
HIGHVES
HOUSING MODULS

development of low cost housing made of light concrete

MASTER THESIS

submitted in fulfilment of the requirements for the degree of Master of Science (MSc.)
to the Faculty of Architecture and Faculty of Civil Engineering of the Graz University of Technology

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on 8th of May 2012

KURZFASSUNG

Entwicklung von low cost Wohnungen aus Leichtbetonen

Der Bedarf an Wohnräume ist in verschiedenen Entwicklungs- und Schwellländern ernorm. Hierbei geht es vor allem um preiswerte Wohnungen für Familien mit Niedrigeinkommen. Da der Beton ein sehr preiswerter und weitverbreiteter Werkstoff in ganzer Welt ist, entstand am Institut für Betonbau im Hinblick auf die Nachhaltigkeit die Idee, mit Fertigteilelementen preiswerte Wohnräume zu schaffen. Im Rahmen dieser Masterarbeit sollten ein Konzept unter Berücksichtigung der architektonischen und städtebaulichen Gesichtpunkte erstellt werden. Konzept für die Herstellung und Zusammenfügen der Elemente sollte ebenfalls behandelt werden.

Folgende Punkte sollten näher betrachtet werden:

- Konzept für die Elemente mit dem Ziel geringster Elementzahl aber größte Vielfalt von Haustypen. Das Gewicht der einzelnen Elemente sollte nicht größer als 5 t betragen.
- Raumkonzept für verschiedene Wohnungsgröße (1 bis 6 Personen)
- Konzept für die Gestaltung zur Berücksichtigung der kulturellen Besonderheit der Einzelländer
- Überlegung zum städtebaulichen Gesichtpunkte für eine Wohngebiet bis zu 3000 Einwohner
- Vorstatische Untersuchung der Elemente
- Konzept zum Zusammenfügen der Elemente
- Beschreibung des Tragverhaltens eines gesamten Bauwerks
- Vorschlag zur Lösung von bauphysikalischen Aufgaben

ABSTRACT

Development of low cost housing made of light concrete

The demand for housing space in many developing and emerging countries is enormous. The main goal of this project is to develop the affordable living space for the families with low income.
As the concrete is very inexpensive and widely used material all over the world, the idea regarding sustainability occurred at he Institute of structural concrete, to use the prefabricated elements to create affordable living space. Within the context of this Master thesis a concept should be created considering the architectural and urbanistic aspects. The concept of producting and joining the elements should be treated as well.

The following points should be considered more closely:

- The concept for the elements aiming minimal number of different elements and the largest variety of house types. The weight of each element should not exceed 5 tons.
- The spatial concept for the various sizes of houses (1-6 persons).
- The concept of design considering cultural characteristics of individual countries.
- To think over how to take into account the urbanistic aspects for designing the residential area for about 3.000 inhabitants.
- Prestatics analyses of the elements.
- The concept of joining the elements.
- Description of structural behavior of the whole building.
- Proposal for solving tasks of construction physics.

Deutsche Fassung:
Beschluss der Curricula-Kommission für Bachelor-, Master- und Diplomstudien vom 10.11.2008
Genehmigung des Senates am 1.12.2008

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Graz, am ……

Boško Marušić and Blaž Mulavec
……
(Unterschrift)

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I declare that I have authored this thesis independently, that I have not used other than the declared sources / resources, and that I have explicitly marked all material which has been quoted either literally or by content from the used sources.

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date

Boško Marušić and Blaž Mulavec
……
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1. PREFACE

1.1 task formulation

The demand for housing space in many developing and emerging countries is enormous.
The main goal of this project is to develop the affordable living space for the families with low income.
As the concrete is very inexpensive and widely used material all over the world, the idea regarding sustainability occurred at he Institute of structural concrete, to use the prefabricated elements to create affordable living space. Within the context of this Master thesis a concept should be created considering the architectural and urbanistic aspects. The concept of producting and joining the elements should be treated as well.

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- The concept of joining the elements.
- Description of structural behavior of the whole building.
- Proposal for solving tasks of construction physics.

1.2 the object of the project

As the object of our project we used the list of demands which we found in the book One2one minimal space – minimal housing written by prof. Dr. Peter Schreibmayer. After we reviewed the literature we decided that this one is the most suitable for our project. When the goal is in the eye, the direction is found. In order to structure the steps leading to the goal, a list of demands is needed. There has to be taken into account architectural and construction engineering aspects, therefore the list is extensive and demanding:

• Basically: Development of innovative housing concept that meets the demand for spatial reduction, without losing the qualities which make living an existential quality of life.

• Basic requirements for dwelling: All manifestations of life, resulting from living together of two adult persons should be possible. Predictable future social developments should be involved in the considerations.

• Innovation: Shaking off existing stereotypes, looking for concepts beyond the familiar solutions.

• Architectural suitability: Despite strict functionality and quantitative reduction - or perhaps because of it - the “inner” and “external” design quality of residential units is very important. This requirement also raises the question, where does the formal aesthetic of minimizing lead. The shape and materiality of the objects must be able to satisfy emotional needs and must be able to compete in the growing visual “density” of modern cities. So, have to be unique and memorable.
• Extensibility: Minimal spaces must be composible to enable larger formations. They need to be able to be built as single units as well as larger compositions of the units. This is also meant as the ability of building larger housing units and cluster like structures.
• Flexibility: Means the adaptability of a system or a unit to different requirements and therefore this is a characteristic, which is relevant for planning.

• Variability: Means the possibility of modification of a constructed unit (the internal and spatial changeability) to be able to meet demands of a modification and therefore it is relevant for the use.

• Fastness: Fast assembling or non-destructive disassembling - so that problems of housing demand can be solved as fast as possible. This means the saving of time and money.

• Cost-effectiveness: cost reduction through space reduction, but also by material economy or material diversity as well as simple production method.

• Feasibility: The design of the residential unit must enable the realization of prototypes under the given conditions, time, financial and production-technical nature. High-tech is replaced with high-intelligence. The competence of a product is not measured by the fact how complicated it is, much more, how simple it is.

1.3 result of literature review

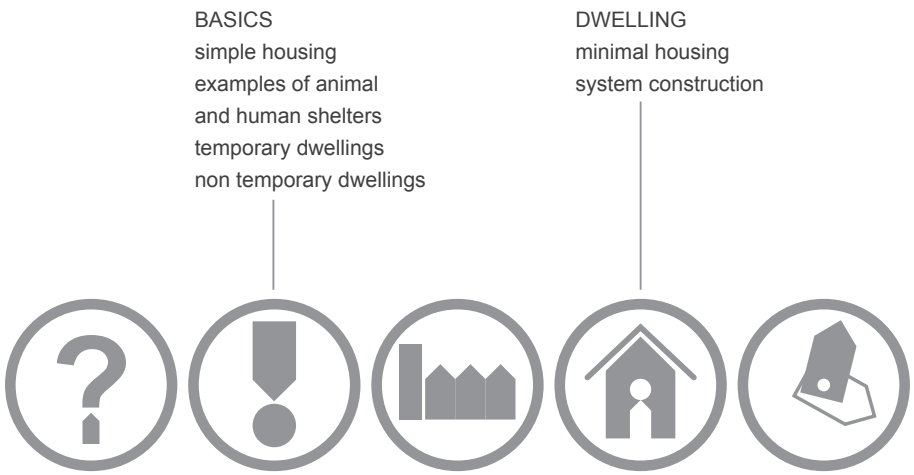
At the begining of our Project in January 2011 we typed different phrases into the search engine Google and into the search engine of the library of the University of technology Graz as well.

Search in the bibliotheca gave out following books that were intresting for us:

- Space – minimal housing (Prof. DI Dr. Peter Schreibmayer)
- 0ne2one minimal space minimal housing (Prof. DI Dr. Peter Schreibmayer)
- Architektur aus der Fabrik (Prof. DI Dr. Peter Schreibmayer)
- Bauen mit System (Prof. DI Dr. Peter Schreibmayer)
- Hyper cubus
- Planung und Entwicklung von low-cost Wohnungen in Indien (Diplomarbeit von Tina Rugelj)
- Climate and architecture (Torben Dhal)
- Geschichte der Architektur (Heinrich Klotz)
- Architektur des 20. Jahrhunderts (Peter Gössel und Gabriele Leuthäuser)
- Maschinen zuhause (Katrin Eberhard)
- Lecture notes project management (Prof. Hans-Lechner at the Faculty of Civil engineering science, TU Graz)
- Energie Atlas - Nachhaltige Architektur (Hegger;Fuchs;Stark;Zeumer)

In those books we found most of our input information in order to be to be able to start developing first ideas and considurations for our project.

1.4 aproach and structure of the work



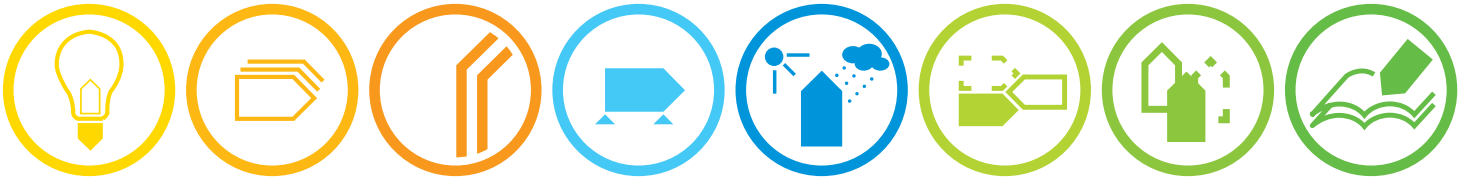
inputs

THE IDEA
considerations and essentials
adaptive modular system

CONSTRUCTION DETAILS
vertical position
horizontal position
facade

CONSTRUCTION PHYSICS
AND INSTALLATIONS

HOUSE FORMATIONS



THE ELEMENTS
concept for production
of the elements

PRESTATICS ANALYSIS

HOUSE TYPES

PROJECT MANAGEMENT

project

2. BASICS

2.1 simple housing

A dwelling is a place for one or more living beings, which is usually protected and covered. In some cases places for certain things are named casings. The term house is not always to be taken literally. We have to distinguish animal and human habitation. They can be of artificial or natural origin, and are generally fixed and weatherproof.

2.1.1 examples of animal and human shelters

Animal shelter

The snail house is a nature given dwelling for most of the snails. The snail house is actually mobile and it makes one complete unit with its dweller. In case that the snail leaves the house, any other animal can occupy the house, the crab for example.
Some examples of shelters that are created by animals themselves:
- Mine (mammals)
- Hill (mammals and insects)
- Stick (for example, beehive)
- Nest (bird)

Human shelter

One of the oldest human artificial habitations is a mobile tent.
In dependence of the culture there are few different types:

- Tipi
- Wigwam
- Jurte

In the present, the tourism and sports industries have developed many different types of tents.
The human dwellings can also be distinguished by material.

The natural building material that can be found in the nature is compact snow which is used for building of igloos in cold environment.

Here are some others:

- Earth cabin
- Clay house
- Leafy house

Depending on the function are:

- Sacral Objects
- Residential buildings
- Public buildings

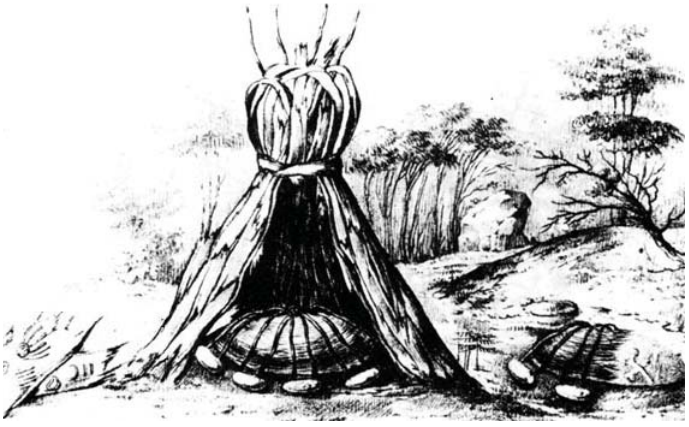
2.2 history

2.2.1 temporary dwellings

In prehistoric time people lived in natural caves. These shelters were the work of nature, easy to use and close to people. The caves were very good weather protection.

The beginning of the dwelling is not identical to the beginning of architecture. The first step of the artificial production of dwelling, which ultimately led to the identity of human beings, marks the beginning of housing. When nomadic people were moving from place to place searching for food, they could not allow themselves only to be dependent on nature weather protection found by chance. Prehistorical hunters and collectors had to prepare themselves the shelters on certain places where they decided to stay for some time. They stayed there as long as the surrounding was rich enough with food. This was the situation that pushed the people to start building the “houses”.

To build a hut and label it although the architecture may oppose the current definition, but we have to apply the general rule that any man made construction serving as the weather protection, is architecture. The hut of Nice (around 400 000 BC) is among the oldest founding of human being culture manifestation known today.



2.2.2 non temporary dwellings

Typology of the Stone Age house - the round house

The first known stone-built houses of the Stone Age were round with one room only. They were built by the agriculturists about 8000 BC. This ground plan type goes back to the early days of the first village settlements, as in the Middle East, in the Fertile Crescent, where the agriculture began.

The rectangular house - Beidha

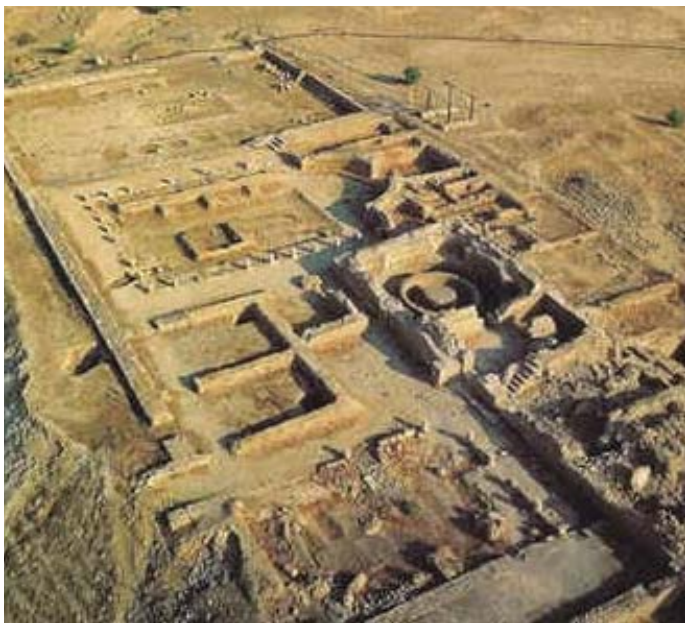
Beidha, located in southern Jordan, is one of those Neolithic culture centers, allowing a reconstruction of early human history and its architecture. First settlements were created by a semi-settled hunter-collector society around 7500 BC. About 7000 BC farmers came to Beidha who knew how to build fix and stronger houses. After the original village was completely burnt down, the new settlement took place. The period of new settlement brought a new age of building houses. Particularly interesting are the transitional forms between the traditional round house and the slowly evolving rectangular ground plan types of houses.

The first city - Jericho

Jericho is known to be the first major urban settlement in human history. It can be described as a preliminary step of urban high culture. It is most likely erected not as a farming town, but as a trading center.
In any case, Jericho took the role of a city that had several public buildings, which were serving and securing the community.

Deir el-Medine

The working class settlement in south-west of Thebes was built under the reign of the King Amenhotep the 1th giving protection to workers and artists and their families “servants at the place of truth” who built the tombs in the Valley of the Kings at the time of Antique. There were 120 families in 70 row houses. The workers settlement was inhabited about 1520-1069 BC, with a short break under Akhenaten 1350-1334 BC.



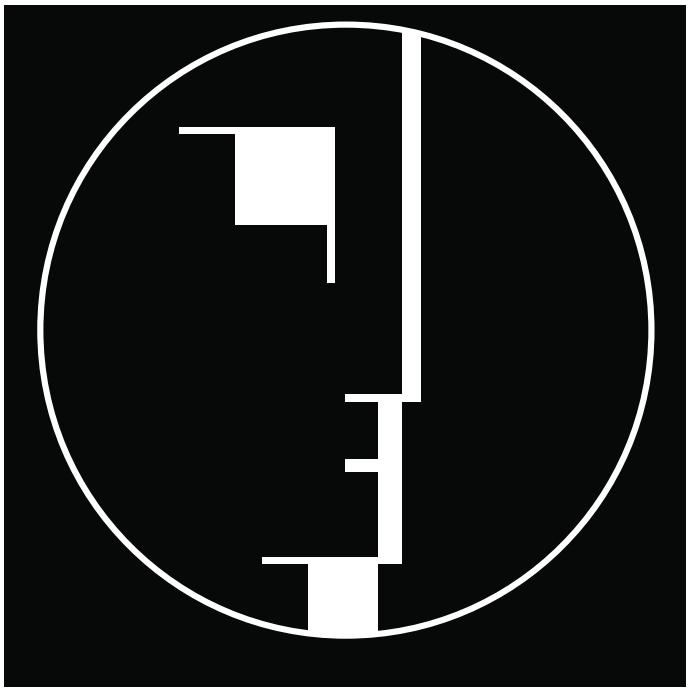
Antike Rom

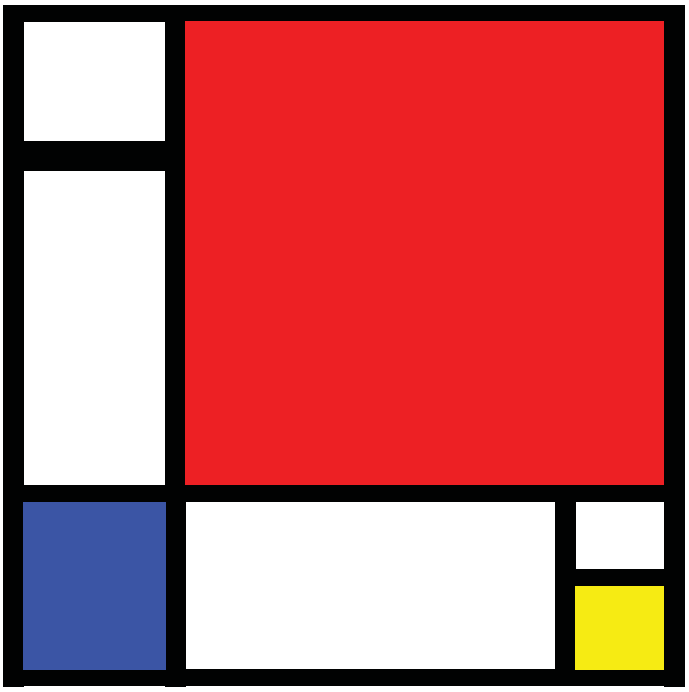
The family housing (domus) in Roman Empire were situated on the countryside and in the cities (except for Rome) and had not more than two floors. The roofs were made from different materials in each region, the clay blocks were used.
Masses of people were coming from the countryside into the city what caused overpopulation and a big housing problem. This problem was tried to be solved by constructing a new type of house called “insulae”. Insulae had more than two floors and were used exclusively for dwelling. There were only two types of houses, strictly private or those with shops.

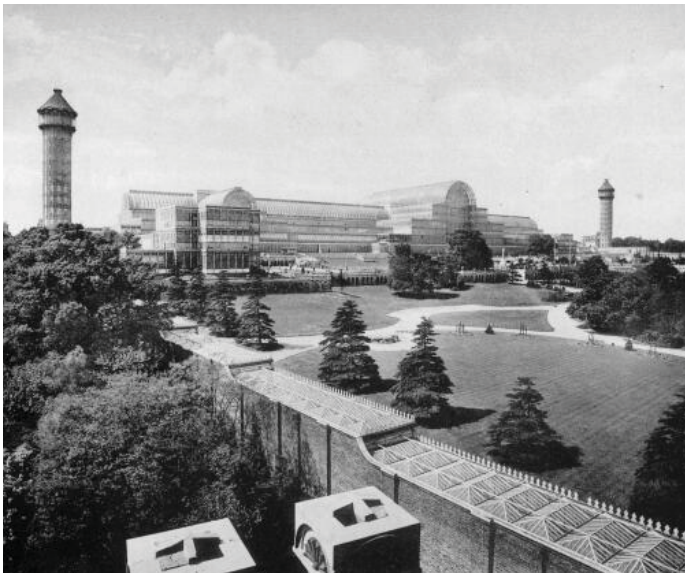
3. PREFABRICATION as an example

First important big step in prefabrication happened at the time of industrial revolution and the arrival of Bauhaus and Modern Age.

At that time some world known architects and engineers lived whose contribution in the field furthered the progress.







The Crystal Palace

was designed by the british architect Joseph Paxton for the first World Expo 1851 in London (Great Exhibition) and built by Charles Fox. The exhibition building was built in the Victorian style. Originally it was set up in Hyde Park and at the end of the exhibition moved to Sydenham in the London district of Lewisham, where it was re-opened in an enlarged form in the year 1845. The name Crystal Palace was characterized by the satirical magazine Punch.

This building represents one of the first examples of the new era in prefabrication.

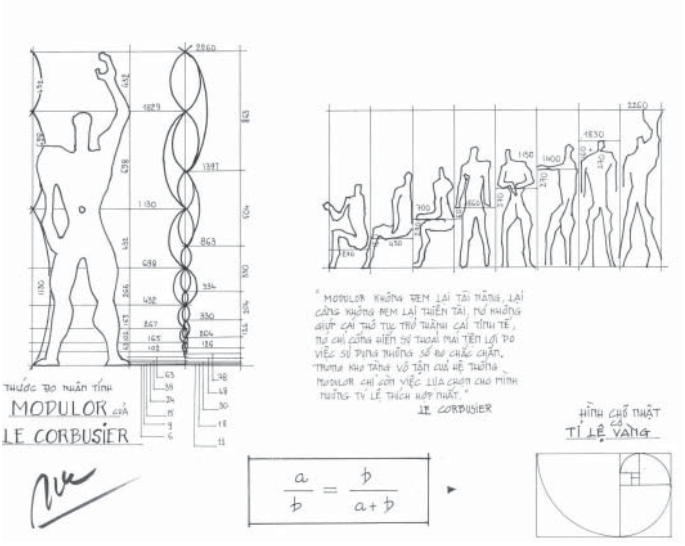
Le Corbusier

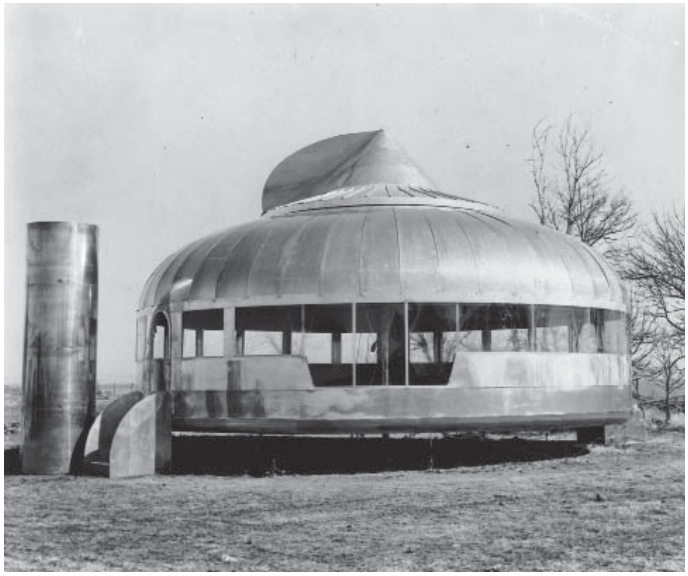
(actually Charles-Edouard Jeanneret-Gris, born October 6, 1887 in La Chaux-de-Fonds in the Swiss canton of Neuchâtel, died 27 August 1965 in Roquebrune-Cap-Martin in Monaco;) was a Swiss-French architect, architectural theorist, urban planner, painter, draftsman, sculptor and furniture designer.

He was one of the most important and influential architects of the 20th Century. His new ideas were controversial and some are controversial even nowadays.

Modulor - Le Corbusier has developed the proportions system in the years between 1942 till 1955. This system represents important modern attempt to give to architecture a mathematical order oriented to the measure of man. He stands by this in the tradition of Vitruvius.

In the year 1948 issued Modulor became the basic writing of architectural history or theory of architecture. In the Modulor 2 issued in 1955 he explained how to use this theory of measures on which all his architectural work was based. By this theory Le Corbusier wanted to give to the architecture again the measure of man and at the same time an objective





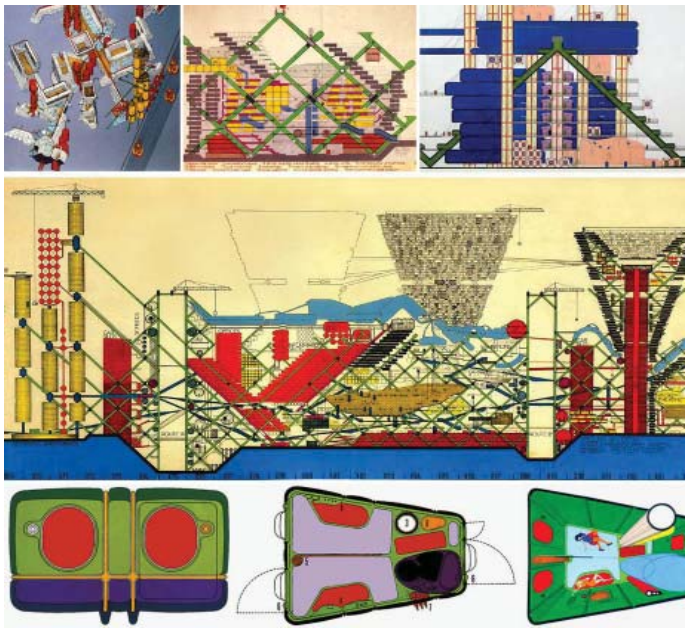
Richard Buckminster Fuller

(often shortened as R. Buckminster Fuller, also known as Bucky Fuller, born 12 July 1895 in Milton, Massachusetts, † 1 July 1983 in Los Angeles) was an American architect, designer, visionar, designer, philosopher and writer. He is ranked next to Frei Otto and Santiago Calatravaone one of the leading representatives of a biomorphic architecture.

Dymaxion is a term he used for some of his inventions used.

Dymaxion House

looks like a flying saucer. It is a house with a possibility of being disassembled, packed and taken along if for example the family moved. The house had a circular shape, because Fuller considered rotundas to be particularly economical. The house had a diameter of 15 m and was 12m high. The 97 m2 of provided living space and equipped with furniture did not exceed the total weight of more than 2227 kg. Fuller lunched the prototype already in 1927 but the house was first produced after the Second World War, when aircraft developed alloy construction made it possible. This house was later called 4-D House and was known for Fuller's basic principle to achieve the maximum benefit from minimal energy and material expenses.



Acrhigramm

(ARCHItecture and teleGRAM) was a group of British architects which published from 1960 to 1974 its drafts from the housing capsule to the "Living City" in the same named journal. Peter Cook, Warren Chalk, Dennis Crompton, David Greene, Ron Herron and Michael Webb belong to Archigram. Archigram represented a stream of utopian avant-garde architecture of the 1960s in Western countries. The group practiced their influence not with realsation of their projects, but by publishing of the drawn designs.

4. DWELLING

In the hierarchy of different levels of needs. Lower levels of needs have to be satisfied before the next level gains significance, claims the psychologist Abraham Maslow.

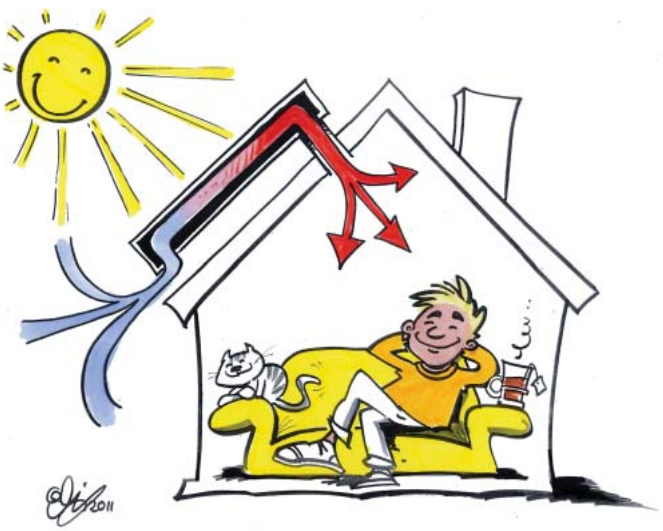
The physical needs such as heat, sleeping and eating are classified before the social relationship. The social relations are followed by the social recognition and self-realization. For all these levels of needs dwelling takes an important part in their satisfaction. When considered from this point of view the dwelling is an action for physical, mental and spiritual livelihood, existentially important enough to make it a human right.

Dwelling is one of the basic human needs and gives individuals or groups physical and psychological protection and among others security and privacy. There is no place to be so important to the people and is so close connected with their lives as the “home” is.

Throughout the history it hasn’t really changed much. However, the “dwelling” is a really aware experience of only some people. For many of them it is lifelong self-evident and it becomes very quickly a habit.

Precisely that is also a risk that just obscures the everyday perception expressed by the true meaning of living and makes it a deeply conservative pursuit of life.

Hanged on behaviour ways and handed down architectural patterns are not to be questioned. The offer is not adapted to the demand and the social changes are not perceived. Because living-on, as usual, is the simplest way, the new residential concepts have it hard. So leands housing far too often in triviality, banality and naivety which mark today the largest proportion of the built environment.



4.1 minimal housing

The problems of dwelling in “tightest spaces” occupied architects since they exist.
Recent history shows that the “minimum” was repeatedly made to the architectural program. It was driven by academic interests but primarily due to economic emergencies.
Caused by the catastrophic housing shortages after the First world war, there have been made many and remarkable efforts to develop adequate housing using the means of volume reduction and new construction methods. How much this problem embedded in the society and even perceived by the architect as a responsibility showed the competition “growing house”, which were brought in the year 1931 by 1079 submitters who delivered their work. Among them were also the architects of their time. The basic idea was to create housing for millions of unemployed which would be at the beginning equipped small and modest. With increasing economic strength it can be qualitatively increased and quality improved. The “minimum” was therefore not a permanent or final state, but only the start position.

4.2 system construction

The system construction is a construction method in which the building is assembled of prefabricated components or modules. The components are manufactured in a factory, transported to site and assembled on a modular basis. The thermal insulation can be ensured in this construction method.

Advantages of the system construction method are a relatively short construction time, weather independence during the pre-fabrication phase, a high precision of often series-produced components and the ability to change the location of the finished building afterwards.

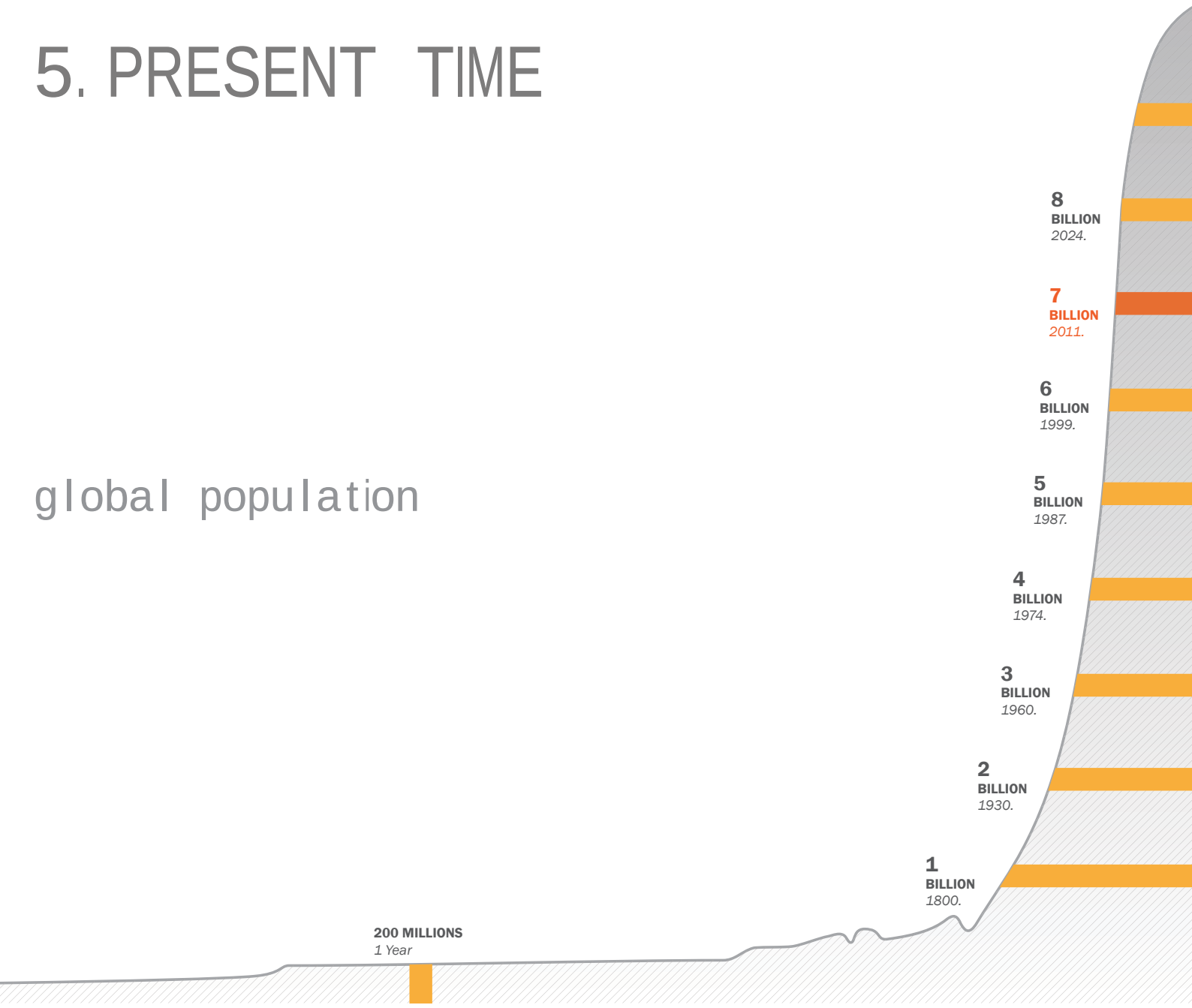
Prefabricated buildings are mainly made of precast concrete. This means that both ceiling plates and wall panels are finished items assembled on the site. The prefabrication construction method - also called large board construction method - is very often used construction method. In everyday language the term “Prefab” is often narrowed from a uniformly designed “Wohnplattenbauten” to be found in large housing areas.

After the 1950s new housing areas occurred worldwide. The term “prefab” settlement is now used in everyday language almost as a synonym for these large settlements. One of the theoretical bases was the Athens Charter with Le Corbusier as responsible, who demanded a new method of urban planning.

To the new ideals counted among other smooth and uniform construction method to ensure that there are no evident deviations in a production class. Historic town centres should be redeveloped through re-arrangement of areas. The idea of the car friendly city developed later. Most of the ideals of the Athens Charter are today considered as misinterpreted or outdated. As in European countries after 1980s barely any new large settlements occurred, so they are nowadays mostly created in new occurring centres in Asia.

5. PRESENT TIME

global population



5.1 escape into the city

Since the early fifties cities have grown enormously. Simultaneously, the housing shortage is omnipresent and has become a social, economical and urbanistic development problem that is hardly solvable or perhaps not anymore at all. The assumption that this scenario is the future of all great cities and is reinforced by the observed worldwide urbanization and the rapid swelling of the migration flows from rural to urban.
Of course, the temptation of better earning opportunities in urban centres is one of the motives, which may however not obscure the dramatic fact that agriculture in many of the countries, is no longer able to feed their population, therefore, the migration into the city is not a question of better life, but a question of survival.

5.2 Metropolis: the new super-city

Until a few decades ago urbanization and city formation were mainly observed in the industrialized hemisphere. This picture has changed completely. While less than one-third of the world's population lived in cities in 1950, some projections estimate that about two thirds of humanity is expected to live in urban areas by 2030. But most of these cities will not be in Europe or North America.

Already today twothirds of all urban population live in major cities of the third World. The global urbanization and its development are no longer historically comparable.

The new mega-city must be capable of receiving huge numbers of people in a short time by using minimum resources, under consideration of an urban organism remaining alive.

5.3 slums

„Slums are no places, they are people.“ R.C. Herdia

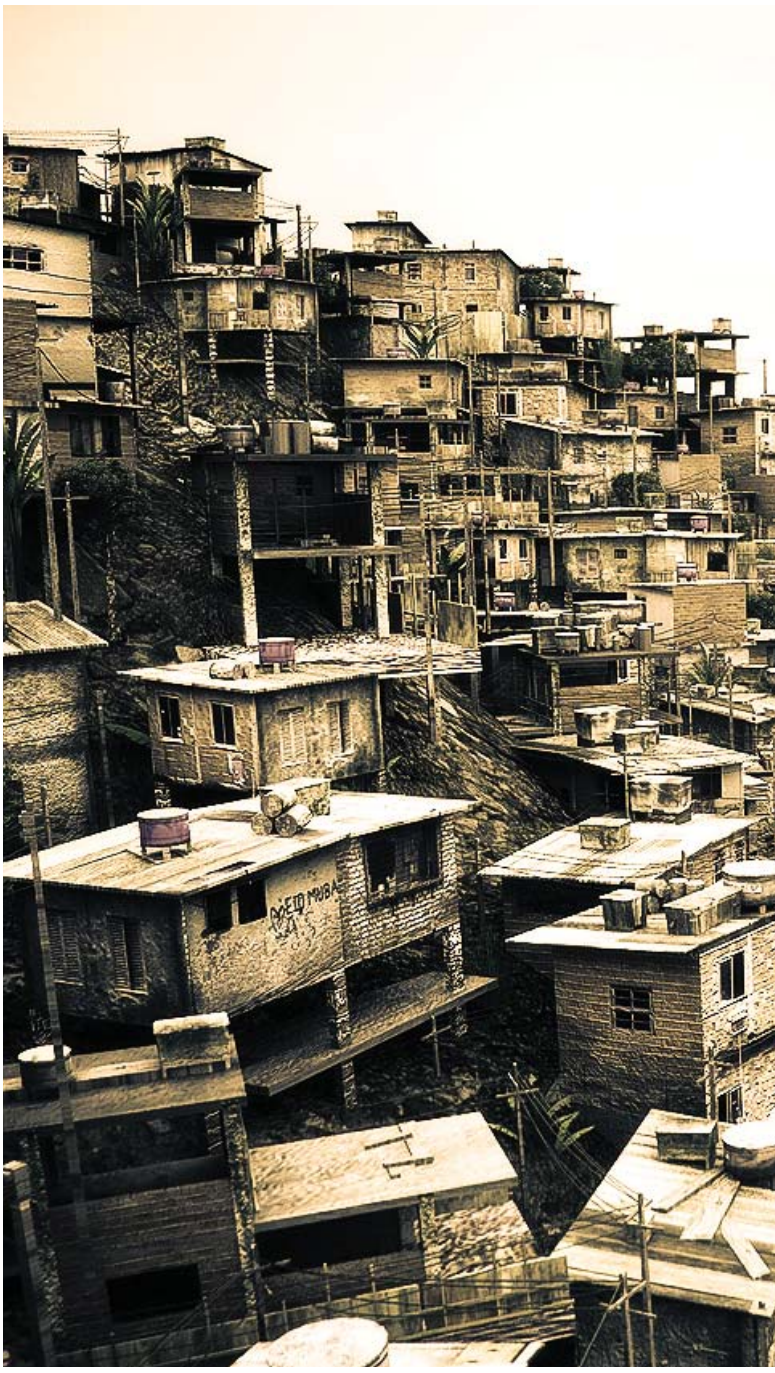
Dealing with slums seems to be a confrontation with the problem of the 3rd World. There are slums everywhere. They are perhaps the main repertoire of actions of these countries with which the ever increasing inflow in cities is intercepted. This should not distract from the fact that housing problem exists in the countries of the 1th World as well. Here is likely the problem to reach such level that will not be easy to hide it or to oversee it, like with already today existing lack of homes is made.

If accepting the existence of megacities as an urban form that can be able to stand the rush of several hundred thousand people per year, because it has developed control mechanisms, for which the old city models offers no solution, than you must also take the “slum” to note .

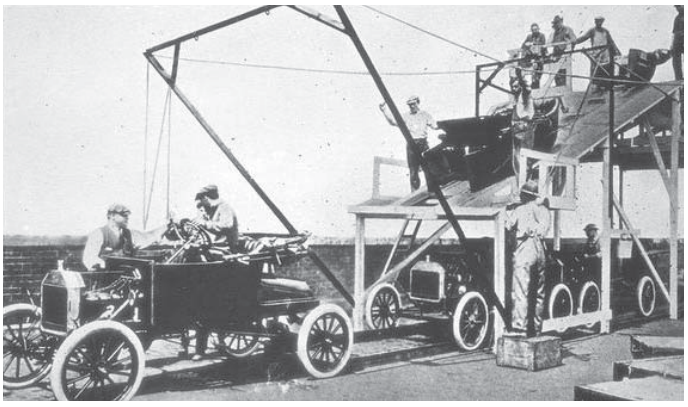
The claim may sound cynical, that the chances of survival of such urban areas are increased by the existence of slums, if not at all ensured, but it hits the heart of the matter pretty well.

Slums are a structural response to the explosive growth of urban population and their poverty and despite the worst hygienic living conditions they represent the vital expression of the architectural and urban planning outcome of actually unplanned intercourse with minimal resources. The from outside into the city the increased inflow is formed by people whose housing has traditionally been located in the hands of families and neighbourhood communities, which have made their homes with traditional materials and technologies in DIY (do it yourself – method). For this purpose external knowledge and external services were not needed. Residential building in the classical urban environment is more complex. Large numbers of inhabitants in high densities request technical infrastructure for supply and waste management, social services and jobs etc. Individual services and traditional practice are no longer sufficient, external knowledge and external services are necessary - and these cause costs, that these people are not able take. And so are slums actually a desperate attempt to adapt old methods to new urban conditions, to enlarge rural patterns in huge dimensions.

Slums cannot be planned, much less prescribed. How could ever be expected that structures of such high density, some are even in size of several hundred thousand people, to function when they are prescribed. Instead of prescribing them, they should be left to arise from the free play of forces. This freedom makes the formation of slums an evolutionary process. The suitable is left alive, useless disappears and eventually at residential areas are created, as an adataption to the conditions of severe shortage, but still meeting the basic requirements of living.



54 house from the factory



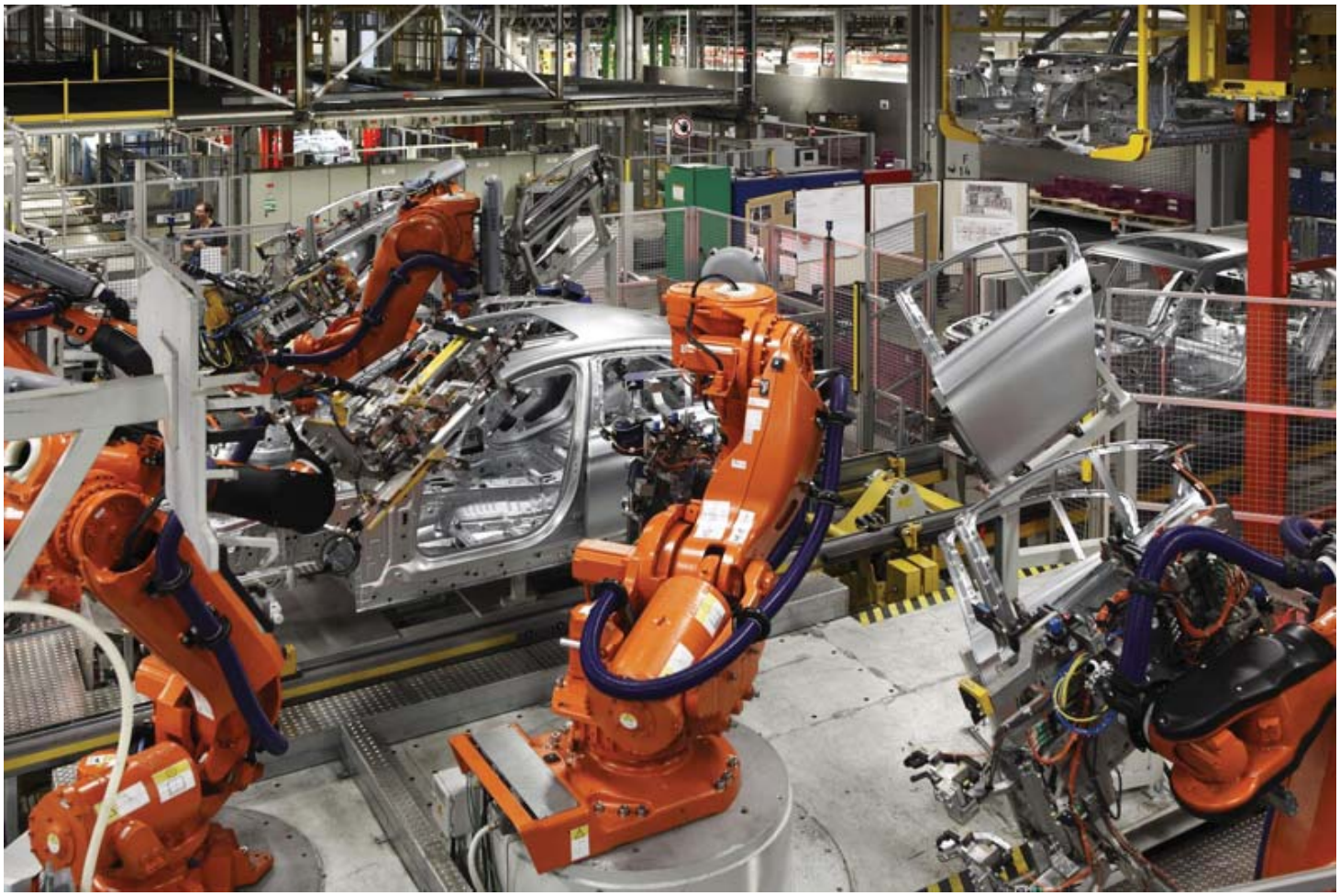
Till today there are more than a billion homless people all over the world. Low cost housing is no longer a problem that is limited to some individual countries rather than being a global problem.

With such large number of people the individual production of those houses is no longer relevant, the need for induastrial prefabrication is required. In this manner the costs are drastically reduced resulting in both direct and indirect huge time saver.

Time is money.

It is an irony of history that after thousands of years of craftsmanship dominated construction, the modern technology could provide all the materials, manufacturing and construction methods to revolutionize the construction from the ground up. The transition from the building trade to the building industry would be possible, but it has never happened.

Over the last fifty years, the development of the construction industry is very strong characterized through the transition from wage intensive to machinery intensive construction method.



THE PROJECT

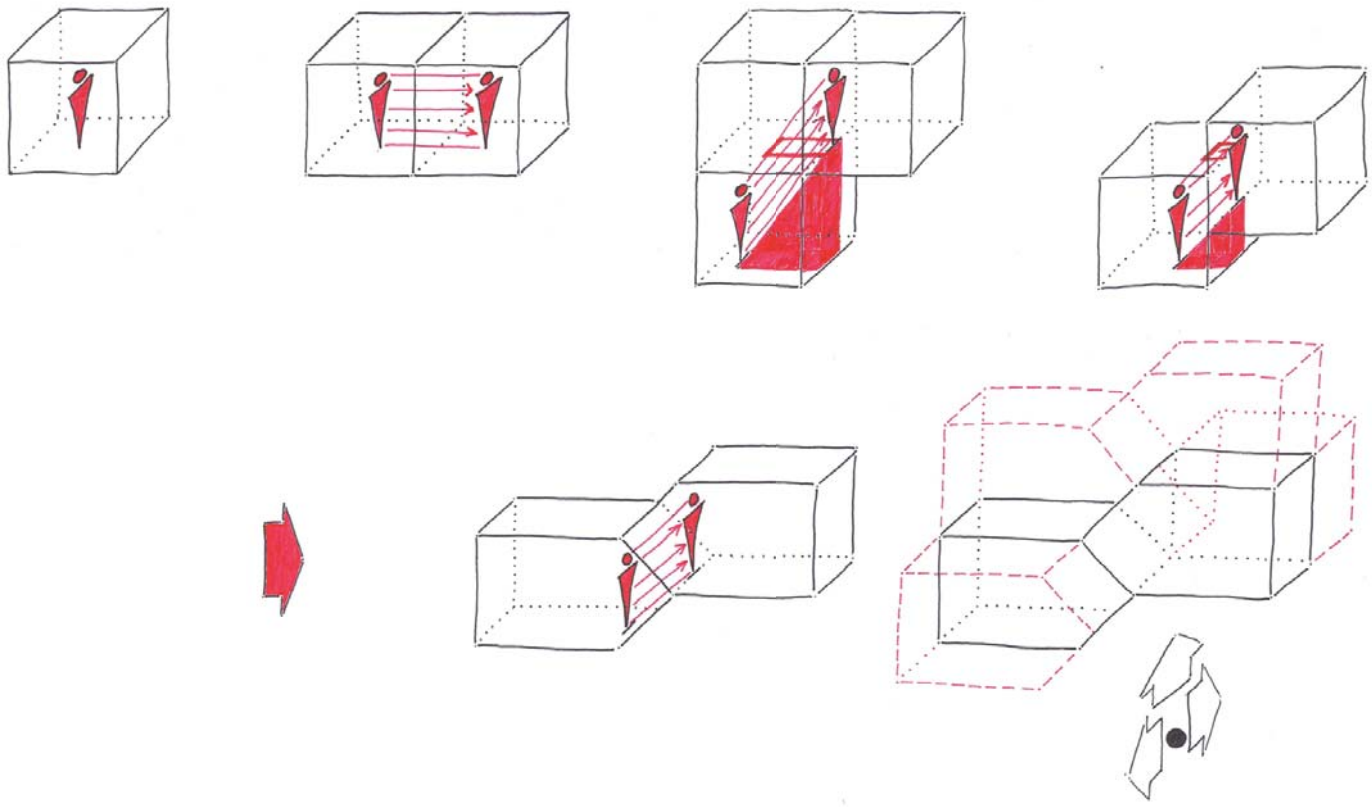
HIGHVES

HOUSING MODULS

6. THE IDEA

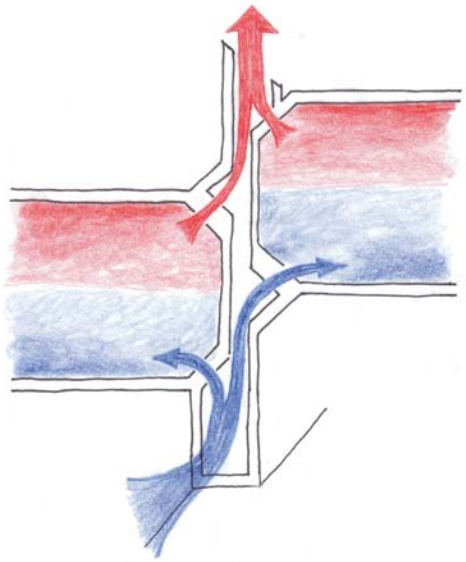
6.1 considerations and essentials

Why this form?



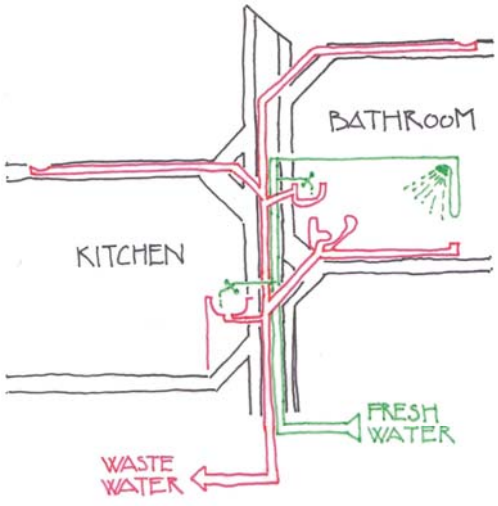
Why this material?

Lightweight concrete has been chosen because concrete is much easier to form as for example steal or wood. With this material the construction weight is reduced for one third of a normal concrete.
Lightweight concrete has also better insulation abilities than normal concrete.



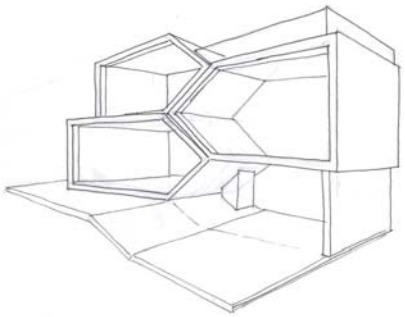
What are the advantages?

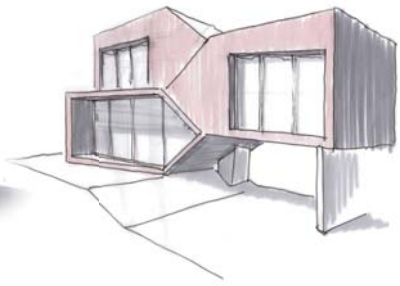
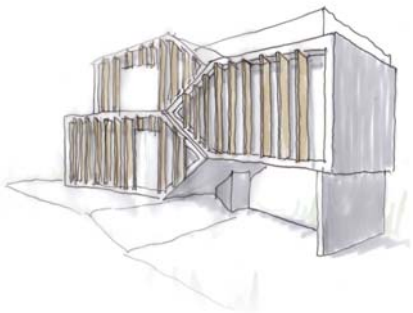
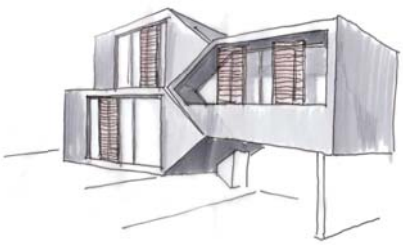
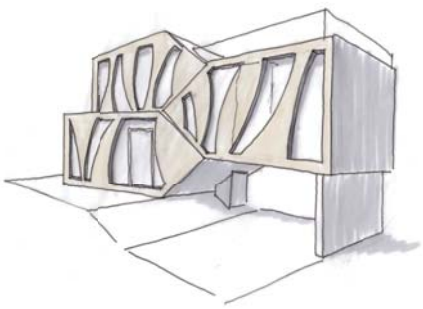
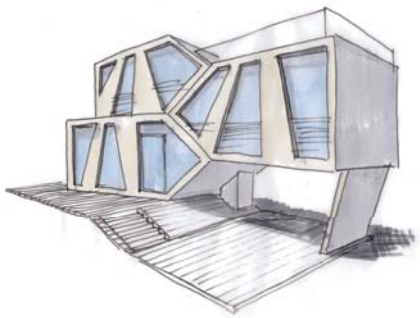
When considering the number of residents the elements can be composed very easily in many different and requested forms of the house. The big open facade surfaces in the front and back side of the house enable us to arrange various types of the facade form and materials for the appearance of the house. It is meant to use the local materials to create the facade. In this way the house itself is integrated in to the local culture. The above mentioned possibilities avoid the typical monotony appearance of the low cost housing.
Almost every built house can look different from another. The only thing they have in common are the construction elements.

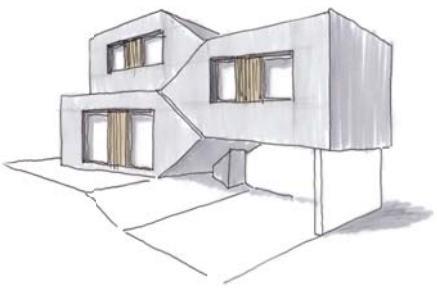


6.2 adaptive modular system

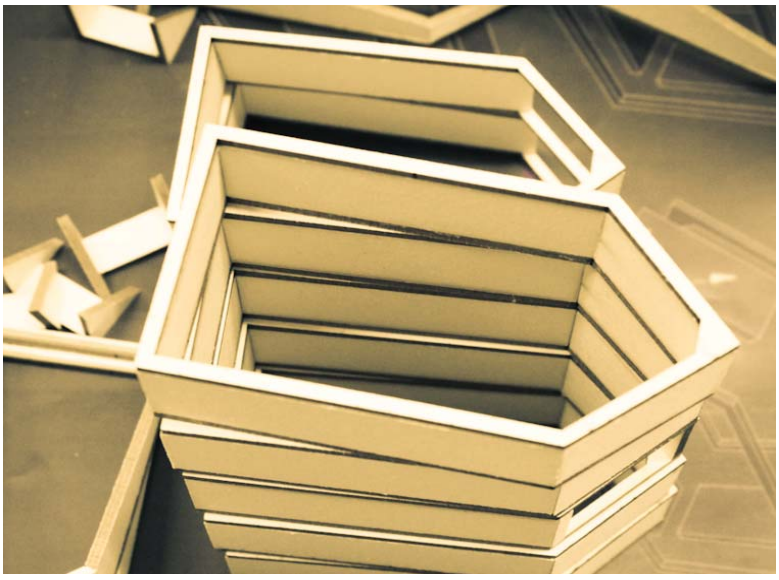
Facade elements can be made of different materials. In addition to common materials such as concrete, steel and wood in different variations local materials can also be used which are specific for the culture that inhabits the buildings. Such form of the facade design gives the homeowner an open possibility to conform the elements to his wishes and ideas.

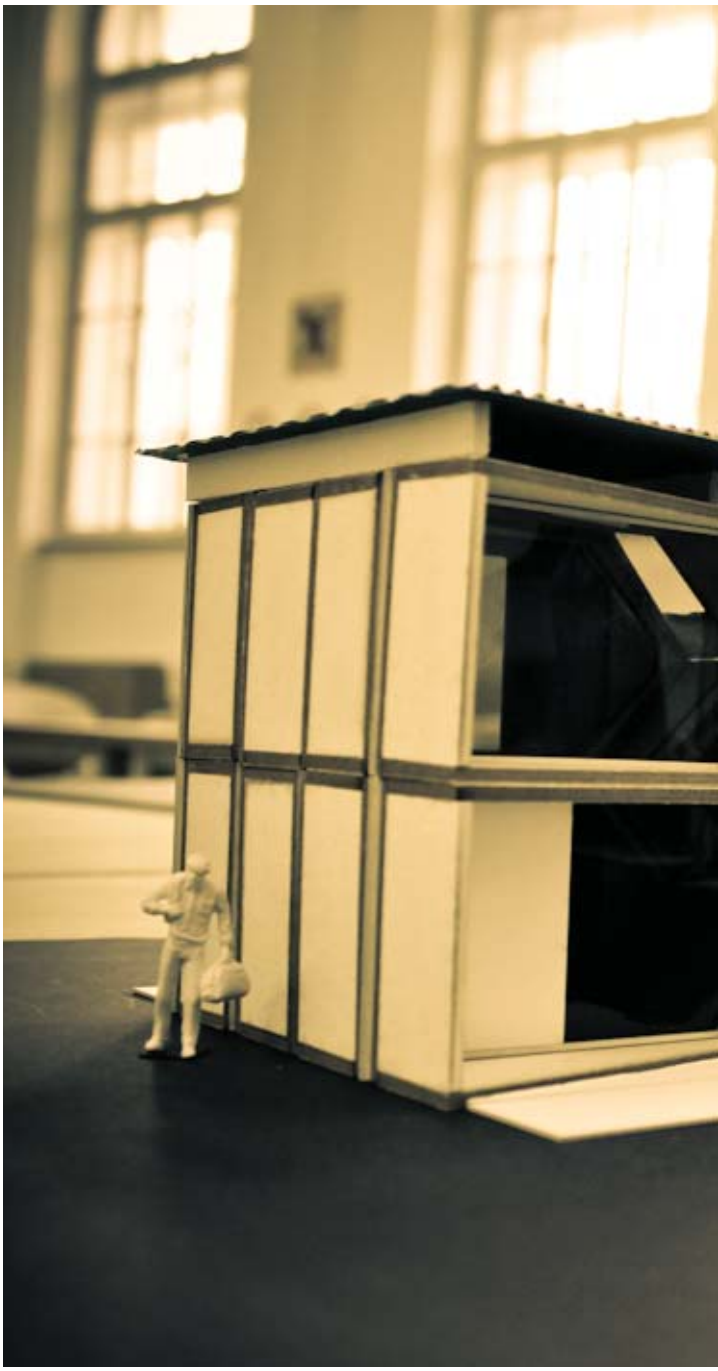




working model





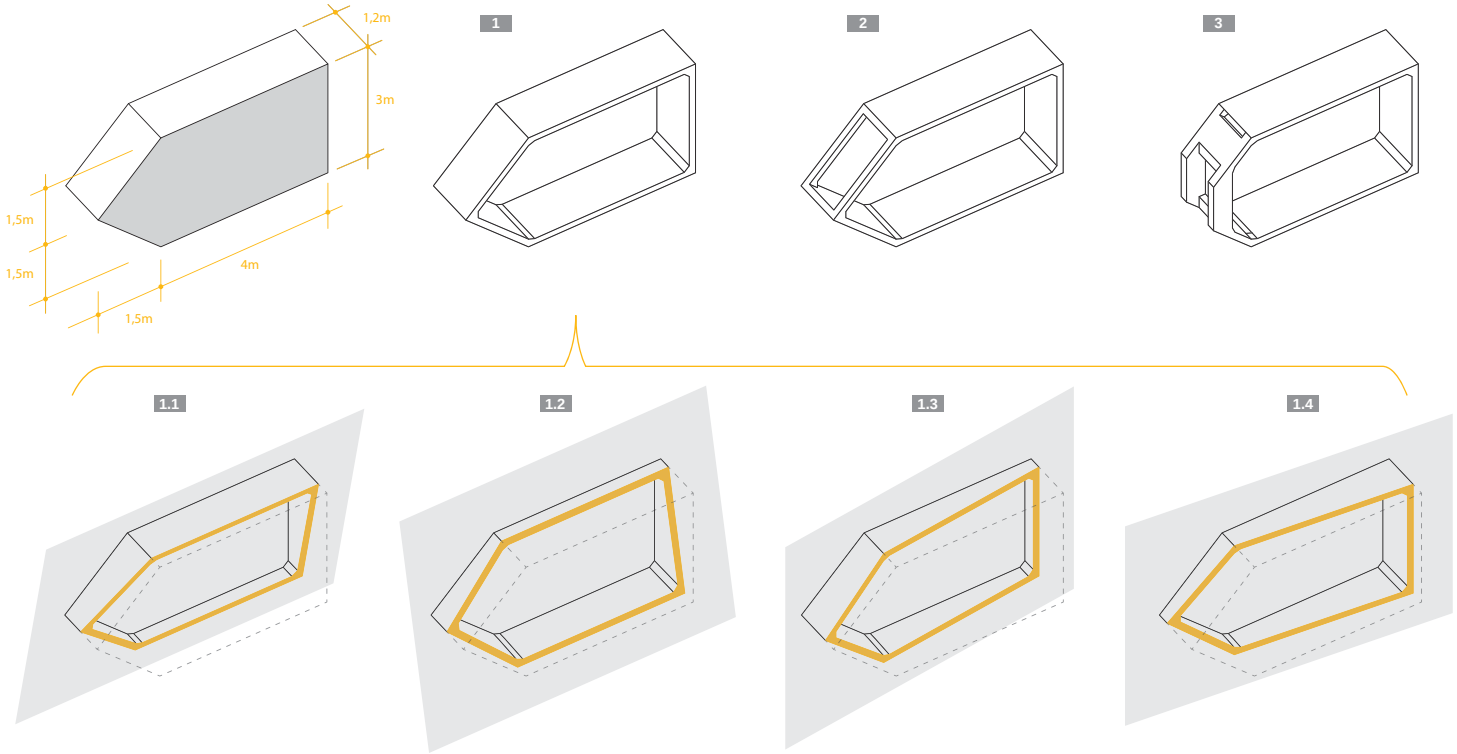
freehand sketch

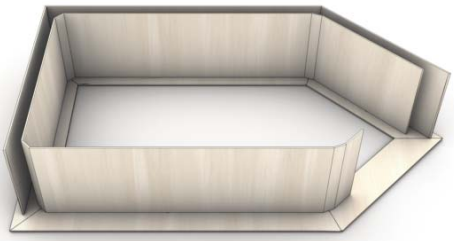
7. THE ELEMENTS

7.1 concept for production of the elements

unified formwork system concept

This grafic explains the small variations of the front triange part of the elements which all have the same basic form that simplifies formwork.



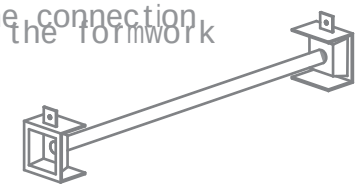


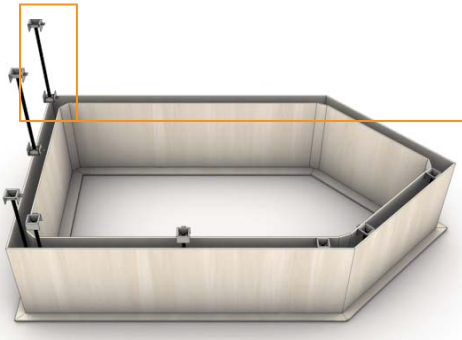
step 1

formwork

step 2

placing of the connection rod tubes in the formwork

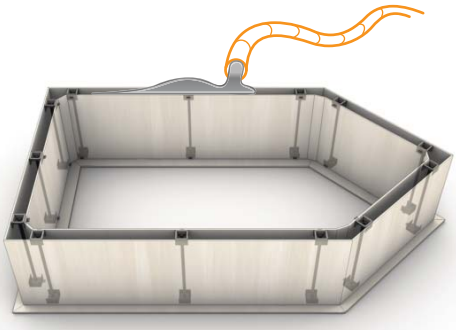


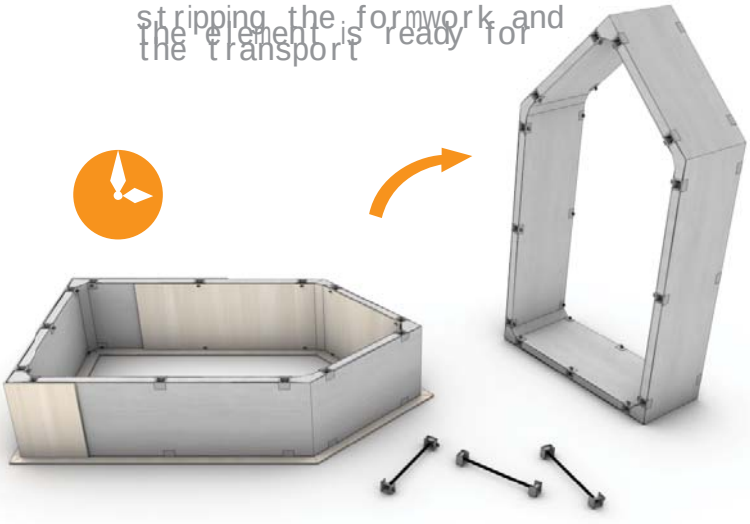


stripping the formwork and the element is ready for the transport

step 3

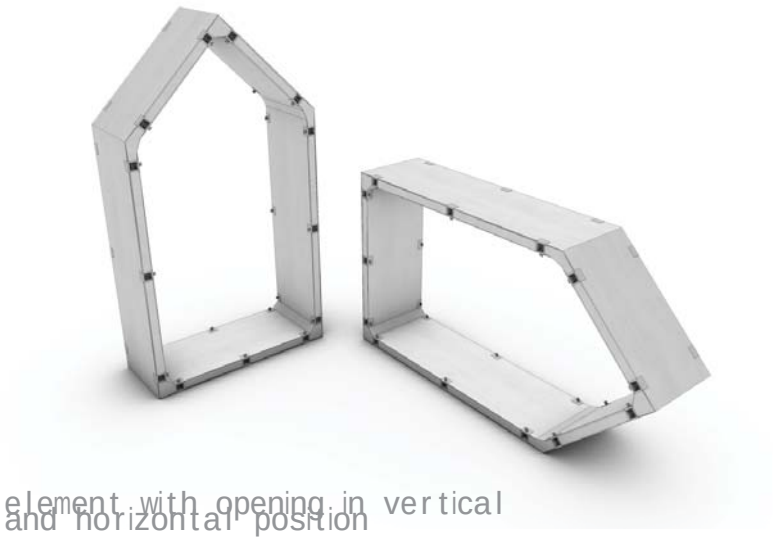
concreting





construction elements

whole element in vertical and horizontal position

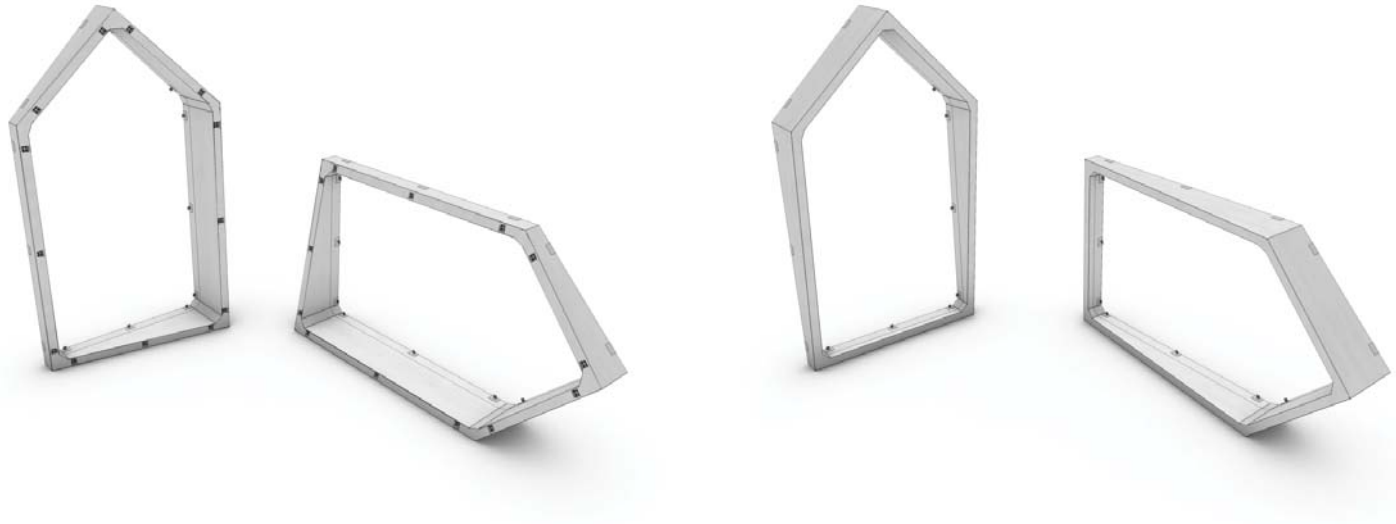


element with opening in vertical and horizontal position

shaft element in horizontal position

facade elements

facade elements in vertical and horizontal position



7.2 interior

cover interior

As the elements are prefabricated in a factory, so is the interior produced and fitted in to the elements.
There are a few different types of interior elements depending on the function which they have.

floor interior

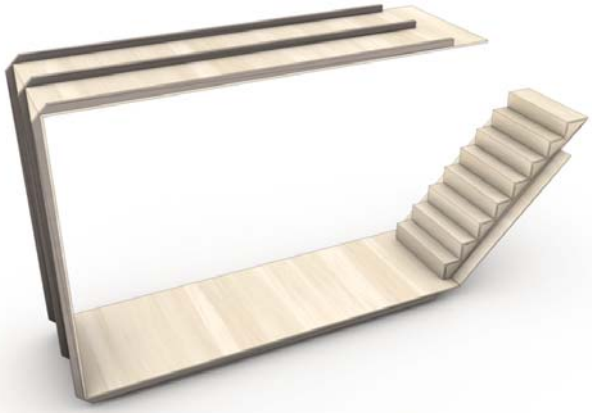
interior with steps

kitchen interior

toilet and shower nterior

cover interior

interior with steps



wardrobe interior

wardrobe interior

wardrobe interior

kitchen interior

toilet interior

toilet and shower interior

8. CONSTRUCTION DETAILS

8.1 construction details vertical position

The modules are conected with threated rods for which appropriate openings in the elements walls exsist in which the rods are set in.

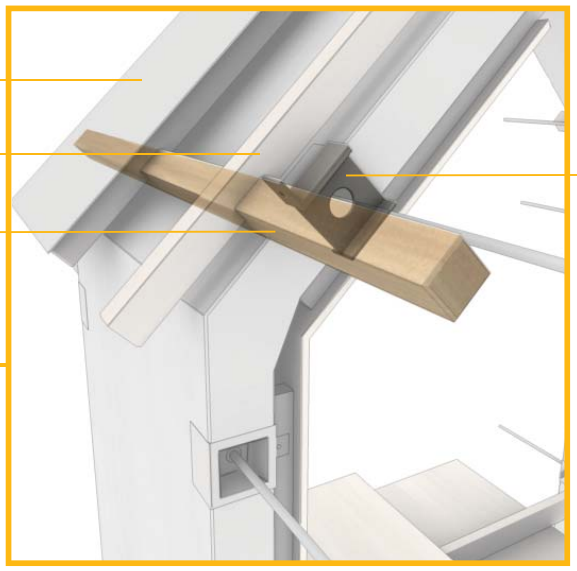
roof-element

connetion detail sheme

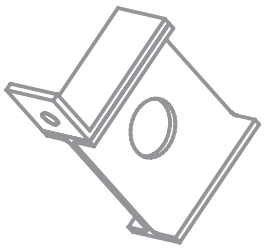
roof sheet metal panels

heb steel beam

wooden beam



serial prefabricated connection steel part

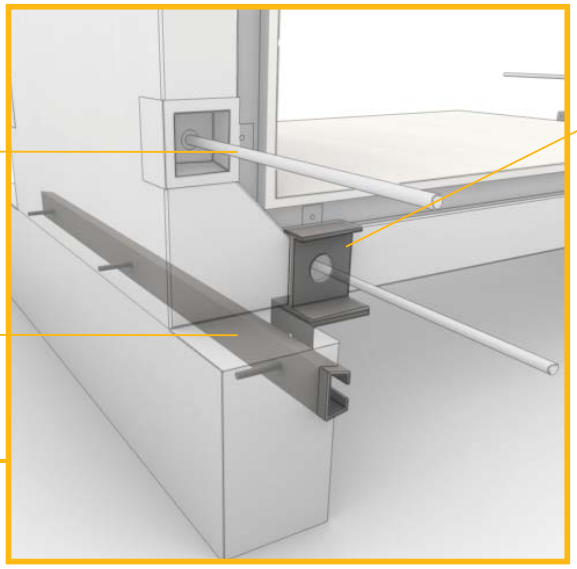


foundation-element

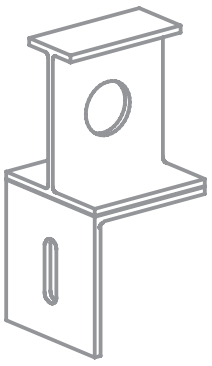
connection detail sheme

threated connection rod

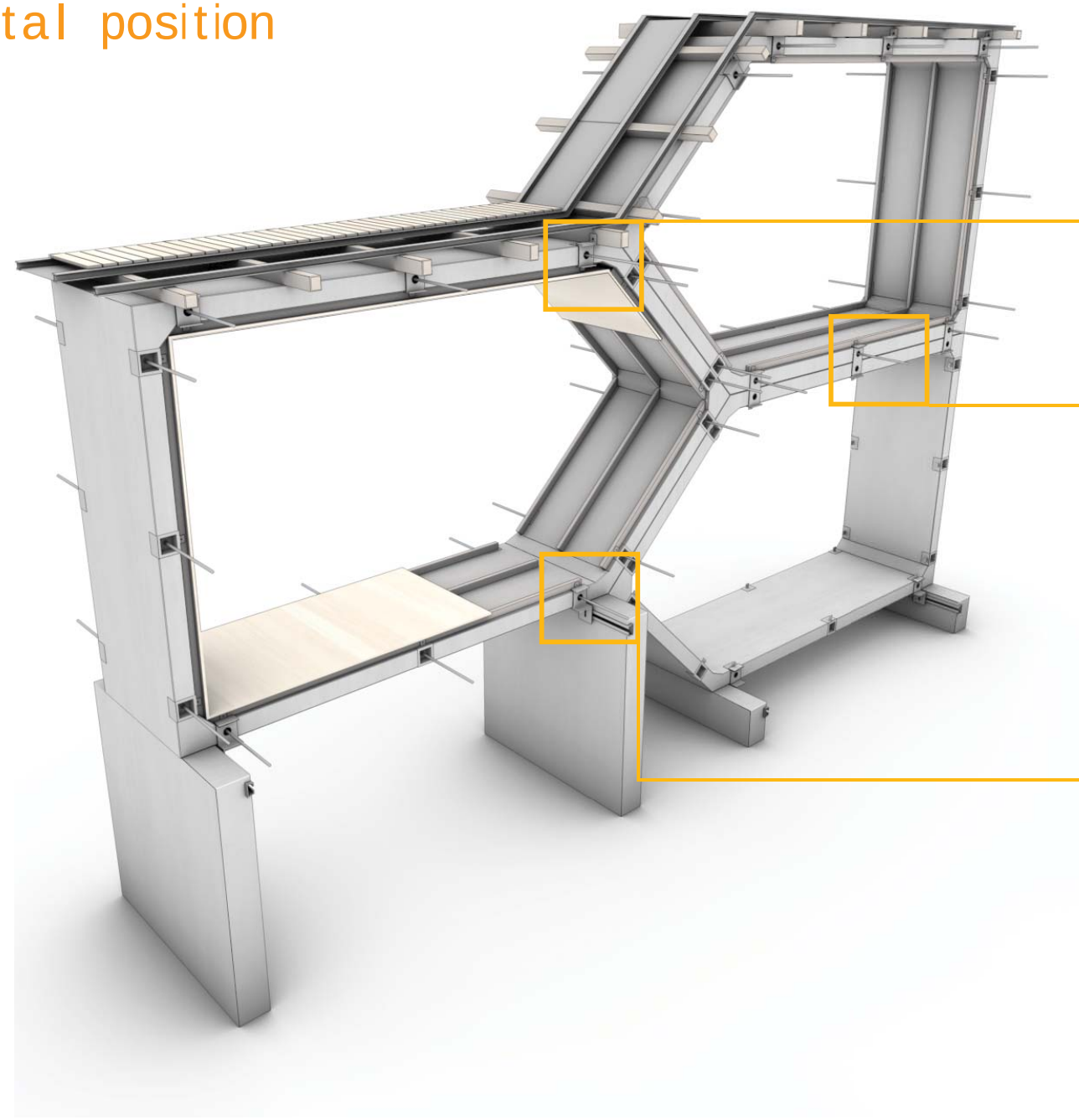
steel hlafen rail

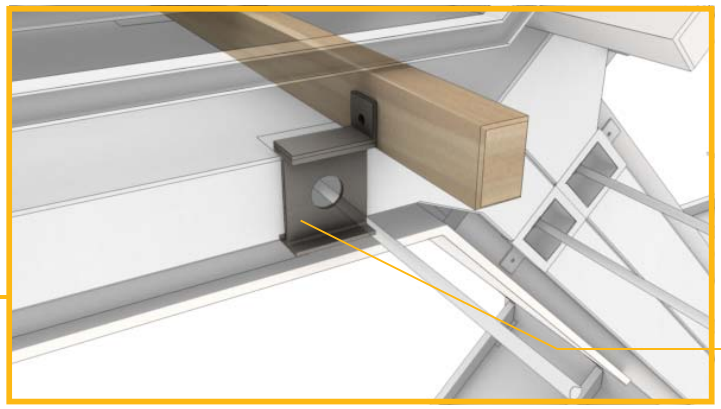


serial prefabricated connection steel part

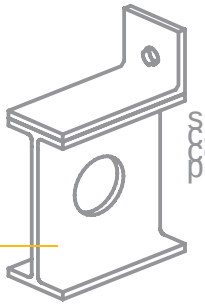


8.2 construction details horizontal position

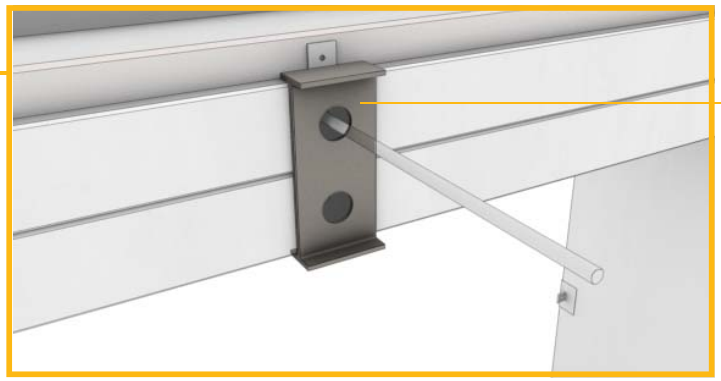




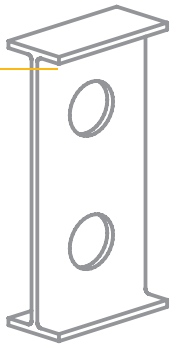
roof-element connection detail sheme

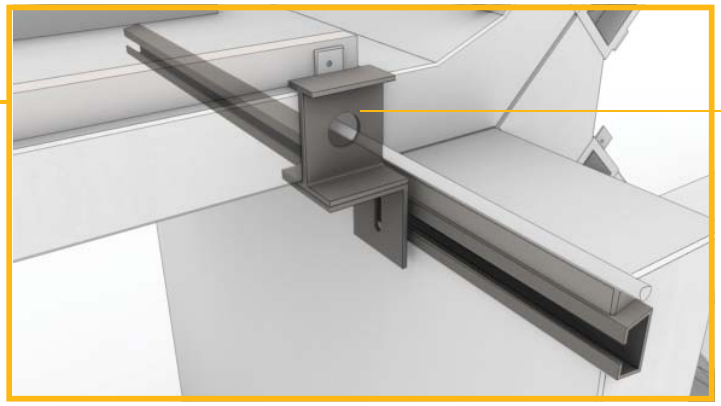


serial prefabricated connection steel parts

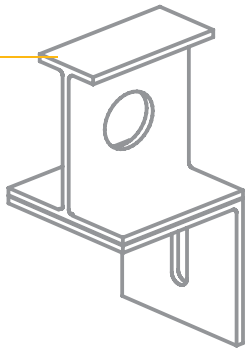


foundation-element connection detail sheme

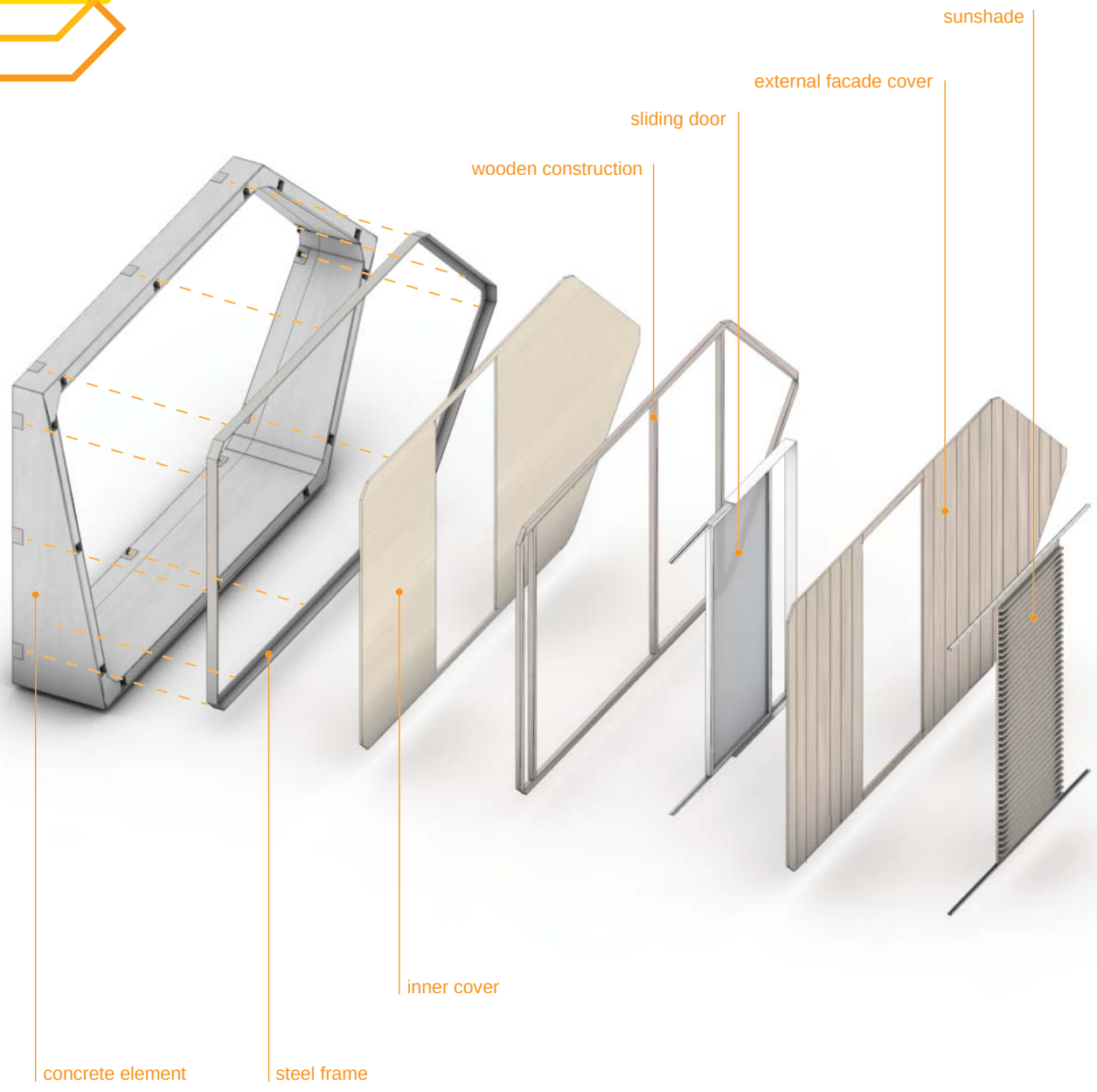


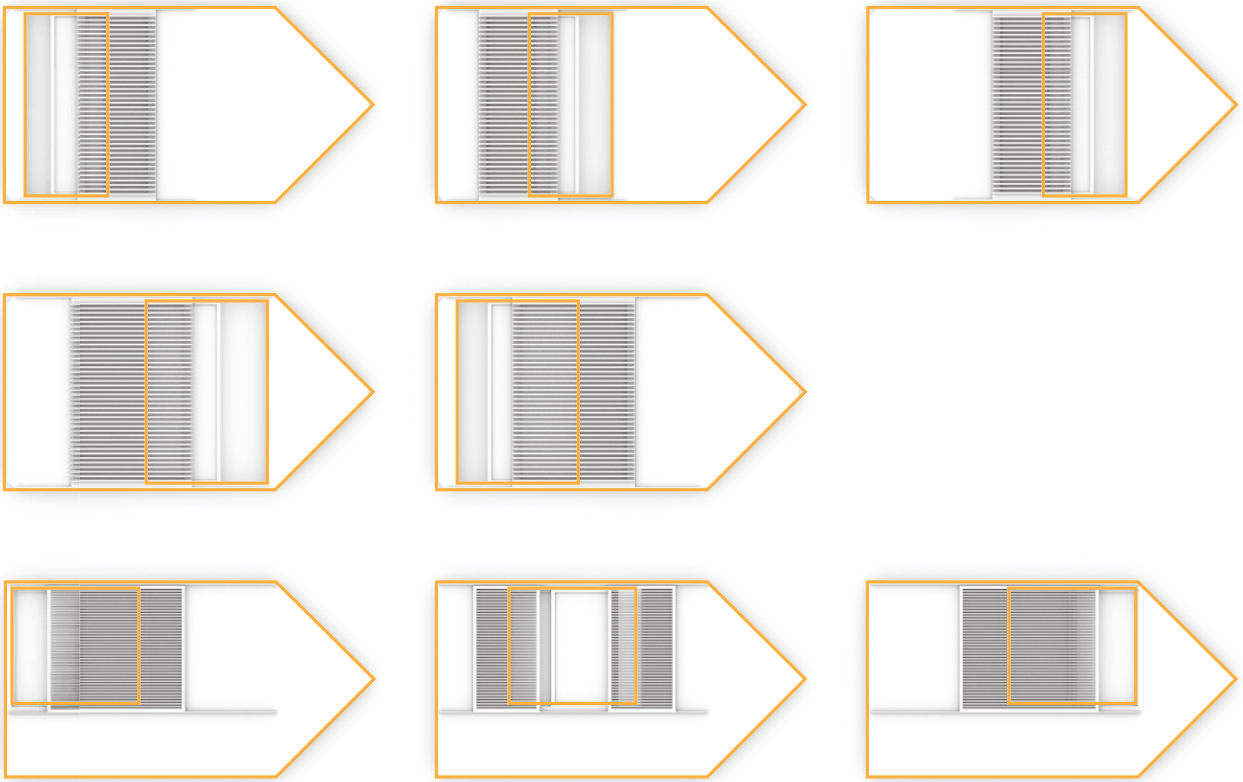


foundation-element connection detail sheme



8.3 facade element principle





These sheme represents few of the possible arrangements of placing the window openings.

9. PRESTATICS ANALYSIS

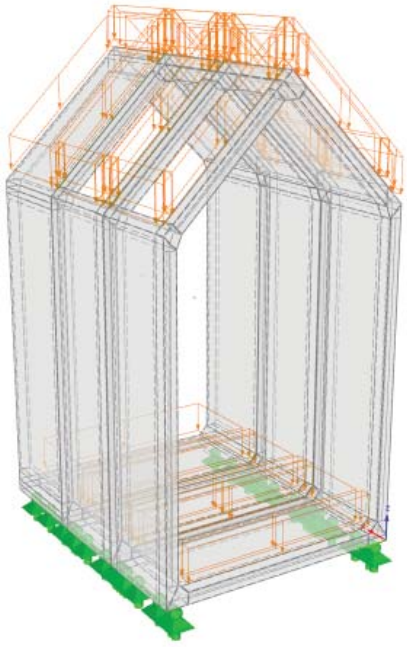
9.1 minimal statical system of 3 modules in vertical position

Loads on the module in different load cases and combinations:

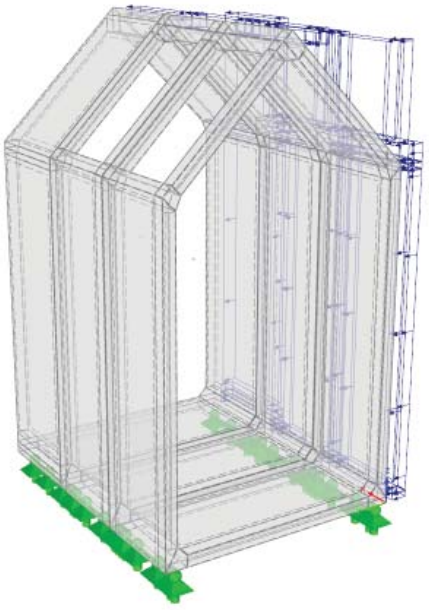
-Own weight of the modules ρ = 16,00
-Payload the deck 2,0 kN
-Payloadthe deck above 2,0 kN
Die Nutzlast im Dachgeschossausbau wird nicht über die Betonwände sondern über eingelegte Holzständer abgetragen.

Wind load parallel and across on the system

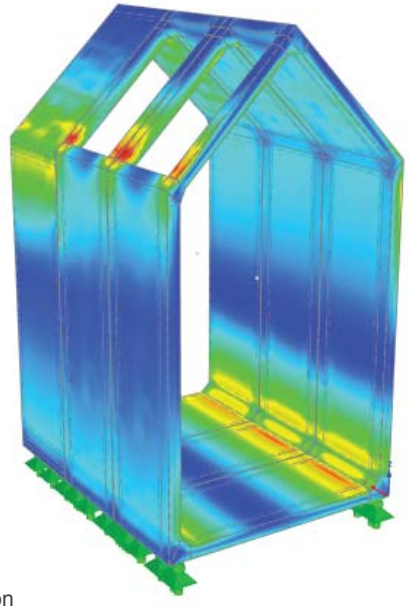
-Wind load 1,0 kN/m2 on the system of modules
-Simulation of wind load on a module above and the resulting horizontal force and moment



The elements have a simple statical concept.
They all have the same basic shape and differ only in the shape of the triangular front section.
Thus all elements consist of a vertical supporting plate and a top and bottom set horizontal plate, depending on the vertical or horizontal position of the element.
The triangular front section is concepted in various forms. Depending on the function of the section it is equiped either with the opening for the stairs or with he opening for the instalation.
The transferflow of the stress in these weakened areas will be reinforced with the local reinforcment of those critical areas.

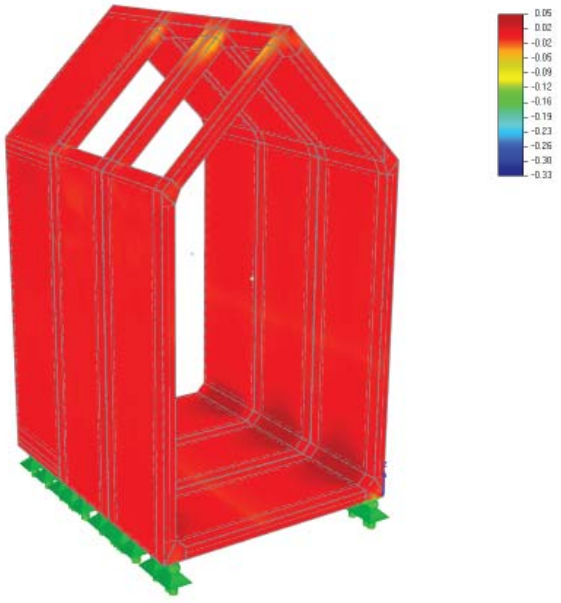


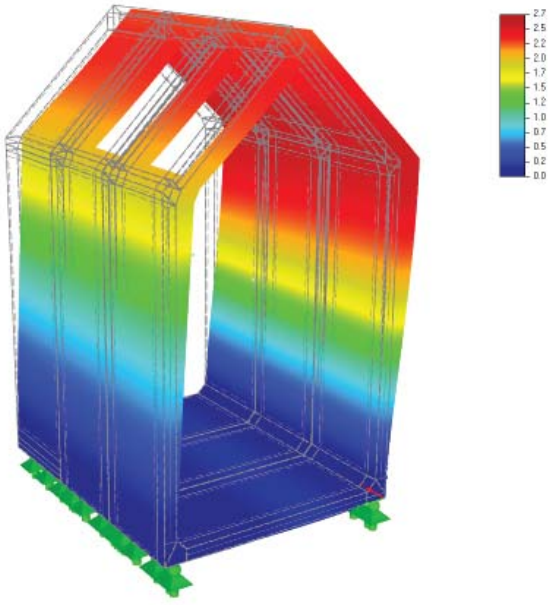
Critical points on the elements for tension in the direction of the Sigma 1 max. tension force.



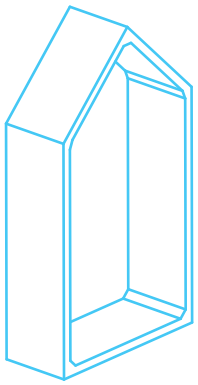
Deformation

Critical points on the elements for pressure in the direction of the Sigma 3 max. pressure force.

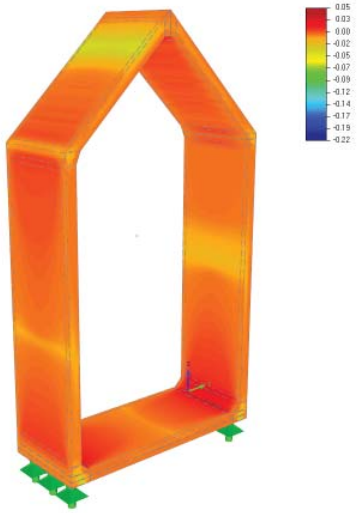




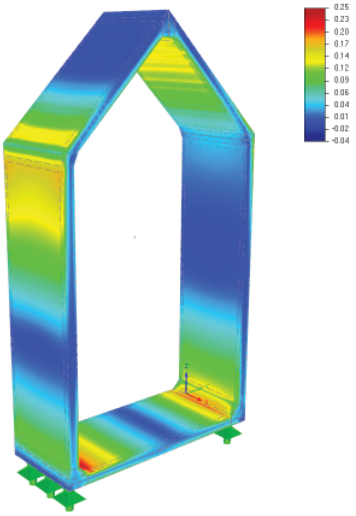
9.2 statical system of whole module



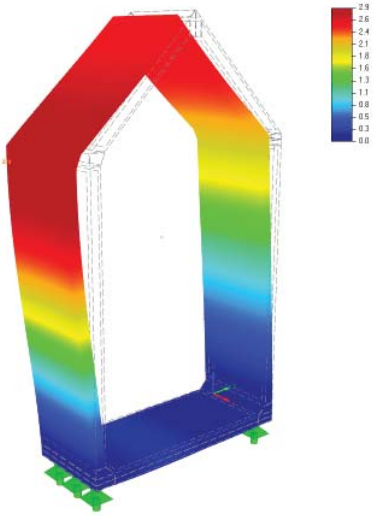
Critical points on the elements for pressure in the direction of the Sigma 3 max. pressure force.



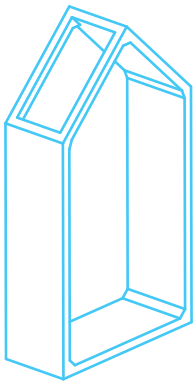
Critical points on the elements for tension in the direction of the Sigma 1 max. tension force.



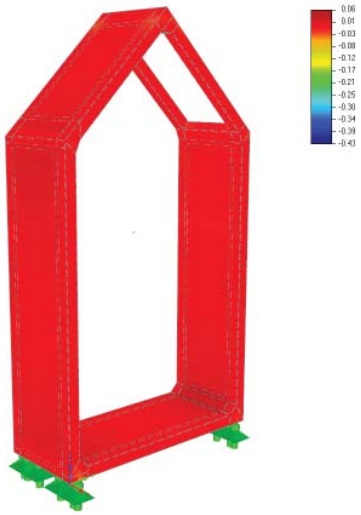
Deformation



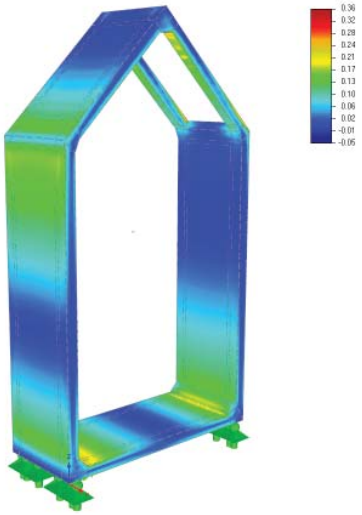
9.3 statical system of modules with opening



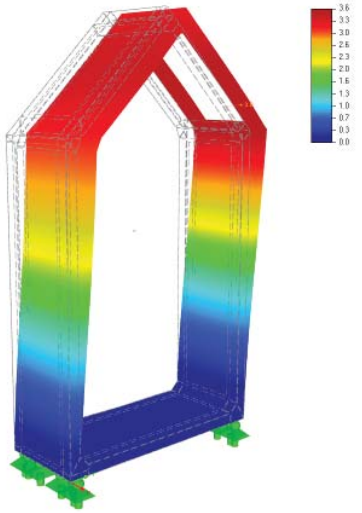
Critical points on the elements for pressure in the direction of the Sigma 3 max. pressure force.



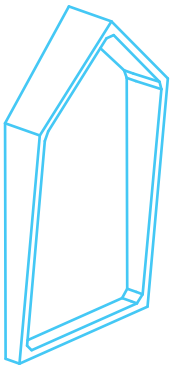
Critical points on the elements for tension in the direction of the Sigma 1 max. tension force.



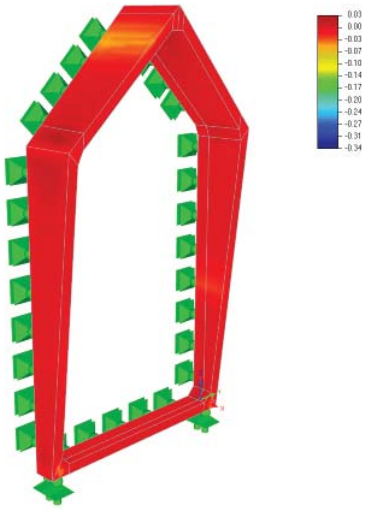
Deformation



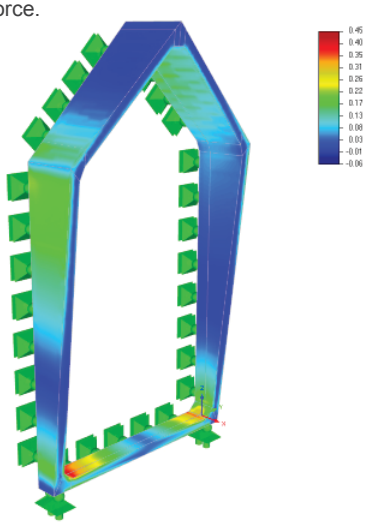
94 statical system of facade modules



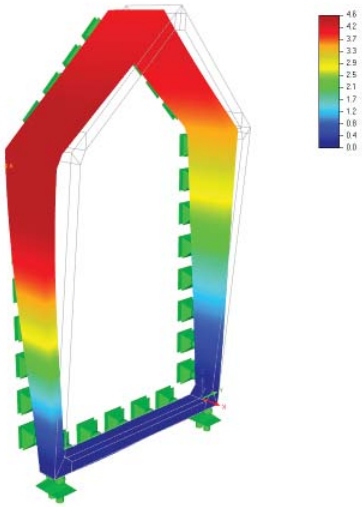
Critical points on the elements for pressure in the direction of the Sigma 3 max. pressure force.



Critical points on the elements for tension in the direction of the Sigma 1 max. tension force.



Deformation



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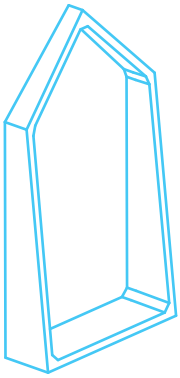
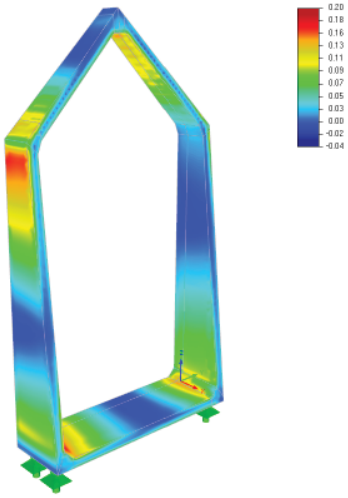
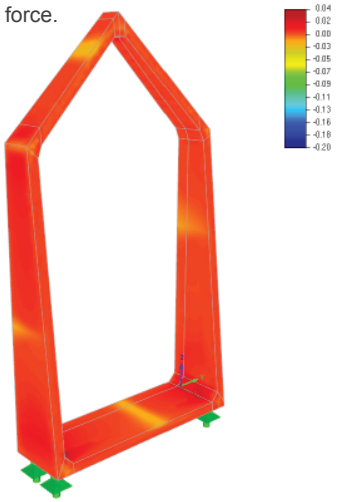




Critical points on the elements for pressure in the direction of the Sigma 3 max. pressure force.



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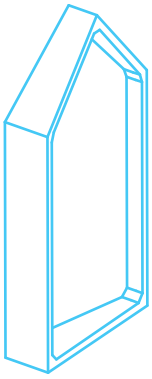
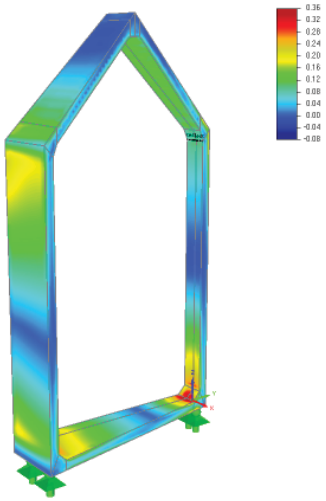
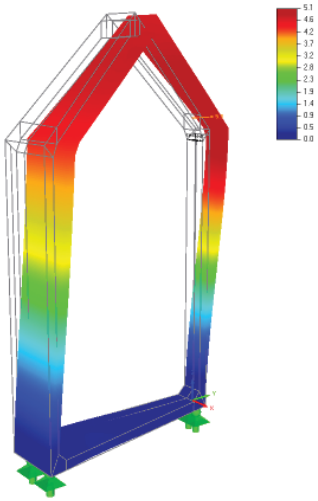






9.5 minimal statical system of 3 modules in horizontal position

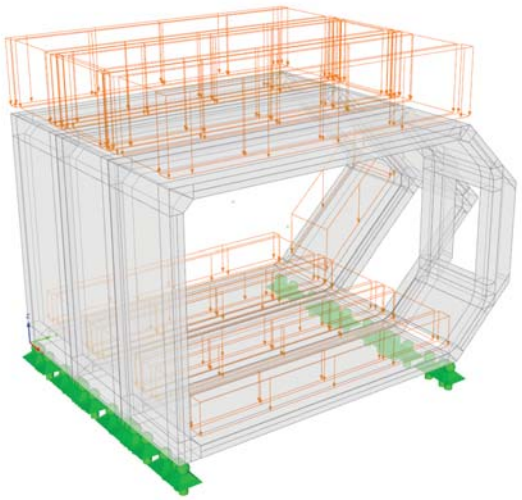
Loads on the module in different load cases and combinations:

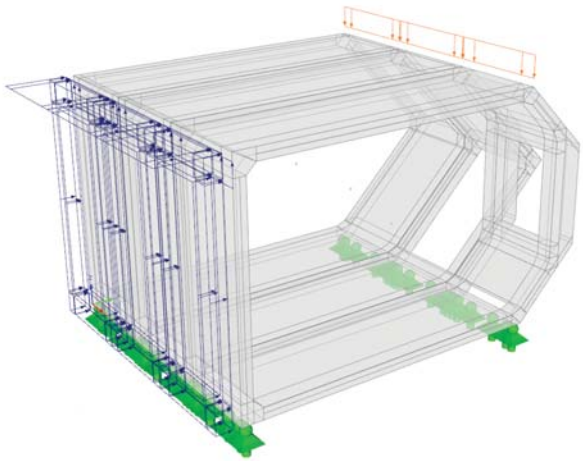
-Own weight of the modules ρ = 16,00
-Payload the deck 2,0 kN
-Payloadthe deck above 2,0 kN
-Payload steps 3,0 kN
-Payload balcony 4,0 kN

Wind load parallel with the system

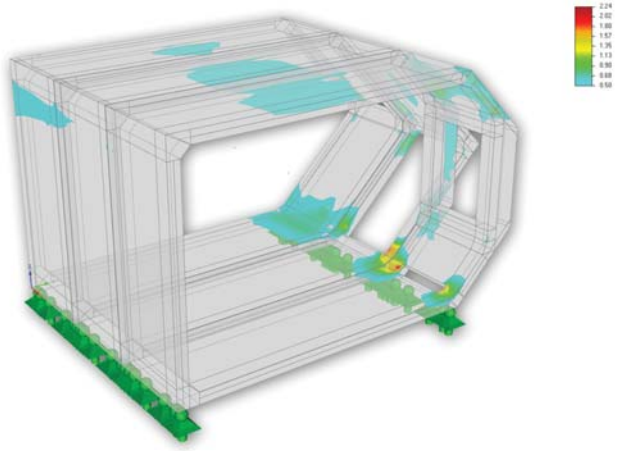
Standort: nicht bekannt - Annahme 1,0 kN/m2 (Liegt im Ueblichen Bereich und deckt die meisten Fällen ab)

-Wind load 1,0 kN/m2 on the system of modules
-Simulation of wind load on a module above and the resulting horizontal force and moment

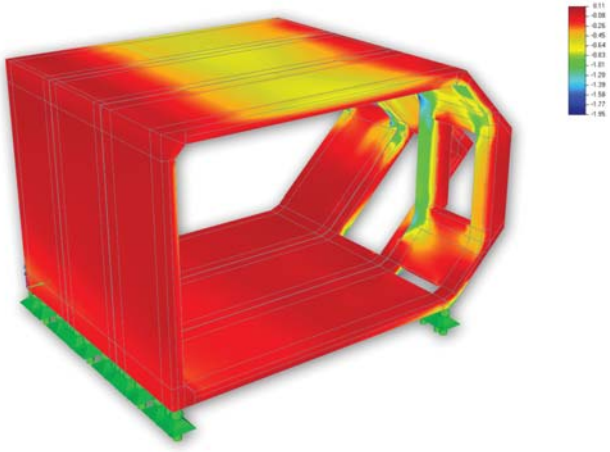




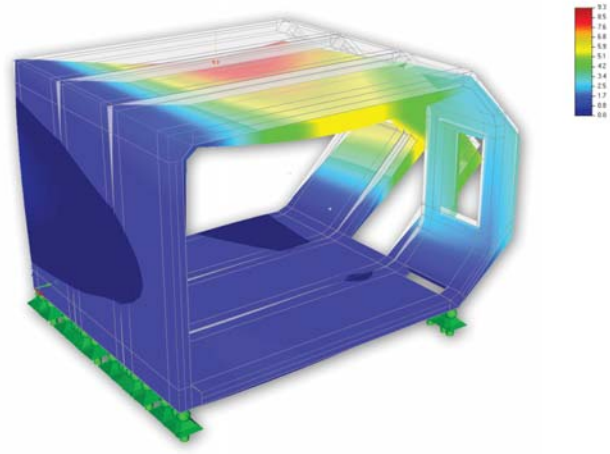
Critical points on the elements for tension in the direction of the Sigma 1 max. tension force.



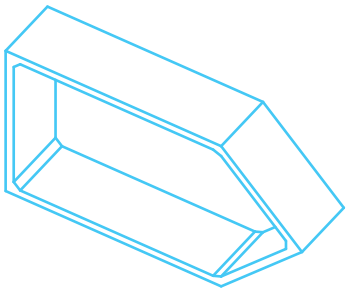
Critical points on the elements for pressure in the direction of the Sigma 3 max. pressure force.



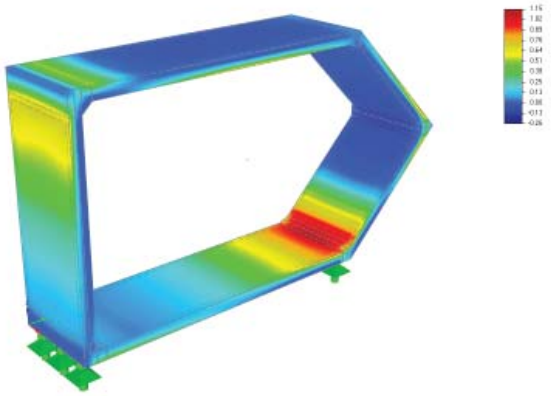
Deformation



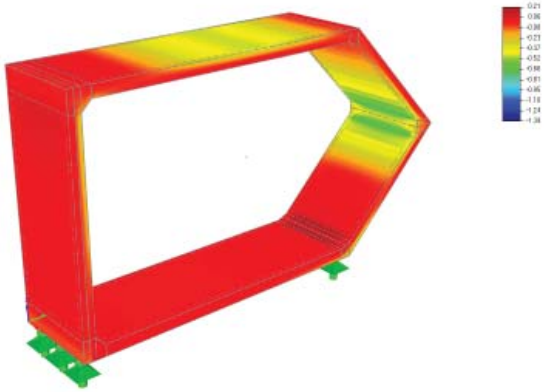
9.6 statical system of whole module in horizontal position



Critical points on the elements for tension in the direction of the Sigma 1 max. tension force.



Critical points on the elements for pressure in the direction of the Sigma 3 max. pressure force.



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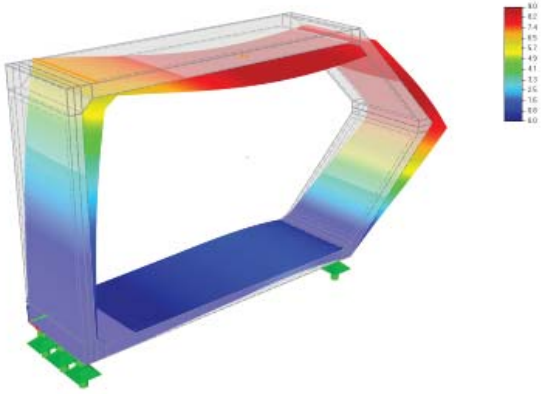
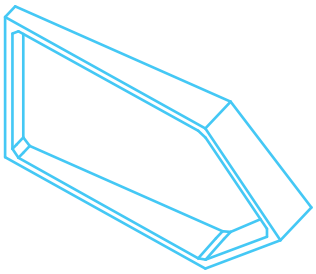


97 statical system of facacde modules in horizontal position



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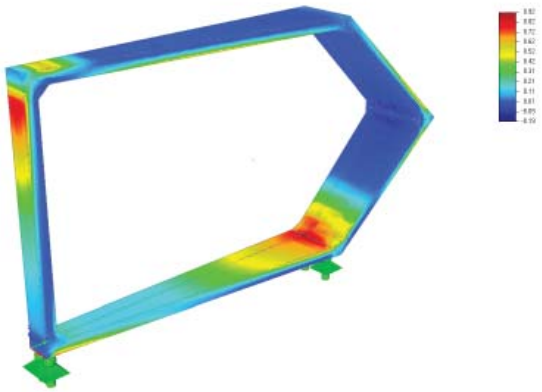

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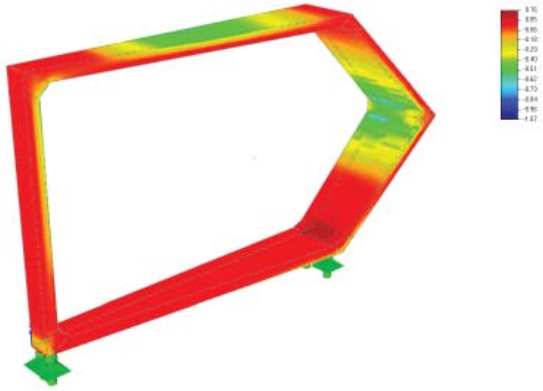

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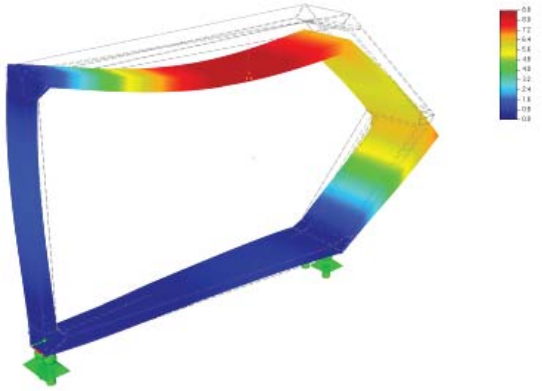
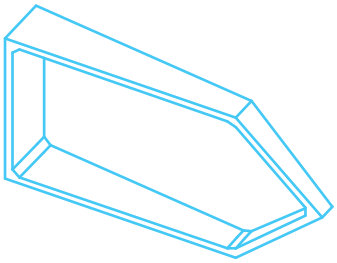
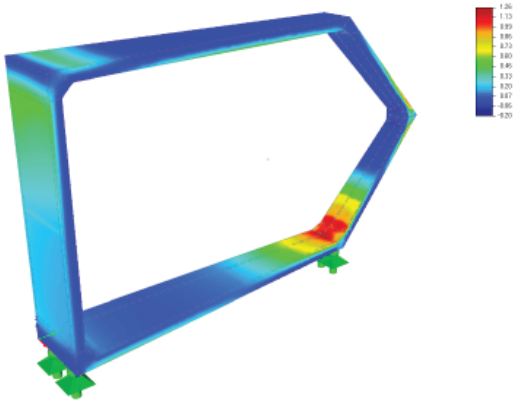
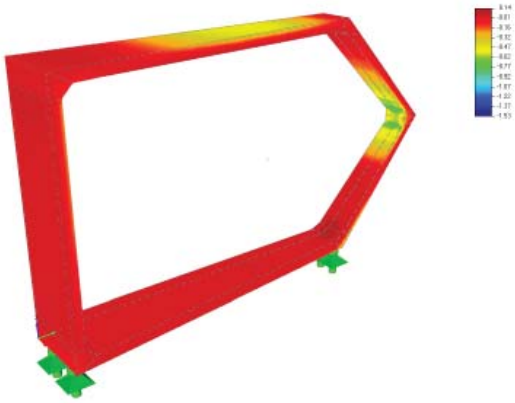




Critical points on the elements for tension in the direction of the Sigma 1 max. tension force.



Critical points on the elements for pressure in the direction of the Sigma 3 max. pressure force.



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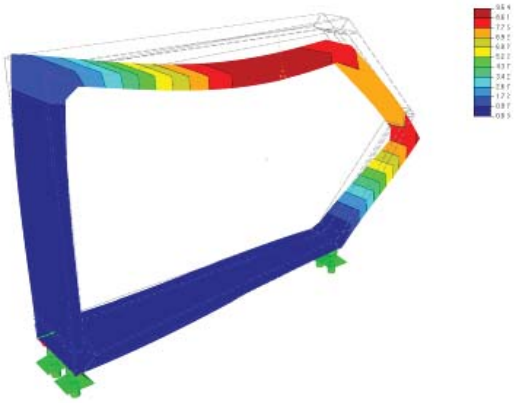

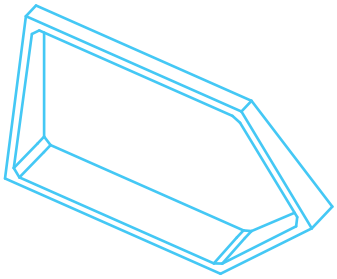

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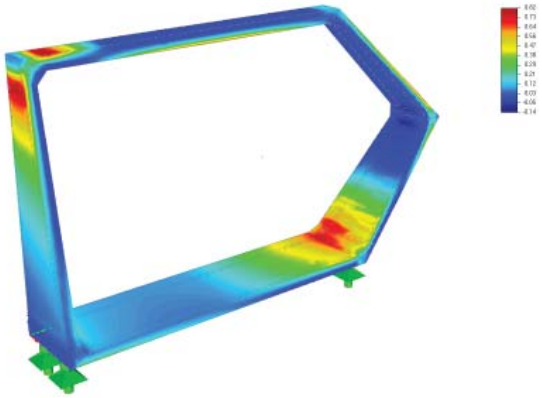
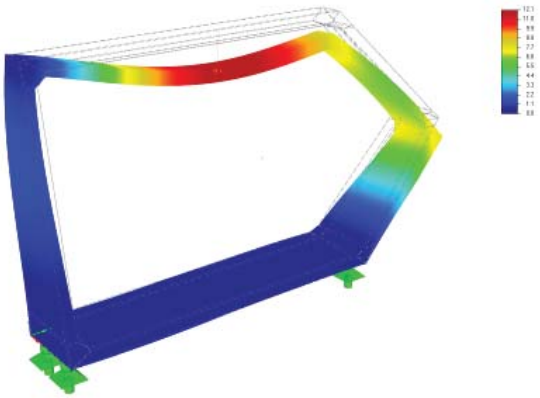


Critical points on the elements for pressure in the direction of the Sigma 3 max. pressure force.



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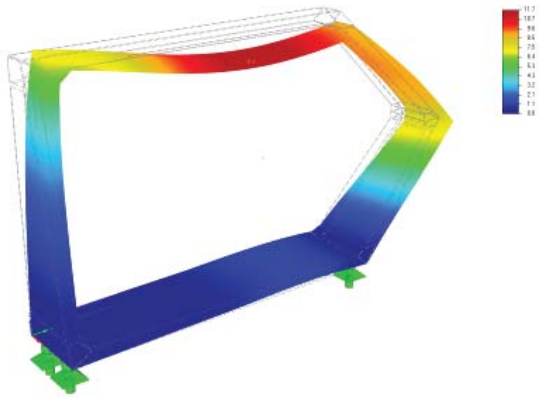
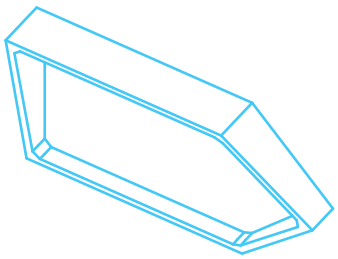
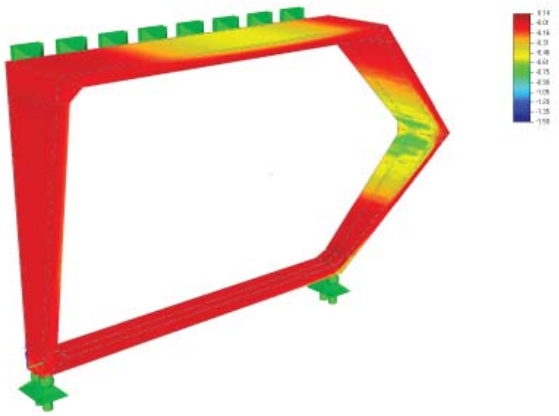
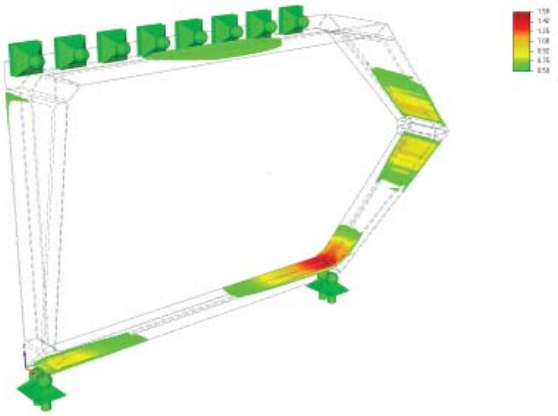




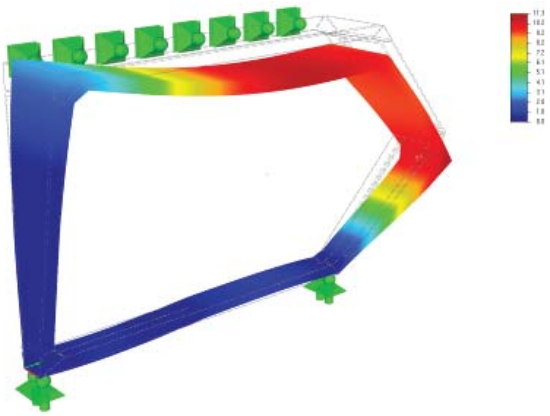
Critical points on the elements for pressure in the direction of the Sigma 3 max. pressure force.



Critical points on the elements for tension in the direction of the Sigma 1 max. tension force.



Deformation



9.8 conclusion of the prestatical analysis

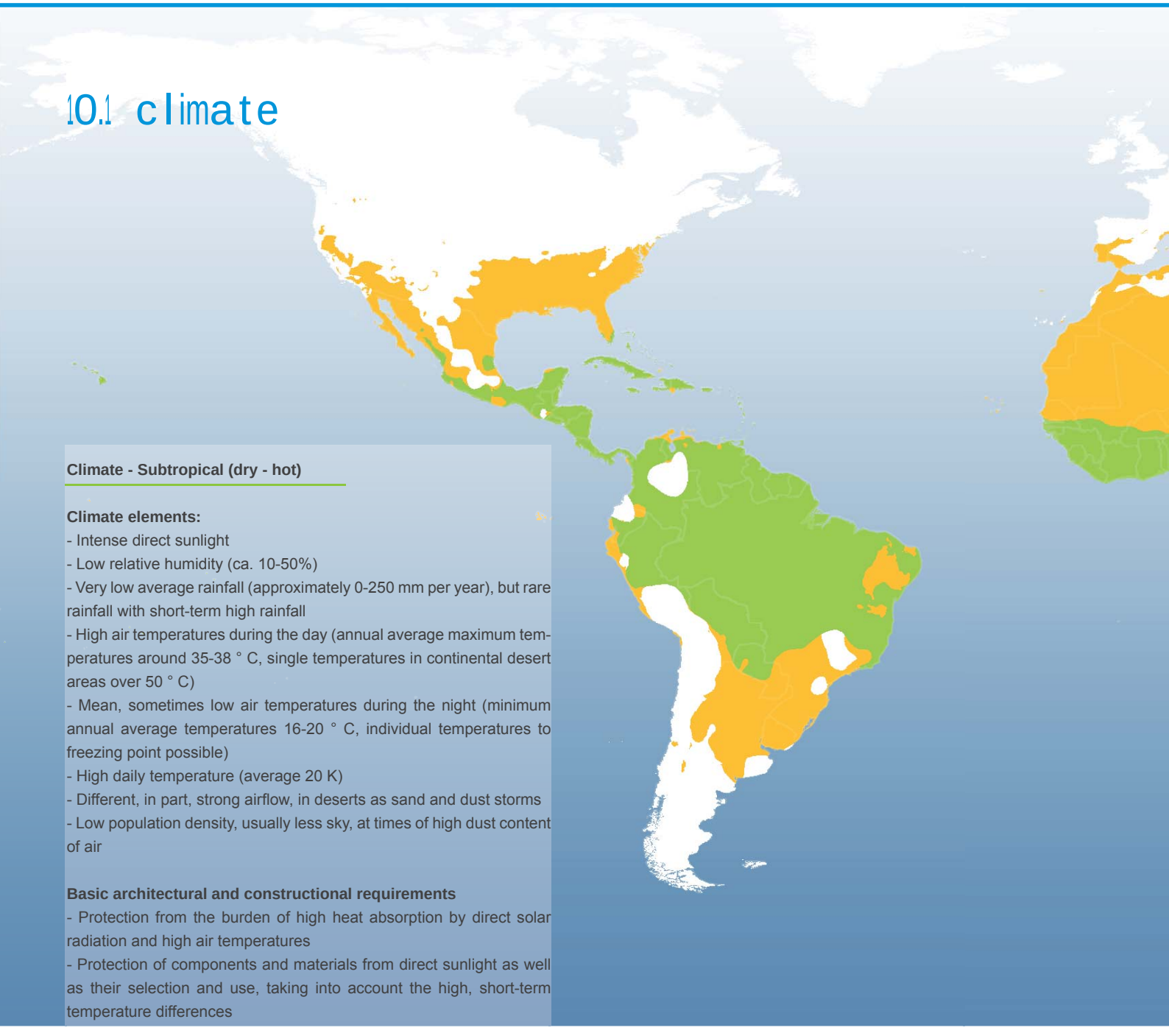
The individual elements or the composition which occur in all types of house types and always repeat itself, were examined statically.
There is no specific location given for the construction defined it is just that the project is designed in this elaborate form for the subtropical and tropical areas.

Each side of the house is separated and supported on two strip foundations so that there are no direct transfer of forces between the two parts of the house. This statical model makes the details simplified as much as possible.
In case of an earthquake affect the joints that connect the elements created as a damper and distributing the deformation.

The prestatical eximination was made with the Dlubal RFEM student software.
The conclusion of this eximination is that the elements are possible to be made with the planed technology and materials.
Most of the elements can carry loads within allowed tensions and deformations.
All elements are reinforced with steel fibers.
All those elements which in some places exceed the max. tension stress of steel fibers 0,5 kN/cm2 need to be reinforced with reinforcment bars d=6mm on all requied shown places.

10. CONSTRUCTION PHYSICS AND INSTALLATIONS

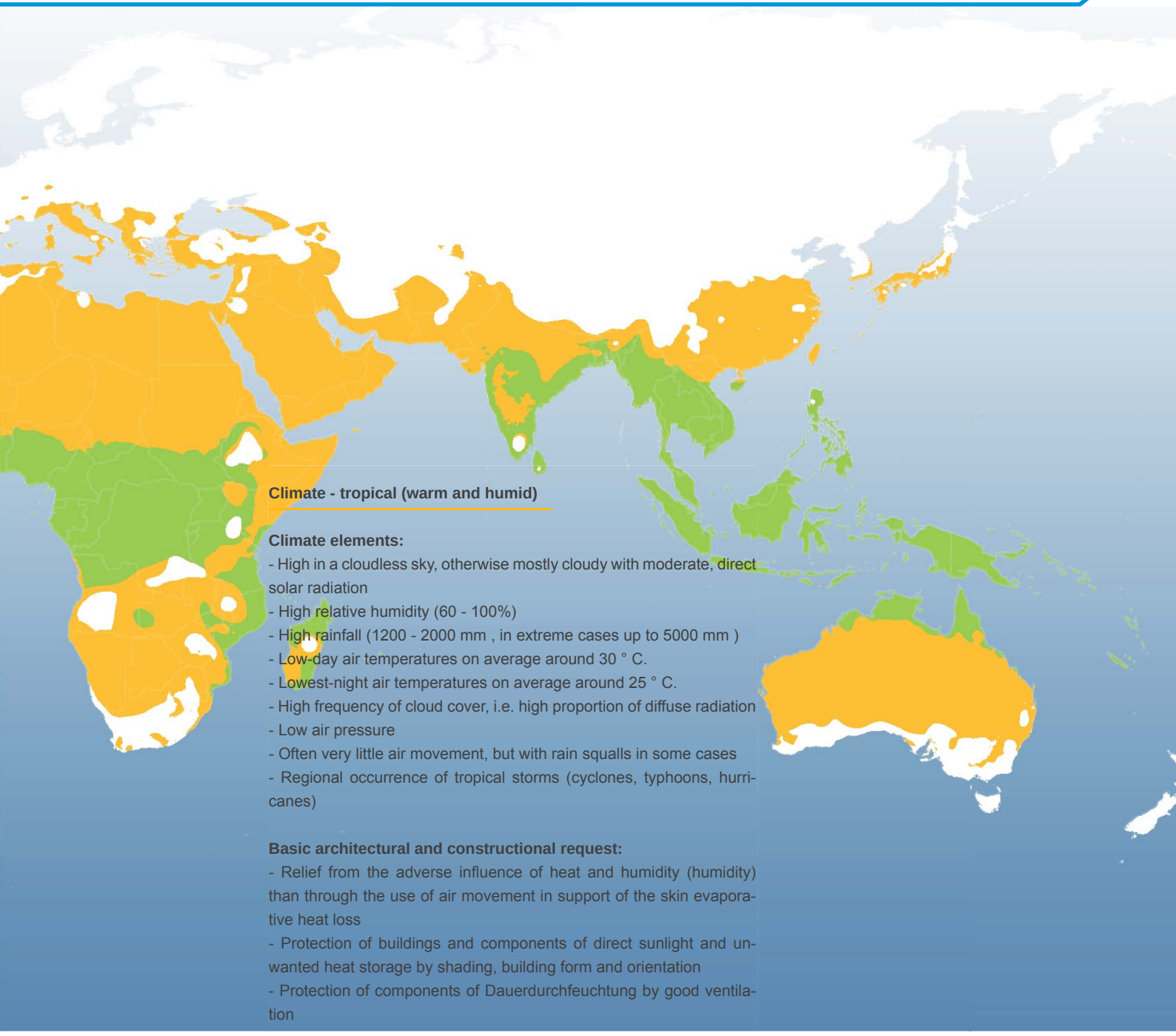
10.1 climate



Climate - Subtropical (dry - hot)

Climate elements:
- Intense direct sunlight
- Low relative humidity (ca. 10-50%)
- Very low average rainfall (approximately 0-250 mm per year), but rare rainfall with short-term high rainfall
- High air temperatures during the day (annual average maximum temperatures around 35-38 ° C, single temperatures in continental desert areas over 50 ° C)
- Mean, sometimes low air temperatures during the night (minimum annual average temperatures 16-20 ° C, individual temperatures to freezing point possible)
- High daily temperature (average 20 K)
- Different, in part, strong airflow, in deserts as sand and dust storms
- Low population density, usually less sky, at times of high dust content of air

Basic architectural and constructional requirements
- Protection from the burden of high heat absorption by direct solar radiation and high air temperatures
- Protection of components and materials from direct sunlight as well as their selection and use, taking into account the high, short-term temperature differences



Climate - tropical (warm and humid)

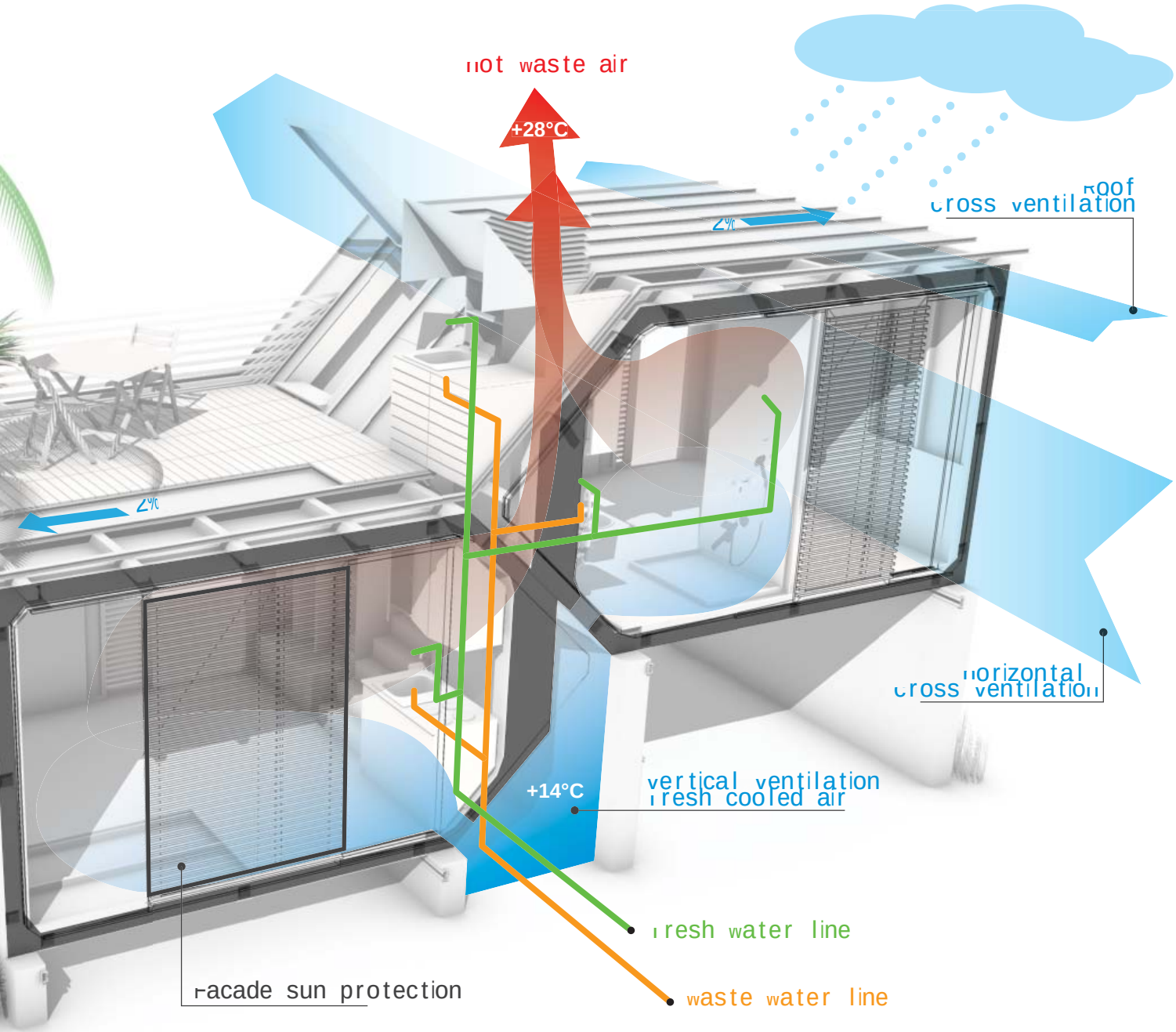
Climate elements:

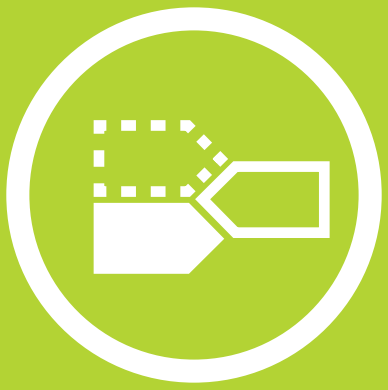
- High in a cloudless sky, otherwise mostly cloudy with moderate, direct solar radiation
- High relative humidity (60 - 100%)
- High rainfall (1200 - 2000 mm , in extreme cases up to 5000 mm)
- Low-day air temperatures on average around 30 ° C.
- Lowest-night air temperatures on average around 25 ° C.
- High frequency of cloud cover, i.e. high proportion of diffuse radiation
- Low air pressure
- Often very little air movement, but with rain squalls in some cases
- Regional occurrence of tropical storms (cyclones, typhoons, hurricanes)

Basic architectural and constructional request:

- Relief from the adverse influence of heat and humidity (humidity) than through the use of air movement in support of the skin evaporative heat loss
- Protection of buildings and components of direct sunlight and unwanted heat storage by shading, building form and orientation
- Protection of components of Dauerdurchfeuchtung by good ventilation

10.2 construction physic and installations sheme


Hot waste air
+28°C
Roof cross ventilation
2%
2%
Horizontal cross ventilation
+14°C
Vertical ventilation
Fresh cooled air
Fresh water line
Waste water line
Façade sun protection

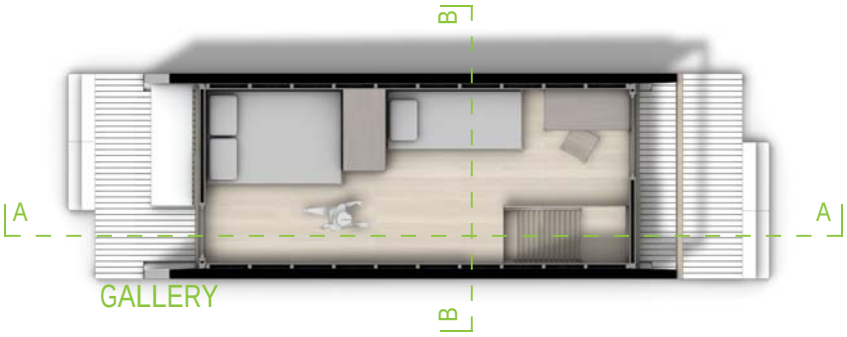


11. HOUSE TYPES

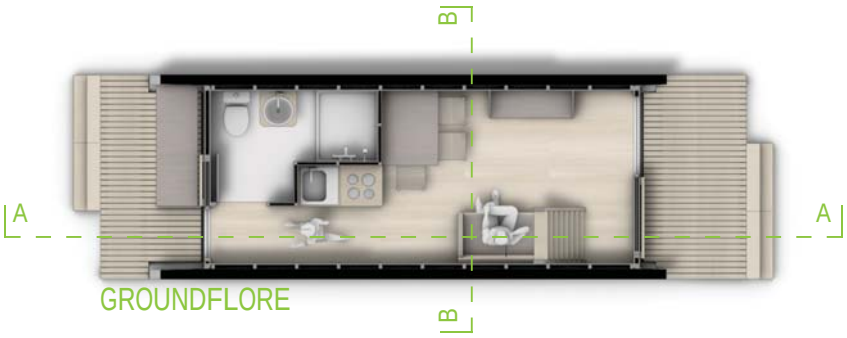
H 1

concrete elements	6
interior elements	4
person	2
living space m²	25,2

FACADE



GALLERY



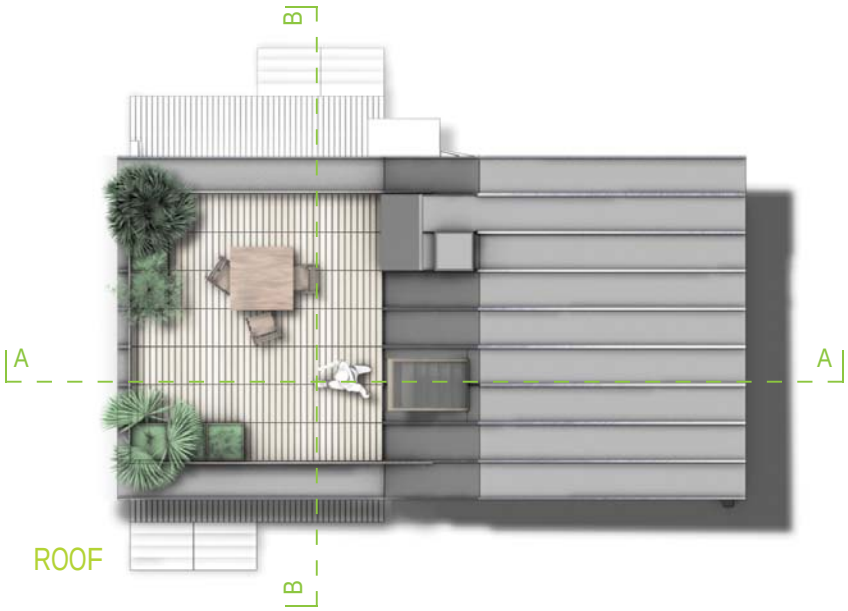
GROUNDFLORE

B-B

A-A

H 2

concrete elements	9
interior elements	5
person	2
living space m²	31,2

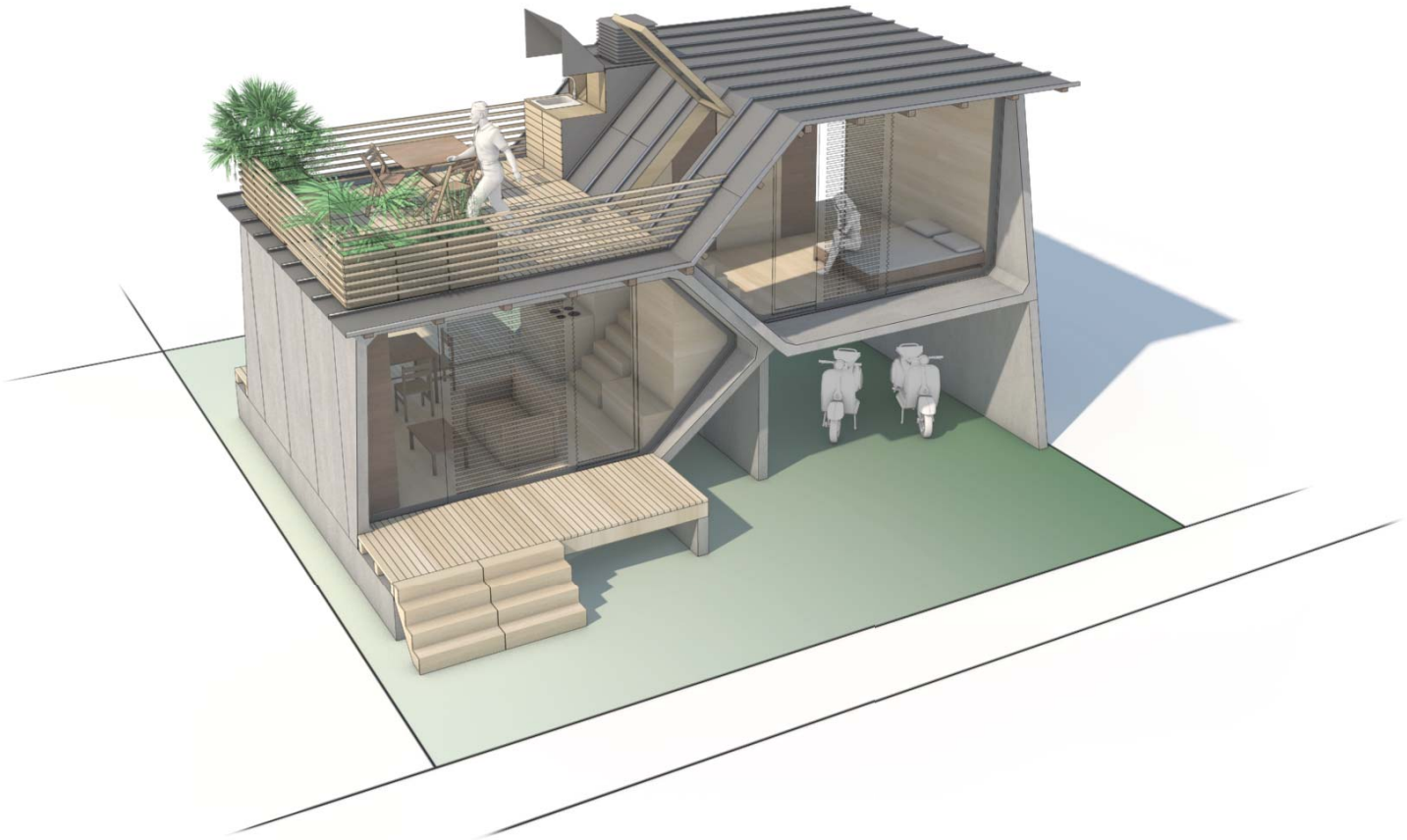

B
A
A
ROOF
B


B
A
A
GROUNDFLORE
B

FACADE

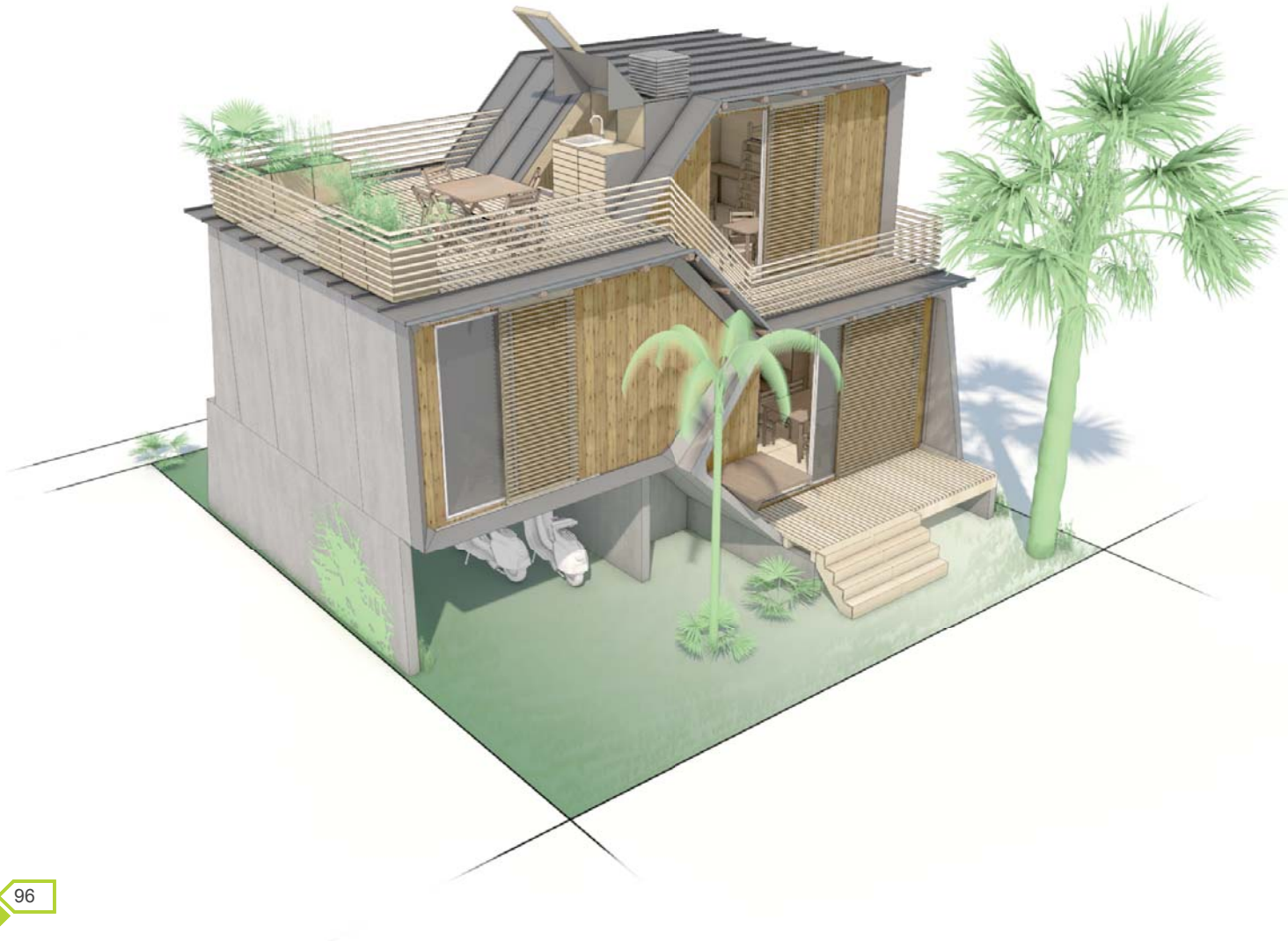
A-A

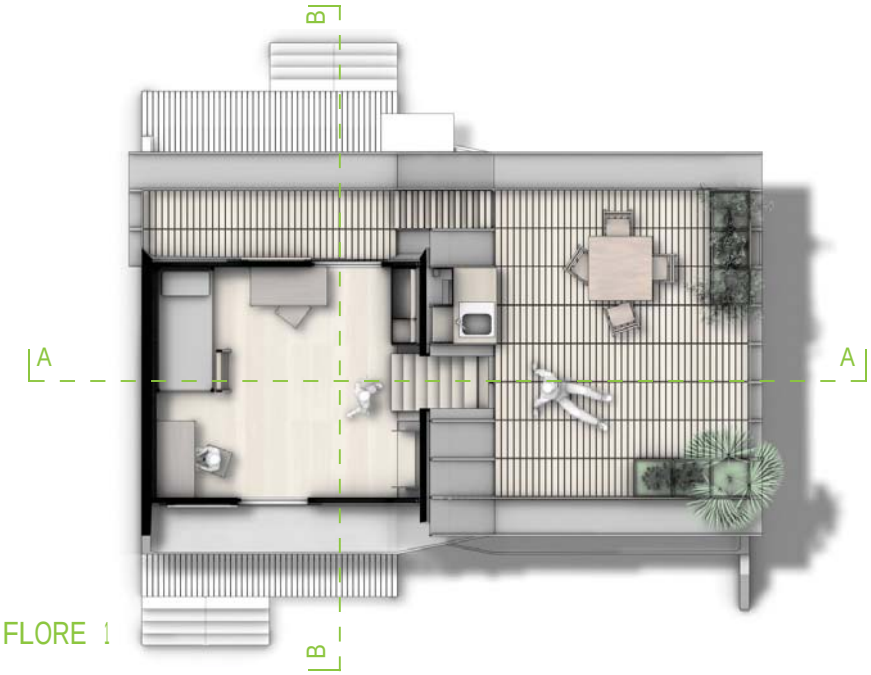
B-B



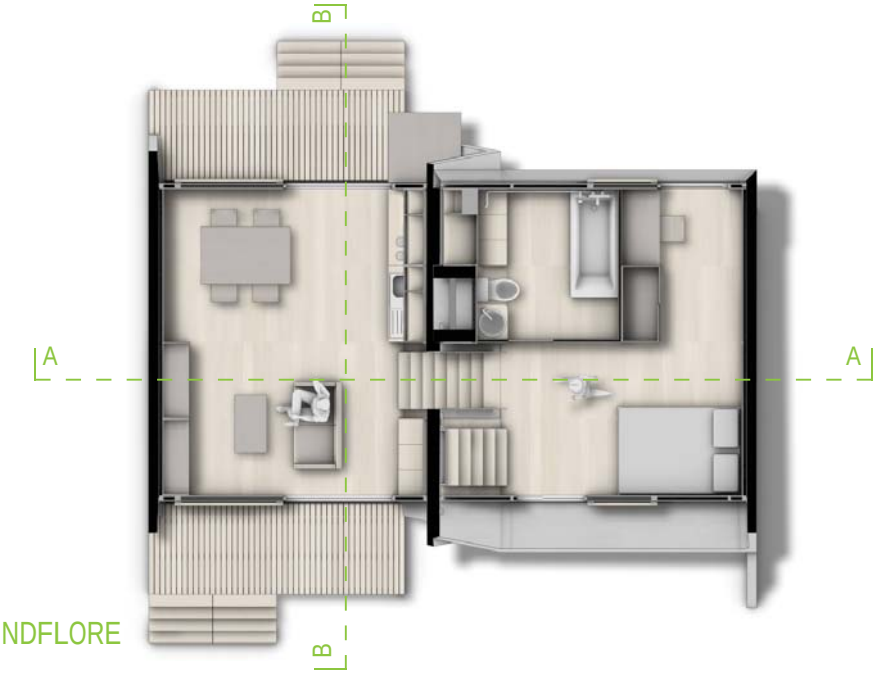
H 3

concrete elements	15
interior elements	9
person	4
living space m²	57,2



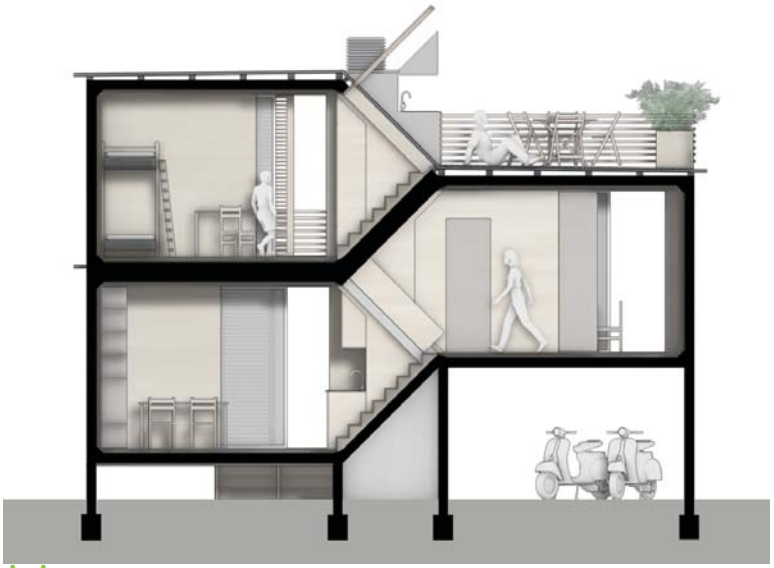


FLORE 1



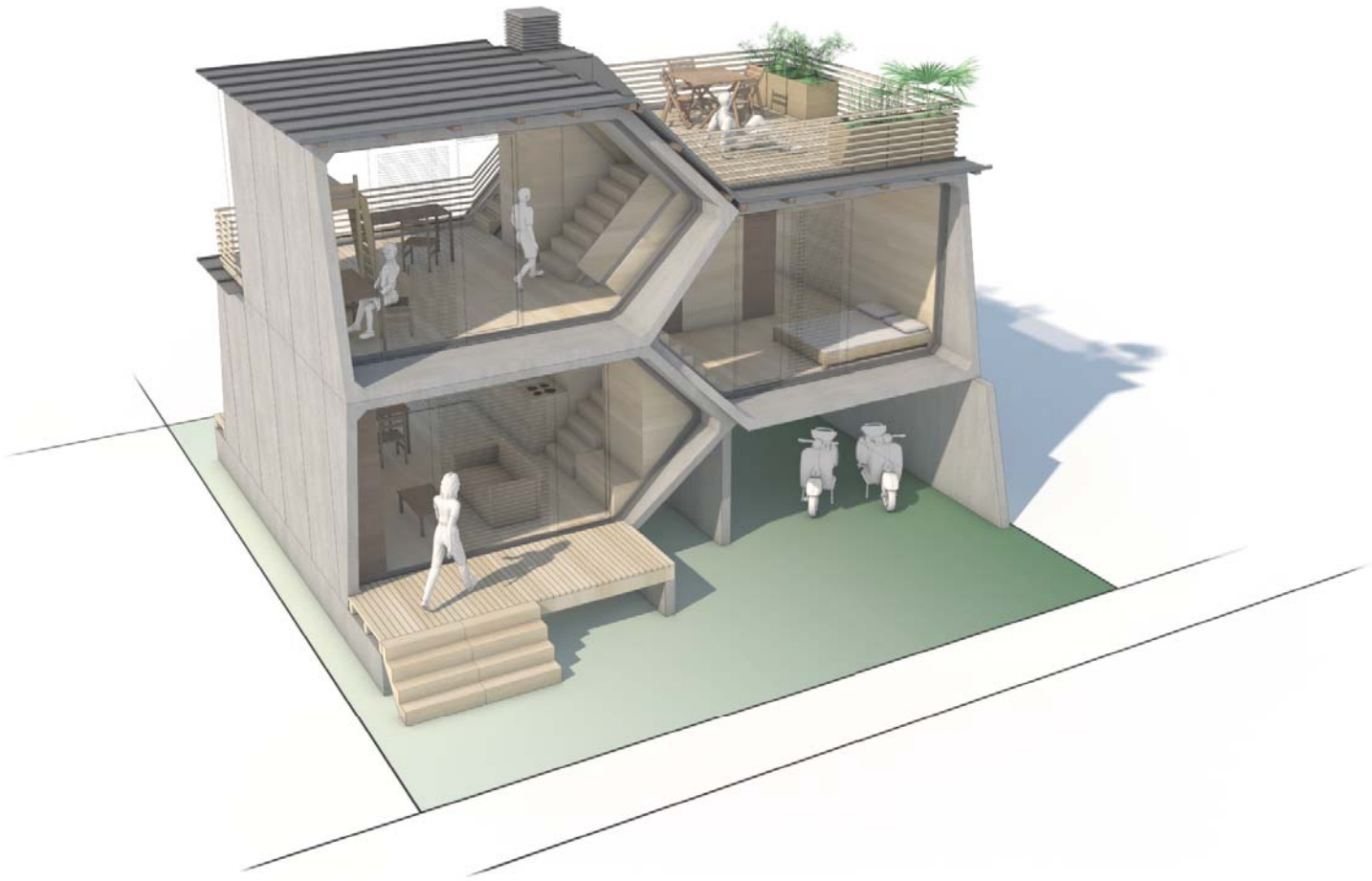
GROUNDFLORE

FACADE



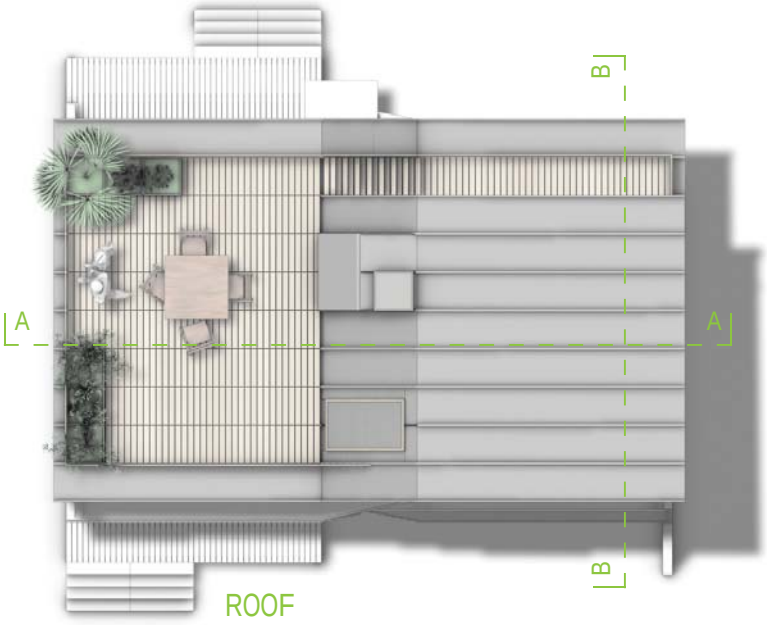
A-A

B-B

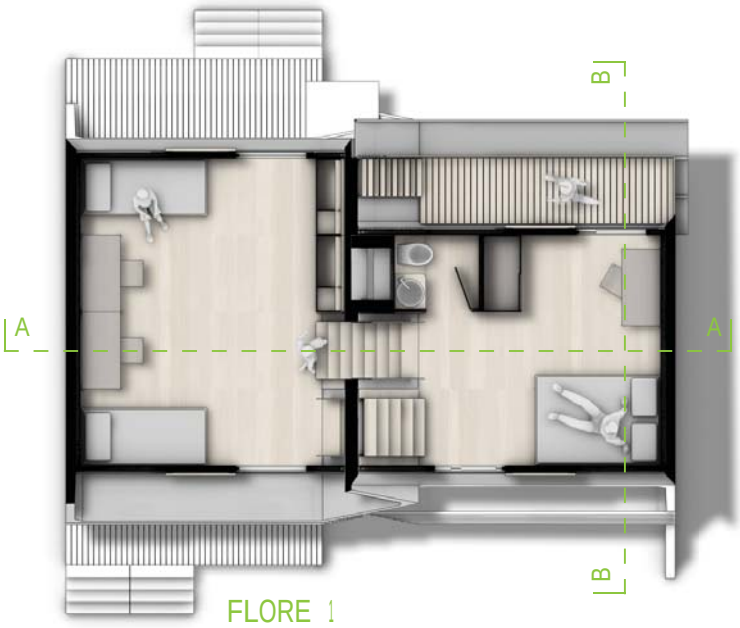


H 4

concrete elements	19
interior elements	11
person	6
living space m²	78



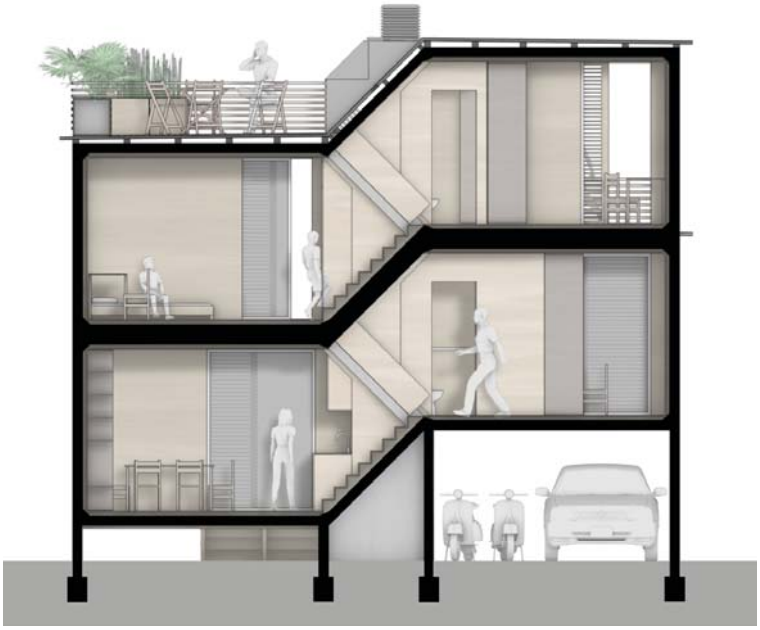
ROOF



FLORE 1

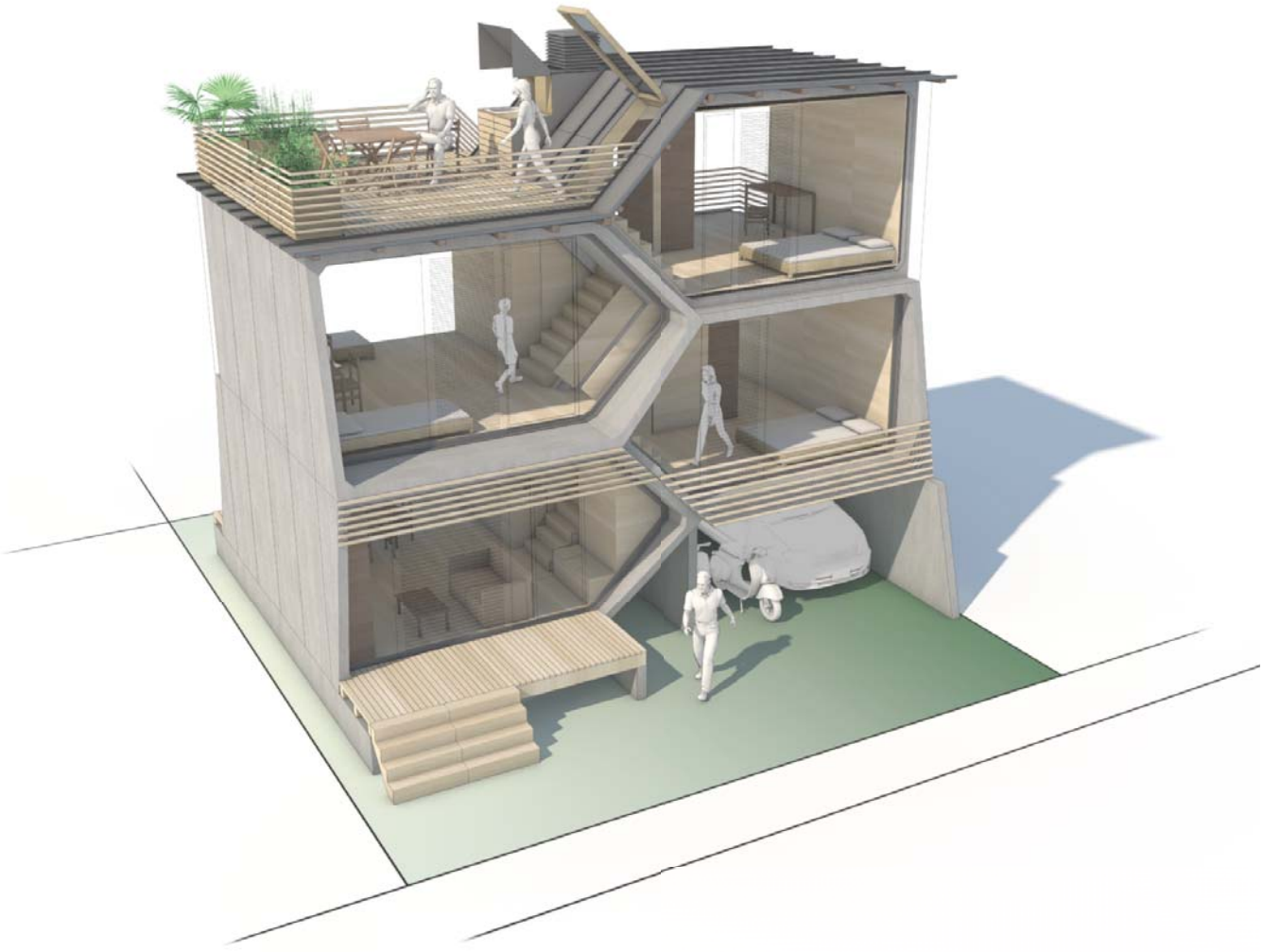
GROUNDFLORE

FACADE



A-A

B-B



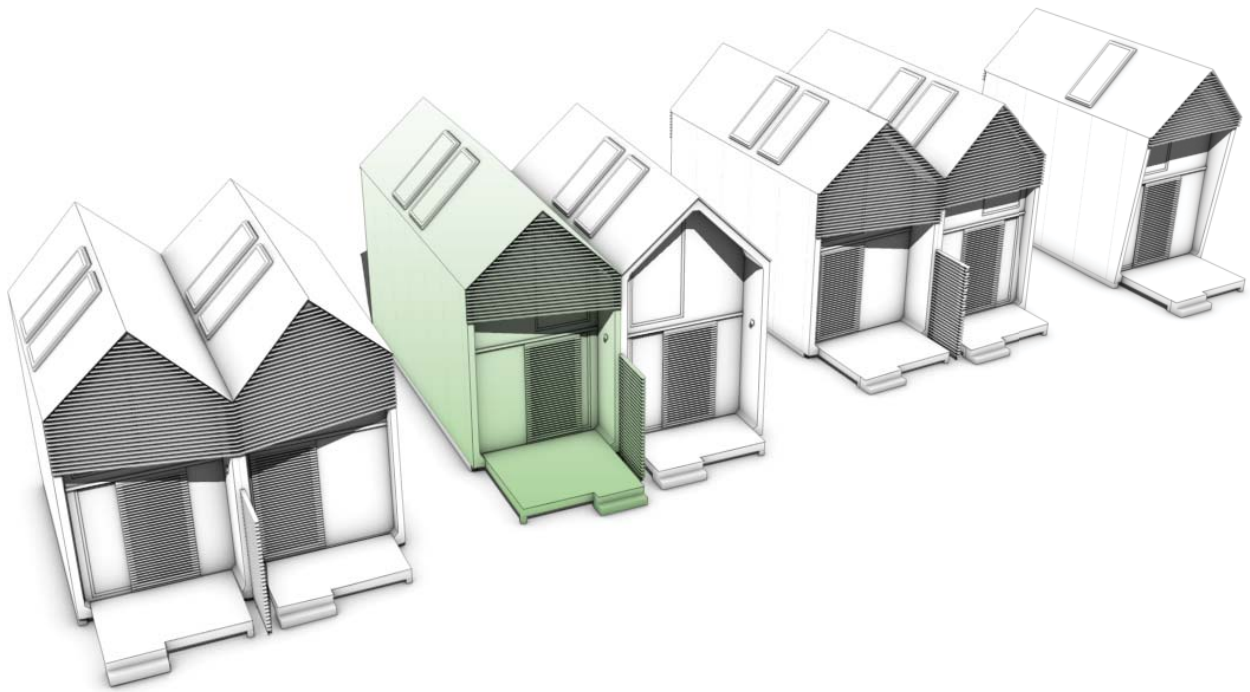
12. HOUSE FORMATIONS

As the goal of our project was to develope a house that is sutible for subtropical and tropical climate zone, that means that this houses have to be sutible for different countries where cultures and costums are different as well. The houses are concepted the way that they can be assembled in different compositions, depending on the terrain or dwelling density or other influencing parameters.

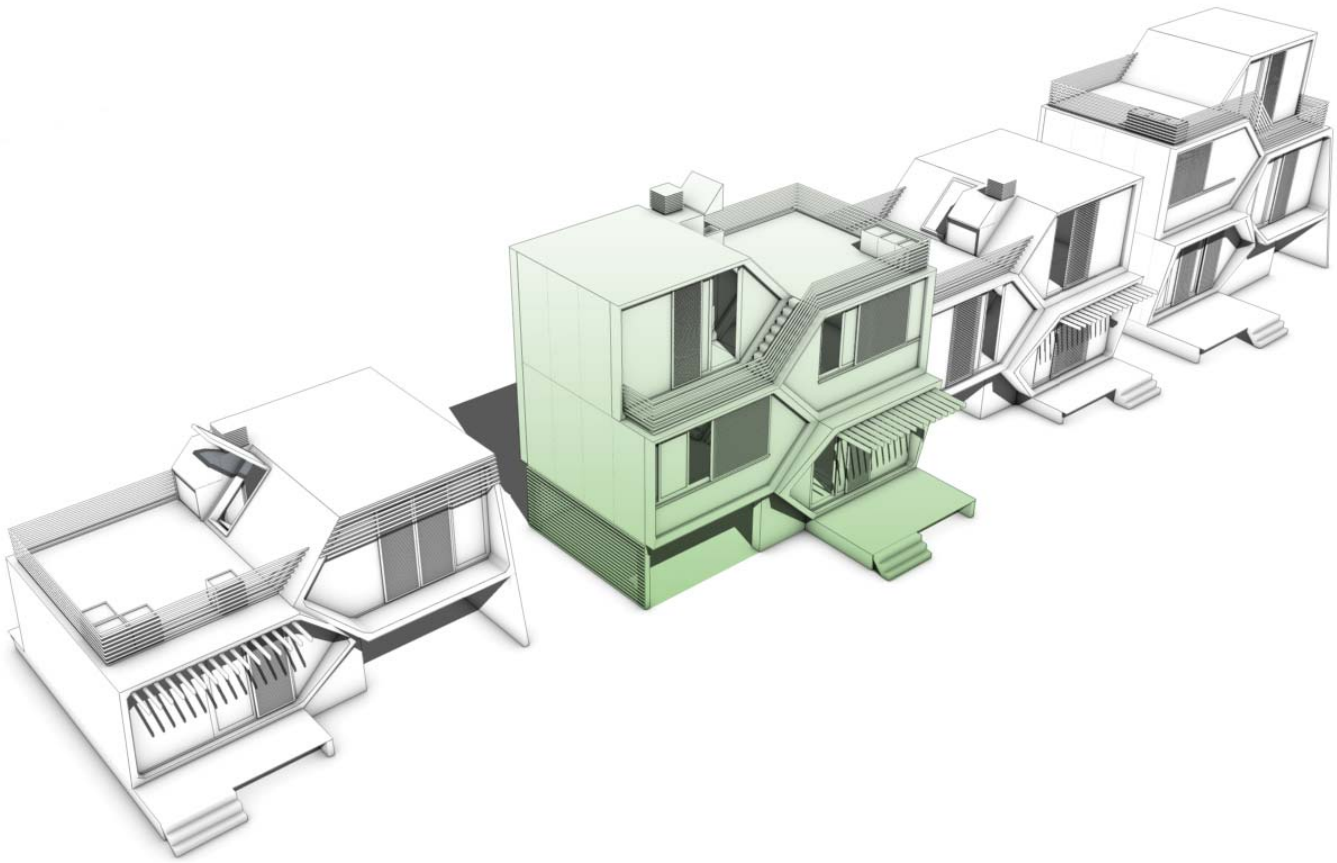
The facades have also the possibility to be made out of different materials and designs, which makes integration in different cultures and different sociological habits much easier.

The possible variations of compositions makes the project topographically adaptable as well.

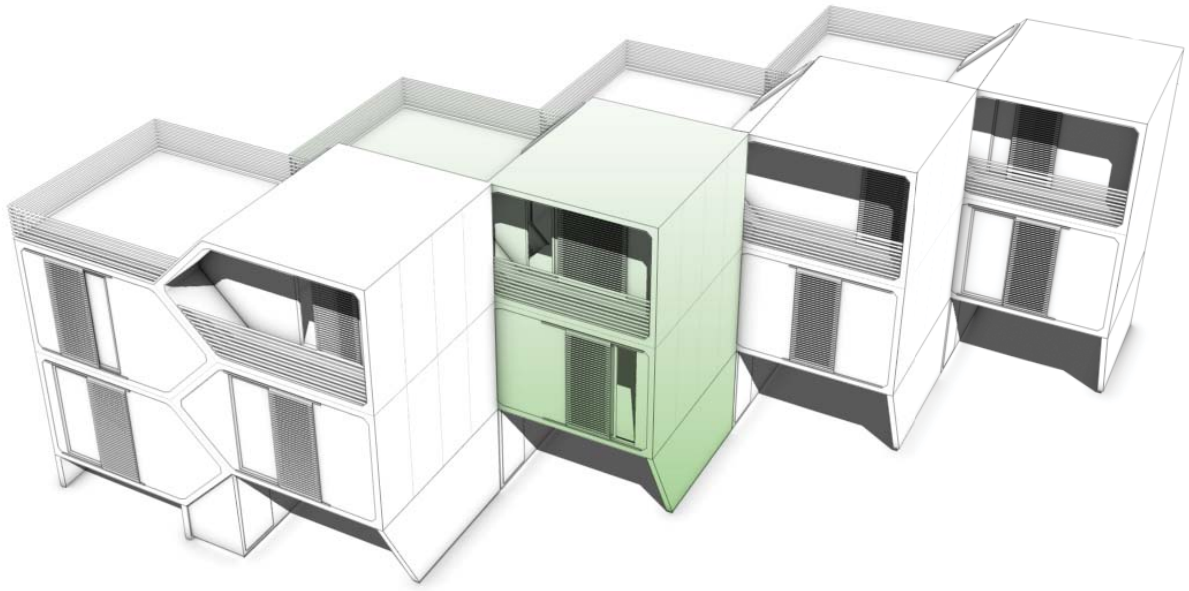
I. vertical types in single or duplex composition



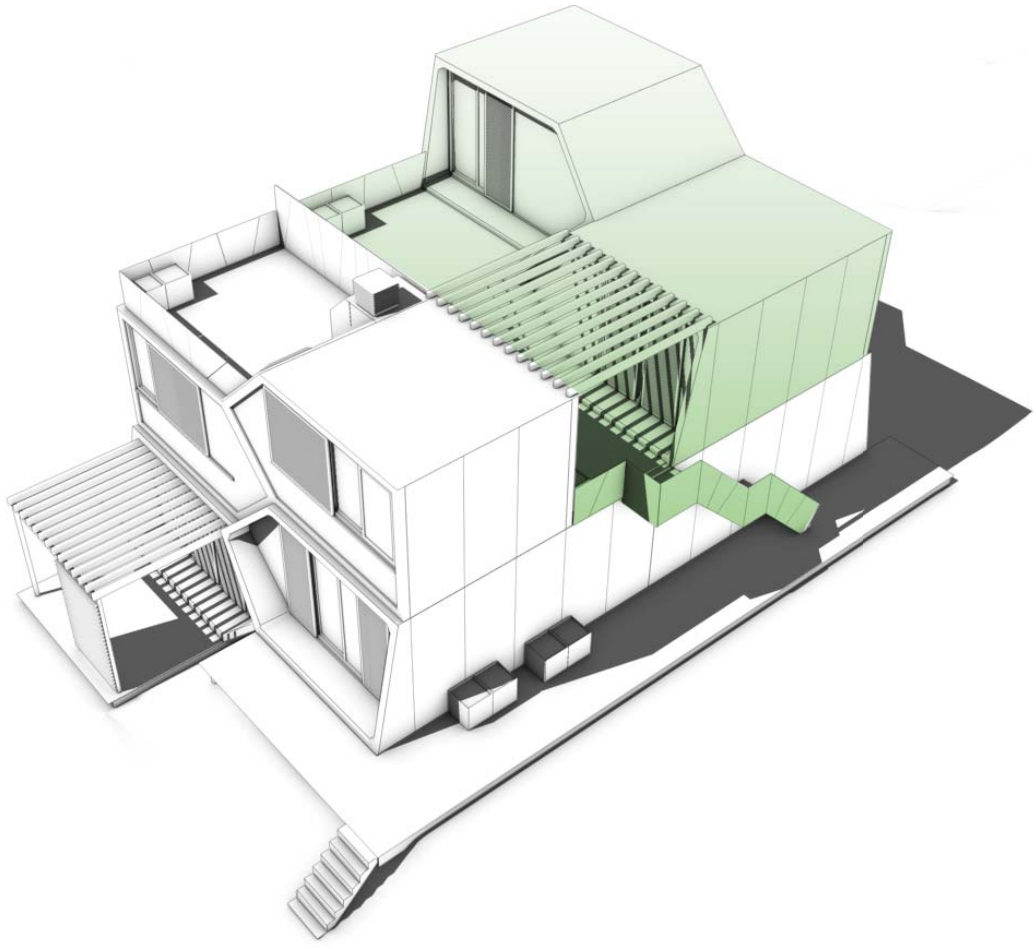
II. horizontal types in a flat grounf line composition



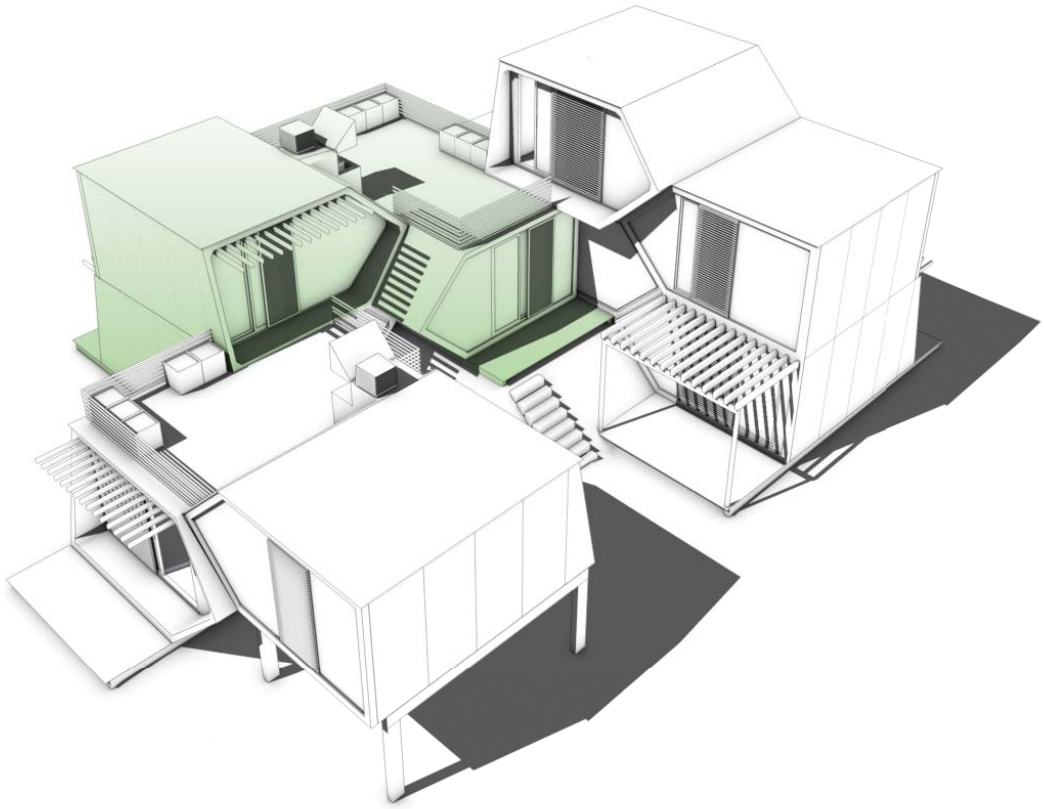
III. horizontal types in a half duplex line compositions



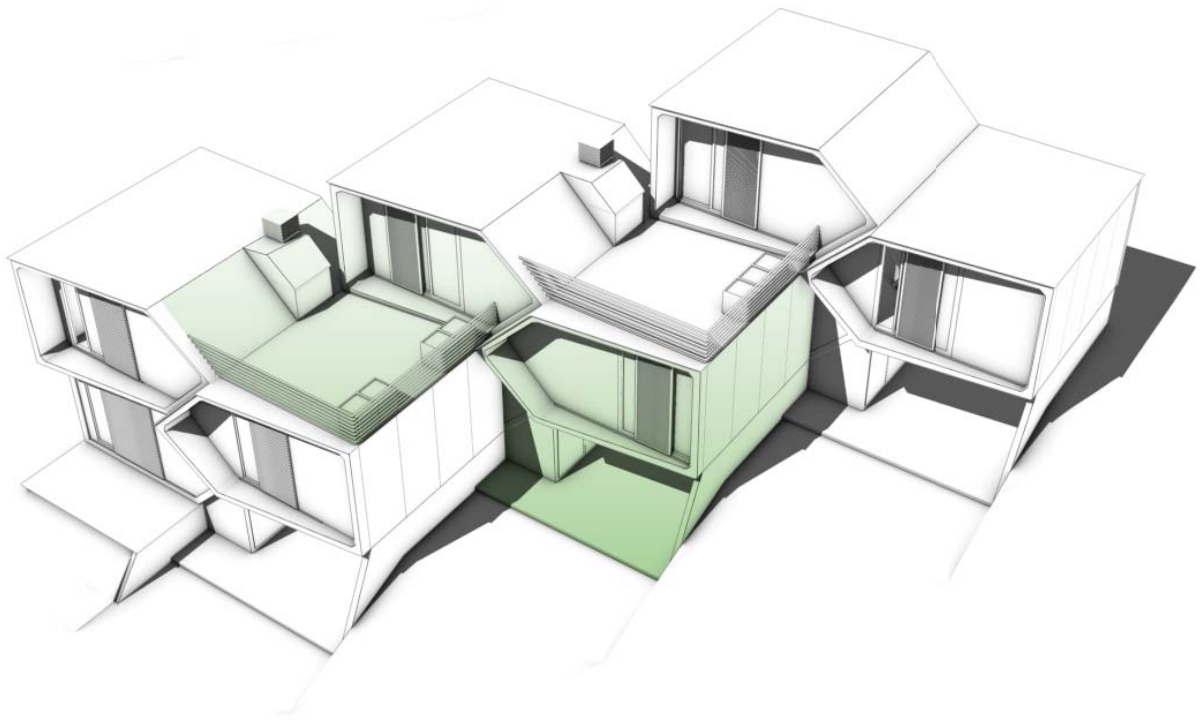
IV. horizontal types in a full duplex composition

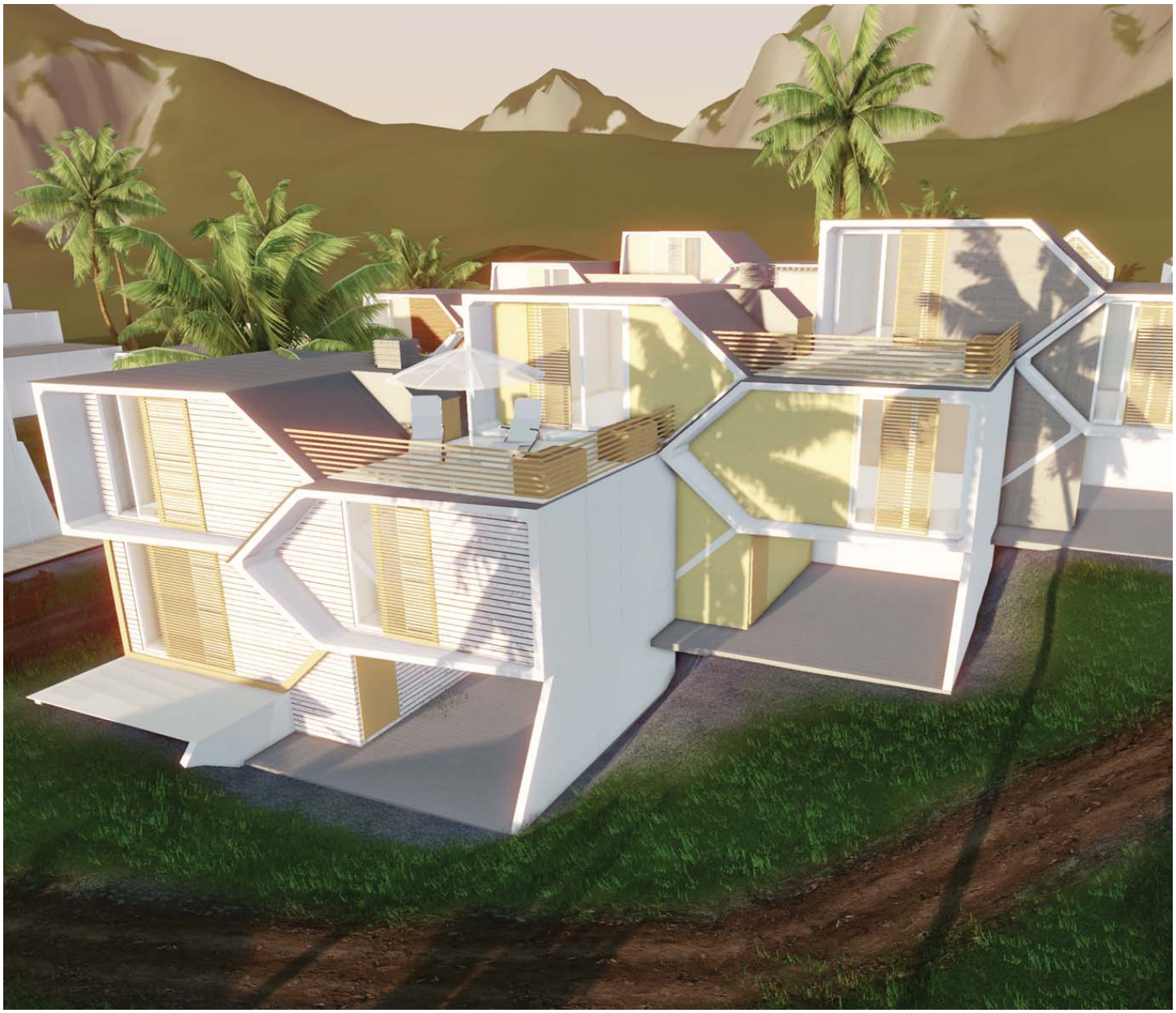


V. horizontal types composition with atrium

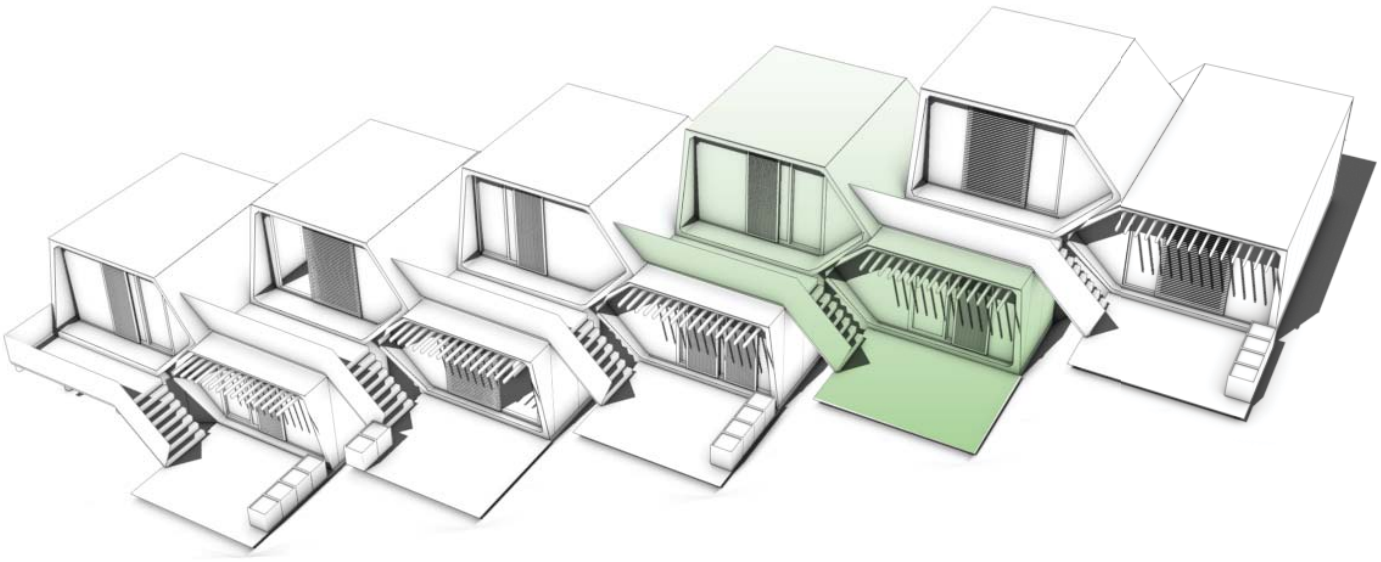


VI. horizontal types in topographically adaptive half duplex composition

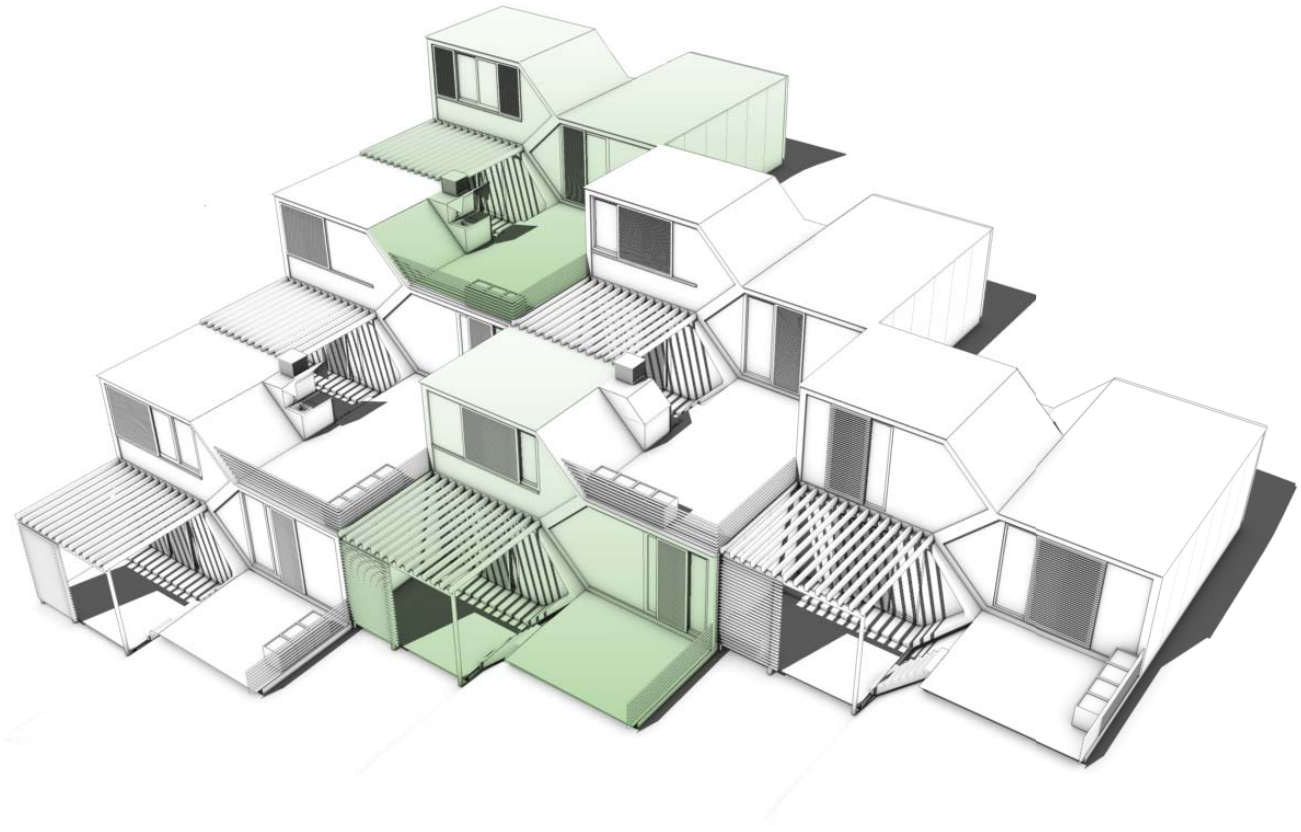




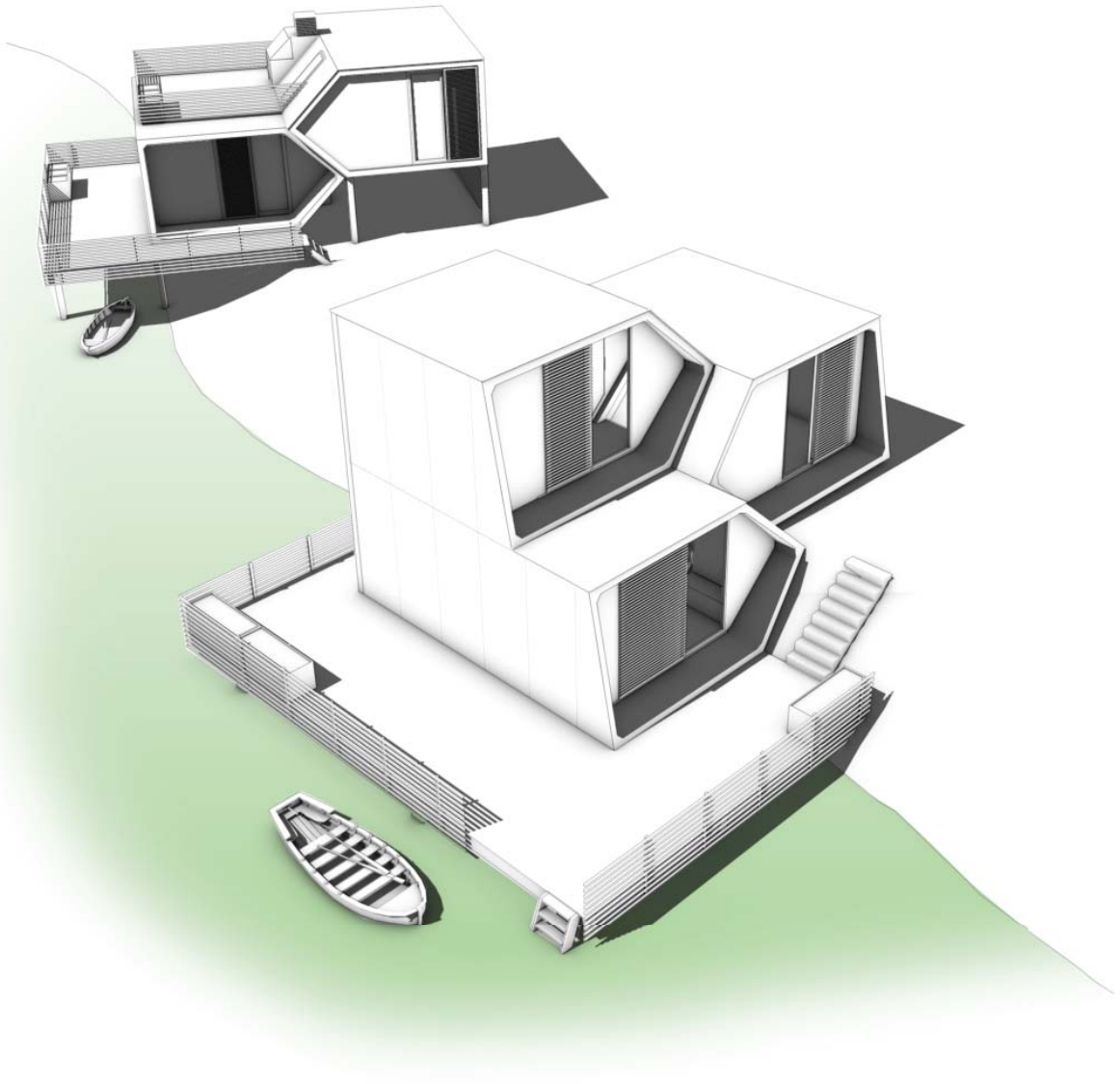
VII. horizontal types in topographically adaptive duplex composition

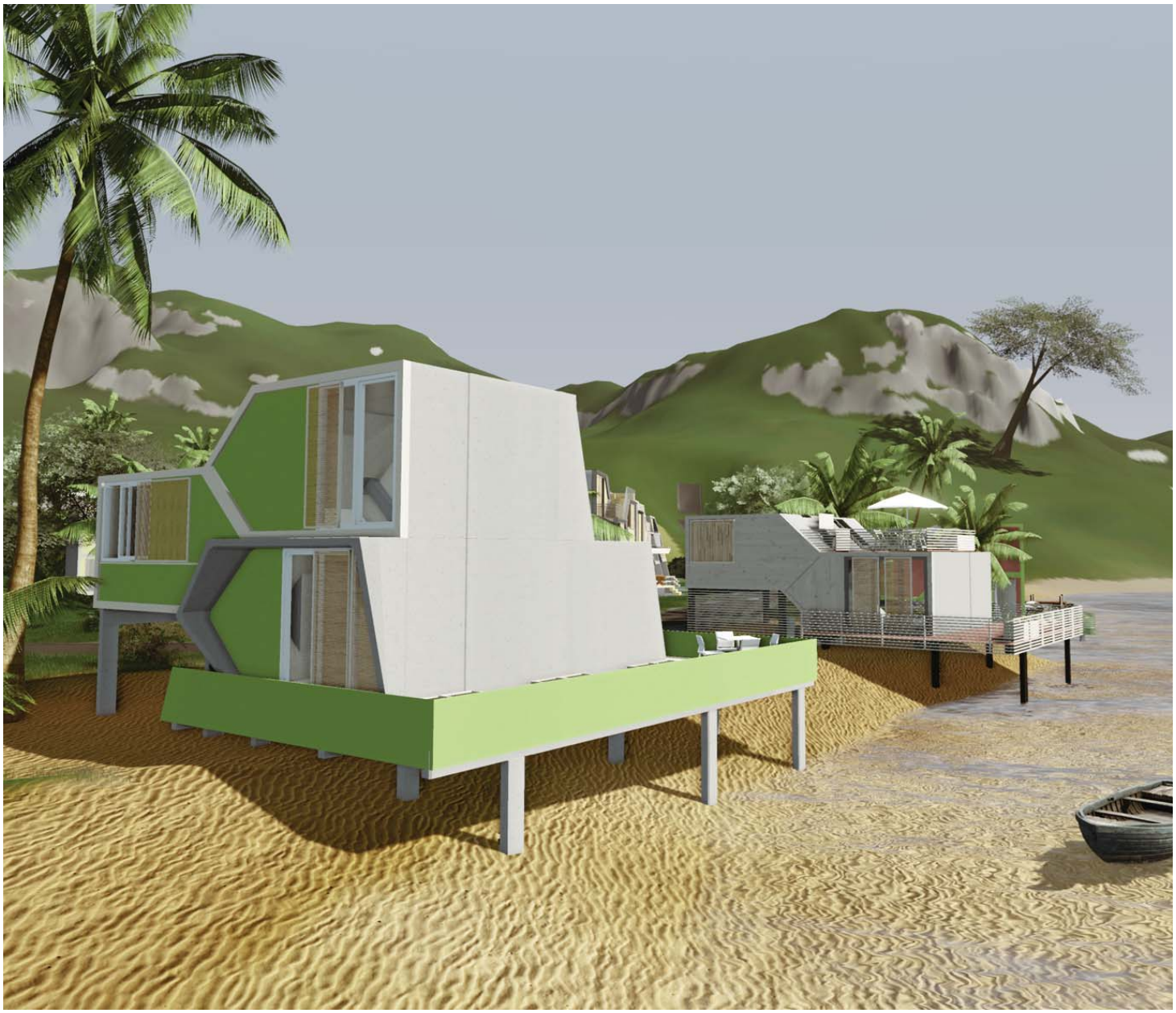


VIII. horizontal types in topographically adaptive favela composition

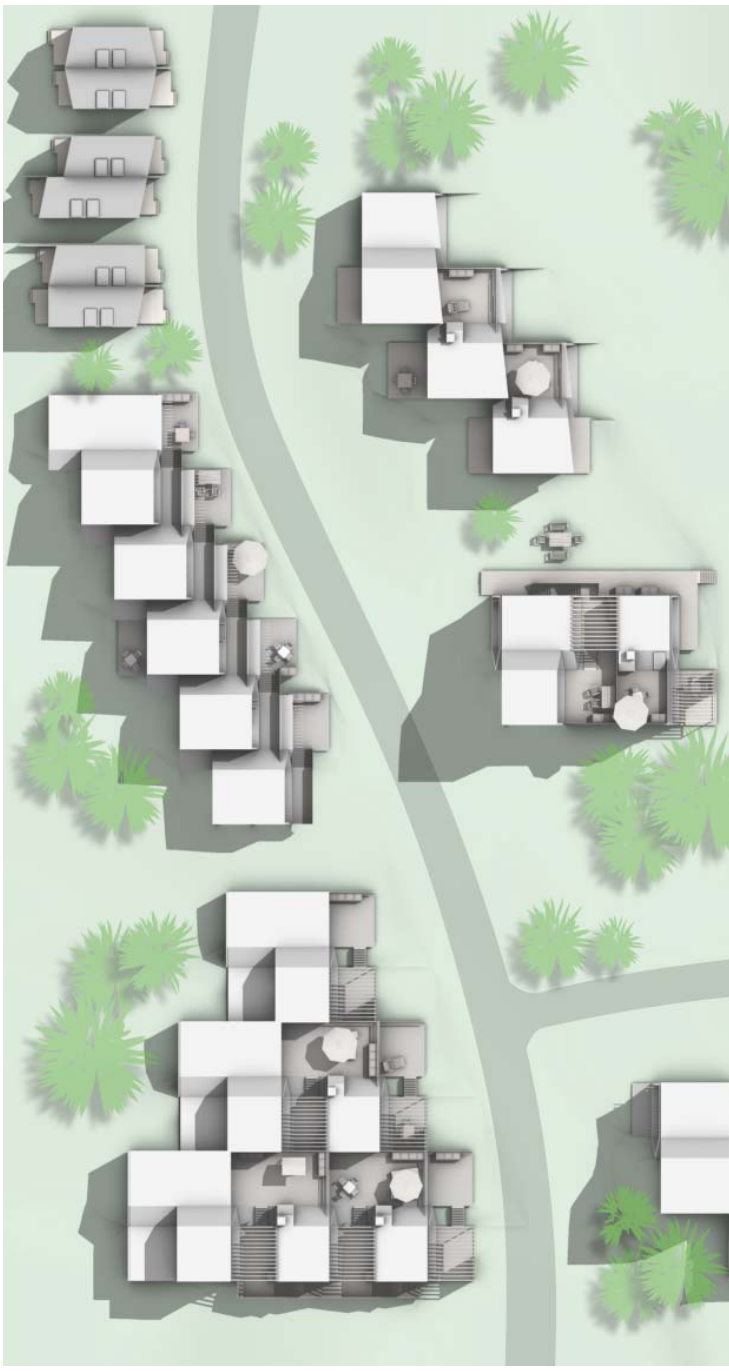


IX. horizontal types at sea or river side





site plan of some possible compositions

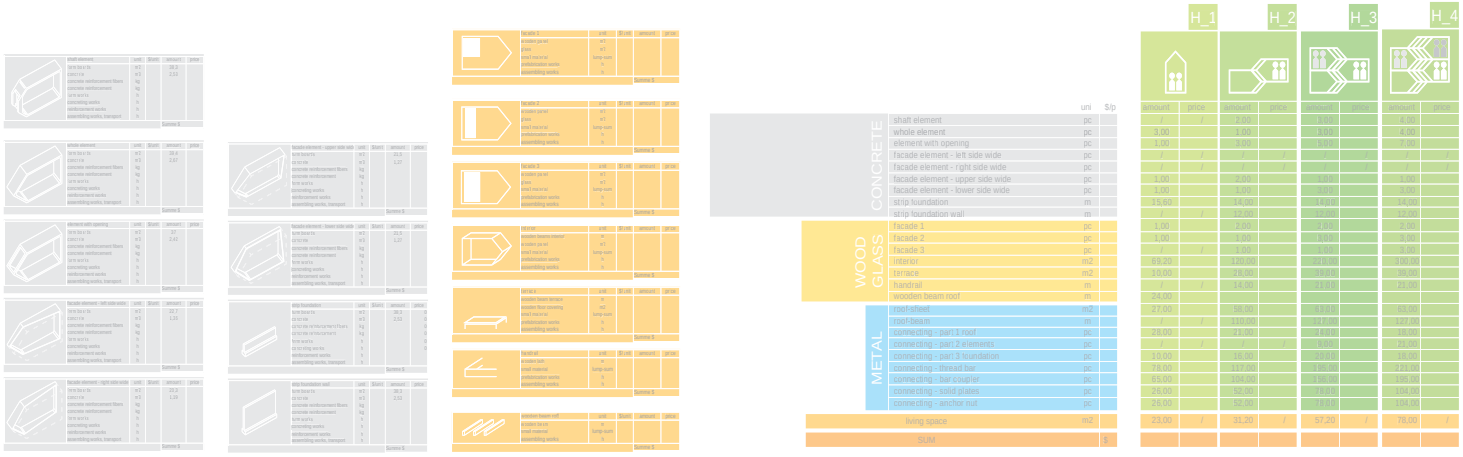



N
0
5
10
20

13. PROJECT MANAGEMENT

Each project is carried out in phases and that is why management organization is required.
According to Hans Lechner translation into naval language means the following facts:
The project leader = the captain
The project coordinators (manager) = the helmsman
The architect = first officer
Projects are companies and they run in phases. After the project start (decision on the top level) emerged by an idea, the final design plans come out after a long, iterative planning process.
In the phase of the project development targets, that are to be achieved, have to be set.
The project development of the entire project includes preparation and the setting the project procedure.
For the final implementation the quantities and qualities as well as schedule and cost frame is to be set.
In this purpose in this chapter our basic solution approach is presented.

13.1 project management - quantity and costs



The cost management is often the sensible part of a project and requires at all times transparent representation of the overall costs.
As a basis for determining the quantity and a possible cost estimation for this project here are lists the parts of each module.
With these lists the calculation can be created for the countries where these projects are to be realized.
The lists include the setting up of a particular module essentials parts, for example for the shaft element:

- form boards
- concrete
- concrete reinforcement fibers
- concrete reinforcement rods
- form works
- concreting works
- reinforcement works
- assembling works
- transport

shaft element	unit	$/unit	amount	price
form boards	m2		38,3	
concrete	m3		2,53	
concrete reinforcement fibers	kg			
concrete reinforcement	kg			
form works	h			
concreting works	h			
reinforcement works	h			
assembling works, transport	h			
			Summe $	

whole element	unit	$/unit	amount	price
form boards	m2		39,4	
concrete	m3		2,67	
concrete reinforcement fibers	kg			
concrete reinforcement	kg			
form works	h			
concreting works	h			
reinforcement works	h			
assembling works, transport	h			
			Summe $	

element with opening	unit	$/unit	amount	price
form boards	m2		37	
concrete	m3		2,42	
concrete reinforcement fibers	kg			
concrete reinforcement	kg			
form works	h			
concreting works	h			
reinforcement works	h			
assembling works, transport	h			
			Summe $	

facade element - left side wide	unit	$/unit	amount	price
form boards	m2		22,7	
concrete	m3		1,36	
concrete reinforcement fibers	kg			
concrete reinforcement	kg			
form works	h			
concreting works	h			
reinforcement works	h			
assembling works, transport	h			
			Summe $	

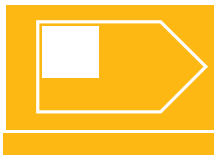
facade element - right side wide	unit	$/unit	amount	price
form boards	m2		20,3	
concrete	m3		1,19	
concrete reinforcement fibers	kg			
concrete reinforcement	kg			
form works	h			
concreting works	h			
reinforcement works	h			
assembling works, transport	h			
			Summe $	

facade element - upper side wide	unit	$/unit	amount	price
form boards	m2		21,5	
concrete	m3		1,27	
concrete reinforcement fibers	kg			
concrete reinforcement	kg			
form works	h			
concreting works	h			
reinforcement works	h			
assembling works, transport	h			
			Summe $	

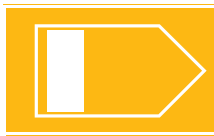
facade element - lower side wide	unit	$/unit	amount	price
form boards	m2		21,5	
concrete	m3		1,27	
concrete reinforcement fibers	kg			
concrete reinforcement	kg			
form works	h			
concreting works	h			
reinforcement works	h			
assembling works, transport	h			
			Summe $	

strip foundation	unit	$/unit	amount	price
form boards	m2		38,3	0
concrete	m3		2,53	0
concrete reinforcement fibers	kg			0
concrete reinforcement	kg			0
form works	h			0
concreting works	h			0
reinforcement works	h			
assembling works, transport	h			
			Summe $	

strip foundation wall	unit	$/unit	amount	price
form boards	m2		38,3	
concrete	m3		2,53	
concrete reinforcement fibers	kg			
concrete reinforcement	kg			
form works	h			
concreting works	h			
reinforcement works	h			
assembling works, transport	h			
			Summe $	



facade 1	unit	$/unit	amount	price
wooden panel	m2			
glass	m2			
small material	lump-sum			
prefabrication works	h			
assembling works	h			
			Summe $	



facade 2	unit	$/unit	amount	price
wooden panel	m2			
glass	m2			
small material	lump-sum			
prefabrication works	h			
assembling works	h			
			Summe $	

facade 3	unit	$/unit	amount	price
wooden panel	m2			
glass	m2			
small material	lump-sum			
prefabrication works	h			
assembling works	h			
			Summe $	

interior	unit	$/unit	amount	price
wooden beams interior	m			
wooden panel	m2			
small material	lump-sum			
prefabrication works	h			
assembling works	h			
			Summe $	

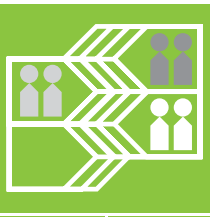
terrace	unit	$/unit	amount	price
wooden beam terrace	m			
wooden floor covering	m2			
small material	lump-sum			
prefabrication works	h			
assembling works	h			
			Summe $	

handrail	unit	$/unit	amount	price
wooden lath	m			
small material	lump-sum			
prefabrication works	h			
assembling works	h			
			Summe $	

wooden beam roff	unit	$/unit	amount	price
wooden beam	m			
small material	lump-sum			
assembling works	h			
			Summe $	

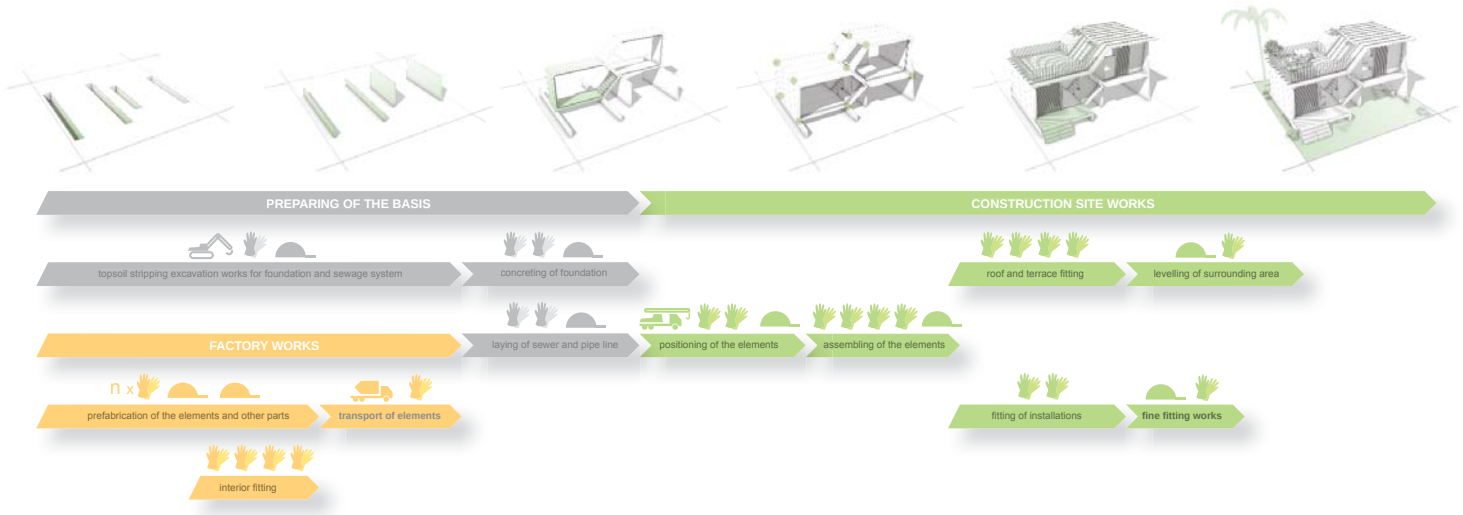
estimated material quantitiy kalkulation table
for the concrete, facade and interior

		uni	$/p
CONCRETE	shaft element	pc	
	whole element	pc	
	element with opening	pc	
	facade element - left side wide	pc	
	facade element - right side wide	pc	
	facade element - upper side wide	pc	
	facade element - lower side wide	pc	
	strip foundation	m	
	strip foundation wall	m	
WOOD GLASS	facade 1	pc	
	facade 2	pc	
	facade 3	pc	
	interior	m2	
	terrace	m2	
	handrail	m	
	wooden beam roof	m	
METAL	roof-sheet	m2	
	roof-beam	m	
	connecting - part 1 roof	pc	
	connecting - part 2 elements	pc	
	connecting - part 3 foundation	pc	
	connecting - thread bar	pc	
	connecting - bar coupler	pc	
	connecting - solid plates	pc	
	connecting - anchor nut	pc	
	living space	m2	
	SUM		$

H_1		H_2		H_3		H_4	
							
amount	price	amount	price	amount	price	amount	price
/	/	2,00		3,00		4,00	
3,00		1,00		3,00		4,00	
1,00		3,00		5,00		7,00	
/	/	/	/	/	/	/	/
/	/	/	/	/	/	/	/
1,00		2,00		1,00		1,00	
1,00		1,00		3,00		3,00	
15,60		14,00		14,00		14,00	
/	/	12,00		12,00		12,00	
1,00		2,00		2,00		2,00	
1,00		1,00		3,00		3,00	
/	/	1,00		1,00		3,00	
69,20		120,00		220,00		300,00	
10,00		28,00		39,00		39,00	
/	/	14,00		21,00		21,00	
24,00							
27,00		58,00		63,00		63,00	
/	/	110,00		127,00		127,00	
28,00		21,00		24,00		18,00	
/	/	/	/	9,00		21,00	
10,00		16,00		20,00		18,00	
78,00		117,00		195,00		221,00	
65,00		104,00		156,00		195,00	
26,00		52,00		78,00		104,00	
26,00		52,00		78,00		104,00	
23,00	/	31,20	/	57,20	/	78,00	/

estimated material quantitiy kalkulation table for basic house types

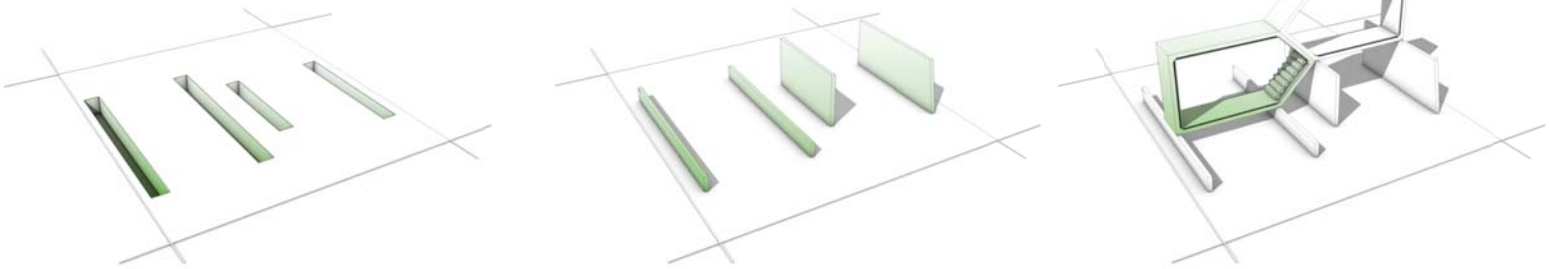
13.2 project management - organization scheme for the construction



Designed on the world-wide use of standardized modules and assuming the planned application areas mainly untrained personnel to that comes into use, is developed in an easily understood visual language of the establishment of process scheme.

Represented here are on site-construction phases from the foundation to completion with the appropriate equipment necessary. The gloves represent the unskilled construction workers (1gloves = 10 workers).

The detailed work instructions in the organization manual (OM) is to be provid from project leaders and engineers on site, illustrated here with the image of the protective helmet, and serve to quality assurance in production and realization.



PREPARING OF THE BASIS

topsoil stripping excavation works for foundation and sewage system

concreting of foundation

FACTORY WORKS

laying of sewer and pipe line

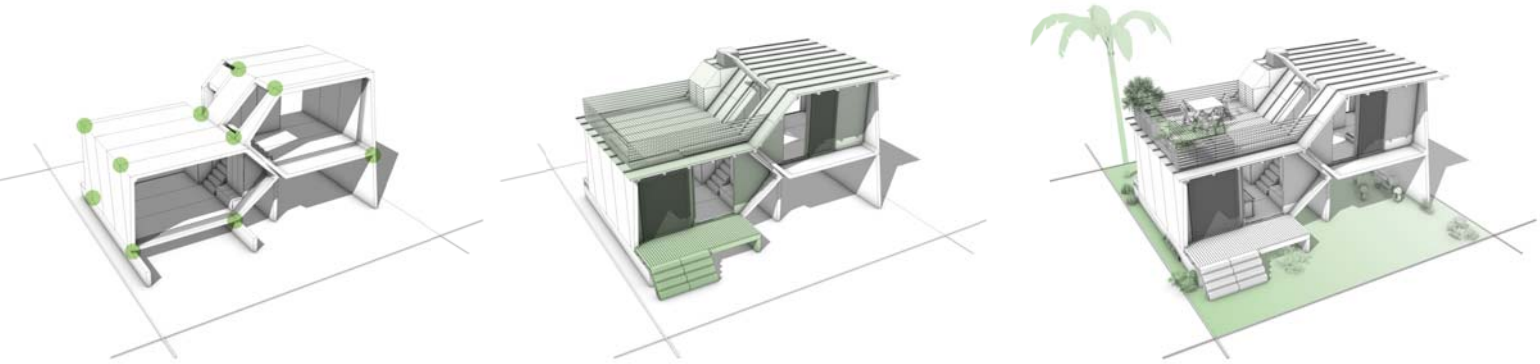
positioning of the

n x

prefabrication of the elements and other parts

transport of elements

interior fitting



CONSTRUCTION SITE WORKS

roof and terrace fitting

levelling of surrounding area

elements

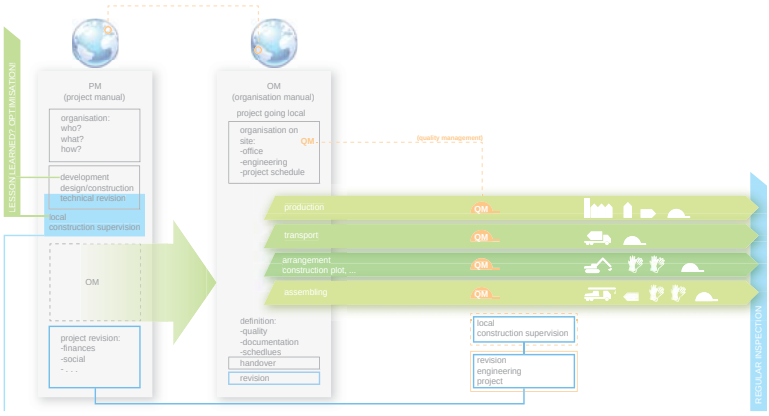
assembling of the elements

fitting of installations

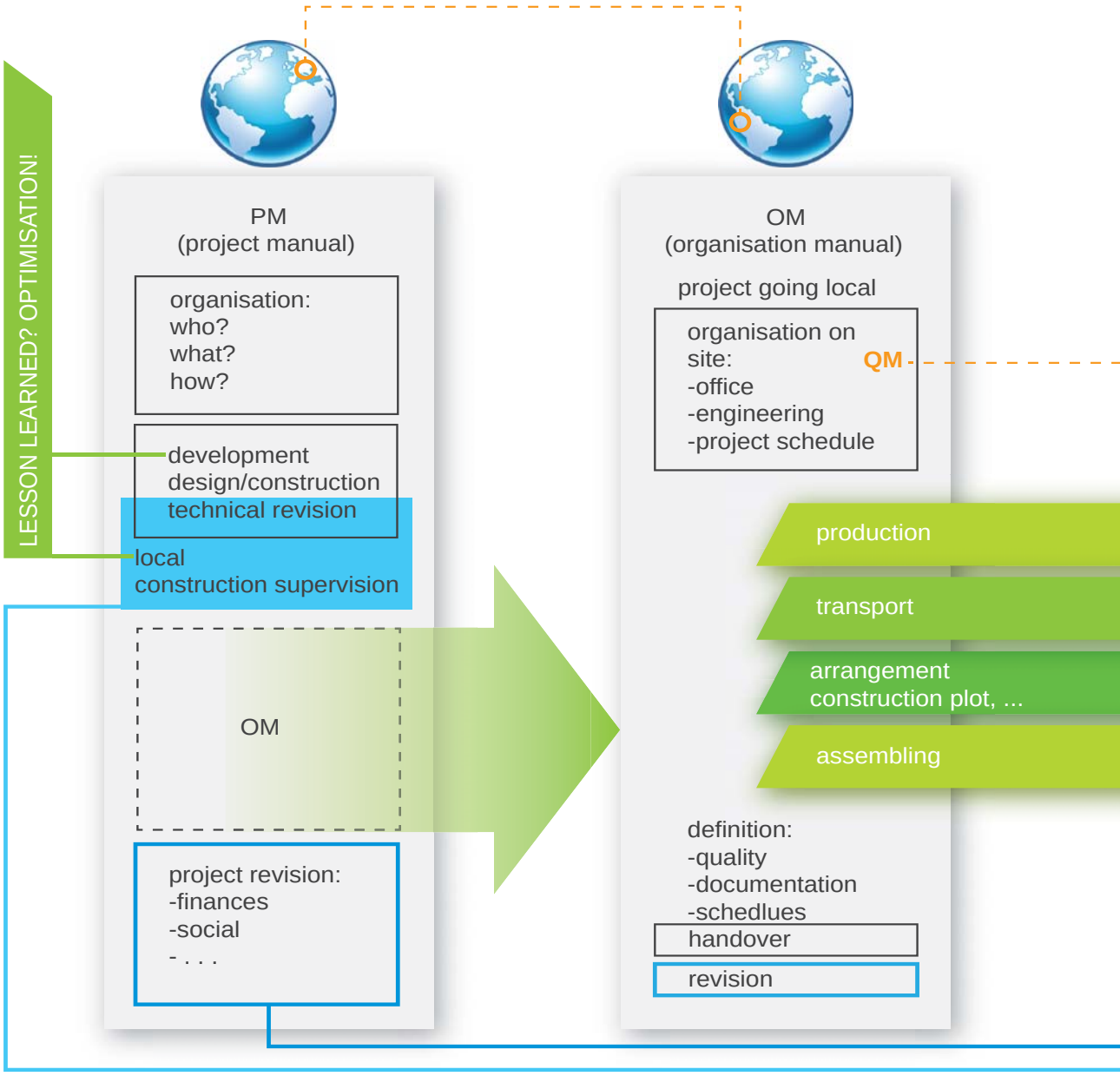
fine fitting works

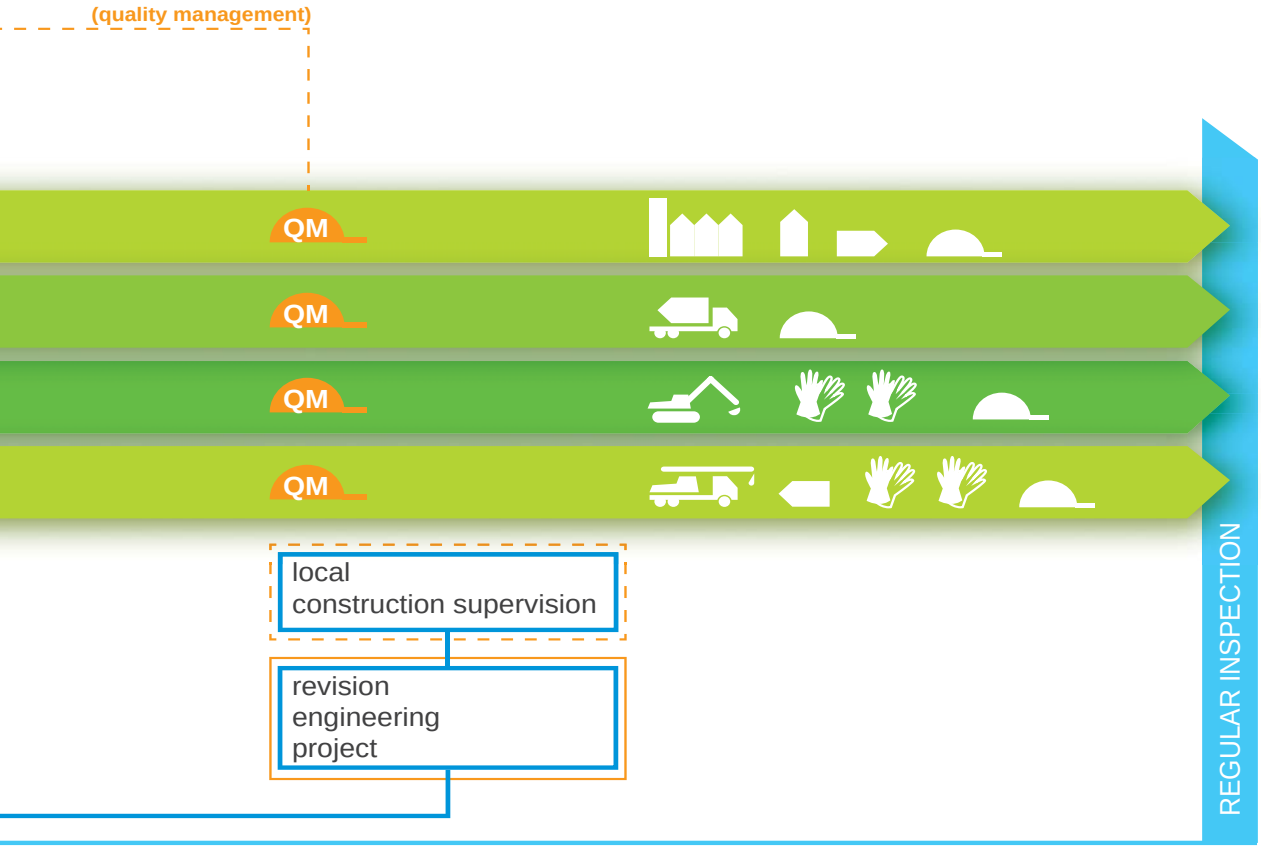
constructions processes scheme

13.3 project management - international procedure



As navigation of projects are serving organizing and construction process schedules.
A possible scheme for this international project is shown on the next page.
A project manual regulates the procedures and responsibilities and there anchored organization manual governs the procedure of the individual projects in the areas of application.
This organization manual includes, among other things, the precise definitions of quantities and qualities of the product and quality management
To the execution of quality control on-site there still comes a superior feedback loop that directly influence the improvement and development of the product. The conection to improvement serves as a feedback instrument.
A regulated-loop procedure for project control (secondary control project) inspection ensures that resources and the use of international fundings are properly being used.


LESSON LEARNED? OPTIMISATION!
PM
(project manual)
organisation:
who?
what?
how?
development
design/construction
technical revision
local
construction supervision
OM
project revision:
-finances
-social
- . . .
OM
(organisation manual)
project going local
organisation on
site:
-office
-engineering
-project schedule
QM
production
transport
arrangement
construction plot, ...
assembling
definition:
-quality
-documentation
-schedlues
handover
revision


(quality management)
QM
QM
QM
QM
local
construction supervision
revision
engineering
project
REGULAR INSPECTION

13.4 project development - tourism

Since these modular structure is suitable for the construction of holiday resorts, arose the idea of generating an opportunity for the promotion of international aid project “Housing for People”.

With every night spent in such “resort” another aid project will be supported and invaluable publicity and support for this project is gained.

Only one example of many possibilities - a holiday village in the Alps has a partner village in Vietnam.

13.5 project development - excursion

VIETNAM

Capital:	Hanoi
Largest city	Ho Chi Minh City
Area	331,210 km2
Population	91,519,289

To test the feasibility of our ideas, we found the way to travel to Vietnam.

On-site and under the impression of local conditions, the technical and construction physical conditions were explored, solutions being considered and the project further developed.

Recognizing the limitations of the construction (assembly) on-site had a major impact on the overall concept what also brought us to the idea of representation of the construction processes in a simple and understandable form.

"...AND SO EVERYBODY HAS A TASK IN HIS LIFE."

sources

969798 Bauen mit System
3 JAhre Experiment und Realität
Peter Schreibmayer
Johann Grabner

Minimal space - minimal housing
Peter Schreibmayer
Johann Grabner

Architektur Fabrik
Peter Schreibmayer

One2one
Minimal space - minimal housing
Peter Schreibmayer

Energie Atlas
Nachhaltige Architektur
Hegger
Fuchs
Stark
Zeumer

Lecture notes project management
Prof. Hans-Lechner
at the Faculty of Civil engineering science, TU Graz

bibliography

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Anita Aigner

Wohnen in der Stadt
Liesbeth Waechter-Böhm

Planning and design of low-cost housing in India
Tina Rugelj
Architektur des 20. Jahrhunderts
Gabrielel Leuthäiser
Peter Gössel

3i-isolet Leichtbeton-Systembau
Eva Maria Traschler

Innovations in concrete
David Bennett

The art of precast concrete
David Bennett

Sustainable concrete architecture
David Bennett

Architectural insitu concrete
David Bennett

Baustoff Beton
Martin Peck

Kosten von energetischen Baumaßnahmen
Reinhard Steyer

Wohnhäuser - individuell und kostengünstig
Dieter Boeminghaus

Next Nature
Koert van Mensvoort
Hendrik-Jan Grievink

list of figures

All figures that are not listed are either our own or were selfmade.

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