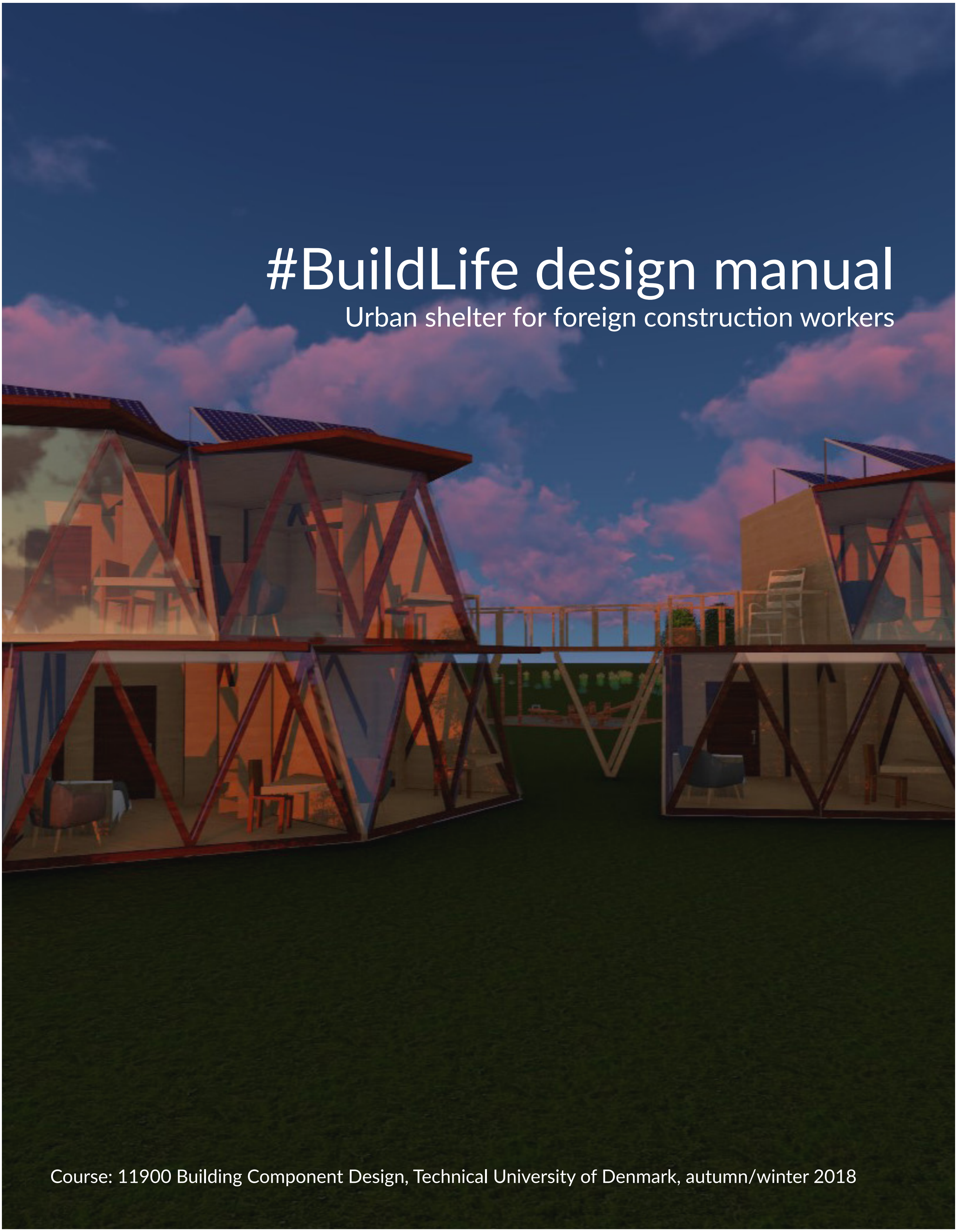


#BuildLife design manual

Urban shelter for foreign construction workers

Course: 11900 Building Component Design, Technical University of Denmark, autumn/winter 2018

Group 01

Alex Schlachter	s182781
Elsa Maria Iuliano	s182746
Jens Esben Okholm Møller	s180198
Trine Bentzen	s143936

1.1_Table of content
1.2_Readers guide
1.3_Credit
1.4_Signatures

OVERVIEW 1.

1.1_Table of content

1.2_Readers guide

The design manual explains the full design process of the #BuildLife shelter. The beginning of the manual will describe the requirements of the assignment and how the shelter will address and challenge these requirements. Throughout the report the different chapters will explain how the shelter improves the work-life-balance for the workers in a sustainable way. The design-concept of the shelter will be elaborated and the component that allows easy assembly and disassembly will thoroughly be described in pictures and text. Finally all elements needed will be presented along with a guide for assembly and disassembly.

1.3_Credits

We would like to give a thank you to Christian Rønne and Claus Simonsen for guidance throughout the full 13-week period. Furthermore, a proper thank to Skylab and the workshop in 119, keflico for providing necessary guidance, work and tools. And finally Simon Klint Bergh from 3D-print huset for guiding us through the different material options and general knowledge about the 3D print technology printed component.

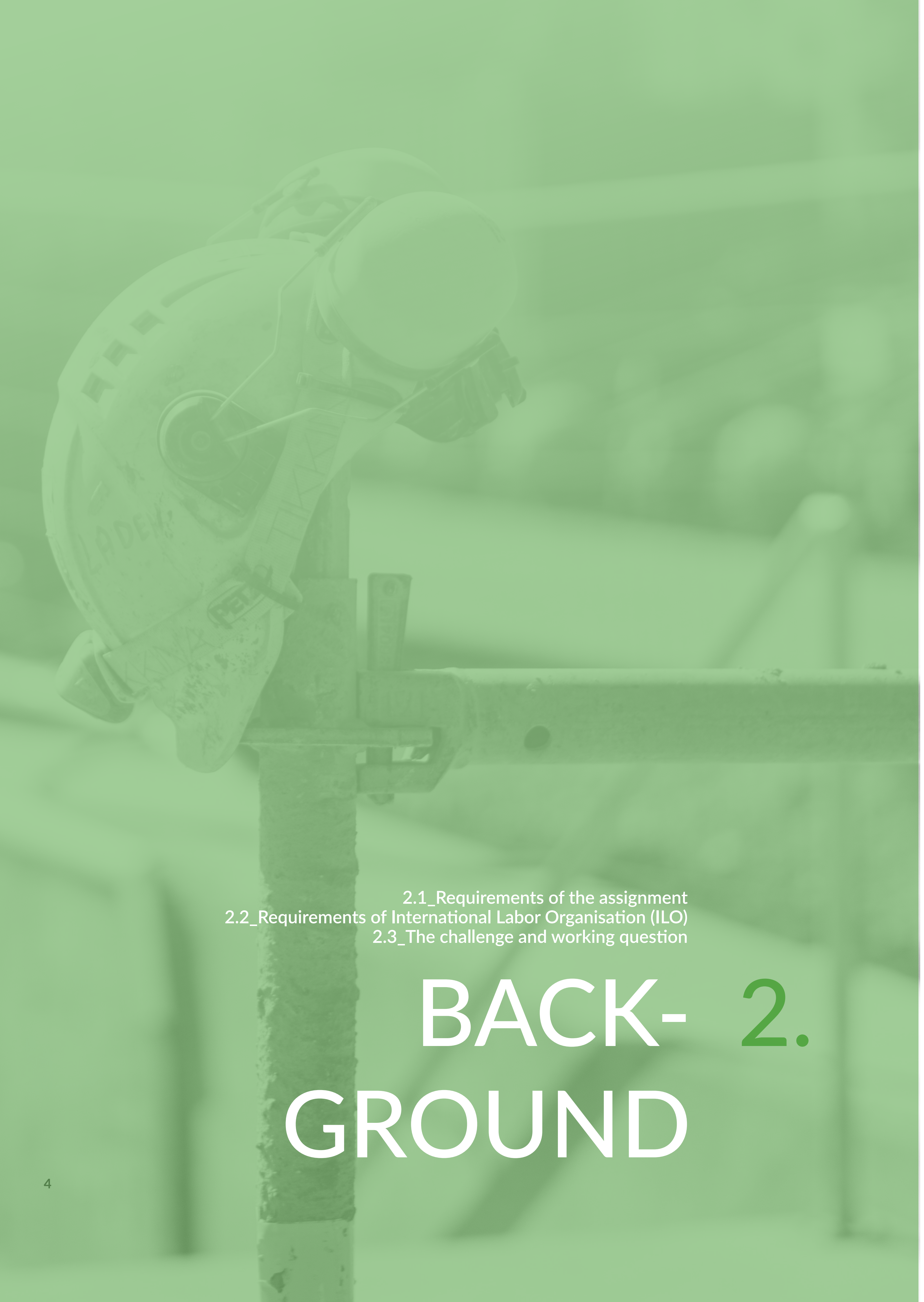
1.4_Signatures

Alex Schlachter, s182781

Elsa Maria Iuliano, s182746

Jens Esben Okholm Møller, s180198

Trine Bentzen, s143936



BACK- GROUND 2.

2.1_Requirements of the assignment

The urban shelter has to have a footprint of maximum 10 m^2, while providing a temporary living area with low-tech passive energy and heating concepts. It should be easy to assemble and disassemble by two persons, which means that the parts cannot be very heavy or large.

Furthermore the shelter has to be mobile, in order to allow new locations for this temporary home. The mobility is achieved by making it possible to flat pack the parts. It shall address the idea of private, semi-private and public areas. The shelter and surroundings should be an asset to the local area, so it benefits inhabitant, the city and city life. The shelter consists of components which forms a unit.

In addition to the physical demands the shelter shall address sustainability issues in terms of the production, use, maintenance and disposal.

10 m² footprint *Passive design* *DfD* *Flat-packed* *Private/semi-private/public*

2.2_Requirements of the ILO

The International Labor Organisation (ILO) has a set of minimum requirements [1]. The design of #BuildLife is fulfilling and exceeding many these requirements in order to improve the housing quality even further.
Some of the ILO requirements are; the height inside the shelter, the size of the bed, amount of workers pr. square meter, amount of daylight, privacy, furniture and after work facilities.

ILO requires that the kitchen and the sleeping facilities are kept apart. The kitchen is therefore not placed in the units, but will be in a separate kitchen unit [1].

2.3_The challenge and the working quesiton

#BuildLife aims to:

> *Improve the lifestyle of construction workers [who temporarily has left their families for work] when they are working on expanding the city of Copenhagen.*

The Danish building industry struggles finding labor, as the number of projects to build is accelerating while the number of immigrant construction workers is continually decreasing. Jyllands-Posten recently showed that there has been a 65% decrease in arrivals of workers from foreign countries between 2016 and 2017. One of the reasons to this, is the improving conditions in other countries within Europe [2]. Denmark used to be an attractive workplace due to the high wages, but other countries now offer the same wages. In order for Denmark to still be an attractive workplace, it is necessary to improve other conditions. The designed shelter will improve the living conditions for the workers, which eventually will make the workers choose Denmark over other countries who only offer the standardized container-homes.

3.1_Activities and environment
3.2_Passive solutions
3.3_Sustainable development goals

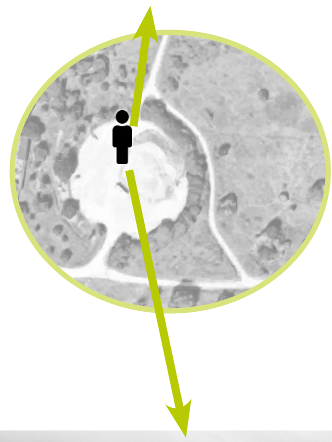
CONCEPT 3.

3.1_Activities and environment

The aim for the shelter is to improve the life quality of the construction workers and integrate the workers in the Danish society so they will consider moving more permanently and work as Denmark strongly needs the labor. One of the main issues of the current housing situation for the workers is the poor architecture and the lack of inspiring surroundings, as the containers often are placed on construction sites or near them. This does not provide a pleasant work-life balance.

Placing the shelters in unused areas close to nature and close to the city will provide a better frame for the private life after working hours. In the shelter the worker can decide to go to his or her private space in the shelter-unit which the worker has for him/herself. Alternatively, the kitchen unit is available as a semi-private area where the resident of the shelter can come to socialize and make food together or individually. Making food together is a social activity. Besides the kitchen unit there are also semi-private spaces on top of the shelters, where the workers can have a small urban garden in the small garden beds or sit on the chairs and enjoy the fresh air and nice view.

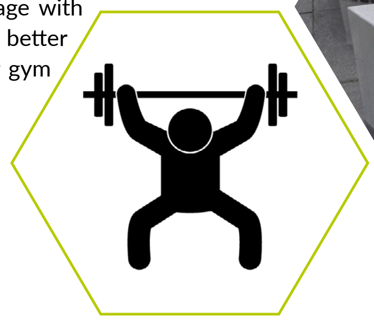
The public spaces are the remaining surroundings of the shelter. The shelter provides some interesting architecture in the parks and invites people to spend time near the shelters where public BBQs are installed. This way the people living in the shelter can socialize and meet the people of the city while being close to their home. In the public spaces there will furthermore be installed a public, outdoor gym which can be used by people passing and also the workers in the shelters. In Amager Fælled it would be naturally used by some of the guests who are running in the park.



A system consists of 5 units which are connected with stairs and a walkway on first floor. In order to standardize the system, the columns underneath the raised walkway are identical to the bracing in the unit. This emphasizes the rhythm in the structure of the #BuildLife units.

To make the system fit in the park environment of Amager Fællede, all the facade elements and the walkway will be made out of wood and green roofs on the terrace. This creates an outdoor semi-private space for the construction workers which coherents with the environment in the park.

In the public space of the park some activities will be installed in order to make the workers engage with the local community and hereby achieve a better integration. These activities include an outdoor gym and BBQs.

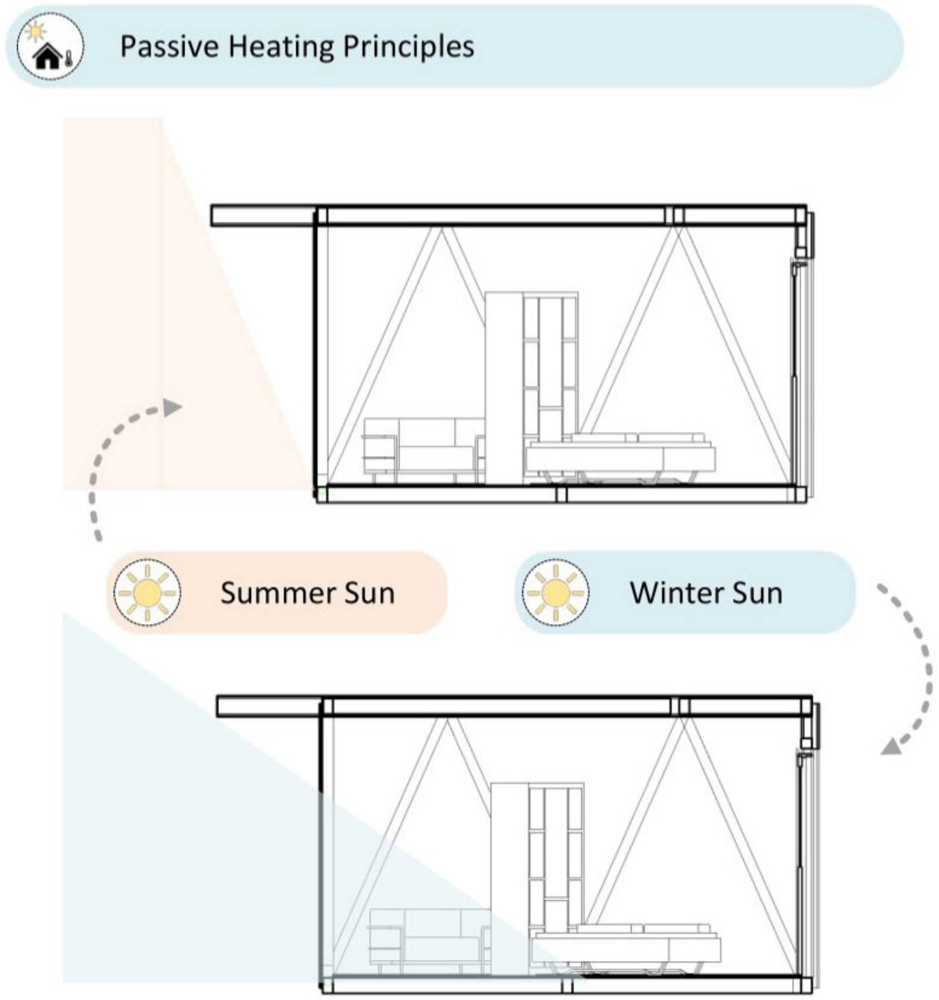


3.2_Passive solutions

One of the main design features in the #BuildLife shelter is the geometrical shape which provides passive heating. The concept of passive heating is to take advantage of the solar power through the large windows. The sun can be used to heat up the shelter on sunny days in the winter, but can at the same time easily result in overheating in the summer. The shelter therefore has a big glass surface facing south. In order to prevent overheating in the summer (when the sun is high) the roof structure will shade for the summer sun rays and prevent overheating. In the winter when the sun is lower, the sun will shine on the windows and heat the shelter up with the greenhouse effect, and thereby reduce the energy needed for heating.

If the passive sun heating is not enough, #BuildLife will use the energy from the solar panels installed on the roof of the shelter to power the heaters inside. Since there is no kitchen facilities in the unit the energy usage is not so high therefore the supply of energy from the panel should be enough (heating, lightning and charging). In case of no sun, there will be a connection to the urban-grid or to a generator.

Electrical cables can be pulled through the roof and along the edges of the structural beam system. From here, several sockets and lamps can be reached within the unit. In this case, the visible cables will contribute to the industrial appearance of the unit design and therefore fit within our design specification.



3.3_Sustainable development goals

The shelter, and the function it provides, can be related to three of the seventeen sustainable development goals. In this section it is briefly explained which goals and indicators which can be addressed with the shelter.

3.4 By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being.
- **3.4.1** Mortality rate attributed to cardiovascular disease, cancer, diabetes or chronic respiratory disease
- **3.4.2** Suicide mortality rate

3.5 Strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol
- **3.5.2** Harmful use of alcohol, defined according to the national context as alcohol per capita consumption (aged 15 years and older) within a calendar year in litres of pure alcohol

3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination
- **3.9.1** Mortality rate attributed to household and ambient air pollution
- **3.9.2** Mortality rate attributed to unsafe water, unsafe sanitation and lack of hygiene (exposure to unsafe Water, Sanitation and Hygiene for All (WASH) services)

The third sustainable development goal is addressed through the improved lifestyle of the workers. The shelter will create a better work-life-balance which improves the mental health and mental well-being of the workers. Furthermore, the shelter will encourage the workers to have a more active spare-time as the facilities for cardio- and strength training will be avaliable just outside the shelter. The improved mental- and physical health will thereby have a positive influcence on indicator 3.4.1, 3.4.2 and 3.5.2.
Finally the shelter is made of non-toxic materials which provides a good indoor environment and furthermore the materials are treated with a minimum of chemicals which will minimize the pollution to air, water and soil (see the impact assessment in chapter 6 - to be made in the 3-week period).

8.8 Protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular women migrants, and those in precarious employment
- **8.8.1** Frequency rates of fatal and non-fatal occupational injuries, by sex and migrant status
- **8.8.2** Increase in national compliance of labour rights (freedom of association and collective bargaining) based on International Labour Organization (ILO) textual sources and national legislation, by sex and migrant status

The eighth goal is adressed by the function of the unit, as it provides an adequate option for resting when the workers are off duty. A well rested worker will make less mistakes and thereby have less injuries (8.8.1) and furthermore the shelter is adressing the requirements of ILO and thereby contributing to indicator 8.8.2.

12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse
- **12.5.1** National recycling rate, tons of material recycled

Goal twelve is one of the main focuses in the design of the shelter. It has been high priority throughout the design process to use a minimum amount of materials and allow easy disassembly for reuse of the structure elsewhere or disassembe completely for recycling. This is adressing both the reduction, recycling and reuse, and thereby adressing 12.5.1 of recycling materials as an attempt to move towards a more circular economy.

THE DESIGN 4.

4.1_Design overview

In this section the design of the unit will be elaborated in detail. From the system to the unit to the component.
The system consists of five units in a cluster, where the units are stacked on two floors; three on the ground and two on top. This setup brings the construction workers closer together and encourages social interactions and thereby creates a better living envirmonment.

4.2_Elaboration of the requirements

The shelter is 15 m2 and designed to fit one worker. The minimum demands from the ILO is 7,5 m2 pr. worker, which means that the workers get double the space when living in the shelter compared to the minimum requirement. The requirement of this project was a footprint of maximum 10 m2. This is challenged by the 15 m2 shelter, but is respected when the units are stacked. When two units are placed on top of three, the average footprint of one shelter becomes 9 m2.

The requirements of ILO are not addressing how many workers which can live in the same unit, but in order to provide a good and adequate life for the workers, privacy is an important factor. A private unit allows the partner and/or family of the worker to visit them. The sheter consists of just one room, which means no internal walls. Thereby the inside space has a optimal utilization, and the big window facade can light (and heat) up the entire room during the day.

The assignment states that kitchen facilities are required. This is however in conflict with the requirements of the ILO. Therefore, it was decided to do a separate kitchen unit in which the workers can come together and socialize. This division of sleeping and kitchen facilities adresses the seperation of private and semi-private areas, as the kitchen is semi-private. The area around the shelters is public space.

In general, the design of the unit thrives to address all requirements of both the given assignment and the ILO, in order to create a good living space for construction workers. The design incorporates an aesthetical value both to its inhabitants and the location.

Wooden framework constructions rank among the most appreciated and aesthetic designs, and the solution with the customized joints enables an easy assembly - and more importantly disassembly process - which adds a new and innovative perspective to the context of the urban shelter. As the structural bracing system is visible from the inside of the unit, it improves the architectural quality and makes the inhabitants conscious of the structural system behind the unit. The innovation and simplicity creates a special connection to the construction workers living in the unit. Referring to our goal to improve the living conditions of temporary construction workers in Copenhagen, our design more than exceeds the standard container solution, while offering a sustainable, technically approved and aesthetically highly appreciated urban housing solution.

Because the elements are prefabricated, there will be zero waste at the building site and the amount of possible errors during the assembly process are reduced to a minimum. It is also intended that no matter which field the construction worker is in (electricity, painting, carpenter etc.), it will be possible for the worker to assemble the units on their own with the help of a small crane of the supplier truck (see chapter 4.4). This will ensure a careful handling of the material and a fast building process.

The assembly and disassembly of the shelter is an important requirement. The shelter is designed so that two to three people should be able to assemble the shelter without using tools, screws, nails or bolts. All parts can individually be lifted by two people. For some of the heavy lifts (when the parts have been assembled) and placing the shelters on top of each other, a crane is recommended. The easy assembly and disassembly without tools is a part of the design strategy which allows the structure to be erected many places over and over again without damaging the materials. The assembly instruction is elaborated in chapter 5. When all materials have been disassemled they can be flatpacked and placed on a truck (see picture to the right).

Another requirement is the passive energy and heating concepts. The passive energy concept will be adressed by the solar panels on the roof, and the passive heating was adressed in chapter 3.2.

4.3_Concept development

The design process throughout the first part of the course has been iterative and filled with brainstorming sessions to come up with solutions to problems which has arisen through the period. The overall design process is described in the following text and in the illustration on the next page.

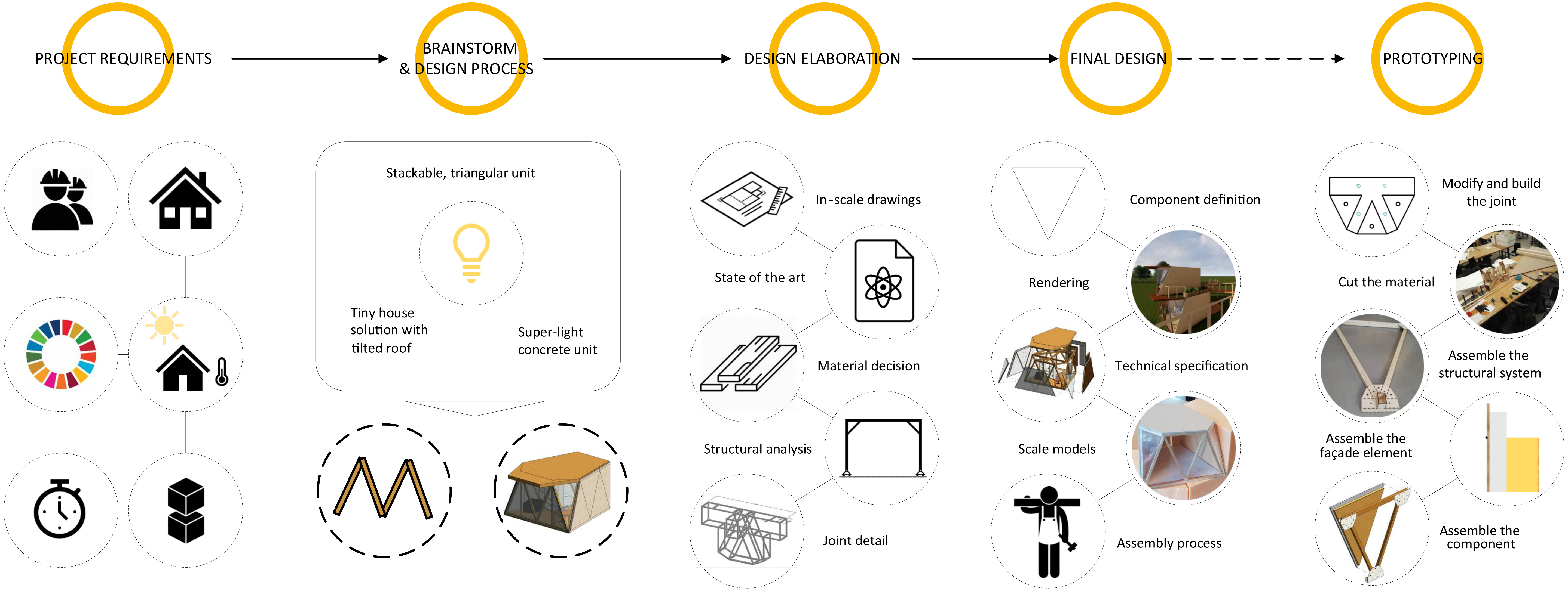
Project requirements
The aim of the urban shelter is to provide a temporary urban living space for construction workers with a minimal footprint while fulfilling and exceeding the requirements of ILO. The shelter strives to achieve the four elements of good engineering design; functional, efficient, economical and aesthetical.
Passive heating, green roofing and renewable energy production on the roof secures a minimum consumption of energy and resources during the use phase. This will result in a minimum consumption of resources during the use phase. The shelter is designed for easy disassembly and transport of elements. The overall sustainability is visible through the connection to the SDG's (Sustainable Development Goals).

Brainstorm & design process
Based on the problem definition as well as the objectives of the assignment, the initial ideas for the shelter developed. The design process took off in three directions, which means that multiple concepts were created and developed simultaneously. The aim of this was to find many solutions and merge the best elements into one solution. During the design process, the different concepts were componentized, leading to a versatile and simple bracing structure, where prefabricated and componentized façade elements can be attached to. These façade element can be attached either as a solid sandwich element with insulative properties or as glass elements.
The chosen concept contributes to the following objectives; component-based design, stackable units / minimal footprint, SDG 3, 8 and 12, ILO requirements, simple assembly and disassembly and furthermore, a cozy and modern living space

Design elaboration
After merging the different ideas and agreeing on the concept and design, the elaboration started. In-scale drawings were created to support the design process. The information from the scale drawings provided enough data to make some adjustments in order to improve the design. Through the state of art report, materials were chosen, structural specifications and linking joints were made. This research paper added great value to the design process as and provided the best options for our shelter, as we always had our problem and objectives in mind. Furthermore, a structural analysis were made for the shelter in order to validate the parameters of the load carrying elements.

Final design
In the final design stage of the design process, all findings were combined and ideas from earlier stages were again considered for prototyping. The 1:1 component was defined and designed in detail. Furthermore, the shelter was described on different levels in: component, unit and system. Based on these specifications, renderings were made for the entire system (consisting of 5 units). In addition, a further development on the technical specifications were made by finalizing the digital model and creating a list of all materials needed to build the unit. This list was then translated into the scale of 1:20 and 1:5 to build our physical scaled models. To complete the final design, an explanation of the assembly processes of the unit was created. This assembly is elaborated in the following chapter. The process can also be reversed.

Prototyping
The Prototyping phase started with some technical and practical consideration that led to the modification and improvement of the joint, the clicking system and the attaching system between facade and structural frame. The joints were then built and the different materials cut in the right shape. Everything was ready to start the actual assembly of the prototype: first the structural frame (joints and beams) was put together and the functioning of the clicking-system was tested. Then the facade was built in all it different layers and finally the component was assembled, the structure was laid on the facade and attached with the pin and dowel system.



4.5_Project realization

The resulting concept from the design process is a shelter-system that will replace the container units on the construction site in order to offer the foreign workers a better living environment. The following process shows a possible timeline from the early consideration of #BuildLife to the final assembly on site:

1 A new construction project is planned to be executed in Copenhagen. As Denmark cannot provide sufficient amount of skilled labour, cheap construction workers come to Denmark on a temporary basis to execute the project.

2 The construction manager is responsible to provide housing for the workers during project period. Instead of the poor living environment in a container, #BuildLife can be chosen for the procurement of the housing units for the construction workers. The decision for #BuildLife comes from the recognition that a better living context and the balance between work and life, improves also the production performances of the workers.

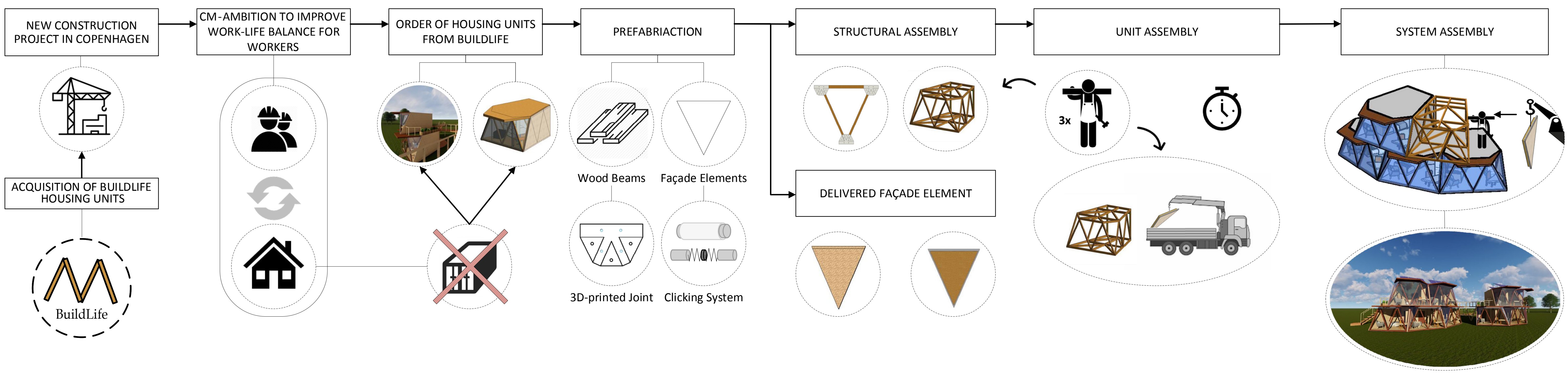
3 The order of the housing units leads to the evaluation of how many units are needed for that certain project, and where the units should be placed. #BuildLife offers an entire system which can be installed additionally to the single units.

4 After the order is placed, the prefabrication phase starts, in which all required parts of the unit (structural beams, joints and facade elements) are manufactured in a factory. The manufacturing at a fabric leads to a higher precision and quality of the components and faster production.

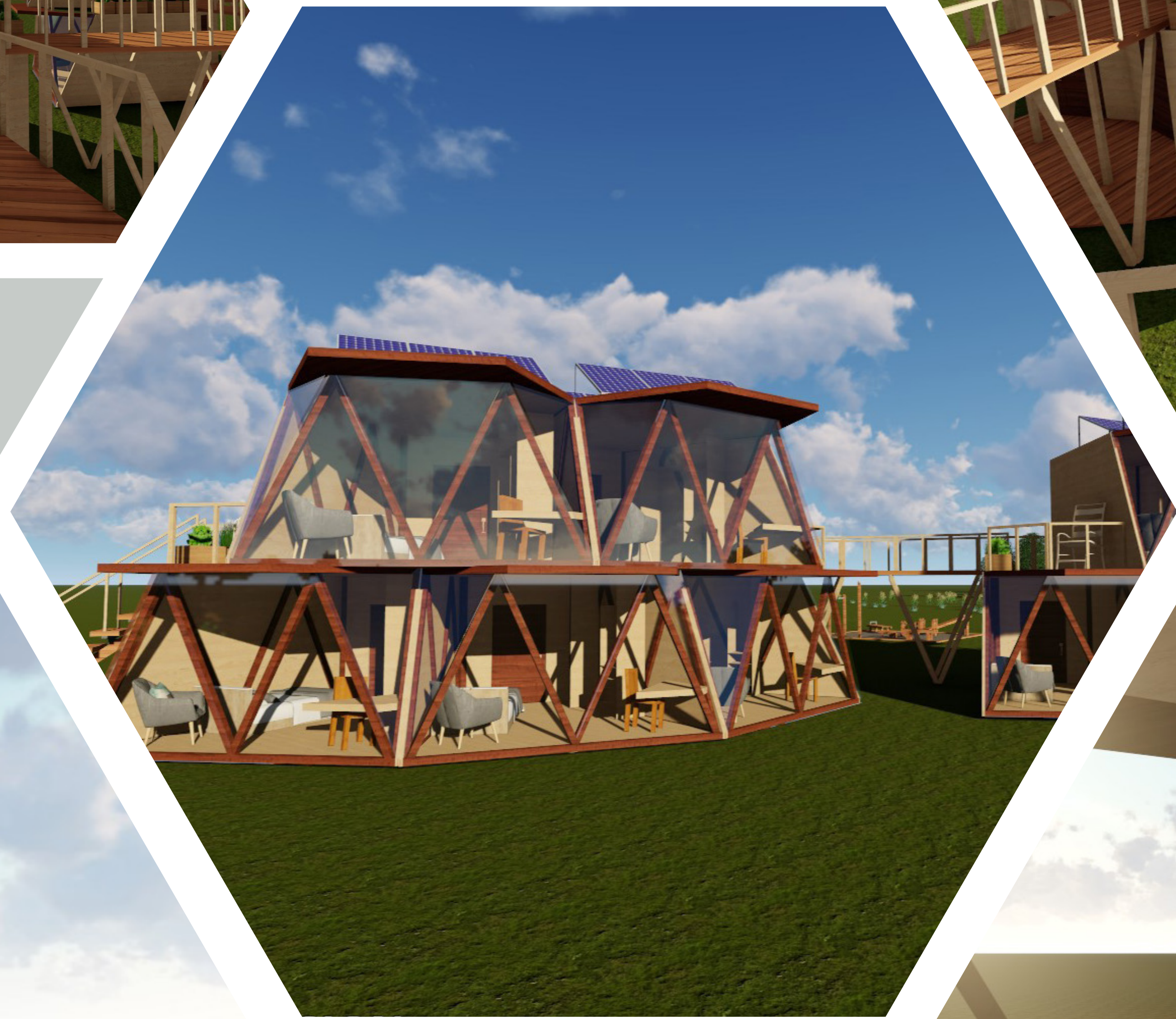
5 All the components are brought in situ, at the location the units will be placed. The structure is easily assembled due to the clicking system and the prefabrication of all the beams.

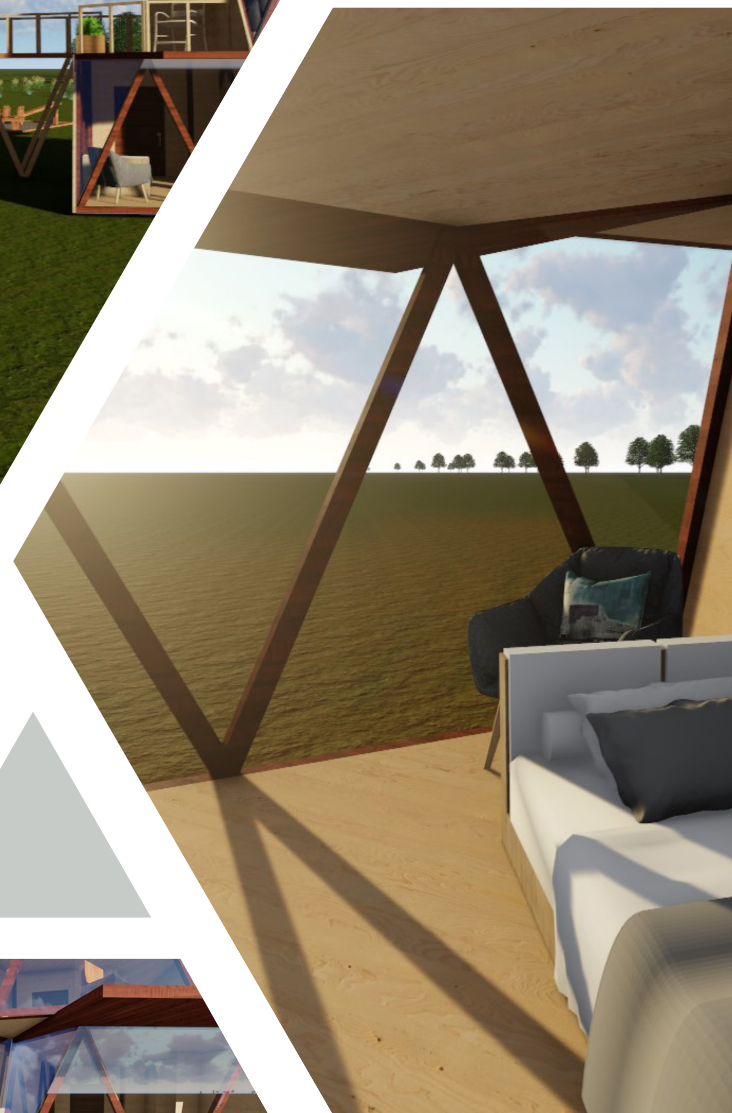
6 The facade elements, when delivered, are placed directly on the structure with help from the crane on the delivering truck. In this way the assembly process is fastened up and there is no need of additional machinery help.

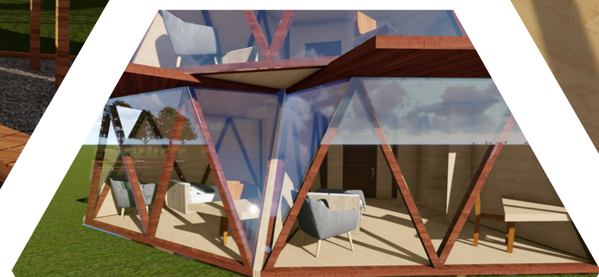
7 Finally the unit-system can be assembled. The two upper units can be stacked on top of the three lower units and all additional facilities can be built (the stairs, the balcony, etc.).

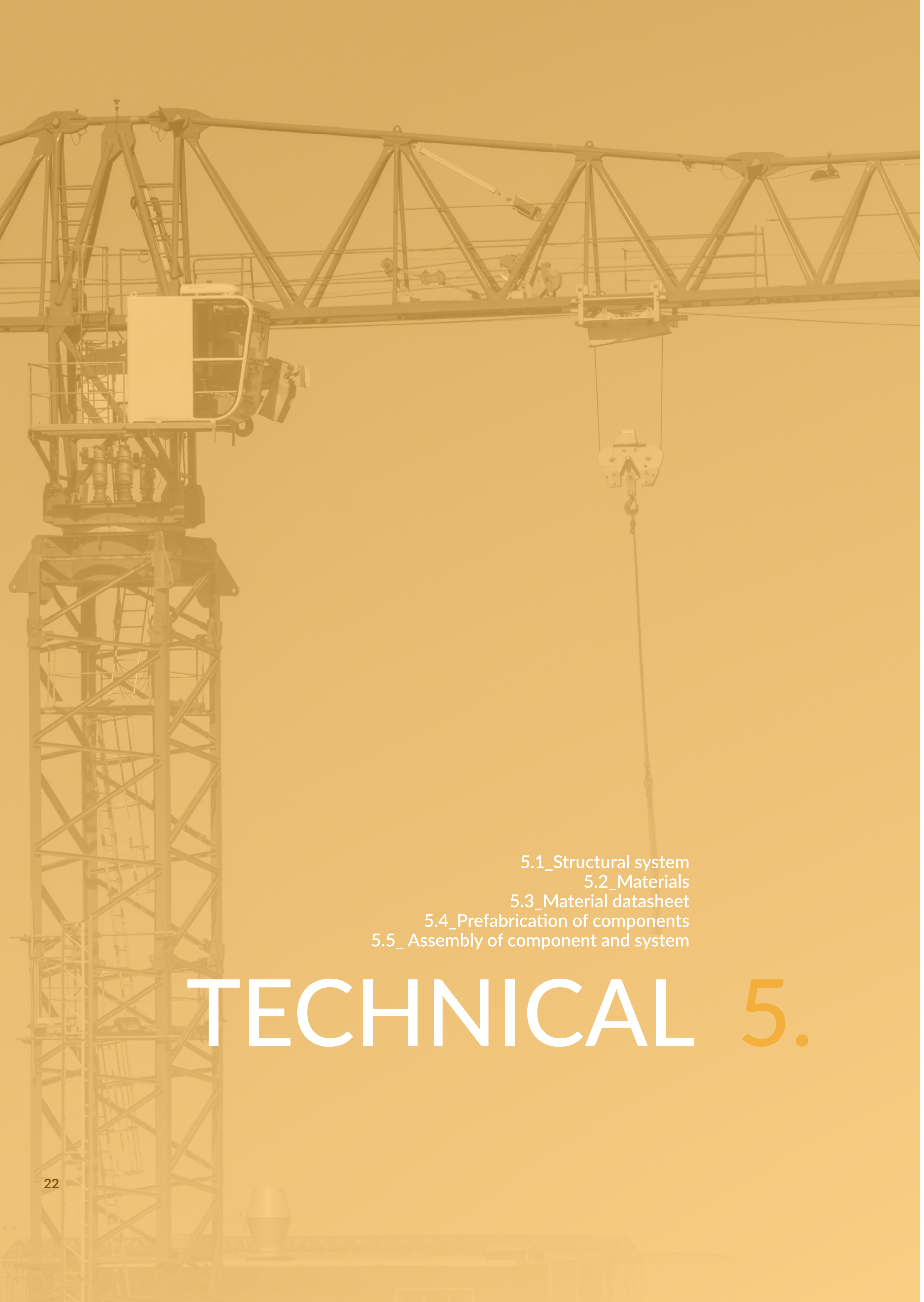


4.6_Concept visualization





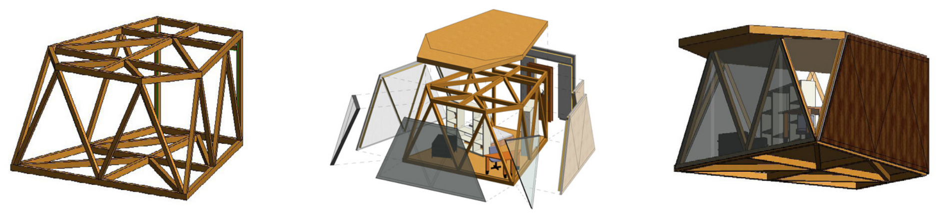




TECHNICAL 5.

5.1_Structural system

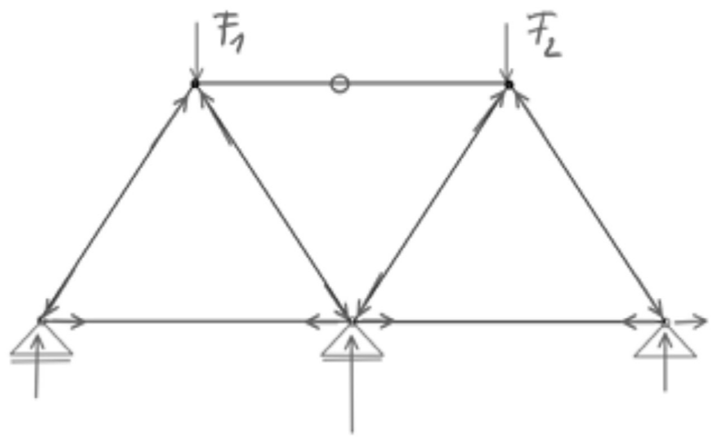
The structural system of the shelter is based on a framing wood skeleton, which is using the advantages of trusses, to optimize the material efficiency. In general the structural framing is based on a network of connected bars, transferring acting forces through the system towards the supports.



Structural framing provides an almost unlimited architectural versatility due to its simple solution and flexibility in interior arrangements. Furthermore, the diagonal bracing provides a lateral stability when limiting the system to only axial stresses.
The static system in the structural framing is based on normal forces transferred through the system into the supports. One of the advantages of this system is that it only uses hinged joints, which makes the design of the joints much more flexible due to the lack of moments. Hinged joints enabling the beams to rotate about the pin, so bearing loads are limited to only normal forces which lowers the requirements on the material and the foundation.

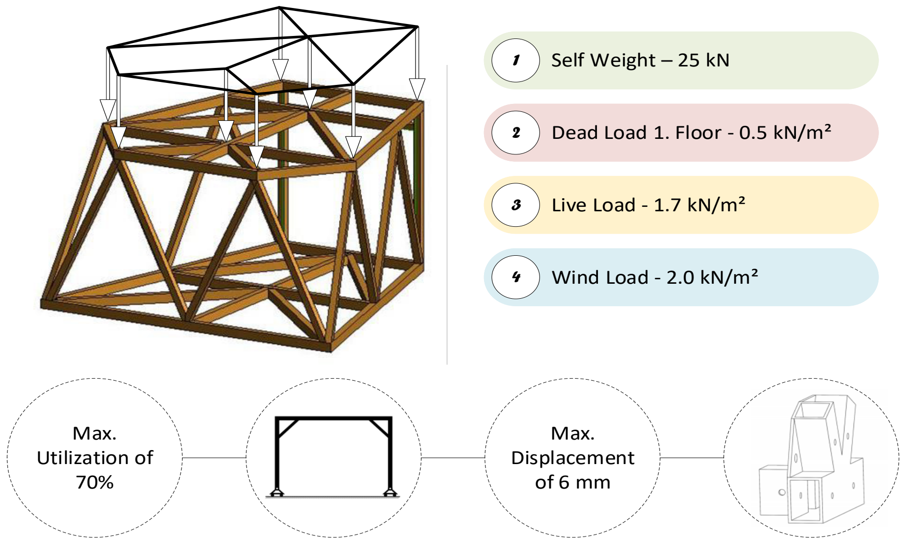
Another benefit is the little use of structural material which immediately leads to less cost due to the component-based network. The light-weight system is fast and easy to assemble by using standardized components like beams and joints. The structure and the facade components can be prefabricated and then put together on site. The solution is also not restricted to a specific material enabling our team to choose the most suitable to meet the requirements mentioned in chapter 2.

The following sketch shows the load distribution applicable to the shelter.



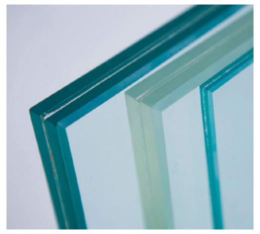
Using FEM-Design, structural analysis of the shelter was performed in order to optimize the dimensions of the structural frame according to the applied forces. The applied forces are based on the eurocodes, since the shelter is supposed to be used the year around; and therefore have to account for extreme weather which the eurocode loads are based on. In the calculation the loads of self weight, live and dead load as well as wind load attacking from one side was applied. With the calculaiton, external loads of wind and the unit above, has been taken into account as well as the internal loads of the unit itself.

As a result of the structural analysis the dimensions of the structural beams were optimized to 95mm x 95mm for the bracing as well as 95mm x 145mm for the horizontal parts. This leads to a total utilization of about 70% and a maximal displacement of 6 mm, caused by wind.



5.2_Materials

The amount of materials needed for the shelter is optimized to be a minimum amount. The utilisation of the structural beams is high and the choice of materials has been made with the aim of making a building with a low environmental impact. The amounts and types of materials is described in detail here. For more information about the reasoning behind our material choices, please refer to the state of art report.



Glass (721.3 kg)
Double Layer insulative glass is used for the front side of the unit. This will ensure a comfortable housing during the winter period by its good thermal insultion properties as well as enabling passive heating.

Wood (636.1 kg)
While being the only renewable framing material, other important qualities of wood are versatility, sustainability, strength, aesthetics and insulative properties as well. In this case, wood is both chosen as a strong and still lightweight material for both the structural system and the supporting plates on the facade elements.

Valchromat (272.2 kg)
This modified MDF-plate was introduced to us in Skylab Wood Workshop. After some research, we decided to use Valchromat as the outer layer of our facade as this material is moisture resistant and therefore suitable for an outdoor use. Furthermore, the datasheet (see Appendix) states that Valchromat is a very environmentally friendly non toxic material which is 30% stronger than normal MDF-

EPS (31.5 kg)
EPS is a highly insulative material which has been commonly used on the construction industry for already over 50 years. As stated in the data sheet enclosed in the appendix, EPS is also recognized as an environmental product contributing to the general design specifications of our unit.

Wood Wool Board (164.3 kg)
Wood is a sustainable raw material and due to its good thermal capacity, wood wool boards are a better and more sustainable solution to mineral fiber boards as rocket wool. Furthermore it supports the interior climate and fits perfectly to a wooden construction system.

Plywood Plates (214.4 kg)
Plywood is a building material that is used in everything from furniture to house construction. It is a versatile and highly workable building material because the layering of thin sheets of wood gives it great strength and flexibility.

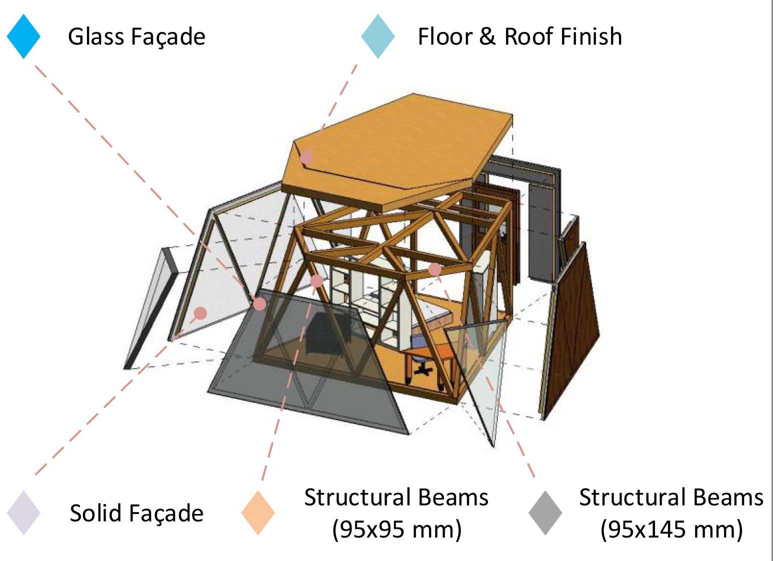
Other materials and furniture: 331.6 kg (15%)

Total weight of unit: 2503.5 kg

5.3_Material datasheet

The following page gives an overwiew about technical information about the designed unit, focussing on the different materials and dimensions. This overview provides a comprehensive dataset of the most important components in the unit.

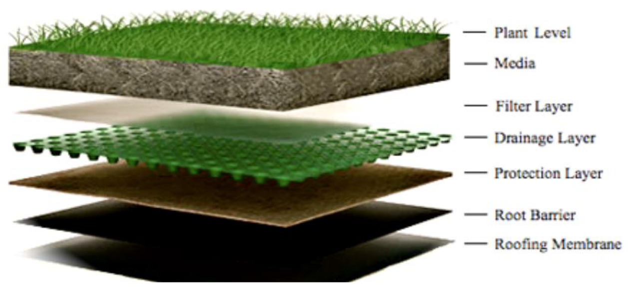
Extruded Model



Floor & Wood Finish

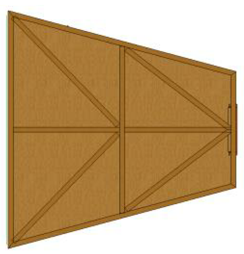
1 Roof Finish

The roof structure consists of the exact same layer as the componentized walls. The only difference lies in the insulation layer 1 (polystyrene) which is slightly tilted, so the water will flow down.
Furthermore, the roof will enable to carry solar panels on both the upper units and the sunshade eaves as well as a green roof finish as shown below:



2 Floor Finish

The Floor consists of a parquet flooring finish, the wood wool insulation as an in between insulation. A foundation is not needed as the support of the floor frame is sufficient.



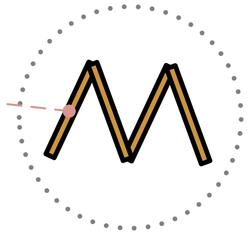
Components	Parquet Flooring
	Wood Wool Insulation
	Outer Woodlayer
Area:	15.4 m²
Weight:	115 kg

Structural Beams

95x95 mm

2.752 m

Diagonal Bracing
Number: 12



2.50 m

Vertical Posts
Number: 2

2.40 m

Sunshade Eaves Beam
Number: 3

2.172 m

Horizontal Door Support
Number: 1

FACT SHEET

Material:	Density:	Pieces:	Total Length:	Total Weight:
Wood C24	420 kg/m²	18	31.7 m	169 kg

95x145 mm

Roof Frame

X.XXX m

2x	3.450 m	2x	1.400 m
1x	2.220m	1x	2.300 m

Roof Bracing

X.XXX m

2x	2.990 m	2x	2.290 m
1x	3.332 m	1x	1.111 m
1x	2.815 m	1x	1.793 m

Floor Frame

X.XXX m

6x	2.300 m	1x	2.200 m

Floor Bracing

X.XXX m

2x	2.221 m	1x	3.410 m
2x	2.800 m	2x	3.198 m

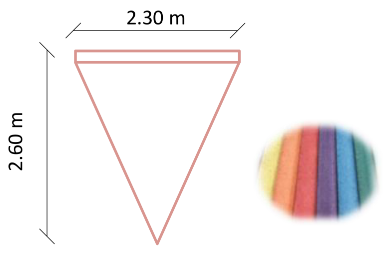
FACT SHEET

Material:	Density:	Pieces:	Total Length:	Total Weight:
Wood C24	420 kg/m²	26	71.5 m	450.4 kg

Solid Façade

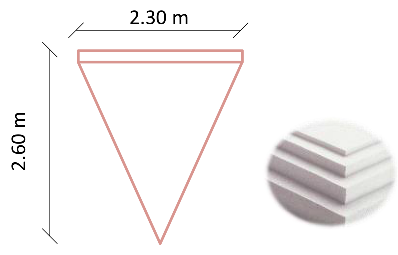
1 Outer Woodlayer

Material:	Valchromat
Density:	750 kg/m³
Thickness:	8 mm
Area:	3.2 m²
Weight:	Ca. 19 kg



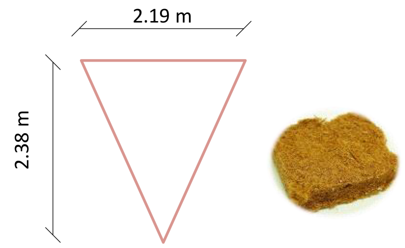
2 Insulation Layer 1

Material:	Polystyrene
Density:	15 kg/m³
Thickness:	50 mm
Area:	3.2 m²
Weight:	2.4 kg



3 Insulation Layer 2

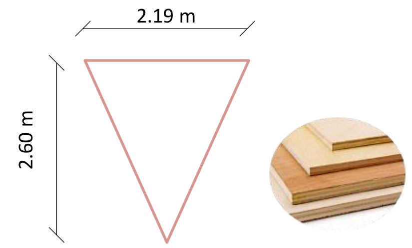
Material:	Wood Wool Board
Density:	40 kg/m³
Thickness:	90 mm
Area:	2.6 m²
Weight:	9.4 kg



4 Vapour Barrier

5 Inner Layer

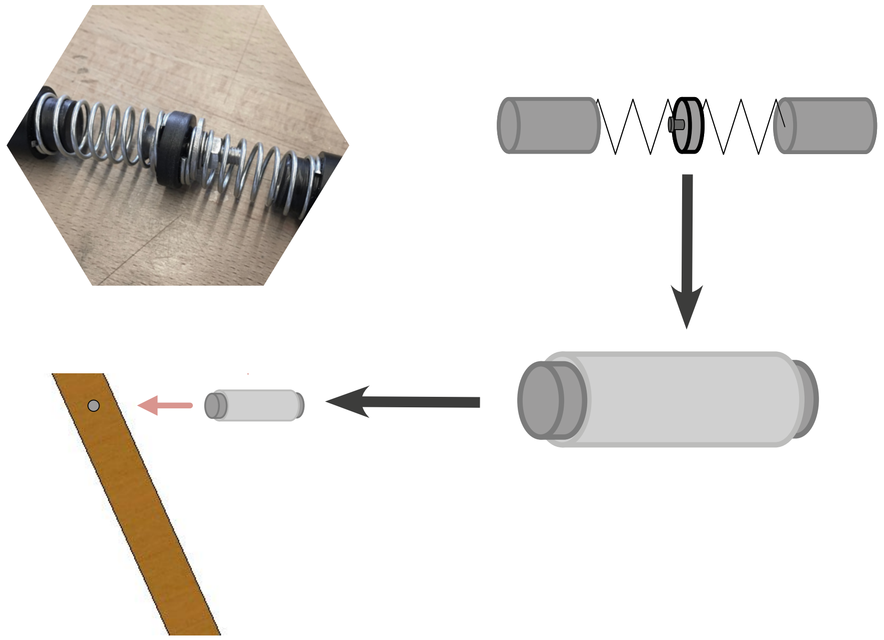
Material:	Plywood Plate
Density:	650 kg/m³
Thickness:	10 mm
Area:	2.6 m²
Weight:	16.9 kg



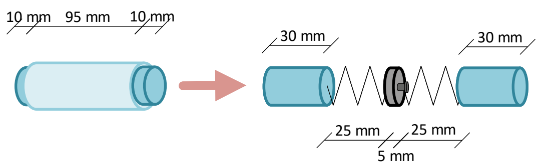
5.4_Prefabrication of components

All components of the building are pre-fabricated off site at a factory. All beams are cut in correct lengths and with the right angles in order to fit in the joints perfectly. When the lengths and angles have been adjusted, the holes for the spring system are drilled. The facade system is also pre-fabricated, which means that all layers are applied in the right order, and the dowels to attach the facade to the joints are ready for use.

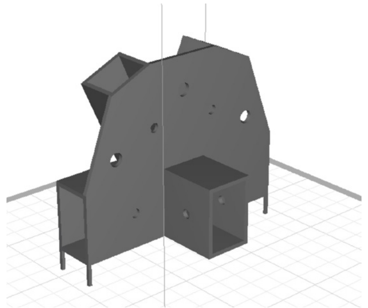
The spring system consists of a PVC-tube, two springs, two dowels, one plate and a screw and bolt system. The springs connect the dowel to the middle plate with the screw and bolt.

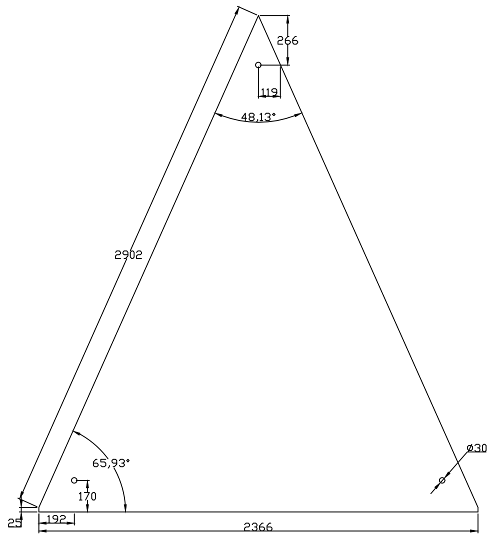


The PVC-tube should be 95 mm, dowels 30 mm, springs 25 mm, the plate in the middle 5 mm and the screw 15 mm. See dimensions below.

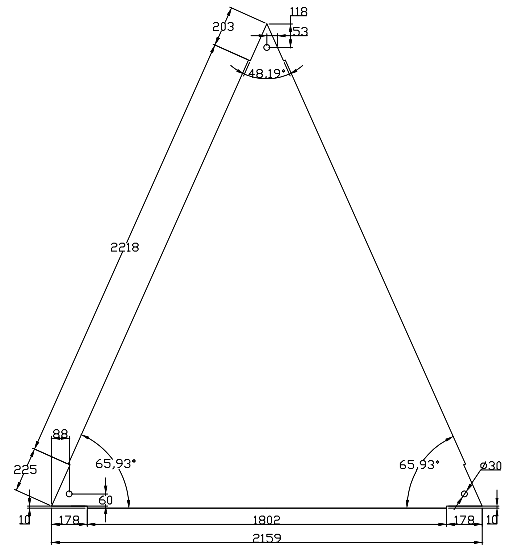


The 3D printed joints are specified in the print file delivered by #BuildLife. The dimensions are specified on the following page. All dimensions are given in milimeters. There has been added 2 mm of slack in the joint in order to make it possible to insert the beams. Inside dimensions are therefore 97 mm instead of 95 mm.

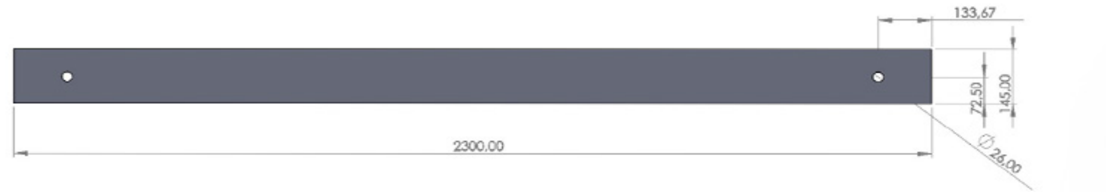




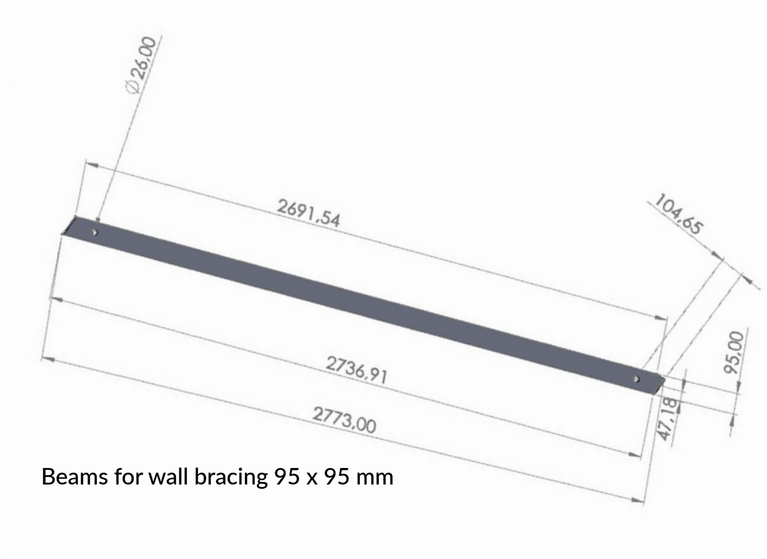
Facade dimensions for outside layers



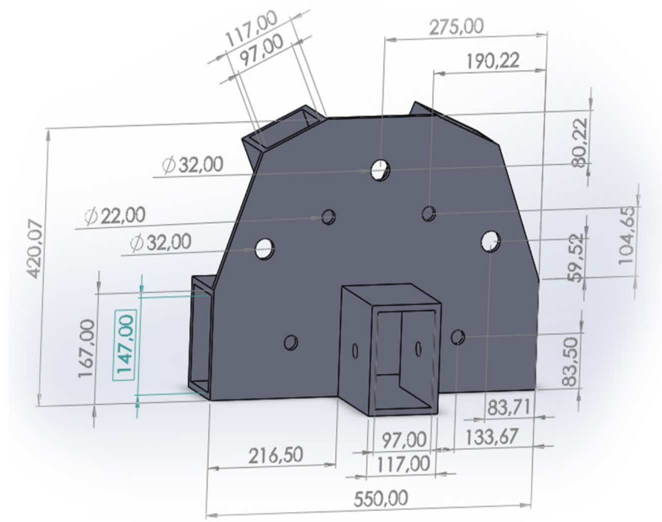
Facade dimensions for inside layers

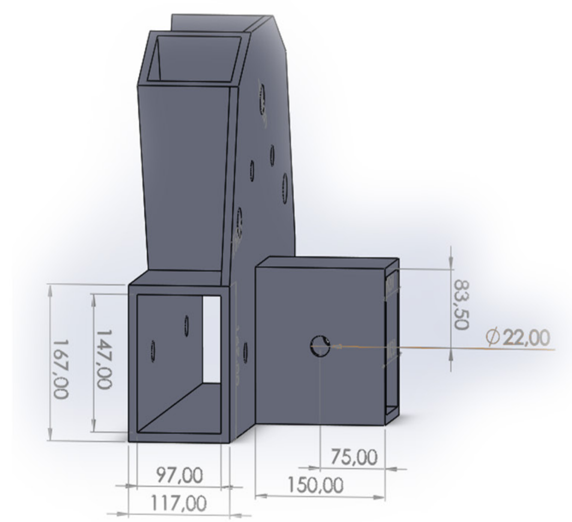


Beams for roof and floor structure; 2300 x 95 x 145 mm



Beams for wall bracing 95 x 95 mm

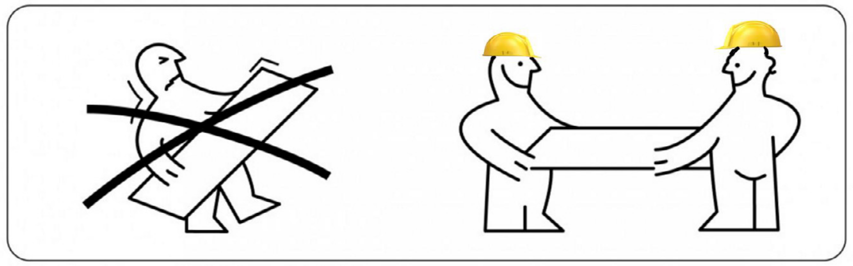




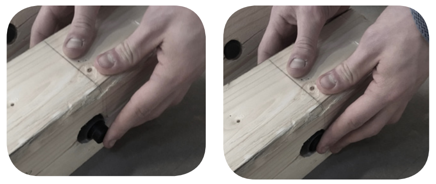
Dimensions for 3D printed joint

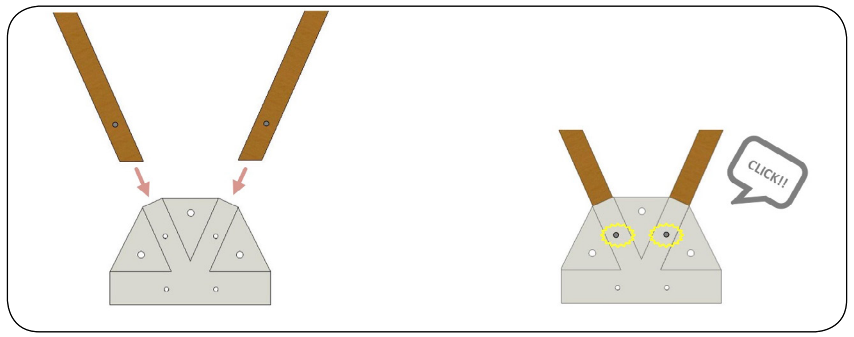
5.5_Assembly of component and system

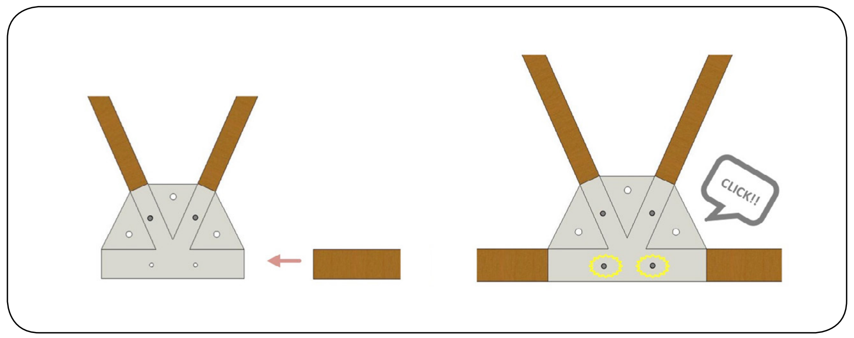
Throughout the assembly process there will be no need of tools. However it is recommended to be minimum 3 people for assembly and two people pr. component.



Detail of assembly for beams and joints with clicking system:
The clicking system sits in the breams. It consists of two independent spring systems with dowels. When the plastic dowels are pushed inwards, the beam can enter the joint. When the beam is pushed far enough, the dowel reaches the hole in the joint and the spring system will push it through the hole so it locks. The system says a loud click, which lets the user know that it has locked.

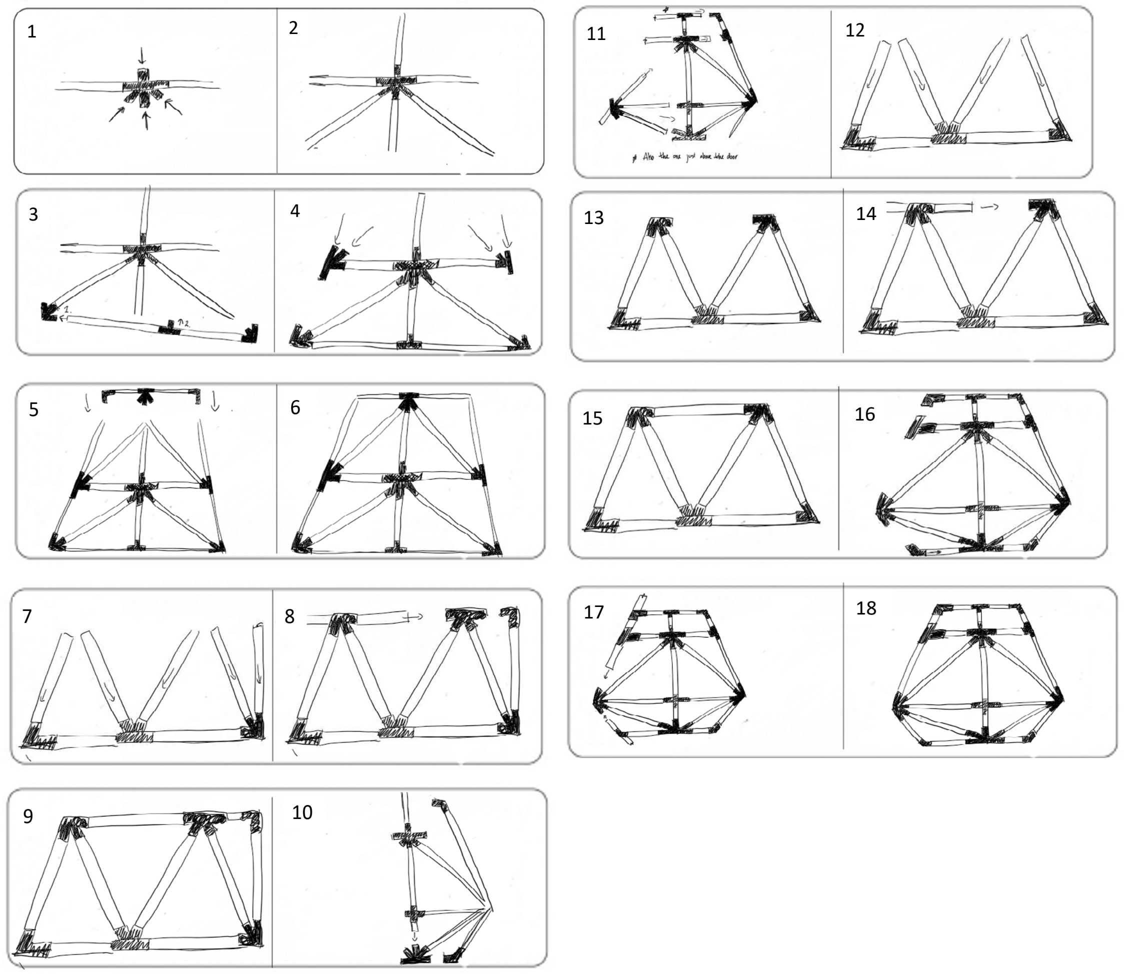






Assembly of structural system:
The full structural system is assemblied one beam at a time. All joints work the same as on the detail on the previous page; lift the beam, push the dowel and instert the beam in the joint. When the dowel clicks the beam is locked in the joint, and the next beam an be insterted. The full structure can be assemblied by three people.

The disassembly is the reveresed process of the assembly. For this process you also do not need tools.

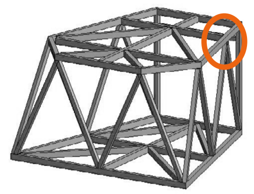


6.1_The making of the scale models
6.2_How to fabricate a 1:1 component

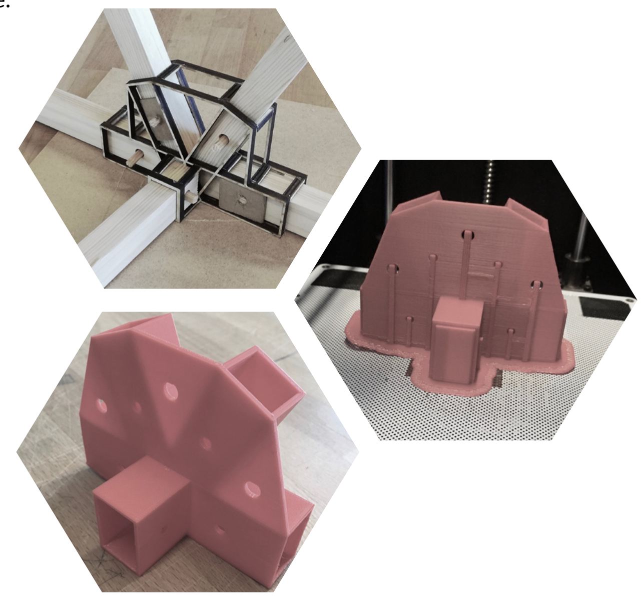
PROTO TYPE 6.

6.1_The making of the scale models

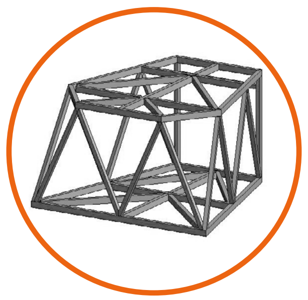
The 1:5 component was first made by laser-cutting in order to show the concept of the joint. Concept dowels and beams were inserted in order to give the right impression of the function of the joint. Later on the technology was tested by printing the joint in the 3D printer in skylab. The component was only printed in 1:5 as the printers in skylab were too small to print the full-scale component. However, this shows that it is possible to apply the technology in real life if the right sized printers had been avaliable.



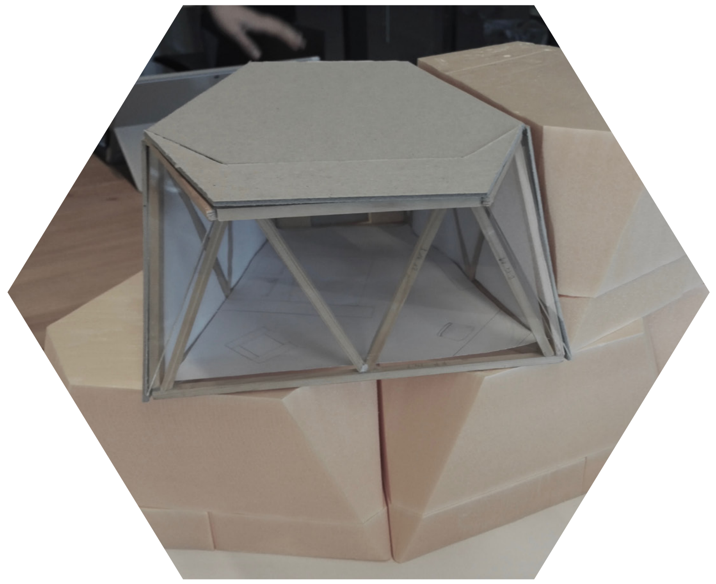
1:5 component



The 1:20 model was made out of small wooden beams which we connected with glue. Cardboard was cut in order to visualize the facade components, and foam was added on the inside to visualize the insulation. The structural system is visible in the 1:20 model and shows the architectural concept.



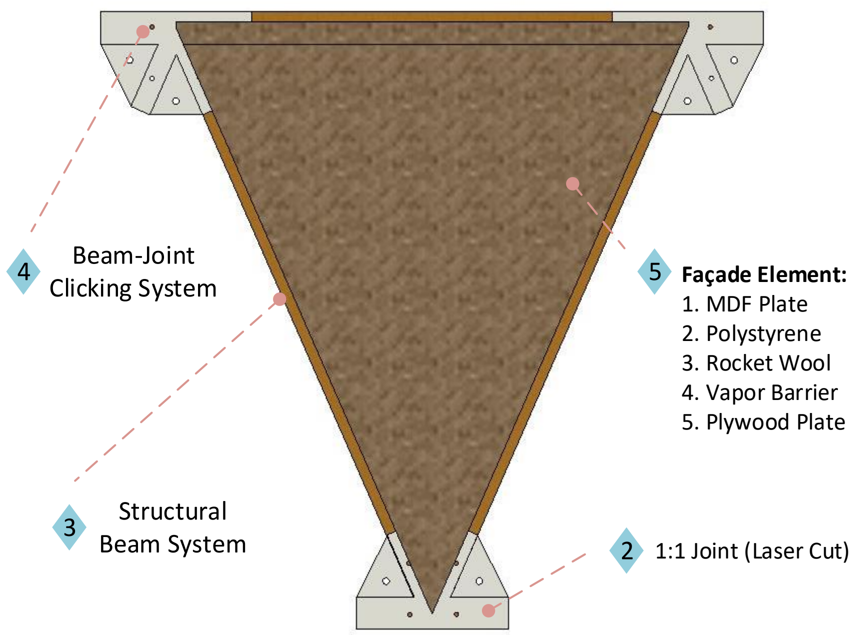
1:20 model



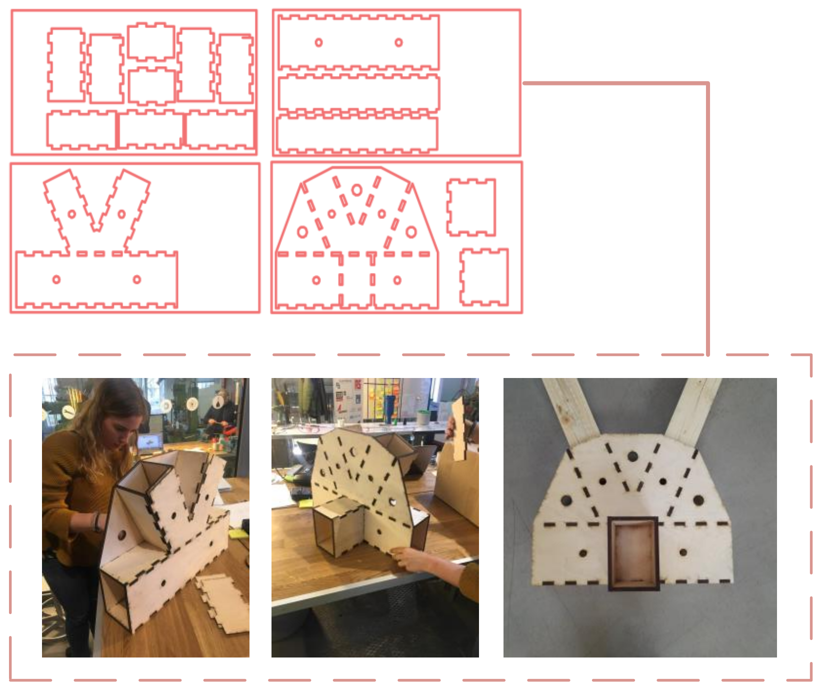
6.2_How to fabricate 1:1 component

In the following page there is an overview of the five phases we went through to build the 1:1 Prototype. In the following page, each phase of the fabrication is described.

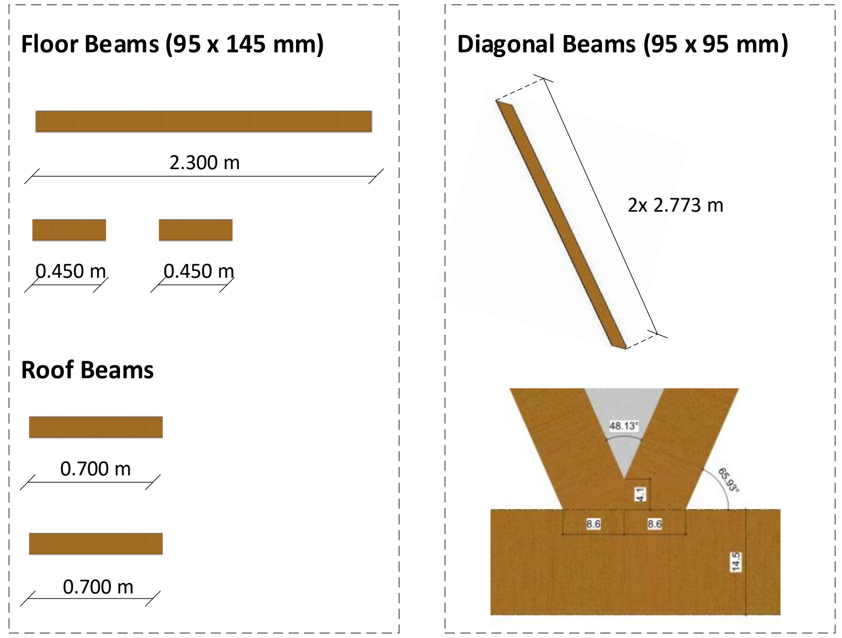
1 Finished Prototype



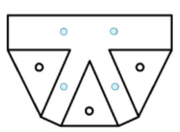
2 1:1 Joint (Laser Cut)



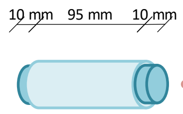
3 Structural Beam System



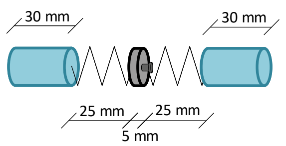
4 Beam-Joint Clicking System



Laser Cut Joint



Plastic Tubes to prevent wood from shrinking



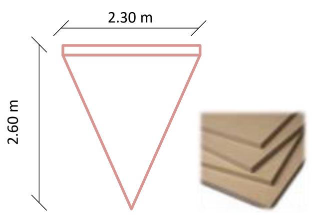
Clicking system consisting of two plastic dowels and two springs

Pictures

5 Façade Assembly

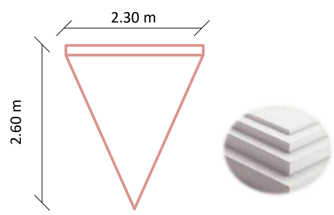
1 Outer Woodlayer

Material: MDF Plate
Density: 720 kg/m³
Thickness: 1 cm
Weight: 23.0 kg



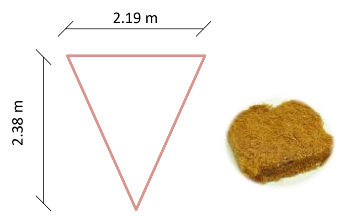
2 Insulation Layer 1

Material: Polystyrene
Density: 15 kg/m³
Thickness: 5 cm
Weight: 2.4 kg



3 Insulation Layer 2

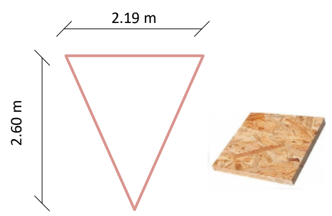
Material: Rock Wool
Density: 60 kg/m³
Thickness: 9 cm
Weight: 14.0 kg



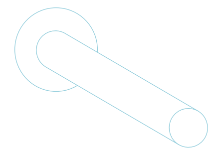
4 Vapour Barrier

5 Inner Layer

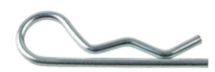
Material: Plywood Plate
Density: 650 kg/m³
Thickness: 1 cm
Weight: 16.9 kg



6 Connection Parts

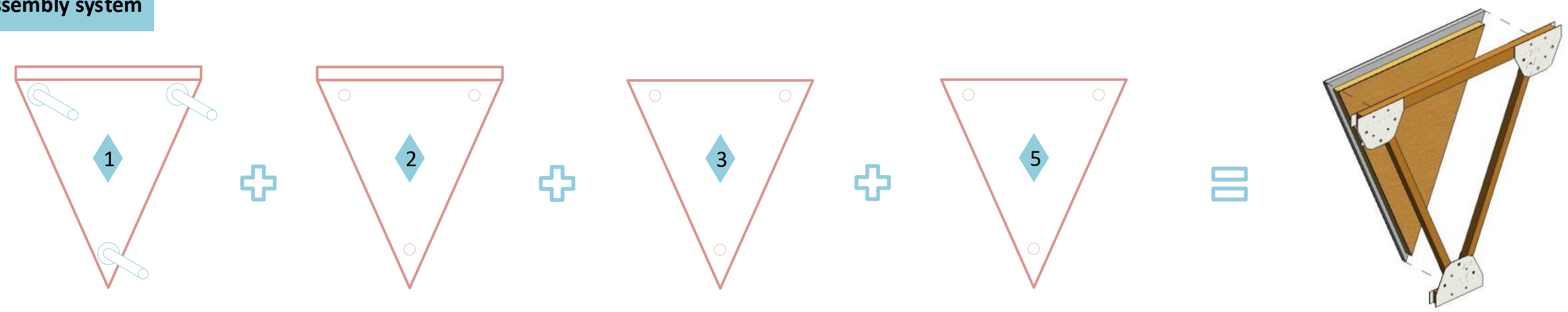


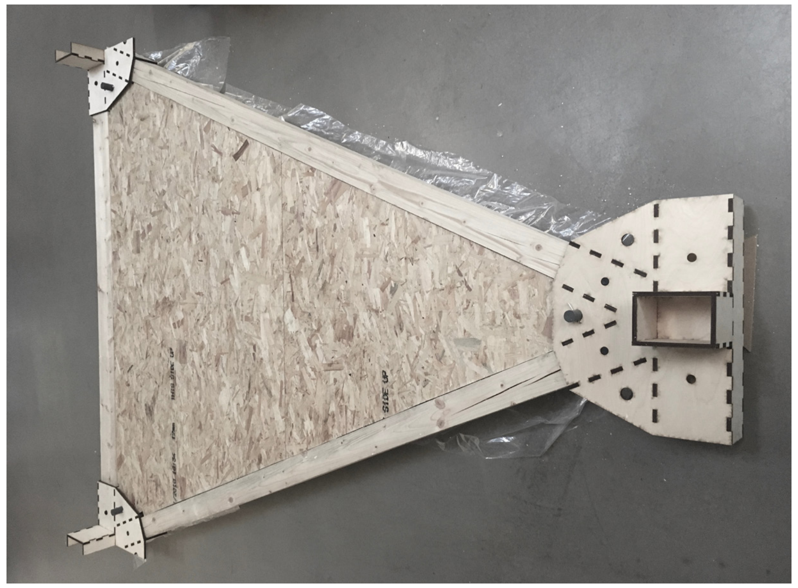
Dowel (3 cm x 17 cm)



Hitch Pin Clip for locking

Assembly system





1 **Resulting Component**

Once all the different layers and beams have been cut in the correct dimensions, the complete component can be assembled. First the beams are inserted in the joint, the clicking-system snaps and holds the structure together. Then the facade element can be inserted between the structural beams and attached to it with the pin clip in the dowel. Now the component is ready! On the following steps 2-5 there will be an explanation on how to make the parts ready for the quick assembly.

2 **Laser-cut 1:1 Joints**

After realizing that the 3D print of the component was not going to work out, the laser-cut in plywood plates seemed to be the best option. In order to produce the three joints for the 1:1 model, the drawings were prepared in Sketchup and Autocad, based on a virtual 3D model of the joint. The different pieces for the joint assembly were cut in both 3 mm plates and 6 mm plates, and then glued together to reach the thickness of 9 mm. This was done in order to get joint strong enough to stand the weight of the wooden beams and of the facade element when assembled. The holes for the clicking-system were dimensioned with a diameter of 22 mm for the beams clicking system and 32 mm for the facade attachment. After the pieces were cut, they were put together as a puzzle and glued to make them to one joint.

3 **Construction of wooden frame**

The wooden frame is composed by three beams, two have a section of 95 x 95 mm and are 2773 mm long, the last one has a rectangular section of 95 x 145 mm and is 2300 mm long. The particularity of the longer beams is that at the edges, a special angled cut is needed so that they can rest on each other without depending on the strength of the joint. With prefabrication the precision of the cut is not a problem, since the cuts can easily be made in the sawmill with specific settings. The holes for the clicking system are drilled with an electrical drill. It is very important that these are straight and made in the right position so that they fit perfectly with the ones in the joint, so there are no problems with the clicking system. The holes in the beams are drilled with a 26 mm drill in order to fit the PVC-tubes with the clicking system. The tubes are installed in order to avoid any issues with the deformations and expansion of the wood under moist conditions.

4 **Production of clicking-system**

The clicking system is inspired by the telescoping umbrella system. The dowels in the beam are pushed from both sides, so the beam can enter the joint. When the dowels arrives at the hole in the joint it snaps out and in this way, the beam can not move anymore and can be hold together with the rest of the structure. The system consists of two springs placed at the center of the system and hold together by a bolt and a nut. Then attached to the springs there is two plastic dowels with a diameter of 20 mm, that will have the strength to hold the structure system in place. This whole construction is put and glued into hollow plastic tubes with a diameter of 26 mm, this has the function to avoid the issues of the wood deformation and will keep the clicking-system in place.

5 **Assembly of facade**

The last step of the 1:1 component fabrication is the assembly of the facade element. As shown on the assembly plan, the facade is composed by five layers; MDF outside plate, Polystyrene insulation, Rockwool insulation and plywood for the inside plate and the dowel system. On the assembly plan, the dimensions of the different layers and plates can be found. Once all the materials are cut in the right dimension, they can be put on of each other and glued together. There are several aspects which have to be carried out with attention in this phase. First the layers need to be dimensioned precisely, so that they will perfectly go in between the frame structure, second the dowels and the holes in the layers have to be placed right so that once the dowels are glued they can go through all the layers and attach to joint. This is the most delicate phase of the assembly process, because if it is not done right the whole system is not going to work. But it did work out on the 1:1 model which was created in the 3-week period.

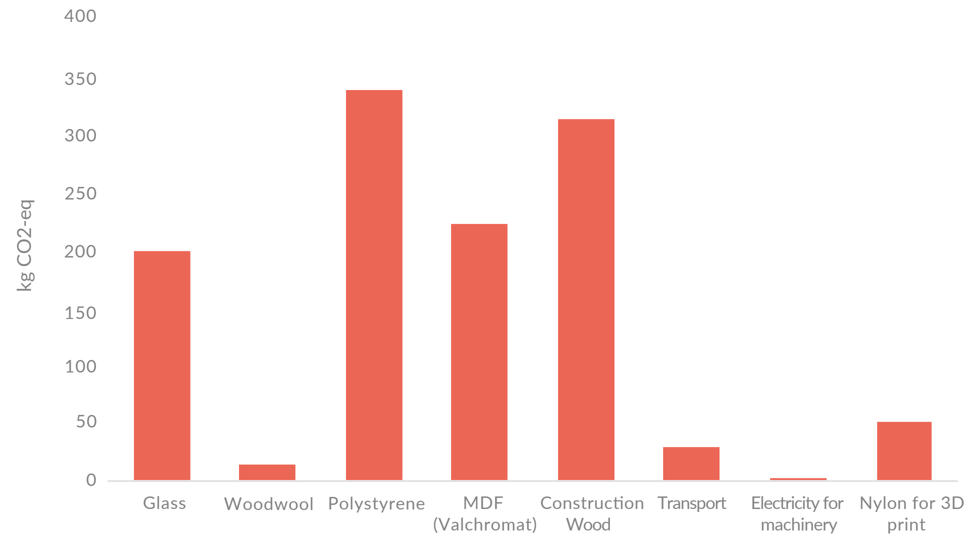
PERSPECTIVE 7.

7.1_Carbon footprint of #BuildLife vs average

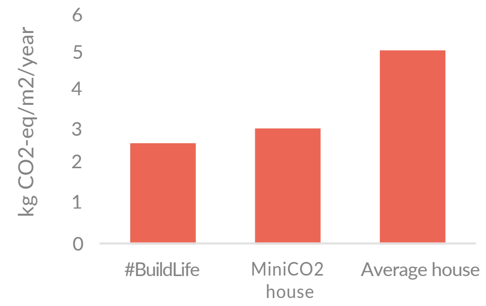
In order to compare the sustainability of the shelter to an average, a small LCIA (Life Cycle Impact Assessment) was made on the impact from creating the #BuildLife shelter. The LCIA of #BuildLife is made only for the production of the materials, the assembly and transportation to the site. Use and end-of-life scenarios have been neglected for this comparison in order to keep the time consumtion on the assessment to a minimum. The LCIA was made with ReCiPe midpoint 2016 (H) which is one of the most respected LCIA methods.

The materials for constructing a Danish reference house for living has a GWP (Global Warming Potential) of 5 kg CO2/m^2/year on a period of 50 years [3]. A more environmentally friendly option has a GWP of 3 kg CO2/m^2/year also on a 50 year period [3]. The #BuildLife shelter has a GWP of 2,6 kg CO2/m^2/year when the expected lifetime of the shelter is 30 years.

The impact from the diffent materials is shown below. The graph shows the full Global Warming Potential for the 15 m2 shelter. The graph shows that the carbon footprint could be easily improved by finding a substitute material for polystyrene as the impact is high on a realtively small amount.



When the results are divided into per square meter and per year the result becomes 2,6 kg CO2-eq/m^2/year.



Compared to an average house the #BuildLife shelter has an environmental benefit for GWP. It was not possbile to find the carbon footprint of a typical containerhome, even thought this result also would have been interesting to compare with.

The input of the LCIA can be found in appendix A5

7.2_Other applications of the shelter

The LCA analysis confirms the strong sustainability characteristic of the #BuildLife unit. Especially the simple assemble and disassemble process as well as the use of sustainable materials makes it a valuable housing unit. This unit can be applied as a temporary housing to many different groups in the society besides the construction workers. Housing in the unit is temporary - not because the durability of the materials, but because the unit is made to be placed in spaces where people need it the most. The unit is designed to be disassembled, transported and assembled at another location and due to that, the most suitable inhabitants are people, who temporarily live in an area, where cheap and comfortable accommodations are not available, and a close distance to their daily workplace is required. Due to the adequate thermal insulation, it is also not affected by seasonal changes and could therefore be build and re-build many different places around the world.
The designed unit system creates collaboration and communication within the community, as the units and systems are interconnected.
Finally, the system design can be further developed to include more shelters next to each other, creating a semicircle or even a full circle with a courtyard in the middle.

Other inhabitant groups to the shelter might be:

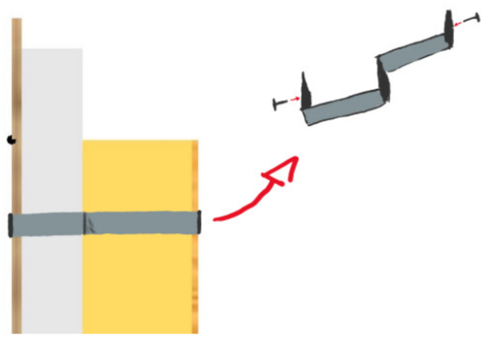
- Band members of a local festival
- Circus artists
- Students
- Temporary workers from different backgrounds
- Communities or teams (religious, sport, etc.)
- Sustainability enthusiasts
- Wood structure enthusiasts

7.3_Future iprovements of the design

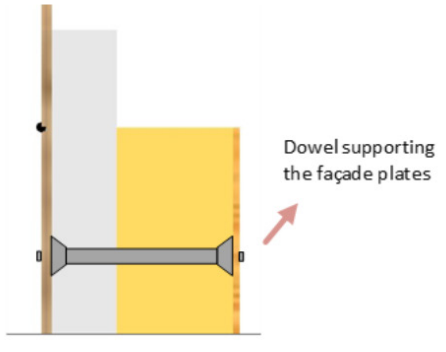
An overall reflection from the course with particular attention on what we discovered during the prototyping phase, this chapter sums up the learnings. Based on the issues we have faced with the current design, it was found necessary to discuss future implications or alternatives for the concept in order to impove the design.

Further design development:
The first and biggest challenge in the unit was the design of the joint. The idea of having a customized and strong 3D-printed joint is still one of the main characteristics of our design. Yet, during the prototyping phase, we faced some issues regarding the 3D-printing technology as it is not yet developed enough to mass produce the joints for our unit. It takes way too long (over 200 hours for one joint) and it is still really costly when printing great dimensions. Furthermore, it is difficult to find printers that can print the joint in one full piece. Therefore, we also considered to find alternatives to the 3D printing; for example the laser cut joint of the prototype. If a structural analysis and sufficient modifications were to be applied, it could become more feasible, time- and cost-wise compared to the option of printing.

The second critical issue concerns the span of the facade element. Because of the size of the facade element, it buckles in the middle. This is due to the wide span without additional support. The three supporting dowels on each edge of the triangle does not provide sufficient support and therefore, the facade is not tight fit to the structural frame. There are several measurements that needs to be taken to solve this issue. Since it is not possible to resize the facade element (because it would completely change the design) the first thing that could be done is to change the orientation of the wooden plates (inside and outside) from vertical to horizontal. This would give more structure to the facade element. The plates could also be unified with a supporting structure between them. Alternatively or additionally a dowel system should be implemented either inside the facade elements between the two wooden plates or with the structural frame (as it is already in the corners. The first option would keep the layers tight and prevent the buckling. The second option would attatch the facade-layers to the beams (also in the middle point.) In this case a simple metal or plastic compression component can be placed on the side of the facade element.



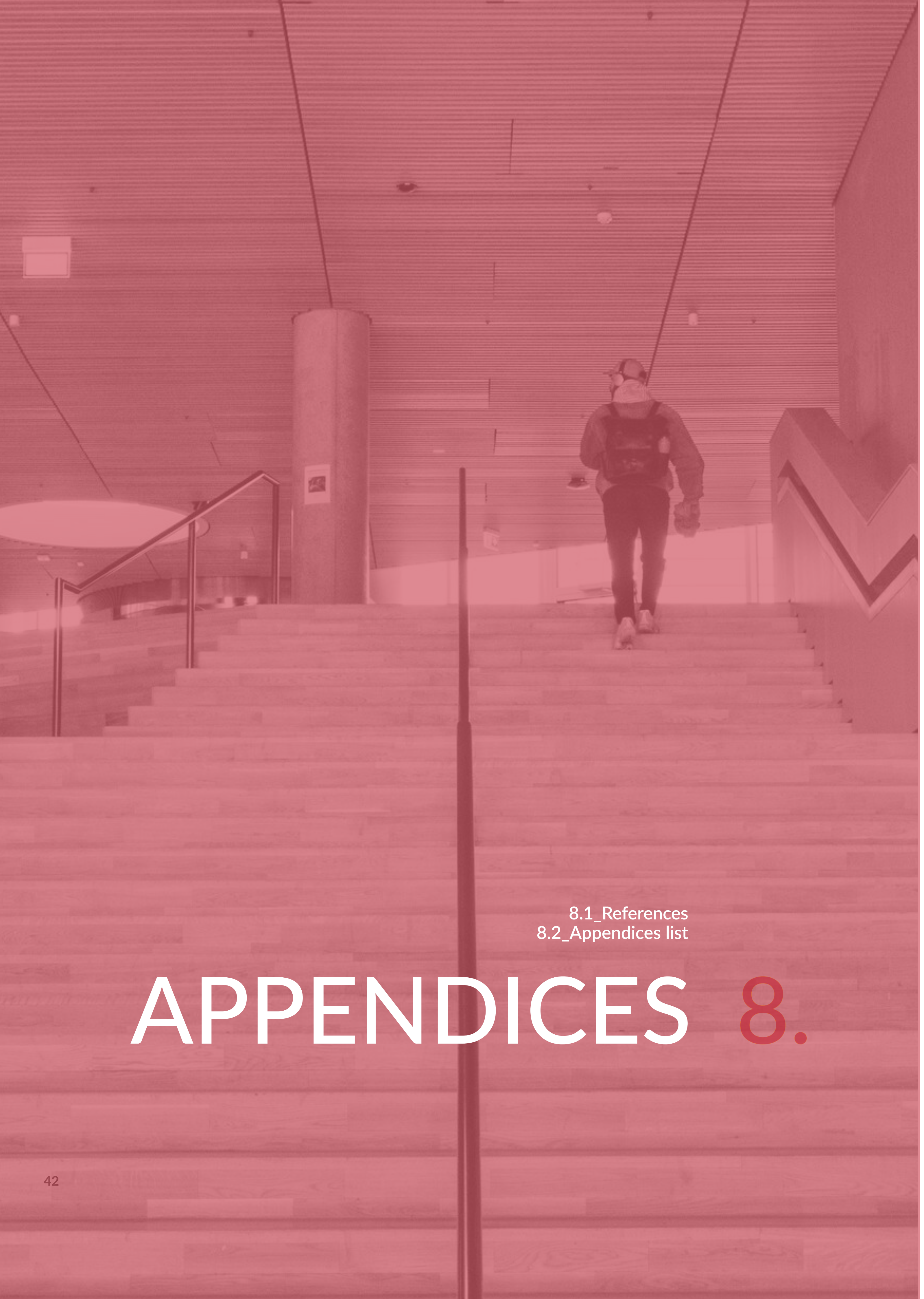
Option 1: Compression Component



Option 2: Dowel between wood plates

Another issue deriving from the facade component is that the dimension and the chosen material made the component much heavier than expected. It is necessary to have three people carrying the facade element. And currently the component can only be assembled if the component lays on the ground and then is lifted vertically after being attatched to the structural bracing. This finding resulted in a small change of the assembly plan on site as the facade elements are delivered on a truck with a mechanical arm, so they can be directly placed in the joint and pinned on the wooden structure. Without laying them first on the ground and without the need of human labour to put them up again. Please see chapter 4.4 for a detailed overview of the order and prefabrication process of our the #BuildLife urban shelter.

A dripping edge on roof around exposed facade parts of the unit is added to prevent water ingress in the facade. Waterproofness and airtightness of the facade is a main criteria and therefore a protections are necessary. Either the waterproof and airtight tape or a plastic cap should be placed on the diagonal open facade ends, preventing water to penetrate the facade from the side.
The design of the dripping edge has an additional benefit as it allows air to flow around the facade and take moisture out, if it still occurs.



APPENDICES 8.

8.1_References

[1] https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---emp_ent/---multi/documents/publication/wcms_116344.pdf | last visited 11-01-2019

[2] https://www.thenewfederalist.eu/denmark-is-seeking-migrant-workers | last visited 04-12-2018

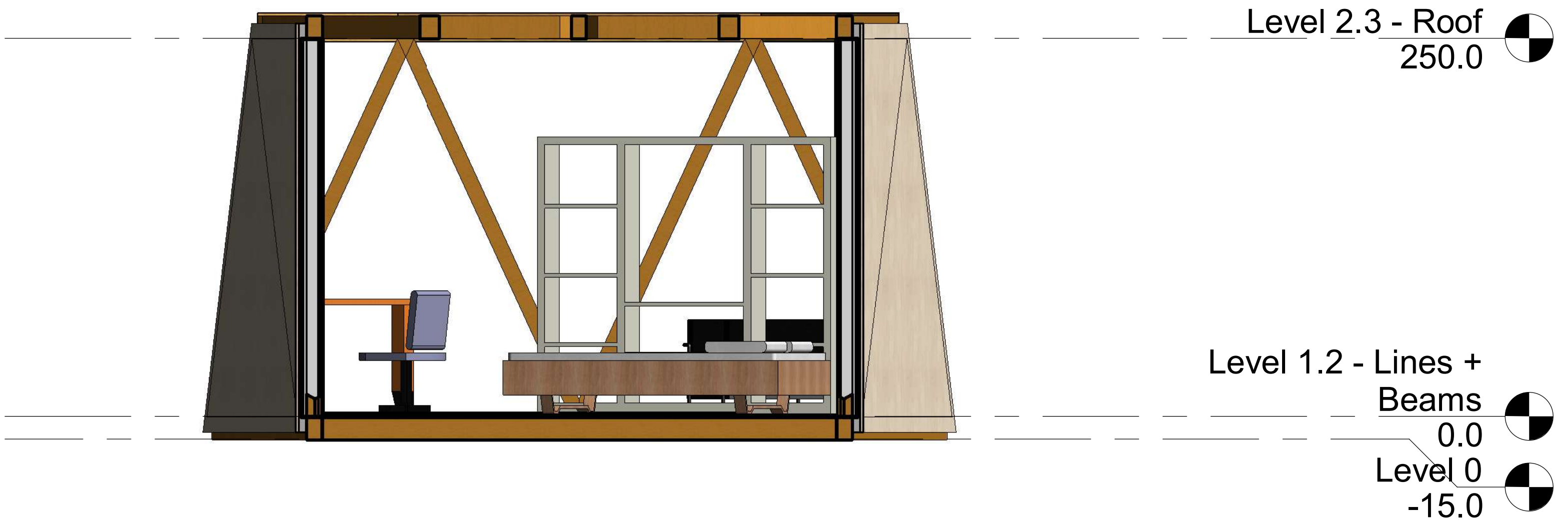
[3] https://concito.dk/files/dokumenter/artikler/bygningers_klimapaavirkning_endelig_270214.pdf | last visited 24-01-2019

8.2_Appendices list

A1: Unit drawings 1:50 scale
A2: Material list for 1:1 unit
A3: Component elevation 1:50 scale
A4: Material datasheets
- Valchromat
- EPS
- Woodwool board
- 3D print material (nylon)
- Plywood

A5: LCA input and results

A1_ Unit drawings 1:50 scale



1 Section 2 (20)
1 : 50

Danmarks Tekniske Universitet
DTU

11900 - Building Component Design

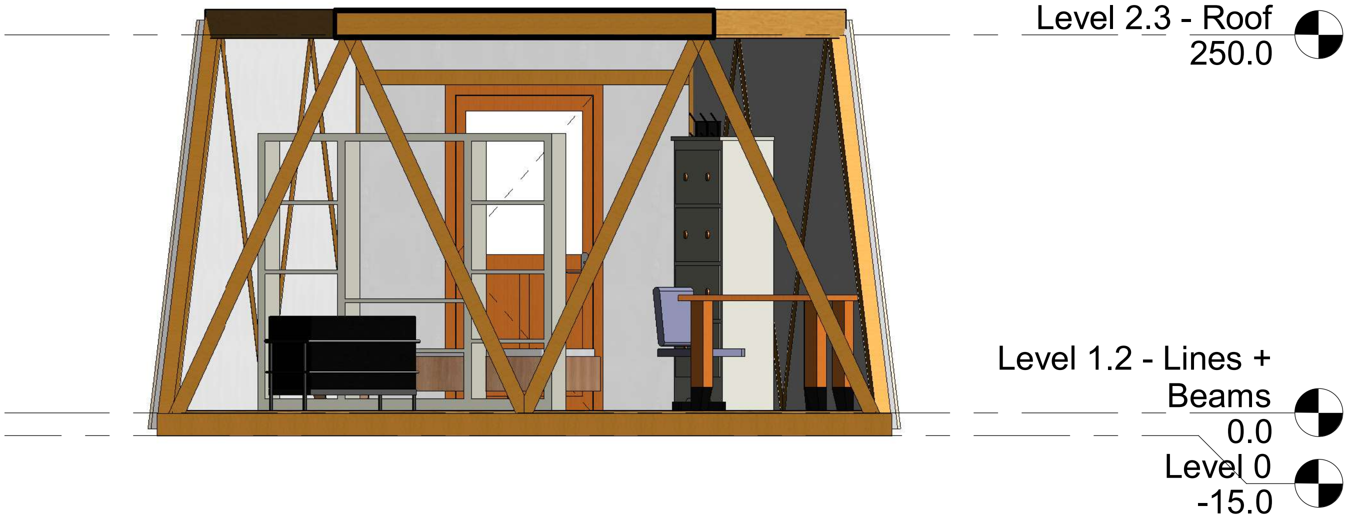
Urban Shelter

Project number	11900
Date	26/01/2019
Drawn by	Alex Schlachter
	Elsa Iluiano
	Trine Bentzen
	Jens Okholm

A4.2

Scale	1 : 50

1/16/2019 3:14:21 PM



1 Elevation North (20)
1 : 50

Danmarks
Tekniske
Universitet
DTU

11900 - Building Component Design

Urban Shelter

Project number	11900
Date	11/09/18
Drawn by	Alex Schlachter
	Elsa Iluiano
	Trine Bentzen
	Jens Okholm

A4.3

Scale	1 : 50

1/16/2019 3:14:22 PM

1 Elevation South
1 : 50

Danmarks Tekniske Universitet
DTU

11900 - Building Component Design

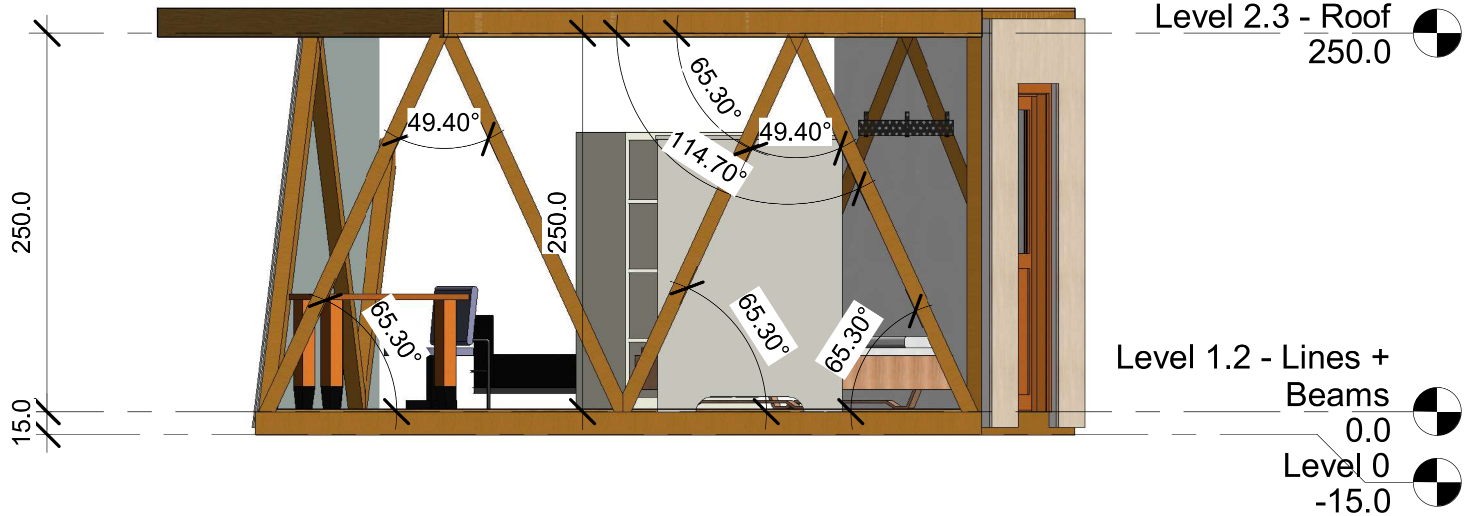
Urban Shelter

Project number	11900
Date	11/10/18
Drawn by	Alex Schlachter
	Elsa Iluiano
	Trine Bentzen
	Jens Okholm

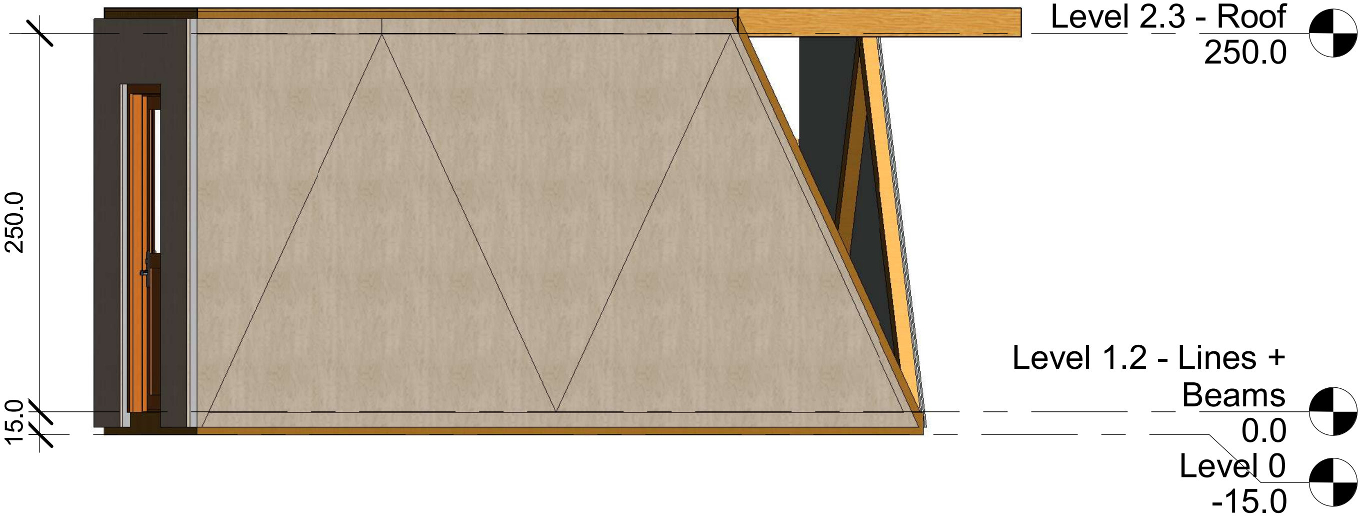
A4.4

Scale	1 : 50

1/16/2019 3:14:23 PM



1 Elevation 1 - a (50)
1 : 50



2 Elevation 2 - a (50)
1 : 50

Danmarks
Tekniske
Universitet

DTU

11900 - Building Component Design

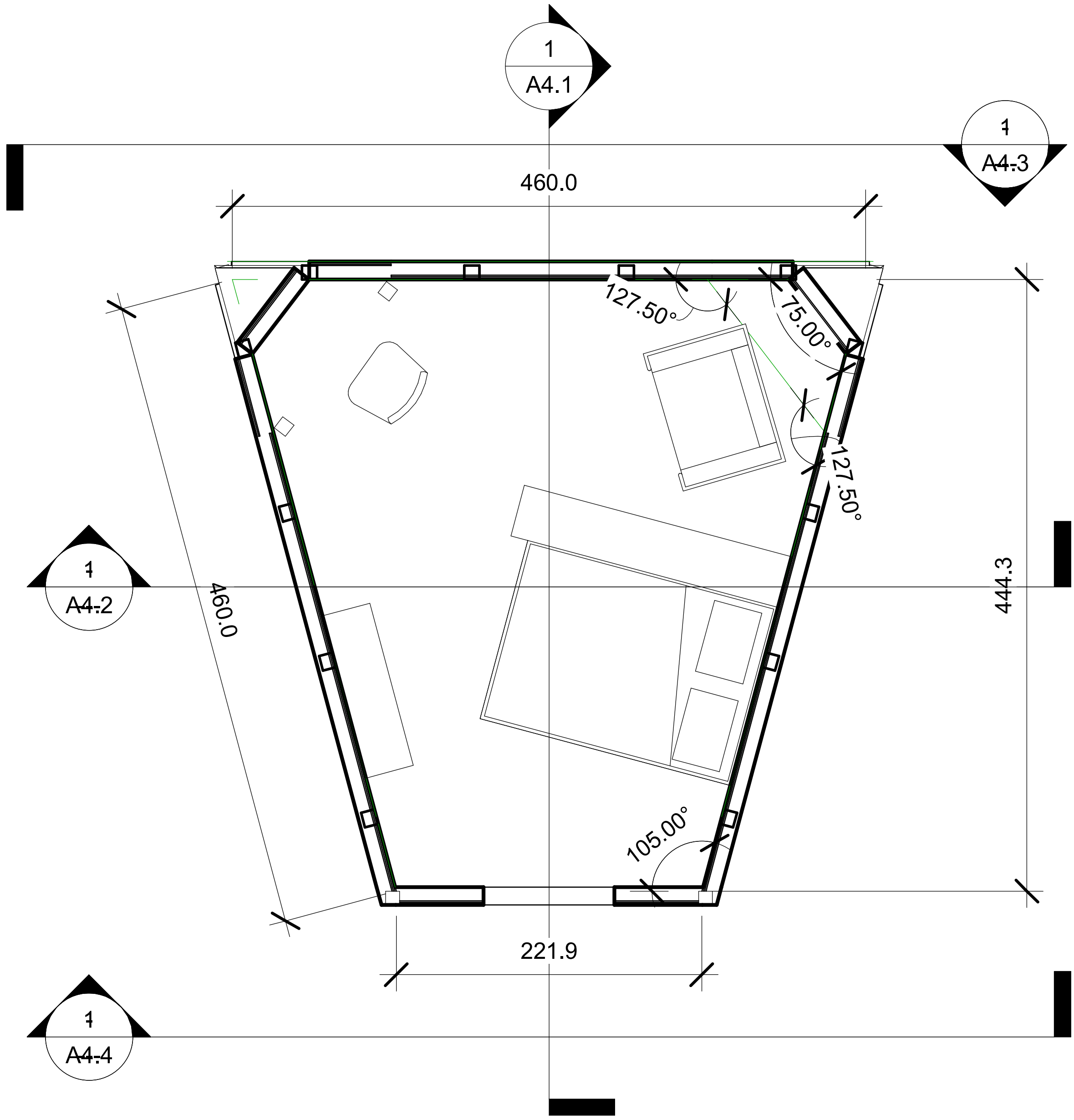
Urban Shelter

Project number	11900
Date	01/16/19
Drawn by	Alex Schlachter
	Elsa Iluiano
	Trine Bentzen
	Jens Okholm

A4.5

Scale	1 : 50

1/16/2019 3:14:24 PM



1 Level 1.0 - Layout
1 : 50

Danmarks Tekniske Universitet
DTU

11900 - Building Component Design

Urban Shelter

Project number	11900	A4.6	
Date	26/01/2019		
Drawn by	Group 1		
Checked by		Scale	1 : 50

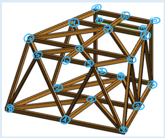
1/16/2019 3:15:17 PM

A2_ Material list for 1:1 unit

Urban Shelter - Structural Design (C24 = 420 kg/m³)								
Type	**Pieces**	**a [m]**	**b [m]**	**Length [m]**	**V [m³]**	**V cum. [m³]**	**Weight/ Beam**	**Weight [kg]**
Bracing	12	0,095	0,1	2,752	0,026	0,314	10,980	131,766
				33,024				**131,766**
Roof Frame	1	0,095	0,145	2,220	0,031	0,031	12,844	12,844
	2	0,095	0,145	3,450	0,048	0,095	19,960	39,920
	2	0,095	0,145	1,400	0,019	0,039	8,100	16,199
	1	0,095	0,145	2,300	0,032	0,032	13,307	13,307
				14,220	**0,196**	**0,196**		**82,270**
Floor Frame	3	0,095	0,145	4,600	0,063	0,190	26,613	79,840
	1	0,095	0,145	2,220	0,031	0,031	12,844	12,844
				16,020	**0,094**	**0,221**		**92,684**
Vertical Posts	2	0,095	0,1	2,500	0,024	0,048	9,975	**19,950**
Door Support	1	0,095	0,1	2,172	0,021	0,021	8,667	**8,667**
SUM	**25**			**63,264**		**0,730**		**306,719**

Urban Shelter - Roof/Floor (C24 = 420 kg/m³)								
Type	**Pieces**	**a [m]**	**b [m]**	**Length [m]**	**V [m³]**	**V cum. [m³]**	**Weight/ Beam**	**Weight [kg]**
Roof Bracing	2	0,095	0,145	2,990	0,041	0,082	17,299	34,597
	1	0,095	0,145	3,332	0,046	0,046	19,277	19,277
	2	0,095	0,145	2,290	0,032	0,063	13,249	26,498
	1	0,095	0,145	2,815	0,039	0,039	16,286	16,286
	1	0,095	0,145	1,111	0,015	0,015	6,428	6,428
	2	0,095	0,145	1,793	0,025	0,049	10,373	20,747
				21,404	**0,295**	**0,295**		**123,833**
Floor Bracing	2	0,095	0,145	2,221	0,031	0,061	12,850	25,699
	2	0,095	0,145	2,800	0,039	0,077	16,199	32,399
	2	0,095	0,145	3,198	0,044	0,088	18,502	37,004
	1	0,095	0,145	3,410	0,047	0,047	19,729	19,729
				19,848	**0,273**	**0,273**		**114,831**
0	**16**			**41,252**		**0,568**		**238,663**

Urban Shelter - 3D Printed Joints (Nylon = 1150 kg/m³, 10 mm thick)					
Type	**Pieces**	**V [m³]**	**V cum. [m³]**	**Weight/ Joint**	**Weight [kg]**
Joint 1	3	0,006	0,017	6,693	20,079
Joint 2	2	0,007	0,014	8,131	16,261
Joint 3	2	0,006	0,012	6,693	13,386
Joint 4	2	0,004	0,007	4,065	8,131
Joint 5	2	0,006	0,012	6,693	13,386
Joint 6	2	0,004	0,008	4,600	9,200
Joint 7	3	0,008	0,023	8,625	25,875
Joint 8	2	0,006	0,012	6,693	13,386
Joint 9	1	0,005	0,005	5,750	5,750
Joint 10	2	0,004	0,008	4,313	8,625
Joint 11	2	0,003	0,006	3,450	6,900
0	**23**	**0,057**	**0,123**		**140,979**



Urban Shelter - Façade Element								
Type	**Density**	**Pieces**	**Thick. [m]**	**Area [m²]**	**V [m³]**	**V cum. [m³]**	**Weight/ Piece**	**Weight [kg]**
Triangular (Copm.)		**6**						
Outer Woodlayer (Valchromat= 750 kg/m³)	750	2	0,008	9,580	0,077	0,153	57,480	114,960
Insulation 1 (Polystyrene = 15 kg/m³)	15	2	0,050	9,580	0,479	0,958	7,185	14,370
Insulation 2 (Wood Fiber Board = 40 kg/m³)	40	2	0,090	7,530	0,678	1,355	27,108	54,216
Waterproof Fabric		2	0,000	10,000	0,000	0,000	0,000	0,000
Inner Layer (Plywood-Plate = 650 kg/m³)	650	2	0,010	7,530	0,075	0,151	48,945	97,890
			0,158		**2,617**	**2,617**		**281,436**
Triangular (Side)		**2**						
Outer Woodlayer	750	2	0,008	1,770	0,014	0,028	10,620	21,240
Insulation 1	15	2	0,050	1,770	0,089	0,177	1,328	2,655
Insulation 2	40	2	0,090	1,150	0,104	0,207	4,140	8,280
Waterproof Fabric		2	0,000	2,000	0,000	0,000	0,000	0,000
Inner Layer (Plywood-Plate)	650	2	0,010	1,150	0,012	0,023	7,475	14,950
			0,158		**0,435**	**0,435**		**47,125**
Triangular (Entrance)		1						
Outer Woodlayer	750	1	0,008	4,000	0,032	0,032	24,000	24,000
Insulation 1	15	1	0,050	4,000	0,200	0,200	3,000	3,000
Insulation 2	40	1	0,090	1,710	0,154	0,154	6,156	6,156
Waterproof Fabric		1	0,000	4,000	0,000	0,000	0,000	0,000
Inner Layer (Plywood-Plate)	650	1	0,010	1,710	0,017	0,017	11,115	11,115
			0,158		**0,403**	**0,403**		**44,271**
Door		**1**						
Door (0.90 x 2.10x0.035) Cherry	630	1	0,035	1,890	0,066	0,066	41,675	41,675
Roof								
Outer Woodlayer	750	1	0,008	15,330	0,123	0,123	91,980	91,980
Insulation 1	15	1	0,050	15,330	0,767	0,767	11,498	11,498
Insulation 2	40	1	0,090	11,768	1,059	1,059	42,363	42,363
Waterproof Fabric		1	0,000	15,330	0,000	0,000	0,000	0,000
Inner Layer (Plywood-Plate)	650	1	0,010	13,908	0,139	0,139	90,402	90,402
			0,158		**0,000**	**2,087**		**236,243**
Sunshade Eaves								
Beams	420	3	0,1	0,1	7,200	0,072	0,216	90,720
Outer Woodlayer	750	1	0,008	3,331	0,027	0,027	19,986	19,986
								110,706
Floor								
Parkett finish	600	1	0,015	15,15	0,227	0,227	136,350	136,350
Insulation 2	40	1	0,090	14,809	1,333	1,333	53,312	53,312
Waterproof Fabric		1	0,000	15,372	0,000	0,000	0,000	0,000
		1	**0,090**		**1,333**	**1,333**	**53,312**	**53,312**
						1,565		**814,768**

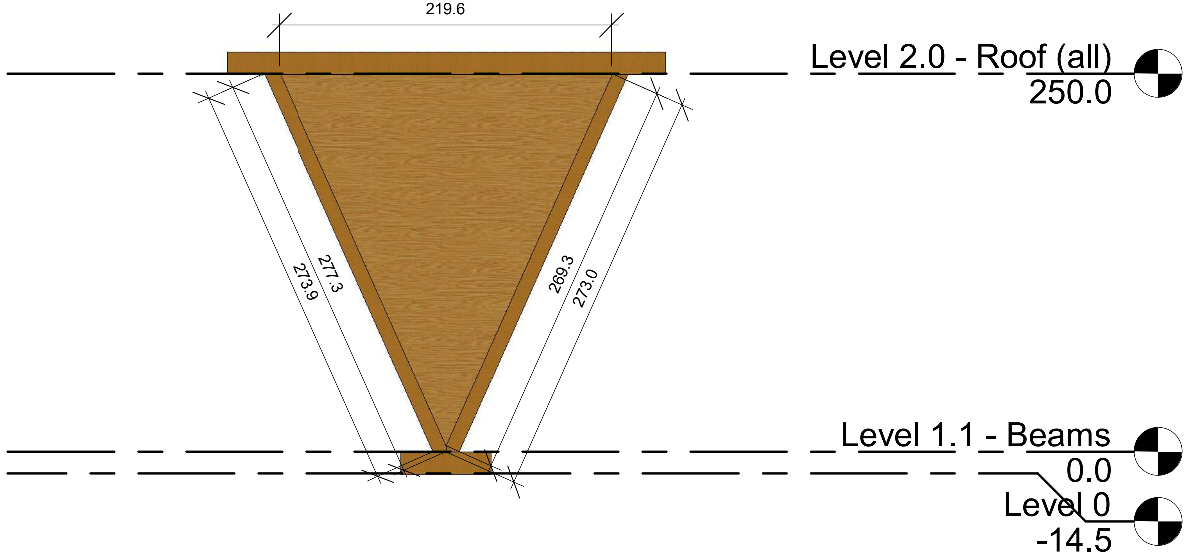
TOTAL					
Strctural Design + Joint	**Roof/ Floor**	**Façade (S)**	**Façade (G)**	**Interior**	**SUM [kg]**
447,698	238,663	814,768	712,320	290,000	**2503,449**

Urban Shelter - Glass Façade Element (Insulation Gladd = kg/m³)								
Density		**Pieces**	**Thick. [m]**	**Area [m²]**	**V [m³]**	**V cum. [m³]**	**Weight/ Piece**	**Weight [kg]**
Triangular (Copm.)								
Glass Layer 1	8000	1	0,004	9,23	0,037	0,037	295,360	295,360
Air Layer	0	1	0,004	9,23	0,037	0,037	0,000	0,000
Glass Layer 2	8000	1	0,004	9,23	0,037	0,037	295,360	295,360
Frame						0,000	0,000	0,000
					0,111	**0,111**		**590,720**
Triangular (Side)								
Glass Layer 1	8000	1	0,004	1,9	0,008	0,008	60,800	60,800
Air Layer	0	1	0,004	1,9	0,008	0,008	0,000	0,000
Glass Layer 2	8000	1	0,004	1,9	0,008	0,008	60,800	60,800
Frame						0,000	0,000	0,000
					0,023	**0,023**		**121,600**
					0,134		**0,000**	**712,320**

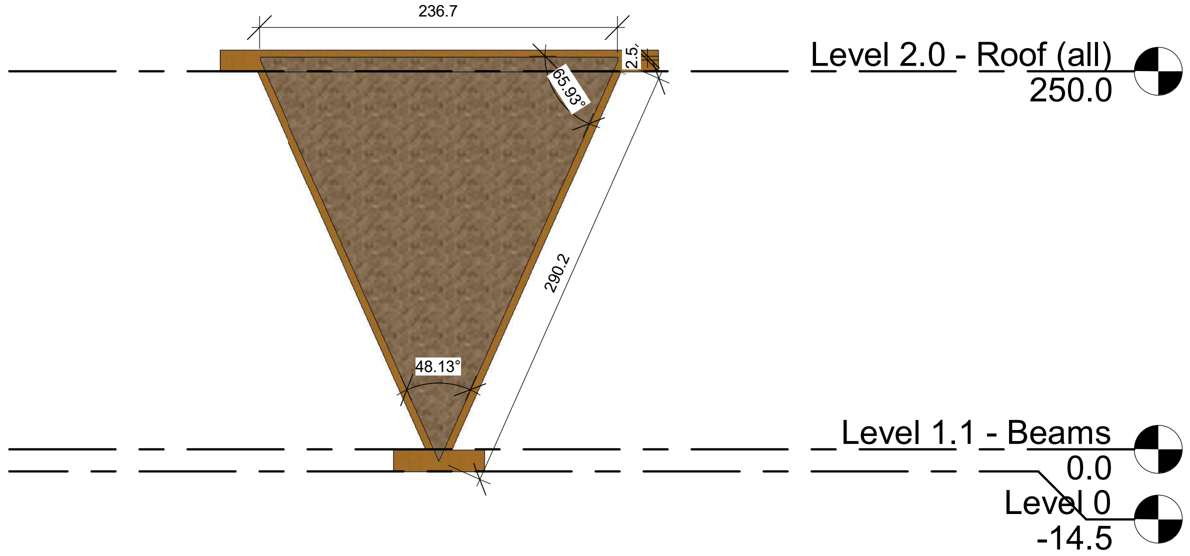
Urban Shelter - Interior (C24 = 420 kg/m³)	
Pieces	**Weight [kg]**
Bed	100,000
Armchair	30,000
Deskchair	15,000
Desk	30,000
Bookshelf	25,000
Dresser	80,000
Mirror	10,000
	290,000

Urban Shelter - Small Elements (Clicking System etc.)					
Type	**Pieces**	**Material**	**Length T [cm]**	**Width (cm)**	**Comments**
Clicking System					
Springs	164	Metal	2,500	1,500	15 Springs one joint
Dowels	164	Plastic	3,000	2,000	Carved to fit on spring
Screws	82	Metal	1,000	0,200	
Nut	82	Metal	-	-	
Plastic Joint	82	Metal	0,500	2,000	
Plastic Tube	82	Plastic	9,500	3,000	Prevents wood from shrinking
Façade					
Waterproof Tape	1	Tape	1000	0,100	Create a water resistant coat (between façade elements
Dowel with Plate	28	Plastic	18,000	3,000	Screwed together with metal screw
Pins	28	Metal	5,000	0,300	
Dripping edge		Plastic	13000		Dripping edge around the roof, to prevent water from going into the façade
					0,000

A3_ Component elevation 1:50 scale



1 Section 2 (50)
1 : 50



2 Section 3 (50)
1 : 50

Danmarks Tekniske Universitet DTU

11900 - Building Component Design

Urban Shelter

Project number	1
Date	25 January, 2019
Drawn by	Alex Schlachter
	Elsa Iluiano
	Trine Bentzen
	Jens Okholm

A4.6

Scale	1 : 50

1/23/2019 11:30:04 AM

A4_ Material datasheets

ENVIRONMENTAL PRODUCT DECLARATION

as per ISO 14025 and EN 15804

Owner of the Declaration	EUMEPS European Manufacturers of Expanded Polystyrene
Programme holder	Institut Bauen und Umwelt e.V. (IBU)
Publisher	Institut Bauen und Umwelt e.V. (IBU)
Declaration number	EPD-EUM-20160269-IBG1-EN
ECO EPD Ref. No.	ECO-00000506
Issue date	4/20/2017
Valid to	4/19/2022

Expanded Polystyrene (EPS) Foam Insulation (density 15 kg/m³)

EUMEPS

Institut Bauen und Umwelt e.V.

ECO PLATFORM EPD EN 15804 VERIFIED

www.ibu-epd.com / https://epd-online.com

1. General Information

EUMEPS – Expanded Polystyrene (EPS) Foam Insulation	Expanded Polystyrene (EPS) Foam Insulation (density 15 kg/m³)
Programme holder IBU - Institut Bauen und Umwelt e.V. Panoramastr. 1 10178 Berlin Germany	**Owner of the Declaration** EUMEPS – European Association of EPS Weertersteenweg 158 B-3680 Maaseik Belgium
Declaration number EPD-EUM-20160269-IBG1-EN	**Declared product / Declared unit** Expanded polystyrene foam (EPS) produced by EUMEPS members. The EPD applies to 1 m³ and 1 m² with R-value 1 (in EPD Annex) with average density of 15 kg/m³.
This Declaration is based on the Product Category Rules: Insulating materials made of foam plastics, 07.2014 (PCR tested and approved by the SVR) **Issue date** 4/20/2017 **Valid to** 4/19/2022	**Scope:** The companies contributing to the data collection produce one third of the expanded polystyrene foam boards sold by the members of the EUMEPS association in Europe. The data have been provided by 21 factories out of 20 companies for the year 2015. The applicability of the document is restricted to EPS boards produced by manufacturing plants of EPS converters who are members of their national EPS association, which themselves are members of EUMEPS. The owner of the declaration shall be liable for the underlying information and evidence; the IBU shall not be liable with respect to manufacturer information, life cycle assessment data and evidences.
Wermanyer Prof. Dr.-Ing. Horst J. Bossenmayer (President of Institut Bauen und Umwelt e.V.)	**Verification** The CEN Norm /EN 15804/ serves as the core PCR Independent verification of the declaration according to /ISO 14025/ ☐ internally ☒ externally
Lehmann Dr. Burkhart Lehmann (Managing Director IBU)	Grahl Prof. Dr. Birgit Grahl (Independent verifier appointed by SVR)

2. Product

2.1 Product description / Product definition

This EPD describes Expanded Polystyrene foam (EPS). The closed cell structure is filled with air (98% air; only 2% polystyrene) and results in a light weight, tough, strong and rigid thermoplastic insulation foam.

The products are mainly used for thermal and acoustical insulation of buildings. The foam is available in various dimensions and shapes. Boards can be supplied with different edge treatments such as butt edge, ship lap, tongue and groove. Density range is from about 13 to 17 kg/m³ corresponding to a compressive strength value of about 60 kPa.
This EPD is applicable to homogeneous EPS products without material combinations or facings. Most important properties are the thermal conductivity and compressive strength.

The applicability of the document is restricted to EPS boards produced by manufacturing plants of EPS converters who are members of their national EPS association, which themselves are members of EUMEPS. The data have been provided by a representative mix of 21 converters from amongst the EUMEPS membership from all parts of Europe, based upon production during 2015.

For the placing on the market of the product in the EU/EFTA (with the exception of Switzerland) Regulation (EU) No. 305/2011 (CPR) applies. The product needs a Declaration of Performance taking into consideration /EN 13163:2012+A1:2015 Thermal insulation products for buildings — Factory made expanded polystyrene (EPS) products — Specification/ and the CE-marking.
These products are additionally approved for use in specific applications under mandatory or voluntary agreement or certification schemes at the national

level. These products are controlled and certified by Notified Bodies.
A large number of the manufacturing plants are certified according to /ISO 9001/ and/or /ISO 14001/.

2.2 Application
The performance properties of EPS thermal insulation foams make them suitable for use in many applications. The range of products described in this document is used in applications such as wall insulation, pitched roof insulation, ETICS, cavity wall insulation, ceiling insulation, insulation for building equipment and industrial installations.

2.3 Technical Data
Performance data of the product in accordance with the Declaration of Performance with respect to its Essential Characteristics according to EN 13163:2012+A1:2015.

Additional data:

Constructional data

Name	Value	Unit
Thermal conductivity acc. to /EN 12667/	0.032	W/(mK)
Density	13-17	kg/m³
Compressive stress or compressive strength acc. to /EN 826/	60	kPa
Bending strength acc. to /EN 12089/	115	kPa
Water vapour transmission μ acc. to /EN 12086/	20-40	

2.4 Delivery status
Polystyrene is normally transported by lorry.
The product dimensions can vary depending on, for example, the product, the manufacturer, the application and the applicable quality label.
Dimensional data: length: max. 8000 mm, width: max. 1300 mm, thickness: max.1000 mm.

2.5 Base materials / Ancillary materials
EPS foams are made of polystyrene (94% by weight), blown with pentane up to 6% by weight, which is released partly during or shortly after production. The consideration of pentane emissions is explained in chapter 3.
The polymeric flame retardant (Butadiene styrene brominated copolymer, CAS-nr. 1195978-93-8) is present at ca. 0.6% by weight to provide fire performance. In addition to the basic materials, the manufacturers use secondary (recycled) material. No other additives are used in relevant amounts. Polystyrene and pentane are produced from oil and gas, therefore linked to the availability of these raw materials.

2.6 Manufacture
The conversion process of EPS beads to foamed insulation consists of the following manufacturing stages: pre-foaming, conditioning and finally block moulding. During the pre-foaming and moulding stages heating by steam causes the foaming of the beads due to the pentane blowing agent. The final shape is achieved by hot wire cutting of the block to give the desired board dimensions. Finally, the board edges are trimmed by cutting or grinding to obtain the desired edge detail. Typically cut offs are 100% recycled in line.

2.7 Environment and health during manufacturing
No further health protection measures, beyond the regulated measures for manufacturing companies, are necessary during any of the conversion steps for EPS.

EPS insulation is already in use for more than 50 years. No negative effects are known to people, animals or the environment.

No ozone depleting substances as regulated by the EU, such as CFC or HCFCs, are used as blowing agents for the production of EPS.

2.8 Product processing/Installation
There are no special instructions regarding personal precautions and environmental protection during product handling and installation.
Product specific handling recommendations can be found in product and application literature, brochures and data sheets provided by the suppliers.

2.9 Packaging
The products are packed loose, bundled by tape or packed on 4 or 6 sides with PE-film. The polyethylene based packaging film is recyclable and recycled in those countries having a suitable return system. A few manufacturers use cardboard in addition.

2.10 Condition of use
Water pick up by capillarity does not occur with well manufactured EPS foams, due to the closed cell structure. The thermal insulation performance of EPS is practically unaffected by exposure to water or water vapour.
Properly installed EPS boards (see: Installation) are durable with respect to their insulation, structural and dimensional properties. They are water resistant, resistant against microorganisms and against most chemical substances. EPS, however, should not be brought into contact with organic solvents.

The application of insulation material has a positive impact on energy efficiency of buildings. Quantification is only possible in context with the construction system of the building.
Dependent on the specific material and the frame conditions of installation, residual pentane may diffuse. Quantified measurements and release profiles cannot be declared.

2.11 Environment and health during use
EPS insulation products in most applications are neither in direct contact with the environment nor with indoor air. When naked EPS products were tested for VOC emissions, the emissions proved to be below the most stringent regulatory limit values in countries with such regulation (see chapter 7.1).

2.12 Reference service life
If applied correctly the lifetime of EPS insulation is equal to the building life time, usually without requiring any maintenance. Durability studies on applied EPS show no loss of technical properties after 35 years. Additional tests with products under artificial aging

show that “no deficiencies are to be expected from EPS fills placed in the ground over a normal life cycle of 100 years.”/Langzeitverhalten 2004/, /Long-term performance 2001/.

2.13 Extraordinary effects

Fire
EPS products usually achieve the fire classification Euroclass E according to /EN 13501-1/. In their end use application, constructions with EPS can achieve a classification of B-s1,d0 according to /EN13501-1/. Ignition of the foam can only be observed after longer flame exposures. If the contact with the external heat source stops, the flame extinguishes and neither further burning nor smouldering can be observed. Tests according to /EN 45545-2/, the test to evaluate the toxicity of produced combustion gasses for railway components show for EPS insulation products CIT (Conventional Toxicity Index) values up to only 0.04. This means that EPS insulation products do not have a high contribution to the toxicity of smoke produced in case of fire /PlasticsEurope 2015/.

Water
EPS rigid foam is chemically neutral and not water soluble. No water soluble substances are released, which could lead to pollution of ground water, rivers or seas.
Because of the closed cell structure EPS insulation can be used even under moist conditions. In the case of unintended water ingress, e.g. through leakage, there is normally no need for replacement of EPS insulation. The insulation value of EPS remains almost unchanged in moist conditions.

Mechanical destruction
Not relevant for EPS products that have superior mechanical properties.

2.14 Re-use phase
Construction techniques should be employed to maximise the separation of EPS boards at the end of life of a building in order to maximise the potential for re-use. Another option for re-use is to leave the EPS boards in place when the existing construction is thermally upgraded.

2.15 Disposal
EPS manufacturers advise that their products should be treated according to the EU waste strategy. The first option is recycling. Take back schemes are already in place in many countries. Recycling of EPS in many cases is technically and economically feasible, e.g. as aggregate in light weight concrete /Waste Study 2011/.
At the end of its life cycle as the second option an EPS product can be ultimately incinerated with energy recovery. Due to the high calorific value of polystyrene, energy embedded in EPS boards can be recovered in municipal waste incinerators equipped with energy recovery units for steam and electricity generation and for district heating.

In this EPD two EoL scenarios are considered: 100% thermal treatment (EoL1) and 100% material recycling (EoL2) are taken into consideration, also to allow easily the calculation of several mixed scenarios. For example to calculate the global warming potential (GWP) for a 70/30 scenario, following calculation rule for module 3 is applied:

$$\mathbf{GWP_{C3\ calc} = 70\% * GWP_{C3/1} * 30\%\ GWP_{C3/2}}$$

The same calculation rule is valid for modules C3, C4 and D.

The material is assigned to the waste category: 17 06 04 insulation materials other than those mentioned in 17 06 01 (insulation materials containing asbestos) and 17 06 03 (other insulation materials consisting of or containing dangerous substances) /AVV/.

2.16 Further information
Additional information can be found at www.eumeps.org or at the homepages of the respective manufacturer.

3. LCA: Calculation rules

3.1 Declared Unit
The declared unit is 1 m³ expanded polystyrene rigid foam. In addition, the results for the functional unit of a volume per square metre that leads to an R-value of 1 are considered. The conversion factors are listed in the table below.

Declared unit

Name	Value	Unit
Gross density	15	kg/m³
Conversion factor to 1 kg	0.066	-
Declared unit	1	m³

The primary data is weighted over the annual amount of saleable EPS by mass per producer.
Declaration type according to PCR part A:
2b) Declaration of an average product as an average from several manufacturers’ plants.

3.2 System boundary
Type of the EPD: cradle to gate - with options.
The analysis of the product life cycle includes production of the basic materials, transport of the basic materials, manufacture of the product and the packaging materials and is declared in module A1-A3. Transport of the product is declared in module A4, and disposal of the packaging materials in module A5. Gained energy from packaging incineration is declared in module D, beyond the system boundary.

The use stage is not taken into account in the LCA calculations. The positive impact on environment due to energy saving depends on the application system in the building. This needs to be considered on next level by the evaluation of buildings. The end-of-life scenarios include the transport to end-of-life stage (C2)

EoL-scenario 1: 100% incineration: The effort and emissions of an incineration process is declared in module C4. Resulting energy is declared in module D

EoL-scenario 2: 100% Material recycling: The effort of material treatment is considered in C3. Resulting benefits on avoided primary material is declared in module D.

3.3 Estimates and assumptions
The applied European average polystyrene data set "Expandable Polystyrene (EPS)" - provided by /PlasticsEurope/ in 2015 - already include blowing agent and flame retardant as a defined recipe. Due to the limited variation of ingredients within the EPS production, this generic data set fulfills the requirement of an LCA in an adequate way.

3.4 Cut-off criteria
All data from the production data acquisition are considered, i.e. all raw materials and their transport, water, thermal and electrical energy, packaging materials and production waste.
Machines, facilities and infrastructure required during manufacture are not taken into account.

3.5 Background data
Background data is taken from the GaBi software /GaBi ts/, see www.gabi-software.com/databases.

3.6 Data quality
For life cycle modelling of the considered products, the GaBi ts Software System for Life Cycle Engineering and GaBi ts database is used.
The annual quantities for 2015 have been provided by the manufacturers and used as primary data.

3.7 Period under review
As a good basis EUMEPS foreground data already exists from the generation of environmental product declarations in 2011. For the current EPD update only former detected parameters with significant influence are collected this time. Important processes are basically the consumption of thermal energy and electricity. For the included ingredients only small variations are possible. Waste and water consumption is of marginal importance in regard to the considered environmental categories.
Moreover the collection of 2015 production volumes is essential to allow the calculation of a new weighted average.
The data collected by the manufacturers is based on yearly production amounts. The production data refers to the yearly consumption in 2015.

3.8 Allocation
The production process does not deliver any co-products. The applied software model does not contain any allocation.
Nevertheless the overall EPS production of all participating EUMEPS members comprises further products with differing densities beside the product considered in this study. Data for raw material input, thermal and electrical energy as well as auxiliary material are allocated by mass.

3.9 Comparability
Basically, a comparison or an evaluation of EPD data is only possible if all the data sets to be compared were created according to /EN 15804/ and the building context, respectively the product-specific characteristics of performance, are taken into account. The used background database has to be mentioned.

4. LCA: Scenarios and additional technical information

The following technical information is a basis for the declared modules or can be used for developing specific scenarios in the context of a building assessment if modules are not declared (MND).
The values refer to the declared unit of 1 m³.

Transport to the building site (A4)

Name	Value	Unit
Transport distance	200	km
Capacity utilisation (including empty runs)	70	%
Gross density of products transported	15	kg/m³
Capacity utilisation volume factor	25	-

Installation in the building (A5)
The amount of installation waste varies and is not declared in this EPD. For the calculation of the environmental impact of EPS including a certain amount of installation waste the values for the production stage (A1-A3) and end of life (C3, C4 and D) have to be multiplied with the amount of waste (e.g. 2% installation waste, factor 1.02).

End of life (C1-C4)
The transport distance to disposal respective recycling is 50 km.
For the End of Life stage two different scenarios are considered. One scenario with 100% incineration (sc. 1; module C4 and D, R1<0.6)) and one scenario with 100% material recycling (sc. 2; module C3 and D) are calculated.
The incineration of EPS results in benefits, beyond the system boundary, for thermal energy and electricity under European conditions. The material recycling scenario generates benefits due to avoiding of primary EPS production.

Name	Value	Unit
Collected separately Scenario 2	15	kg
Collected as mixed construction waste Scenario 1	15	kg
Recycling Scenario 2	15	kg
Energy recovery Scenario 1	15	kg

Reuse, recovery and/or recycling potentials (D), relevant scenario information
Scenario 1: Module D includes the benefits of the incineration process C4 (incineration of EPS). A waste incineration plant with R1-value < 0.6 is assumed.
Scenario 2: For the calculation of benefit by recycling the data set "Expandable polystyrene" /PlasticsEurope/ is used, same as on input side.

5. LCA: Results

The following tables display the environmental relevant results according to /EN 15804/ for 1 m³ EPS board. The two EoL Scenarios are represented in modules C3, C4 and D. Scenario 1 reflects the thermal treatment of EPS with energy recovery. Scenario 2 shows the environmental results in case of material recycling considering avoided primary EPS material.

DESCRIPTION OF THE SYSTEM BOUNDARY (X = INCLUDED IN LCA; MND = MODULE NOT DECLARED)

PRODUCT STAGE			CONSTRUCTION PROCESS STAGE		USE STAGE							END OF LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARIES
Raw material supply	Transport	Manufacturing	Transport from the gate to the site	Assembly	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Reuse-Recovery-Recycling-potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	X	X	MND	MND	MND	MND	MND	MND	MND	MND	X	X	X	X

RESULTS OF THE LCA - ENVIRONMENTAL IMPACT: 1 m³ EPS foam (15 kg/m³)

Parameter	Unit	A1-A3	A4	A5	C2	C3/1	C3/2	C4/1	C4/2	D/1	D/2
GWP	[kg CO_2-Eq.]	47.08	0.89	0.92	0.15	0.00	10.88	50.57	0.00	-27.58	-35.96
ODP	[kg CFC11-Eq.]	2.97E-9	4.10E-12	2.27E-12	5.85E-13	0.00E+0	1.68E-9	9.68E-11	0.00E+0	-7.30E-10	-2.91E-9
AP	[kg SO_2-Eq.]	1.19E-1	2.35E-3	7.21E-5	4.44E-4	0.00E+0	1.13E-2	2.89E-3	0.00E+0	-1.23E-1	-9.77E-2
EP	[kg $(PO_4)^{3-}$-Eq.]	1.10E-2	5.50E-4	1.52E-5	9.51E-5	0.00E+0	1.31E-3	6.07E-4	0.00E+0	-5.89E-3	-8.68E-3
POCP	[kg ethene-Eq.]	2.50E-1	-6.92E-4	6.39E-6	-1.48E-4	0.00E+0	1.71E-3	3.62E-4	0.00E+0	-8.00E-3	-1.82E-2
ADPE	[kg Sb-Eq.]	2.29E-5	5.94E-8	5.83E-9	4.62E-9	0.00E+0	1.15E-6	2.45E-7	0.00E+0	-2.94E-6	-1.95E-5
ADPF	[MJ]	1315.70	12.29	0.13	2.16	0.00	163.88	4.80	0.00	-368.23	-1154.90

Caption	GWP = Global warming potential; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential of land and water; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone photochemical oxidants; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources

RESULTS OF THE LCA - RESOURCE USE: 1 m³ EPS foam (15 kg/m³)

Parameter	Unit	A1-A3	A4	A5	C2	C3/1	C3/2	C4/1	C4/2	D/1	D/2
PERE	[MJ]	29.38	0.70	2.42	0.01	0.00	11.60	0.74	0.00	-44.71	-15.94
PERM	[MJ]	2.40	0.00	-2.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PERT	[MJ]	31.78	0.70	0.02	0.01	0.00	11.60	0.74	0.00	-44.71	-15.94
PENRE	[MJ]	738.50	12.33	8.97	2.17	0.00	179.52	605.74	0.00	-390.88	-1179.20
PENRM	[MJ]	608.82	0.00	-8.82	0.00	0.00	-600.00	-600.00	0.00	0.00	0.00
PENRT	[MJ]	1347.50	12.33	0.15	2.17	0.00	-420.48	5.74	0.00	-390.88	-1179.20
SM	[kg]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.00
RSF	[MJ]	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
NRSF	[MJ]	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
FW	[m³]	2.55E-1	1.75E-3	2.05E-3	1.10E-5	0.00E+0	2.03E-2	9.60E-2	0.00E+0	-1.29E-1	-1.81E-1

Caption	PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM = Use of non-renewable primary energy resources used as raw materials; PENRT = Total use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water

RESULTS OF THE LCA – OUTPUT FLOWS AND WASTE CATEGORIES: 1 m³ EPS foam (15 kg/m³)

Parameter	Unit	A1-A3	A4	A5	C2	C3/1	C3/2	C4/1	C4/2	D/1	D/2
HWD	[kg]	1.41E-2	9.33E-7	1.13E-9	8.05E-10	0.00E+0	4.79E-8	4.59E-9	0.00E+0	-1.59E-7	-1.40E-2
NHWD	[kg]	6.36E-1	1.04E-3	1.34E-3	1.09E-5	0.00E+0	4.25E-2	5.01E-2	0.00E+0	-1.09E-1	-5.74E-1
RWD	[kg]	1.26E-2	1.76E-5	8.77E-6	2.51E-6	0.00E+0	6.23E-3	3.74E-4	0.00E+0	-8.93E-3	-9.63E-3
CRU	[kg]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MFR	[kg]	0.00	0.00	0.00	0.00	0.00	15.00	0.00	0.00	0.00	0.00
MER	[kg]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EEE	[MJ]	0.00	0.00	1.56	0.00	0.00	0.00	79.40	0.00	0.00	0.00
EET	[MJ]	0.00	0.00	3.56	0.00	0.00	0.00	181.02	0.00	0.00	0.00

Caption	HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EEE = Exported electrical energy; EEE = Exported thermal energy

In addition an EPD annex contains the LCA results for 1 m² with a specific R-value 1, because the provided function by an insulation material is the thermal resistance provided.

6. LCA: Interpretation

All impact categories, with the exception of POCP, are dominated by the influence of the basic material polystyrene and its production. The polystyrene employed in the production process already contains a large part of the environmental burdens.
The foaming process for the declared product also contributes significantly to the environmental impacts. The emission of pentane during that process contributes to the Photochemical Ozone Creation Potential (POCP).

The effort (input of additional energy and material) for the end-of-life scenarios (C3 and C4) and the resulting potential benefits of electricity and steam in scenario 1 (module D/1), due to the combustion, is separated. This results in negative values in module D/1. The recycling effort in scenario 2 causes benefits as well in module D/2 by avoiding production of primary EPS material.
Transports have a low influence on all impact categories compared to the contributions from the other areas.

7. Requisite evidence

7.1. VOC emission to indoor air

EPS products can be used for indoor applications, however they typically are not directly exposed to the indoor air, but covered by some kind of covering layer such as gypsum board.
The emissions of EPS have been measured for samples based upon 12 different kinds of EPS raw material. The measurements according to /CEN TS 16516/ and /ISO 16000 3-6-9-11/ were performed by Eurofins Product Testing A/S, Denmark in April 2016. The tested products all comply with the requirements of DIBt (October 2008) and /AgBB/ (May 2010) for use in applications directly exposed to indoor air.

VOC Emissions

Name	Value	Unit
Overview of Results TVOC (28 d)	25	µg/m³
TVOC (C6 - C16) TVOC (3 d)	72	µg/m³
R (dimensionless) average	0.084	-
Carcinogenic Substances (28 d)	<1	µg/m³

All tested products live up to the current regulations in place around Europe and has emissions
which are below AgBB limit values and would be rated A+ in the French VOC regulation.

7.2 Leaching performance

Leaching behaviour is not relevant for EPS products

8. References

PCR Part A
PCR - Part A: Calculation rules for the Life Cycle Assessment and Requirements on the Background Report, version 1.4, Institut Bauen und Umwelt e.V., www.bau-umwelt.com, March 2016

PCR Part B
PCR - Part B: Requirements on the EPD for Insulating materials made of foam plastics, version 1.3, Institut Bauen und Umwelt e. V., www.bau-umwelt.com, July 2014

AgBB
Evaluation scheme Health-related Evaluation Procedure for Volatile Organic Compounds Emissions (VOC and SVOC) from Building Products, Committee for Health-related Evaluation of Building Products, Status May 2010

AVV
Ordinance concerning the European Waste Directory (Waste Directory Ordinance - AVV): Waste Directory Ordinance dated 10th December 2011 (Federal Legal Gazette I p. 3379), which has been modified by Article 5 Paragraph 22 of the law dated 24th February 2012 (Federal Legal Gazette. I p. 212).

CEN TS 16516
CEN TS 16516:2013-12: Construction products - Assessment of release of dangerous substances - Determination of emissions into indoor air

EN 826
EN 826:1996-05: Thermal insulating products for building applications – Determination of compression behaviour

EN 12086
EN 12086:1997-08: Thermal insulating products for building applications – Determination of water vapour transmission properties

EN 12089
EN 12089:1997-08: Thermal insulating products for building applications – Determination of bending behaviour

EN 12667
EN 12667:2001-05: Thermal performance of building materials and products – Determination of thermal resistance by means of guarded hot plate and heat flow meter method

EN 13501-1
EN 13501-1:2010-01: Fire classification of construction products and building elements – Part 1: Classification using data from reaction to fire tests

EN 13163
EN 13163:2009-02: Thermal insulation products for buildings – Factory made products of expanded polystyrene (EPS) - Specification

EN 45545-2
Railway applications - Fire protection on railway vehicles

GaBi ts
GaBi ts 7 dataset documentation for the software system and databases, LBP, University of Stuttgart and thinkstep, Leinfelden-Echterdingen, 2016 (http://documentation.gabi-software.com/)

ISO 9001

DIN EN ISO 9001:2008-12: Quality management systems – Requirements

ISO 14001
ISO 14001:2009-11: Environmental management systems – Requirements with guidance for use

ISO 16000 parts 3-6-9-11
Indoor air - Part 3:2011, Part 6:2011, Part 9:2006 and Part 11:2006

Langzeitverhalten 2004
Alterungsbeständigkeit von EPS mit Langzeitnachweis, Carbotech AG, Basel, S-E-E.ch, St. Gallen, 2004

Long-term performance 2001
Long term performance and durability of EPS as a lightweight filling material, Tor Erik Frydenlund, Roald Aaboe, EPS geofoam conference abstract, 2001

PlasticsEurope
European Association of polymer producers, PlasticsEurope AISBL, Brussels, www.plasticseurope.org, 2016

PlasticsEurope 2015
Factsheet "Toxicity of Combustion Gases from PS foams"; published by PlasticsEurope AISBL; Brussels/Belgium; January 2015

Waste Study 2011
Post-Consumer EPS Waste Generation and Management in European Countries 2009; Consultic, 2011

Institut Bauen und Umwelt
Institut Bauen und Umwelt e.V., Berlin(pub.): Generation of Environmental Product Declarations (EPDs);
www.ibu-epd.de

ISO 14025
DIN EN ISO 14025:2011-10: Environmental labels and declarations — Type III environmental declarations — Principles and procedures

EN 15804
EN 15804:2012-04+A1 2013: Sustainability of construction works — Environmental Product Declarations — Core rules for the product category of construction products

	Publisher Institut Bauen und Umwelt e.V. Panoramastr. 1 10178 Berlin Germany	Tel Fax Mail Web	+49 (0)30 3087748- 0 +49 (0)30 3087748- 29 info@ibu-epd.com **www.ibu-epd.com**
	Programme holder Institut Bauen und Umwelt e.V. Panoramastr 1 10178 Berlin Germany	Tel Fax Mail Web	+49 (0)30 - 3087748- 0 +49 (0)30 – 3087748 - 29 info@ibu-epd.com **www.ibu-epd.com**
	Author of the Life Cycle Assessment thinkstep AG Hauptstraße 111 - 113 70771 Leinfelden-Echterdingen Germany	Tel Fax Mail Web	+49 771341817-0 +49 77134181725 info@thinkstep.com **www.thinkstep.com**
	Owner of the Declaration EUMEPS-European Association of EPS Weertersteenweg 158 B-3680 MAASEIK Belgium	Tel Fax Mail Web	+32 89 75 61 31 - info@eumeps.org **www.eumeps.org**

ROCKWOOL® INSULATION

1. Identification of the substance/mixture and of the company

1.1 Product identifier
ROCKWOOL® stone wool insulation

1.2 Relevant identified uses of the substance or mixture and uses advised against
Thermal insulation, acoustic insulation and fire protection in building construction applications.

No uses advised against for physical, health and environmental considerations as covered by REACH.

In terms of site use, the product shall be used in accordance with technical guidance published by ROCKWOOL®.

1.3 Details of the supplier of the safety data sheet
ROCKWOOL® Pencoed, Bridgend, CF35 6NY
Tel: 01656 862621 Fax: 01656 862302
Email of person responsible: sds@rockwool.com

1.4 Emergency telephone number
ROCKWOOL® Customer Solutions and Sales Support 9am-5pm Tel: 0871 222 1780 Email: sds@rockwool.com

2. Hazards identification

2.1 Classification of the substance or mixture
There is no hazard statement associated with this material. ROCKWOOL® mineral wool is not classified as dangerous according to Regulation (EC) No 1272/2008 on classification, labelling and packaging of substances and mixtures (CLP).

2.2 Label elements
The overall conclusion in accordance with the CLP regulation, REACH registration and the Globally Harmonised System (GHS) is that there are no hazardous classifications associated with ROCKWOOL® fibres in respect to physical, health and environmental considerations.

2.3 Other hazards
Use of high speed cutting tools can generate dust.

If in contact with constant heat >175°C, the binder will be slowly broken down.

Further information can be found in Section 8.

3. Composition/information on ingredients

3.1 Substances

Substance	EC identification number	REACH registration number	Content (% weight)	Classification, labelling and packaging (EU Regulation (CE) 1272/2008)
Stone wool[1]	926-099-9	01-211-947-2313-44	95-100%	Not classified[2]
Synthetic thermosetting polymer binder			0-5%	Not classified
Mineral oil			0-0.5%	Not classified
Silicon oil/emulsion[3]			0-0.5%	Not classified

3.2 Facing materials
ROCKWOOL® may be supplied faced with various common building materials such as aluminium foil, mineral tissue/scrim/fleece, polethylene/polypropylene film, wire mesh, bitumen, plaster board, cementitious board, ablative coatings, etc.

[1] *Man-made vitreous (silicate) fibres with random orientation with alkaline oxide and alkali earth oxide (Na2O+K2O+CaO+MgO+BaO) content greater than 18% by weight and fulfilling one of the Nota Q conditions of Regulation 1272/2008.*

[2] *Not classified H351 "suspected of causing cancer". Stone wool fibres are not classified carcinogenic according to the Nota Q of Regulation 1272/2008. ROCKWOOL® stone wool products do not contain CLP classified substances >0.1%.*

[3] *Silicon oil/emulsion is used in place of mineral oil in certain ROCKWOOL® products such as preformed pipe sections.*

4. First aid measures

4.1 Description of first aid measures

Inhalation:
Remove from exposure. Rinse the throat and clear dust from airways.

Skin:
If itching occurs, remove contaminated clothing and wash skin gently with cold water and mild soap.

Eye:
Rinse abundantly with water for at least 15 minutes.

Ingestion:
Drink plenty of water if accidentally ingested.

4.2 Most important symptoms and effects, both acute and delayed

The mechanical effect of coarse fibres in contact with throat, skin or eyes may cause temporary itching/ inconvenience.

4.3 Indication of any immediate medical attention and special treatment needed

None required. If any adverse reaction or discomfort continues from any of the above exposures, seek professional medical advice.

5. Firefighting measures

5.1 Extinguishing media

Suitable extinguishing media:
Water, foam, carbon dioxide (CO2), and dry powder

Unsuitable extinguishing media:
None

5.2 Special hazards arising from the substance or mixture

None special. Use normal body and respiratory protection for fire.

5.3 Advice for firefighters

The unfaced products are non combustible, some packaging materials or facings may however be combustible.

6. Accidental release measures

6.1 Personal precautions, protective equipment and emergency procedures

In case of presence of high concentrations of dust, use the same personal protective equipment as mentioned in section 8.

6.2 Environmental precautions

None required

6.3 Methods and materials for containment and cleaning up

Vacuum cleaner or dampen with water spray prior to sweeping up.

6.4 Reference to other sections

For personal protection equipment, see section 8. For waste disposal, see section 13.

7. Handling and storage

7.1 Precautions for safe handling

No specific measures. Preferably use a knife for cutting. If a power tool is used, provide effective dust extraction. Ensure adequate ventilation of workplace. See section 8. Avoid unnecessary handling of unwrapped product. See section 8.

7.2 Conditions for safe storage, including any incompatibilities

Technical measures:
No special measures necessary.

Suitable storage conditions:
Products should be kept dry, if possible in original packaging.

Incompatible materials:
None.

Packaging material:
Products are typically packed in polyethylene film, cardboard and/or on wooden pallets.

8. Exposure controls/personal protection

8.1 Control parameters

Workplace exposure limit (WEL) 5mg/m^3 gravimetric measure (total inhalable dust) and 2 fibres/ml airborne fibre limit, 8-hour time weighted averages. HSE guidance assumes that the gravimetric measure would be reached before the fibre measure. (Ref. HSE EH40).

8.2 Exposure controls

8.2.1 Appropriate engineering controls

No specific requirements

8.2.2 Individual protection measures, such as personal protective equipment

Eye protection:
Wear goggles if working above shoulders or where there is heavy dust development. Eye protection to EN 166 is advised.

Hand protection:
Use gloves conforming with EN 388 to avoid itching.

Skin protection:
Cover exposed skin.

Respiratory protection:
When working in unventilated areas or during operations which can generate emission of (various) dusts, wearing a disposable face mask in accordance with EN 149 FFP1 is recommended.

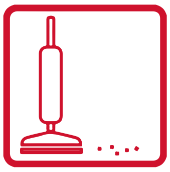
At high temperatures not usually found in building construction (>175°C), the product binder will slowly decompose and trace gases will be released. When high temperature appliances are first put into service, gases should be vented to control exposure to fumes or appropriate respirators used.

The following text and pictograms are printed on packaging:

The mechanical effect of fibres in contact with skin may cause temporary itching.

Cover exposed skin. When working in unventilated area, wear disposable face mask.

Rinse in cold water before washing.



Clean area using vacuum equipment.

Ventilate working area if possible.

Waste should be disposed of according to local regulations.

Wear goggles when working overhead.

9. Physical and chemical properties

9.1 Information on basic physical and chemical properties

a) Appearance	Solid, grey-green
b) Odour	Odourless
c) Odour threshold	Not relevant. No odour
d) pH	Not relevant. Solid
e) Melting point	>1000°C
f) Initial boiling point and range	Not relevant. Solid
g) Flash point	Not relevant. Non-combustible (ref. UK and Ireland Building Regulations)
h) Evaporation rate	Not relevant. Solid
i) Flammability	Not relevant. Non-combustible (ref. UK and Ireland Building Regulations)
j) Upper/lower flammability or explosive limits	Not relevant. Non-combustible (ref. UK and Ireland Building Regulations)
k) Vapour pressure	Not relevant. Solid
l) Vapour density	Not relevant. Solid
m) Relative density	Depends on product (typ. between 20 and 300 kg/m^3)
n) Solubility (ies)	Generally chemically inert and insoluble in water
o) Partition coefficient n-octanol/water	Not relevant. Insoluble in water
p) Auto-ignition temperature	Not relevant. Non-combustible (ref. UK and Ireland Building Regulations)
q) Decomposition temperature	When heated to approx 175°C for the first time, release of binder decomposition products occurs
r) Viscosity	Not relevant. Solid
s) Explosive properties	Not relevant. Non-combustible (ref. UK and Ireland Building Regulations)
t) Oxidising properties	Not relevant. Non-oxidising

9.2 Other information

No further chemical or physical properties to report.

10. Stability and reactivity

10.1 Reactivity
Not reactive

10.2 Chemical stability
Stable

10.3 Possibility of hazardous reactions
Not reactive

10.4 Conditions to avoid
None specified

10.5 Incompatible materials
None specified

10.6 Hazardous decomposition products
When heated to approx 175°C for the first time, release of binder decomposition products occurs. See 8.2.2

11. Toxicological information

11.1 Information on toxicological effects

a) Acute toxicity
No acute toxicity

b) Irritation
In the case of coarser fibres there can be mechanical effects on skin, upper respiratory system (mucous membranes) and eyes that can cause temporary, self-fading effects (e.g. itching). No chemical effects ensue.

c) Corrosivity
No corrosivity

d) Sensitisation
No sensitisation

e) Repeated dose toxicity
No repeated dose toxicity

f) Carcinogenicity
None. Owing to its high bio-solubility, the fibre used in ROCKWOOL® stone wool insulation materials is assessed as free from suspicion of possible carcinogenic effects in accordance with Regulation (EC) No 1272/2008 (ref. Nota Q). In October 2001, the International Agency for Research on Cancer (IARC) classified rock (stone) wool insulation as Group 3 (not classifiable as to its carcinogenicity in humans) ie not suspected of causing cancer in humans.

g) Mutagenicity
No mutagenicity

h) Toxicity for reproduction
No toxicity for reproduction

12. Ecological information

12.1 Toxicity
None. This product is not expected to cause harm to animals or plants during normal conditions of use. Stone wool is principally made from non scarce rock material and recycled stone wool.

12.2 Persistence and degradability
None

12.3 Bioaccumulative potential
None

12.4 Mobility in soil
None

12.5 Results of PBT and vPvB assessment
No assessment required

12.6. Other adverse effects
Relying on entrapped air for its thermal properties, the products do not, and never have used blowing agents with Ozone Depleting Potential or Global Warming Potential. No flame retardants are added.

13. Disposal considerations

13.1 Waste treatment methods
ROCKWOOL® material is recyclable. Please refer to our website www.rockwool.co.uk for more information. ROCKWOOL® insulation is classified as non-hazardous waste. ROCKWOOL® insulation waste is covered by the non-hazardous entry "17 06 04 insulation materials other than those mentioned in 17 06 01 and 17 06 03" in the European Waste Catalogue, established by EC Decision 2000/532/EC (hazardous waste). Under landfill regulations ROCKWOOL® insulation waste is categorised as "waste accepted at landfills for non-hazardous waste" in accordance with EC Decision 2003/33/EC (landfill acceptance criteria).

14. Transport information

14.1 UN number
Not applicable

14.2 UN proper shipping name
Not applicable

14.3 Transport hazard class(es)
Not applicable

14.4 Packing group
Not applicable

14.5 Environmental hazards
Not applicable

14.6 Special precautions for user
None specified

15. Regulatory information

15.1 Safety, health and environmental regulations/ legislation specific for the substance or mixture
The overall conclusion in accordance with the CLP, GHS and REACH regulations is that there are no hazardous classifications associated with ROCKWOOL® fibres in respect to physical, health and environmental aspects.

15.2 Chemical safety assessment
No assessment required

16. Other information

This safety data sheet has been prepared in accordance with Annex II to Regulation (EC) No 1907/2006 (REACH), as amended by Commission Regulation (EU) No 2015/830.

Although REACH Regulations do not require a safety data sheet to be provided for ROCKWOOL® stone wool insulation, this format is used by ROCKWOOL® to provide standardized health and safety information.

All stone wool insulation products supplied by ROCKWOOL® Limited are made of fibres exonerated from classification as a carcinogen in accordance with Regulation (EC) No. 1272/2008 (ref. Nota Q).

ROCKWOOL® fibres are subject to independent assessment by EUCEB.

Membership of the EUCEB certification scheme is voluntary and certifies compliance with the parameters laid down in Nota Q, as defined by Regulation (EC) No. 1272/2008.

This data sheet does not constitute a workplace assessment.

The information provided represents the state of our knowledge regarding this material at the date of its publication.

The information provided does not constitute a product specification and no warranty expressed or implied is hereby made.

The information relates only to the specific material designated when used in applications it has been designed for. This information may not be valid for such material used in combination with any other materials or in any other processes, unless specified in the text.

Company	ROCKWOOL® Limited, Pencoed, Bridgend, CF35 6NY
Trade name	ROCKWOOL®
Revised on	November 2018
Authorised by	N Ralph
Product name	ROCKWOOL® stone insulations products
Replaces issue	June 2017
Changes made	Reference to Commission Regulation (EU) No 2015/830 added. November 2018. References to superseded Regulations and Directives removed. Wording amended to improve clarity. June 2017. Text accompanying pictograms amended in Section 8, 6 July 2015. Mineral oil content changed from 0-0.3% to 0-0.5% in Table 3. 31 October 2014. Some wording amended to improve clarity. 21 January 2014. Layout amended to enable branding. Updated PPE references. Legal disclaimer updated. Contact email address changed. 04 October 2012. Re-formatted to bring headings in line with Commission Regulation (EU) 453/2010 (REACH). 05 May 2011. Supplementary information provided on Workplace Exposure Limits. Pictograms used on packaging added. 05 May 2010. Re-formatted to conform to REACH regulations. R38 classification removed from Sections 2 and 15 in accordance with Commission Regulation (EC) 790/2009. 20 July 2009.

November 2018

ROCKWOOL® Limited

Pencoed
Bridgend
CF35 6NY

Tel: 01656 862 621

info@rockwool.co.uk

rockwool.co.uk

Siemplekamp
Maschinen- und Anlagenbau

WOOD-FIBER INSULATION BOARD

› Siempelkamp dry process

www.siempelkamp.com

WOOD-FIBER INSULATION BOARD

Wood-Fiber Insulation Boards are one of the first industrially made insulation products. Despite serious competition from mineral fiber and plastic foam products today they gain market share in Germany

Why using Wood-Fiber Insulation Board:

- **Wood is a sustainable raw material**
  Its processing is not very energy intensive.
  It's ecologically sound.

- **It increases living comfort**
  The thermal capacity of wood is much higher than that of mineral fiber or plastic foam, hence Wood-Fiber Insulation Boards protect much better against summer heat.

- **It supports uniform interior climate**
  The thermal conductivity of Wood-Fiber Insulation Boards is not much affected by moisture which enables diffusion-open wall designs. Picked-up moisture will be released over time without problems.

- **It fits into the system**
  For buildings based on wooden constructions a Wood-Fiber Insulation Board 'fits into the system'.

A convincing concept for the production of Wood-Fiber Insulation Boards

The raw material for the production of insulation boards are wood chips. They are fiberized in a conventional steam refiner and dried in a flash dryer.

In difference to the traditional wet-manufacturing process the revolutionary Dry Process with a new bonding system has been developed. After the fibers are dried, they are blended with a special, fast curing Isocyanate resin. To apply this resin a new method of spraying the fibers inside a tower was researched in depth, developed, and tested by the Siempelkamp Research and Development Department.
Also new: after pre-pressing, the mat enters a calibration and curing step using Siempelkamp's unique pre-heating unit ContiTherm. Here the mat is heated rapidly by blowing a steam-air mixture through it.

For the new concept, the ContiTherm was equipped with an extended calibration zone. The modified system allows for heating and curing even thickest mats of up to 300 mm. Finally, the endless board is cut by a diagonal saw to the required length.

Siempelkamp is pleased that their efforts of developing new technologies and machines have led to a break-through which now allows the production of wood-fiber insulation boards using a continuous dry-manufacturing process.

ContiTherm

Resin application

PROCESS

Siempelkamp developed a new process and doing so extended the properties of the Wood Fiber Insulation Board.

The **Dry Process** developed by Siempelkamp uses proven process technology in many manufacturing steps:

- efficient drying of wood fibers in a flash dryer
- utilizing a highly reactive PMDI-resin for rapid curing
- application of the resin in a special ‘Dry Blowline’
- mechanical mat-forming with dry fiber
- fast heating of the mat according to the Siempelkamp ContiTherm-principle
- cross-cutting of the endless, cured board by a diagonal saw
- cut-to-size online and to demand

With the **Dry Process** essential advantages are achieved:

- board density can be as low as 80 kg / m3 (5 lbs. / cu.ft.)
- thickness is up to 300 mm (9 in.) – homogeneous in one layer
- no water treatment is necessary
- energy costs are low

Optionally, flexible boards may be produced on the same production line, after addition of some equipment, with:

- bonding by bi-component fibers (BICO)
- board density as low as 40 kg / m³

New Siempelkamp Dry Process

PRODUCTION PLANT DATA

Raw material Wood (without bark) Binder Hydrophobic additive (for special applications) Fire retardant (depending on density)	 softwood (like spruce, fir, pine) PMDI (for rigidboards) Option: Bico-fibers (for flexible boards) paraffin emulsion ammoniumphosphate
Site (for the production line without warehouse, infrastructure etc.) Masterboard width	approx 6,500 m² (70,000 sq. ft.) approx 150 m x 42 m (500 ft. x 140 ft.) approx. 2,400 to 2,600 mm (8.0 – 8.5 ft.), depending on final board size
Rigid board – Capacity (depending on density and thickness) Throughput	36 – 72 m³ / h (1,270 – 2,540 cu. ft / hour) up to 7 t / h (7.7 ton / hour) wood
Option: flexible board – Capacity (depending on density and thickness) Throughput	45 – 75 m³ / h (1,585 – 2,648 cu. ft. / hour) up to 3 t / h (3.3 ton / hour) wood

APPLICATION

Wood-Fiber Insulation Boards are being utilized for thermal and sound insulation in roofs – walls – floors. They protect against cold during winter and – most importantly – against heat in the summer.

roofing:

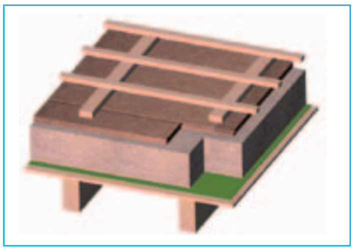
- Insulation on top of rafters
  (sufficiently compression resistant to carry the load of the cladding, e.g. roofing tiles)
- Insulation under the rafters (formwork) for additional insulation if the rafter height is not sufficient
- Insulation between the rafters
  (e.g. in the pre-fabricated housing industry)

walls:

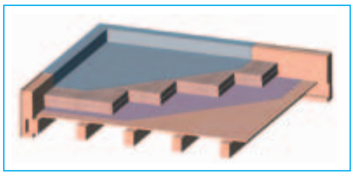
- Insulation of exterior and interior walls
  (against heat and sound transmission)
- Substrate for EIFS
  (Exterior Insulating and Finishing Systems)
  Interior insulation for renovation works

flooring:

- Compression-resistant insulation for floating screeds
- Insulation against impact noise
  (e.g. under laminate flooring or parquet)

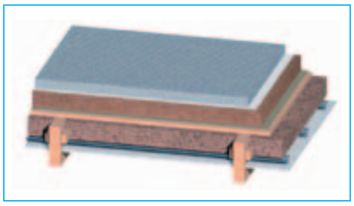


Insulation on top of rafters

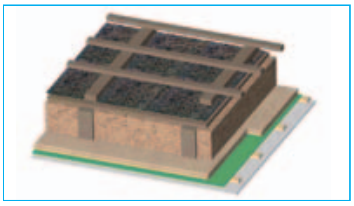


flat roof insulation

Exterior Insulation and Finishing System (EIFS)



Floating floor screed on Wood-Fiber Insulation Board



Option: flexible board insulation between rafters

Wood-Fiber Insulation Board according to the Siempelkamp Dry Process

Property / rigid boards			Density [kg/m³] / [lbs./cu.ft.]		
			110/6.9	140/8.7	200/12.5
Compression	EN 826	kPa	appr. 20	appr. 70	appr. 200
		p.s.i.	appr. 2.9	appr. 10.1	appr. 29.0
Thermal Conductivity nominal value	EN 13171	W/m*K	appr. 0.037	appr. 0.040	appr. 0.045
Fire behaviour [a)]	EN 13501		Class E		

a) with fire retardant (depending on density)

02.2012/1000GB

Siempelkamp Maschinen- und Anlagenbau GmbH & Co. KG · Siempelkampstrasse 75 · 47803 Krefeld · Germany · Phone: +49 (0) 21 51 / 92-30 · Fax: +49 (0) 21 51 / 92-56 04

THE FACTS

ORGANICALLY COLOURED WOOD FIBRE BOARD Valchromat®

CONTENTS

HISTORY OF VALCHROMAT

Valchromat® was created by the research department of Valbopan as a result of a thorough and consistent research based on the need to improve and develop new and existing wood related products. It was created because of a gap in the market place, which called for a product combining colour and other specific features lacking in existing products. Valchromat® was first introduced in Paris during the 1998 Approfal Fair, winning Valbopan's technical staff both the technological innovation prize and the display prize. Since then this product has undergone different industrial tests in order to achieve its stage of maturity. Tests in furniture applications were carried out during this period in co-operation with technicians, architects and designers to appraise its benefits for a variety of uses. Finally during the third quarter of 1999 Valchromat® came into the market through distribution channels in France, Switzerland and Belgium.

EVOLUTION OF MDF (MEDIUM DENSITY FIBRE BOARD)

Over the last 30 years MDF has never really been completely accepted by specialists as an adequate product for different finishes and decorative purposes. Valchromat® has broken this taboo by introducing a new aesthetic concept of its own. Therefore not only do its chemical and physical – mechanical characteristics comply with MDF specifications, but also its standards that guarantee limitless decorative applications. Valchromat® is at least 30% stronger and more stable/resistant than standard MDF board. It is completely moisture resistant, provided the correct finish is applied. Valchromat® increases the life span of tools used in its manufacturing due to a lubricant agent in its composition.

ADVANTAGES FOR ARCHITECTS AND DESIGNERS

Uniqueness

Valchromat® is a "one of a kind" product, and Valbopan are the only company in the world who produce it. It is not only unique for its look and colour, but for its diverse extensive application possibilities.

Natural look

Although it is essentially a manufactured product, Valchromat® has a texturised surface that gives it a very special look and feeling unlike artificially painted surfaces.

Variety

There are 8 different colours and 7 different thicknesses. Corporate colours can be manufactured at a minimum order of 100m3 but we cannot go lighter than our standard yellow as the dyes are toxic and expensive and the results are poor.

Wear and Tear

Due to Valchromat® being coloured consistently all the way through, the panels can be scratched a number of times, but they are easy to repair. All that is required is sanding and re-lacquering and they are back to brand new.

Different finishing possibilities

Valchromat® accepts any kind of finishing. By applying a glossy lacquer one can have a modern trendy look, and by applying oil one can create a slightly more conventional look. A mat or waxed look, and fire retardant and texturised finishes are all achievable using Valchromat®.

Easy to Assemble
During the planning stage of a project, architects and designers won't have to worry about hiding the edges. Valchromat® can be fitted without further finishing.

Non toxic
Valchromat® is classified E1 (Low on formaldehyde) according to European norms. There is a growing concern amongst MDF users since even the general purchaser for IKEA (furniture manufacturers) wants to exclude all the formaldehyde from their furniture. Valchromat® has been approved by the British standards association as safe to use in the manufacture of children's toys.

Sustainability
Our manufacture is very environment friendly – no waste water, no dangerous fumes, the use of waste from other manufacturers and the use of thin otherwise useless pine branches. Valchromat® can be recycled.

ADVANTAGES FOR MANUFACTURERS

High Density Profile
This characteristic is very important since it means that after machining, there is little or no sanding required, thus drastically reducing the cost of labour. This also allows an easier finishing, as fewer coats are required. It is enough to apply one coat of sealer followed by one or two coats of lacquer (although a little extra should be applied to the edges).

Moisture and UV Resistance
The panels have to be lacquered on all edges but Valchromat® may be used for kitchens, bathrooms and flooring. We have some customers using it externally, but it is best suited for interior applications.

Strength
Valchromat® is at least 30% stronger than standard MDF making it a lot more stable.

Easy to Machine
Besides the fact that Valchromat® does not require sanding, it should also be remembered that Valchromat® has a much lower percentage of sand and metal. It also has a high melamine content that acts as a lubricant for the cutting tools, enabling them to last a lot longer. Valchromat® is entirely made of pine fibres extracted from Portuguese forests. The use of sub products such as branches, bark and residue from timber mills contributes to the sustained management of the planets forests.

Important Notes
- **Small light brown pine chips are visible at random throughout a sheet of Valchromat® board, adding to its unique natural look!**
- **Whilst variances in colour remain within acceptable parameters, according to cielab norms allied to data colours software, it is important to note that slight variations may occur. This is due to the natural pine fibres and eco friendly organic dyes that make Valchromat® the innovative product it is!**
- **Sheet size available in SA: 2.5m x 1.85m**
- **Thicknesses available in SA: 8mm, 16mm, 22mm, 30mm**
- **Grey and Orange are currently not available in 22mm**
- **Tonal variance will occur with different finishing applications**

MANUFACTURING

Raw Materials

From the very beginning a rigorous selection of raw material is carried out. Wood, pigments and glues are carefully selected. Valchromat® is made exclusively of pine wood. The glue is exclusively developed for Valchromat® in association with a resin manufacturer. It is mainly made of a synthetic resin formed by melamine-urea-formaldehyde.
Valchromat® is certified E1 (Low on formaldehyde). Exhaustive research was carried out in order to obtain colour stability, minimum toxicity whilst keeping in mind ecological factors. Valchromat® is therefore entirely made up from organic pigments like those used in the children's textile industry, and thoroughly complies with the strict eco-tex regulations.

Fibre preparation

The wood is peeled from the bark and sent into a chopper to be torn into small chips. The chips are then run through a very powerful magnet (this removes about 99% of all metal) followed by a washing stage which removes 80-90% of all the sand – this reduces the wear and tear of tools when cutting or machining. Once the chips have been sorted to similar sizes, they are cooked with steam (pressure and temperature). The chips are now soft but the fibres still need to be isolated by defibration (two gigantic texturised discs spine against each other to isolate the fibres). Pigments are prepared in-house, using an electronic supervising system which has been specifically developed for the manufacturing of Valchromat® and which rigorously controls the mix of all chemical products involved in the making of the glue.

Pressing

When the mixture of coloured fibre and glue dries, the Valchromat® is pressed in a large dimension monoplate press, forming large sized sheets. This press stage ensures that Valchromat® has a better density profile thus allowing more stability and better finishing properties.

Colour

Valchromat®'s colour is obtained by adding organic pigments to wood fibre providing a thoroughly uniform coloured piece of wood. It is equally resistant to daylight and artificial light. Colour quality control is explained below. Finish: After a 48 hour period sheets are calibrated at a homogenous thickness (0.1mm or 0.2mm), and mechanically polished. At this stage each sheet's colour is subject to a spectrophotometric control and classified according to the variation allowed for each colour.

Quality Control

For colour control, spectrophotometric technology allied to datacolour's software is used, as it is widely accepted by both the paint and textile industries. Its regulation complies with cielab norms. For other testing Valchromat® then applies standard cen tests designed for fibre panels. It was in this text that Valbopan together with manufacturing specialists, architects and designers set up the Valchromat® specifications designed to comply with EN (European) regulations. During the manufacturing process main features such as colour, internal strength and humidity resistance are regularly tested (at least once an hour) to allow for any necessary adjustments. Once the manufacturing process is complete Valchromat® features are once again thoroughly tested.

PROPERTIES

Density and technical details according to EN (European) standards

thickness	8	12	16	19	22	25	30	Unit
density	0,80	0,79	0,76	0,75	0,73	0,69	0,69	g/cm^3
swell8	10	7	5	5	5	5	4	%
internal bond	1,10	1,10	1,10	1,00	0,95	0,90	0,85	N/mm^2
bending strength	30	30	30	30	30	22	22	N/mm^2
modulus of elasticity	2700	2500	2500	2500	2500	2300	2300	N/mm^2
thickness swell	17	16	15	15	15	10	10	%
internal bond after cyclic test	0,30	0,25	0,20	0,20	0,15	0,10	0,15	N/mm^2

Cyclical testing

Cyclical tests – moisture resistant test standard EN 321 - Tests are repeated twice

	temp(˚C)	hours
water	20	72
freezer	-12 to -20	24
oven	70	72

Colour fastening

Tests for resistance to artificial light are done under British standard norms (BS 1006) – 24 hours in a solar box.

colour	reference	result
yellow	syw	4
black	sbl	4
blue	srb	4
brown	sbr	5
green	sgr	2
red	ssc	3

MATERIAL SAFETY DATA SHEET FOR VALCHROMAT

Storage and transportation

Storage and transportation should be carried out in accordance with the EPF recommendations for MDF, no special precautions need to be taken. For transportation, Valchromat® is classified as a non hazardous product; no labeling required.

Handling and machining Valchromat

The usual safety requirements for fabrication and machining should be observed with regard to dust extraction, dust collection and fire precautions. Because of the possibility of sharp edges, protective gloves should be worn when handling panels. Although the contact with dust from Valchromat® does not present any special problem, a small percentage of personnel might be sensitive or even allergic to machining dust in general.

Environmental and health aspects in use

Valchromat® is chemically inert. Gas release from surfaces and edges is so low that they are not detectable by instrumental analysis. Formaldehyde emission is below the limit for wood-based materials. There is no migration affecting the foodstuffs and consequently, Valchromat® is approved for contact with foodstuffs. The surfaces are resistant to all common household solvents and chemicals and therefore, have been used in many applications where cleanliness and hygiene are important.

Maintenance

Although it depends on the desired final look of the panels, Valchromat® can be used such as it is, without any surface protection (like lacquers or paints).

Valchromat in fire situations

The panels are difficult to ignite and have properties that retard "spread of flame", thus prolonging evacuation time. Due to incomplete burning, as with any organic material, hazardous substances are to be found in the smoke. However Valchromat® is classified Euroclass D (smoke class s1, drop class d0) according to EPF regulations. In dealing with fires in which Valchromat® is involved the same fire fighting techniques should be employed as with other wood-based building materials.

Waste disposal

Valchromat® can be brought to controlled waste disposal sites according to current national and/or regional regulations. However there are two other alternatives: recycling (Valbopan has the patent for this process); energy recovery in approved industrial incinerators.

Technical data

Physical-chemical characteristics

Physical state	Solid sheet
Density	0,76 g/cm3 (varies considerably in different thicknesses)
Solubility	Insoluble in water, oil, methanol, diethyl ether, n-octanol, acetone
Boiling point	None
Evaporation rate	None
Melting point	Doesn't melt
Heavy metals	Valchromat® doesn't contain toxic compounds of antimony, barium, cadmium, chromiumIII, chromiumVI, lead, mercury, selenium

Stability and reactivity data

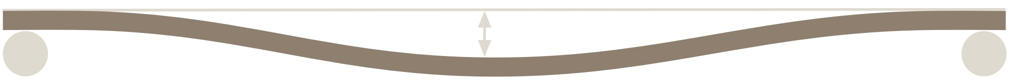
Stability	Very stable
Hazardous reactions	Not reactive nor corrosive
Material incompatibility	Strong acids or alkaline solutions will stain the surface
Fire and explosion data	Ignition temperature Approx. 375 ºC
Thermal decomposition	Possible above 220 ºC. Depending upon the burning conditions (temperature, amount of oxygen, etc...) toxic gases may be emitted, e.g. carbon monoxide, carbon dioxide, ammonia
Flammability	Valchromat® isn't considered to be flammable. They will burn only in fire situation, in presence of open flames
Extinguishing media	Valchromat® is considered as a class A material. Carbon dioxide, water spray, dry chemical foam can be used to extinguish flames. Water dampens and prevents rekindling. Wear self breathing apparatus and protective clothing.
Protection against fire explosion	None required as for wood based building materials.
Storage and transport	Valchromat® is classified as non-hazardous for transportation purposes and there are no specific requirements.
Machining	Use gloves to protect from sharp edges and edges and safety-glasses to prevent eye injury. No special working equipment is necessary, except protections to minimize dust exposure in case of sheet machining.
Disposal considerations	Waste material shall be handled according to local regulations. Burning is approved in industrial incinerators. Valbopan has the patent for recycling Valchromat.
Health information	Valchromat® is not dangerous for humans and animals. There is no evidence of Valchromat® toxicological effects and eco-toxicity. Valchromat® surfaces are physiologically safe and approved for contact with foodstuffs.
Working areas	General dust regulations apply. Although Valchromat® dust is thinner than usual.
Formaldehyde emission	←8mg when tested according to EN120 (perforator method)
Additional remarks	Valchromat® are solid sheets and there are would not be any health hazards associated with them.

All the above information is based on the current state of technical knowledge, but does not constitute any form of guarantee. It is the personal responsibility of users of the product described in this information leaflet to comply with the appropriate laws and regulations.

FORMULA FOR BOWING OF VALCHROMAT SHELVES SUPPORTING WEIGHT

There is a formula, based on several factors, that gives one an idea of the "worst case scenario", If the distance between supports is 1000mm then, the worst situation would be to have a bow of 1mm, which might be too much! With a support every 500mm, there should be no bending to bear this load. If you maintain this distance between supports it will only support approximately 4Kg without bending.

total wieght	distance supports	mod elasticity	width	thickness	acceleration	bending	bending
kg	mm	N/mm2	mm	mm	m/s2	mm	cm
W	L	E	b	t	a	d	d
20	1000	2700	300	8	9.81	73.9	7.4
20	1000	2500	300	12	9.81	23.7	2.4
20	1000	2500	300	16	9.81	10.0	1.0
20	1000	2500	300	19	9.81	6.0	0.6
20	1000	2500	300	22	9.81	3.8	0.4
20	1000	2300	300	25	9.81	2.8	0.3
20	1000	2300	300	30	9.81	1.6	0.2



$$\text{difference between straight and bent =bending} = \frac{5 \times W \times L^3}{32 \times E \times b \times t^3}$$

A5_ LCA input and results

Products

Outputs to technosphere: Products and co-products	Amount	Unit	Quantity	Allocation	Waste type	Category	Comment
#BuildLife Unit	1	p	Amount	100 %		_Materials for #Buildl	
Add							

Outputs to technosphere: Avoided products	Amount	Unit	Distribution	SD2 or 2SD	Min	Max	Comment
Add							

Inputs

Inputs from nature	Sub-compartment	Amount	Unit	Distribution	SD2 or 2SD	Min	Max	Comment
Add								

Inputs from technosphere: materials/fuels	Amount	Unit
Tempering, flat glass {GLO}| market for | Conseq, U	721,3	kg
Wood wool {RoW}| production | Conseq, U	164,3	kg
Polystyrene, extruded {GLO}| market for | Conseq, U	31,5	kg
Medium density fibreboard {RER}| medium density fibre board production, uncoated | Conseq, U	272,2*0,00075 = 0,204	m3
Roundwood, parana pine from sustainable forest management, under bark {BR}| softwood forestry, parana pine, sustainable forest manage	636,6/420 = 1,52	m3
Transport, freight, lorry 7.5-16 metric ton, EURO6 {RER}| transport, freight, lorry 7.5-16 metric ton, EURO6 | Conseq, U	2,5035*50 = 125	tkm
Electricity, medium voltage {DK}| market for | Conseq, U	1	kWh
Nylon 6-6 {RER}| production | Conseq, U	6	kg
Add		

Inputs from technosphere: electricity/heat	Amount	Unit	Distribution	SD2 or 2SI
Add				

SimaPro 8.:	Impact ass	Date:	24/01/2019	Time:	14.05						
Project	#BuildLife										
Calculation	Analyze										
Results:	Impact assessment										
Product:	1 p #BuildLife Unit (of project #BuildLife)										
Method:	ReCiPe 2016 Midpoint (H) V1.02										
Indicator:	Characterization										
Skip catego	Never										
Exclude inf	No										
Exclude lor	No										
Sorted on i	Impact category										
Sort order:	Ascending										
Impact cate	Unit	Total	#BuildLife Unit	Tempering,	Wood wool	Polystyrene	Medium der	Roundwood	Transport,	Electricity,	Nylon 6-6 {RER}| production | Conseq, U
Global warr	kg CO2 eq	1171,893	0	199,3207	14,13202	339,9874	223,491	314,8659	28,78013	0,034994	51,28073
Stratospher	kg CFC11 e	0,000916	0	4,09E-05	7,12E-06	0,000452	8,45E-05	0,000264	1,86E-05	1,71E-07	4,87E-05
Ionizing rad	kBq Co-60	-21,38316	0	-15,83902	0,438896	3,018406	-7,960413	-1,083182	0,047305	-2,76E-05	-0,005125
Ozone form	kg NOx eq	4,067127	0	0,421175	0,045328	0,249079	0,310269	2,915536	0,038418	0,000399	0,086923
Fine particu	kg PM2.5 e	6,426623	0	0,249711	0,027866	0,166086	0,553083	5,354543	0,03062	0,00013	0,044585
Ozone form	kg NOx eq	4,20698	0	0,428708	0,047803	0,270366	0,340657	2,988432	0,040613	0,000406	0,089995
Terrestrial a	kg SO2 eq	3,562512	0	0,71973	0,037114	0,371845	0,80724	1,423239	0,057412	0,000331	0,1456
Freshwater	kg P eq	0,278216	0	0,027614	0,005386	0,023198	0,159877	0,052084	0,007323	3,07E-05	0,002703
Marine eutr	kg N eq	0,034646	0	0,001183	0,000462	0,001848	0,011185	0,004814	0,00047	2,03E-06	0,014682
Terrestrial e	kg 1,4-DCB	1519,44	0	126,297	66,37528	181,5173	609,2215	238,4236	293,7661	0,785903	3,053043
Freshwater	kg 1,4-DCB	6,965959	0	-2,350572	0,267193	1,915048	5,194801	1,241883	0,57596	0,019878	0,101768
Marine eco	kg 1,4-DCB	11,34759	0	-2,401859	0,39222	2,654511	7,661916	1,963136	0,913768	0,024938	0,138958
Human carc	kg 1,4-DCB	24,98668	0	1,336012	0,790066	3,674	12,9181	4,59441	0,726405	0,00458	0,943106
Human non	kg 1,4-DCB	379,6828	0	44,90877	7,434812	50,49235	205,7792	46,0459	22,65969	0,234562	2,127493
Land use	m2a crop e	3081,012	0	-1,079533	129,8084	1,037918	156,7665	2792,246	2,038601	0,17623	0,017546
Mineral res	kg Cu eq	2,031515	0	0,136485	0,115658	0,1617	0,801169	0,722837	0,088191	0,000824	0,004652
Fossil reso	kg oil eq	318,9104	0	65,18378	4,182793	64,7128	72,95984	86,08681	9,781303	0,006978	15,99612
Water cons	m3	10,92531	0	1,499203	0,080547	2,425499	4,037761	1,326426	0,198124	0,000273	1,357473