, a first prototype is already built. This small test house named STEAMlab21 is used to do research on prefab panels, demand controlled HVAC systems and electrical energy balance. Next to that, it was built in collaboration with the high school VTI and 14 industrial partners. At VTI, it serves for didactical reasons and students will mainly practice installing wall assemblies and integration of technical installations. Finally, it also boosts communication and awareness concerning the challenges we want to address (e.g. attendance of federal minister of education at the official opening).

<http://www.horizon-ugent.be/2016/10/18/steamlab-21-a-cooperation-between-vti-kortrijk-and-ghent-university-as-a-preparation-for-the-solar-decathlon-competition/>

In 2016, the Horizon Knowledge Hub was created at Ghent University. Started as an interdisciplinary knowledge platform supported by 13 professors related to the renovation of apartment buildings, it has evolved into an interdisciplinary project where researchers from different fields and faculties collaborate on challenges of mutual interest. The website provides an overview of some results related to e.g. architectural design, facade renovation, technical design, urban planning, macro-economy, electrical energy balance etc. Both student work as well as scientific results from funded research programs are posted here. <http://www.horizon-ugent.be/knowledgehub/>



Figure 12. Reconversion of Etrimo Building, Breugelparc, Zellik.

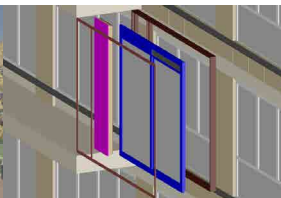


Figure 13. Research facade renovation for Etrimo buildings.



Figure 14. PRO3 prefabricated building systems.

⁷ Horizon (2017). E-cube. Retrieved September 2017, from <http://www.horizon-ugent.be>

3.3. Innovation and Impacts

201713

Life cycle cost⁸

Throughout the last few decades there has been a big emphasis on increasing energy legislation throughout the world. Now that we are reaching the final limits of energy efficiency in building design, focus is switching towards life-cycle analysis.

Nowadays, the focus is typically put on the life cycle cost on material level, which can be found in catalogues. However, a more holistic reasoning concerning sustainability is required. We are convinced that re-usability and recycling on component level is more interesting compared to the approach on material level. Existing traditional buildings are often no fit to meet the requirements of everyday life, the changing social needs and evolving functional requirements of the building. The existing apartment buildings dating back from the 50's till 70's typically comprise relatively small rooms in line with the standard at that time. A lack of integrated flexibility and adaptability often causes demolition of major building parts or even demolition of entire buildings.

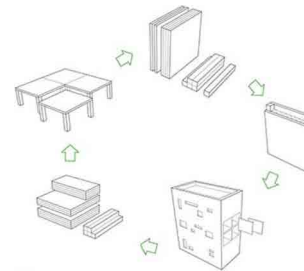


Figure 15. A 4-Dimensional approach towards a dynamic and sustainable building stock. (Anne Paduart)

To increase the building's transformation capacity and allow reuse of building components, building design must be different from traditional design methods, but also need to omit recent design trends to render it more robust. The re-configuration and recycling of building components in constructions clearly presents major environmental, social and economic benefits when considering the life cycle of buildings.

This approach will be displayed consistently in every detail of the pavilion design. Facade finishing, interior finishing, technical installations, etc. are all disconnected from the structural frame. This makes it possible to easily change these layers, as the lifespan of all these components is typically different.

Flexible module system

The Solar Decathlon pavilion is illustrating one of the possibilities when using a modular building system based on our new designed modules. The main focus will be on the adaptability of the system: e.g. enlargement of an apartment when changing family compositions, easily adaptable interior layout, etc. The modular system yields the possibility to develop a new generation of housing units. This principle is illustrated in figure 16. Furthermore, these modules can also be placed on top of already existing buildings (e.g. Residence II building). This is based on a densification principle and will upgrade the appearance of the whole building, encouraging an overall renovation. Scenario-analysis on the possibilities of this building system will be illustrated in the pavilion during the contest week.

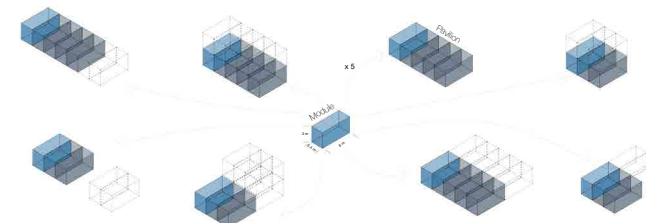


Figure 16. Modulation & expandability of the module

⁸ Paduart, A. (2012). Re-design for Change: A 4-Dimensional Approach towards a dynamic and sustainable building stock (PhD research), Vrije Universiteit Brussel, Department of Architectural Engineering

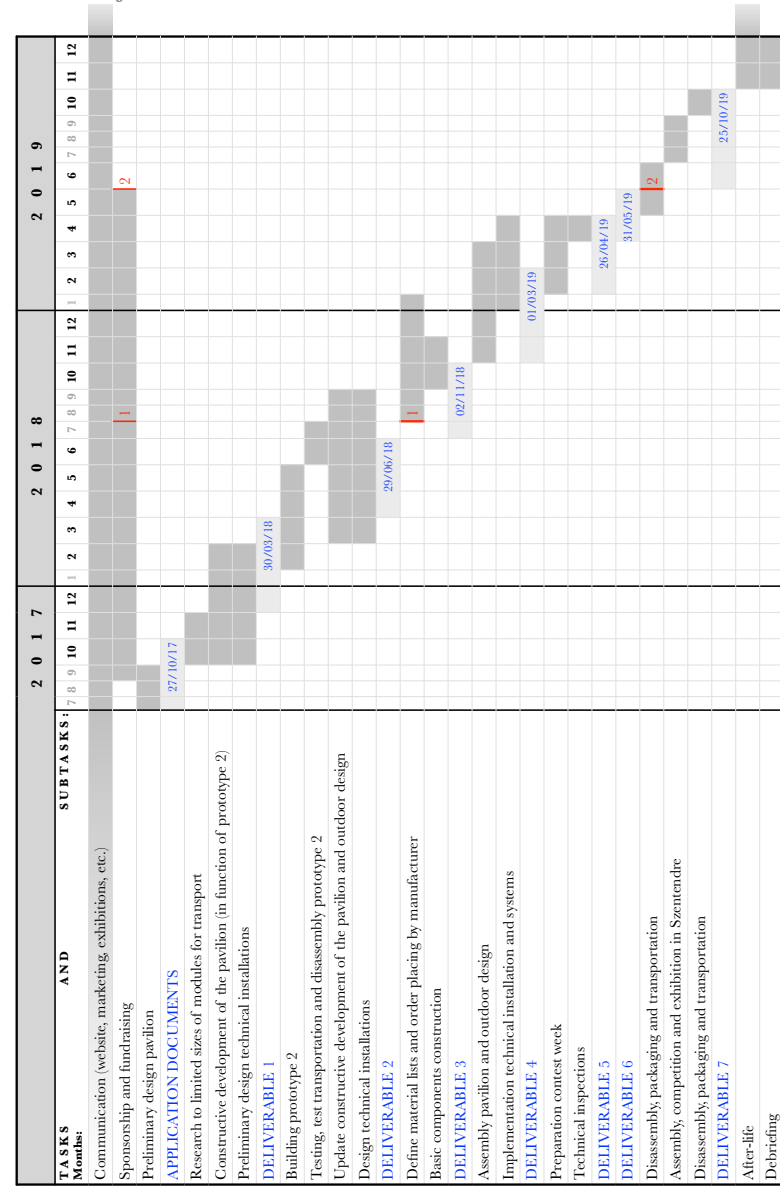
D E V E L O P M E N T	Preliminary design technical installations	<ul style="list-style-type: none"> PoC study IOT-controlled HVAC Personal heating/cooling concept scenario analysis Preliminary sizing and integration in modules 	February, '18
	DELIVERABLE #1	Schematic Design Documentation & Dissemination Materials <ul style="list-style-type: none"> Press Release #1 Project Manual #1 Project Drawings #1 Audiovisual #1 Web Page 	30 March 2018
	Building Prototype 2	<ul style="list-style-type: none"> Structural frame in plywood Building envelope and double skin facade Foundation system and roof structure 	February, '18 May, '18
	Tests prototype 2	<ul style="list-style-type: none"> Testing installation, structural behavior and connections Transportation and disassembly tests 	June, '18 July, '18
	Update constructive design and outdoor design	<ul style="list-style-type: none"> Improve architectural and structural drawings for final pavilion Develop a BIM model to simplify communication and coordination Health and Safety plan Finalize landscape design 	March, '18
	Design technical installations	<ul style="list-style-type: none"> Finalize IOT-control HVAC system Dynamic building simulation to optimize summer/winter heat balance Dynamic building simulations with integrated HVAC system Optimize interaction control algorithms Electricity schemes and integration 	September, '18
DELIVERABLE #2	Design Documentation & Dissemination Materials <ul style="list-style-type: none"> Press Release #2 Project Manual #2 Project Drawings #2 Audiovisual #1 Web Page 	29 June 2018	
M A N U F A C T U R I N G	Define material lists and production	<ul style="list-style-type: none"> Define all materials and components Technical workshops with manufacturers Order placing at manufacturers 	August, '18 January, '19
	Basic components construction	<ul style="list-style-type: none"> Compose structural modules, floor and roof Compose prefab facade elements Compose interior wall components and finishing Constructing bathroom, kitchen, etc. 	October, '18 November, '18
	DELIVERABLE #3	Design Development Documentation & Dissemination Materials <ul style="list-style-type: none"> Press Release #3 Project Manual #3 Project Drawings #3 Electric and PV Chart and Checklists Workshop Documentation Audiovisual #2 Architectural Model TEE data and documents #1 	2 November 2018
	Assembly pavilion	<ul style="list-style-type: none"> General assembly Overall performance evaluation (blower door, IR, heat flux) Outdoor design 	November, '18 March, '19
	Implementation technical installation	<ul style="list-style-type: none"> Installation of components Initiate system operation and commissioning Performance assessment based on co-heating test 	January, '19 May, '19
			Go/No Go Decision point 1: financial analysis

F I N E - T U N I N G	DELIVERABLE #4	Construction Documentation & Dissemination Materials <ul style="list-style-type: none"> Press Release #4 Project Manual #4 Project Drawings #4 Electric and PV Chart and Checklists TEE data and documents #2 SDE Solar Village Visiting Guide Information Design Approval Documents 	1 March 2019
	Preparation contest week	<ul style="list-style-type: none"> Information panels, brochures, finalize Augmented Reality tour Description guided tours Dinner party preparation Event scheduling 	February, '19 April, '19
	Technical inspections	<ul style="list-style-type: none"> Structural drawings, electrical and photovoltaic drawings signed and stamped by a qualified licensed professional 	April, '19
	DELIVERABLE #5	Updated Construction Documentation & Dissemination Materials <ul style="list-style-type: none"> Press Release #5 Project Manual #5 Project Drawings #5 Electric and PV Chart and Checklists TEE data and documents #3 SDE Solar Village Visiting Guide Information Design Approval Documents 	26 April 2019
DELIVERABLE #6	Design Adjustments Documentation & Dissemination Materials <ul style="list-style-type: none"> Press Release #6 Project Manual #6 Project Drawings #6 Electric and PV Chart and Checklists Jury Reports Audiovisual #3 Design Approval Documents 	31 May 2019	
Disassembly, packaging & transportation	<ul style="list-style-type: none"> Disassembly of pavilion into five modules, panels & outdoor construction Packaging of modules Transportation by truck to Szentendre 	Go/No Go Decision point 2: financial analysis	May, '19 June, '19
C O N T E S T	Assembly, competition and exhibition in Szentendre	<ul style="list-style-type: none"> Assembly on site, directed by Site Operation Manager Installing all modules + connecting Mounting prefab wall components and interior finishing Organising guided tours Participating events Continuous monitoring follow-up and remediation 	July, '19 September, '19
	Disassembly, packaging & transportation	<ul style="list-style-type: none"> Disassembly on site, directed by Site Operation Manager Disconnecting all modules Dismounting prefab wall components and interior finishing 	October, '19
A F T E R L I F E	DELIVERABLE #7	As Built Documentation & Dissemination Materials <ul style="list-style-type: none"> Press Release #7 Project Manual #7 Project Drawings #7 Electric and PV Chart and Checklists SDE19 Official Dissemination Materials TEE data and documents #4 	25 October 2019
	Rebuilding of the pavilion	<ul style="list-style-type: none"> Second life: GreenBridge/City of Antwerp Initiate follow-up programs with sponsors 	November, '19 (?)
	Debriefing	<ul style="list-style-type: none"> General debriefing with building industry partners Develop project summary and lessons-learned Continuous working on challenges of high-rise buildings 	November, '19 December, '19

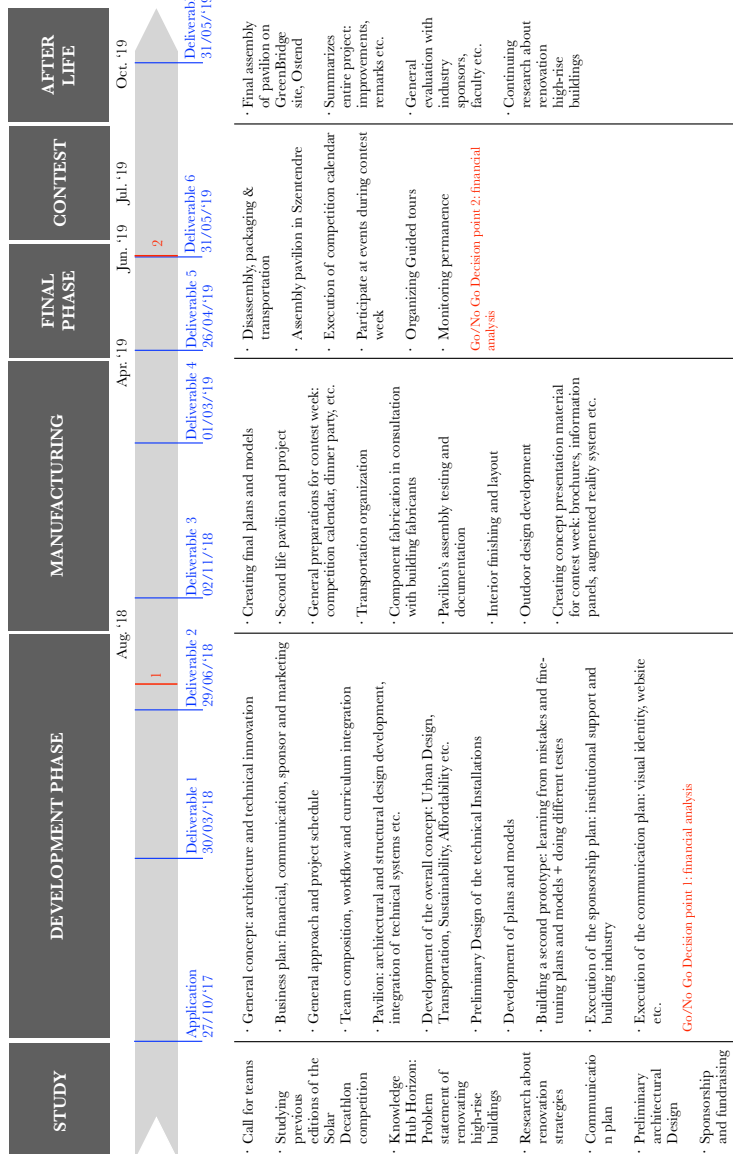
Work Breakdown Structure

STUDY	DEVELOPMENT	MANUFACTURING	FINE-TUNING	CONTEST	AFTER-LIFE
<p>Communication</p> <ul style="list-style-type: none"> · Communication Plan · Visual communication materials · Sponsorship concepts and actions · Initiate augmented reality tour design · Participation in national public events · Social Media Activities (Facebook, Instagram, Twitter,...) · Other activities contributing to energy literacy and awareness · Creating website <p>Sponsorship & Fundraising</p> <ul style="list-style-type: none"> · Letter of commitment · Interest from building industry · Sponsorship packages, brochure · Printed model of the pavilion to showcase · Collaboration with sector organizations (contractors, architects,...) <p>Preliminary Architectural Design</p> <ul style="list-style-type: none"> · Pavilion design & concept development · Building principles & technical APPLICATION 	<p>Construction Development</p> <ul style="list-style-type: none"> · Analyze transport boundary conditions for sizing · Internal layout of the competition house · Develop structural modular system · Build full-scale envelope design mockup · Landscape design <p>Preliminary design technical installations</p> <ul style="list-style-type: none"> · IFC study IOT-controlled HVAC · Energy coding concept, scenario analysis · Preliminary sizing and integration in modules <p>DELIVERABLE #1</p> <p>Building Prototype 2</p> <ul style="list-style-type: none"> · Structural frame to be used, use OSB · Building envelope and double skin facade · Foundation system and roof structure <p>Testing Prototype 2</p> <ul style="list-style-type: none"> · Testing installation, structural behavior, and connections · Transportation and disassembly tests <p>Update Constructive Design And Outdoor Design</p> <ul style="list-style-type: none"> · Improve architectural and structural drawings for final pavilion · Develop final IFC for supply, construction and installation · Health and Safety plan · Finalize landscape design <p>Design Technical Installations</p> <ul style="list-style-type: none"> · Finalize IOT-controlled HVAC system · Dynamic building simulation to optimize summer/winter heat balance · Dynamic building simulations with integrated HVAC system · Outdoor thermal algorithms · Electricity schemes and integration <p>DELIVERABLE #2</p>	<p>Define Material Lists And Production</p> <ul style="list-style-type: none"> · Define all materials and components · Technical workshops with manufacturers · Order placing at manufacturers <p>Go/No-Go Decision point 1: financial analysis</p> <p>Basic Components Construction</p> <ul style="list-style-type: none"> · Compose external modules, floor and roof elements · Compose interior wall components and finishing · Constructing bathroom, kitchen, etc. <p>DELIVERABLE #3</p> <p>Assembly, Pavilion</p> <ul style="list-style-type: none"> · General assembly · Overall performance evaluation (blower door, IR, heat flux) · Outdoor design <p>Implementation</p> <p>Technical Installation</p> <ul style="list-style-type: none"> · Installation of components · Initiate system operation and commissioning · Performance assessment based on co-heating test <p>DELIVERABLE #4</p>	<p>Preparation Contest Week</p> <ul style="list-style-type: none"> · Information panels, brochures, finalize · Augmented Reality tour · Description guided tours · Dinner party preparation · Event scheduling <p>Technical Inspections</p> <ul style="list-style-type: none"> · Structural drawings, technical specifications, details, site plan and stamped by a qualified licensed professional <p>DELIVERABLE #5</p> <p>DELIVERABLE #6</p> <p>Disassembly, Packaging & Transportation</p> <ul style="list-style-type: none"> · Disassembly of pavilion into five modules, panels & outdoor construction · Packaging of modules · Transportation by truck to Szentendre <p>Go/No-Go Decision point 1: financial analysis</p>	<p>Assembly, Competition & Exhibition</p> <ul style="list-style-type: none"> · Assembly on site, directed by Site Operation Manager · Installing all modules + connecting · Mounting prefab wall components and interior finishing · Organizing guided tours · Opening event · Contests, exhibiting · Follow-up and remediation <p>Disassembly, Packaging & Transportation</p> <ul style="list-style-type: none"> · Disassembly on site, directed by Site Operation Manager · Disconnecting all modules · Dismounting prefab wall components and interior finishing 	<p>DELIVERABLE #7</p> <p>Rebuilding Pavilion</p> <ul style="list-style-type: none"> · Second life: Greenbridge/ City of Antwerp · Initiate follow-up programs with sponsors <p>Debriefing</p> <ul style="list-style-type: none"> · General debriefing with building industry partners · Develop project summary · Continuous working on challenges of high-rise buildings

4.3. Project schedule



4.4. Technical scope summary



4.5. Project Management

Overall approach for Organization

Ghent University Horizon Team has adopted on organization structure with different team levels:

Level 1: Core Team

The Student Team Leader, Contest Captain, Faculty Advisor and Faculty Coaches safeguard the mission and vision of the project, and focus on team management and support. They determine the primary strategies, coordination of tasks and overall project's progress. These guys are the head of the Horizon Team!

Level 2: Operational Management

This group consists of a number of leading students with specific topics, called focus managers. These students have a passion for their specific focus but coordinate this with each other. They are responsible for the work progress and the organization of tasks within their group of students. This is the beating heart of the Horizon Team!

Level 3: Focus Teams

Each focus team consists of a number of students and is led by a focus manager. These students are, depending on the topic they are working on, studying architecture, engineering, electromechanics or communication management. These are the hands that build to the project!

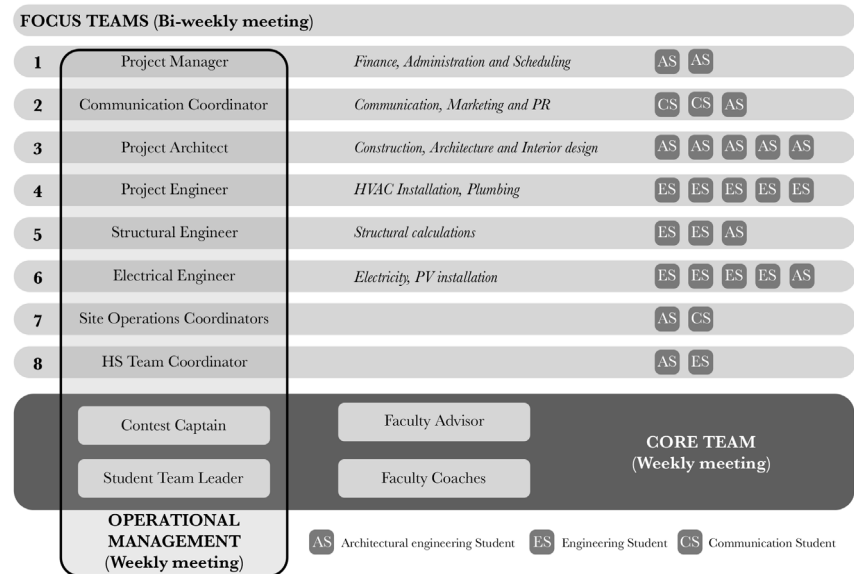


Figure 18. Team Organisation

Important notes:

- The number of students can vary along the process depending on the specific needs.
- All team members can participate in different topics at the same time: e.g. a student can participate simultaneously in the design team and the structural team, a project architect can also be the HS manager, etc.
- An interdisciplinary project requires an interdisciplinary team. Next to students studying engineering and architecture, collaborations with students of different faculties have been initiated and are operational for e.g. communication, marketing, city planning, and ICT.

Risk Management

To ensure the overall progress of the project, milestones are defined above. Timing is discussed in both operational management and core team. For critical steps the project schedule comprises some redundancy. A cash flow buffer is foreseen to cope with production issues: in case of extensive production delays or severe defects, alternative solutions will be costly. For critical aspects (combination likelihood and impact) a back-up scenario is considered (e.g. when the IoT-control would fail, a basic control algorithm can be implemented based on CO₂, RH, T and VOC detection). Important alternative scenario's will be considered in simulations as base-case reference.

Project Changes

The design will need updates based on the evolution of component design. In those instances, strategic choices are made in the core team in collaboration with the operational management. Using the BIM model, coordination is key, and version management is simplified. After every deliverable review from the SDE19 organization, the core team will discuss decisions on strategic level, practical changes are implemented by the operational management. After each SDE19 feedback on a deliverable the project schedule is revised and updated in the technical scope summary.

Quality Assurance

The faculty advisor, Faculty coaches and industrial partnerships provide a professional context with people with both practical and management experience. Next to that, at regular intervals the core team will discuss the progress with external parties such as the European Interreg ACE-retrofitting project and the Energetic valorization consortium that are involved in the project. Next to the inherent quality control by the faculty people in the project (which already delivered on two previous SD competitions) the broad network of the people involved ensure the proper counseling. And technical documents will be reviewed by an experienced architect – that led the 2011 E-cube project and has no other faculty responsibilities.

Internal Communication

To accommodate a swift project progress, the core team and operational management is in close contact with all participating students and faculty and SDE19 organization. They will organize weekly or bi-weekly team meetings with different groups as described in the team structure scheme above. The core-team will meet weekly to discuss the overall progress. Each focus team comprises a number of students working together very extensively, under supervision of a focus manager. Information management and BIM is cloud-based and has already been implemented, and an information manager has implemented an information structure with adequate meta-data information and guide for new team members.

5. TECHNICAL QUALIFICATIONS AND RESOURCES

University support is solicited as part of the proposal development phase, seeking support commitments at several departmental and the president's administrative levels of our University. This effort has resulted in early and clear support commitments (see attached letters). The following institutional support is been realized: integration of the project in different departments curriculum; research groups will deliver academic support; campus space for building the Ghent University Horizon Team, IT support for developing the team website, use of building equipment and administrative support. Please see attached letters of intent for support details.

Curriculum Integration

Team Belgium's Solar Decathlon participation is an interdisciplinary effort of students of different departments at Ghent University, but coordinated from within the faculty of Engineering & Architecture. One of the challenges of the Solar Decathlon competition is to assure the projects continuity within the context of an academic setting with changing student populations, and with various commitment levels. In order to assure a successful competition event, we propose to foremost work within the context of our existing curricular structures, which are well adapted and flexible enough to accommodate the competition efforts. Working within the context of existing courses will ensure that students receive academic credits for their efforts, and that they do not become overloaded when making contributions.

Most of the students are selected from the master in engineering and architecture, because the Solar Decathlon topic is fully integrated in their curriculum. This degree program provides a solid architectural education with the technical rigour of an engineering program, something which is different in comparison to most other architecture programs. Our educational programs are based on three pillars that carry equal weight, namely: architectural design, building engineering, and the history and theory of architecture. The department of architecture shares many curriculum components with other engineering majors, including the civil engineering program, which renders them very suitable for the project.

The following existing courses will be used to accommodate the various project tasks:

- The aim of the **Master studio** is doing research by design on the theme of "intelligent ruins". This comes down to developing structural systems that allow different uses in the course of time. Special attention is given to a combination of architecture, structure and technical systems. Students will, in consideration with thesis students, develop the concept of the pavilion.
- The **Design Development studio** is part of the core curriculum, and takes place during the second semester of the 1st Master year of our architecture program. Starting from an existing schematic design, this studio offers students an opportunity to extend the design effort into a completely ready-to-build pavilion. This effort will include the development of the structural and enclosure systems, technical installations, heating and cooling equipment, etc.
- Within our curriculum there is ample room for students to take up free electives in the form of **advanced topics courses**, which allow students to engage independent study projects over the course of a semester or more. The course structure is very flexible and allows for a wide range of study subjects and initiatives, which makes it an ideal vehicle for specialized work related to the development of the Solar Decathlon project. Therefore, different special topics courses will be offered to students (construction technics, building physics, interior design, urban planning...) in the period leading up to the contest in July 2019.
- The Solar Decathlon project was made available as a **research thesis** to second master students from the 2017-'18 academic year and will be offered again as a **development thesis** to a select group, which will reinforce the team during the 2018-'19 academic year. This rather small group of students are crucial for the success of the project, as their part of work will be significantly bigger than this in design studio's.

Excellent team members graduating at the end of academic year 2017-2018 could continue the project as paid researchers, also called decathletes in the SDE19 Rules. Special scholarships from Ghent University allow to reduce all overhead costs. This is an important principle as it will encourage long-term commitment which will warrant the project's continuity and precludes any important information, knowledge and experience is going lost.

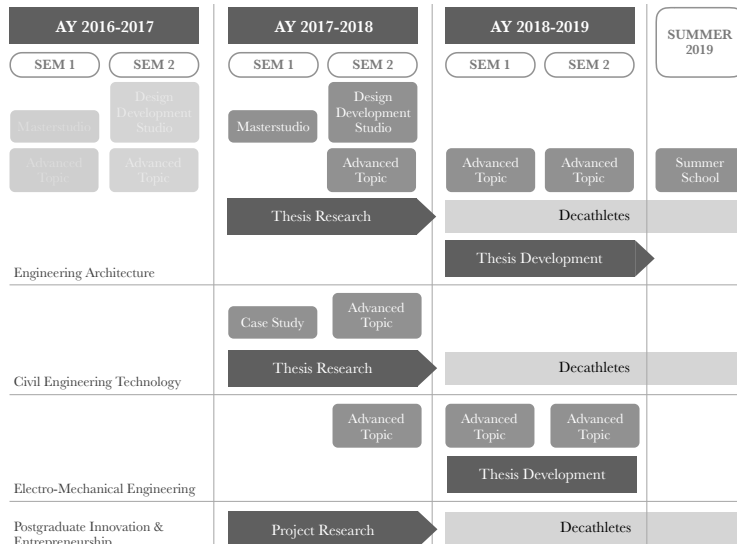


Figure 18. Curriculum Integration.

As described above, an interdisciplinary effort of students at different departments and faculties of Ghent University is prerequisite:

- A collaboration with electro-mechanic engineering students is put in place. Their focus will be on the sizing and execution of the technical installations. E.g. optimizing the electrical energy balance, sizing of heat exchangers, implementing control algorithms, etc.
- Students from the civil engineering department are working on the structural performance of the prefabricated modular systems. Detailed structural calculations using FEM models compare the implication of adopting either a steel structure compared to a wood-base structure.
- Finally, all tasks related to communication, administration, PR and project management will be executed as a project by postgraduate students innovation & entrepreneurship, in collaboration with students from the marketing and communication faculty.

Project team's existing equipment and facilities

The team can use the Test Centre for Façade Components to build and test building components. The lab is equipped with 4 state-of-the-art test rigs to evaluate airtightness, watertightness, and resistance to wind loads. Next to that there is a guarded hot box to assess the thermal performance of configurations, or to subject a component to different climate loads. Impact tests can be done with a soft or hard impactor, and standard mechanical tests can be performed as well. On a material level there is standard equipment for guarded heat flux measurements, capillary absorption tests, diffusion tests, sorption isotherms etcetera. For outdoor exposure testing, we use two test buildings: E-cube (SD competition, Washington, 2011) in Ostend, and STEAM-lab21 in Courtrai. Both can also be used for system evaluation of technical installations based on benchmark tests. For existing buildings, blower doors are used, in combination with IR, heat flux measurements, temperature and relative humidity sensors, portable weather stations, tracer-gas measurements, co-heating equipment... On the numerical side, we have extensive experience in modeling energy efficiency of whole buildings (Transys, Modetica, Capsol, in-house developed multi-zone models), and building components (Wufi, Delphin, Trisco, Bisco).

Project team qualifications and expertise



Prof. dr. eng. arch. Nathan Van Den Bossche (faculty advisor) is associate professor building science at the Faculty of Engineering and Architecture at Ghent University in Belgium. In 2005 he obtained his master's degree in architectural engineering, in 2008 a teachers degree, in 2009 a certificate as carpenter, and his PhD in 2013. Since then, he followed a post-graduate program in law for court experts, and a bachelor in real estate. He was appointed associate professor at Ghent University in 2016. He is in charge of the Test Centre for Façade Components at Ghent University, and author and co-author of over 100 research articles published in international journals, proceedings of international conferences and books. As a consultant he was involved in projects by Zaha Hadid Architects, Neutelings Riedijk, Renzo Piano, Jean Nouvel, Stephane Beel, and others.



Eng. arch. Marc De Kooning (contest captain) is a senior teaching assistant at Ghent University. He has extensive experience as a practitioner in architecture projects, and was in charge of the Ghent University Team that built the E-cube in Washington (2011). He is specialized in architectural design, affordable and D-I-Y design, and scenario-analysis. His non-sense approach and spirited attitude propels students in the design studio's that he is involved in.



Kristel Dewulf (faculty coach) is an expert in Front End Innovation and Sustainable Product Innovation, involved in several innovation projects together with Delft University of Technology (NL), University Ghent (B), and a wide range of international design consultancies. Kristel is currently working as Innovation Coach for the Faculty of Engineering and Architecture at Ghent University (Belgium), coaching engineering students in start-up and in-company innovation projects. She is also business manager and head of design at ENT Studios, an engineering consultancy located at Ghent (Belgium).



Prof. dr. eng. arch. Jelle Laverge (faculty coach) received his engineering and law masters degree from Ghent University. From 2005 to 2007 he was a part-time employee of Bureau Bouwtechniek in Antwerp. He was a visiting scholar at the University of Texas at Austin during the summer of 2011. With a dissertation entitled 'Design strategies for residential ventilation systems', he obtained a PhD in 2013, and was appointed professor in 2016. He is a member of ISIAQ, SRS and ASHRAE.



Prof. dr. eng. Michel De Paepe (faculty coach) is professor of Thermodynamics at the Faculty of Engineering and Architecture at Ghent University. He graduated as Master of Science in Electro-Mechanical Engineering at Ghent University in 1995. In 1999 he obtained a PhD in Electro-Mechanical Engineering at Ghent University, graduating on 'Steam Injected Gas Turbines with Water Recovery'. He was appointed full professor in 2014, and is a leading international expert on heat exchanger design and waste heat recovery. He is in charge of the thermodynamics research lab and facilities at Ghent University.



Prof. dr. eng. Jan Desmet (faculty coach) received the Polytechnical Engineer degree from the polytechnical academy in Courtrai, the M.Sc. degree in Electrical Engineering from the V.U.Brussels and his Ph.D. degree at the K.U.Leuven, Belgium. Currently he is full professor at the Ghent University teaching Power Quality, Renewable Energy, µGrids and industrial electric measurement techniques. His research interests include PQ, LV distributed generation, renewables, storage and their mutual interactions. His research lab is the only one over Europe with a free programmable artificial grid of 240kVA, including all renewable sources. Since November 2014, research group Lemcko became member of the prestigious DERLab group.

Prof. dr. eng. arch. Arnold Janssens: building physics and building construction//**Prof. dr. eng. arch. Jan Belis:** glass construction//**Prof. dr. eng. arch. Pieter Pauwels:** BIM expert//**Prof. dr. eng. arch. Michiel Dehaene:** urban analysis and design//**Prof. arch. Jan Moens:** building science and founder Bureau Bouwtechniek//**Eng. arch. Elisa Van Kenhove:** legionella research//**Eng. Hugo Monteyne:** affordable sustainable building design//**Eng. arch. Arthur De Roover:** structural engineer//**Prof. dr. eng. arch. Ronald De Meyer:** intelligent building design

6. APPENDIX: LETTERS OF SUPPORT

University support

- Dean Faculty of Engineering and Architecture, Prof. dr. eng. Patrick De Baets

Building industry support

- Etex
- Unilin

Institutional support

- Engie
- EnerGhentIC
- Ecohouse Antwerp, Belgium



DEAN'S OFFICE

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DATE	PAGE	OUR REFERENCE
11 October 2017	1/2	EA51/PDB/HVN/2017-186

Dear Madam
Dear Sir

The **Faculty of Engineering and Architecture of Ghent University** offers one of the best engineering study programs in Europe, with more than 4500 students, supported with approximately 350 professors, 1300 researchers and 250 administrative and technical staff members. Scientific discovery and technological progress are at the heart of our mission, a mission that offers a very challenging learning environment to our students. In 2017 our university celebrates its 200th anniversary.

As part of its mission, the Faculty of Engineering and Architecture recognizes the need for a vision that engages sustainable development, a vision that should foremost be integrated into the curriculum of our various programs. Buildings, products, and services have a substantial and long lasting impact on the environment; their designers therefore carry a great responsibility. With regard to building design, these responsibilities encompass all succeeding project phases, from material selection and extraction to production and execution processes, as well as the eventual use and decommissioning phases. Given our school's mission and ambitions with regard to sustainable development, we support our students' initiative to participate in the Solar Decathlon competition. We fully support them in this endeavour and are very confident that will success in building a competitive and attractive zero-energy Solar Decathlon House. The Solar Decathlon creates a great opportunity to showcase recent research and technological initiatives on sustainable development and energy efficiency at our faculty. The initiative also fully fits into our faculty's long tradition of technological innovation in construction and construction related fields. **In light of this history, the Solar Decathlon offers a great opportunity to celebrate our 200th anniversary.**



DATE	PAGE	OUR REFERENCE
11 October 2017	2/2	EA51/PDB/HVN/2017-186

In light of the above, the Faculty of Engineering and Architecture, represented by its Dean Patrick De Baets, declare to support the *Horizon Team*, represented by a team of students from Ghent University, and their faculty advisor, Prof. Nathan Van Den Bossche.

More specifically, we propose to provide the following types of support:

- we will provide, free of charge, a large covered or indoor working area where students can manufacture, assemble, test and store the building prior to shipping it to Szentendre in 2019;
- we will assist students in their manufacturing efforts by allowing them to use faculty workshops;
- we will encourage and support the team to apply for financial support through the existing funding mechanisms.



Prof. Patrick De Baets
Dean of The Faculty of Engineering, Ghent University

LETTER OF INTENT

Between :

Promat Research and Technology Centre, a company incorporated under the laws Belgium, inscribed in the Company register under registration n° 0441.829.654., with registered office at 2830 Tisseit, Bormstraat 23, hereby duly represented by Eric Betrand.

hereinafter referred to as 'PRTC'

And :

Rijksuniversiteit Gent, public institute with legal personality, with registered office at 9000 Gent, Sint-Pietersnieuwstraat 25, hereby duly represented by

hereinafter referred to as 'RUG'

hereinafter collectively and each individually referred to as the 'Parties'

Taking into consideration the following :

1. Whereas the RUG, more particular Team Horizon under the direction of prof. dr. ir. Nathan Van Den Bossche, desires to participate in the contest relating to the Team Belgium 2018 Solar Decathlon Project, hereinafter referred to as the '**Project**'
2. Whereas PRTC is part of Etex Building Performance, a division of the Etex group, and has the following products and systems available which can be of use for the Project :
 - Plasterboard and fibre cement boards for vertical and horizontal, interior and exterior applications
 - Plasters, compounds and accessories to install and finish
 - Metal frame systems
 - Fire protection solutions such as boards, spray, paints, fire stopping and fire sealing products
3. Whereas the RUG and PRTC have expressed their respective will to investigate the eventual possibility to collaborate with regard to the realization of the Project and to conclude a collaboration agreement.

Has been agreed what follows :

Article 1 :

The Parties will in good faith and on an exclusive basis during a period of 12 months after the signing of the present agreement investigate the possibility to conclude an eventual collaboration agreement regarding the Project according to the following principles :

LETTER OF INTENT-solar decathlon-final version

- depending on the first concept of the Project that RUG will submit to PRTC, PRTC is eventually willing to provide the following support : supply of building materials and systems of Etex Building Performance at a preferential rate or support during the design of their solution.

In return for this eventual support by PRTC, the RUG is eventually willing to accept that :

1. PRTC will be the exclusive supplier of lightweight building materials for this project.
2. PRTC will receive free of any charge all know-how, all scientific results and learning from this Project.
3. The Horizon team will put maximum effort into communication of this project and its partners to the construction industry and a large public
4. The logo's of Etex Building Performance and its commercial brands Siniat, Promat and EOS will be prominently mentioned on communication relating to this Project (website, newsletters, public reports, ...)
5. PRTC, the Etex Group and affiliated companies can all use pictures and plans related to the project for internal and external communication, free of charge, including its websites.
6. Horizon team will give upon request a number of presentation about their project to the employees or PRTC or her affiliated companies upon request.

ARTICLE 2

Except the obligation to investigate in good faith and on an exclusive basis during a period of 12 months after the signing of the present agreement the possibility to conclude an eventual collaboration agreement regarding the Project, everything else contained in the present agreement is non-binding.

The Parties are under no obligation to conclude an eventual collaboration agreement.

The contact persons are

1. At Etex Building Performance : Geert Houvenaghel, Head of Dryco Department.
2. At University of Ghent : Nathan Van Den Bossche, prof. dr. ir

On behalf of PRTC

Eric Bertrand, Managing-Director

On behalf of University of Ghent

Nathan Van den Bossche

LETTER OF INTENT-solar decathlon-final verslon



UNILIN bvba
division insulation

Waregemstraat 112
8792 Desselgem
Belgium
T +32 56 73 50 91
F +32 56 73 50 90
info.insulation@unilin.com
www.unilin.com

Desselgem, 17 oktober 2017

Subject: Declaration of Intent – SDE19

UNILIN Division Insulation, represented by Ann-Sophie Martens, hereby declares to support the "Ghent University Team Horizon" during the Solar Decathlon Project 2019. The Team of students are represented by their faculty team leader, Prof. Dr. Ir. Arch. Nathan Vandenbossche.

The UNILIN group is part of Mohawk Inc, the world's largest flooring company, with operations in North- and South America, Europe, Russia and Asia. UNILIN's global aim is to create beautiful, convenient and energy-efficient quality products for every home. UNILIN produces laminate, engineered wood and vinyl floors, boards, decorative panels, roofing element and insulation panels. The group counts more than 4.900 employees and has 20 production units all over the world.

UNILIN Division Insulation, being one of the biggest manufacturers of PIR Insulation boards in the European market, creates innovative and energy-efficient insulation products for flat and pitched roofs, floors, walls and other applications such as agricultural construction. In the development of our Ecoon structural Roof Panels, an innovative construction method represented by an all-in-one self-supporting roof product combining thermal insulation, rafters and ceiling board, we consistently strive to create better insulation performances of our panels to cope with the constantly increasing energy legislations. It's our persistent challenge to produce slim insulation panels and boards with the lowest Lambda- and U-values. This not only generates living comfort, but also financial and environmental benefits for our stakeholders.

Households should be minimizing energy consumption. Due to a good insulation, energy consumption can be limited. Ecoon Roof Panels are one of the most energy-efficient product of roof insulation applications in the market, which makes them a perfect fit for insulating the building envelope and so minimizing the energy consumption. Additional energy should be generated by renewable resources, such as e.g. photovoltaic panels. By focusing primarily on a well-insulated building envelope, installations can be performed in a smaller and cheaper way. That is why our products go hand in hand with those sustainable solutions.

Our intention is to support our Belgian colleagues to build a resource responsible and energy-efficient home by different levels of architectural and engineering challenges. UNILIN insulation can be helpful in the field of expertise of energy calculation, intelligent building components and sustainable architecture. We can assist the Belgian team in building design concepts, technical support within the possibilities of the company. But also new insulation techniques and materials can be used for this project.

All the best,

Ann-Sophie Martens

Marketing Manager Belgium UNILIN Insulation
+32 56 73 59 97 / +32 57 44 34 29
ann-sophie.martens@unilin.com

UNILIN bvba, division insulation

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btw BE 0405414072

UNILIN. FOR SMART LIVING.



Prof. Dr. Ir.-arch. Nathan Van Den Bossche
 Universiteit Gent
 Department of Architecture and urban planning
 Jozef Plateastraat 22
 9000 Gent

Contact person Dr. Ir. Benoît Codrons

Tel. + 32 2 382 05 49

E-mail benoit.codrons@engie.com

Linkebeek, 25/10/2017

To Whom it may concern

Letter of Interest for the project Horizon
"Sustainable renovation of high-rise housing blocks in private ownership"
For submission by UGent to the Solar Decathlon 2019

On behalf of ENGIE Laborelec, I would like to express our interest for the aims and goals of the HORIZON project.

ENGIE Laborelec is a leading research and competence centre and an international consultant and service provider in energy and power technology. It was established in 1962 in order to support Belgian electricity companies with research, development, and specialized services. Today, it is part of ENGIE, a world leader in energy. ENGIE Laborelec participates in projects supporting the energy transition, including applied to or in relation with building renovation. Our headquarter is located near Brussels, and we are part of a large network of other ENGIE Labs (France, the Netherlands, Germany, Middle-East, Chile and Singapore). ENGIE is a global energy player and an expert operator in the businesses of electricity, natural gas and energy services. The Group develops its businesses around a model based on responsible growth to take on the major challenges of energy's transition to a low-carbon economy: access to sustainable energy, climate-change mitigation and adaptation, security of supply and the

Laborelec, Rodestraat 125, 1630 Linkebeek, Belgium
 Tel.: + 32 2 382 02 11 – Fax: + 32 2 382 02 41
 www.laborelec.com



Restricted | 1 / 2

rational use of resources. The Group considers thus the energy efficiency of buildings as an important issue.

ENGIE Laborelec recognizes the current need for an integrated approach to collective dwelling building renovation that takes into account difficulties like

- outdated infrastructure
- inefficient technical installations
- poor thermal performance
- non conformity to current standards and regulations
- multiple ownership making the decision process difficult and impairing the possibility to tackle the renovation problem in its globality.

In particular, ENGIE Laborelec is very interested in the way energy aspects can be addressed in such an approach.

UGent's HORIZON project is aligned within that vision. Indeed, it addresses the need of research related to the renovation of post-war housing blocks in private ownership and provides a first step to deal with these multidimensional problems with a complex interdependency. ENGIE Laborelec believes that the multidisciplinary approach adopted by UGent is the right way to address the ten criteria of the Solar Decathlon and to make this project a success.

Yours sincerely,

Philippe De Raedemaeker

Director

New Energy Department, IT & Operational Support

Laborelec

Restricted | 2 / 2

UGENT-ENERGHENTIC

UGENT-ENERGHENTIC

Jeroen De Maeyer
Business Development Manager (IOF)

To whom it may concern

E Jeroen.DeMaeyer@ugent.be
T +32 9 264 79 14
M +32 471 58 88 32

DATE PAGE
12 October 2017 2/2

Campus Zwijnaarde
Technologiepark 913
B-9052 Zwijnaarde
Belgium

www.energhentic.ugent.be

DATE PAGE
12 October 2017 1/2

Solar Decathlon 2019

EnerGhentIC would like to express its interest in contributing to the Ghent University Team Horizon Solar Decathlon 2019 initiative.

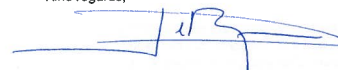
EnerGhentIC is the interdisciplinary community of Ghent University researchers working on the energy challenge. It has been set up to stimulate activities w.r.t. research & valorisation; education and training; and stimulating the energy transition. Our vision is "EnerGhentIC will provide an interdisciplinary critical mass of Ghent University researchers, interacting with companies, policy makers, students and colleagues, all working together on the energy challenge, creating inspiring technologies & ideas." The community runs across several research groups of different faculties and counts about 150 FTE members. A support team of 4 people (2,5FTE) supports this community of researchers.

The activities of EnerGhentIC are organised around three topics, in line with the H2020 approach: energy efficiency, renewables and energy systems. The Solar Decathlon is linked both to the topic of the energy efficiency (in buildings) as well as to the topic renewables (@consumer level). Within EnerGhentIC there are several national, regional and EU projects running and several researchers from different research groups within EnerGhentIC can be linked to the Solar Decathlon challenge. More information can be found on our website.

Central elements in our vision are the multidisciplinary and the interaction between Ghent University and the different stakeholders. We identify both aspects in the Solar Decathlon 2019 initiative. First of all, this initiative will allow Ghent University researchers to bring their research results into real life. Furthermore, it is clearly coupled to the education programmes at Ghent University both at the master and the continuous education level; it will as such stimulate and provide inspiration to students w.r.t. the energy transition and energy efficient buildings in particular. Finally, Solar Decathlon will interact in a direct manner with industry, discussing their solutions and their challenges. This will lead to new research questions and new industrial collaborations.

EnerGhentIC's support team will assist the Ghent University Horizon Team under supervision of faculty advisor prof. Nathan Van Den Bossche by opening up its industrial network, providing linkages to the whole of the community and by providing expert advice w.r.t. to the interaction with the industrial and other stakeholders. Finally, the Solar Decathlon initiative will be disseminated both within the community at Ghent University as well as in EnerGhentIC's network.

Kind regards,



Jeroen De Maeyer
Business Developer EnerGhentIC





Solar Decathlon Europe, 2019

To whom it may concern,

The EcoHouse Antwerp would like to express its interest to contribute to the Horizon Team participating in the 2019 Solar Decathlon competition in Szentendre, Hungary, and hereby declares to support the Ghent University Horizon Team and their faculty Advisor Prof. Nathan Van Den Bossche.

The city of Antwerp is the largest city in Flanders, with a population of over 500.000 people. The port of Antwerp is one of the biggest in the world, ranked second in Europe, within top 20 in the world. The existing building stock comprises a significant share of large scale apartment buildings that require a thorough renovation. A specific focal point is the interaction with fellow-ownership in the building blocks.

The city of Antwerp is partner in the European Interreg NEW-project ACE-retrofitting. The goal of the project is to:

- Develop a toolbox that allows apartment owners, boards of fellow-owners and syndics to deal with the various bottlenecks that impede the rapid and thorough energy refurbishment of apartment building blocks.
- Provide an operational framework that supports building professionals in their specific tasks as building expert in the renovation process.
- Match the demand side and supply side; bringing owners, architects and contractors together that specialize in apartment buildings.

In this project we see a large and important overlap with the Ghent University Horizon project. These projects are also complementary, as the Horizon project focuses on theoretical, scientific and technical aspects, whereas the ACE-project mainly focuses on the operational framework and practical implementation.

The EcoHouse Antwerp expresses its ambition to intensify the collaboration in the context of the Solar Decathlon competition as follows:

- We can provide an expert think tank to discuss design proposals
- We can address a national and international network of experts and policy makers
- We will investigate the possibility to adopt the Solar Decathlon pavilion as a local HUB and information point for inhabitants, either as pop-up concept, traveling or permanent pavilion.

PS. More information on the EcoHouse Antwerp : <http://www.livinggreen.eu/the-projects/ecohouse/>



Kind regards,

Dirk Van Regenmortel | coördinator EcoHuis Antwerpen

Stad Antwerpen | Stadsontwikkeling | EHA
 Turnhousebaan 139 | 2140 Borgerhout
 tel + 32 (0)3 217 08 54 | fax +32 (0)3 217 08 88
dirk.vanregenmortel@stad.antwerpen.be | www.antwerpen.be/ecohuis

5.2.3 Budget

201713

		<h1>TEAM GHENT UNIVERSITY</h1> <h2>BUDGET</h2>					
Total (€):							
Research & Development Phase					299.581		
1	Submission fee	A fee is already paid to the EEF.			750		
2	Employees	Number of persons:	Number of months:	Cost per person (€):	233.000		
	- Academic staff	2 (50%)	18	7.000	126.000		
	- Project staff	2 (50%)	12	3.300	39.600		
	- Job student	2 (50%)	18	3.300	59.400		
	- Job student	2 (100%)	2	2.000	8.000		
Communication Exhibitions, events, creating website, server costs, advertising products, etc.					20.000		
1	Visit SD Denver 2017	Unit	Quantity:	Cost per unit (€):	5.400		
	- Flight	Brussels - Denver (back and forth)	persons	5	800	4.000	
	- Lodging		persons	5	280	1.400	
1	Prototype 1	Prototype 1, called STEALlab 21, is already built in cooperation with VTI Courtrai. Numerous technical tests are planned to be performed: pressurisation test for airtightness, thermography, water tightness testing of components etc.				12.750	
	Prototype 2	Unit:	Quantity:	Cost per unit (€):	21.431		
	- Foundation system	lump sum	1	1.500	1.500		
	- Frame structures	apiece	2	1.000	2.000		
	- Floor panels (SIP)	m ²	14,4	90	1.296		
	- Exterior wall panels (SIP)	m ²	28,5	85	2.423		
	- Facade finishing	m ²	28,5	50	1.425		
	- Windows	m ²	7,5	750	5.625		
	- Roof panels (SIP)	m ²	14,4	85	1.224		
	- Roof finishing	m ²	10,8	60	648		
	- Fixing & bonding materials	e.g. bolts, crews, tape etc.	lump sum	1	200	200	
	- Interior wall panels	m ²	16,5	60	990		
	- Interior doors	apiece	2	300	600		
	- Permanent closets	m	3	1.000	3.000		

- Paintwork		lump sum	1	500	500
Workshops		Unit:	Quantity:	Cost per unit (€):	5.250
- First workshop		persons	2	750	1.500
- Second workshop		persons	5	750	3.750
Budget for deliverables	Model, DVD/CD, printing costs, etc.	lump sum	1	1.000	1.000
Construction phase					309.470
Direct materials		Unit:	Quantity:	Cost per unit (€):	144.970
- Foundation system		lump sum	1	7.500	7.500
- Frame structures		apiece	10	1.000	10.000
- Floor panels (SIP)		m ²	72	90	6.480
- Exterior wall panels (SIP)		m ²	72	85	6.120
- Facade finishing		m ²	75	50	3.750
- Windows		m ²	46	750	34.500
- Sunscreens		m ²	38	250	9.500
- Roof panels (SIP)		m ²	72	85	6.120
- Roof finishing (2x)	test & definitive layer	m ²	180	60	10.800
- Ramp		lump sum	1	7.500	7.500
- Fixing & bonding materials	e.g. bolts, crews, tape etc.	lump sum	1	1.000	1.000
- Interior wall panels		m ²	95	60	5.700
- Interior doors		apiece	10	300	3.000
- Permanent closets		m	15	1.000	15.000
- Paintwork		lump sum	1	2.000	2.000
- Mobile closets		lump sum	1	10.000	10.000
- Decor		lump sum	1	2.000	2.000
- Interior and exterior lighting		lump sum	1	4.000	4.000
Outdoor design		m ²	300	75	22.500
Technical installations		Unit:	Quantity:	Cost per unit (€):	127.000
- PV system		m ²	60	400	24.000
- Thermal solar system		lump sum	1	7.000	7.000
- Plumbing		lump sum	1	20.000	20.000
- HVAC system		lump sum	1	30.000	30.000
- Electrical system		lump sum	1	15.000	15.000
- Energy storage system		lump sum	1	8.000	8.000
- Domestic Appliances	e.g. refrigerator, dishwasher, oven, clothes washer and dryer etc.	lump sum	1	12.000	12.000
- Home electronics	e.g. TV, computer, DVD-player etc.	lump sum	1	3.000	3.000
- e-bikes & charging station		lump sum	1	8.000	8.000
Consultancy and Inspection		lump sum	1	5.000	5.000

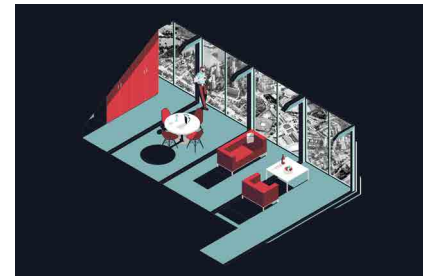
Equipment, tools	e.g. sawing machine, drilling machine, etc.	lump sum	1	10.000	10.000
Transportation					17.500
Ghent (Belgium) - Szentendre (Hungary) (back and forth): 1500 km		Unit:	Quantity:	Cost per unit (€):	
		Trucks	6	2.500	15.000
Tarpaulin		apiece	5	500	2.500
Final phase					46.000
SD Szentendre 2019		Unit:	Quantity:	Cost per unit (€):	21.000
- Travel	Ghent - Szentendre (back and forth)	persons	20	300	6.000
- Lodging	during 30 days (changing teams included)	persons	15	1.000	15.000
Cranes and Construction equipment	Twice (assembly and disassembly)	lump sum	2	2.500	5.000
Communication on Site	Information panels, Augmented Reality system, flyers, uniforms, videos of assembly, dinner party etc.	lump sum	1	15.000	15.000
Insurances		lump sum	1	5.000	5.000
After-life					50.000
Permanent assembly in Ostend	Transport, assembly, cranes, permanent foundation etc.				50.000
Other					20.000
1 Monitoring & Testing equipment	e.g. weather station etc.				20.000
Total costs:					
Ghent University	Incurring costs (1):				38.900
	Employees costs (2):				233.000
Residual Costs					470.651
Total estimated costs:					742.551
Safety margin for unexpected costs (5%):					37.128
Total estimated cost including safety margin:					779.678
Fixed costs Ghent University: incurred costs (1) and employees costs (2):					271.900
Residual anticipated sources:					510.000
Anticipated costs Ghent University:					40.000

Total budget from EEF and EMI:	100.000
City of Ghent:	15.000
Province of East Flanders:	15.000
Government of Flanders:	30.000
Fundraising:	80.000
Industry Sponsorship:	230.000
Total anticipated sources:	781.900

5.2.4 Abstract for Public Release



TEAM GHENT UNIVERSITY
ABSTRACT FOR PUBLIC RELEASE



FACULTY ADVISOR
Prof. dr. eng. arch. Nathan Van Den Bossche
Nathan.VanDenBossche@UGent.be

STUDENT TEAM LEADERS
info.horizon@UGent.be

THE MOBBLE

Modular Building Block

Problem Statement

The high-rise apartment buildings constructed in the 60's and 70's due to a large housing shortage after the second World War, are typically outdated and no longer meet code requirements. The majority of these high-rise buildings are in desperate need of a thorough renovation.

Goal

The Ghent University Horizon Team aspires to showcase the potential and the necessity of renovating large scale apartment buildings. In addition, we want to raise awareness concerning health issues such as poor indoor air quality, high relative humidities, mould risks and critical legionella concentrations in tap water. This communication is mainly oriented towards the general public, but also architects, contractors, building experts and policy makers need to be triggered and informed.

Project description

We will build a characteristic high-rise apartment to address these technical, scientific and societal challenges. Based on the experience from our two previous participations at the Solar Decathlon competitions in Washington and Datong, the Ghent University Horizon Team decided to design and construct the pavilion using a modular system. The standard module would be completely prefabricated by students. Not only the structural frame, but also HVAC systems, kitchen, bathroom, interior finishing, etc. is included. Once finished, the modules can easily be transported to Szentendre, resulting in a limited installation time on site.

Modular

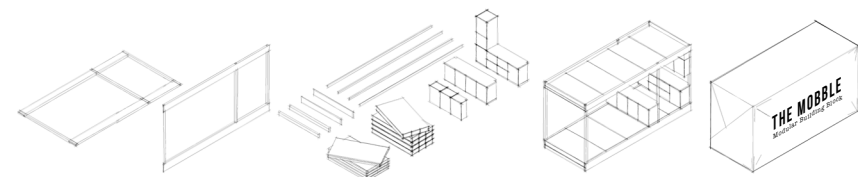
The competition house is an illustration of a modular building system, called The Mobble, which will focus on adaptability and flexibility. This system can be used in different manners: to create new building configurations; to add some housing layers on top of existing high-rise buildings; or represent a characteristic apartment. The underlying blueprint allows to reorganize the apartment very easily, which renders it apt for various social configurations, from starters, over young families, up to elderly people.

Life cycle cost

Nowadays, life cycle cost mainly focusses on material level. However, a more holistic reasoning concerning sustainability is required. We are convinced that re-usability and recycling on component level is more interesting compared to the approach on material level.

Technical installations

Energy efficiency is a prerequisite, but in these types of buildings with complex social mixes the HVAC systems should be intelligent and demand-controlled as well. Hence, an innovative IoT-approach is required to ensure an optimal trade-off between indoor air quality, comfort, and energy use. Finally, a heat pump driven by building integrated photovoltaics with battery storage finally renders the building extremely energy efficient.



Team Ghent University

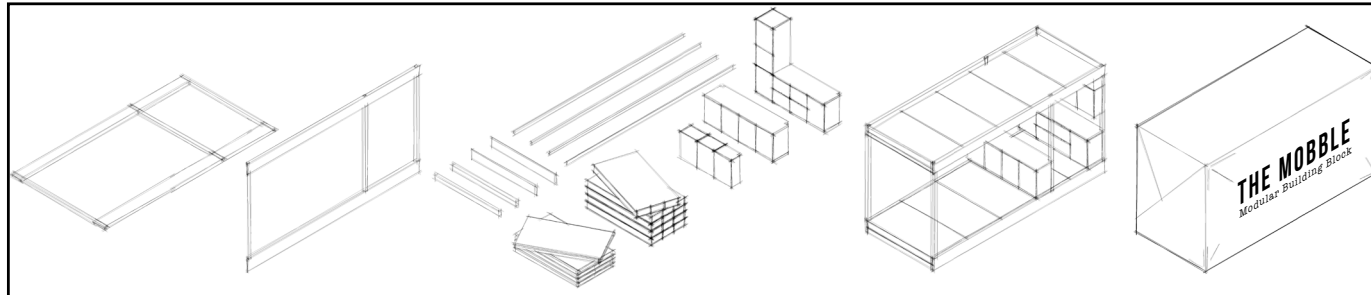
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5.2.5 Summary Slide



TEAM GHENT UNIVERSITY

SUMMARY SLIDE

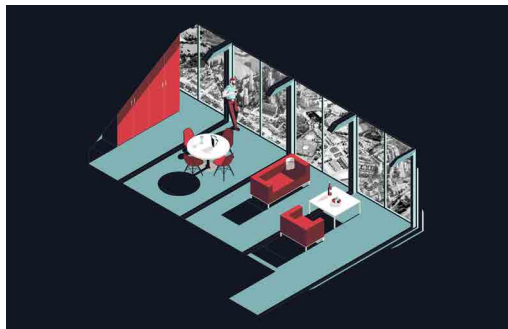


MODULAR | RECYCLE | RENOVATE

Nathan Van Den Bossche, Faculty Advisor Ghent University
Nathan.VanDenBossche@UGent.be +32 (0)476 97 85 91

THE MOBBLE

Modular Building Block



PROBLEM STATEMENT

Many outdated and energy inefficient high-rise buildings

GOALS / IMPACT

- Showcase the potential of renovating and expand high-rise buildings.
- Raise awareness regarding responsible energy use in apartment buildings
- Creating a knowledge hub concerning renovation of high-rise buildings.
- Inform professionals about the potential and opportunities in high-rise renovation.

PROJECT DESCRIPTION

- Modular building system, called The Mobble: flexibility and adaptability
- A new vision on embedded energy, LCA on component level
- Intelligent and demand-controlled HVAC systems
- Full IoT-approach

5.3 Brief met mededeling selectie

15 12 2017



**solar
decathlon
europe** 19
SZENTENDRE
HUNGARY

NATHAN VAN DEN BOSSCHE
INTERNATIONAL HELLENIC UNIVERSITY
ST. PIETERSNIEUWSTRAAT 33
9000 GENT, BELGIUM

The art of smart building.

sde19 call for teams - team designation

Dear Ghent University,

The joint EEF_SDE19 Selection Committee is delighted to announce that your team has been selected to participate in the upcoming Solar Decathlon Europe, set for July 2019, in Szentendre, Hungary. After careful evaluation of your full application submitted on 13 November 2017, the expert Jury members of the Selection Committee unanimously supported your proposal and awarded it a very high overall score. Well done!


The jury procedure was detailed in scope, including a compliance check, preliminary scoring and final full assessments. These steps help to maintain the standards, calibre and rigour of the SDE mandate.

The SDE19 Organisation will be contacting you after the holiday season with an outline of upcoming milestones, including an update on the Rules, a calendar for Deliverables, workshops and Speed Peer Reviews. The terms and conditions for seed funding will also be communicated to teams in the new year. In the meantime, the SDE19 Organisation urges teams to re-familiarise themselves with the existing version of the Rules with an eye on Deliverable #1. If you have questions, please address them to wat@solardecathlon.eu. Your questions will be addressed after the holiday season.

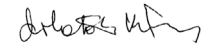
A communiqué listing the selected teams will be published on the SDE website in coming days. The solardecathlon.eu site will continue to publish key info and stories about the development and lead-up to the SDE19 competition event in Szentendre, and the Solar Decathlon worldwide movement. For more detailed info about the specific edition of the SDE19, the SDE19 Organisation will be launching an SDE19-specific website, which will be linked to the existing solardecathlon.eu portal.

The Energy Endeavour Foundation and the SDE19 Organisation look forward to a fruitful collaboration with the selected teams, sharing the objective of an intrepid, responsible and successful edition of the Solar Decathlon in Europe. We wish to thank you for your thorough and winning proposal, for your continued professionalism, inspiring goals and ambitions for what promises to be a formidable international event. Congratulations!

Best regards,



Louise Holloway
Director
Energy Endeavour Foundation



Dr. Károly Matolcsy
Competition Director
Solar Decathlon Europe 2019



5.4 Geselecteerde teams

University of Brighton, United Kingdom

Technical University of Civil Engineering Bucharest, Romania

Budapest University of Technology and Economics, Hungary

Universitat Politècnica de Catalunya, Spain

Delft University of Technology, Netherlands

Technical University of Denmark, Denmark

Ghent University, Belgium

International Hellenic University, Greece

Ecole Nationale Supérieure d'Architecture et de Paysage de Lille, France

University of Maryland, U.S.A.

Politecnico di Milano, Italy

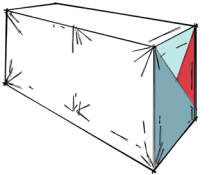
University of Miskolc, Hungary

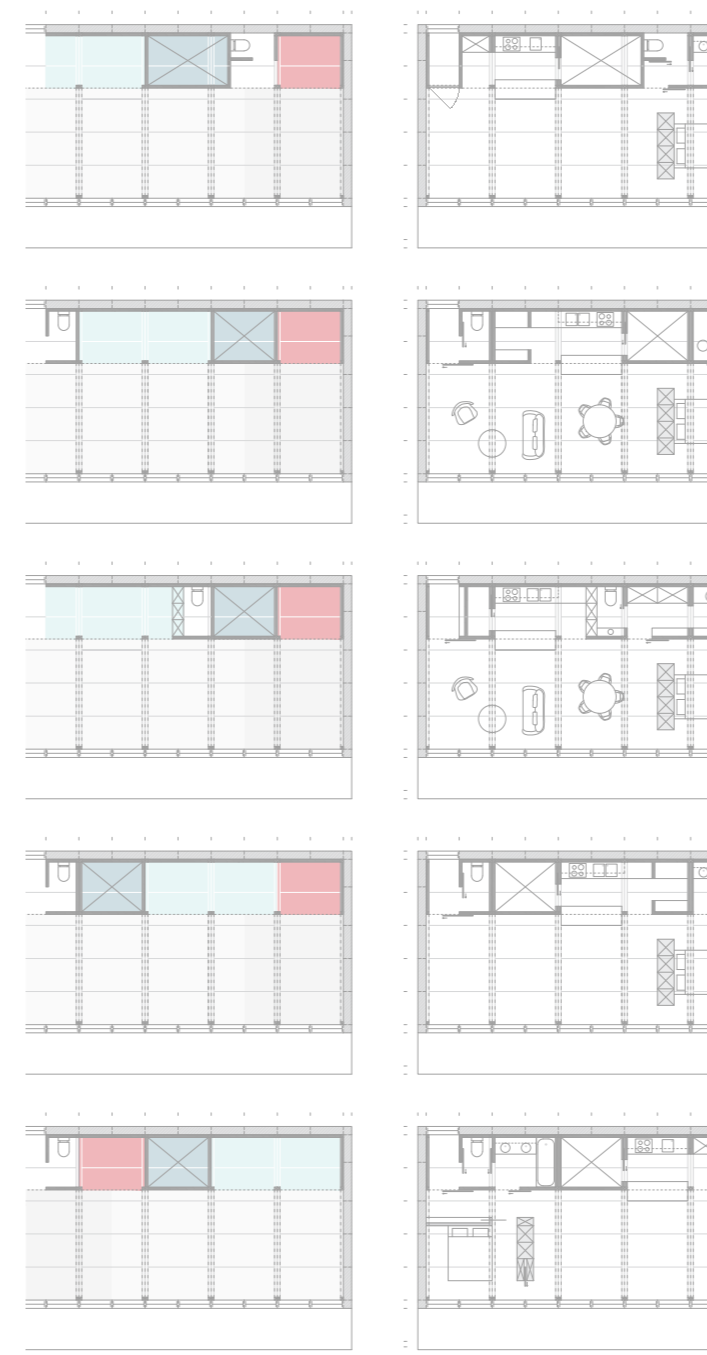
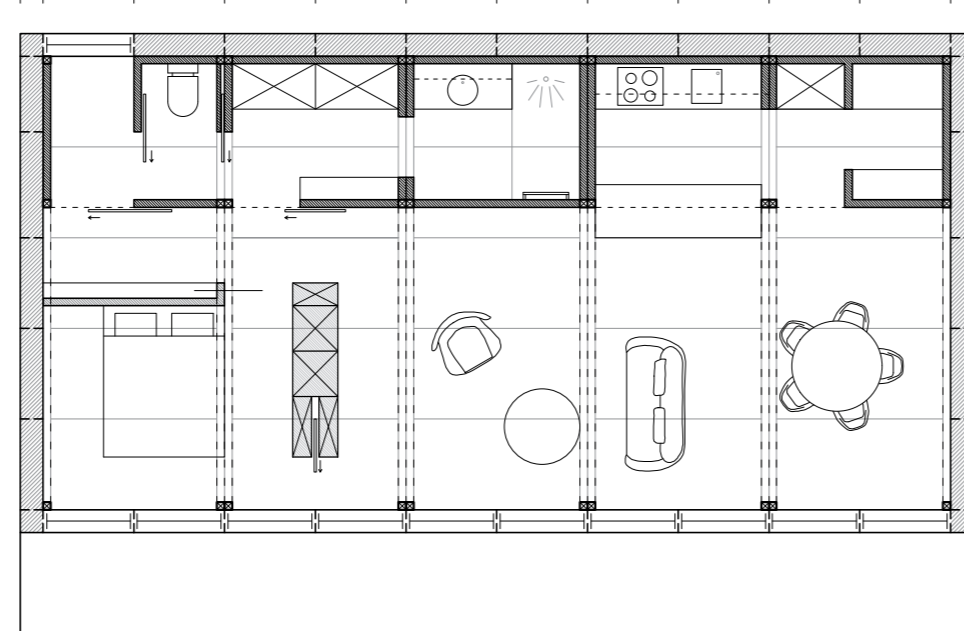
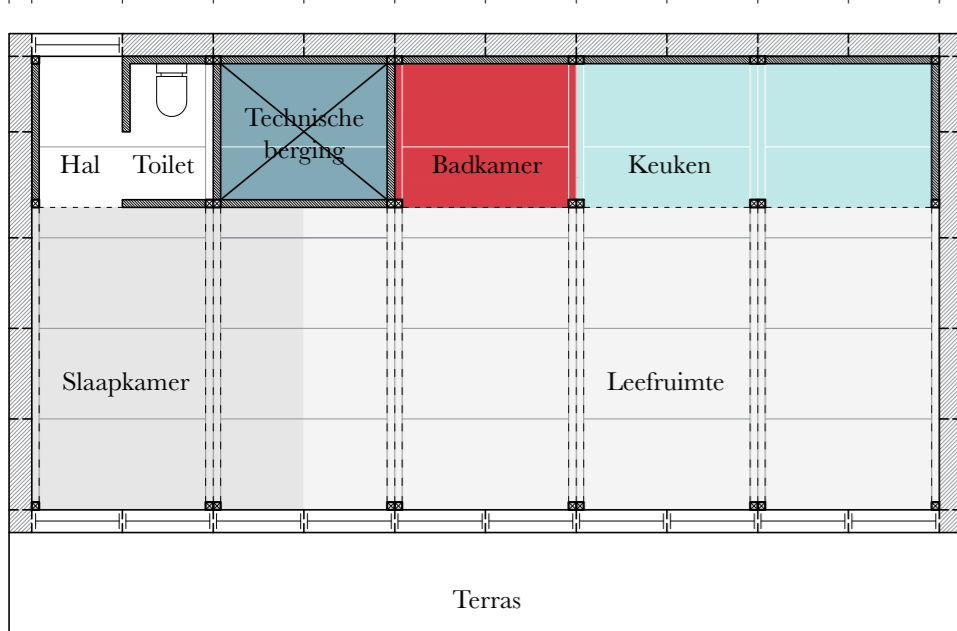
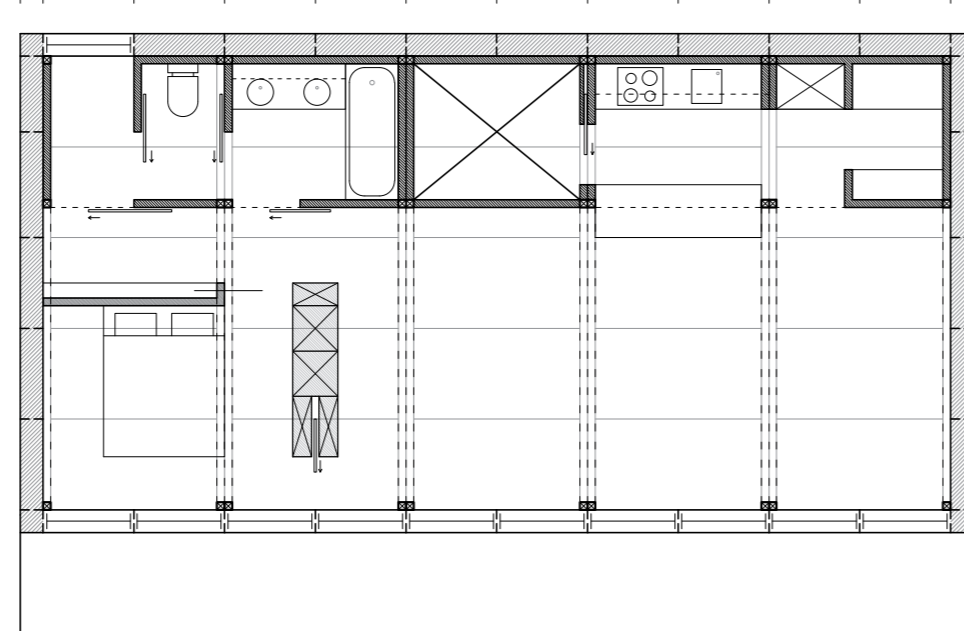
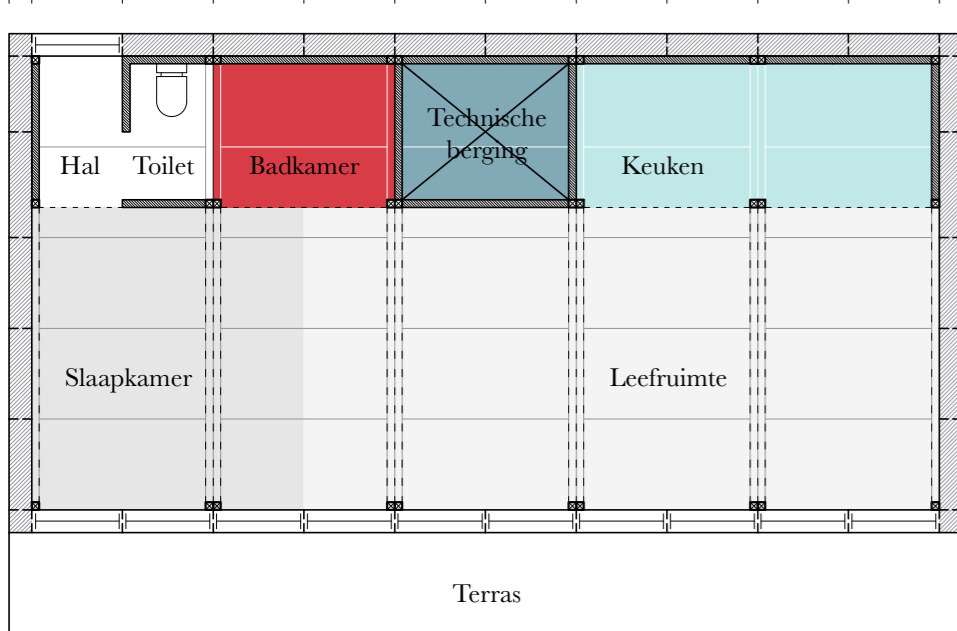
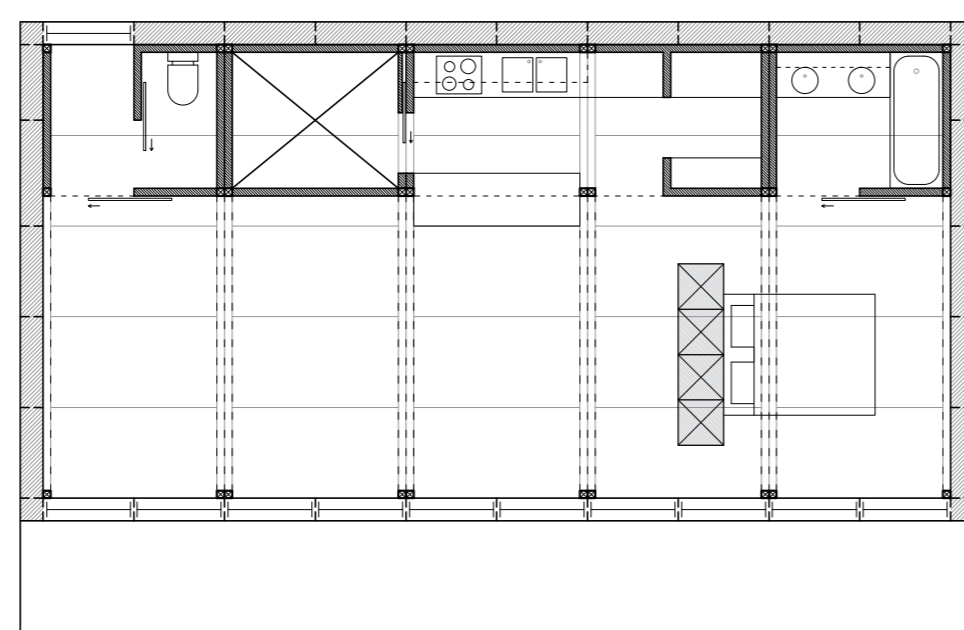
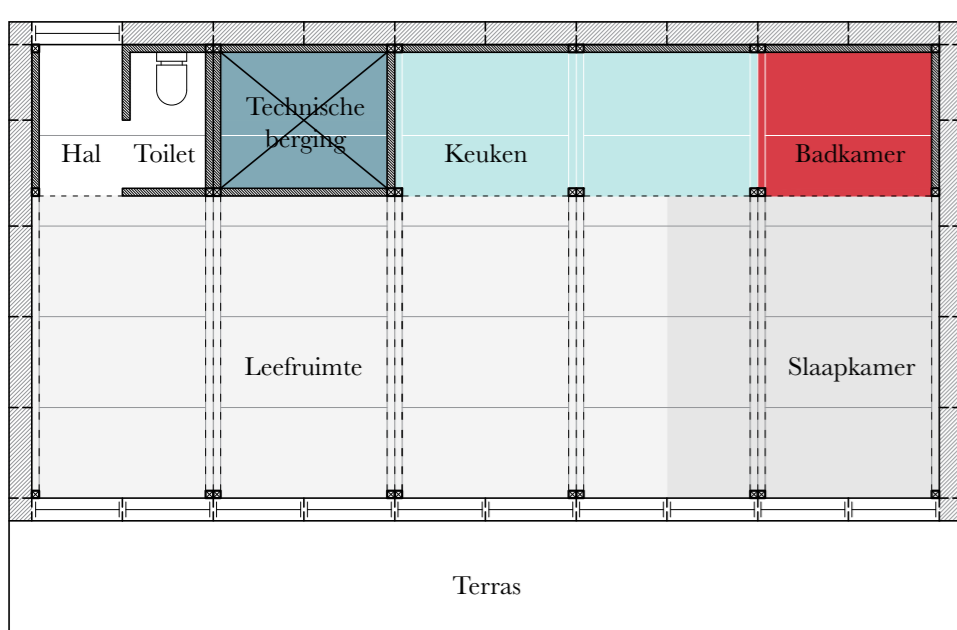
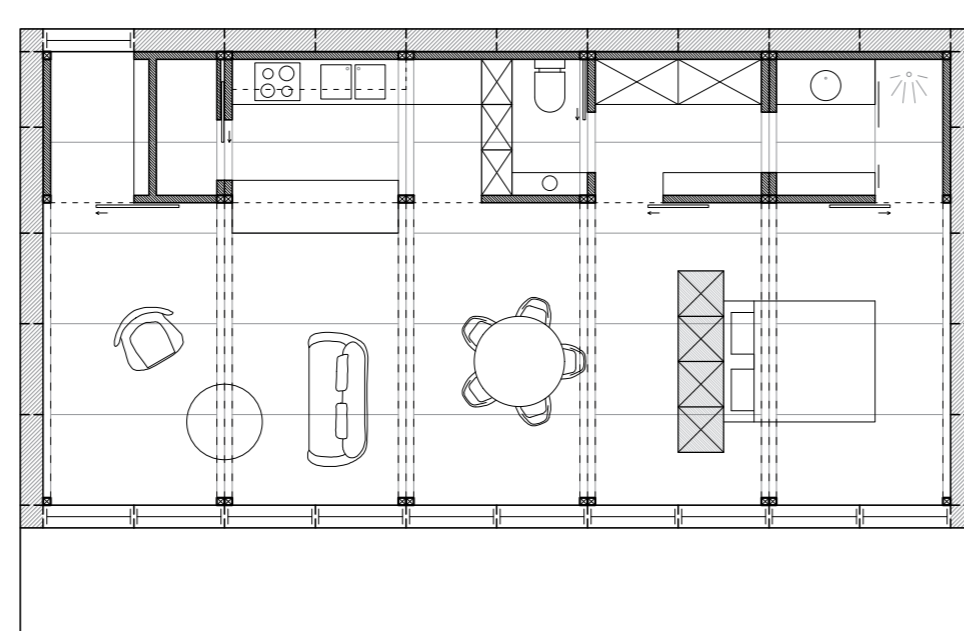
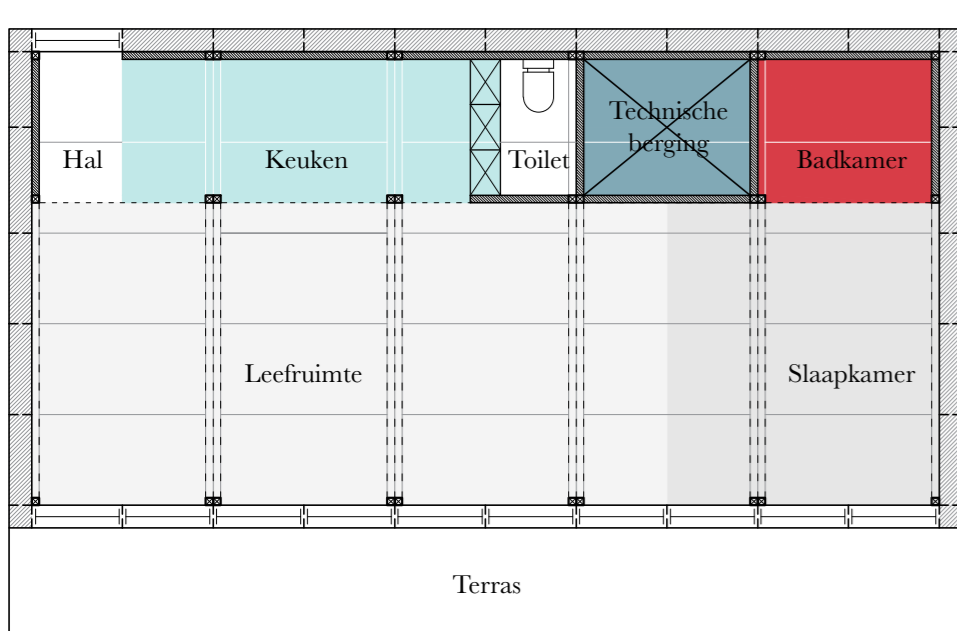
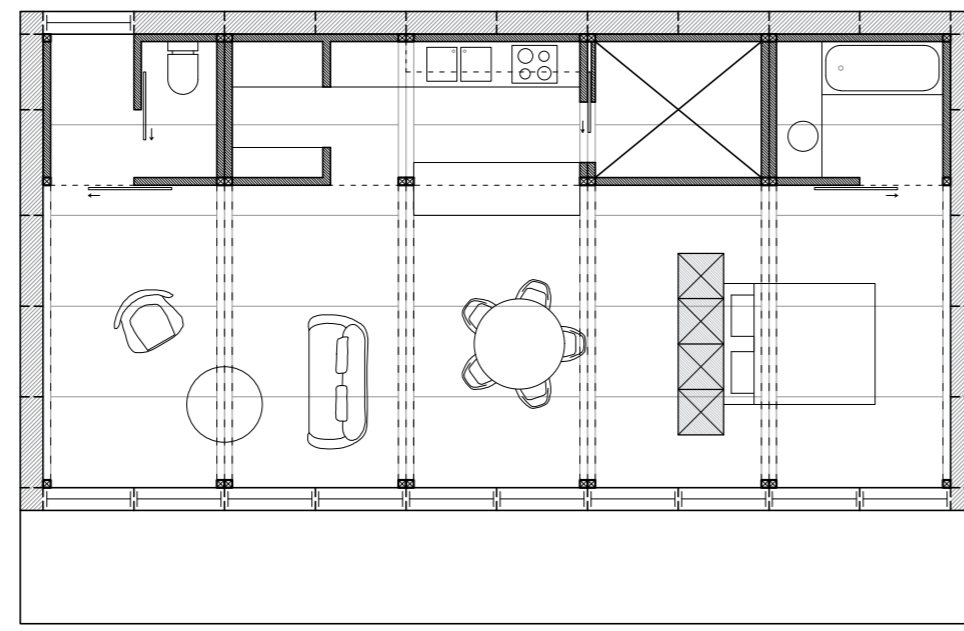
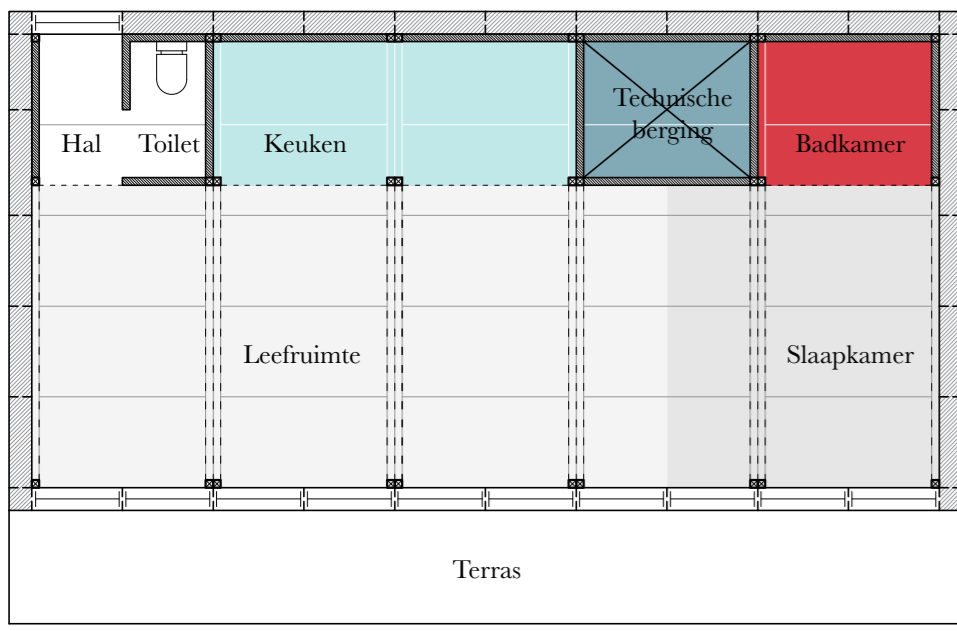
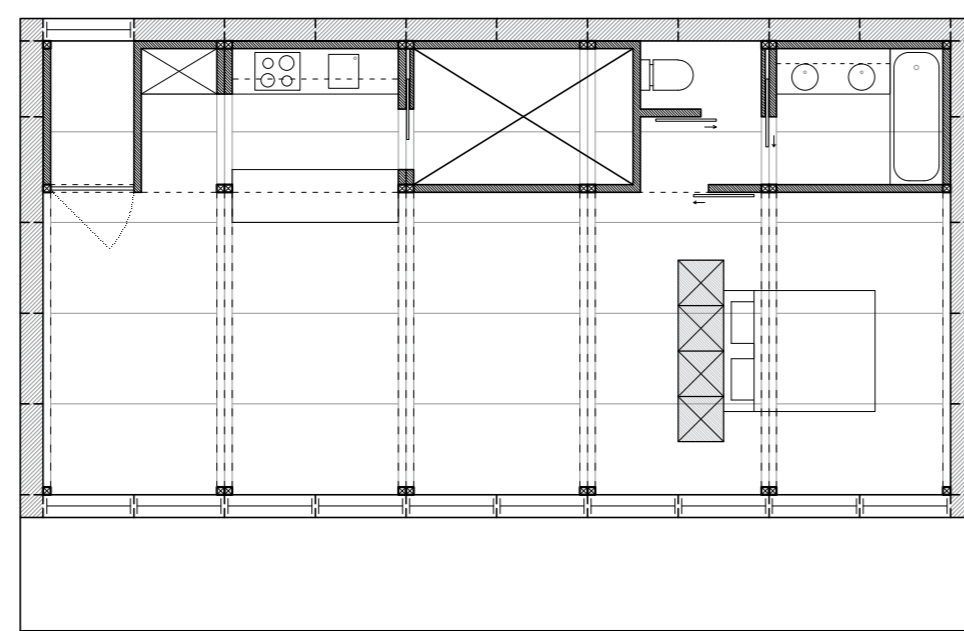
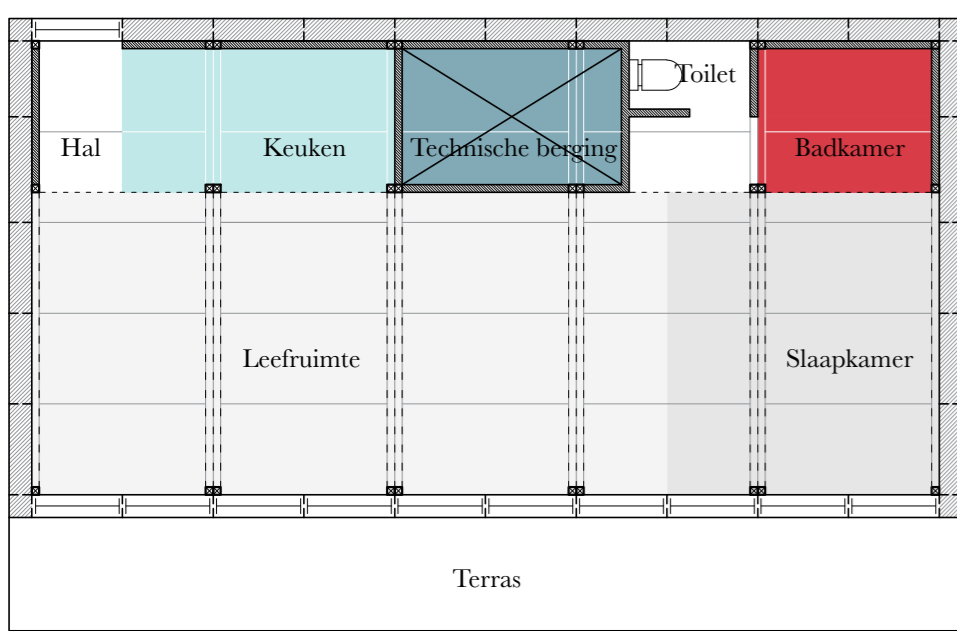
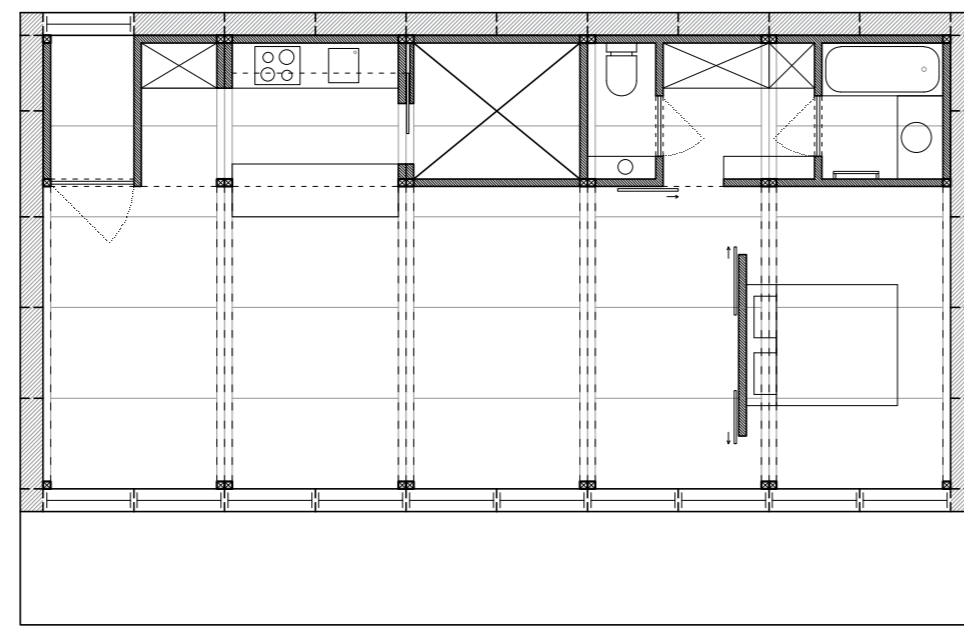
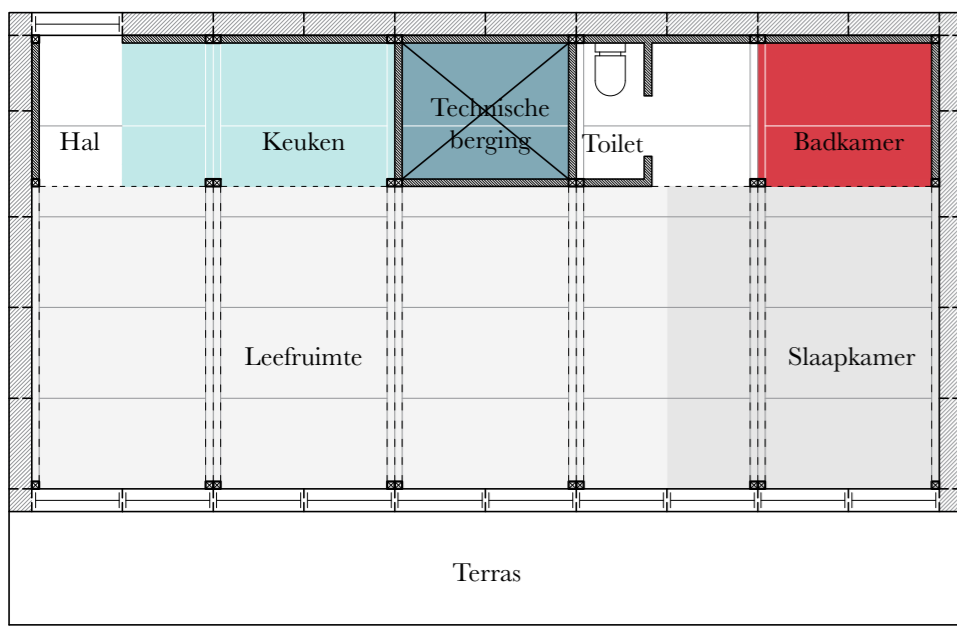
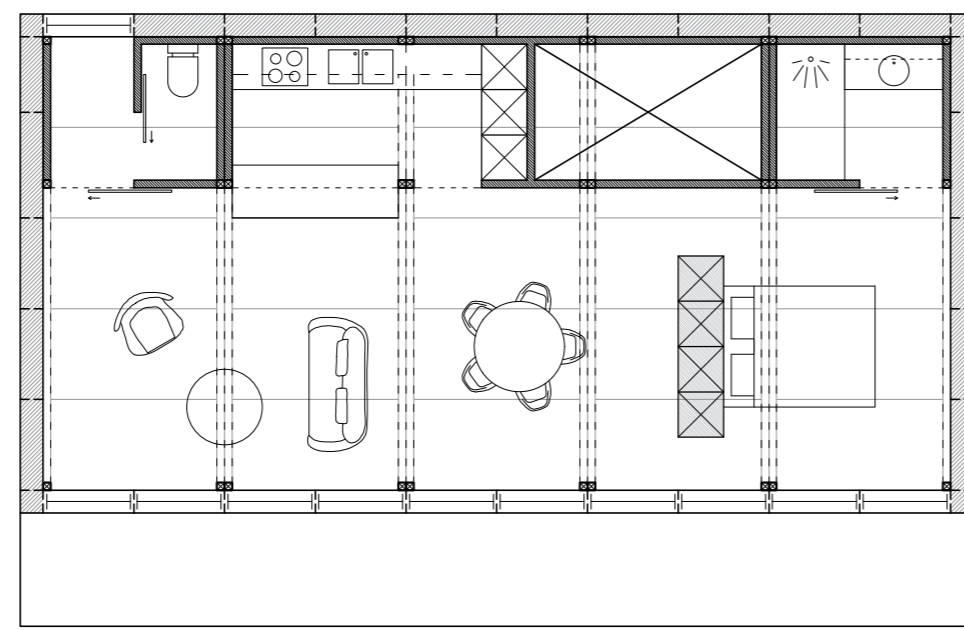
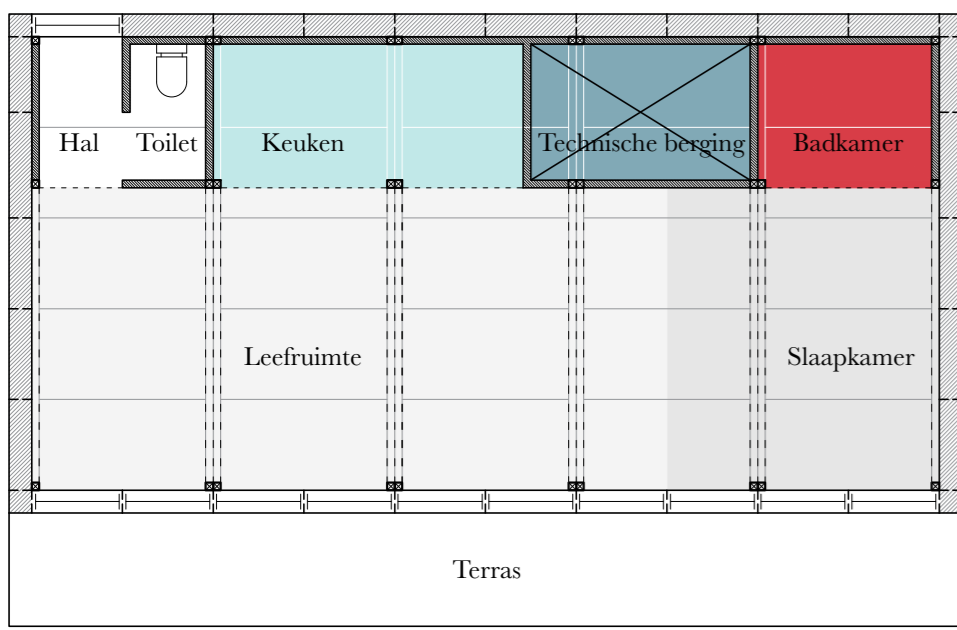
Universidad de Sevilla, Spain

King Mongkut's University of Technology Thonburi, Thailand

University of Applied Sciences Utrecht, Netherlands

Universitat Politècnica de València, Spain





6

HOOFDSTUK Technische uitwerking van paviljoen

INHOUDSTAFEL

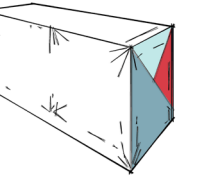
- 6.1 Plannen
 - 6.1.1 Varianten op de plattegrond
 - 6.1.2 Ontwerpkuzes, grondplannen en doorsneden
- 6.2 Uitvoeringstekeningen
 - 6.2.1 Kader
 - 6.2.2 Stuklijst panelen
 - 6.2.3 Stuklijst fundering, balkon en helling
 - 6.2.4 Steunhaken
 - 6.2.5 Buitenschrijnwerk
- 6.3 Interieur
 - 6.3.1 Schuifwanden
 - 6.3.2 Lamp

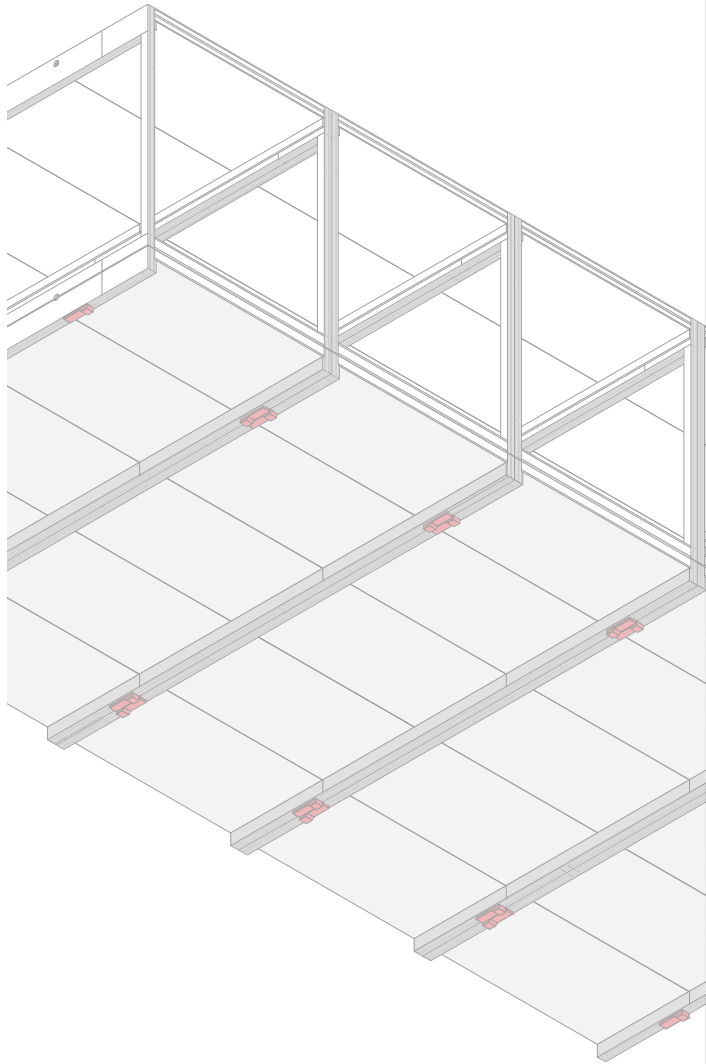
WOORD VOORAF

De maatvoering van de *Mabble* wordt getoetst aan de hand van varianten op de plattegrond van het paviljoen. Hiermee wordt de veelzijdigheid, de aanpasbaarheid en de brede inzetbaarheid van het paviljoen gedemonstreerd.

In de linker kolom wordt telkens een schema weergegeven met de plaats van de verschillende diene programma-onderdelen in kleur aangeduid en rechts de varianten op de plattegrond per schema.

De eerste plattegrond op deze poster stelt de definitieve programma-indeling van het paviljoen voor.





HOOFDSTUK

Technische uitwerking van paviljoen

INHOUDSTAFEL

6.1 Plannen

6.1.1 Varianten op de plattegrond

6.1.2 Ontwerpkeuzes, grondplannen en doorsnedes

6.2 Uitvoeringstekeningen

6.2.1. Kader

6.2.2. Stuklijst panelen

6.2.3. Stuklijst fundering, balkon en helling

6.2.4. Steunhaken

6.2.5. Buitenschrijnwerk

6.3 Interieur

6.3.1 Schuifwanden

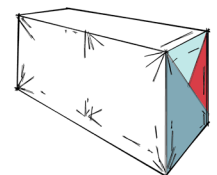
6.3.2 Lamp

WOORD VOORAF

Het paviljoen moet aan een aantal basiscriteria voldoen:

- Studenten bouwen het paviljoen zelf op. Dit impliceert een beperking op het gewicht van de afzonderlijke elementen. Bovendien hebben studenten geen professionele gereedschappen ter beschikking;
- Het paviljoen moet de opgelegde regels uit het wedstrijdreglement nauwkeurig volgen.

De ontwerpkeuzes worden verder toegelicht en de gedetailleerde grondplannen, doorsnedes en 3D-beelden zijn bijgevoegd.

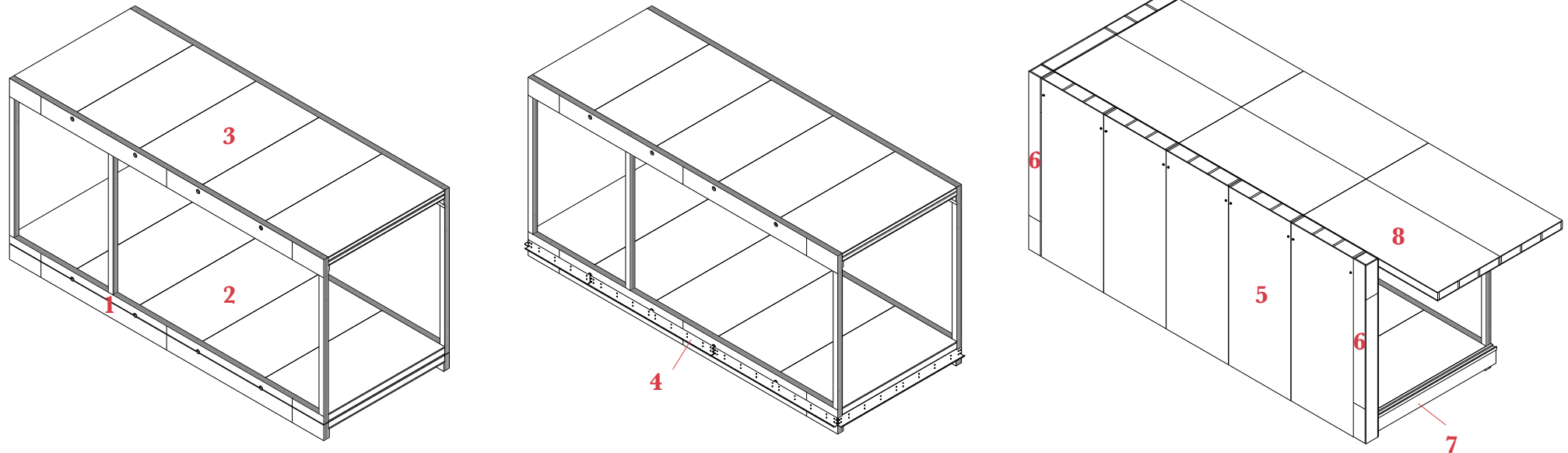


Benamingen

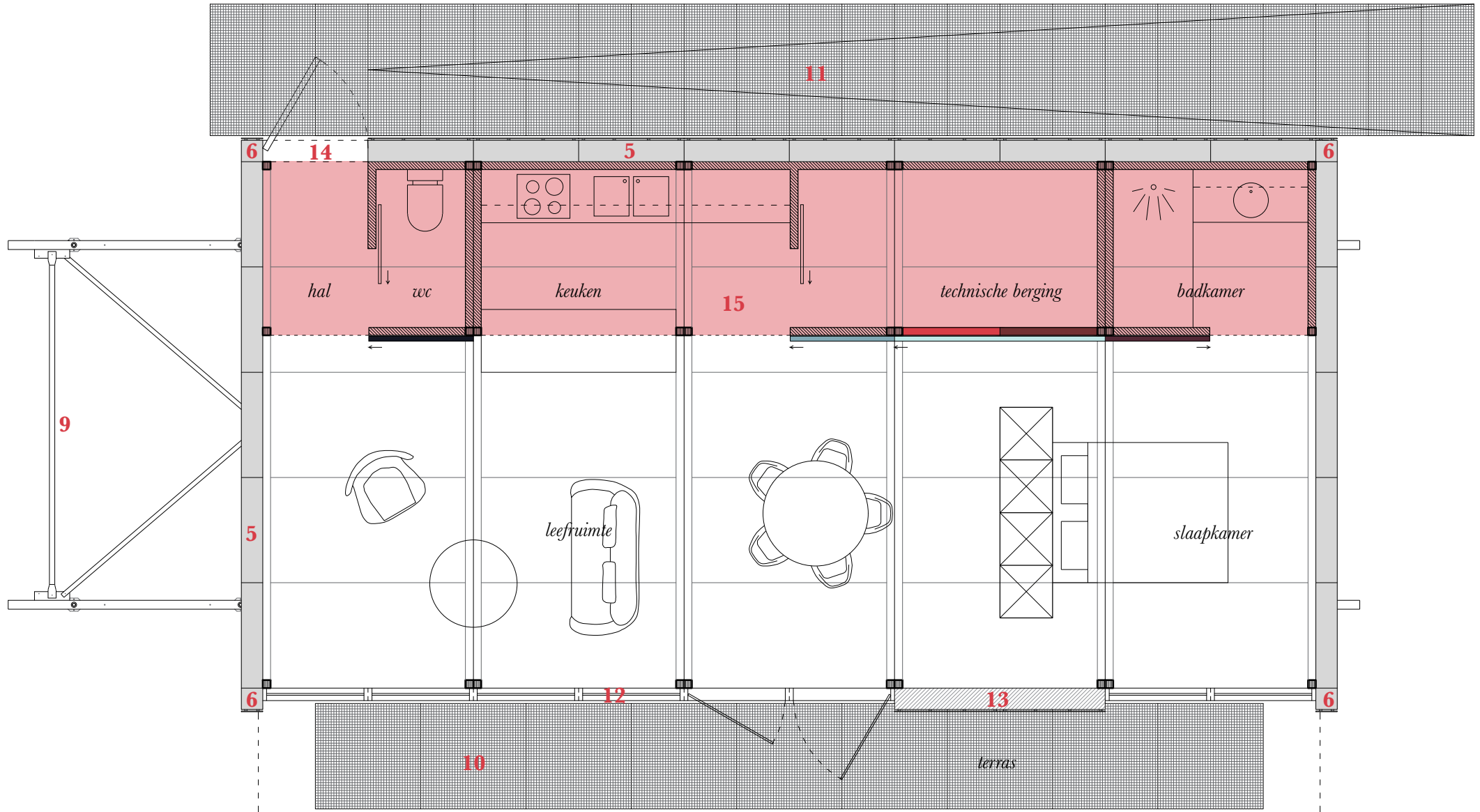
- 1 Kader
- 2 Vloerpanelen
- 3 Dakpanelen
- 1+2+3= The Mobble
- 4 Steunhaak
- 5 Gevelpanelen
- 6 Hoekpanelen
- 7 Buitenschrijnwerk
- 8 Tweede laag dakpanelen
- 9 Fundering in staal
- 10 Balkon in staal
- 11 Helling in staal
- 12 Ramen
- 13 Technisch paneel
- 14 Deur
- 15 Verlaagd plafond in dienende zone

THE MOBBLE

Modular Building Block



Figuur 1. Isometrie - Aanduiding onderdelen.

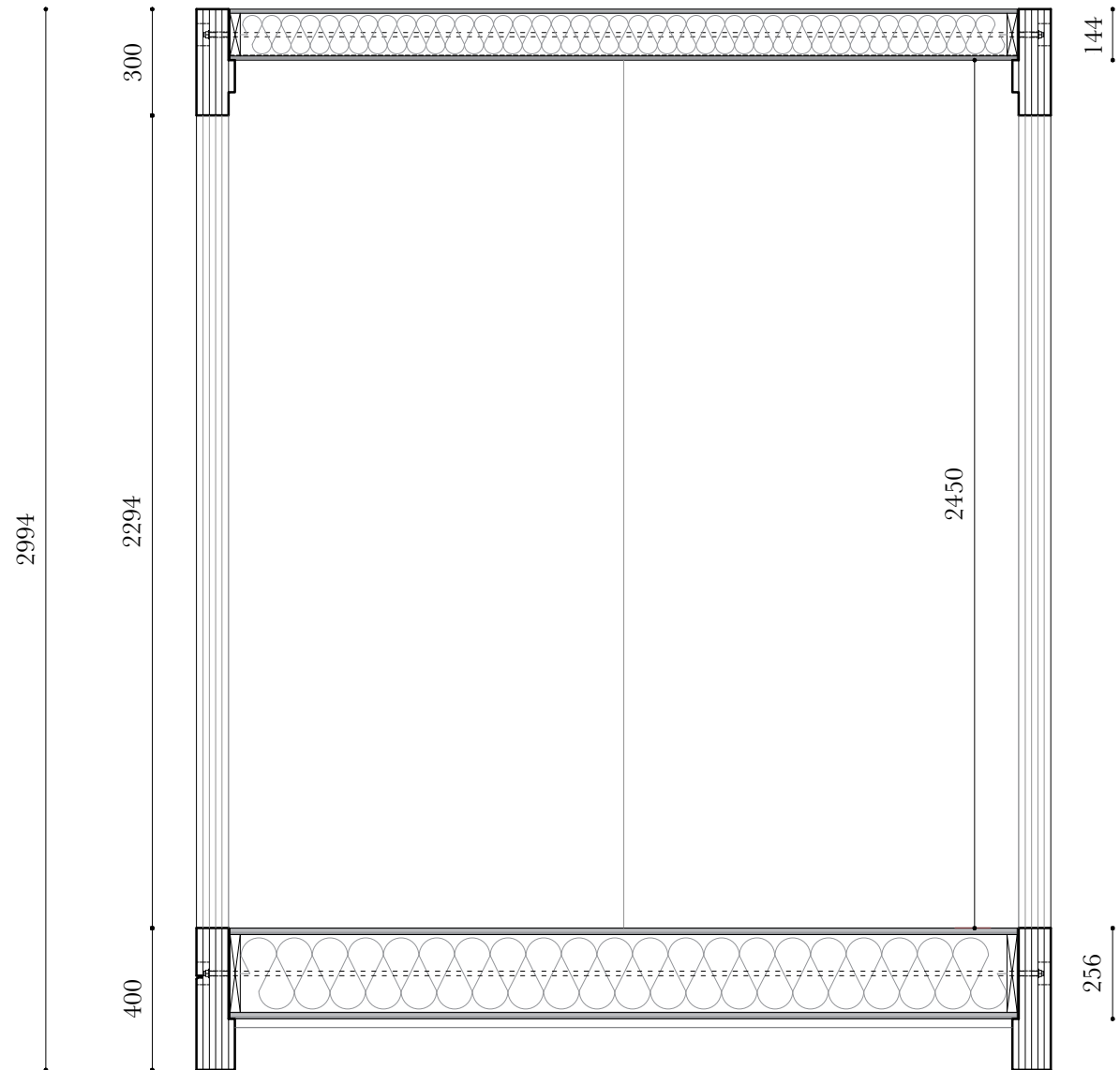


Figuur 2. Grondplan 1/60 - Aanduiding onderdelen.

Belangrijke ontwerpdetails

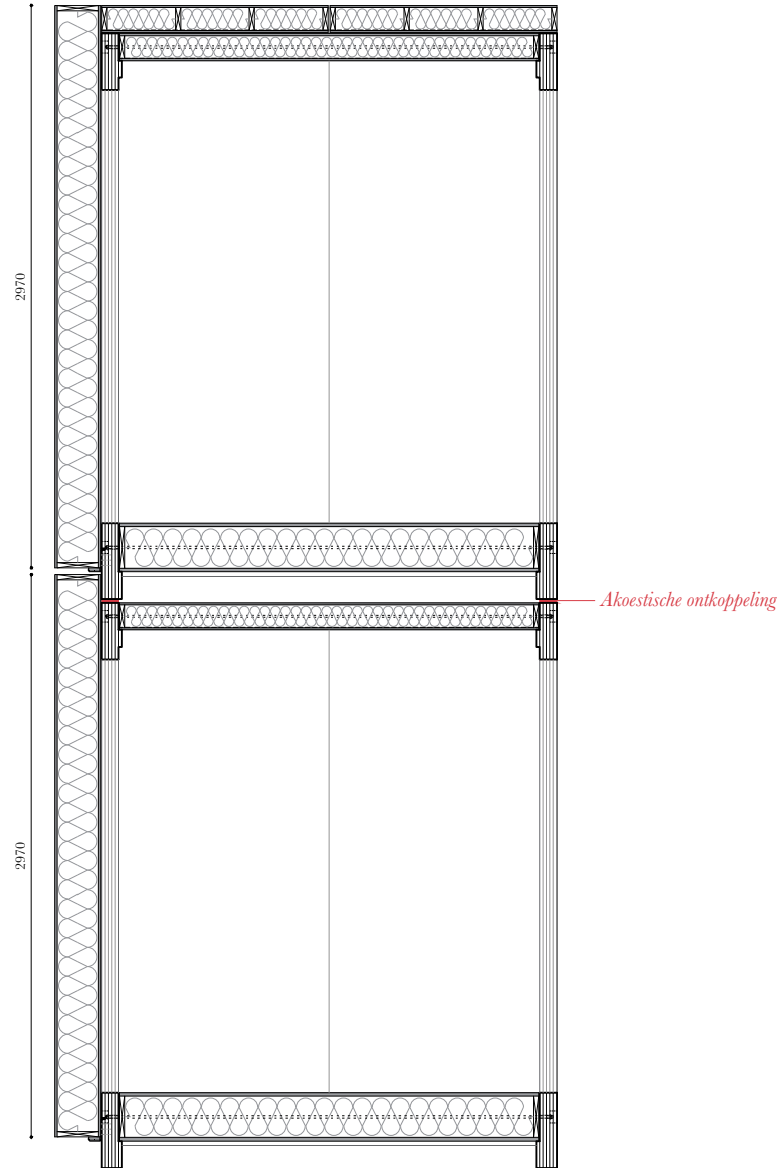
DETAIL 1 — De hoogte van vloer tot plafond bedraagt 2450mm. De nuttige hoogte bedraagt 2994mm. De hoogte van het kader is afhankelijk van de hoogte van het dakpaneel. De keuze voor de hoogte van de onder- en bovenbalk is in de eerste plaats een arbitraire keuze. Uit berekeningen blijkt dat zowel boven- als onderbalk een beetje overgedimensioneerd zijn omwille van de onzekerheid over het gedrag van de module tijdens het transport. Er is uiteindelijk beslist om de dimensionering van de boven- en onderbalk te behouden. Stroken van 300mm en 400mm leveren bovendien geen rest. (Uit een standaard multiplexplaat van 1220mm x 2440mm kunnen 3 stroken van 400mm gehaald worden en 4 stroken van 300mm zonder overschot te hebben.)

De vloer- en dakpanelen worden los tussen de kaders gelegd. Vier trekstaven zijn in het kader verzonken en zitten telkens tussen de verschillende panelen. Deze staven worden nagespannen om zo de twee kaders en de panelen samen te houden.

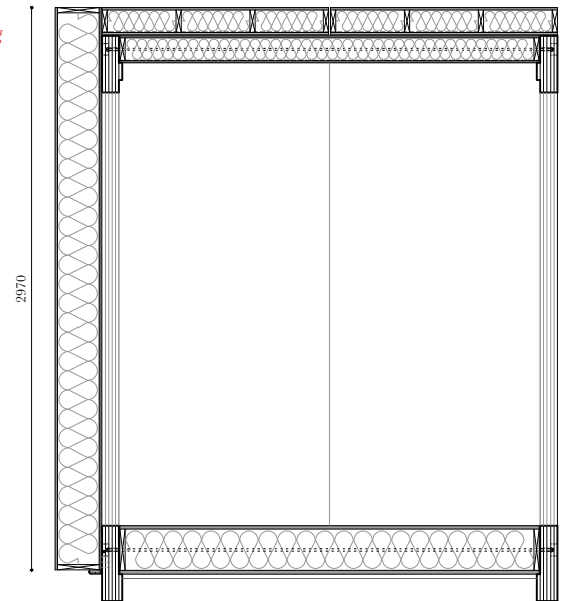


Figuur 3. Snede 1/20 - DETAIL 1.

DETAIL 2 en 3 — De gevelpanelen en tweede laag dakpanelen zijn zodanig geconcepieerd dat de modules kunnen gestapeld worden zonder daarvoor aangepaste panelen te gebruiken. De hoogte van het gevelpaneel hangt af van de dikte van de tweede laag dakpanelen. De rode arcering duidt de akoestische ont koppeling aan.

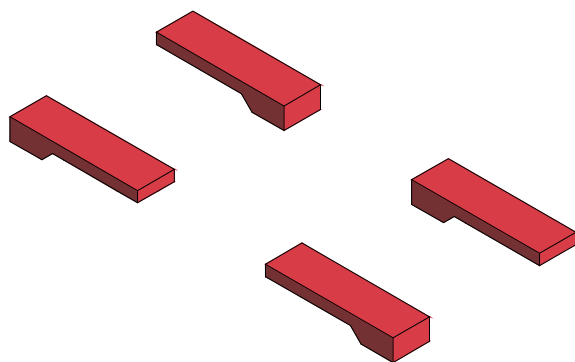


Figuur 4. Snede 1/60 - DETAIL 2.

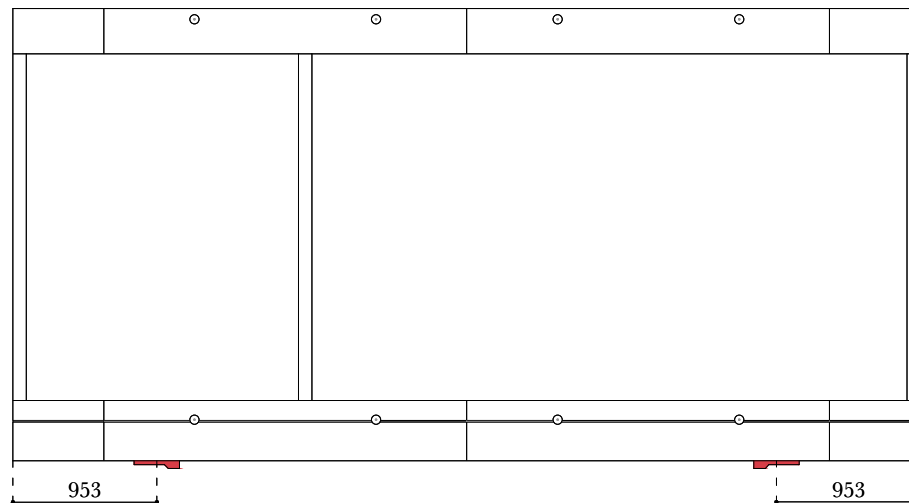


Figuur 5. Snede 1/60 - DETAIL 3.

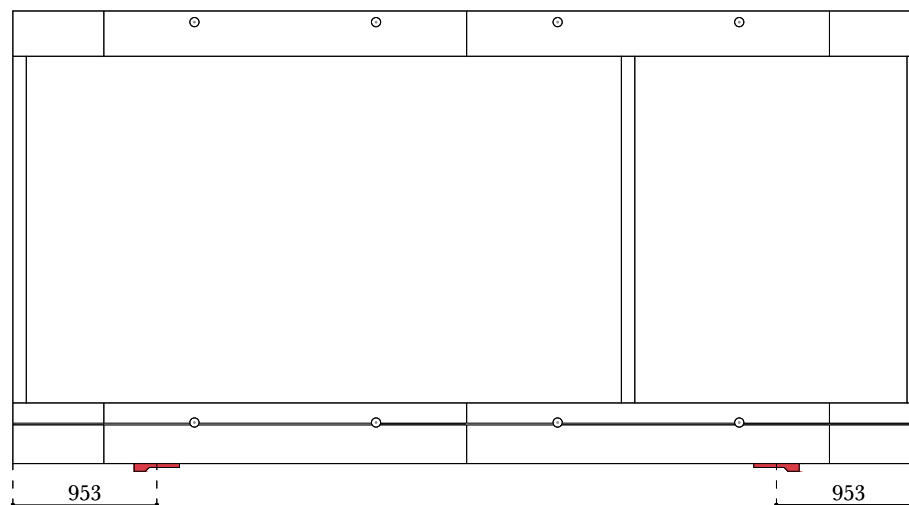
DETAIL 4 — Er worden twee steunvoeten (zie rode arcering) onderaan aan het kader geschroefd. De steunvoeten worden verzaagd uit gerecycleerd polypropyleen. Per *Mobble* staan twee kaders symmetrisch t.o.v. elkaar en worden de steunvoeten bij het ene kader naar binnen geplaatst en bij het andere kader naar buiten, zoals aangegeven op de tekening. De kaders worden (zoals een trein) automatisch gecentreerd op het funderingsspoor. PP is gekozen voor de goede geleidbaarheid over het spoor en om geen problemen te hebben met vocht (dient als vochtstop).



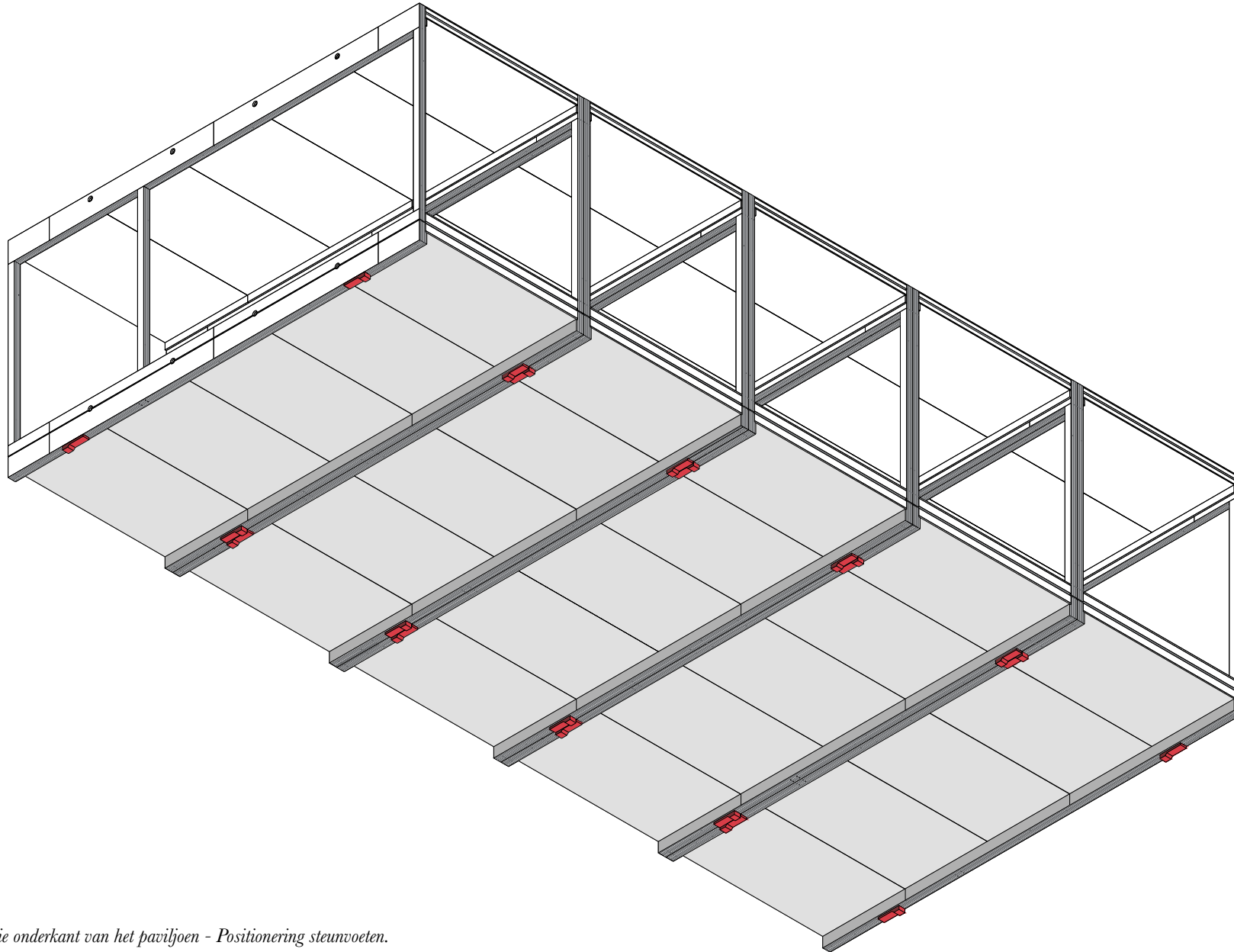
Figuur 6. Isometrie steunvoeten.



Figuur 7. Aanzicht 1/50 - DETAIL 4 - Linkerkader: steunvoeten zijn naar buiten geplaatst.



Figuur 8. Aanzicht 1/50 - DETAIL 4 - Rechterkader: steunvoeten zijn naar binnen geplaatst.



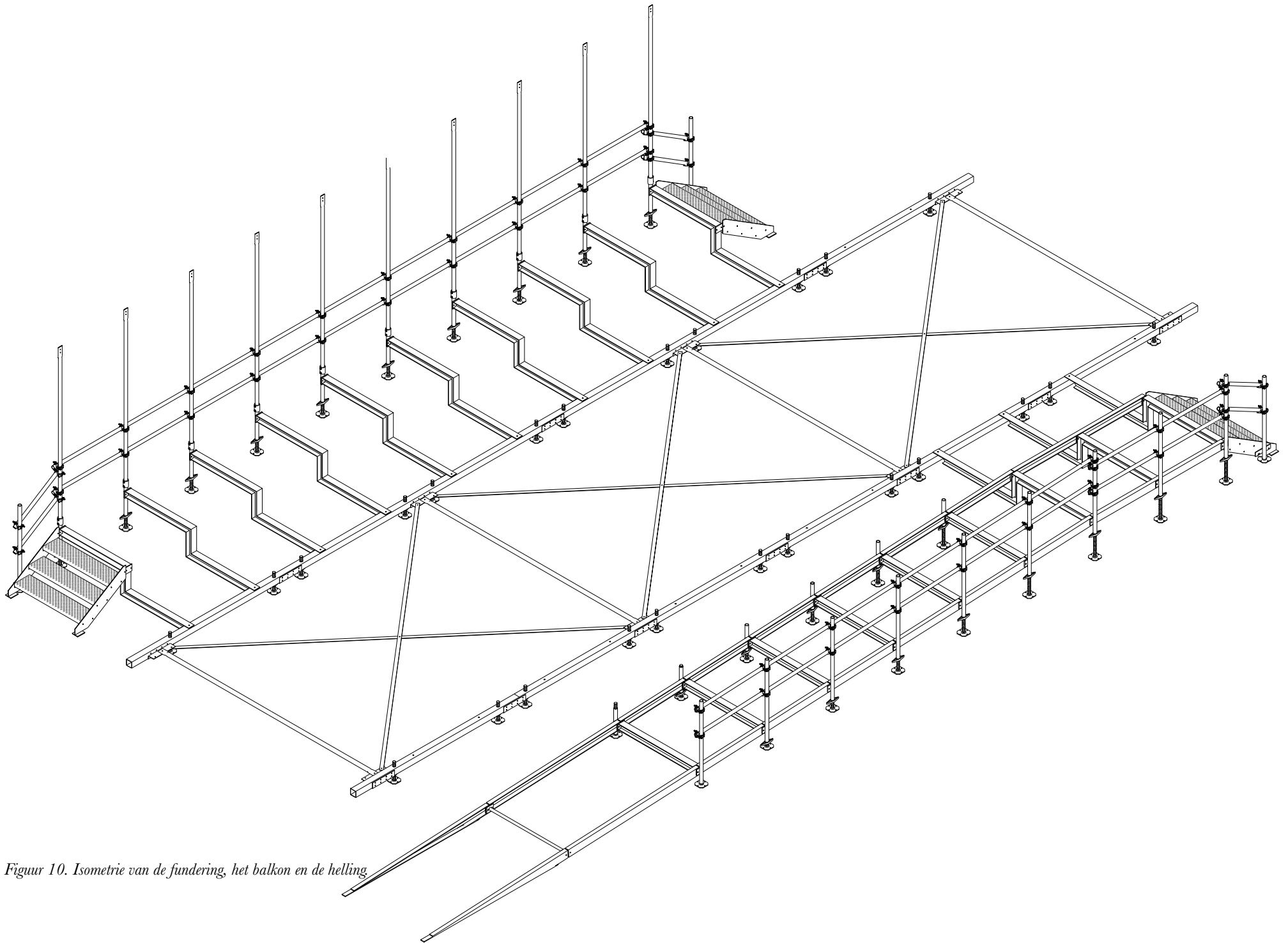
Figuur 9. Isometrie onderkant van het paviljoen - Positionering steunvoeten.

Systeem voor fundering, helling en balkon

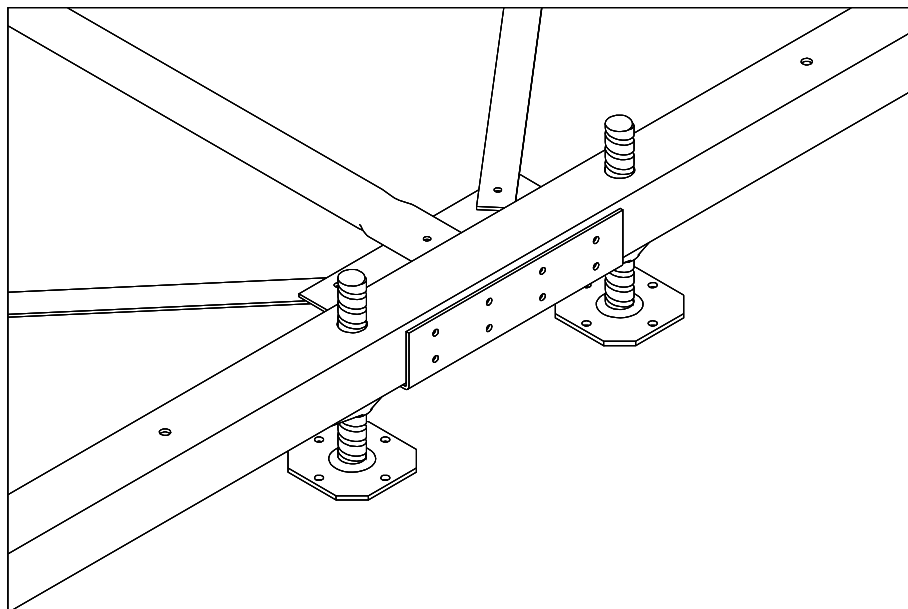
De fundering, het balkon en de helling zijn ontworpen op basis van volgende criteria:

- Elk onderdeel van de fundering, het balkon en de helling kan door minimaal twee personen worden gedragen;
- De hoogte van de fundering moet afstelbaar zijn omdat er geen zekerheid is over hoe vlak het terrein zal zijn waarop het paviljoen komt te staan. Hetzelfde geldt voor het *after life* van het paviljoen. Daarom is gekozen voor het gebruik van stellingvoeten.

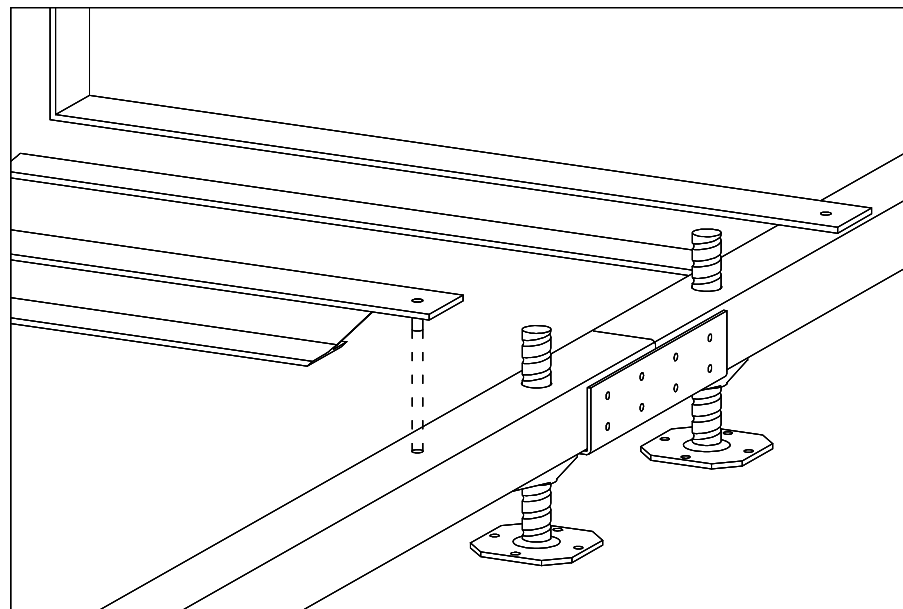
De fundering bestaat uit twee sporen waarover de *Mobbles* kunnen schuiven. Per *Mobble* staan de twee steunvoeten van het linkerkader en de twee steunvoeten van het rechterkader ten op zichte van elkaar 180° gedraaid. De *Mobbles* worden op deze wijze automatisch gecentreerd (op de juiste plaats gehouden).



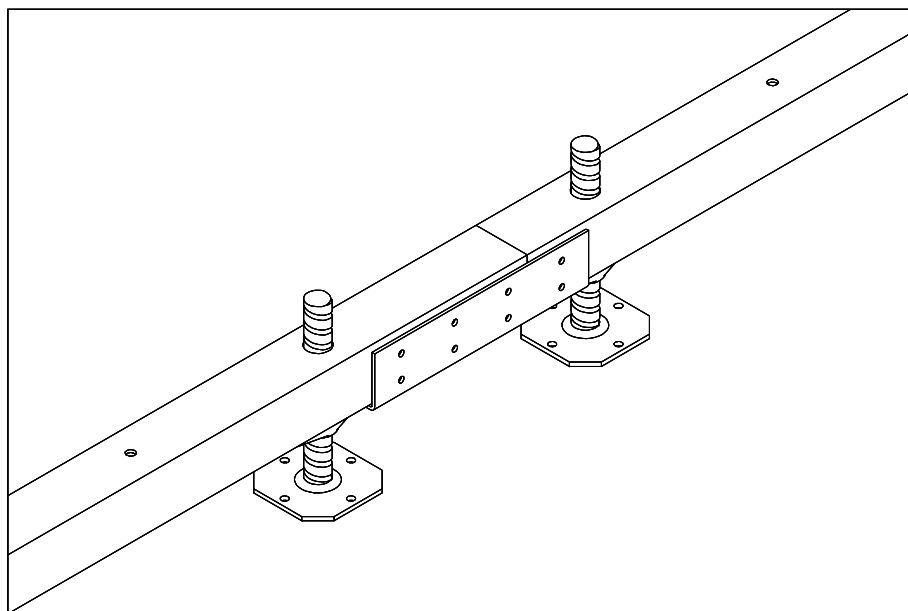
Figuur 10. Isometrie van de fundering, het balkon en de helling.



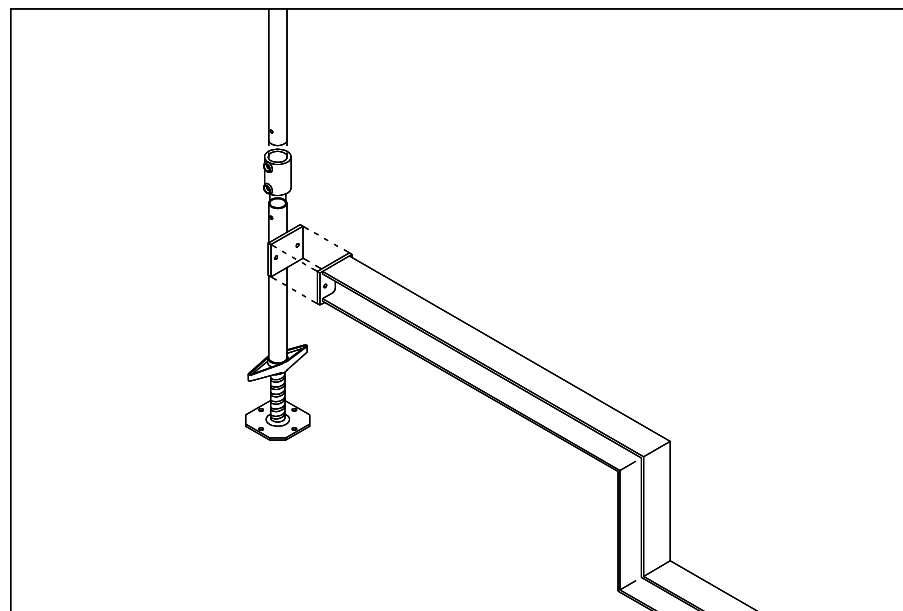
Figuur 11. Isometrie - Bevestiging van de windverbanden van de fundering aan de kokerprofielen.



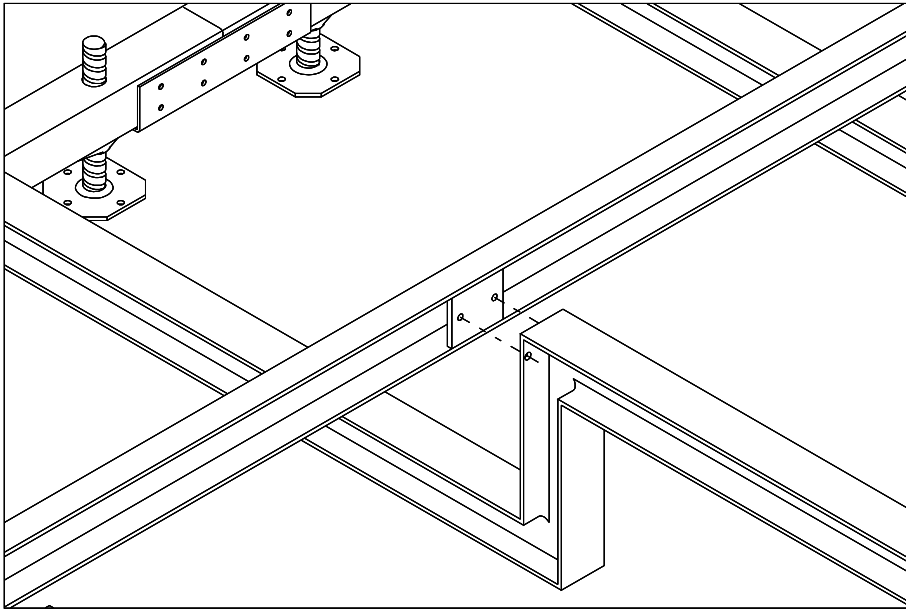
Figuur 13. Isometrie - Haaksysteem van het HEA100-profiel aan het kokerprofiel met stalen pen.



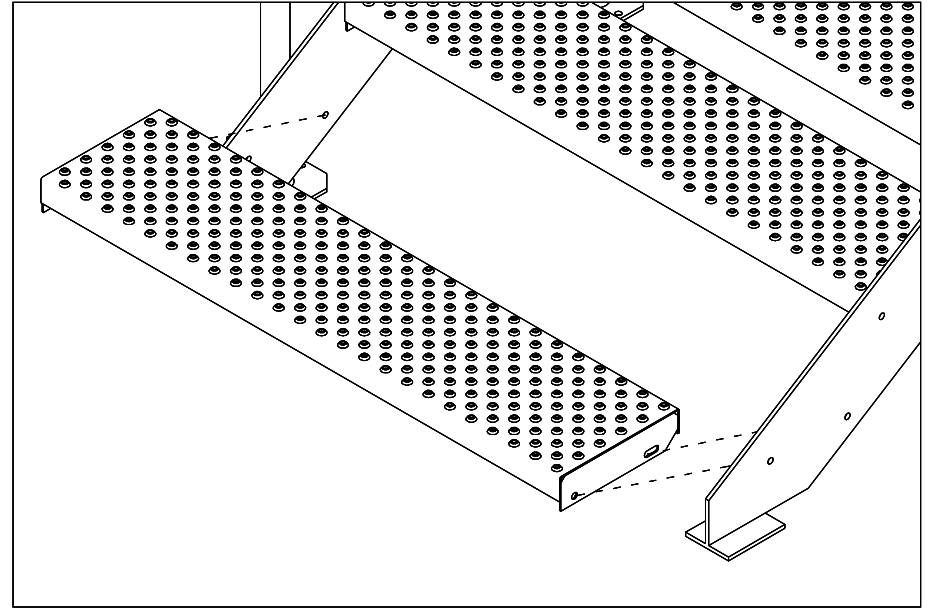
Figuur 12. Isometrie - Verbindingsplaat ter versterking van de twee kokerprofielen.



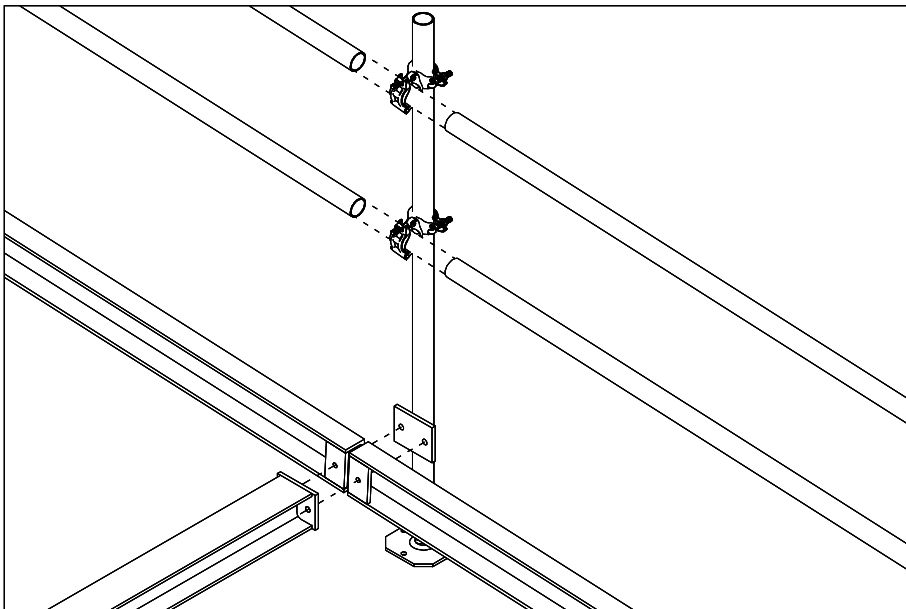
Figuur 14. Isometrie - Bevestiging van het HEA100-profiel aan de steigerbuis van het balkon.



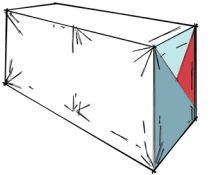
Figuur 15. Isometrie - Bevestiging UPE120-profiel aan het HEA100-profiel (helling).

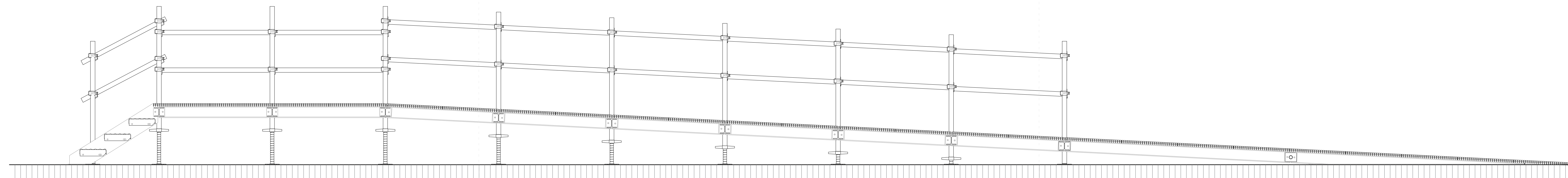


Figuur 17. Isometrie - Bevestiging van de geprofileerde traptreden met de staalplaat van de trap.



Figuur 16. Isometrie - Bevestiging van het HEA100- en UPE120-profiel aan de steigerbuis van de helling





Doorsnede AA - 1/20

WOORD VOORAF
 Grondplan, doorsnede en isometrie van de fundering, het balkon en de helling

6

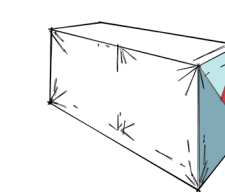
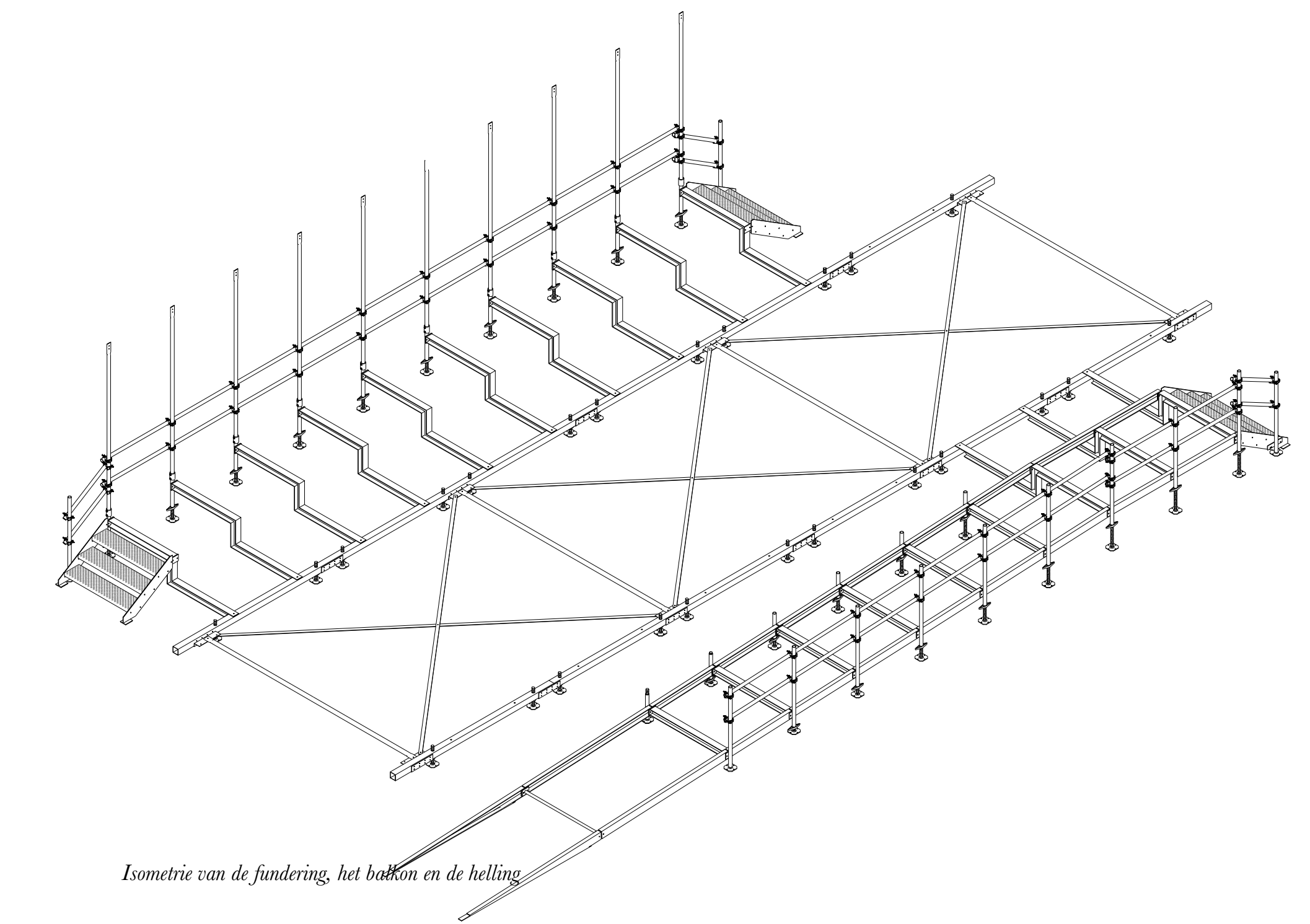
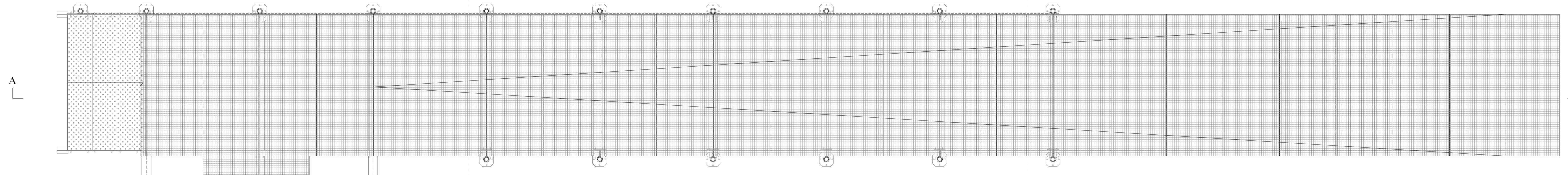
HOOFDSTUK
Technische uitwerking van paviljoen

INHOUDSTAFEL

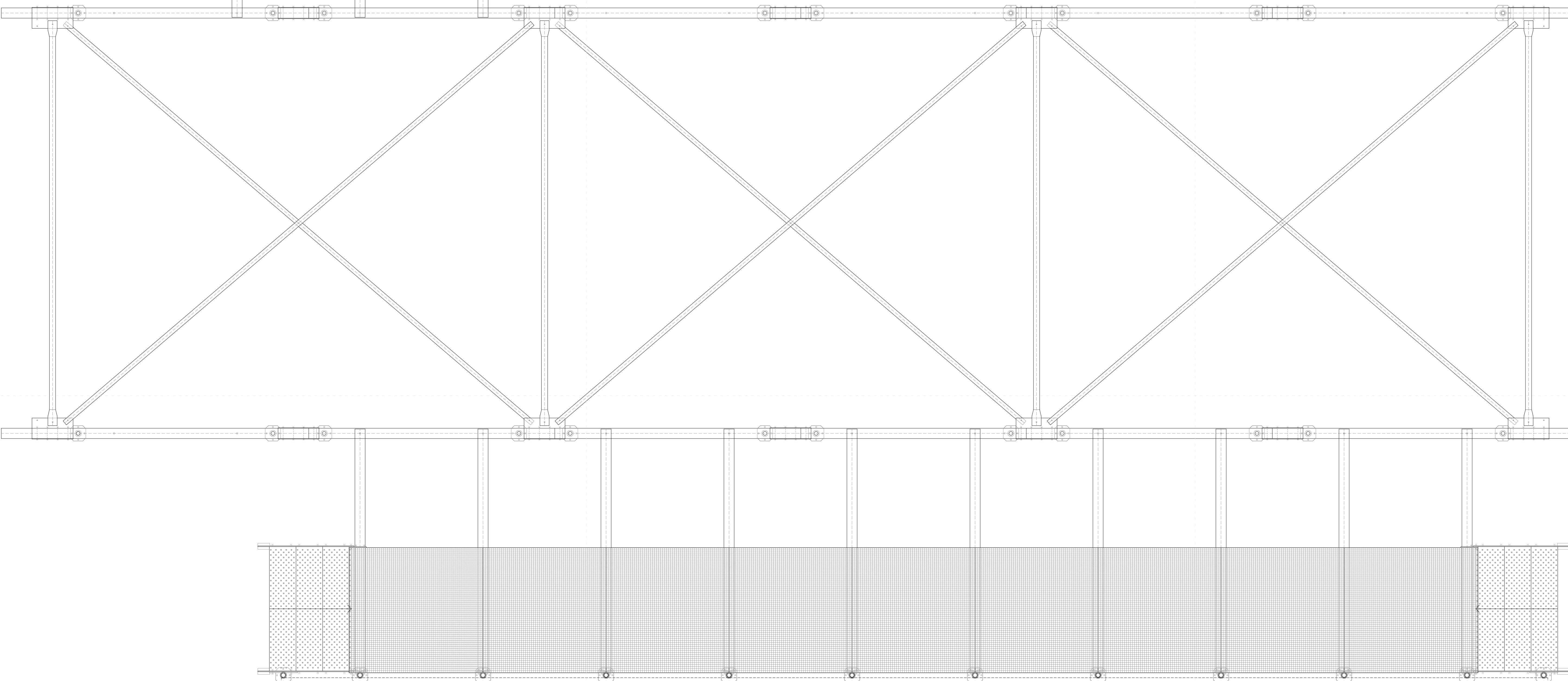
6.1 Plannen
 6.1.1 Varianten op de plattegrond

6.2 Uitvoeringstekeningen
 6.2.1. Kader
 6.2.2. Stuklijst panelen
 6.2.3. Struinhaken
 6.2.3. Buitenschrijfwerk

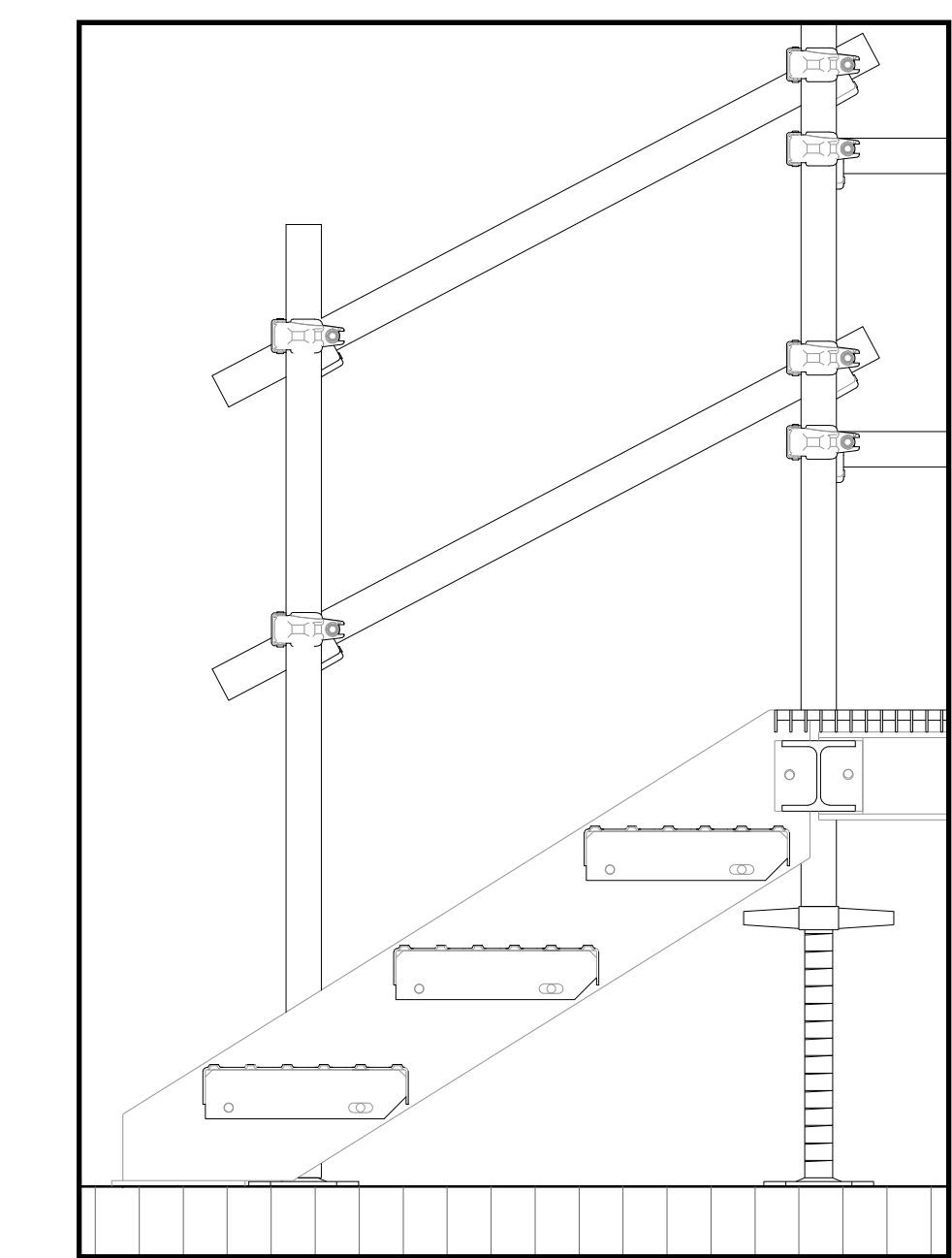
6.3 Interieur
 6.3.1. Schuifwanden
 6.3.2. Lamp

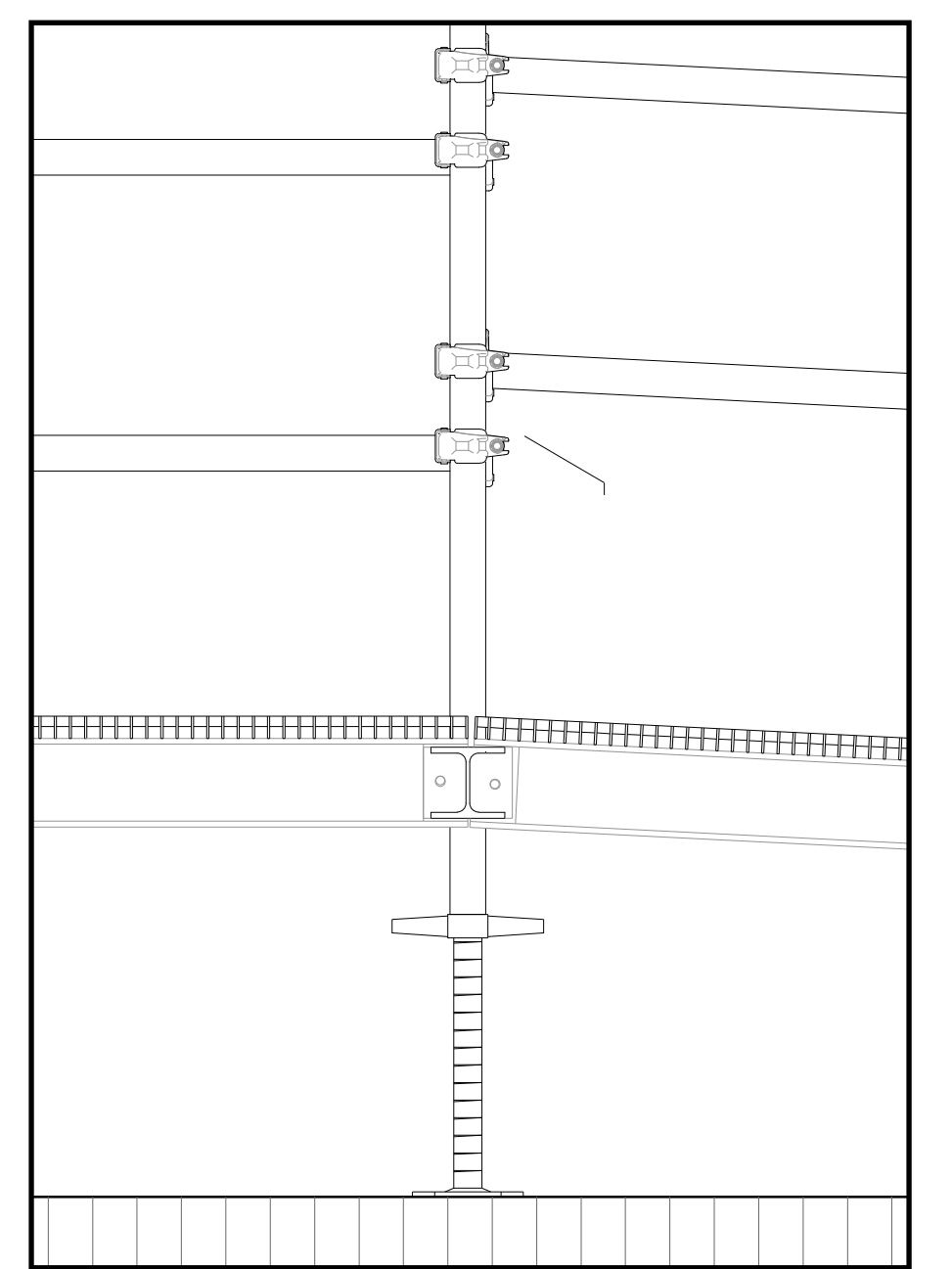
Isometrie van de fundering, het balkon en de helling



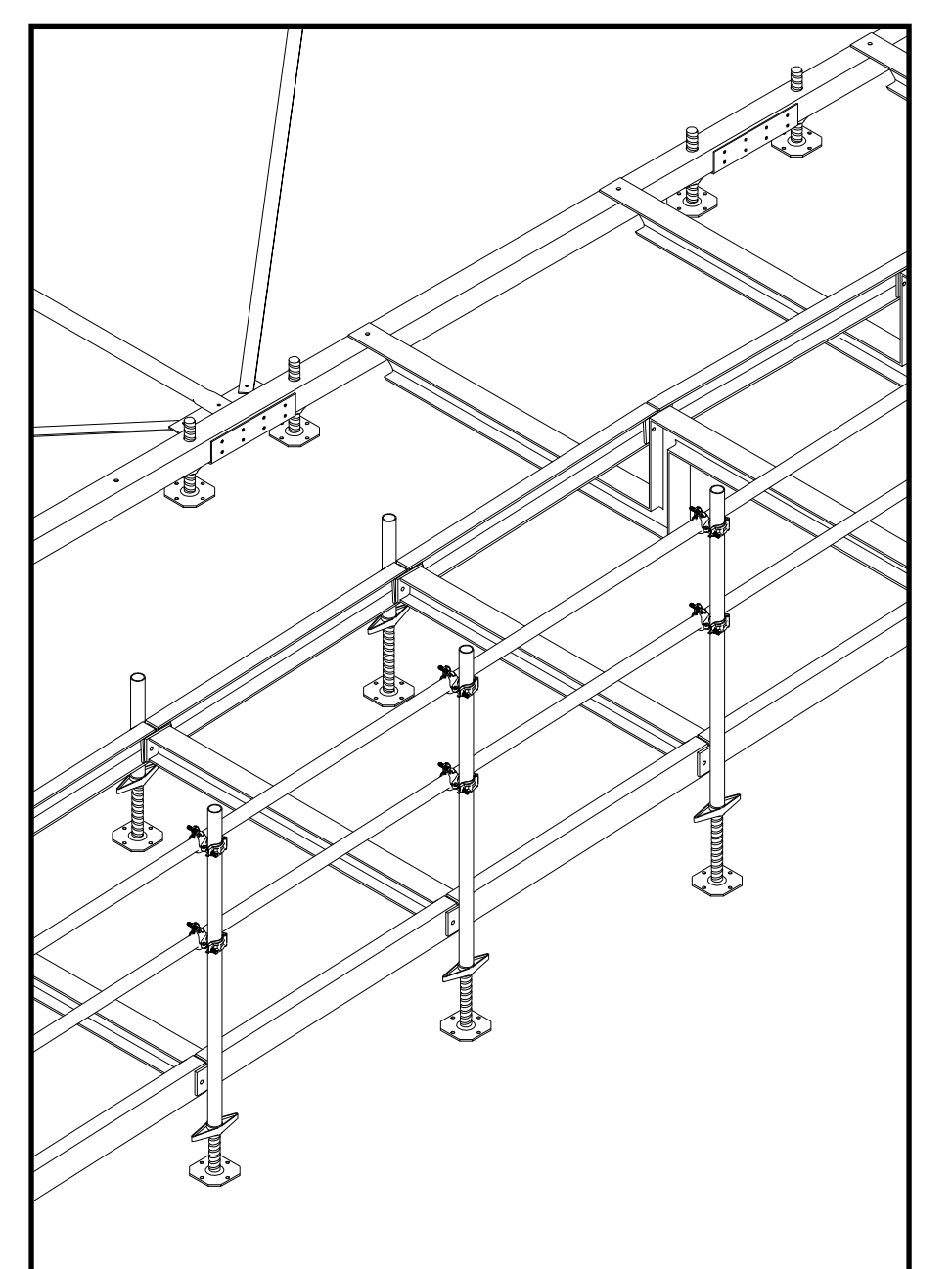
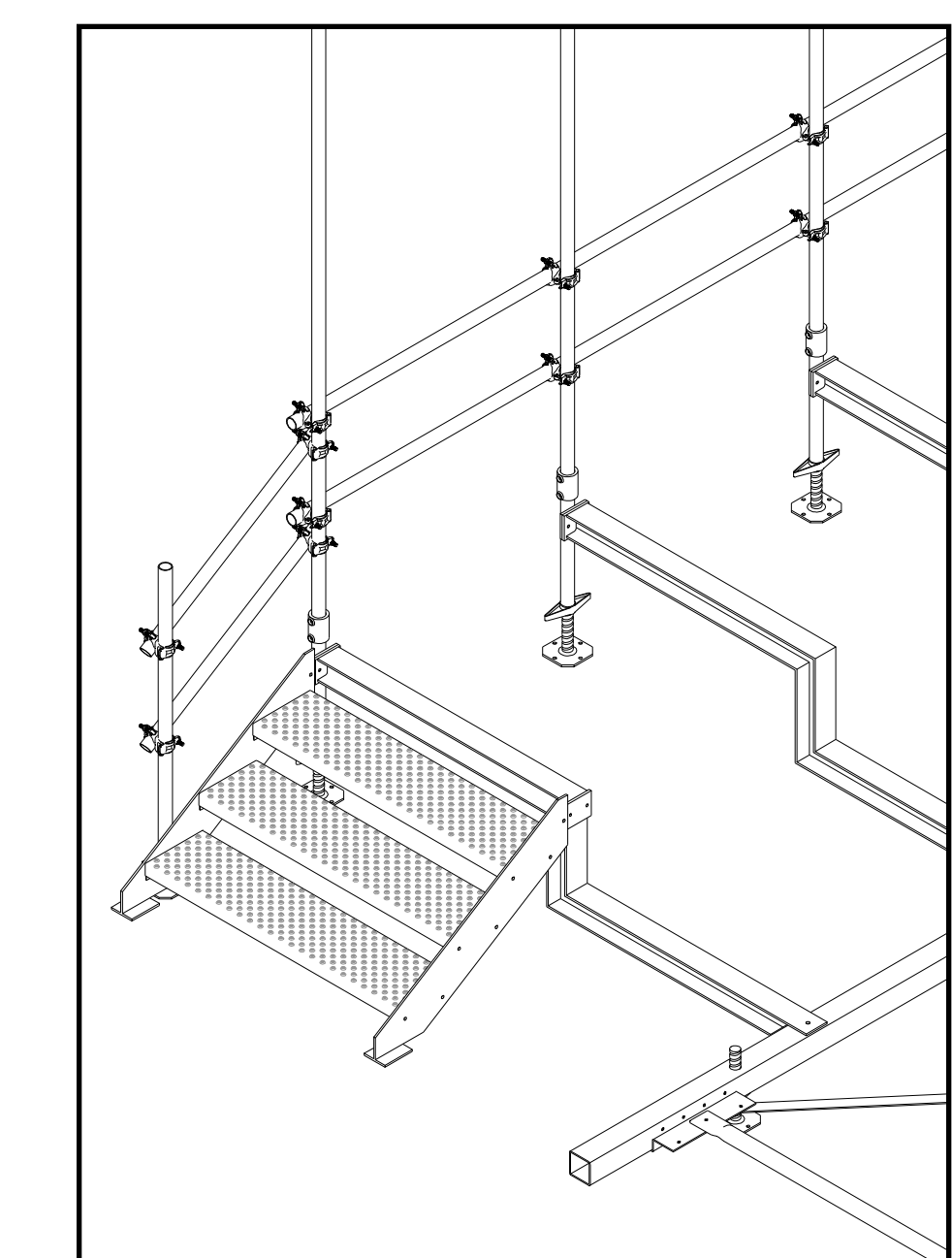
Grondplan - 1/20

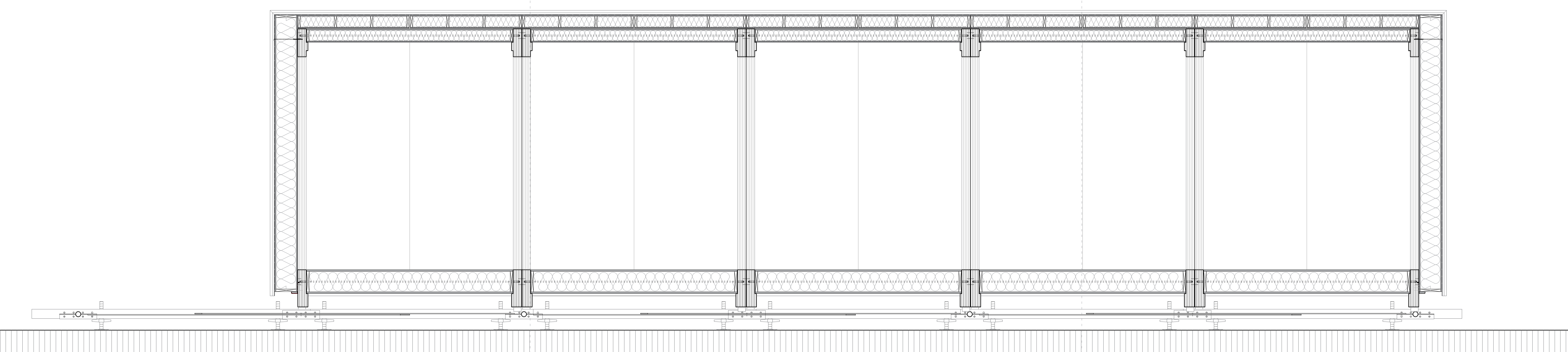


Detail 1 - 1/10



Detail 2 - 1/10





Doorsnede BB - 1/20

WOORD VOORAF
Grondplan en doorsneden van het paviljoen.

6

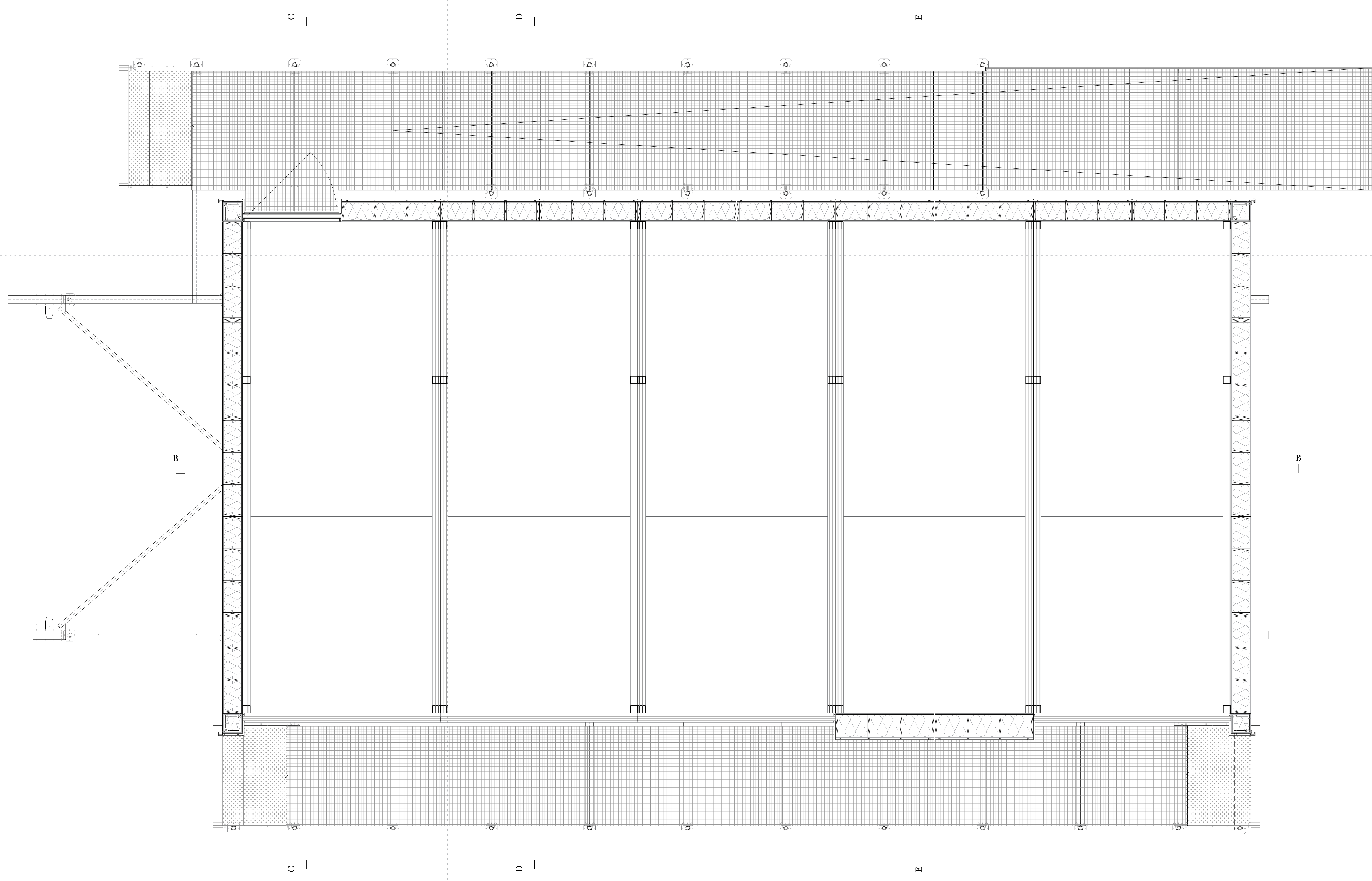
HOOFDSTUK
Technische uitwerking van paviljoen

INHOUDSTAFEL

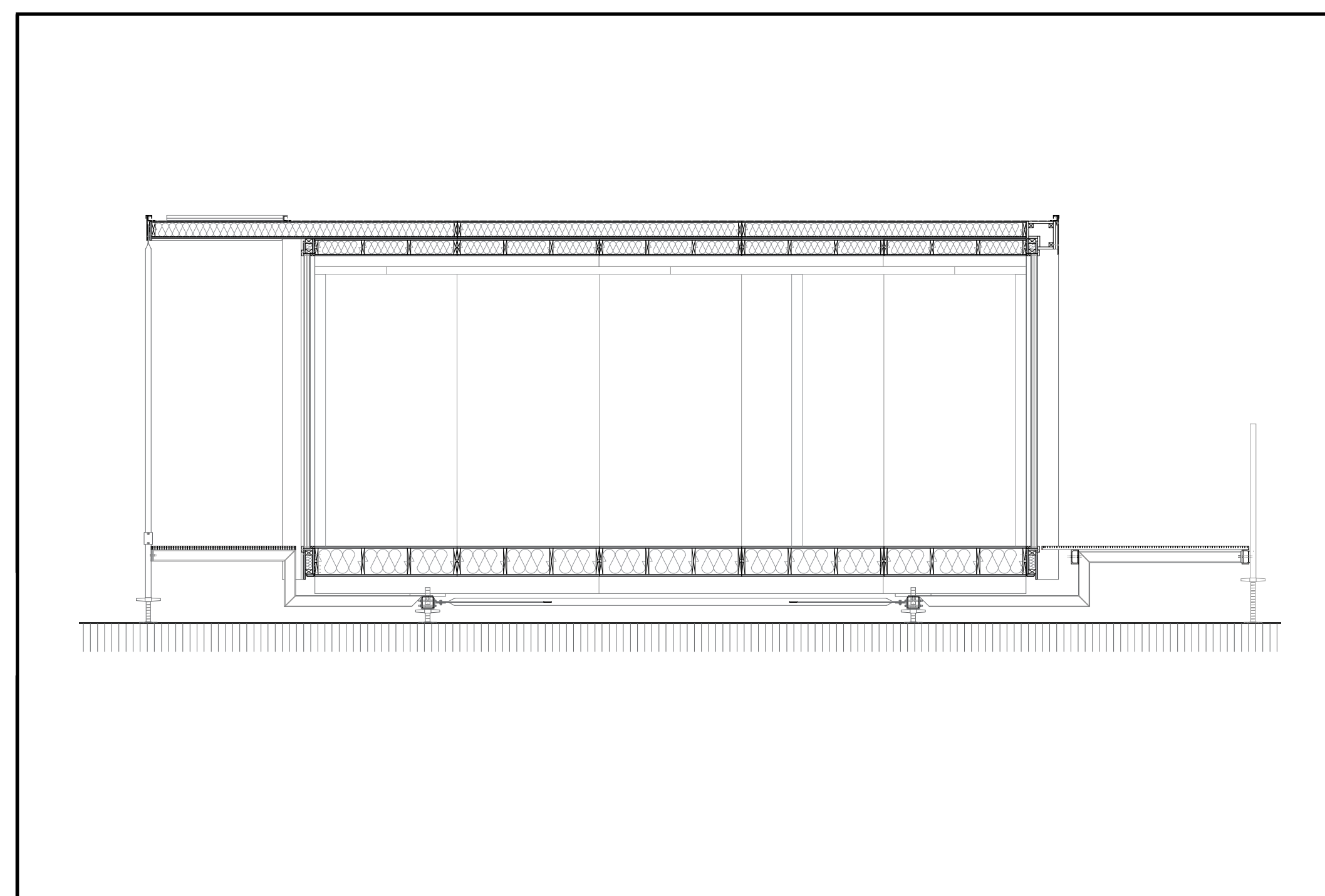
6.1 Plannen
6.1.1 Varianten op de plattegrond

6.2 Uitvoeringstekeningen
6.2.1. Kader
6.2.2. Stuklijst panelen
6.2.3. Stuklijst fundering, balkon en helling
6.2.4. Steunbalken
6.2.5. Buitenschrijfwerk

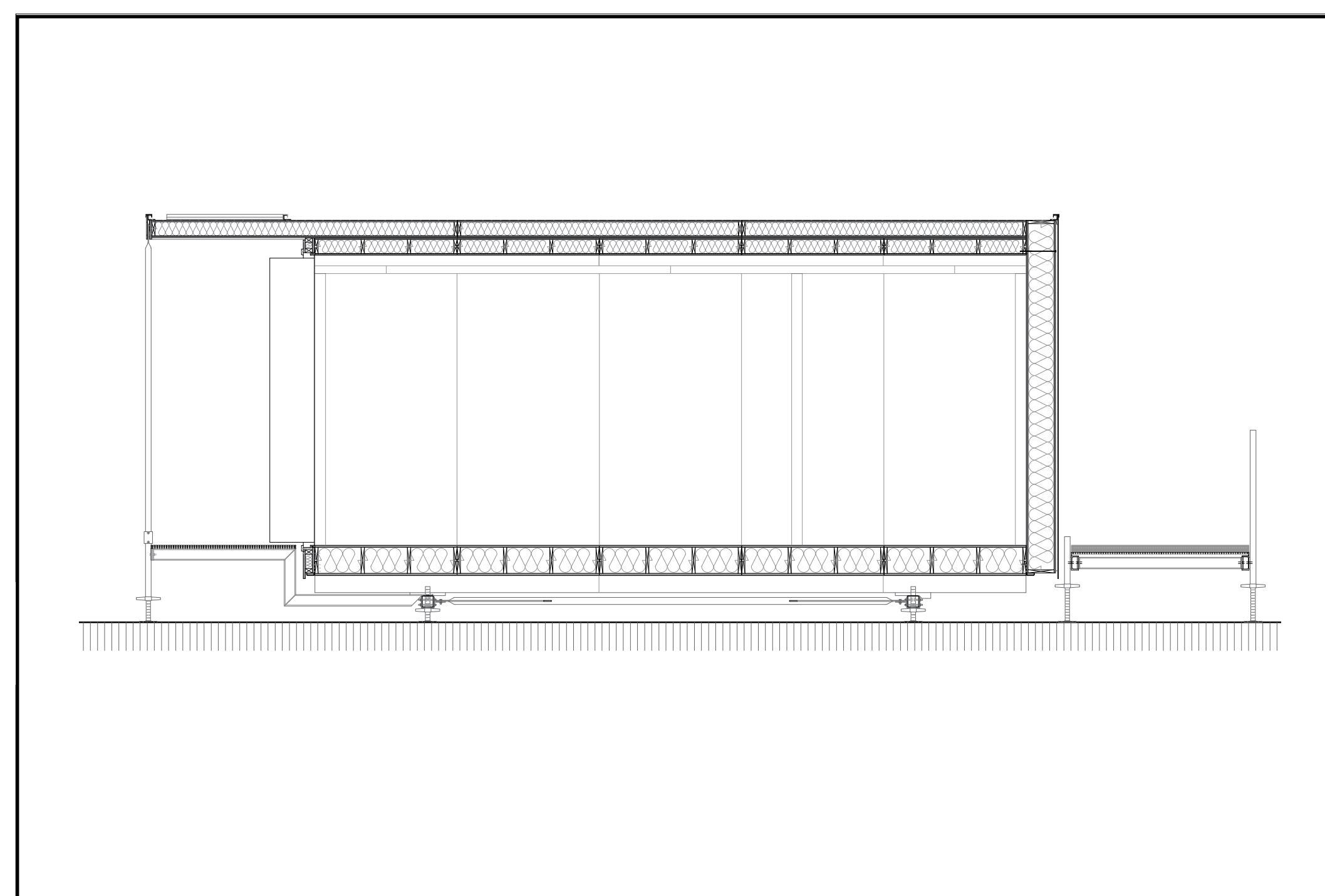
6.3 Interieur
6.3.1. Schuifwanden
6.3.2. Lamp

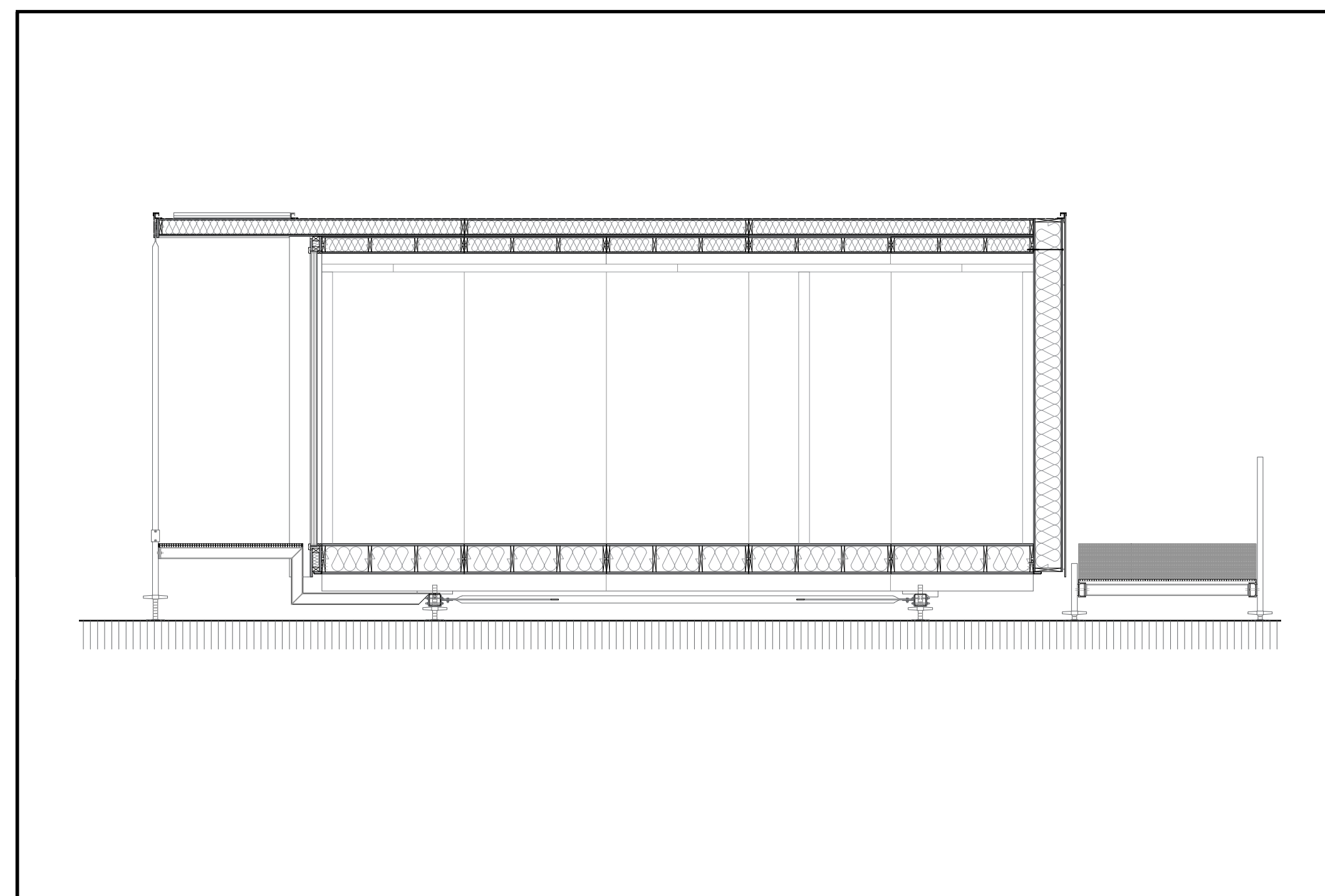
Grondplan - 1/20



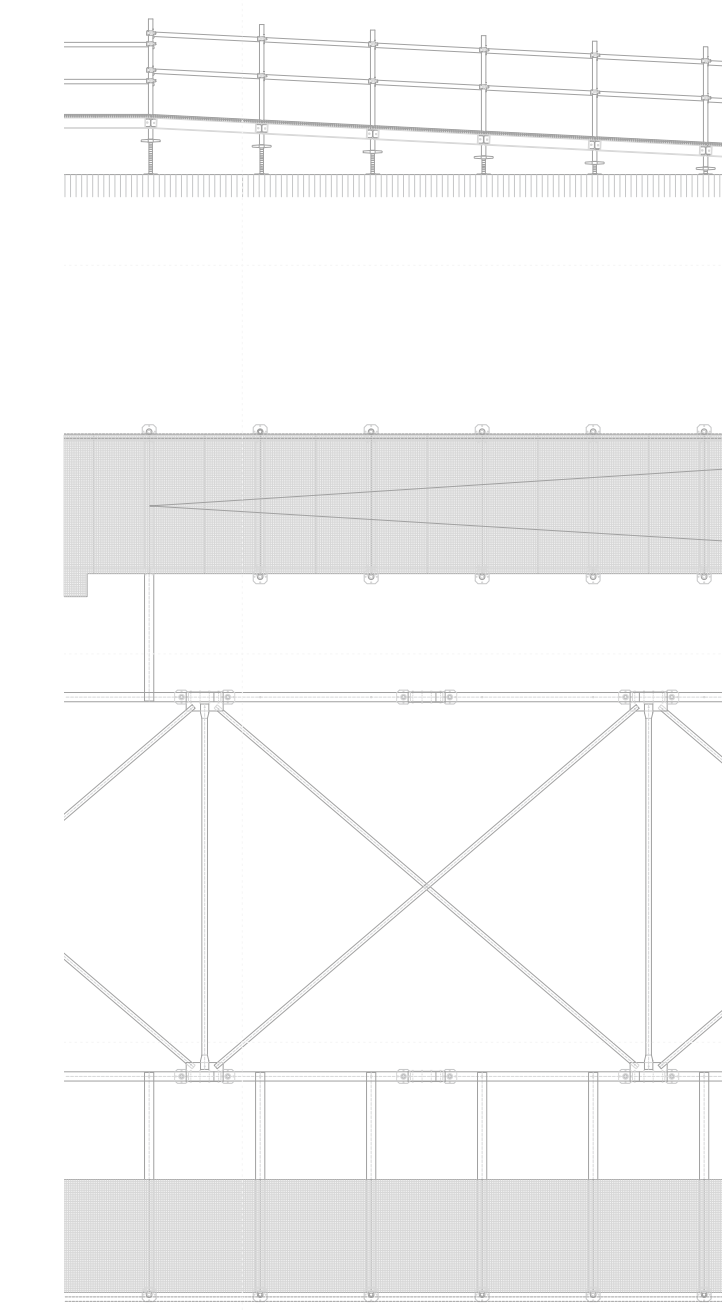
Doorsnede CC - 1/40



Doorsnede DD - 1/40



Doorsnede EE - 1/40



6

HOOFDSTUK
Technische uitwerking van paviljoen

INHOUDSTAFEL

6.1 Plannen
 6.1.1 Varianten op de plattegrond

6.2 Uitvoeringstekeningen
 6.2.1. Kader
 6.2.2. Stuklijst panelen
 6.2.3. Stuklijst fundering, balkon en helling
 6.2.4. Struwbakken
 6.2.5. Buitenschrijfwerk

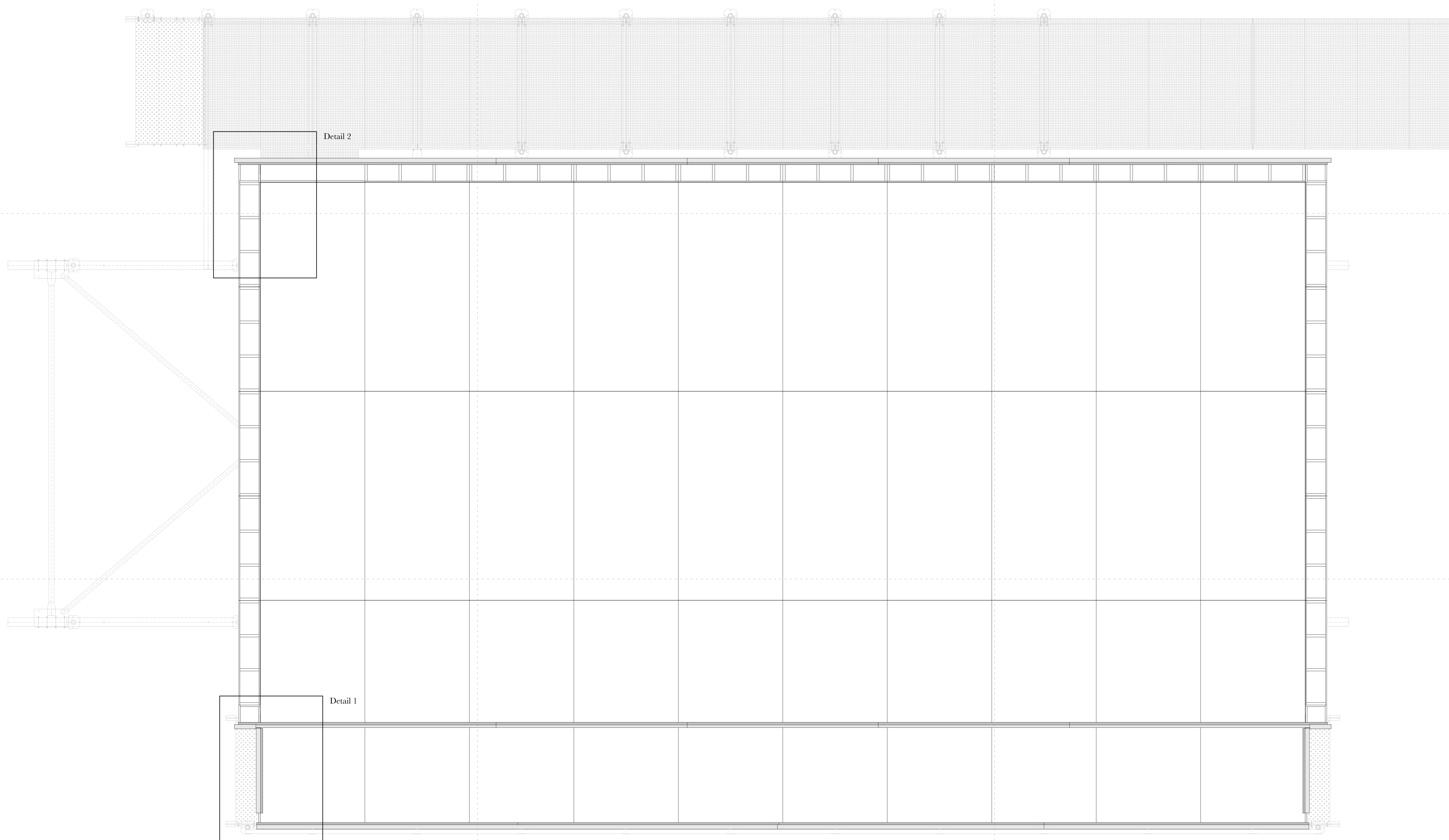
6.3 Interieur
 6.3.1. Schuifvanden
 6.3.2. Lamp

WOORD VOORAF

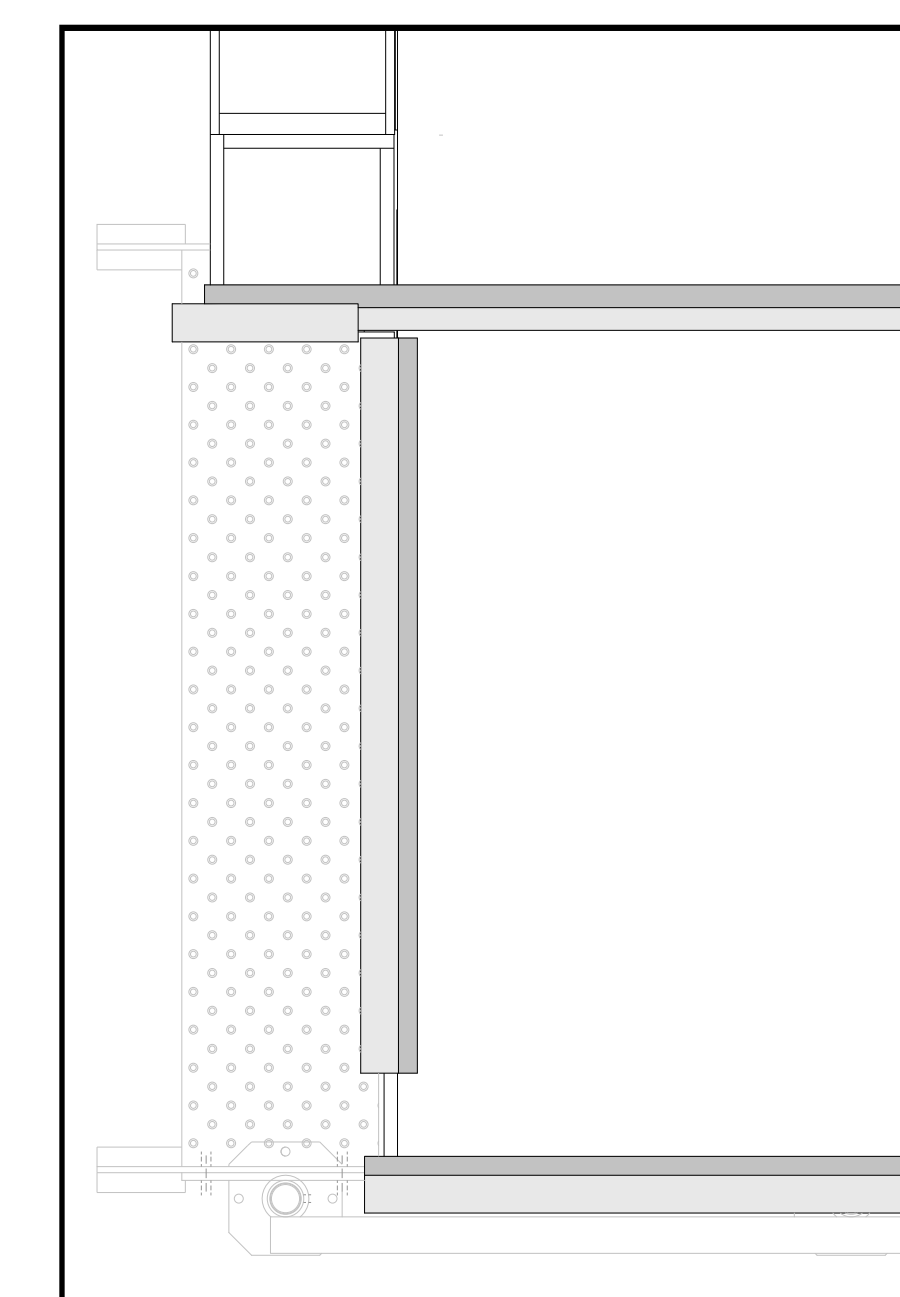
Dakaanzicht, gevel en isometrie van het paviljoen.

De twee korte zijden (en het dak) van het paviljoen worden afgewerkt met de dakdichting. Er wordt m.a.w. geen bijkomende afwerking voorzien. Deze keuze is een gevolg van de representatie van het paviljoen als appartement. Bij een appartement wordt enkel de glasgevel afgewerkt, de andere zijden grenzen aan de andere bouwaparatesen. De gevel langs de helling wordt wel afgewerkt omdat bezoekers langs deze buitenwand geïnformeerd zullen worden afvoeren het paviljoen te betreden.

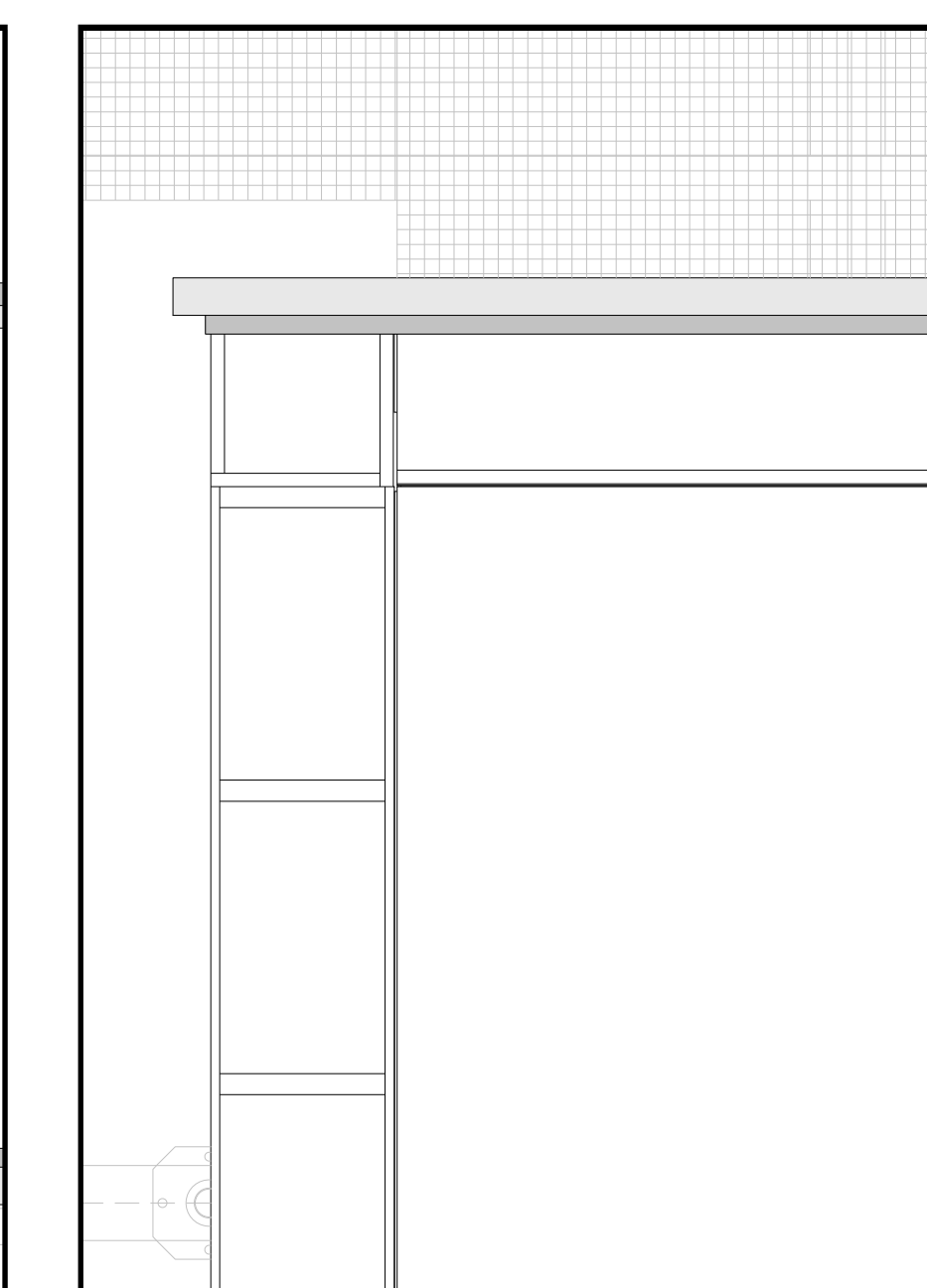
Twee mogelijkheden voor de plaatsing van de dakafdichtingsbanen worden weergegeven.

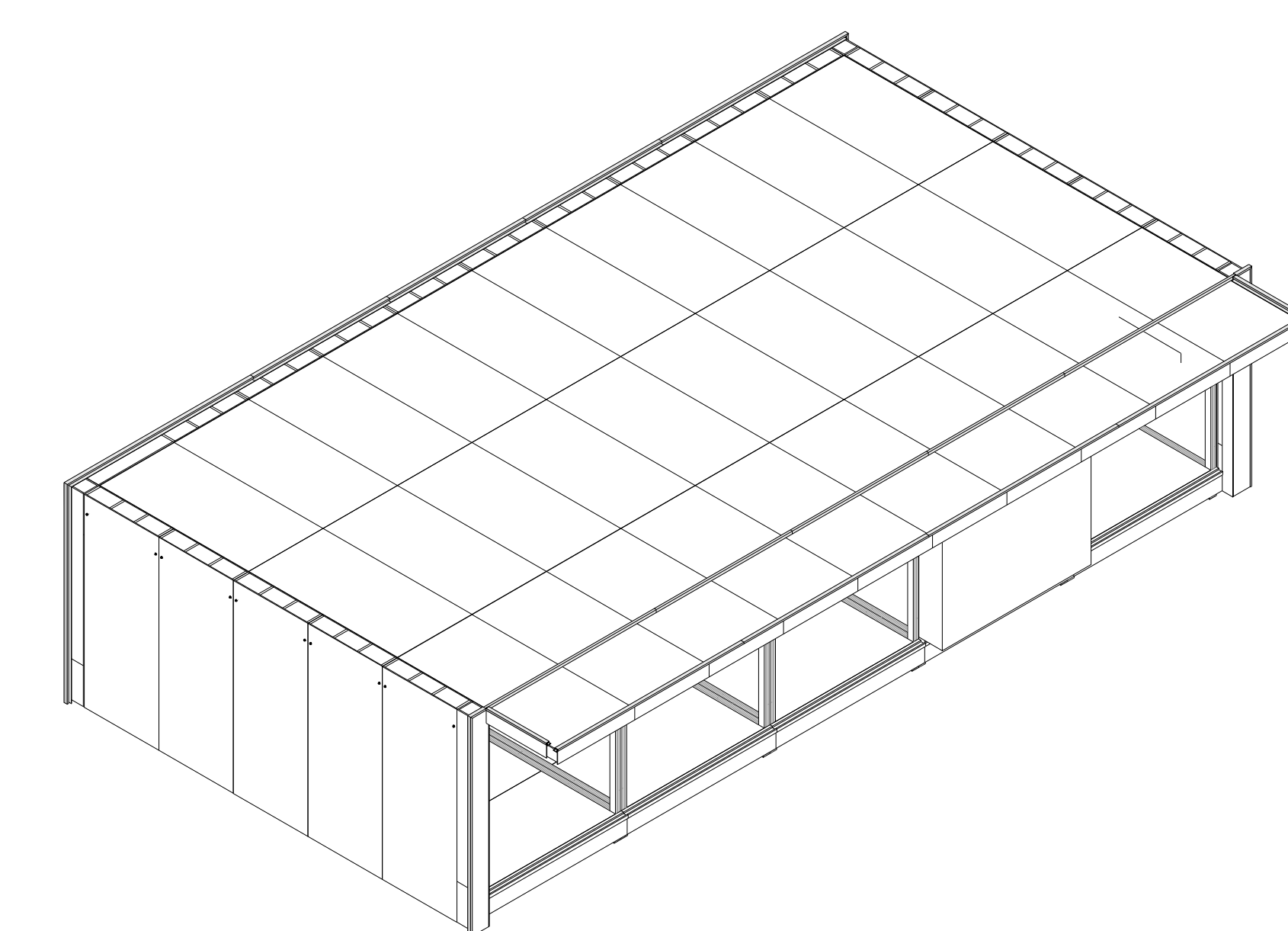
Dakaanzicht - 1/20



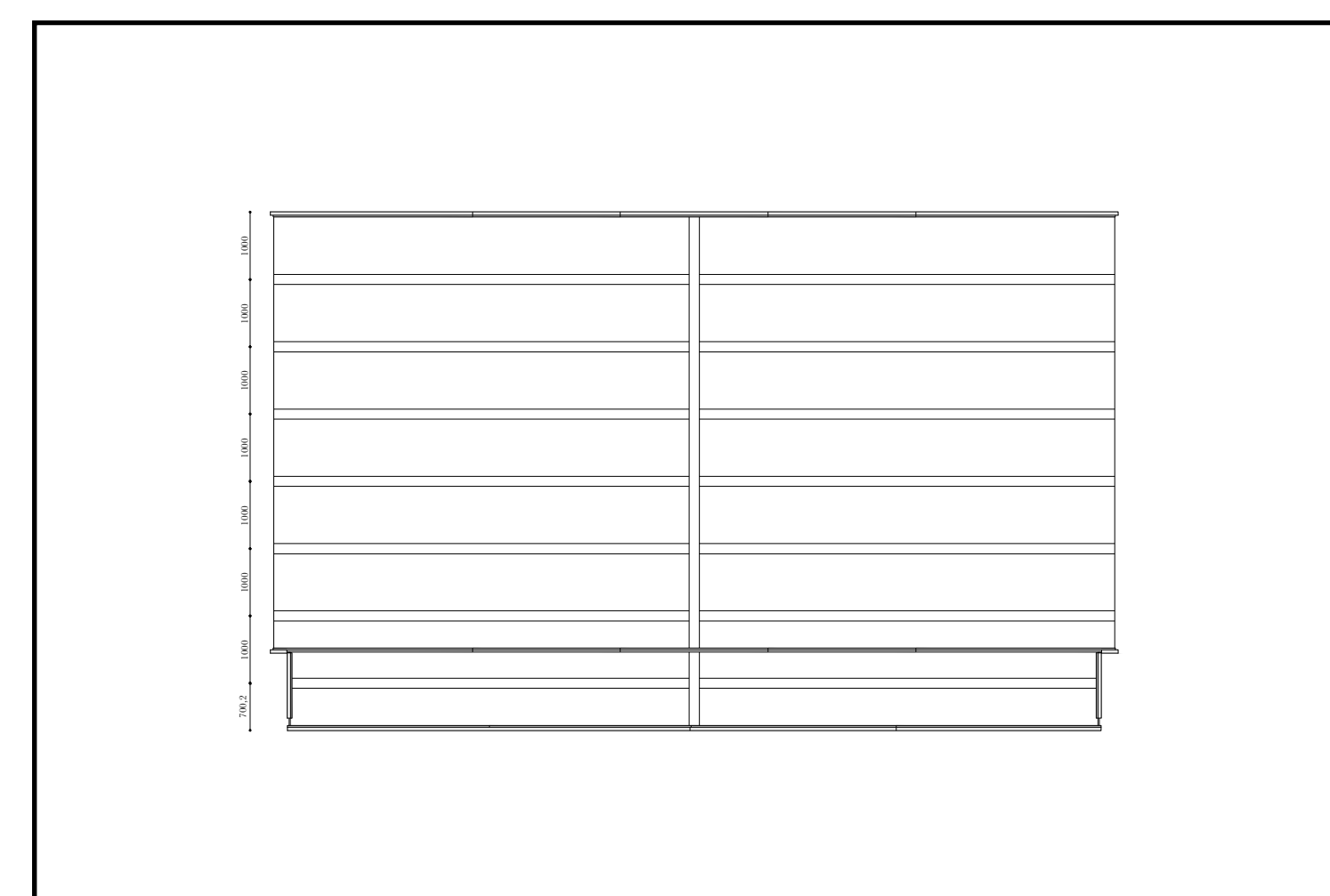
Detail 1 dakprofielen - 1/10



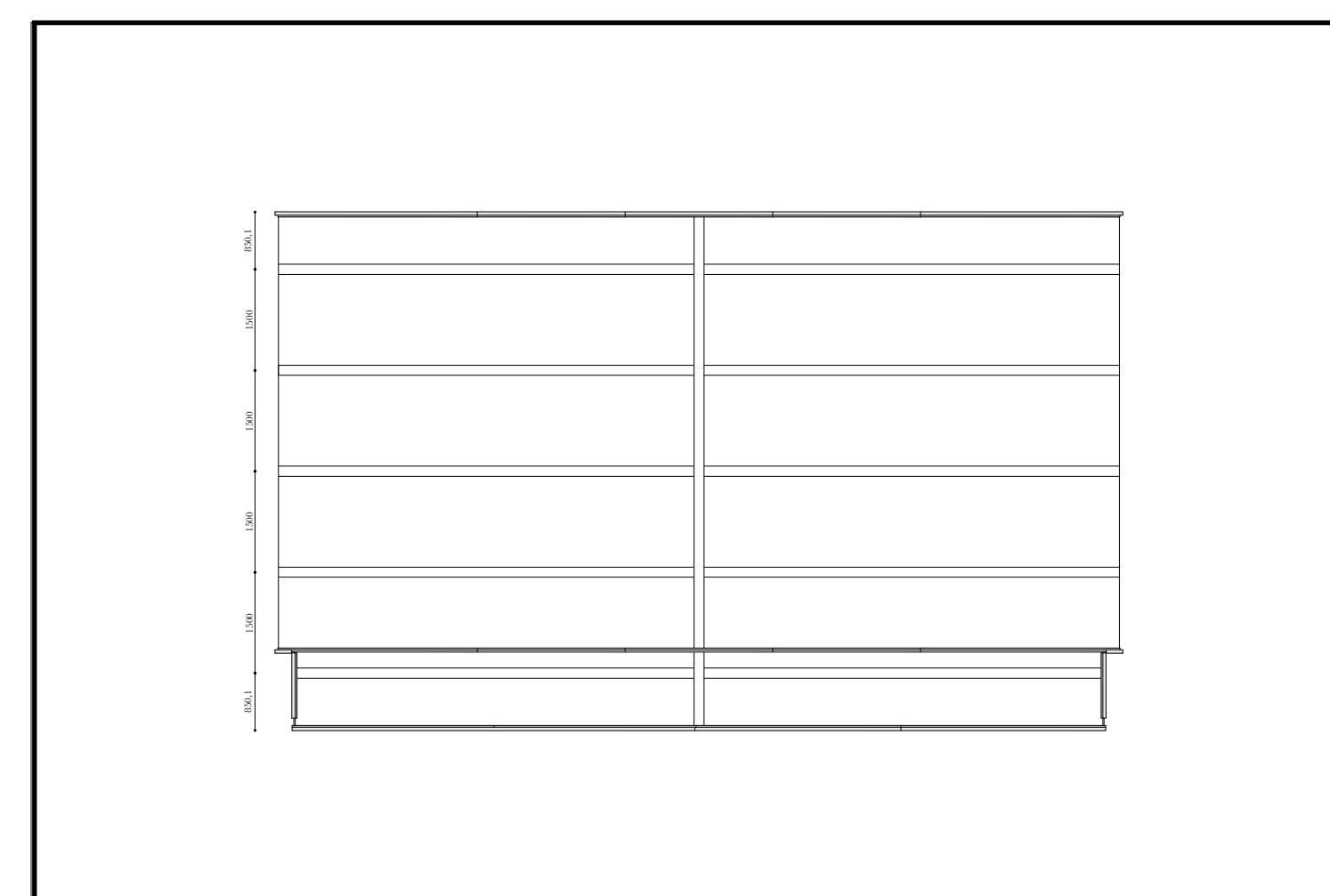
Detail 2 dakprofielen - 1/10



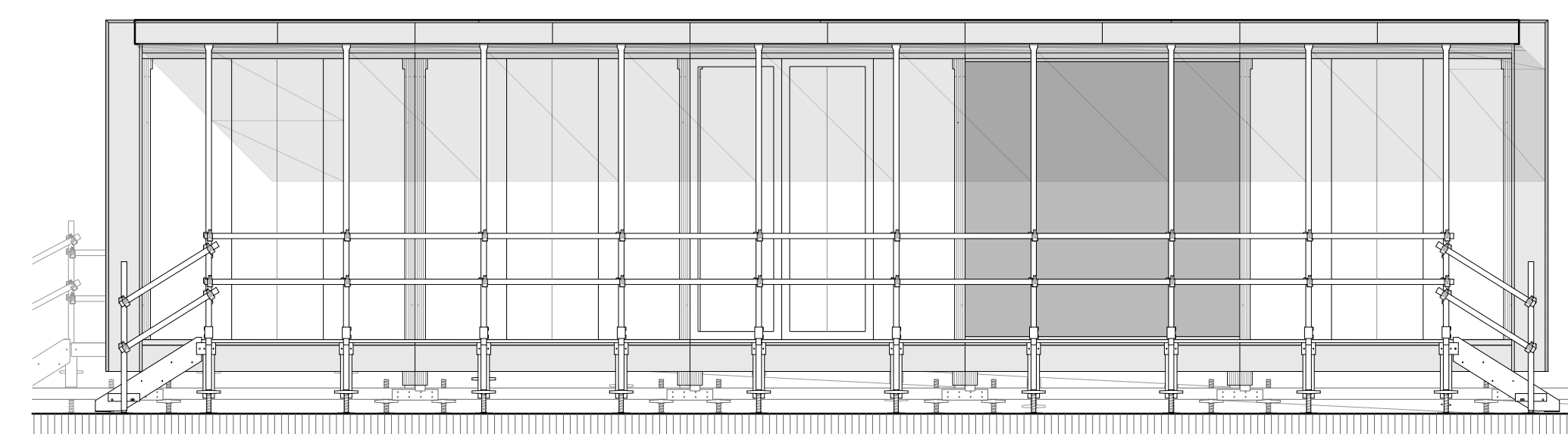
Isometrie van het paviljoen.



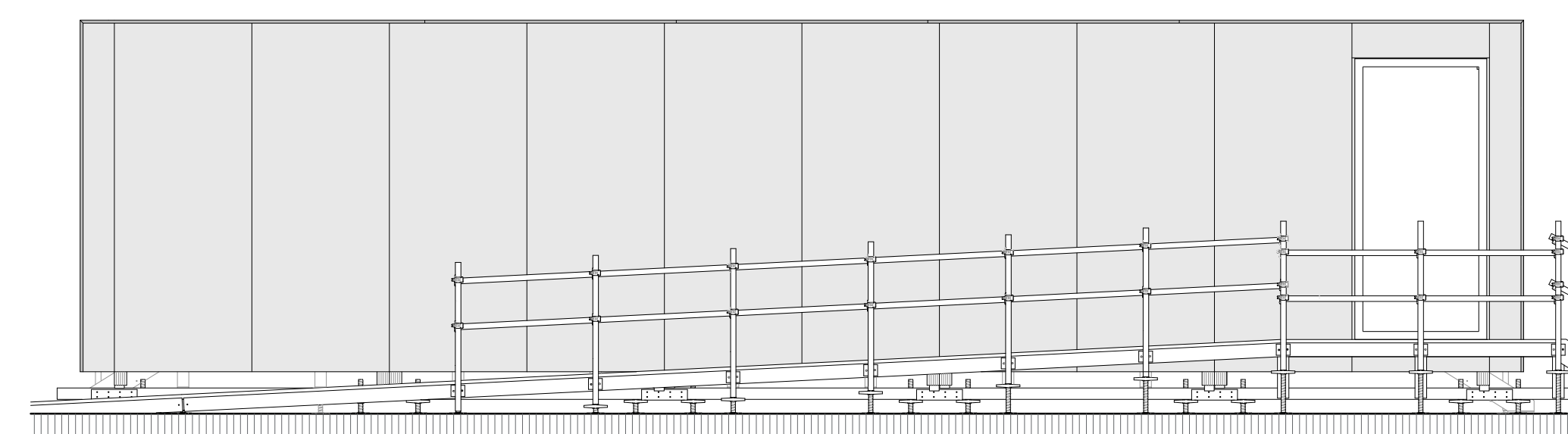
Dakaanzicht optie 1: dakdichtingsbanen van 1m - 1/100



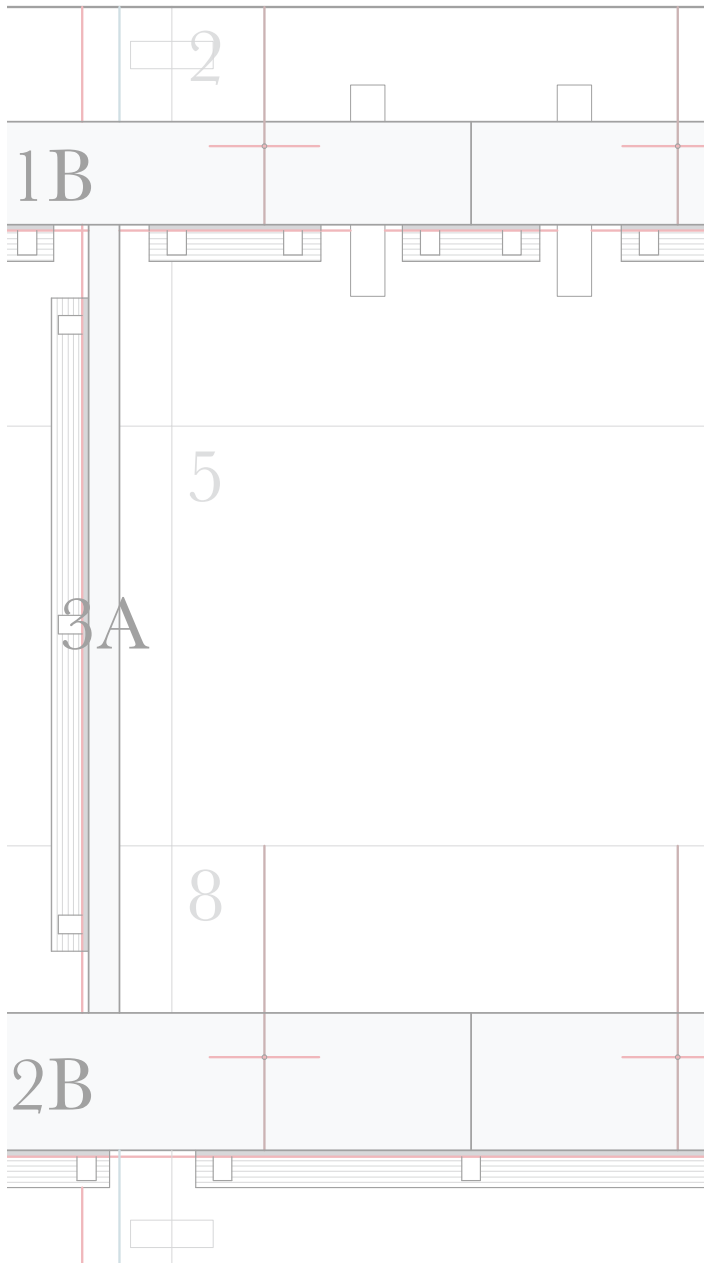
Dakaanzicht optie 2: dakafdichtingsbanen van 1,5m - 1/100



Aanzicht langs balkon - 1/50



Aanzicht langs helling - 1/50



6

HOOFDSTUK

Technische uitwerking van paviljoen

INHOUDSTAFEL

6.1 Plannen

- 6.1.1 Varianten op de plattegrond
- 6.1.2 Ontwerpkeuzes, grondplannen en doorsnedes

6.2 Uitvoeringstekeningen

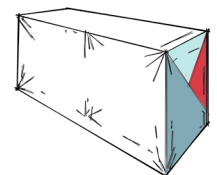
- 6.2.1. Kader
- 6.2.2. Stuklijst panelen
- 6.2.3. Stuklijst fundering, balkon en helling
- 6.2.4. Steunhaken
- 6.2.5. Buitenschrijnwerk

6.3 Interieur

- 6.3.1 Schuifwanden
- 6.3.2 Lamp

WOORD VOORAF

De *Mobble* bestaat uit twee structurele kaders waartussen panelen worden geplaatst. Het is belangrijk dat alle kaders even groot zijn zodat alle *Mobbles* gelijk zijn. Daarom wordt er een sjabloon gemaakt om alle kaders op te bouwen. In deze bundel is het maken van het sjabloon, de zaagplannen voor de kaders en de legpatronen van de kaders opgenomen. Er is een verschil tussen het linkse en rechtse kader.

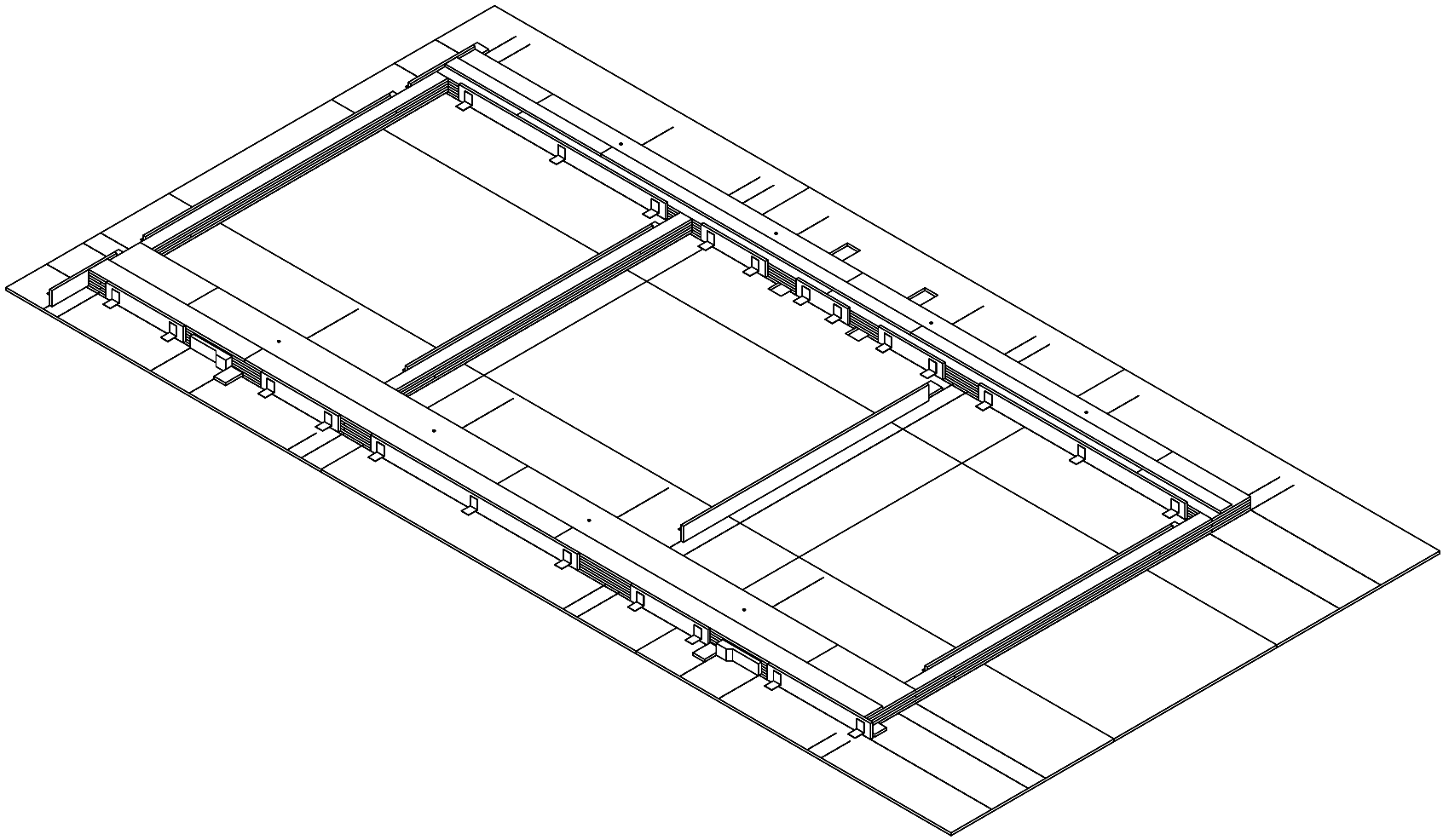


Benodigheden - Gereedschap

Boormachine
Klokboor
Rolmeter
Potlood
Boren
Frees
Winkelhaak
Wipzaag
Spuitsbus
Zaagtafel
Lijm
Schroeven

Benodigheden - Materiaal

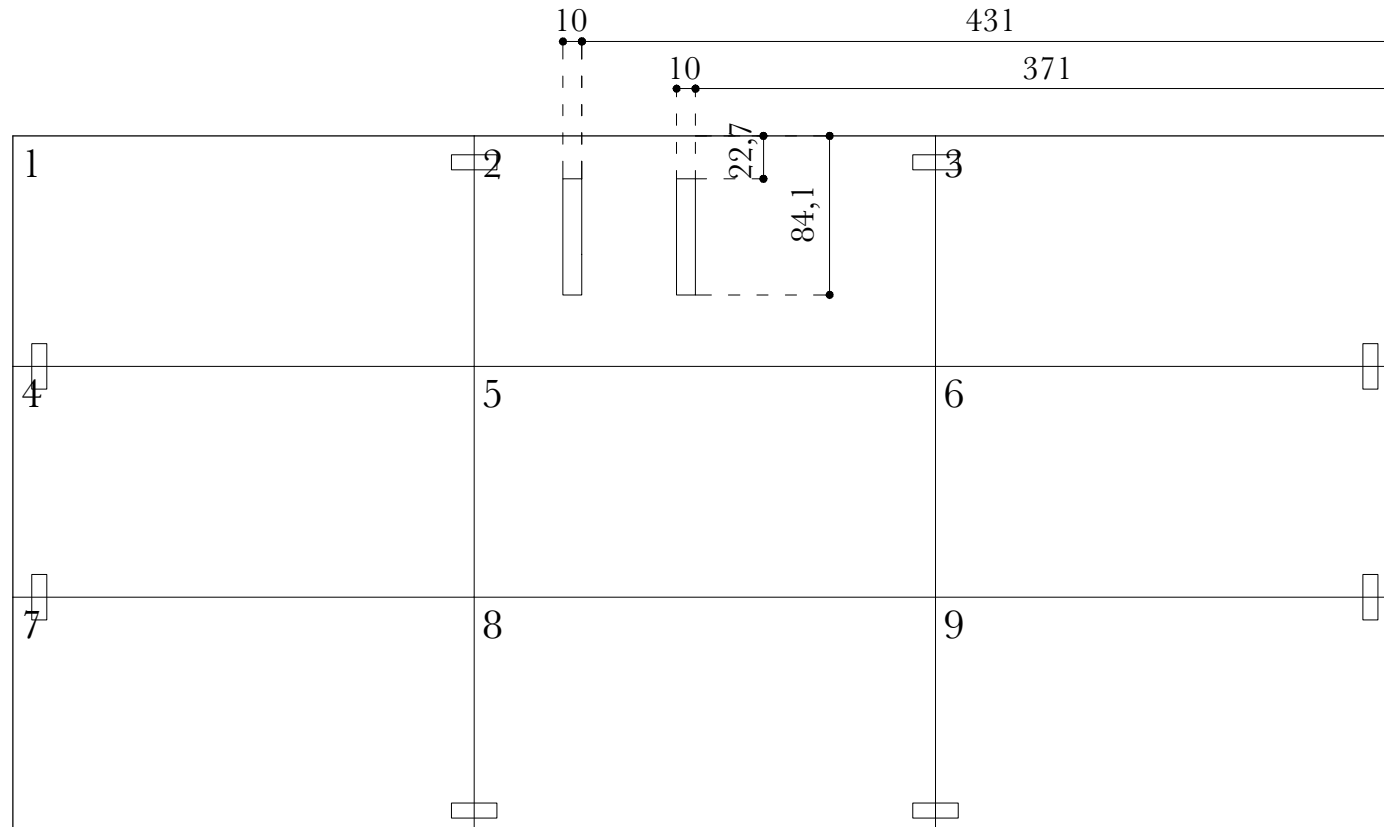
9 spaanplaten
20 multiplexplaten (10 voor kader links, 10 voor kader rechts)
39 L-ijzers
Stratifié-platen
8 koppelplaatjes
4 steunvoeten (2 voor kader links, 2 voor kader rechts)



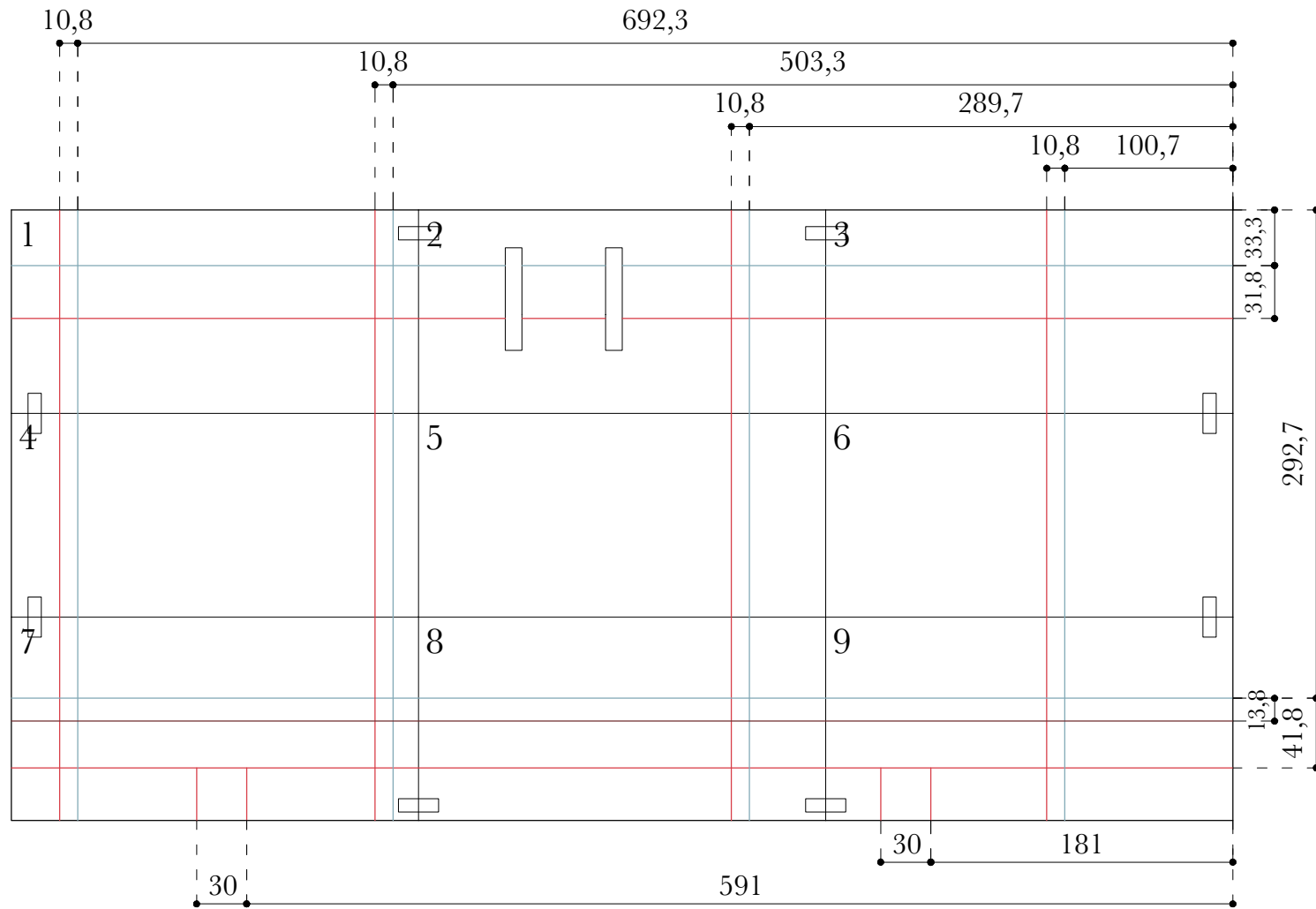


Stap 1 - Werkvloer

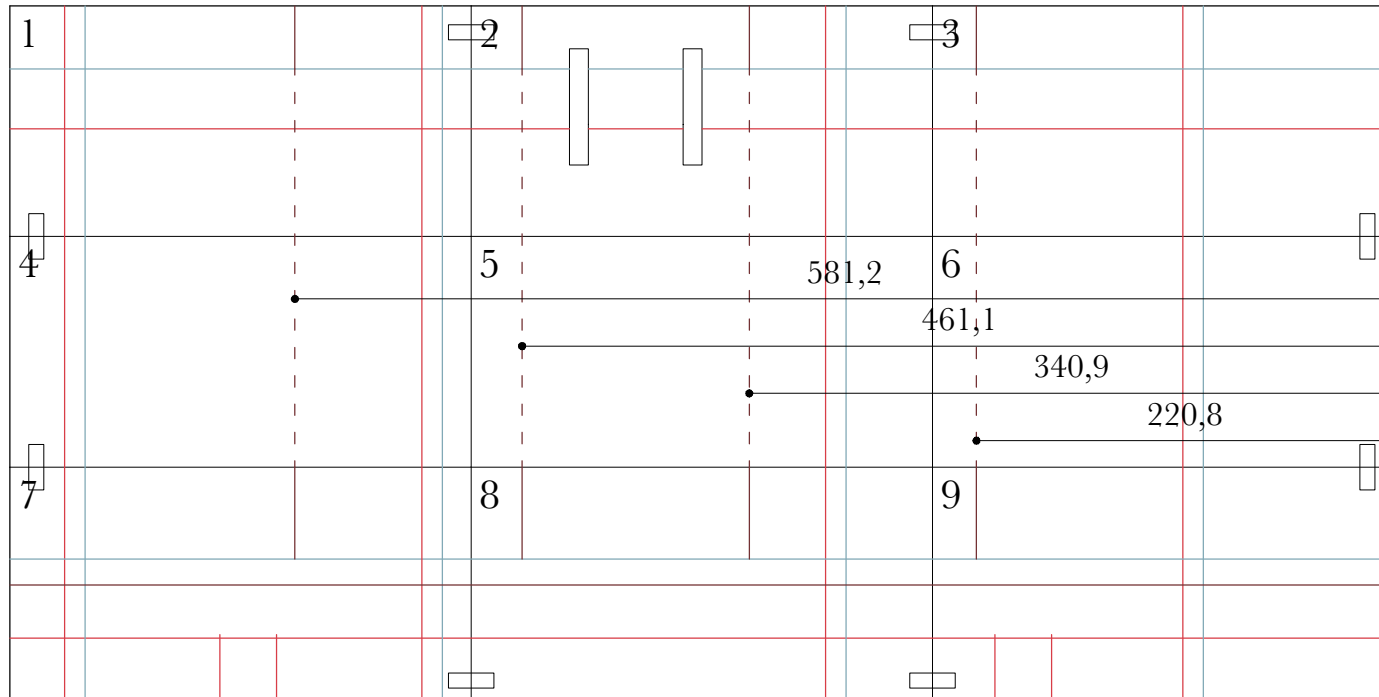
Zaag met een wipzaag de twee gaten uit de spaanplaat zoals aangeduid op de tekening. Geef deze plaat in de linker bovenhoek nummer 2. Leg de 9 spaanplaten op een vlakke ondergrond en nummer de platen zoals hieronder geïllustreerd. Koppel de platen met behulp van koppelplaatjes (ongeveer 10 cm van de rand van de plaat).



Stap 2 - Aanduiden referentielijnen

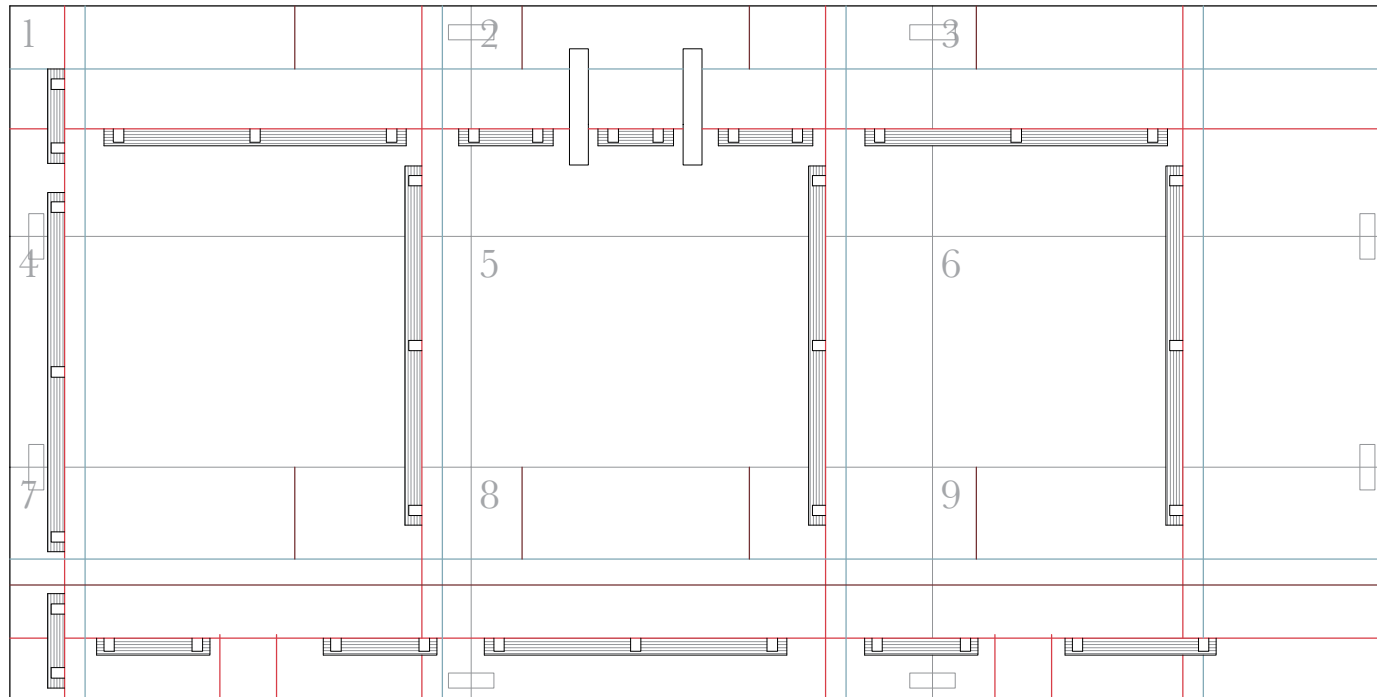


Stap 2 - Aanduiden referentielijnen



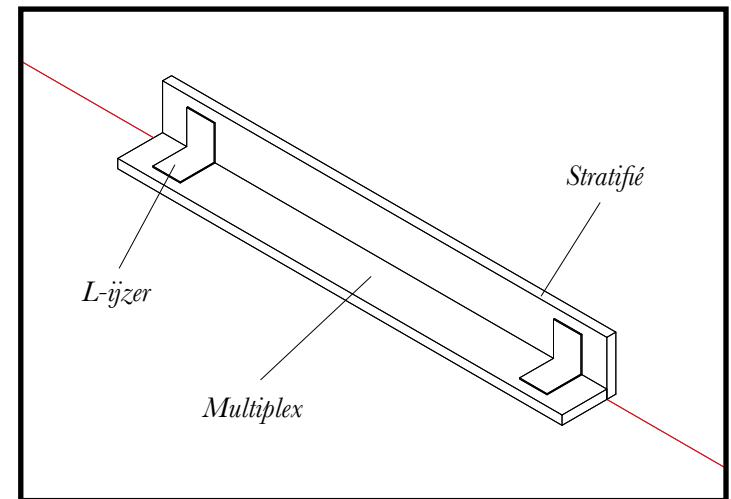
Stap 3 - Multiplex en L-ijzers plaatsen

Leg stroken (van ongeveer 9 cm) multiplex tegen de rode lijn zoals weergegeven in onderstaande figuur. Plaats twee of drie L-ijzers gelijk met de rode lijn op elke strook multiplex.

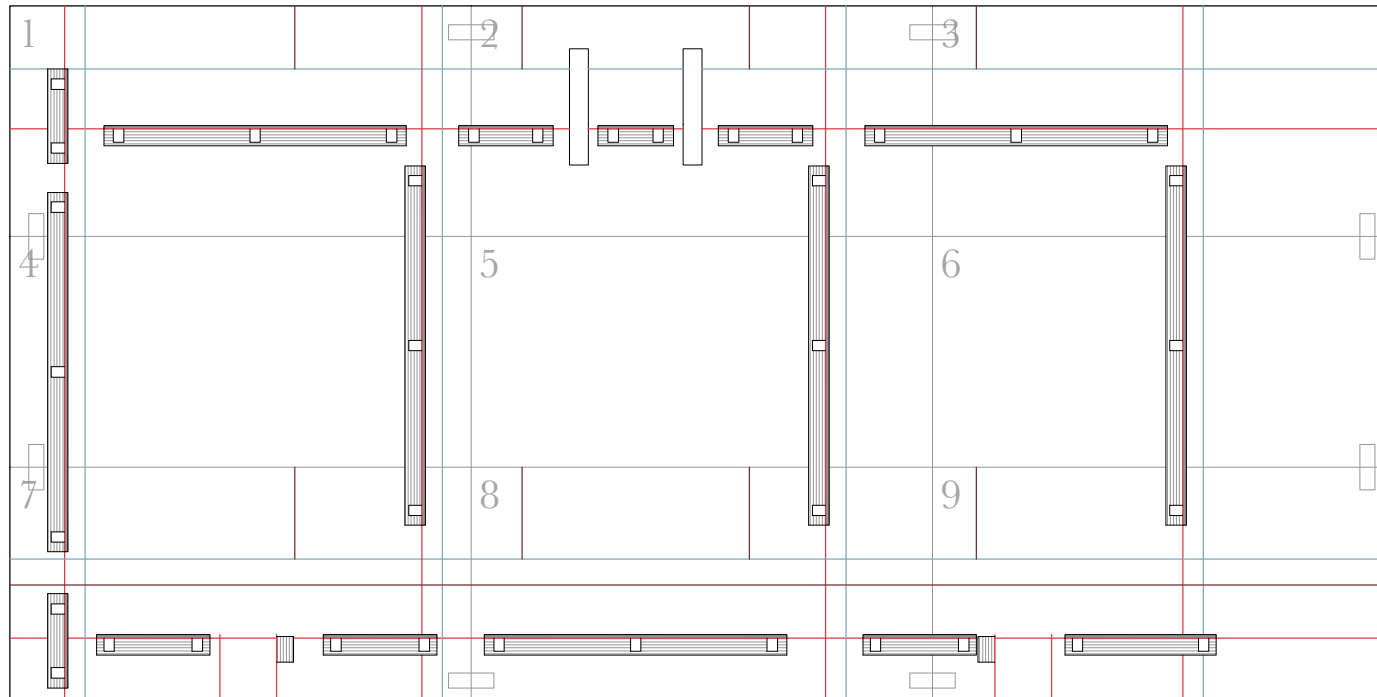


Stap 4 - Bekisting plaatsen

Plaats de stratifié (die even breed is als de multiplex) tegen de rode lijn en schroef vast aan de L-ijzers.



Principetekening bekisting 3D

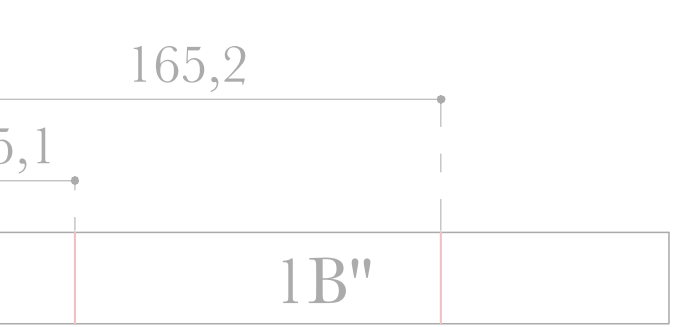




x1



x1



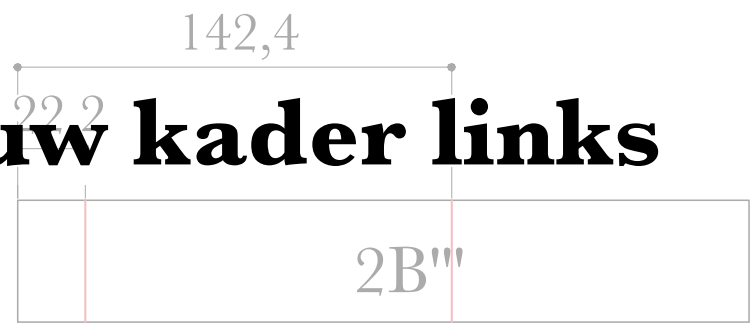
x1



x1

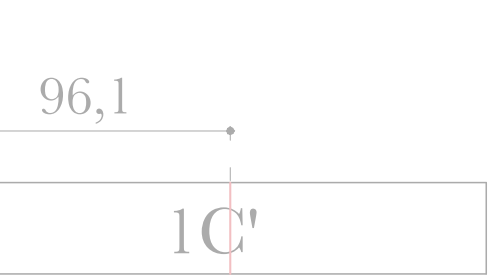


x1

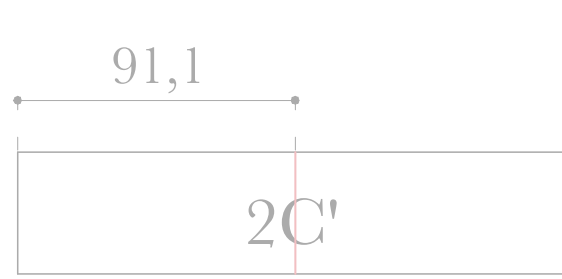


x1

Voorbereiding opbouw kader links



x1

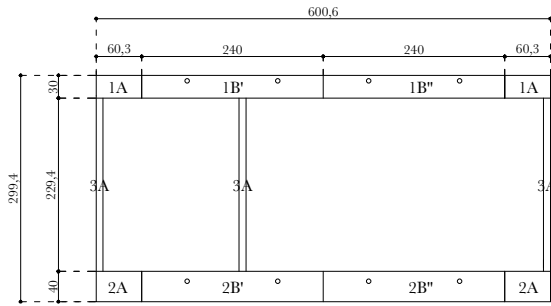


x1

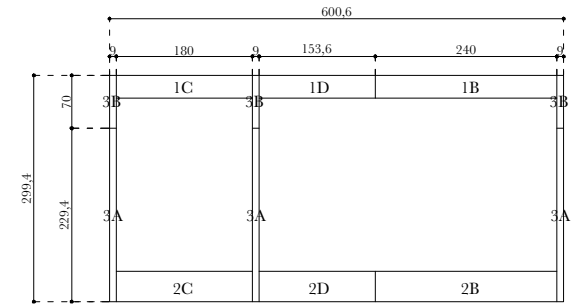
5

22,5

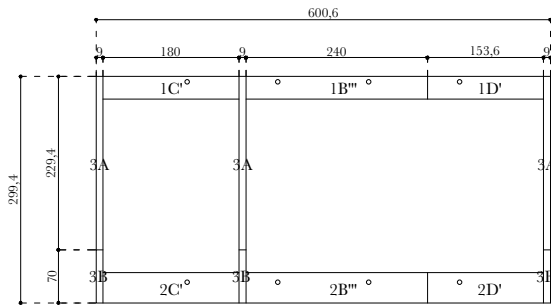
Laag 1



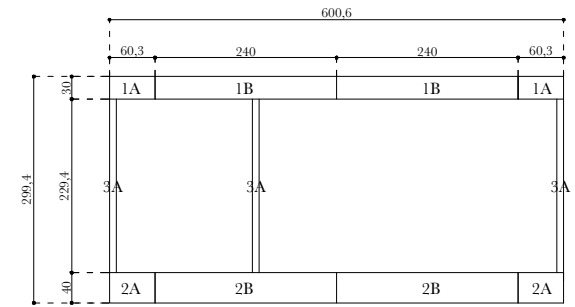
Laag 4



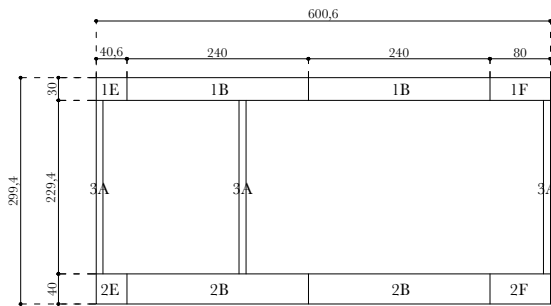
Laag 2



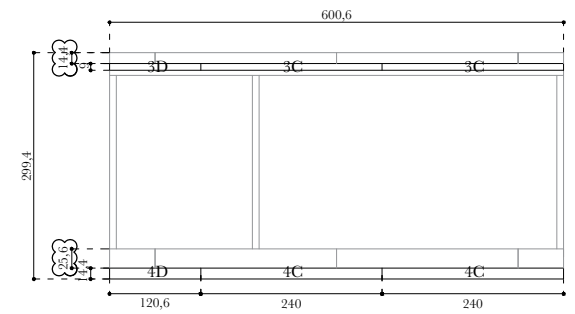
Laag 5



Laag 3

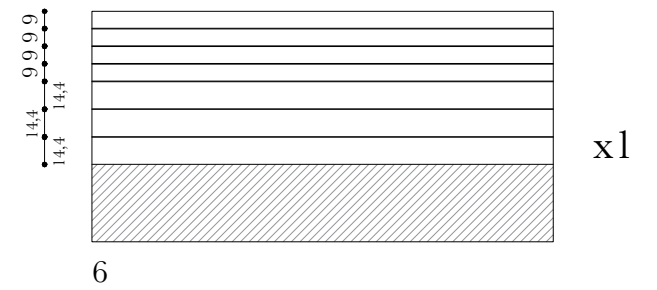
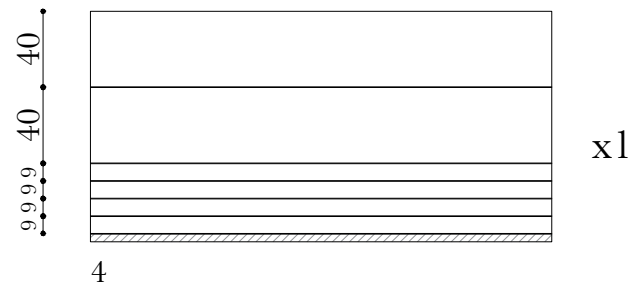
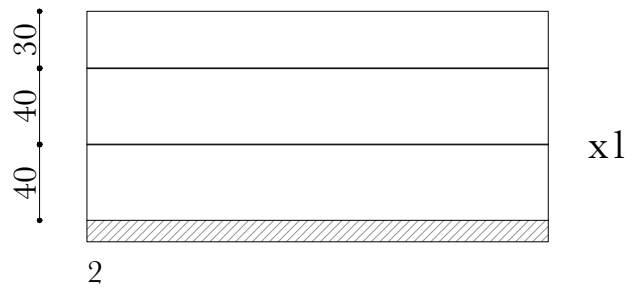
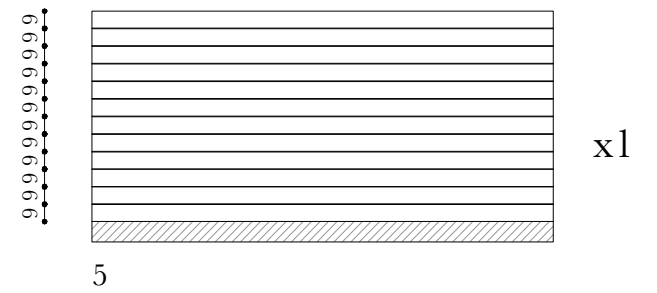
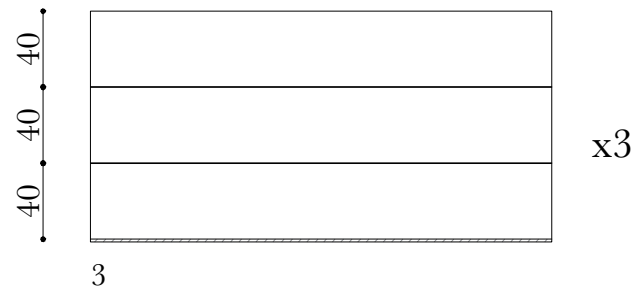
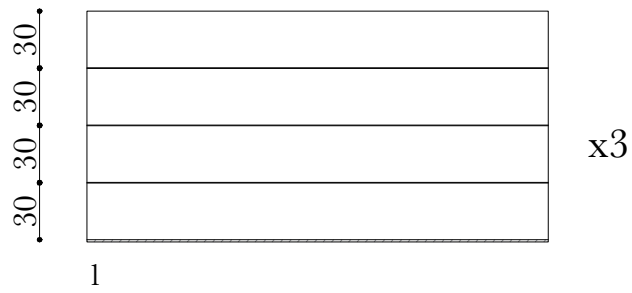
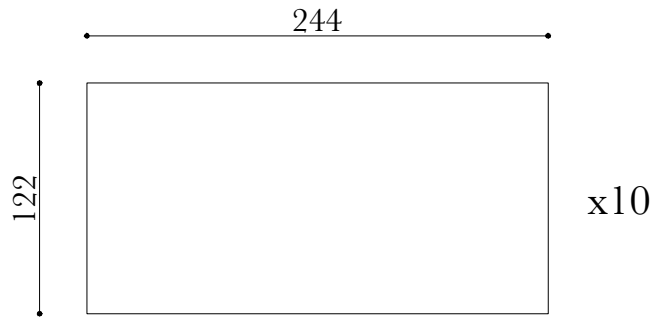


Laag 6

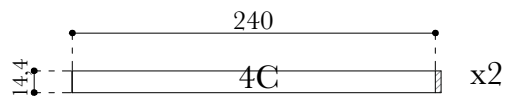
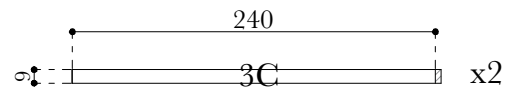
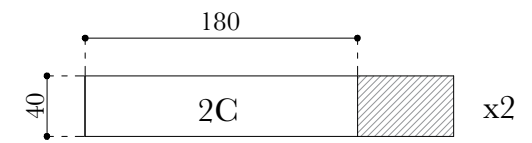
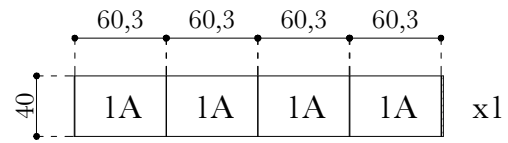
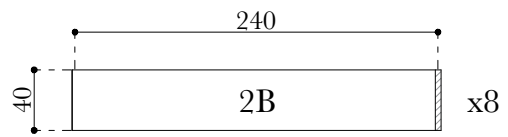
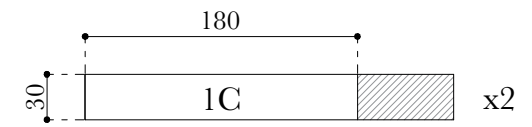
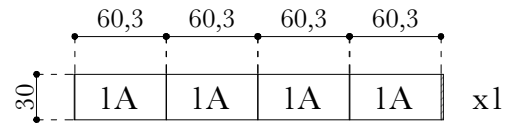
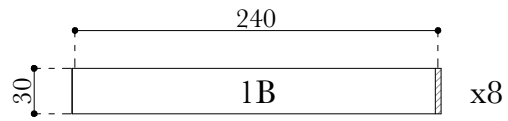


Zaagplan kader links

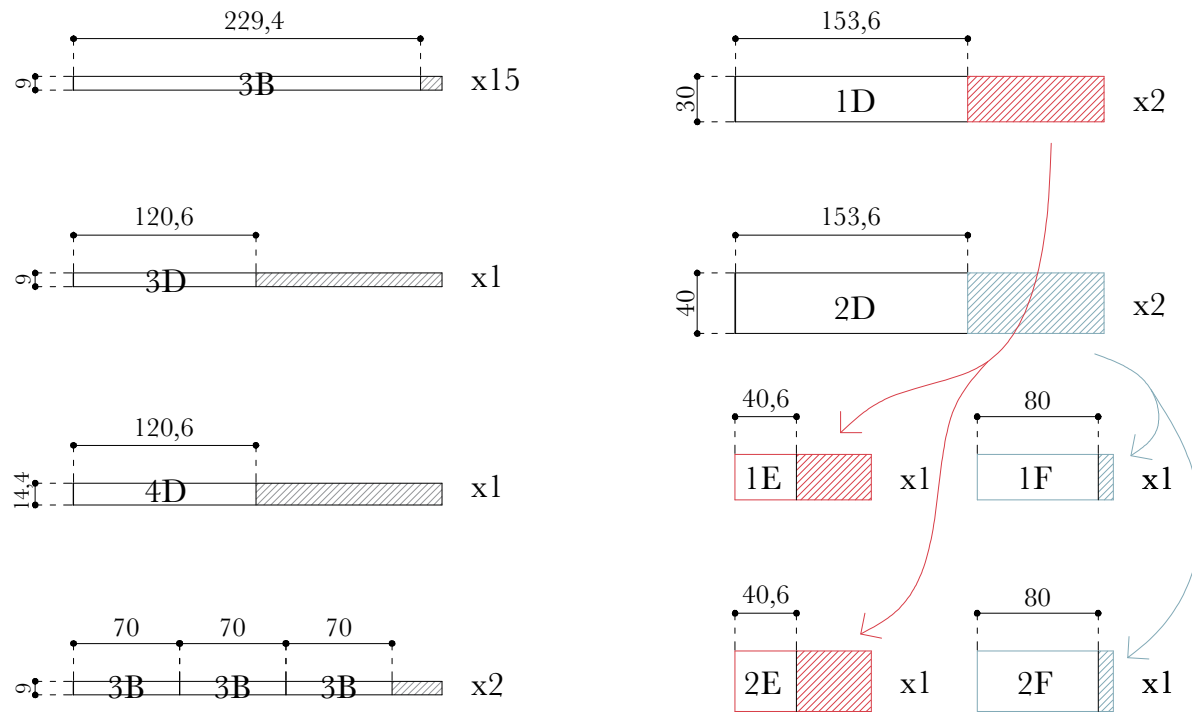
Zaag de platen in volgorde zoals weergegeven.



Afkorten en coderen



Afkorten en coderen



Resultaat

Bovenbalk - 30 cm

- x4 1A 60,3 cm
- x8 1B 240,0 cm
- x2 1C 180,0 cm
- x2 1D 153,6 cm
- x1 1E 40,6 cm
- x1 1F 80,0 cm

Kolom - 9 cm

- x15 3A 229,4 cm
- x6 3B 70,0 cm

Onderbalk - 40 cm

- x4 2A 60,3 cm
- x8 2B 240,0 cm
- x2 2C 180,0 cm
- x2 2D 153,6 cm
- x1 2E 40,6 cm
- x1 2F 80,0 cm

Steunbalk voor dakpanelen - 9 cm

- x2 3C 240,0 cm
- x1 3D 120,6 cm

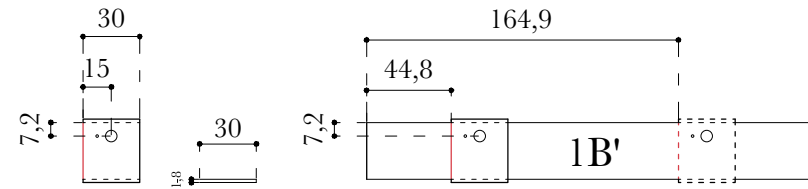
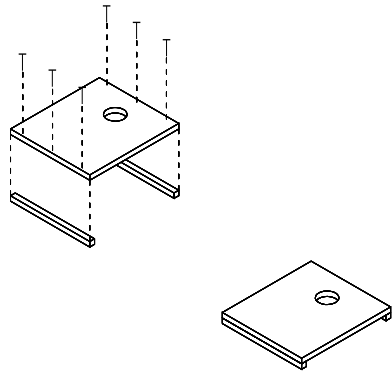
Steunbalk voor vloerpanelen - 14,4 cm

- x2 4C 240,0 cm
- x1 4D 120,6 cm

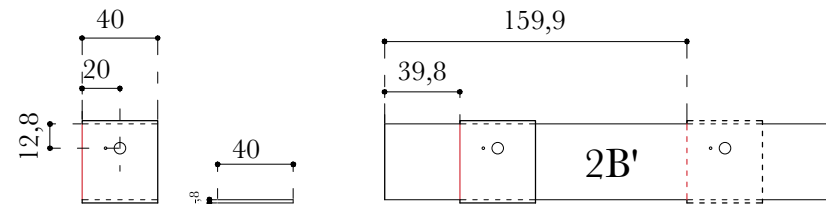
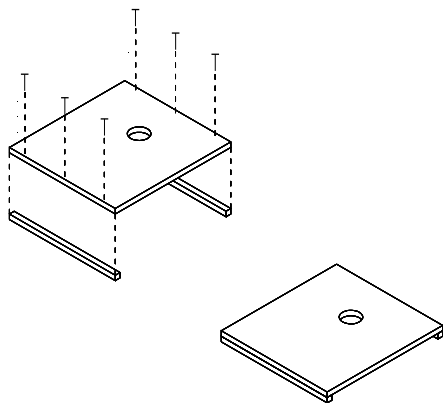
Aanduiding hulplijnen (rood)

Duid de rode lijnen aan op de planken en geef de juiste codering.

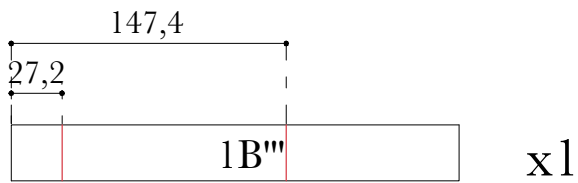
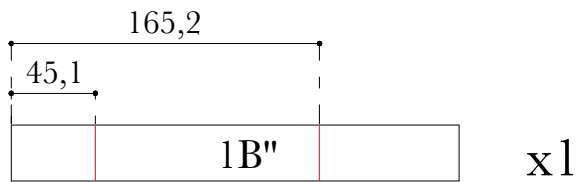
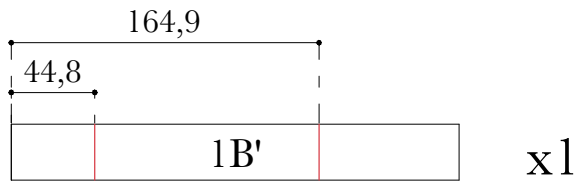
Hulpconstructie bovenbalk - Gat boren



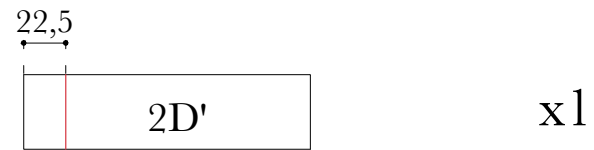
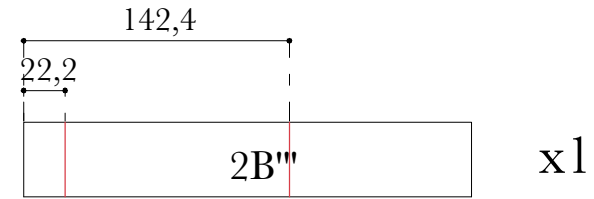
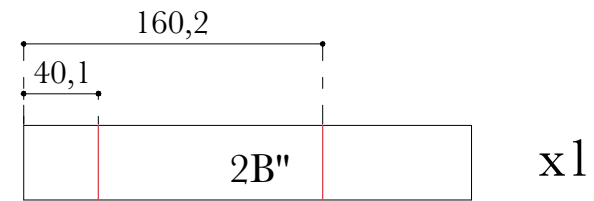
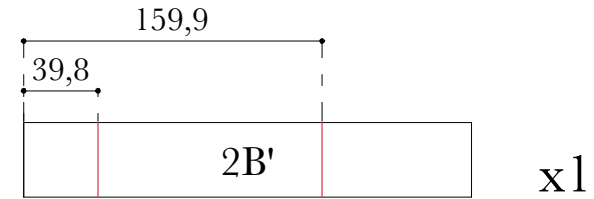
Hulpconstructie onderbalk - Gat boren



Bovenbalk - 30 cm

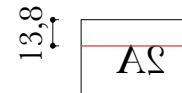


Onderbalk - 40 cm



Sleuf 15 mm diep zagen

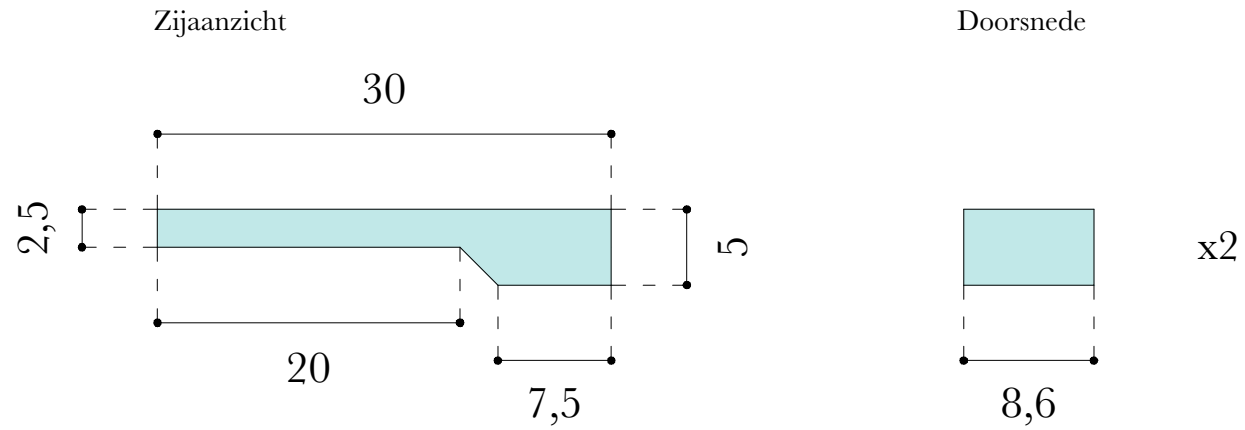
De plankjes 2B', 2B'' en twee plankjes A2 moeten aan de onderkant een groef hebben (15 mm diep in de multiplex). Draai hiervoor de plankjes om zoals weergegeven op de figuur zodat de groef op de juiste plaats wordt aangebracht.



Nieuwe codering: 2A'

Steunvoeten

Verzaag uit polypropyleen de vorm zoals aangeduid op de tekening.
(Twee steunvoeten per kader.)



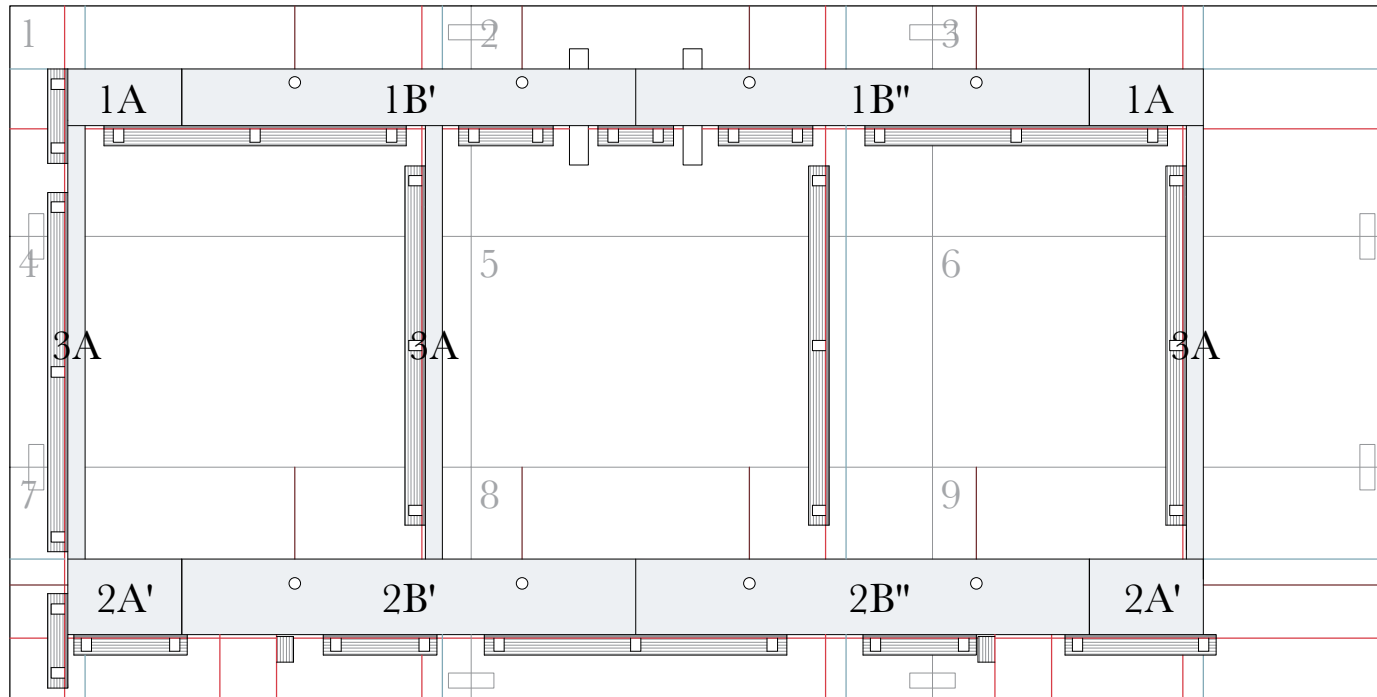


Opbouw kader links

Bij het plaatsen van de planken moet rekening gehouden worden met de kromtes van de planken.
Combineer tegengestelde krommingen.

Laag 1

Van linksonder beginnen leggen. Dit geldt voor alle lagen.

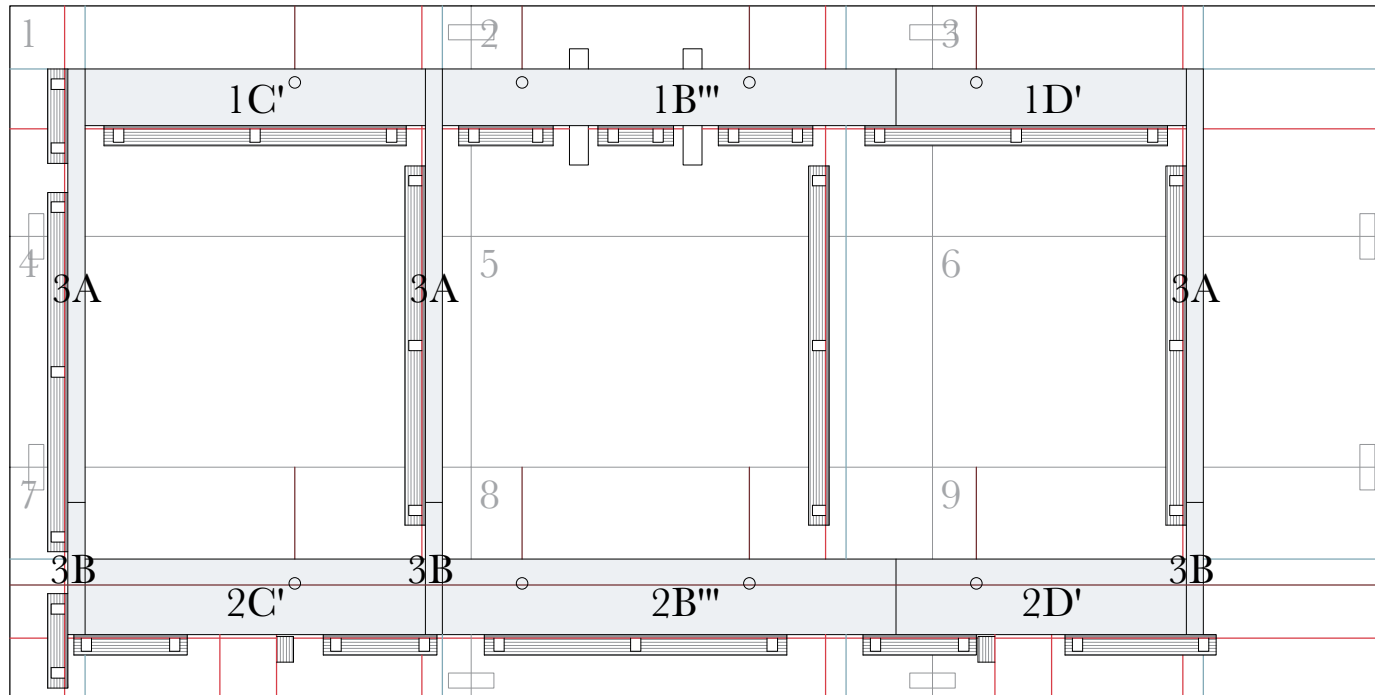


Laag 2

Duid elk stuk van laag 2 één voor één aan op laag 1, lijm dan één voor één het stuk aan de onderliggende laag. Niet tenslotte de twee lagen aan elkaar, rekening houdende met de vrijwaringszone. Dit geldt voor alle lagen.

! Gedachtesteun:

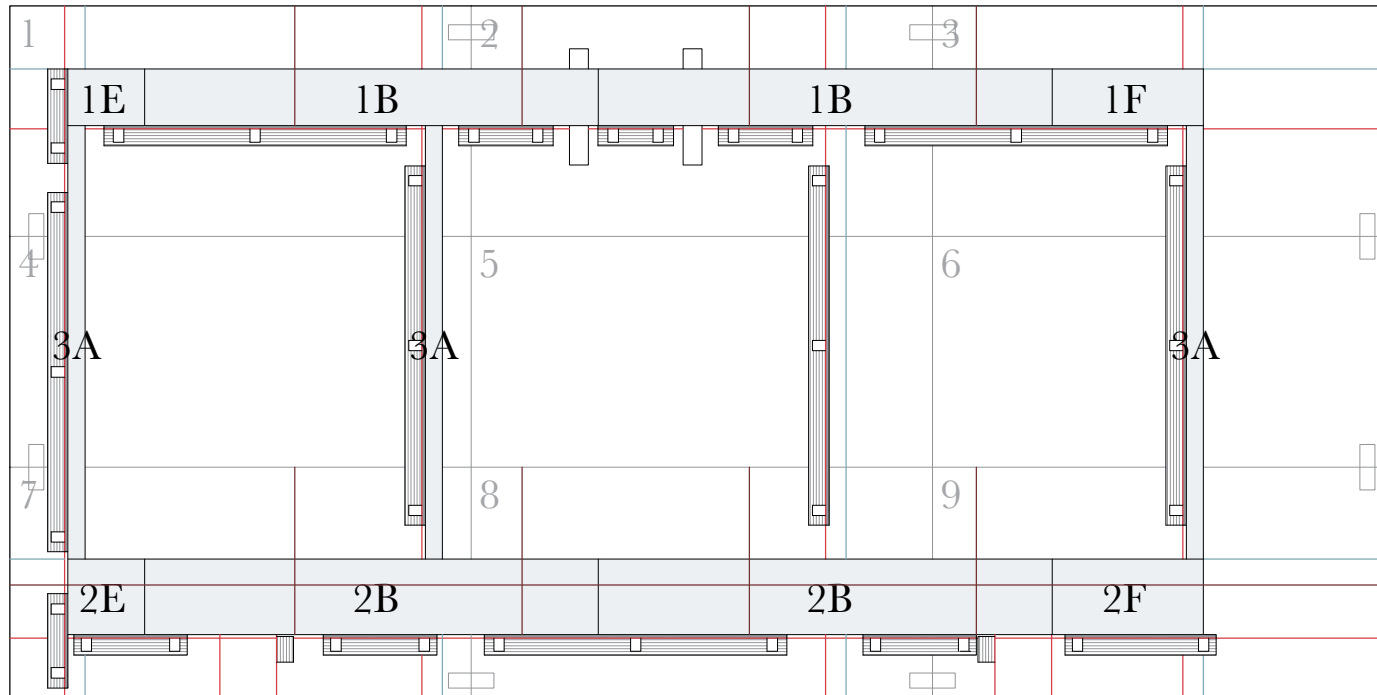
Duid de lijnen aan en vrijwaar deze zones.



Laag 3

! Gedachtesteun:

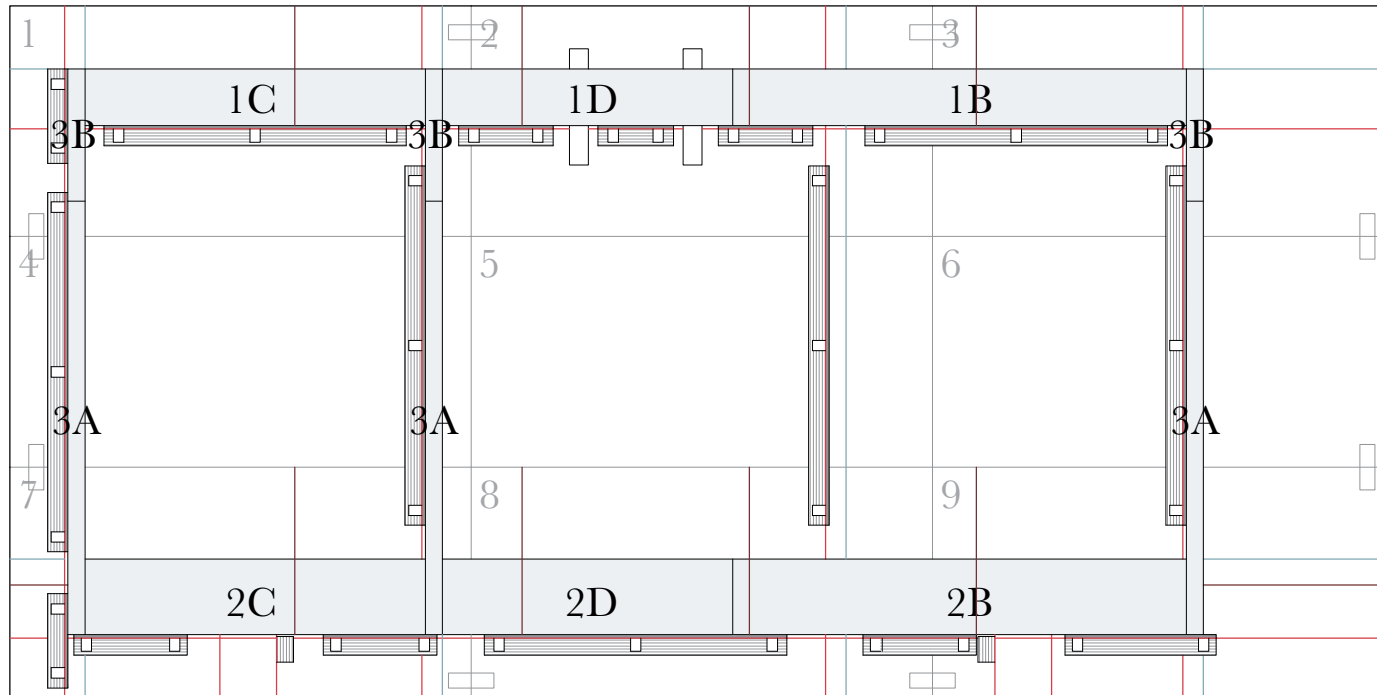
Duid de lijnen aan en vrijwaar deze zones.



Laag 4

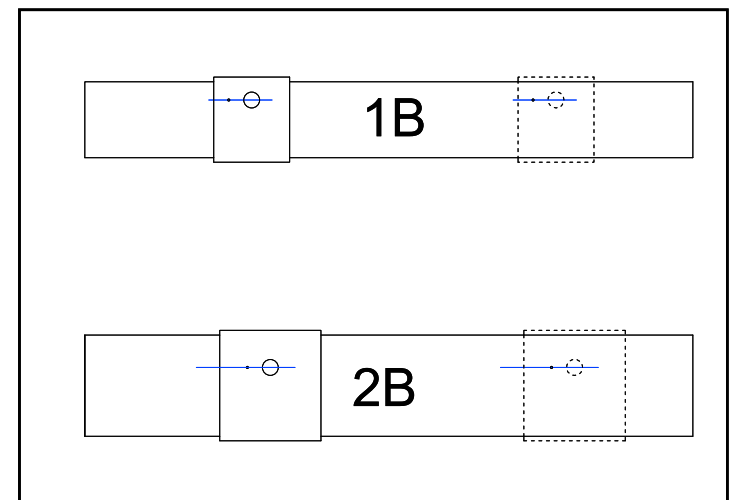
! Gedachtesteun:

Duid de lijnen aan en vrijwaar deze zones.



Laag 5

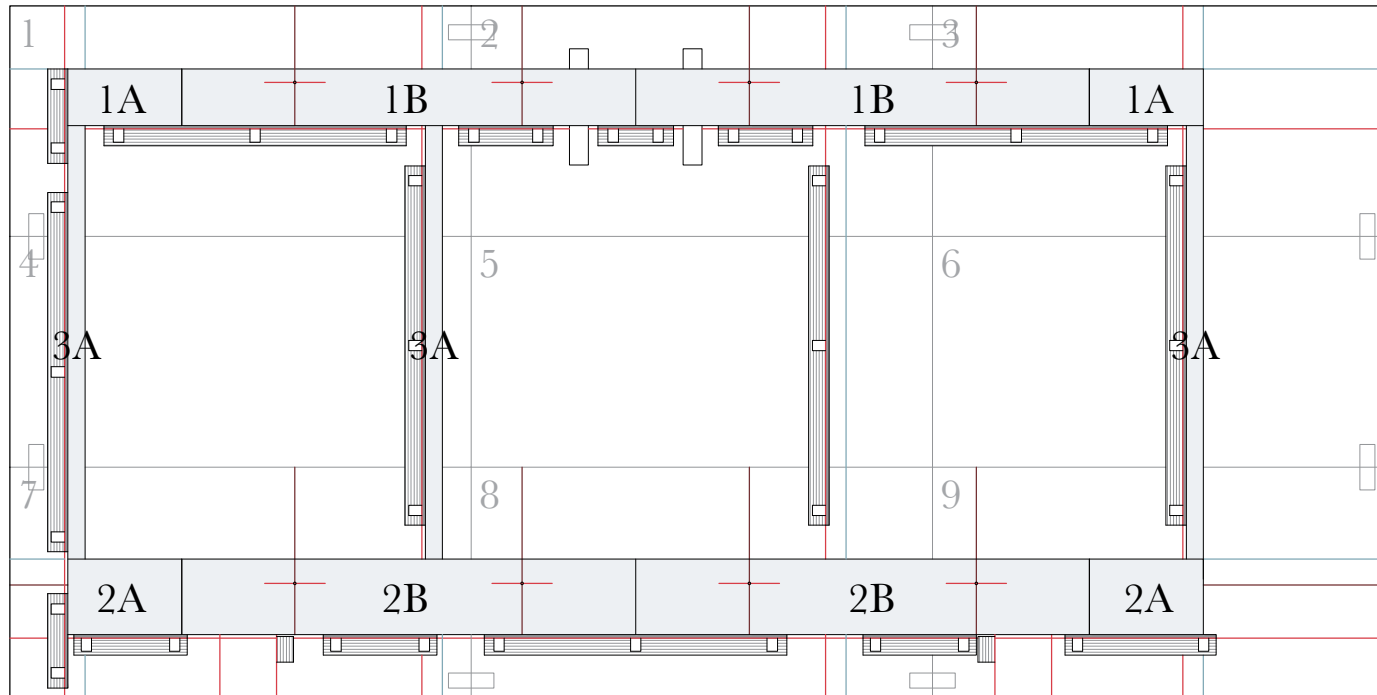
Vooraleer laag 5 wordt geplaatst, moet een horizontale lijn aangeduid worden op 2 plankjes 1B en 2 plankjes 2B d.m.v. het kleine gaatje in het hulpstuk. Het plaatsen van de laag zelf is analoog aan de vorige stappen. Op het snijpunt van de twee assen moet er in dit stadium een gat worden geboord (diameter 15 mm). Concreet: vier gaten boren in de onderbalk en vier gaten boren in de bovenbalk.



Principetekening aanduiding lijnen

! Gedachtesteun:

Duid de lijnen aan en vrijwaar deze zones.

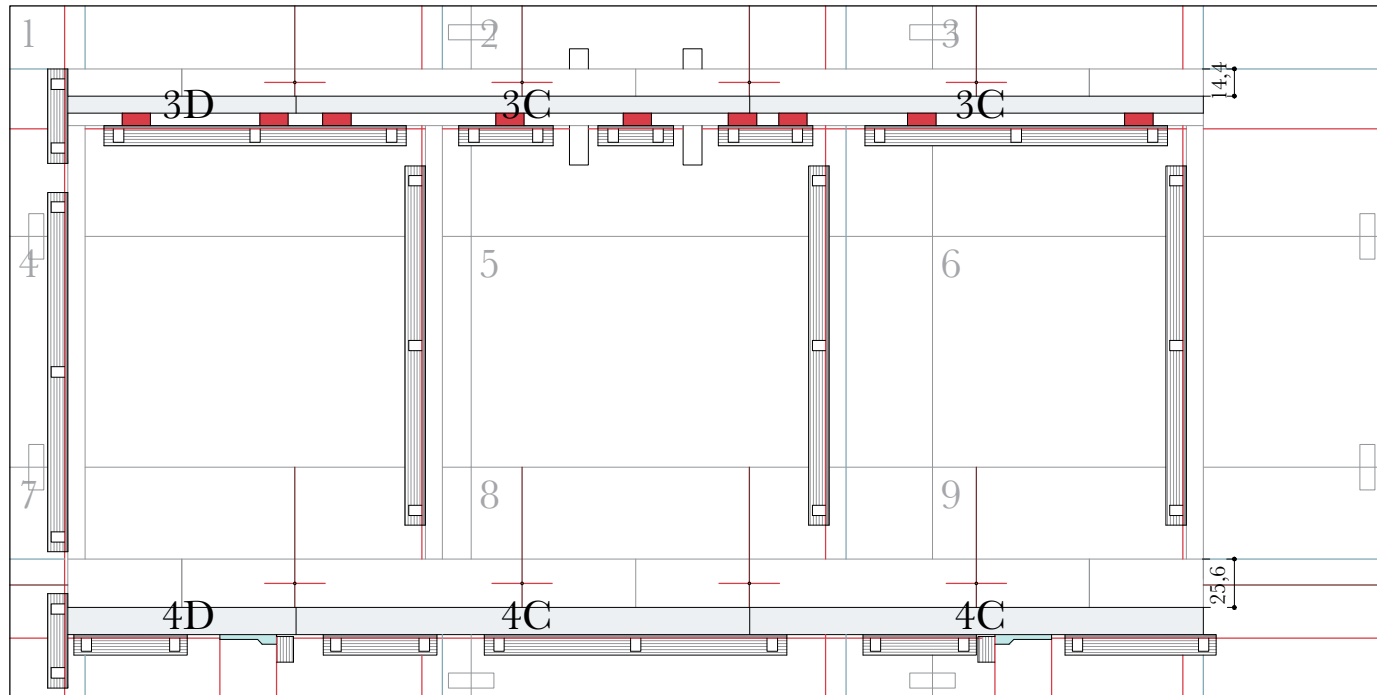


Laag 6

Voor de laatste laag moet een afstandhouder gemaakt worden om de planken 3D, 3C en 3C juist te positioneren, zie rode blokjes. Tenslotte moeten de steunvoeten geplaatst worden. De steunvoeten mogen niet in hetzelfde vlak als het kader liggen, dus moet er een afstandhouder (ongeveer 2 mm dik) onder de steunvoet geplaatst worden. De steunvoeten worden op drie plaatsen kops geschroefd in het kader.

! Opmerking:

Let goed op de richting van de steunvoeten.

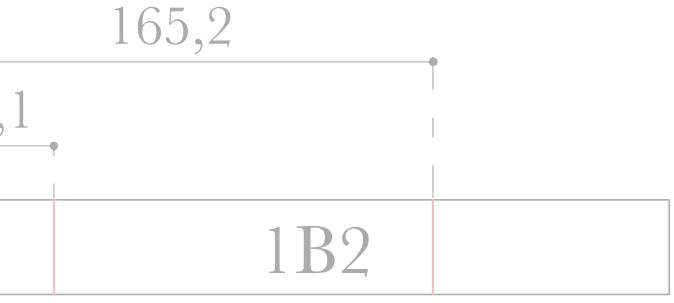




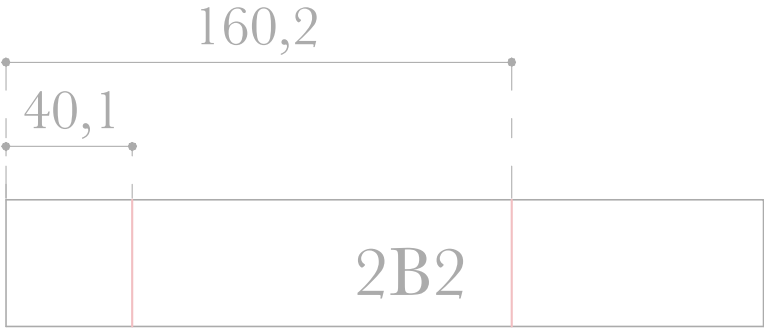
x1



x1



x1



x1



x1



x1

Vorbereitung opbouw kader rechts

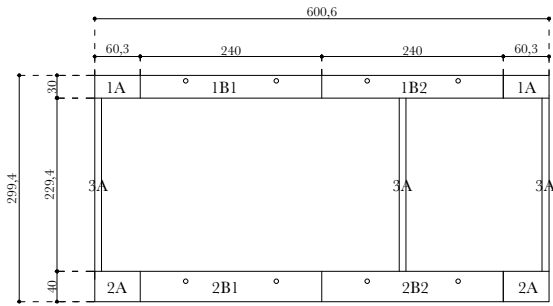


x1

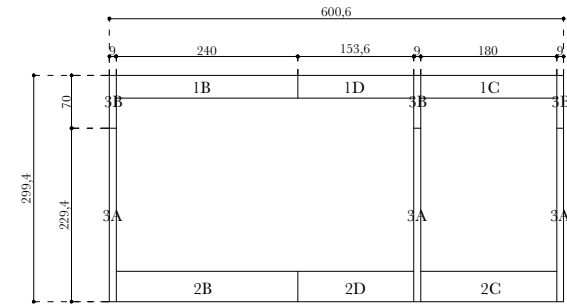


x1

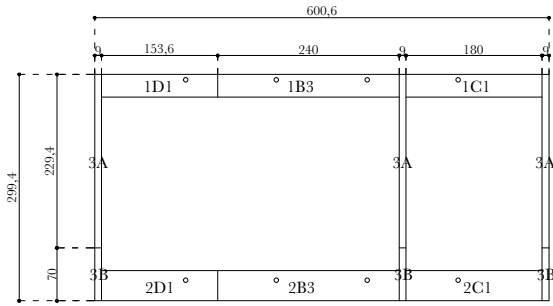
Laag 1



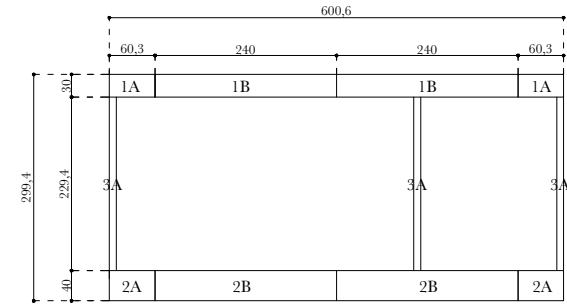
Laag 4



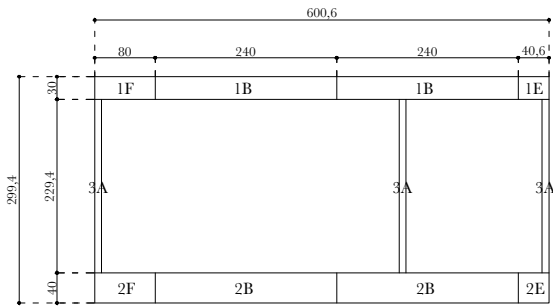
Laag 2



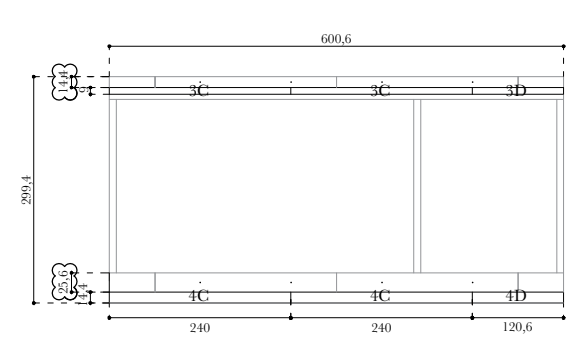
Laag 5



Laag 3



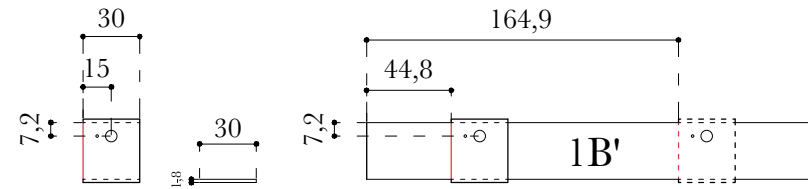
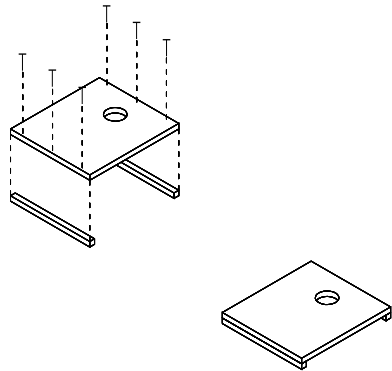
Laag 6



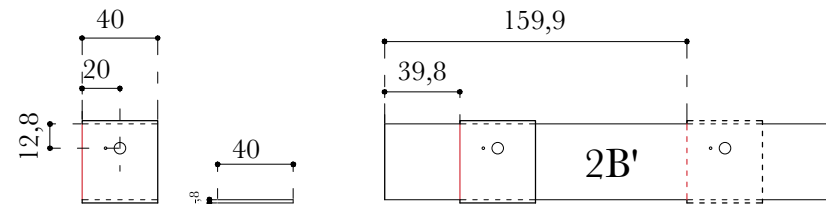
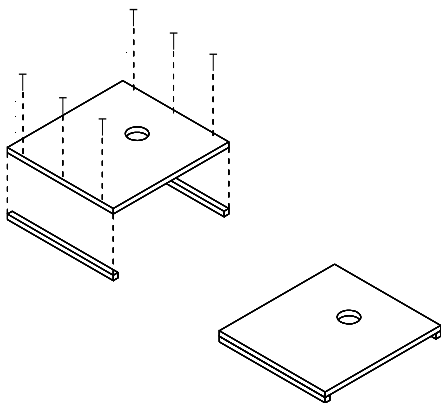
Aanduiding hulplijnen (rood)

Duid de rode lijnen aan op de planken en geef de juiste codering.

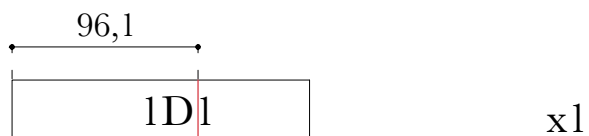
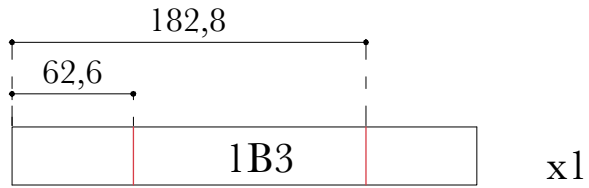
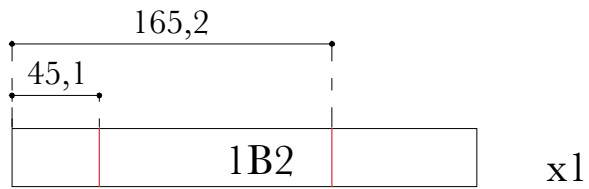
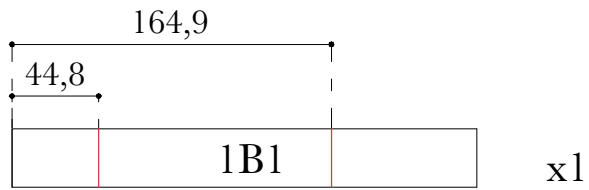
Hulpconstructie bovenbalk - Gat boren



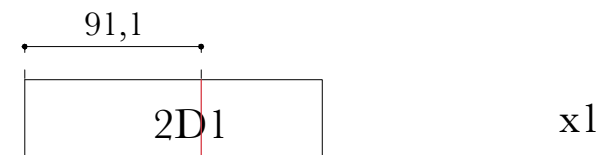
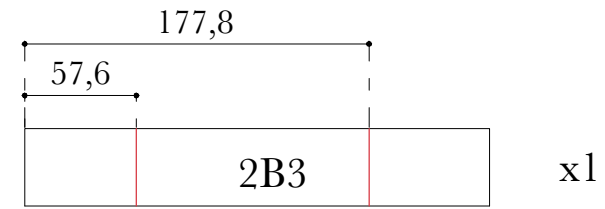
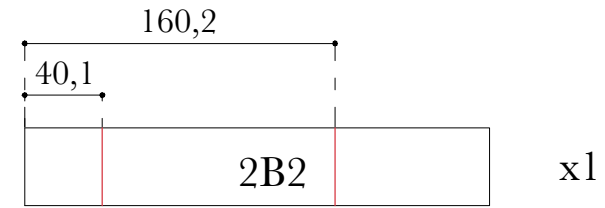
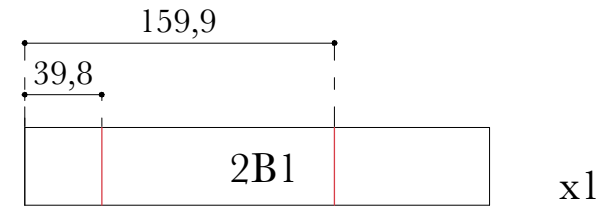
Hulpconstructie onderbalk - Gat boren



Bovenbalk - 30 cm

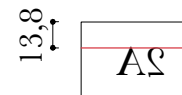
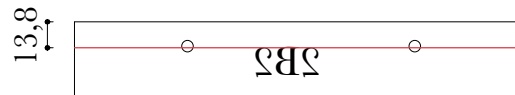
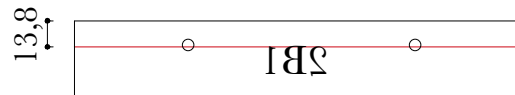


Onderbalk - 40 cm



Sleuf 15 mm diep zagen

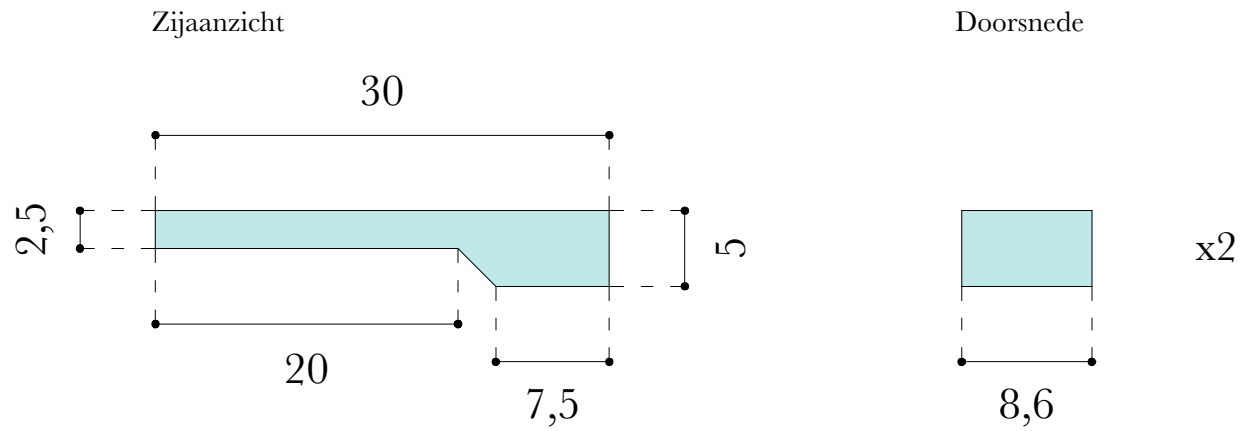
De plankjes 2B1, 2B2 en twee plankjes A2 moeten langs de onderkant een groef hebben (15 mm diep in de multiplex). Draai hiervoor de plankjes om zoals weergegeven op de figuur zodat de groef op de juiste plaats wordt aangebracht.



Nieuwe codering: 2A1

Steunvoeten

Verzaag uit polypropyleen de vorm zoals aangeduid op de tekening.
(Twee steunvoeten per kader.)





Opbouw kader rechts

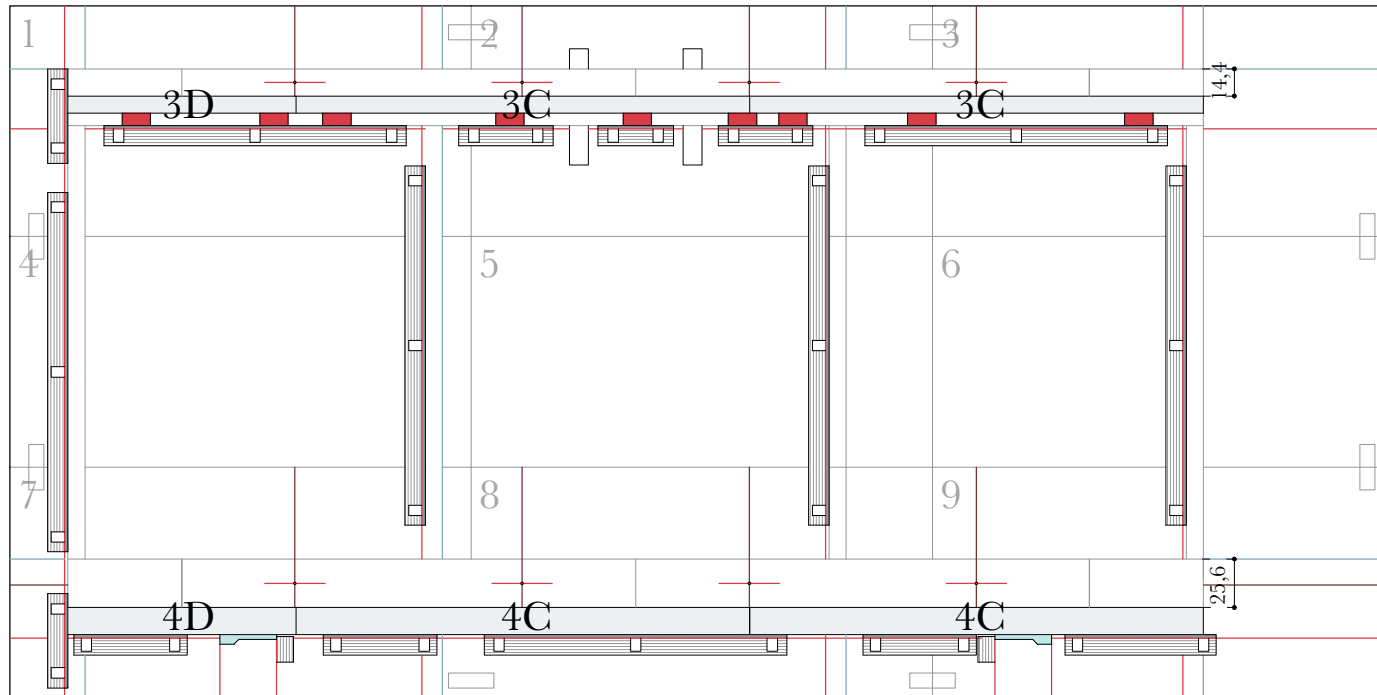
Bij het plaatsen van de planken moet rekening gehouden worden met de kromtes van de planken.
Combineer tegengestelde krommingen.

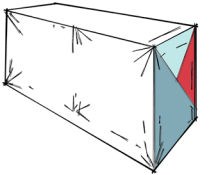
Laag 6

Voor de laatste laag moet een afstandhouder gemaakt worden om de planken 3D, 3C en 3C juist te positioneren, zie rode blokjes. Tenslotte moeten de steunvoeten geplaatst worden. De steunvoeten mogen niet in hetzelfde vlak als het kader liggen, dus moet er een afstandhouder (ongeveer 2 mm dik) onder de steunvoet geplaatst worden. De steunvoeten worden op drie plaatsen kops geschroefd in het kader.

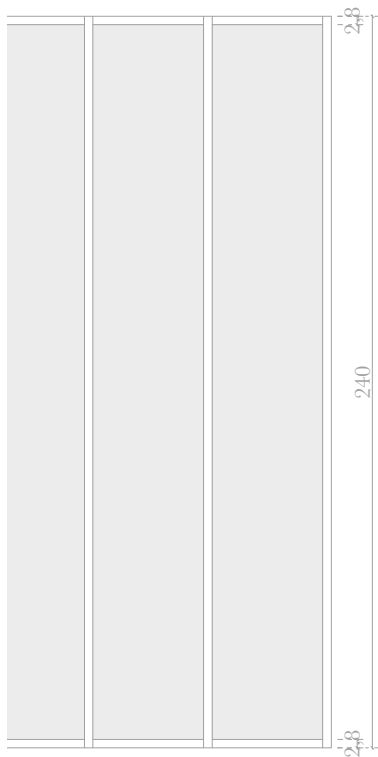
! Opmerking:

Let goed op de richting van de steunvoeten.

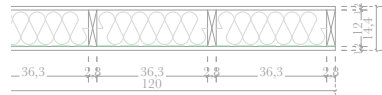
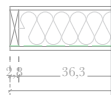




paneel 2



Dakpaneel



aal: 20

Aantal: 10

merkingen:
pscherm

Opmerkingen:
Dampscherm

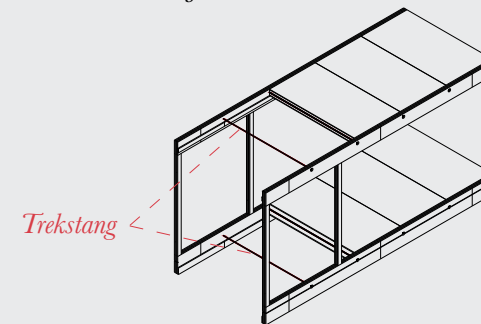
6

HOOFDSTUK

Technische uitwerking van paviljoen

WOORD VOORAF

Tussen de kaders liggen de vloer- en dakpanelen. Deze panelen worden nagespannen door middel van trekstangen tussen de panelen, die in het kader verzonken zijn.



INHOUDSTAFEL

6.1 Plannen

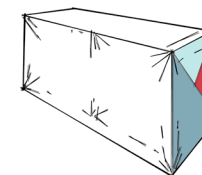
- 6.1.1 Varianten op de plattegrond
- 6.1.2 Ontwerpkeuzes, grondplannen en doorsnedes

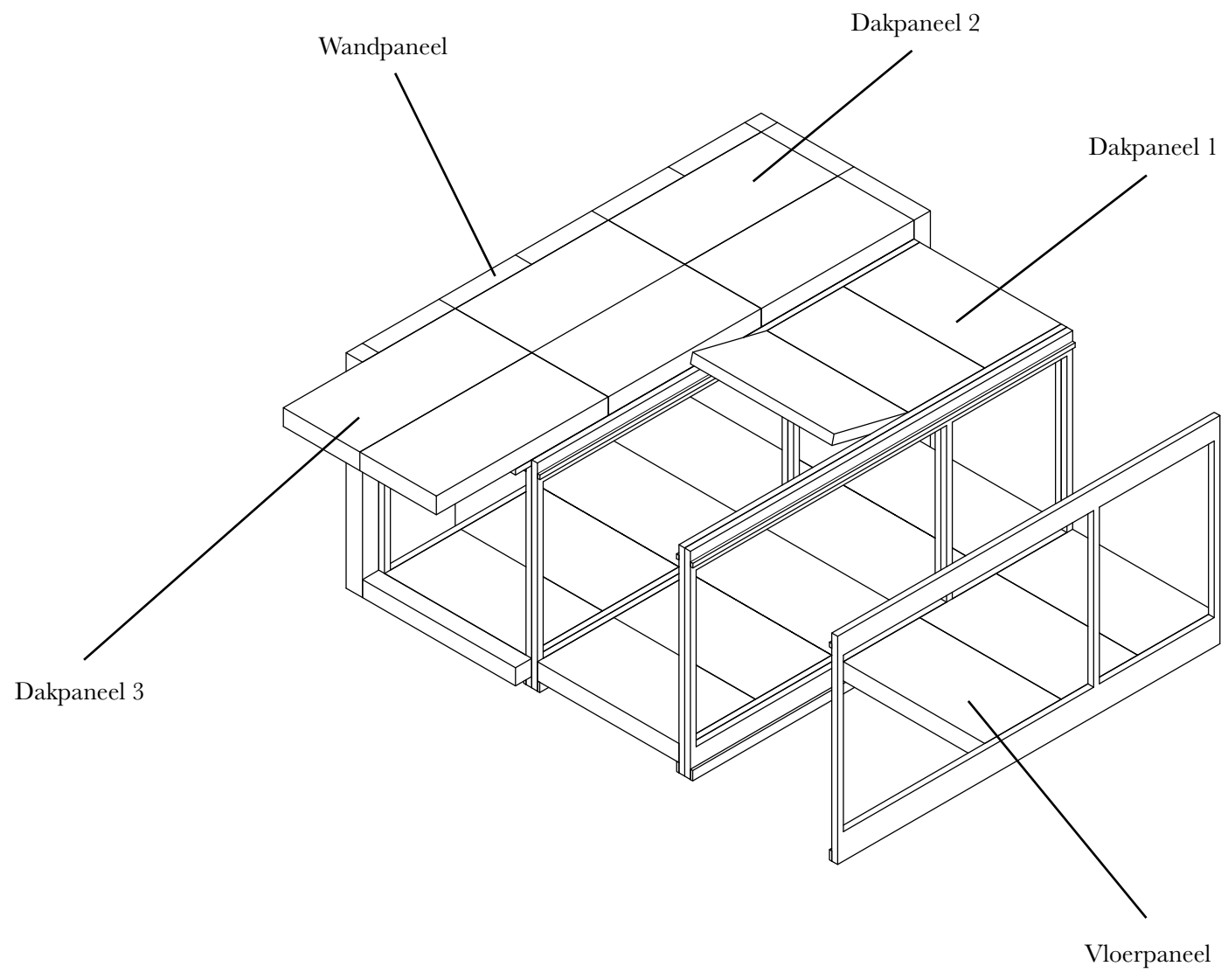
6.2 Uitvoeringstekeningen

- 6.2.1. Kader
- 6.2.2. Stuklijst panelen
- 6.2.3. Stuklijst fundering, balkon en helling
- 6.2.4. Steunhaken
- 6.2.5. Buitenschrijnwerk

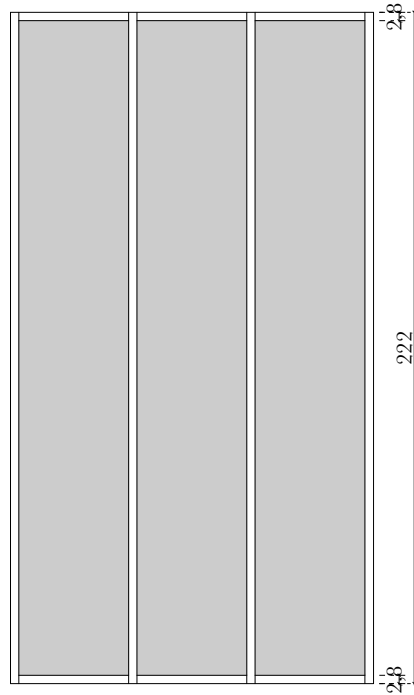
6.3 Interieur

- 6.3.1 Schuifwanden
- 6.3.2 Lamp

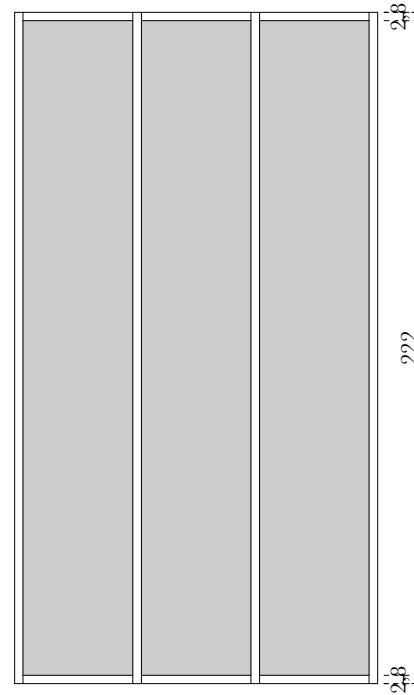




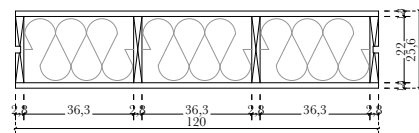
Vloerpaneel



Dakpaneel 1



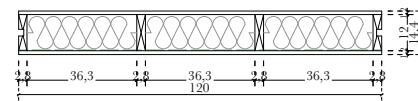
Zichtzijde (binnenzijde)



Aantal: 25

Opmerkingen:
Centrale randvoeg

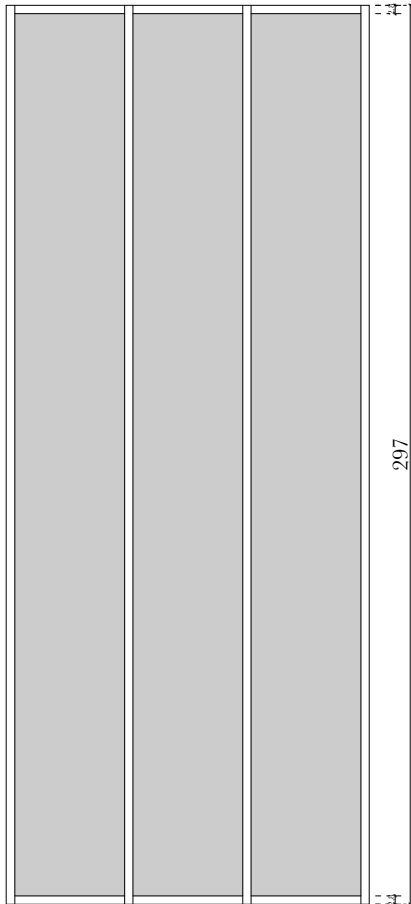
Zichtzijde (binnenzijde)



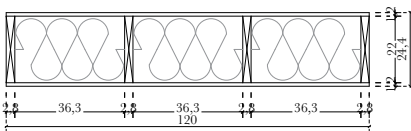
Aantal: 25

Opmerkingen:
Centrale randvoeg
Dampscherm

Wandpaneel

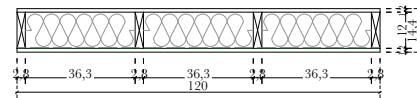
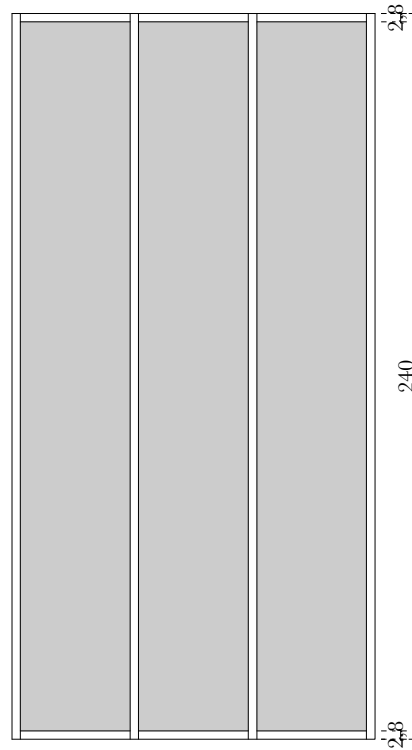


Zichtzijde (binnenzijde)



Aantal: 20

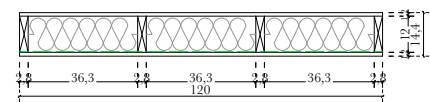
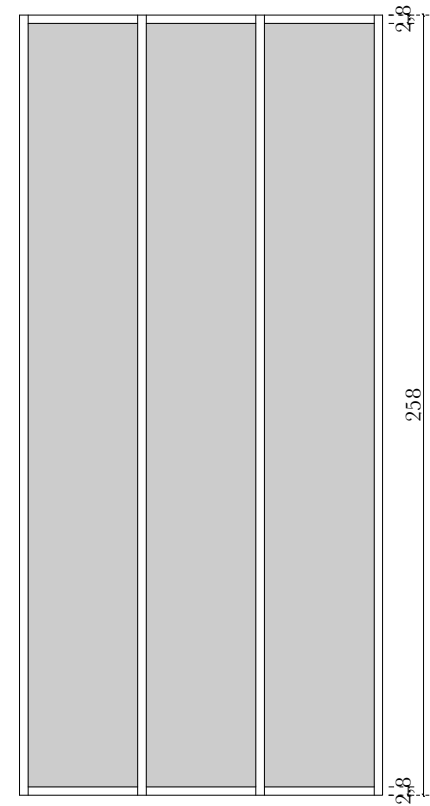
Dakpaneel 2



Aantal: 20

Opmerkingen:
Dampscherm

Dakpaneel 3



Aantal: 10

Opmerkingen:
Dampscherm

6

HOOFDSTUK

Technische uitwerking van paviljoen

INHOUDSTAFEL

6.1 Plannen

- 6.1.1 Varianten op de plattegrond
- 6.1.2 Ontwerpkeuzes, grondplannen en doorsnedes

6.2 Uitvoeringstekeningen

- 6.2.1. Kader
- 6.2.2. Stuklijst panelen
- 6.2.3. Stuklijst fundering, balkon en helling
- 6.2.4. Steunhaken
- 6.2.5. Buitenschrijnwerk

6.3 Interieur

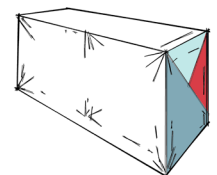
- 6.3.1 Schuifwanden
- 6.3.2 Lamp

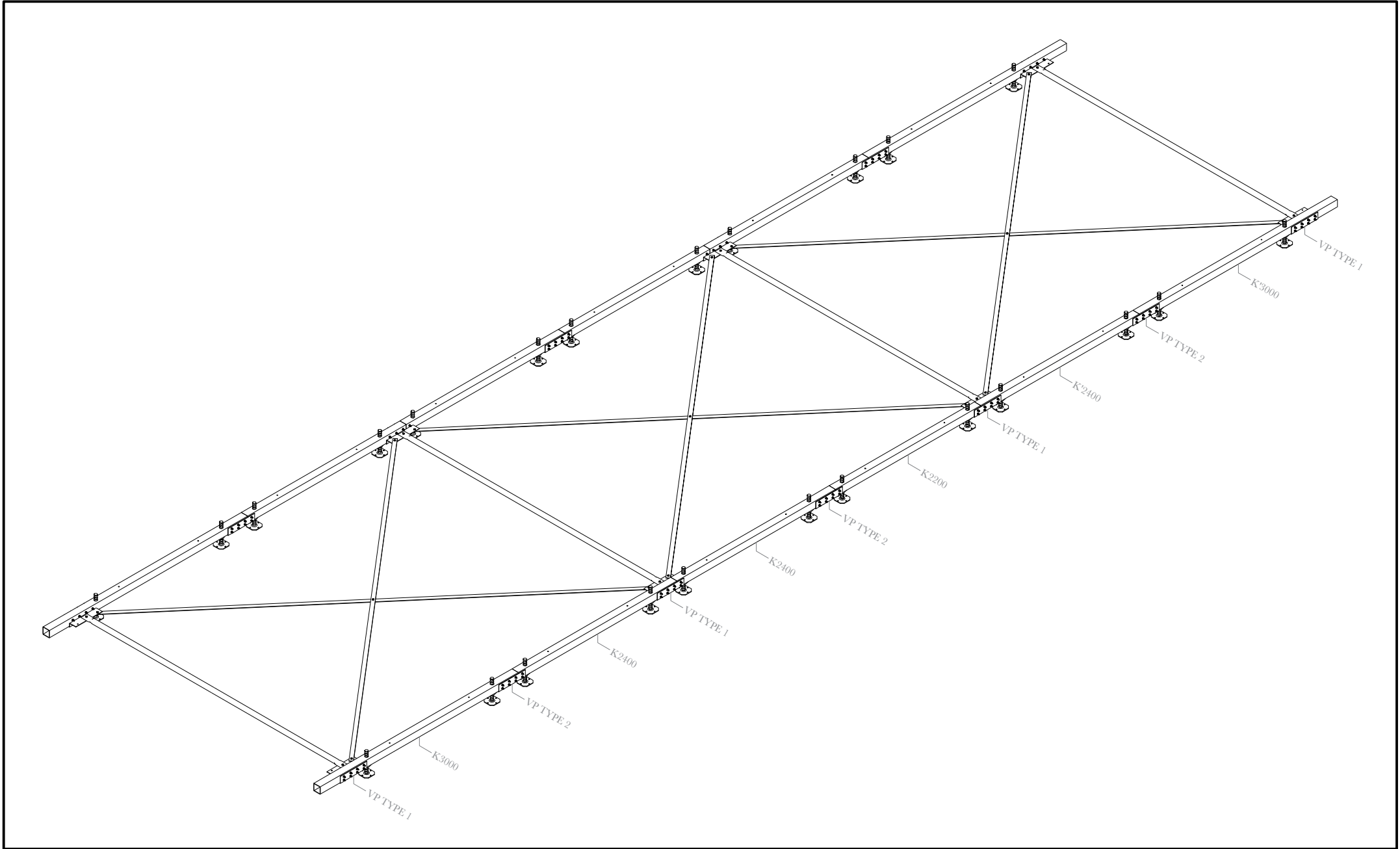
WOORD VOORAF

De fundering, het balkon en de helling zijn ontworpen op basis van volgende criteria:

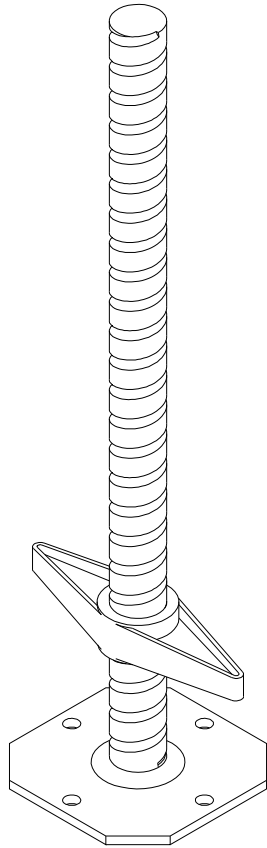
- Elk onderdeel van de fundering, het balkon en de helling kan door minimaal twee personen worden gedragen;
- De hoogte van de fundering moet afstelbaar zijn omdat er geen zekerheid is over hoe vlak het terrein zal zijn waarop het paviljoen komt te staan. Hetzelfde geldt voor het *after life* van het paviljoen. Daarom is gekozen voor het gebruik van stellingvoeten.

De fundering bestaat uit twee sporen waarover de *Mobbles* kunnen schuiven. Per *Mobble* staan de twee steunvoeten van het linkerkader en de twee steunvoeten van het rechterkader ten op zichte van elkaar 180° gedraaid. De *Mobbles* worden op deze wijze automatisch gecentreerd (op de juiste plaats).



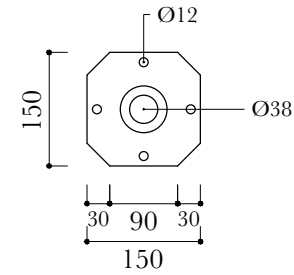


Stuklijst fundering



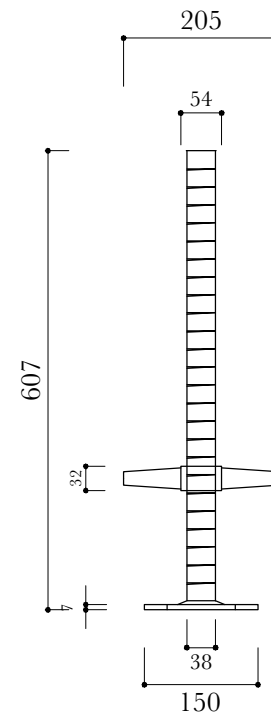
3D

1/5



Bovenaanzicht

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Zijaanzicht

1/10

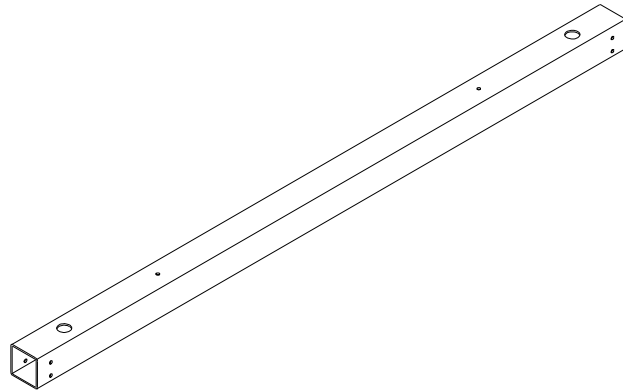
Steunvoeten

Gegevens

- Stuks: 24
- Materiaal: Staal
- Druksterkte: 36 kN

Stap

Deze steunvoeten worden op een hoogte van 300mm afgeslepen en nadien geplaatst. Via de voetspindel kan de hoogte van de kokers worden bijgesteld om een vlak geheel te vormen vooraleer de modules worden geplaatst.



3D

1/20

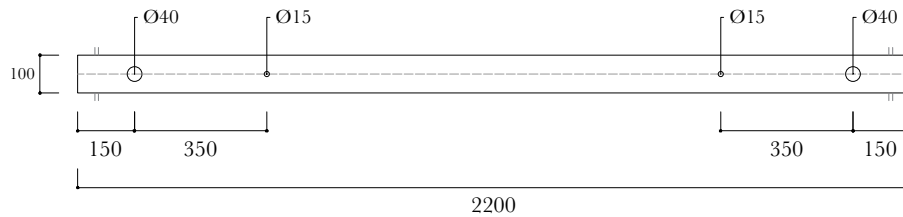
Kokerprofiel K2200

Gegevens

- Stuks: 2
- Materiaal: Staal
- Profiel: 100x100mm

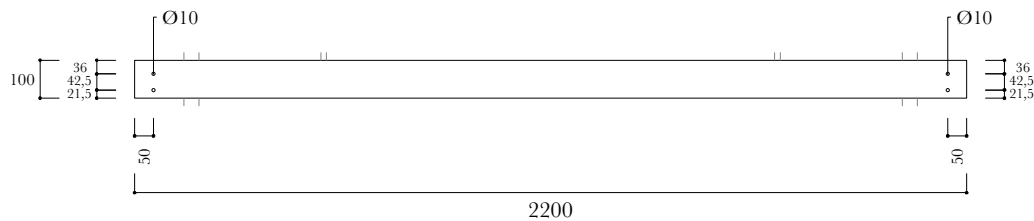
Stap

De kokerprofielen worden bovenop de stellingvoeten of funderingsvoeten geplaatst waarvoor gaten worden voorzien op voorhand. Deze stellingvoeten zijn verbonden via een inklemming (ze steken door het kokerprofiel).



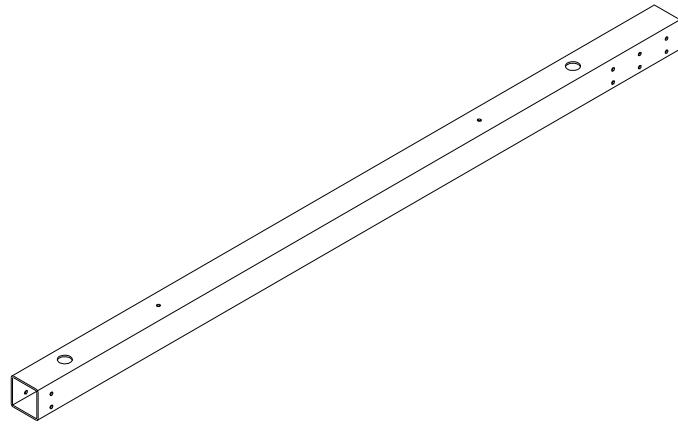
Bovenaanzicht

1/20



Zijaanzicht

1/20



3D

1/20

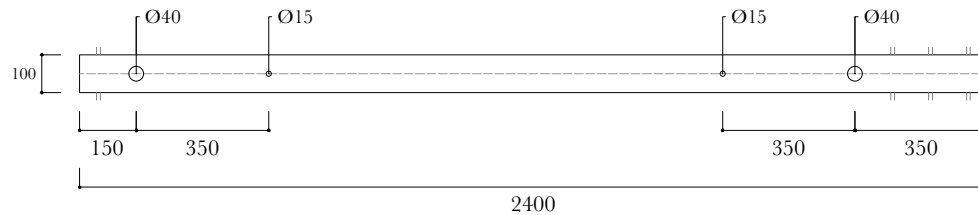
Kokerprofiel K2400 + K'2400

Gegevens

- Stuks: 6
- Materiaal: Staal
- Profiel: 100x100mm

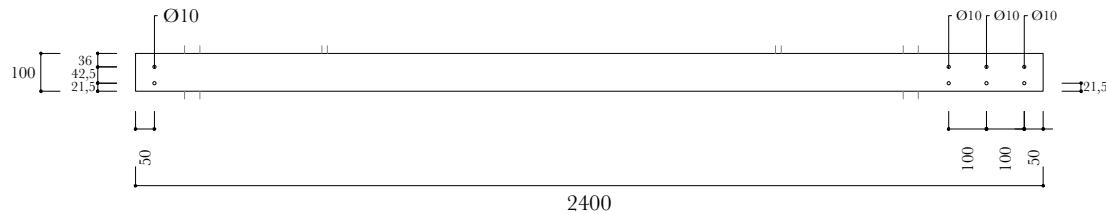
Stap

De kokerprofielen worden bovenop de stellingvoeten of funderingsvoeten geplaatst waarvoor gaten worden voorzien op voorhand. Deze stellingvoeten zijn verbonden via een inklemming (ze steken door het kokerprofiel).



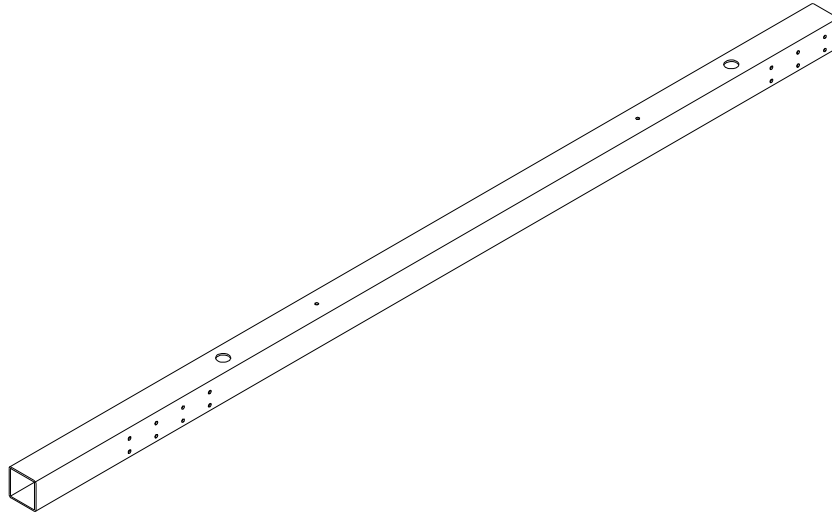
Bovenaanzicht

1/20



Zijaanzicht

1/20



3D

1/20

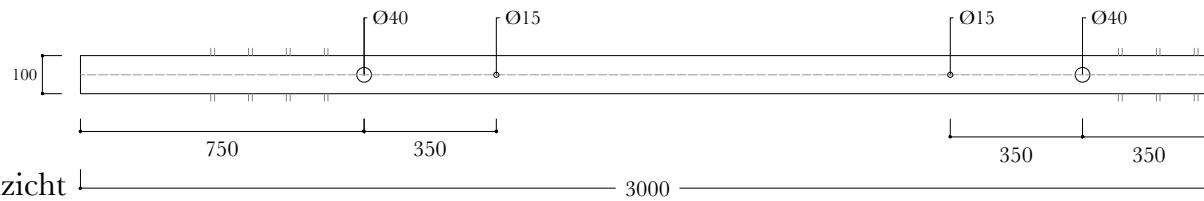
Kokerprofiel K3000 + K'3000

Gegevens

- Stuks: 4
- Materiaal: Staal
- Profiel: 100x100mm

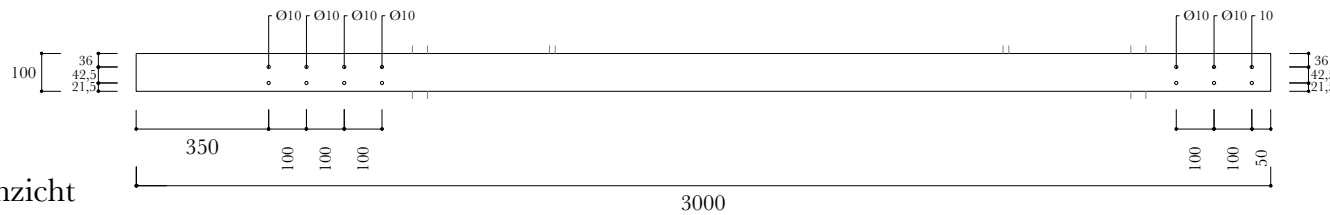
Stap

De kokerprofielen worden bovenop de stellingvoeten of funderingsvoeten geplaatst waarvoor gaten worden voorzien op voorhand. Deze stellingvoeten zijn verbonden via een inklemming (ze steken door het kokerprofiel).



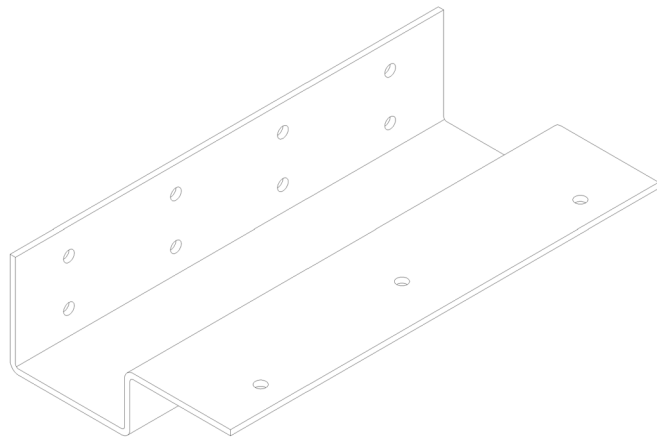
Bovenaanzicht

1/20



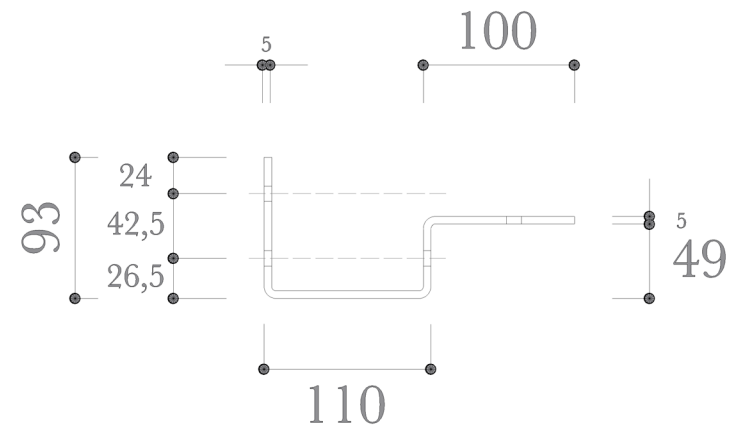
Zijaanzicht

1/20



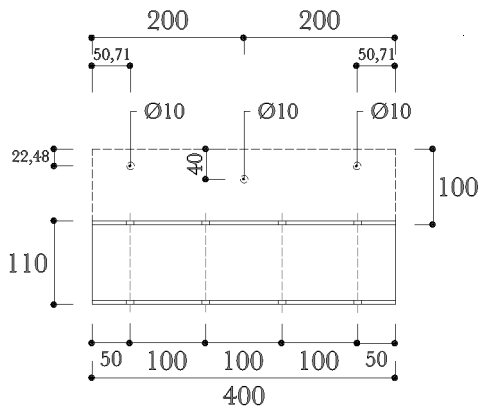
3D

1/5



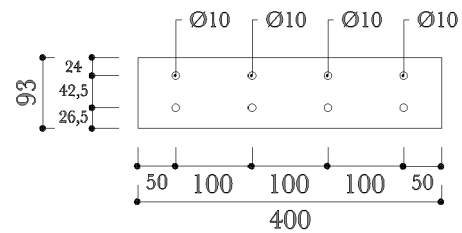
Zijaanzicht

1/5



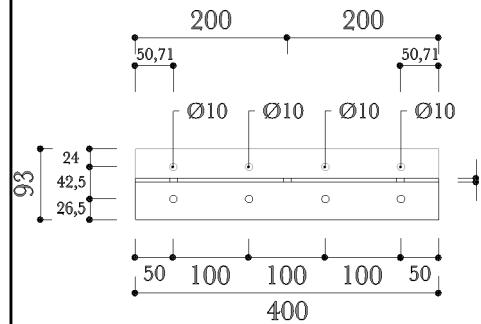
Bovenaanzicht

1/10



Vooraanzicht

1/10



Achteraanzicht

1/10

Verbindingsplaat - Type 1

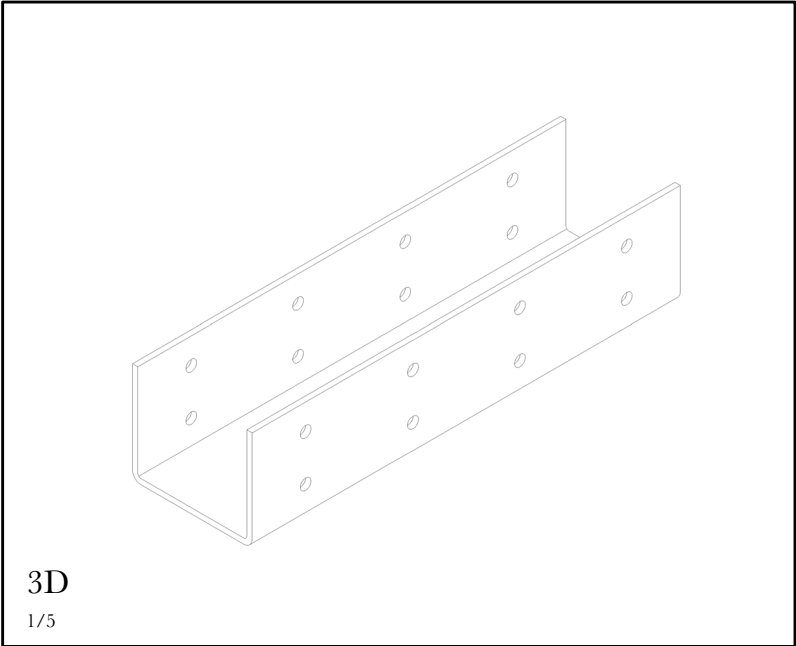
Gegevens

- Stuks: 8
- Materiaal: Staal
- Dikte: 5 mm

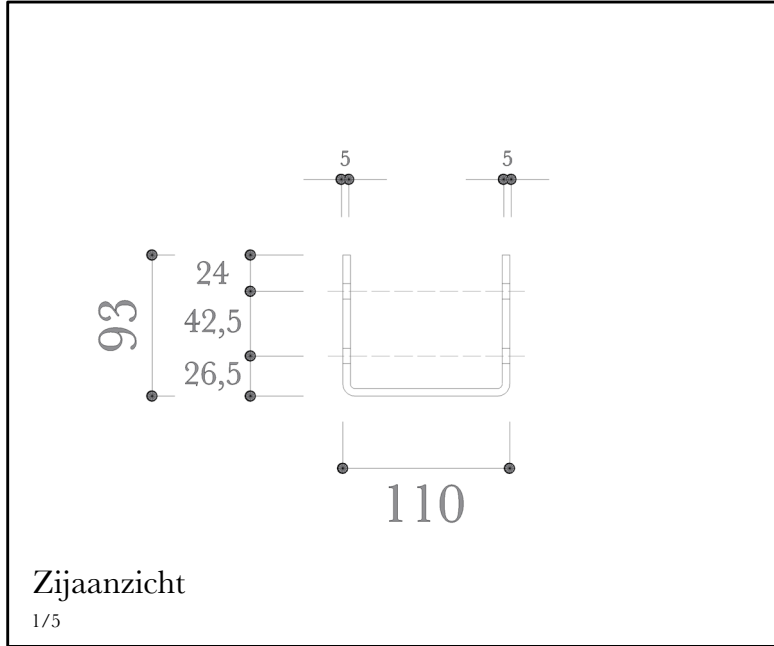
Stap

Deze verbindingsplaat dient geplaatst te worden om 2 redenen:

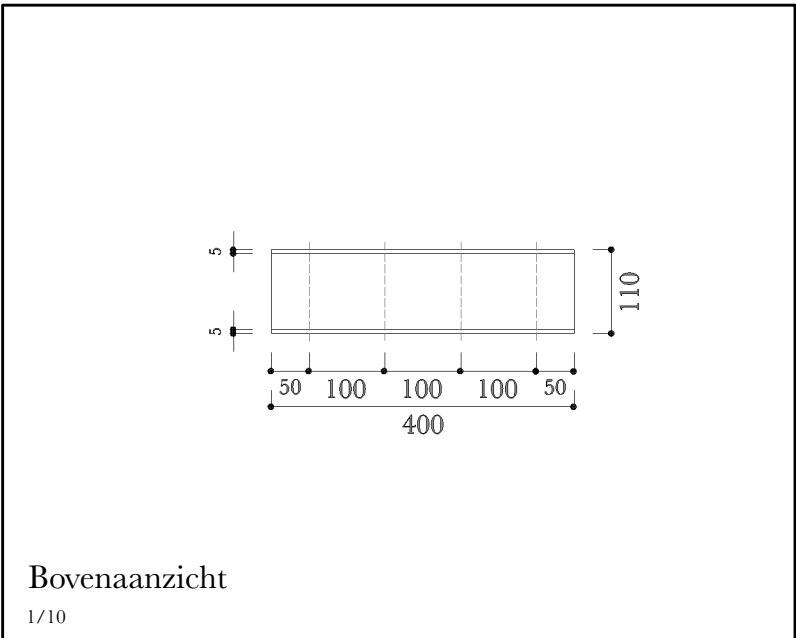
- versteviging van de verbinding tussen de kokers;
- verbindingsplaat tussen de 2 parallelle kokerrails.



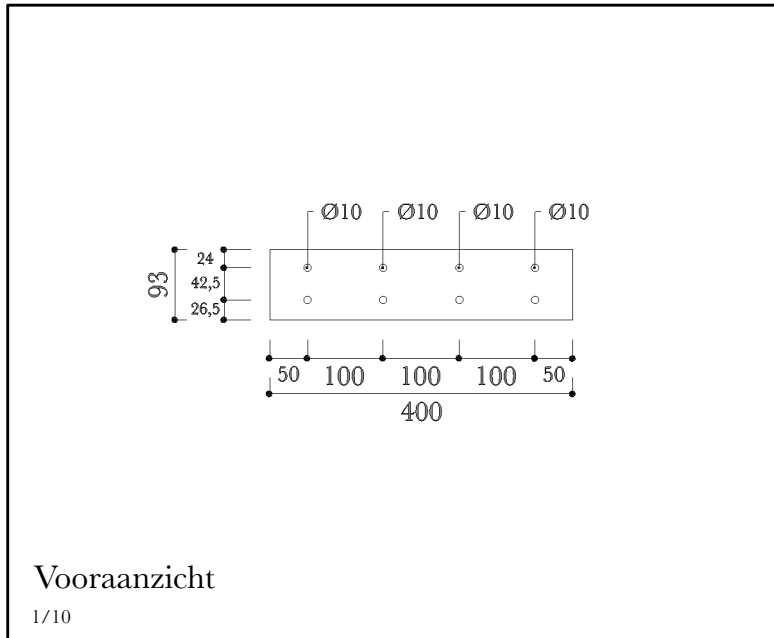
3D
1/5



Zijaanzicht
1/5



Bovenaanzicht
1/10



Vooraanzicht
1/10

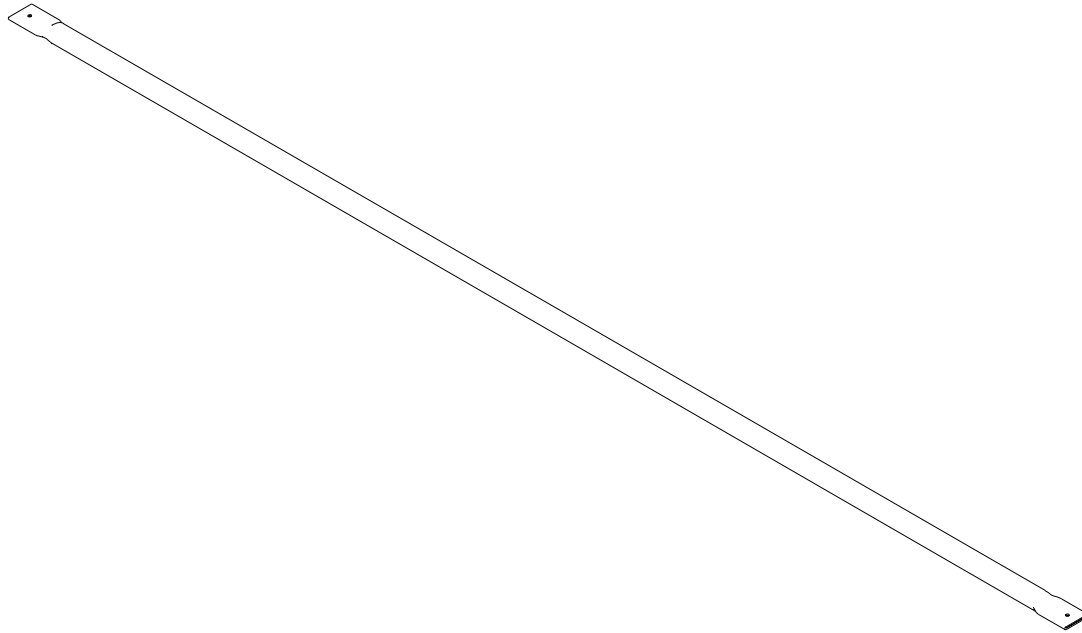
Verbindingsplaat - Type 2

Gegevens

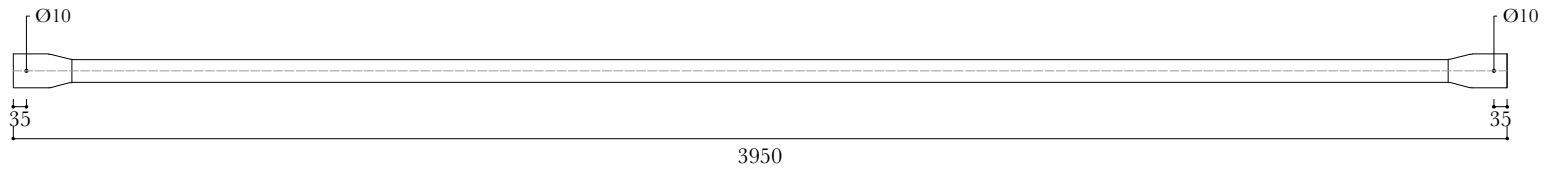
- Stuks: 6
- Materiaal: Staal
- Dikte: 5 mm

Stap

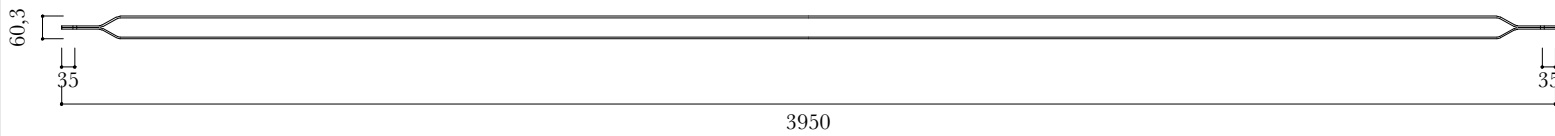
Deze verbindingsplaat dient geplaatst te worden om de verbinding tussen aansluitende kokerprofielen te verstevigen.



3D
1/20



Bovenaanzicht
1/20



Zijaanzicht
1/20

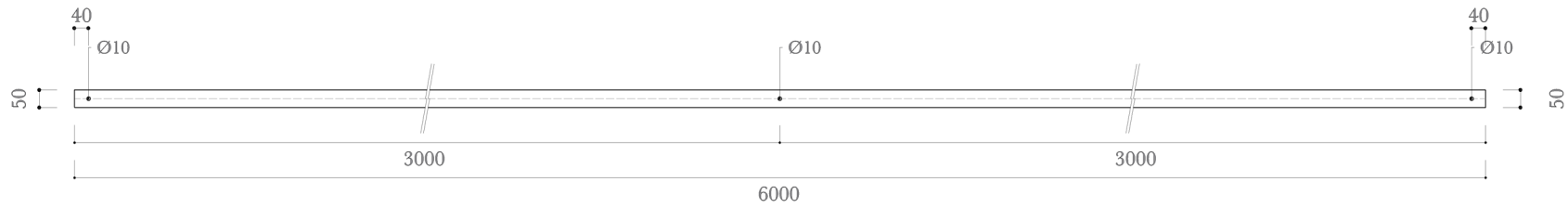
Verbindingskokers

Gegevens

- Stuks: 4
- Materiaal: Staal
- Sectie: $\text{Ø}60,3\text{mm}/4,5\text{mm}$

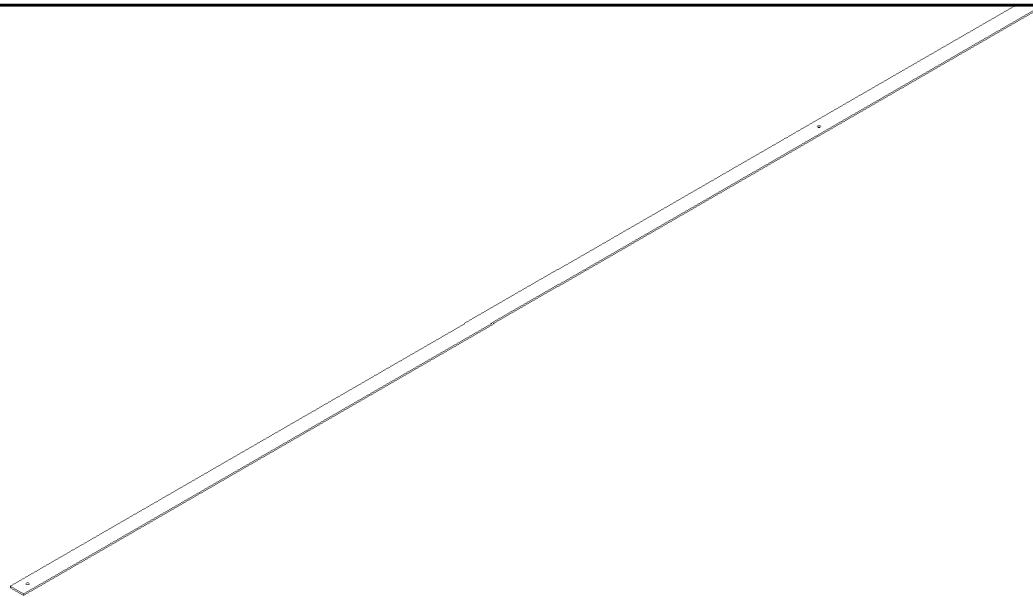
Functie

Deze ronde kokerprofielen hebben als functie het dwars verbinden van de parallelle kokerstroken om het geheel aan stijfheid te doen inwinnen.



Bovenaanzicht

1/20



3D

1/20

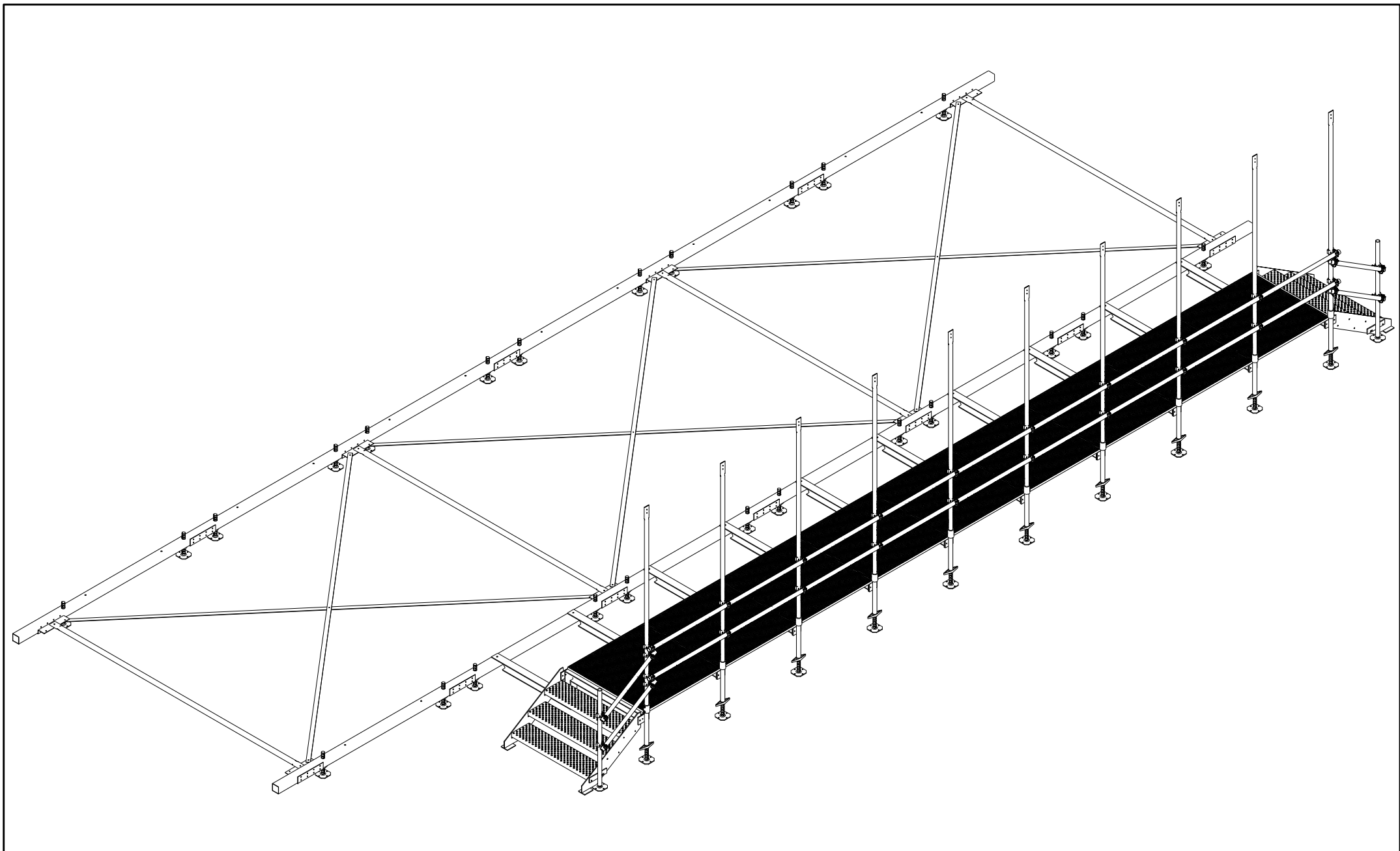
Plaatstaal

Gegevens

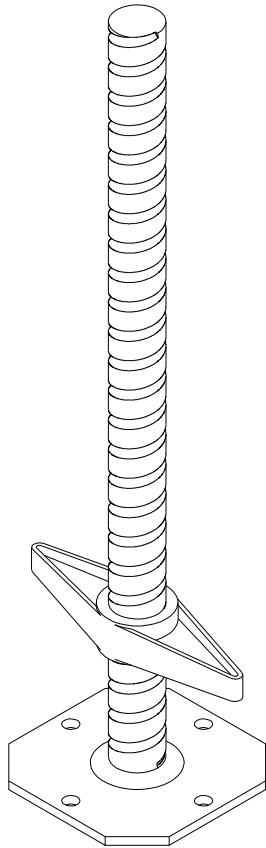
- Stuks: 6
- Materiaal: Staal
- Sectie: 50mm/8mm

Functie

Deze smalle, rechthoekige staalplaten hebben als functie het diagonaal verbinden van de parallelle kokerstroken om het geheel aan stijfheid te doen inwinnen.

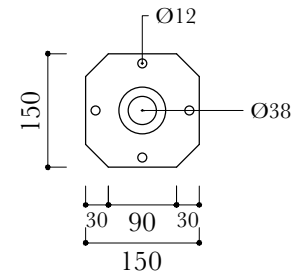


Stuklijst balkon



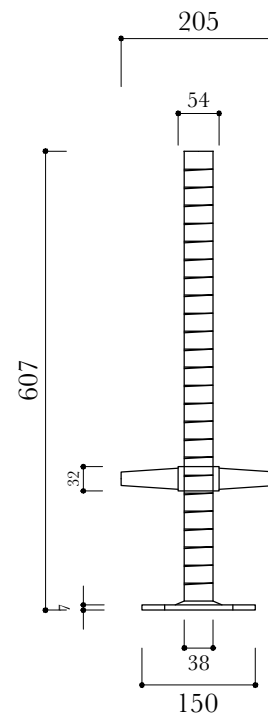
3D

3D-BEELD
1:5



Bovenaanzicht

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Zijaanzicht

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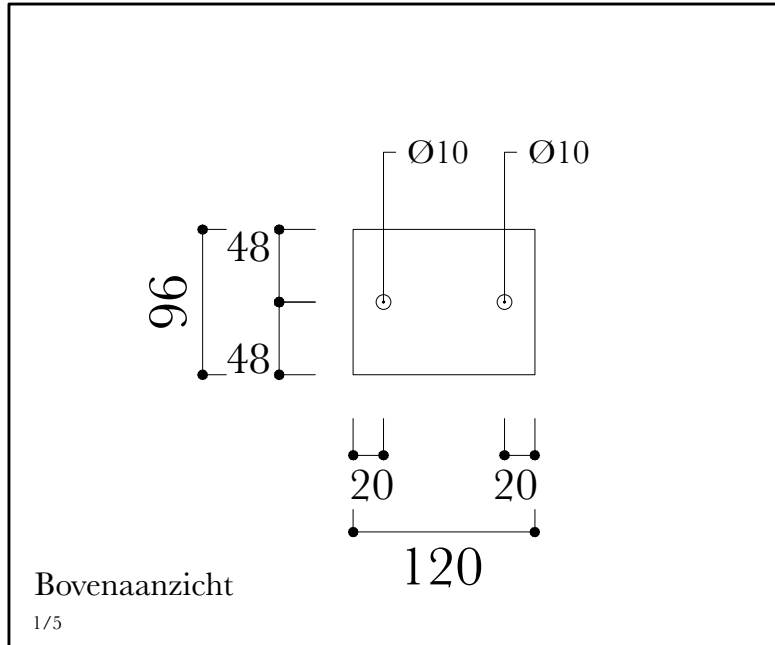
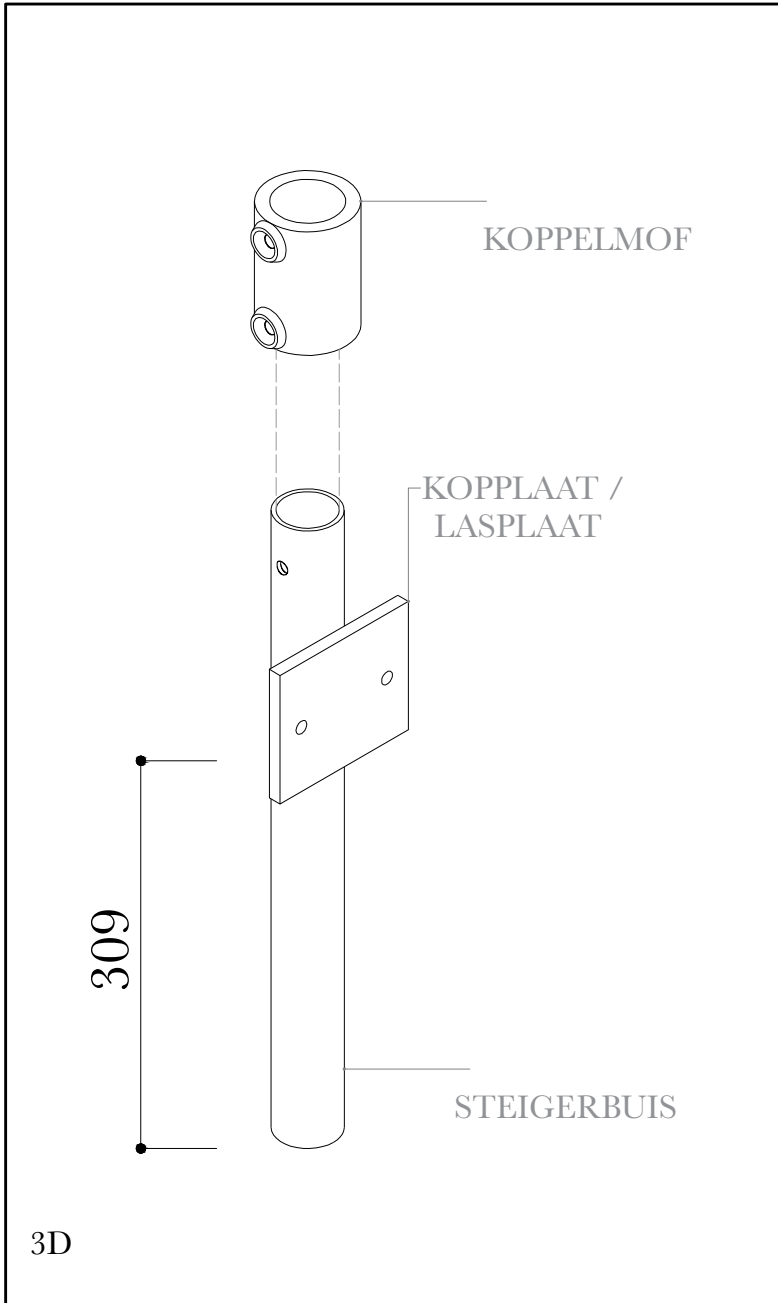
Steunvoeten

Gegevens

- Stuks: 24
- Materiaal: Staal
- Druksterkte: 36 kN

Stap

Deze steunvoeten worden op een hoogte van 500mm afgeslepen en nadien geplaatst. Via de voetspindel kan de hoogte van de kokers worden bijgesteld om een vlak geheel te vormen vooraleer de modules worden geplaatst.



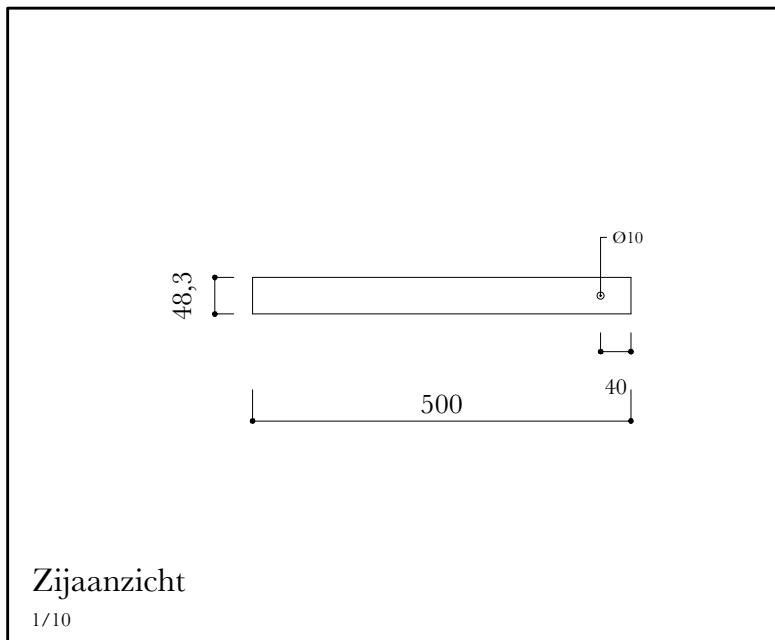
Kopplaat

Gegevens

- Stuks: 18
- Materiaal: Staal
- Dikte: 10mm

Stap

Deze kopplaat wordt gelast op een HEA100-profiel en steigerbuis, nadien worden ze tegen elkaar gebout.



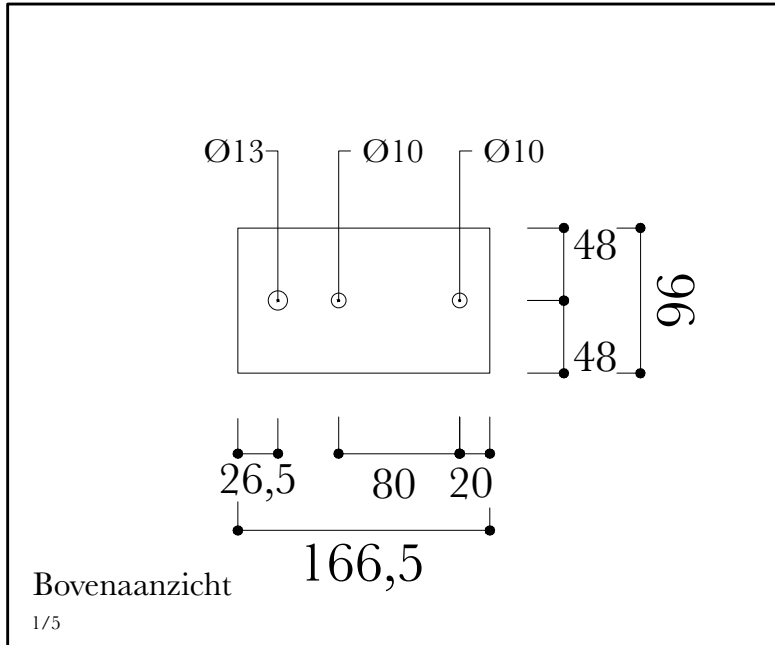
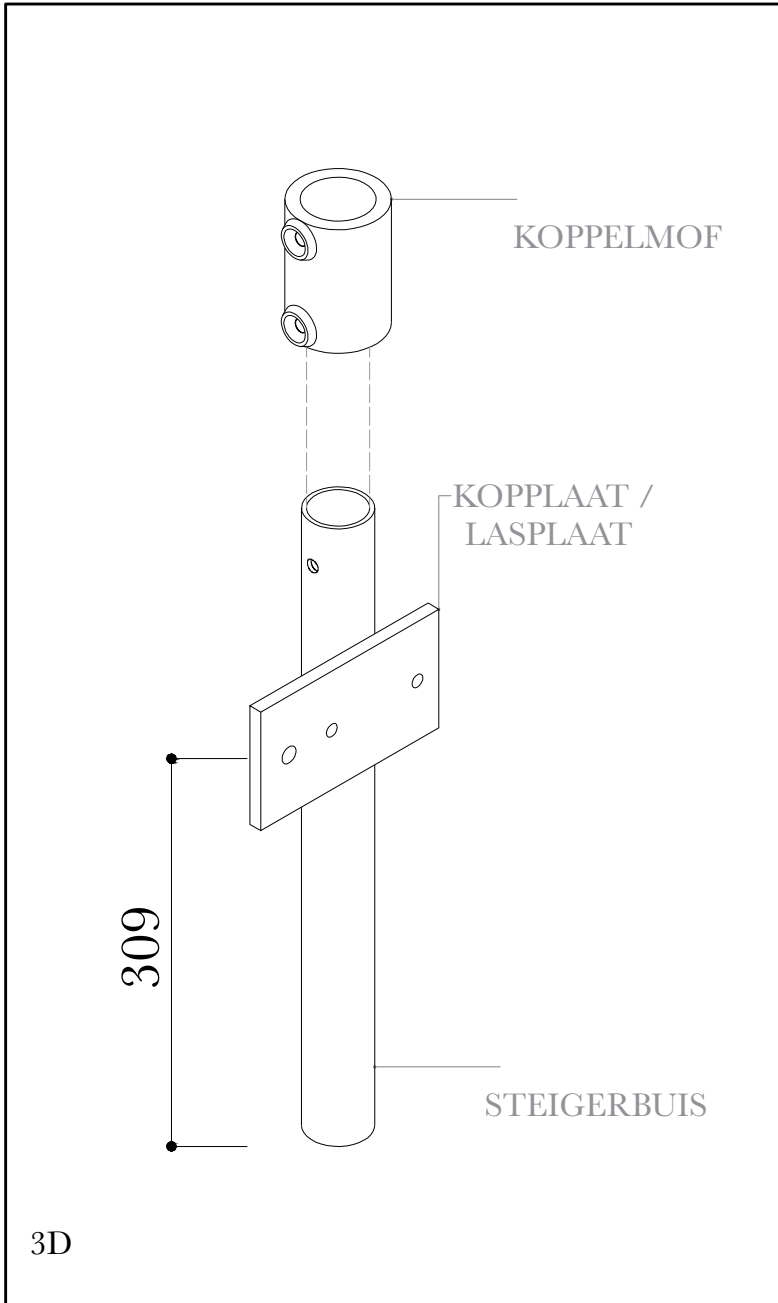
Steigerbuis

Gegevens

- Stuks: 18
- Materiaal: Staal
- Sectie: Ø48.3mm/3,25mm

Stap

Deze buis wordt over de steunvoet geschoven en er wordt een kopplaat opgelast.



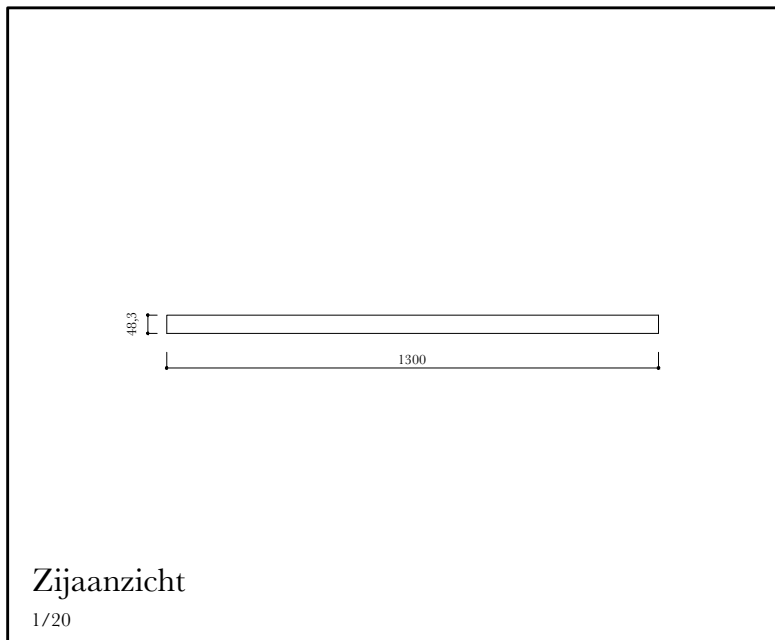
Kopplaat trap bovenaan

Gegevens

- Stuks: 2 (spiegelbeelden)
- Materiaal: Staal
- Dikte: 10mm

Stap

Deze kopplaat wordt op de steigerbuis gelast. Het spiegelbeeld van deze plaat wordt vervolgens op een andere steigerbuis gelast.



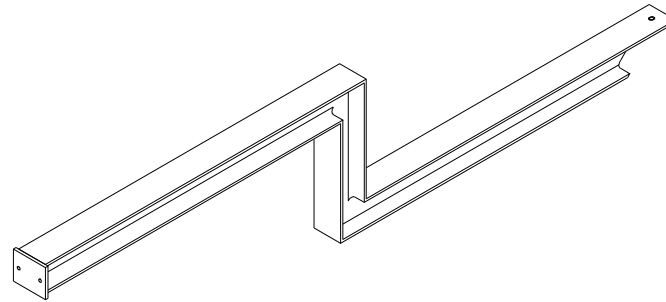
Steigerbuis

Gegevens

- Stuks: 2
- Materiaal: Staal
- Sectie: Ø48.3mm/3,25mm

Stap

Deze buis wordt over de steunvoet geschoven en er wordt een kopplaat opgelast op een hoogte van 309mm.



3D

Gelast HEA100- profiel

Gegevens

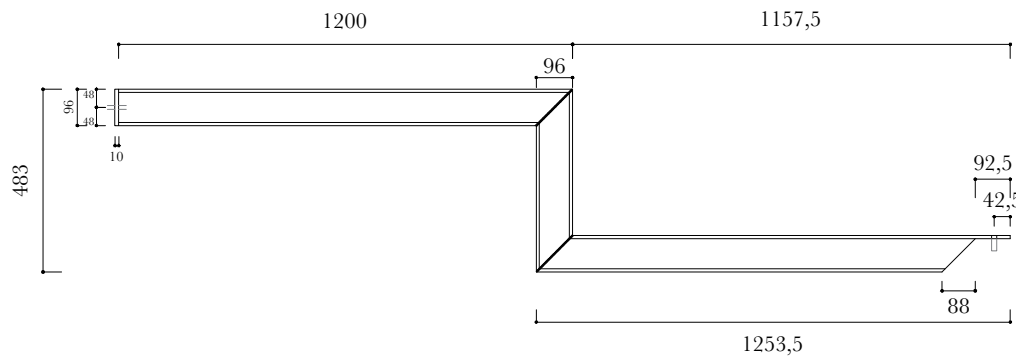
- Stuks: 8
- Materiaal: Staal
- Profiel: HEA 100

Stap

Deze gelaste profielen worden aan het funderingssysteem opgelegd met een stalen pen en aan het andere uiteinde via een kopplaat vastgebout op een stalen buis die over de steunvoet geschoven is.

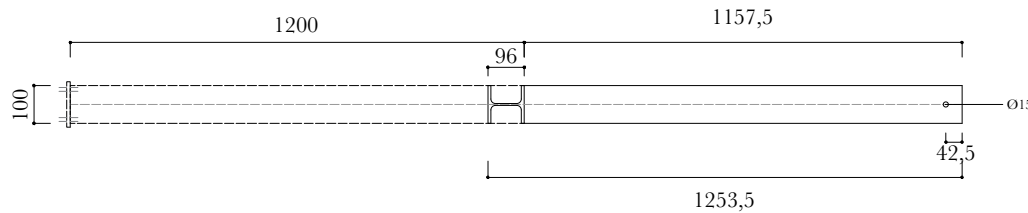
In de gelaste diameteropening (15mm) wordt een kort stalen buisje gelast (40mm lang) waarmee het geheel in de fundering kan 'gehaakt' worden.

Op het uiteinde wordt een kopplaat gelast die dezelfde is als deze die ook op de steigerbuis van het balkon wordt gelast.



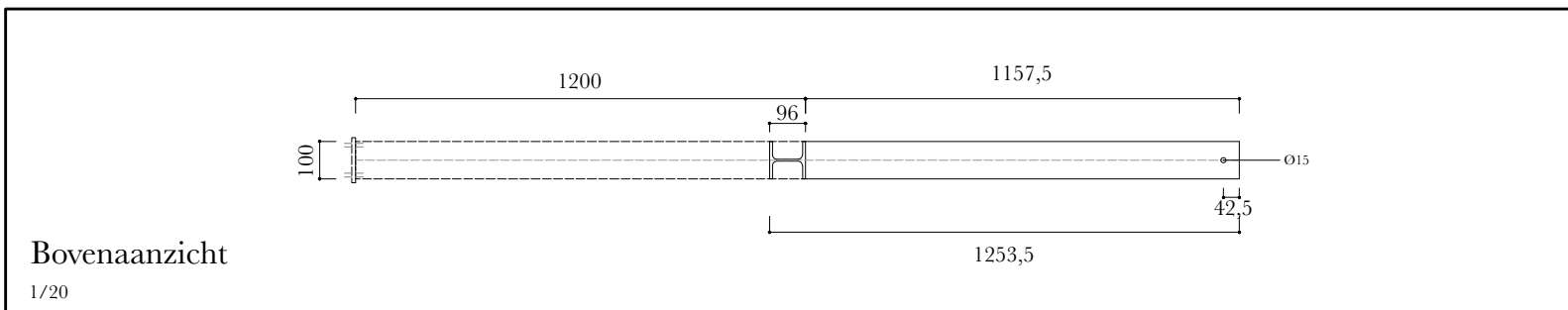
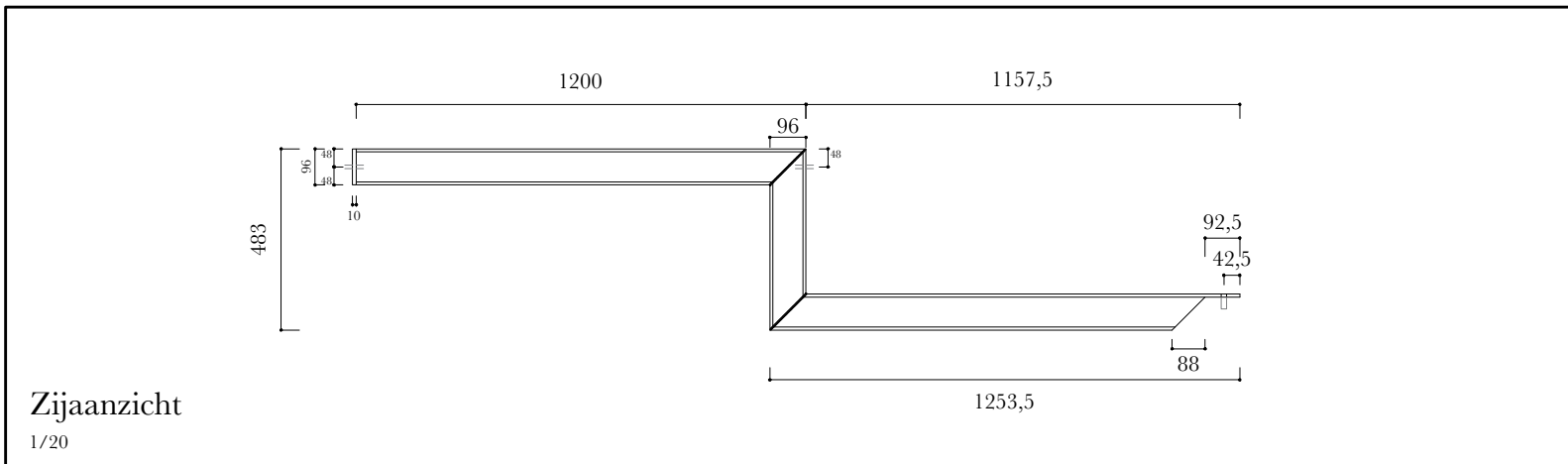
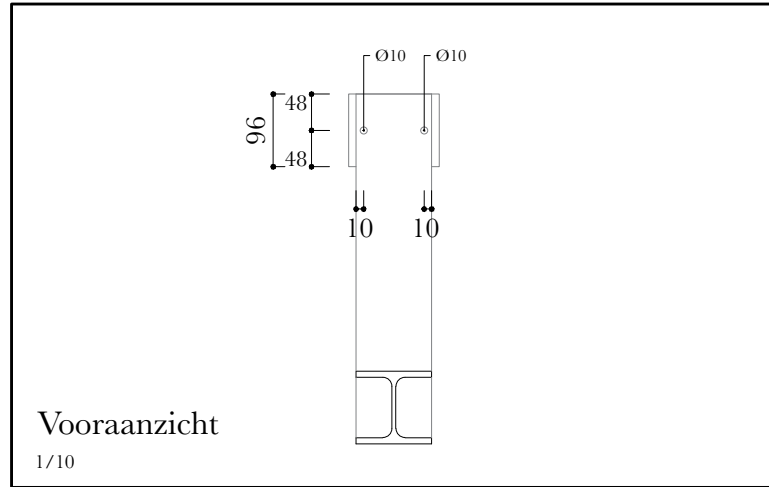
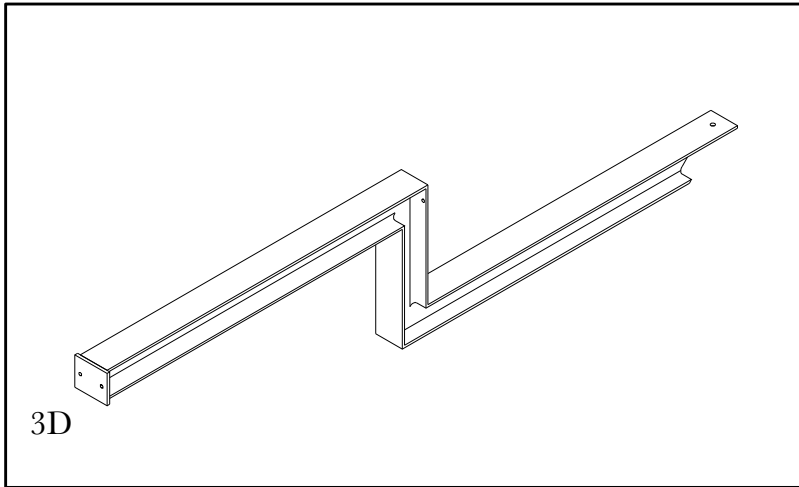
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Gelast HEA100- profiel

Uiteinden terras

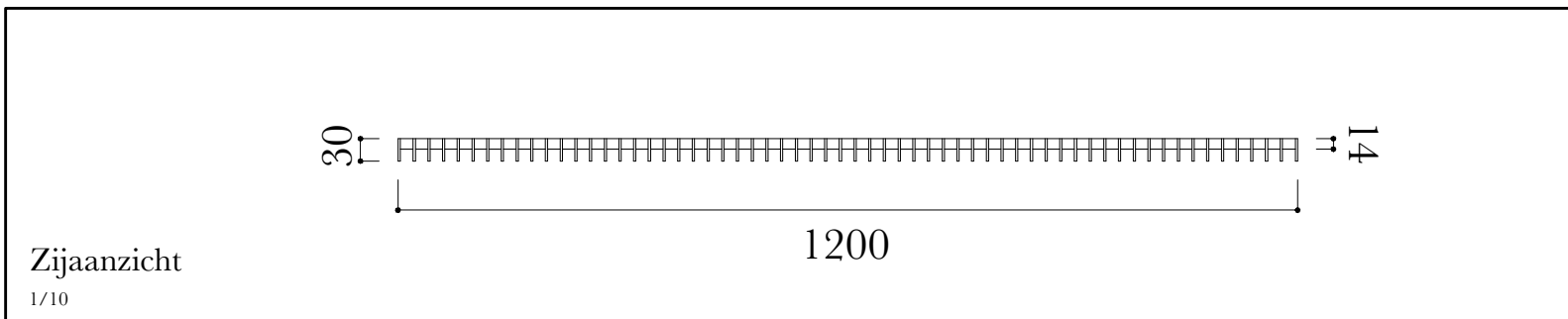
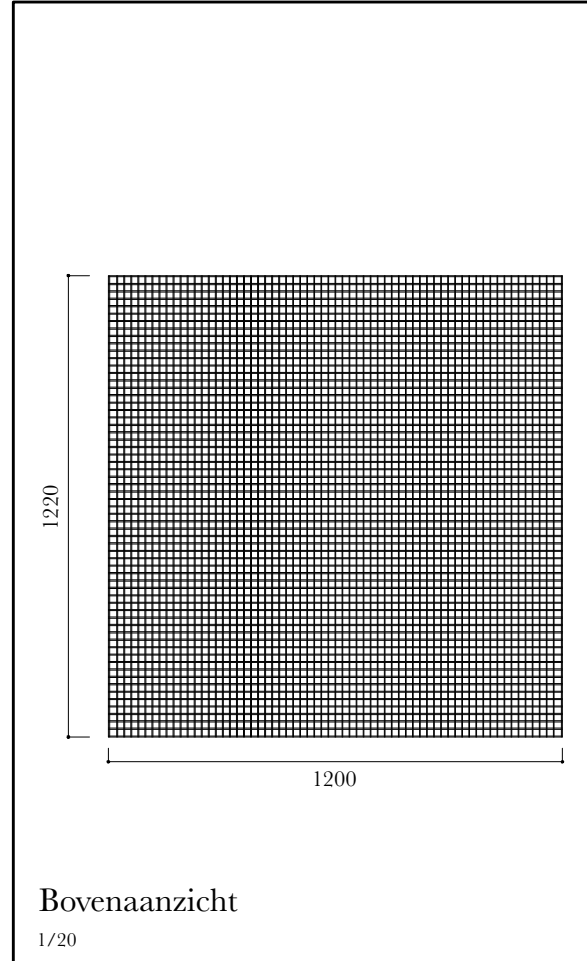
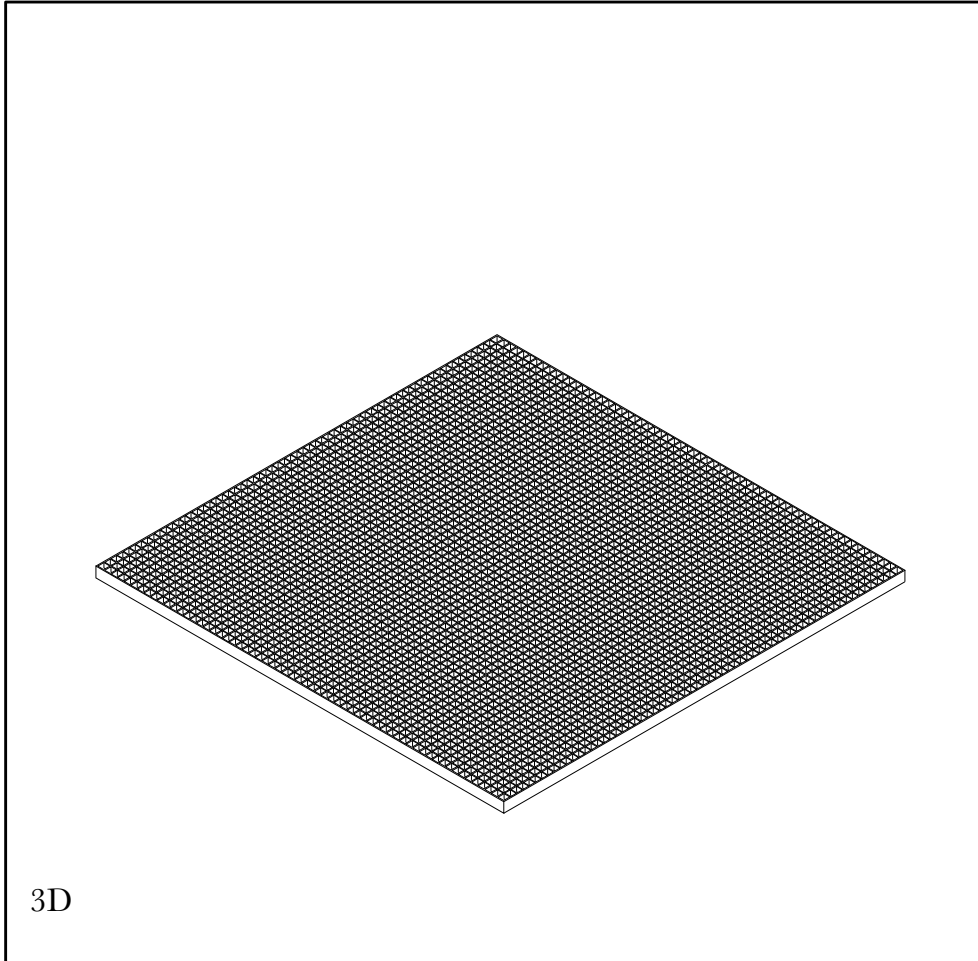
Gegevens

- Stuks: 2
- Materiaal: Staal
- Profiel: HEA 100

Stap

Dit gelaste profiel wordt als ondersteuning van de helling gebruikt. In de 15mm opening aan het opleggingsvlak wordt een stalen cilinder van 40mm lengte gelast en diameter 14mm. Op deze manier kan het profiel in de fundering 'gehaakt' worden.

Dit specifieke profiel wordt gebruikt aan de uiteinden van het balkon, om een verbinding te maken met de trapplaten.



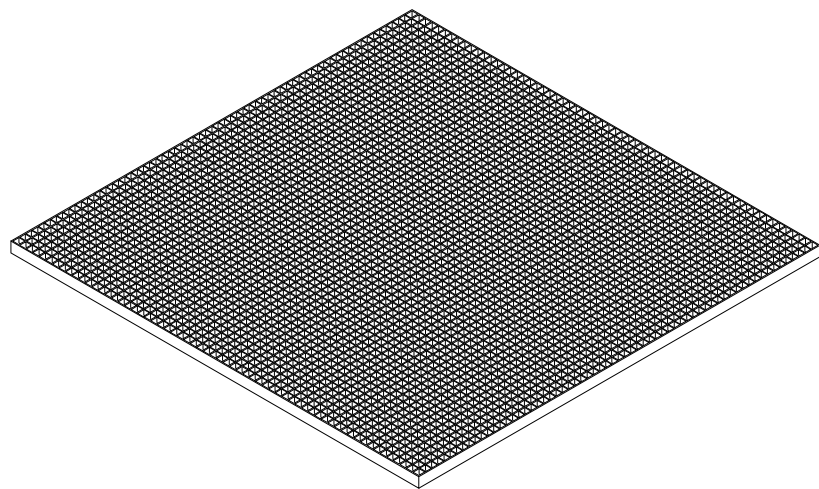
Zwaarlastrooster type RH

Gegevens

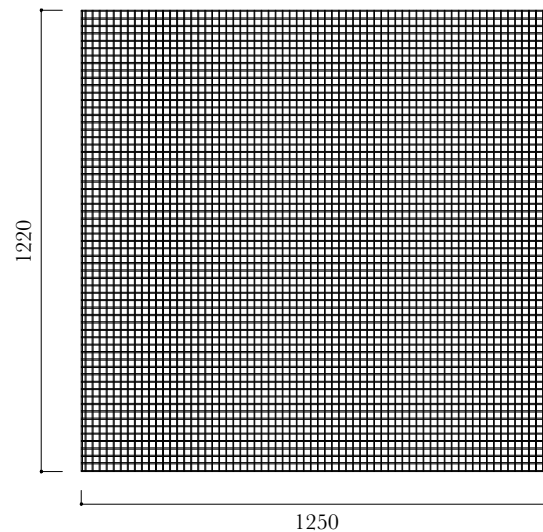
- Stuks: 7
- Materiaal: Staal (warm, verzinkt)
- Maaswijdte: 16,6 x 16,6mm
- Drukstaven:
 - hoogte 30mm
 - dikte 3mm
- Vulstaven:
 - hoogte 14mm
 - dikte 2mm
- Draagvermogen:
 - 300 kg/m²
- Max. doorbuiging: 6mm

Stap

Deze roosters dienen als vloerplaten van het terras.

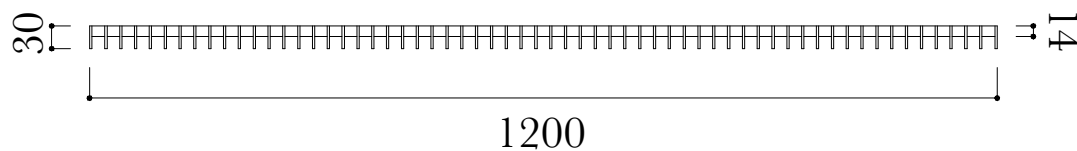


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Zwaarlastrooster type RH

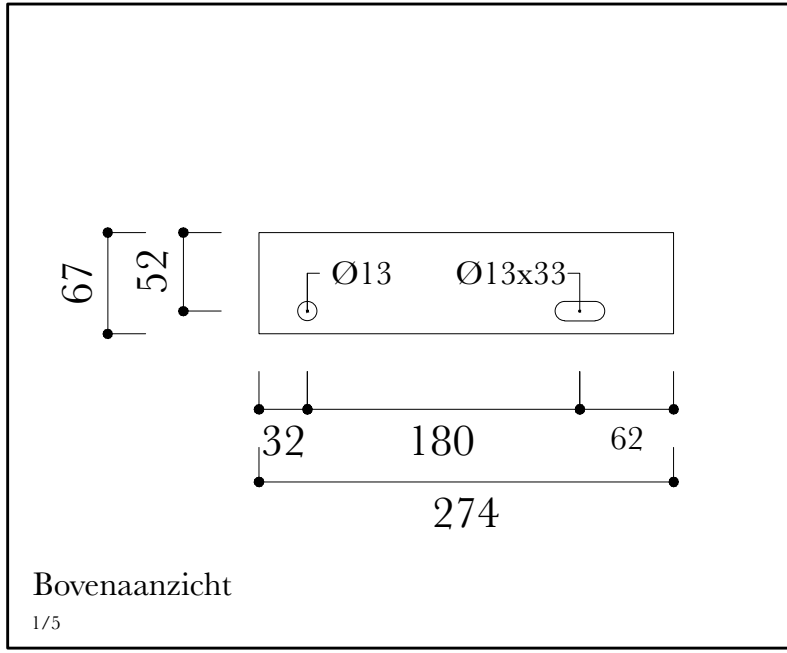
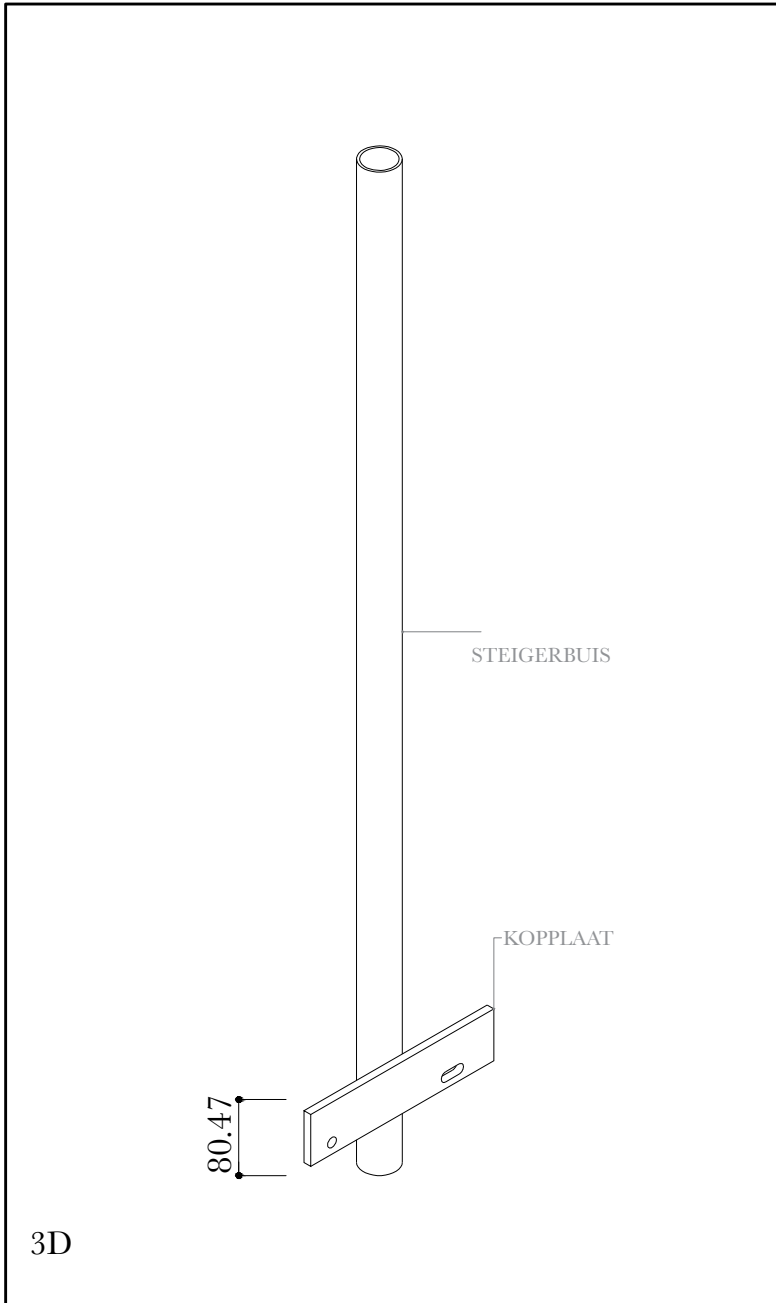
Uiteinden terras

Gegevens

- Stuks: 2
- Materiaal: Staal (warm, verzinkt)
- Maaswijdte: 16,6 x 16,6mm
- Drukstaven:
 - hoogte 30mm
 - dikte 3mm
- Vulstaven:
 - hoogte 14mm
 - dikte 2mm
- Draagvermogen: 300 kg/m²
- Max. doorbuiging: 6mm

Stap

Deze roosters dienen als vloerplaten van het terras en worden aan de zijkanten geplaatst. Deze zijn iets langer om de volledige ligger te bedekken tot aan de trap.



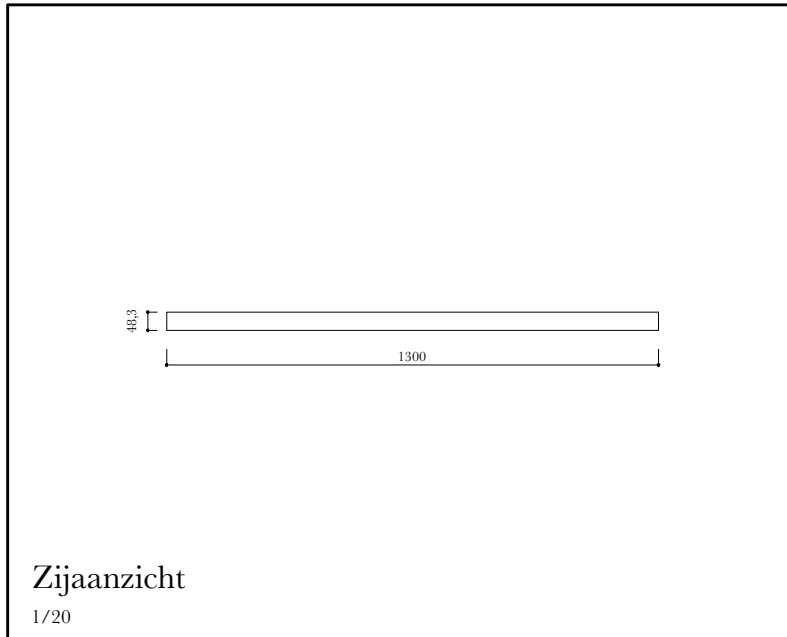
Kopplaat trap

Gegevens

- Stuks: 2 (spiegelbeelden)
- Materiaal: Staal
- Dikte: 10mm

Stap

Deze kopplaat wordt op de steigerbuis gelast. Het spiegelbeeld van deze plaat wordt vervolgens op een andere steigerbuis gelast.



Steigerbuis

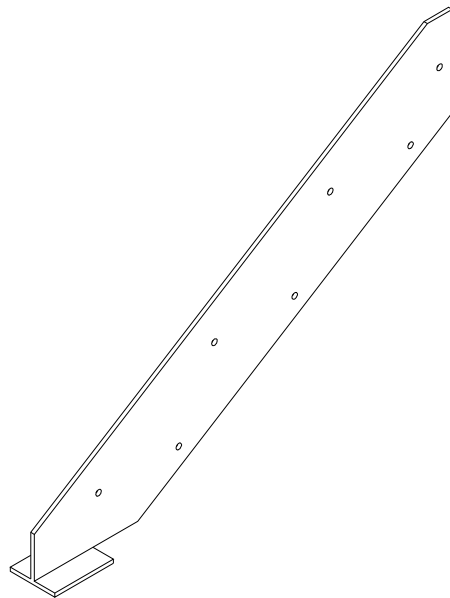
Gegevens

- Stuks: 2
- Materiaal: Staal
- Sectie: Ø48.3mm/3,25mm

Stap

Deze buis wordt over de steunvoet geschoven en er wordt een kopplaat opgelast op een hoogte van 285mm.

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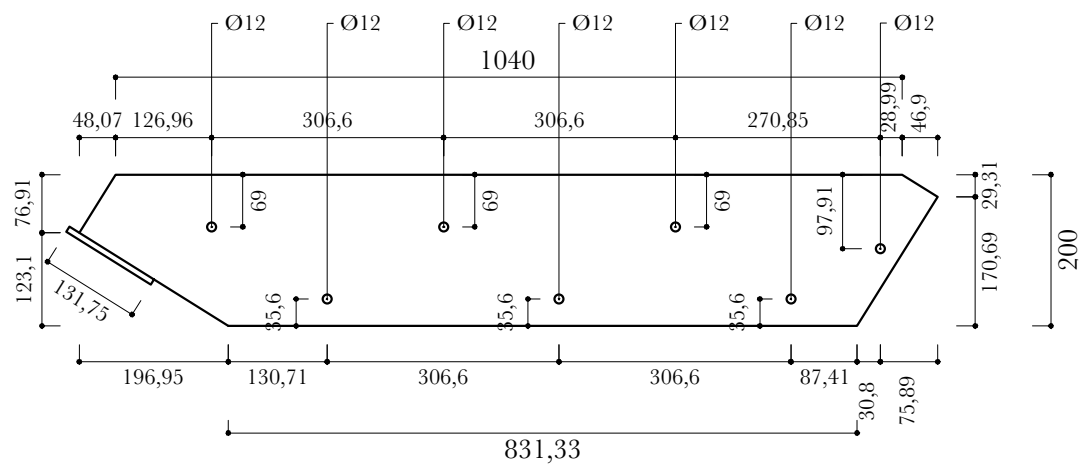
Staalplaat trap

Gegevens

- Stuks: 4 (spiegelbeelden)
- Materiaal: Staal
- Dikte: 8mm

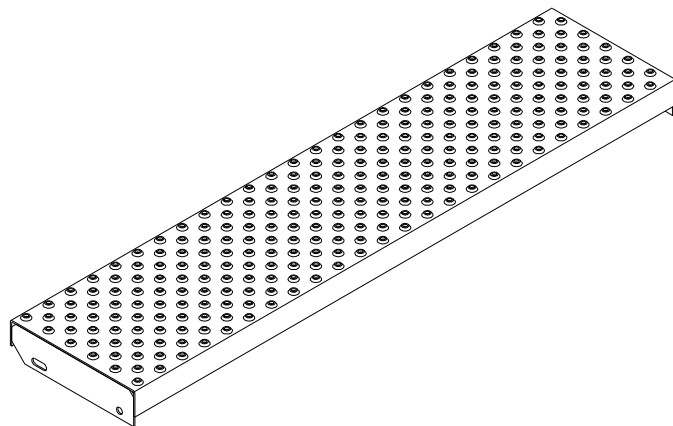
Stap

Er wordt een staalplaat met dikte 8mm gebruikt waarin gaten worden voorzien. Deze wordt uiteindelijk op een kleinere staalplaat van 8mm dikte gelast om het geheel van stijfheid te voorzien wanneer het de grond raakt.

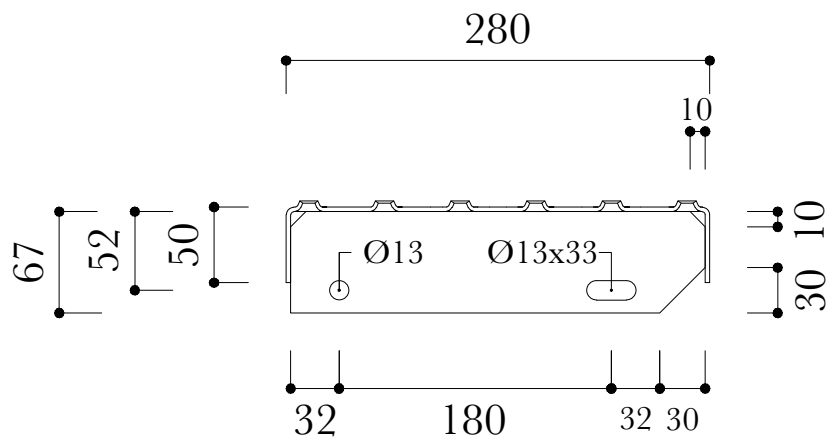


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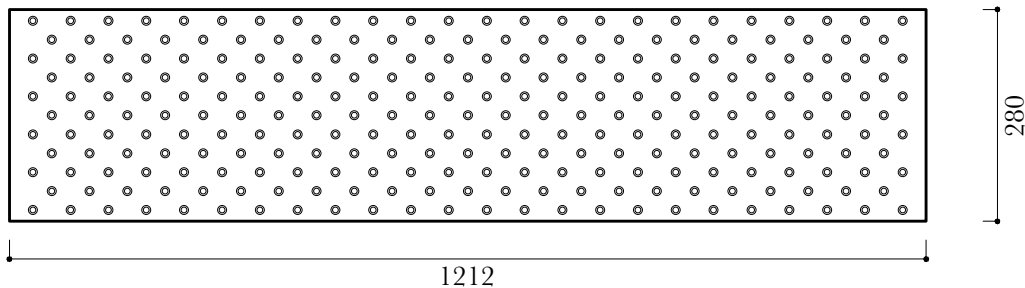


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Perfotreden type AP50 ZAA

Gegevens

- Stuks: 6
- Materiaal: Staal
- Doorbuiging: 6mm
- Dikte: 3mm
- Belasting: 14 daN

Stap

Dit zijn geprofileerde traptreden dewelke geperforeerd zijn met gaten van 8mm diameter. Aan de kopse kanten wordt een plaat ingelast om de verbinding met de staalplaat te maken.

Steigerbuis - luifel

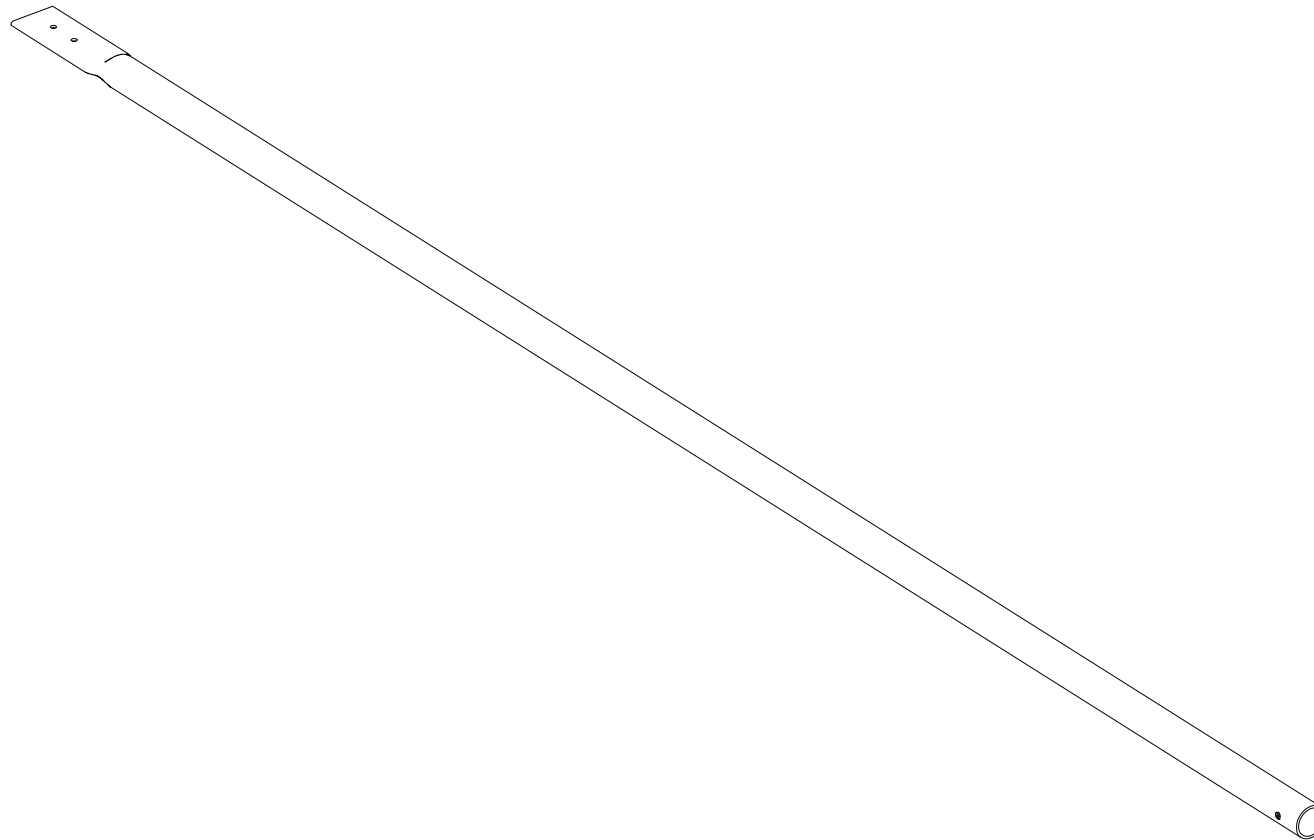
Gegevens

- Stuks: 10
- Materiaal: Staal
- Sectie: $\text{Ø}48.3\text{mm}/3,25\text{mm}$

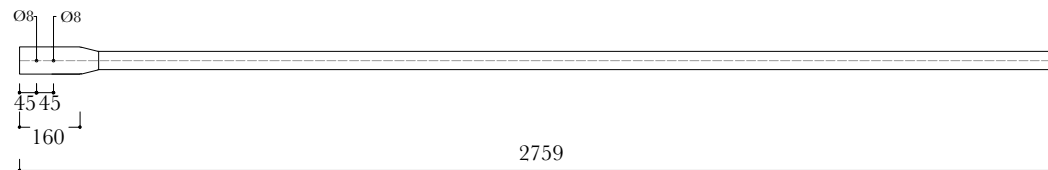
Stap

Deze steigerbuizen worden gebruikt om de luifel vast te zetten en de windbelasting die op de luifel zal werken op te nemen.

Deze buizen worden in de koppelmoffen geschoven en vastgezet alsook ter hoogte van de dakrand.

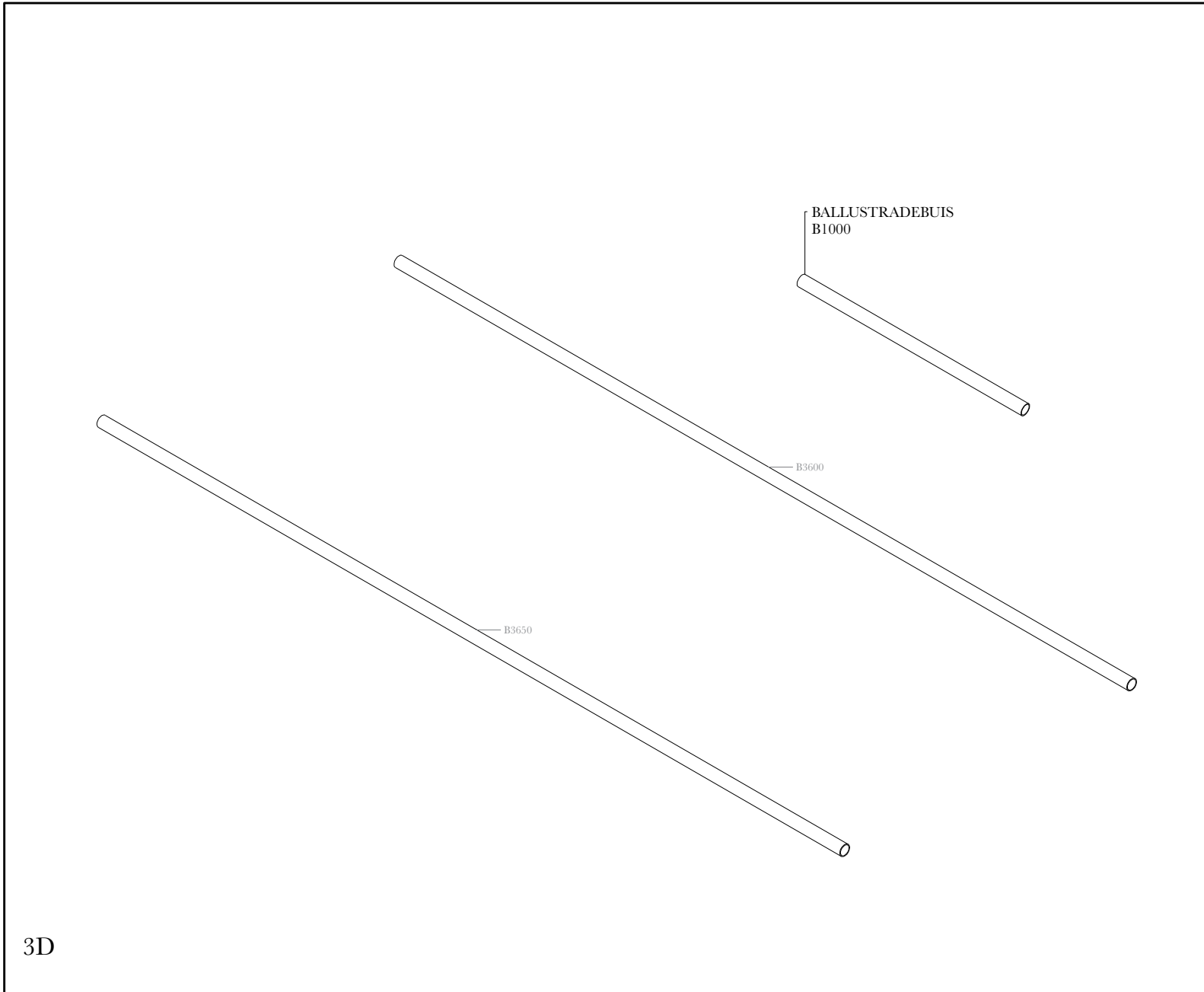


3D

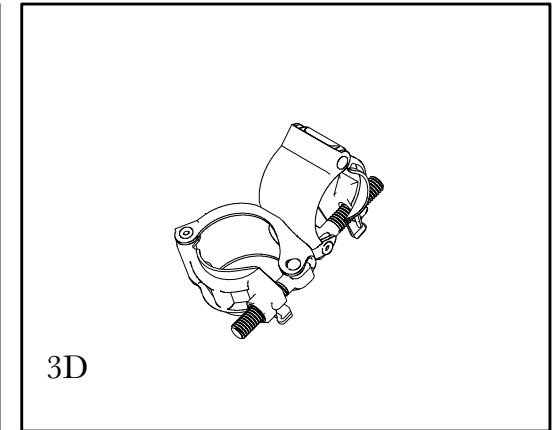


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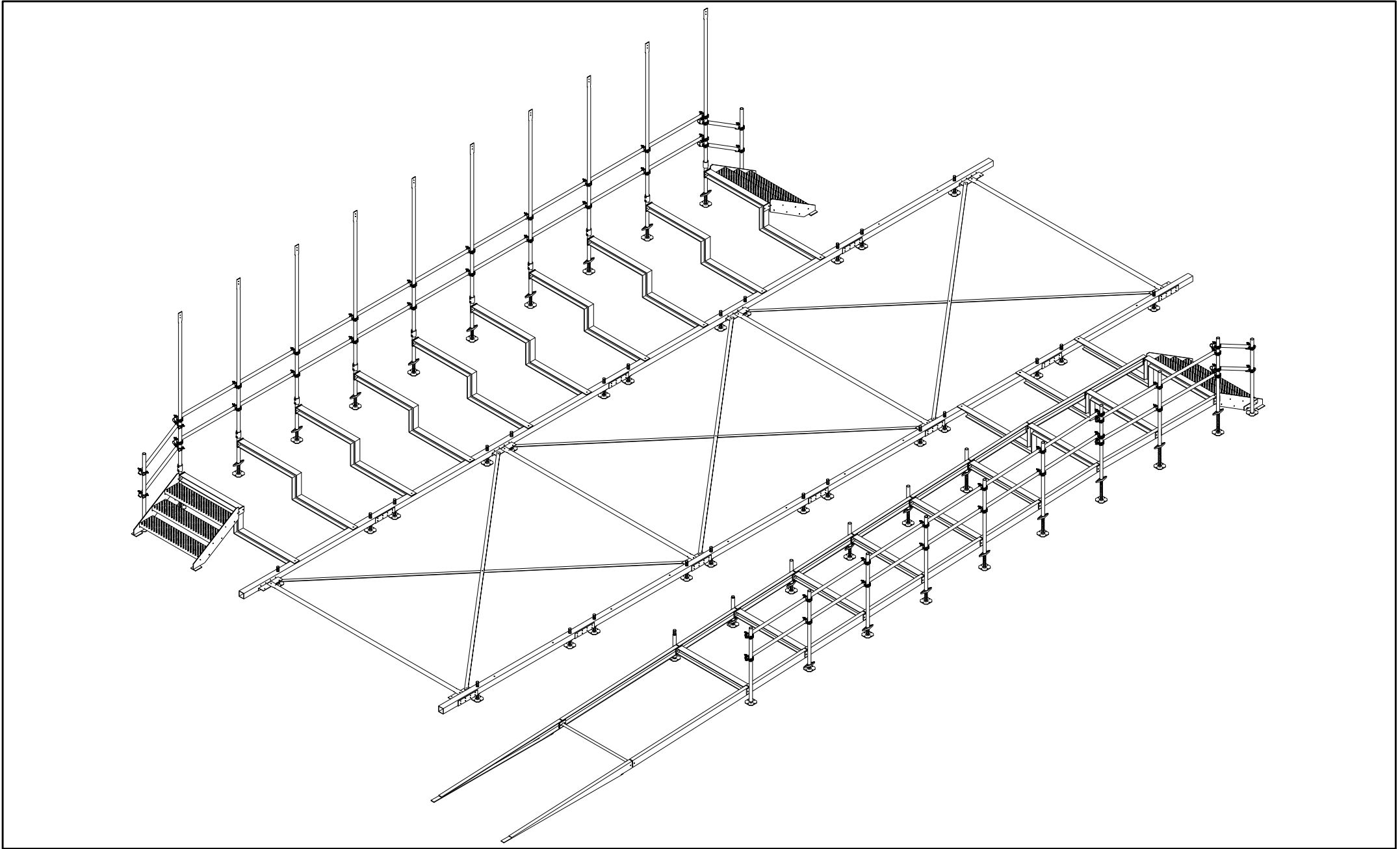
Ballustrade - buis

Gegevens

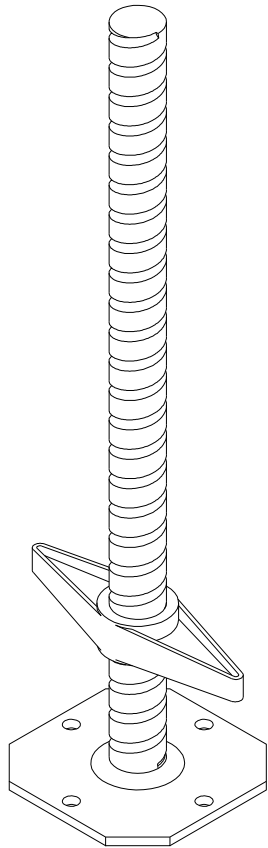
- Stuks: B3650: 4 (3650mm)
B3600: 2 (3600mm)
B1000: 4 (1000mm)
- Draaikoppeling: 28
- Materiaal: Staal
- Sectie: Ø48.3mm/3,25mm

Stap

Deze balkonbuizen worden gebruikt als ballustrade-buis of borstweringen worden in 2 rijen boven en onder elkaar voorzien. Deze worden met de verticale steigerbuizen verbonden door middel van een draaikoppeling.



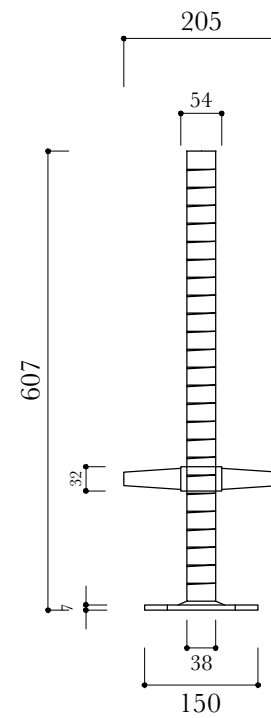
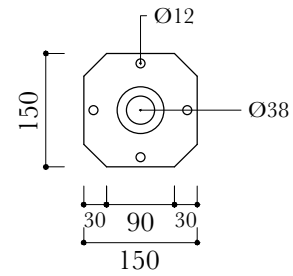
Stuklijst helling



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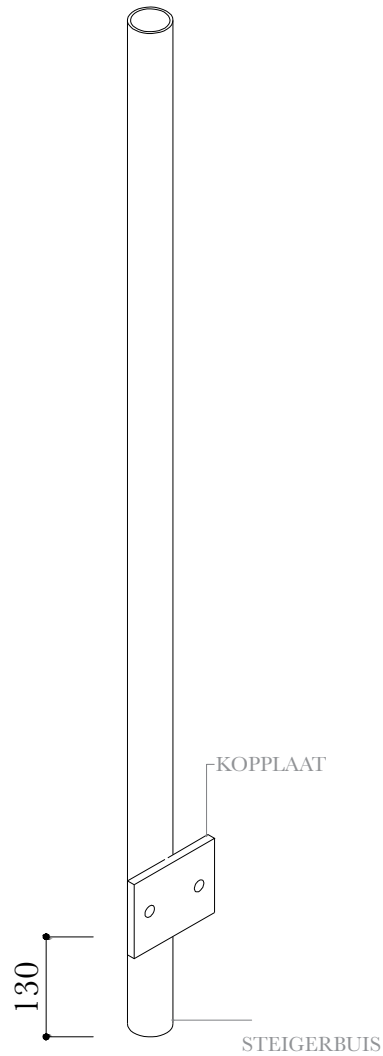
Stellingvoeten

Gegevens

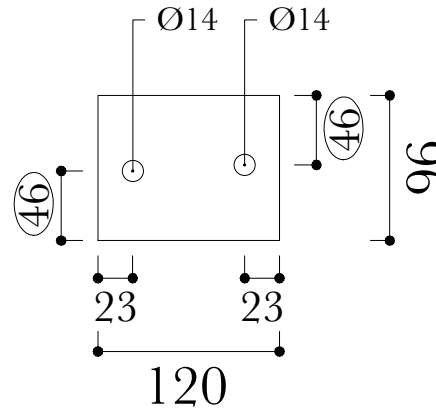
- Stuks: 16
- Materiaal: Staal
- Sterkte: 36 kN

Stap

Deze steunvoeten worden op een hoogte van 500mm afgeslepen en nadien geplaatst. Via de voetspindel kan de hoogte van de kokers worden bijgesteld om de helling te vormen.

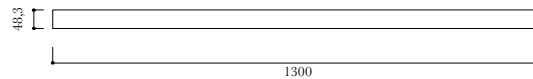


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Kopplaat - Type 1

Gegevens

- Stuks: 7
- Materiaal: Staal
- Dikte: 10mm

Stap

Deze kopplaat wordt op 2 zaken gelast:

- op de stalen buizen;
- op de HEA100 profielen van de helling (deze aantallen zijn meegerekend bij de desbetreffende profielen).

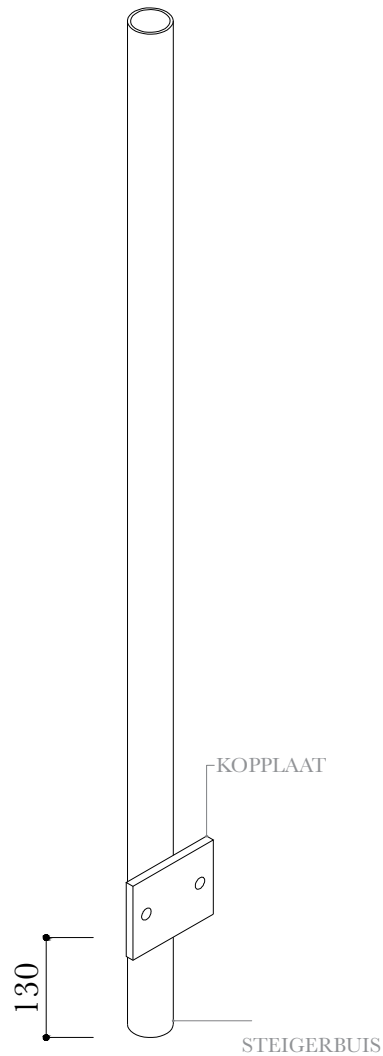
Steigerbuis

Gegevens

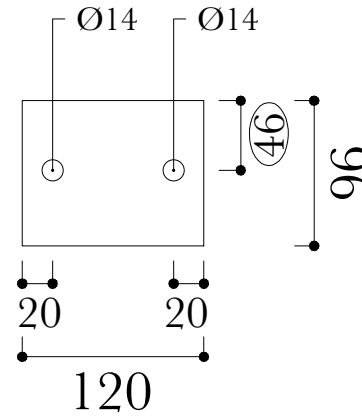
- Stuks: 7
- Materiaal: Staal
- Sectie: Ø48.3mm/3,25mm

Stap

Deze buis wordt over de steunvoet geschoven en er wordt een kopplaat opgelast op een hoogte van 130mm.

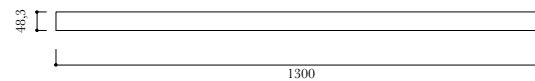


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Kopplaat - Type 2

Gegevens

- Stuks: 2
- Materiaal: Staal
- Dikte: 10mm

Stap

Deze kopplaat wordt op 2 zaken gelast:

- op de stalen buizen;
- op de HEA100 profielen van de overloop (deze aantallen zijn meegerekend bij de desbetreffende profielen).

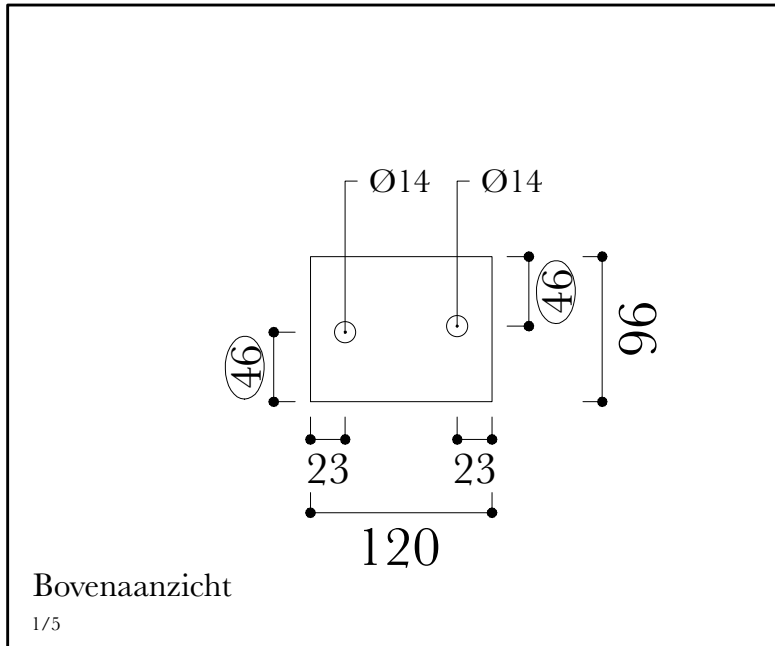
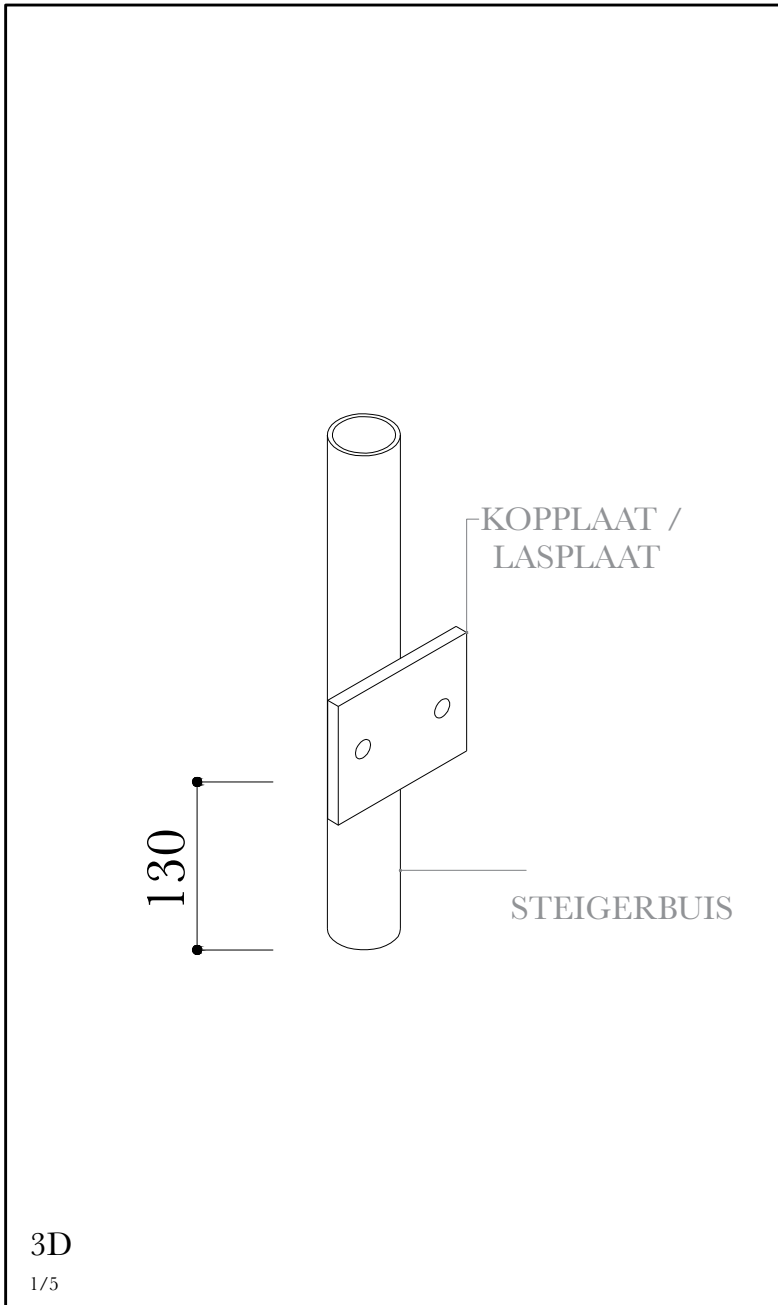
Steigerbuis

Gegevens

- Stuks: 2
- Materiaal: Staal
- Sectie: Ø48.3mm/3,25mm

Stap

Deze buis wordt over de steunvoet geschoven en er wordt een kopplaat opgelast op een hoogte van 130mm.



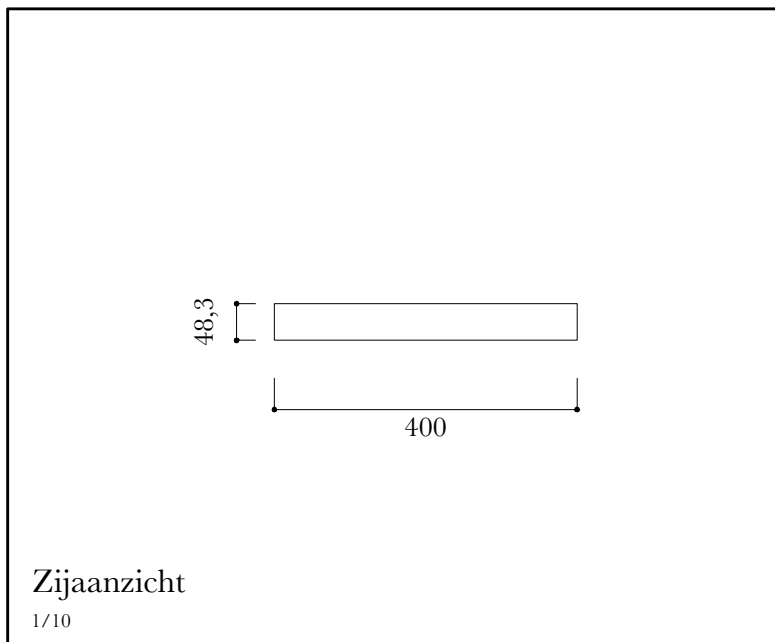
Kopplaat - Type 2

Gegevens

- Stuks: 10
- Materiaal: Staal
- Dikte: 10mm

Stap

Deze kopplaat wordt op de korte steigerbuizen gelast die geplaatst worden tussen helling en paviljoen om de vrijstaande HEA100 profielen te ondersteunen.



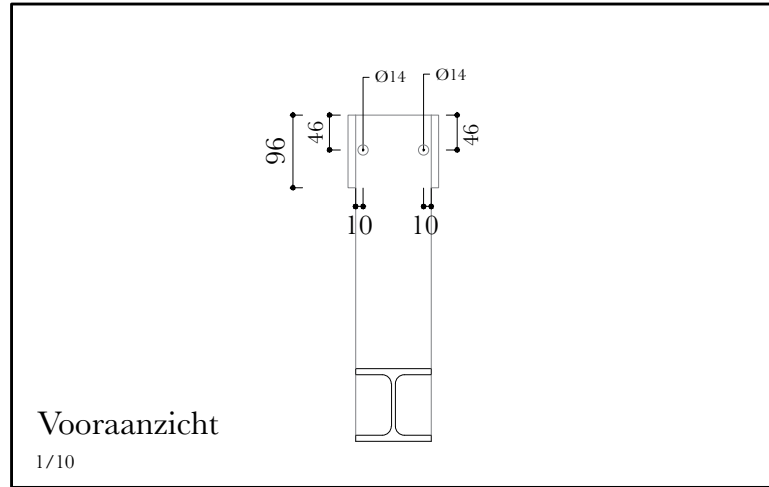
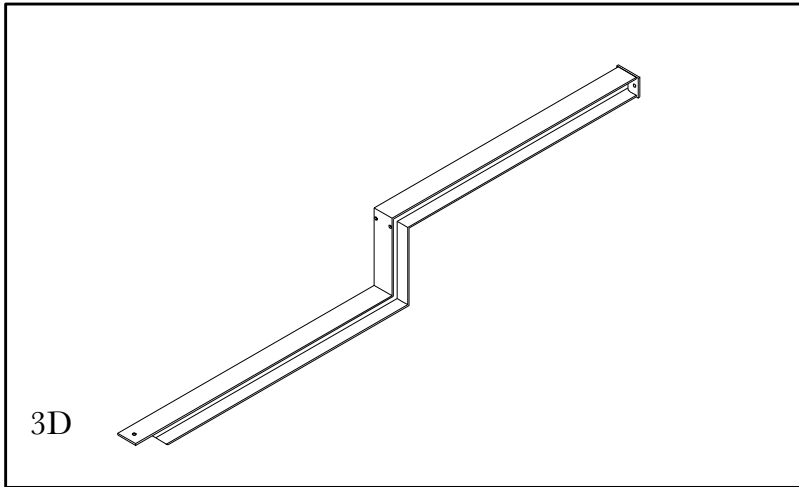
Steigerbuis

Gegevens

- Stuks: 6
- Materiaal: Staal
- Sectie: Ø48.3mm/3,25mm

Stap

Deze buis wordt over de steunvoet geschoven en er wordt een kopplaat opgelast op een hoogte van 130mm.



Gelast HEA100-profiel

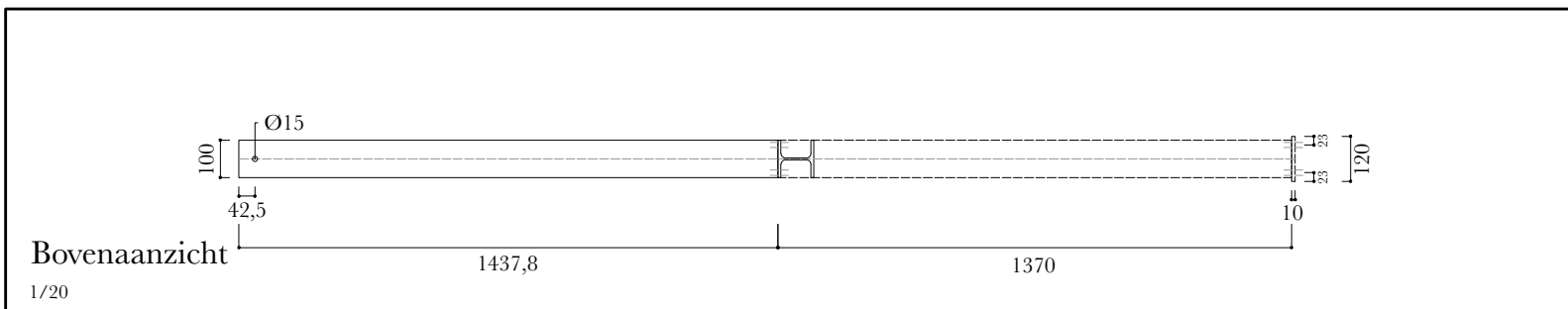
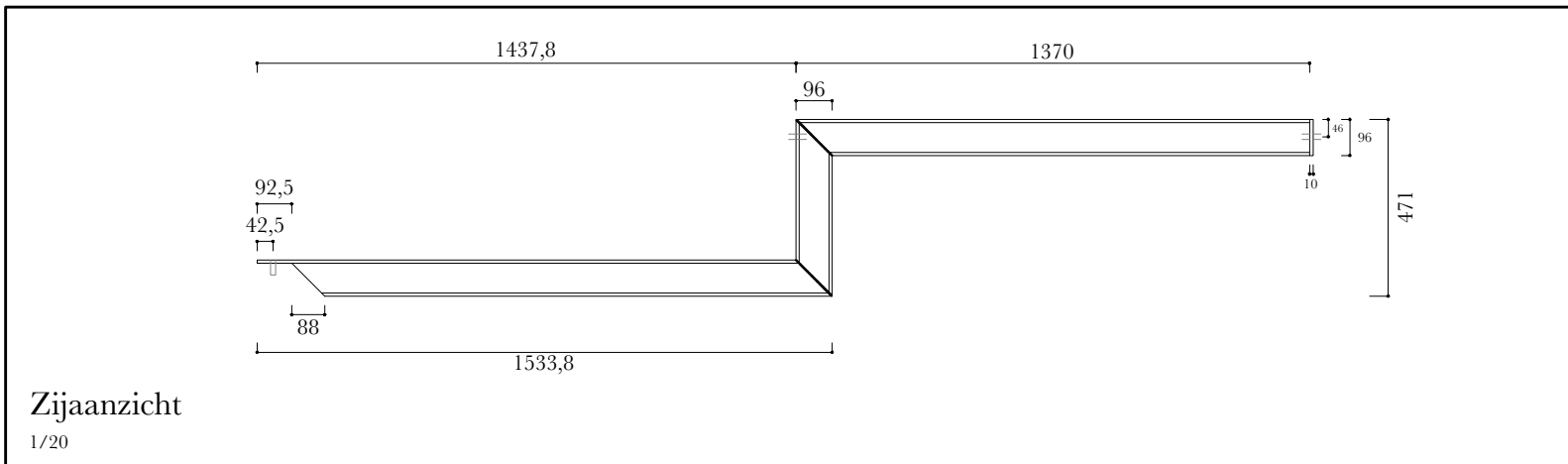
Gegevens

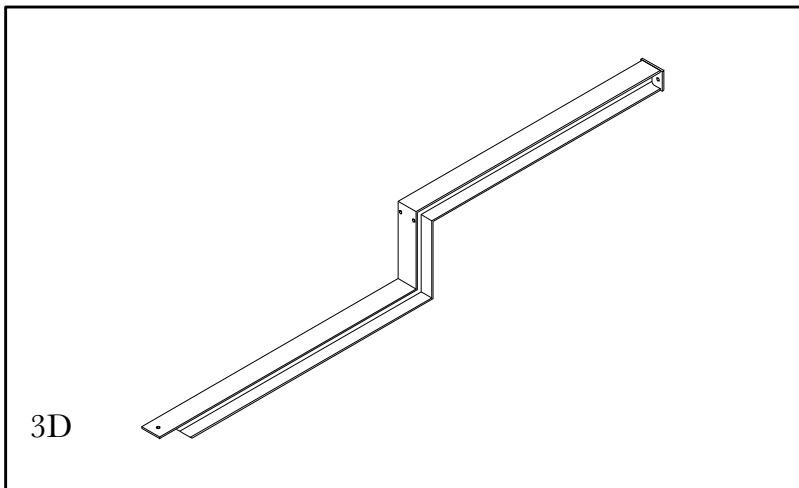
- Stuks: 2
- PROFIEL: 2
- KOPPLAAT TYPE 2: 2
- Materiaal: Staal
- Profiel: HEA 100

Stap

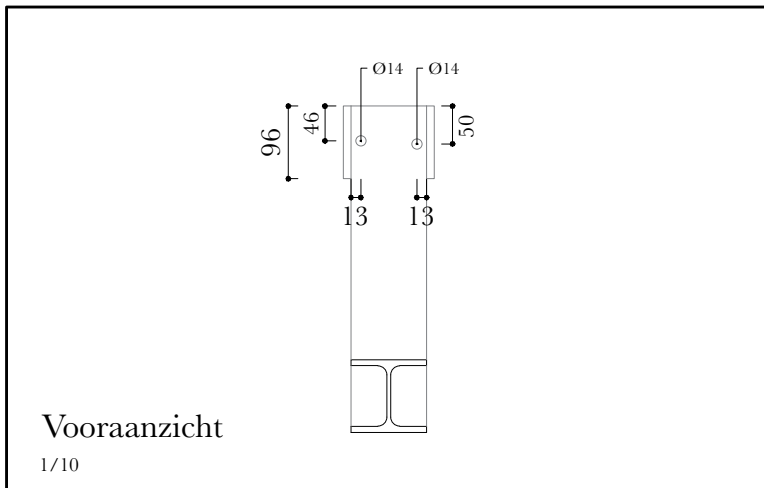
Dit gelaste profiel wordt als ondersteuning van de helling gebruikt. In de 15mm opening aan het opleggingsvlak wordt een stalen cilinder van 40mm lengte gelast en diameter 14mm. Op deze manier kan het profiel in de fundering 'gehaakt' worden. Op de kopse zijde van dit profiel wordt een kopplaat van type 2 gelast.

Dit specifieke profiel wordt gebruikt voor de overloop van de helling. Met het bovenvlak zal het zich op een hoogte van 608mm bevinden.





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Vooraanzicht

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Gelast HEA100-profiel

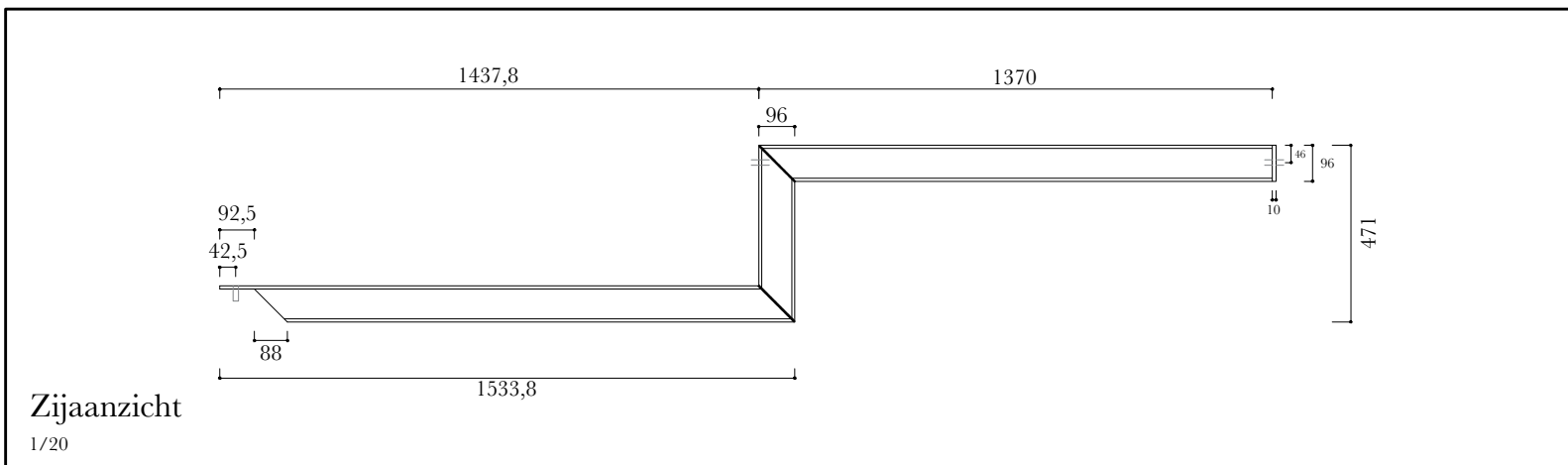
Gegevens

- Stuks: 1
- PROFIEL: 1
- KOPPLAAT TYPE 1: 1
- Materiaal: Staal
- Profiel: HEA 100

Stap

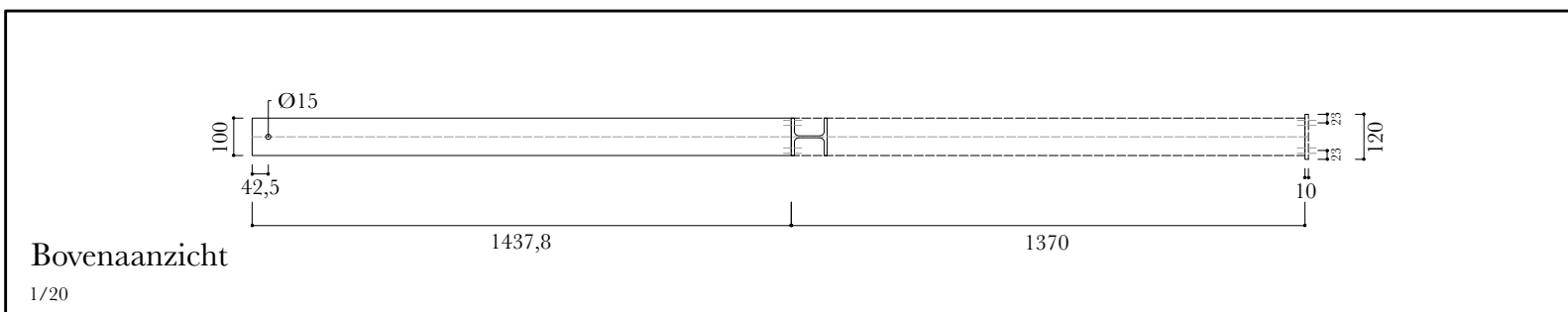
Dit gelaste profiel wordt als ondersteuning van de helling gebruikt. In de 15mm opening aan het opleggingsvlak wordt een stalen cilinder van 40mm lengte gelast en diameter 14mm. Op deze manier kan het profiel in de fundering 'gehaakt' worden. Op de kopse zijde van dit profiel wordt een kopplaat van type 1 gelast

Dit specifieke profiel wordt gebruikt ter hoogte van de raaklijn tussen helling en overloop, het vormt als het ware de overgang van de overloop naar de helling. Met het bovensvlak zal het zich op een hoogte van 608mm bevinden.



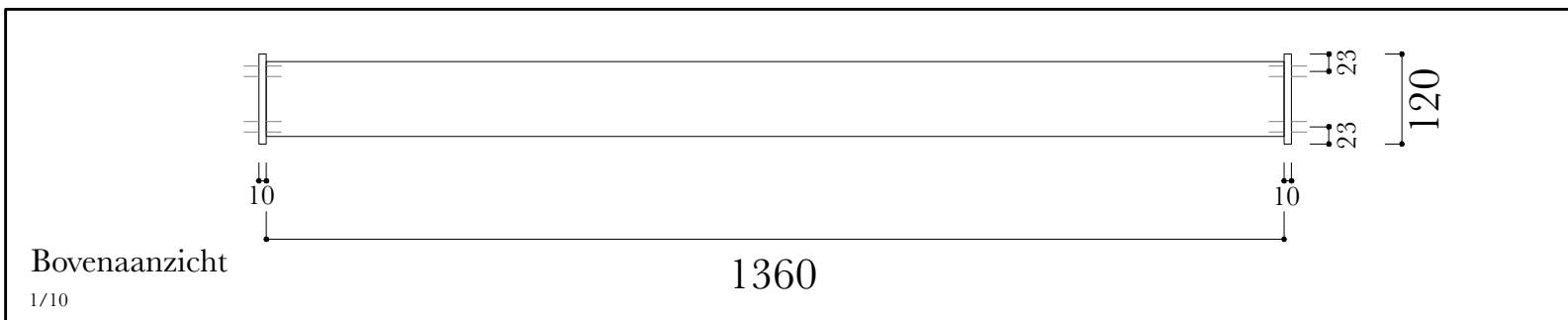
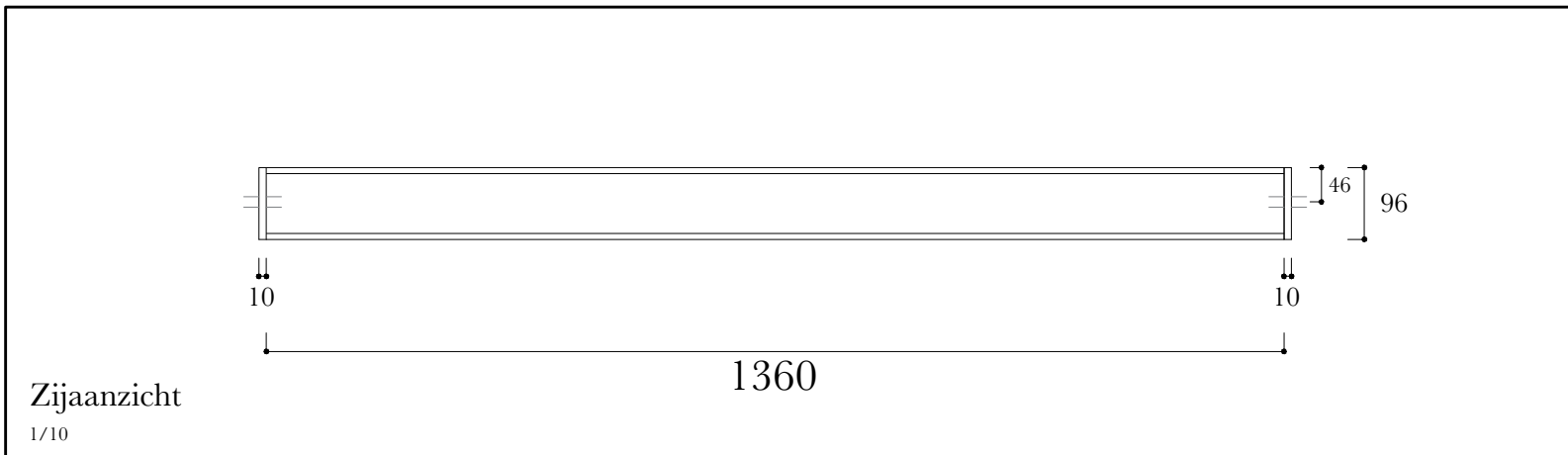
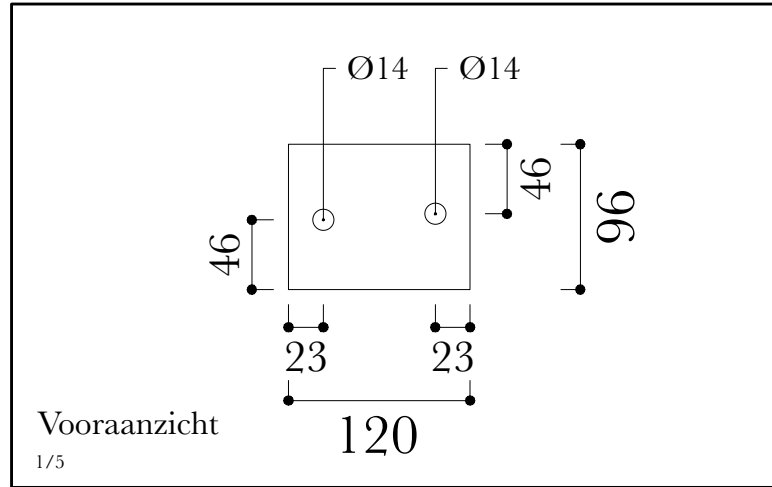
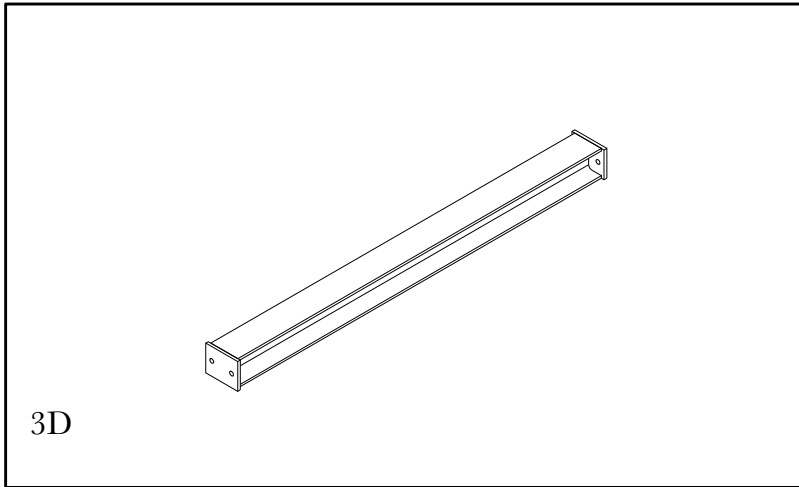
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Gelast HEA100-profiel

Gegevens

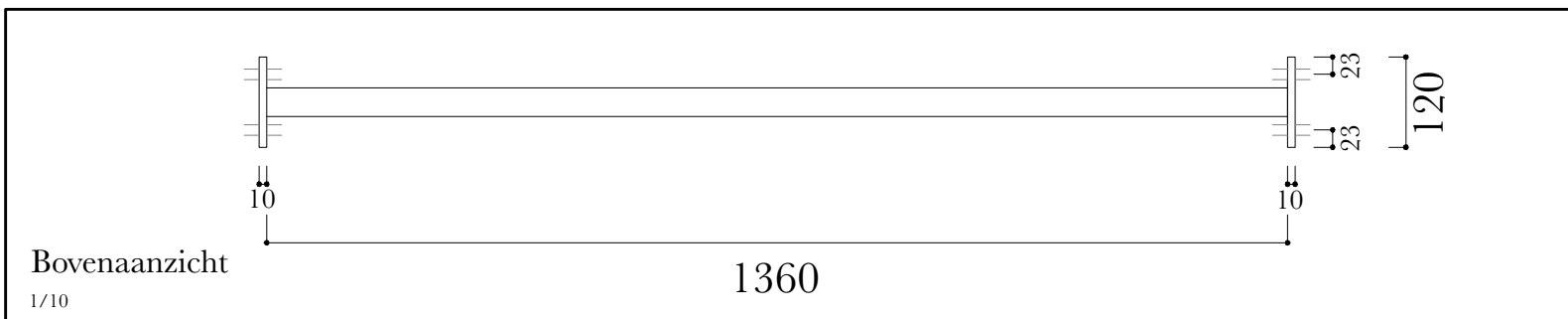
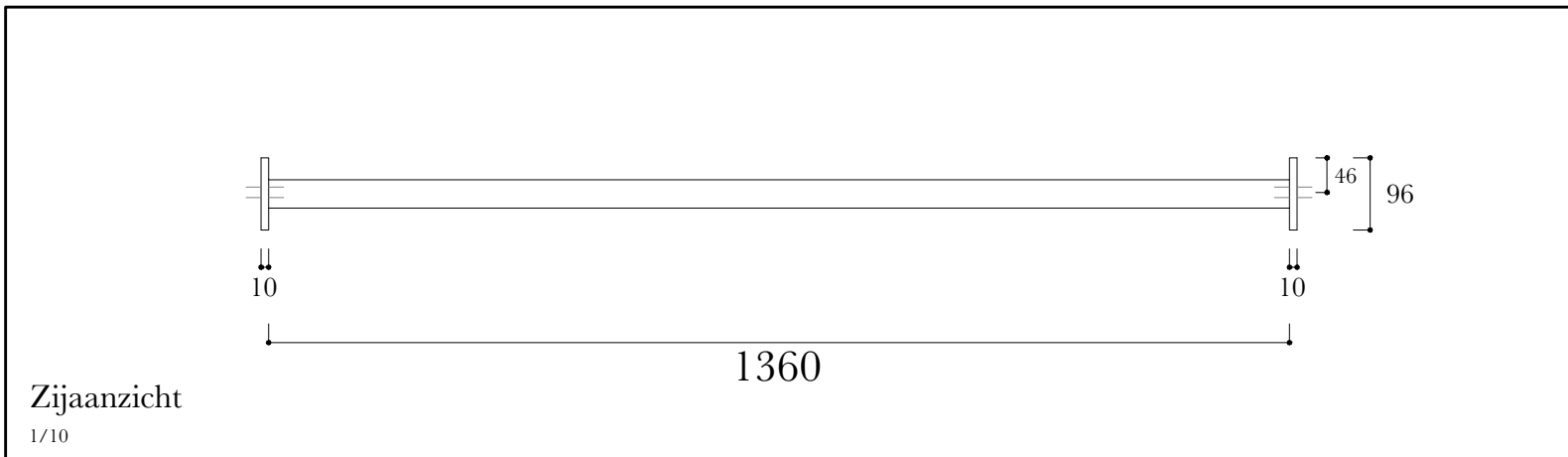
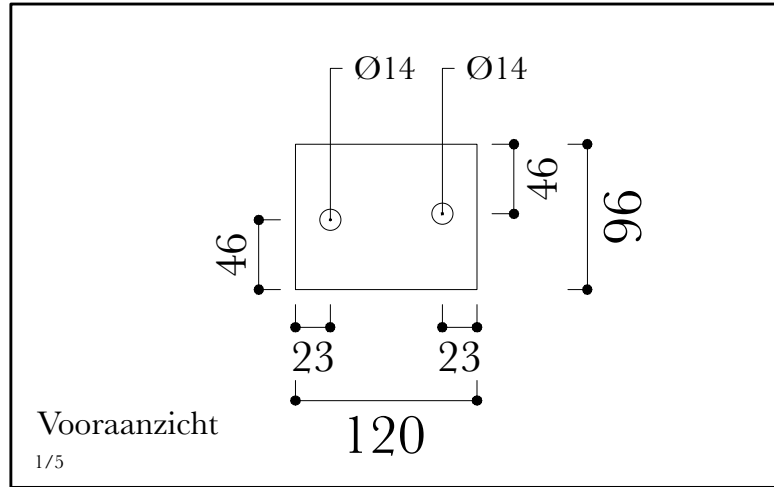
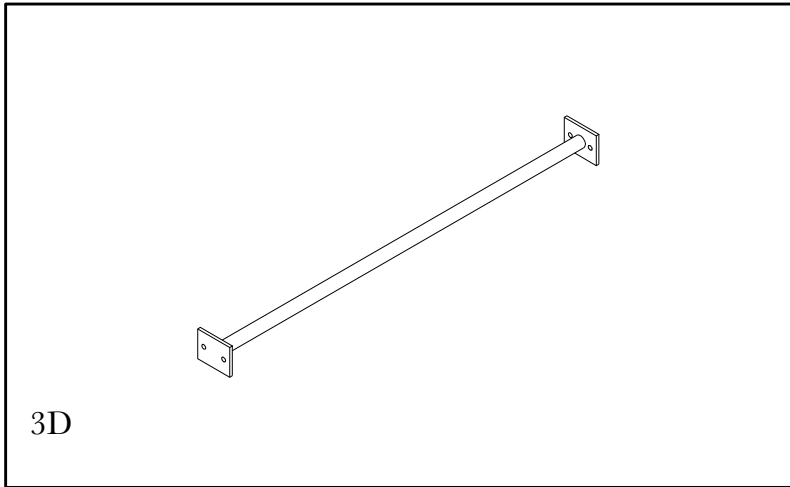
- Stuks: 6
- PROFIEL: 6
- KOKERPROFIEL TYPE 1: 12
(spiegelbeelden)
- Materiaal: Staal
- Profiel: HEA 100

Stap

Dit gelaste profiel wordt als ondersteuning van de helling gebruikt. Het is volledig losstaand van het funderingssysteem en wordt er dus niet in 'verankerd'. Op de kopse zijden van dit profiel wordt een kopplaat van type 1 gelast.

Met het bovenzvlak zal dit profiel zich op volgende hoogtes bevinden in de helling:

- 548 mm
- 488 mm
- 428 mm
- 368 mm
- 308 mm
- 248 mm



Kokerprofiel Ø 38 mm

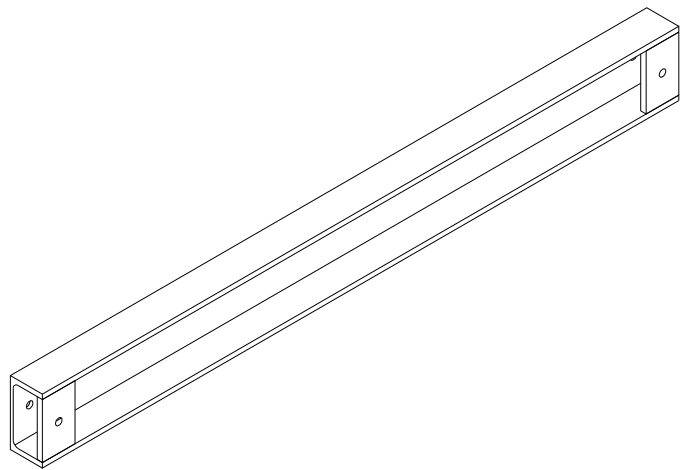
Gegevens

- Stuks: 1
- PROFIEL: 2
- KOPPLAAT TYPE 1: 2
(spiegelbeelden)
- Materiaal: Staal
- Profiel: Ø38mm/2,6mm

Stap

Dit gelaste profiel wordt als ondersteuning van de helling gebruikt. Het is volledig losstaand van het funderingssysteem en wordt er dus niet in 'verankerd'. Op de kopse zijden van dit kokerprofiel wordt een kopplaat van type 1 gelast.

Met het bovenvlak zal de bovenzijde van de kopplaat zich op een hoogte van 128mm bevinden.



3D

UPE120- profiel (L 1190 mm)

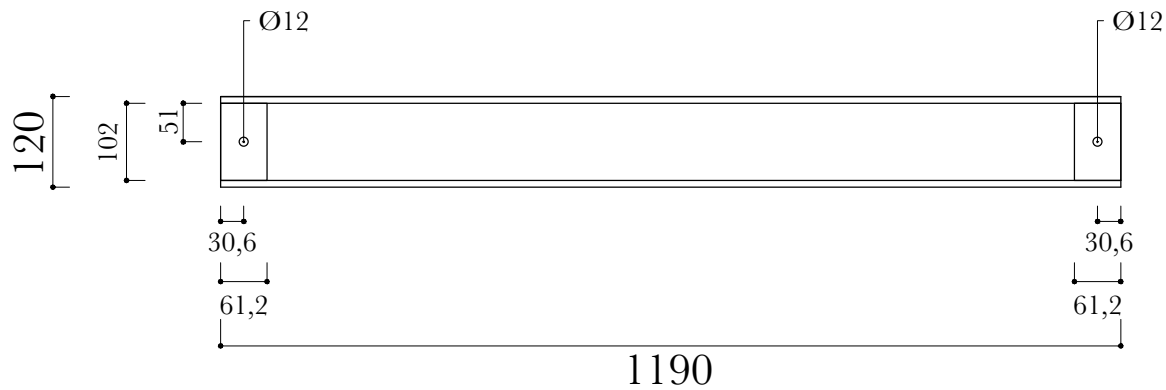
Gegevens

- Stuks: 12
- Materiaal: Staal
- Profiel: UPE 120

Stap

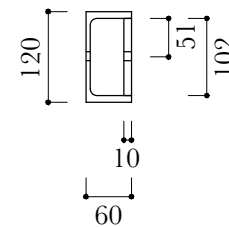
In dit UPE profiel worden twee kopplaten met dikte 10mm gelast om de verbinding met het HEA100 profiel en de steunvoet te maken. Op dezelfde hoogte wordt er dus ook een opening gemaakt in het UPE profiel zelf.

Dit UPE profiel wordt gebruikt in de helling en komt het vaakst voor.



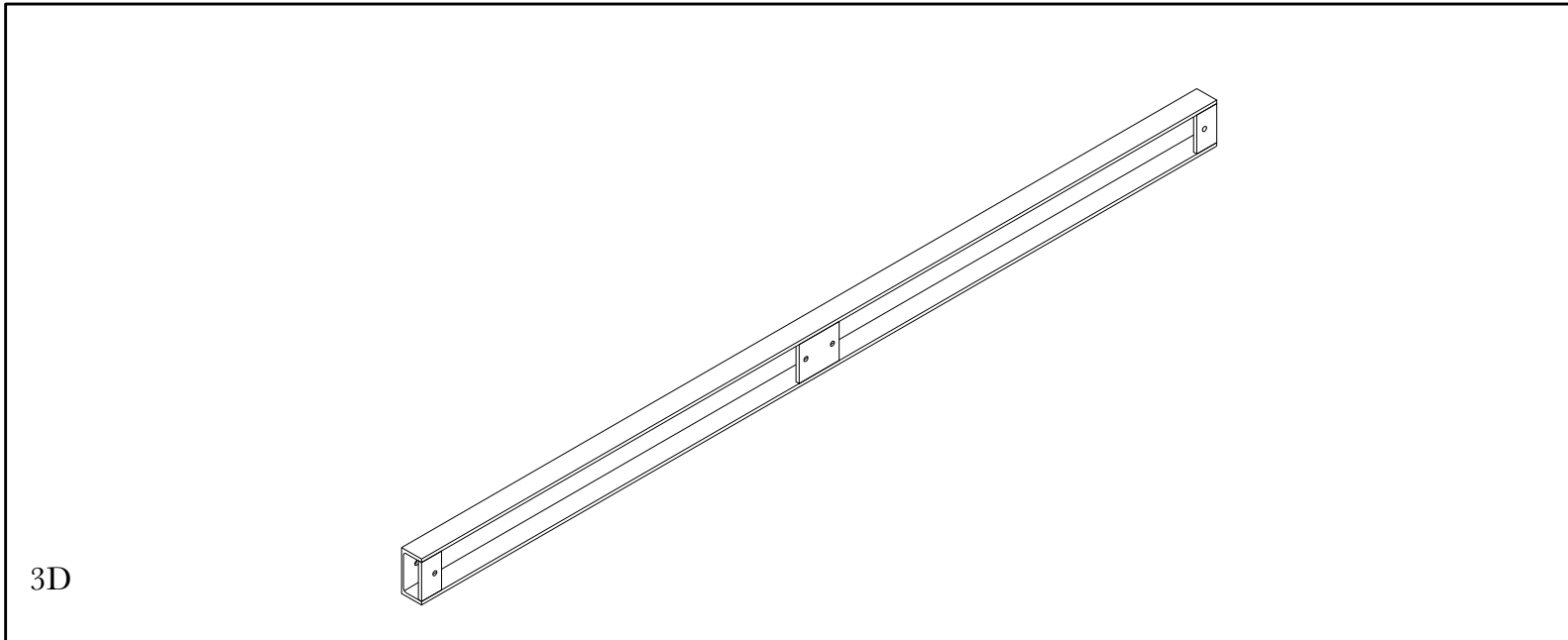
Zijaanzicht

1/10



Vooraanzicht

1/10



UPE120- profiel (L 2400 mm)

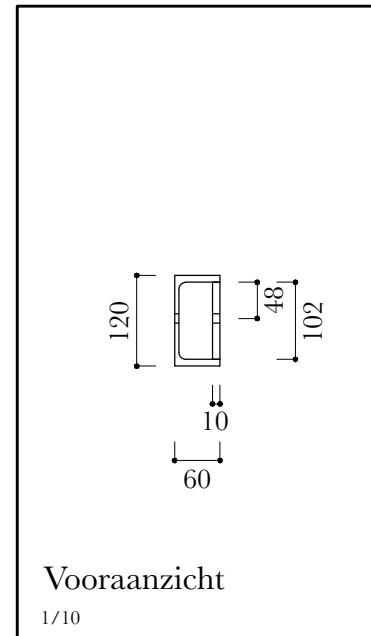
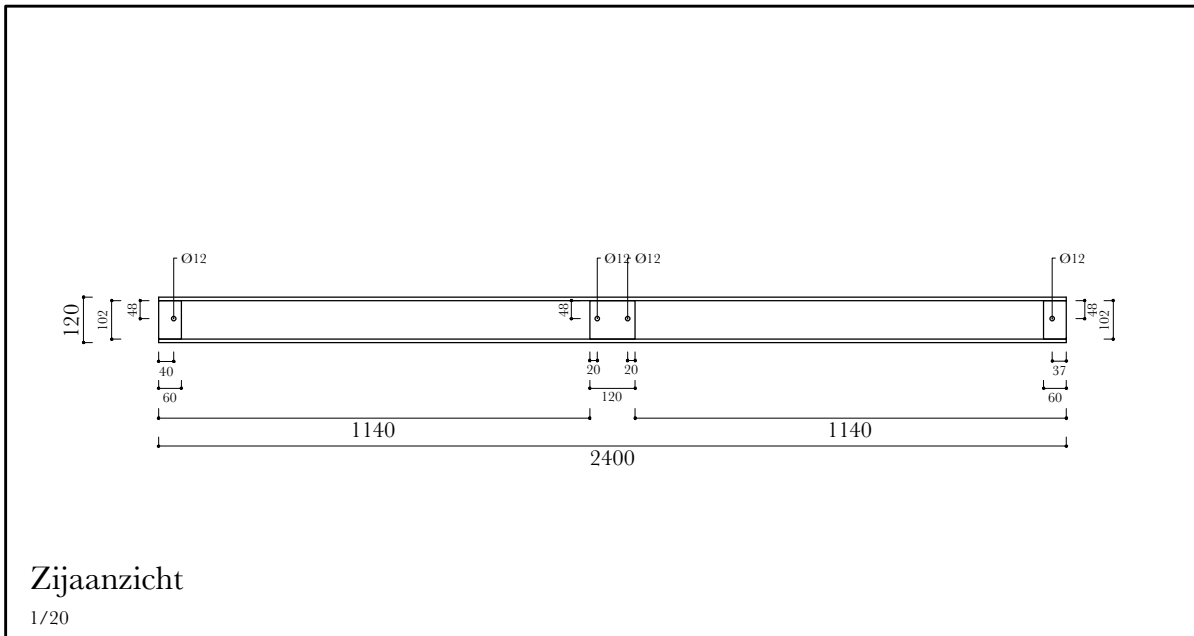
Gegevens

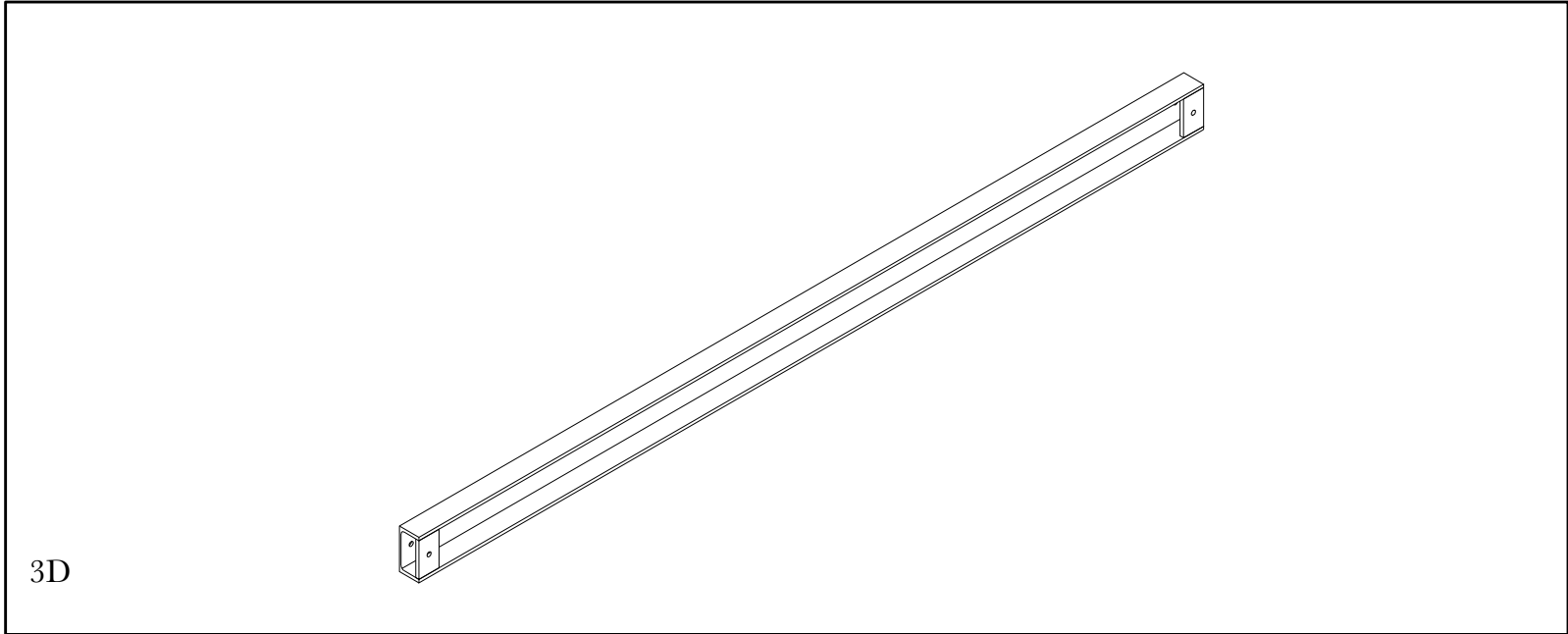
- Stuks: 2
- Materiaal: Staal
- Profiel: UPE 120

Stap

In dit UPE profiel worden drie kopplaten met dikte 10mm gelast om de verbinding met het HEA100 profiel en de steunvoet te maken. Op dezelfde hoogte wordt er dus ook een opening gemaakt in het UPE profiel zelf.

Dit UPE profiel wordt gebruikt in de overloop.





UPE120- profiel (L 2391,5 mm)

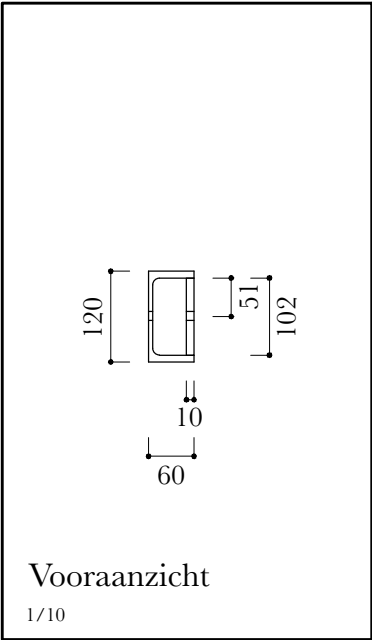
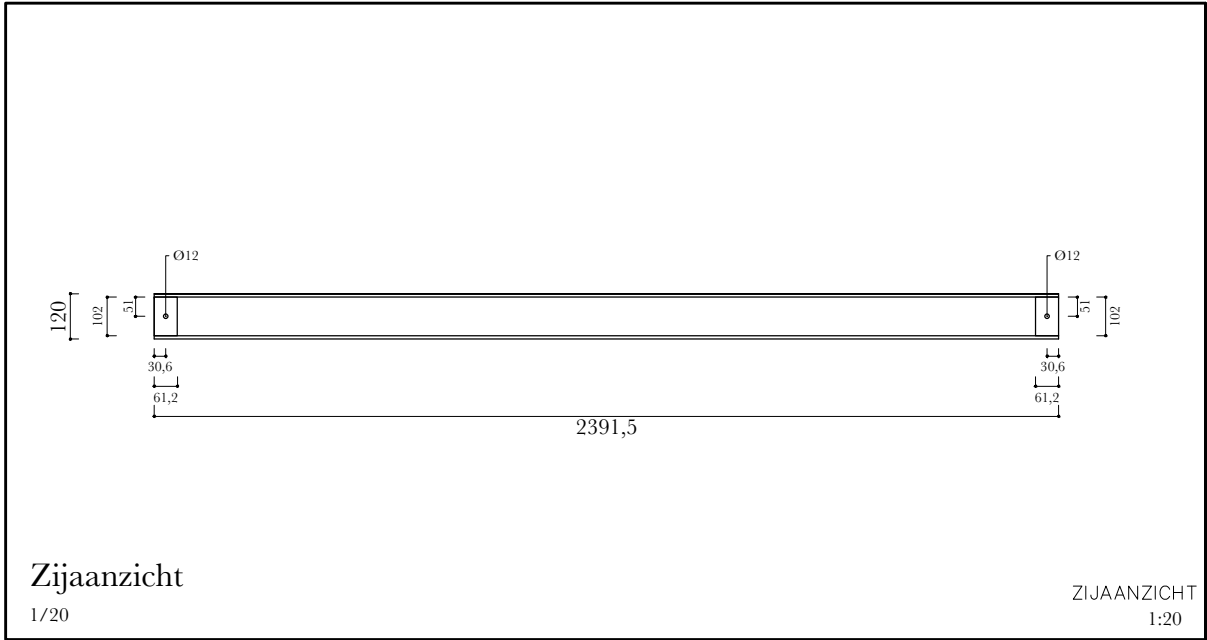
Gegevens

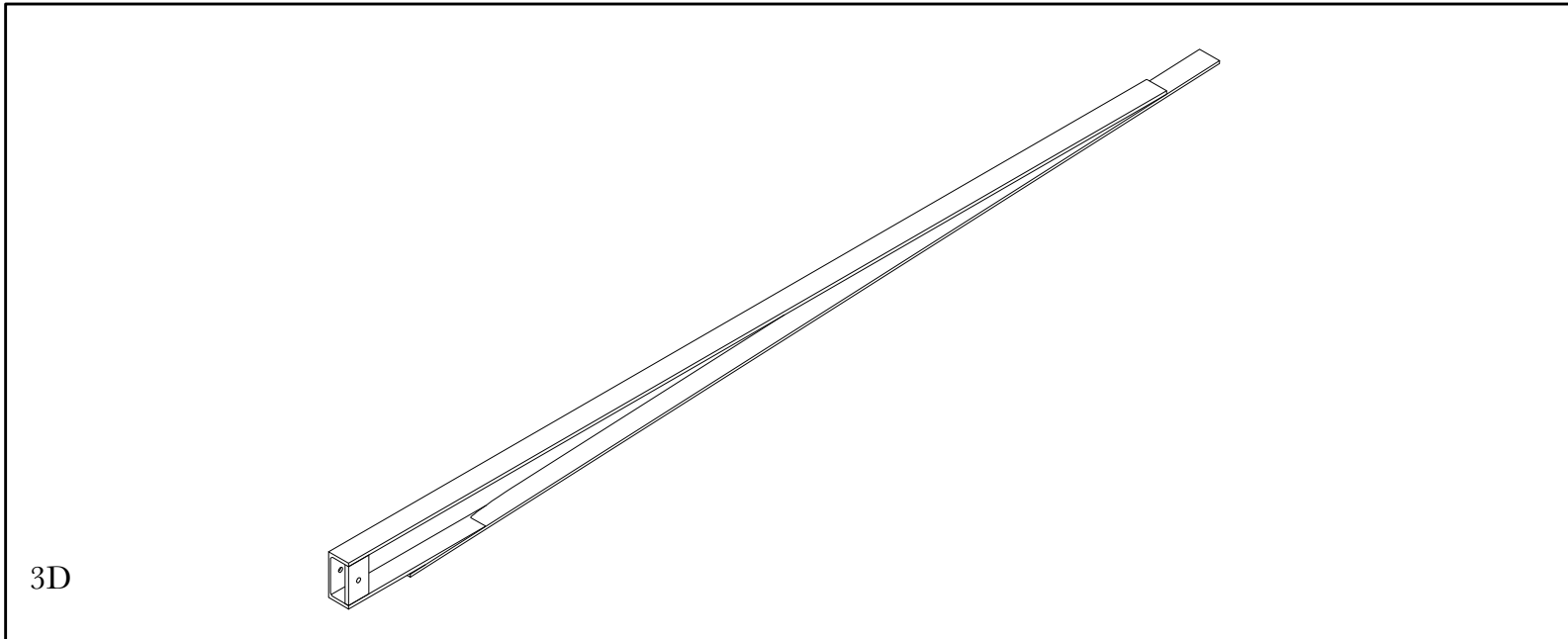
- Stuks: 2
- Materiaal: Staal
- Profiel: UPE 120

Stap

In dit UPE profiel worden twee kopplaten met dikte 10mm gelast om de verbinding met het HEA100 profiel en de steunvoet te maken. Op dezelfde hoogte wordt er dus ook een opening gemaakt in het UPE profiel zelf.

Dit UPE profiel wordt gebruikt in de helling en vormt de verbinding tussen het laatste HEA100 profiel en het ronde kokerprofiel.





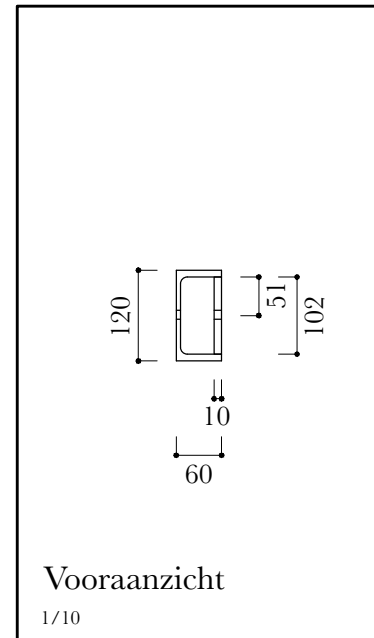
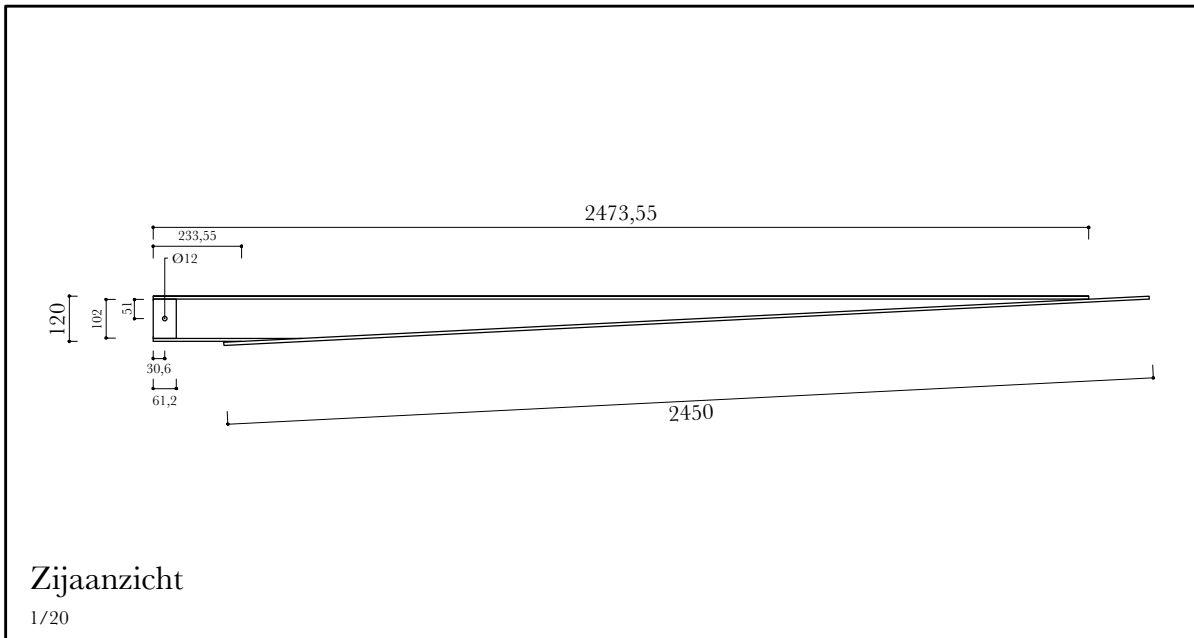
UPE120- profiel + staalplaat
(L 2473,55 mm)

Gegevens

- Stuks: 2
- Materiaal: Staal
- Profiel: UPE 120

Stap

In dit UPE profiel wordt één kopplaat gelast om de verbinding met het HEA100 profiel en de steunvoet te maken. Op dezelfde hoogte wordt er dus ook een opening gemaakt in het UPE profiel zelf.



Dit UPE profiel wordt gebruikt in de helling en vormt het deel dat de grond zal raken. Het UPE profiel zal schuin worden afgeslepen en op een stalen plaat van 8mm dikte gelast worden.

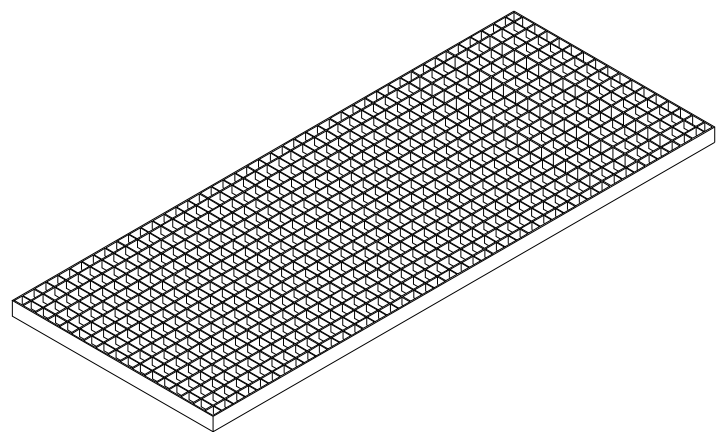
Zwaarlastrooster - Type RH

Gegevens

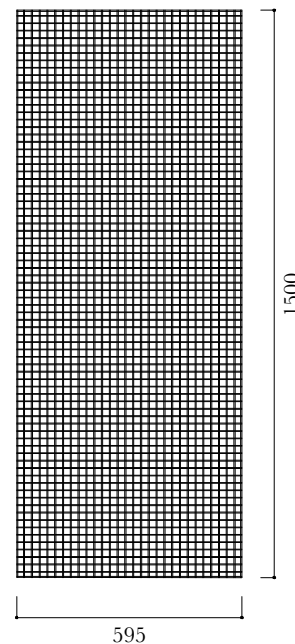
- Stuks: 20
- Materiaal: Staal (warm, verzinkt)
- Drukstaven:
 - hoogte 30mm
 - dikte 3mm
- Vulstaven:
 - hoogte 14mm
 - dikte 2mm
- Draagvermogen:
 - 300 kg/m²
- Max. doorbuiging:
 - 10,8mm

Stap

Deze roosters dienen als vloerplaten van de helling.

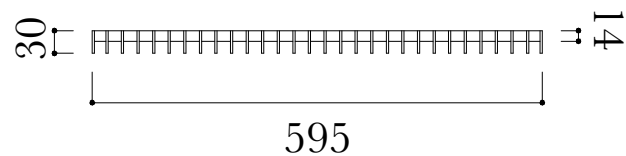


3D



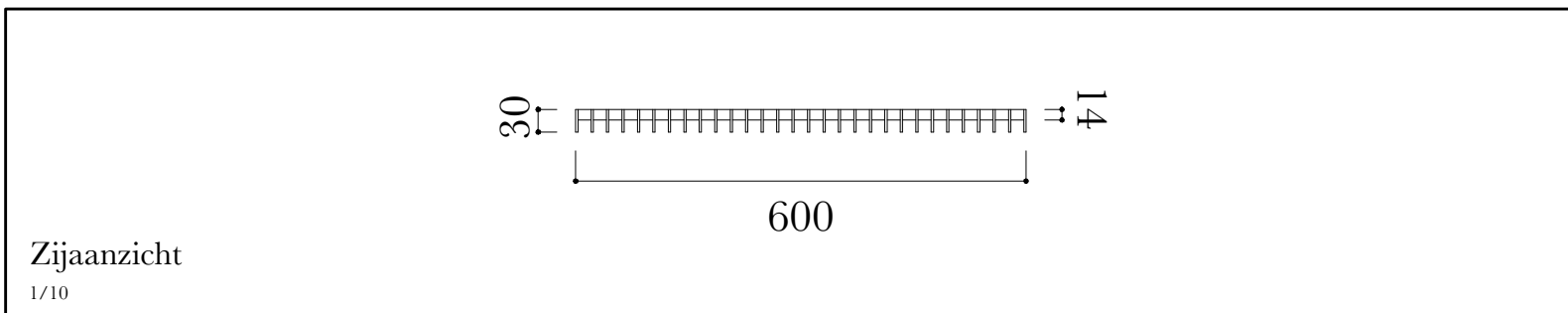
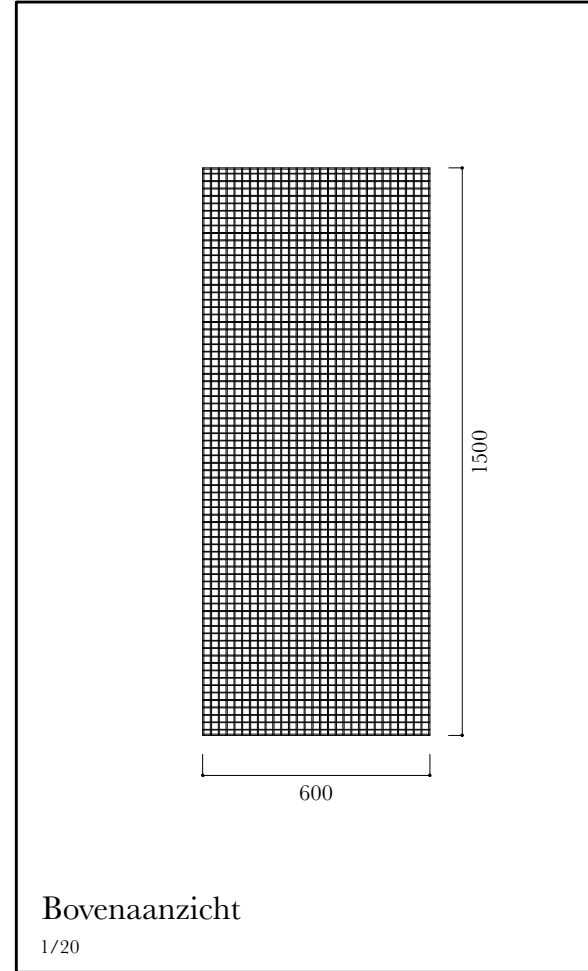
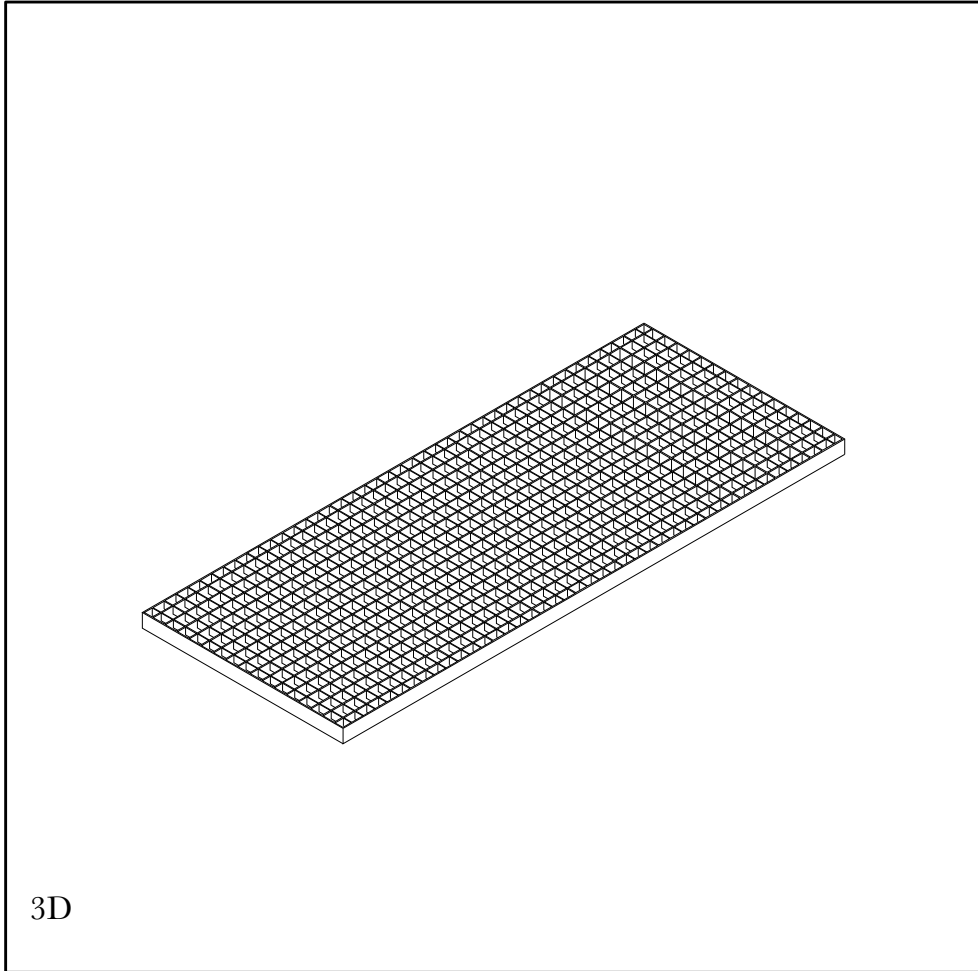
Bovenaanzicht

1/20



Zijaanzicht

1/10



Zwaarlastrooster - Type RH

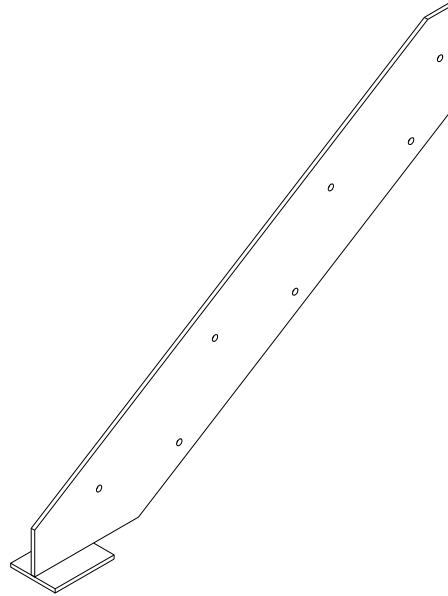
Gegevens

- Stuks: 4
- Materiaal: Staal (warm, verzinkt)
- Drukstaven:
 - hoogte 30mm
 - dikte 3mm
- Vulstaven:
 - hoogte 14mm
 - dikte 2mm
- Draagvermogen:
 - 300 kg/m²
- Max. doorbuiging:
 - 10,8mm

Stap

Deze roosters dienen als vloerplaten van de helling.

3D



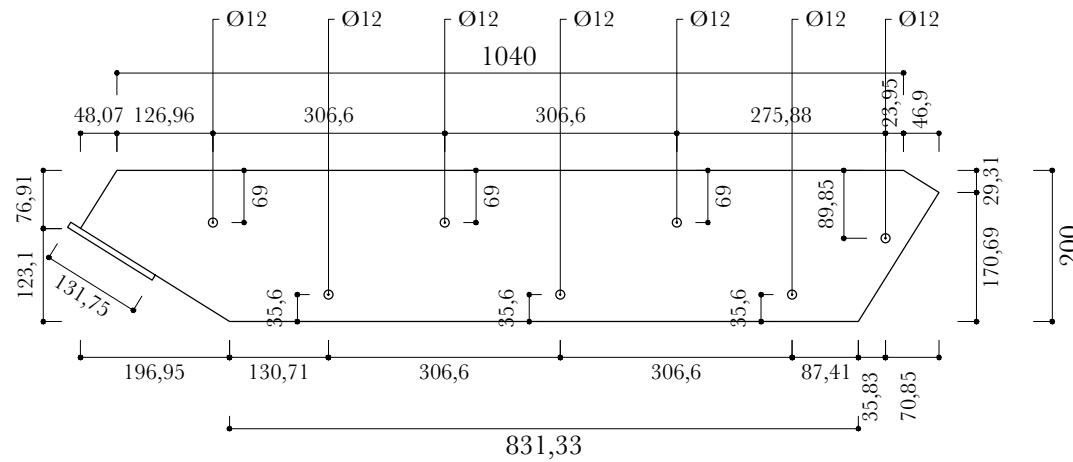
Staalplaat trap

Gegevens

- Stuks: 2
- Materiaal: Staal
- Dikte: 8mm

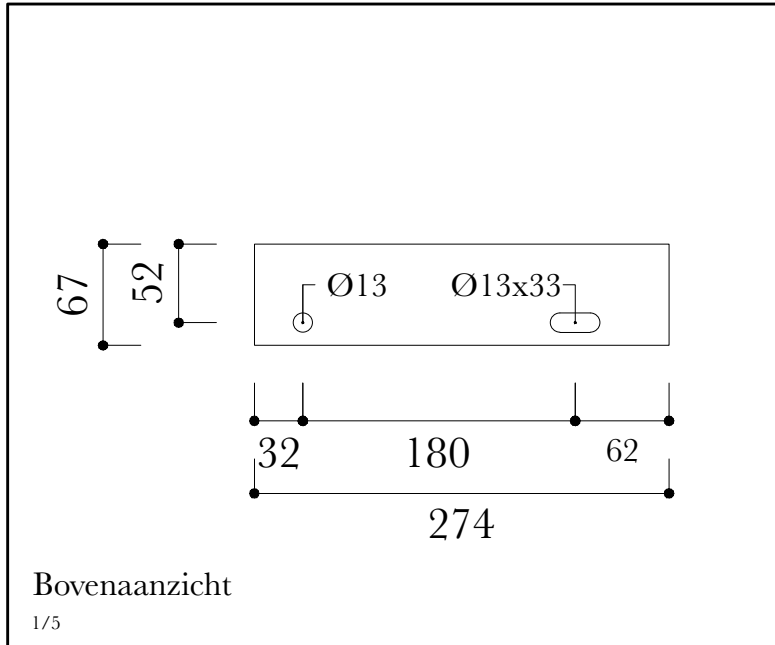
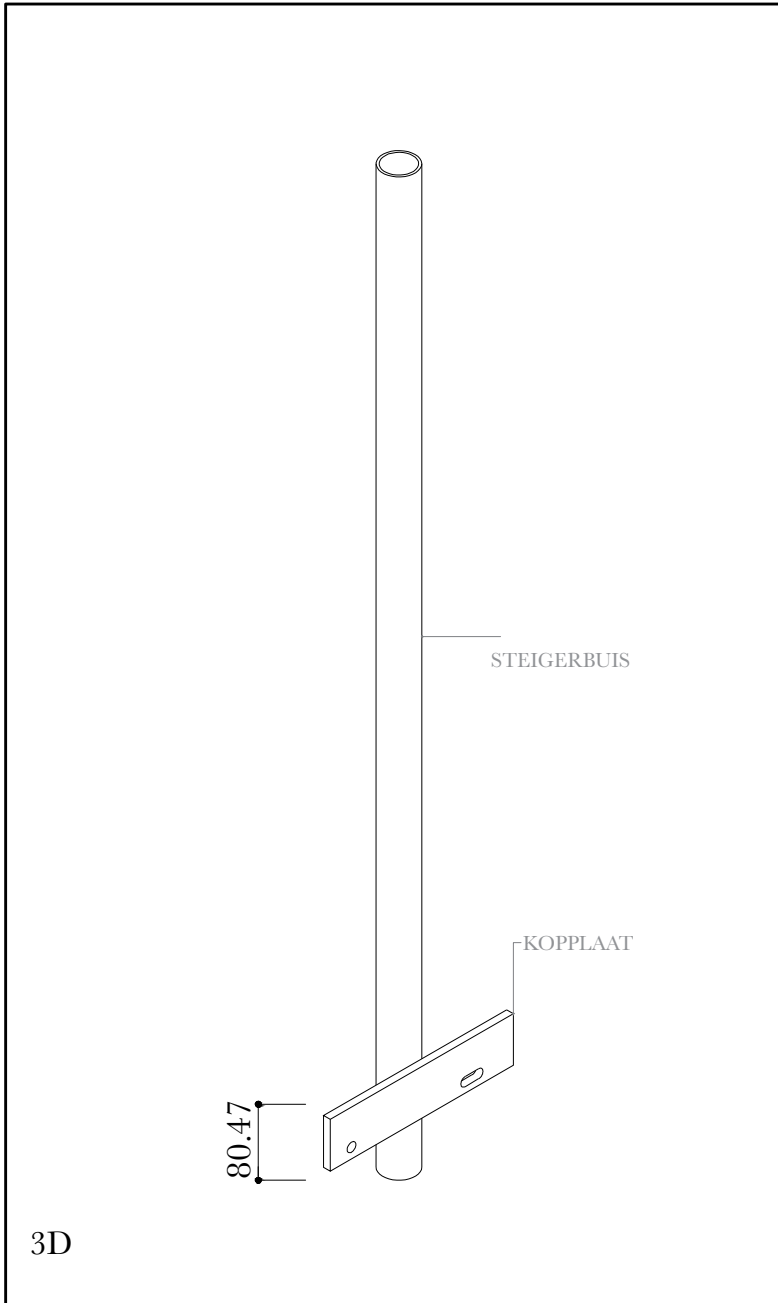
Stap

Er wordt een staalplaat met dikte 8mm gebruikt waarin gaten worden voorzien. Deze wordt uiteindelijk op een kleinere staalplaat van 8mm dikte gelast om het geheel van stijfheid te voorzien wanneer het de grond raakt.



Zijaanzicht

1/10



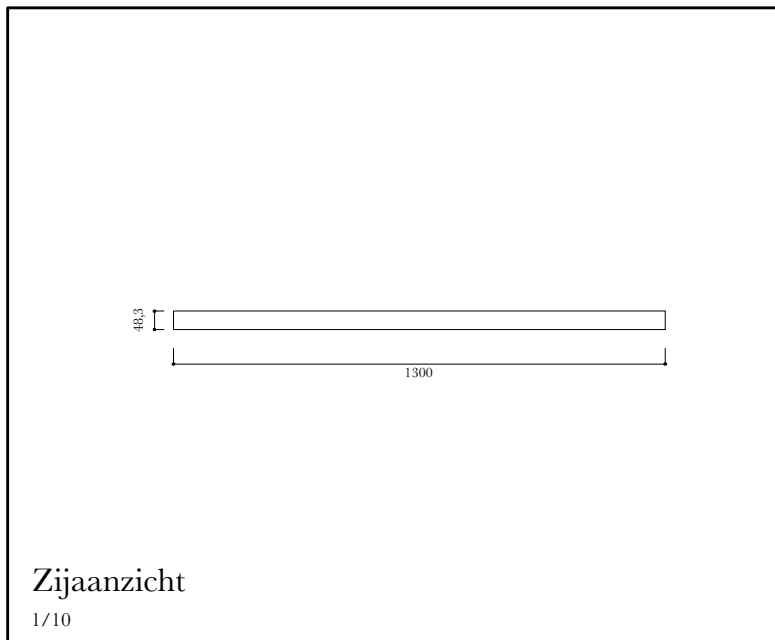
Kopplaat trap

Gegevens

- Stuks: 1
- Materiaal: Staal
- Dikte: 10 mm

Stap

Deze kopplaat wordt op de steigerbuis gelast. Het spiegelbeeld van deze plaat wordt vervolgens op een andere steigerbuis gelast.



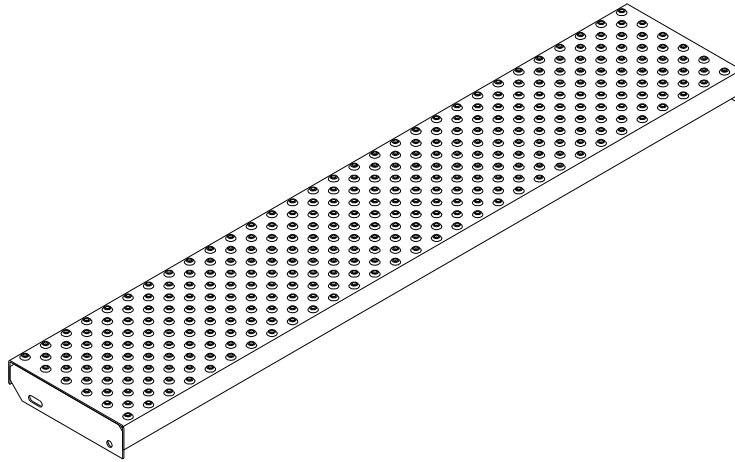
Steigerbuis

Gegevens

- Stuks: 1
- Materiaal: Staal
- Sectie: Ø48.3mm/3,25mm

Stap

Deze buis wordt over de steunvoet geschoven en er wordt een kopplaat opgelast op een hoogte van 14,5mm.



3D

Perfortreden

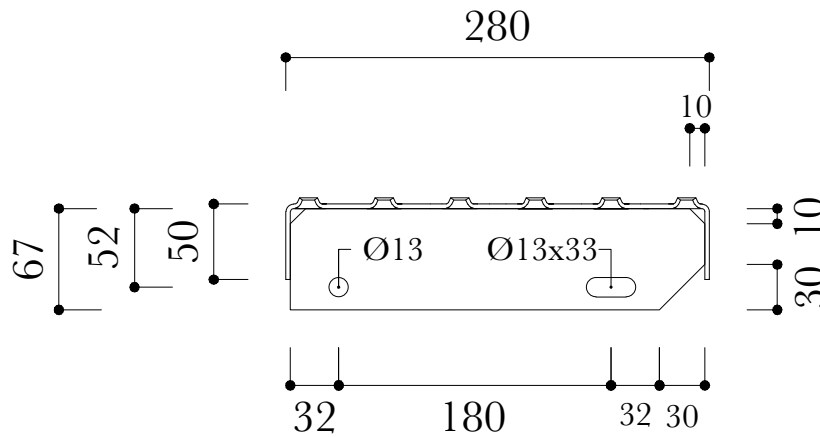
Type AP50 ZAA

Gegevens

- Stuks: 3
- Materiaal: Staal
- Doorbuiging: 7.5mm
- Dikte: 3mm
- Belasting: 7 daN

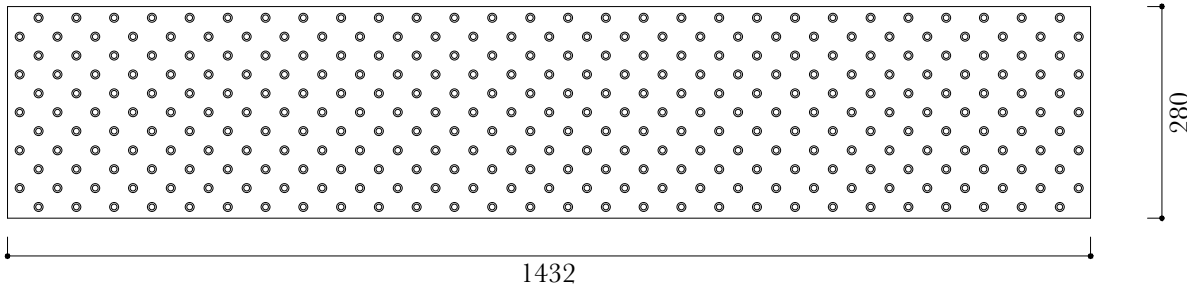
Stap

Dit zijn geprofileerde traptreden dewelke geperforeerd zijn met gaten van 8mm diameter. Aan de kopse kanten wordt een plaat ingelast om de verbinding met de staalplaat te maken.



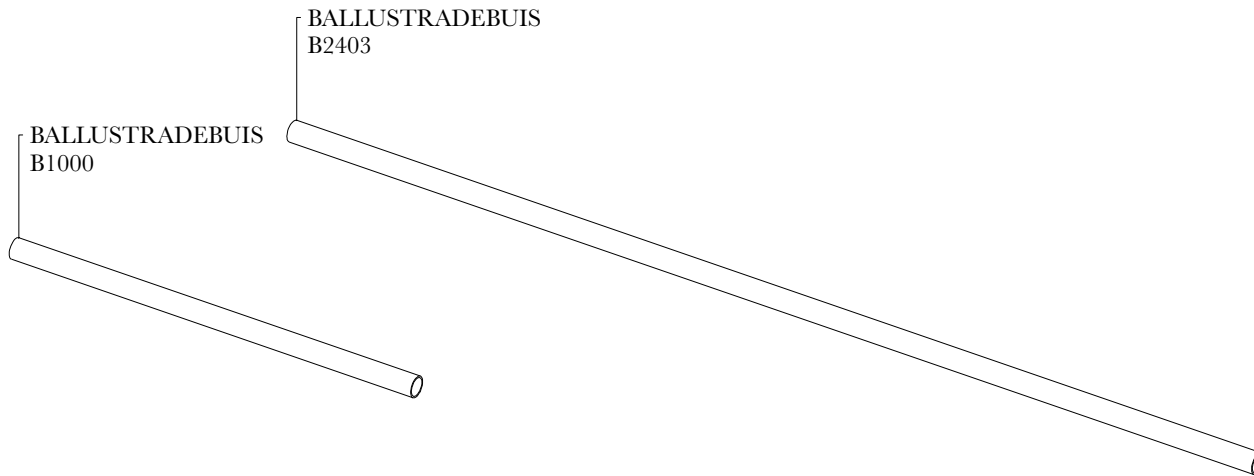
Zijaanzicht

1/5

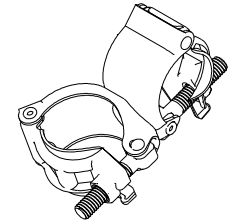


Bovenaanzicht

1/20



3D



3D

Ballustrade- buis

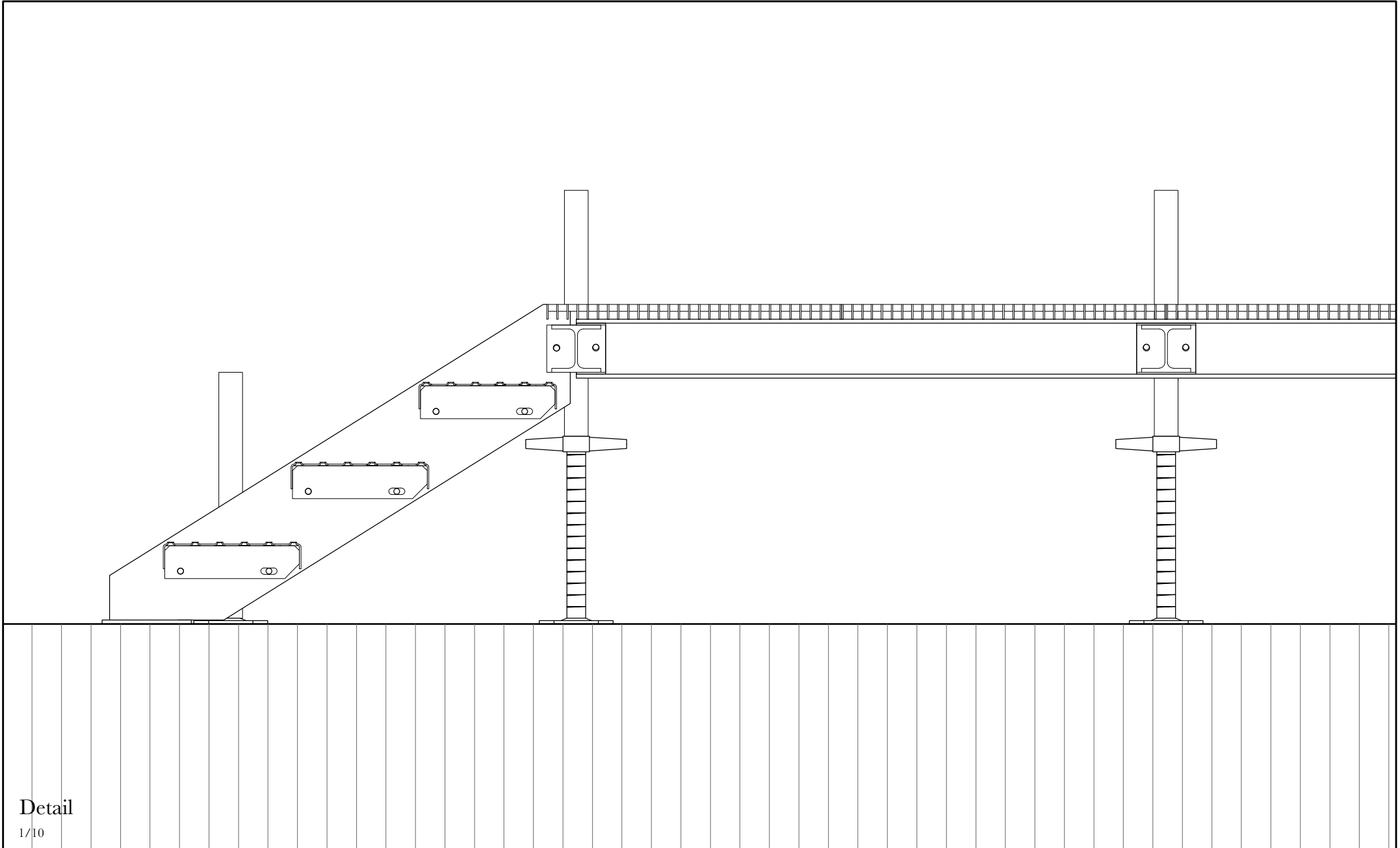
Type AP50 ZAA

Gegevens

- Stuks: B2403: 8 (2403mm)
B1000: 2 (1000mm)
- Draaikoppeling: 24
- Materiaal: Staal
- Sectie: Ø48.3mm/3,25mm

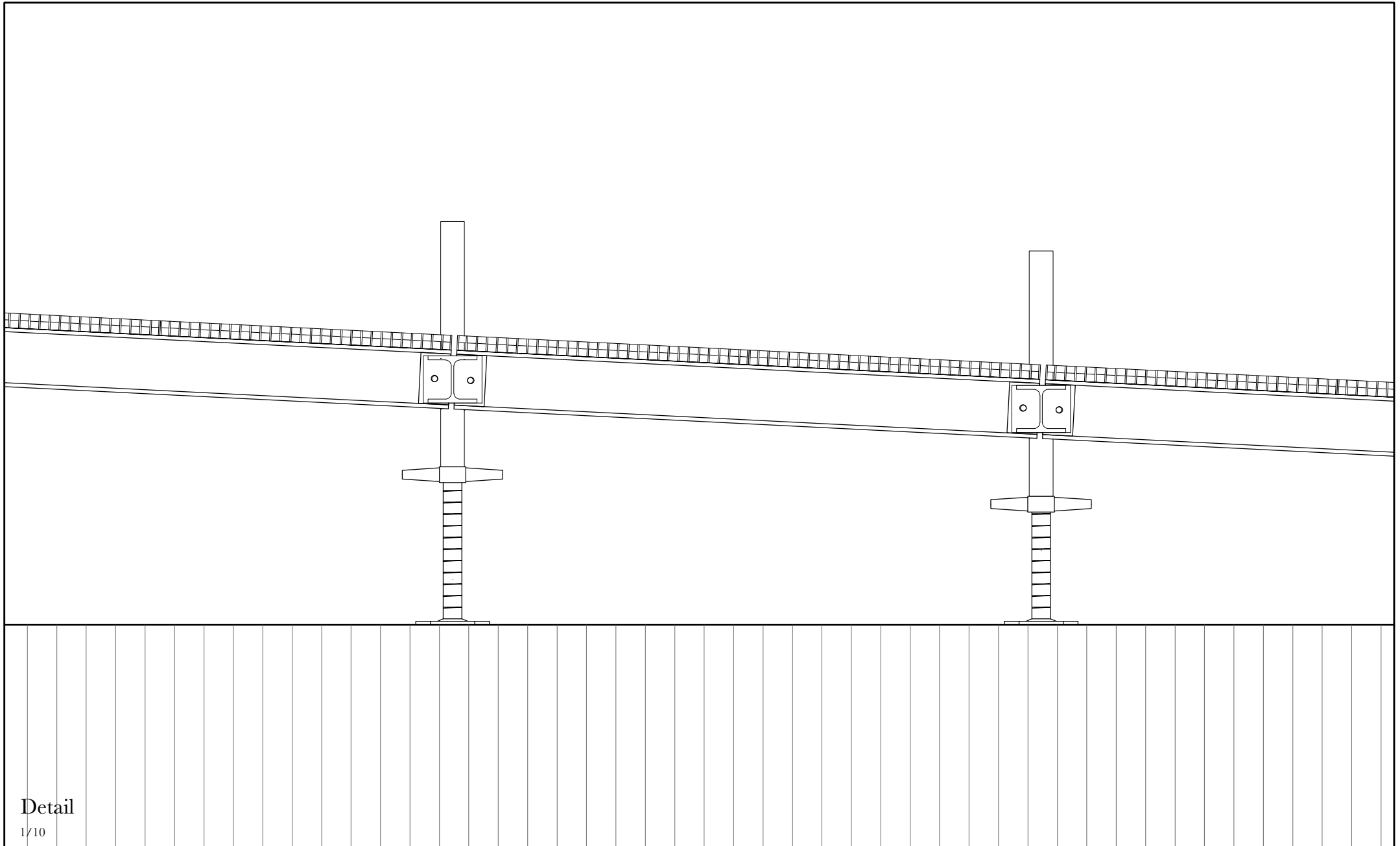
Stap

Deze buisprofielen worden gebruikt als ballustrade-buis of borstwering. Deze worden met de verticale ballustrade-buizen verbonden door middel van een draaikoppeling.



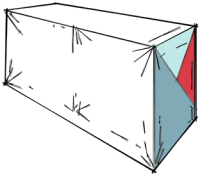
Detail

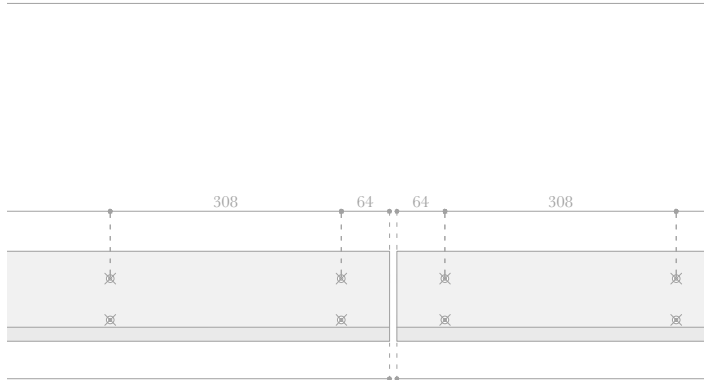
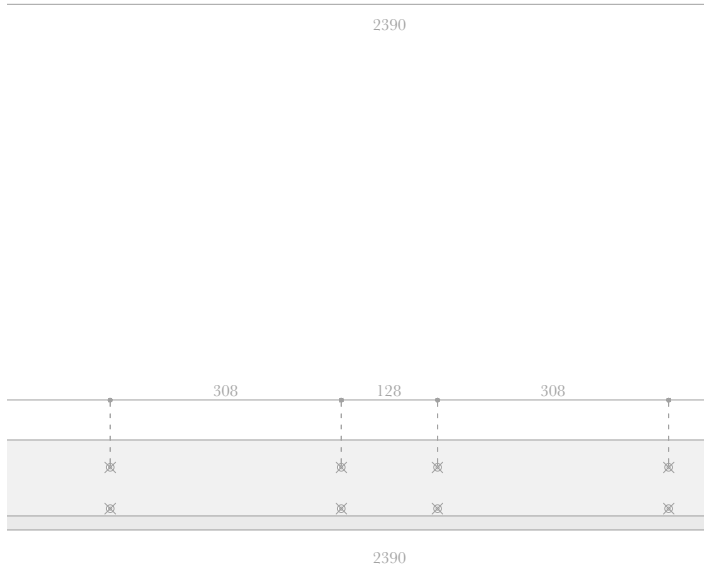
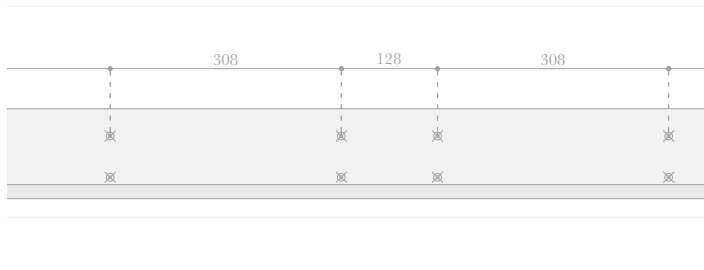
1/10



Detail

1/10





HOOFDSTUK

Technische uitwerking van paviljoen

INHOUDSTAFEL

6.1 Plannen

- 6.1.1 Varianten op de plattegrond
- 6.1.2 Ontwerpkeuzes, grondplannen en doorsnedes

6.2 Uitvoeringstekeningen

- 6.2.1. Kader
- 6.2.2. Stuklijst panelen
- 6.2.3. Stuklijst fundering, balkon en helling
- 6.2.4. Steunhaken
- 6.2.5. Buitenschrijnwerk

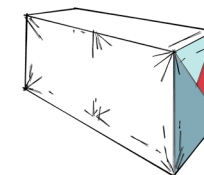
6.3 Interieur

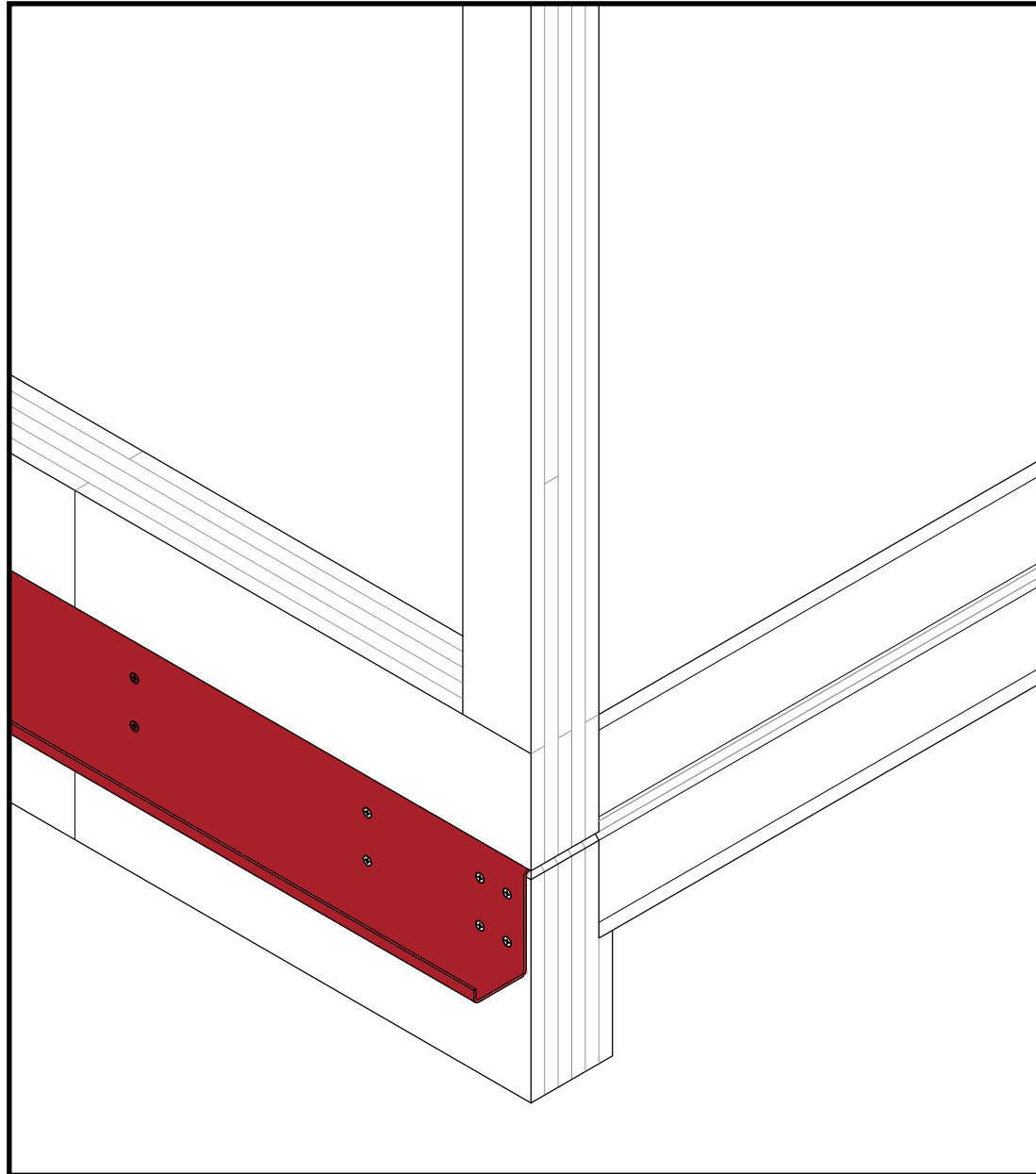
- 6.3.1 Schuifwanden
- 6.3.2 Lamp

WOORD VOORAF

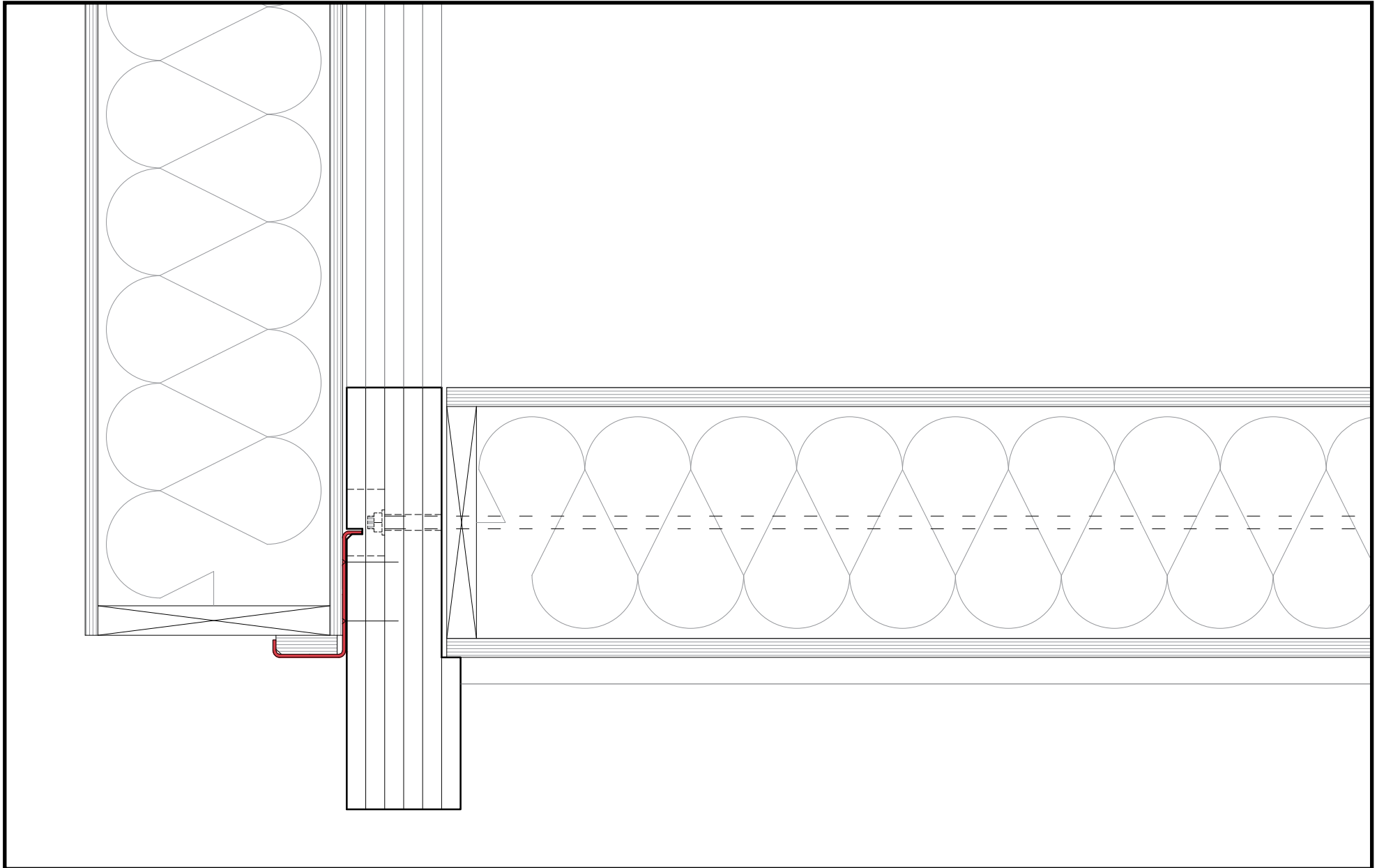
De steunhaken dienen als ondersteuning van de gevelpanelen en het buitenschrijnwerk. De steunhaken op de kopse zijden houden de twee kaders en de vloerpanelen bij elkaar. De haken worden geplaatst in een gleuf rondom de module, zie tekeningen volgende pagina.

In dit deel is een overzicht te vinden van de 'knip'-plannen, stuklijst en de plaatsing van de steunhaken.



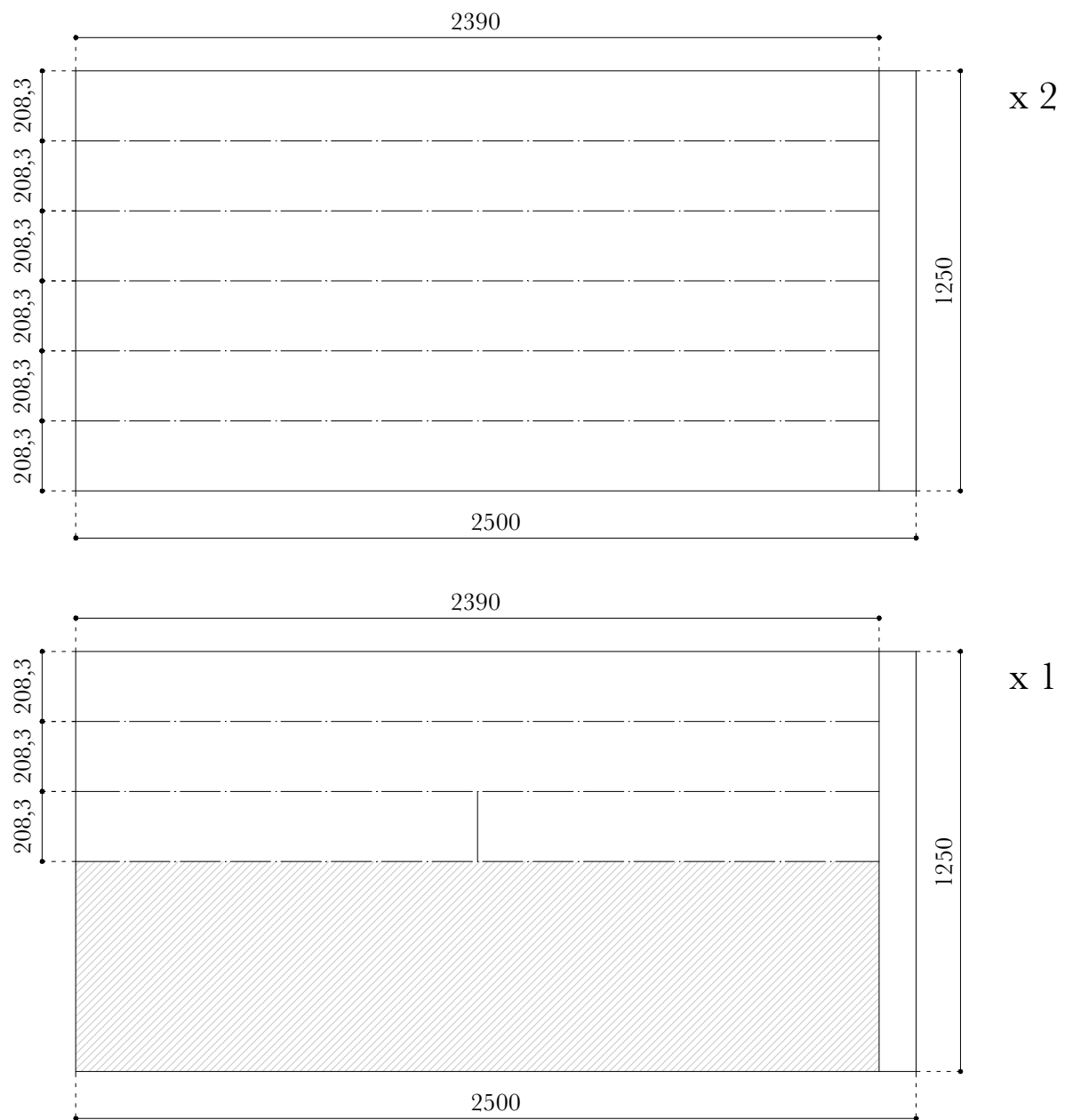


Figuur 1. Isometrie - Geplooid profiel in de gleuf van het kader.

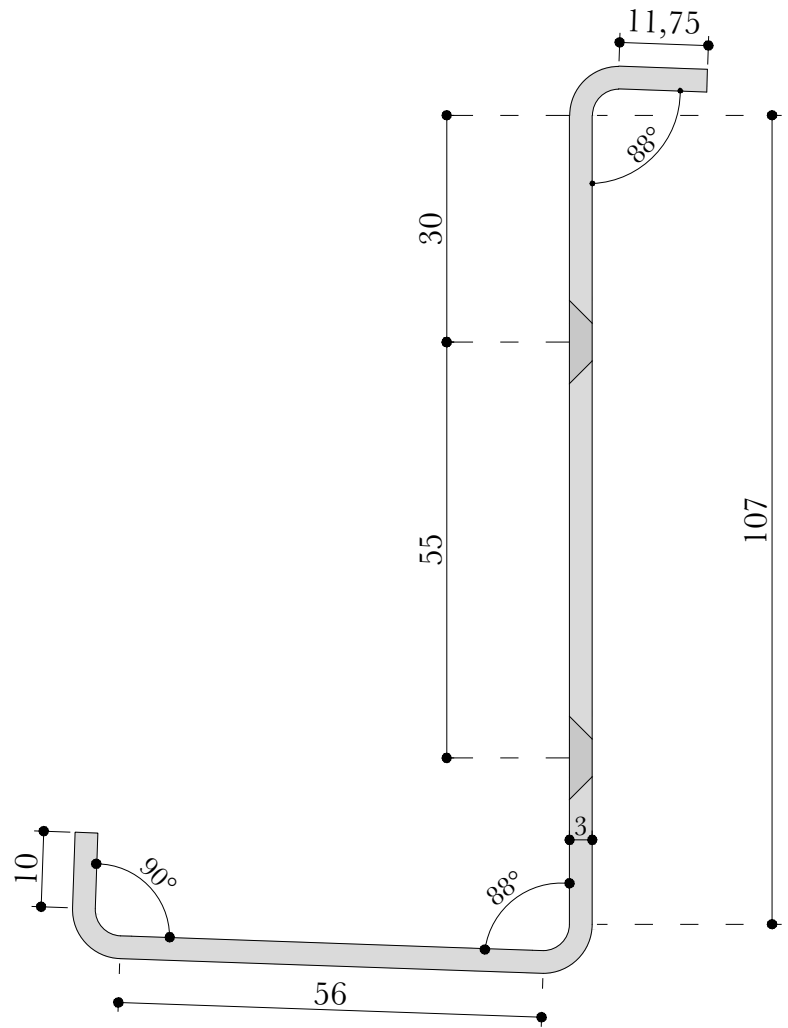


Figuur 2. Doorsnede 1/5 - Geplooid profiel in de gleuf van het kader - Bevestigingsstelsel van het gevelpaneel onderaan.

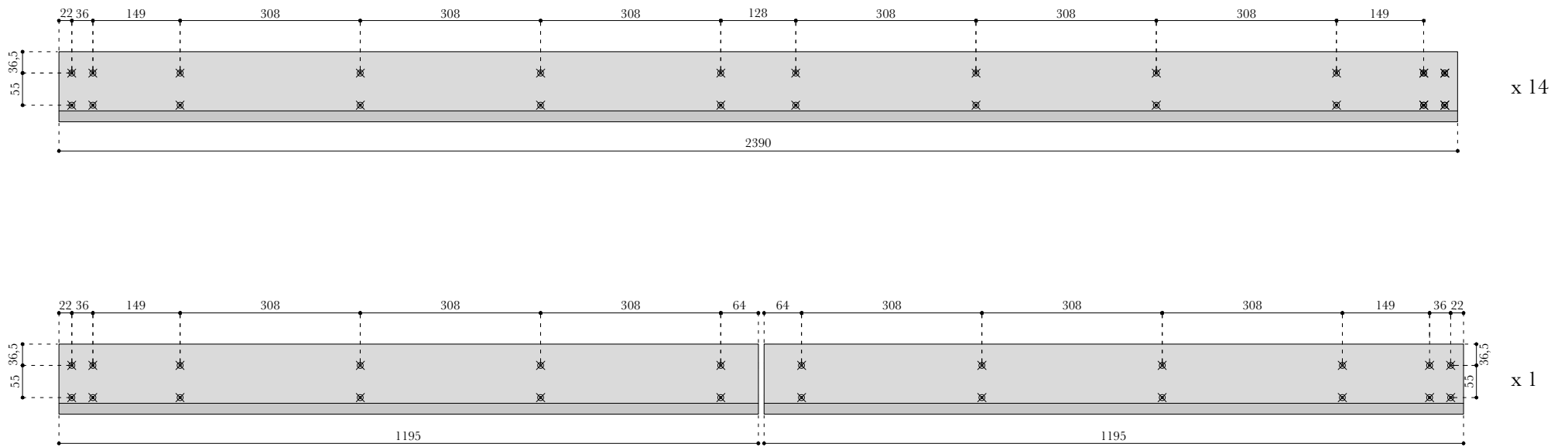
Sendzimir verzinkte platen
2500 x 1250 x 3 mm



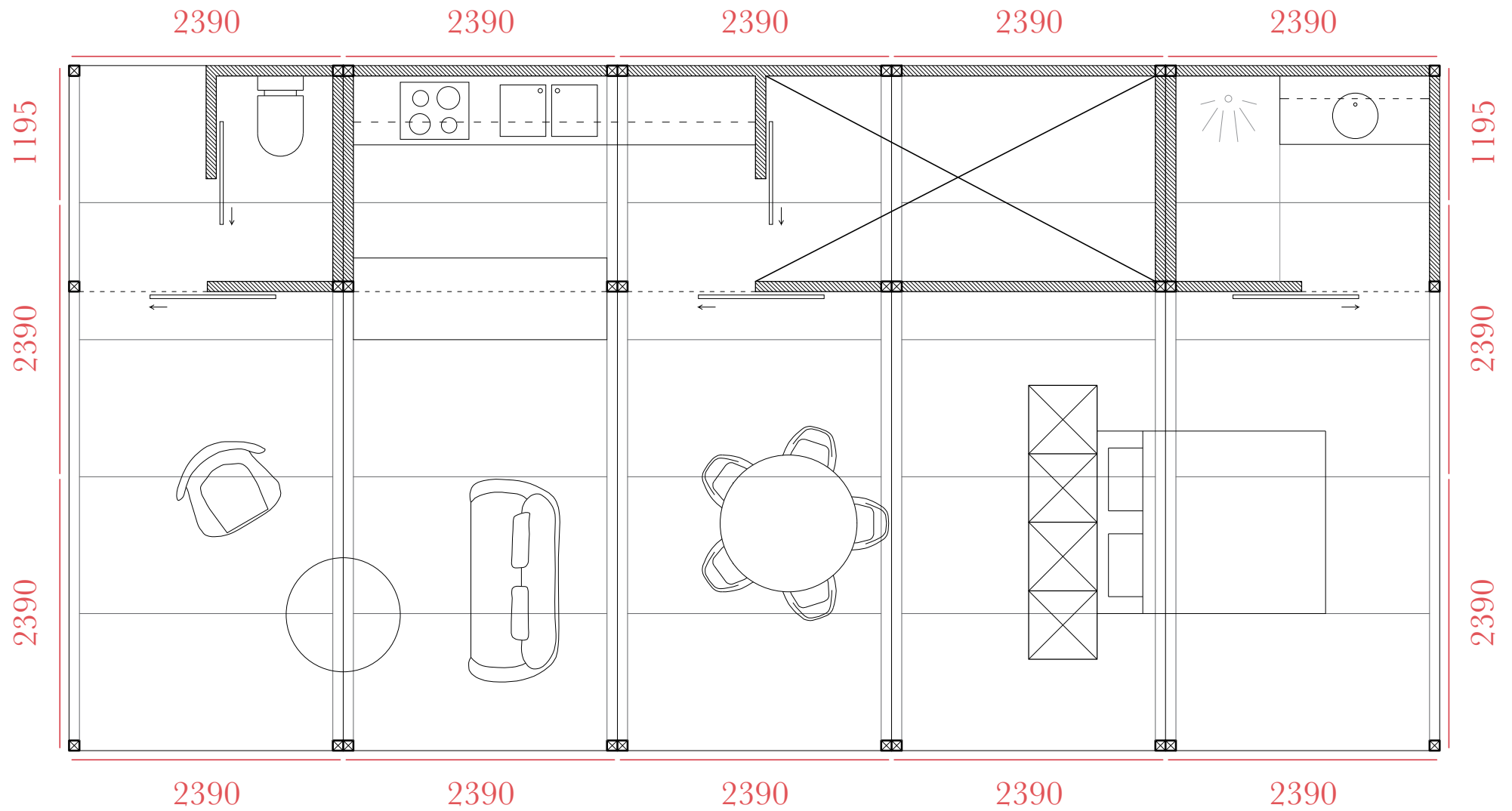
Figuur 3. Plan 1/20 - 'Knip'-plan.



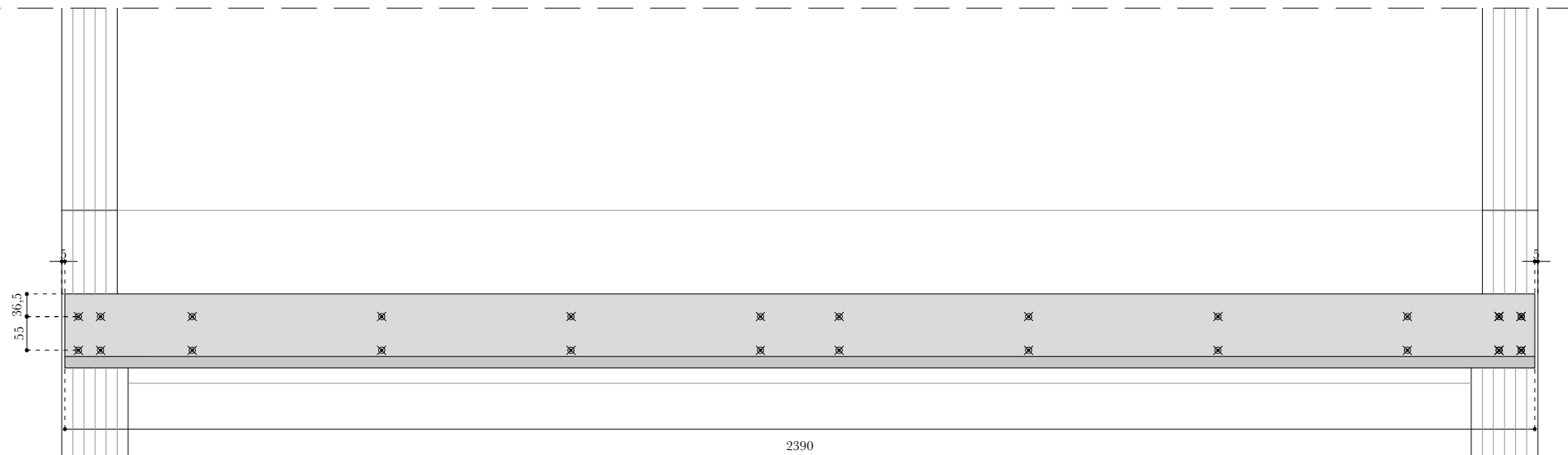
Figuur 4. Doorsnede geplooid profiel 1/2.



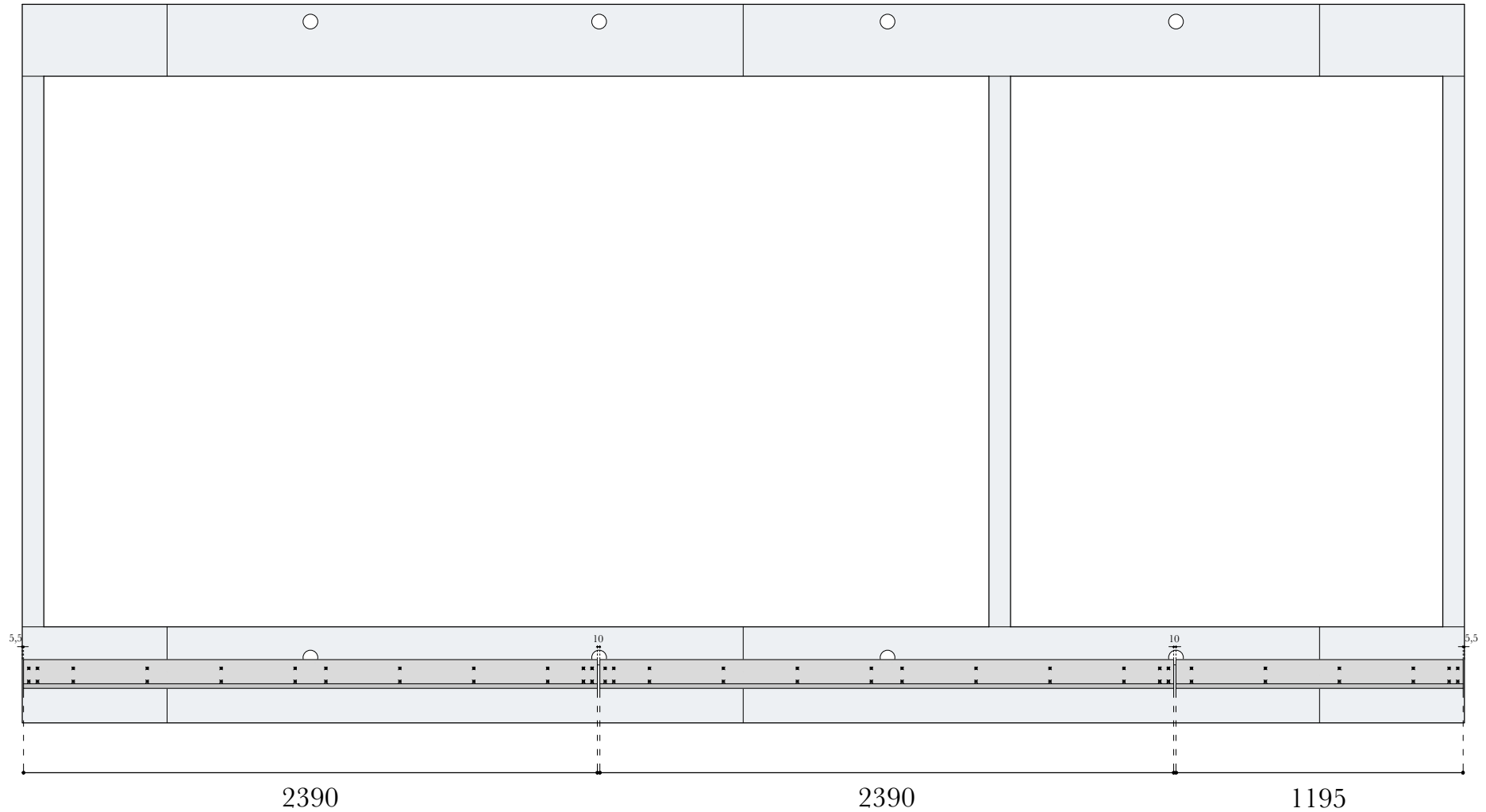
Figuur 5. Stuklijst 1/10. Het bovenste profiel in twee geknipt geeft het onderste profiel.



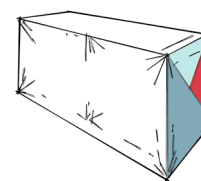
Figuur 6. Grondplan 1/50 - Aanduiding plaatsing van de geplooid profielen - Op de kopse zijden wordt altijd het profiel met breedte 2390mm gebruikt. De langse zijde bevat twee stukken van 2390mm en één stuk van 1195mm.

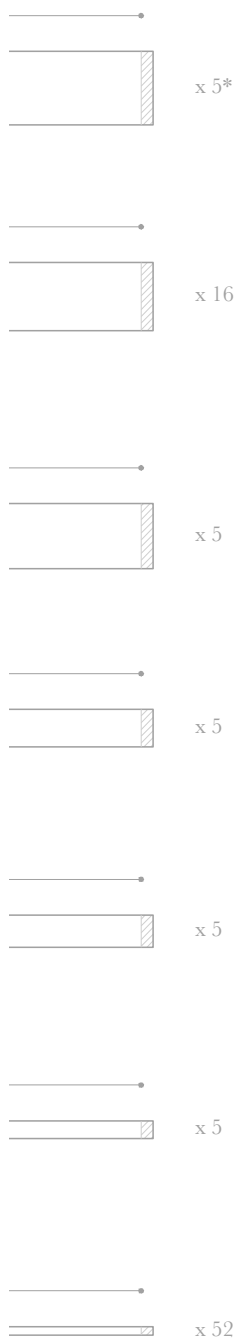


Figuur 7. Aanzicht 1/10 - Gedetailleerde aanduiding van de plaatsing van het geplooid profiel op de kopse zijde van de module.



Figuur 8. Aanzicht 1/25 - Gedetailleerde aanduiding van de plaatsing van de geplooid profielen op de langse zijde van de module.





A2

243

Schrijnwerk deu

D2

215

Schrijnwerk deu

J2

124

Schrijnwerk deu

K2

106

Schrijnwerk deu

N2

58

Onderlat gevelpa

G1

160

Kopse plaat huij

G1

160

Kopse plaat huij

HOOFDSTUK

Technische uitwerking van paviljoen

WOORD VOORAF

De zaagplannen, de afkortplannen en de plaatsing van de verschillende onderdelen van het buitenschrijnwerk komen in deze bundel aan bod.

INHOUDSTAFEL

6.1 Plannen

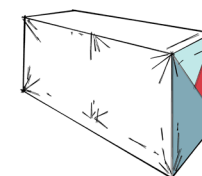
- 6.1.1 Varianten op de plattegrond
- 6.1.2 Ontwerpkeuzes, grondplannen en doorsnedes

6.2 Uitvoeringstekeningen

- 6.2.1. Kader
- 6.2.2. Stuklijst panelen
- 6.2.3. Stuklijst fundering, balkon en helling
- 6.2.4. Steunhaken
- 6.2.5. Buitenschrijnwerk

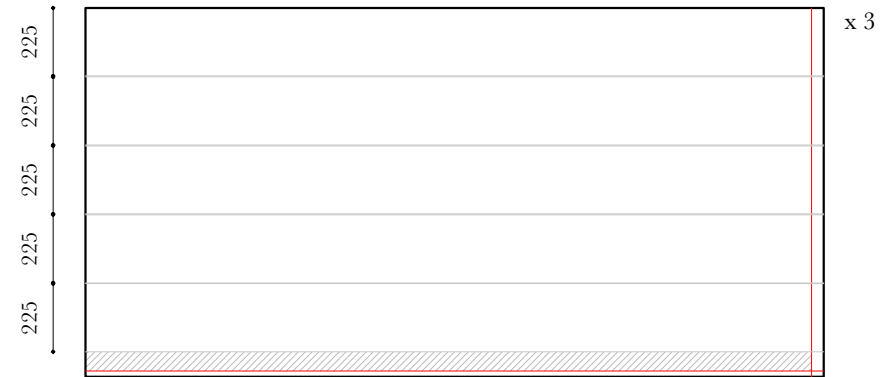
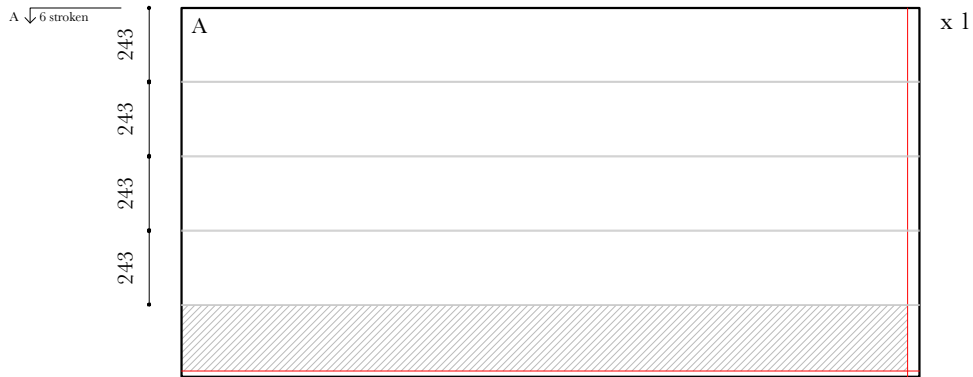
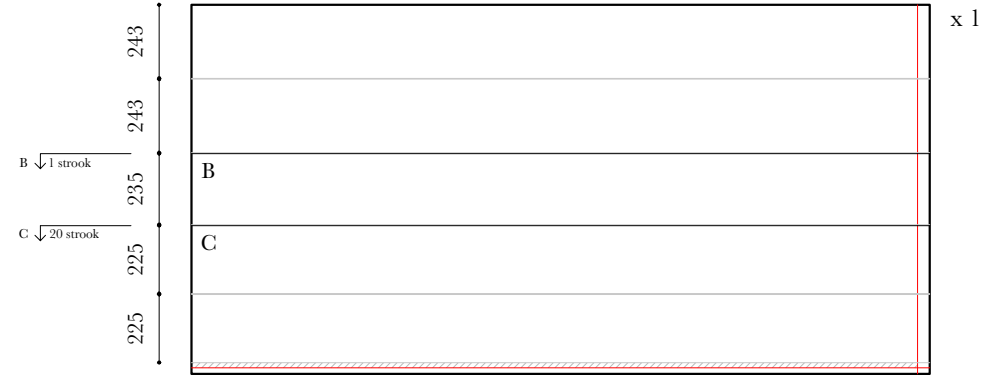
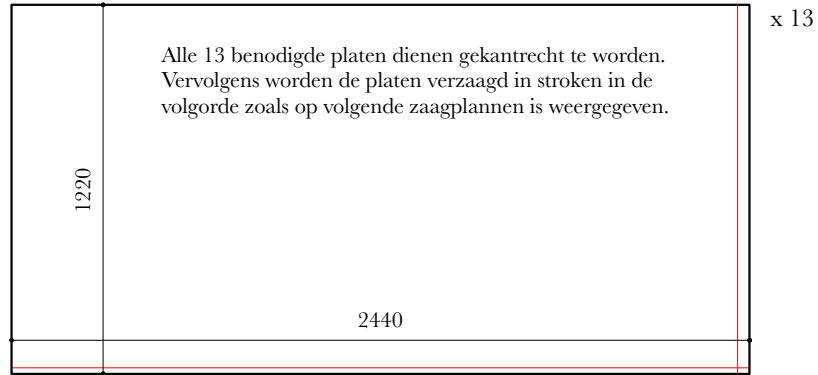
6.3 Interieur

- 6.3.1 Schuifwanden
- 6.3.2 Lamp

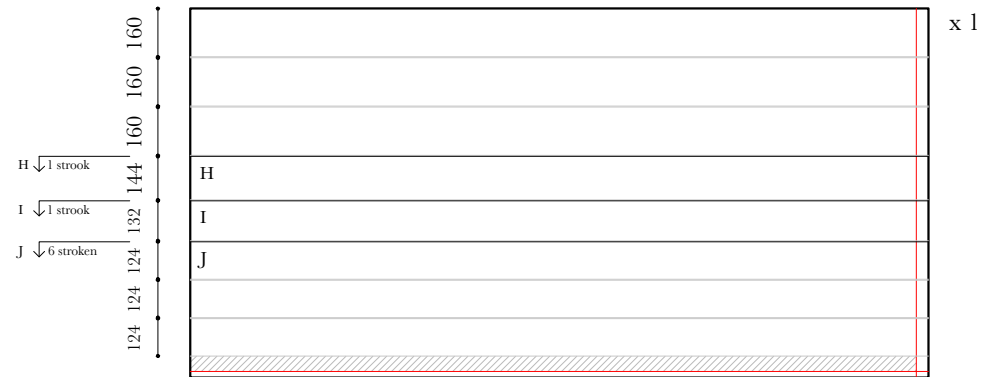
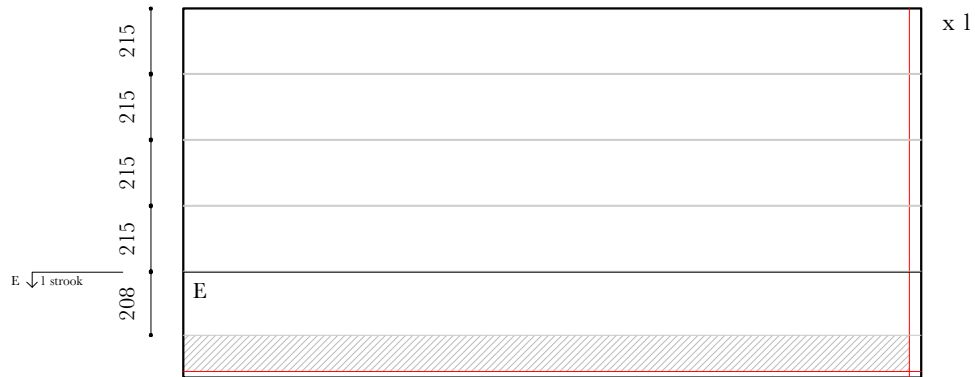
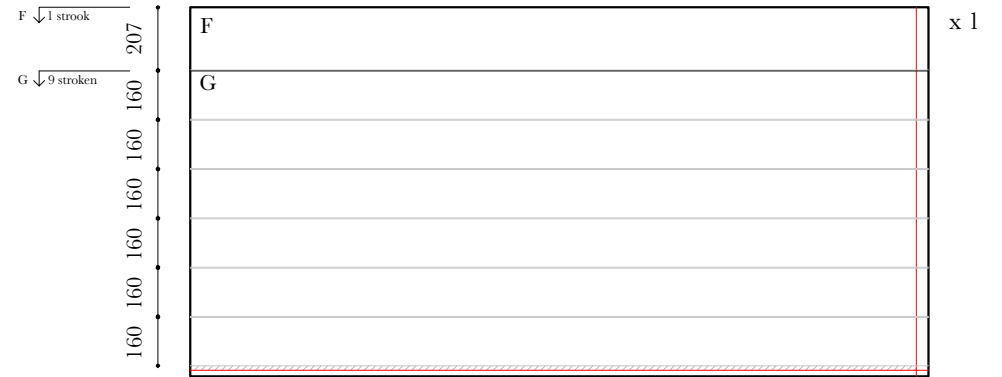
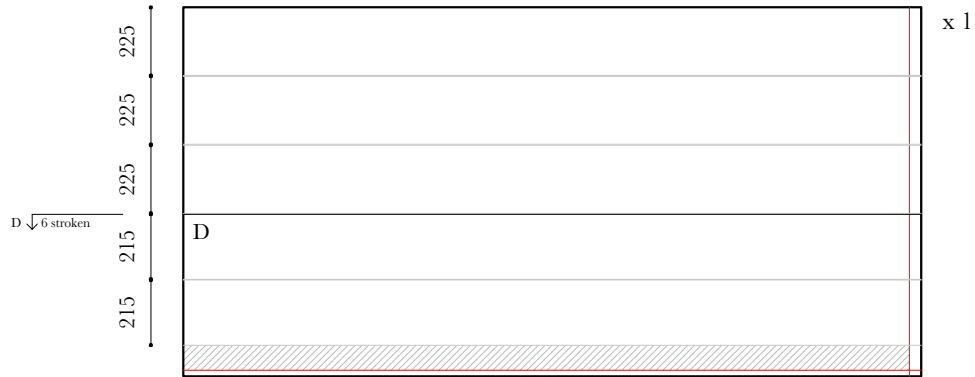


Legende:

A - 243mm - 6 stroken
B - 235mm - 1 strook
C - 225mm - 20 stroken
D - 215mm - 6 stroken
E - 208mm - 1 strook
F - 207mm - 1 strook
G - 160mm - 9 stroken
H - 144mm - 1 strook
I - 132mm - 1 strook
J - 124mm - 6 stroken
K - 106mm - 6 stroken
L - 91mm - 1 strook
M - 76mm - 1 strook
N - 58mm - 15 stroken
O - 28mm - 69 stroken



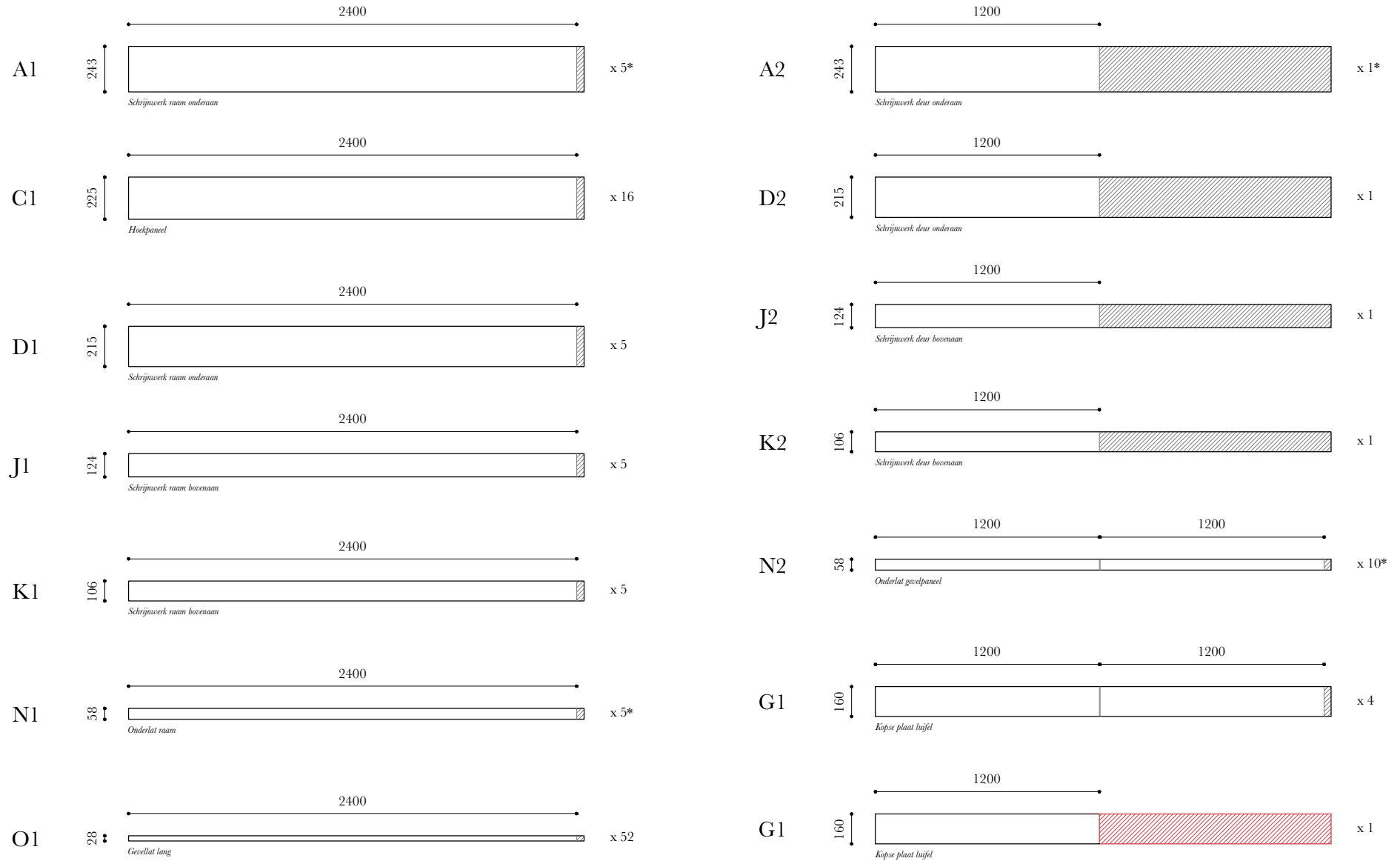
Figuur 1a. Zaagplan 1/25 - Belangrijk: respecteer de alfabetische volgorde! - Geef alle stroken de juiste letter.



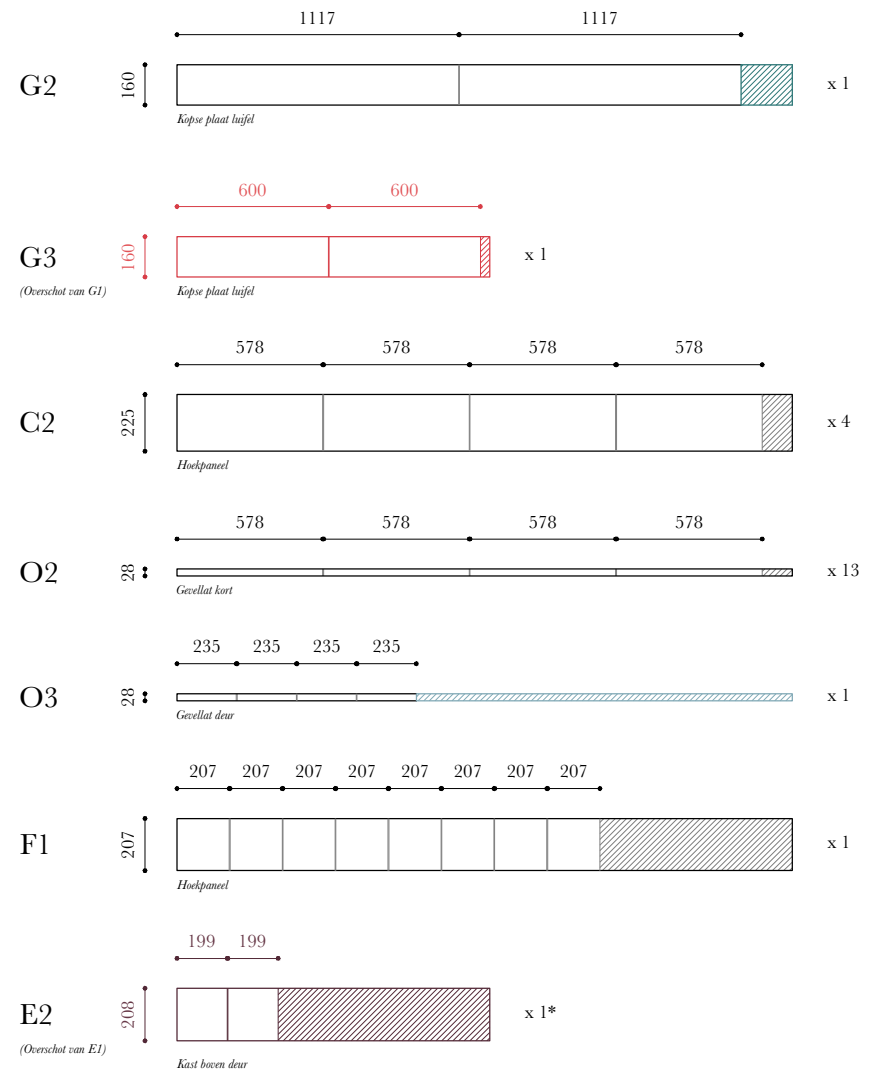
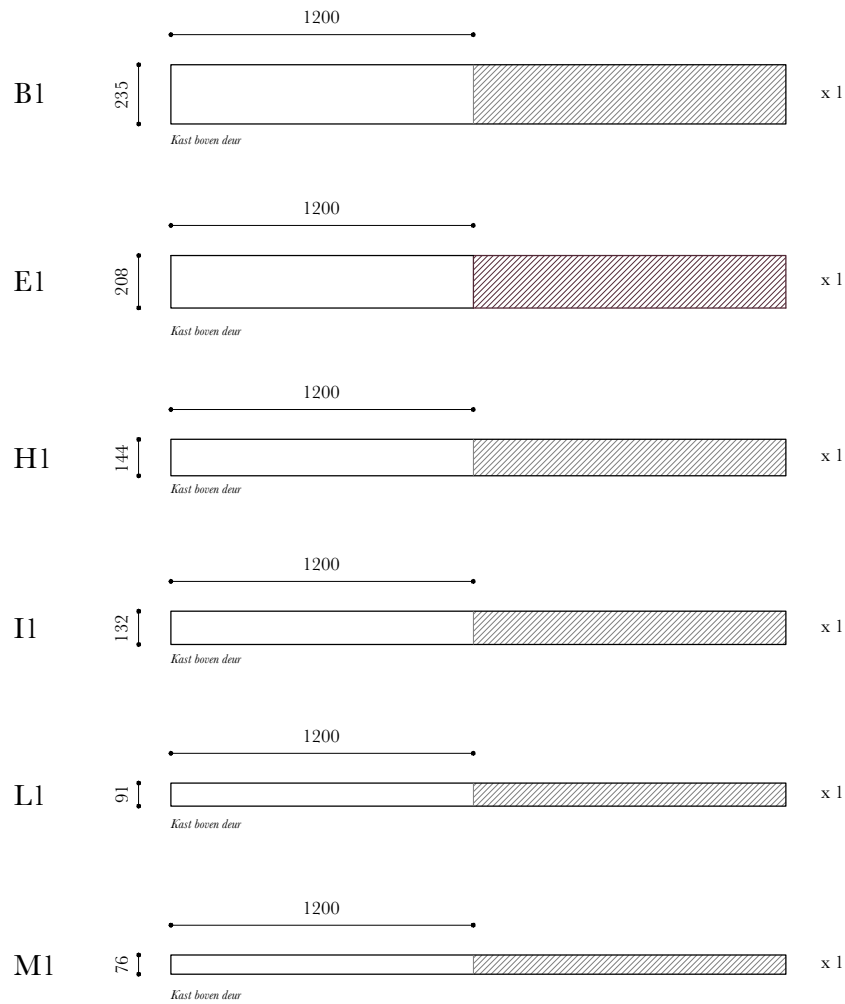
Figuur 1b. Zaagplan 1/25 - Belangrijk: respecteer de alfabetische volgorde! - Geef alle stroken de juiste letter.

Opmerkingen:

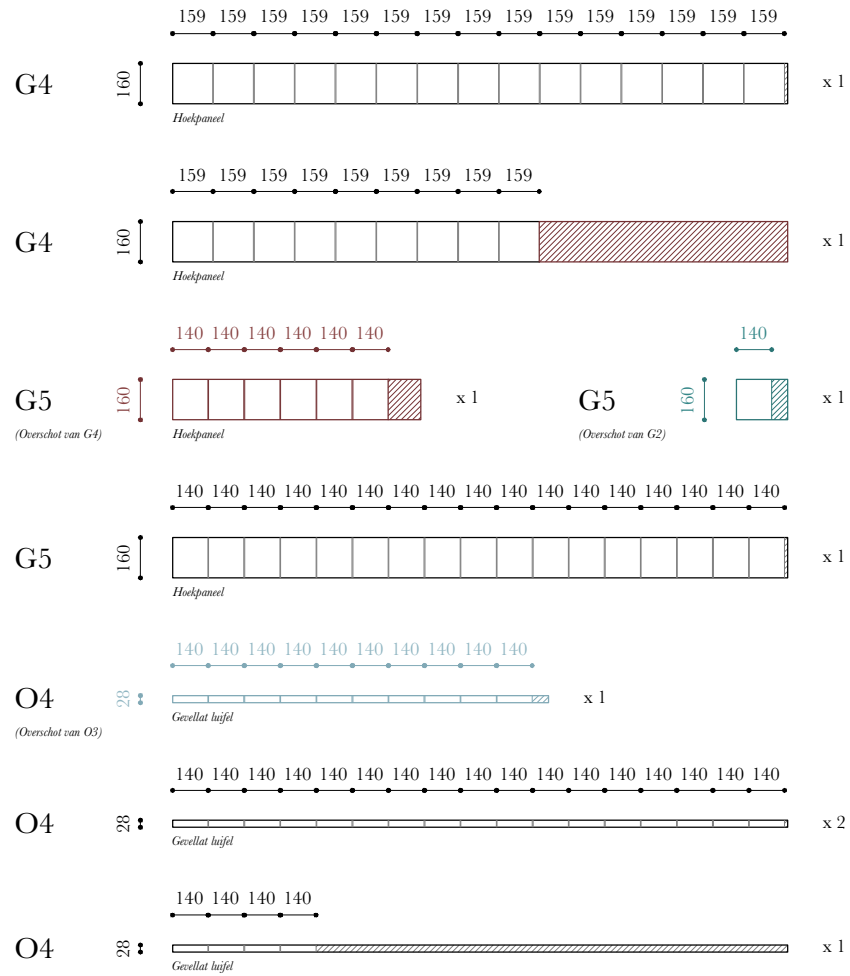
- De gekleurde arceerde stukken (overschot) worden later in het afkortplan opnieuw verzaagd.
- Er is telkens als geheugensteun een korte beschrijving toegevoegd om snel te achterhalen waar het desbetreffende stuk moet komen.
- Bij de onderdelen A1, A2, N1, N2 en E2 staat een asterisk (*). Dit duidt aan dat er nog een bewerking zal moeten toegepast worden alvorens de verschillende componenten samen te stellen.



Figuur 2a. Afkortplan 1/30 - Geef alle onderdelen de juiste codering zoals weergegeven.

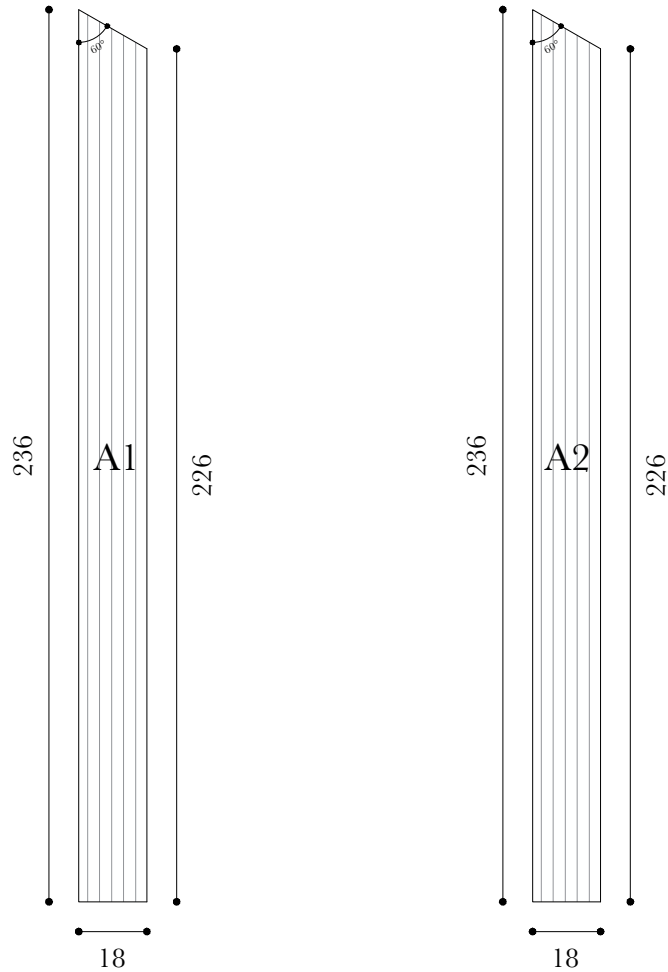


Figuur 2b. Afkortplan 1/30 - Geef alle onderdelen de juiste codering zoals weergegeven.

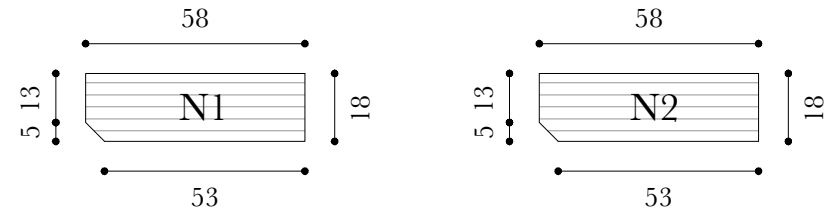


Figuur 2c. Afkortplan 1/30 - Geef alle onderdelen de juiste codering zoals weergegeven.

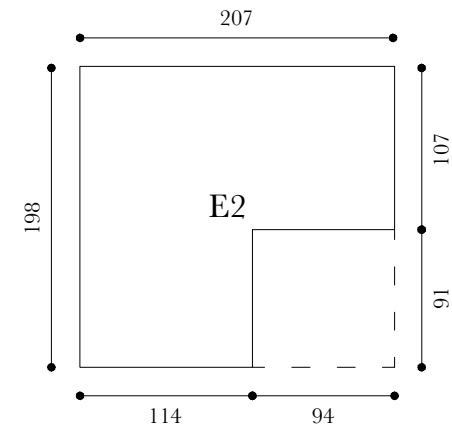
De onderdelen A1, A2, N1, N2 en E2 moeten als volgt bijgewerkt worden:



Figuur 3a. De schuine rand dient voor de afwatering aan het raam (A1) en deur (A2) - 1/2.

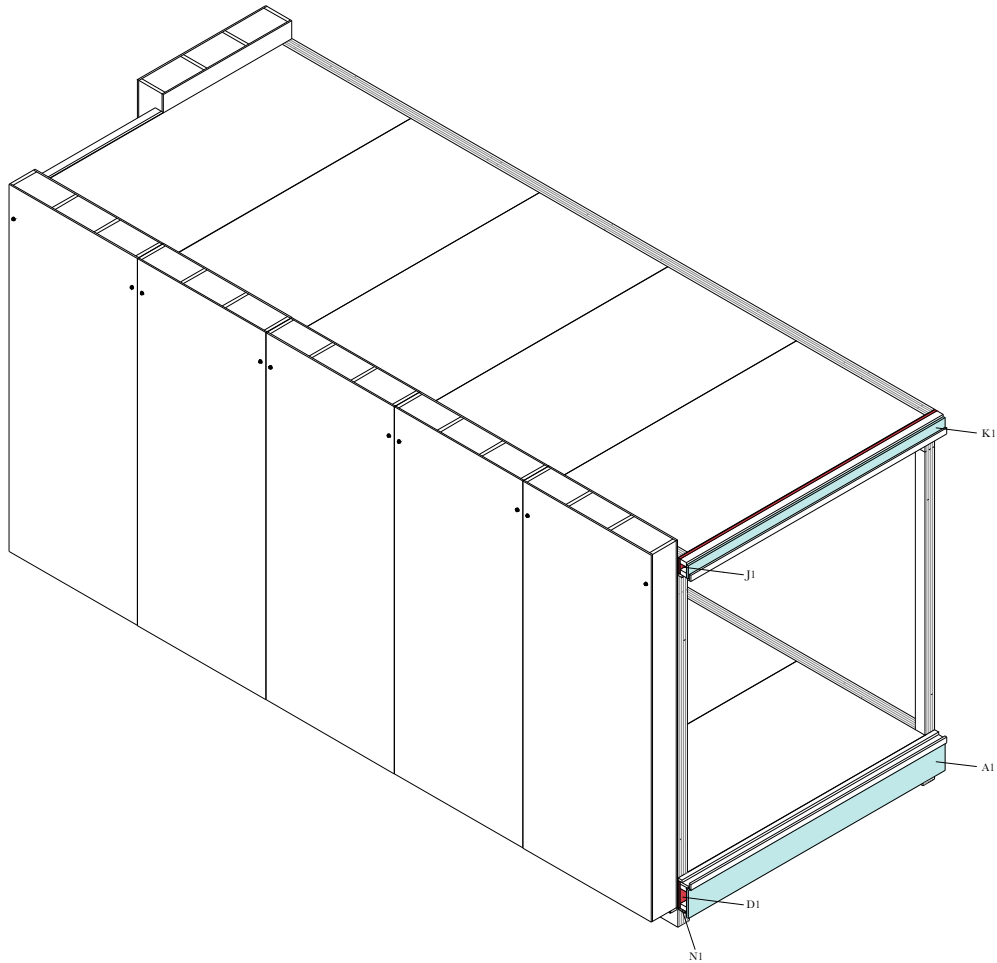


Figuur 3b. De schuine rand dient voor een vlottere plaatsing van de wandpanelen in de steunhaken - 1/2.

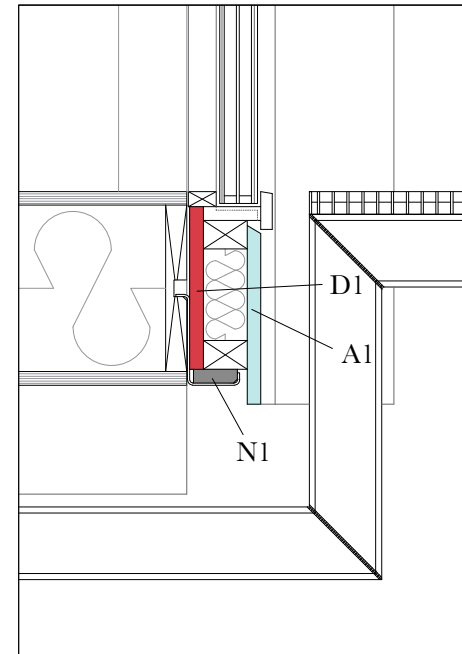
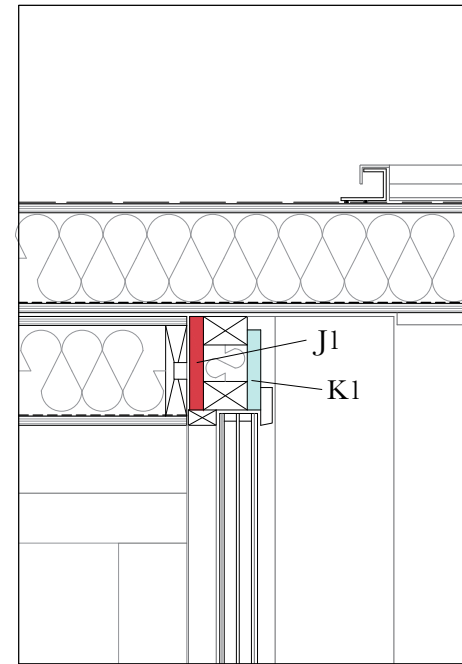


Figuur 3c. Kast boven het schrijnwerk van de deur - Kast kan weggenomen worden om door te stapelen (zie snede pag. 6.1.2 -15) - 1/5.

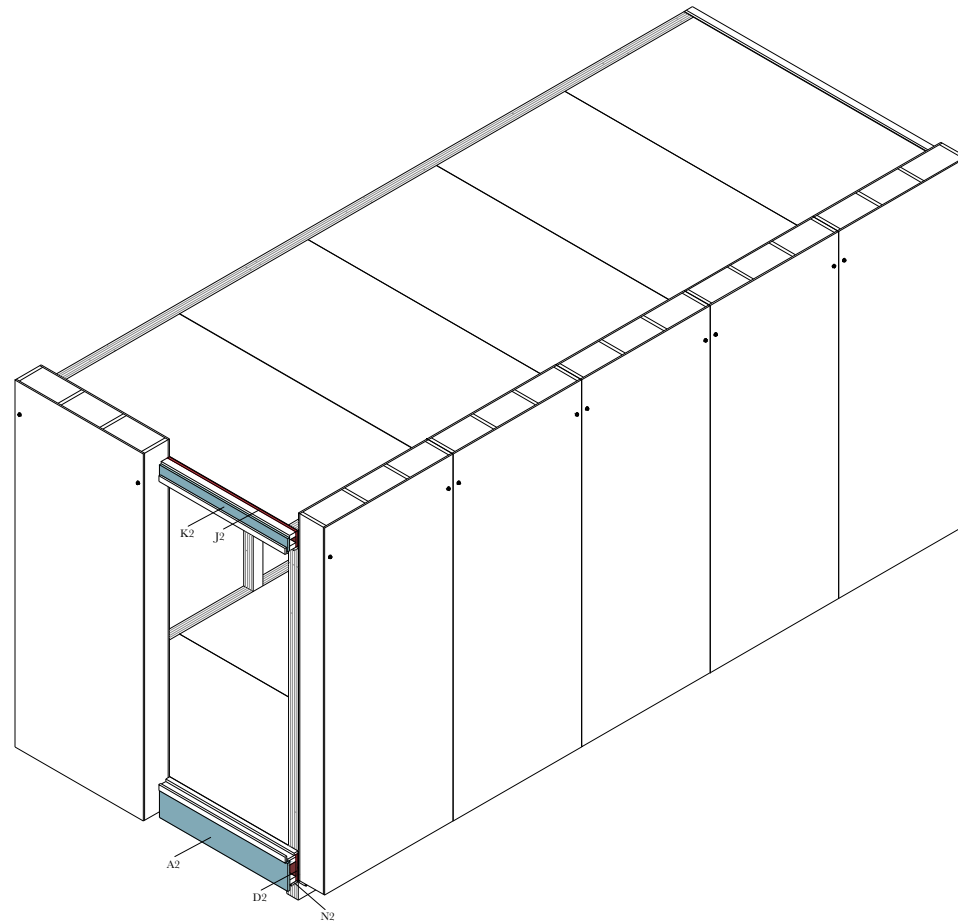
De volgende tekeningen illustreren waar de verschillende onderdelen moeten komen.



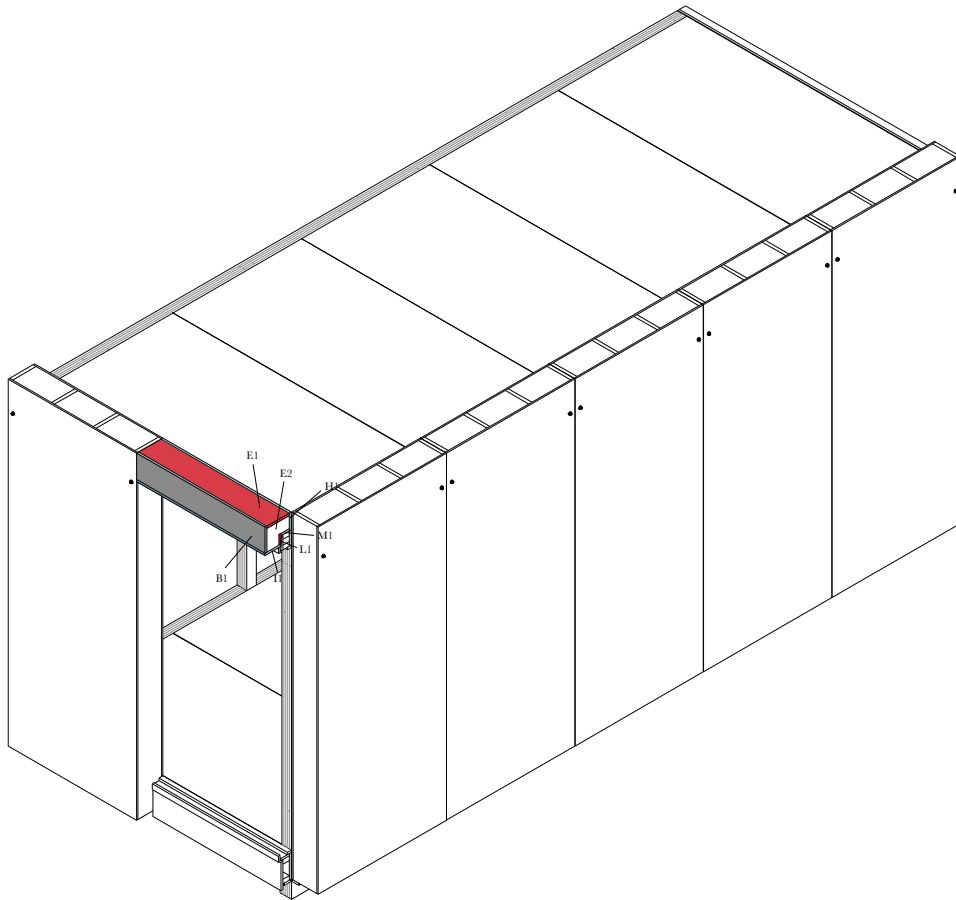
Figuur 4. Isometrie - Schrijnwerk onder en boven het raam.



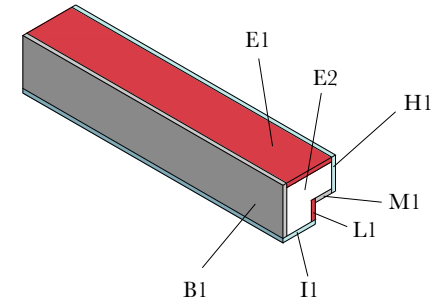
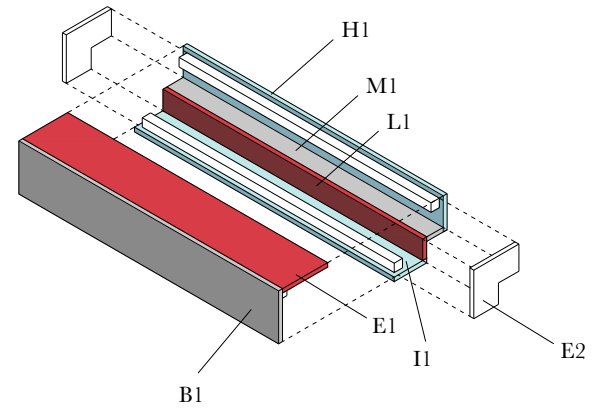
Figuur 5. Detail 1/10 - Schrijnwerk onder en boven het raam.



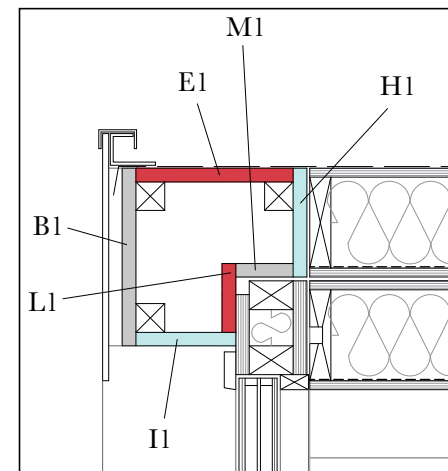
Figuur 6. Isometrie - Schrijnwerk onder en boven de deur - Zelfde principe als bij het raam.



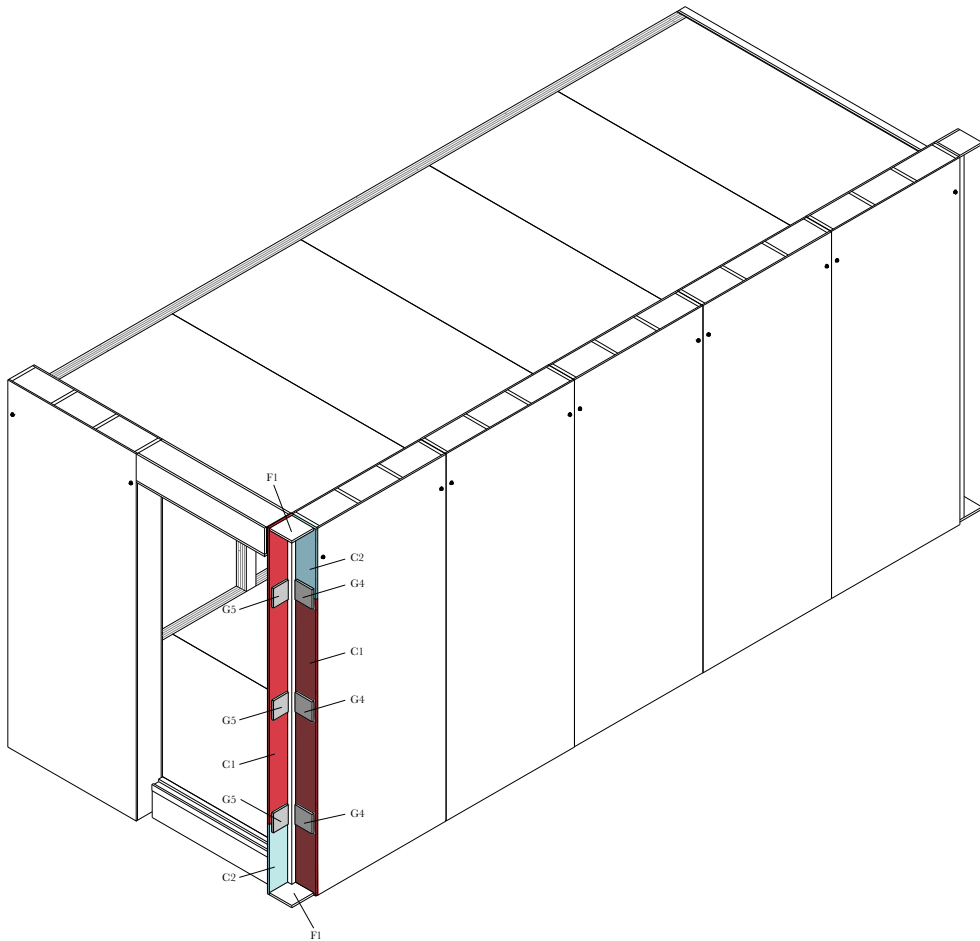
Figuur 7. Isometrie - Wegneembare kast boven schrijnwerk van de deur.



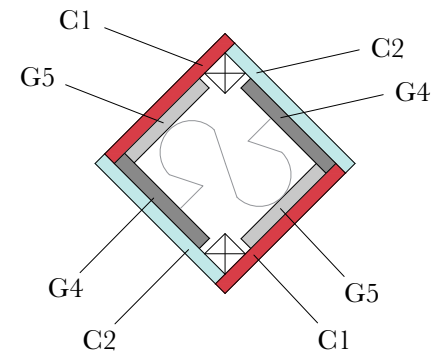
Figuur 8. Isometrie - Samenstelling kast boven schrijnwerk van de deur.



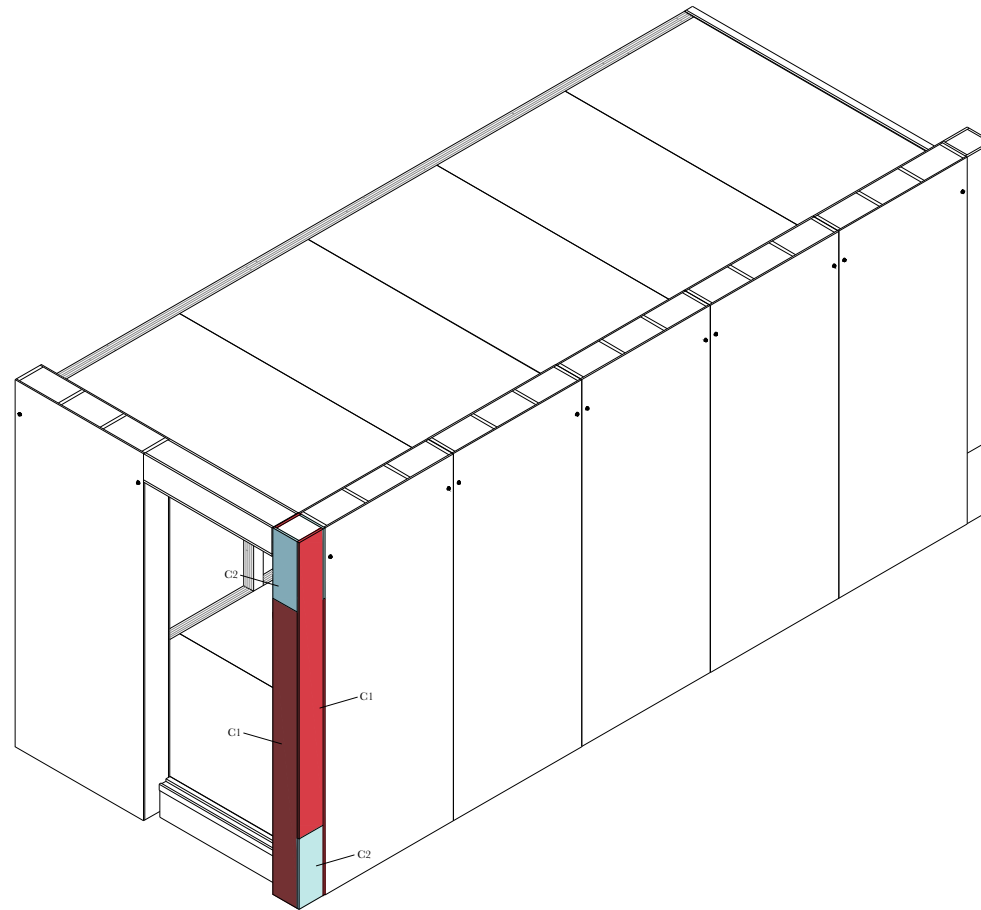
Figuur 9. Detail 1/10 - Kast boven schrijnwerk van de deur.



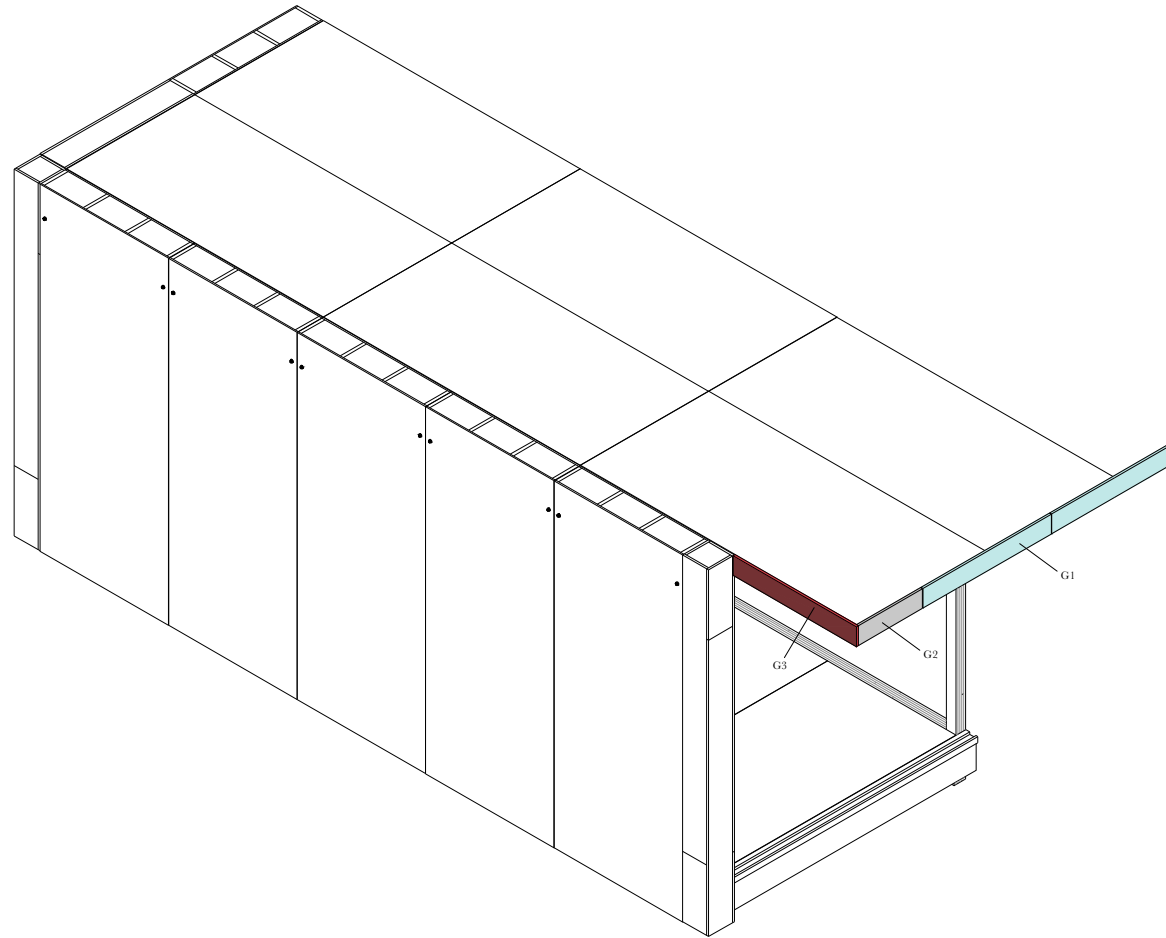
Figuur 10. Isometrie - Hoekpaneel in open toestand.



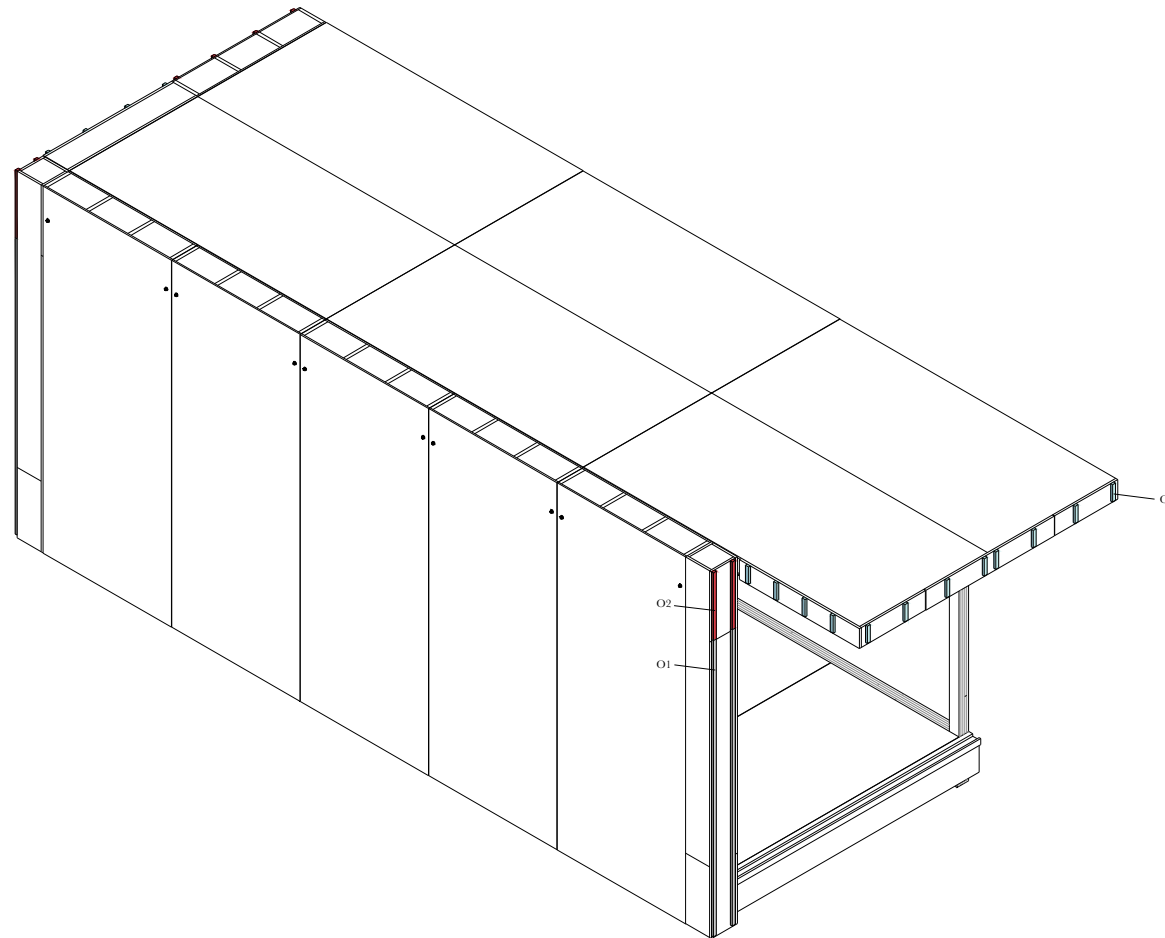
Figuur 11. Detail 1/10 - Hoekpaneel.



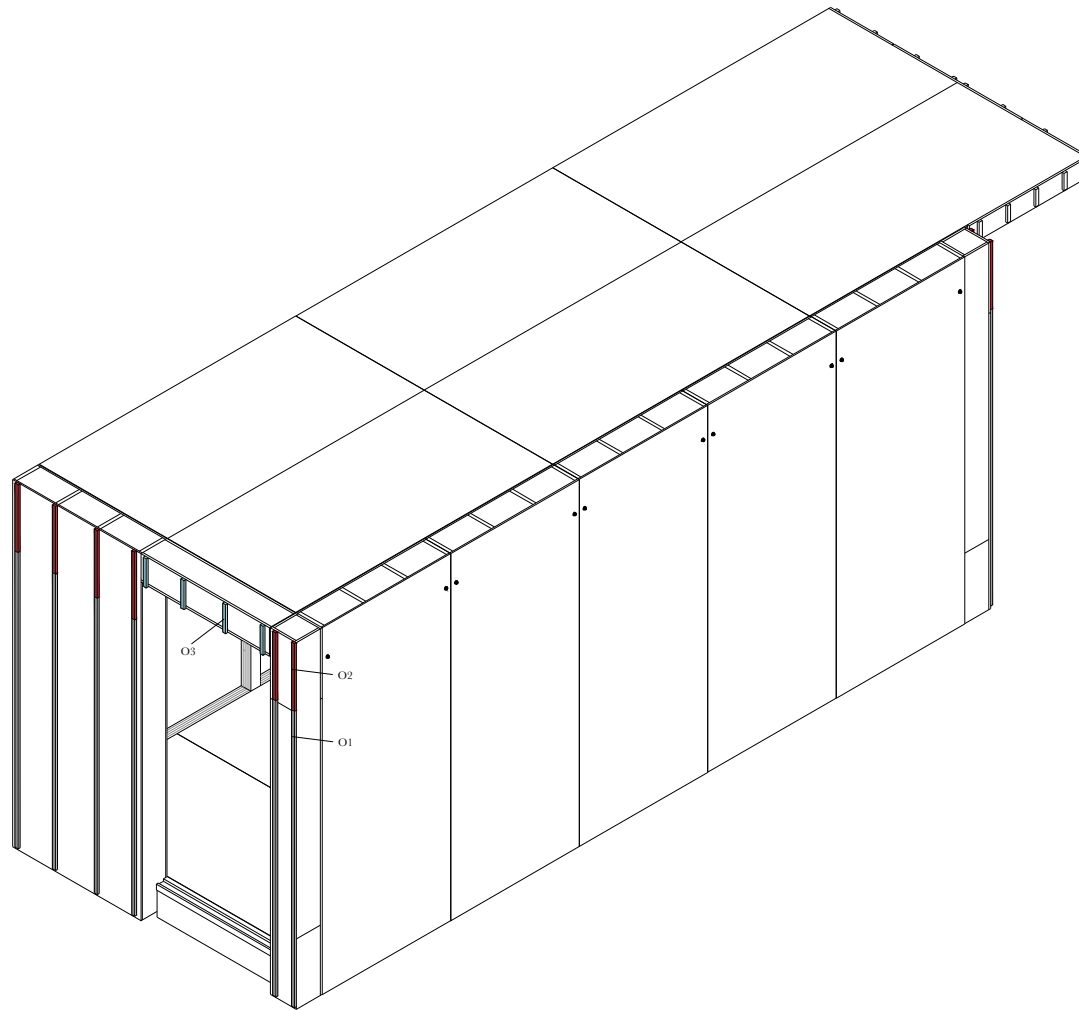
Figuur 12. Isometrie - Hoekpaneel in gesloten toestand.



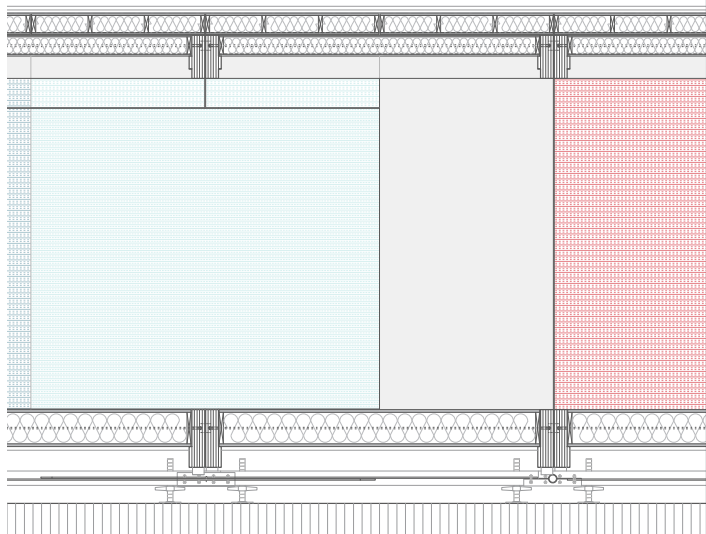
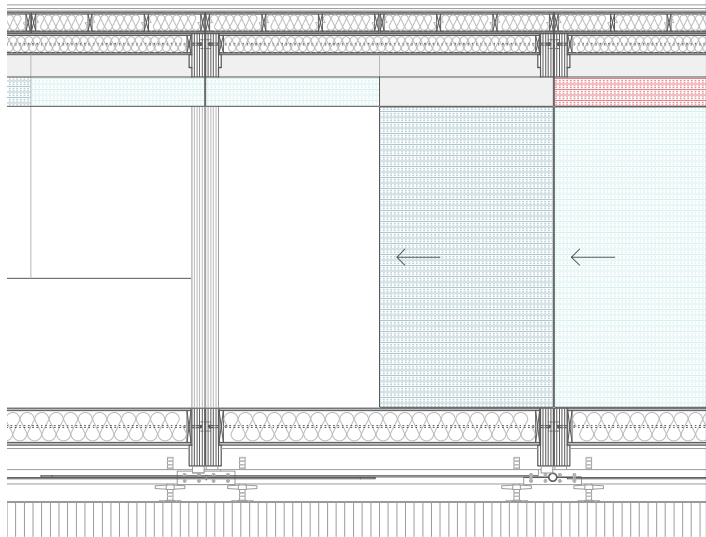
Figuur 13. Isometrie - Afwerking van de tweede laag dakpanelen.



Figuur 14a. Isometrie - Gevellatten.



Figuur 14b. Isometrie - Gevellatten.



6

HOOFDSTUK

Technische uitwerking van paviljoen

INHOUDSTAFEL

6.1 Plannen

- 6.1.1 Varianten op de plattegrond
- 6.1.2 Ontwerpkeuzes, grondplannen en doorsnedes

6.2 Uitvoeringstekeningen

- 6.2.1. Kader
- 6.2.2. Stuklijst panelen
- 6.2.3. Stuklijst fundering, balkon en helling
- 6.2.4. Steunhaken
- 6.2.5. Buitenschrijnwerk

6.3 Interieur

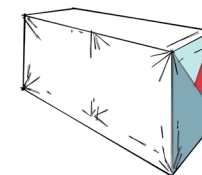
- 6.3.1 Schuifwanden
- 6.3.2 Lamp

WOORD VOORAF

Het interieur van het paviljoen legt door het gebruik van schuifwanden (schuifborden) de nadruk op informatieoverdracht aan de bezoeker.

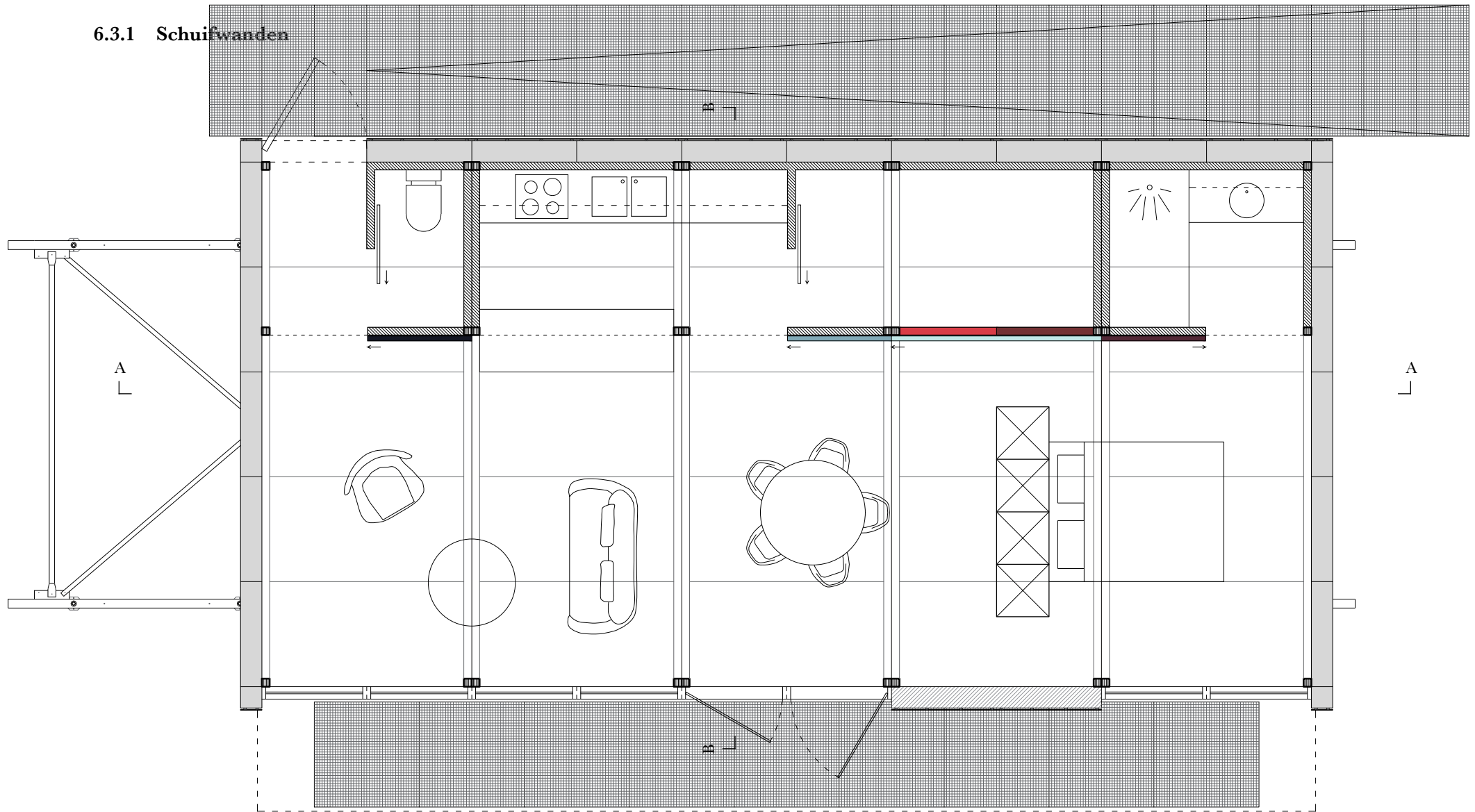
De wand tussen de dienende en bediende zone bestaat uit vaste panelen en schuifwanden. De schuifwanden (in open toestand) bevatten de basisinformatie over de *Mobble* en het geleverde onderzoek errond. Indien de schuifwanden worden gesloten, wordt bijkomende, gedetailleerdere informatie zichtbaar. Het open en dicht schuiven van de wanden/borden refereert naar het les geven in de klas. In het paviljoen draait alles rond de bezoeker informeren, iets bijbrengen, onderwijzen en overtuigen van een nieuwe manier van wonen.

Een imitatie van de *Petite Potence wall lamp* van Jean Prouvé krijgt een plaats in het paviljoen. Deze lamp is gekozen om het tijdloze van *basic*-denken te demonstreren, ze symboliseert de zoektocht naar een ultieme, vanzelfsprekende eenvoud.

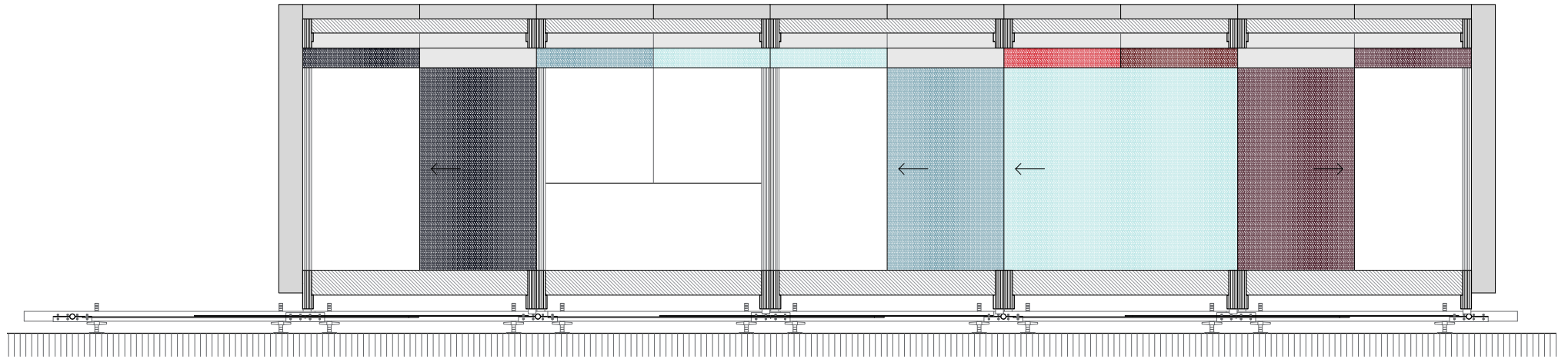


6.3 Interieur

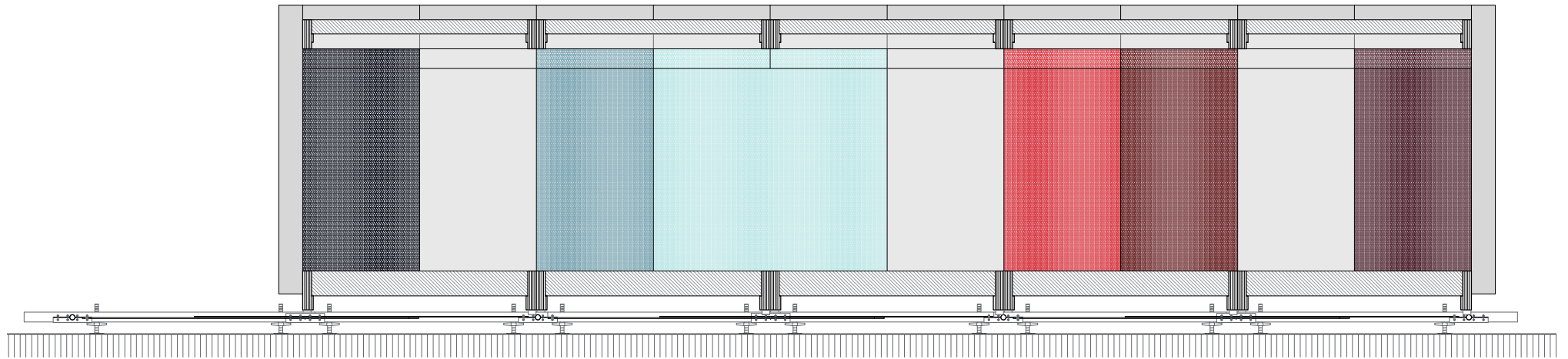
6.3.1 Schuifwanden



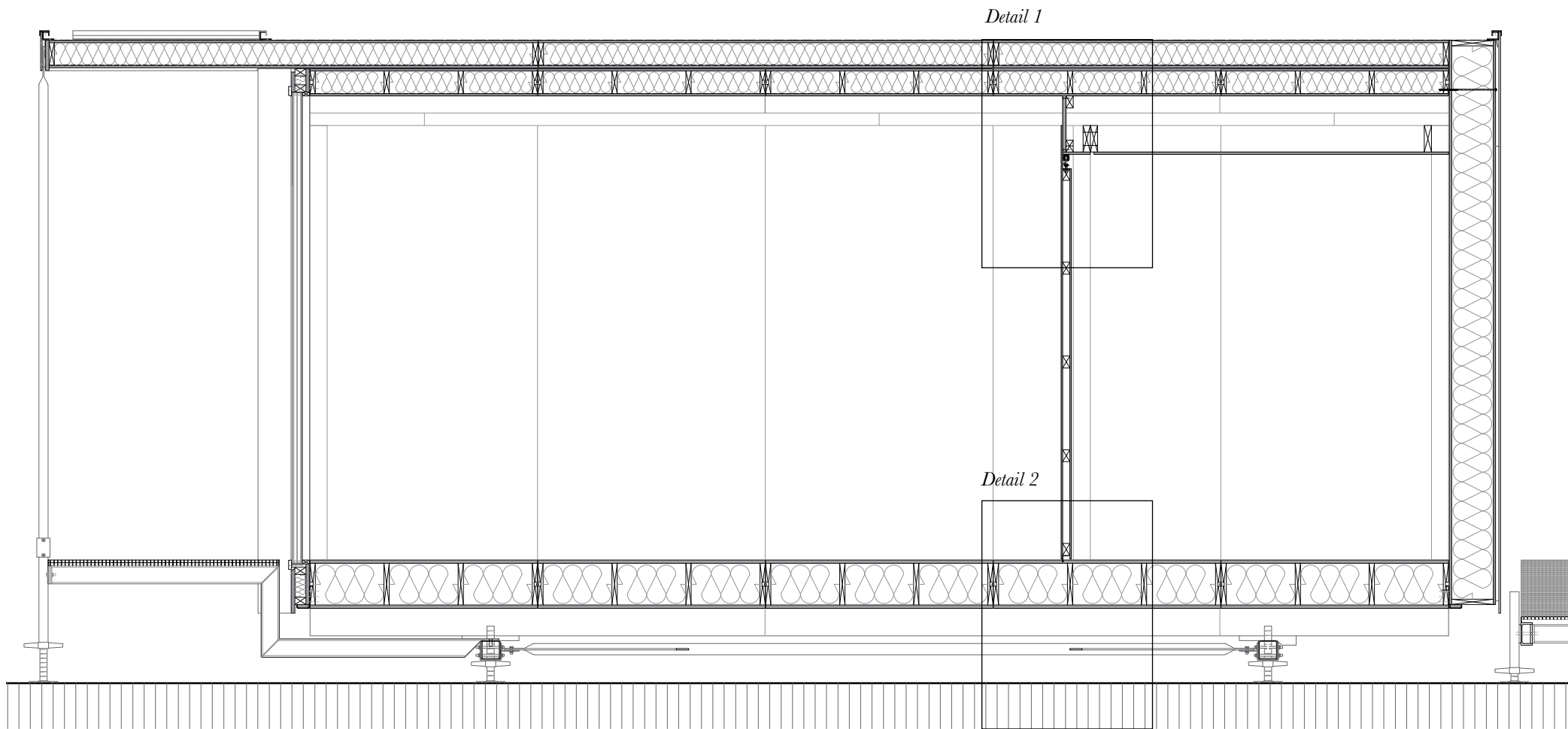
Figuur 1. Grondplan paviljoen - 1/60 - Aanduiding schuifwanden.



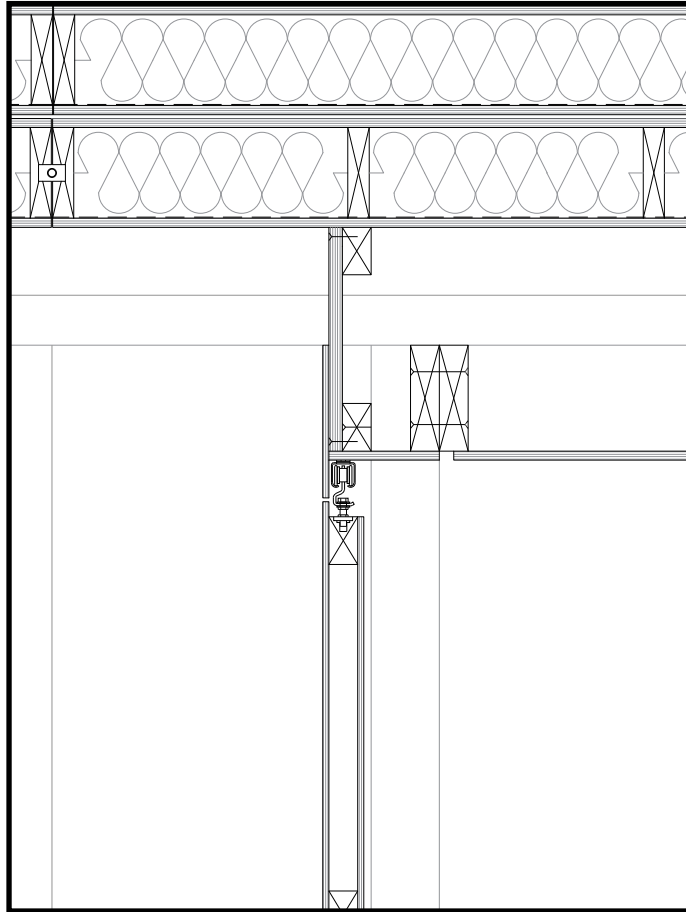
Figuur 2. Doornsede AA - 1/60 - Schuifwanden in open toestand.



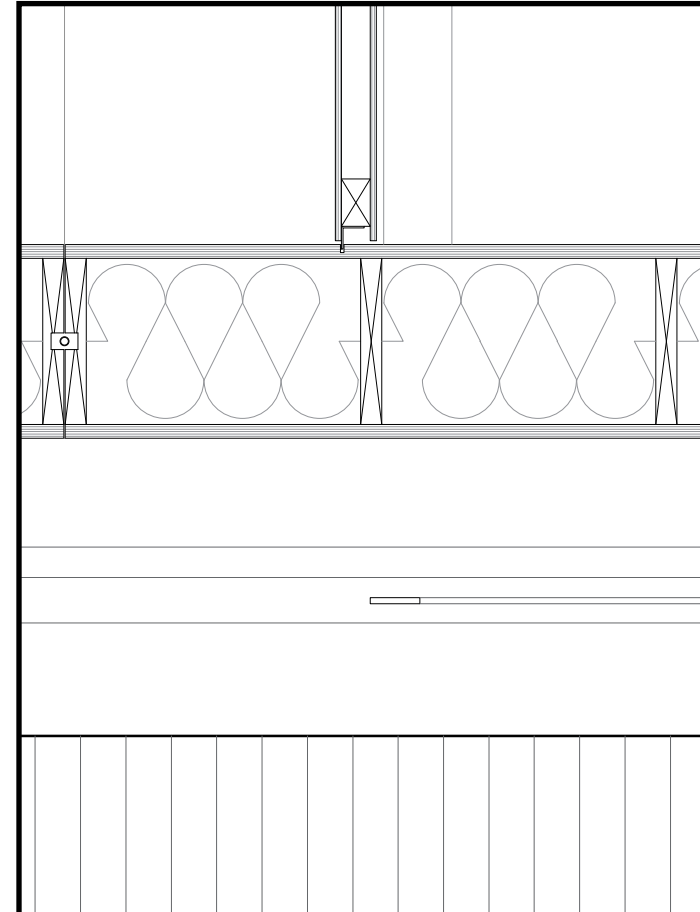
Figuur 3. Doornsede AA - 1/60 - Schuifwanden in gesloten toestand.



Figuur 4. Doornsede BB - 1/30.

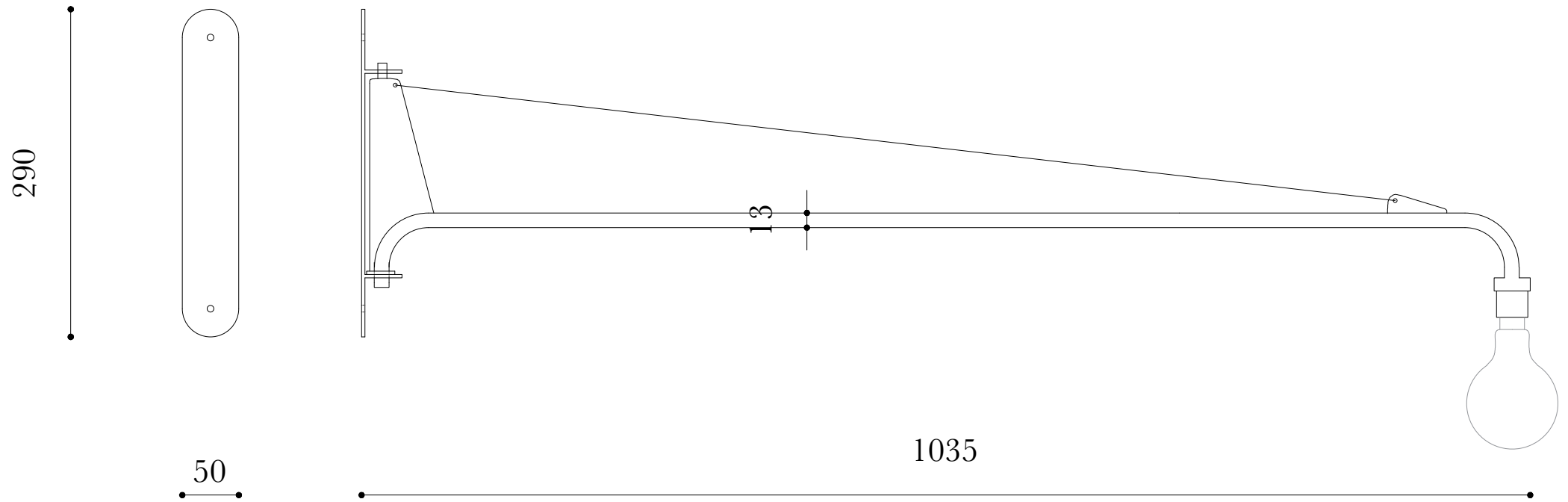


Figuur 5. Detail 1 - 1/10.

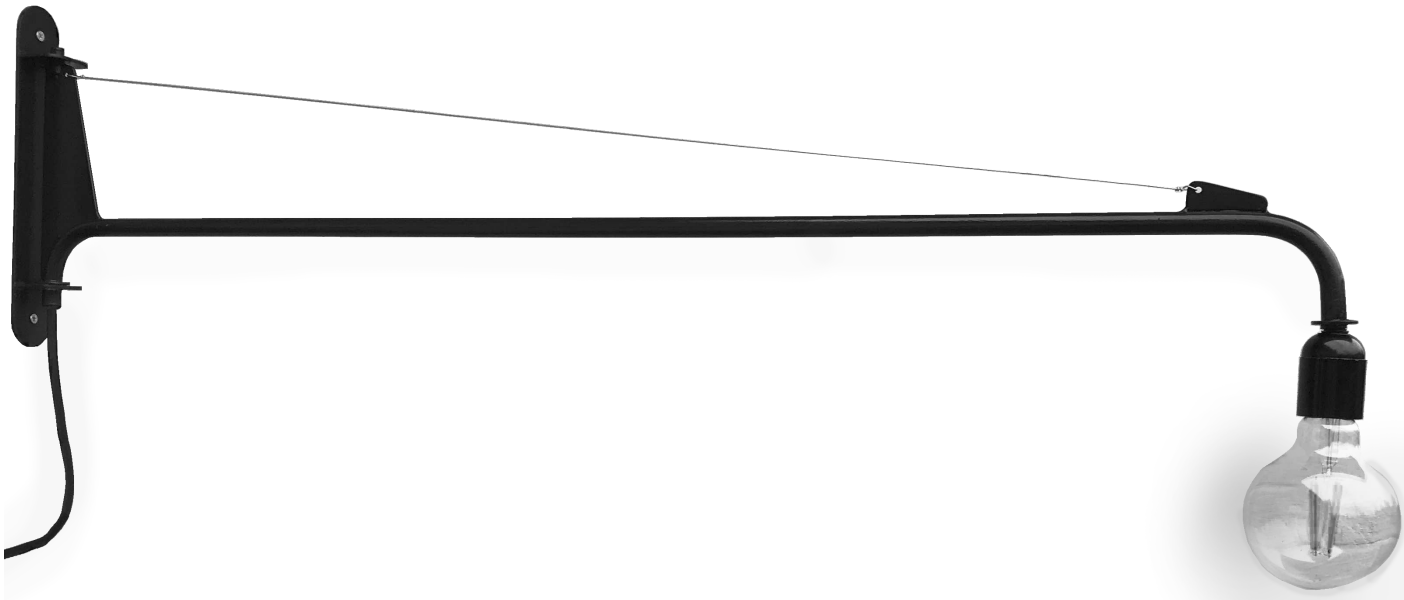


Figuur 6. Detail 2 - 1/10.

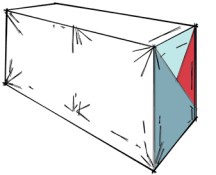
6.3.2 Lamp



Figuur 7. Lamp van Jean Prouvé - 1/5.



Figuur 8. Proefstuk.





7

HOOFDSTUK

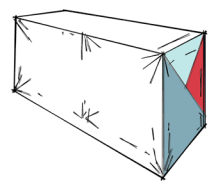
Huisstijl

WOORD VOORAF

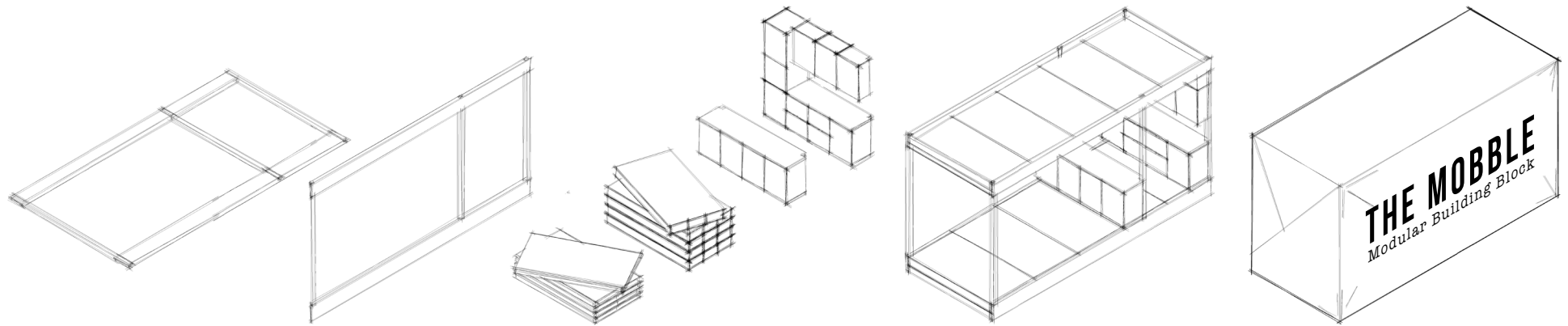
Voor de wedstrijd is het belangrijk een huisstijl te ontwikkelen om bekendheid en herkenbaarheid te bedingen. De huisstijl maakt deel uit van *Communication & Social Awareness*, één van de tien beoordelingscriteria van de *Solar Decathlon*-wedstrijd.

INHOUDSTAFEL

- Beeld
- Naam
- Logo
- Website
- Social Media
- Sweater
- Posters
- Sponsorboekje



The new cool is living in a Mobble



WISHING YOU
A MERRY CHRISTMAS



AND A MOBBLE NEW YEAR!

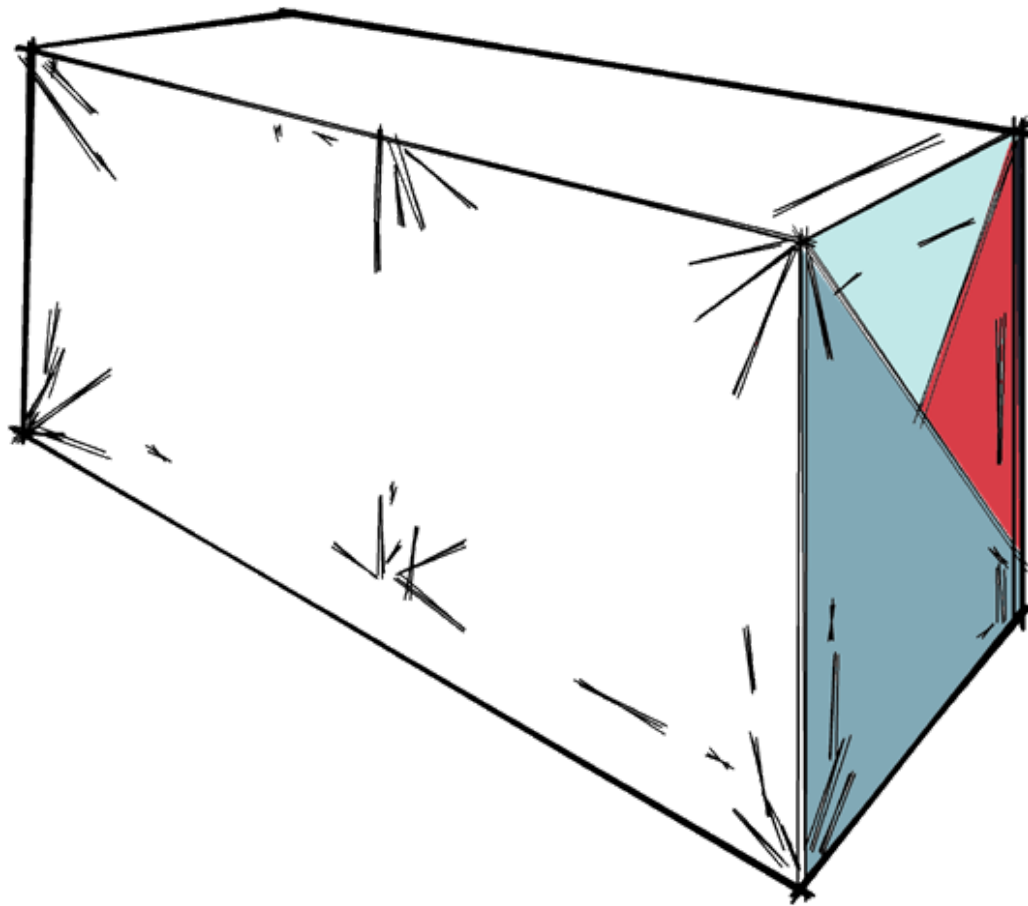
The new cool is living in a Mobble



THE MOBBLE

Modular Building Block





The new cool is living in a Mobble





Renovation of high rise buildings



Modular and adaptable system



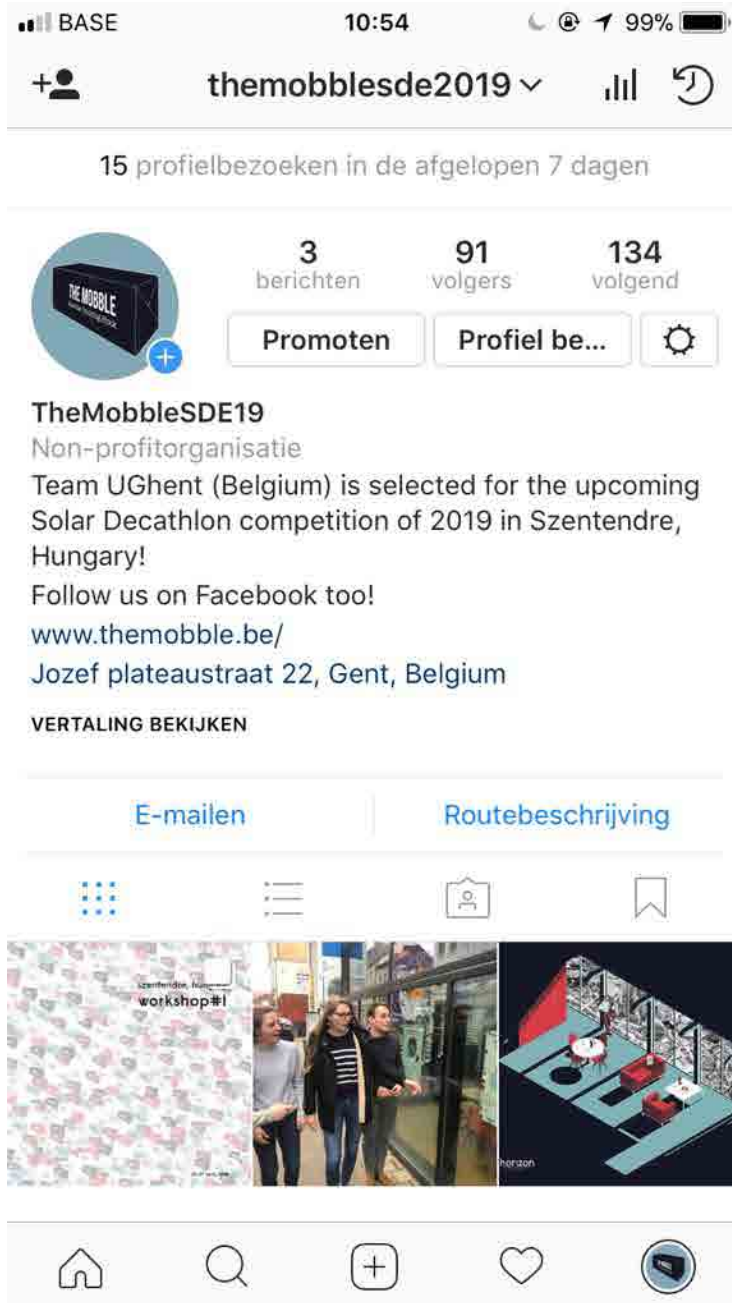
Innovative technical challenges



Team Ghent University
Solar Decathlon 2019 Szentendre, Hungary



Website: www.themobble.be

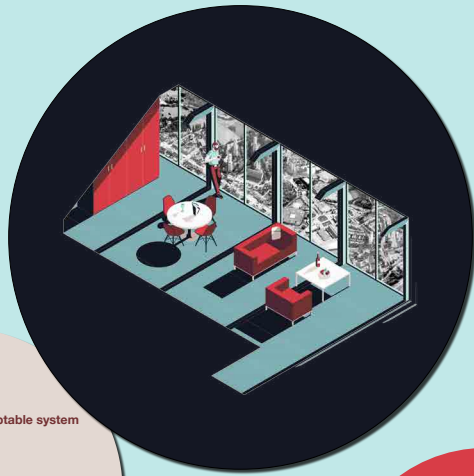



The image shows a Facebook page for 'Team Ghent University - Solar Decathlon Europe 2019'. The page features a cover photo of a tall, modern building with a unique modular design, titled 'THE MOBBLE Modular Building Block'. The page includes a navigation menu on the left with options like 'Startpagina', 'Info', 'Foto's', 'Video's', 'Community', 'Recensies', and 'Berichten'. The main content area shows a post with a 'Schrijf iets op deze pagina...' prompt and a 'Foto's' section displaying various modular building blocks. The right sidebar shows a rating of 5.0 stars and a 'Chatbericht sturen' button.


The new cool is living in a Mobble




THE NEW COOL IS LIVING IN A MOBBLE



 Modular and adaptable system

 Innovative technical challenges

 Renovation of high rise buildings

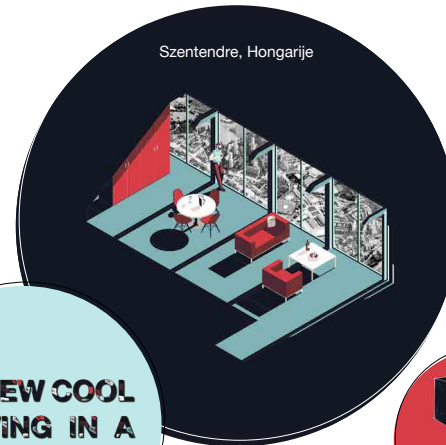
Ghent University is selected to participate in the next edition of the Solar Decathlon Europe in 2019, Szentendre, Hungary with their proposal:

THE MOBBLE
Modular Building Block



UGent geselecteerd voor Solar Decathlon 2019

Szentendre, Hongarije



THE NEW COOL
IS LIVING IN A
MOBBLE



@TheMobleSDE19

VOLG ONS!

WAT?

De Solar Decathlon is een internationale wedstrijd tussen universiteiten van over heel de wereld, die uitgedaagd worden om nul-energie woningen te ontwerpen, bouwen en exploiteren. Voor de wedstrijd in Hongarije ligt de nadruk op te bouwen uit identieke modules.

CONCEPT

Het paviljoen is een representatie van een typisch Etrimo-appartement en zal voor de wedstrijd dienen ter demonstratie van door de UGent ontwikkelde renovatiestrategieën. Anderzijds is om praktische redenen de keuze gemaakt om het paviljoen op te bouwen uit identieke modules.

MOBBLE?

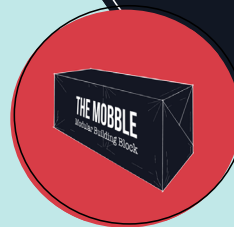
De module heeft de naam **MOBBLE** gekregen. Een **MOBBLE** kan fungeren als noodwoning, mantelzorgwoning in de tuin of een tiny house. Doorontwikkelen op het maken van grotere gehelen met de **MOBBLE** resulteert in intelligente modellen voor laag- en middelhoogbouw.

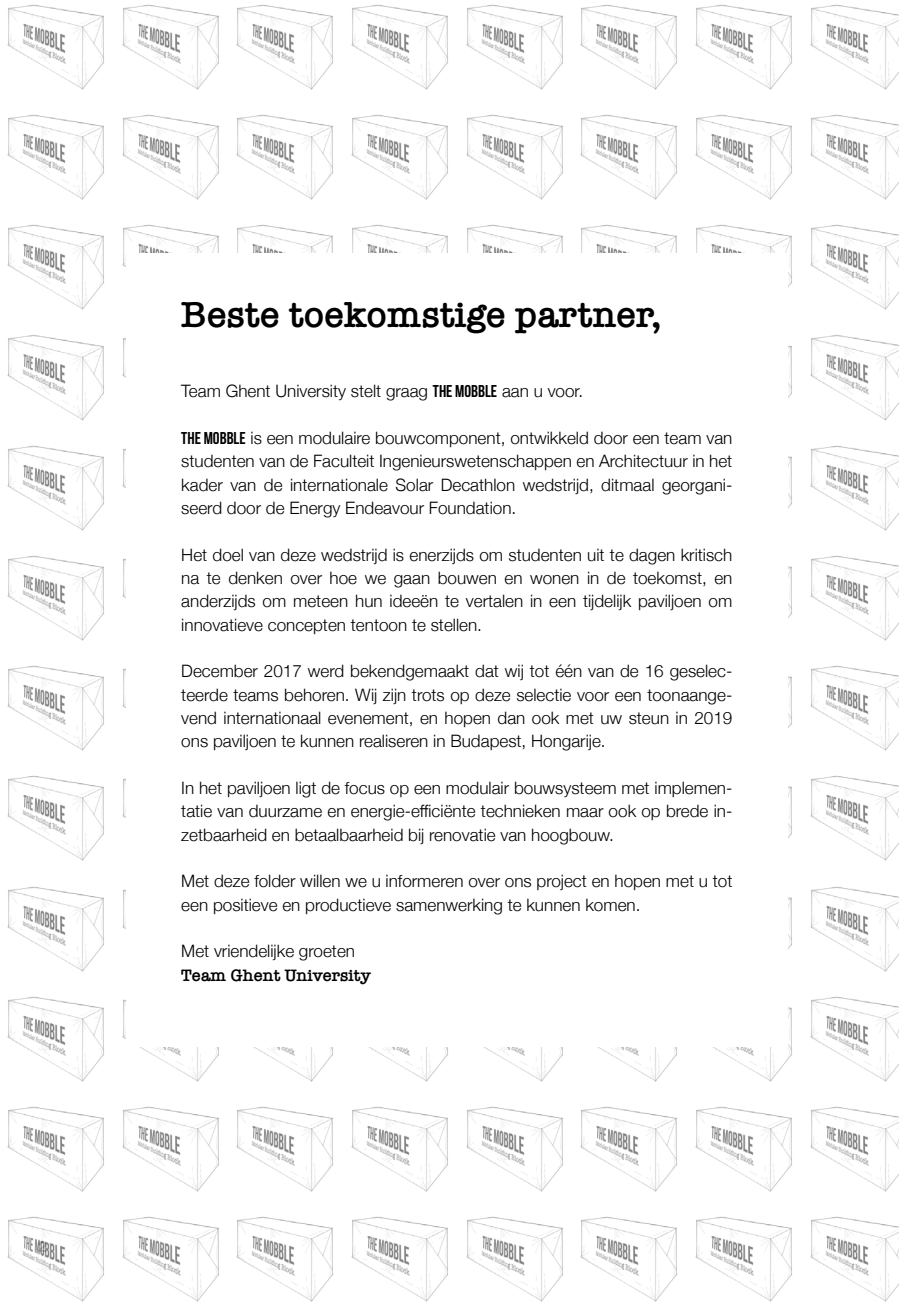


Poster FEA Symposium 2018

Poster school

Become a MOBBLE partner





Beste toekomstige partner,

Team Ghent University stelt graag **THE MOBBLE** aan u voor.

THE MOBBLE is een modulaire bouwcomponent, ontwikkeld door een team van studenten van de Faculteit Ingenieurswetenschappen en Architectuur in het kader van de internationale Solar Decathlon wedstrijd, ditmaal georganiseerd door de Energy Endeavour Foundation.

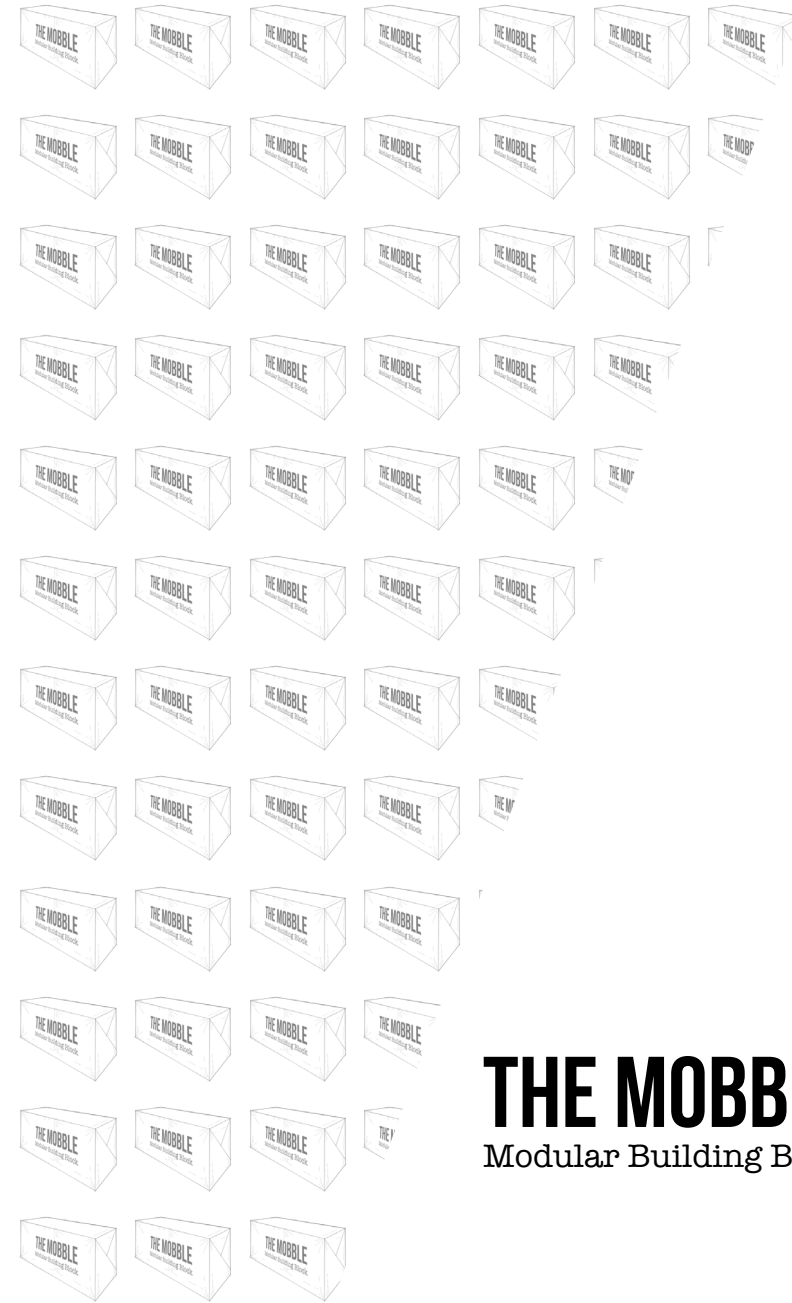
Het doel van deze wedstrijd is enerzijds om studenten uit te dagen kritisch na te denken over hoe we gaan bouwen en wonen in de toekomst, en anderzijds om meteen hun ideeën te vertalen in een tijdelijk paviljoen om innovatieve concepten tentoon te stellen.

December 2017 werd bekendgemaakt dat wij tot één van de 16 geselecteerde teams behoren. Wij zijn trots op deze selectie voor een toonaangevend internationaal evenement, en hopen dan ook met uw steun in 2019 ons paviljoen te kunnen realiseren in Budapest, Hongarije.

In het paviljoen ligt de focus op een modulaair bouwsysteem met implementatie van duurzame en energie-efficiënte technieken maar ook op brede inzetbaarheid en betaalbaarheid bij renovatie van hoogbouw.

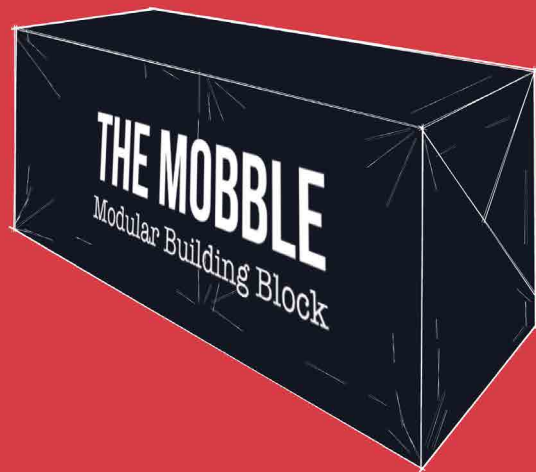
Met deze folder willen we u informeren over ons project en hopen met u tot een positieve en productieve samenwerking te kunnen komen.

Met vriendelijke groeten
Team Ghent University



THE MOBBLE

Modular Building Block



Volg ons!



@TheMobbleSDE19

Inhoudstafel



Team Ghent University

- 06 Studententeam
- 07 Facultair team



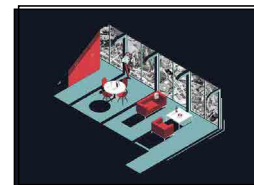
Solar Decathlon

- 08 Wedstrijd
- 08 Vorige deelnames
- 09 Verloop van de wedstrijd
- 10 Solar Decathlon Europe



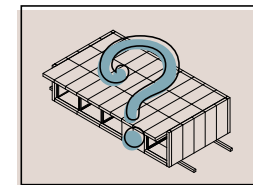
Horizon

- 12 Horizon project
- 12 Problematiek
- 13 Missie
- 13 SDE19



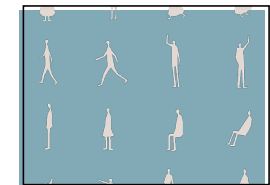
Ontwerp paviljoen

- 14 Concept
- 15 Vertaling
- 16 Opbouw mobble
- 19 Mogelijkheden
- 20 Technische uitdagingen



After life

- 22



Sponsorship

- 24 Waarom partner worden?
- 25 Waarmee kan u ons helpen?
- 26 Sponsorniveaus

Team Ghent University

Studententeam

Team Ghent University is een equipe van gemotiveerde ingenieursstudenten van de Universiteit Gent. Het merendeel van de studenten zijn masterstudenten van de Faculteit Ingenieurswetenschappen-architectuur die samenwerken met studenten Postgraduaat Innoverend Ondernemen voor Ingenieurs.

Ingenieur-architecten	Stabiliteitsingenieurs	Technische Installaties	Project managers
Sven De Turck Febe Lanckmans Laura Landuyt Bjorn Pieters Ineke Tavernier Matthias Van Hove	Astrid Schepens Tessa Van Nieuwenhuysse Piet Verstraete Robin Vervaeck	Joni Bauwens Sven De Turck Rebecca De Vuyst Matthias Van Hove	Astrid Schepens Ineke Tavernier



6

Facultair team



Prof. dr. ir. arch. Nathan
Van Den Bossche
Bouwtechniek



Arch. Marc De Kooning
**Architectuurontwerp
en constructie**



Prof. dr. ir. arch. Arnold Janssens
**Bouwfysische aspecten
van gebouwen**



Kristel Dewulf
Innovatie en duurzaamheid



Prof. arch. Jan Moens
**Bouwtechnische aspecten
van de bouw huid**



Prof. dr. ir. arch. Ronny De Meyer
**Architectuurontwerp: intelli-
gente ruïnes**



Leen Veldeman
Communication en PR



Prof. dr. ir. arch. Pieter Pauwels
BIM



Prof. dr. ir. arch. Jelle Laverge
Technische installaties

Ir. Arthur De Roover // Prof. dr. ir. Michel De Paepe // Ing. Martijn Vyncke // Ir. Hugo Monteyne // Ir. arch. Klaas Calle // Ir. arch. Elisa Van Kenhove // Ir. arch. Stéphanie Van Linden // Prof. ir. Wim Boydens // Prof. dr. ir. arch. Marijke Steeman // Prof. dr. Johan Albrecht // Prof. dr. Hendrik Slabbinck // Prof. dr. ir. Wouter Decorte // Dr. ir. arch. Ruben Verstraeten // Prof. dr. ir. arch. Michiel Dehaene // Ir. Wim Beyne // Prof. dr. Liselot Hudders

7

Solar Decathlon

Wedstrijd

Wat?

De Solar Decathlon (SD) competitie is een internationale **STUDENTENWEDSTRIJD** op academisch niveau. Hierbij worden Universiteiten over heel de wereld uitgedaagd om een duurzaam en energie efficiënt **PAVILJOEN** te ontwerpen en te bouwen.

De oorsprong van de Solar Decathlon wedstrijd ligt in de Verenigde Staten in 2002, waar het toen georganiseerd werd door The United States Department of Energy. Sindsdien vond de wedstrijd om de twee jaar plaats in de Verenigde Staten. Ondertussen wordt de Solar Decathlon wereldwijd georganiseerd: Europa (2010, 2012, 2014, 2019), China (2013, 2017), Latijns-Amerika (2015) en Afrika (2019).

Doel?

The United States Department of Energy heeft deze wedstrijd ontwikkeld om mensen bewust te maken en te informeren over energieverbruik, duurzame en energie-efficiënte technologieën en hernieuwbare energie. Hierbij willen ze ook studenten stimuleren om creatief te denken en innoverende oplossingen te zoeken.

Vorige deelnames

E-cube, 2011

In 2011 nam de Universiteit Gent voor het eerst deel aan de 5^{de} editie van de Solar Decathlon, te Washington D.C., USA. Team Belgium verdedigde met de 'E-cube' (naam van het paviljoen) daarmee ook de Europese eer.

De E-cube stelt een kubusvormige woning voor met de nadruk op betaalbaarheid en het 'doe-het-zelf' karakter. Team Belgium was winnaar van het onderdeel Affordability.

Solatrium, 2013

Twee jaar later maakte Universiteit Gent deel uit van het internationale BEMANY-team, wat een samenwerking was tussen de UGent en twee Amerikaanse universiteiten: Worcester Polytechnic Institute en Polytechnic Institute of New York University. Dit team deed mee aan de SD in 2013 in Datong, China.

De basispijlers, nl. een op zonne-energie aangedreven huis rond een centraal atrium, verklaren meteen waar de naam Solatrium van het paviljoen vandaan komt. Team BEMANY eindigde op een mooie 8^e plaats.



E-cube, 2011



Solatrium, 2013

FASE I: VOORONDERZOEK EN ONTWIKKELING

Binnen de door de organisatie opgelegde thematiek wordt door het team een maatschappelijke relevante renovatieproblematiek gekozen en kan het onderzoek naar innoverende ideeën en de ontwikkeling van een intelligent ontwerp voor het paviljoen van start gaan.

THEMA WEDSTRIJD: ZIE SOLAR DECATHLON PAG. 10
RENOVATIEPROBLEMATIEK: ZIE HORIZON PAG. 12

AUG
2017

Verloop van de wedstrijd

DEC
2017

BEKENDMAKING SELECTIE

Midden december werd bekendgemaakt dat we geselecteerd zijn voor de volgende Solar Decathlon Europe in 2019 in Szentendre, Hongarije.

FEB
2018

FASE II: UITWERKING EN PROTOTYPE

In deze fase ligt de focus op de ontwikkeling van een paviljoen. De constructieve architecturale plannen en innoverende technische installaties worden uitgewerkt. Er wordt een prototype gebouwd om uit te testen.

SEPT
2018

FASE III: BOUWEN VAN PAVILJOEN

In de derde fase wordt het definitieve paviljoen opgebouwd en worden de technische installaties ingebouwd. Hierna wordt het paviljoen in componenten uit elkaar gehaald en is het klaar voor transport naar Hongarije.

FASE IV: TRANSPORT EN OPBOUW PAVILJOEN









Tijdens deze fase van de wedstrijd worden de verschillende paviljoenen van elk geselecteerd team in een Solar Village geconstrueerd in Hongarije. Na een opbouwperiode van 10 dagen, worden de paviljoenen gedurende een langere periode opengesteld voor het publiek.

FASE V: WEDSTRIJD

Elk team wordt tijdens deze periode beoordeeld op basis van 10 criteria, waarbij per thema 100 punten kunnen verdiend worden. Zie rechts.

JULI
2019

DE TIEN BEOORDELINGSCRITEERIA:

-  **Architecture**
-  **Engineering & Construction**
-  **Energy Efficiency**
-  **Communication & Social Awareness**
-  **Neighbourhood Integration & Impact**
-  **Innovation & Viability**
-  **Circularity & Sustainability**
-  **Comfort Conditions**
-  **House Functioning**
-  **Energy Balance**

Solar Decathlon



Solar Decathlon Europe

Europese editie

Het is de eerste keer dat de Universiteit Gent meedoet aan de Europese editie van de Solar Decathlon wedstrijd. Bij de Europese editie (versus Amerikaanse editie) wordt gefocust op een maatschappelijke problematiek in een stedenbouwkundige context typisch aan Europa.

Thematiek

SDE19 focust op de **RENOVATIE** van bestaande gebouwen. Teams kunnen één van de volgende onderwerpen kiezen:

- Renovatie van het traditionele Hongaarse rechthoekige appartementsgebouwen
- Ontwikkelen van rooftopappartementen (om de stedelijke dichtheid te verhogen)
- Een renovatieproject dat typisch is voor het land van herkomst

Team Ghent University focust op het laatste voorstel. Ons onderwerp draait rond de vele, quasi identieke, appartementsgebouwen die onder meer opgetrokken zijn door de firma Etrimo in de jaren '50-'70 aan de rand van vele Belgische steden. Deze appartements-

blokken zijn vandaag aan grondige renovatie toe en dit blijkt een niet zo eenvoudige opdracht te zijn.

Universiteit Gent heeft in 2016 een uitgebreid kennis- en onderzoeksplatform opgericht over deze renovatie-problematiek: Horizon. Voor meer uitleg zie pag. 10.

Geselecteerde teams

- University of Brighton, United Kingdom
- Technical University of Civil Engineering, Romania
- University of Technology and Economics, Hungary
- Universitat Politècnica de Catalunya, Spain
- Delft University of Technology, Netherlands
- Technical University of Denmark, Denmark
- International Hellenic University, Greece
- ENS d'Architecture et de Paysage de Lille, France
- University of Maryland, U.S.A.
- Politecnico di Milano, Italy
- University of Miskolc, Hungary
- Universidad de Sevilla, Spain
- King Mongkut's University of Technology, Thailand
- University of Applied Sciences Utrecht, Netherlands
- Universitat Politècnica de València, Spain
- **Ghent University, Belgium**



Horizon project

In 2016 startte de Universiteit Gent het Horizon project op. Dit is een **KENNISPLATFORM** rond de ontwikkeling van duurzame renovatie voor residentiële hoogbouw. Het platform wordt ondersteund door tientallen academici en onderzoekers. Hun doel is het groeperen en publiekelijk ter beschikking stellen van alle onderzoeken omtrent deze problematiek.



Problematiek

Voorgeschiedenis

Tijdens de tweede wereldoorlog werden vele woningen vernietigd. Samen met de naoorlogse babyboom zorgde dit voor een grote woningnood in België. Om deze situatie het hoofd te bieden, werd het repetitieve **HOOGBOUWMODEL** veelvuldig toegepast.

Deze industriële bouwmethoden maakten het mogelijk om een grote hoeveelheid woningen te realiseren op korte tijd. Bovendien waren deze woningen een hele verbetering in vergelijking met de huizen van voor de oorlog op vlak van hygiëne en leefbaarheid.

Eén van de grote aannemersbedrijven die in de jaren '50 tot '70 de Belgische markt domineerden was de firma Etrimo. Het bouwbedrijf zorgde voor een revolutie binnen de woningbouw door een aantrekkelijke formule aan te bieden volgens een sleutel-op-de-deur concept. Deze onderneming ontwikkelde woontorens aan de lopende band met een minimum aan architecturale kwaliteiten. Door vergaande standaardisatie van zowel woontypologieën, structuur als gebruikte materialen was het mogelijk om op een zeer korte tijd een groot aantal projecten te realiseren.

Huidige problemen

De appartementsblokken zijn verouderd, energetisch inefficiënt en voldoen niet meer aan de huidige normen inzake brandveiligheid, toegankelijkheid, etc. Daarnaast behoort elk appartement toe aan een andere eigenaar (private eigendom), waardoor totaalrenovatie

van een bouwblok een moeilijke zaak is. De renovatie van deze woningen is een complex proces dat afgeremd wordt door een aantal praktische, technische, financiële, organisatorische en juridische obstakels.

Horizon focust grotendeels op de Etrimo gebouwen, vanwege de grote aantallen die in België aanwezig te vinden zijn. Deze woontorens hebben een aantal interessante pluspunten, waardoor een grondige renovatie van deze appartementsgebouwen de moeite waard is. Deze **VOORDELEN** zijn:

- Groene omgeving
- Mooi uitzicht
- Hoge repetitiviteit
- Voordelen van collectief wonen
- Betaalbare appartementen
- Interessante stedelijke locatie
- Structuur in goede staat

Om de problematiek van deze appartementen volledig te kunnen onderzoeken is er een enquête uitgevoerd met als doel het achterhalen van de klachten van de inwoners. Deze klachten werden vertaald in **PIJNPUNTEN** die de bewoners ervaren en waarvoor oplossingen moeten worden gezocht:

- Slechte thermische prestaties van de bouwschil
- Verouderde technische installaties
- Onvoldoende brandveiligheid
- Onvoldoende akoestische isolatie
- Ontoereikende circulatie
- Geen toegangscontrole

Etrimo-gebouw Breughelpark, Brussel



Organisatie Etrimo-plan

Alle woontorens, neergepoot door de firma Etrimo, zijn volgens één principe opgebouwd. Alle appartementen zijn telkens per vier rond een circulatiekoker geschikt, hebben een terras en de planindeling van de vier appartementen is telkens gelijk, zie afbeelding hieronder. Dit schema werd horizontaal twee tot vier keer herhaald, afhankelijk van de afmetingen van het beschikbare terrein.

Missie

De Horizon kennishub van Universiteit Gent streeft ernaar een overzicht te geven van het wetenschappelijk onderzoek in verband met de renovatie van naoorlogse woonblokken in private eigendom.

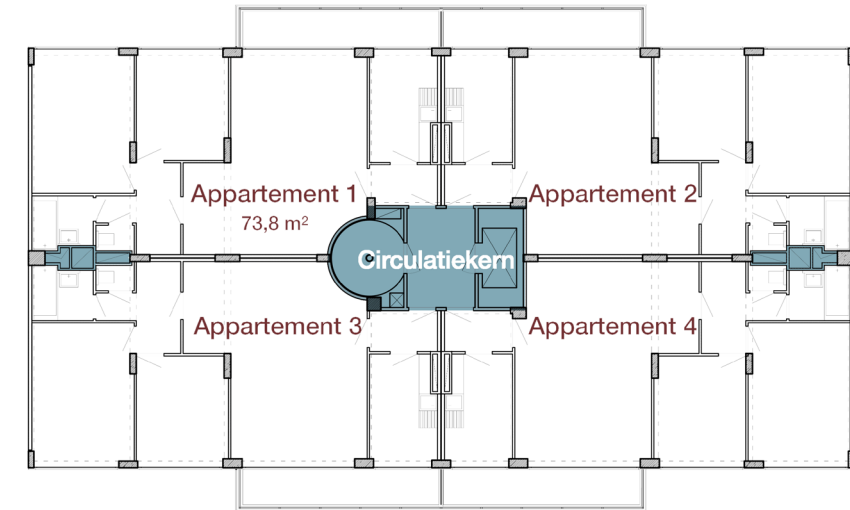
MEER INFORMATIE: [HTTP://WWW.HORIZON-UGENT.BE/NL/](http://www.horizon-ugent.be/nl/).

SDE19

SDE19 focust zich op renovatie van gebouwen. Dit thema herkennen we in het onderzoek van Horizon.

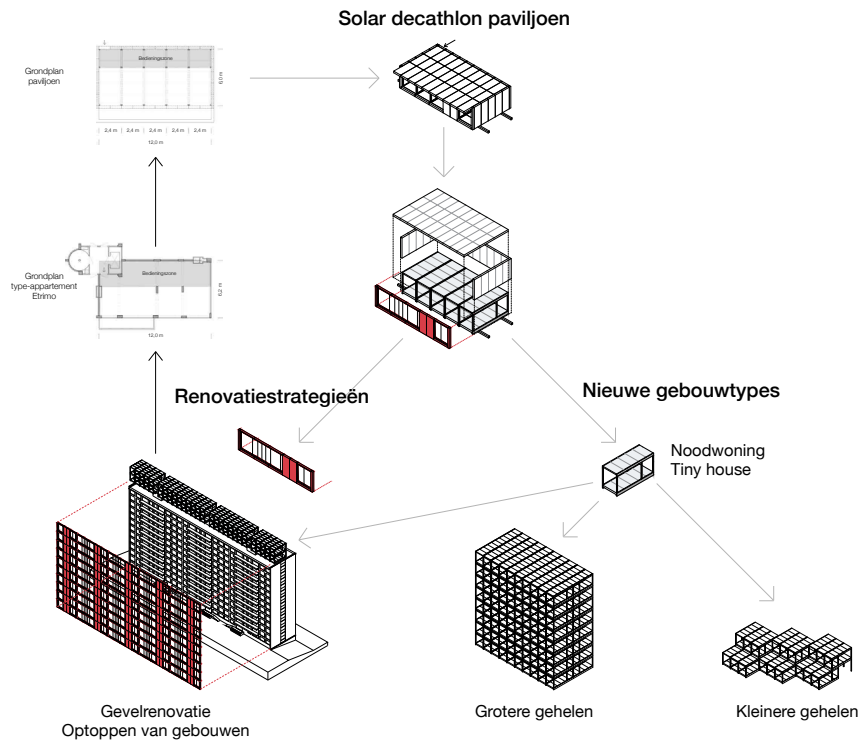
Met de deelname aan de wedstrijd wil Horizon en het Ghent University team het renovatiepotentieel van hoogbouw illustreren, het grote publiek informeren over deze problematiek en renovatiestrategieën naar voor schuiven.

Het ontwerp van het paviljoen zal daarom verwijzen naar een typisch Etrimo-appartement en zal gebruikt worden om renovatieoplossingen uit te testen en te demonstreren.



Etrimo-plan

Ontwerp paviljoen






Concept

Het Solar Decathlon paviljoen kadert enerzijds in de renovatieproblematiek van de Etrimo-appartementen, zoals hiervoor beschreven. Concreet representeert het paviljoen een proefopstelling om renovatiestrategieën voor hoogtorens te demonstreren aan een breed publiek. Anderzijds hebben we om standaardisatie en mobiliteitsredenen de keuze gemaakt om het paviljoen op te bouwen uit modules. De modules zijn identiek en hebben als koosnaam **THE MOBBLES** verworven. Eén **MOBBLE** kan fungeren als noodwoning, een mantelzorgwoning in de tuin of tiny house, een betaalbare woning voor jongvolwassenen.

Doorontwikkeling tot grotere gehele met deze modules resulteert in intelligente modellen voor laag- en mid-

delhoogbouw. De modulariteit brengt een hoge flexibiliteit en aanpasbaarheid met zich mee.

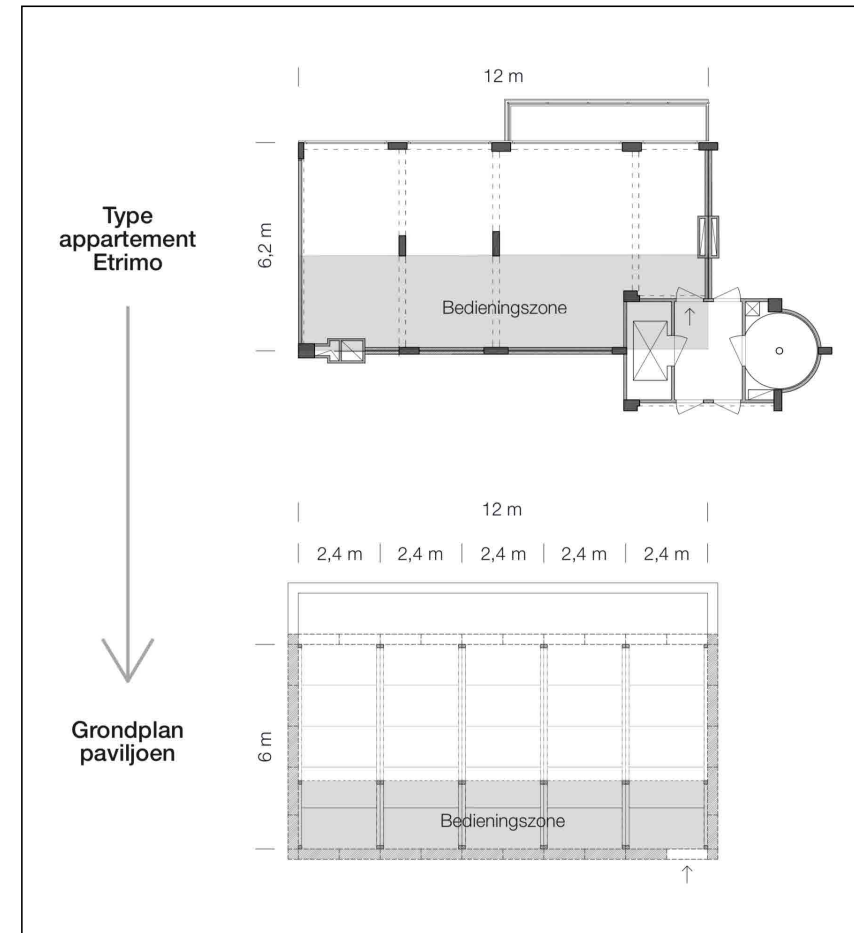
Hieruit kunnen de volgende 3 pijlers gedestilleerd worden:

-  **Modulair bouwsysteem**
-  **Inzetbaarheid bij renovatie van hoogbouw**
-  **Implementatie van intelligente technieken**

Vertaling

Het vertrekpunt voor het grondplan van het paviljoen is het meest voorkomende type-appartement uit een appartementsgebouw opgetrokken door de bouwfirm Etrimo. De geometrie en de daarbijhorende afmetingen worden bijna letterlijk gekopieerd, alsook het ge-

bruik van éézijdige beglazing, het balkon en de typerende bedieningsstrook, zie grijze arcering op plannen hieronder. Het appartement/paviljoen wordt betreden vanuit de rechter onderhoek.



Ontwerp paviljoen

Opbouw paviljoen

De opbouw van het paviljoen bestaat uit vijf gelijke modulaire eenheden. Een module wordt een **MOBBLE** genoemd. Het paviljoen bestaat dus uit vijf **MOBBLES**.

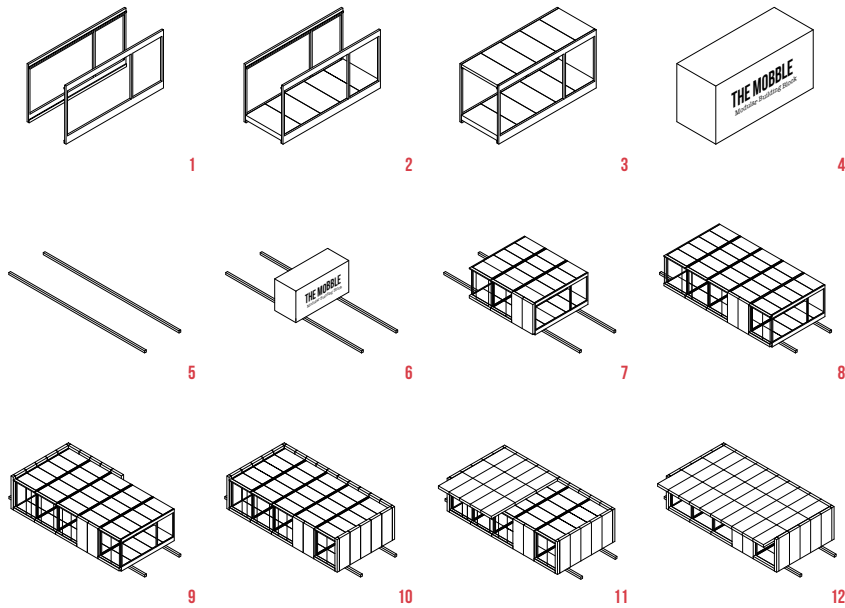
De afmetingen van een **MOBBLE** zijn: L6,0m x B2,4m x H3,1m. De lengte en breedte zijn veelvoud van 1,2m wat gebaseerd is op de standaardbreedte van typische sandwichpanelen. Een andere reden voor het gebruik van veelvoud van 1,2m vloeit voort uit standaardafmetingen voor transport en van courant te verkrijgen handelsmaten van hout.

De **MOBBLE** is opgebouwd uit twee structurele kaders (1). Tussen deze kaders worden de vloerpanelen (2) en de eerste laag dakpanelen geplaatst (3). Vervolgens worden binnenmuren, vaste meubelelementen en de technische installaties ingebouwd. Enkel nog de module in een strak kleedje steken (lees: beschermzeil) (4) en de **MOBBLE** is klaar voor transport. Op deze wijze worden

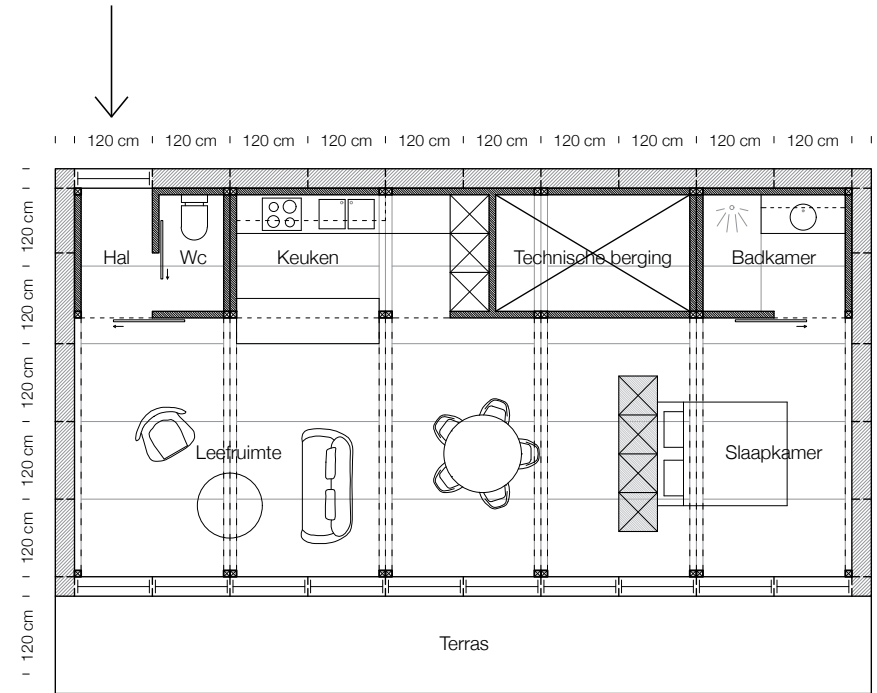
voor de wedstrijd in totaal vijf mobbels geprefabriceerd en afgewerkt met ramen, gevelpanelen en de tweede laag dakpanelen, alvorens ze vervoerd worden naar Szentendre.

Ter plaatse worden eerst de funderingsporen uitgezet (5). Als eerste zal de middelste **MOBBLE** (6) geplaatst worden, vervolgens de twee **MOBBLES** (7) die die middelste flankeren en tenslotte de buitenste twee **MOBBLES** (8). Na het plaatsen van de **MOBBLES**, worden de gevelpanelen geïnstalleerd (9, 10) en als laatste element de extra laag dakpanelen (11, 12).

Het is een eenvoudig bouwconcept dat studenten en doe-het-zelvers in staat stelt zelf de handen uit de mouwen te steken om een eigen paviljoen of woning in elkaar te knutselen. Een handleiding van de **MOBBLE** komt er aan!

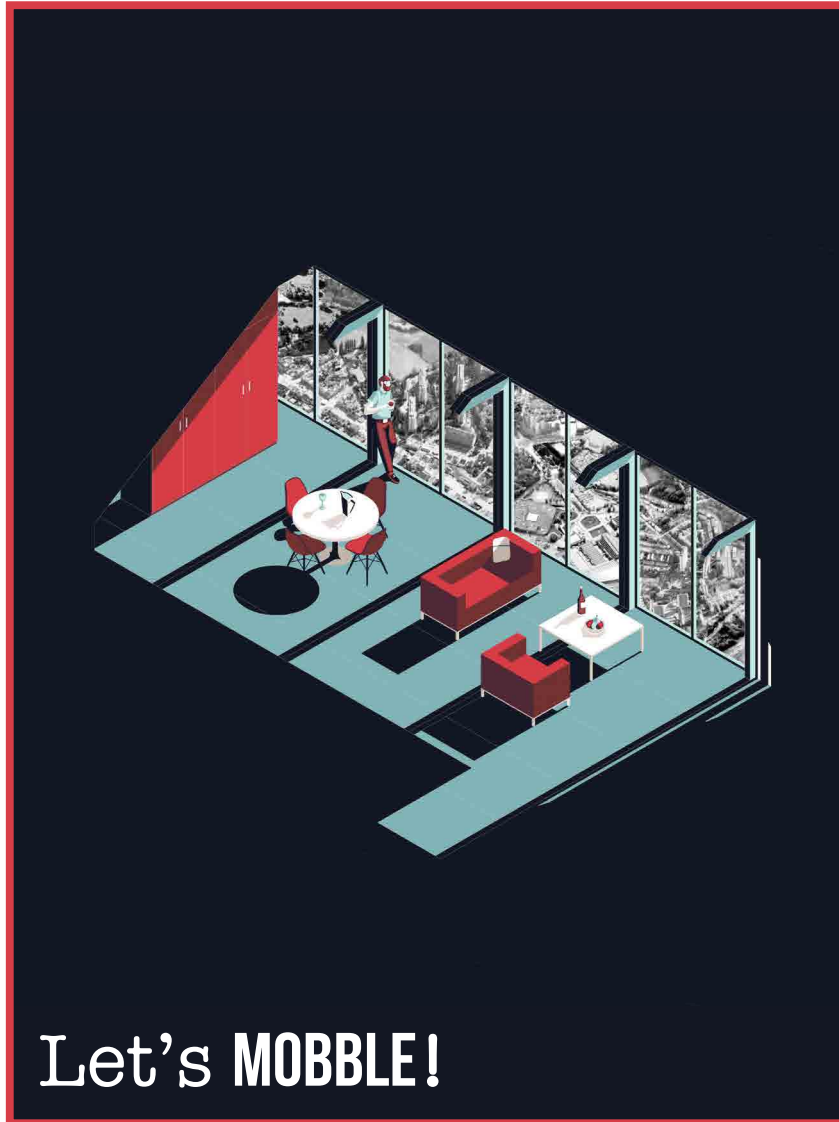


Opbouw van paviljoen stap per stap



Planindeling paviljoen

Ontwerp paviljoen



Mogelijkheden

Nieuwe wooneenheden

Modulair bouwen heeft specifieke voordelen en toepassingsgebieden. Doordat het een aanpasbaar, **FLEXIBEL** bouwsysteem is kunnen er snel nieuwe wooneenheden worden gebouwd, verplaatst of verwijderd:

- Noodwoning
- Mantelzorgwoning
- Tiny house
- Tijdelijke uitbreiding van een woning
- Kangoeroewoning
- Nieuwe woongroepen

Renovatie

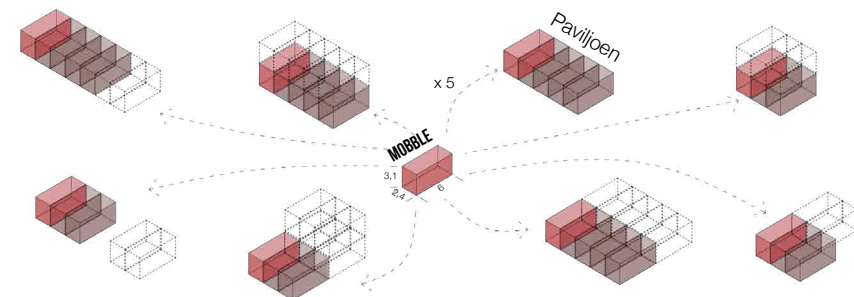
Ook voor het renoveren van gebouwen zijn er toepassingen. Door de lichte constructie is het mogelijk om een serie Mobbles op het dak van de te renoveren gebouwen te plaatsen. In een eerste renovatiefase kunnen gezinnen tijdelijk verhuizen naar deze rooftop-module-appartementen terwijl hun appartementen vernieuwd worden. Zij verhuizen dan terug en een nieuwe reeks inwoners zullen tijdelijk in de mobbles huizen tot ook hun appartement volledig is gerenoveerd. Na dit proces kan er worden geopteerd om de Mobbles te laten staan en zal het appartementsgebouw meer woontiteiten bevatten wat ook de **VERDICHING** in de stad bevordert. De renovatiekost kan op deze wijze ook worden beperkt.

Levenscyclusanalyse

Door het verstrengen van de energiewetgeving gedurende de laatste decennia, wordt de nadruk vooral gelegd op de beperking van fossiele energieconsumptie. Nu de limieten van energie-efficiëntie in het ontwerpen van gebouwen ongeveer bereikt zijn, gaat de focus over op levenscyclusanalyse, gezondheid en binnenmilieu. Terwijl vandaag de nadruk vooral gelegd wordt op de levenscycluskosten op materiaalniveau, is in onze ogen een meer holistische benadering over duurzaamheid noodzakelijk. We zijn ervan overtuigd dat herbruikbaarheid en recycling op **COMPONENTNIVEAU** interessanter is in vergelijking met de aanpak op materiaalniveau.

Bestaande verouderde gebouwen zijn vaak niet geschikt om te voldoen aan de dynamische eisen van het dagelijkse leven, de veranderende sociale behoeften en de snel evoluerende technische vereisten van gebouwen. Een gebrek aan geïntegreerde flexibiliteit en aanpassingsvermogen zorgt voor zeer zware renovaties en heeft meestal afbraak tot gevolg.

Het modulair bouwen vergroot de transformatiecapaciteit van het gebouw. De modulaire eenheden zullen makkelijker en sneller worden aangepast wat de renovatieprocedure positief zal beïnvloeden. De mogelijke herconfiguratie en recycling van bouwcomponenten in constructies kan belangrijke ecologische en economische voordelen opleveren.



Flexibiliteit modules

Ontwerp paviljoen

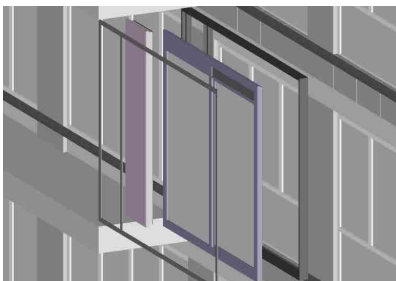
Technische uitdagingen

Geprefabriceerde gevelelementen voor renovatie

We willen op het paviljoen innovaties demonstreren die technische uitdagingen het hoofd bieden. We denken vooral aan een systeem met geprefabriceerde gevelelementen om zo een snelle en lage energie gevelrenovatie te realiseren met minimale overlast voor eigenaars en huurders. Door middel van all-in-one panelen die we integreren met het buitenschrijnwerk, kunnen we HVAC-systemen voor zowel opwekking als distributie inbouwen.

Hierdoor kunnen de meest cruciale elementen, de slechte geïsoleerde buitenschil en de verouderde technieken, met het toepassen van één geïntegreerd systeem worden opgelost. De integratie van gevelzonnepanelen maakt deze toepassing nog interessanter.

Prefab gevelrenovatie



20

Slimme HVAC-systemen

Naast het bouwen van een energie-efficiënte woning, is Smart Living een ander focuspunt. Dit in samenwerking met HomeLab – een creatief lab waar onderzoekers nauw samenwerken met bedrijven én gebruikers om concepten als Internet of Things (IoT) en Smart Living om te zetten in de huis-, tuin- en keukentoepassingen van de toekomst. HomeLab is opgericht binnen de onderzoeksgroep Imec aan de Universiteit Gent.

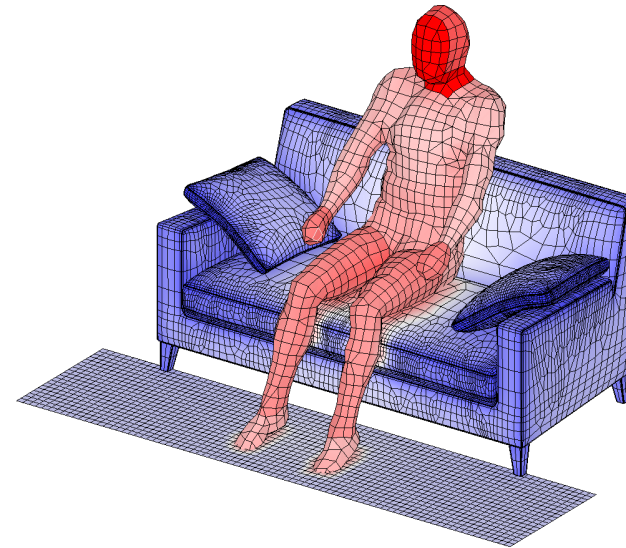
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Persoonlijke klimatisatie

Een eerste toepassing van het Smart Living systeem is het vinden van een optimale balans tussen energie efficiëntie en comfort. De energie efficiëntie van gebouwen is de laatste jaren positief geëvolueerd. Dit zelfs in zoverre dat we bijna de limieten ervan hebben bereikt. De dikte van isolatielagen is maar rendabel tot een zekere waarde. Ook de productie- en distributierendementen van stookinstallaties hebben hun limieten. De manier waarop deze energie echter gebruikt wordt om comfort te realiseren, is tot op heden amper in vraag gesteld. Het energiereductiepotentieel is hier echter nog zeer groot. De gerealiseerde energiebesparing bij gebouwrenovaties ligt vaak lager dan voorstellingen, omdat men typisch meer ruimtes constant verwarmd na renovatie.

De huidige normen vertrekken steeds van het klimatiseren van een volledige ruimte, of zelfs een volledig gebouw, om zo een goed comfort van personen in de ruimte te kunnen garanderen. De onderzoeksvraag die zich hier stelt, is of het niet mogelijk is dit comfort uitsluitend te realiseren in een verkleinde zone rondom het individu. Dit kan door licht, warmte, koelte en verse lucht rechtstreeks af te geven aan de zone waar de gebruiker zich bevindt. Daardoor hoeft de rest van de ruimte niet meer te voldoen aan deze comforteisen (lees: lagere lichtsterkte, lagere of hogere temperatuur, lagere luchtkwaliteit, etc.). Het spreekt voor zich dat dit gepaard zal gaan met een verlaging van de energiebehoefte. Om bovenstaande techniek te realiseren is het belangrijk om een goed detectiesysteem te ontwikkelen. Onderzoek naar smartphonedetectie etc. is lopende.

Het is onze ambitie om via het paviljoen volgende projecten te illustreren: kanaalloze ventilatietoepassingen; geïntegreerde ventilatievoorzieningen in o.a. bedeinden en meubels; door smartphone aangestuurde stralingspanelen in plafond; automatisch gestuurde ver-



Persoonlijke klimatisatie

lichting; etc.

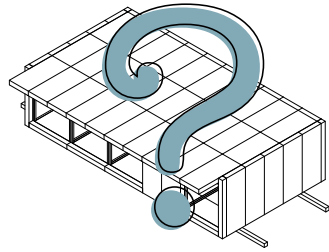
Productie-consumptie

Een ander gebruik van smart living is het aansturen van apparaten en klimatisatie. Vanuit een duurzaam standpunt is het belangrijk gebruik te maken van 'groene energie', zijnde zonne- en windenergie. Met de opkomst van slimme energiemeters wordt het echter ook mogelijk een evenwicht te vinden tussen productie en consumptie van energie. Het huidige onevenwicht komt grotendeels door een periodieke verschijning van

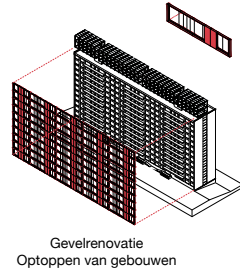
een piekproductie overdag en een piekconsumptie 's avonds. Door het gebruik van energieopslag wordt het mogelijk dit onevenwicht lokaal op te vangen. Dit wordt gerealiseerd via elektrische energieopslag met batterijen en thermische opslag in buffervaten. Een slimme aansturing van apparaten en klimatisatie is hierbij onmisbaar om tot een energie reductie te leiden.

21

After life



Renovatiestrategieën



De uitstraling van de SD-wedstrijd is groot. Door de maatschappelijk relevante problematiek die in het paviljoen wordt onderzocht en gedemonstreerd zal het paviljoen (en het prototype) de wedstrijd overleven. Het paviljoen of delen ervan kunnen op allerlei manieren ingezet worden voor demonstratieve, pedagogische, onderzoeks- en commerciële doeleinden.

Onderzoeksprojecten rond het renoveren van appartementsgebouwen zullen na de wedstrijd vervolgd worden aan de Universiteit Gent.

MEER INFO: WWW.HORIZON-UGENT.BE/KNOWLEDGEHUB

Er zijn contacten lopende met stad Antwerpen om het paviljoen na de wedstrijd als pop-up in te zetten om appartementsbewoners en -eigenaars, VME's, syndici etc. in te lichten over renovatie van appartementsblokken.

MEER INFO: WWW.ANTWERPEN.BE/RENOVATIECOACH

Daarnaast hebben we de ambitie om **THE MOBBLE** verder te ontwikkelen in grotere gehelen als antwoord op het woningtekort voor sociale woningen in Gent. Zie artikel rechts.

Nieuwe gebouwtypes



Flexibel wonen: bejaarde (groot)ouders in een container in uw tuin

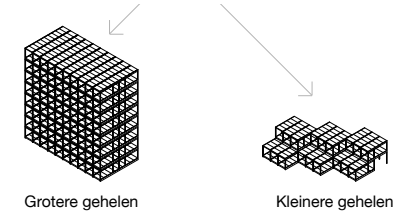
17-03-15, 06.22u - Belga

Bron: demorgen.be



Zorgen voor uw bejaarde ouders of grootouders: als het aan de Vlaamse overheid ligt, doet u dat straks in een container in uw achtertuin. Een aantal partners werkt aan de bouw van een perfect uitgeruste verplaatsbare woonruimte die opa of oma langer thuis moet houden, zo bericht Het Nieuwsblad.

Nieuwe gebouwtypes



Zijn containers de nieuwe sociale woningen?

07-02-18, 06.00u - Yannick Verberckmoes en Michiel Martin

Bron: demorgen.be



Gent haalde de mosterd voor zijn woonproject in het buitenland, waar woonboxen al langer bestaan, zoals in het Nederlandse Almere. © Hollandse Hoogte / Jordi Huisman

Om het woningtekort het hoofd te bieden, wil Gent binnenkort containerwoningen bouwen. Een noodoplossing volgens minister Homans. Maar de Vlaamse bouwmeester Leo Van Broeck wil er net veel meer zien.

"Containerwoningen kunnen de gigantische wachtlijst voor sociale woningen inkorten."

**THE NEW COOL
IS LIVING IN A
MOBBLE**

Partnership

Waarom partner worden?

POSITIEF IMAGO

- Positioneer uw bedrijf als een jong, duurzaam en toekomstgezinde onderneming
- Het is tijd om een standpunt in te nemen inzake een andere manier van wonen en denken erover. Politici, opdrachtgevers en consumenten vragen om tot actie over te gaan
- Steun onderzoek naar duurzaamheid en energie-efficiënte technieken bij de ontwikkeling van nieuwe gebouwtypes.

KENNIS- EN NETWERKUITBREIDING

- Verwerven van inzichten in onze nieuwe onderzoeken
- Workshops organiseren voor uw bedrijf rond vernieuwde bouwmethoden en technieken
- Indienen van onderzoekvoorstel gerelateerd aan het paviljoen
- Samenwerken met een nieuwe lichte ingenieursstudenten van de Universiteit Gent

PUBLICITEIT

- Verbaal dankwoord op evenementen
- Vernoeming op sociale media
- Vermeld worden bij elke vorm van officiële communicatie: posters, T-shirts, brochures, banners, e-nieuwsbrief, website etc.
- Lezingen aan Universiteit Gent
- Gebruik de Solar Decathlon Europe wedstrijd als een moment om toekomstige klanten aan te spreken (duizenden bezoekers worden verwacht)

Blijf up to date met onze driemaandelijke nieuwsbrief waarin wij actuele ontwikkelingen, cradle to cradle nieuws, events en updates over **THE MOBBLE** en het Solar Decathlon project graag met u delen.

Wilt u ook onze nieuwsbrief graag ontvangen?
E-mail uw gegevens naar **INFO@THEMOBBLE.BE**.

Waarmee kan u ons helpen?

Voor de ontwikkeling en de bouw van het paviljoen is er een behoorlijk budget nodig. Dit bedrag is voornamelijk nodig voor de organisatie en de deelname aan de wedstrijd in Szentendre zelf, maar ook voor promotie-evenementen, drukwerk, onderzoek etc. De lijst hieronder geeft een raming weer.

VOORONDERZOEK EN ONTWIKKELING

Inschrijvingsgeld	€ 750 ✓
Communicatie	€ 20.000
Academische medewerkers	€ 126.000 ✓
Projectmedewerkers	€ 99.000 ✓
Jobstudenten	€ 8.000 ✓
Workshops in Szentendre	€ 5.250
Deliverables	€ 1.000
Bezoek SD Denver 2017	€ 5.400 ✓
Prototype 1 STEAMlab21	€ 12.750 ✓
Totaal	€ 278.150

PROTOTYPE 2

Funderingssysteem	€ 1.500
Structureel kader	€ 2.000
Vloer-, dak- en wandpanelen	€ 13.200
Gevelafwerking	€ 1.500
Ramen	€ 5.600
Dakafwerking	€ 600
Verbindingen	€ 200
Binnenwanden	€ 1.000
Binnendeuren	€ 600
Permanente meubels	€ 3.000
Verwerken	€ 500
Totaal	€ 29.700

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Vervoer van modules (heen en weer)	€ 15.000
Beschermzeil	€ 2.500
Wedstrijd	
Transport en verblijf studenten	€ 21.000
Huur kranen en gereedschappen	€ 5.000
Communicatie	€ 15.000
Verzekering	€ 5.000
Totaal	€ 63.500

Totaalbedrag:	€ 724.850
Budget UGent:	- € 251.900
Wedstrijdgeld:	- € 100.000
SPONSORBUDGET:	€ 372.950

UITWERKING EN BOUWEN VAN PAVILJOEN

Bouwen	
Funderingssysteem	€ 7.500
Structureel kader	€ 10.000
Vloer-, dak- en wandpanelen	€ 27.500
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Zonneschermen	€ 9.500
Ramen	€ 34.500
Dakafwerking	€ 10.800
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Binnenwanden	€ 5.700
Binnendeuren	€ 3.000
Permanente meubels	€ 15.000
Verwerken	€ 2.000
Mobiele meubels	€ 10.000
Binnen- en buitenverlichting	€ 4.000

Buitenontwerp € 22.500

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€ 316.250

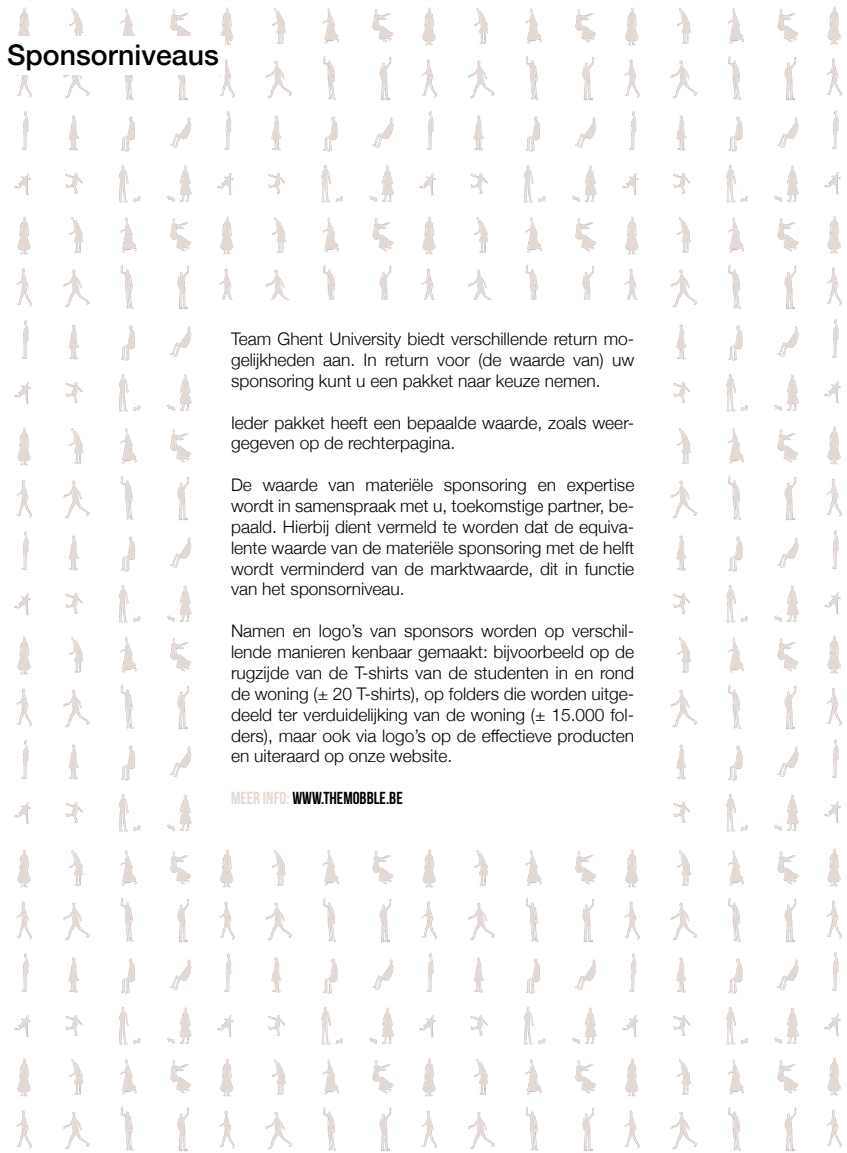
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Team Ghent University biedt verschillende return mogelijkheden aan. In return voor (de waarde van) uw sponsoring kunt u een pakket naar keuze nemen.

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Bedankt!

Indien u interesse heeft om partners te worden van Team Ghent University, vragen wij u vriendelijk contact op te nemen via telefoon of e-mail, zodat wij een afspraak met u kunnen maken.

Alvast dank voor uw tijd en hopen op een positieve respons.

Contactgegevens:
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Team Ghent University

Vakgroep Architectuur en Stedenbouw
Faculteit Ingenieurswetenschappen en Architectuur
Universiteit Gent
Jozef Plateastraat 22

Volg ons!

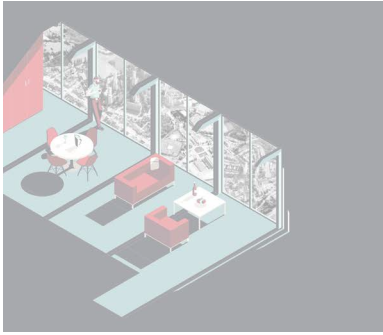


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DR
an Van Den Bossche
che@UGent.be

STUDENT TEAM LEADERS
info.horizon@UGent.be

MOBBLE ar Building Block

Statement
Apartment buildings constructed in the 60's
to a large housing shortage after the second
re typically outdated and no longer meet
ents. The majority of these high-rise build-
erate need of a thorough renovation.

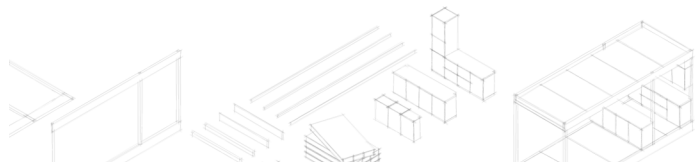
iversity Horizon Team aspires to showcase
nd the necessity of renovating large scale
dings. In addition, we want to raise aware-
g health issues such as poor indoor air
relative humidities, mould risks and critical
centrations in tap water. This communica-
oriented towards the general public, but
, contractors, building experts and policy
be triggered and informed.

Project description
We will build a characteristic hi
address these technical, scientifi
lenges. Based on the experience fi
participations at the Solar Decat
Washington and Datong, the Ghe
Team decided to design and cons
ing a modular system. The stand
completely prefabricated by stu
structural frame, but also HVAC s
room, interior finishing, etc. is inc
the modules can easily be transp
resulting in a limited installation ti

Modular
The competition house is an illus
building system, called The Mob
on adaptability and flexibility. Th
on adaptability and flexibility. Th
in different manners: to create ne
tions; to add some housing layer
high-rise buildings; or represent
ment. The underlying blueprint
the apartment very easily, which r
ous social configurations, from sta
ilies, up to elderly people.

Life cycle cost
Nowadays, life cycle cost mainly
level. However, a more holistic
sustainability is required. We are
ability and recycling on compone
esting compared to the approach c

Technical installations
Energy efficiency is a prerequisite.
buildings with complex social mix
should be intelligent and demar
Hence, an innovative IoT-approa
sure an optimal trade-off betwee
comfort, and energy use. Finally, a
building integrated photovoltaics
finally renders the building extrem



HOOFDSTUK

Deliverable #1

WOORD VOORAF

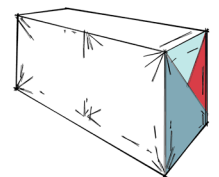
Op bepaalde tijdstippen moet elk deelnemend team een aantal documenten versturen naar de organisatie van de wedstrijd. Dit worden de *deliverables* genoemd. Er zijn in totaal zeven *deliverables* waarvan de eerste reeds op 30 maart 2018 is verzonden. Dit hoofdstuk bevat de documenten van *Deliverable #1*.

INHOUDSTAFEL

Project Manual

Press Release

Project Drawings

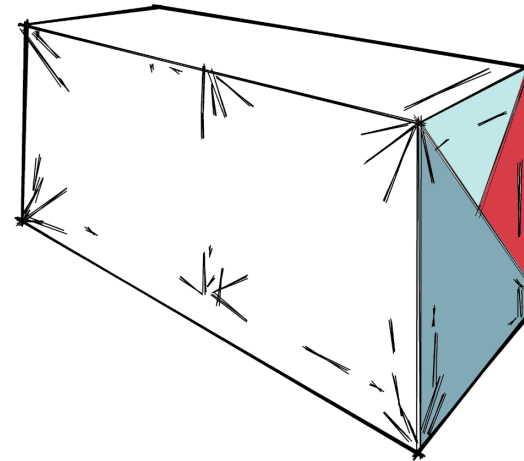


Hoofdstuk 8: Deliverable #1

8.1 Project Manual

THE MOBBLE

Modular Building Block



Project Manual
Deliverable #1
30 March 2018

SUMMARY OF CHANGES

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RULES CHECKLIST

Rule description	Content Requirement(s)	Drawing(s)/Report(s)
3.2 Team Officers and Contact Information	Team officer's contact information completely fulfilled in Table 1 (SDE WAT)	
4.3 Lot Conditions and attribution	Drawing(s) showing the storage and unloading areas and corresponding load's calculations	
4.3 Lot Conditions	Calculations showing the structural design remains compliant even if there is a level difference, and drawing(s) showing shimming methods and materials to be used in case	
4.4 Footings	Drawing(s) showing the locations and depths of all ground penetrations on the competition site	
4.4 Footings	Drawing(s) showing the location, contact area and soil-bearing pressure of every component resting directly on the ground	
4.7 Construction Equipment	Drawing(s) showing the assembly and disassembly sequences and the movement of heavy machinery on the competition site and specifications for heavy machinery	
5.1 Solar Envelope Dimensions	Drawing(s) showing the location of all house and site components relative to the solar envelope	
6.1 Structural Design Approval	Structural drawings and calculations signed and stamped by a qualified licensed professional	
6.1 Electrical and Photovoltaic Design Approval	Electrical and Photovoltaic drawings and calculations signed and stamped by a qualified licensed professional	
6.1 Codes Design Compliance	List of the country of origin codes complied, properly signed by the faculty advisor	
6.2 Architectural Footprint	Drawing(s) showing all information needed by the Rules Officials to digitally measure the architectural footprint	
6.2 Architectural Footprint	Drawing(s) showing all the reconfigurable features that may increase the footprint if operated during contest week	
6.3 Measurable Area	Drawing(s) showing the Measurable Area	
6.4 Entrance and Exit Routes	Drawing(s) showing the accessible public tour route, specifying the entrance and exit from the house to the main street of SDE Solar Village	
7.3 PV Technology Limitations	Specifications and contractor price quote for photovoltaic components	
7.4 Batteries	Drawing(s) showing the location(s) and quantity of stand-alone, PV-powered devices and corresponding specifications	
7.4 Batteries	Drawing(s) showing the location(s) and quantity of hard-wired battery banks components and corresponding specifications	
7.6 Thermal Energy Storage	Drawing(s) showing the location of thermal energy storage components and corresponding specifications	
7.7 Desiccant Systems	Drawing(s) describing the operation of the desiccant system and corresponding specifications	
7.8 Humidification systems	Specifications for humidification systems and corresponding certifications of the different elements.	
8.1 Containers locations	Drawing(s) showing the location of all the water tanks	

8.2 Water Delivery	Drawing(s) showing the fill location(s), quantity of water requested at each fill location, tank dimensions, diameter of opening(s) and clearance above the tank(s)	
8.3 Water Removal	Drawing(s) showing the quantity of water to be removed from each fill location, tank dimensions, diameter of opening(s) and clearance above the tank(s).	
8.5 Greywater reuse	Specifications for greywater reuse systems	
8.6 Rainwater Collection	Drawing(s) showing the layout and operation of rainwater collection systems	
8.8 Thermal Mass	Drawing(s) showing the locations of water-based thermal mass systems and corresponding specifications	
8.9 Greywater Heat Recovery	Specifications for greywater heat recovery systems.	
9.1 Placement	Drawing(s) showing the location of all vegetation and, if applicable, the movement of vegetation designed as part of an integrated mobile system	
9.2 Watering Restrictions	Drawings showing the layout and operation of greywater irrigation systems	
10.2 SDE Sensors' Location and wire routing	Drawing(s) showing the location of bi-directional meters, metering box, sensors, cables and feed-through to pass the instrumentation wires from the interior to the exterior of the house	
11.2 Use of the Solar Decathlon Europe Logo	artwork, and content of all communications materials, including signage	
11.3 Teams' sponsors & Supporting Institutions	Drawing(s) showing the dimensions, materials, artwork, and content of all communications materials, including signage	
11.4 Team Uniforms	Drawing(s) showing the artwork, content and design of the team uniform	
12.4 Public Tour	Drawing(s) showing the public tour route, indicating the dimensions of any difficult point, complying with the accessibility requirements	
23.0 Contest 9: Drying Method	Drawing(s) showing the clothes drying method and the place where the clothes will be dried.	
23.0 Contest 9: House Functioning	Appliances and corresponding technical specifications (Appliances and Home Electronic Equipment specifications and user manuals).	
36.5 Photovoltaic systems design	Specifications of PV generators, inverters, wiring, cables, protections, earthing systems, interface with the electricity distribution network	
36.5 Photovoltaic systems design	Inverters' certificates	
36.5 Photovoltaic systems design	Maintenance plan for PV generators, supporting structure, inverters, wiring, cables, protections, circuit breakers in case of fire and earthing system. Fire protection systems for PV DC wiring	
36.5 Photovoltaic systems design	The corresponding table "design summary" must be filled out	
51.3 Fire Safety	Specifications for Fire Reaction of Constructive elements, extinguishers and fire resistance of the house's structure.	
51.3 Fire Safety	Drawings showing compliance with the evacuation of occupants' requirements and fire extinguishers location	
51.4 Safety against falls	Specifications of compliance with the slipperiness degree classes of floors included in House tour	

51.4 Safety against falls	Drawing(s) showing compliance with conditions for uneven flooring, floors with different level, Restricted Areas stairs, Public Areas Staircases, Restricted Areas Ramps and Public Areas Ramps	
51.4 Safety for avoiding trapping and impact risk	Drawing(s) showing compliance with conditions for avoiding trapping and impact risk	
51.4 Safety against the risk of inadequate lighting	Specifications for level of illumination of house tour areas light fittings	
51.5 Accessibility for People with Disabilities and Special Needs	Interior and exterior plans showing the entire accessible tour route	
51.6 Structural Safety	Specifications for the use of dead loads, live loads, safety factors and load combinations in the structural calculations	
51.7 Electrical and PV Systems	Complete the "Electrical System Design PV Chart and Checklist".	
51.7 Electrical and PV Systems	Specifications of the wiring, channels, panels and protections of the electrical installation	
51.7 Electrical and PV Systems	One-line electrical diagram and drawings showing the grounding, execution and paths	

CONTESTS SUPPORT DOCUMENTS

1 ARCHITECTURE DESIGN NARRATIVE

1.1 Architectural concept

1.1.1 Introduction

The Solar Decathlon pavilion aspires to tackle some of the renovation problems of the Etrimo apartments. In particular, the pavilion represents a test set-up to demonstrate renovation strategies for high-rise towers to a broad audience.

Furthermore, renovating the inside of the apartment allows to adopt a new blueprint as design principle, which was developed based on extensive scenario analysis: a minimal set of interventions provide a range of possibilities for various plan configurations, from starters, over young families, up to elderly people. We also add a new angle to the ongoing debate on life-cycle-cost and cradle to cradle. Our design puts more emphasis on re-use on a component scale than recycling on the material scale.

1.1.2 Anchor points

The pavilion is designed with the following three anchor points in mind:

1. A modular building system

We have chosen to build the pavilion in modules for reasons of standardization and transportation. All modules are identical and are named Mobbles. One Mobble can act as an emergency home, a caretaker home in the garden of a small house, or as an affordable home for young adults.

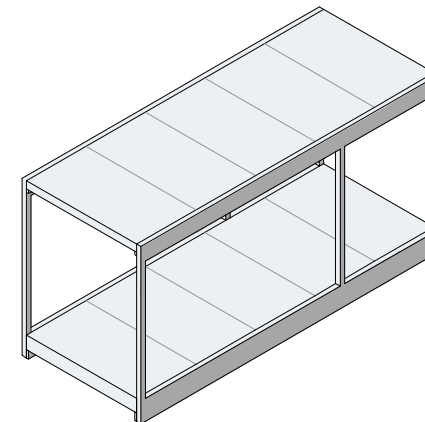


Figure 1: One Mobble

Developing into larger units with these modules results in intelligent models for low and medium high-rise buildings. The modularity culminates in high flexibility and adaptability.

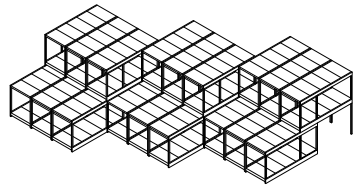


Figure 2: Flexibility and adaptability of the Mobbles

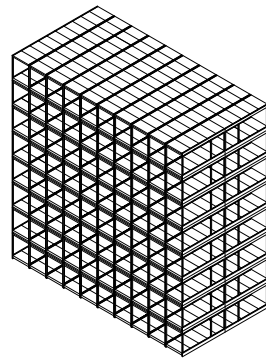


Figure 3: High rise building made of Mobbles

2. Employability for renovation of high-rise buildings

The Solar Decathlon pavilion fits in the renovation problem of the Etrimo apartments in Belgium. The story about apartments built by the Etrimo company will be described in part neighbourhood integration.



Figure 4: Etrimo apartment

The modules also have applications for renovating of buildings. The light construction makes it possible to place a series of Mobbles on top of the roof of the buildings to be renovated. In a first renovation phase, families can temporarily move to these rooftop module apartments while their apartments are being renovated. Then, they will return to their apartment and the following residents will temporarily stay in the Mobbles until their house has been completely renovated. After this process, it's possible to maintain the module apartments. At the end, the apartment building will contain more housing units, which also promotes densification in the city. The renovation cost can also be limited in this way.

3. Implementation of smart technologies

The pavilion comprises specific solutions to tackle the technical challenges in renovating large-scale building blocks, the building industry is confronted with. More specifically, prefab panels with vacuum insulation are used for the building envelope; IoT-controlled heating, cooling and ventilation is installed with direct online output of energy use and indoor air quality; and a heat pump driven by building integrated photovoltaics with battery storage finally renders the building extremely energy efficient.

1.1.3 Translation

The starting point for the pavilion's floor plan is the typical apartment from an Etrimo building. The geometry and corresponding dimensions are copied almost literally, as well as the use of one-sided glazing, the balcony and the typical operating strip (entrance, kitchen, bathroom), indicated as gray shading on the plans below. The apartment/pavilion is accessed from the bottom right corner.

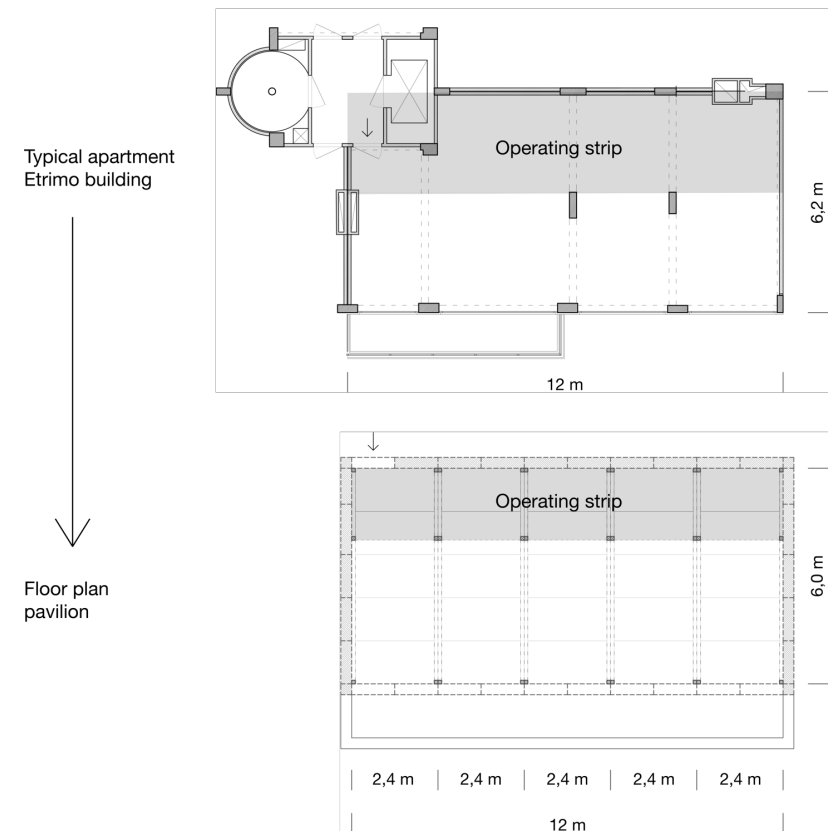


Figure 5: Translation Etrimo apartment to pavilion

1.1.4 Design of the pavilion

The pavilion consists of five identical modular units, one module is called a Mobble.

The dimensions of a Mobble are: L6,0m x W2,4m x H3,1m. The length and width are multiples of 1.2m which is based on the standard width of typical sandwich panels. Another reason for the use of multiples of 1.2m results from standard dimensions for transport and commercially available sizes of wood panels (plywood).

The Mobble is composed out of two structural frames (1). Between these frames the floor panels (2) and the first layer of roof panels are placed (3). Next, interior walls, furniture elements and technical installations will be installed. The module gets a protective sail and then the Mobble is ready for transport. In this way, the five modules will be prefabricated and finished with windows. The facade panels and the second layer of roof panels will be installed on site in Szentendre.

Once there, we start off with mounting the foundation (5). Then, the middle Mobble (6) will be installed, followed by the two flanking Mobbles (7) and finally the outer two Mobbles (8). After installing the Mobbles, the façade panels can be mounted (9, 10), as well as the additional layer of roof panels (11, 12).

It is a simple construction concept that enables students and do-it-yourselfers to manufacture their own house. A manual of 'How to construct a Mobble' is coming!

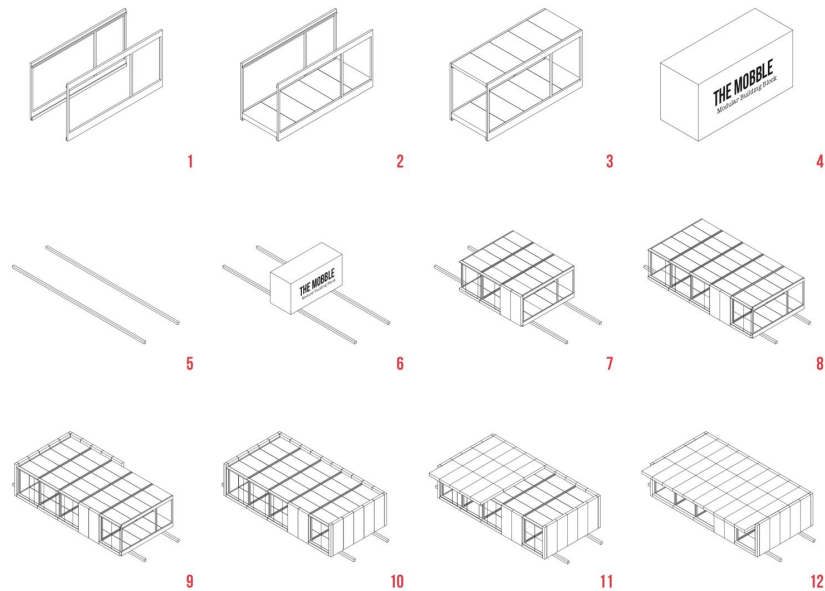


Figure 6: Construction pavilion

1.1.5 Layout of the plan

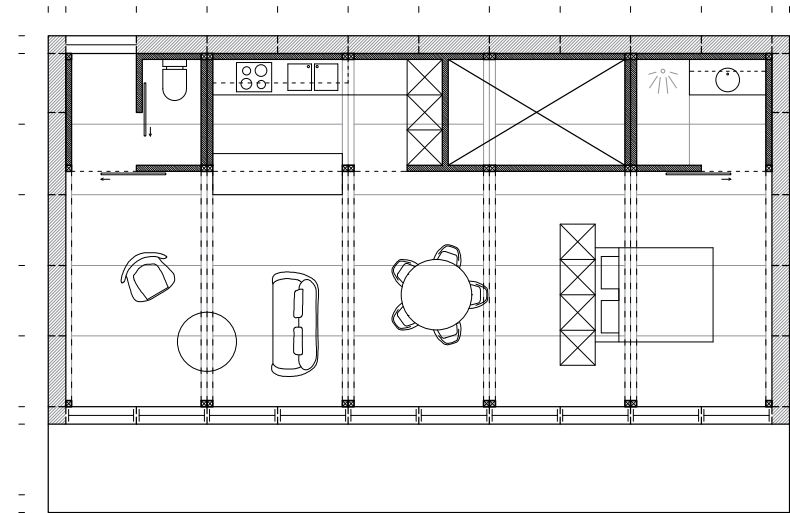


Figure 7: Floor plan pavilion

1.2 Summary of reconfigurable features

1.3 Lighting Design Narrative

First simulations regarding this topic give following results (measurements made on the 21st of March at 12:00):



Figure 8: Simulation in Dialux

G- value	81,5 %
Reflectance factor of walls	56 %
Reflectance factor of floor	13 %
Reflectance factor of ceiling	56 %
Reflectance factor of underside of the canopy	56 %
Reflectance factor of glazing	14,5 %
Reflectance factor of terrace	32 %

Table 1: Input values

	Illuminance [lux]	Daylight factor [%]
Living space (100 %)	357	2,68
Living space (50 %)	194	1,464
Open kitchen	38,7	0,293
Living space + open kitchen	305	2,302
Bedroom (100%)	336	2,536
Bedroom (50%)	168	1,269

Table 2: Output values

The daylight factors we get when looking at the output values are the main values. The maximum daylight factor for the living space will be around 10 %. This will give us a value that accords to the given values in the set of rules which leads to the conclusion that, in this design-faze, we will meet the requirements.

The following pictures show the daylight-change during the day. The measurements were made on the 21st of March with an overcast sky and the glass façade oriented South-West.

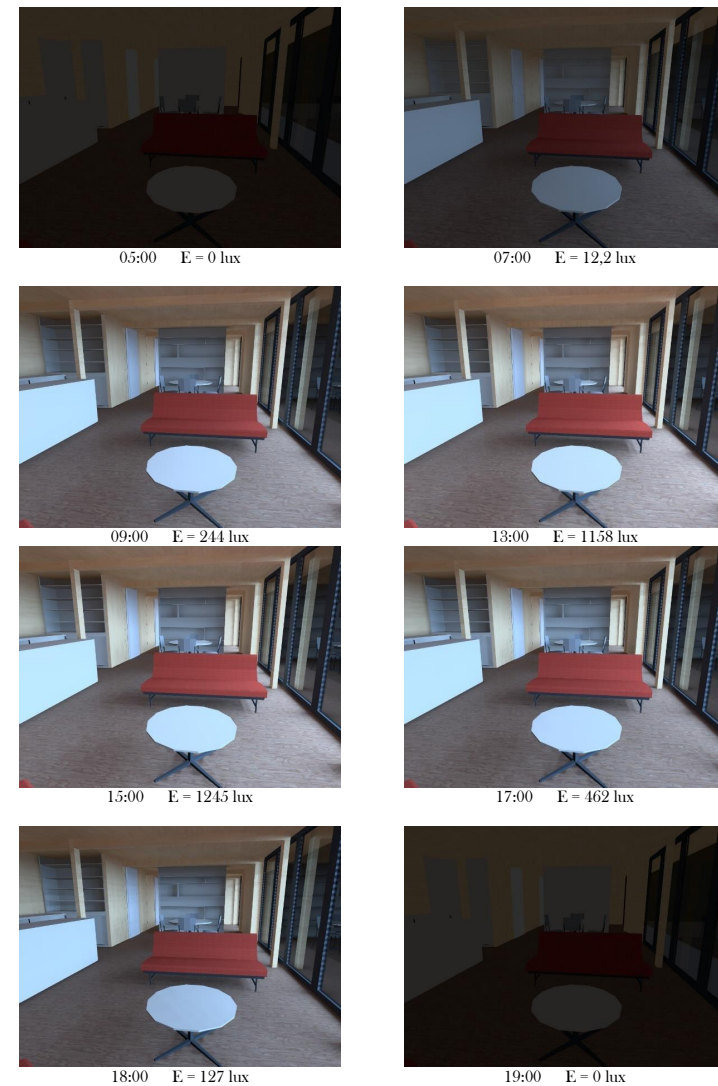


Figure 9: Simulation of daylight-change in Dialux for a whole day

2 ENGINEERING & CONSTRUCTION DESIGN NARRATIVE

2.1 Structural design

2.1.1 Introduction

One of the greatest challenges of the Ghent University Team for Solar Decathlon Europe competition is essentially the difference in method of working for a pavilion and a direct link with the renovation of an existing apartment building. The theme is mainly about applying new techniques in inefficient apartments in order to make them energy neutral and upgrade their architectural quality. Our pavilion showcases an abstract translation of an apartment and demonstrates the possible application of these new techniques but the techniques couldn't be copied and pasted literally to the apartment. A translation must be made.

The structure of all Etrimo building consists of reinforced concrete. For the pavilion we have chosen to use a wooden structure. The material and systems proposals for the pavilion are based on a DIY-philosophy. The structural design is conceived in such a way that the components can easily be found in a current store for building components and are therefore based on standard sizes.

2.1.2 Structural elements

The pavilion can be divided into different elements:

1. Structural modules = Mobbles
 - a. Structural frame;
 - b. Floor and roof panels;
 - c. Tensile bars to keep the structure together;
2. Foundation system associated with balcony and ramp;
3. Second layer of roof panels and wall panels;
4. Finishing façade incl. technical panel.
5. Windows

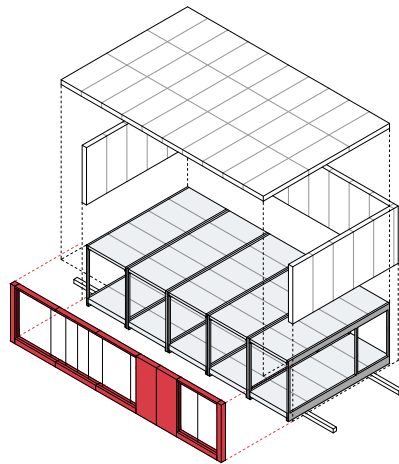


Figure 10: Structural elements

1. Structural modules

One module is composed of two structural frames. Between these frames the floor panels and the first layer of roof panels are placed.

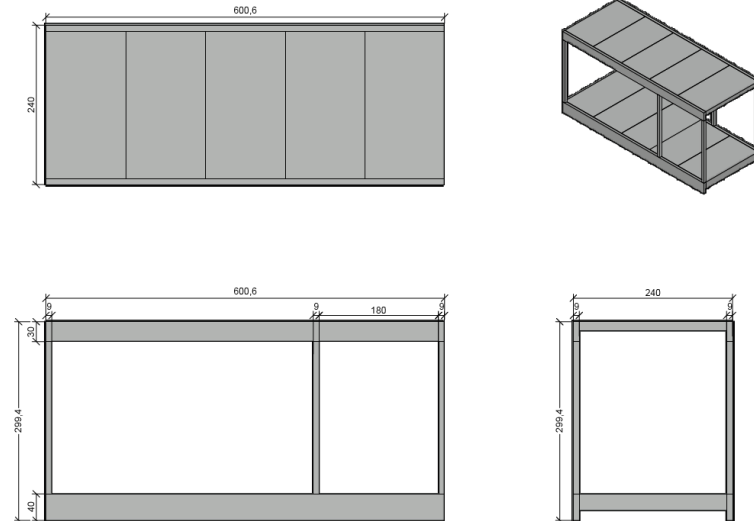


Figure 11: Dimensions of one Mobble

a. Structural frames

One module is composed of two structural frames. This frame consists of six layers of plywood, ranked in relation to each other (Figure 12: Different layers plywood). Those layers are glued and nailed together, to keep them attached. This structural frame will be made in a template that we will use to make all frames so they are identical.

To guarantee the stability and stiffness of the frames, calculations are made and tests will be performed on the frame. Please, see section on Structural calculations.

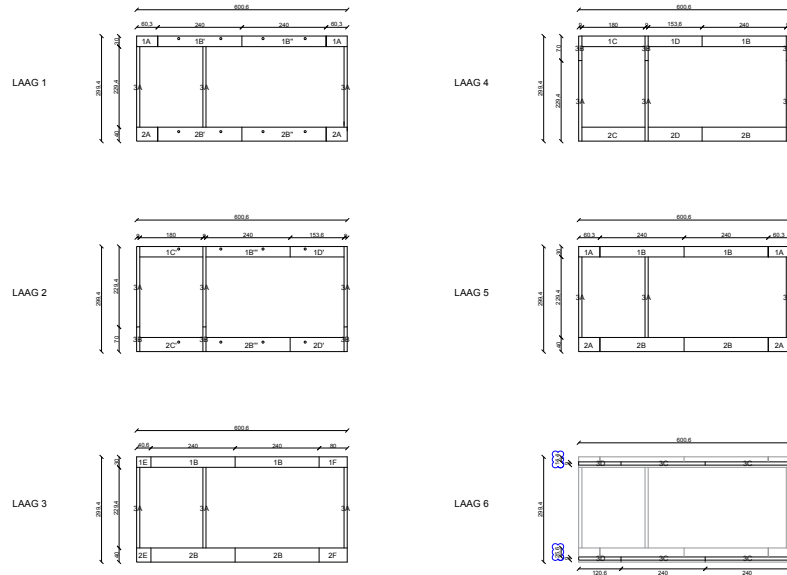


Figure 12: Different layers plywood

b. Floor and roof panels

The floor and roof panels of the Mobble are filled with rock wool.

The panels are made of four beams in order to assure the stiffness. One can count on 'Constructions with general stiffness', to capture the wind loads. In this case the horizontal and vertical rigid panels work together to obtain a general stability of the building.

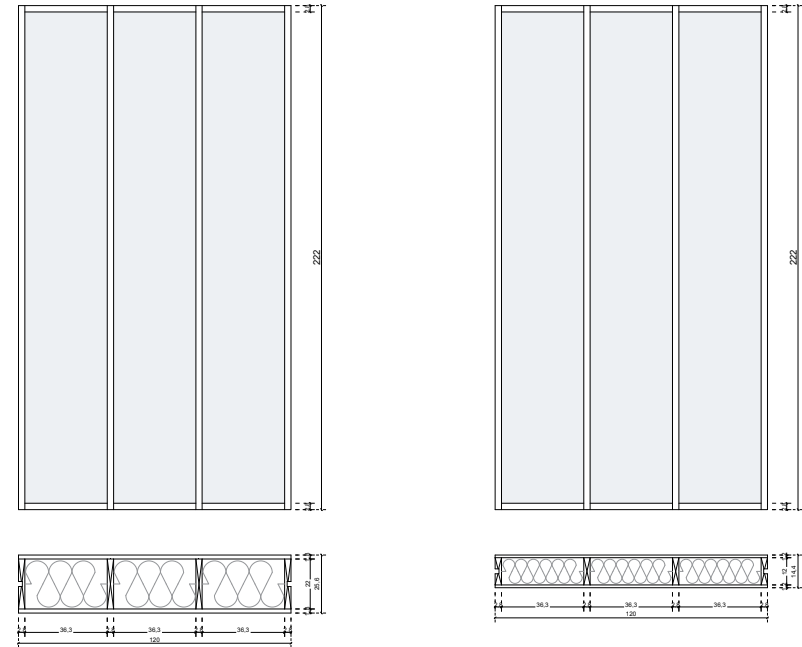


Figure 13: Floor panels

Figure 14: First layer roof panels

c. Tensile bars to keep the structure together

To keep the two frames stable, tensile bars are placed between the floor panels and the first layer roof panels. These tensile bars are made out of steel and will be connected to the frame by bolts and nuts, like bobbins are held together.

2. Foundation system associated with balcony and ramp;

Will be elaborated in the next deliverable.

3. Second layer of roof panels and wall panels

After transporting the Mobbles to Szentendre, the second layer of roof panels and the wall panels will be placed.

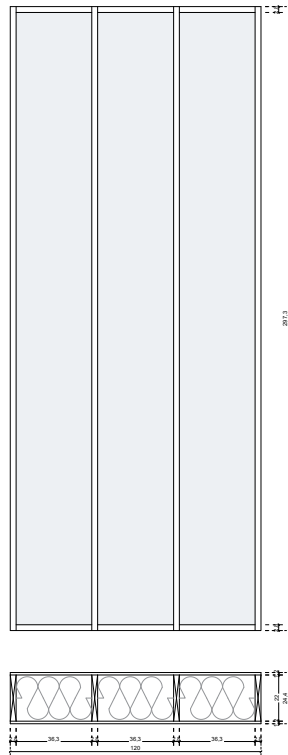


Figure 15: Second layer roof panels

The panels are made of four beams in order to assure the stiffness. One can count on 'Constructions with general stiffness', to capture the wind loads. In this case the horizontal and vertical rigid panels work together to obtain a general stability of the building.

4. Finishing facade incl. technical panel

The technical panel will include technical installations as a good insulation. At this moment this concept is in design phase. The elaborations will be explained in the following deliverables.

5. Windows

Modularity is one of the pillars of our concept and we want to apply this in the windows as well. This translates in techniques that make the windows easily replaceable and adaptable.

2.1.3 More than just a pavilion

We started investigating larger cohousing models with the Mobble. This includes using the same dimensions and building materials.

For each of those systems, the forces will be calculated and placed upon the system. Afterwards this will be put in a computer software where the several characteristics will be studied. These characteristics will determine if the dimensions of the building materials should be adjusted or if the columns should have to be placed differently. At last the building knots will be studied. On the basis of the computer software and the different fasteners that exists, several knot solutions will be summed up for each building system.

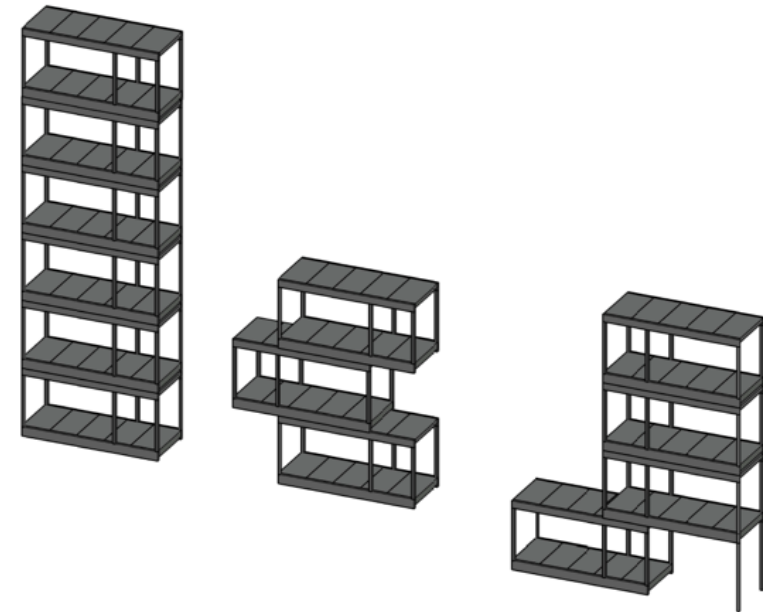


Figure 16: Different construction possibilities

2.2 Constructive Design

2.2.1 Motivation and requirements for material sections

1. Construction floor: floor panels

The floor consists of sandwich panels (Figure 17: Floor panels). These panels have an insulation layer with a thickness of 22 cm. In between the mineral wool, wooden rafters of 2,8 cm assure the overall stiffness of the panels. The sandwich elements have a plywood finishing layer of 1,8 cm.

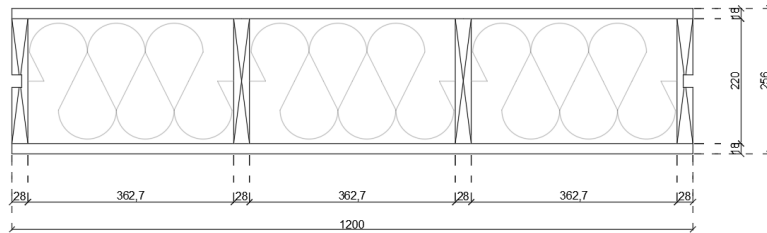


Figure 17: Floor panels

The U-values of the panels are determined by the Belgian manufacturer Unilin. The floor panels have a U-value of 5 m²K/W. To check whether or not this is a realistic value for a sandwich panel, we used the heterogeneous calculation method to calculate the U-value of the panels.

floor panel	
Thicknesses [m]	
Mineral wool	0,22
Plywood	0,018
Sections rafters	0,22 x 0,028
λ-value [W/(mK)]	
Mineral wool [m]	0,037
Plywood	0,17
timber wood rafters	0,13

Table 3: Calculations U-value floor panel

Our calculation results in a mean thermal resistance of R=5,06 (m²K)/W. This approximates the value of the manufacturer.

The floor panels are placed between the frames. If we consider the whole floor, this is actually a heterogeneous construction because of the presence of the plywood frames. Again, we use the heterogeneous method, described in the 'transmissie referentie document' (a Belgian standard for the calculation of transmission losses) to calculate a mean U-value of the floor.



Figure 18: Floor panel

The calculation of the mean U-value conforms the method described above results in the following:

$$U_{\text{floor}} = 0,22 \text{ W/(m}^2\text{K)}$$

2. Construction wall: sidewall panels

The sidewalls of the pavilion consist of sandwich panels (Figure 19: Wall panels). These panels have an insulation layer with a thickness of 22 cm. In between the mineral wool, wooden rafters of 2,8 cm assure the overall stiffness of the panels. The sandwich elements have a plywood finishing layer of 1,2 cm.

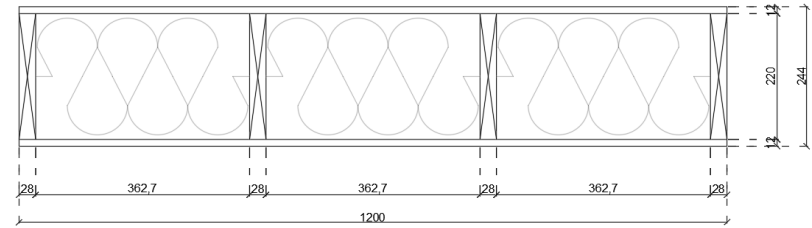


Figure 19: Wall panels

The U-values of the panels are determined by the Belgian manufacturer Unilin. The wall panels have a U-value of 5 m²K/W. To check whether or not this is a realistic value for a sandwich panel, we used the heterogeneous calculation method to calculate the U-value of the panels.

wall panel	
Thicknesses [m]	
Mineral wool	0,22
Plywood	0,012
Sections rafters	0,22 x 0,028
λ-value [W/(mK)]	
Mineral wool [m]	0,037
Plywood	0,17
timber wood rafters	0,13

Table 4: Calculations U-value wall panel

The use of the calculation method described in the 'transmissie referentie document' results in $U_{\text{wall}}=0,19 \text{ W/(m}^2\text{K)}$.

3. Construction roof: Double layer of roof panels

The roof consists of a double layer of sandwich panels. These panels have an insulation layer with a thickness of 12 cm. In between the mineral wool, wooden rafters of 2,4 cm assure the overall stiffness of the panels. The sandwich elements have a plywood finishing layer of 1,2 cm.

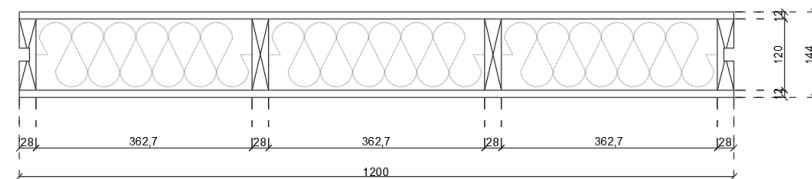


Figure 20: Second roof panel

The roof is a double layered construction. One layer of sandwich panels is placed between the wooden frames. A second layer of panels is placed on top of it as showed in the image below.



Figure 21: Double layered floor panels

The U-values of the panels are determined by the Belgian manufacturer Unilin. The roof panels have a U-value of 5 m²K/W. To check whether or not this is a realistic value for a sandwich panel, we used the heterogenous calculation method to calculate the U-value of the panels.

roof panel	
Thicknesses [m]	
Mineral wool	0,12
Plywood	0,012
Sections rafters	0,12 x 0,024
λ-value [W/(mK)]	
Mineral wool [m]	0,037
Plywood	0,17
timber wood rafters	0,13

Table 5: Calculations U-value roof panels

Our calculation results in $U_{roof} = 0,18 \text{ W/(m}^2\text{K)}$.

4. Construction glass facade

Not been elaborated yet.

5. Construction finishing façade: backside wall

The wall at the entry side of the pavilion is a double wall, a combination of a prefabricated sandwich panel and a self-made sandwich panel of the same type as the interior walls. The prefab sandwich panel has the same dimensions and characteristics as the side wall panels. The interior wall has a mineral wool insulation layer with a thickness of 5,8 cm finished with a plywood panels of 1,2 cm. In between the mineral wool rafters are added to assure the stiffness of the panel. Besides, the backside wall has a cladding with a strongly ventilated cavity. The total build-up of this wall is shown in the image below (Fig. X).



Figure 22: Finishing façade

This is a double heterogeneous construction. First, we calculated a mean thermal resistance value of the interior wall and the frame. Secondly, we use this value to calculate the U-value of the entire wall. This calculation has the following result:

$$U_{backside\ wall} = 0,16 \text{ W/(m}^2\text{K)}$$

6. Construction interior walls

The interior wall is constructed out of an insulating mineral wool layer of 5,8 cm, rafters with a section of 5,8 cm x 3,8 cm and a plywood finishing of 1,2 cm (Fig. X).



Figure 23: Interior wall

The interior wall has a U-value of 0,58 W/(m²K).

2.2.2 Acoustic performance

Not been elaborated yet.

2.3 Plumbing system design

Not been elaborated yet.

2.4 Electrical design

Not been elaborated yet.

2.5 Photovoltaic (and other electricity producing solar) system design

Not been elaborated yet.

2.6 Solar Thermal Design

Not been elaborated yet.

2.7 Building Integrated Solar Active Systems

Not been elaborated yet.

3 ENERGY EFFICIENCY DESIGN NARRATIVE

3.1 Technical Project Summary

3.1.1 Introduction

Firstly, we want to raise awareness concerning the necessity of a thorough renovation of the Etrimo and similar building blocks. Renovation of the facade will render the building more energy efficient. But this is just the start. Health issues such as poor indoor air quality, high relative humidities, mould risks and critical legionella concentrations in tap water, are equally important. By consequence, HVAC systems should be intelligent and demand-controlled; domestic hot water production will be controlled, and indoor air quality is a priority... These improvements will ameliorate the overall user comfort. The project aspires to reduce the life cycle cost of a building by providing a straightforward building plan that enables a whole range of different floor plans within the same apartment. Hence, this inherent and engineered flexibility will increase the time between renovations, decrease the life cycle cost, and increase the sustainability.

Traditional HVAC systems provide a uniform indoor climate for the whole building/space. The occupants on the other hand each have their own comfort preferences. The result is suboptimal comfort for the occupants and energy losses due to control 'on the safe side'. Recent advances in IT opens the perspective of individualized and personal HVAC systems in offices and home environments. These systems do not aim to heat/cool/ventilate the building space but deliver the heat, cold and fresh air directly to the occupant. These systems don't only improve comfort but especially the potential energy savings is interesting. In addition, such systems could potentially revolutionize the renovation market, where large new HVAC systems are often technically and aesthetically difficult to implement. The Mobble has the goal to illustrate the practical application of such systems inside their pavilion and investigate the potential energy gains.

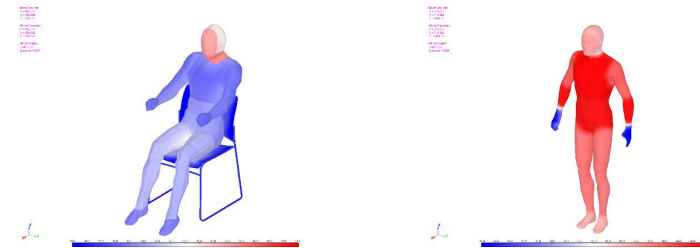
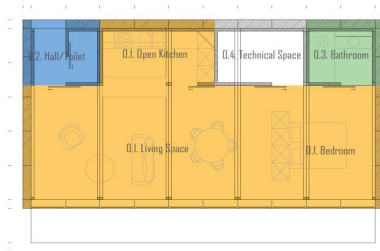


Figure 24: Simulation in Human Thermal Module - Thermoanalytics

3.1.2 Section I - Influence of energy Analysis on House Design and Competition Strategy

We've done a primary stationary heat loss calculation to get a first thought of the performance of the pavilion. This calculation is done according to the Belgian Standard NBN B 62-003.



Space	Net Area [m ²]	Normalized heat losses with ventilation system C/D [W]	Normalized heat losses with ventilation system C/D [W/m ²]
0.1. Living area/ Kitchen/ Bedroom	58,54	4588,52/ 2883,49	78,39/ 49,26
0.2. Hall/ Toilet	4,20	87,30/ 87,30	20,78/ 20,78
0.3. Bathroom	4,03	275,66/ 27,66	68,43/ 68,43
0.4. Technical Space	5,31	151,10/ 151,10	28,45/ 28,45

Table 6: Heat losses

This basic insight will be used to develop a dynamic model of the pavilion in order to gain an accurate simulation of the pavilion in outer conditions. For this, we will use Modelica with weather file UCCL.E.TYM. The model is currently rough, but we gained already followed insights:

- Problems regarding overheating:
 - due to the light weighted structure, the building reacts quickly to the outside conditions
 - In winter, the canopy doesn't block the solar gains, causing short overheating periods.
 - In summer, the canopy blocks the solar gains, which diminishes the cooling load.
- The canopy helps to reduce overheating, but reduces daylight factors, so a balance will need to be found or the overheating issue will need to be dealt differently (f.e. by introducing thermal mass)

3.1.3 Section II- Projected Performance of Final Housing Unit Design (Minimum Requirements)

Not been elaborated yet.

3.1.4 Section II- Adaptations made by the Team in the House for the prototype in Szentendre

Not been elaborated yet.

4 COMMUNICATION PLAN

4.1 Introduction

4.2 Communication project

4.3 Public tour description

4.4 Team visual identity manual

4.4.1 Student team

Team Ghent University is a group of motivated architecture and engineering students from Ghent University. The majority of the students are Master students from the Faculty of Engineering and Architecture who collaborate with Postgraduate Students Innovative entrepreneurship for Engineers.



Project managers

Astrid Schepens
Ineke Tavernier

Engineer-architects

Sven De Turck
Bjorn Pieters
Ineke Tavernier
Matthias Van Hove

Structural engineers

Astrid Schepens
Tessa Van Nieuwenhuysse
Piet Verstraete
Robin Vervaeck

Technical installations

Sven De Turck
Febe Lanckmans
Laura Landuyt
Matthias Van Hove

4.4.2 Faculty team

Prof. dr. eng. Arch. Nathan Van Den Bossche - Building Science
Arch. Marc De Kooning - Architectural design and construction
Prof. dr. eng. Arch. Arnold Janssens - Building Physics
Kristol Dewulf - Innovation and sustainability
Prof. arch. Jan Moens - Building Technology
Prof. dr. eng. Arch. Rommy De Meyer - Architectural design
Leen Veldeman - Communication and PR
Prof. dr. eng. Arch. Pieter Pauwels - BIM
Prof. dr. eng. Arch. Jelle Laverge - Technical installations

4.5 Sponsorship manual



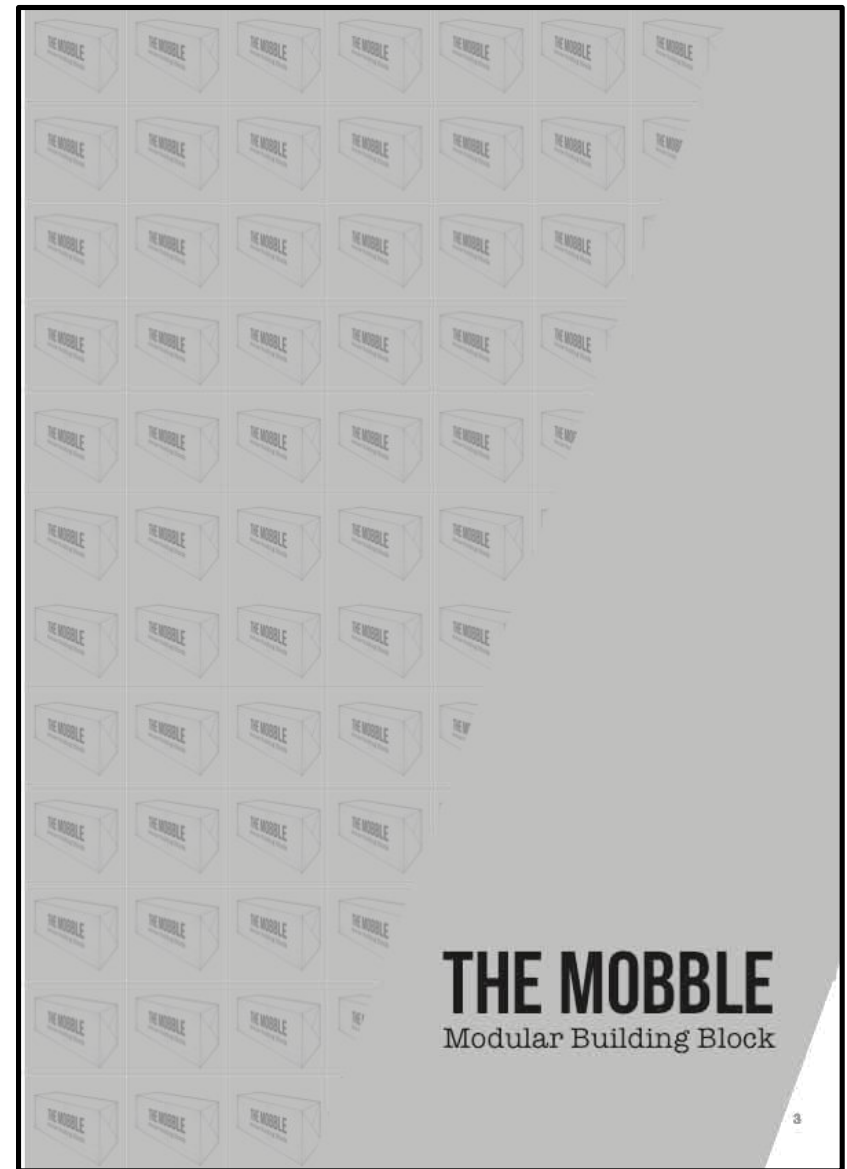
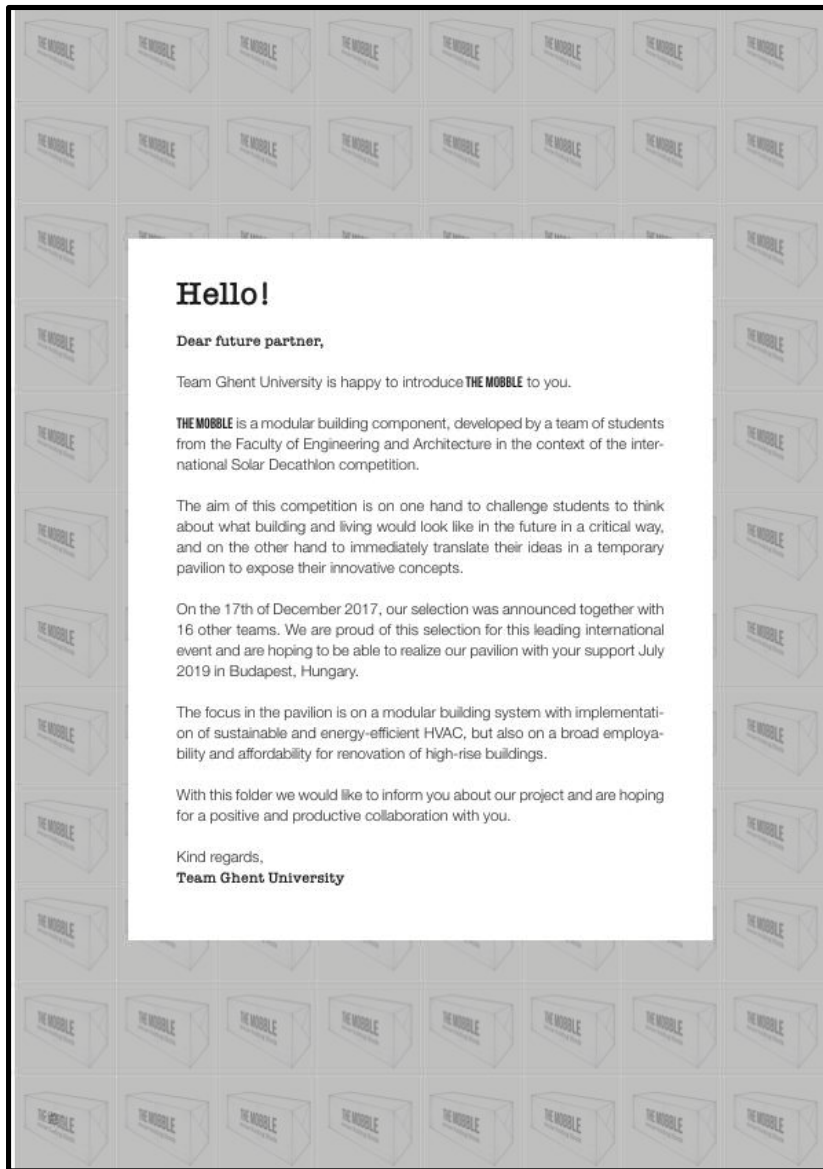
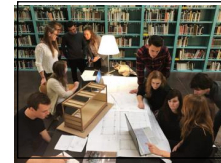




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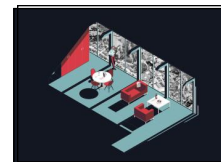
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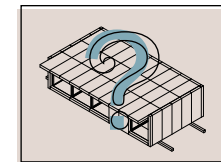
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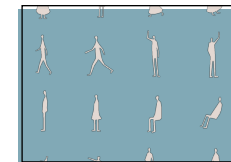
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Team Ghent University

Student team

Team Ghent University is a group of motivated architecture and engineering students from Ghent University. The majority of the students are Master students from the Faculty of Engineering and Architecture who collaborate with Postgraduate students Innovative entrepreneurship for Engineers.

Engineer-architects

Sven De Turk
Febe Lanckmans
Laura Landuyt
Bjorn Pieters
Ineke Tavernier
Matthias Van Hove

Structural engineers

Astrid Schepens
Tessa Van Nieuwenhuysse
Piet Verstraete
Robin Vervaeck

Technical installations

Joni Bauwens
Sven De Turk
Rebecca De Vuyst
Matthias Van Hove

Project managers

Astrid Schepens
Ineke Tavernier



6

Faculty team



Prof. dr. eng. arch. Nathan
Van Den Bossche
Building Science



Arch. Marc De Kooning
Architectural design and construction



Prof. dr. eng. arch. Arnold
Janssens
Building Physics



Kristel Dewulf
Innovation and sustainability



Prof. arch. Jan Moens
Building Technology



Prof. dr. eng. arch. Ronny
De Meyer
Architectural design



Leen Veldeman
Communication and PR



Prof. dr. eng. arch. Pieter Pauwels
BIM



Prof. dr. eng. arch. Jelle Laverge
Technical installations

Ir. Arthur De Roover // Prof. dr. ir. Michel De Paepe // Ing. Martijn Wyncke // Ir. Hugo Monteyne // Ir. arch. Klaas Calle // Ir. arch. Elisa Van Kenhove // Ir. arch. Stéphanie Van Linden // Prof. ir. Wim Boydens // Prof. dr. ir. arch. Marijke Steeman // Prof. dr. Johan Albrecht // Prof. dr. Hendrik Slabbinck // Prof. dr. ir. Wouter Decorte // Dr. ir. arch. Ruben Verstraeten // Prof. dr. ir. arch. Michiel Dehaene // Ir. Wim Beyne // Prof. dr. Liselot Hudders

7

Solar Decathlon

Competition

What?

The Solar Decathlon (SD) competition is an international student-competition on an academic level. Universities from all around the world are challenged to design and build a sustainable and energy-efficient pavilion.

The origin of the Solar Decathlon competition is located in the United States in 2002, organized by The United States Department of Energy. Ever since, the competition has been taking place every 2 years in the United States. In the meanwhile, the Solar Decathlon competition has become a world-wide event, with competitions in 5 continents: Europe (2010, 2012, 2014 and 2019), Asia (2013 and 2017), Latin America (2015) and Africa (2019).

Goal?

The United States Department of Energy has developed this competition to make people conscious and inform them about energy use, sustainable and energy-efficient technologies and renewable energy. In this way, they also want to stimulate students to start thinking creatively in searching for innovative solutions.



E-cube, 2011

Previous participations

E-cube, 2011

In 2011, Ghent University participated for the first time in the 5th edition of the Solar Decathlon, organized in Washington D.C., USA. Team Belgium defended with the E-cube (name of the pavilion) the honor of Europe.

The E-cube represents a cubic shape with emphasis on affordability and it's 'do-it-yourself' character. Team Belgium was the winner of the Affordability contest.



Solatrium, 2013

Two years later, Ghent University was part of the international BEMANY-team, which was a collaboration between Ghent University and two American universities: Worcester Polytechnic Institute and Polytechnic Institute of New York University. This team joined the Solar Decathlon in 2013 in Datong, China.

The basic pillars, namely a solar powered house around a central atrium, immediately explain where they got the name Solatrium for the pavilion. Team BEMANY finished in a nice 8th place.



Solatrium, 2013

Course of the competition

PHASE I: PRELIMINARY RESEARCH AND DEVELOPMENT

Within the themes proposed by the organization, the team chooses a social relevant renovation problem and the search for innovative ideas and the development of an intelligent design for the pavilion can start.

THEME OF THE COMPETITION: SEE SOLAR DECATHLON P. 10

RENOVATION PROBLEM: SEE HORIZON P. 12

AUG
2017

DEC
2017

ANNOUNCEMENT OF SELECTION

Mid-December was announced that we are selected for the next Solar Decathlon Europe in 2019 in Szentendre, Hungary.

FEB
2018

PHASE II: ELABORATION AND PROTOTYPE

In this phase, the focus is put on the development of a pavilion. The constructive architectural plans and innovative technical installations are being elaborated. A prototype will be built as a test.

SEPT
2018

PHASE III: BUILDING A PAVILION

In de derde fase wordt het definitieve derde paviljoen gebouwd. In deze fase worden de technische installaties geïmplementeerd. Vervolgens wordt het paviljoen uit elkaar gehaald en klaar gemaakt voor transport naar Hongarije.

PHASE IV: TRANSPORT AND CONSTRUCTION OF PAVILION

During this phase of the competition, the different pavilions of each selected team will be constructed in a Solar Village in Hungary. After a build-up period of 10 days, the pavilions will be opened for public for a longer period of time.

PHASE V: COMPETITION

Each team will be reviewed during this period based on 10 criteria, in which per theme 100 points can be earned. See to the right.

JULY
2019

THE TEN ASSESSMENT CRITERIA:

- Architecture
- Engineering & Construction
- Energy Efficiency
- Communication & Social Awareness
- Neighbourhood Integration & Impact
- Innovation & Viability
- Circularity & Sustainability
- Comfort Conditions
- House Functioning
- Energy Balance

Solar Decathlon



Solar Decathlon Europe

European edition

It's the first time that Ghent University participates in the European edition of the Solar Decathlon contest. In contrast to the edition in the US, the European editions (2012, 2014, 2019) focus more on renovation and social urban development challenges.

In 2016 Ghent University launched a knowledge and research platform concerning this challenge: the Ghent University Horizon Platform. For more information look at p. 10.

Selected teams

- University of Brighton, United Kingdom
- Technical University of Civil Engineering, Romania
- University of Technology and Economics, Hungary
- Universitat Politècnica de Catalunya, Spain
- Delft University of Technology, Netherlands
- Technical University of Denmark, Denmark
- International Hellenic University, Greece
- ENS d'Architecture et de Paysage de Lille, France
- University of Maryland, U.S.A.
- Politecnico di Milano, Italy
- University of Miskolc, Hungary
- Universidad de Sevilla, Spain
- King Mongkut's University of Technology, Thailand
- University of Applied Sciences Utrecht, Netherlands
- Universitat Politècnica de València, Spain
- **Ghent University, Belgium**

Theme

SDE19 focuses on the renovation of existing buildings. The teams can choose between one of the topics below:

- Renovation of traditional Hungarian rectangular apartment buildings
- Development of rooftop apartments (to increase the urban density)
- A renovation project typical for the native country

Team Ghent University focuses on the last subject. Our design is all about the nearly identical apartment buildings that were built by the company Etrimo in the 50' - '70 in the suburbs of the Belgian cities. These apartment buildings require a thorough low-energy renovation, but there are various technical, administrative, scientific, architectural, practical, legal, and financial issues to be tackled. That sounds like a job for us!

10



11

Horizon

Horizon project

In 2016 Ghent University started the Horizon project. This is a knowledge platform for the development of sustainable renovation of residential high rise. The platform is supported by several academics and researchers. Their goal is to centralize research about this subject and make it accessible to the public.



Challenges

History

During the second world war many homes were destroyed. This, combined with the baby boom that followed, caused a huge shortage of houses in Belgium. To tackle this challenge the repetitive high rise building model was adopted as concept.

This industrial building method made it possible to realize a large amount of homes in a short period of time. These apartments were a huge improvement compared to the typical houses constructed before the war in terms of hygiene, general comfort and quality of life. Next to that, the typical price (typically about 750€ - not corrected for inflation) rendered it affordable for a large part of the population.

One of the big construction companies that dominated the market in the '50 - '70 in Belgium was Etrimo. The company caused a revolution in residential building with their attractive ready-made formula. This company developed these apartment buildings at a high speed – however, with a minimum of architectural qualities. By using standardization in terms of typologies, structure and building materials, it was possible to produce a large amount of projects in a very short period of time.

Challenges today

These apartment buildings are outdated, energetically inefficient and no longer meet the standards concerning fire safety, accessibility, acoustics, etc. A complete and thorough renovation of the building is difficult because

every apartment is typically the property of a different owner, so this is a very complex process that is slowed down by various practical, technical, financial, organizational and legal obstacles.

Horizon focusses on the Etrimo buildings, because of the large building stock of identical or similar buildings that can be found in Belgium. These residential towers have a number of interesting advantages, and that's the reason why a thorough renovation of these buildings is worthwhile. The advantages are:

- Green environment
- Nice view
- High repetitiveness
- Advantages of a collective way of living
- Affordable apartments
- Interesting urban location
- Good structural integrity

To tackle the problems of these buildings an inquiry has been held to investigate the concerns of the owners and tenants. This resulted in a few obstacles that need to be resolved:

- Bad thermal performance of the building envelope
- Outdated technical installations
- Insufficient fire safety
- Insufficient acoustic and thermal comfort
- Inadequate circulation
- No access control

Etrimo building Breughelpark, Brussel



Organization Etrimo-ground plan

All Etrimo residential towers were built according to one principle. All apartments are arranged per four around a circulation core, have a terrace and the plan layout of the four apartments is always the same, as shown on the plan below. This scheme was repeated horizontally two to four times, depending on the dimensions of the available building plot.

Mission

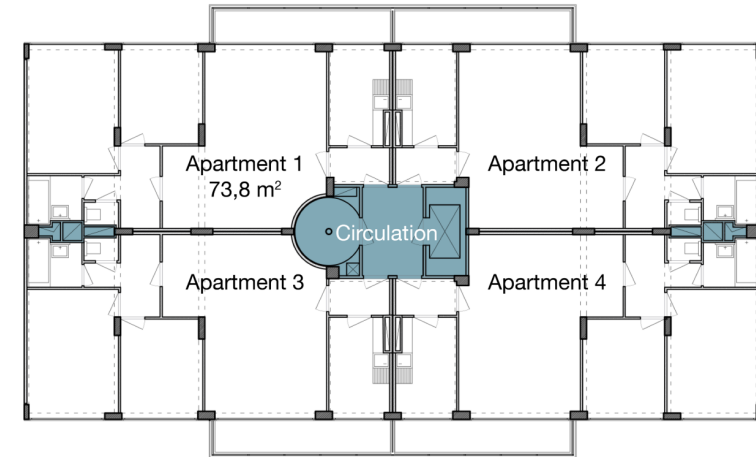
The Horizon knowledge hub of Ghent University aims to provide an overview of scientific research in connection with the renovation of post-war residential blocks in private ownership. For more information, please visit <http://www.horizon-ugent.be>.

SDE19

SDE19 focuses on renovation of buildings, which aligns with the goals of the Ghent University Horizon platform.

By participating in the competition, Horizon and the Ghent University team want to illustrate the renovation potential of high-rise buildings, inform the general public about this topic and develop innovative renovation strategies.

The design of the pavilion will therefore refer to a typical Etrimo apartment and will be used to test and demonstrate renovation solutions.



Plan of an Etrimo building

Our design

Solar decathlon pavilion

Renovation strategies

New building types

Emergency home
Tiny house

New apartments

Larger units

Facade renovation
Rooftop module apartments

Floor plan pavilion

Apartment Etrimo building

Concept

The Solar Decathlon pavilion aspires to tackle some of the renovation problems of the Etrimo apartments, as described above. In particular, the pavilion represents a test set-up to demonstrate renovation strategies for high-rise towers to a broad audience. On the other hand, we have chosen to build the pavilion in modules for reasons of standardization and transportation. All modules are identical and are named Mobbles. One Mobble can act as an emergency home, a caretaker home in the garden of a small house, or as an affordable home for young adults. Furthermore, the Mobble is a flexible building block that introduces a new concept of living: the Mobble allows you to adjust your house along the path of your life according to your needs. Life is too interesting, dynamic and challenging to be hampered by a static pile of bricks.

Developing our Mobbles into larger units results in intelligent models for low and medium high-rise buildings. The modularity culminates in a high flexibility and adaptability.

The following 3 pillars can be distilled:

- A modular building system
- Implementation of smart technologies
- Employability for renovation of high-rise buildings

Translation

The starting point for the pavilion's floor plan is the typical apartment from an Etrimo building. The geometry and corresponding dimensions are copied almost literally, as well as the use of one-sided glazing, the balcony and the typical operating strip (entrance, kitchen, bathroom), indicated as gray shading on the plans below. The apartment/pavilion is accessed from the bottom right corner.

Typical apartment
Etrimo building

Operating strip

12 m

6,2 m

Floor plan pavilion

Operating strip

12 m

6,0 m

15

Our design

Design of the pavilion

The pavilion consists of five identical modular units, one module is called a Mobble.

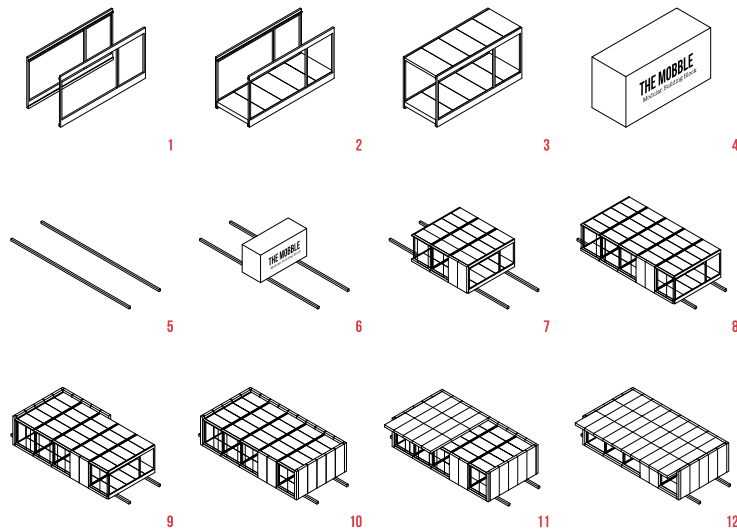
The dimensions of a Mobble are: L6,0m x W2,4m x H3,1m. The length and width are multiples of 1,2m which is based on the standard width of typical sandwich panels. Another reason for the use of multiples of 1,2m results from standard dimensions for transport and commercially available sizes of wood panels (plywood).

The Mobble is composed out of two structural frames (1). Between these frames the floor panels (2) and the first layer of roof panels are placed (3). Next, interior walls, furniture elements and technical installations will be installed. The module gets a protective sail and then the Mobble is ready for transport (4). In this way, the five modules will be prefabricated and finished with windows. The facade panels and the second layer of

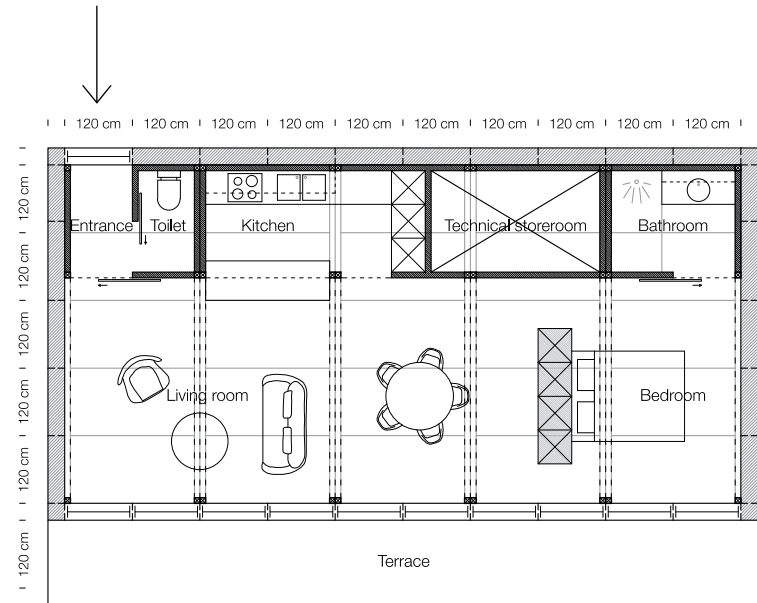
roof panels will be installed on site in Szentendre.

Once there, we start off with mounting the foundation (5). Then, the middle Mobble (6) will be installed, followed by the two flanking Mobbles (7) and finally the outer two Mobbles (8). After installing the Mobbles, the facade panels can be mounted (9,10), as well as the additional layer of roof panels (11,12).

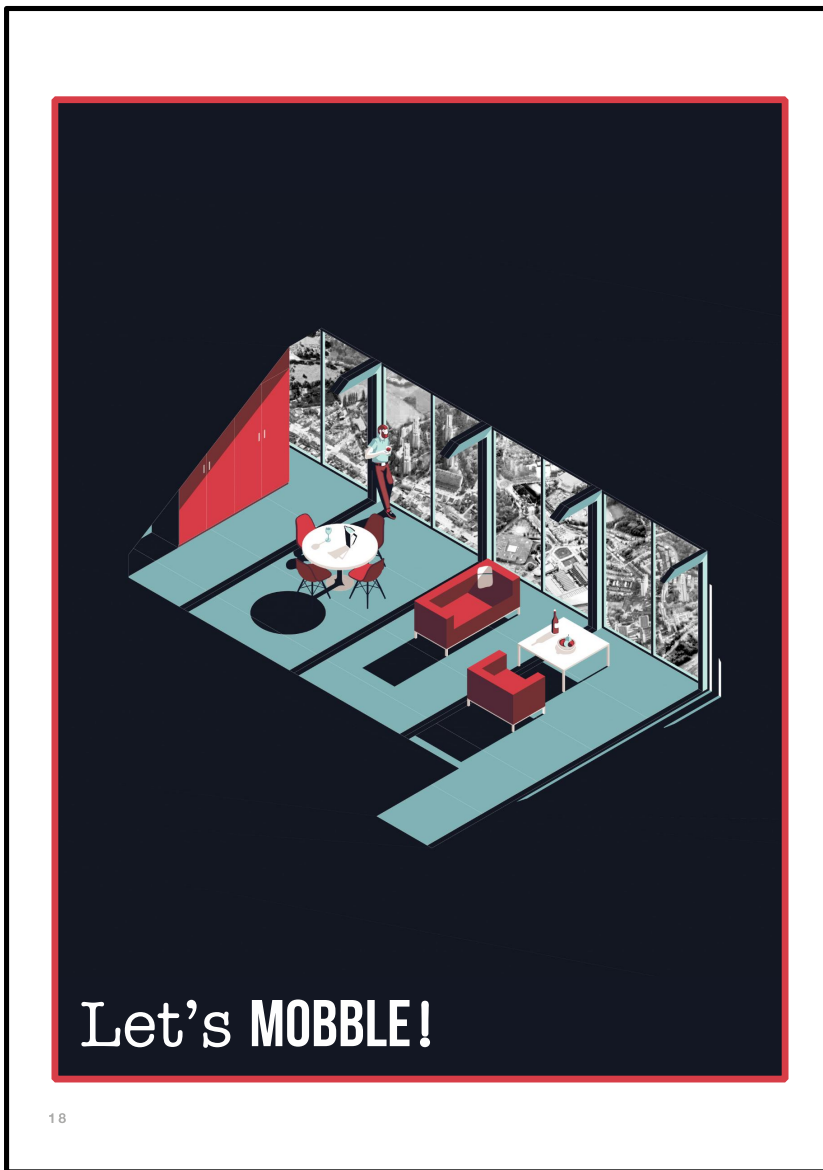
It is a simple construction concept that enables students and do-it-yourselfers to manufacture their own house. A manual of 'How to construct a Mobble' is coming!



Design of the pavilion step-by-step



Floor plan of the pavilion



Our design

Potential of modular building

New housing units
 Modular building has specific advantages and application areas. Because it's an adaptable, flexible building system, new housing units can be built, moved or removed quickly.

- Emergency houses
- Care houses
- Tiny houses
- Garden offices
- Pop-up stores or information centres
- Temporary extension of houses
- Kangaroo houses
- New housing units

Renovation
 There are also applications for renovating buildings. The light construction renders it possible to place a series of Mobbles on top of the roof of the buildings to be renovated. In a first renovation phase, families can temporarily move to these rooftop module apartments while their apartments are being renovated. Then, they will return to their apartment and the following residents will temporarily stay in the Mobbles until their house has been completely renovated. After this process, it's possible to maintain the module apartments. At the end, the apartment building will contain more housing units, which also promotes densification in

the city. The renovation cost can also be limited in this way, as the profit on the additional housing units can be used to partially pay for the overall renovation cost.

Life cycle analysis
 Throughout the last few decades, EU legislation has put a strong emphasis on limiting fossil energy consumption of newly constructed buildings. Given that the limits of energy efficiency are within reach (passive houses, zero-energy house, energy plus homes...), the focus is shifting towards life cycle analysis, health and indoor environment. While today the main emphasis is typically on the life cycle costs at material level, in our view a more holistic approach on sustainability is required. We are convinced that reusability and recycling at component level is more interesting compared to the material level approach.

Existing outdated buildings are often not suited to meet the dynamic demands of daily life, the changes in social needs and the rapidly evolving technical requirements of buildings. A lack of integrated flexibility and adaptability entails radical and thorough renovations and sometimes even integral demolition.

The modular construction approach increases the transformation capacity of the building. The modular units will be adapted more easily and quickly, which will positively influence the renovation procedure. The possible reconfiguration and recycling of components in constructions can result in important ecological and economic benefit.

Flexibility of the modules

Our design

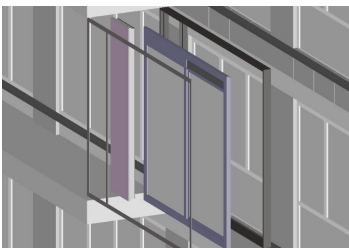
Technical challenges

Prefabricated facade panels as a tool for renovation

We want to use the pavilion to demonstrate innovations as possible solutions for the technical challenges of our century. In particular, we are currently conceiving innovative strategies to realize a quick and low energy facade renovation with prefabricated facade elements, causing negligible nuisance for owners and tenants. All-in-one panels can integrate HVAC systems in the renovation panel, as well as distribution for ventilation, heating, cooling, and domestic hot water systems.

In this way, the most crucial problems, i.e. the bad thermally insulated building envelope, outdated services, and deprecated facade and appearance, can be solved simultaneously by adopting one integrated system. The integration of photovoltaic cells in the facade panels can even enlarge the assets of the system.

Prefab facade renovation



20

Smart HVAC systems

Besides building an energy-efficient house, the smart living concept is yet another focal point we want to highlight in the SDE19 competition. In collaboration with the Ghent University HomeLab – a 600m² full scale test house to evaluate integrated concepts for IoT applications – innovative strategies are explored to reduce the energy use in dwellings, as well as increasing comfort and well-being.

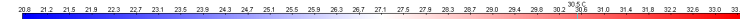
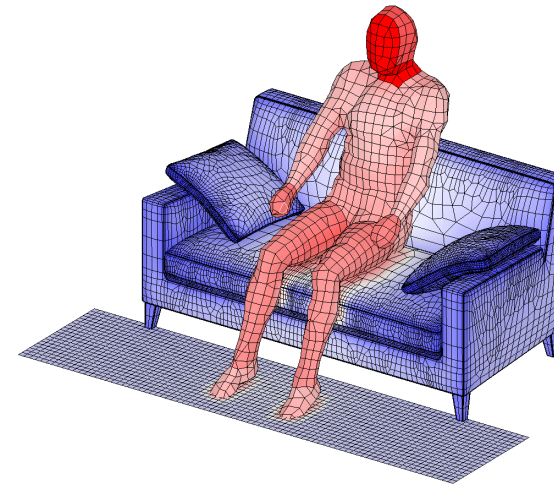
VISIT: [HTTPS://WWW.IMEC-INT.COM/EN/WHAT-WE-OFFER/INNOVATION-SERVICES/SMART-SPACES/HOMELAB](https://www.imec-int.com/en/what-we-offer/innovation-services/smart-spaces/homelab)

Personal indoor climate conditions

A first application of the Smart Living system is nothing less than a new and disruptive approach towards heating, cooling and ventilating buildings by balancing overall energy efficiency and individualized comfort conditions. The last few years, the energy efficiency of buildings enhanced significantly. We can even state that the limits of energy efficiency improvement for the building envelope are almost reached, considering the trade-off between reducing energy losses and embedded energy when increasing insulation thickness. Likewise, the production – and distribution efficiency have their limits as well. Contrarily, it is surprising that the way in which energy is used to realize comfort has barely been questioned so far, even though the energy reduction potential is very high at this level. Various research projects and measurement campaigns have concluded repeatedly that the actual energy savings after renovation are lower than predicted, mainly due to a shift towards slow low-temperature heating systems that work 24/7, and user-related rebound effects.

In the traditional approach, HVAC systems and controls provide an acceptable comfort level on the scale of an entire room, or even an entire building. The question at hand is whether it is feasible to realize a similar or better comfort level in buildings by adopting personal HVAC systems, i.e. controlling the climate restricted to the particular location of specific individuals. This can be achieved by providing lighting, heating, air conditioning and air supply directly to the zone in which the user is present, when the user is present. In this way, the rest of the room doesn't need to fulfil the comfort requirements; a lower illumination, lower or higher temperatures and a lower air supply rate is acceptable there. It is obvious that this HVAC concept comprises the potential to reduce the energy use tremendously. To turn this system into practice, a close collaboration is required with detection and control

50



Personal climatisation

systems, e.g. by addressing the potential of smartphones in that respect.

We aspire to demonstrate following concepts in the pavilion: ductless ventilation systems, integrated ventilation systems (e.g. in walls and furniture), smartphone-controlled radiation panels in the ceiling, automatically controlled lighting etc.

Production-consumption

Controlling devices and climate conditions is another application of the Smart Living concept. From a sustainability point of view, it is important to use 'green energy', such as solar and wind energy. Due to the rise of smart meters in buildings, it becomes possi-

ble to optimize the balance between production and consumption of energy. The actual unbalance is caused by a peak production at daytime and a peak consumption in the evening. By use of energy storage, it becomes possible to address grid-instability on a local scale. Certainly for large-scale apartment buildings micro-grids may reduce the stress on the grid. Electrical energy can be stored in batteries, whereas buffer tanks are appropriate for thermal energy storage. A smart strategy for controlling of devices and climate conditions is essential to reduce the energy use. Next to that, the potential of embedding phase-changing-materials (PCMs) into an aluminum foam structure to balance storage capacity and thermal admittance is explored.

21

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Our design

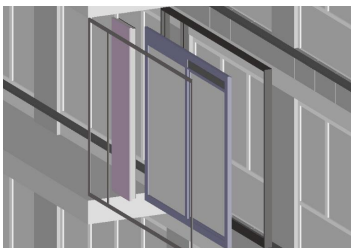
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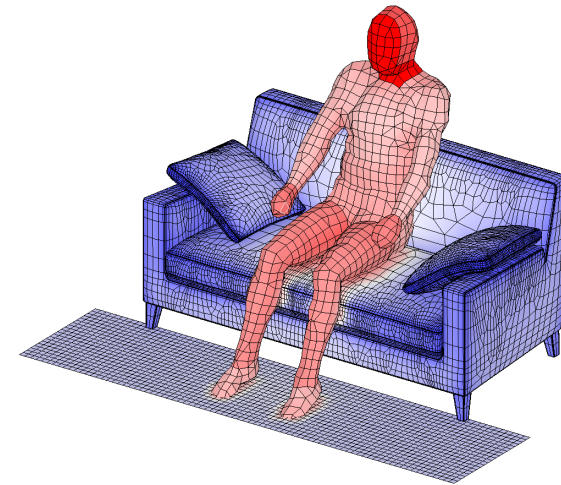
VISIT: [HTTPS://WWW.IMEC-INT.COM/EN/WHAT-WE-OFFER/INNOVATION-SERVICES/SMART-SPACES/HOMELAB](https://www.imec-int.com/en/what-we-offer/innovation-services/smart-spaces/homelab)

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21

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Partnership

Why become a MOBBLE partner?




POSITIVE IMAGE

- The Mobble can help you to present your company as a young, sustainable, future-oriented enterprise.
- Time has come to adopt a clear position about another way of living. Politicians, clients and customers are convinced that we must go beyond words and turn into action.
- Support research towards sustainable and energy efficient techniques for the development of new building typologies.

KNOWLEDGE AND SOCIAL NETWORK AMPLIFICATION

- Gain insight in our new research projects
- Organize workshops for your company about innovative building methods and techniques
- Submit a research proposal related to the pavilion
- Cooperate with a new generation of architects and engineers at Ghent University



PUBLICITY

- Expression of gratitude on events
- Your company will be mentioned on social media
- Your enterprise will be named on all forms of official communication: T-shirts, brochures, banners, e-newsletters etc.
- Lectures at Ghent University
- The Solar Decathlon Europe contest is an exquisite chance to meet future customers (thousands of visitors are expected)

Stay up to date with our quarterly newsletter in which we share information about new developments, cradle to cradle news, events and updates about the Mobble and the Solar Decathlon project.

Would you like to receive our newsletter?
Send your contact details to info@themobble.be

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How can you help us?

For the development and the construction of the pavilion an appropriate budget is required. This is mainly necessary for the organization and the participation of the competition in Szetendre, but also for promotion events, press-work, research, etc. The list below provides an estimation of the total cost.

Total budget: € 724.850

Budget UGent: - € 251.900

Budget of the competition: - € 100.000

SPONSOR BUDGET: € 372.950

RESEARCH AND DEVELOPMENT PHASE

Submission fee	€ 750 ✓
Communication	€ 20.000
Academic staff	€ 126.000 ✓
Project staff	€ 99.000 ✓
Job students	€ 8.000 ✓
Workshops in Szetendre	€ 5.250
Deliverables	€ 1.000
Visit the SD in Denver 2017	€ 5.400 ✓
Prototype 1 STEAMlab21	€ 12.750 ✓
Total	€ 278.150

PROTOTYPE 2

Foundation system	€ 1.500
Frame structures	€ 2.000
Floor, roof and wall panels	€ 13.200
Facade finishing	€ 1.500
Windows	€ 5.600
Roof finishing	€ 600
Fixing and bonding materials	€ 200
Interior wall panels	€ 1.000
Interior doors	€ 600
Permanent closets	€ 3.000
Paintwork	€ 500
Total	€ 29.700

TRANSPORT AND COMPETITION

Transport	
Transportation of the modules	€ 15.000
Tarpauling	€ 2.500
Competition	
Transport & accommodation students	€ 21.000
Rent cranes & construction equipment	€ 5.000
Communication	€ 15.000
Insurances	€ 5.000
Total	€ 63.500

ELABORATION & CONSTRUCTION PAVILION

Construction	
Foundation system	€ 7.500
Frame structures	€ 10.000
Floor, roof and wall panels	€ 27.500
Facade finishing	€ 3.750
Sun screens	€ 9.500
Windows	€ 34.500
Roof finishing	€ 10.800
Ramp	€ 7.500
Fixing and bonding materials	€ 1.000
Interior wall panels	€ 5.700
Interior doors	€ 3.000
Permanent closets	€ 15.000
Paintwork	€ 2.000
Mobile closets	€ 10.000
Interior and exterior lighting	€ 4.000
Outdoor design	€ 22.500
Technical installations	
PV system	€ 24.000
Thermal solar system	€ 7.000
Plumbing	€ 20.000
HVAC system	€ 30.000
Electrical system	€ 15.000
Energy storage system	€ 8.000
Domestic appliances	€ 12.000
Home electronics	€ 3.000
E-bikes and charging station	€ 8.000
Consultancy and inspection	€ 5.000 ✓
Equipment and tools	€ 10.000
Total	€ 316.250

AFTER LIFE

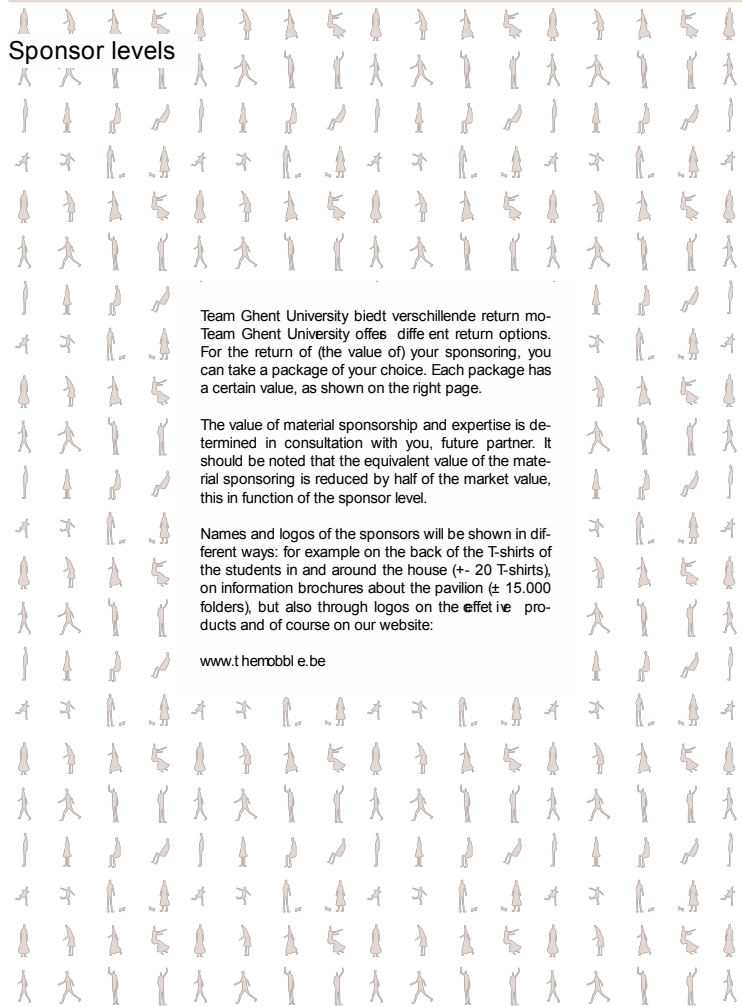
€ 50.000

✓ Already provided by Ghent University

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Partnership

Sponsor levels



Team Ghent University biedt verschillende return mo-
 Team Ghent University offers different return options.
 For the return of (the value of) your sponsoring, you
 can take a package of your choice. Each package has
 a certain value, as shown on the right page.

The value of material sponsorship and expertise is de-
 termined in consultation with you, future partner. It
 should be noted that the equivalent value of the mate-
 rial sponsoring is reduced by half of the market value,
 this in function of the sponsor level.

Names and logos of the sponsors will be shown in dif-
 ferent ways: for example on the back of the T-shirts of
 the students in and around the house (+ 20 T-shirts),
 on information brochures about the pavilion (± 15.000
 folders), but also through logos on the effective pro-
 ducts and of course on our website:

www.therobbie.be

PLATINUM

From € 50.000

Invitation for VIP-tours on SDE2019 for you and your most important costumers
 Collaboration for a network-event in your company
 Words of gratitude on every event
 Customized collaboration can be discussed
 All the benefits of gold package

GOLD

From € 20.000

Lecture by UGent academics in your company about **THE MOBBLE**
 Promotion of your company at exclusive network events
 Banners on events¹
 Logo on team clothing²
 All the benefits of Silver package

SILVER

From € 10.000

Distribution of own promotion material on all events³
 Logo on invitations for all events³
 All the benefits of Bronze package

BRONZE

From € 5.000

Logo on newsletter²
 Logo on sponsor board at SDE2019²
 Recognition on social media
 All the benefits of Friends package

FRIENDS

From € 500

Logo on website with link to own site
 Invitation for exclusive network events⁴
 As first receiving an invitation for events⁵

¹ The banners are the property of the company itself and are lent for a certain period

² The size of the logo is determined according to the sponsor level

³ Both exclusive network events and public informative events on different themes

⁴ These events are for sponsors of the Mobble only

⁵ These events are public with limited access

Thank you!

If you are interested in collaborating with Team Ghent University, we kindly ask you to contact us by telephone or e-mail, so that we can make an appointment with you.

Thank you for your time and we are hoping for a positive response.

Prof. Nathan Van Den Bossche, PhD
Building Science – Ghent University
Faculty of Engineering and Architecture
Sint Pietersnieuwstraat 41 B4
9000 Ghent, Belgium
M +32 (0)476 97 85 91

info@themobble.be

Team Ghent University

Follow us!

 @TheMobbbleSDE19

 www.themobble.be



5 NEIGHBOURHOOD INTEGRATION

5.1 Neighbourhood Integration Strategy

5.1.1 Renovation of apartment buildings

5.1.1.1 Introduction

The SDE19 contest focuses on the renovation of existing apartment buildings. Team Ghent University will focus on a renovation project in a Belgian context, the Etrimo Buildings. Etrimo was a company responsible for a mass production of collective housing in the fifties, sixties and seventies in the suburban zones of many Belgian cities.



Figure 25: Brughel Parc Residence II by Etrimo (Zellik Brussels)

5.1.1.2 Problem statement

Massive destructions throughout the second World War resulted in a large housing shortage in Belgium. As from the 50's, the high-rise condominium model was introduced into suburban districts of metropolitan areas such as Brussels, Antwerp and Liege. Industrial building methods were used to create a high amount of residences. These collective housing blocks were a big improvement in livability and hygienic circumstances compared to the houses constructed before the fifties. The Etrimo (and similar) residences offered a new economic model where all the costs and responsibilities of the seller were taken over by the firm. Besides, by the use of standardization, it was possible to realize a high amount of buildings in a short time range. The problem of an urgent housing need seems to be solved.

However, today these high-rise buildings are typically outdated and don't longer meet code requirements in terms of e.g. fire safety, thermal performance and acoustical performance. Furthermore, the discrepancy between the idealized countryside living and the lack of privacy in these building have also initiated social segregation and concentration. The majority of these high-rise buildings – mainly constructed between 1950 and 1980 – is in desperate need of a thorough renovation. Nevertheless, complex proprietary structures, high demolition cost as

well as some intrinsic qualities (cf. Figure; e.g. location, presence of surrounding green areas and affordability) block large-scale demolition.

In Belgium home-ownership exceeds 80%, and there is a large governmental social housing sector which renders the market for private rental rather small. By consequence, private ownership in apartment blocks introduces several practical, technical, financial, organizational and legal obstructions that hamper thorough renovations.



Figure 26: Breughel Parc Residence II by Etrimo (Zellik Brussels)

The apartment buildings are not fulfilling the current needs. Some important **DISADVANTAGES**:

- The Etrimo buildings are energy inefficient. Thermal insulation is not present in the facade causing high heat losses. Besides, ageing of the technical installations results in a high energy use;
- The circulation is inadequate and not conform the rules on fire safety;
- The buildings are characterized by a poor acoustic insulation;
- There is a lack of collective places;
- Identity reflection is missing;
- Private ownership by multiple owners impedes a possible renovation.

On the other hand, the Etrimo buildings have a lot of assets as well, justifying a thorough renovation to deal with the problems described above. Some **ADVANTAGES**:

- Interesting urban location. Etrimo buildings are typically constructed close to the city center but in a green zone in the suburb providing a magnificent view;
- A high repetitiveness;
- The advantages of collective housing;
- Affordable residences with room for upgrade.

All Etrimo residential towers were built according to one principle. All apartments are arranged per four around a circulation core, have a terrace and the plan layout of the four apartments is always the same, as shown on the plan below. This scheme was repeated horizontally two to four times, depending on the dimensions of the available building plot.

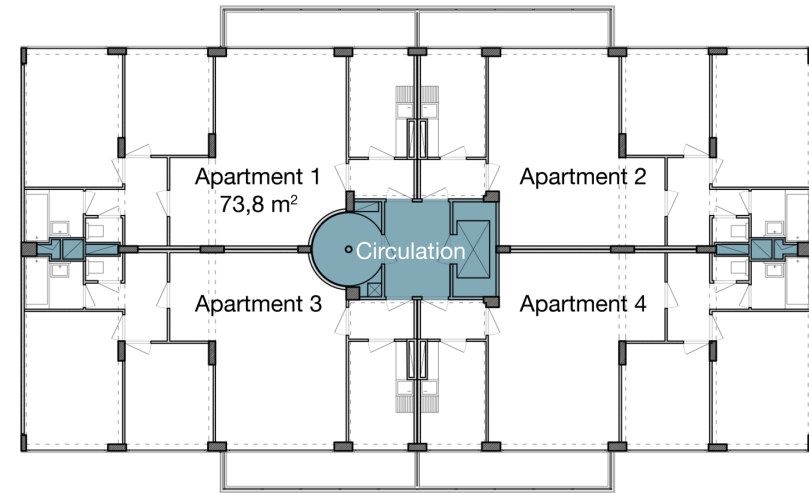


Figure 27: Floor plan Etrimo apartment

In 2016, the Horizon Knowledge Hub was created at Ghent University. Started as an interdisciplinary knowledge platform supported by 13 professors related to the renovation of apartment buildings, it has evolved into an interdisciplinary project where researchers from different fields and faculties collaborate on challenges of mutual interest. The website provides an overview of some results related to e.g. architectural design, facade renovation, technical design, urban planning, macro-economy, electrical energy balance etc. Both student work as well as scientific results from funded research programs are posted here.

More info about Horizon: <http://www.horizon-ugent.be>



5.1.1.3 Research: renovation strategies

In this paragraph examples of renovation strategies will give an insight in the renovation possibilities of the Etrimo buildings.

1. Architectural quality

A first example focusses on the possibility to enhance the architectural quality of the apartments. Within the given structure of the Etrimo buildings, different floor plan configurations are designed with a major attention to flexibility in order to be adaptable to a changing number of occupants.

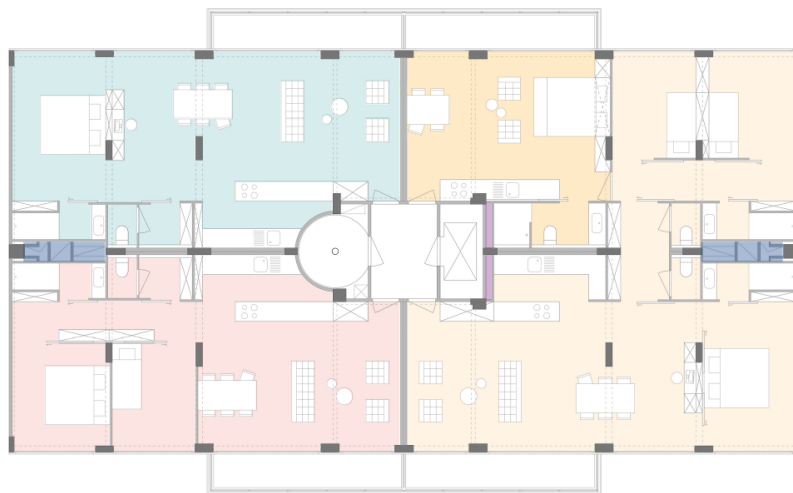


Figure 28: Breughel Parc Residence II, Advanced topic by S. Claerhout, E. Denys, H. De Vids, E. Romaen, E. Van Herzele

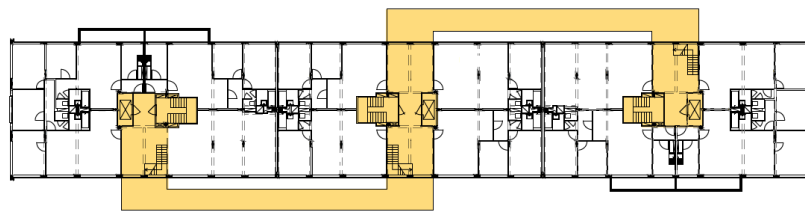


Figure 29: Circulation Etrimo apartment

2. Fire safety and circulation

In the course 'Architectural Design Studio: Design Development', master students investigated the possibilities toward a comfortable and safe circulation conform the fire safety legislation. In their design approach, they also payed attention to the creation of valuable collective places.



Figure 30: Images by H. Bostoen, O. Pinci, C Tang, V. Verzili

3. Facade renovation

We want to use the pavilion to demonstrate innovations as possible solutions for the technical challenges of our century. In particular, we are currently conceiving innovative strategies to realize a quick and low energy facade renovation with prefabricated facade elements, causing negligible nuisance for owners and tenants. All-in-one panels can integrate HVAC systems in the renovation panel, as well as distribution for ventilation, heating, cooling, and domestic hot water systems.

In this way, the most crucial problems, i.e. the bad thermally insulated building envelope, outdated services, and deprecated façade and appearance, can be solved simultaneously by adopting one integrated system. The integration of photovoltaic cells in the façade panels can even enlarge the assets of the system.

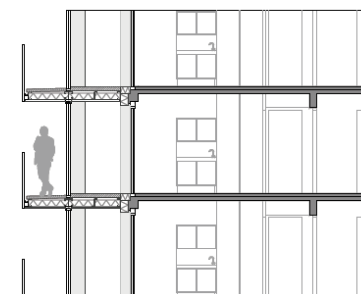


Figure 31: Section Etrimo apartment

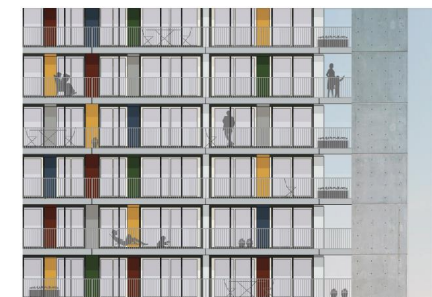


Figure 32: Facade renovation

5.1.2 New typologies

5.1.2.1 Introduction

Furthermore, the Mobble is a flexible building block that introduces a new concept of living: the Mobble allows you to adjust your house along the path of your life according to your needs. Life is too interesting, dynamic and challenging to be hampered by a static pile of bricks. Developing our Mobbles into larger units results in intelligent models for low and medium high-rise buildings. The modularity culminates in a high flexibility and adaptability.

The following scheme will show the integration possibilities of the Mobble.

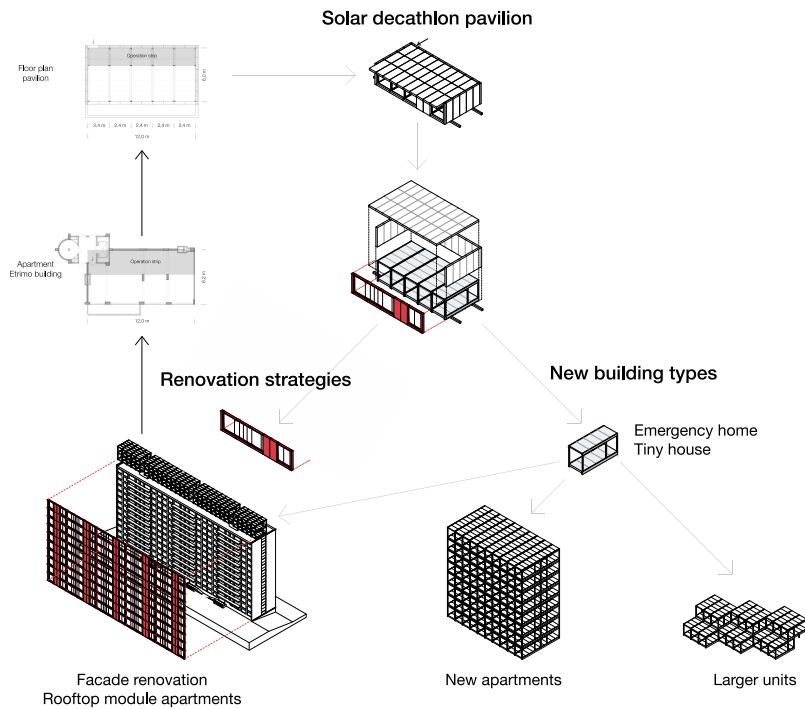


Figure 33: Scheme evolution of the Mobbles

1. Modules on top of existing buildings

There are also applications for renovating buildings. The light construction renders it possible to place a series of Mobbles on top of the roof of the buildings to be renovated. In a first renovation phase, families can temporarily move to these rooftop module apartments while their apartments are being renovated. Then, they will return to their apartment and the following residents will temporarily stay in the Mobbles until their house has been completely renovated. After this process, it's possible to maintain the module apartments. At the end, the apartment building will contain more housing units, which also promotes densification in the city. The renovation cost can also be limited in this way, as the profit on the additional housing units can be used to partially pay for the overall renovation cost.

2. Small scale modular configurations

The fact that the Mobble is a modular building block, is one of its big advantages. With a minimum of effort you can adapt the formation to your current needs. Are you a student who is just graduated and need an affordable living space? You can just buy one Mobble. You fall in love and want to live together? Just add one or two Mobbles. You get children? Add some Mobbles, you get the system. This makes that the system is very flexible, and adjustable to your needs and changing living situation. Bigger wholes of Mobbles can be buildings on their own, where different compositions of families live together.

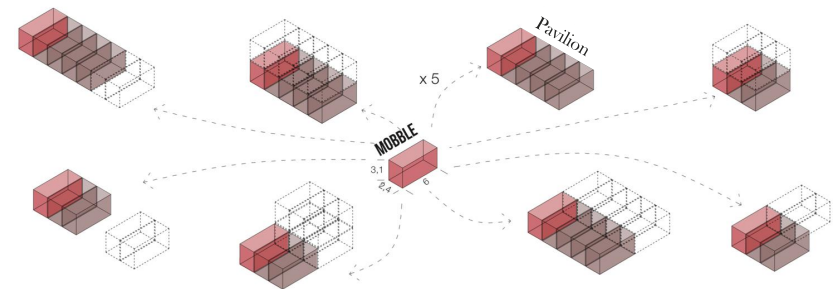


Figure 34: Different configuration possibilities

3. Large scale modular configurations

Research is done by master students during design courses to explore the possibilities of a modular system to construct collective housing. In this research, the dimensions of the Mobble are used. The dimensions are tested in order to find out if the modular system can be applied in larger configurations. Designing configurations on a larger scale implements alternations on the structure and the materials. It is plausible that a high-rise apartment building will be constructed in concrete rather than in plywood with a distance between the columns larger than 2,40m but for example 4,80m. With the dimensions of the modular building system still kept in mind, the design consequences of adapting the modular system on larger scale configurations are examined.

Floor plan configurations, circulation, building techniques and structure are taken into account in the research to design an intelligent modular system.

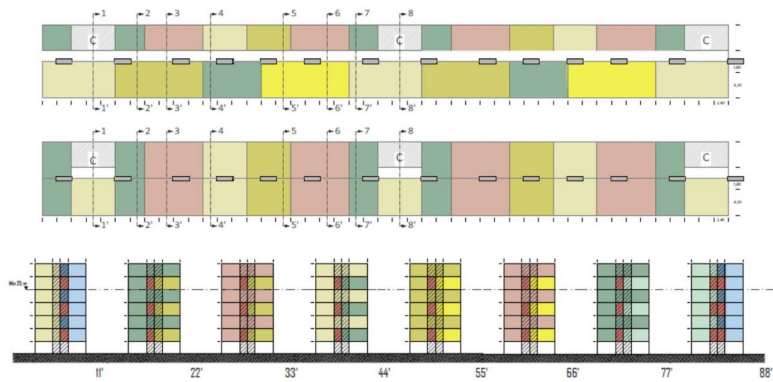


Figure 35: Sections and scheme of a possible apartment configuration for high-rise buildings

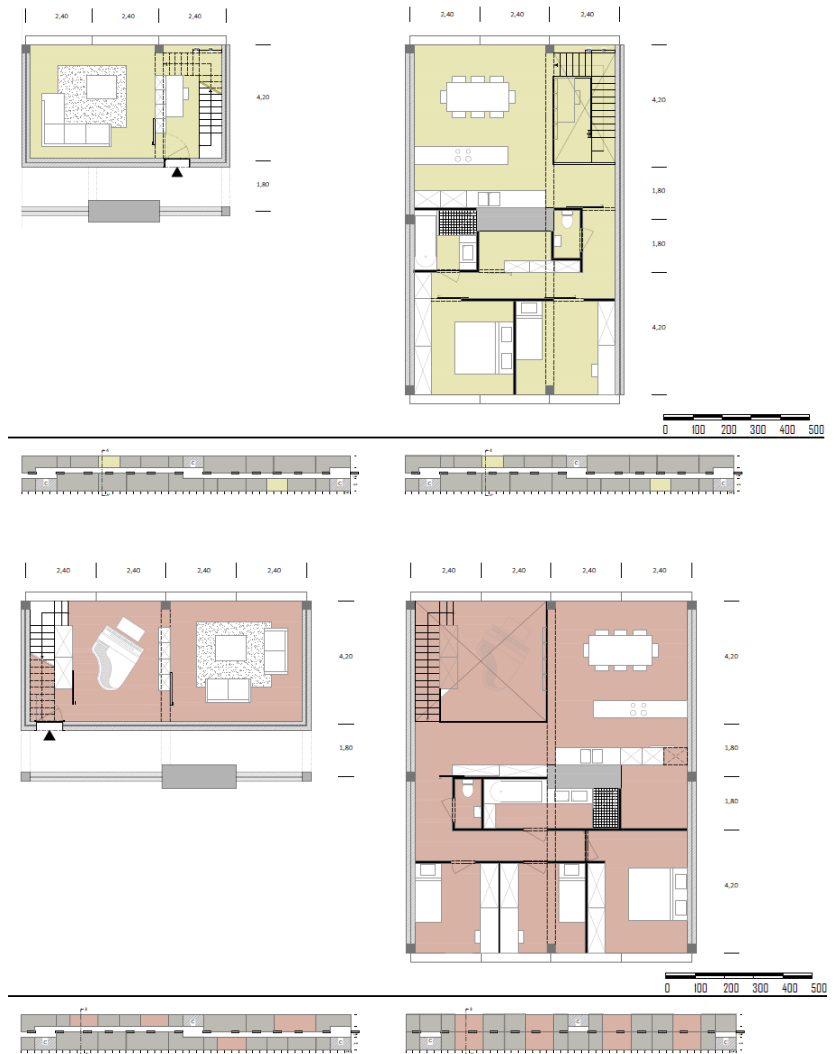


Figure 36: Masterstudio images by B. Pieters, F. Lanckmans and L. Landuyt

5.1.2.2 Tiny houses

Given that the Mobbles have a very simple construction, they are easy to build up. In fact you can actually build them yourself with a basic manual. This not only lower the construction costs, it also creates other possibilities. For example; the units can act as emergency housing after a natural disaster. We can ship prefabricated Mobbles

from Belgium to the affected area, where the modules can be finished with facade and roof panels easily and quickly.



Figure 37: Exposition of the mobble in Ghent

5.2 Transportation and Mobility Strategies

Not been elaborated yet.

5.3 Integration into neighbourhoods. Relationship between our building, and neighbourhood

Not been elaborated yet.

6 INNOVATION & VIABILITY REPORT

6.1 Objective

Life cycle cost

Throughout the last few decades, EU legislation has put a strong emphasis on limiting fossil energy consumption of newly constructed buildings. Given that the limits of energy efficiency are within reach (passive houses, zero-energy house, energy plus homes...), the focus is shifting towards life cycle analysis, health and indoor environment.

Nowadays, the focus is typically put on the life cycle cost on material level, which can be found in catalogues. However, a more holistic reasoning concerning sustainability is required. We are convinced that re-usability and recycling on component level is more interesting compared to the approach on material level. Existing traditional buildings are often no fit to meet the requirements of everyday life, the changing social needs and evolving functional requirements of the building. The existing apartment buildings dating back from the 50's till 70's typically comprise relatively small rooms in line with the standard at that time. A lack of integrated flexibility and adaptability often causes demolition of major building parts or even demolition of entire buildings.

To increase the building's transformation capacity and allow reuse of building components, building design must be different from traditional design methods, but also need to omit recent design trends to render it more robust. The re-configuration and recycling of building components in constructions clearly presents major environmental, social and economic benefits when considering the life cycle of buildings.

This approach will be displayed consistently in every detail of the pavilion design. Facade finishing, interior finishing, technical installations, etc. are all disconnected from the structural frame. This makes it possible to easily change these layers, as the lifespan of all these components is typically different.

Water management

The water management system is based on four principles: reducing people's water footprint, temporary water storage, water filtering and reusing water. The water consumption can be reduced by installing water-saving appliances such as vacuum toilets, special shower heads, efficient clothes washing and dishwashing machines, etc. To increase the conscious use of water by the residents, the consumption of water will be directly visualized. Grey water is collected, pre-treated in filters and conveyed to an innovative system of water purification, also called photo-ozonolysis. This system combines the action of ultraviolet light with that of ozone, so even on the microbial load there is a complete sterilization. Bacteria and viruses are removed from the aqueous phase without creating secondary toxic and harmful substances, creating water which is reusable.¹

IoT controlled building

An innovative IoT-approach is developed to ensure an optimal trade-off between comfort (indoor air quality, temperature, brightness, etc.) and energy use. This means the system is intelligent and demand-controlled: e.g. temperature sensors, CO₂ measurement, smartphone detection, daylight sensors, etc. Continuous monitoring with direct online output of energy use can be used to raise awareness by residents. We will introduce an innovative localized (also called personal) system which providing light, heat and fresh air directly to the consumer, instead of deliver it to the overall building. By shrinking the zone with optimal thermal and visual comfort to the residents positions, the remaining building part could have a lower comfort level. This will raise the overall buildings efficiency without sacrificing thermal comfort of residents. Current research topics at Ghent University will illustrate the possibilities of e.g.: ductless personal ventilation; integrated ventilation at the head of the bed, heating elements in furniture, smartphone driven heating panels in the lowered ceiling, automatic driven lighting, etc.

¹ Hoekstra Y. A. and Mekonnen M. M., The water footprint of humanity, Department of Water Engineering and Management, University of Twente

Integrated HVAC systems in building facade

Nowadays most high-rise building have inefficient facades and outdated technical installations. To encounter these two problems, prefab facade panels with integrated HVAC distribution and production units are developed. As a consequence, a compact design is unavoidable, which opens the road to innovative solutions as phase changing materials. PCM's are integrated in an aluminium foam storage tank and used to raise the efficiency of the thermal energy storage for domestic hot water. Usage of PCM's can reduce the storage volume of a tank with a factor 3-4 in comparison with a conventional water tank, making a facade integration feasible. Ongoing research into Legionella and Legionella Pneumophila problems at the Ghent University, can spare up to 30% on energy consumption for domestic hot water production.² Integrated prefab facade elements use solar radiance to pre-heat the supplied fresh air. The pulsion system is demand-controlled to reduce the energy costs. Passive ventilation solutions could be integrated in the facade to create a good air quality in summer months without needing mechanical systems.

Besides building an energy-efficient house, the smart living concept is yet another focal point we want to highlight in the SDE19 competition. In collaboration with the Ghent University HomeLab – a 600m² full scale test house to evaluate integrated concepts for IoT applications – innovative strategies are explored to reduce the energy use in dwellings, as well as increasing comfort and well-being. Visit: <https://www.imec-int.com/en/what-we-offer/innovation-services/smart-spaces/homelab>.

Personal indoor climate conditions

A first application of the Smart Living system is nothing less than a new and disruptive approach towards heating, cooling and ventilating buildings by balancing overall energy efficiency and individualized comfort conditions. The last few years, the energy efficiency of buildings enhanced significantly. We can even state that the limits of energy efficiency improvement for the building envelope are almost reached, considering the trade-off between reducing energy losses and embedded energy when increasing insulation thickness. Likewise, the production – and distribution efficiency have their limits as well. Contrarily, it is surprising that the way in which energy is used to realize comfort has barely been questioned so far, even though the energy reduction potential is very high at this level. Various research projects and measurement campaigns have concluded repeatedly that the actual energy savings after renovation are lower than predicted, mainly due to a shift towards slow low-temperature heating systems that work 24/7, and user-related rebound effects.

In the traditional approach, HVAC systems and controls provide an acceptable comfort level on the scale of an entire room, or even an entire building. The question at hand is whether it is feasible to realize a similar or better comfort level in buildings by adopting personal HVAC systems, i.e. controlling the climate restricted to the particular location of specific individuals. This can be achieved by providing lighting, heating, air conditioning and air supply directly to the zone in which the user is present, when the user is present. In this way, the rest of the room doesn't need to fulfil the comfort requirements; a lower illumination, lower or higher temperatures and a lower air supply rate is acceptable there. It is obvious that this HVAC concept comprises the potential to reduce the energy use tremendously. To turn this system into practice, a close collaboration is required with detection and control systems, e.g. by addressing the potential of smartphones in that respect.

We aspire to demonstrate following concepts in the pavilion: ductless ventilation systems, integrated ventilation systems (e.g. in walls and furniture), smartphone-controlled radiation panels in the ceiling, automatically controlled lighting etc.

Production-consumption

Controlling devices and climate conditions is another application of the Smart Living concept. From a sustainability point of view, it is important to use 'green energy', such as solar and wind energy. Due to the rise of smart meters in buildings, it becomes possible to optimize the balance between production and consumption of energy. The actual unbalance is caused by a peak production at daytime and a peak consumption in the evening. By use of energy storage, it becomes possible to address grid-instability on a local scale. Certainly for large-scale apartment buildings micro-grids may reduce the stress on the grid. Electrical energy can be stored in batteries, whereas

² Van Kenhove E, De Vlieger P, Laverge J, Janssens A. Towards energy efficient and healthy buildings: trade-off between Legionella pneumophila infection risk and energy efficiency of domestic hot water systems. 12th REHVA world congress. 2016.

buffer tanks are appropriate for thermal energy storage. A smart strategy for controlling of devices and climate conditions is essential to reduce the energy use. Next to that, the potential of embedding phase-changing-materials (PCM's) into an aluminum foam structure to balance storage capacity and thermal admittance is explored.

Building integrated photovoltaics panels (BIPV) and Renewable energy storage (RES)

During the last few years, the integration of decentralized production has introduced new challenges for the electrical distribution grid, such as local unbalance, voltage congestion, etc. Different studies investigate possible solutions to achieve a reliable network without loss of production and further integration of RES (renewable energy sources) production. Nowadays, a battery storage systems in combination with a pricing structure is a cost-efficient solution. A monitoring and controlling protocol is unavoidable to create an efficient system. An IoT-approach makes an easy control possible, e.g. indicating the best period to charge your car battery, etc. Keeping in mind energy principles, the location of PV will be important to take into account. As today, east and west oriented panels have a better production-consumption ratio. The general east-west orientation of high-rise buildings makes a facade integration of PV an interesting topic.

6.2 Contents index and structure

Not been elaborated yet.

7 CIRCULARITY & SUSTAINABILITY REPORT

7.1 Objective

7.2 Contents index and structure

DINNER PARTY MENU

CONTEST WEEK TASKS' PLANNING

COST ESTIMATE & PROJECT FINANCIAL SUMMARY

Business and Fund-Raising Plan

Cost Estimate and Project Summary Budget

The following cost estimate is the approximation of the cost of our project, divided in the different stages of the process.

Total (€):

Research & Development					299.581
1	Submission fee	A fee is already paid to the EEF.			750
2	Employees	Number of persons:	Number of months:	Cost per person (€):	233.000
	- Academic staff	2 (50%)	18	7.000	126.000
	- Project staff	2 (50%)	12	3.300	39.600
	- Job student	2 (50%)	18	3.300	59.400
		2 (100%)	2	2.000	8.000
	Communication	Exhibitions, events, creating website, server costs, advertising products, etc.			20.000
1	Visit SD Denver 2017	Unit	Quantity:	Cost per unit (€):	5.400
	- Flight	persons	5	800	4.000
	- Lodging	persons	5	280	1.400
1	Prototype 1	Prototype 1, called STEALab 21, is already built in cooperation with VTI Courtrai. Numerous technical tests are planned to be performed: pressurisation test for airtightness, thermography, water tightness testing of components etc.			12.750
	Prototype 2	Unit:	Quantity:	Cost per unit (€):	21.431
	- Foundation system	lump sum	1	1.500	1.500
	- Frame structures	apiece	2	1.000	2.000
	- Floor panels (SIP)	m ²	14,4	90	1.296
	- Exterior wall panels (SIP)	m ²	28,5	85	2.423
	- Facade finishing	m ²	28,5	50	1.425
	- Windows	m ²	7,5	750	5.625
	- Roof panels (SIP)	m ²	14,4	85	1.224
	- Roof finishing	m ²	10,8	60	648
	- Fixing & bonding materials	e.g. bolts, crews, tape etc.	lump sum	1	200
	- Interior wall panels	m ²	16,5	60	990
	- Interior doors	apiece	2	300	600
	- Permanent closets	m	3	1.000	3.000
	- Paintwork	lump sum	1	500	500
	Workshops	Unit:	Quantity:	Cost per unit (€):	5.250
	- First workshop	persons	2	750	1.500
	- Second workshop	persons	5	750	3.750
	Budget for deliverables	Model, DVD/CD, printing costs,	lump sum	1	1.000
					1.000

Construction phase					309.470
Direct materials		Unit:	Quantity:	Cost per unit (€):	144.970
- Foundation system		lump sum	1	7.500	7.500
- Frame structures		apiece	10	1.000	10.000
- Floor panels (SIP)		m ²	72	90	6.480
- Exterior wall panels (SIP)		m ²	72	85	6.120
- Facade finishing		m ²	75	50	3.750
- Windows		m ²	46	750	34.500
- Sunscreens		m ²	38	250	9.500
- Roof panels (SIP)		m ²	72	85	6.120
- Roof finishing (2x)	test & definitive layer	m ²	180	60	10.800
- Ramp		lump sum	1	7.500	7.500
- Fixing & bonding materials	e.g. bolts, crews, tape etc.	lump sum	1	1.000	1.000
- Interior wall panels		m ²	95	60	5.700
- Interior doors		apiece	10	300	3.000
- Permanent closets		m	15	1.000	15.000
- Paintwork		lump sum	1	2.000	2.000
- Mobile closets		lump sum	1	10.000	10.000
- Decor		lump sum	1	2.000	2.000
- Interior and exterior		lump sum	1	4.000	4.000
Outdoor design		m ²	300	75	22.500
Technical installations		Unit:	Quantity:	Cost per unit (€):	127.000
- PV system		m ²	60	400	24.000
- Thermal solar system		lump sum	1	7.000	7.000
- Plumbing		lump sum	1	20.000	20.000
- HVAC system		lump sum	1	30.000	30.000
- Electrical system		lump sum	1	15.000	15.000
- Energy storage system		lump sum	1	8.000	8.000
- Domestic Appliances	e.g. refrigerator, dishwasher, oven, clothes washer and dryer etc.	lump sum	1	12.000	12.000
- Home electronics	e.g. TV, computer, DVD-player etc.	lump sum	1	3.000	3.000
- e-bikes & charging station		lump sum	1	8.000	8.000
Consultancy and Inspection		lump sum	1	5.000	5.000
Equipment, tools	e.g. sawing machine, drilling	lump sum	1	10.000	10.000
Transportation					17.500
Ghent (Belgium) - Szentendre (Hungary) (back and forth): 1500 km		Unit:	Quantity:	Cost per unit (€):	
		Trucks	6	2.500	15.000
Tarpaulin		apiece	5	500	2.500
Final phase					46.000
SD Szentendre 2019		Unit:	Quantity:	Cost per unit (€):	21.000
- Travel	Ghent - Szentendre (back and forth)	persons	20	300	6.000
- Lodging	during 30 days (changing teams)	persons	15	1.000	15.000
Cranes and Construction equipment	Twice (assembly and disassembly)	lump sum	2	2.500	5.000
Communication on Site	Information panels, Augmented Reality system, flyers, uniforms, videos of assembly, dinner party etc.	lump sum	1	15.000	15.000
Insurances		lump sum	1	5.000	5.000
After-life					50.000
Permanent assembly in	Transport, assembly, cranes, permanent foundation etc.				50.000
Other					20.000
Monitoring & Testing	e.g. weather station etc.				20.000
Total costs:					
Ghent University	Incurring costs (1):				38.900
	Employees costs (2):				233.000
Residual Costs					470.651
Total estimated costs:					742.551
Safety margin for unexpected costs (5%):					37.128
Total estimated cost including safety margin:					779.678

Fixed costs Ghent University: incurred costs (1) and employees costs (2):	271.900
Residual anticipated sources:	510.000
Anticipated costs Ghent University:	40.000
Total budget from EEF and EMI:	100.000
City of Ghent:	15.000
Province of East Flanders:	15.000
Government of Flanders:	30.000
Fundraising:	80.000
Industry Sponsorship:	230.000
Total anticipated sources:	781.900

Table 7: Cost estimation

SITE OPERATIONS PLAN

HEALTH & SAFETY REPORT AND DOCUMENTS

DETAILED WATER BUDGET

ELECTRICAL AND PV DESIGN SYSTEMS INFORMATION

PROJECT SPECIFICATION

STRUCTURAL CALCULATIONS

1 CHARACTERISTICS OF MATERIALS

1.1 Multiplex

All the calculations with the multiplex frame will be calculated following the Eurocode 1995 and the Belgian national annex NBN EN 1995-1-1: Design of timber structures - Part 1-1: General - Common rules and rules for buildings
NBN EN 1995-1-2: Design of timber structures - Part 1-2: Structural fire design

The frames are build out of 5 layers multiplex. For the strength and stiffness of the multiplex panels the following values may be used according to the technical approval of the supplier (Unilin). But as the multiplex is used in the other direction than normal, the characteristics need to be adjusted.

One multiplex panel exists of 5 layers:

- Three layers that work with the fibre direction and that have a wood quality of C24
- Two layers that work perpendicular to the fibre direction, whereby their stiffness is neglected.

The technical characteristics of one multiplex panel is as followed calculated:

When calculating the strength and the stiffness of the total frame, the junctures must be taken into account. These are positioned in such a way that the frame can still cushion the forces.

The columns will have maximum one juncture in the cross-section. The column will be calculated with material characteristics of one panel multiplied by 4/5.

The beams will have maximum two junctures in the cross-section at the place where the moment is the smallest. The beams will be calculated with material characteristics of one panel multiplied by 3/5 at these places.

This gives the following resistance properties:

	C24	Unilin - normale plaat	Without juncture		1 juncture		2 junctures	
	N/mm ²	N/mm ²	N/mm ²	N/mm ²	N/mm ²	N/mm ²	N/mm ²	N/mm ²
Tensile strength in fiber direction	14	10	*3/5	8,40	*4/5	6,72	*3/5	5,04
Compressive strength in fiber direction	21	14	*3/5	12,60	*4/5	10,08	*3/5	7,56
Tensile strength perpendicular to fiber direction	0,4	7	*2/5	5,60	*4/5	4,48	*3/5	3,36
Compressive strength perpendicular to fiber direction	2,5	12,6	*2/5	8,40	*4/5	6,72	*3/5	5,04
Bending strength	24	20	*3/5	14,40	*4/5	11,52	*3/5	8,64
Shear strength	4	3,5	*3/5	2,40	*4/5	1,92	*3/5	1,44

Table 8: Multiplex characteristics

These characteristic properties are converted with the following safety factors to obtain the design properties:

- $\gamma_{-} = 1,2$

	class 1	class 2	class 3
$k(mod)$			
permanent	0,6	0,6	0,5
long-term	0,7	0,7	0,55
medium-term	0,8	0,8	0,65
short-term	0,9	0,9	0,7
instantaneous	1,1	1,1	0,9
$k(def)$	0,6	0,8	2

Table 9: Material coefficients

1.2 Steel

All the calculations with the material steel will be calculated following the Eurocode 1993 and the Belgian national annex
 NBN EN 1993-1-1: Design of steel structures - Part 1-1: General rules and rules for buildings
 NBN EN 1995-1-2: Design of steel structures - Part 1-2: Structural fire design
 NBN EN 1995-1-8: Design of steel structures - Part 1-8: Design of joints

1.2.1 Foundation system

The foundation is build out of steel S235, with the following resistance properties:

- Young's modulus: $210\,000\text{ N/mm}^2$
- Density: $7850,0\text{ kg/m}^3$
- Yield strength f_y : 235 N/mm^2
- Ultimate strength f_u : 360 N/mm^2

These characteristic properties are converted with the following safety factors to obtain the design properties:

- $\gamma_{inst} = 1,05$ (instability)
- $\gamma_{mat} = 1,25$ (last resistance, material and joints)
- $\gamma_{res} = 1,10$ (sliding resistance of ELS pre-stressed screw joints)
- $\gamma_{res} = 1,25$ (sliding resistance of ELU pre-stressed screw joints)
- $\gamma_{res} = 1,40$ (sliding resistance of pre-stressed screw joints and almond shaped holes or with over measure)

1.2.2 Tensile bars

The tensile bars placed between the sandwich panels, to keep the frames together are quality 4.8.:

- Yield strength f_y : 320 N/mm^2
- Ultimate strength f_u : 400 N/mm^2

1.3 Glue

The glue that will be used will meet the following standards:

- NBN EN 301 - Type I
- NBN EN 15425
- NBN 12436

2 LOADS

All the loads will be calculated following the Eurocode 1991 and the Belgian national annex
 NBN EN 1991-1-1: Actions on structures - Part 1-1: General actions - Densities, self-weight, imposed loads for buildings
 NBN EN 1991-1-3: Actions on structures - Part 1-3: General actions - Snow loads
 NBN EN 1991-1-4: Actions on structures - Part 1-4: General actions - Wind actions

2.1 Permanent loads

The permanent loads of the construction exist out of the self-weight of the modules and the permanent furniture.

- Self-weight frame
- Building panels: roof, wall- and floor panels
- The technical integration of installations
- ...

2.1.1 Floor panels

The floor panels exist of rock wool between two multiplex layers, with each four rafters that provide the stiffness of the panel. The panels have the following dimension and weight.

Height	0,256 m
Width	1,2 m
Length	2,22 m
Multiplex	0,018 m

	#	Height	Width	Length	Density	Weight
		m	m	m	kg/m ³	kg
Rafters	4	0,220	0,028	2,22	580	31,73
Multiplex	2	0,018	1,2	2,22	600	57,54
Rock wool	1	0,220	1,2	2,22	35	20,51
Total					41,21	109,78

0,41 kN/m²

Table 10: Floor panels

2.1.2 Roof panels 1

The first layer of the roof panels exists of rock wool between two multiplex layers, with each four rafters that provide the stiffness of the panel. The panels have the following dimension and weight.

Height	0,144 m
Width	1,2 m
Length	2,22 m
Multiplex	0,012 m

	#	Height	Width	Length	Density	Weight
		m	m	m	kg/m ³	kg
Rafters	4	0,120	0,024	2,22	580	14,83
Multiplex	2	0,012	1,2	2,22	600	38,36
Rock wool	1	0,120	1,2	2,22	35	11,19
Total					24,17	64,38

0,24 kN/m²

Table 11: First layer of roof panels

2.1.3 Roof panels 2 - 3

The second layer of the roof panels exist of rock wool between two multiplex layers, with each four rafters that provide the stiffness of the panel. The panels have the following dimension and weight.

Height	0,244 m
Width	1,2 m
Length	2,4 m
Multiplex	0,012 m

	#	Height	Width	Length	Density	Weight
		m	m	m	kg/m ³	kg
Rafters	4	0,220	0,028	2,4	580	34,30
Multiplex	2	0,012	1,2	2,4	600	41,47
Rock wool	1	0,220	1,2	2,4	35	22,18
Total					34,01	97,95

0,34 kN/m²

Table 12: Second layer roof panels

2.1.4 Wall panels

The wall panels exist of rock wool between two multiplex layers, with each four rafters that provide the stiffness of the panel. The panels have the following dimension and weight.

Height	0,244 m
Width	1,2 m
Length	3,1 m
Multiplex	0,012 m

	#	Height	Width	Length	Density	Weight
		m	m	m	kg/m ³	kg
Rafters	4	0,220	0,028	3,1	580	44,30
Multiplex	2	0,012	1,2	3,1	600	53,57
Rock wool	1	0,220	1,2	3,1	35	28,64
Total					34,01	126,51

0,34 kN/m²

Table 13: Wall panels

2.1.5 Windows incl. frame

The windows inclusive their frame aren't elaborated yet, therefore an estimated value is used: 0,375 kN/m²

2.1.6 Inner walls

The structure of the inner walls isn't elaborated yet. An estimated value is used: 0,30 kN/m²

2.1.7 False ceiling

The technical integration isn't elaborated yet. Up to now a false ceiling is provided in the technical zone: 0,30 kN/m²

2.2 Imposed loads

2.2.1 Category A: Area for domestic and residential activities

The building is designed for residential activities. This implies the practice of category A, with the following applicable loads:

- Floors: 2,0 kN/m²
- Stairs: 2,0 kN/m²
- Balconies: 3,0 kN/m²

2.2.2 Category H: Roofs not accessible except for normal maintenance and repair

The roof will not be accessible except for normal maintenance and repair. This is why the roof will only be submitted to category H.

$$q_k = 0,8 - \frac{A}{100} \geq 0,2$$

The value of the imposed load depends on the area, A, of the calculated element:

- Roof panels: 0,77 kN/m²
- Frame: 0,73 kN/m²

2.3 Snow

As there is no English version of the Hungarian standard MSZ EN 1991-1-3 an its Hungarian Appendix. The snow load is calculated according to EN 1991-1-3 and the Belgian annex.


2.3.1 Snow load in Belgium

The probability of exceptional snowfall and exceptional snow spray in Belgium is very small. Therefore, the extraordinary design situation of snow must not be applied. Furthermore has the building a very small slope, which makes the design situation of distributed snow negligible.

The temporary and permanent load on the roof is calculates the following formula:

$$s = \mu_i C_e C_i S_k$$

The design situation of distributed snow μ_i must not be considered as there is no slope. This means that only the case below must be taken into account. According to Table 14: Snow load shape coefficient the snow load shape coefficient is 0,8

Geval (i) $\mu_1(\alpha)$  $\mu_1(\alpha)$

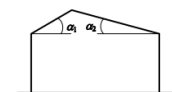


Figure 38: Case - geval (i)

Tabel 5.2 — Sneeuwbelastingsvormcoëfficiënten

Dakhoek of -helling α	$0^\circ \leq \alpha \leq 30^\circ$	$30^\circ < \alpha < 60^\circ$	$\alpha \leq 60^\circ$
μ_1	0,8	$0,8 \frac{(60 - \alpha)}{30}$	0,0
μ_2	$0,8 + 0,8 \alpha/30$	1,6	—

Table 14: Snow load shape coefficient

The characteristic value of snow on the ground at the relevant site s_k depends on the site altitude above sea level A.

$$\text{For } A \leq 100 \text{ m: } s_k = 0,50 \text{ kN/m}^2$$

The exposure coefficient and the thermal coefficient $C_e C_t$ are equal to 1 in all the cases according to the national annex.

Now all the parameters are determined, the snow load can be calculated:

$$s = \mu_i C_e C_t s_k = 0,80 * 1 * 1 * 0,50 = 0,40 \text{ kN/m}^2$$

2.4 Wind loads

2.4.1 General wind calculations: peak velocity pressure

Basic values

The pavilion must be stable and resistant for the SDE19 in Szentendre Hungary, but also for an afterlife in Belgium. Since the fundamental value of the basic wind velocity in Belgium is higher than in Hungary, this value is used for the calculations.

$$v_{b,0} = 26 \text{ m/s}$$

The basic wind velocity v_b depends on the wind direction and the season. Therefore the wind direction factor c_{dir} , and season factor c_{season} must be taken into account. According to the norm NBN EN 1991-1-4, the recommended value of these parameters is equal to one.

$$v_b = c_{dir} \cdot c_{season} \cdot v_{b,0} = 26 \text{ m/s}$$

Heights

Different heights and lengths must be defined for the calculation of the peak velocity pressure. As first the roughness length and the minimum height are determined. Those rely upon the representative terrain categories. For the safety and the uncertainty of the final destination of the afterlife, terrain category I is chosen: *Lakes or flat and horizontal area with negligible vegetation and without obstacles*. The taken maximum height is given by the norm and the reference height is equal to the height of the building.

- The roughness length: $z_0 = 0,01 \text{ m}$
- The minimum height: $z_{min} = 1 \text{ m}$
- The maximum height: $z_{max} = 200 \text{ m}$
- The reference height: $z_e = 3,1 \text{ m}$

Mean wind velocity

The mean wind velocity $v_m(z)$ is proportionate with the terrain roughness factor $c_r(z)$, the terrain orography factor $c_0(z)$ and the basic wind velocity v_b . The recommended value of the orography factor is equal to one and the roughness factor is calculated with following formula:

$$\text{For } z_{min} \leq z \leq z_{max}: c_r(z) = k_r \cdot \ln\left(\frac{z}{z_0}\right)$$

The terrain factor k_r is determined on the basis of the roughness length z_0 of the used terrain category, see above, and the roughness length z_0 of category II ($z_{0,II} = 0,05 \text{ m}$)

$$k_r = 0,19 \cdot \left(\frac{z_0}{z_{0,I}}\right)^{0,07}$$

Now the terrain roughness factor $c_r(z) = 0,97$ and the terrain orography factor $c_0(z) = 1$ are calculated, is it possible to calculate the mean wind velocity:

$$v_m(z) = c_r(z) \cdot c_0(z) \cdot v_b = 25,32 \text{ m/s}$$

Wind turbulence intensity

Besides the mean wind velocity, the wind turbulence intensity $I_v(z)$ must be defined for the calculations of the peak velocity pressure. This by the following formula:

$$\text{For } z_{min} \leq z \leq z_{max}: I_v(z) = \frac{\sigma_v}{v_m(z)}$$

In this formula is the value of the standard division of the turbulence σ_v in proportionate with the terrain factor k_r , the basic wind velocity v_b and the turbulence factor k_t . The recommended value for the last factor is equal to one. Which gives the next expression:

$$\sigma_v = k_r \cdot v_b \cdot k_t = 4,41 \text{ m/s}$$

With the known results for the basic wind velocity and the standard division, the outcome value for the turbulence intensity is 0,17.

Peak velocity pressure

The previous parameters are used for the determination of the peak velocity pressure $q_p(z)$ at height z , which includes mean and short-term velocity fluctuations. This is counted with a air density during storm conditions (recommended value: $1,25 \text{ kg/m}^3$)

$$q_p(z) = (1 + 7 \cdot I_v(z)) \cdot 0,5 \cdot \rho \cdot v_m^2(z) = 890 \text{ kg/m} \cdot \text{s}^2$$

In our case, when the height of the building/modules is smaller or equal to the width of the building, the peak velocity pressure can be considered as an even distribution.

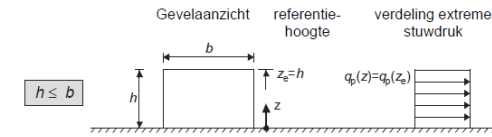


Figure 39: Distribution of peak velocity pressure

The wind force on a structure or a structural element is defined by vectorial summation of the following three components:

- The external forces
- The internal forces
- The friction forces

2.4.2 External forces

The roof and the walls are submitted to an external force. This is the force engaged at the outside of the building due to wind forces.

The external force is determined by the following formula:

$$F_{w,e} = c_s \cdot c_d \cdot \sum_{(surfaces)} w_e \cdot A_{ref}$$

Factor $c_s c_d$

According to EN 1991-1-4 $c_s c_d$ may be determined as follows:

“For framed buildings which have structural walls and which are less than 100 m high and whose height is less than 4 times the in-wind depth, the value of $c_s c_d$ may be taken as 1.”

External pressure w_e

The external pressure is determined as following:

$$w_e = C_{pe} \cdot q_p(z_e)$$

The external pressure coefficients C_{pe} depends on the size of the loaded area A . If the area is smaller than 1 m², $C_{pe,1}$ must be used. If the area is bigger than 10 m², $C_{pe,10}$ must be used. It is necessary to interpolate logarithmically between these areas with the following formula:

$$C_{pe} = C_{pe,10} - (C_{pe,1} - C_{pe,10}) \cdot \log_{10} A$$

As the formula is depending on the surface, the C_{pe} is different for the frame, roof- and wall panels.

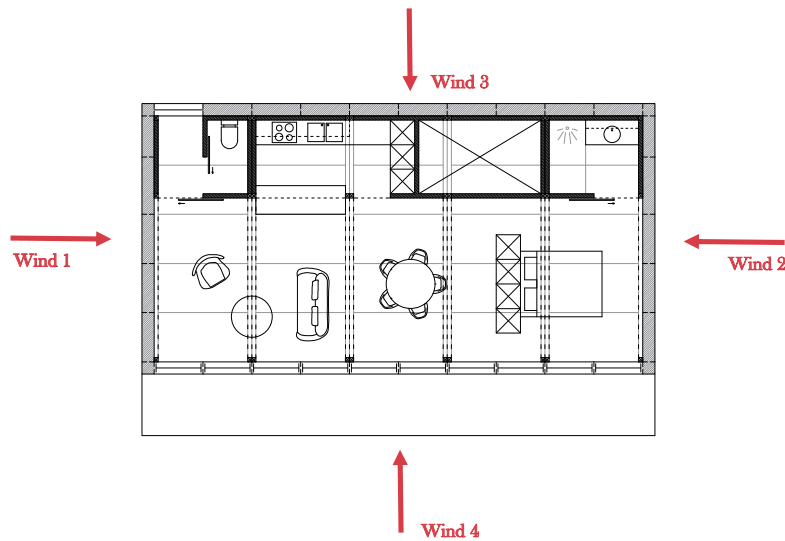


Figure 40: Different wind directions

Zoning Wind 1 and 2

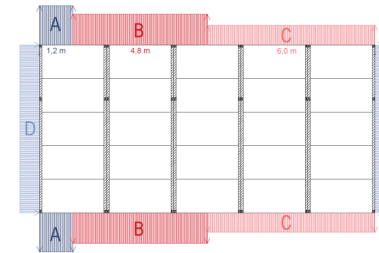


Figure 41: Wind 1 and 2 on wall panels

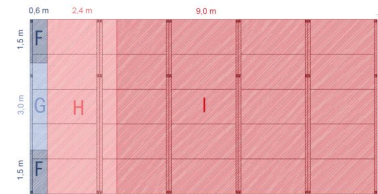


Figure 42: Wind 1 and 2 on roof panels

Zoning Wind 3

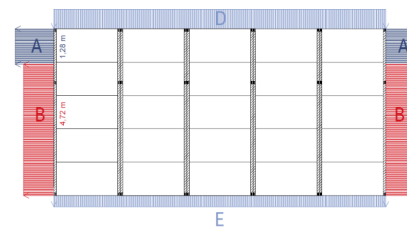


Figure 43: Wind 3 on wall panels

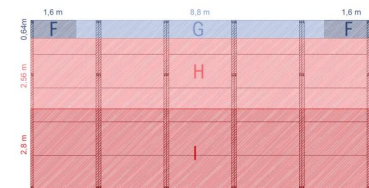


Figure 44: Wind 3 on roof panels

Zoning Wind 4

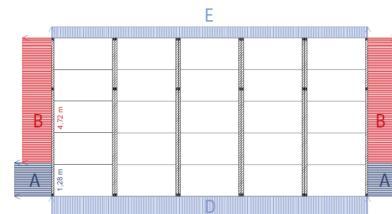


Figure 45: Wind 4 on wall panels

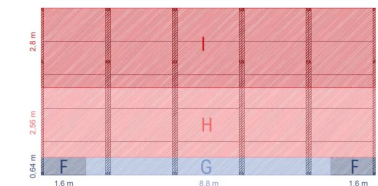


Figure 46: Wind 4 on roof panels

Wind on the roof of the frame

A	7,2 m ²				
	Cpe(10)	Cpe(1)	Cpe(A)	W(e)	Direction
	-	-	-	N/m ²	-
zone F	-1,80	-2,50	-1,90	-1690,08	up
zone G	-1,20	-2,00	-1,31	-1169,02	up
zone H	-0,70	-1,20	-0,77	-686,16	up
zone I	0,20	0,20	0,20	177,92	down
	-0,20	-0,20	-0,20	-177,92	up

Table 15: Wind on the roof of the frame

Wind on the roof panels

A	3 m ²				
	Cpe(10)	Cpe(1)	Cpe(A)	W(e)	Direction
	-	-	-	N/m ²	-
zone F	-1,80	-2,50	-2,17	-1926,84	up
zone G	-1,20	-2,00	-1,62	-1439,60	up
zone H	-0,70	-1,20	-0,96	-855,27	up
zone I	0,20	0,20	0,20	177,92	down
	-0,20	-0,20	-0,20	-177,92	up

Table 16: Wind on the roof panels 2 - 3

Wind direction 1 and 2 on the wall panels

A	3,72 m ²				
e	6 m				
b	6,00 m				
d	12,00 m				
h/d	0,26				
zones	5 zones				
	Cpe(10)	Cpe(1)	Cpe(A)	W(e)	Direction
	-	-	-	N/m ²	-
zone A	-1,20	-1,40	-1,29	-1143,90	out
zone B	-0,80	-1,10	-0,93	-826,27	out
zone C	-0,50	-0,50	-0,50	-444,79	out
zone D	0,70	1,00	0,83	737,88	in
zone E	-0,30	-0,30	-0,30	-268,85	out

Table 17: Wind direction 1 and 2 on the wall panels

Wind direction 3 and 4 on the wall panels

A	3,72 m ²				
e	6,2 m				
b	12,0 m				
d	6,0 m				
h/d	0,52				
zones	4 zones				
	Cpe(10)	Cpe(1)	Cpe(A)	W(e)	Direction
	-	-	-	N/m ²	-
zone A	-1,20	-1,40	-1,29	-1143,90	out
zone B	-0,80	-1,10	-0,93	-826,27	out
zone D	0,74	1,00	0,85	755,36	in
zone E	-0,37	-0,37	-0,37	-330,13	out

Table 18: Wind direction 3 and 4 on the wall panels

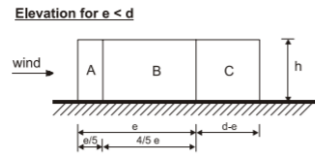


Figure 47: Zoning of lte wall panels

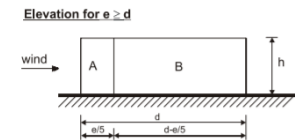


Figure 48: Zoning on the walls

2.4.3 Internal forces

The roof and the walls are submitted to an internal force as well. This is the force engaged at the inside of the building, due to wind forces.

The internal force is determined by the following formula:

$$F_{w,i} = \sum_{(surfaces)} w_i \cdot A_{ref}$$

The internal pressure is determined as following:

$$w_e = C_{pi} \cdot q_p(z_e)$$

The windows cannot be opened, so there are no dominant sides in the office building. According to the norm the value +0,2 and -0,3 must be taken into account as the highest pressures possible.

C _{pi}	0,20	177,92	up	out
	-0,30	-266,87	down	in

Table 19: Internal wind forces

2.4.4 Friction forces

The friction force is determined by the following formula:

$$F_{fr} = c_{fr} \cdot q_p(z_e) \cdot A_{fr}$$

In the norm EN 1991-1-4 is the following written:

“The effects of wind friction on the surface can be disregarded when the total area of all surfaces parallel with (or at a small angle to) the wind is equal to or less than 4 times the total area of all external surfaces perpendicular to the wind (windward and leeward).”

There can be concluded that the effects of wind friction can be disregarded.

2.4.5 Summary of the wind on the frame

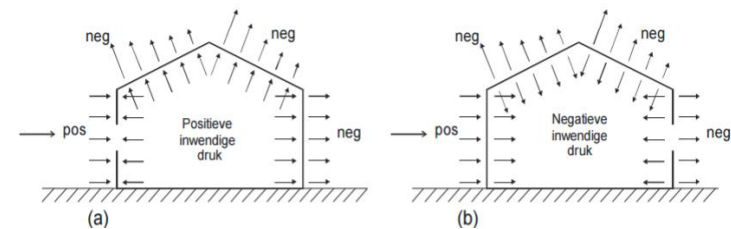


Figure 49: Direction of wind

Wind direction 1 and 2

	W(e)		W(i,up)		W(e)+W(i,up)		W(i,down)		W(e)+W(i,down)	
	N/m ²	Direction	N/m ²	Direction	N/m ²	Direction	N/m ²	Direction	N/m ²	Direction
Roof										
zone F	-1690,08	up	177,92	up	1867,99	up	-266,87	down	-1423,20	up
zone G	-1169,02	up	177,92	up	1346,94	up	-266,87	down	-902,15	up
zone H	-686,16	up	177,92	up	864,08	up	-266,87	down	-419,29	up
zone I	177,92	down	177,92	up	0,00	up	-266,87	down	444,79	down
	-177,92	up	177,92	up	355,83	up	-266,87	down	88,96	up
Wall										
zone A	-1143,90	out	177,92	out	1321,81	out	-266,87	in	-877,03	out
zone B	-826,27	out	177,92	out	1004,19	out	-266,87	in	-559,40	out
zone C	-444,79	out	177,92	out	622,70	out	-266,87	in	-177,92	out
zone D	737,88	in	177,92	out	-559,96	in	-266,87	in	1004,75	in
zone E	-268,85	out	177,92	out	446,76	out	-266,87	in	-1,98	out

Table 20: Summary wind 1 and 2

Wind direction 3 and 4

	W(e)		W(i,up)		W(e)+W(i,up)		W(i,down)		W(e)+W(i,down)	
	N/m ²	Direction	N/m ²	Direction	N/m ²	Direction	N/m ²	Direction	N/m ²	Direction
Roof										
zone F	-1690,08	up	177,92	up	1867,99	up	-266,87	down	-1423,20	up
zone G	-1169,02	up	177,92	up	1346,94	up	-266,87	down	-902,15	up
zone H	-686,16	up	177,92	up	864,08	up	-266,87	down	-419,29	up
zone I	177,92	down	177,92	up	0,00	up	-266,87	down	444,79	down
	-177,92	up	177,92	up	355,83	up	-266,87	down	88,96	up
Wall										
zone A	-1143,90	out	177,92	out	1321,81	out	-266,87	in	-877,03	out
zone B	-826,27	out	177,92	out	1004,19	out	-266,87	in	-559,40	out
zone D	755,36	in	177,92	out	-577,44	in	-266,87	in	1022,23	in
zone E	-330,13	out	177,92	out	508,05	out	-266,87	in	-63,26	out

Table 21: Summary wind 3 and 4

2.4.6 Summary wind for shed

The total wind pressure on the shed is determined by the summation of the pressure on top of the shed and the pressure on bottom of the shed.

- The pressure on top is equal to the pressure of the roof zone: zone F,G,H,
- The pressure on bottom is equal to the pressure of the façade zone adjacent to the shed: zone A,B,C,D,E

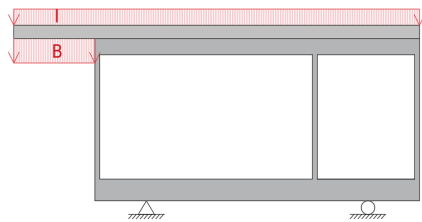


Figure 50: Wind 1 and 2 on shed

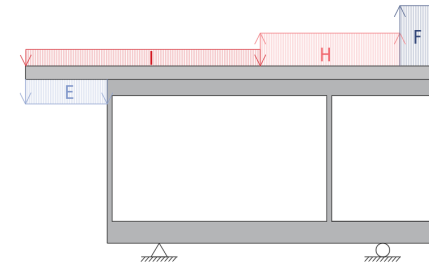


Figure 51: Wind 3 on shed

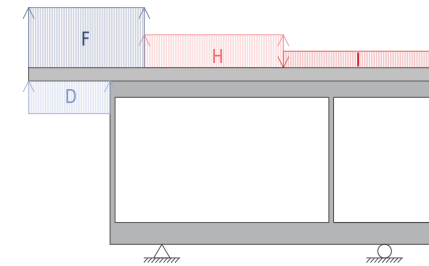


Figure 52: Wind 4 on shed

	Characteristic	Direction
	kN/m ²	-
Wind 1 (=2)	1,004	down
Wind 3	0,152	down
Wind 4	-2,682	up

Table 22: Summary different wind direction on shed

3 STRUCTURAL DESIGN OF THE FRAME - VERTICAL LOADS

The calculations are made with the software Diamonds of BuildSoft. Diamonds' analysis engine is based on the robust and powerful PARDISO sparse solver technology.

3.1 Summary of loads taking place on the frame

3.1.1 Upper beam

Height		Characteristic value					ULS					SLS				
Load	Tributary width	Line load	Tributary width	Point load		γ	ψ0	ψ0	ψ1	ψ2						
kN/m ²	m	kN/m	m	kN		-	-	-	-	-						
Permanent																
Own weight	1,80	0,09	0,16			1,35	-	-	-	-						
Roofpanel 1	0,24	1,20	0,29			1,35	-	-	-	-						
Roofpanel 2-3	0,34	1,20	0,41			1,35	-	-	-	-						
False ceiling	0,30	1,20	0,36			1,35	-	-	-	-						
L-profiles	-	-	0,10	1,20	0,12	1,35	-	-	-	-						
Shed	0,34	1,20	0,41	0,75	0,31	1,35	-	-	-	-						
Variable																
Cat H	0,73	1,20	0,87			1,5	0	0	0	0						
Snow	0,40	1,20	0,48			1,5	0,5	0,5	0	0						
Wind 1 (= 2)	0,44	1,20	0,53			1,5	0,6	0,6	0,2	0						
Wind 3 (en 4) - zone F	1,87	1,20	2,24			1,5	0,6	0,6	0,2	0						
Wind 3 (en 4) - zone H	0,86	1,20	1,04			1,5	0,6	0,6	0,2	0						
Wind 3 (en 4) - zone I	0,36	1,20	0,43			1,5	0,6	0,6	0,2	0						
Wind 1 (= 2) shed	1,00	1,20	1,21	0,75	0,90	1,5	0,6	0,6	0,2	0						
Wind 3 shed	0,15	1,20	0,18	0,75	0,14	1,5	0,6	0,6	0,2	0						
Wind 4 shed	2,68	1,20	3,22	0,75	2,41	1,5	0,6	0,6	0,2	0						

Table 23: Summary of loads - upper beam

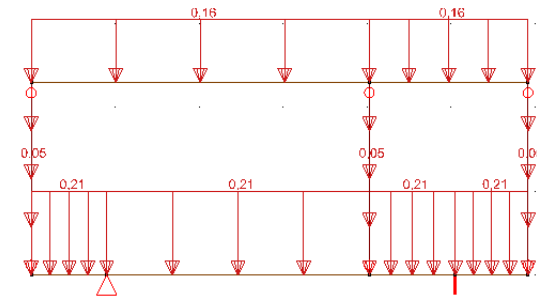


Figure 53: Load - Own weight

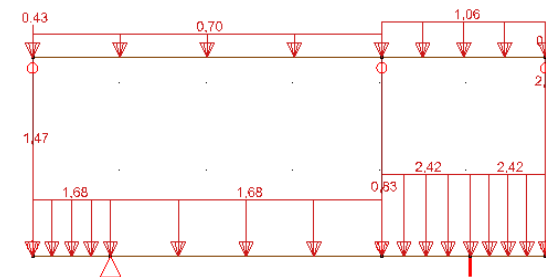


Figure 54: Load - Permanent load

3.1.2 Under beam

Height		Characteristic value					ULS					SLS				
Load	Tributary width	Line load	Tributary width	Point load		γ	ψ0	ψ0	ψ1	ψ2						
kN/m ²	m	kN/m	m	kN		-	-	-	-	-						
Permanent																
Own weight	2,4	0,09	0,22			1,35	-	-	-	-						
Floor panel	0,41	1,2	0,49			1,35	-	-	-	-						
Wallpanel // with frame	0,34	3,2	1,09			1,35	-	-	-	-						
L-profile // with frame	-	-	0,10			1,35	-	-	-	-						
Inner walls // with frames	0,30	2,45	0,74			1,35	-	-	-	-						
Own weight columns	0,54	0,09	0,05	2,294	0,11	1,35	-	-	-	-						
Inner walls ⊥ with frame	0,30	1,2	0,36	2,294	0,83	1,35	-	-	-	-						
L-profiel ⊥ with frame	-	-	0,10	1,200	0,12	1,35	-	-	-	-						
Windows with framework	0,375	1,2	0,45	2,994	1,35	1,35	-	-	-	-						
Wall panels ⊥ with frame	0,34	1,2	0,41	3,100	1,27	1,35	-	-	-	-						
Variable																
Cat A	2,00	1,2	2,40			1,5	0,7	0,7	0,5	0,3						

Table 24: Summary of loads - under beam

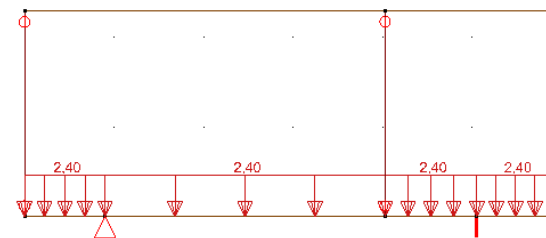


Figure 55: Load - imposed load category A

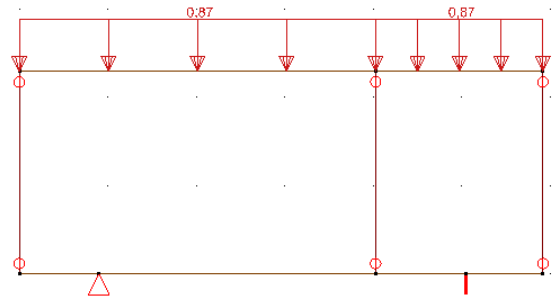


Figure 56: Load - Imposed load category H

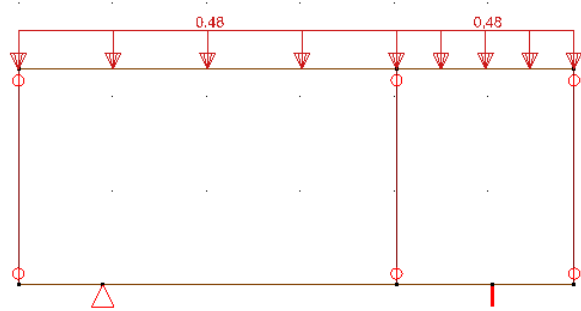


Figure 57: Load - Snow

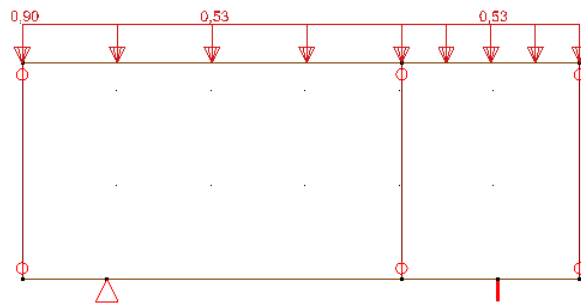


Figure 58: Load - Wind 1 and 2

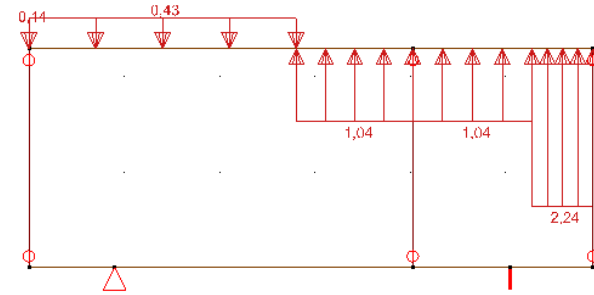


Figure 59: Load - Wind 3

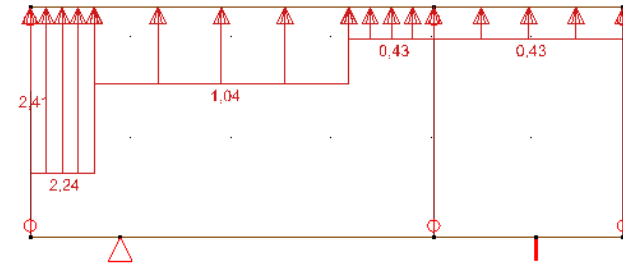


Figure 60: Load - Wind 4

3.2 ULS: Ultimate Limit State Calculations

The calculations for the stability and the resistance of the frame are made in load combination ULS STR:

- *Fundamental combination:* $E_d = E\{\gamma_{G,j} \cdot G_{k,j} + \gamma_p \cdot P + \gamma_{Q,1} \cdot Q_{k,1} + \sum_{i>1} \gamma_{Q,i} \cdot \psi_{0,i} \cdot Q_{k,i}\}$

Due to the complexity of the different multiplex layers of the frame, three models are made for the beams:

- *Cross section without junctures*
- *Cross section with one junctures*
- *Cross section with two junctures.*

The global picture of the result is best given by the first model, but this is too optimistic cause then the calculations are made without the junctures in the frames. Therefore model 2 and model 3 are used at the cross sections where the junctures are places in the beams, so that the resistance can be ensured. See section 1.2. *Material characteristic of multiplex* for the resistance properties. The columns have all one juncture, so in every model the column is calculated with the material properties of one juncture.

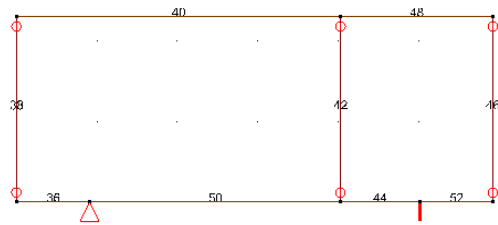


Figure 61: Model 1 - Beam with no junctures and the numbering of the elements

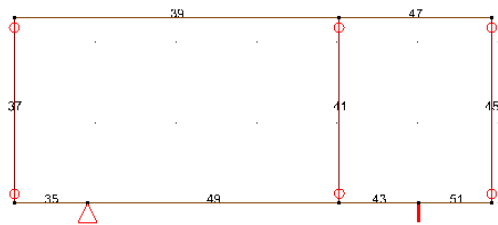


Figure 62: Model 2 - Beam with one juncture and the numbering of the elements

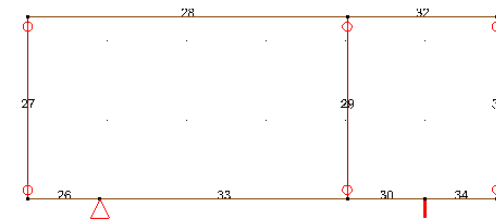


Figure 63: Model 3 - Beam with two junctures and the numbering of the elements

In the fundamental ULS combination the following criteria must be checked:

Unity check

The total unity check (in %) consist of the cross-section check (in %) where the following criteria are evaluated:

- *Tension*
- *Compression*
- *Biaxial bending*
- *Shear Y*
- *Shear Z*
- *Torsion*
- *Biaxial bending and tension*
- *Biaxial bending and compression*

And the stability check (in %), where the following criteria are evaluated:

- *Buckling in and out of plane*
- *Lateral torsional buckling*

The detailed calculation of each criteria of each bar can be found in the attachment. Below is the global check of each model shown.

Without junctures

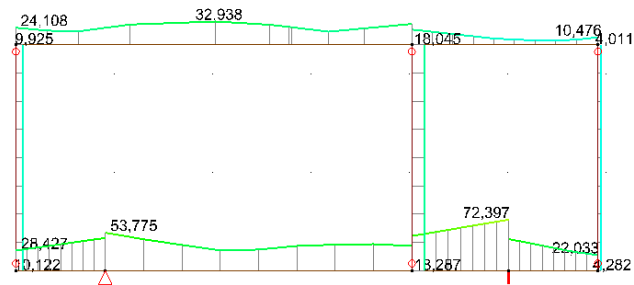


Figure 64: Resistance check of the beams without junctures in %

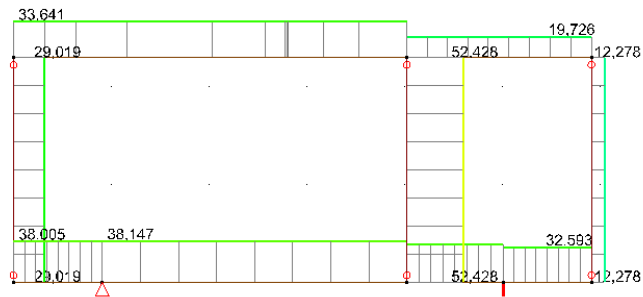


Figure 65: Stability check of the beams without junctures in %

With one juncture

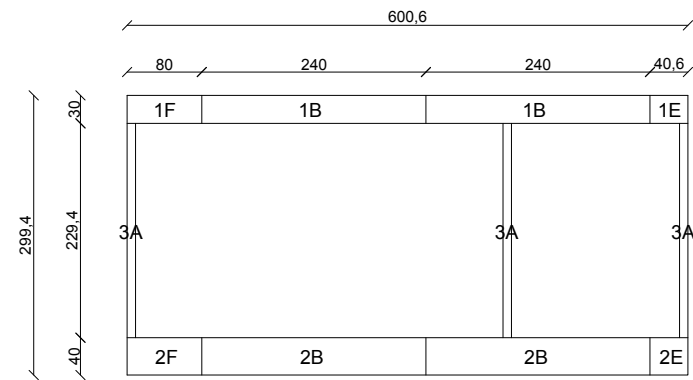


Figure 66: Multiplex layer 3

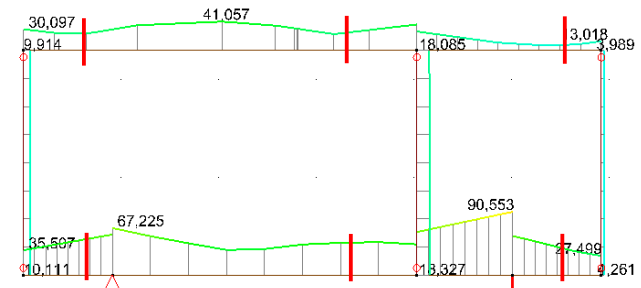


Figure 67: Resistance check of the beams with one juncture in %

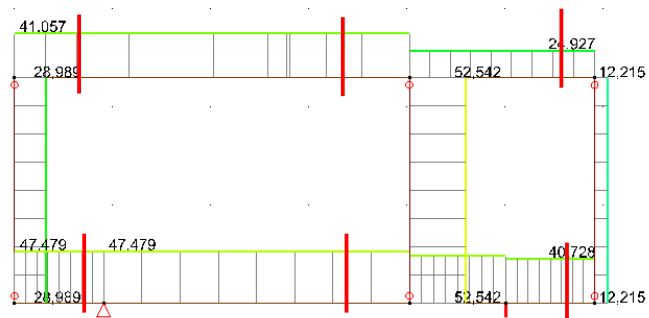


Figure 69: Stability check of the beams with one juncture in %

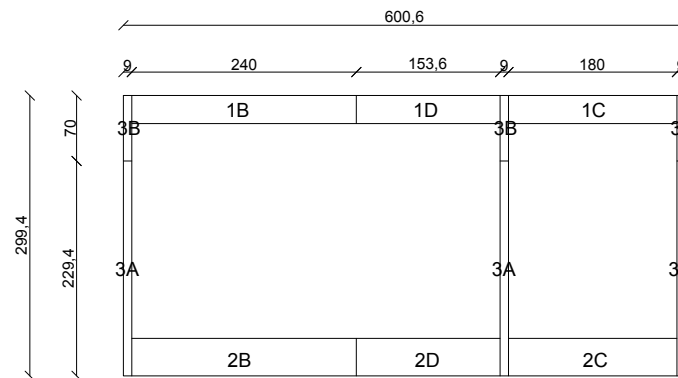


Figure 71: Multiplex layer 2 and 4

With two junctures

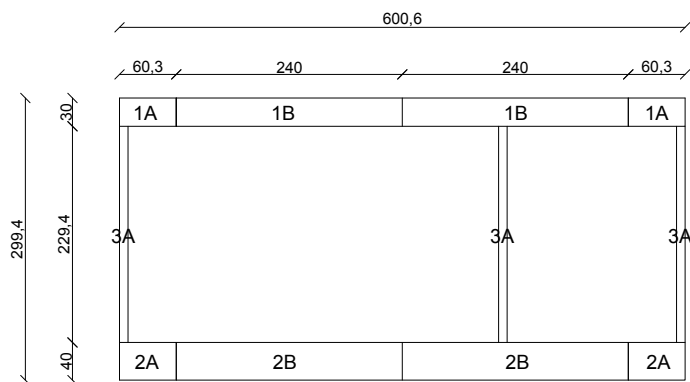


Figure 70: Multiplex layer 1 and 5

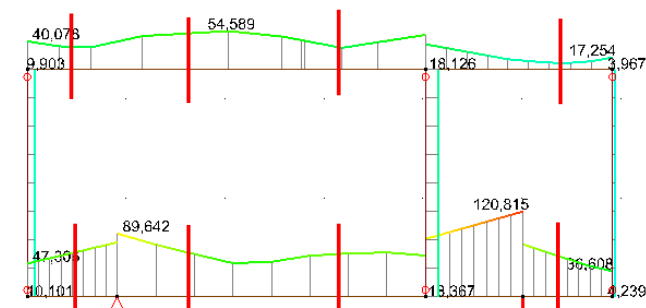


Figure 72: Resistance check of beams with two junctures in %

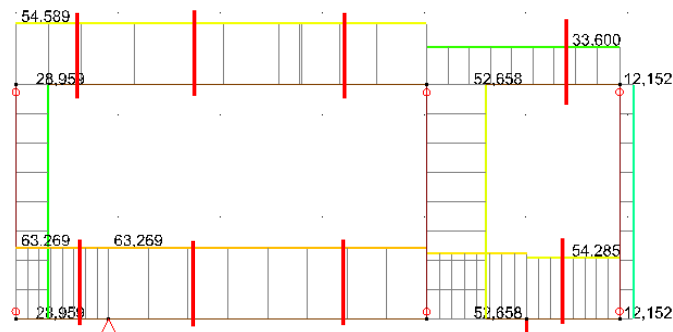


Figure 73: Stability check of beams with two junctures in %

3.3 SLS: Serviceability limit state

The calculations for the limit state of deflections are made in load combination SLS

- Quasi-permanent combination: $E_d = E\{\sum_{j \geq 1} G_{k,j} + P + \sum_{i > 1} \psi_{2,i} \cdot Q_{k,i}\}$

3.3.1 Limit state of deflection

The permissible deflection for multiplex is

- For a beam on two supports $z_{max} = w_{inst} \leq l/500$
- For a beam on two supports taken creep into account $z_{max} = w_{net,fin} \leq l/350$
- For cantilevering beams: $z_{max} = w_{inst} \leq l/250$
- For cantilevering beams taken creep into account: $z_{max} = w_{net,fin} \leq l/175$

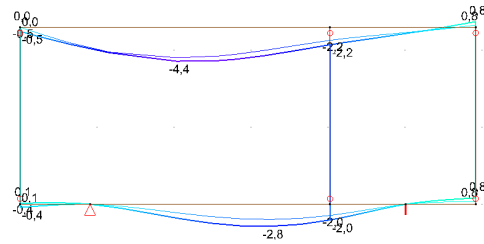


Figure 74: Deflection without creep

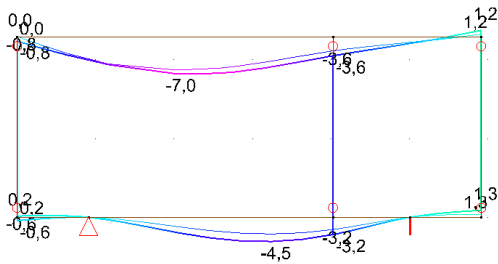


Figure 75: Deflection with creep

	Without creep				With creep			
	l m	z mm	z(max) mm	Satisfied?	z mm	z(max) mm	Satisfied?	
Upper beam	6,01	4,4	12,012	OK	7	17,16	OK	
Under beam	4,1	2,8	8,2	OK	4,5	11,7143	OK	
Cantilevering beam left	0,91	0,4	3,632	OK	0,6	5,18857	OK	
Cantilevering beam right	0,91	0,8	3,632	OK	1,3	5,18857	OK	

Table 25: Deflection of the frame

The deflections in the beams are allowed.

4 STRUCTURAL DESIGN FOR LATERAL FORCES - WIND

4.1 Summary of wind loads

According to STS 23, one can count on ‘Constructions with general stiffness’, to capture the wind loads. In this case the horizontal and vertical rigid panels work together to obtain a general stability of the building.

“In order, for a building, to belong to the category of constructions with general rigidity, the following must be complied:

- The roof and floors must be rigid throughout the total surface
- The rigid walls are connected to the floor slabs and the roof and they must be present in both perpendicular directions. If no further justification is given, their total length, in function of the dimension of the building and the number of building layers, must be equal to or longer than the following minimum:

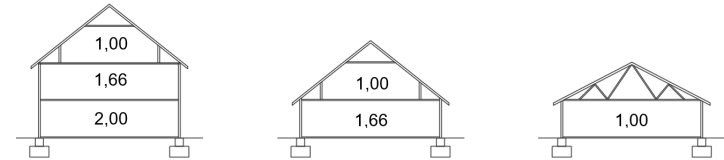


Figure 76: Minimum value of wall length

This means for our pavilion with one building layer:

$$A_{red\ walls} \leq A_{blue\ walls}$$

Which gives for wind direction 1 and wind direction 2, a minimum total length of the walls perpendicular to the wind direction of 6 meters.

For wind direction 3 and 4, a minimum total length of the walls perpendicular to the wind direction of 12 meters.

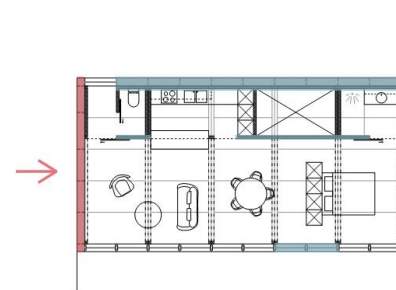


Figure 76: Wind direction 1 and 2

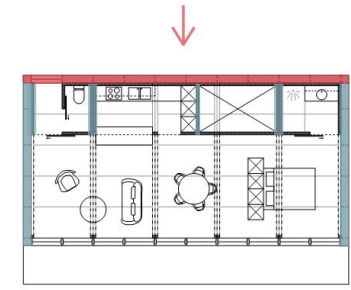


Figure 77: Wind direction 3 and 4

In both direction is the pavilion satisfied to this requirement.

5 FIRE RESISTANCE

The calculations for the fire resistant of the frame are made in load combination ULS STR:

- Accidental combination: $E_d = E\{\sum_{j \geq 1} G_{k,j} + P + A_d + (\psi_{1,1} \text{ or } \psi_{2,1}) \cdot Q_{k,1} + \sum_{i > 1} \psi_{2,i} \cdot Q_{k,i}\}$

5.1 Mechanical properties of multiplex

To calculate the structural fire resistance of the structural elements - frame, the mechanical properties of the materials must be adapted:

- For the resistance calculations:

$$f_{f,i,d} = k_{mod,fi} \cdot k_{fi} \frac{f_k}{\gamma_{M,fi}} = 1 * 1,15 \frac{f_k}{1}$$

$$E_{f,i,d} = k_{mod,fi} \cdot k_{fi} \frac{E_{k,0,05}}{\gamma_{M,fi}} = 1 * 1,15 \frac{E_{k,0,05}}{1}$$

	Without juncture	1 juncture	2 junctures
	N/mm ²	N/mm ²	N/mm ²
Tensile strength in fiber direction	9,66	7,73	5,80
Compressive strength in fiber direction	14,49	11,59	8,69
Tensile strength perpendicular to fiber direction	6,44	5,15	3,86
Compressive strength perpendicular to fiber direction	9,66	7,73	5,80
Bending strength	16,66	13,25	9,94
Shear strength	2,76	2,21	1,66

Table 26: Fire material mechanical properties

5.2 Method 1: Useful section

The fire resistance of the structural elements are determined following Method 1 from *WTCB: Deel 2 Berekening van het brandgedrag van houtconstructie..*

According to this method, the cross section of the structural elements must be adjusted.

The useful section is obtained by removing a layer from the original sections over the whole fire-affected periphery (each side exposed to the fire).

$$d_{ef} = d_{char} + k_0 \cdot d_0 = \beta_0 \cdot (t - t_{pr}) + k_0 \cdot 7 = 49 \text{ mm}$$

With: β_0 : carbonization speed (= 0,7 mm/min for glued wood)

t : duration of fire (= 60 min)

t_{pr} : time duration which the protective material (if present) the wooden element protect (= 0 min)

$$k_0: \text{ For } t < 20 : k_0 = t/20$$

$$\text{ For } t > 20 : k_0 = 1$$

Upper beam:

- Width: 90 mm - 49 mm = 41 mm
- Height: 300 mm - 49 mm = 259 mm

Under beam:

- Width: 90 mm - 49 mm = 41 mm
- Height: 400 mm - 49 mm = 359 mm

Column

- Width and height: 90 mm - 49 mm = 41 mm

5.3 Unity check

The total unity check (in %) consist of the cross-section check (in %) where the following criteria are evaluated:

- Tension
- Compression
- Biaxial bending
- Shear Y
- Shear Z
- Torsion
- Biaxial bending and tension
- Biaxial bending and compression

And the stability check (in %), where the following criteria are evaluated:

- Buckling in and out of plane
- Lateral torsional buckling

The detailed calculation of each criteria of each bar can be found in the attachment.

Below is the global check of the third model. Since this model already meets the requirement, other models are no longer calculated.

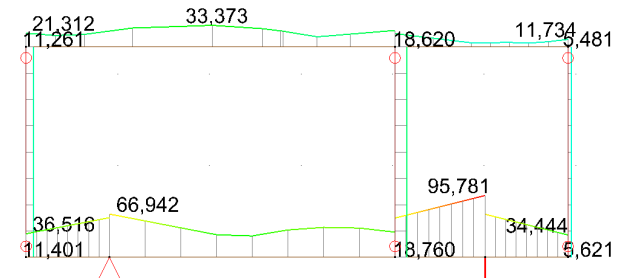


Figure 78: Resistance check of beams with three junctures and columns with one, in %

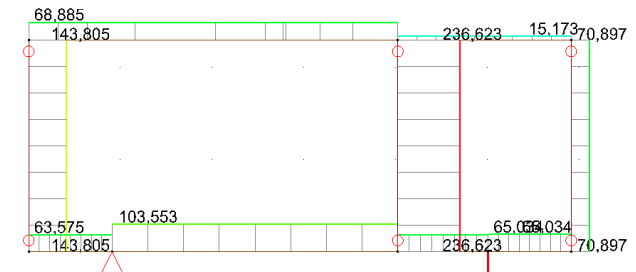
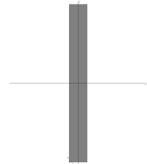


Figure 79: Stability check of beams with three junctures and columns with one, in %

The beams meet the requirements for the resistance check and the stability check. The columns need fire protection to slow down the cross section reduction, because at this moment are they not strong enough for the buckling in the plane. The fire protection is not elaborated yet.

Overview timber check according to Eurocode 5 : EN 1995-1-1 (--) : bar 1

Data



Cross-section: MP 9x40
 Material: Timber Multiplex C24 - FR - 2 naden(1)
 Bar length: 0,91 m
 Buckling length in plane: 0,91 m
 Buckling length out of plane: 0,91 m

Checks

Axial tension	0,000%
Axial compression	0,000%
Bending	55,541%
Shear force y'-axis	0,000%
Shear force z'-axis	61,397%
Torsion	0,000%
Bending and axial tension	55,541%
Bending and axial compression	0,000%
Buckling in and out of plane	0,000%
Lateral torsional buckling	63,575%

Resistance checks according to Eurocode 5 : EN 1995-1-1 (--) : bar 1

Axial tension (§6.1.2) **0,000%**

Maximum at node 1 in combination Load group 1

$N_{Ed} = 0,00 \text{ kN}$

$N_{t,Rd} = A \cdot f_{t,0,d} = 71,14 \text{ kN}$

$A = 14719,0 \text{ mm}^2$ $f_{t,0,d} = 4,8 \text{ N/mm}^2$
 $k_{mod} = 1,000$ $\gamma_M = 1,200$

Axial compression (§6.1.4)

This bar is not subjected to compression

Bending (§6.1.6) **55,541%**

Maximum at node 7 in combination Load group 1

$M_{y,Ed} = 4,05 \text{ kNm}$
 $M_{z,Ed} = 0,00 \text{ kNm}$

$M_{y,Rd} = W_{y,el} \cdot f_{m,d} = 7,30 \text{ kNm}$
 $M_{z,Rd} = W_{z,el} \cdot f_{m,d} = 0,83 \text{ kNm}$

$W_{y,el} = 880687 \text{ mm}^3$ $W_{z,el} = 100580 \text{ mm}^3$ $f_{m,d} = 8,3 \text{ N/mm}^2$
 $k_{mod} = 1,000$ $\gamma_M = 1,200$ $k_m = 0,700$

Shear force y'-axis (§6.1.7)

This bar is not subjected to shear force V_y

Shear force z'-axis (§6.1.7) **61,397%**

Maximum at node 7 in combination Load group 1

$V_{z,Ed} = 5,58 \text{ kN}$

$V_{z,Rd} = A_{el,z'} \cdot k_{cr} \cdot f_{v,d} = 9,09 \text{ kN}$

$A_{el,z'} = 9812,7 \text{ mm}^2$ $k_{cr} = 0,670$ $f_{v,d} = 1,4 \text{ N/mm}^2$
 $k_{mod} = 1,000$ $\gamma_M = 1,200$

Torsion (§6.1.8)

This bar is not subjected to torsion

Bending and axial tension (§6.2.3)

55,541%

Maximum at node 7 in combination Load group 1

$$\begin{aligned} N_{Ed} &= 0,00 \text{ kN} \\ M_{y,Ed} &= 4,05 \text{ kNm} \\ M_{z,Ed} &= 0,00 \text{ kNm} \end{aligned}$$

$$\begin{aligned} N_{t,Rd} &= A \cdot f_{t,0,d} = 71,14 \text{ kN} \\ M_{y,Rd} &= W_{y,el} \cdot f_{m,d} = 7,30 \text{ kNm} \\ M_{z,Rd} &= W_{z,el} \cdot f_{m,d} = 0,83 \text{ kNm} \end{aligned}$$

$A = 14719,0 \text{ mm}^2$	$W_{y,el} = 880687 \text{ mm}^3$	$W_{z,el} = 100580 \text{ mm}^3$
$f_{t,0,d} = 4,8 \text{ N/mm}^2$	$f_{m,d} = 8,3 \text{ N/mm}^2$	$k_{m} = 0,700$
$K_{mod} = 1,000$	$\gamma_M = 1,200$	

Bending and axial compression (§6.2.4)

This bar is not subjected to compression

Stability checks according to Eurocode 5 : EN 1995-1-1 (--) : bar 1

Buckling in and out of plane (§6.3.2)

This bar is not subjected to buckling

Lateral torsional buckling (§6.3.3)

63,575%

Maximum at node 7 in combination Load group 1

$$\begin{aligned} N_{Ed} &= 0,00 \text{ kN} \\ M_{y,Ed} &= 4,05 \text{ kNm} \end{aligned}$$

$$\begin{aligned} N_{c,Rd} &= A \cdot f_{c,0,d} = 106,59 \text{ kN} \\ M_{y,Rd} &= W_{y,el} \cdot f_{m,d} = 7,30 \text{ kNm} \end{aligned}$$

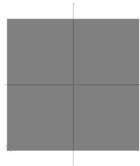
$A = 14719,0 \text{ mm}^2$	$W_{y,el} = 880687 \text{ mm}^3$
$f_{c,0,d} = 7,2 \text{ N/mm}^2$	$f_{m,d} = 8,3 \text{ N/mm}^2$

$k_{crit} = 0,874$	$k_{c,2} = 0,393$
$\lambda_{rel,m} = 0,915$	$\sigma_{m,crit} = 11,9 \text{ N/mm}^2$
$M_{y,crit} = 10,45 \text{ kNm}$	$L_{ef} = 1,18 \text{ m}$

$I_z = 2061887 \text{ mm}^4$	$I_{cor} = 7654145 \text{ mm}^4$
$E_{0,05} = 2412 \text{ N/mm}^2$	$G_{0,05} = 402 \text{ N/mm}^2$

Overview timber check according to Eurocode 5 : EN 1995-1-1 (--): bar 2

Data



Cross-section: MP 9x9
 Material: Timber Multiplex C24 - FR - 1 naad(1)
 Bar length: 2,29 m
 Buckling length in plane: 2,29 m
 Buckling length out of plane: 2,29 m

Checks

Axial tension	0,000%
Axial compression	11,401%
Bending	0,001%
Shear force y'-axis	0,000%
Shear force z'-axis	0,000%
Torsion	0,000%
Bending and axial tension	0,000%
Bending and axial compression	1,300%
Buckling in and out of plane	143,805%
Lateral torsional buckling	0,000%

Resistance checks according to Eurocode 5 : EN 1995-1-1 (--): bar 2

Axial tension (§6.1.2)

This bar is not subjected to tension

Axial compression (§6.1.4)

11,401%

Maximum at node 1 in combination Load group 1

$$N_{Ed} = 1,85 \text{ kN}$$

$$N_{c,Rd} = A \cdot f_{c,0,d} = 16,24 \text{ kN}$$

$$A = 1681,0 \text{ mm}^2 \quad f_{c,0,d} = 9,7 \text{ N/mm}^2$$

$$k_{mod} = 1,000 \quad \gamma_M = 1,200$$

Bending (§6.1.6)

This bar is not subjected to bending

Shear force y'-axis (§6.1.7)

This bar is not subjected to shear force V_y

Shear force z'-axis (§6.1.7)

This bar is not subjected to shear force V_z

Torsion (§6.1.8)

This bar is not subjected to torsion

Bending and axial tension (§6.2.3)

This bar is not subjected to tension

Bending and axial compression (§6.2.4)

1,300%

Maximum at node 1 in combination Load group 1

$$N_{Ed} = 1,85 \text{ kN}$$

$$M_{y,Ed} = 0,00 \text{ kNm}$$

$$M_{z,Ed} = 0,00 \text{ kNm}$$

$$N_{c,Rd} = A \cdot f_{c,0,d} = 16,24 \text{ kN}$$

$$M_{y,Rd} = W_{y,el} \cdot f_{m,d} = 0,13 \text{ kNm}$$

$$M_{z,Rd} = W_{z,el} \cdot f_{m,d} = 0,13 \text{ kNm}$$

$$A = 1681,0 \text{ mm}^2 \quad W_{y,el} = 11487 \text{ mm}^3$$

$$f_{c,0,d} = 9,7 \text{ N/mm}^2 \quad f_{m,d} = 11,0 \text{ N/mm}^2$$

$$k_{mod} = 1,000 \quad \gamma_M = 1,200$$

$$W_{z,el} = 11487 \text{ mm}^3$$

$$k_m = 0,700$$

Stability checks according to Eurocode 5 : EN 1995-1-1 (--): bar 2

Buckling in and out of plane (§6.3.2)

143,805%

Maximum at node 1 in combination Load group 1

$N_{Ed} = 1,85$ kN
 $M_{y,Ed} = 0,00$ kNm
 $M_{z,Ed} = 0,00$ kNm

$N_{c,Rd} = A \cdot f_{c,0,d} = 16,24$ kN
 $M_{y,Rd} = W_{y,el} \cdot f_{m,d} = 0,13$ kNm
 $M_{z,Rd} = W_{z,el} \cdot f_{m,d} = 0,13$ kNm

$A = 1681,0$ mm² $W_{y,el} = 11487$ mm³ $W_{z,el} = 11487$ mm³
 $f_{c,0,d} = 9,7$ N/mm² $f_{m,d} = 11,0$ N/mm² $k_m = 0,700$

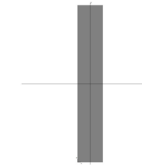
$k_{c,y} = 0,079$ $k_{c,z} = 0,079$
 $k_y = 6,779$ $k_z = 6,779$
 $\lambda_{rel,y} = 3,454$ $\lambda_{rel,z} = 3,454$ $\beta_c = 0,200$
 $\lambda_y = 193,821$ $\lambda_z = 193,821$ $E_{0,05} = 3698$ N/mm²

Lateral torsional buckling (§6.3.3)

This bar is not subjected to lateral torsional buckling

Overview timber check according to Eurocode 5 : EN 1995-1-1 (--): bar 3

Data



Cross-section: MP 9x30
 Material: Timber Multiplex C24 - FR - 2 naden(1)
 Bar length: 4,03 m
 Buckling length in plane: 4,03 m
 Buckling length out of plane: 5,92 m

Checks

Axial tension	0,000%
Axial compression	0,000%
Bending	33,373%
Shear force y'-axis	0,000%
Shear force z'-axis	25,474%
Torsion	0,000%
Bending and axial tension	0,000%
Bending and axial compression	33,373%
Buckling in and out of plane	33,373%
Lateral torsional buckling	68,885%

Resistance checks according to Eurocode 5 : EN 1995-1-1 (--) : bar 3

Axial tension (§6.1.2)

This bar is not subjected to tension

Axial compression (§6.1.4)

0,000%

Maximum at 2,81 m of node 3 in combination Load group 1

$$N_{Ed} = 0,00 \text{ kN}$$

$$N_{c,Rd} = A \cdot f_{c,0,d} = 76,90 \text{ kN}$$

$$A = 10619,0 \text{ mm}^2 \quad f_{c,0,d} = 7,2 \text{ N/mm}^2$$

$$k_{mod} = 1,000 \quad \gamma_M = 1,200$$

Bending (§6.1.6)

33,373%

Maximum at 2,03 m of node 3 in combination Load group 1

$$M_{y,Ed} = 1,27 \text{ kNm}$$

$$M_{z,Ed} = 0,00 \text{ kNm}$$

$$M_{y,Rd} = W_{y,el} \cdot f_{m,d} = 3,80 \text{ kNm}$$

$$M_{z,Rd} = W_{z,el} \cdot f_{m,d} = 0,60 \text{ kNm}$$

$$W_{y,el} = 458387 \text{ mm}^3 \quad W_{z,el} = 72563 \text{ mm}^3 \quad f_{m,d} = 8,3 \text{ N/mm}^2$$

$$k_{mod} = 1,000 \quad \gamma_M = 1,200 \quad k_m = 0,700$$

Shear force y'-axis (§6.1.7)

This bar is not subjected to shear force V_y

Shear force z'-axis (§6.1.7)

25,474%

Maximum at node 5 in combination Load group 1

$$V_{z,Ed} = 1,67 \text{ kN}$$

$$V_{z,Rd} = A_{el,z'} \cdot k_{cr} \cdot f_{v,d} = 6,56 \text{ kN}$$

$$A_{el,z'} = 7079,3 \text{ mm}^2 \quad k_{cr} = 0,670 \quad f_{v,d} = 1,4 \text{ N/mm}^2$$

$$k_{mod} = 1,000 \quad \gamma_M = 1,200$$

Torsion (§6.1.8)

This bar is not subjected to torsion

Bending and axial tension (§6.2.3)

This bar is not subjected to tension

Bending and axial compression (§6.2.4)

33,373%

Maximum at 2,03 m of node 3 in combination Load group 1

$$N_{Ed} = 0,00 \text{ kN}$$

$$M_{y,Ed} = 1,27 \text{ kNm}$$

$$M_{z,Ed} = 0,00 \text{ kNm}$$

$$N_{c,Rd} = A \cdot f_{c,0,d} = 76,90 \text{ kN}$$

$$M_{y,Rd} = W_{y,el} \cdot f_{m,d} = 3,80 \text{ kNm}$$

$$M_{z,Rd} = W_{z,el} \cdot f_{m,d} = 0,60 \text{ kNm}$$

$$A = 10619,0 \text{ mm}^2 \quad W_{y,el} = 458387 \text{ mm}^3 \quad W_{z,el} = 72563 \text{ mm}^3$$

$$f_{c,0,d} = 7,2 \text{ N/mm}^2 \quad f_{m,d} = 8,3 \text{ N/mm}^2 \quad k_m = 0,700$$

$$k_{mod} = 1,000 \quad \gamma_M = 1,200$$

Stability checks according to Eurocode 5 : EN 1995-1-1 (--): bar 3

Buckling in and out of plane (§6.3.2)

33,373%

Maximum at 2,03 m of node 3 in combination Load group 1

$N_{Ed} = 0,00$ kN
 $M_{y,Ed} = 1,27$ kNm
 $M_{z,Ed} = 0,00$ kNm

$N_{c,Rd} = A \cdot f_{c,0,d} = 76,90$ kN
 $M_{y,Rd} = W_{y,el} \cdot f_{m,d} = 3,80$ kNm
 $M_{z,Rd} = W_{z,el} \cdot f_{m,d} = 0,60$ kNm

$A = 10619,0$ mm ²	$W_{y,el} = 458387$ mm ³	$W_{z,el} = 72563$ mm ³
$f_{c,0,d} = 7,2$ N/mm ²	$f_{m,d} = 8,3$ N/mm ²	$k_m = 0,700$
$k_{c,y} = 0,668$	$k_{c,z} = 0,011$	
$k_y = 1,102$	$k_z = 47,027$	
$\lambda_{rel,y} = 1,029$	$\lambda_{rel,z} = 9,550$	$\beta_c = 0,200$
$\lambda_y = 53,847$	$\lambda_z = 499,845$	$E_{0,05} = 2412$ N/mm ²

Lateral torsional buckling (§6.3.3)

68,885%

Maximum at 2,03 m of node 3 in combination Load group 1

$N_{Ed} = 0,00$ kN
 $M_{y,Ed} = 1,27$ kNm

$N_{c,Rd} = A \cdot f_{c,0,d} = 76,90$ kN
 $M_{y,Rd} = W_{y,el} \cdot f_{m,d} = 3,80$ kNm

$A = 10619,0$ mm ²	$W_{y,el} = 458387$ mm ³
$f_{c,0,d} = 7,2$ N/mm ²	$f_{m,d} = 8,3$ N/mm ²
$k_{crit} = 0,484$	$k_{c,z} = 0,011$
$\lambda_{rel,m} = 1,437$	$\sigma_{m,crit} = 4,8$ N/mm ²
$M_{y,crit} = 2,21$ kNm	$L_{br} = 3,96$ m
$I_z = 1487545$ mm ⁴	$I_{br} = 5356801$ mm ⁴
$E_{0,05} = 2412$ N/mm ²	$G_{0,05} = 402$ N/mm ²

Overview timber check according to Eurocode 5 : EN 1995-1-1 (--): bar 4

Data



Cross-section: MP 9x9
 Material: Timber Multiplex C24 - FR - 1 naad(1)
 Bar length: 2,29 m
 Buckling length in plane: 2,29 m
 Buckling length out of plane: 2,29 m

Checks

Axial tension	0,000%
Axial compression	18,760%
Bending	0,000%
Shear force y'-axis	0,000%
Shear force z'-axis	0,000%
Torsion	0,000%
Bending and axial tension	0,000%
Bending and axial compression	3,520%

Buckling in and out of plane

236,623%

Lateral torsional buckling

0,000%

Resistance checks according to Eurocode 5 : EN 1995-1-1 (--) : bar 4

Axial tension (§6.1.2)

This bar is not subjected to tension

Axial compression (§6.1.4)

18,760%

Maximum at node 4 in combination Load group 1

$$N_{Ed} = 3,05 \text{ kN}$$

$$N_{c,Rd} = A \cdot f_{c,0,d} = 16,24 \text{ kN}$$

$$A = 1681,0 \text{ mm}^2 \quad f_{c,0,d} = 9,7 \text{ N/mm}^2$$

$$k_{mod} = 1,000 \quad \gamma_M = 1,200$$

Bending (§6.1.6)

This bar is not subjected to bending

Shear force y'-axis (§6.1.7)

This bar is not subjected to shear force V_y

Shear force z'-axis (§6.1.7)

This bar is not subjected to shear force V_z

Torsion (§6.1.8)

This bar is not subjected to torsion

Bending and axial tension (§6.2.3)

This bar is not subjected to tension

Bending and axial compression (§6.2.4)

3,520%

Maximum at node 4 in combination Load group 1

$$N_{Ed} = 3,05 \text{ kN}$$

$$M_{y,Ed} = 0,00 \text{ kNm}$$

$$M_{z,Ed} = 0,00 \text{ kNm}$$

$$N_{c,Rd} = A \cdot f_{c,0,d} = 16,24 \text{ kN}$$

$$M_{y,Rd} = W_{y,el} \cdot f_{m,d} = 0,13 \text{ kNm}$$

$$M_{z,Rd} = W_{z,el} \cdot f_{m,d} = 0,13 \text{ kNm}$$

$$A = 1681,0 \text{ mm}^2 \quad W_{y,el} = 11487 \text{ mm}^3$$

$$f_{c,0,d} = 9,7 \text{ N/mm}^2 \quad f_{m,d} = 11,0 \text{ N/mm}^2$$

$$k_{mod} = 1,000 \quad \gamma_M = 1,200$$

$$W_{z,el} = 11487 \text{ mm}^3$$

$$k_m = 0,700$$

Stability checks according to Eurocode 5 : EN 1995-1-1 (--) : bar 4

Buckling in and out of plane (§6.3.2)

236,623%

Maximum at node 4 in combination Load group 1

$$N_{Ed} = 3,05 \text{ kN}$$

$$M_{y,Ed} = 0,00 \text{ kNm}$$

$$M_{z,Ed} = 0,00 \text{ kNm}$$

$$N_{c,Rd} = A \cdot f_{c,0,d} = 16,24 \text{ kN}$$

$$M_{y,Rd} = W_{y,el} \cdot f_{m,d} = 0,13 \text{ kNm}$$

$$M_{z,Rd} = W_{z,el} \cdot f_{m,d} = 0,13 \text{ kNm}$$

$$A = 1681,0 \text{ mm}^2 \quad W_{y,el} = 11487 \text{ mm}^3$$

$$f_{c,0,d} = 9,7 \text{ N/mm}^2 \quad f_{m,d} = 11,0 \text{ N/mm}^2$$

$$W_{z,el} = 11487 \text{ mm}^3$$

$$k_m = 0,700$$

$$k_{c,y} = 0,079 \quad k_{c,z'} = 0,079$$

$$k_y = 6,779 \quad k_{z'} = 6,779$$

$$\lambda_{rel,y} = 3,454 \quad \lambda_{rel,z'} = 3,454$$

$$\lambda_y = 193,821 \quad \lambda_{z'} = 193,821$$

$$\beta_c = 0,200$$

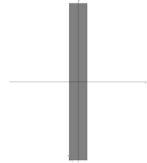
$$E_{0,05} = 3698 \text{ N/mm}^2$$

Lateral torsional buckling (§6.3.3)

This bar is not subjected to lateral torsional buckling

Overview timber check according to Eurocode 5 : EN 1995-1-1 (--): bar 5

Data



Cross-section: MP 9x40
 Material: Timber Multiplex C24 - FR - 2 naden(1)
 Bar length: 0,98 m
 Buckling length in plane: 0,98 m
 Buckling length out of plane: 4,10 m

Checks

Axial tension	0,000%
Axial compression	0,000%
Bending	57,058%
Shear force y'-axis	0,000%
Shear force z'-axis	95,781%
Torsion	0,000%
Bending and axial tension	57,058%
Bending and axial compression	0,000%
Buckling in and out of plane	0,000%
Lateral torsional buckling	62,961%

Resistance checks according to Eurocode 5 : EN 1995-1-1 (--): bar 5

Axial tension (§6.1.2) 0,000%

Maximum at node 4 in combination Load group 1

$N_{Ed} = 0,00 \text{ kN}$

$N_{t,Rd} = A \cdot f_{t,0,d} = 71,14 \text{ kN}$

$A = 14719,0 \text{ mm}^2$ $f_{t,0,d} = 4,8 \text{ N/mm}^2$
 $k_{mod} = 1,000$ $\gamma_M = 1,200$

Axial compression (§6.1.4)

This bar is not subjected to compression

Bending (§6.1.6) 57,058%

Maximum at node 8 in combination Load group 1

$M_{y,Ed} = 4,16 \text{ kNm}$
 $M_{z,Ed} = 0,00 \text{ kNm}$

$M_{y,Rd} = W_{y,el} \cdot f_{m,d} = 7,30 \text{ kNm}$
 $M_{z,Rd} = W_{z,el} \cdot f_{m,d} = 0,83 \text{ kNm}$

$W_{y,el} = 880687 \text{ mm}^3$ $W_{z,el} = 100580 \text{ mm}^3$ $f_{m,d} = 8,3 \text{ N/mm}^2$
 $k_{mod} = 1,000$ $\gamma_M = 1,200$ $k_m = 0,700$

Shear force y'-axis (§6.1.7)

This bar is not subjected to shear force V_y

Shear force z'-axis (§6.1.7) 95,781%

Maximum at node 8 in combination Load group 1

$V_{z,Ed} = 8,71 \text{ kN}$

$V_{z,Rd} = A_{el,z'} \cdot k_{cr} \cdot f_{v,d} = 9,09 \text{ kN}$

$A_{el,z'} = 9812,7 \text{ mm}^2$ $k_{cr} = 0,670$ $f_{v,d} = 1,4 \text{ N/mm}^2$
 $k_{mod} = 1,000$ $\gamma_M = 1,200$

Torsion (§6.1.8)

This bar is not subjected to torsion

Bending and axial tension (§6.2.3)

57,058%

Maximum at node 8 in combination Load group 1

$$N_{Ed} = 0,00 \text{ kN}$$

$$M_{y,Ed} = 4,16 \text{ kNm}$$

$$M_{z,Ed} = 0,00 \text{ kNm}$$

$$N_{t,Rd} = A \cdot f_{t,0,d} = 71,14 \text{ kN}$$

$$M_{y,Rd} = W_{y,el} \cdot f_{m,d} = 7,30 \text{ kNm}$$

$$M_{z,Rd} = W_{z,el} \cdot f_{m,d} = 0,83 \text{ kNm}$$

$$A = 14719,0 \text{ mm}^2 \quad W_{y,el} = 880687 \text{ mm}^3 \quad W_{z,el} = 100580 \text{ mm}^3$$

$$f_{t,0,d} = 4,8 \text{ N/mm}^2 \quad f_{m,d} = 8,3 \text{ N/mm}^2 \quad k_m = 0,700$$

$$k_{mod} = 1,000 \quad \gamma_M = 1,200$$

Bending and axial compression (§6.2.4)

This bar is not subjected to compression

Stability checks according to Eurocode 5 : EN 1995-1-1 (--) : bar 5**Buckling in and out of plane** (§6.3.2)

This bar is not subjected to buckling

Lateral torsional buckling (§6.3.3)

62,961%

Maximum at node 8 in combination Load group 1

$$N_{Ed} = 0,00 \text{ kN}$$

$$M_{y,Ed} = 4,16 \text{ kNm}$$

$$N_{c,Rd} = A \cdot f_{c,0,d} = 106,59 \text{ kN}$$

$$M_{y,Rd} = W_{y,el} \cdot f_{m,d} = 7,30 \text{ kNm}$$

$$A = 14719,0 \text{ mm}^2 \quad W_{y,el} = 880687 \text{ mm}^3$$

$$f_{c,0,d} = 7,2 \text{ N/mm}^2 \quad f_{m,d} = 8,3 \text{ N/mm}^2$$

$$k_{crit} = 0,906 \quad k_{c,z} = 0,022$$

$$\lambda_{rel,m} = 0,872 \quad \sigma_{m,crit} = 13,1 \text{ N/mm}^2$$

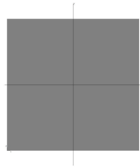
$$M_{y,crit} = 11,52 \text{ kNm} \quad L_{ef} = 1,07 \text{ m}$$

$$I_z = 2061887 \text{ mm}^4 \quad I_{tor} = 7654145 \text{ mm}^4$$

$$E_{0,05} = 2412 \text{ N/mm}^2 \quad G_{0,05} = 402 \text{ N/mm}^2$$

Overview timber check according to Eurocode 5 : EN 1995-1-1 (--): bar 6

Data



Cross-section: MP 9x9
 Material: Timber Multiplex C24 - FR - 1 naad(1)
 Bar length: 2,29 m
 Buckling length in plane: 2,29 m
 Buckling length out of plane: 2,29 m

Checks

Axial tension	0,000%
Axial compression	5,621%
Bending	0,000%
Shear force y'-axis	0,000%
Shear force z'-axis	0,000%
Torsion	0,000%
Bending and axial tension	0,000%
Bending and axial compression	0,316%
Buckling in and out of plane	70,897%
Lateral torsional buckling	0,000%

Resistance checks according to Eurocode 5 : EN 1995-1-1 (--): bar 6

Axial tension (§6.1.2)

This bar is not subjected to tension

Axial compression (§6.1.4)

5,621%

Maximum at node 2 in combination Load group 1

$$N_{Ed} = 0,91 \text{ kN}$$

$$N_{c,Rd} = A \cdot f_{c,0,d} = 16,24 \text{ kN}$$

$$A = 1681,0 \text{ mm}^2 \quad f_{c,0,d} = 9,7 \text{ N/mm}^2$$

$$k_{mod} = 1,000 \quad \gamma_M = 1,200$$

Bending (§6.1.6)

This bar is not subjected to bending

Shear force y'-axis (§6.1.7)

This bar is not subjected to shear force V_y

Shear force z'-axis (§6.1.7)

This bar is not subjected to shear force V_z

Torsion (§6.1.8)

This bar is not subjected to torsion

Bending and axial tension (§6.2.3)

This bar is not subjected to tension

Bending and axial compression (§6.2.4)

0,316%

Maximum at node 2 in combination Load group 1

$$N_{Ed} = 0,91 \text{ kN}$$

$$M_{y,Ed} = 0,00 \text{ kNm}$$

$$M_{z,Ed} = 0,00 \text{ kNm}$$

$$N_{c,Rd} = A \cdot f_{c,0,d} = 16,24 \text{ kN}$$

$$M_{y,Rd} = W_{y,el} \cdot f_{m,d} = 0,13 \text{ kNm}$$

$$M_{z,Rd} = W_{z,el} \cdot f_{m,d} = 0,13 \text{ kNm}$$

$$A = 1681,0 \text{ mm}^2 \quad W_{y,el} = 11487 \text{ mm}^3$$

$$f_{c,0,d} = 9,7 \text{ N/mm}^2 \quad f_{m,d} = 11,0 \text{ N/mm}^2$$

$$k_{mod} = 1,000 \quad \gamma_M = 1,200$$

$$W_{z,el} = 11487 \text{ mm}^3$$

$$k_m = 0,700$$

Stability checks according to Eurocode 5 : EN 1995-1-1 (--) : bar 6

Buckling in and out of plane (§6.3.2)

70,897%

Maximum at node 2 in combination Load group 1

$$N_{Ed} = 0,91 \text{ kN}$$

$$M_{y,Ed} = 0,00 \text{ kNm}$$

$$M_{z,Ed} = 0,00 \text{ kNm}$$

$$N_{c,Rd} = A \cdot f_{c,0,d} = 16,24 \text{ kN}$$

$$M_{y,Rd} = W_{y,el} \cdot f_{m,d} = 0,13 \text{ kNm}$$

$$M_{z,Rd} = W_{z,el} \cdot f_{m,d} = 0,13 \text{ kNm}$$

$$A = 1681,0 \text{ mm}^2$$

$$W_{y,el} = 11487 \text{ mm}^3$$

$$W_{z,el} = 11487 \text{ mm}^3$$

$$f_{c,0,d} = 9,7 \text{ N/mm}^2$$

$$f_{m,d} = 11,0 \text{ N/mm}^2$$

$$k_m = 0,700$$

$$k_{c,y} = 0,079$$

$$k_{c,z} = 0,079$$

$$k_y = 6,779$$

$$k_z = 6,779$$

$$\lambda_{rel,y} = 3,454$$

$$\lambda_{rel,z} = 3,454$$

$$\lambda_y = 193,821$$

$$\lambda_z = 193,821$$

$$\beta_c = 0,200$$

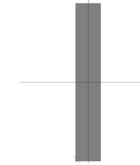
$$E_{0,05} = 3698 \text{ N/mm}^2$$

Lateral torsional buckling (§6.3.3)

This bar is not subjected to lateral torsional buckling

Overview timber check according to Eurocode 5 : EN 1995-1-1 (--) : bar 7

Data



Cross-section: MP 9x30

Material: Timber Multiplex C24 - FR - 2 naden(1)

Bar length: 1,89 m

Buckling length in plane: 1,89 m

Buckling length out of plane: 5,92 m

Checks

Axial tension	0,000%
Axial compression	0,000%
Bending	14,479%
Shear force y'-axis	0,000%
Shear force z'-axis	20,600%
Torsion	0,000%
Bending and axial tension	14,479%
Bending and axial compression	0,000%
Buckling in and out of plane	0,000%
Lateral torsional buckling	15,173%

Resistance checks according to Eurocode 5 : EN 1995-1-1 (--) : bar 7

Axial tension (§6.1.2) 0,000%

Maximum at node 6 in combination Load group 1

$$N_{Ed} = 0,00 \text{ kN}$$

$$N_{t,Rd} = A \cdot f_{t,0,d} = 51,33 \text{ kN}$$

$$A = 10619,0 \text{ mm}^2 \quad f_{t,0,d} = 4,8 \text{ N/mm}^2$$

$$k_{mod} = 1,000 \quad \gamma_M = 1,200$$

Axial compression (§6.1.4)

This bar is not subjected to compression

Bending (§6.1.6) 14,479%

Maximum at node 5 in combination Load group 1

$$M_{y,Ed} = 0,55 \text{ kNm}$$

$$M_{z,Ed} = 0,00 \text{ kNm}$$

$$M_{y,Rd} = W_{y,el} \cdot f_{m,d} = 3,80 \text{ kNm}$$

$$M_{z,Rd} = W_{z,el} \cdot f_{m,d} = 0,60 \text{ kNm}$$

$$W_{y,el} = 458387 \text{ mm}^3 \quad W_{z,el} = 72563 \text{ mm}^3 \quad f_{m,d} = 8,3 \text{ N/mm}^2$$

$$k_{mod} = 1,000 \quad \gamma_M = 1,200 \quad k_m = 0,700$$

Shear force y'-axis (§6.1.7)

This bar is not subjected to shear force V_y

Shear force z'-axis (§6.1.7) 20,600%

Maximum at node 5 in combination Load group 1

$$V_{z,Ed} = 1,35 \text{ kN}$$

$$V_{z,Rd} = A_{el,z'} \cdot k_{cr} \cdot f_{v,d} = 6,56 \text{ kN}$$

$$A_{el,z'} = 7079,3 \text{ mm}^2 \quad k_{cr} = 0,670 \quad f_{v,d} = 1,4 \text{ N/mm}^2$$

$$k_{mod} = 1,000 \quad \gamma_M = 1,200$$

Torsion (§6.1.8)

This bar is not subjected to torsion

Bending and axial tension (§6.2.3)

14,479%

Maximum at node 5 in combination Load group 1

$$N_{Ed} = 0,00 \text{ kN}$$

$$M_{y,Ed} = 0,55 \text{ kNm}$$

$$M_{z,Ed} = 0,00 \text{ kNm}$$

$$N_{t,Rd} = A \cdot f_{t,0,d} = 51,33 \text{ kN}$$

$$M_{y,Rd} = W_{y,el} \cdot f_{m,d} = 3,80 \text{ kNm}$$

$$M_{z,Rd} = W_{z,el} \cdot f_{m,d} = 0,60 \text{ kNm}$$

$$A = 10619,0 \text{ mm}^2 \quad W_{y,el} = 458387 \text{ mm}^3 \quad W_{z,el} = 72563 \text{ mm}^3$$

$$f_{t,0,d} = 4,8 \text{ N/mm}^2 \quad f_{m,d} = 8,3 \text{ N/mm}^2 \quad k_m = 0,700$$

$$k_{mod} = 1,000 \quad \gamma_M = 1,200$$

Bending and axial compression (§6.2.4)

This bar is not subjected to compression

Stability checks according to Eurocode 5 : EN 1995-1-1 (--) : bar 7

Buckling in and out of plane (§6.3.2)

This bar is not subjected to buckling

Lateral torsional buckling (§6.3.3)

15,173%

Maximum at node 5 in combination Load group 1

$N_{Ed} = 0,00$ kN

$M_{y,Ed} = 0,55$ kNm

$N_{c,Rd} = A \cdot f_{c,0,d} = 76,90$ kN

$M_{y,Rd} = W_{y,el} \cdot f_{m,d} = 3,80$ kNm

$A = 10619,0$ mm²

$W_{y,el} = 458387$ mm³

$f_{c,0,d} = 7,2$ N/mm²

$f_{m,d} = 8,3$ N/mm²

$k_{crit} = 0,954$

$k_{c,z} = 0,011$

$\lambda_{rel,m} = 0,808$

$\sigma_{m,crit} = 15,2$ N/mm²

$M_{y,crit} = 6,99$ kNm

$L_{ef} = 1,25$ m

$I_z = 1487545$ mm⁴

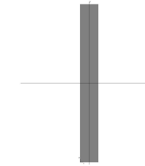
$I_{cr} = 5356801$ mm⁴

$E_{0,05} = 2412$ N/mm²

$G_{0,05} = 402$ N/mm²

Overview timber check according to Eurocode 5 : EN 1995-1-1 (--) : bar 8

Data



Cross-section: MP 9x40

Material: Timber Multiplex C24 - FR - 2 naden(1)

Bar length: 3,12 m

Buckling length in plane: 3,12 m

Buckling length out of plane: 4,10 m

Checks

Axial tension	0,000%
Axial compression	0,000%
Bending	55,541%
Shear force y'-axis	0,000%
Shear force z'-axis	66,942%
Torsion	0,000%
Bending and axial tension	55,541%
Bending and axial compression	0,000%
Buckling in and out of plane	0,000%
Lateral torsional buckling	103,553%

Resistance checks according to Eurocode 5 : EN 1995-1-1 (--) : bar 8

Axial tension (§6.1.2) 0,000%

Maximum at node 7 in combination Load group 1

$$N_{Ed} = 0,00 \text{ kN}$$

$$N_{t,Rd} = A \cdot f_{t,0,d} = 71,14 \text{ kN}$$

$$A = 14719,0 \text{ mm}^2 \quad f_{t,0,d} = 4,8 \text{ N/mm}^2$$

$$k_{mod} = 1,000 \quad \gamma_M = 1,200$$

Axial compression (§6.1.4)

This bar is not subjected to compression

Bending (§6.1.6) 55,541%

Maximum at node 7 in combination Load group 1

$$M_{y,Ed} = 4,05 \text{ kNm}$$

$$M_{z,Ed} = 0,00 \text{ kNm}$$

$$M_{y,Rd} = W_{y,el} \cdot f_{m,d} = 7,30 \text{ kNm}$$

$$M_{z,Rd} = W_{z,el} \cdot f_{m,d} = 0,83 \text{ kNm}$$

$$W_{y,el} = 880687 \text{ mm}^3 \quad W_{z,el} = 100580 \text{ mm}^3 \quad f_{m,d} = 8,3 \text{ N/mm}^2$$

$$k_{mod} = 1,000 \quad \gamma_M = 1,200 \quad k_m = 0,700$$

Shear force y'-axis (§6.1.7)

This bar is not subjected to shear force V_y

Shear force z'-axis (§6.1.7) 66,942%

Maximum at node 7 in combination Load group 1

$$V_{z,Ed} = 6,09 \text{ kN}$$

$$V_{z,Rd} = A_{el,z'} \cdot k_{cr} \cdot f_{v,d} = 9,09 \text{ kN}$$

$$A_{el,z'} = 9812,7 \text{ mm}^2 \quad k_{cr} = 0,670 \quad f_{v,d} = 1,4 \text{ N/mm}^2$$

$$k_{mod} = 1,000 \quad \gamma_M = 1,200$$

Torsion (§6.1.8)

This bar is not subjected to torsion

Bending and axial tension (§6.2.3)

55,541%

Maximum at node 7 in combination Load group 1

$$N_{Ed} = 0,00 \text{ kN}$$

$$M_{y,Ed} = 4,05 \text{ kNm}$$

$$M_{z,Ed} = 0,00 \text{ kNm}$$

$$N_{t,Rd} = A \cdot f_{t,0,d} = 71,14 \text{ kN}$$

$$M_{y,Rd} = W_{y,el} \cdot f_{m,d} = 7,30 \text{ kNm}$$

$$M_{z,Rd} = W_{z,el} \cdot f_{m,d} = 0,83 \text{ kNm}$$

$$A = 14719,0 \text{ mm}^2 \quad W_{y,el} = 880687 \text{ mm}^3 \quad W_{z,el} = 100580 \text{ mm}^3$$

$$f_{t,0,d} = 4,8 \text{ N/mm}^2 \quad f_{m,d} = 8,3 \text{ N/mm}^2 \quad k_m = 0,700$$

$$k_{mod} = 1,000 \quad \gamma_M = 1,200$$

Bending and axial compression (§6.2.4)

This bar is not subjected to compression

Stability checks according to Eurocode 5 : EN 1995-1-1 (--) : bar 8

Buckling in and out of plane (§6.3.2)

This bar is not subjected to buckling

Lateral torsional buckling (§6.3.3)

103,553%

Maximum at node 7 in combination Load group 1

$$N_{Ed} = 0,00 \text{ kN}$$

$$M_{y,Ed} = 4,05 \text{ kNm}$$

$$N_{c,Rd} = A \cdot f_{c,0,d} = 106,59 \text{ kN}$$

$$M_{y,Rd} = W_{y,el} \cdot f_{m,d} = 7,30 \text{ kNm}$$

$$A = 14719,0 \text{ mm}^2$$

$$W_{y,el} = 880687 \text{ mm}^3$$

$$f_{c,0,d} = 7,2 \text{ N/mm}^2$$

$$f_{m,d} = 8,3 \text{ N/mm}^2$$

$$k_{crit} = 0,536$$

$$k_{e,z} = 0,022$$

$$\lambda_{rel,m} = 1,365$$

$$\sigma_{m,crit} = 5,3 \text{ N/mm}^2$$

$$M_{y,crit} = 4,70 \text{ kNm}$$

$$L_{ef} = 2,62 \text{ m}$$

$$I_z = 2061887 \text{ mm}^4$$

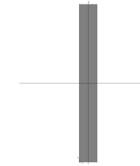
$$I_{tor} = 7654145 \text{ mm}^4$$

$$E_{0,05} = 2412 \text{ N/mm}^2$$

$$G_{0,05} = 402 \text{ N/mm}^2$$

Overview timber check according to Eurocode 5 : EN 1995-1-1 (--) : bar 9

Data



Cross-section: MP 9x40

Material: Timber Multiplex C24 - FR - 2 naden(1)

Bar length: 0,91 m

Buckling length in plane: 0,91 m

Buckling length out of plane: 0,91 m

Checks

Axial tension	0,000%
Axial compression	0,000%
Bending	57,058%
Shear force y'-axis	0,000%
Shear force z'-axis	66,587%
Torsion	0,000%
Bending and axial tension	57,058%
Bending and axial compression	0,000%
Buckling in and out of plane	0,000%
Lateral torsional buckling	65,034%

Resistance checks according to Eurocode 5 : EN 1995-1-1 (--) : bar 9

Axial tension (§6.1.2) 0,000%

Maximum at node 8 in combination Load group 1

$$N_{Ed} = 0,00 \text{ kN}$$

$$N_{t,Rd} = A \cdot f_{t,0,d} = 71,14 \text{ kN}$$

$$A = 14719,0 \text{ mm}^2 \quad f_{t,0,d} = 4,8 \text{ N/mm}^2$$

$$k_{mod} = 1,000 \quad \gamma_M = 1,200$$

Axial compression (§6.1.4)

This bar is not subjected to compression

Bending (§6.1.6) 57,058%

Maximum at node 8 in combination Load group 1

$$M_{y,Ed} = 4,16 \text{ kNm}$$

$$M_{z,Ed} = 0,00 \text{ kNm}$$

$$M_{y,Rd} = W_{y,el} \cdot f_{m,d} = 7,30 \text{ kNm}$$

$$M_{z,Rd} = W_{z,el} \cdot f_{m,d} = 0,83 \text{ kNm}$$

$$W_{y,el} = 880687 \text{ mm}^3 \quad W_{z,el} = 100580 \text{ mm}^3 \quad f_{m,d} = 8,3 \text{ N/mm}^2$$

$$k_{mod} = 1,000 \quad \gamma_M = 1,200 \quad k_m = 0,700$$

Shear force y'-axis (§6.1.7)

This bar is not subjected to shear force V_y

Shear force z'-axis (§6.1.7) 66,587%

Maximum at node 8 in combination Load group 1

$$V_{z,Ed} = 6,06 \text{ kN}$$

$$V_{z,Rd} = A_{el,z'} \cdot k_{cr} \cdot f_{v,d} = 9,09 \text{ kN}$$

$$A_{el,z'} = 9812,7 \text{ mm}^2 \quad k_{cr} = 0,670 \quad f_{v,d} = 1,4 \text{ N/mm}^2$$

$$k_{mod} = 1,000 \quad \gamma_M = 1,200$$

Torsion (§6.1.8)

This bar is not subjected to torsion

Bending and axial tension (§6.2.3)

57,058%

Maximum at node 8 in combination Load group 1

$$N_{Ed} = 0,00 \text{ kN}$$

$$M_{y,Ed} = 4,16 \text{ kNm}$$

$$M_{z,Ed} = 0,00 \text{ kNm}$$

$$N_{t,Rd} = A \cdot f_{t,0,d} = 71,14 \text{ kN}$$

$$M_{y,Rd} = W_{y,el} \cdot f_{m,d} = 7,30 \text{ kNm}$$

$$M_{z,Rd} = W_{z,el} \cdot f_{m,d} = 0,83 \text{ kNm}$$

$$A = 14719,0 \text{ mm}^2 \quad W_{y,el} = 880687 \text{ mm}^3 \quad W_{z,el} = 100580 \text{ mm}^3$$

$$f_{t,0,d} = 4,8 \text{ N/mm}^2 \quad f_{m,d} = 8,3 \text{ N/mm}^2 \quad k_m = 0,700$$

$$k_{mod} = 1,000 \quad \gamma_M = 1,200$$

Bending and axial compression (§6.2.4)

This bar is not subjected to compression

Stability checks according to Eurocode 5 : EN 1995-1-1 (--) : bar 9

Buckling in and out of plane (§6.3.2)

This bar is not subjected to buckling

Lateral torsional buckling (§6.3.3)

65,034%

Maximum at node 8 in combination Load group 1

$$N_{Ed} = 0,00 \text{ kN}$$

$$M_{y,Ed} = 4,16 \text{ kNm}$$

$$N_{c,Rd} = A \cdot f_{c,0,d} = 106,59 \text{ kN}$$

$$M_{y,Rd} = W_{y,el} \cdot f_{m,d} = 7,30 \text{ kNm}$$

$$A = 14719,0 \text{ mm}^2$$

$$f_{c,0,d} = 7,2 \text{ N/mm}^2$$

$$W_{y,el} = 880687 \text{ mm}^3$$

$$f_{m,d} = 8,3 \text{ N/mm}^2$$

$$k_{crit} = 0,877$$

$$\lambda_{rel,m} = 0,910$$

$$M_{y,crit} = 10,57 \text{ kNm}$$

$$k_{c,z} = 0,396$$

$$\sigma_{m,crit} = 12,0 \text{ N/mm}^2$$

$$L_{ef} = 1,16 \text{ m}$$

$$I_z = 2061887 \text{ mm}^4$$

$$E_{0,05} = 2412 \text{ N/mm}^2$$

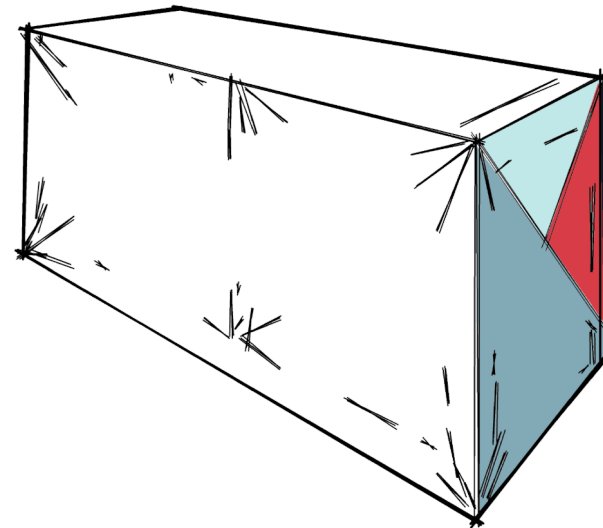
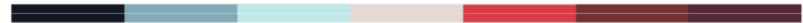
$$I_{tor} = 7654145 \text{ mm}^4$$

$$G_{0,05} = 402 \text{ N/mm}^2$$

8.2 Press Release

THE MOBBLE

Modular Building Block



Press release
Deliverable #1
30 March 2018

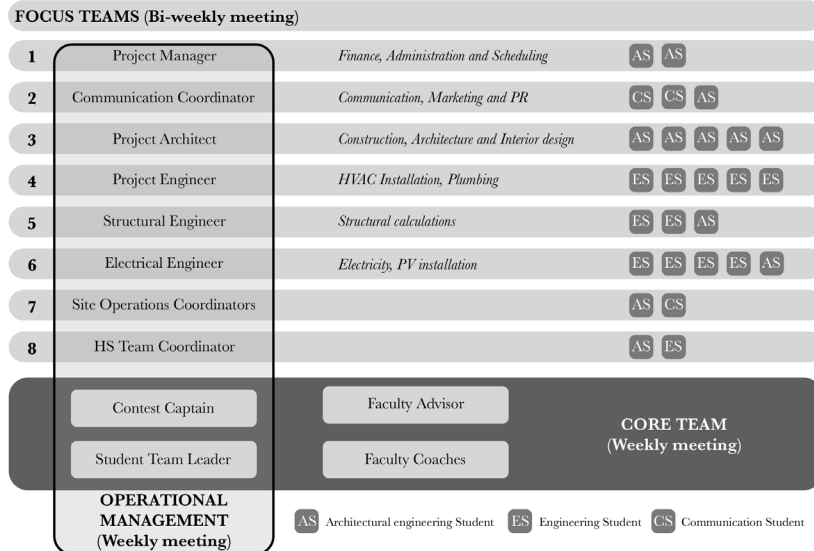


LIST OF TEAM MEMBERS

Team officers

Faculty Advisor	Prof. Nathan Van Den Bossche
Project Manager	Astrid Schepens
Project Architect	Ineke Tavernier
Project Engineer	Astrid Schepens
Site Operation Coordinator	Sven De Turck
Structural Engineer	Ir. Arthur De Roover
Technical installations	Matthias Van Hove
Student Team Leader	Ineke Tavernier
Health & Safety Team Coordinator Safety Officers	Laura Gil
Contest Captain	Marc De Kooning
Sponsorship Manager	Björn Pieters

Overall approach for Organization



Ghent University Horizon Team has adopted on organization structure with different team levels:

Level 1: Core Team

The Student Team Leader, Contest Captain, Faculty Advisor and Faculty Coaches safeguard the mission and vision of the project, and focus on team management and support. They determine the primary strategies, coordination of tasks and overall project's progress. These guys are the head of the Horizon Team!

Level 2: Operational Management

This group consists of a number of leading students with specific topics, called focus managers. These students have a passion for their specific focus but coordinate this with each other. They are responsible for the work progress and the organization of tasks within their group of students. This is the beating heart of the Horizon Team!

Level 3: Focus Teams

Each focus team consists of a number of students and is led by a focus manager. These students are, depending on the topic they are working on, studying architecture, engineering, electromechanics or communication management. These are the hands that build to the project!

Student team

Team Ghent University is a group of motivated architecture and engineering students from Ghent University. The majority of the students are Master students from the Faculty of Engineering and Architecture who collaborate with Postgraduate students Innovative entrepreneurship for Engineers.



Curriculum Integration

Team Belgium's Solar Decathlon participation is an interdisciplinary effort of students of different departments at Ghent University, but coordinated from within the faculty of Engineering & Architecture. One of the challenges of the Solar Decathlon competition is to assure the projects continuity within the context of an academic setting with changing student populations, and with various commitment levels. In order to assure a successful competition event, we propose to foremost work within the context of our existing curricular structures, which are well adapted and flexible enough to accommodate the competition efforts. Working within the context of existing courses will ensure that students receive academic credits for their efforts, and that they do not become overloaded when making contributions.

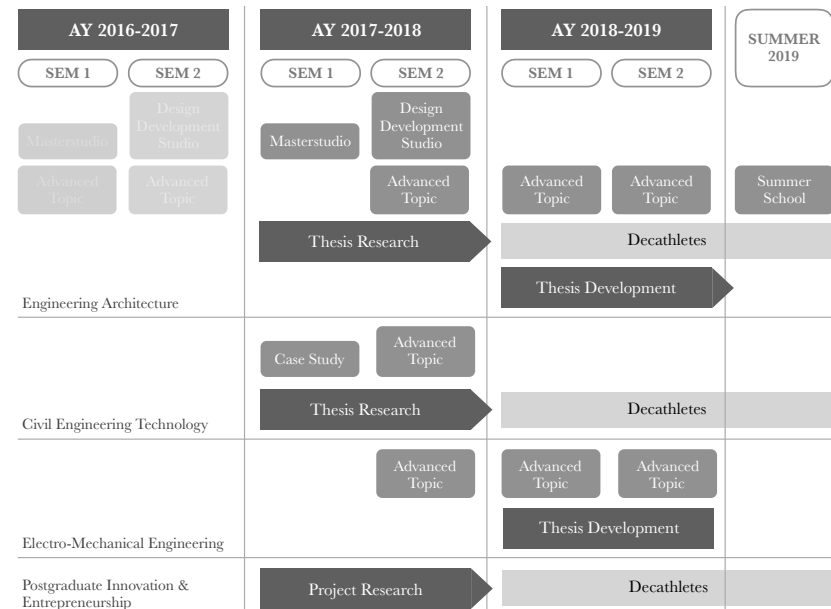
Most of the students are selected from the master in engineering and architecture, because the Solar Decathlon topic is fully integrated in their curriculum. This degree program provides a solid architectural education with the technical rigour of an engineering program, something which is different in comparison to most other architecture programs. Our educational programs are based on three pillars that carry equal weight, namely: architectural design, building engineering, and the history and theory of architecture. The department of architecture shares many curriculum components with other engineering majors, including the civil engineering program, which renders them very suitable for the project.

The following existing courses will be used to accommodate the various project tasks:

- The aim of the **Master studio** is doing research by design on the theme of "intelligent ruins". This comes down to developing structural systems that allow different uses in the course of time. Special attention is given to a combination of architecture, structure and technical systems. Students will, in consideration with thesis students, develop the concept of the pavilion.
- The **Design Development studio** is part of the core curriculum, and takes place during the second semester of the 1st Master year of our architecture program. Starting from an existing schematic design, this studio offers students an opportunity to extend the design effort into a completely ready-to-build pavilion. This effort will include the development of the structural and enclosure systems, technical installations, heating and cooling equipment, etc.
- Within our curriculum there is ample room for students to take up free electives in the form of **advanced topics courses**, which allow students to engage independent study projects over the course of a semester or more. The course structure is very flexible and allows for a wide range of study subjects and initiatives, which makes it an ideal vehicle for specialized work related to the development of the Solar Decathlon project. Therefore, different special topics courses will be offered to students (construction technics, building physics, interior design, urban planning...) in the period leading up to the contest in July 2019.
- The Solar Decathlon project was made available as a **research thesis** to second master students from the 2017-'18 academic year and will be offered again as a **development thesis** to a select group, which will reinforce the team during the 2018-'19 academic year. This rather small group of students are crucial for the success of the project, as their part of work will be significantly bigger than this in design studio's.

Excellent team members graduating at the end of academic year 2017-2018 could continue the project as paid researchers, also called decathletes in the SDE19 Rules. Special scholarships from Ghent University allow to reduce all overhead costs. This is an important principle as it will

encourage long-term commitment which will warrant the project's continuity and precludes any important information, knowledge and experience is going lost.



As described above, an interdisciplinary effort of students at different departments and faculties of Ghent University is prerequisite:

- A collaboration with electro-mechanic engineering students is put in place. Their focus will be on the sizing and execution of the technical installations. E.g. optimizing the electrical energy balance, sizing of heat exchangers, implementing control algorithms, etc.
- Students from the civil engineering department are working on the structural performance of the prefabricated modular systems. Detailed structural calculations using FEM models compare the implication of adopting either a steel structure compared to a wood-base structure.
- Finally, all tasks related to communication, administration, PR and project management will be executed as a project by postgraduate students innovation & entrepreneurship, in collaboration with students from the marketing and communication faculty.

Project team qualifications and expertise



Prof. dr. eng. arch. Nathan Van Den Bossche (faculty advisor) is associate professor building science at the Faculty of Engineering and Architecture at Ghent University in Belgium. In 2005 he obtained his master's degree in architectural engineering, in 2008 a teachers degree, in 2009 a certificate as carpenter, and his PhD in 2013. Since then, he followed a post-graduate program in law for court experts, and a bachelor in real estate. He was appointed associate professor at Ghent University in 2016. He is in charge of the Test Centre for Façade Components at Ghent University, and author and co-author of over 100 research articles published in international journals, proceedings of international conferences and books. As a consultant he was involved in projects by Zaha Hadid Architects, Neutelings Riedijk, Renzo Piano, Jean Nouvel, Stephane Beel, and others.



Eng. arch. Marc De Kooning (contest captain) is a senior teaching assistant at Ghent University. He has extensive experience as a practitioner in architecture projects, and was in charge of the Ghent University Team that built the E-cube in Washington (2011). He is specialized in architectural design, affordable and D-I-Y design, and scenario-analysis. His no-nonsense approach and spirited attitude propels students in the design studio's that he is involved in.



Kristel Dewulf (faculty coach) is an expert in Front End Innovation and Sustainable Product Innovation, involved in several innovation projects together with Delft University of Technology (NL), University Ghent (B), and a wide range of international design consultancies. Kristel is currently working as Innovation Coach for the Faculty of Engineering and Architecture at Ghent University (Belgium), coaching engineering students in start-up and in-company innovation projects. She is also business manager and head of design at ENT Studios, an engineering consultancy located at Ghent (Belgium).



Prof. dr. eng. arch. Jelle Laverge (faculty coach) received his engineering and law masters degree from Ghent University. From 2005 to 2007 he was a part-time employee of Bureau Bouwtechniek in Antwerp. He was a visiting scholar at the University of Texas at Austin during the summer of 2011. With a dissertation entitled 'Design strategies for residential ventilation systems', he obtained a PhD in 2013, and was appointed professor in 2016. He is a member of ISIAQ, SRS and ASHRAE.



Prof. dr. eng. Michel De Paepe (faculty coach) is professor of Thermodynamics at the Faculty of Engineering and Architecture at Ghent University. He graduated as Master of Science in Electro-Mechanical Engineering at Ghent University in 1995. In 1999 he obtained a PhD in Electro-Mechanical Engineering at Ghent University, graduating on 'Steam Injected Gas Turbines with Water Recovery'. He was appointed full professor in 2014, and is a leading international expert on heat exchanger design and waste heat recovery. He is in charge of the thermodynamics research lab and facilities at Ghent University.



Prof. dr. eng. Jan Desmet (faculty coach) received the Polytechnical Engineer degree from the polytechnic academy in Courtrai, the M.Sc. degree in Electrical Engineering from the V.U.Brussels and his Ph.D. degree at the K.U.Leuven, Belgium. Currently he is full professor at the Ghent University teaching Power Quality, Renewable Energy, μ Grids and industrial electric measurement techniques. His research interests include PQ, LV distributed generation, renewables, storage and their mutual interactions. His research lab is the only one over Europe with a free programmable artificial grid of 240kVA, including all renewable sources. Since November 2014, research group Lemcko became member of the prestigious DERLab group.

Prof. dr. eng. arch. Arnold Janssens: building physics and building construction//**Prof. dr. eng. arch. Jan Belis:** glass construction//**Prof. dr. eng. arch. Pieter Pauwels:** BIM expert//**Prof. dr. eng. arch. Michiel Dehaene:** urban analysis and design//**Prof. arch. Jan Moens:** building science and founder Bureau Bouwtechniek//**Eng. arch. Elisa Van Kenhove:** legionella research//**Eng. Hugo Monteyne:** affordable sustainable building design//**Eng. arch. Arthur De Roover:** structural engineer//**Prof. dr. eng. arch. Ronald De Meyer:** intelligent building design

PROJECT DESCRIPTION

The SDE19 contest focuses on the renovation of existing apartment buildings. Team Ghent University will focus on the renovation of large-scale apartment buildings in the Belgian context. Contractors such as Etrimo and Amelinckx were responsible for a mass production of collective housing in the fifties, sixties and seventies in the suburban zones of many Belgian cities.



Figure 1: Breughel Parc Residence II by Etrimo (Zellik Brussels)

Problem statement

Massive destructions throughout the second World War resulted in a large housing shortage in Belgium. As from the 50's, the high-rise condominium model was introduced into suburban districts of metropolitan areas such as Brussels, Antwerp and Liege. Industrial building methods were used to create a high amount of residences. These collective housing blocks were a big improvement in quality, comfort and hygiene compared to the houses constructed before the fifties. Due to standardization, it was possible to realize a high number of buildings in a short period of time. The problem of an urgent housing need seems to be solved.

However, today these high-rise buildings are typically outdated and don't longer meet code requirements in terms of e.g. fire safety, thermal performance and acoustical performance. Furthermore, the discrepancy between the idealized countryside living and the lack of privacy in these building has also initiated social segregation and concentration. The majority of these high-rise buildings – mainly constructed between 1950 and 1980 – is in desperate need of a thorough renovation. However, in Belgium home-ownership exceeds 80%, and there is a large governmental social housing sector which renders the market for private rental rather

small. By consequence, private ownership in apartment blocks introduces several practical, technical, financial, organizational and legal obstructions that hamper thorough renovations.



Figure 2: Breughel Parc Residence II by Etrimo (Zellik Brussels)

In 2016, the Horizon Knowledge Hub was created at Ghent University. Started as an interdisciplinary knowledge platform supported by 13 professors related to the renovation of apartment buildings, it has evolved into an interdisciplinary project where researchers from different fields and faculties collaborate on challenges of mutual interest. The website provides an overview of some results related to e.g. architectural design, facade renovation, technical design, urban planning, macro-economy, electrical energy balance etc.

More info about Horizon: <http://www.horizon-ugent.be>

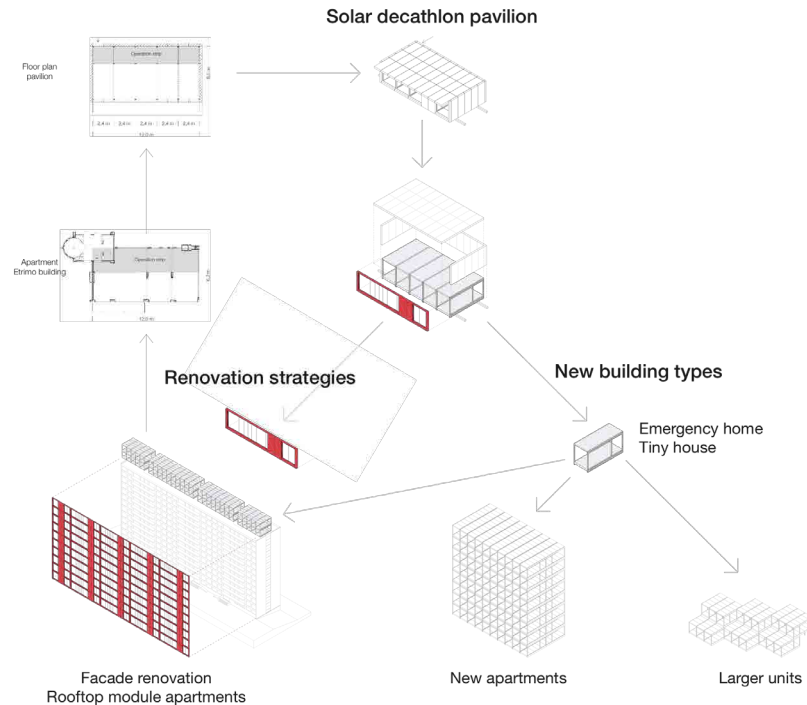
Solar Decathlon Pavilion

Our Solar Decathlon pavilion aspires to tackle some of the renovation problems of large-scale apartment buildings. In particular, the pavilion represents a test set-up to demonstrate renovation strategies for high-rise towers to a broad audience. Furthermore, renovating the inside of the apartment allows to adopt a new blueprint as design principle, which was developed based on extensive scenario analysis: a minimal set of interventions provide a range of possibilities for various plan configurations, from starters, over young families, up to elderly people.

Next to that, the pavilion also addresses a different issue related to the housing challenges we are facing in cities today. There is a clear housing need in cities, and we are in desperate need to develop a new angle on living and house-ownership to address the societal challenges. There is a trend towards densification, co-housing, house-sharing, tiny houses, roof-top additions... The common denominator in these projects is to balance temporary personal housing requirements with the building stock to move away from a static residential market dominated by ownership. Hence, a modular building concept was developed as a basic

building block to tackle a number of these issues and create innovative opportunities. We have created the Mobble.

The following scheme shows the integration possibilities of the Mobble and the relation between the apartment building challenge, the pavilion, and the Mobble as modular building unit.



Scheme evolution of the Mobbles

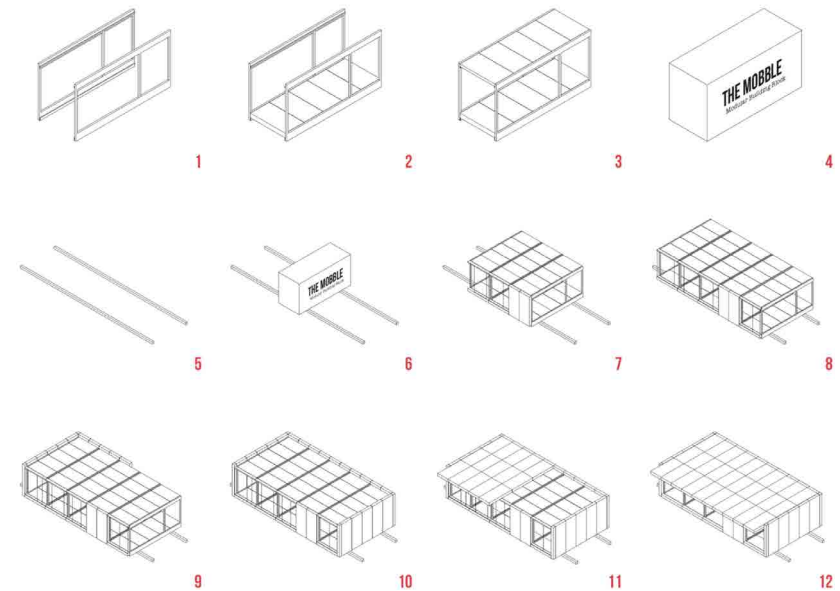
The Mobble is a flexible building block that introduces a new concept of living: the Mobble allows you to adjust your house along the path of your life according to your needs. The fact that the Mobble is a modular building block, is one of its big advantages. With a minimum of effort you can adapt the formation to your current needs. Are you a student who is just graduated and need an affordable living space? You can just buy one Mobble. You fall in love and want to live together? Just add one or two Mobbles. You get children? Add some Mobbles, you get the system. This makes that the system is very flexible, and adjustable to your needs and changing living situation. Bigger wholes of Mobbles can be buildings on their own, where different compositions of families live together.

Construction

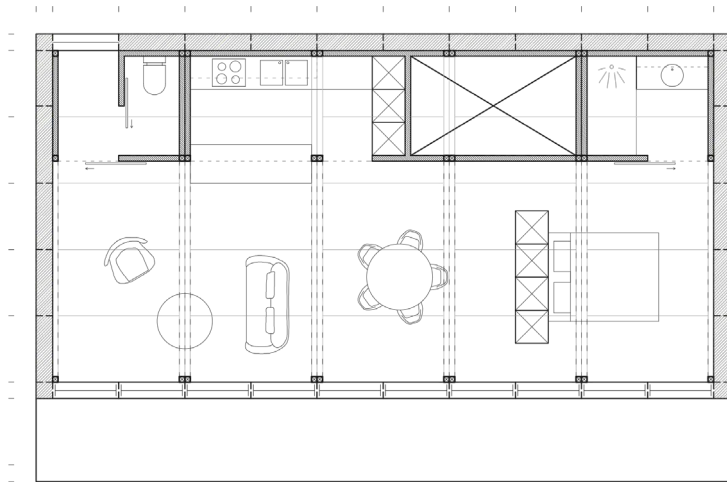
The Mobble is composed out of two structural frames (1). Between these frames the floor panels (2) and the first layer of roof panels are placed (3). Next, interior walls, furniture elements and technical installations will be installed. The module gets a protective sail and then the Mobble is ready for transport. In this way, five modules will be prefabricated and finished with windows. The facade panels and the second layer of roof panels will be installed on site in Szentendre.

Once there, we start off with mounting the foundation (5). Then, the middle Mobble (6) will be installed, followed by the two flanking Mobbles (7) and finally the outer two Mobbles (8). After installing the Mobbles, the façade panels can be mounted (9, 10), as well as the additional layer of roof panels (11, 12).

It is a simple construction concept that enables students and do-it-yourselfers to manufacture their own house. A manual of 'How to construct a Mobble' is coming!



Construction pavilion



Floor plan pavilion

Engineering

Integrated HVAC systems in building facade

Nowadays most high-rise building have inefficient facades and outdated technical installations. To encounter these two problems, prefab facade panels with integrated HVAC distribution and production units are developed. As a consequence, a compact design is unavoidable, which opens the road to innovative solutions as phase changing materials. Usage of PCM's may reduce the storage volume of a tank with a factor 3-4 in comparison with a conventional water tank, making a facade integration feasible. Ongoing research into Legionella and Legionella Pneumophila problems at the Ghent University, can lead to a reduction up to 30% on energy consumption for domestic hot water production.

IoT controlled building with Personal indoor climate conditions

A first application of the Smart Living system and IoT-control is nothing less than a new and disruptive approach towards heating, cooling and ventilating buildings by balancing overall energy efficiency and individualized comfort conditions. The last few years, the energy efficiency of buildings enhanced significantly. We can even state that the limits of energy efficiency improvement for the building envelope are almost reached, considering the trade-off between reducing energy losses and embedded energy when increasing insulation thickness. Likewise, the production –and distribution efficiency have their limits as well. Contrarily, it is surprising that the way in which energy is used to realize comfort has barely been questioned so far, even though the energy reduction potential is very high at this level. Various research projects and measurement campaigns have concluded repeatedly that the actual energy savings after renovation are lower than predicted, mainly due to a shift towards slow low-temperature heating systems that work 24/7, and user-related rebound effects.

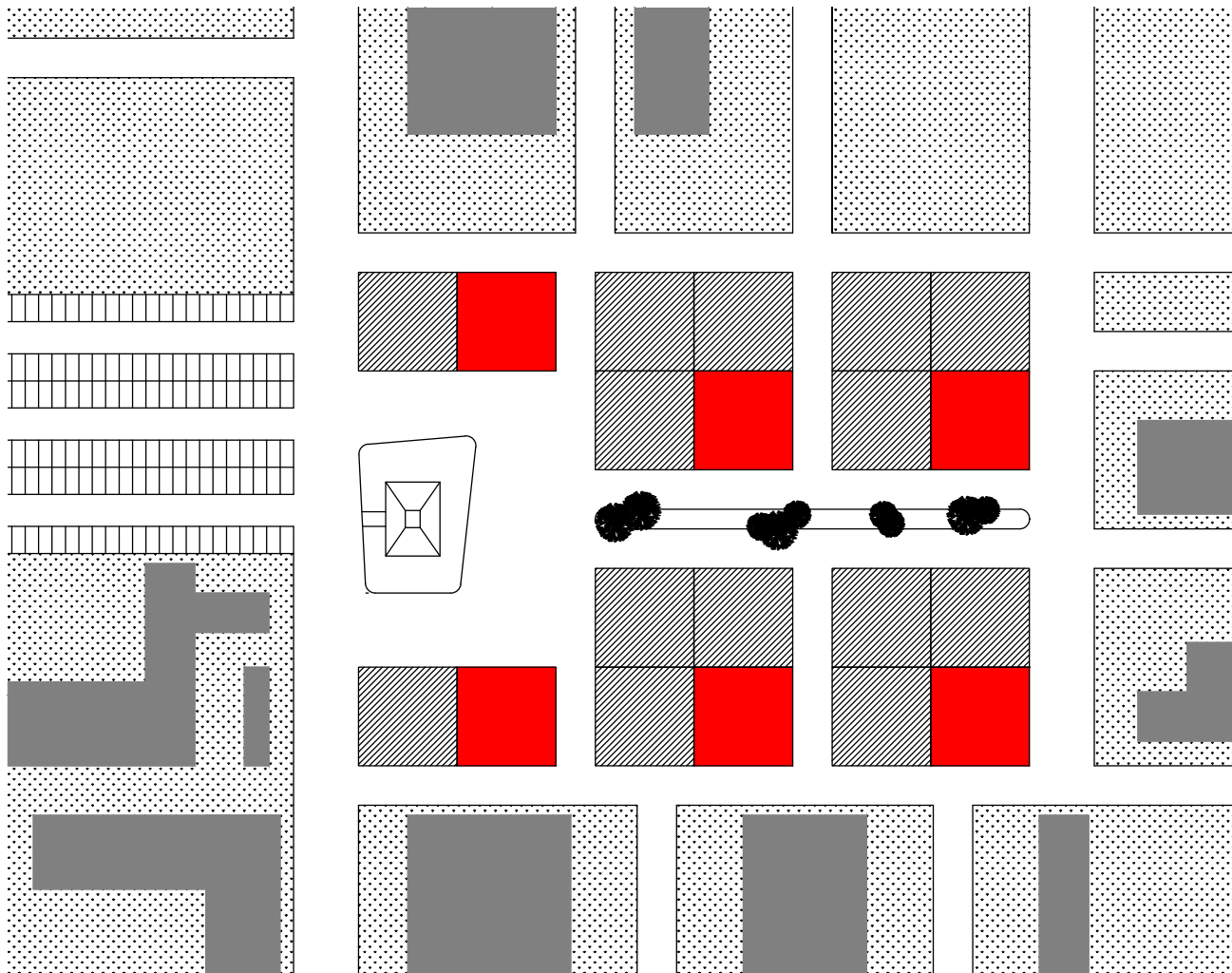
In the traditional approach, HVAC systems and controls provide an acceptable comfort level on the scale of an entire room, or even an entire building. The question at hand is whether it is feasible to realize a similar or better comfort level in buildings by adopting personal HVAC systems, i.e. controlling the climate restricted to the particular location of specific individuals. This can be achieved by providing lighting, heating, air conditioning and air supply directly to the zone in which the user is present, when the user is present. In this way, the rest of the room doesn't need to fulfil the comfort requirements; a lower illumination, lower or higher temperatures and a lower air supply rate is acceptable there. It is obvious that this HVAC concept comprises the potential to reduce the energy use tremendously. To turn this system into practice, a close collaboration is required with detection and control systems, e.g. by addressing the potential of smartphones in that respect.

We aspire to demonstrate following concepts in the pavilion: ductless ventilation systems, integrated ventilation systems (e.g. in walls and furniture), smartphone-controlled radiation panels in the ceiling, automatically controlled lighting etc.

In collaboration with the Ghent University HomeLab – a 600m² full scale test house to evaluate integrated concepts for IoT applications – innovative strategies are explored to reduce the energy use in dwellings, as well as increasing comfort and well-being. Visit: <https://www.imec-int.com/en/what-we-offer/innovation-services/smart-spaces/homelab>.

8.3 Project Drawings

The new cool is living in a Mobble

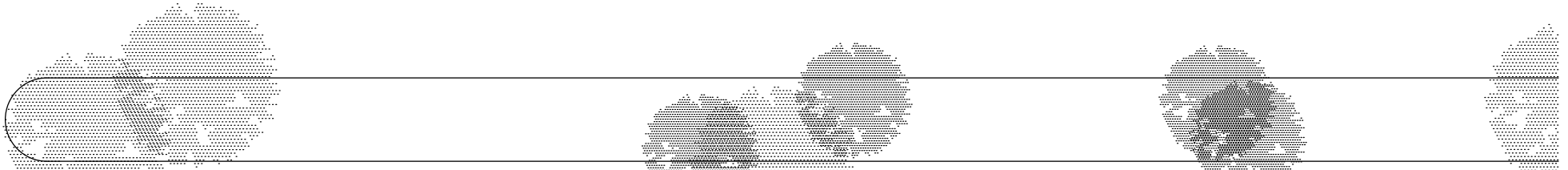
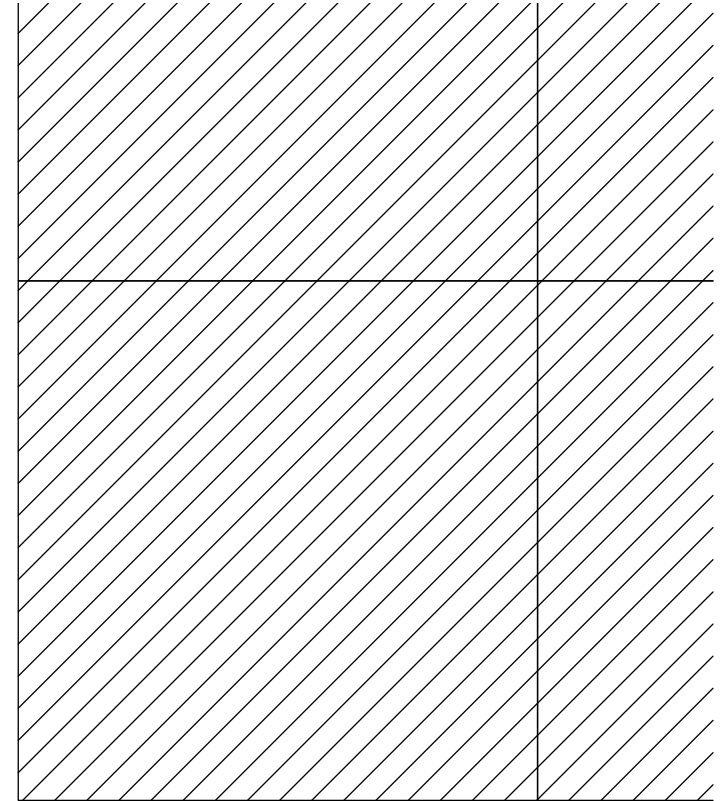
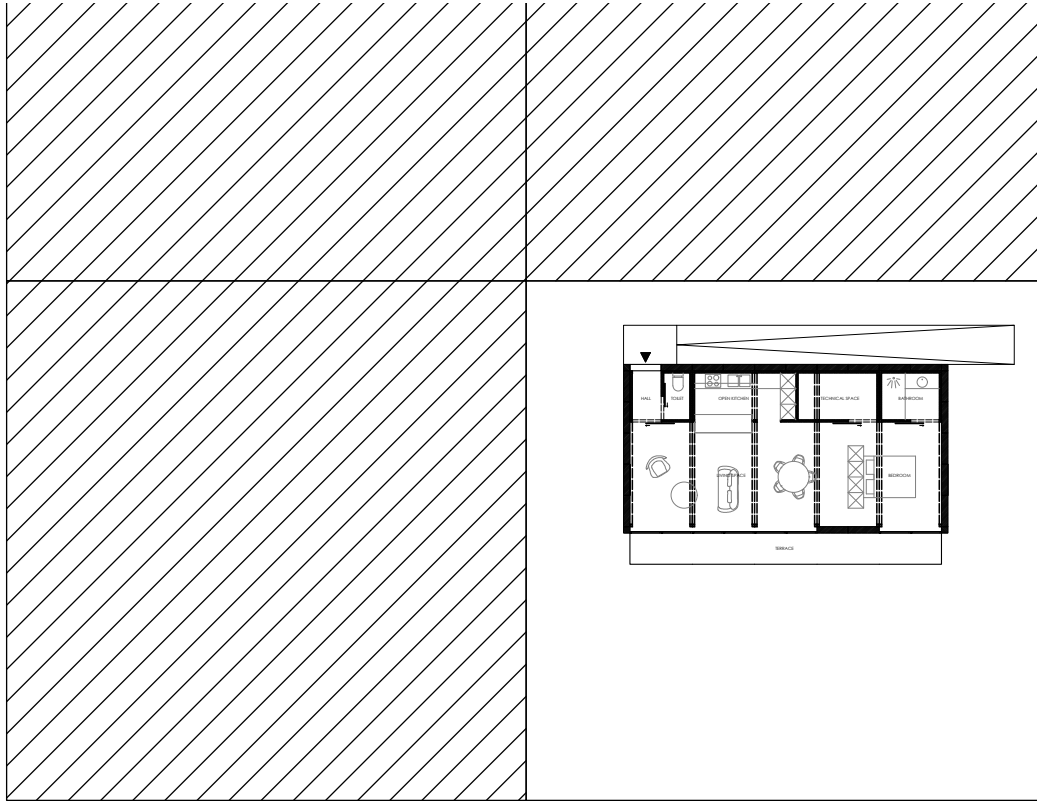


■ PREFERRED SITE
▨ OTHER SITES



SOLAR VILLAGE PLAN
SCALE 1:1000

AR-001
SDE SOLAR
VILLAGE PLAN



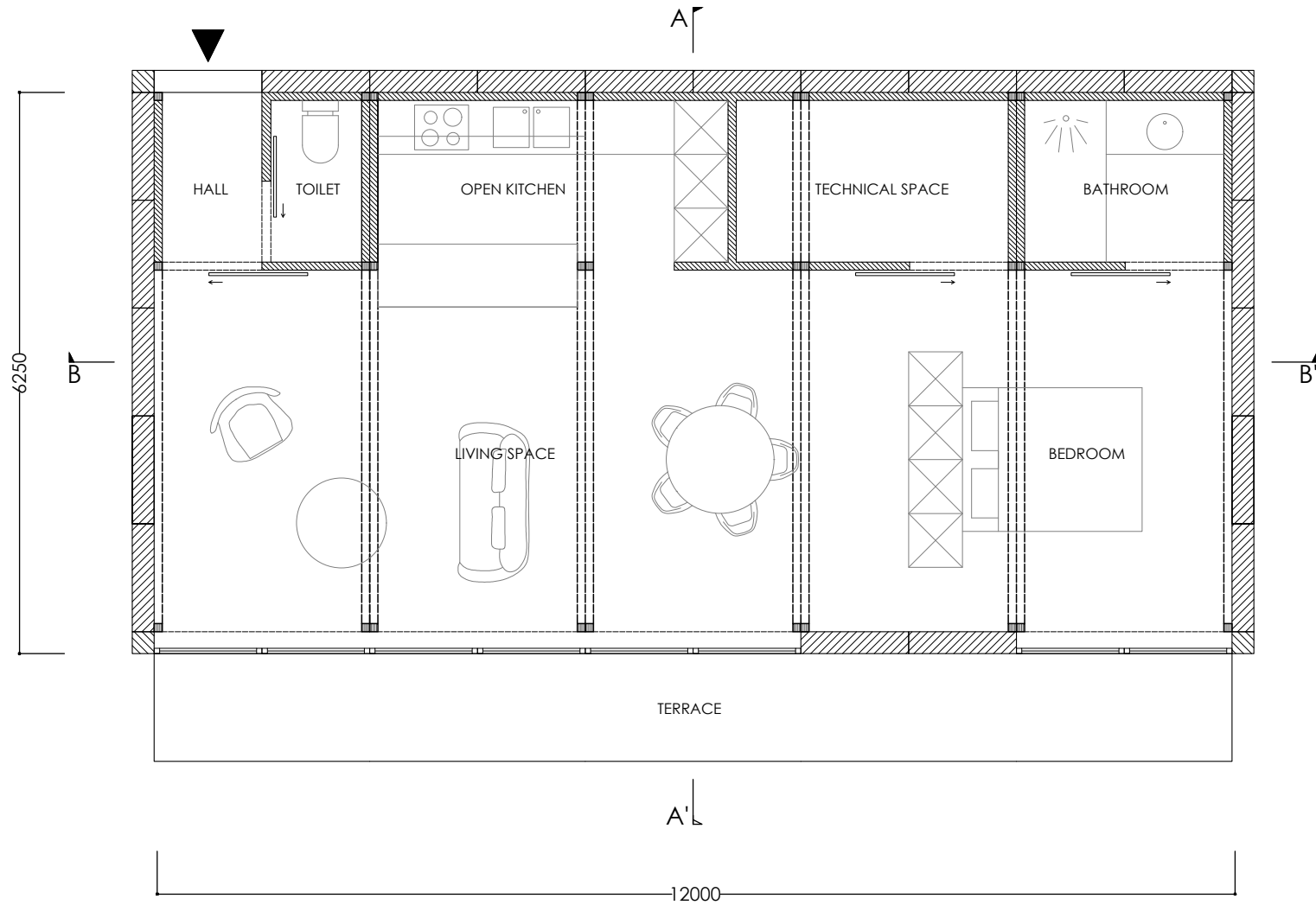
 OTHER SITES



PREFERRED SITE
SCALE 1:200

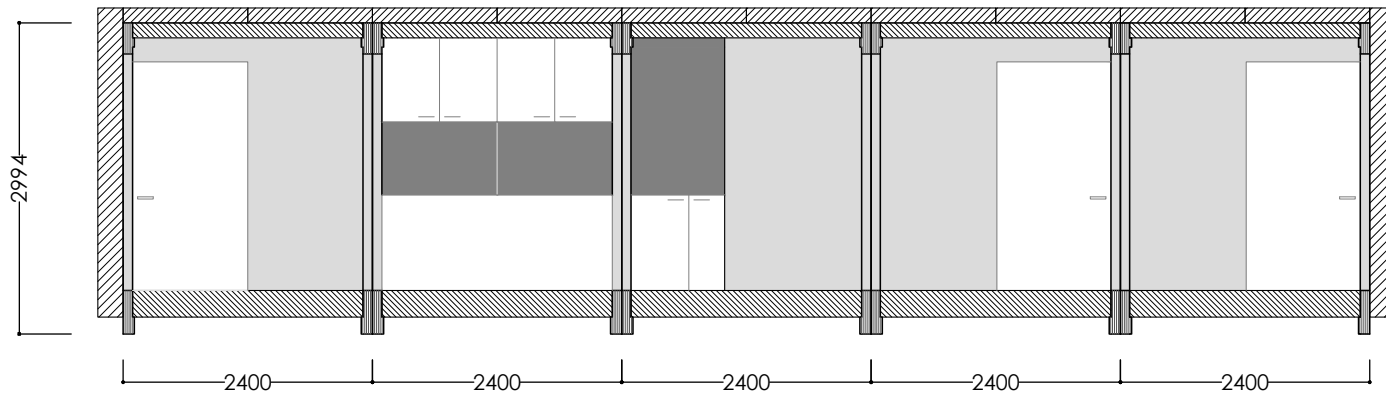
AR-002
SITE PLAN

The new cool is living in a Mobble



FLOOR PLAN - PAVILION
SCALE 1:50

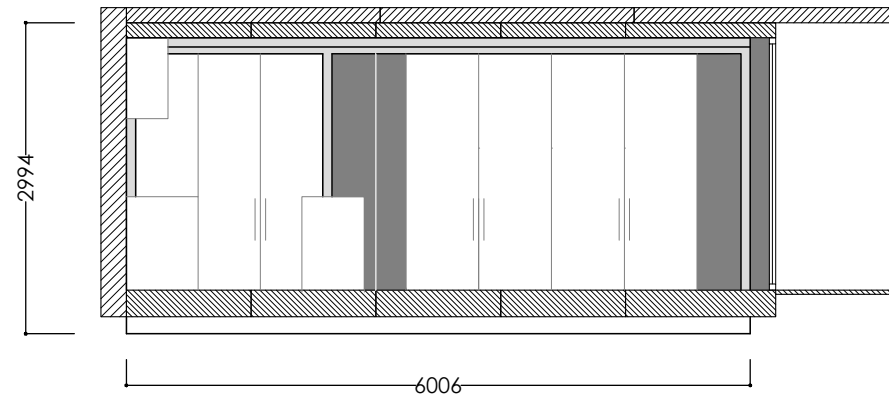
AR-021
FLOOR PLAN



LONGITUDINAL SECTION - PAVILION
SECTION BB'
SCALE 1:50

AR-201
LONGITUDINAL
SECTION

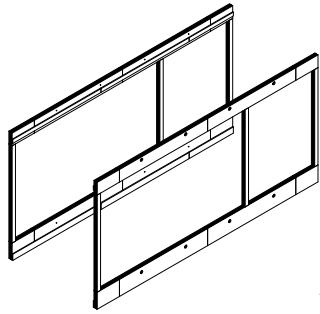
The new cool is living in a Mobble



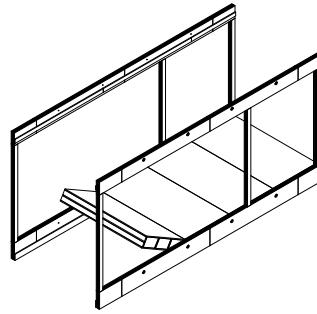
TRANSVERSAL SECTION - PAVILION
SECTION AA'
SCALE 1:50

AR-211
TRANSVERSAL
SECTION

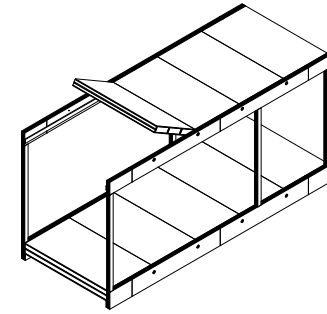




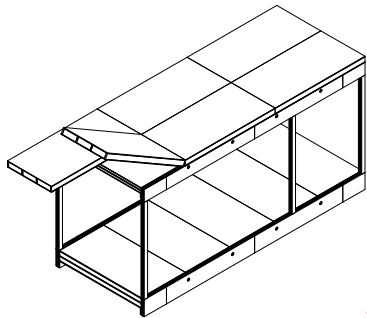
1



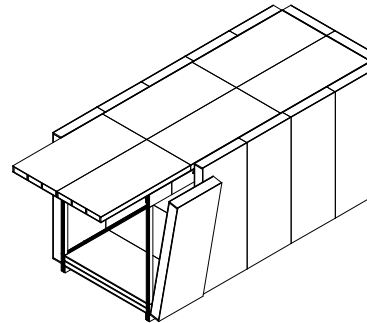
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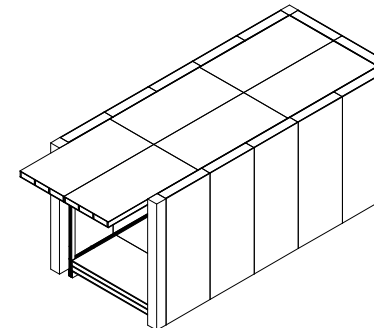
3



4



5



6

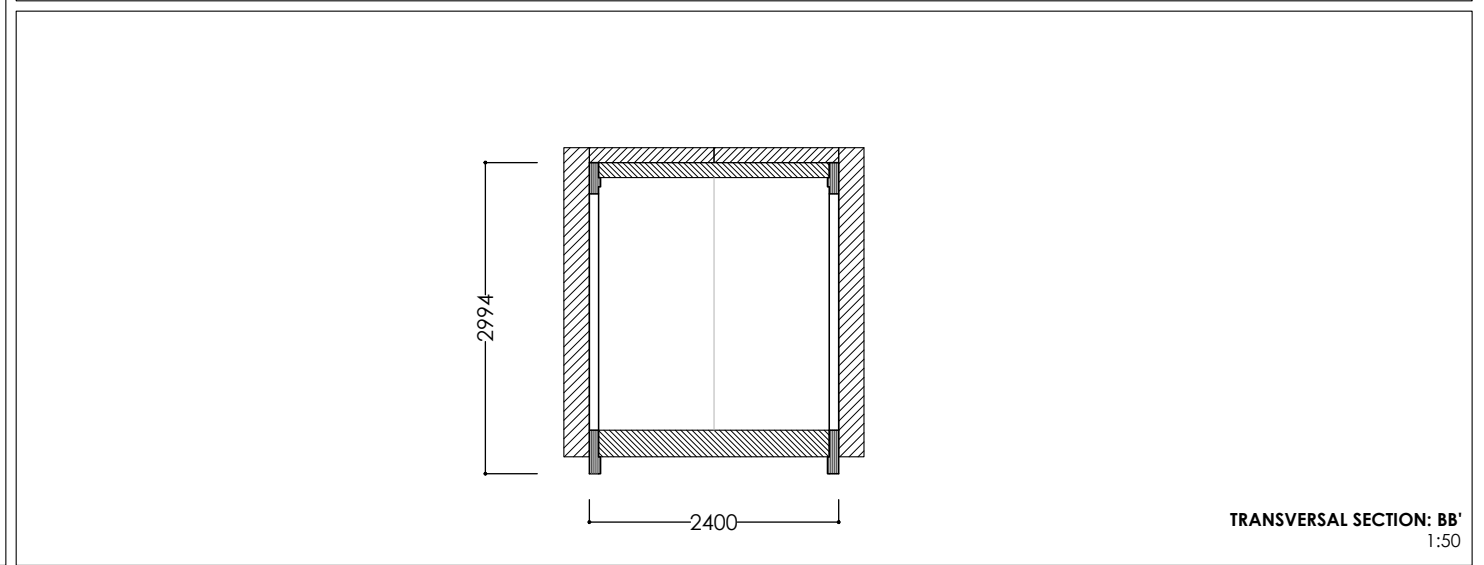
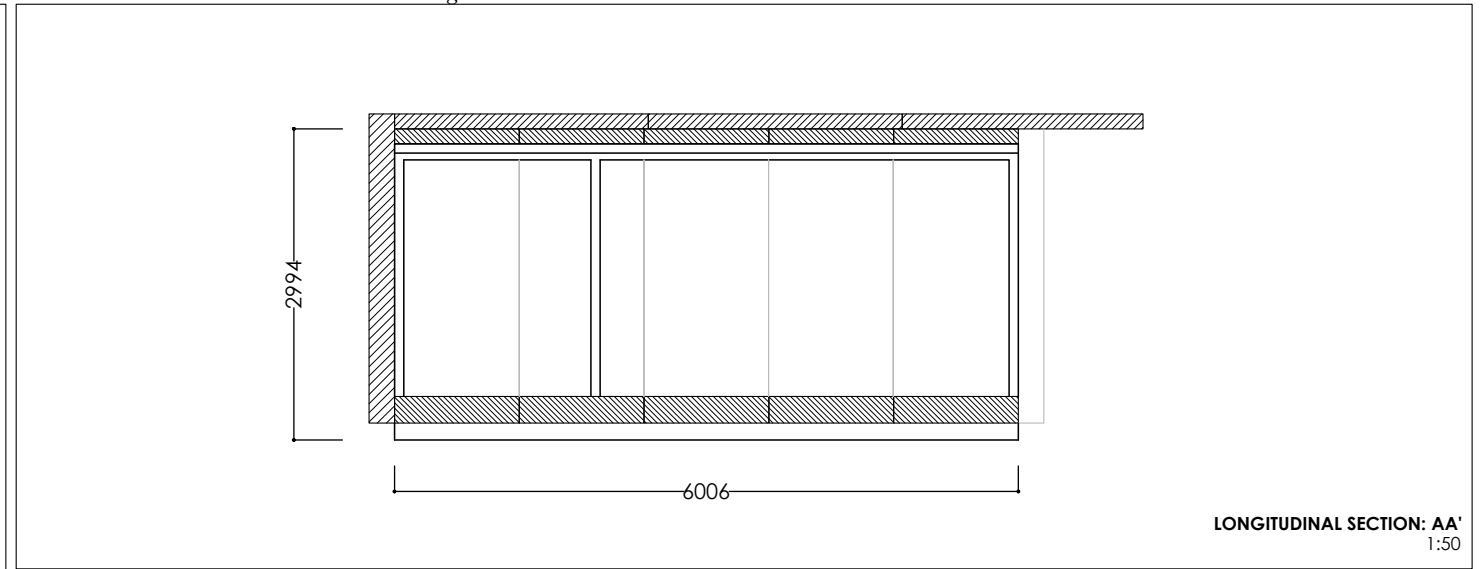
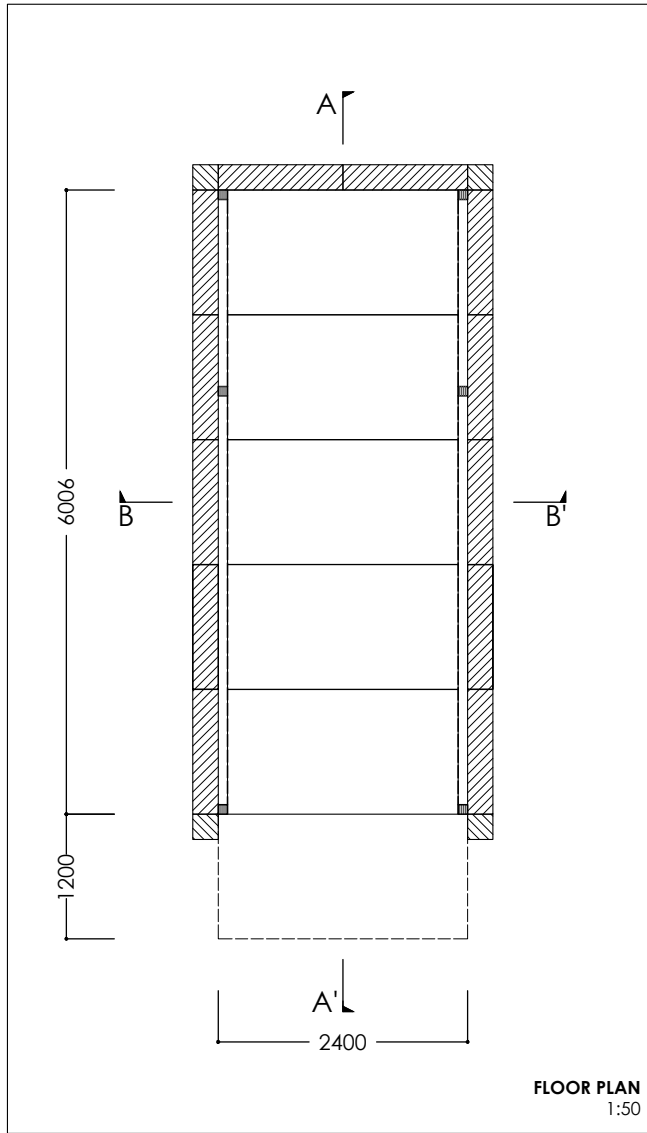


- | | | | |
|---|------------------|---|---------------|
| 1 | STIFF FRAMEWORKS | 4 | ROOF PANELS |
| 2 | FLOOR PANELS | 5 | WALL PANELS |
| 3 | CEILING PANELS | 6 | CORNER PANELS |

THE MOBBLE'S STRUCTURE
PROTOTYPE
SCALE 1:100

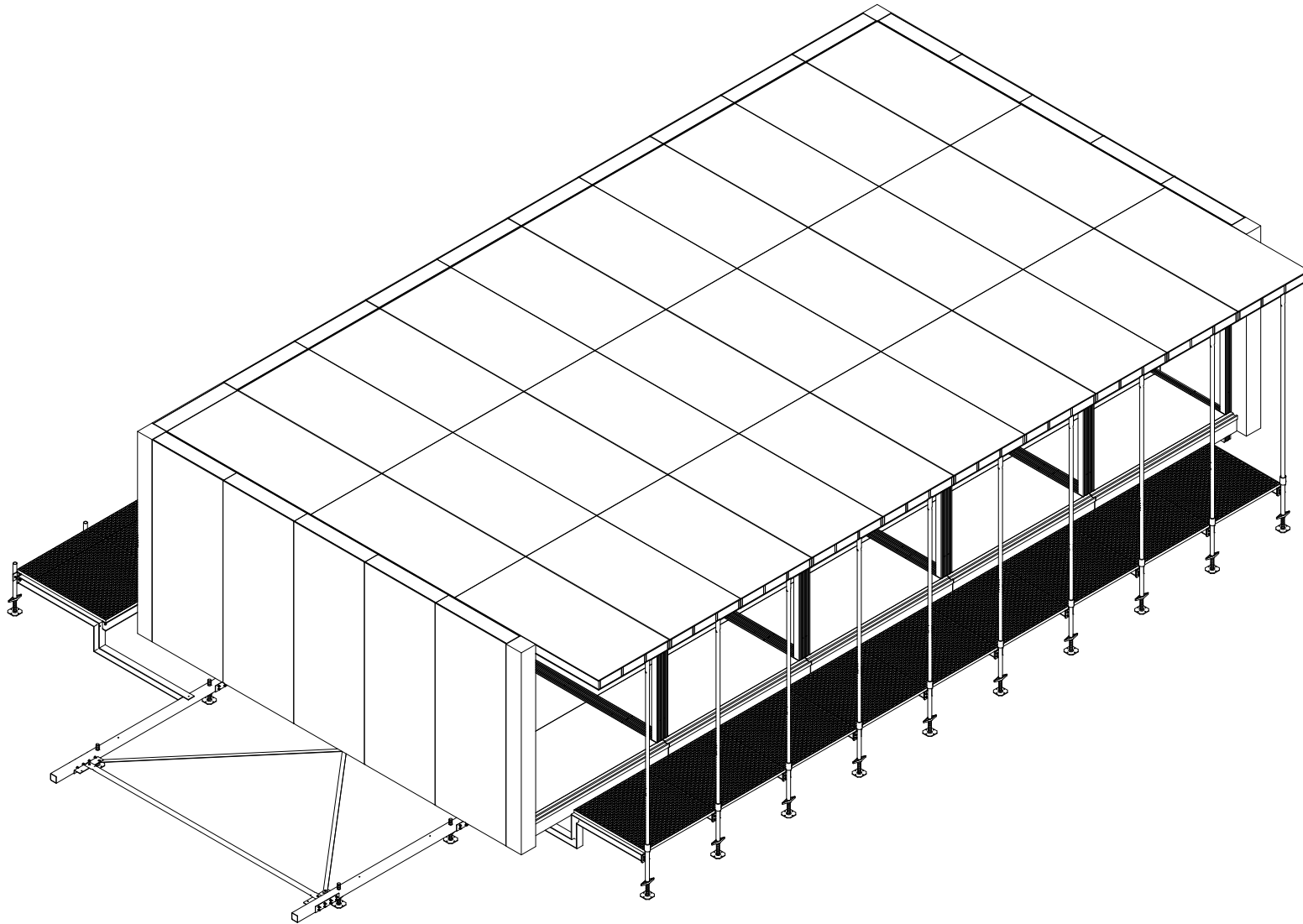
ST-201
STRUCTURAL
BLOW - UPS

The new cool is living in a Mobble



THE MOBBLE'S STRUCTURE
FLOOR PLAN + SECTIONS PROTOTYPE
SCALE 1:100

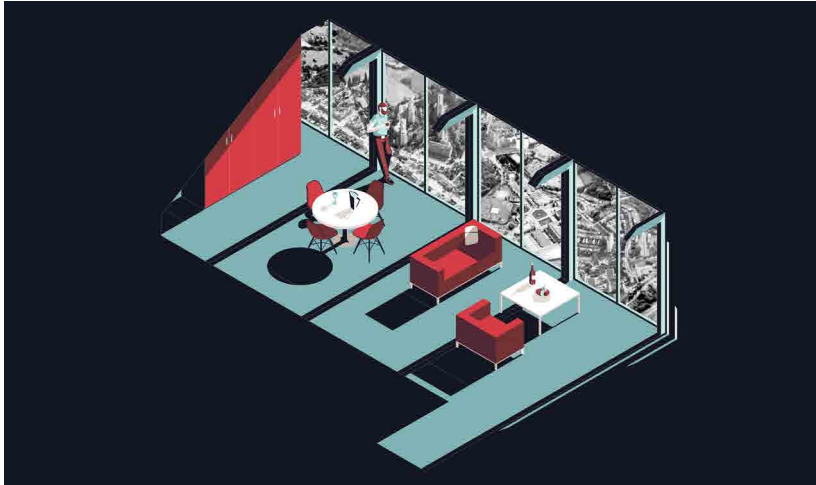
ST-201
STRUCTURAL
BLOW - UPS



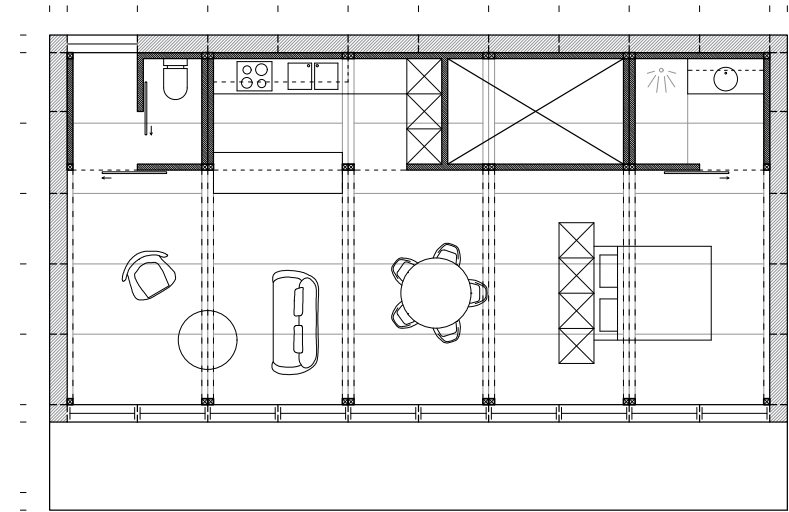
PAVILION - EXTERIOR

GE-401
EXTERIOR
RENDERINGS

PROJECT IMAGES



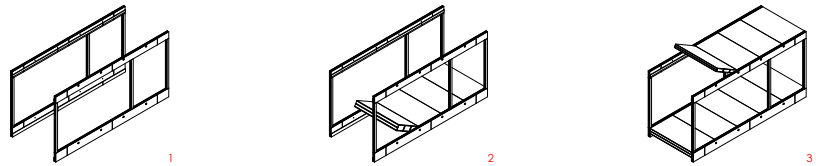
Concept image



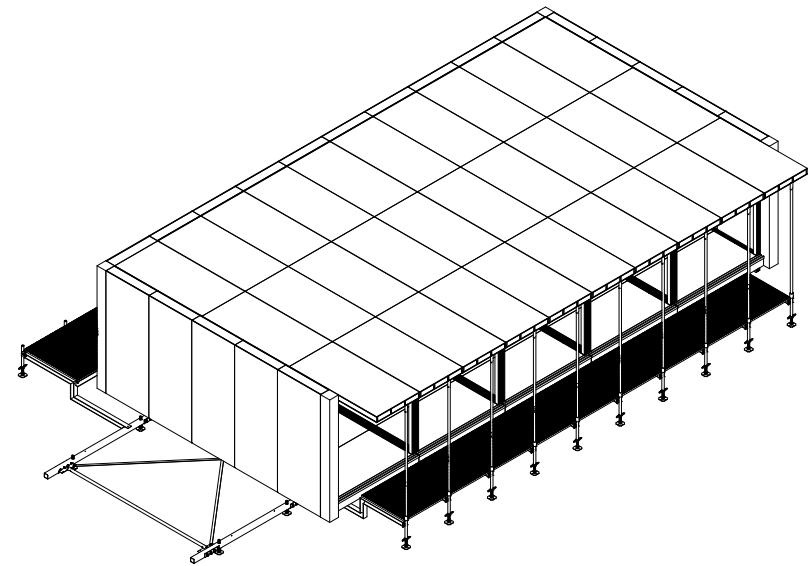
Layout of the plan



Prototype at Sint-Pietersplein, Ghent



The Mobble's structure



Isometric view of the pavilion

