EXPLORATIONS FOR REVERSIBLE BUILDINGS

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BAMB
BUILDINGS AS MATERIAL BANKS

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Figure 1 *Reversible GTB Lab Module produced at the ODS work-place in Ridderkerk including the Reversible Wooden Cassettes produced by The NewMakers.*

BACKGROUND

In past three years Reversible Building Approach to design and construction of buildings has been extensively researched within the EU H2020 BAMB project. **'Reversibility'** is defined as a process of transforming buildings or dismantling its systems, products and elements without causing damage to building and its parts and materials. Building design that can support such processes is **reversible (circular) building design** and can be key 'accelerant' of CE in construction.

Reversible Building is seen as a backbone of circular building and circular economy in construction. It is a driving force behind circularity of building materials and their potential multiple applications in the future. This book will illustrate key indicators of reversible buildings and how they have been explored through International Design Studios with students from seven EU universities including students of architecture, industrial design, and civil engineering. Through three thematic international design studios building design parameters which address spatial capacity of building as well as how to design new buildings while reusing 70 % of existing building product an element has been studied. The publication gives an overview of a broad exploration of factors that determent transformation capacity of buildings and reuse potential of building products and elements. The publication is published as E-Book and accessible to everyone interested in the new world of dynamic circular buildings enabling circular material streams through the built environment of material resources.

The International Design Studio results presented in this book have addressed two key elements of Reversible Buildings (i) spatial reversibility and (ii) technical reversibility.
International Design Studios in 2016 primarily addressed the spatial capacity of buildings to accommodate multiple functions and spatial configurations. Spatial reversibility defines the ratio between fixed and variable space and the capacity of variable space to accommodate different functions. International Design Studios in 2017 addressed the technical aspects of reversible buildings. Technical reversibility is about the design of the building structure considering individual recovery and exchangeability of building elements. The two key indicators of technical reversibly are independency and exchangeability of building elements and have been addressed during design studio works.

chap

ter 1

SPATIAL REVERSIBILITY

1.1

INTRODUCTION

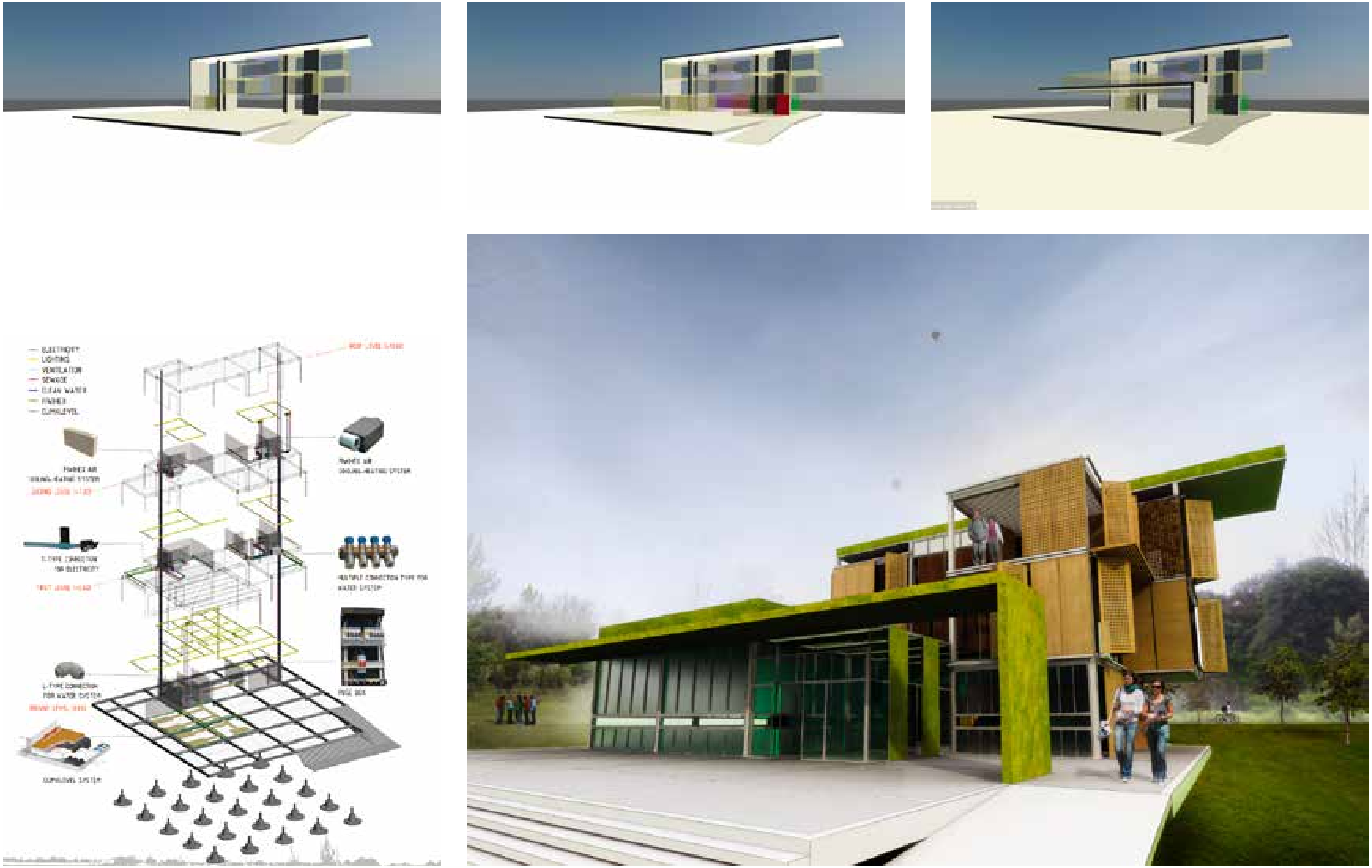

Figure 2 *Reference transformation model. Green transformable Building Lab version 1*

INTERNATIONAL DESIGN STUDIO 2016

This chapter presents results of International Design Studio (IDS) “Green Transformable Buildings” which was testing reversible design concepts for Green Transformable building Lab (GTB Lab), a pilot project of the European Buildings as Material Banks project (BAMB).

This IDS project focused on strategies for reversible building design approach and looked for new concepts and solutions for design of dynamic and circular buildings. IDS investigated the design approach to transformable buildings and how transformation models emerge.

The assignment dealt with the question of design of transformation model for a building that can be transformed from apartments to offices and to educational/ exhibition spaces. The design, approach, analyses and concepts will contribute to the construction of Green Transformable Building Lab which is constructed as a part of the IBA Labor site of the Internationale Bau Ausstellung Parkstad in 2020 (IBA Parkstad) near Maastricht.

Students of architecture and industrial design form three universities (Istanbul Technical University, University of Twente and University of Sarajevo) have been working in international design groups, each defining the constrains for their own transformation model and implementing the findings on concepts for Green Transformable Building. This chapter elaborates on the applied reversible building design methodology and students results.

DESIGN BRIEF

The design brief for the International Design Studio 2016 was: Develop an integrated design concept for a Dynamic multi¬purpose structure that will actively interact with changing climate, energy concept and boost material circularity.

Design should result with dynamic building structure balancing between the architectural form of the carrier of transformations as more stable part of the structure with upgrading possibilities and easy exchangeable/dynamic parts of the structure subject to easy customization and reconfiguring and upgrading. Challenge will be in careful design of integration of climate and energy and other installation concepts that allow for smooth transition from one use concept to another without demolition and waste generation activities. Such Green and transformable building structure will be used as a showcase and laboratory for dynamic and circular buildings.

This means that a flexible and dynamic structure needs to be put in place that will make different additions, replace¬ments and upgrade of use, energy and climate concepts possible. The studio work has been built on previously developed transformation model and design protocols. This studio was testing these concepts and made the stapes further to systematic development of building transformation models. Three groups have developed individual transformation models and one studio group has tested implementation of previously developed transformation model on the location for Laboratory for Green Transformable Building.

DESIGN ASSIGNMENT

To answer this brief requirements Design assignment dealt with four mayor elements:

1. Understanding spatial requirements for different use functions

Analyses and development of complementary spatial typologies for trans-functional/ transformable buildings

Result: number of transformation models representing different compatible typologies This has been elaborated in chapter 2.

2. Understanding the requirements for design of the core / carrier of transformation

Analyses of different structural forms representing the carrier of transformation and complementary energy and climate systems

Result: three principle solutions for design of transformation carrier (also testing the feasibility of the proposed GTB Lab carrier) This has been elaborated in chapter 3.

3. Understanding the process of integration of technical and spatial configurations into different compatible functional transformation models

Analyses of energy and structural concepts per use scenario and making provisions for their integration into different transformation models.

Result: three to four functional transformation models (also testing the feasibility of the proposed GTB Lab transformation model) This has been elaborated in chapter 3

4. Understanding dependences between esthetic, functional and physical systems of architecture

Architectural integration of dynamic spatial and technical parameters into a transformation models providing a physical(functional and esthetic) answer to the dynamic concepts of space use and circular building component/ material use

Result: Design principle solutions for three possible building use scenarios illustrating the form and functional changes This has been elaborated in chapter 3

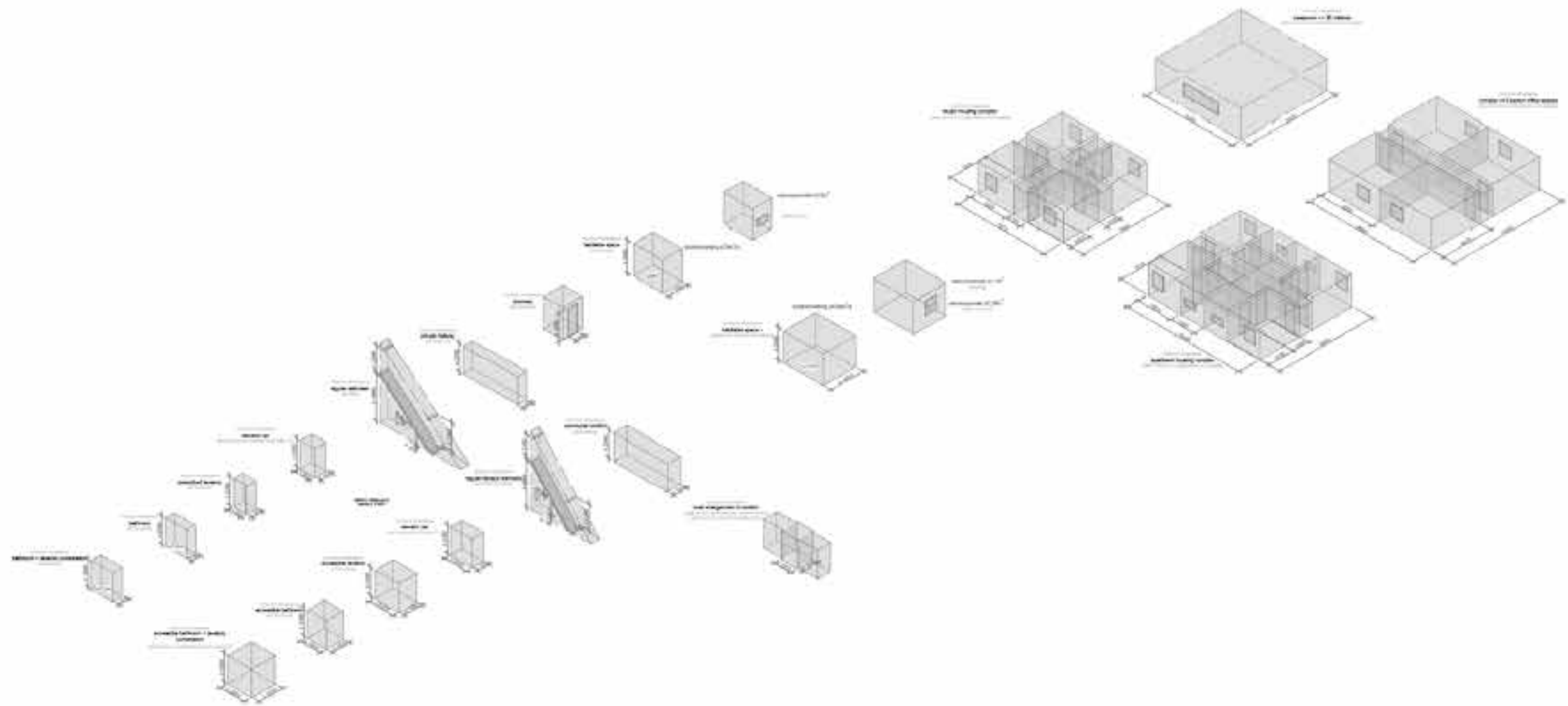

Figure 3 *Analyses of complementary spatial typologies for trans-functional/transformable buildings*

TOWARDS DESIGN OF REVERSIBLE BUILDINGS AND TRANSFORMATION MODELS METHODOLOGY

The ideal transformation model, that can answer all future scenarios, does not exist. Therefore it is important to understand spatial and technical performance requirements for different transformation scenarios and define a set of compatible spatial and technical constrains that will form one transformation model.

Transformation model sets up a number of constrains / system rules within which number of transformations are possible. In order to define transformation model compatible spatial and technical concepts need to be clustered. For example:

If we would see transformable housing (TH) as a sum of number of concepts that include use of studio housing, housing for elderly, urban family housing etc TH=h1+h2+h3

Transformable Office as sum of office concepts : cell office, open office, lounge office type TO=o1+o2+o3
Transformable Education as sum of education concepts: small classes, combined group classes, big class TE=e1+e2+e3

Mapping of spatially/ typologically compatible scenarios would help do define a cluster of compatible functionalities that can form one transformation model being for example:
TM1= h1+h2+h3+o2 +o3+e3

An example of one such transformation model is shown in the figure representing reference Green Transformable Building Lab.

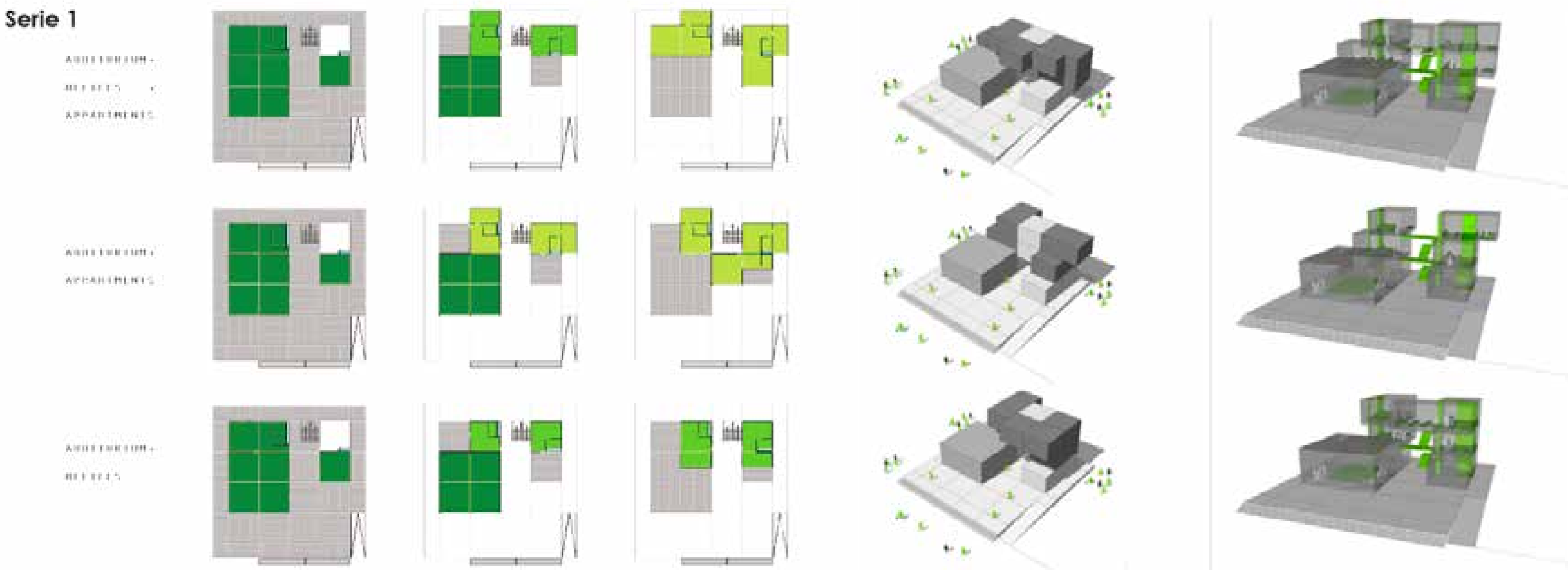

Figure 4 *Spatial transformation of functions*

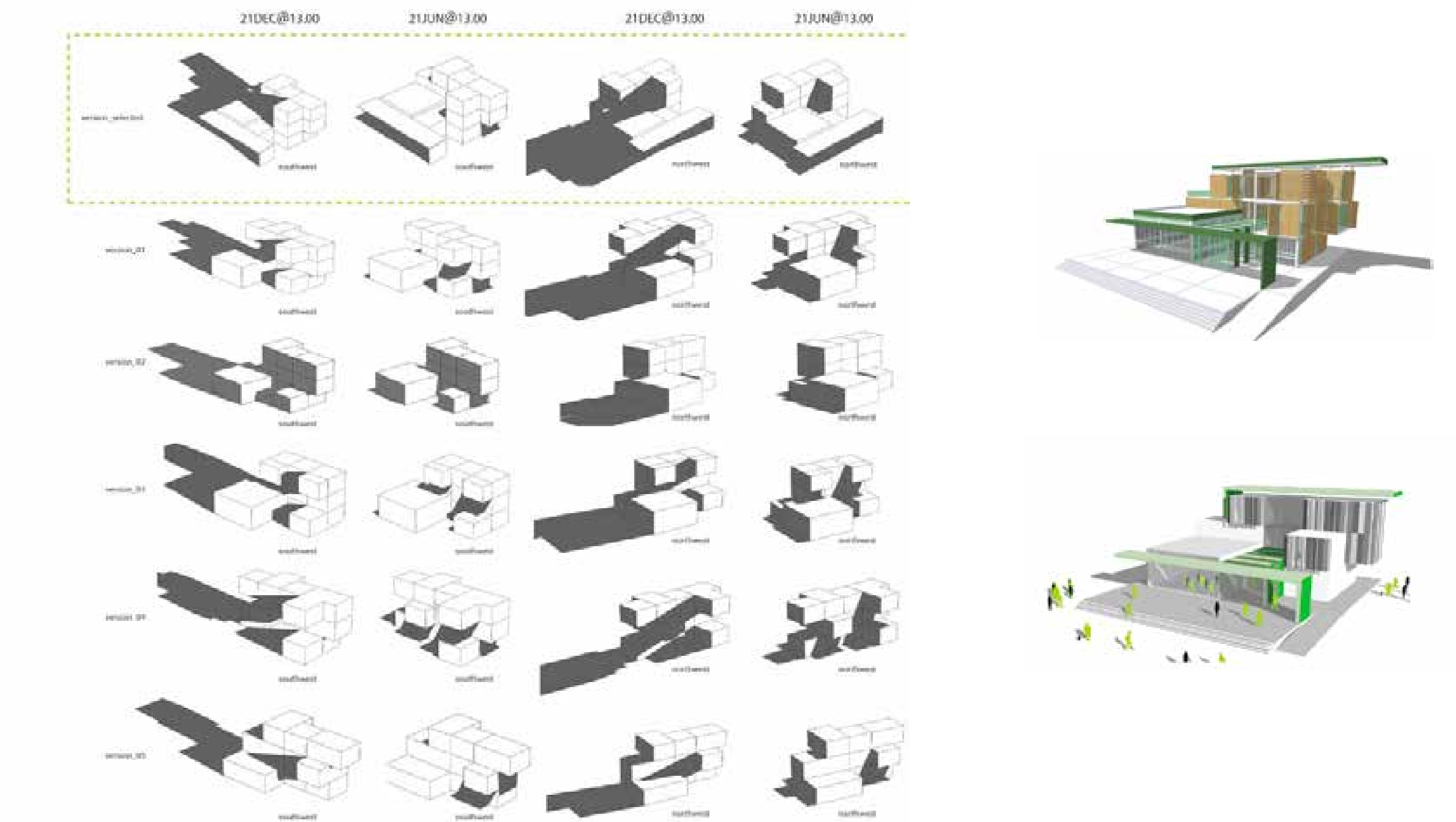

Figure 5 *Transformation scenarios within one model (Green Transformable Building Lab 1.0)*

One can cluster four major reversible forms of building and system design as presented in the table below. Different transformation models will emerge out of the combination of scenarios and reversible form the table. Students enrolled with International design studio 2016 where asked to research the spatial and technical constrains of transformation models that will facilities all 4 reversible forms and scenarios.

4 Reversible building forms

		BUILDING LEVEL	scenario 1	scenario 2	scenario 3	scenario 4
Reuse of building	1	**transfunctional**	housing	office	education	public
Reuse of building	2	**monofunctional transformation**	studio	urban family	eldery	disabled
Relocation of building	3	**transportable**	location A	location B	location C	location ...
Extend and reconfiguration of building	4	**1+2+3 transformable**	extendable	transfunctional	monofunctional transformation	transformable

Next to the spatial mapping, technical mapping plays also an important role. Technical mapping shapes in the end the physical career of transformation with its boundary conditions. Seven forms of carrier of physical transformation have been presented to the students enrolled with International Design Studios and each group of students has chosen one core principle to investigate its transformation potential. The results of this investigation are summarized in chapter 2.

		SYSTEM / component LEVEL				
Reconfiguration / Reuse of system	1	**transfunctional**	PARTLY reuse	reconfigure to other functionality	PARTLY reconfigure to other functionality	PARTLY UPCYCLE
Reuse of system	2	**monofunctional transformation**	reuse	reconfigure to adjust to new use scenario	PARTLY RECONFIGURE	PARTLY UPCYCLE
Relocation of system	3	**transportable**	reuse in other building	reconfigure to adjust to other building		
Extend and reconfiguration of system	4	**1+2+3 transformable**	PARTLY reuse	reconfigure to other functionality / use scenario	PARTLY replace to other location	PARTLY size adjustment or addition

Figure 6 *Four forms of reversible building design (Durmisevic, 2015)*

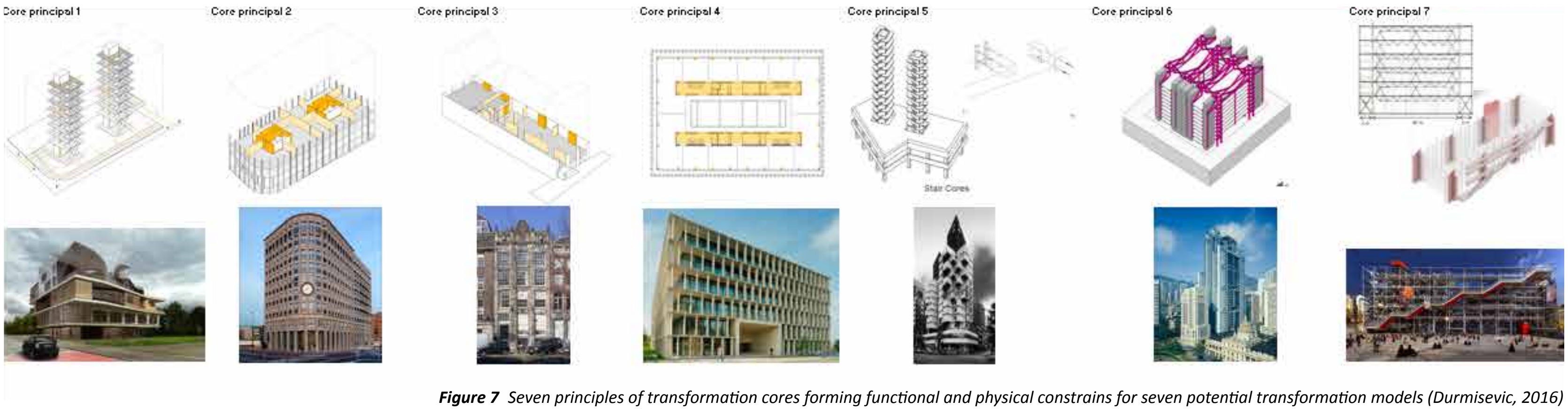

Figure 7 *Seven principles of transformation cores forming functional and physical constrains for seven potential transformation models (Durmisevic, 2016)*

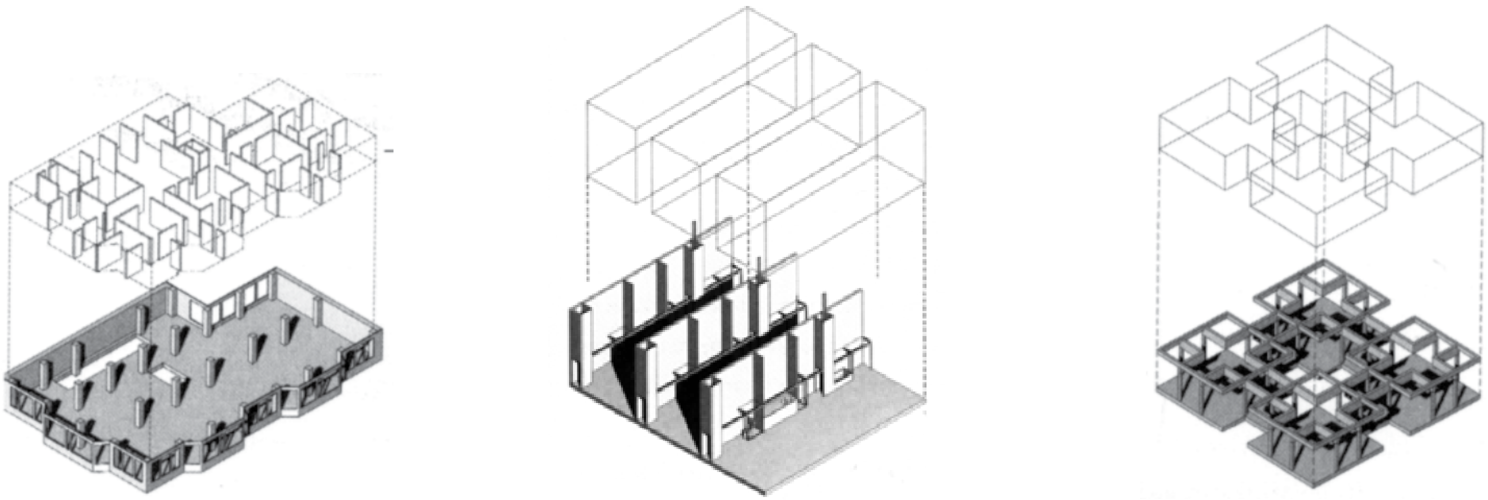

Figure 8 *(Leupen , 2004)*

METHODOLOGY USED DURING DESIGN STUDIO 2016

The Design protocol developed by Durmisevic (2006) has been used as a reference for this assignment that was based primarily on the research by design. The focus of this studio was on the first 3 steps of design protocol below:

Design Protocol for design of Dynamic and Circular buildings:

STEP 1
Definition of the transformation performance through specification of the long and short term use scenarios.

STEP 2
Shaping transformation model through mapping of spatial and technical Framework.

STEP 3
Based on specification of integrated transformation model the form, position and hierarchy of elements defining carrier of transformation and variable elements can be defined .

STEP 4
Independence and Life cycle coordination will indicate the disassembly sensitive parts of the systems.

STEP 5
Design of exchangeable connections between fixed and variable components.

STEP 6
Evaluation by use of the knowledge model in order to match the design solution with desired performance indicators (TC and RP)

Each transformation scenario / type of required flexibility will result in different hierarchy and composition of components and their final configuration.

STUDENTS AND TUTORS

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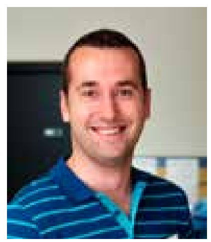

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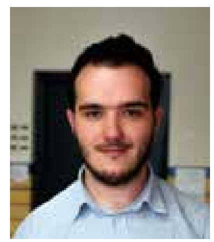

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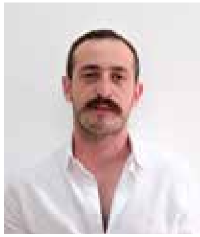
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Samed Tezgah


Babür Tüzer

1.2

DESIGN OF THE CORE AND ITS CAPACITY

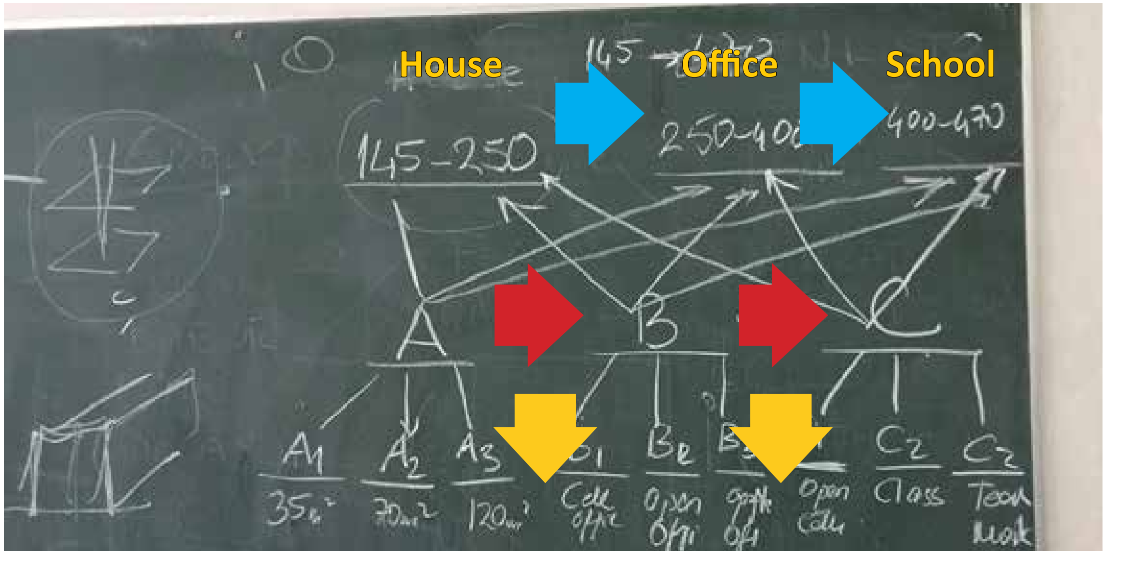


Figure 9 *Design studio assignment (Durmisevic, 2016) for the understanding how transformation models emerge and system roles/constrains behind the transformation models*

METHODOLOGY AND OBJECTIVES - RESEARCH BY DESIGN

Assignment for Design Studio 2016 has been split into two parts.

The first dealt with definition of transformation models and understanding their boundaries. Second part dealt with implementation of transformation models on the specific project location.

The first set of Design investigation was organized around the analyses of transformation models that will support transformation from function A to B and to C including the expandability from 145m2 to 250m2 to 475m2.

Student have been divided into 10 groups out of which first 8 Transformation models have emerged. Groups have been rearranged and each was asked to integrate technical and climate concepts into the transformation models in the second evaluation cycle 5 transformation models remained as model that have been used as a starting point for design of GTB lab concept on the specific location. The evaluation methodology is presented at the end of this chapter.

CHAIN CORE CONCEPT

TRANSFORMATION CONCEPT 1

CHAIN CORE

Ruud Brnkhuis
Lena Löhner

The starting point of the chain core concept is basically one central core and supporting columns on the flanks of the buildings. The core serves as the main fundament of the structure and provides space for inner infrastructures, such as piping, ventilation, staircases and elevators. As a result of the spatial requirements for the different use scenarios, three scenarios are created for housing, office and education. The basic footprint of the building is 12 x 12 meters. In order to have freedom in the size of different spaces, the core is placed off-center. Since the core is 2 meters in width, the surface area can be divided in 12 x 6 meters and 12 x 4 meters. Because of the larger front areas, it is possible to have an open office of 60 square meters or two classrooms of 30 square meters. The back areas can be filled with smaller office cells or the kantine. In each scenario, the core has the same functionalities. The wet spaces are situated on the sides of the core and in between are the vertical communication, staircases and elevators placed. The strength of this principle is that each space can be arranged in different settings, there are no restrictions in placement as long as the spaces fit in the front area or the back area. In terms of extendability, on the front and back side, new modules can be added. These modules cantilever 2 meters and provide additional space. Each building can be chained to another building, through connecting two cores with floors. The benefit of this is that there is no need for an additional 'third' core in between two buildings.

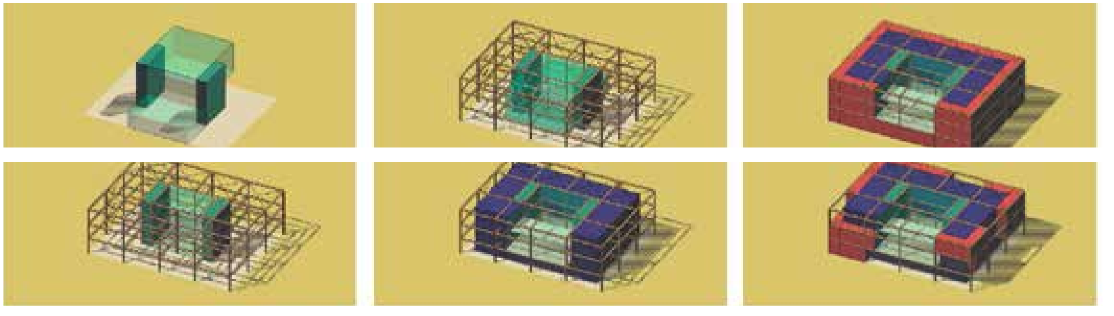


Figure 10 *Transformation models*

Figure 11 *Housing plan*

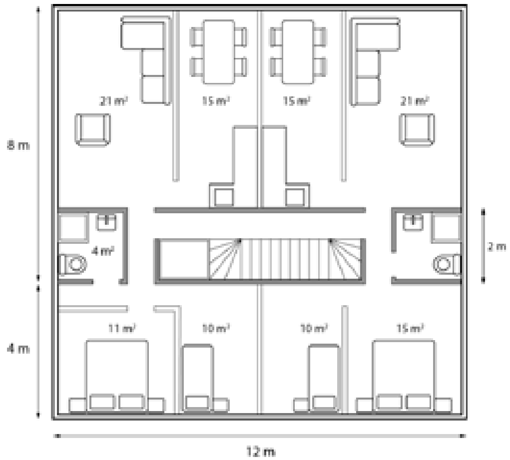
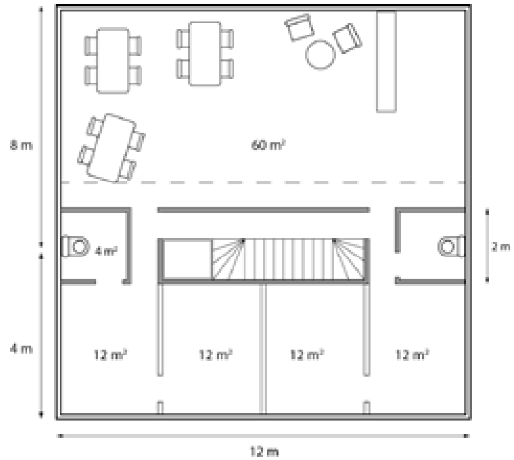


Figure 12 *Office plan*



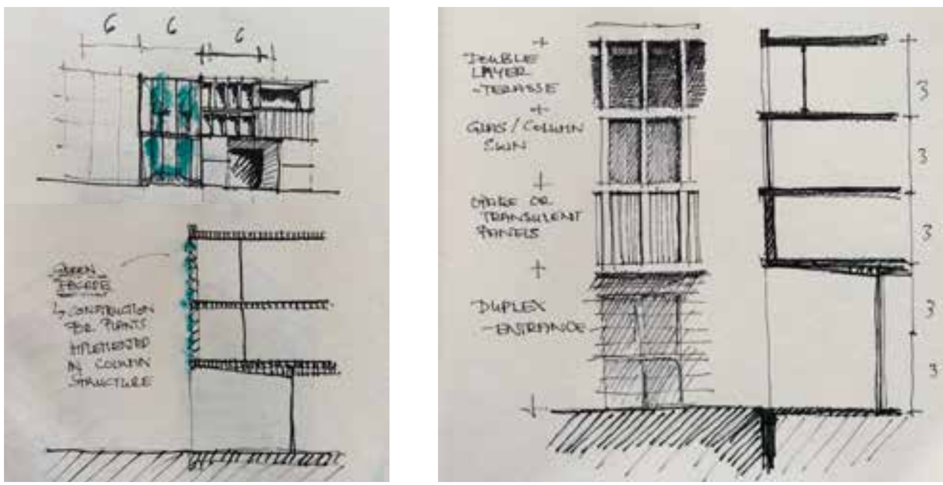


Figure 13 *Section and facade view*

Figure 14 *Renders*

THE INBETWEENER

TRANSFORMATION CONCEPT 2

LONGITUDINAL CORE

Erkan Akan
Erkan Aybar
Babür Tüzer

The starting point of the longitudinal core concept are two peripheral cores accommodating the main vertical structure including vertical communication, vertical installation services and stability element. Such concept frees the space in between of fixed vertical elements and enables great level of flexibility in spatial configuration and variety of infill systems to be applied.

The basic footprint of the core is 15m x 3m which is accompanied with basic footprint of ca 250m2. Because of the larger front areas, it is possible to have an open office or classrooms as well as apartments with ca 120m2. Building services are feed into the space through raised floor and under the ceiling.

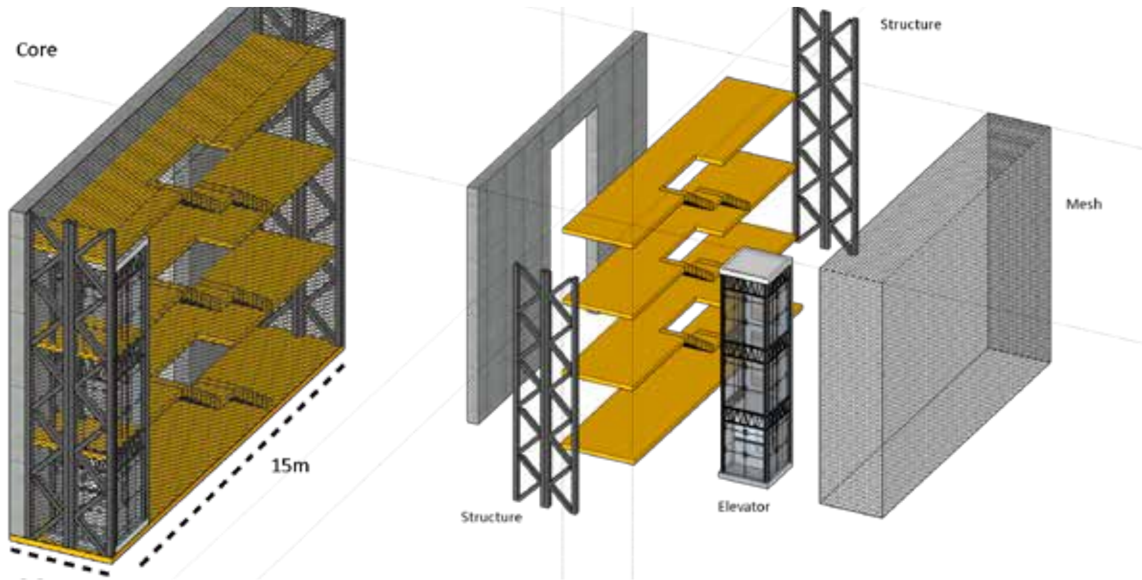


Figure 15 *Exploded view core*

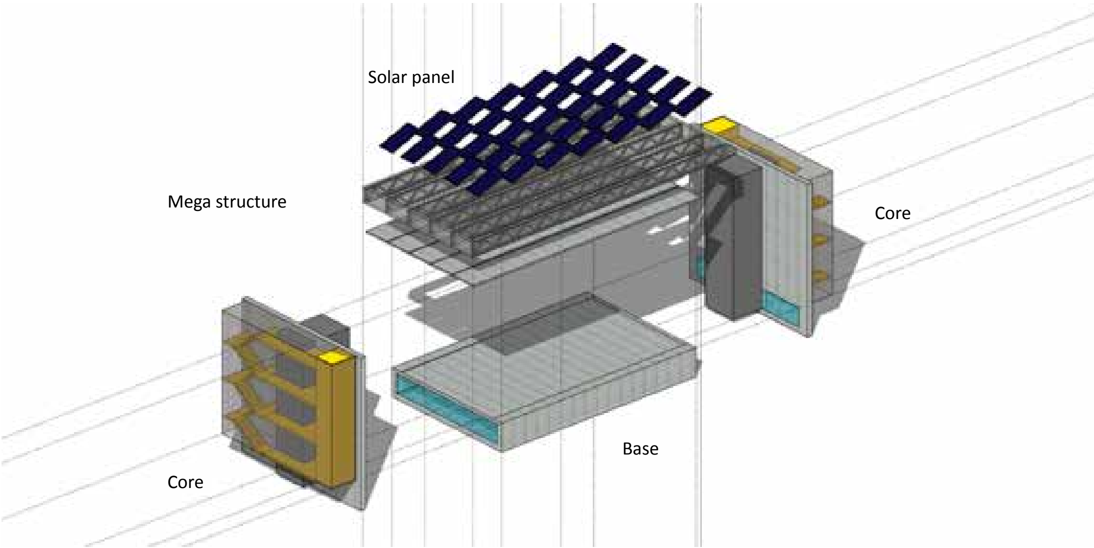


Figure 16 *Isometric perspective*

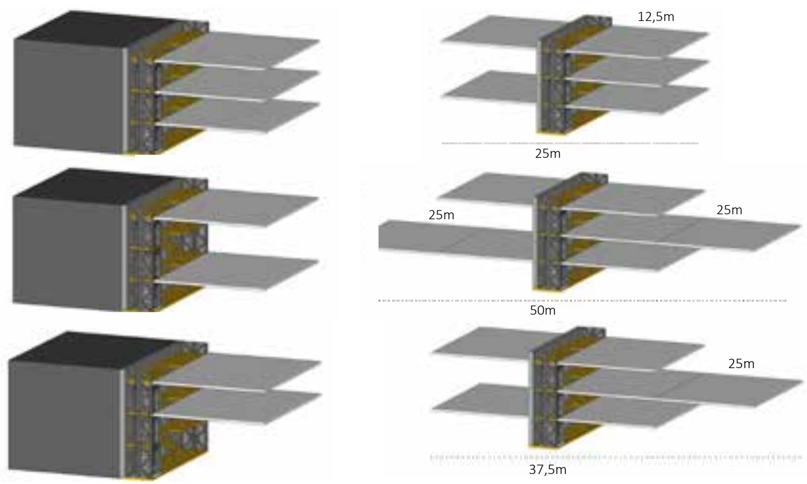


Figure 17 *Core capacity*

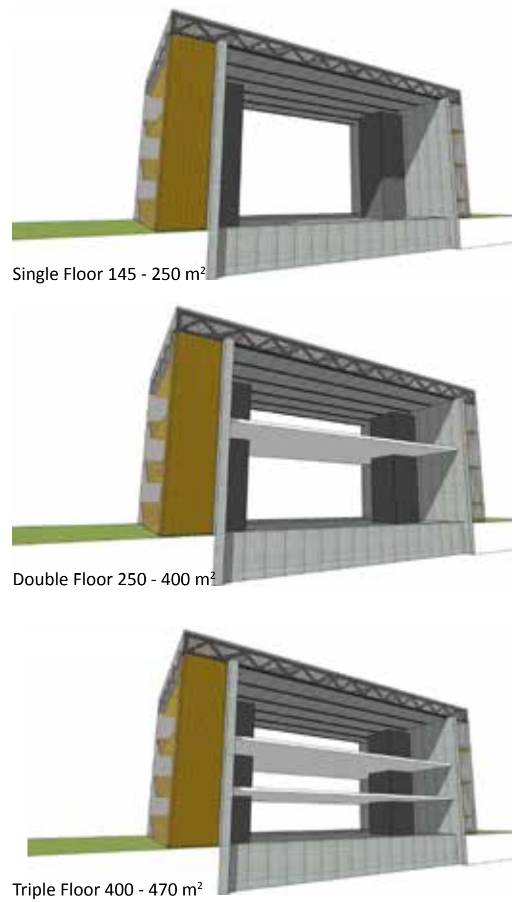


Figure 18 *Flexibility*

THE FLAVIO CONCEPT

TRANSFORMATION CONCEPT 3

SUPER STRUCTURE CORE

Çağlasu Altinkaynak
Marc van den Berg
Esra Dem
Sejla Hasanbegović
Han de Jong
Flavio Mancuso

The core of this concept is a big steel outer structure, which carries the ceiling of the modular units at the ground floor. This ceiling also functions as a green area on the roof, which can be for example a garden office or small gardens for residents cq. bigger public garden. The idea is that this roof gives back green area which is taken from the ground. The outer structures contains movable panels which are covered with solar panels, which can always be directioned to the sun. Besides, the panels can close the inner space from sun. A grid at the bottom and at the top can be opened or closed to circulate air flow (cold) air in order to regulate the inner climate and to let fresh air flow in. On the ground floor modular units with different functions are placed according to the current function of the lab. When the lab needs to be extended, one extra steel beam will be added in order to extend the core. Different units can be added or several units can merge into fewer bigger units. Different options are possible: for example for the residential function, an inner corridor can be created to reach the different houses, which also make place for small private gardens. In the case of living or education, this can be filled up classrooms or offices.

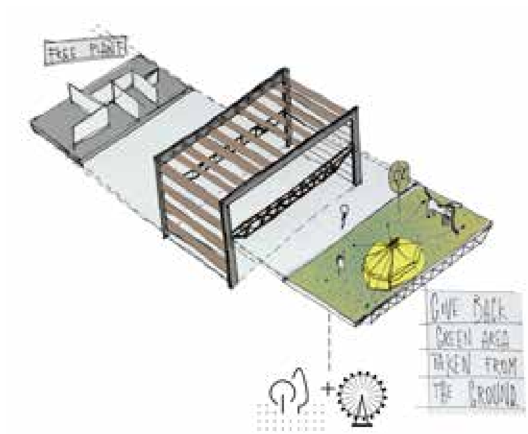


Figure 19 The concept

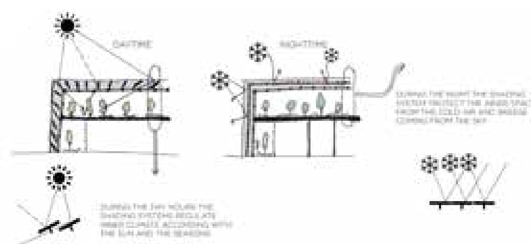


Figure 20 Climate system

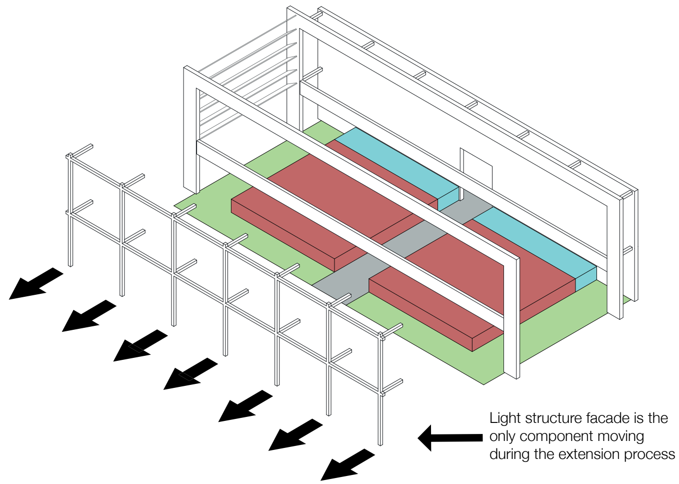


Figure 21 *Modules extension process*

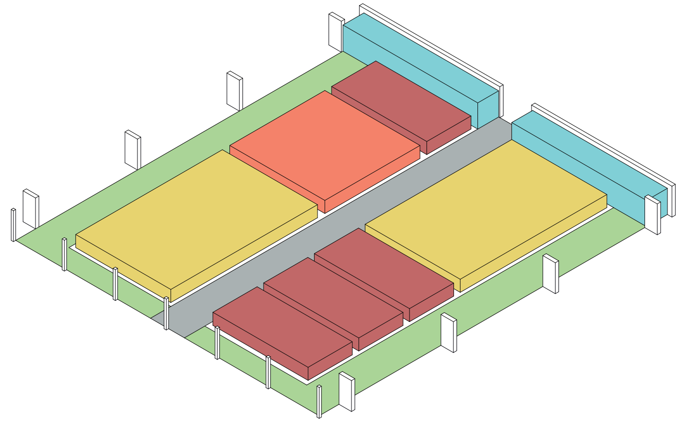


Figure 22 *Detailed organisation of differen functional modules*

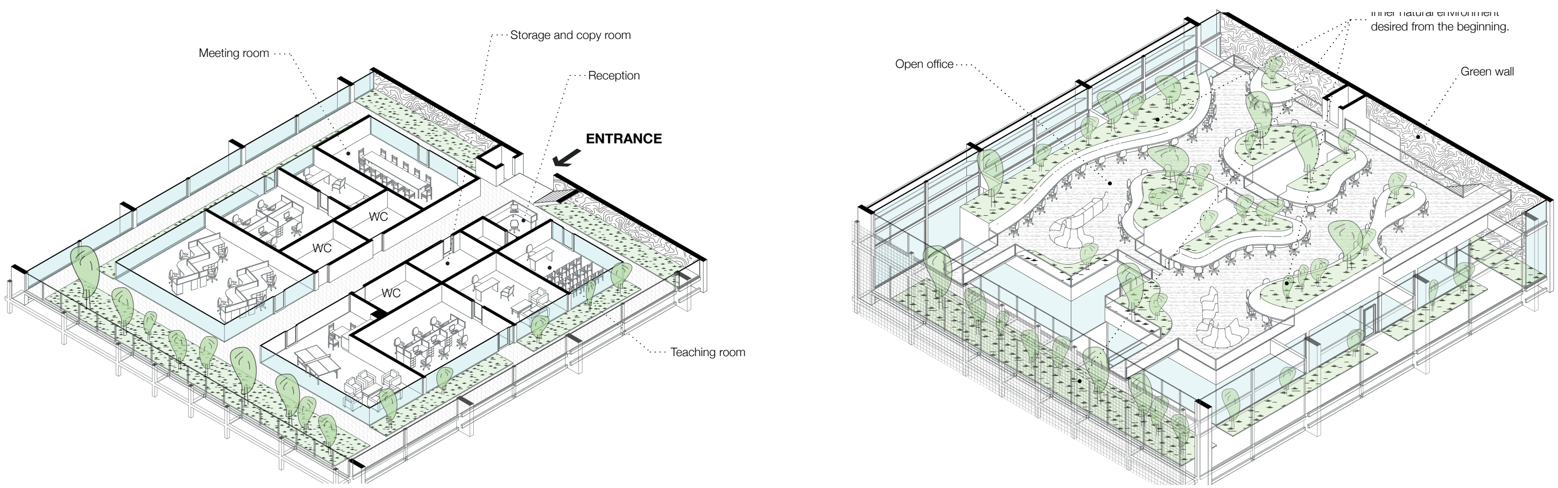


Figure 23 *Left: first floor with office functionality; Right: indoor garden on the second floor.*

LINEAR CORE

TRANSFORMATION CONCEPT 4

LINEAR CORE

Murat Nizam
Çiğdem Nur Kebapci
Samed Tezgah

The chosen core concept is a linear core which has more possibilities to extend and to connect in different ways with different variations. Thanks to the linear core, users can reach the spaces easily wherever they are located. Vertical cores include stairs, elevator and service shafts and there can be multiple if needed.

Possibilities of transformation;
Having different site plans (L, U, I shaped building islands)
Using the gallery as a common public space; galleries and staircases can be modular and demountable
Spatial transformation withint the spaces. Inner walls are modular and demountable, with a possibility of sliding.

Transformation model (functional mapping)
Components (Columns, Floors, Walls, Glasses etc.) are prefabricated and they are demountable and easily replacable, because of the use of modular system, defined by modules of 1,5 m x 1,5 m. Also the spaces can change their program easily with interior transformation.

Pro's and Con's of the elaborated core concept.
+ Modules can be combined to form a larger housing neighborhood. Corridors can be lit with natural lighting and are suitable for natural ventilation. The roof and the facade have a lot of potencial for photo voltaic energy production. Program can change and adapt however needed, since all the vertical and horisontal circulation is inside the core.
- The size of core is larger.

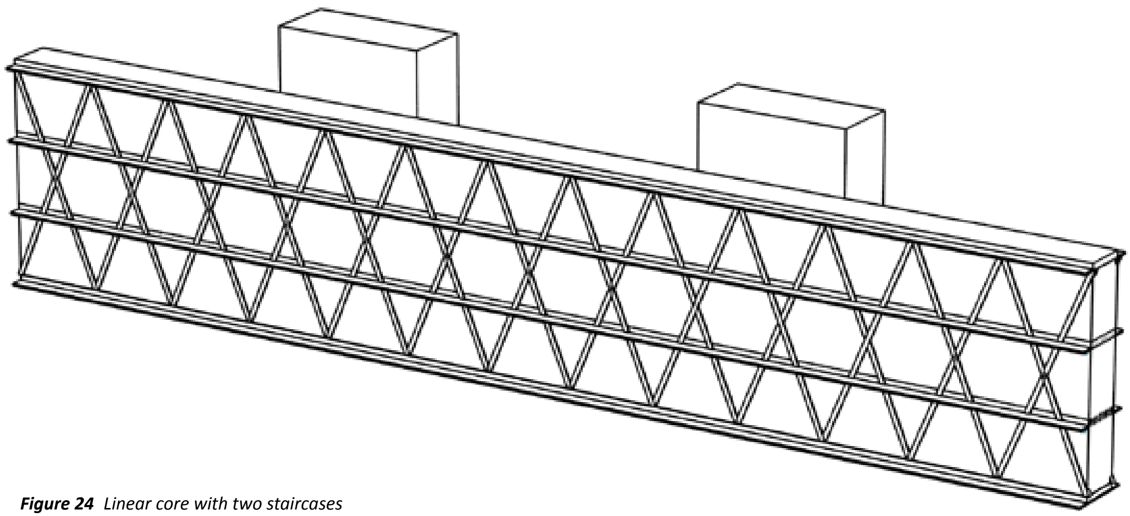


Figure 24 *Linear core with two staircases*

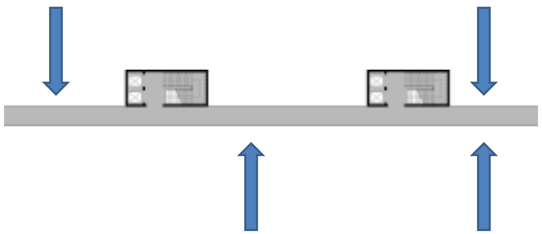


Figure 25 Topview of the core showing the hallway and staircases. The blue arrows indicate how the modules can be connected.

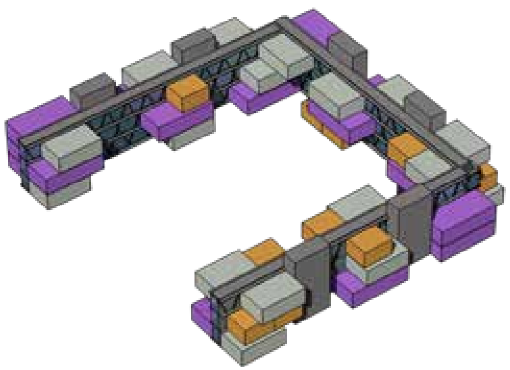
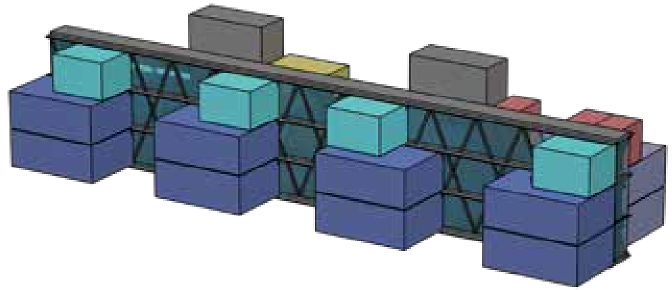
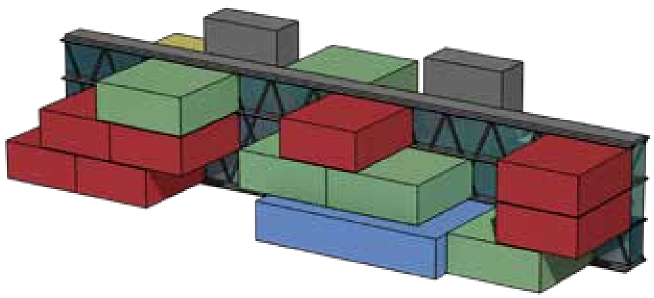


Figure 26 Example transformation possibilities



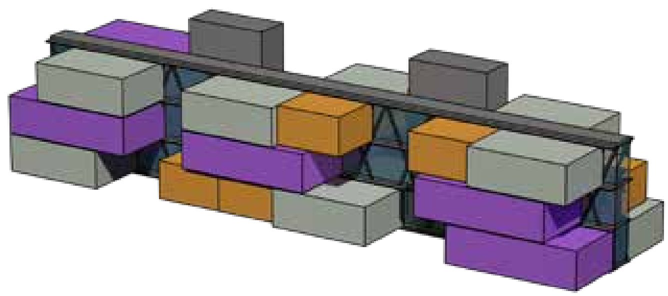
Modules
35 m2 Management Office
70 m2 open classroom
140 m2 Standart Classroom
280 m2 Library/conferance hall

Figure 27 Use Scenario 1 – Education System



Modules
90 m2 Cell Office
180 m2 Double Cell Office
250 m2 Open Office

Figure 28 Use Scenario 2 – Office System



Modules
45 m2 Housing 1
70 m2 Housing 2
120 m2 Housing 3

Figure 29 Use Scenario 3 – Housing System

TRANSFORMATION CONCEPT 5

CENTRAL CORE CONCEPT

Anil Akay
Ece Atasoy
Pieter Beurskens
Vedad Colo
Tuğçe Tarhan

The study executed by Anil Akay, Ece Atasoy, Pieter Beurskens, Vedad Colo and Tuğçe Tarhan departed from the central core concept, based on the NEST project, developed by ETH Zurich. The central core concept is called as such, considering the vertical circulation area and vertical installations are located in the middle of the building design. In order to fit the transformation brief, we started with functional mapping from the biggest scenario towards the smaller scenarios, to define the minimum required size of the central core. The educational requirements for the circulation area were found normative for the stair width to be 1,8m, next to that the requirement to be 100% accessible for disabled people required an elevator, resulting in an internal core size of 6x6,6m. This size allows the core to fit all scenarios without any structural adaptations, which can also be called the passive transformation capacity of the design. Furthermore, the core is developed following a modular grid of 300x 300mm.

The base scenario, which can be seen as the start situation of the building with its main structural elements, consisting of the cantilevered roof and bottom floors that are connected to the central core, creates a column free space with maximum floor plan flexibility.

The first functions will be housed on the bottom floors and later when extension is required, following the design brief, another floor can be hanged to the roof to create extra space, without disturbing the bottom floor plan with columns. As a concluding remark, there can be said the central core requires quiet an amount of space, which could be argued as a design flaw, if the building is used for the small scenario.

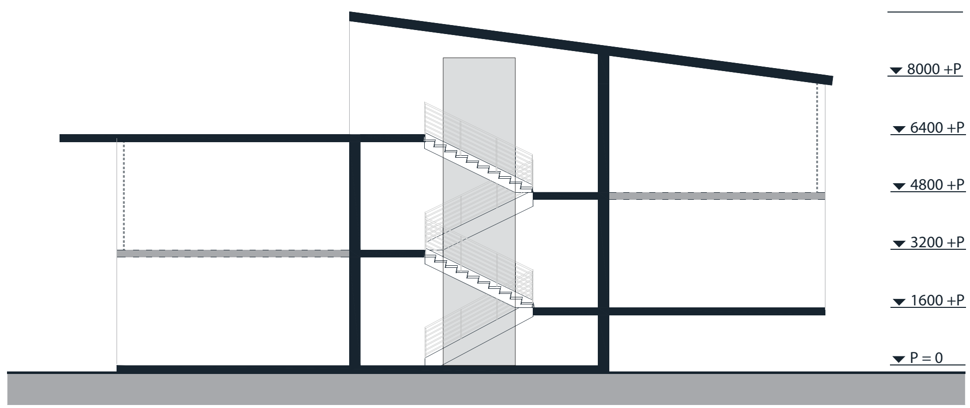


Figure 30 *Section - base scenario*

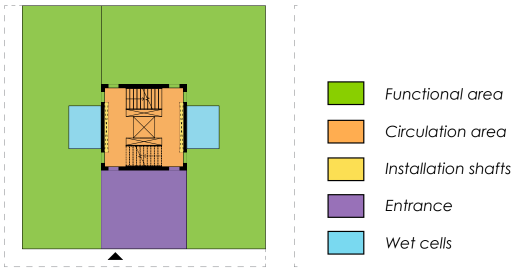


Figure 31 Floor plan concept

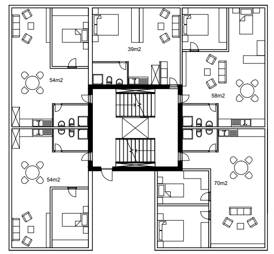


Figure 32 small housing plan

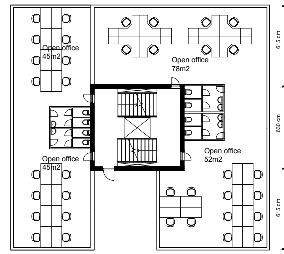


Figure 33 Open office plan

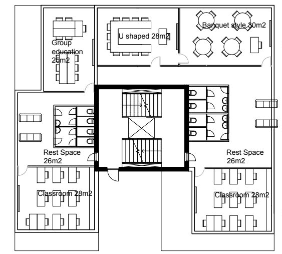


Figure 34 Education plan

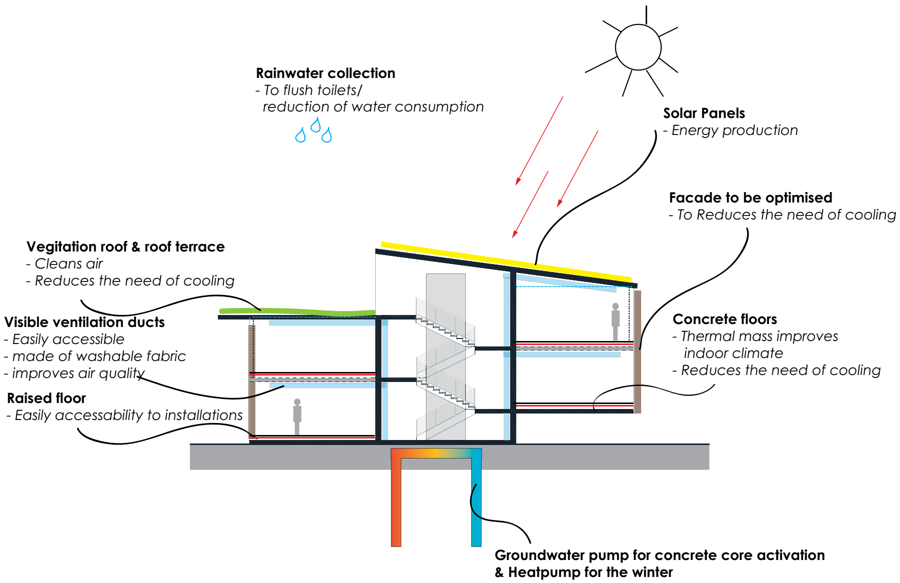


Figure 35 Integration climate concept

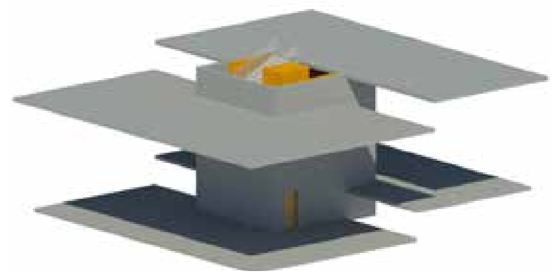


Figure 36 3D view core - base scenario

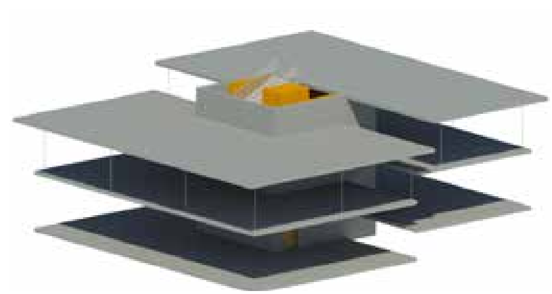


Figure 37 3D view core - expanded scenario

TRANSFORMATION CONCEPT 6
SUPER STRUCTURE CORE

Patrick de Laat
Harun Sabljaković
Joska Sesink

The core concept that provided the starting point during the Sarajevo Design Studio was a superstructure. Inspired by greenhouses it was decided to create a load bearing core creating a non-climatised buffer climate for the functional modules, offering an innovative and low energy climate concept. Shielding the modules from outside weather conditions provided the possibility to construct lightweight, energy- and cost efficient modules that can be arranged throughout the space. During the concept development there was evolved through rigid and more dynamic arrangements of the functional spaces.

A modular basic module was selected, which can be combined to provide larger spaces and enable customisation for the different spatial requirements derived from the different use scenarios for housing, education and office spaces. The different transformation scenarios dictates the number of functional modules that are to be arranged in the superstructure and thus determines the volume that is occupied within the core. The transformation model potentially creates the possibility for quick and easy transformation of functionality and surface area. Nevertheless the concept faces difficulties in regulating the climate during summer. Simultaneously the volume is inefficiently used in the smaller scenarios as there is a large empty space within the core, and extension or reduction of the core is an effortful and costly operation.

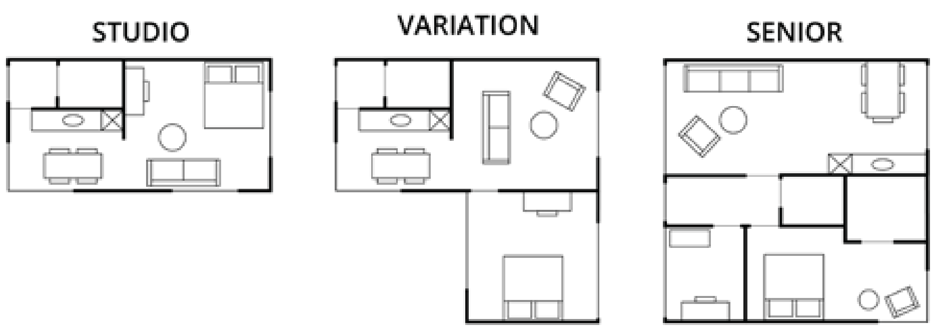


Figure 38 *Modudularity of the different housing functionalities.*

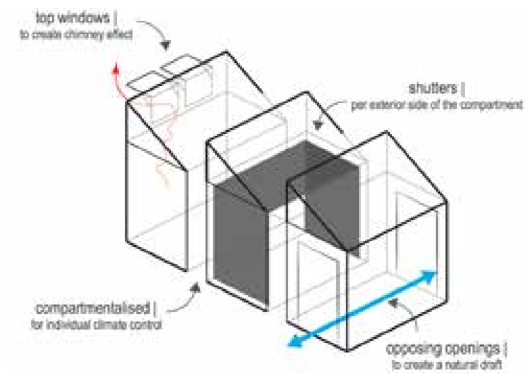


Figure 39 *Climate concept elements*

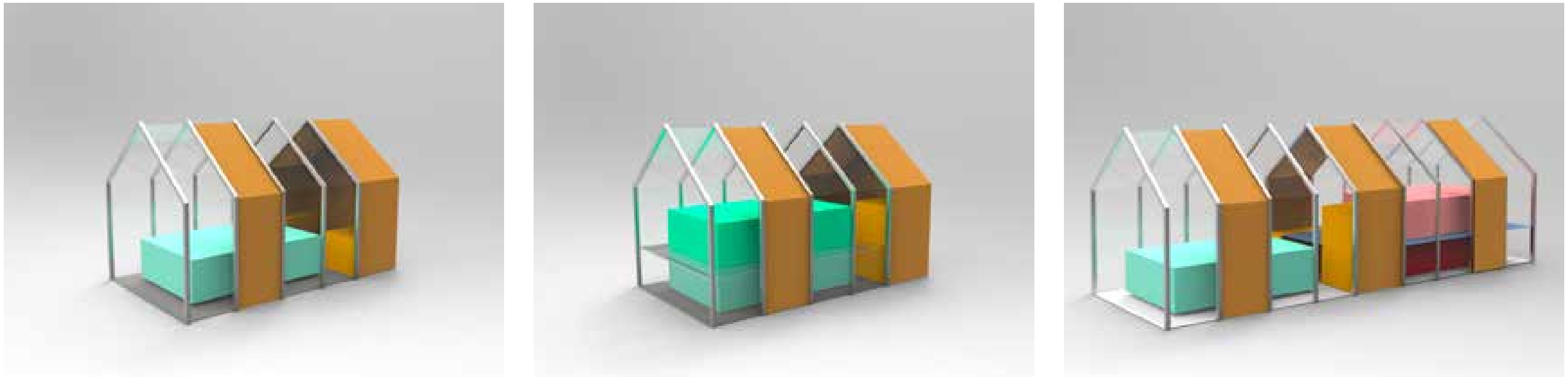


__Figure 40__ Concept evolution. __A.__ Initial design; __B.__ Final design with improved transformation capacity

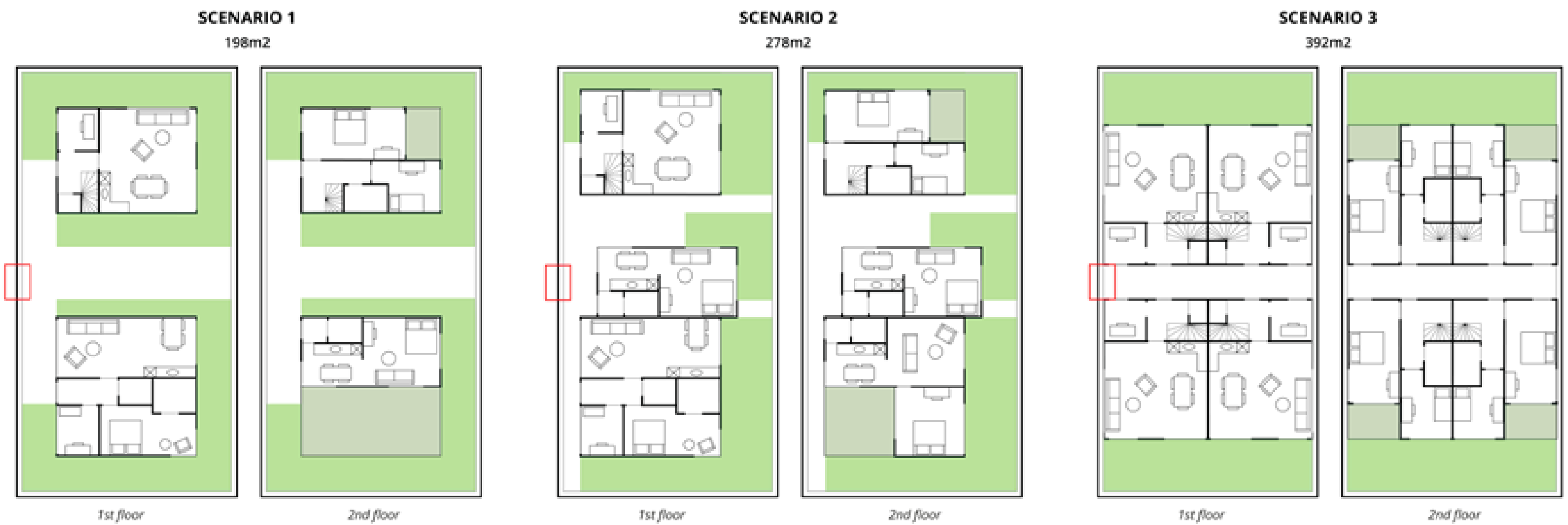


Figure 41 *Climate concept elements*

TRANSFORMATION CONCEPT 7

CENTRAL CORE

Hieu Nguyen
Deniz Mahmutović

For this concept the central core concept was chosen. To make optimal use of the building typology, the building will be expand around the core The initial idea was to have equal units which would expand by merging with each other. First approach was to have rectangular floor plan. After few attempts it was decided that it is impossible to equal units with this kind of configuration, because corner units could not have communication with a core. We concluded that hexagonal base would enable us to have equal unit that are at the same time connected for the central core.

After it was decided to use hexagonal floor plan of the building, the next step was to design units for each function that would be included inside like: offices, education and apartments. For each function several types were developed: small, medium and large.

Small apartment (1 unit) was designed with students in mind. It consists of living room space witch is at the same time sleeping area, small kitchen and work area. At the entrance there's a hall form witch user can enter main living space or toiled. Medium apartments (2 units) are for small families. After entering apartment there's toilet on the left, washing room on the right. On the outer rim of the apartment there are main living area witch consist out of living room, kitchen and dining room, next to this space children room is positioned next to it a bed room. Large apartment (3 units) is for family with two children. There's a circular communication between entrance, living room, dining room kitchen and storage space, at the same time those space are divided, so it provide good environment for everyday living. Bedrooms and toilets are isolated so feeling of privacy is provided.

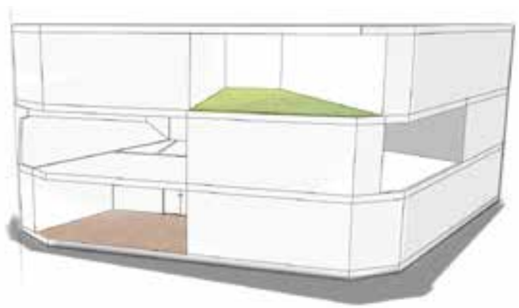


Figure 42 *render*

Form of the building is formed by combining opened and closed spaces/units and terraces. Combinations are limitless, so.

Figure 43 *Floor plan*

Figure 44 *Different functional modules*

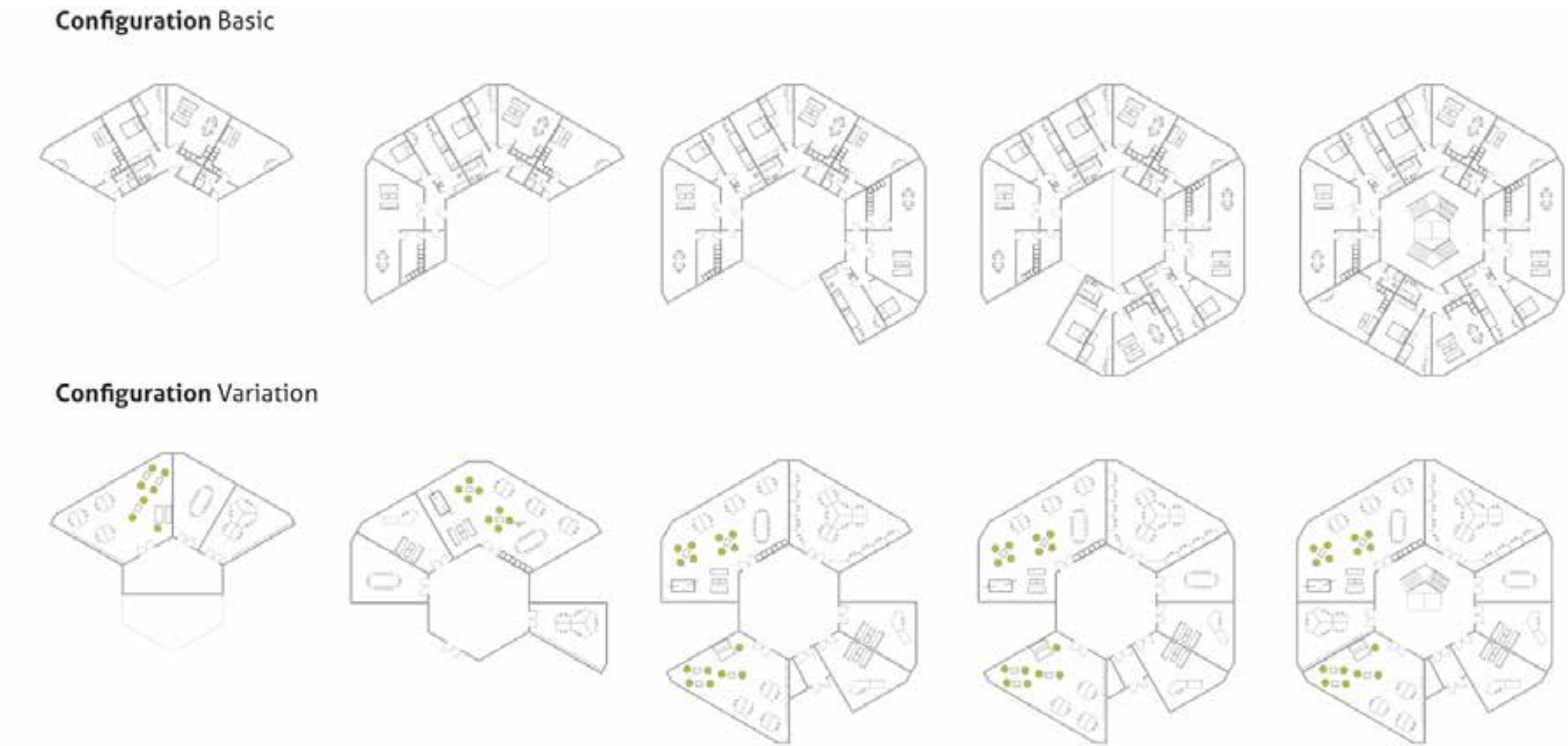


Figure 45 *Transformation models*

TRANSFORMATION CONCEPT 8
SUPER STRUCTURE CORE

Çağlasu Altinkaynak
Marc van den Berg

Based on the Centre Pompidou (Paris), the starting point for exploration of a transformable building design was a superstructure. In this concept, the load-bearing structure and the installations form an outer shell that provides transformation possibilities within. We developed a draft design of a building that consists of a ground floor of about 150 m2 in the base use scenario. This building then extends in the first and second use scenario by stacking one or two floors on top of the ground floor. A staircase from glass is added at the outside of the building in those two scenarios. This superstructure as core principle offers much horizontal freedom and flexibility. However, our analysis also revealed that it restricts the position of certain rooms in the building (like the wet cells) and that daylight issues might arise due to the large horizontal span widths. A potential improvement is therefore to extend the superstructure horizontally instead of vertically.

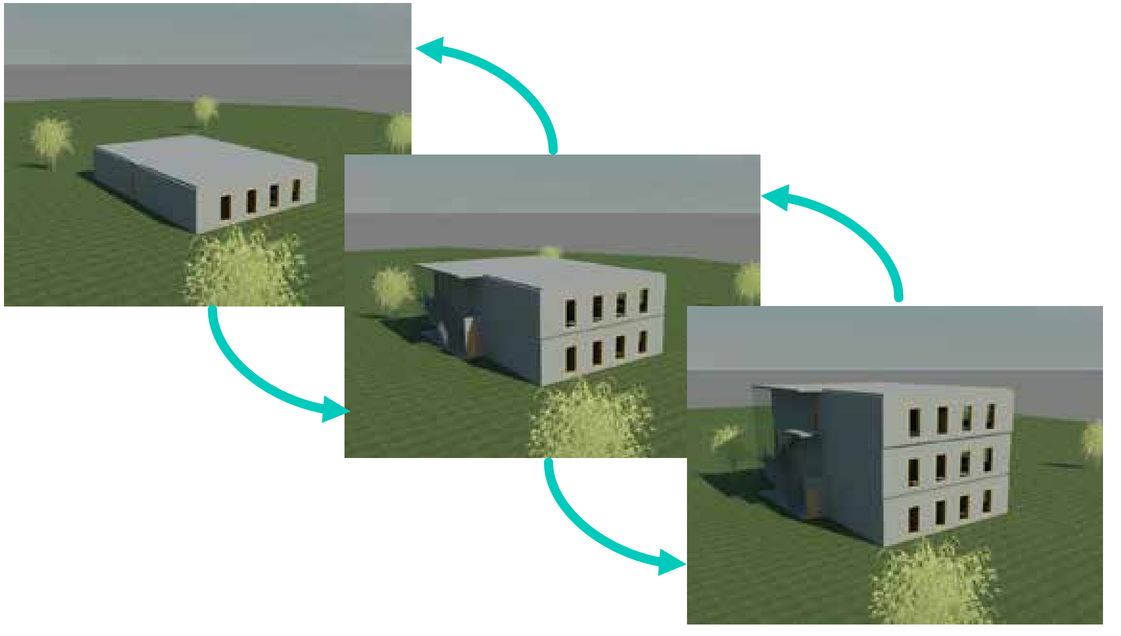


Figure 46 *Transformation concept*

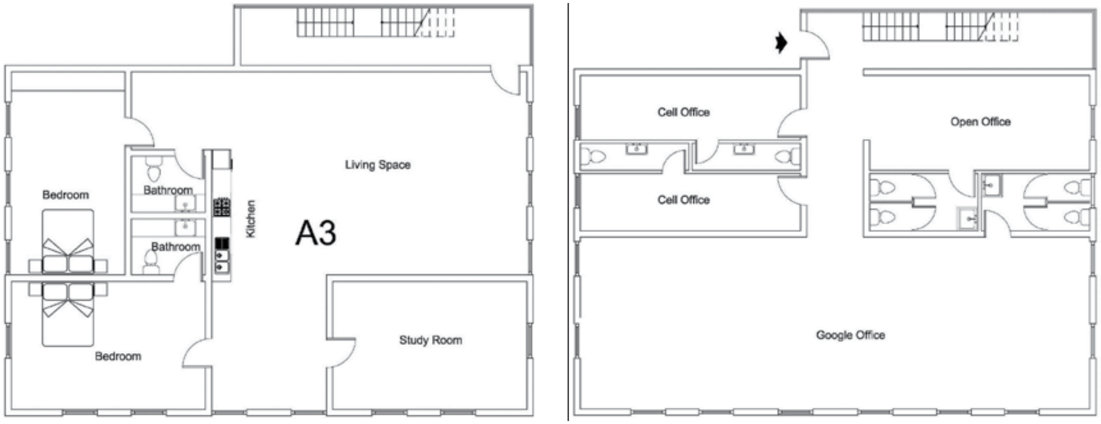


Figure 47 *Housing Floor plans -1st, 2nd and 3rd floor*

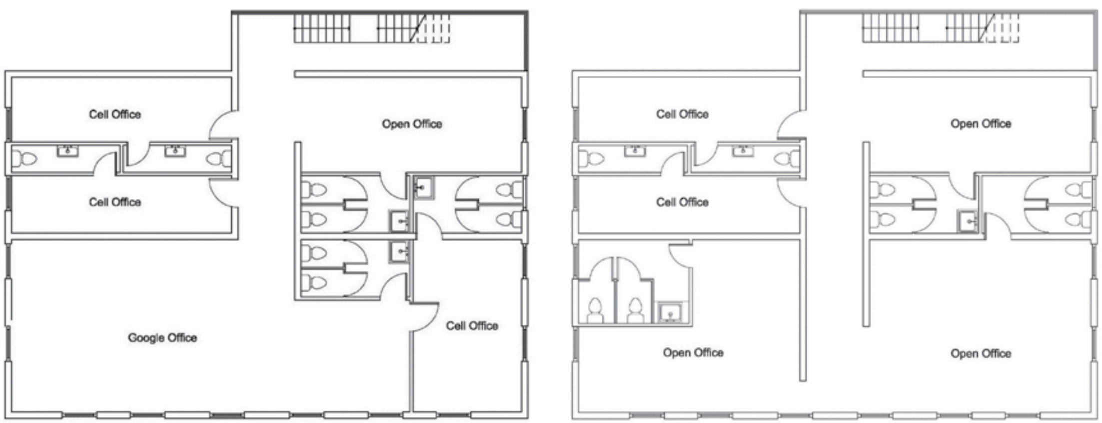


Figure 48 *Offce Floor plans -1st, 2nd and 3rd floor*

TRANSFORMATION CONCEPT 9
CENTRAL CORE

Esra Dem
Sejla Hasanbegović

The starting point of the central core concept is one central core which is accommodating the main vertical structure including vertical communication, vertical installation services and stability element. Such concept frees the space around the core. However, the downside of the concept lays in the fact that natural light and ventilation is available only from one side, the space around the core has spatial limitations due to the specific loadbearing concept. Spaces cannot be combined in two directions because of the core in centre which create barrier between the two spaces. Only combination possible is longitudinal which is not always suitable for classrooms.

Figure 49 *Reference project*

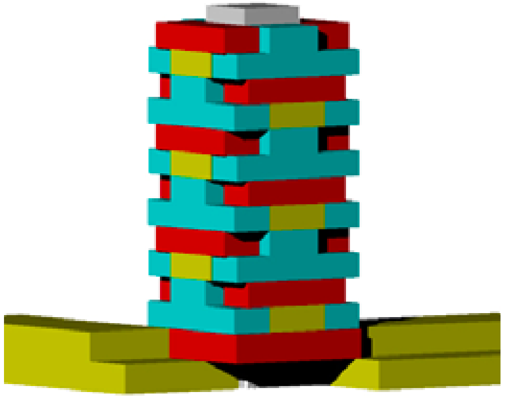


Figure 50 *Tower model*

Figure 51 *Floor plan transformation models*

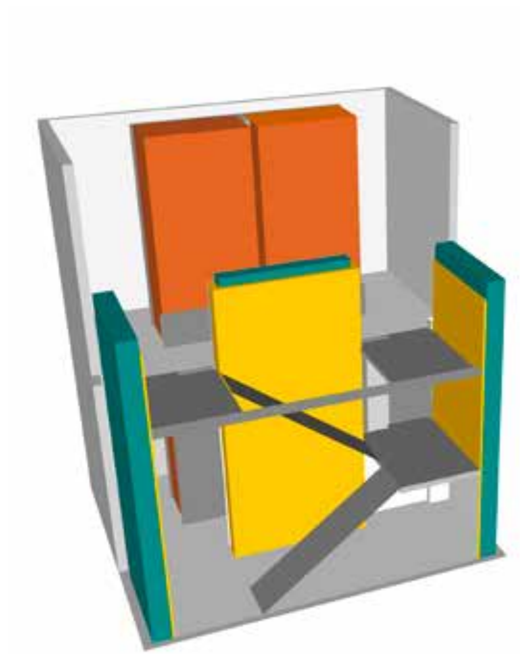


Figure 52 *Core design*

TRANSFORMATION CONCEPT 10
CENTRAL CORE

Patrick de Laat
Çiğdem Nur Kebapcı

Our group, consisting of Çiğdem Nur Kebapcı and Patrick de Laat, had been granted the central core concept to work with during the international design studio in Sarajevo.

This concept's most noticeable implications on the design seem clearly related to its size. In order for a core to be a central core we argued that it would have to include a corridor completely around it. We could barely achieve this in the largest scenario of the three given scenarios, which resulting in a building with only about one and a half storeys. The relative space needed in this design for circulation makes it debatable whether or not the second (half of a) storey justifies this occupation of space. Therefore, our group concluded that a genuine central core concept is not really suitable for the scale required in the scenarios of this assignment.

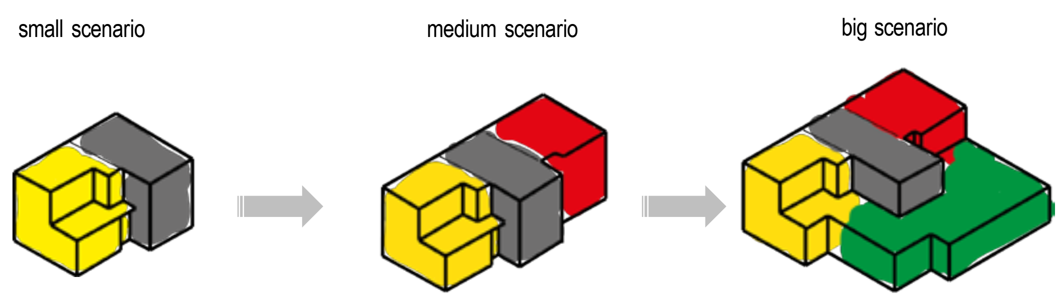


Figure 53 *Scenarios (the gray mass represents the core)*

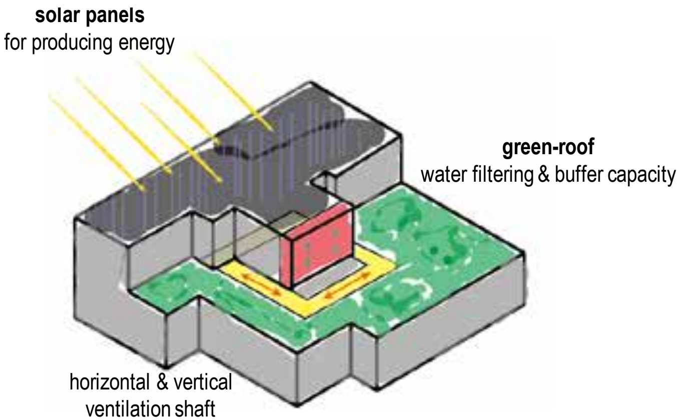


Figure 55 *Climate plan*

Figure 54 *Floor plans*

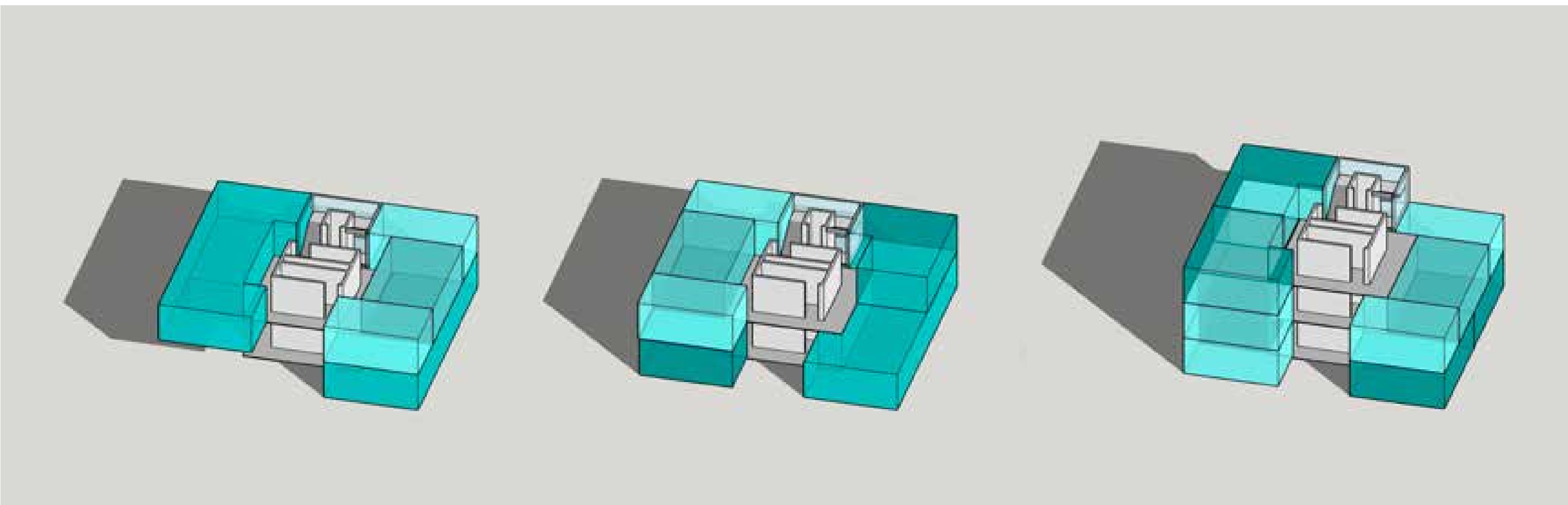
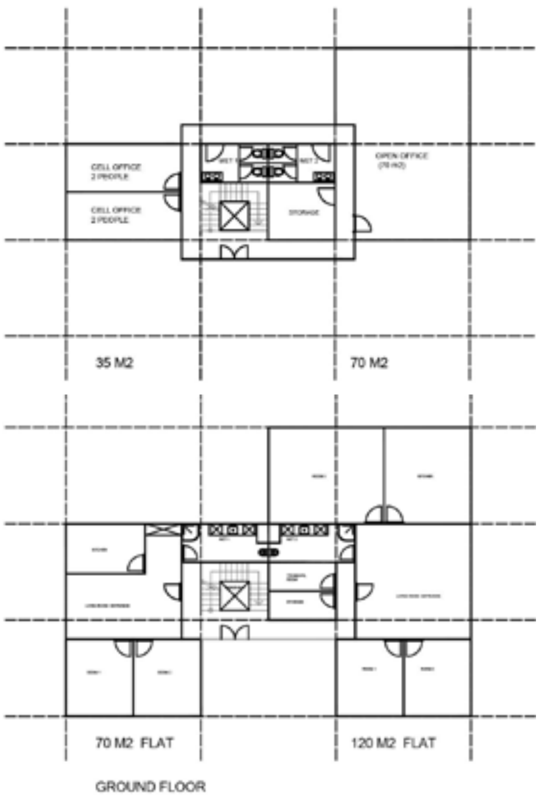


Figure 56 *Different configurations*

TRANSFORMATION CONCEPT 11
CENTRAL CORE CONCEPT

Anil Akay
Ece Atasoy
Tuğçe Tarhan

The starting point of this central core concept is contrary to previous one with central core and cantilevers around the core this concept has one central core with fixed grid of columns forming the outside limits of the space. The grid between the core and columns is 9m and provides more spatial capacity which can accommodate all required functions. However, the downside of the central core remains the fact that natural light and ventilation is available only from one side.



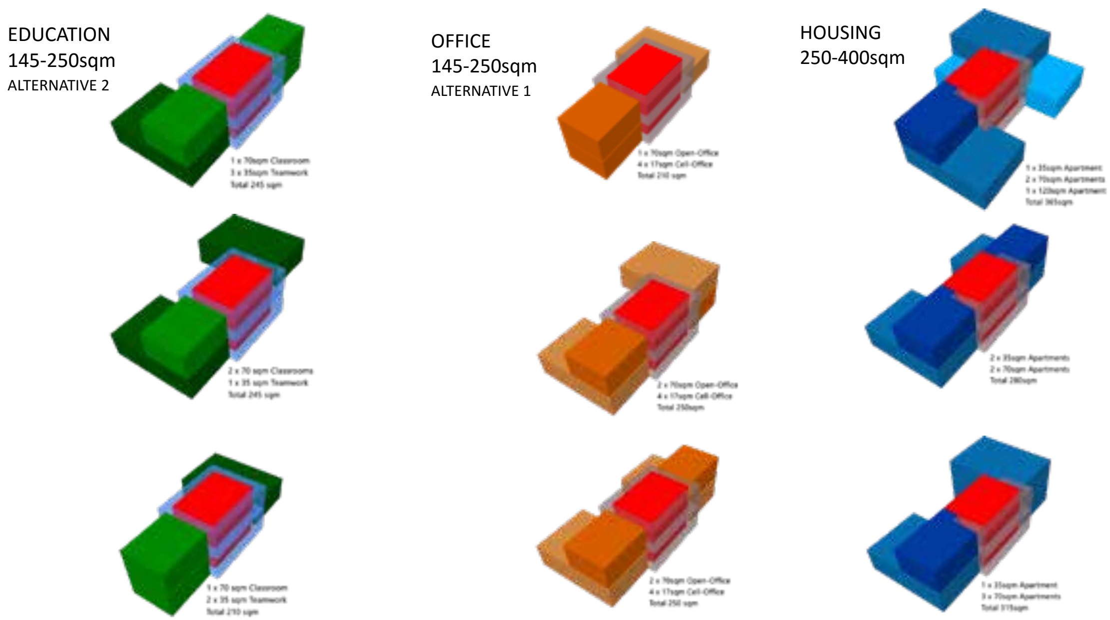


Figure 57 Grid and core strucuture

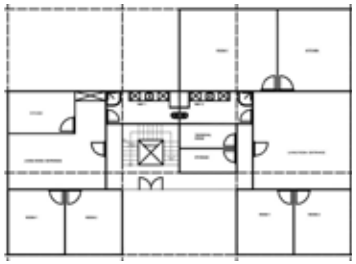


Figure 58 Housing plan

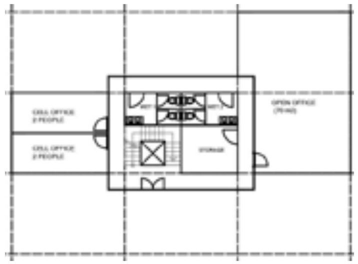


Figure 59 Office plan

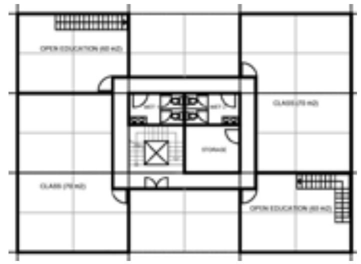


Figure 60 Education plan

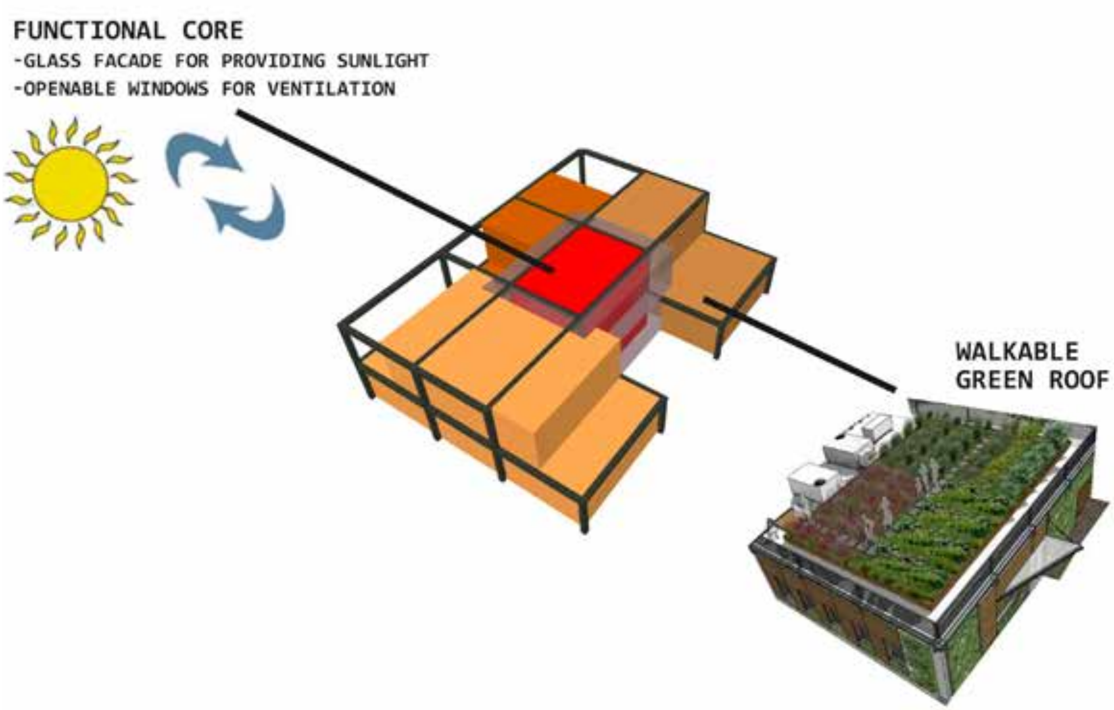


Figure 61 Integration climate concept

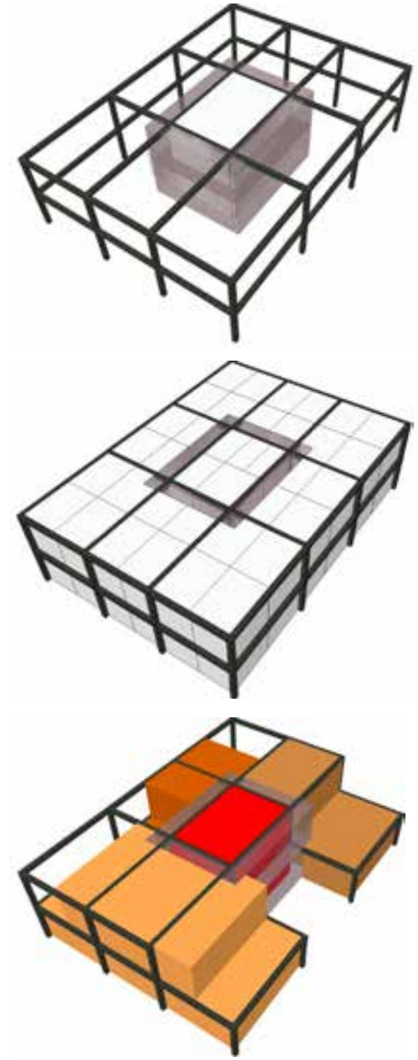


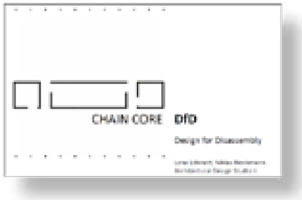
Figure 62 Transformation models

EVALUATION OF PRESENTED POTENTIALS

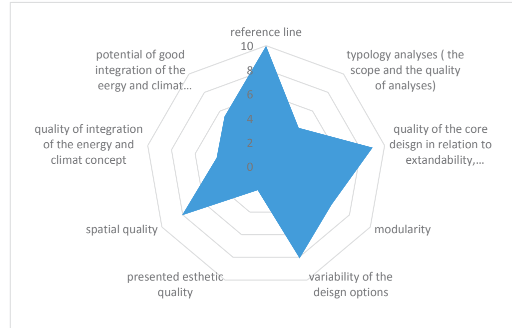
After the investigation of number of transformation models seven models with major transformation potential have been evaluated by analyzing the following aspects.

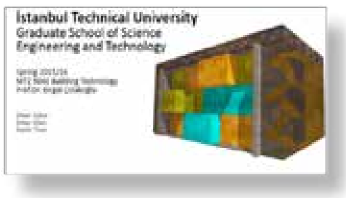
1. typology analyses
2. quality of core design analyses in relation to extendibility, transfunctionality and nonfunctional flexibility
3. modularity
4. quality of variability of the design options
5. presented esthetic quality
6. spatial quality
7. quality of presented integration: energy and climate concept
8. potential for good integration of the energy and climate concept

The first four models have been recognized as the once that have potential to be used for the development of the concepts for Green Transformable Building Lab on the location near Maastricht. Their special quality was in typological analyses, quality of variable design options, potential for good integration of climate and energy oncepts.

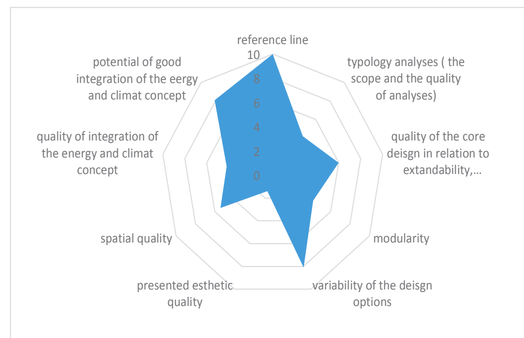


	poor	1-3	4-7	8-10	outstanding	weight	
1 typology analyses						70%	4,2
quality of core design analyses in relation to extandability, 2 transfunctionality and monofunctional fexibility						100%	9
3 modularity						70%	6,3
4 variability of the deisgn options						90%	8,1
5 presented esthetic quality						80%	2,1
6 spatial quality						90%	8,1
7 quality of presented integration: energy and climat concept						70%	4,2
8 potential for good integration of the eergy and climat concept						90%	5,4
overal quality of transformation model						47,4	7,3

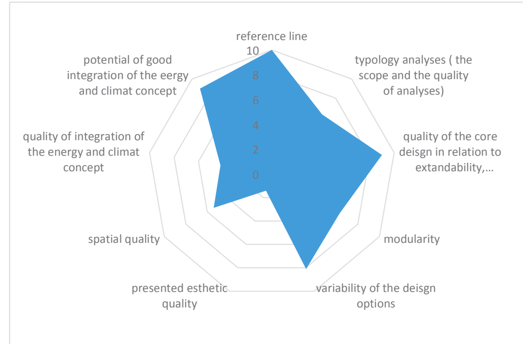




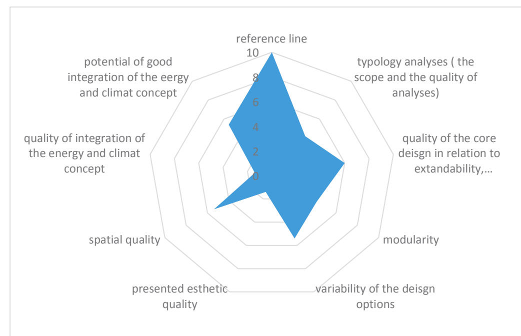
	poor	1-3	4-7	8-10	outstanding	weight	
1 typology analyses						70%	4,2
quality of core design analyses in relation to extandability, 2 transfunctionality and monofunctional fexibility						100%	6
3 modularity						70%	4,2
4 variability of the deisgn options						90%	8,1
5 presented esthetic quality						70%	1,4
6 spatial quality						90%	5,4
7 quality of presented integration: energy and climat concept						70%	4,2
8 potential for good integration of the eergy and climat concept						90%	8,1
overal quality of transformation model						41,6	6,4

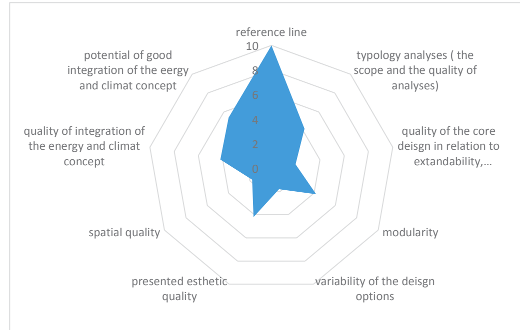


	poor	1-3	4-7	8-10	outstanding	weight	
1 typology analyses						70%	6,3
quality of core design analyses in relation to extandability,							
2 transfunctionality and monofunctional fexibility						100%	9
3 modularity						70%	6,3
4 variability of the deisgn options						90%	8,1
5 presented esthetic quality						70%	1,4
6 spatial quality						90%	5,4
7 quality of presented integration: energy and climat concept						70%	4,2
potential for good integration of the eergy and climat concept						90%	9
overal quality of transformation model						49,7	7,6

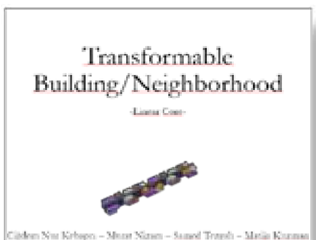


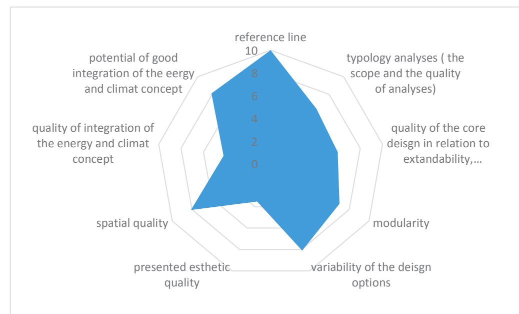
	poor	1-3	4-7	8-10	outstanding	weight	
1 typology analyses						70%	4,2
quality of core design analyses in relation to extandability,							
2 transfunctionality and monofunctional fexibility						100%	6
3 modularity						70%	4,2
4 variability of the deisgn options						90%	5,4
5 presented esthetic quality						70%	1,4
6 spatial quality						90%	5,4
7 quality of presented integration: energy and climat concept						70%	1,4
8 potential for good integration of the eergy and climat concept						90%	5,4
overal quality of transformation model						33,4	5,1





	poor	1-3	4-7	8-10	outstanding	weight	
1 typology analyses						70%	4,2
quality of core design analyses in relation to extandability, 2 transfunctionality and monofunctional fexibility						100%	2
3 modularity						70%	4,2
4 variability of the deisgn options						90%	1,8
5 presented esthetic quality						70%	4,2
6 spatial quality						90%	1,8
7 quality of presented integration: energy and climat concept						70%	4,2
8 potential for good integration of the eergy and climat concept						90%	5,4
overal quality of transformation model							27,8 / 4,3





	poor	1-3	4-7	8-10	outstanding	weight	
1 typology analyses						70%	6,3
quality of core design analyses in relation to extandability, 2 transfunctionality and monofunctional fexibility						100%	6
3 modularity						70%	7
4 variability of the deisgn options						90%	8,1
5 presented esthetic quality						70%	3,5
6 spatial quality						90%	8,1
7 quality of presented integration: energy and climat concept						70%	4,2
8 potential for good integration of the eergy and climat concept						90%	8,1
overal quality of transformation model							51,3 / 7,9

1.3

INTEGRATION OF SELECTED CORE PRINCIPLES INTO DESIGN OF GTB LAB MODEL

USE/SPATIAL AND TECHNICAL REQUIREMENTS

The main aim of the GTB Lab is to provide:

- Comfort by continue upgradability of building and its components/material to required quality level and new standards
- Reduction of building waste 70%
- Reduction of row material use 50 %

The general requirements for the design of GTB Lab:

- Adaptability to different requirements
- Upgradeability on building and component level
- Re-configurability on building and component level
- No over dimensioning always fit to purpose
- Energy positive
- Comfortable & healthy climate in & around the building

USE/SPATIAL REQUIREMENTS

User requirements for Green Transformable Building Lab have been clustered into

- a functional core (gray colored functions)
- variable office space (yellow)
- housing spaces (green)

Figure 63 *GTB Lab use/spatial requirements for four scenarios*

Scenario 0 Core/Carrier of transformation model			**Scenario 1:** Education and research facility for dynamic and circular buildings			**Scenario 2** Education and research facility for dynamic and circular buildings			**Scenario 3** Education and research facility + office hub for dynamic and circular buildings+ appartments			**Scenario 4** Education and research facility		
function			**function**	**nr**	**m2**	**function**	**nr**	**m2**	**function**	**nr**	**m2**	**function**	**nr**	**m2**
			1 teamwork/ mini classroom space 1x30m2	1	30	2 teamwork/ mini classroom spaces 1x30m2	1	60	2 teamwork/ mini classroom space 1x30m2	1	60	2 teamwork/ mini classroom space 1x30m2	1	30
						meeting room	1	20		1		meeting room	1	20
						2 office spaces 15m2	1	30	open office spaces for 20 work places (with inetnal felxibility/ transfotmation to cell office type) including meeting room	1	160	4 office spaces 15m2	1	15
							1						1	
Vertical comunication	1	30	Vertical comunication	1	30	Vertical comunication	1	30	Vertical comunication	1	30	Vertical comunication	1	30
			2 apartment/studios (35 m2 each) with possible integration into one and extendibility in the second phase to 160m2 (internal transformation scenarios of apartment units) (verdieping) 2x 35m2 (extantion to 160m2)	1	35	2 apartment one for disabled 70m2 and one family apartment 120m2 (internal transformation scenarios of apartment units) (1st/2nd floor))	1	70	extendability of 70m2 apartment to 100m2 aapartemnt to be used by disabled and one family apartment 120m2 (internal transformation scenarios of apartment units) (1st/2nd floor)	1	220	2 helth apartment of 50m2 and one apartment for disabled 120m2 (internal transformation scenarios of apartment units) (ground fl/1st fl)	1	220
				1	35	apartment	1	120						
Public lounge (meeting, lecture, exhibition) with attached snack, coffee, copy wifi facility 1x (ca 70m2)	1	70	Public lounge (meeting, lecture, exhibition) with attached snack, coffee, copy wifi facility 1x (ca 70m2)	1	70	Public lounge (meeting, lecture, exhibition) with attached snack, coffee, copy wifi facility 1x (ca 70m2)	1	70	Public lounge (meeting, lecture, exhibition) with attached snack, coffee, copy wifi facility 1x (ca 70m2)	1	70	Public lounge (meeting, lecture, exhibition) with attached snack, coffee, copy wifi facility 1x (ca 70m2)	1	70
Technical spaces including Vertical instal net.20m2	1	20	Technical spaces including Vertical instal net.20m2	1	20	Technical spaces including Vertical instal net.20m2	1	20	Technical spaces including Vertical instal net.20m2	1	20	Technical spaces including Vertical instal net.20m2	1	20
Storage 10m2	1	10	Storage 10m2	1	10	Storage 10m2	1	10	Storage 10m2	1	10	Storage 10m2	1	10
Toilet groups 2x	1	15	Toilet groups 2x	1	30	Toilet groups 4x	1	60	Toilet groups 4x	4	60	Toilet groups 2x	2	30
green garden 1st fl. outsade exhibition/workplace ground floor energy/climat roof water storage under the dack			green garden 1st fl. outsade exhibition/workplace ground floor energy/climat roof water storage under the dack			green garden 1st fl. outsade exhibition/workplace ground floor energy/climat roof water storage under the dack			green garden 1st fl. outsade exhibition/workplace ground floor energy/climat roof water storage under the dack			green garden 1st fl. outsade exhibition/workplace ground floor energy/climat roof water storage under the dack		
Total		**145**	**Total**		**260**			**490**			**630**			**445**

TECHNICAL REQUIREMENTS

Energy

- Energy independent
- Local energy/heat storage
- Local energy heat production
- Local cooling
- Eliminate Energy losses through facade
- South: optimize revisable facade for light and heat reflection
- North: optimize revisable facade for light and heat absorption
- Use of polymer based dynamic facade elements for
- movement automation without energy use
- Natural ventilation
- Optimize color use to heat absorption/reflection
- Optimize material use for heat/cold storage

Water/waste water

- Local Water collection
- Waste water treatment and local reuse

Information /communication

- Interactive control walls (with electronic (individual massages)internet wall)
- Connected with other world labs
- Information about companies as founding fathers and material and processes built and benefits they have created

Air quality

Inside

- CO_2, nox etc hazardous particles (fine dust) absorption
- Green longs

Outside

- Natural ventilation

Light

- Natural light
- Optimize color use to light absorption/reflection
- Led light

Reconfiguration/transformation

- Modularity
- Upgradability of modules by reversibility and reuse
- (upgrading by adding new technology/ new functionality/replacing functionality

Reconfiguration/transformation requirements

- Use of durable materials and connections to prevent from damaging during reconfiguration
- Standardization of connections
- Possible exploitation of 3D printing of building connections

On building level

- Modularity (unit/ system/ component/)
- Independency between different functional modules
- Exchangeability of different functional modules

On module level

- Upgradability of modules by reversibility and reuse
- (upgrading by adding new technology/ new functionality/replacing functionality
- Upgrading/ reuse scenario for each system/ component

Individualization of modulation

- Possibility for in-time customization of modules without bringing them back to the manufacture
- Possible exploitation of 3D printing for customization

Short term Adaptability

- Adaptability to the daily and seasonal weather conditions and use change
- (quick spatial modification- spatial inside/ outside

The focus of IDS 2016 was primarily on user requirements and general understanding of principles of technical requirements which will be elaborated further through the next International Design Studio.

LINEAR CORE

TRANSFORMATION CONCEPT 1

CHAIN CORE

Ruud Brnkhuis
Lena Löhner
Hieu Nguyen
Niklas Riekman

Continuing the development of the chain core concept, a site analysis and climate have been conducted in order to gain information about the climate and the spatial arrangement of buildings. For the climate, the sun orientation, wind velocity and direction, and temperature have been analysed. This information can be used for the orientation of the building, as the placement of specific spaces. As a result of the site analysis, a L shaped platform have been designed in order to accommodate public spaces, such as terraces, and the building itself. This platform is accessible from multiple directions, stairs are facing the exhibition space and slopes for wheelchairs are incorporated in the design. For the exhibition space, space dividers can be used to define an area. Furthermore, the site consists of smaller exhibition spaces with a big path in between.

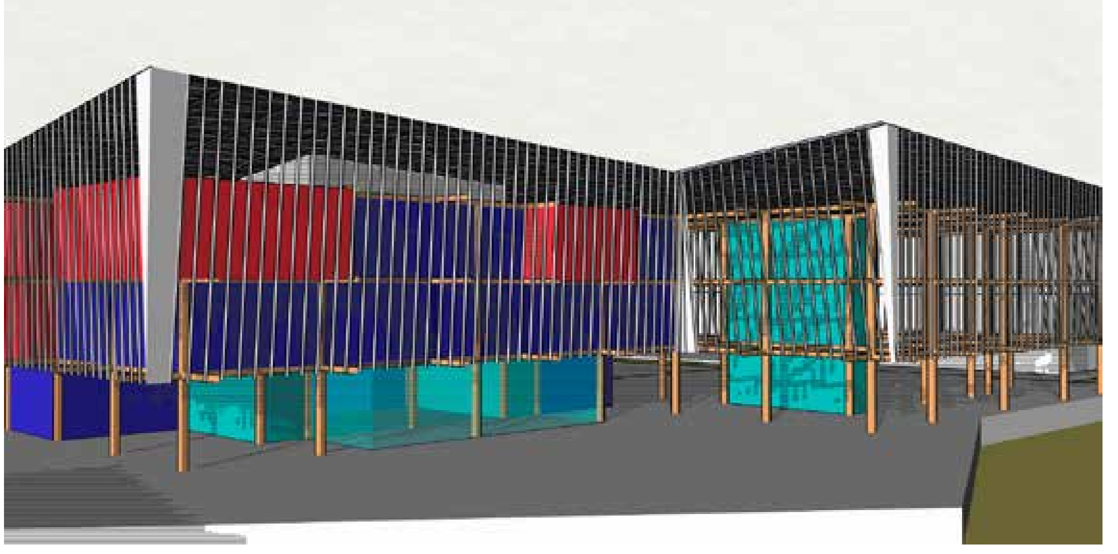


Figure 64 *Outer view*

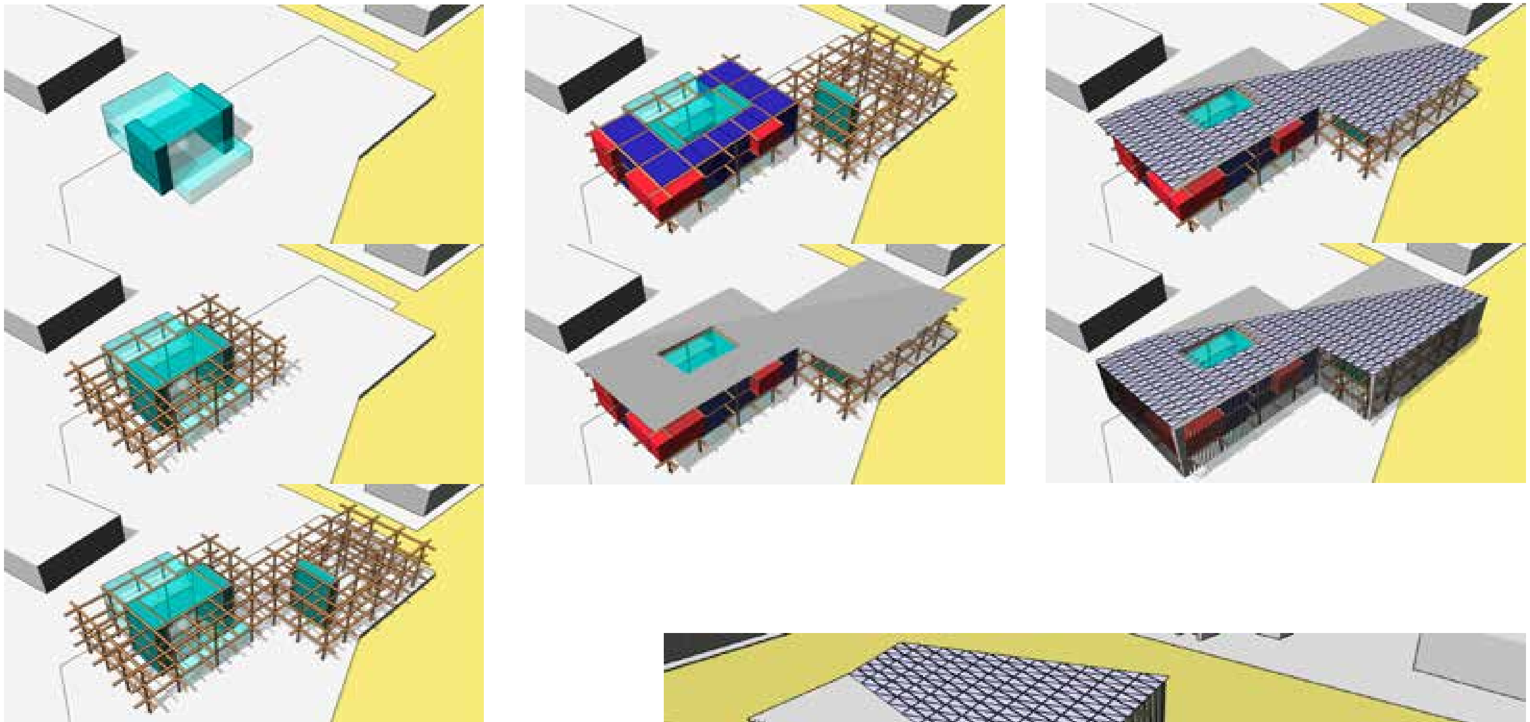


Figure 65 Transformation models

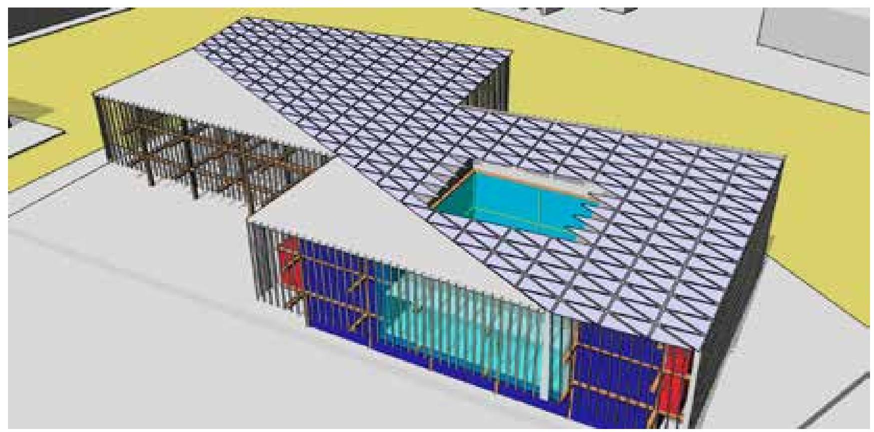


Figure 66 Upper view

THE INBETWEENER

TRANSFORMATION CONCEPT 2

LONGITUDINAL CORE

Erkan Akan
Erkan Aybar
Babür Tüzer
Pieter Beurskens

Continuing the development of the longitudinal core concept, a site analysis and climate have been conducted in order to gain information about the climate and the spatial arrangement of buildings. For the climate, the sun orientation, wind velocity and direction, and temperature have been analysed. This information can be used for the orientation of the building, as the placement of specific spaces. As a result of the site analysis and accessibility of the building and the park attached to the building, a broken linear shaped building has been designed in order to accommodate public spaces and interaction between the square in front of the building and public space behind the building.

Figure 67 *Aerial view of building and public space*

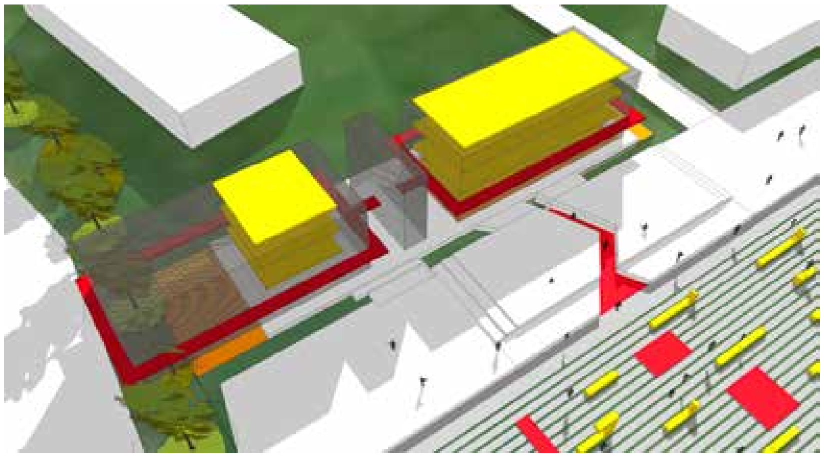


Figure 68 *Aerial view of building design*

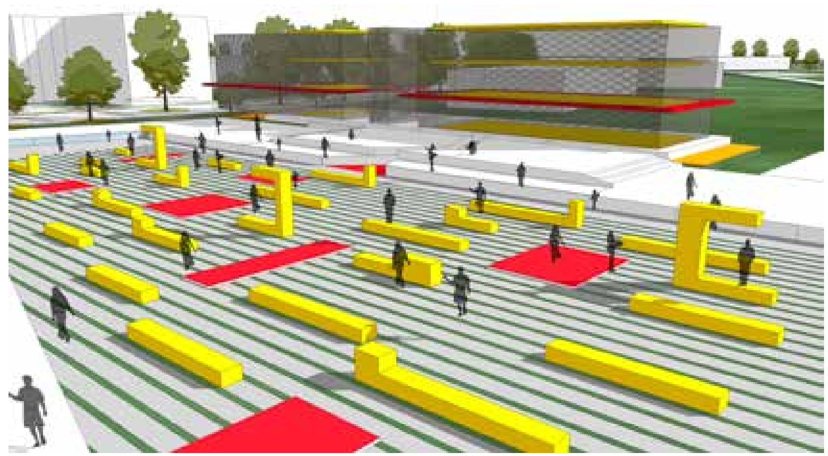


Figure 69 *Public space*

THE FLAVIO CONCEPT

TRANSFORMATION CONCEPT 3

SUPER STRUCTURE CORE

Begüm Aktaş
Han de Jong
Flavio Mancuso
Joska Sesink

During the Istanbul Design Studio the FLAVIO concept was further developed, adapting the initial design according to the climate and spatial requirements derived from the site analysis. Based on the local climate it was decided to make the square building longitudinal, increasing the area on the south facade to enable heat collection during winter and simultaneously providing a buffer towards the North for insulation. This alteration has influenced the transformation capacity of the building as the building can now be enlarged or reduced in two directions, influencing both the construction and transformation characteristics. Additionally the internal transformations of the functional modules between functionalities and areas were slightly changed, distributing the functionalities more evenly throughout the building and integrating a public area.

Around the GTB-Lab several other buildings are located which are part of the 'Wijk van Morgen', these are connected by a big square, which also should function as an exhibition space. By creating connection paths between the different buildings, a grid arises on the square, shown in the figure on the right. By arranging green spaces, small exposition spaces and street furniture in the grid, a dynamic and playful area is created which can facilitate the different functionalities required.

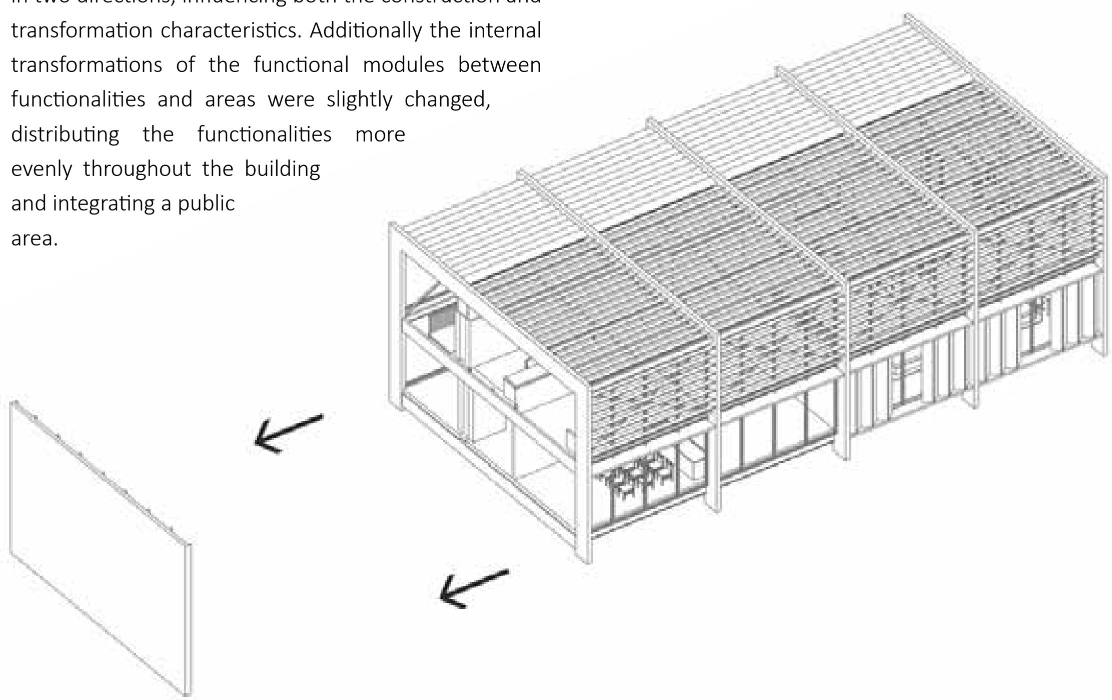


Figure 70 *Longitudinal positioning of the building*

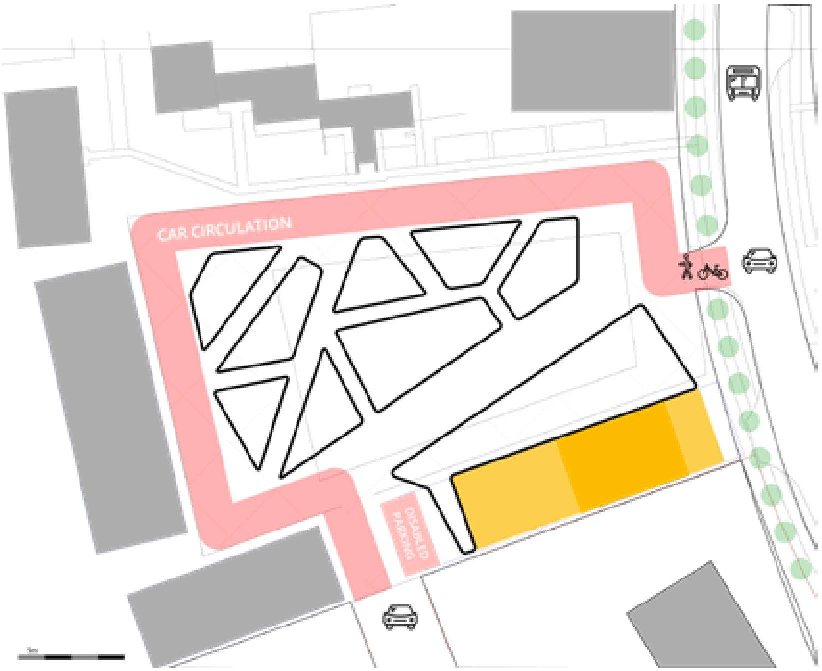


Figure 71 *Spatial design of the public area*

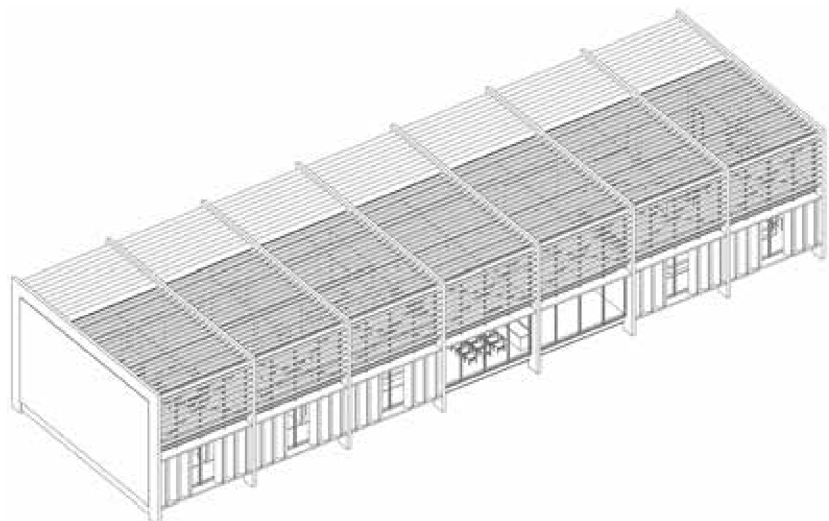


Figure 72 *Transformation model*

LINEAR CORE

TRANSFORMATION CONCEPT 4

LINEAR CORE

Murat Nizam
Çiğdem Nur Kebapc
Matija Kuzmani
Samed Tezgah

Public Space Design

The public space was located on the North side of our building. We designed the entrance of the building from this public innovation park and another one directly from the street, reachable by stairs. From the park, pedestrians can reach the building by ramps which are paralel to green bands, this solution allows people to reach the building easier. On the public park, greens and pavements are designed on the north-south direction to underline the building facade.

Adaptation of concept to site and local climate

Building has two different facades, on the north and south sides. South side has more opaque walls (trombe wall to keep heat energy) and dynamic sun shaders which can be opened or closed in different climat conditions. On the north side, the facade is more open and hosts mainly offices which have indirect and stable sun light.

Figure 73 *Public space design*

Figure 74 *Map of public space*

Figure 75 *Building front facade*

PLUG & PLAY

TRANSFORMATION CONCEPT 12

REDESIGN

Elsa Adema
Marc van den Berg
Annika Danckert
Emily Hamilton
Alp Görüşük

Public space design

We needed a platform for the building, which was limited to a 30m width according to the site boun-daries and access. This platform creates a hierarchy from public to private, from the innovation square to the building itself. This hierarchy is strengthened by a platform that is dissolving into the square. A 6m x 6m grid is the basis of the platform design.

Looking at the innovation square and the connections and relations of the buildings facing it, we created a walk around for the exhibition space. Water and greenery is integrated in the public square design. Small bridges that are placed according to the grid are helping to generate an interesting path.

Adaption of concept to site and local climate

As we were developing the existing building design on a new site several changes need to be done. As the building is turning north, in the direction of the innovation square the L-shaped overhangs are partly redundant. Load bearing walls and the core stay in similar positions as in the existing approach and installations are made “plug & play” to the fixed shafts.

Structural elements are made out of wood and glass, additionally a solar chimney is used.

Figure 76 Building transformations

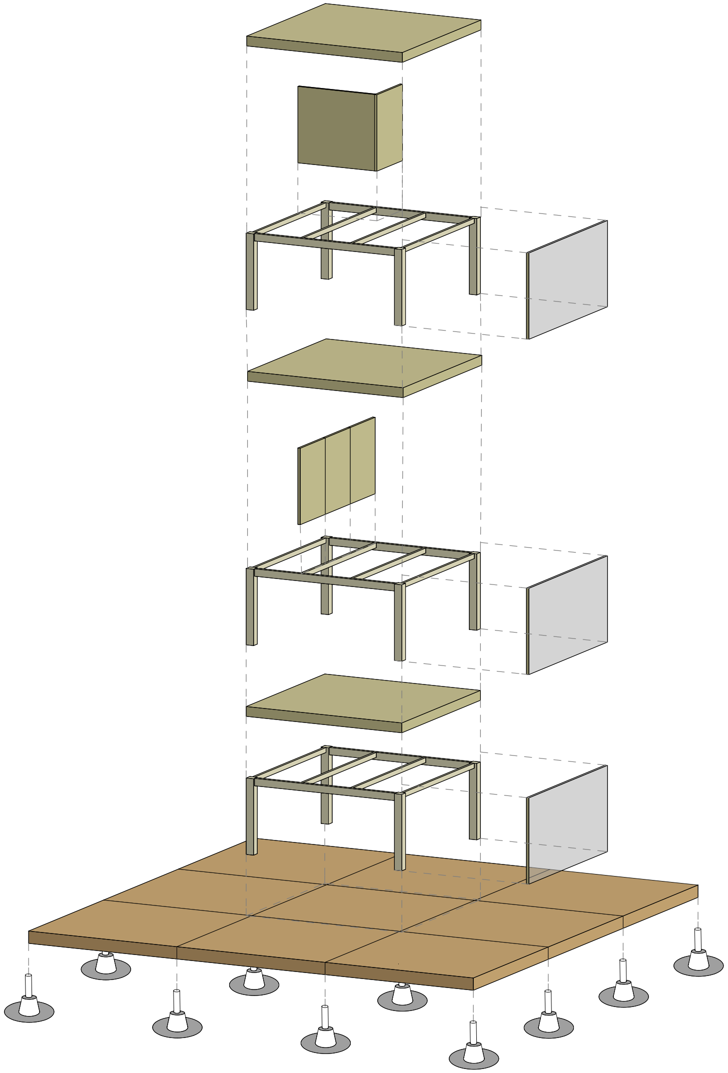


Figure 77 *Modualr assembling*

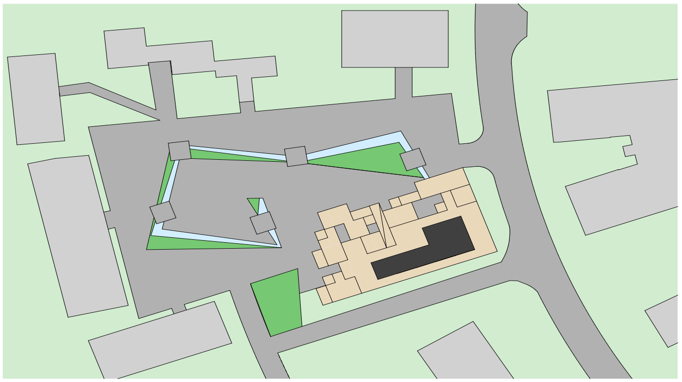


Figure 78 *Site plan*

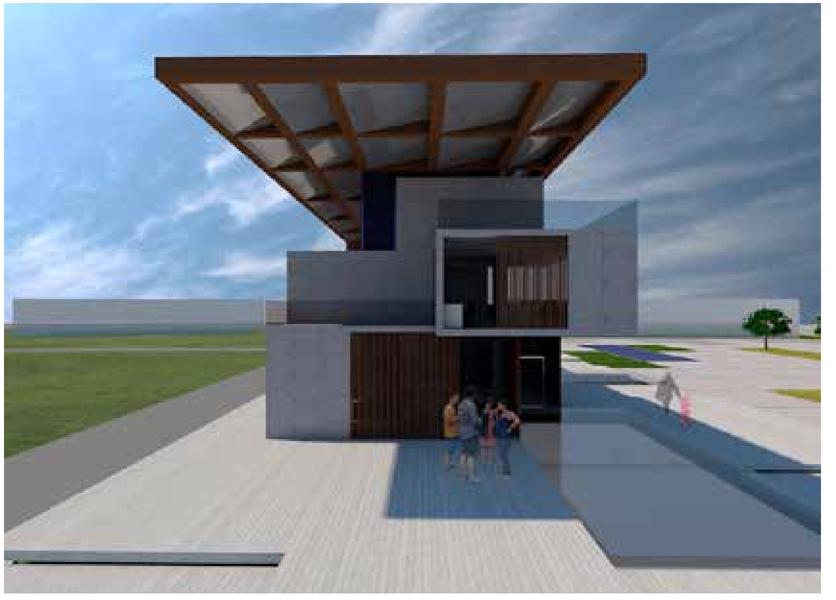


Figure 79 *Render TETRA square*

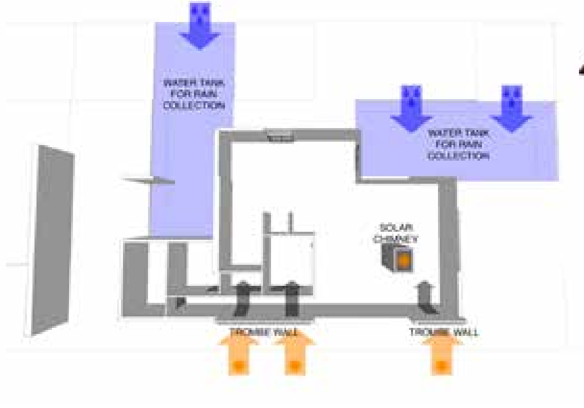


Figure 80 *Climate plan*

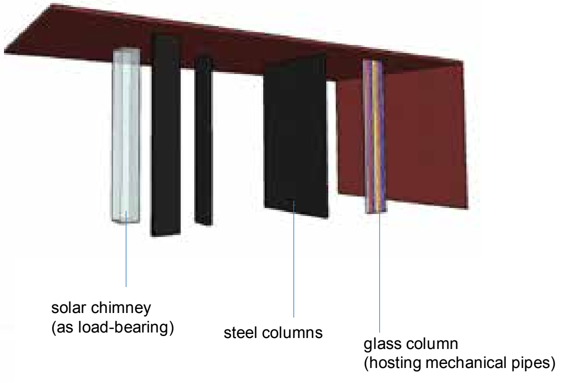


Figure 81 *Core TETRA*

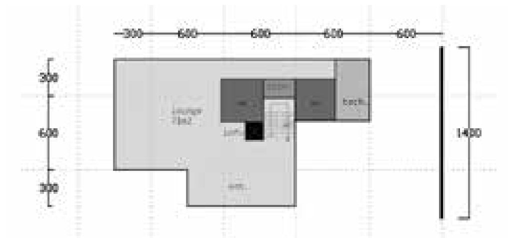


Figure 82 *Ground floor for scenario 0-1-2*

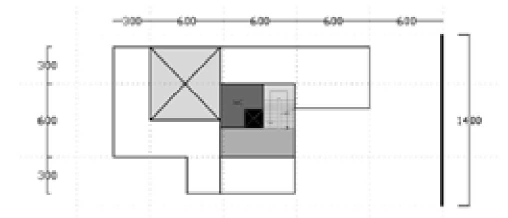


Figure 83 *1st floor for scenario 0*

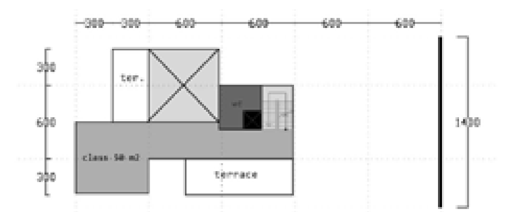


Figure 84 *1st floor for scenario 1*

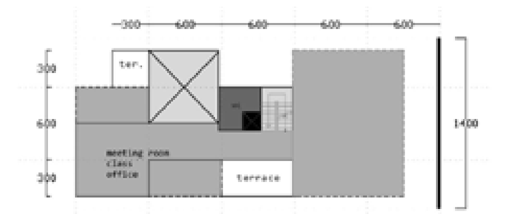


Figure 85 *1st floor for scenario 2*

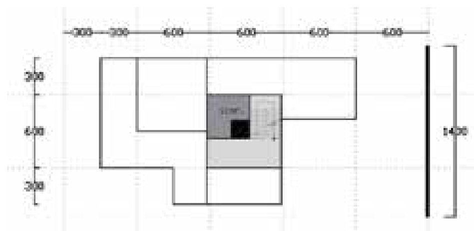


Figure 91 *2nd floor for scenario 0*

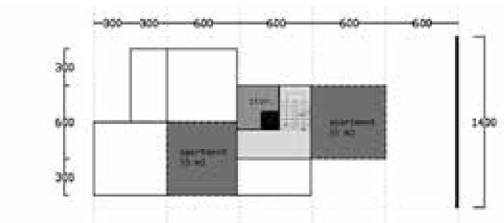


Figure 90 *2nd floor for scenario 1*

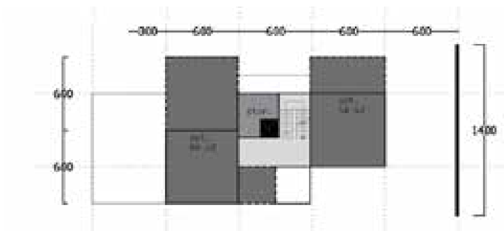


Figure 86 *2nd floor for scenario 2*

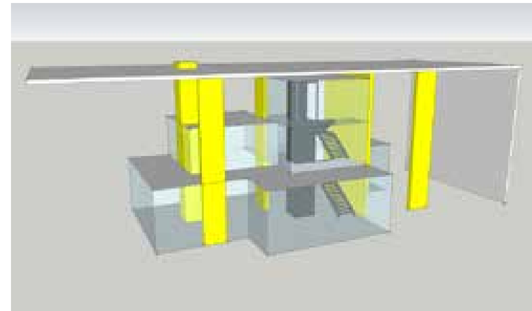


Figure 87 *Scenario 0*

Figure 88 *Scenario 1*

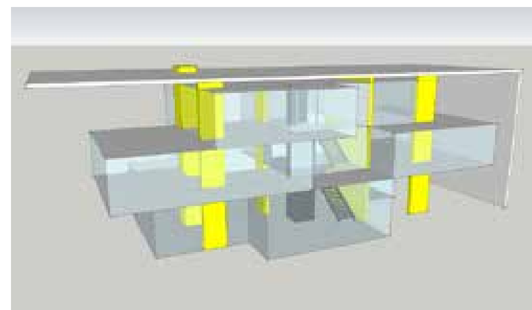


Figure 89 *Scenario 2*

CHAIN CORE CONCEPT

TRANSFORMATION CONCEPT 1

CHAIN CORE

Ruud Brnkhuis
Sejla Hasanbegović
Deniz Mahmutović

For the final design of the building, new floorplans have been drawn based on the requirements of the scenarios and both the climate and site analysis. For the ground floor, a large proportion of the grid is allocated to outdoor exhibition and workspaces. The ground floor has the same lay out for all scenarios. For each scenario, depending on the requirements of the scenarios, modules can be added in order to adapt space and extend where appropriated. Office and education spaces are mostly situated on the north side. In order to let sun come in apartments, housing spaces are placed on the south side.

Structural elements are made out of wood, the core is made of concrete. The facade consists of large glass panels which enables light and warmth to come in the building. Sunshades and plants prevent over or under shading, so occupants can always enjoy the benefits of natural daylight. Through adapting to the sun's orientation, energy consumption of the building can be reduced. In order to facilitate natural ventilation, a inner garden is situated near the core. This green garden migrates air pollution levels by lowering extreme summer temperatures through photosynthesis and capturing gases.

Figure 92 *Floorplans based on the scenarios*

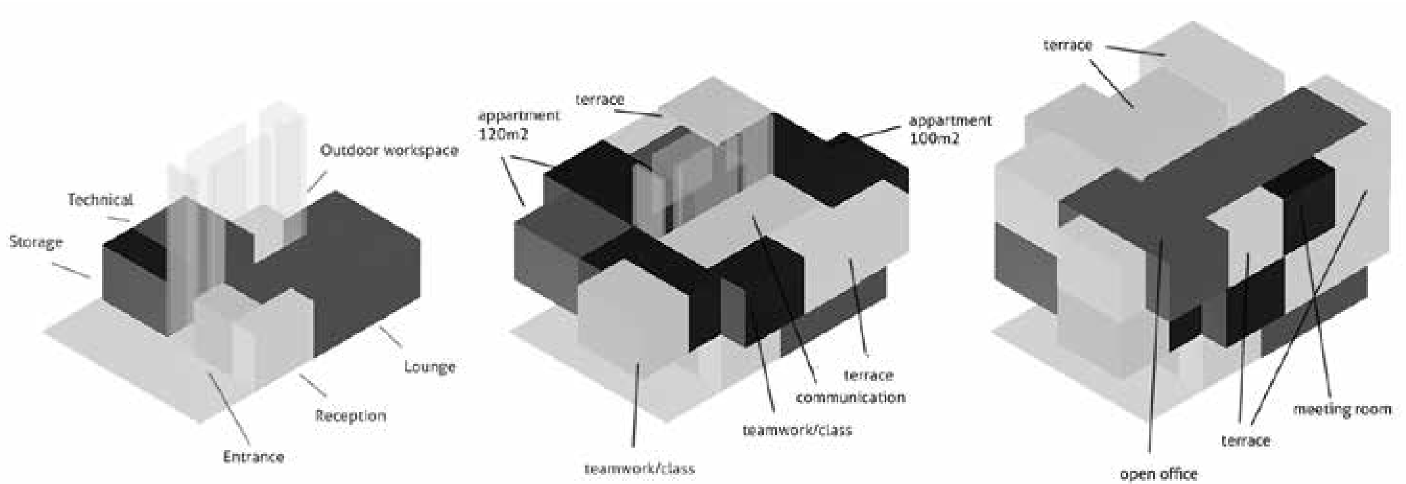


Figure 93 *3D representation of the spaces.*

Figure 94 *Final design*

THE INBETWEENER

TRANSFORMATION CONCEPT 2

LONGITUDINAL CORE

Erkan Akan
Erkan Aybar
Vedad Colo
Babür Tüzer
Pieter Beurskens

The final design of the longitudinal core design, called 'the inbetweener', received major design interventions compared to the previous developments. These major design changes are originating from the renewed focus on the specific site, climate and functional requirements. This resulted in a slightly adapted core which is now opened up on three sides of the facade, instead of two, from which the name was derived 'the inbetweener'. Since the design was meant to be used in dense urban areas, between two buildings. Therefore, on the East side of the building a main entrance is added, which is clearly visible from the main road to visitors. Next to the main entrance on the East facade, the North facade is designed in such a way that it is able to be opened up easily and blend in with the activities that will be planned on the square on the Northside of the building.

In the base scenario of the buildings there can be made a distinction in two cores: 1) the technical core, used for the installations and climate control, located on the West facade, and; 2) the circulation core to allow vertical transport, which is located on the corner between the South and West facade. In the base scenario functional areas can be added on the ground floor and later on when the functional areas require expansion, new floors can be attached to the corridor on the first level.
In order to make the building self-sustaining with renewable energy, solar panels will be placed on top of the roof. Next to that all rain water will be collected on the roof and used to flush toilets.

The facade is developed in such a way that it allows easy modifications in order to fulfill the changing requirements followed by the different function changes. To allow easy modifications the facade concept is composed of 1) a generic facade frame, which can be filled in with closed and open facade elements and 2) add-ons, which allows different types of horizontal and vertical shading elements to be connected to the facade. The generic facade frame and add-ons are connected with intermediate elements to the structure that allow the facade elements to be independently replaced and reconfigured, according to the changing needs.

Figure 95 *Section view*

THE FLAVIO CONCEPT

TRANSFORMATION CONCEPT 3

SUPER STRUCTURE CORE

Begüm Aktaş
Han de Jong
Flavio Mancuso
Hieu Nguyen
Joska Sesink

Within the last phase of the Design Studio the building was further optimised to fit the climatic and spatial context of the building site. A shading system was designed to provide shade on the south facade during summer and allow heat collection during winter (figure below), by optimising the position of the beams to the movement of the sun.

Also, an energy roof was added to the building, containing several functions. Solar panels generate energy for the building, surrounded by green areas to optimise the efficiency of the panels. The green areas simultaneously function as a garden for residents and can potentially provide a source of locally grown food in the future. Additionally, it functions as both insulation and water buffer for the building.

Transformation of the building is enabled by adding structural modules to the core, on the east and/or west facade. These structural modules are filled with functional modules, which can be combined and altered to meet the requirements for the different functionalities of housing, educational, or work areas. The 'zero' transformation scenario consists of two structural modules and the core, containing the public area. The public- and circulation area have a double height and provides space for the technical spaces. The figure at the right shows the different transformations, in which smaller apartment are joined together to create big apartments, and small offices are transformed into big working areas.

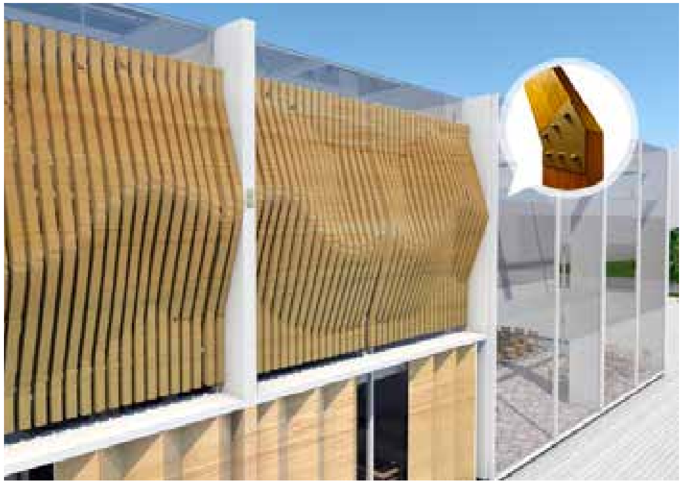


Figure 96 *Shading system.*

Figure 97 *Climate plan.*

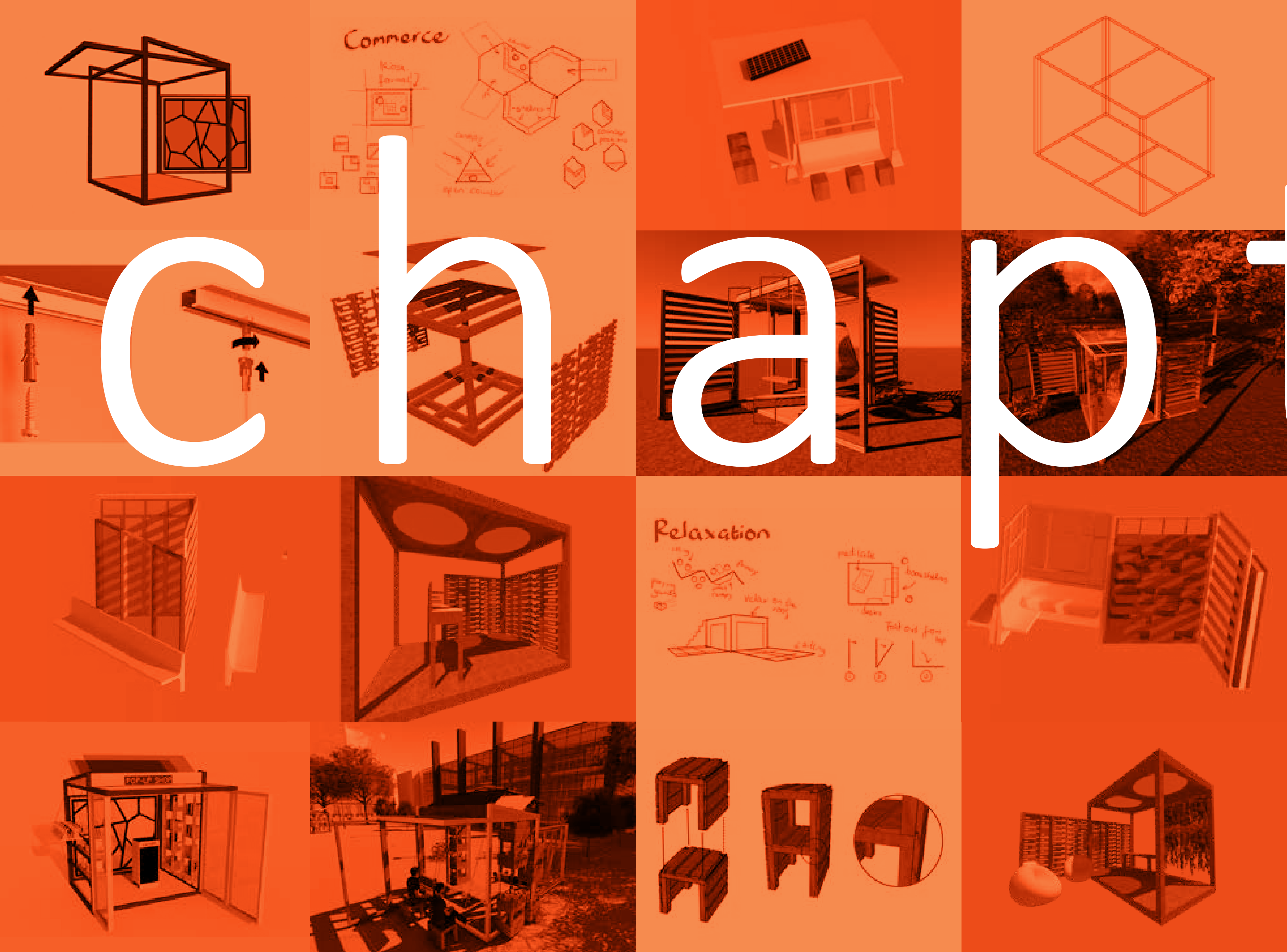
TRANSFORMATION CONCEPT 12/13
REDESIGN

Elsa Adema
Anil Akay
Çağlasu Altinkaynak
Ece Atasoy
Marc van den Berg
Alp Görüşük
Tuğçe Tarhan

Support from Istanbul
Annika Danckert
Emily Hamilton

For the final design of the Green Transformable Building Lab and the adjacent innovation square, two redesign proposals were integrated into one, named 'Tetra'. The building is located on an elevated platform that seems to dissolve into the square. It is facing north and has entrances to the square as well as the main street. One of the characteristic L-shaped overhangs is maintained yet extended, mainly for aesthetic reasons. The building has five columns that function as a central core to which rooms can be added in a playful manner. The basic scenario contains a number of spaces that remain the same during all transformations: a public lounge, storage space, toilet groups and vertical circulations. Taking into account both proportionality and accessibility, this base configuration is extended with more box-shaped rooms during the first and second scenario that our design deals with. Structural elements are made out of wood and glass. The facade combines wire mesh that is movable by the wind and modular wooden panels. A solar chimney together with a Trombe wall on the south facade enable natural ventilation and help to heat and cool the building in all seasons. Rainwater is collected under the building's platform and made visible through glass floor plates. Further analysis is necessary to verify fire regulations, particularly in relation to the chosen climate systems.

Figure 98 *Visualisation TETRA*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Commerce
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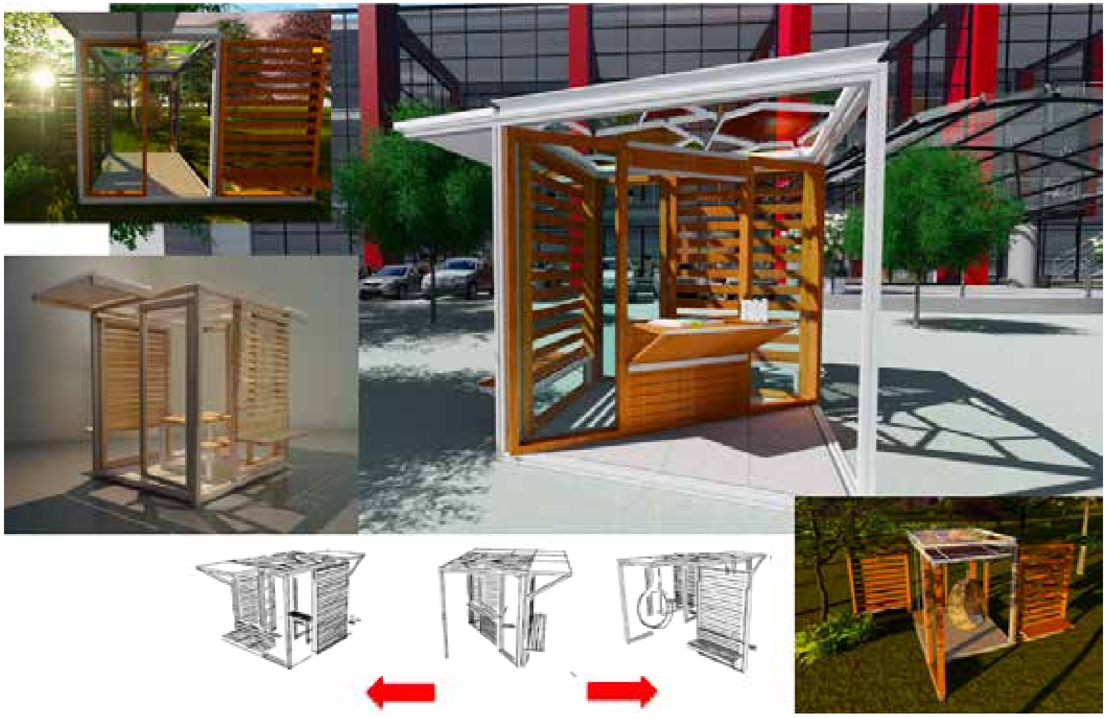
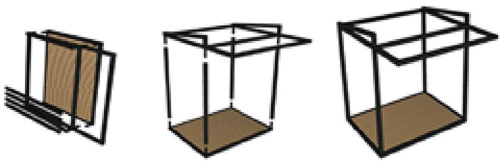
TECHNICAL REVERSIBILITY

2.1

INTRODUCTION





Contrary to the International Design Studio Design 2016 primarily addressing spatial capacity of building to accommodate multiple functions and spatial configurations, International Design Studio 2017 addressed technical aspects of reversible buildings. Technical reversibility is about the design of the building structure taking into account individual recovery and exchangeability of building elements. Two key indicators of technical reversibly are independency and exchangeability of building elements. Both indicators are directly related to the design for disassembly approach of building configurations. This design approach has been investigated with students from five universities during design studio in addition to the requirement for high value recovery of elements also introducing design with existing materials.

Figure 99 *2x wooden panels (2230 x 3465)*

Figure 100 *2x window frames (2230 x 3465)*

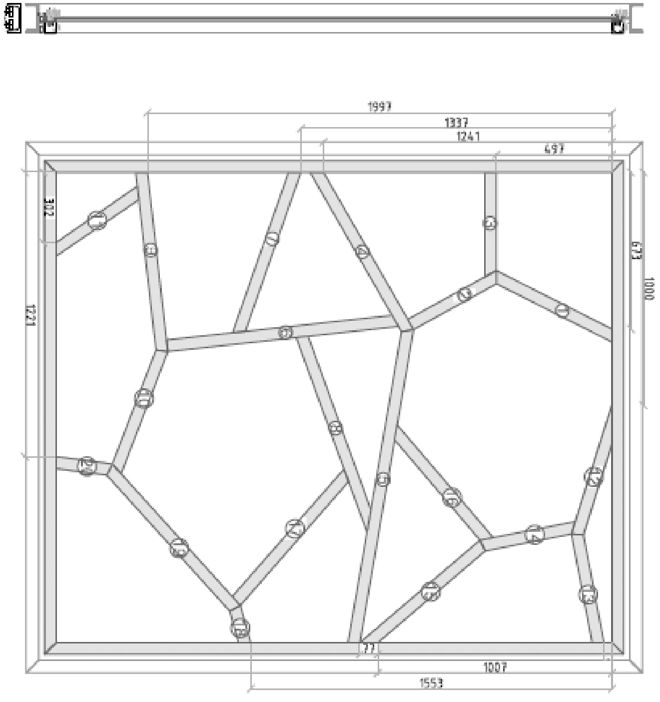


Figure 101 *1x soap frame (2650 x 2280)*

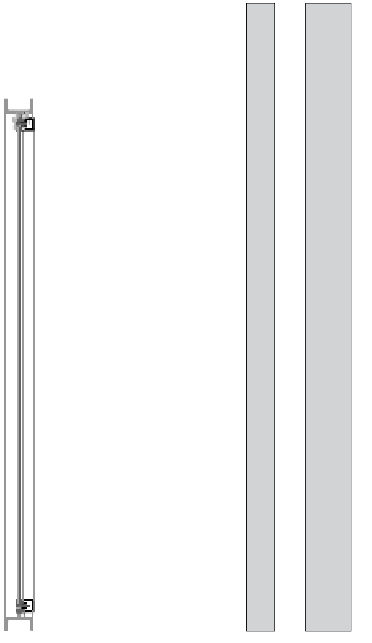


Figure 102 *extrusion profile (80 x 80 x infinity, 50 x 50 x infinity)*

DESIGN BRIEF

The design task was to create a design of a reversible system accommodating three functions and reusing 70% of the existing materials. The existing material bank consists of two types of wooden facade elements produced by De Groot Vroomshoop. Steel profiles and one steel component has been produced by steel company ODS. The delivered existing materials are shown in the three images below.

One of the requirements was that the design needed to be reversible meaning that the design can be used for three different functions. Each function has its own design. Each design has to be (easy) reversible to the second and the third design reuseing materials from the previous scenario. However, reversibility is not only introduced for these three use options, but also for a new life. After use, the materials must be in a good shape so they can be reused in a new life.
With these existing materials in mind, three different designs need to be made the “Working Pixel”, the “Relaxation Pixel” and the “Commercial Pixel”.

STUDENTS

Studio Maastricht

Studio Istanbul

Studio Mostar

2.2

STUDIO ISTANBUL

DESIGN APPROACH

The student studio designed a reversible Urban Pixel creating one concept with three different scenarios. Existing and given materials were used including one thin solar film for electricity. The design included flexibility on short term and reversibility on long term considering materials which are easy to reuse and which are not.

Alternatives

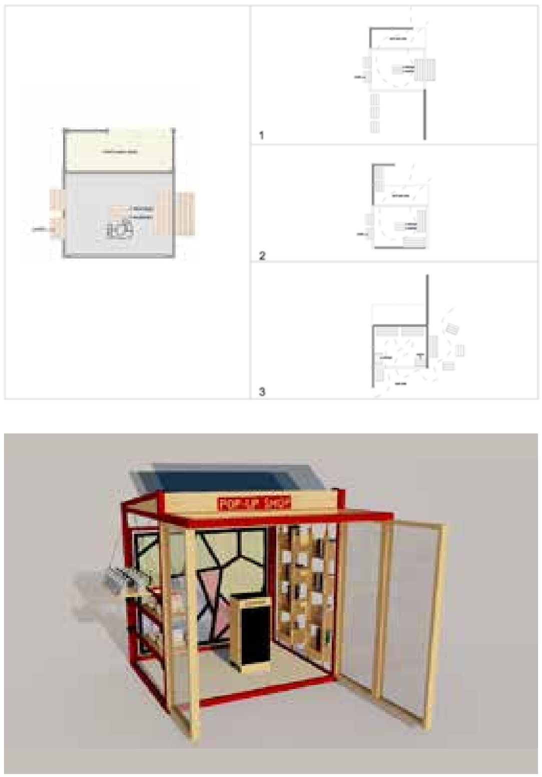


Figure 103 Concept 1: Pop-up shop

Alternatives

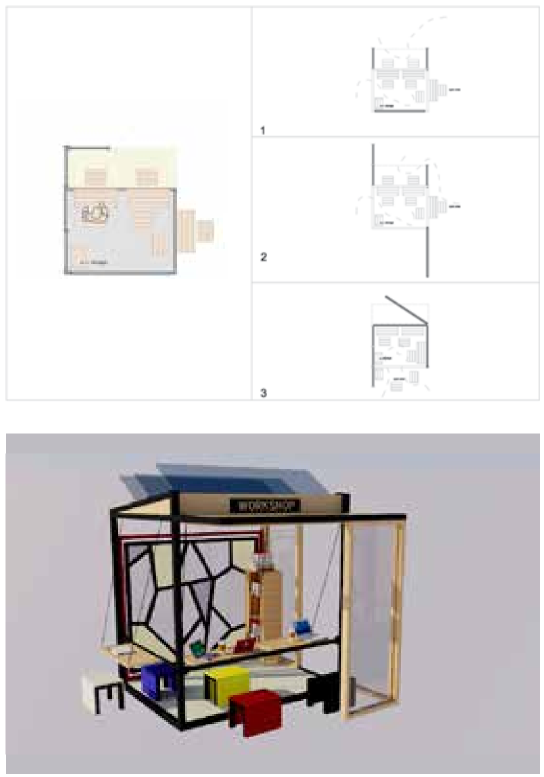


Figure 104 Concept 2: Workshop

Alternatives

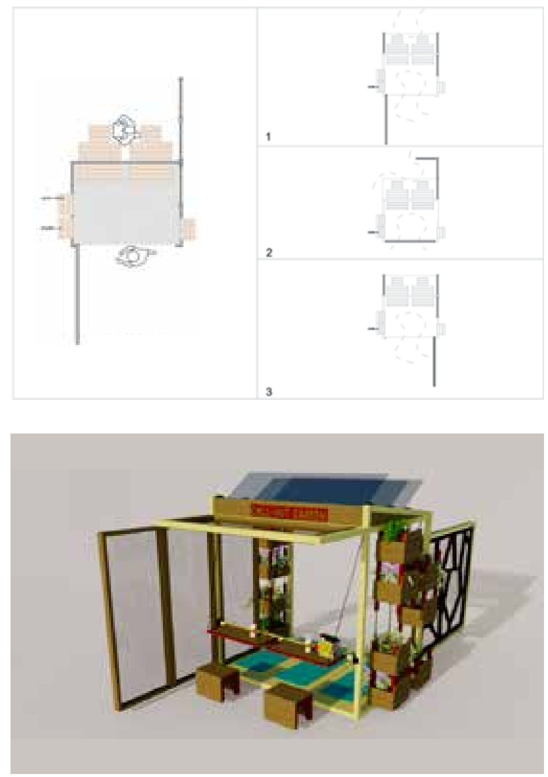


Figure 105 Concept 3: Green Chill Place

type	part nr.	level	Type of element	Dimension	amount	not used	used	extracted
SS	1,00	Facade sub-system					1	
C	1,10	wooden frame					1	
E	1,11	element	Beams	75x34x2230	1		1	
E	1,12	element	Beams	65x34x2230	1		1	
E	1,13	element	Beams	95x75x2230	1		1	
E	1,14	element	Posts	Total length 3335 - part 1: 46x140x2885 - part 2: 46x75x450	2		2	
E	1,15	element	Posts	total length 3300 - part 1: 34x140x2885 - part 2: 34x75x450	5		5	
E	1,20	element	wooden panels	18x142x2140	27		27	
E	1,30	element	Insulation	75x450x490	4	4		
E	1,31	element	Insulation	140x450x2850	4	4		
E	1,40	element	Gypsum panel	10x1115x2910	2	2		
SS	2,00	Facade sub-system - closed					1	
C	2,10	wooden frame					1	
E	2,11	element	Beams	75x34x2230	1	1		
E	2,12	element	Beams	65x34x2230	1	1		
E	2,13	element	Beams	95x75x2230	1	1		
E	2,14	element	Posts	Total length 3335 - part 1: 46x140x2885 - part 2: 46x75x450	2	2		
E	2,15	element	Posts	total length 3300 - part 1: 34x140x2885 - part 2: 34x75x450	5		5	
E	2,20	element	wooden panels	18x142x2140	27		27	
E	2,30	element	Insulation	75x450x490	4	4		
E	2,31	element	Insulation	140x450x2850	4	4		
E	2,40	element	Gypsum panel	10x1115x2910	2	2		
SS	3,00	Facade sub-system - open					1	
C	3,10	Wooden frame					1	
E	3,11	element	Beams	75x34x2230	1	1		
E	3,12	element	Beams	65x34x2230	1	1		
E	3,13	element	Beams	95x75x2230	1	1		
E	3,14	element	Beams	34x140x972	2	2		
E	3,15	element	Posts	Total length 3335 - part 1: 46x140x2885 - part 2: 46x75x450	4		4	
E	3,16	element	Posts	total length 3300 - part 1: 34x140x2885 - part 2: 34x75x450	3		3	
E	3,17	element	Posts	total length 3300 - part 1: 34x140x358 - part 2: 34x75x450	2		2	
C	3,20	component	window component	105x972x2500	2		2	
E	3,30	element	Trespa exterior finishing	6x863x1082	2	2		
E	3,40	element	Batten (to connect trespa)	21x45x863	4	4		
E	3,41	element	Batten (to connect trespa)	21x45x3425	1	1		
E	3,50	element	Insulation	75x450x490	4	4		
E	3,51	element	Insulation	140x450x360	4	4		
E	3,60	element	Gypsum panel	10x1115x392	2	2		
SS	4,00	Wooden frame with window 2					1	
C	4,10	Wooden frame					1	
E	4,11	element	Beams	75x34x2230	1	1		
E	4,12	element	Beams	65x34x2230	1	1		
E	4,13	element	Beams	95x75x2230	1	1		
E	4,14	element	Beams	34x140x972	2	2		
E	4,15	element	Posts	Total length 3335 - part 1: 46x140x2885 - part 2: 46x75x450	4		4	
E	4,16	element	Posts	total length 3300 - part 1: 34x140x2885 - part 2: 34x75x450	3		3	
E	4,17	element	Posts	total length 3300 - part 1: 34x140x358 - part 2: 34x75x450	2		2	
C	4,20	component	window component	105x972x2500	2		2	
E	4,30	element	Trespa exterior finishing	6x863x1082	2	2		
E	4,40	element	Batten (to connect trespa)§	21x45x863	4	4		
E	4,41	element	Batten (to connect trespa)	21x45x3425	1	1		
E	4,50	element	Insulation	75x450x490	4	4		
E	4,51	element	Insulation	140x450x360	4	4		
E	4,60	element	Gypsum panel	10x1115x392	2	2		
C	5,00	Content soap frame					1	
E	5,11	element	irregular frames	50x50x...	20		20	
E	5,21	element	irregular glass panels	...	14		14	
E	5,31	element	surrounding frame	50x50x2280	2		2	
E	5,32	element	surrounding frame	50x50x2650	2		2	
		element	extrusion profile	80x80x infinity (or 50x50x...m^1) 2m^1 = 1 unit	25			25
Total					**223**			

Added new elements

part nr.	Level	Type of element	Dimension	Am.nt
6,01	element	darkened glass panels	800 x 2500	3
6,02	element	main frame connection	160 x 160	4
6,03	element	connecting hinges	80 x 80	12
6,04	element	2mm steel wire	100m role	1
6,05	component	ground floor	2172 x 2810	1
6,06	element	clamps	ca. 50x10	32
6,07	component	prefab foundation	500x300x300	4
6,08	element	pins for main frame	Ø 23 x 250	8
6,09	element	thin film solar panel	2500 x 800	1
6,10	element	cable clamp	small	4
Total amount of new elements				**70**
Total (reused + not reused + new)				**234**

part nr.	Relations	type of connection	Price (€)
6,01	6,01 - 6,03	2	272.76
6,02	6,02 - 5,35	4	30
6,03	see other	differs	360
6,04	6,04 - 6,06	2	70.3
6,05	6,05 - 2,15	4	182.67
6,06	see other	differs	10
6,07	6,07 - 6,08	6	132
6,08	6,08 - 5,35	5	20
6,09	6,09 - 6,01	6	
6,10	6,10 - 6,04	6	
Total			**1077.73**

% reused elements		70,2
direct	39,6	
indirect	30,6	
% new elements		29,8
Total		**100,0**

Figure 106 *Overview of used Elements*

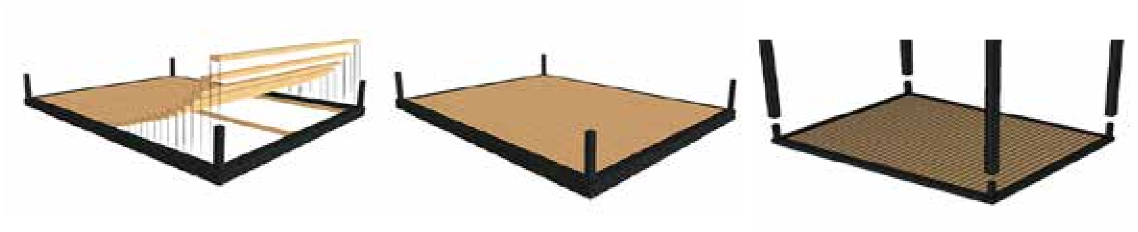


Figure 108 *Building up the ground floor*

Figure 107 *Building up the main frame*

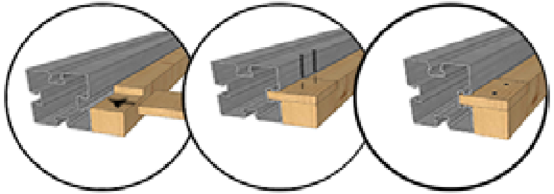


Figure 109 *Attachement wooden floor on the steel frame*

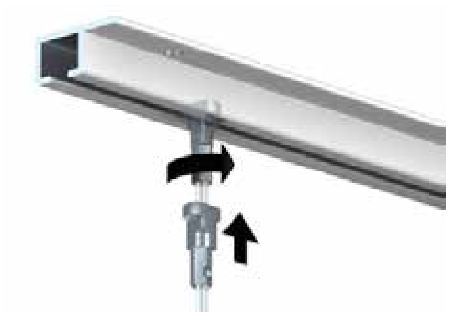


Figure 110 *Connection of wires of the turning tabels /shelves*

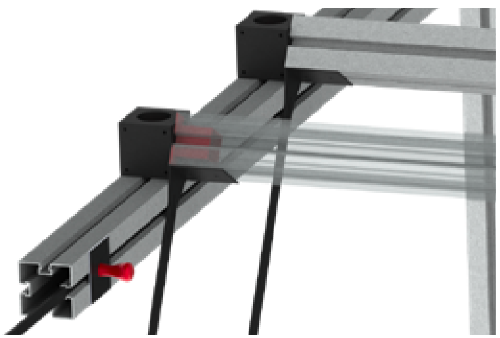


Figure 111 *Connection Roof-Steel frame, slightly tilted*

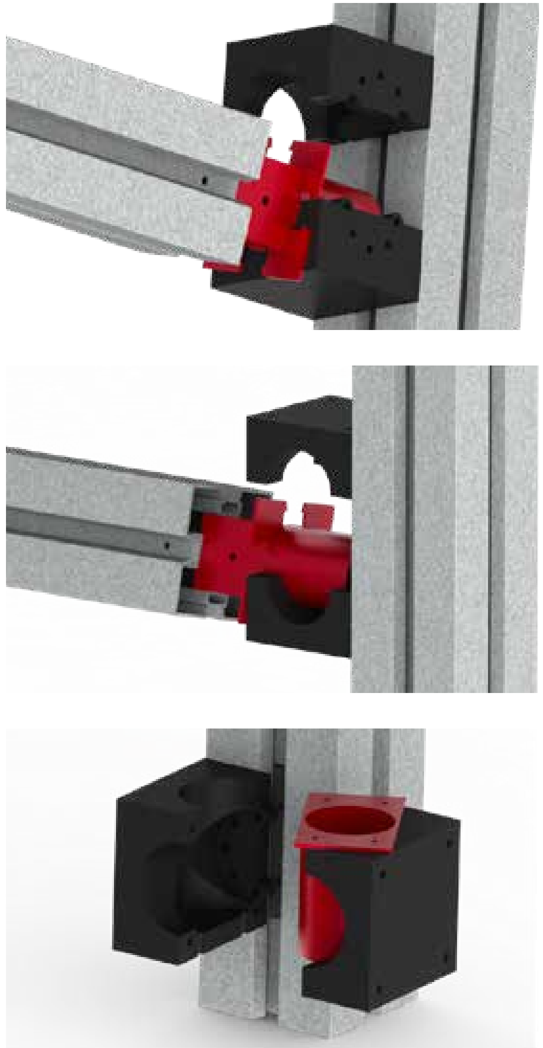


Figure 112 *Design of the hinges including all components, making rotations and replacement of components possible*

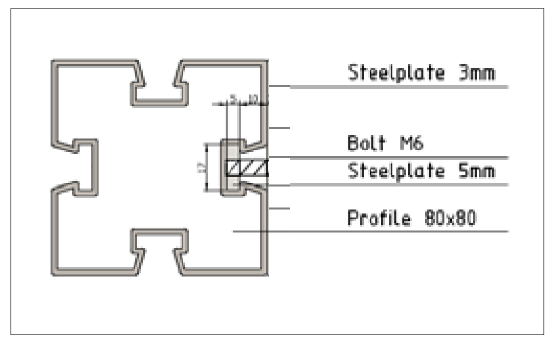


Figure 113 *Detail steel frame*

Figure 114 *Three uses: sitting, gardening and storage*

Figure 115 *Creating a complete interior from existing wooden panels and beams based on boxes linked to each other or used separately*

Basic Information								Type of actions performed				
type	part nr.	level	Type of element	Dimension	Amount	Relations	Type of connection	no change	deformative	subtractive	additive	combination
SS	1,00	Facade sub-system										
C	1,10	wooden frame										
E	1,11	element	Beams	75x34x2230	1	1,11-1,20	4			1		
E	1,12	element	Beams	65x34x2230	1	same	4			1		
E	1,13	element	Beams	95x75x2230	1	same	4			1		
E	1,14	element	Posts	Total length 3335 - part 1: 46x140x2885 - part 2: 46x75x450	2	same	4			2		
E	1,15	element	Posts	total length 3300 - part 1: 34x140x2885 - part 2: 34x75x450	5	same	4			5		
E	1,20	element	wooden panels	18x142x2140	27	1,20 - 1,14	4			27		
E	1,30	element	Insulation	75x450x490	4							
E	1,31	element	Insulation	140x450x2850	4							
E	1,40	element	Gypsum panel	10x1115x2910	2							
SS	2,00	Facade sub-system - closed										
C	2,10	wooden frame										
E	2,11	element	Beams	75x34x2230	1	2,11 - 6,01	5	1				
E	2,12	element	Beams	65x34x2230	1	same	5	1				
E	2,13	element	Beams	95x75x2230	1	same	5	1				
E	2,14	element	Posts	Total length 3335 - part 1: 46x140x2885 - part 2: 46x75x450	2	same	5			2		
E	2,15	element	Posts	total length 3300 - part 1: 34x140x2885 - part 2: 34x75x450	5	2,15 - 6,05	4			5		
E	2,20	element	wooden panels	18x142x2140	27	2,20 - 2,14	4	2		25		
E	2,30	element	Insulation	75x450x490	4							
E	2,31	element	Insulation	140x450x2850	4							
E	2,40	element	Gypsum panel	10x1115x2910	2							
SS	3,00	Facade sub-system - open										
C	3,10	Wooden frame										
E	3,11	element	Beams	75x34x2230	1	3,11 - 6,01	5	1				
E	3,12	element	Beams	65x34x2230	1	same	5	1				
E	3,13	element	Beams	95x75x2230	1	same	5	1				
E	3,14	element	Beams	34x140x972	2							
E	3,15	element	Posts	Total length 3335 - part 1: 46x140x2885 - part 2: 46x75x450	4	3,15 - 6,03	4	4				
E	3,16	element	Posts	total length 3300 - part 1: 34x140x2885 - part 2: 34x75x450	3	existing	4	3				
E	3,17	element	Posts	total length 3300 - part 1: 34x140x358 - part 2: 34x75x450	2	existing	4	2				
C	3,20	component	window component	105x972x2500	2	3,20 - 6,03	4	2				
E	3,30	element	Trespa exterior finishing	6x863x1082	2							
E	3,40	element	Batten (to connect trespa)	21x45x863	4							
E	3,41	element	Batten (to connect trespa)	21x45x3425	1							
E	3,50	element	Insulation	75x450x490	4							
E	3,51	element	Insulation	140x450x360	4							
E	3,60	element	Gypsum panel	10x1115x392	2							
SS	4,00	Wooden frame with window 2										
C	4,10	Wooden frame										
E	4,11	element	Beams	75x34x2230	1	4,11 - 6,01	5			1		
E	4,12	element	Beams	65x34x2230	1	same	5			1		
E	4,13	element	Beams	95x75x2230	1	same	5			1		
E	4,14	element	Beams	34x140x972	2							
E	4,15	element	Posts	Total length 3335 - part 1: 46x140x2885 - part 2: 46x75x450	4	4,15 - 6,03	4	4				
E	4,16	element	Posts	total length 3300 - part 1: 34x140x2885 - part 2: 34x75x450	3	existing	4	3				
E	4,17	element	Posts	total length 3300 - part 1: 34x140x358 - part 2: 34x75x450	2	existing	4	2				
C	4,20	component	window component	105x972x2500	2	4,20 - 6,03	4	2				
E	4,30	element	Trespa exterior finishing	6x863x1082	2							
E	4,40	element	Batten (to connect trespa)	21x45x863	4							
E	4,41	element	Batten (to connect trespa)	21x45x3425	1							
E	4,50	element	Insulation	75x450x490	4							
E	4,51	element	Insulation	140x450x360	4							
E	4,60	element	Gypsum panel	10x1115x392	2							
C	5,00	Content soap frame										
E	5,11	element	irregular frames	50x50x...	20	existing		20				
E	5,21	element	irregular glass panels	...	14	existing		14				
E	5,31	element	surrounding frame	50x50x2280	2	existing		2				
E	5,32	element	surrounding frame	50x50x2650	2	5,32 - 6,03	4	2				
		element	extrusion profile	80x80x infinity (or 50x50x...m^1) 2m^1 = 1 unit	25	5,35 - 5,35	4	25				
Total					**223**			**93**	**0**	**71**	**0**	**0**
Percentage								56,7	0,0	43,3	0,0	0,0

Figure 116 *Element Level Change*

2.3

STUDIO MOSTAR

Amount	Length (cm)	Section (cm)	Material
MAIN CONSTRUCTION ELEMENTS			
5	188	18X6	Wood
4	200	10x10	Wood
2	200	18x6	Wood
2	200	14x6	Wood
5	188	14x6	Wood
4	118	10x10	Wood
4	58	18x6	Wood
TRIMMING			
12	21	6x2.8	Wood
4	28.5	6x4.2	Wood
6	167.8*	6x4.2	Wood
8	155.8	6x4.2	Wood
3	20.2	6x4.2	Wood
* Two elements have a notch that could not be measured. It looks like clip from circle length of 39cm starting from the 74th cm.			
OUTER WALLS OF BUILDING BLOCKS CONSTRUCTION -FACADES			
2	208.2	70x1.8	Plywood
3	202	70x1.8	Plywood
4	167.6	220x1.8	Plywood
2	188	42x1.8	Plywood
2	114.6	38x1.8	Plywood

Figure 118 *Pixel Elements Specification*

Figure 117 *Existing material bank to be reused for new design*

Basic Information

Type	el.nr	level	Type of element	Dimension	Given amount of parts	relations	type of connection	Not used elements	Used elements	Extracted elements	Added
		MAIN CONSTRUCTION ELEMENTS									
E	1.00	element	Column	10x10x200	4	1.00 - 1.20,1.40,1,5,1.91	4. , 4. , 3., 2.	0	4	0	4
E	1.10	element	Beam	14x6x200	2	1.10 - 1.50,1.91	4. , 2.	0	2	0	0
E	1.20	element	Beam	18x6x188	5	1.20 - 1.0,1.20,1.80,1.81,1.90	4. 3., 2. , 2.	0.5	4.5	1	1
E	1.30	element	Beam	14x6x188	5	1.30 - 1.3,1.5,1.91,	3., 4. ,2.	0.5	4.5	1	0
E	1.40	element	Beam	18x6x200	2	1.4 - 1.0, 1.80,1.81	4. , 2. , 2.	0	2	0	0
E	1.50	element	Pilar	10x10x118	4	1.50 - 1.0,1.10,1.91	3. , 4 ,2.	2	2	2	0
E	1.60	element	Beam	18x6x58	4	1.6 - 1.9	4.	0	4	0	0
		TRIMMINGS / ELEMENTS									
E	1.70	element		6x2.8x21	12			12	0	12	0
E	1.71	element		6x4.2x28.5	4			4	0	4	0
E	1.72	element		6x4.2x167.5	6	1.72 - 1.72, 1.73	2.	3	3	3	0
E	1.73	element		6x4.2x155.8	8	1.73 - 1.73, 1.72	2., 4.	0	8	8	0
E	1.74	element		6x4.2x20.2	3			3	0	3	0
		OUTER WALLS OF BUILDING BLOCKS CONSTRUCTION - FACADES									
E	1.80	element	board	70x1.8x208.2	2	1.80 - 1.20,1.40	2. , 2.	0.5	1.5	0.5	2
E	1.81	element	board	70x1.8x202	3	1.81 - 1.20,1.40	2. , 2.	0	3	0	0
E	1.82	element	board	42x1.8x188	2	1.82 - 1.82	2.	0	2	0	0
E	1.83	element	board	38x1.8x114.6	2	1.83 - 1.83	2.	0	2	0	0
		COMPONENTS									
C	1.90	component	board with small colored pieces	220x1.8x167.6	2	1.91 - 1.10,1.30	2. ,2.	0	2	0	0
E	1.91	element	board with the cicle hole	220x1.8x167.6	2	1.90 - 1.50,1.10,1.6	2. ,4. ,2.	0	2	0	0
Total					**66**			**24**	**30**	**34**	**3**

Added new elements

	el.nr	level	Type of element	Dimension	Amount						
	2.0	element	beam	18x6x160	2	2,0 - 1.4, 1.2	4.	0	2	0	0
	2.1	element	bord	10x1.8x315.2	2	2.1 - 1.2	2.	0	2	0	0
	2.2	element	glass	1,54 m2	2	2.2 - 1.90	5.	0	2	0	0
	2.3	element	lazy bag		2	/	/	0	2	0	0
	2.4	element	rope	10 m	1	/	1.	0	1	0	0
	2.5	element	silikon		1	2.5 - 2.2, 1.91	5.	0	1	0	0
	2.6	element	screw,nail	Ø 6mm	35	2.6 - 1.0,1.1,1.2,1.3,1.4,1.8,1.81	2.	0	35	0	0
	2.7	element	L- fasteners	60x90x90	30	2.7 - 1.90,1.60	4.	0	30	0	0
	2.8	element	mehanism for sliding walls		1	2.8 - 1.90	2.	0	1	0	0
Total amount of new elements					**9**						
Total (reused + not reused + new)					**100**						

% reused elements		70,1
direct	15,7	
indirect	54,3	
% new elements		29,9
Total		**100,0**

Figure 119 *Overview of used Elements*

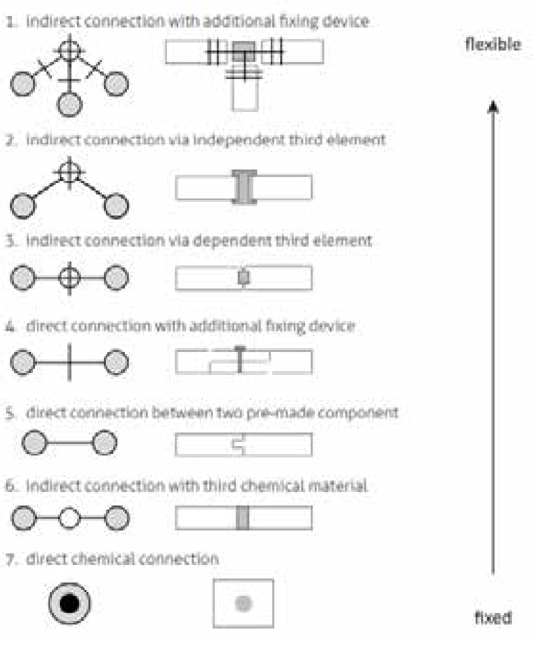


Figure 120 Types of connections

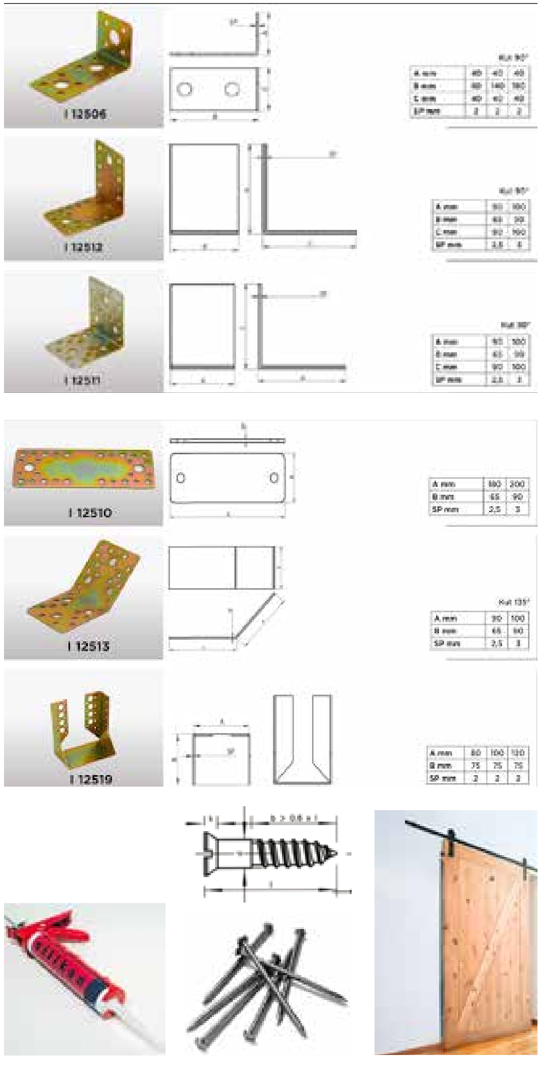
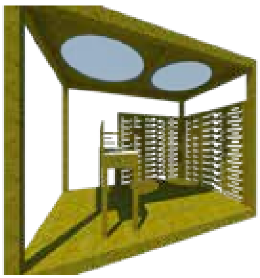
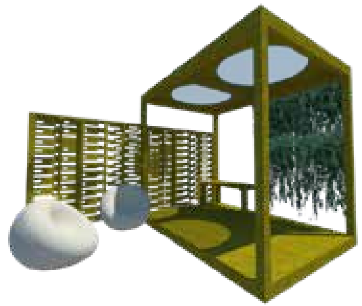


Figure 121 Connections





Option 1: Kiosk

Option 2: Chill and Work

Option 3: Be Human

Figure 122 *Existing materials are reused in a reversible pixel that can be transformed when functions are changed.*

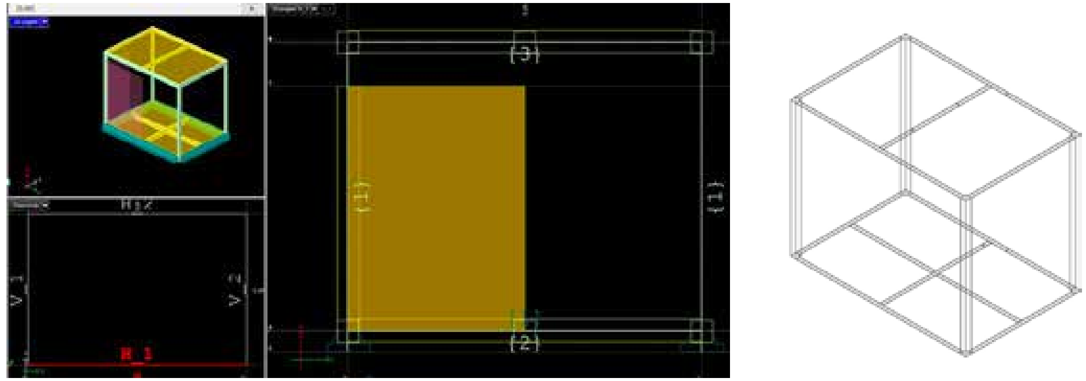


Figure 125 *Statistical Analysis*

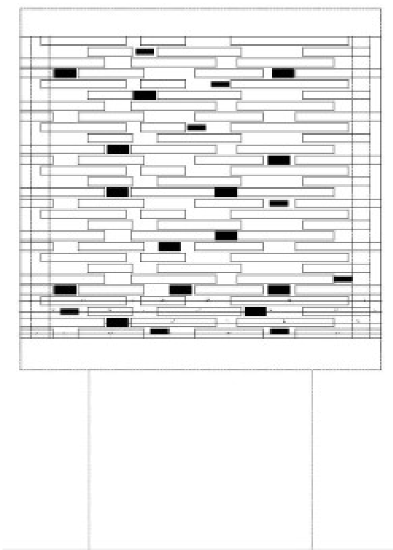


Figure 123 *Wall of small parts with different lengths*

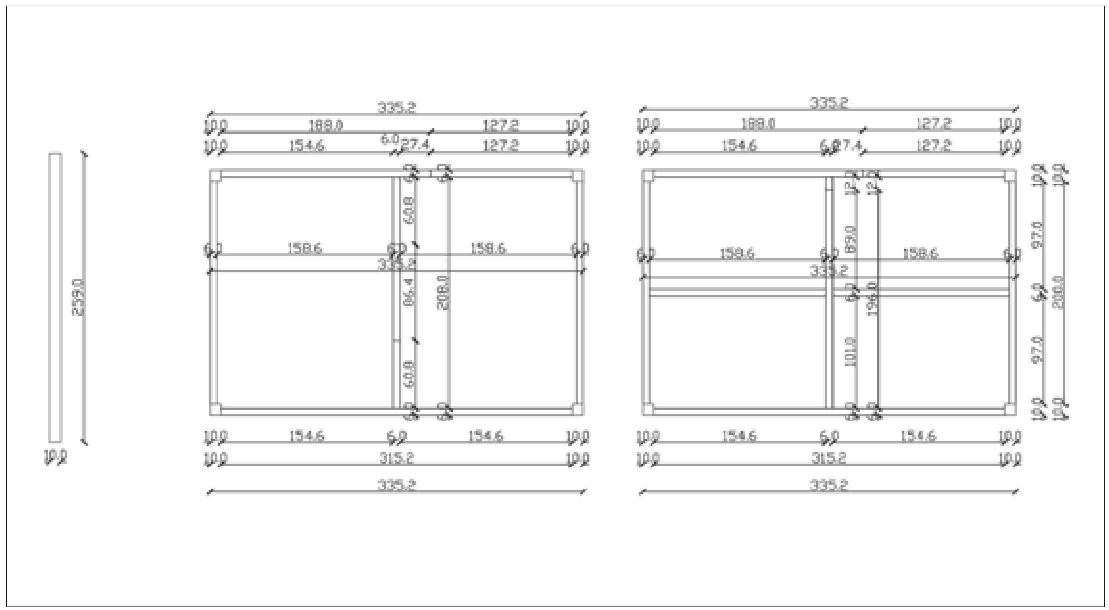


Figure 124 *Technical Drawings*

Basic Information								Type of actions performed						
type	part. no.	level	Type of element	Dimension	Am.nt	Relations	Type of connection	no change	defor-mative	subtrac-tive	addi-tive	combi-nation	%direct reuse	%indirect reuse
MAIN CONSTRUCTION ELEMENTS														
E	1.00	element	Column	10x10x200	4	1.00 - 1.20,1.40,1,5,1.91	4. , 4. , 3., 2.	4	0	0	4	4	4	0
E	1.10	element	Beam	14x6x200	2	1.10 - 1.50,1.91	4. , 2.	2	0	0	0	0	2	0
E	1.20	element	Beam	18x6x188	5	1.20 - 1.0,1.20,1.80,1.81,1.90	4. 3., 2. , 2.	3	2	2	5	5	4.5	0.5
E	1.30	element	Beam	14x6x188	5	1.30 - 1.3,1.5,1.91,	3., 4. ,2.	2	3	3	5	5	4.5	0.5
E	1.40	element	Beam	18x6x200	2	1.4 - 1.0, 1.80,1.81	4. , 2. , 2.	2	0	0	0	0	2	0
E	1.50	element	Column	10x10x118	4	1.50 - 1.0,1.10,1.91	3. , 4. ,2.	0	2	2	2	2	2	2
E	1.60	element	Beam	18x6x58	4	1.6 - 1.9	4.	0	2.5	2.5	2.5	2.5	0	4
TRIMMINGS / ELEMENTS														
E	1.70	element		6x2.8x21	12									
E	1.71	element		6x4.2x28.5	4		2.	4	4	4	4	4	0	4
E	1.72	element		6x4.2x167.5	6	1.72 - 1.72	2.	3	3	3	3	3	0	3
E	1.73	element		6x4.2x155.8	8	1.73 - 1.73, 1.72	2., 4.	8	8	8	8	8	0	8
E	1.74	element		6x4.2x20.2	3									
OUTER WALLS OF BUILDING BLOCKS CONSTRUCTION - FACADES														
E	1.80	element	board	70x1.8x208.2	2	1.80 - 1.20,1.40	2. , 2.	1.5	1.5	1.5	1.5	1.5	1.5	0
E	1.81	element	board	70x1.8x202	3	1.81 - 1.20,1.40	2. , 2.	3	3	3	3	3	3	0
E	1.82	element	board	42x1.8x188	2	1.82 - 1.82	2.	2	2	2	2	2	0	2
E	1.83	element	board	38x1.8x114.6	2	1.83 - 1.83	2.	2	2	2	2	2	0	2
E	1.91	element	board with the cicle hole	220x1.8x167.6	2	1.91 - 1.10,1.30	2. ,2.	2	0	0	0	0	2	0
C	1.90	component	board with small colored pieces (97 pieces of lath)	220x1.8x167.6	2	1.90 - 1.50,1.10,1.6	2. ,4. ,2.	2	0	0	0	0	2	0
								1	1	1	1	1	1	1
Total					**66**			**40**	**30**	**30**	**39**	**39**	**22,5**	**77,5**
Percentage								22,5	16,9	16,9	21,9	21,9	4,9	15,9
Added new elements														
		level	**Type of element**	**Dimension**	**Am.nt**									
	2.0	element	beam	18x6x160	2	2,0 - 1.4, 1.2	4.	2	0	0	0	0	2	0
	2.1	element	bord	10x1.8x315.2	2	2.1 - 1.2	2.	2	0	0	0	0	2	0
	2.2	element	glass	1.54 m2	2	2.2 - 1.91	5.	2	0	0	0	0	2	0
	2.3	element	lazy bag		2	/	/	2	0	0	0	0	2	0
	2.4	element	rope	10 m	1	/	1.	1	0	0	0	0	1	0
	2.5	element	silikon		1	2.5 - 2.2, 1.91	5.	1	0	0	0	0	1	0
	2.6	element	screw,nail	Ø 6mm	35	2.6 - 1.0,1.1,1.2,1.3,1.4,1.8,1.81	2.	35	0	0	0	0	35	0
	2.7	element	L- steel brackets	60x90x90	30	2.7 - 1.90,1.60	4.	20	0	0	0	0	20	0
	2.8	element	mehanism for sliding walls		1	2.8 - 1.90	1	1	0	0	0	0	1	0
Total amount of new elements					**76**									
total (reused + not reused + new)					**254**									

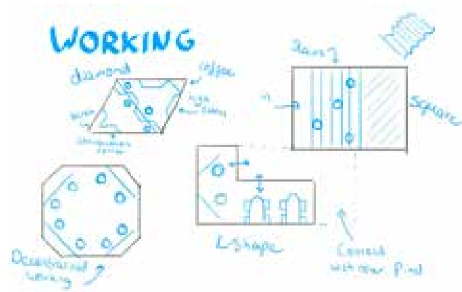
Figure 126 *Element Level Change*

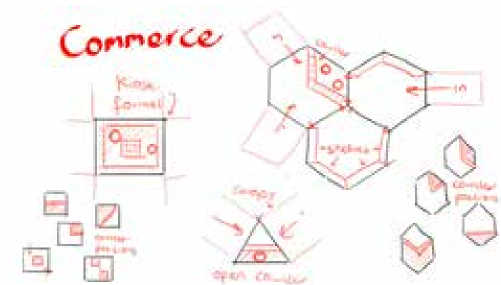
2.4

STUDIO MAASTRICHT

DESIGN APPROACH

A reversible model is designed for a building module that can be transformed into different forms and functions reusing the same set of elements.
The design priorities consisted of two criteria: architectural quality en transformability.





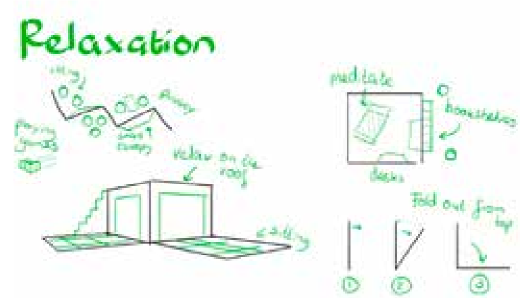


Figure 127 *Three transformable concepts*

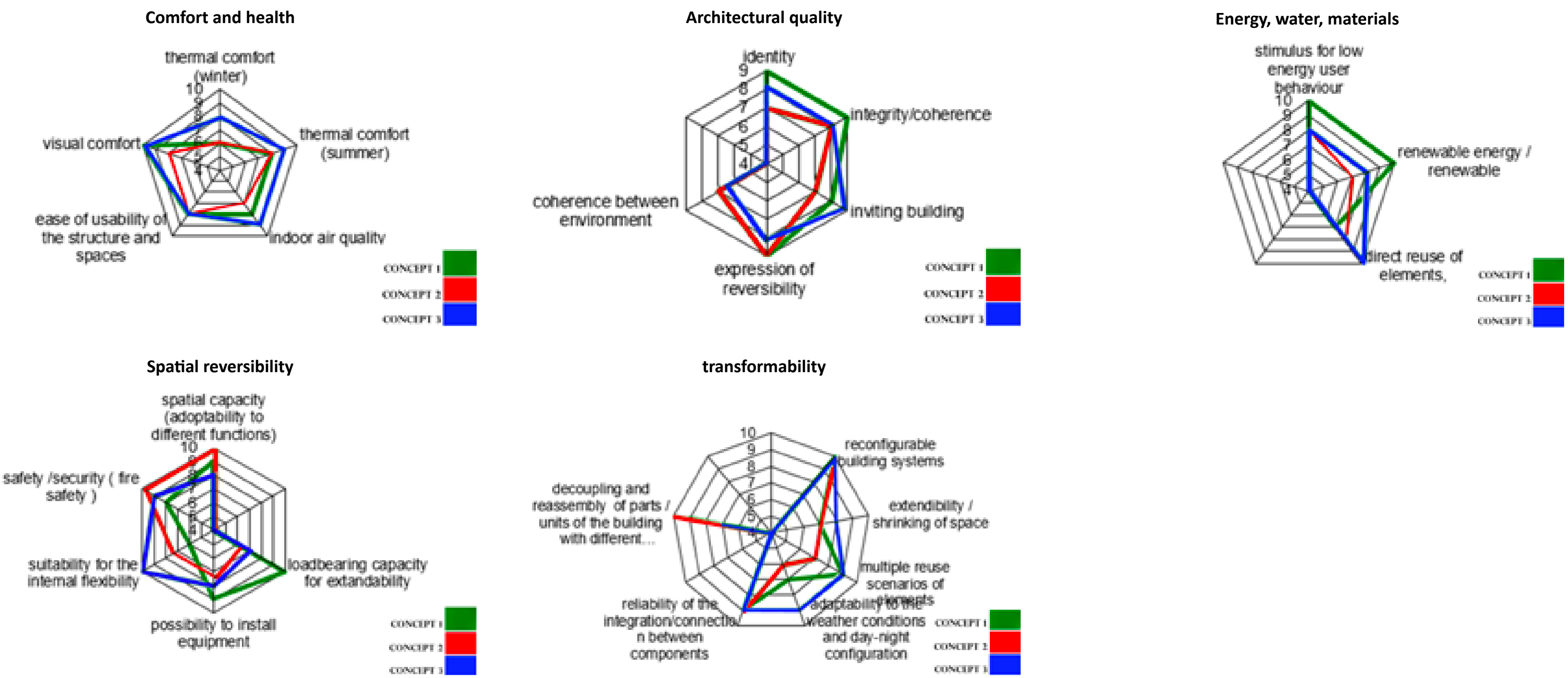


Figure 128 *Concept of choice: Concept 1 Relaxation*

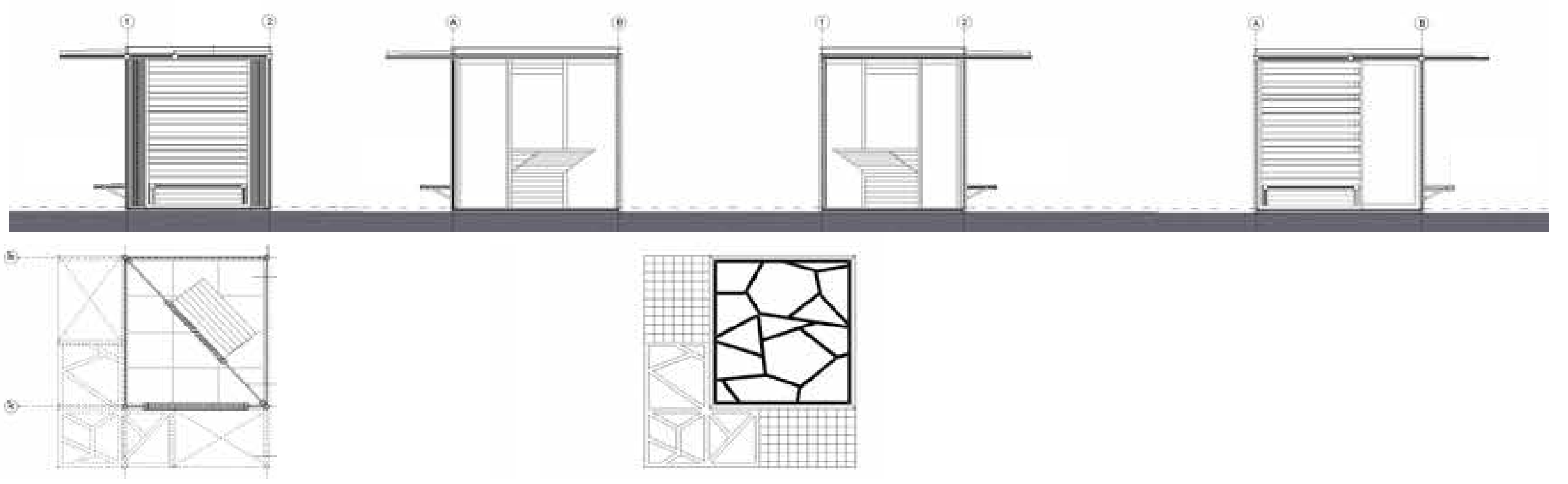


Figure 129 *Commercial: facades and plans*

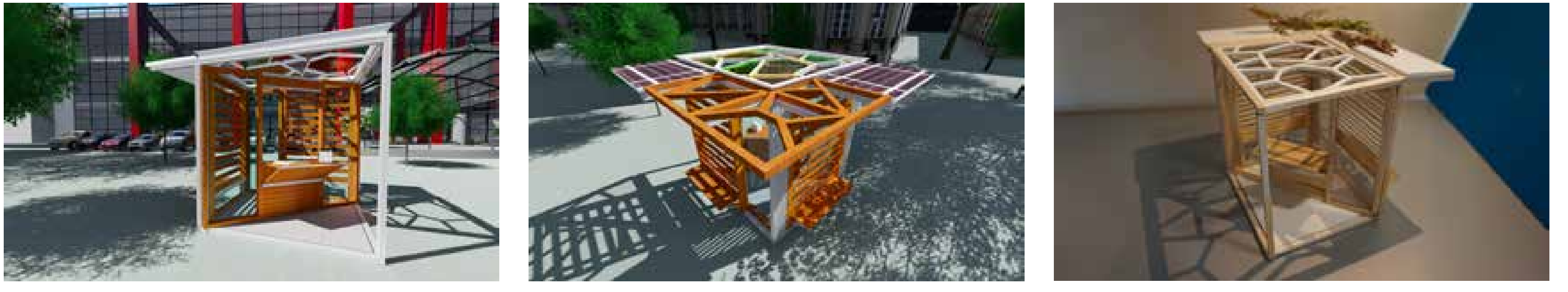


Figure 130 *Commercial: visualisations*

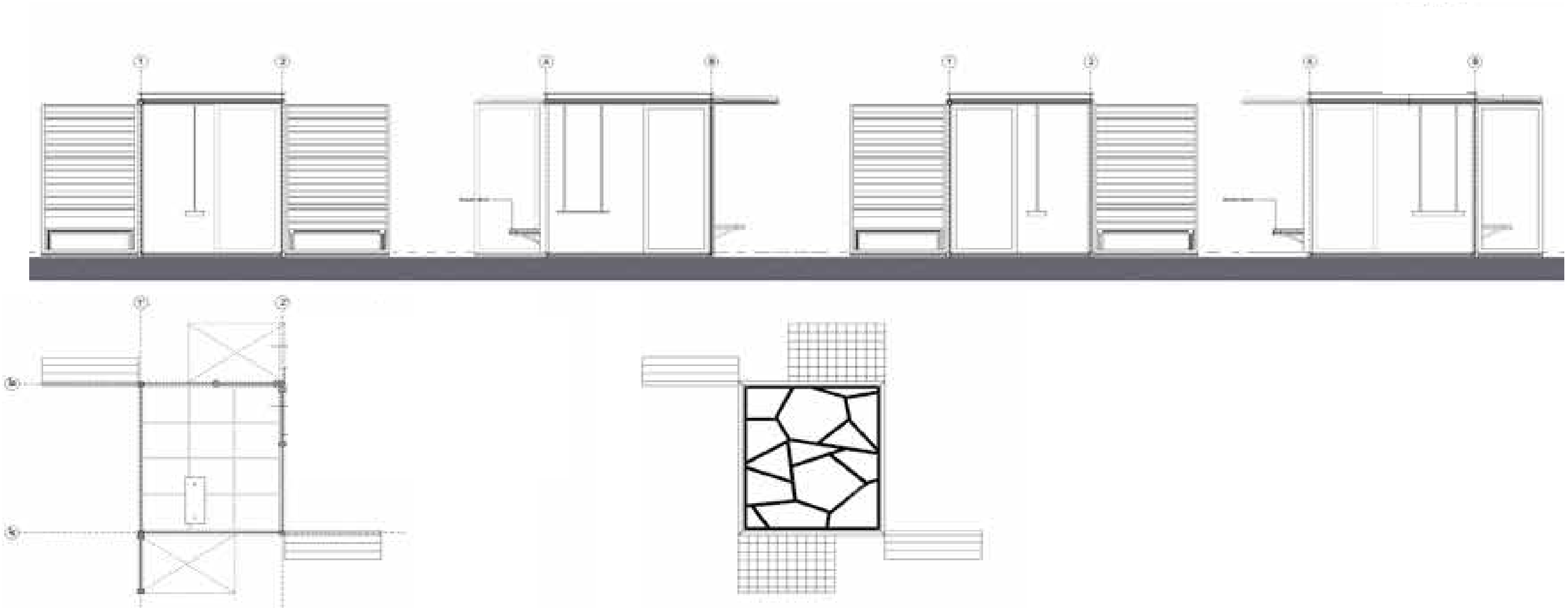


Figure 131 *Relaxation: facades and plans*

Figure 132 *Relaxation:visualisations*

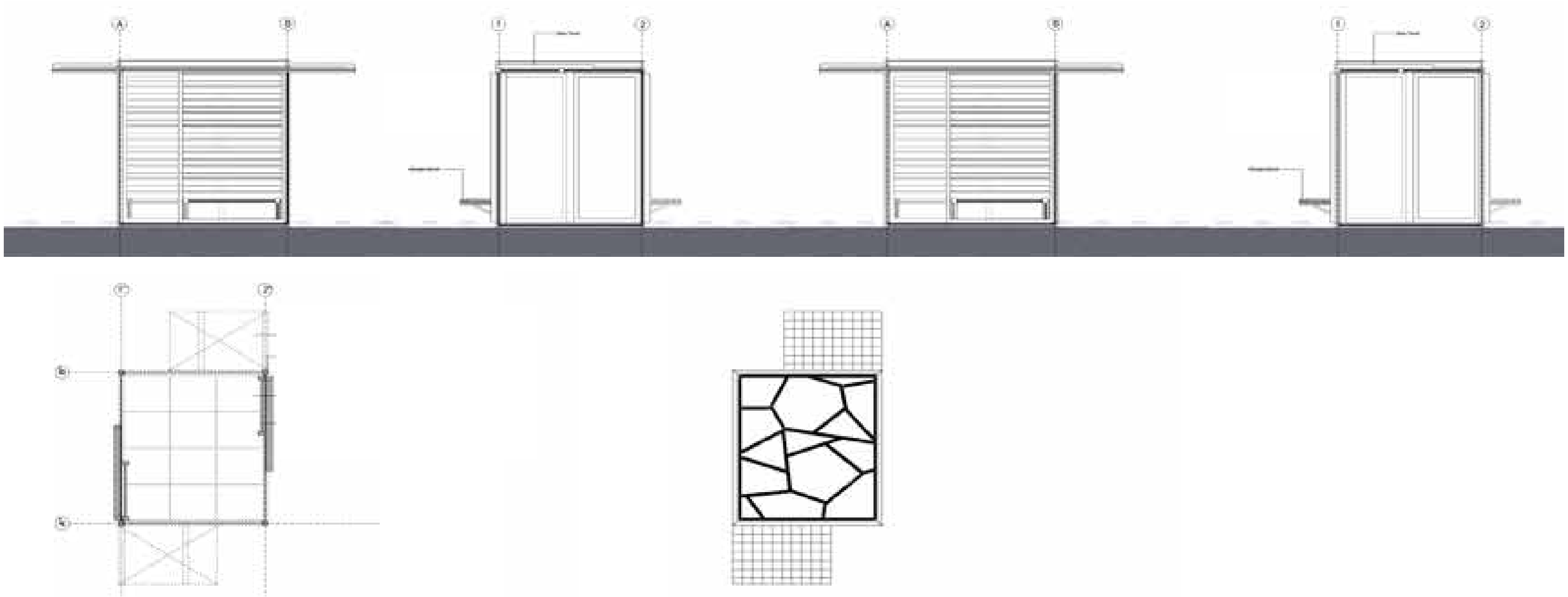


Figure 133 *Working: facades and plans*

Figure 134 *Working: visualisations*

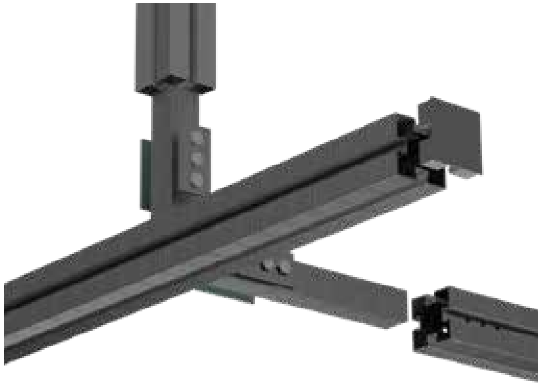


Figure 136 *Connection steel frame*

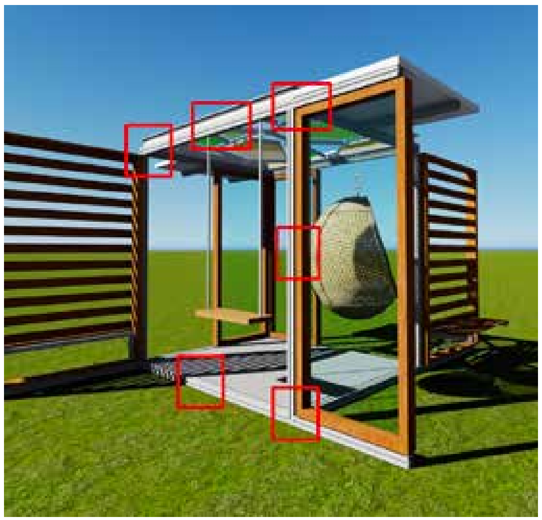


Figure 135 *Connections overview*

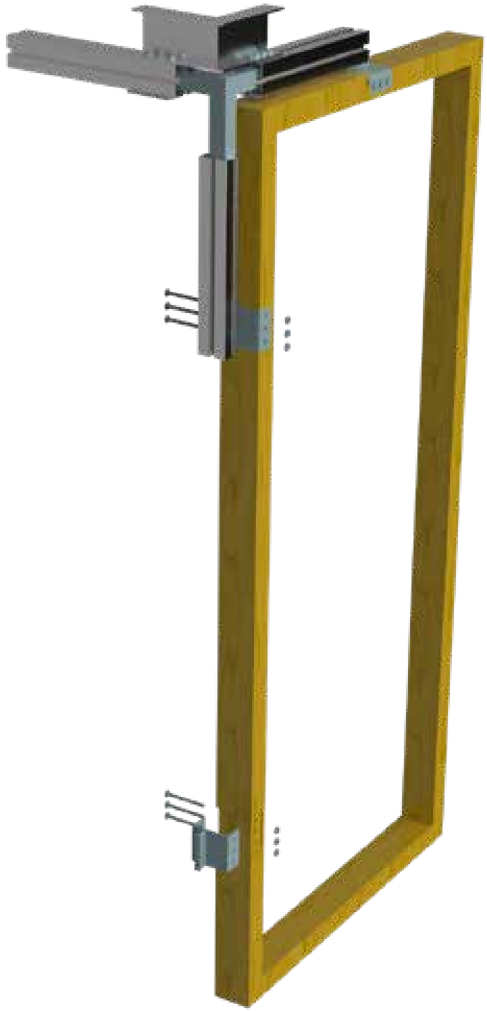


Figure 138 *Connection wooden frame - steel frame*

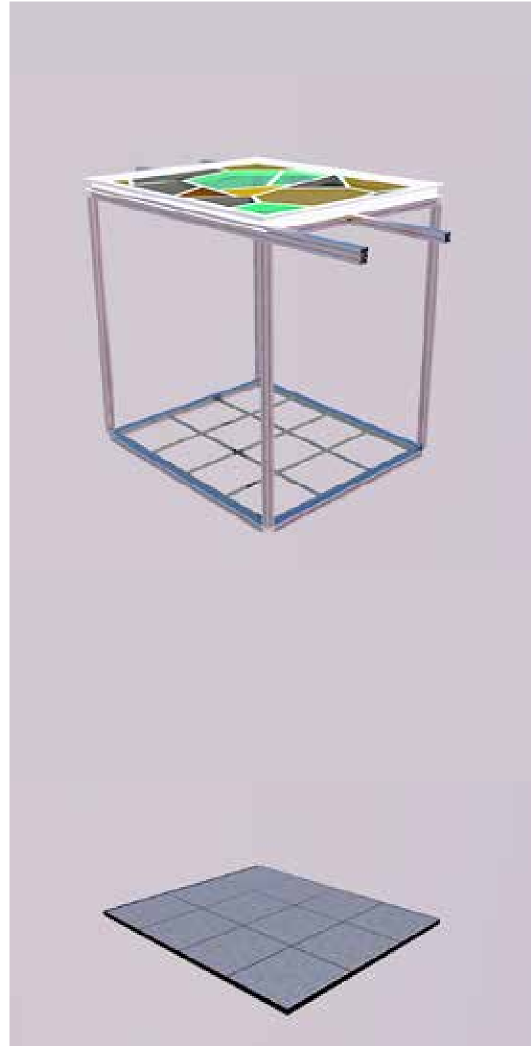


Figure 137 *Foundation and frame*

Connections
Timber/windows panels to frame: 1
Beams within frame: 1
Soap frame to beam frame: 4 (bolts)
Plexiglass to soap frame: 6
Timber/windows frames: 4 (screws)

Recommendations
Reuse the funky wooden panel
Usage of isolation material (cushioning for example)
Location electrical parts solar panels
Sockets

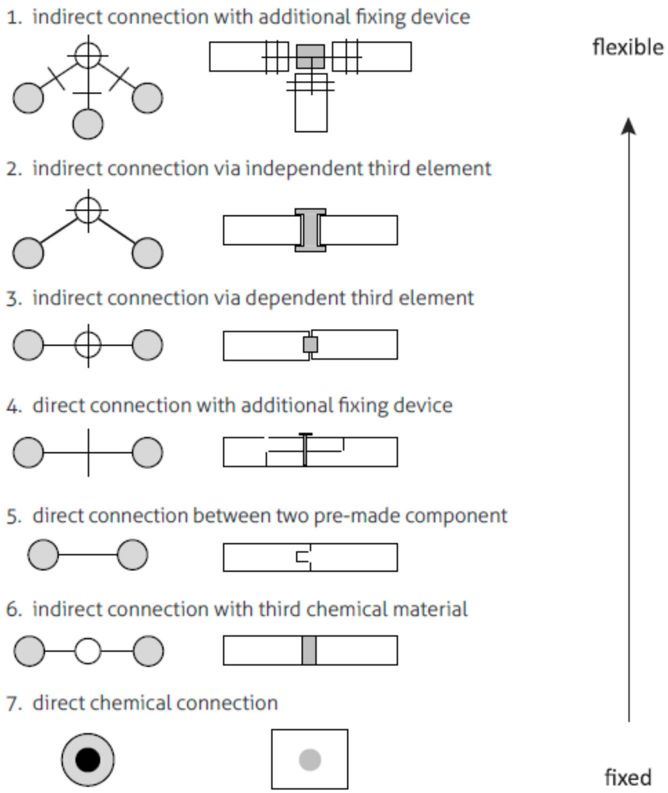


Figure 139 *Flexibility of connections*

level	Type of element	Dimension	Amount
Furniture	Wooden boards	1500*142	6
Furniture	Swing		1
Furniture	Hanging chair		1
Energy	Solar Panel	1500*1000	2
Energy	Battery + Transformer	200*300*100	1
Foundation	Foundation frame (T-profile steel beams)	20m^1 = 1 unit	1,2
Connection	Plastic plugs	80 *80 *50	4
Connection	Steel Three pin element	46*46*500 (every pin)	6
Connection	Steel Five pin element	46*46*500 (every pin)	1
Connection	Plastic Corner element		2
Connection	Panel Connection Clam	4 clams for one panel = 1 unit	6
Connection	Clam placeholder	30m^1 = 1 unit	0,3
Connection	Hanging furniture Clam		2
Roof coverage	Plexiglass board	2540*2170	1
Roof structure	Wooden beams	5000	4
Foundation	Concrete tiles v	600*700	12

	Weight (kg)	%
Total reused materials	1260	75%
New elements	430	25%
Total	**1689**	**100%**

	Number of elements	%
Reused elements	142,5	73,40%
New elements	51,5	26,60%
Total	**194**	**100%**

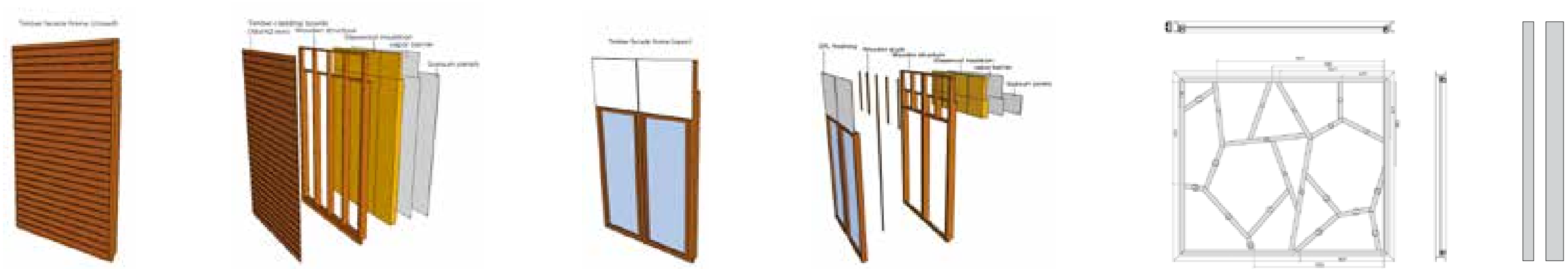


Figure 140 *Set of Materials*

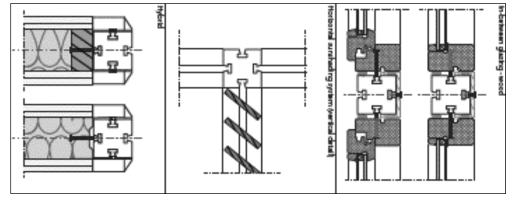
2.5

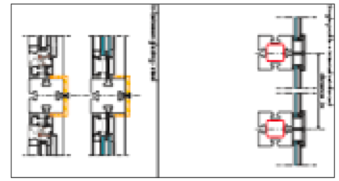
TECHNICAL ANALYSES OF MOST PREFERED PIXEL

Key technical requirements for transformation were related to the ambition to develop a method of construction that will allow multiple use options of key elements of the structure. In this case we developed new steel profiles and associated reversible connections. This reversible method of construction has:

- A dimensional tolerance that makes it possible to apply steel profiles within buildings with different dimensionsofstructuralgridandfloortoceilingheight. The aim of the prototype was to develop a principle that will make dimensional tolerance possible. Studies of building typologies of housing and their structural characteristics, done by WP3, indicate that the structural span and height differ on average 5 cm and that possibility to adjust dimension of facade elements would increase their reuse potential. Important aspect of prototype design was to develop a principle which will make this possible while through further engineering the exact tolerance (in length and height) for this system will be investigated.

- Geometry of the profile that makes it possible to connect and disassemble different building components (as inner wall, facade panels, roof, cantilevers, sun shading, sliding panels, installation modules, without damaging surrounding parts or component itself.





- Geometry of the connection with interlocking principles that take care of the integrity of the structure and eliminates damages to the connection or connected profiles during transformations.

- A proposed method of construction that is upgradable in a sense that new steel profiles can be upgraded with additional inserts in order to carry more load (for example green roof of 2,5KN/m2) if needed which adds to its multi-functionality and increases its reuse potential. In addition steel profiles can function as a column and as a beam. In the case of greater span (4,8m) two profiles can be connected in order to form high beam.

The ambition set up for this prototype with respect to the technical requirements has been evaluated through following criteria:

CONSTRUCTIVE STRENGTH

With constructive rigidity we mean the strength that the connection and profiles actually have. How much force can it take and when will it collapse. The evaluation has been done based on expert optinion and assesments done by a structural engineer at Janssen and ODS and structural knowledge and logic thinking as a technicians. Dimension adjustability

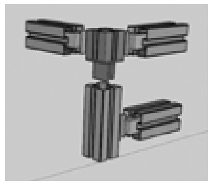
This subject describes how flexible a connection is in terms of its dimensional tolerance as described in previouse section. For example: can you add another beam to the connection and can you expand the structure or decrease its dimension simply by making a slight adjustment on the connection? Yet again the numbers in the schedule can be seen as a ratio.

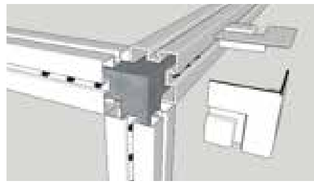
REUSE OF MATERIALS

This subject describes the reuse of the used materials to make struture. A material which is added that can only be used for one particular application scores lower than a material that can be reused in other situations and applications.

DAMAGING OF THE STRUCTURAL BEAM

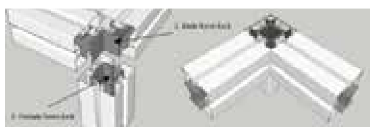
This subject describes the amount of changes (damage) that come with a particular kind of connection. If one connection asks for lots of changes in the structural beam (as figure below right wher aditional wholes were requierd) it scores lower in our test. For example is it needed to drill or screw in to the beams. Yet again the numbers on the schedule can be seen as a ratio.

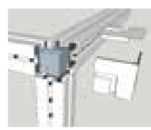




CAPACITY AND AVAILABILITY TO REINFORCE THE STRUCTURAL BEAM

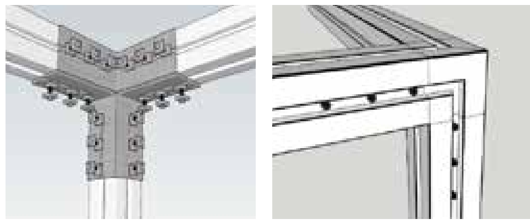
This subject describes the amount of room and possibilities there are to reinforce a beam while a particular kind of connection is being used. We looked at when the connection could have any negative impact on this. Yet again the numbers in the schedule can be seen as a ratio. Solutions that were providing less space for future inserts have been scored as less good as for example the type of connection right in the figure below in comparision with the connection in the left.





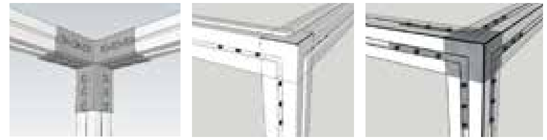
SLOT AVAILABILITY FOR FACADE ELEMENTS

This subject describes the amount of room and possibilities there are to connect any facade systems to the exterior slots of the steel profile. If the main connection of the beam is using this space to connect the beams and columns, there would be no space left to make the connection between the structure and the facade system or panels. Yet again the numbers in the schedule can be seen as a ratio. Figures below ilustrate connection solution which makes it dificult to add standard fasade profiles, figure left presents improved connection solution.



AESTHETICS

This subject describes the architectural quality that the connections have. Internal connections usually score higher in this subject because they're simply not visible from the outside of the pixel. Exterior connections on the other hand will score lower because the connection will be visible from the outside which diminishis the esthetic quaity of the connetion. The contiunitiy of slot lines and posisbility to create a conherent design were main crietria for this aspect. Few principle differences are shown in the figure below. Yet again the numbers on the schedule can be seen as a ratio.



ASSEMBLING SPEED

This subject describes the difficulty level and time needed to assemble a particular connection. **This subject is focused on the assembling speed during construction and not during production.** How many different steps and time are needed to make a particular connection while under construction? Connections that have more separat parts for assembly and require more steps for assembly get low scores. Yet again the numbers on the schedule can be seen as a ratio.

	Constructive strength	Adjustability	Versatility	Beam damage	Reinforcement capacity	Slot use	Esthetics	Construction speed
Connection 1								
Connection 2								
Connection 3								
Connection 4								
Connection 5								
Connection 6								
Connection 7								
Connection 8								

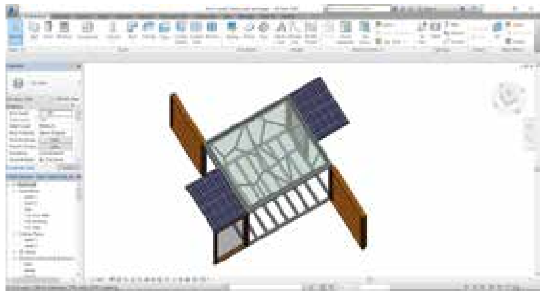
EVALUATION MATRIX

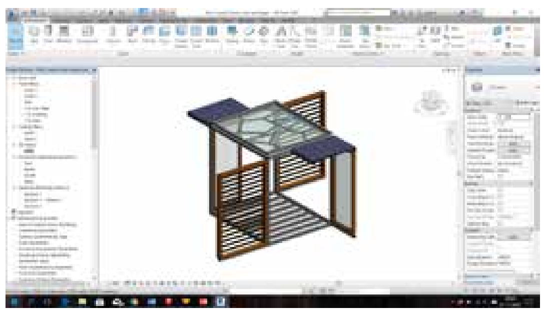
Overview of criteria matrix that has been used to make selecton of connections that are in the line with technical requirements is presented in the tabel below and individual connections and their evaluation will be presented in the following section:

REVIT MODEL

Revit model has been created for Urban Pixel project, because the opportunities in Revit about the information you can add to a material is high. This creates the opportunity to pass on the information from the old building and reuse them in a new building. This creates a representation of which materials from the model can be reused in a new building. BAMB is doing research if the materials of the building who will be demolished could be placed in a second hand web shop. This creates a new platform were designers/builders of new building can collect their materials and start the designing with the materials in mind. The reversible market could be created on this way. The model of the urban pixel will be modelled that it could be used for a reversible market. The urban pixel model is a collaboration of elements who are fitted with information and a nlsfb code. This creates a very usable Revit. This is a requirement because there will work people on this model who don't know all the information and the story behind the elements.

The Revit model is fitted with the beams who are the main construction and on these beams are the panels, foundation and bench connected. Al those elements together form a very usable model with a lot of information. The connection details will be added in a later stadium of the project. This will happen when we connect the AutoCAD drawing in pdf form to the model with a link.
On the pictures at te left is a view of the revit model.





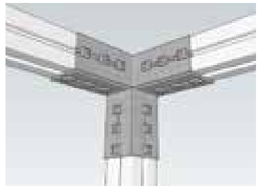
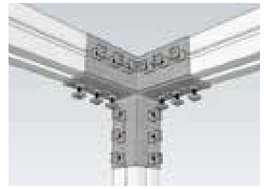
EVALUATION OF REVERSIBLITY OF CONNECTIONS

	Constructive strength	Adjustability	Versatility	Beam damage	Reinforcement capacity	Slot use	Esthetics	Construction speed
Connection 1	1	2	2	2	2	-1	-2	1
Connection 2	-2	-1	2	2	2	-1	1	2
Connection 3	1	2	-1	-1	0	0	2	-2
Connection 4	2	2	-2	-1	-1	0	2	1
Connection 5	1	2	0	-1	-1	0	2	1
Connection 6	0	2	2	-1	-1	0	1	0
Connection 7	1	2	2	-1	1	0	2	0

Connection 1: L shaped profile connected on slot

See Detail 1 in the appendix

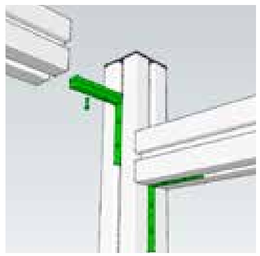
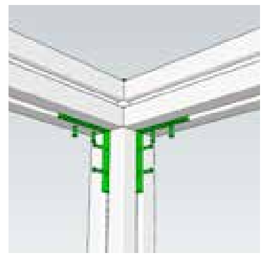
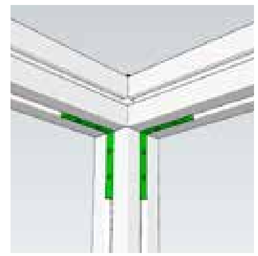
	Advantage	Disadvantage
Constructive strength	High in general	Based on clamping and friction, it might slip off
Adjustability	High	
Versatility	Usable in every direction	
Beam damage	No beam damage	
Reinforcement capacity	Internals of beam empty	
Slot use		Slot completely blocked in place of connection
Esthetics		Prominent and in sight
Assembling speed	Relatively simple and fast	

Connection 2: L shape in slot

See Detail 2 in the appendix

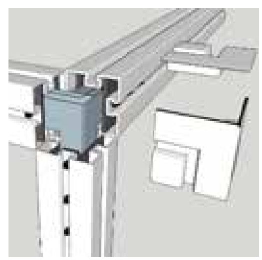
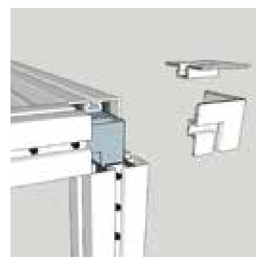
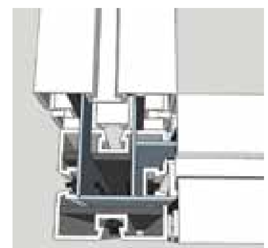
	Advantage	Disadvantage
Constructive strength		Little material strength, based on clamping, might shear
Adjustability		Only adjustable in hight as long as it doesn't go above the beam
Versatility	Usable in every direction	
Beam damage	No beam damage	
Reinforcement capacity	Internals of beam empty	
Slot use		Slot completely blocked in place of connection
Esthetics	In sight but not very prominent	
Assembling speed	Very simple and fast	

Connection 3: Interior steel plates

See Detail 3 in the appendix

	Advantage	Disadvantage
Constructive strength	Strong in every direction	
Adjustability	Easily adjustable trough screws	
Versatility		Made out of 3 different pieces, useable in 4 directions at most
Beam damage		3 holes per slot
Reinforcement capacity	Internals available in crucial spots	
Slot use	Only partialy blocked by screws	
Esthetics	Only screws are visible	
Assembling speed		Very complex and hard to assemble

Cube with slots

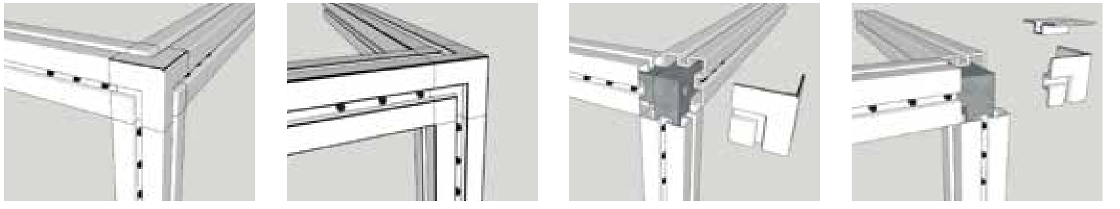
See Detail 4 in the appendix

	Advantage	Disadvantage
Constructive strength	Strong in every direction	
Adjustability		Strengt loss trough bending when adjusted
Versatility	Useable in every direction	
Beam damage	No beam damage	
Reinforcement capacity	Internals of beam empty	
Slot use		Slot completely blocked in place of connection
Esthetics	In sight but not very prominent	
Assembling speed	Relatively simple and fast	

Connection 4: Solid three way connection

See Detail 5 in the appendix

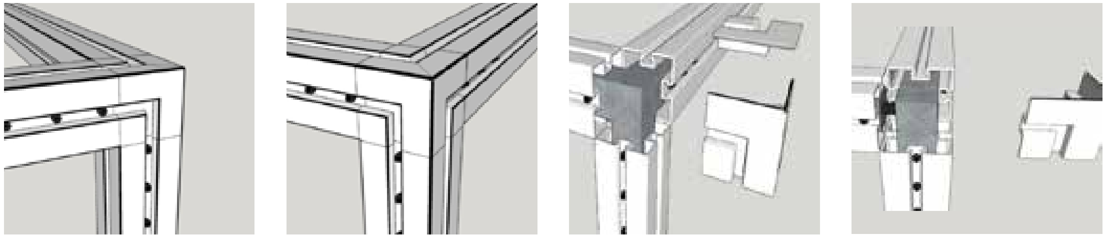
	Advantage	Disadvantage
Constructive strength	Strong in every direction	
Adjustability		Strengt loss trough bending when adjusted
Versatility	Useable in every direction	
Beam damage	No beam damage	
Reinforcement capacity	Internals of beam empty	
Slot use		Slot completely blocked in place of connection
Esthetics	In sight but not very prominent	
Assembling speed	Relatively simple and fast	



Connection 5: Solid two way connection with screw on arms

See Detail 5 in the appendix

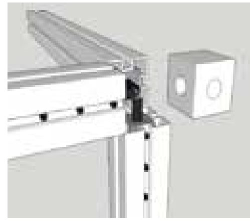
	Advantage	Disadvantage
Constructive strength	Only weak at the screw-thread connection	
Adjustability	Easily adjustable trough screws	
Versatility		Only useable in 3 different connections
Beam damage		3 holes per slot
Reinforcement capacity		Internals blocked in place of connection
Slot use	Only partialy blocked by screws	
Esthetics	Only screws are visible	
Assembling speed	Relatively simple and fast	



Connection 6: Solid 80x80x80 cube with screw on arms

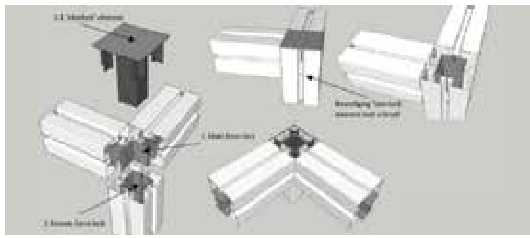
See detail 6 in the appendix

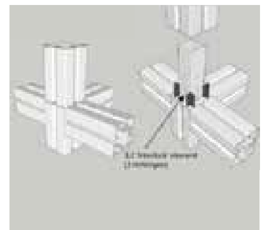
	Advantage	Disadvantage
Constructive strength	Only weak at the screw-thread connection	
Adjustability	Easily adjustable trough screws	
Versatility	Usable in every direction	
Beam damage		3 holes per slot
Reinforcement capacity		Internals blocked in place of connection
Slot use	Only partialy blocked by screws	
Esthetics	Only screws are visible	
Assembling speed	Relatively simple and fast	



Connection 7: Interlock connection

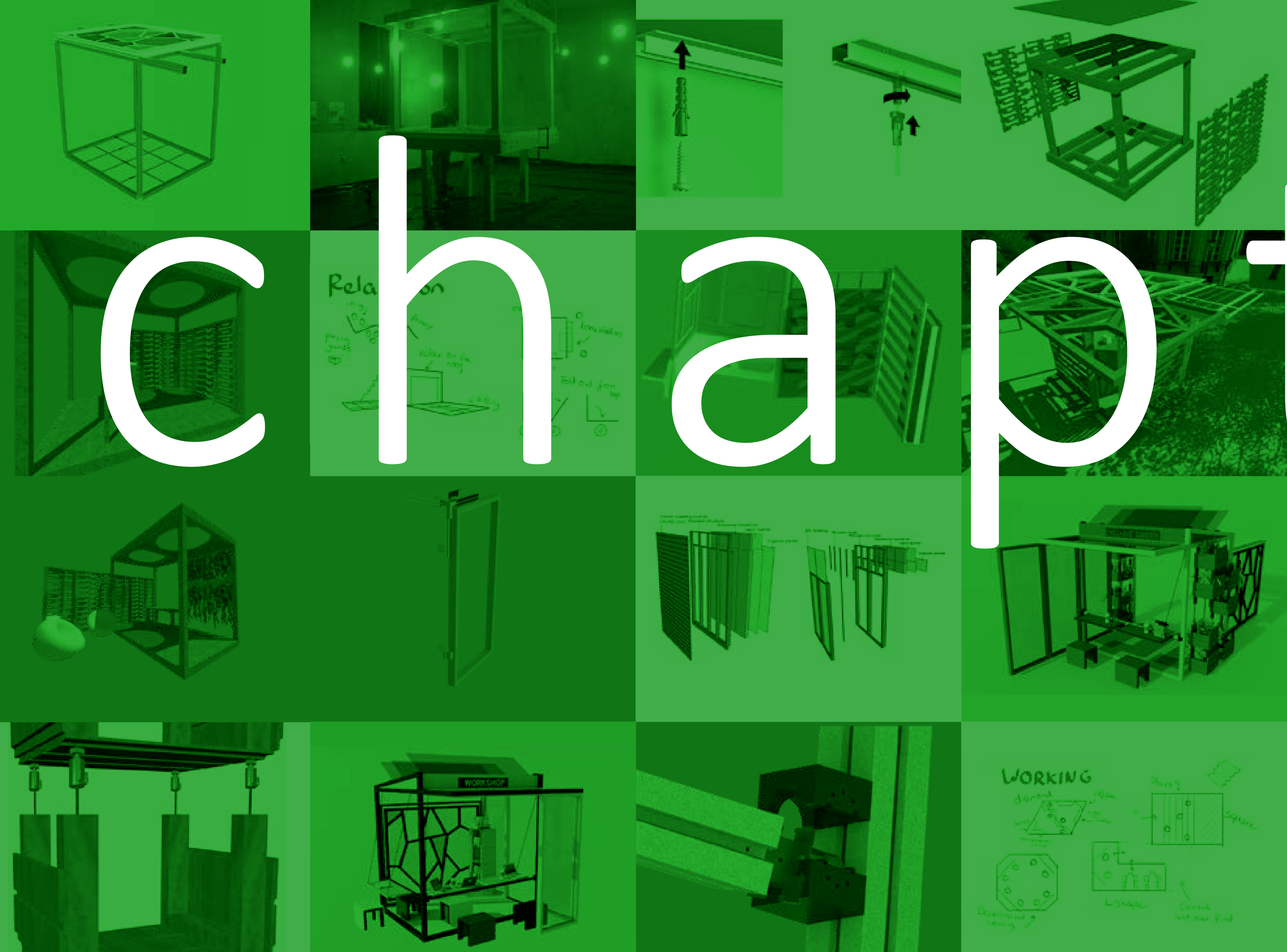
	Advantage	Disadvantage
Constructive strength	Strong in every direction	
Adjustability	Easily adjustable trough screws	
Versatility	Useable in every direction	
Beam damage		Slot in slot and 3 holes per slot
Reinforcement capacity	Beam can be reinforced with connection	
Slot use	Only partialy blocked by screws	
Esthetics	Only screws are visible	
Assembling speed		Not too complex but not fast either





The interlock connection is made up out of three different base parts.

1. Male form-lock element, which can be attached to the Quattro beam trough the necessary amount of screws. The screws will be placed in the slot so they have the least amount of impact on the beam. This part could already be attached in the factory.
2. Female form-lock element, which can be attached to the Quattro beam trough the necessary amount of screws. The screws will be placed in the slot so they have the least amount of impact on the beam. This part could already be attached in the factory.
3. 'Interlock' element. This element slides over the form-lock connection and holds the different parts together. This base part will be connected by two or four screws. This enables quick assembly. It would be possible to make a different variation of this element to extend the beam.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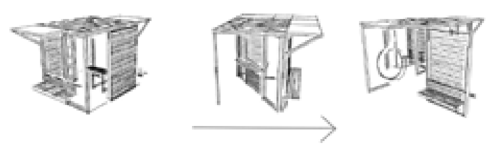
CONCLUSION

SUMMARY OF THE RESULTS

Industrial Design Students from six different Universities has participated in workshops about Reversible Building Design, International Design Studios. In the past three months the international design studios have taken place in Istanbul, Mostar and Heerlen as a part of testing and development of design principles for Reversible Buildings and their implementation into two pilots Green Design Centre (**GDC**) in Mostar and Green Transformable Building Lab (**GTB Lab**) in Heerlen.



The students have investigated design approach for reversible buildings. Over 70 students with different disciplines (architecture, structural design, industrial design, civil engineering and interior design) from six universities [Istanbul Technical University, Zuyd University of Applied Science, University of Mostar, University of Dzemal Bjedic, University of Twente and Sarajevo Green Design Foundation including support of Architectural Dialog Association form Mostar] collaborated, in order to investigate and understand the complexity behind reusing existing building materials in the development of new structures as the case of Reversible Urban Pixel.

The Reversible Urban Pixel is envisioned as a space that can be placed in different urban areas while adjusting its form and function to the needs of the particular spot. In the begging one Reversible Urban Pixel will be assembled as part of GTB Lab in the Netherlands and GDC in Mostar to exhibit the Reversible Building Design concept and reuse potential of elements. The Reversible Urban Pixel has been designed using existing building materials, while allowing three different functions in which each function should enable three use scenarios. Internationa Design Studio was set up and lead by Elma Durmisevic, research leader of Reverible Building Design EU BAMB Work Package in collaboration with Birgul Colakoglu, Maja Popovac, Vlaho Akmadzic, Sanela Klaric, Reonald Westerdijk, Senada Demirovic, Pieter Beurskens, Patrick de Laat, John Oorschot, Renata Androsevic, Ahmed Shawky.

Studios were made possible by GTB Lab and GDC industry partners.

In order to reflect reality two companies in the Netherlands and the wood industry in Mostar were asked to provide existing building elements and component that were to be disposed. De Groot Vroomshoop (construction firm in the Netherlands provided wood facade subsystem) and ODC (supplier of Steel profiles in The Netherlands provided two steel facade subsystems) and existing wooden structure in Mostar was provided as a set of existing elements for the design challenge for Mosatr Pixel.

The final design studio took place at the Zuyd University of Applied science and Friday 26 May 2017 three final Reversible Urban Pixels were presented by the project teams. The findings are now under evaluation in order to assess the feasibility of the realization of a Reversible Urban Pixel and to take the learning process to the next step of understanding the complexity of the realization of a Reversible Urban Pixel with the use of an existing set of elements and components.