DESIGN ECOLOGY

KEY ASPECTS OF DESIGN, STRUCTURE AND MATERIALS
RELATED WITH THE SELF-SUFFICIENT BUILDINGS

HIGHER SCHOOL OF ECONOMICS

Graduate School of Urbanism

shukhov lab

KEY ASPECTS OF DESIGN, STRUCTURE AND MATERIALS RELATED WITH THE SELF-SUFFICIENT BUILDINGS

MASTER PROTOTYPING FUTURE CITIES

GRADUATE SCHOOL OF URBANISM,
NATIONAL RESEARCH UNIVERSITY HIGHER SCHOOL OF ECONOMICS

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IAAC ENDESA
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This work is aimed to develop principles of self-sufficient development on the territory of Moscow.
Self-sufficient or autonomous building is the building, whose production and operation are independent of urban infrastructure networks, such as electric grid, plumbing and so on. The life cycle of such buildings is associated with a lower level of consumption of resources and the preservation of heat in the building. Otherwise, infrastructure, used in such projects is aimed to produce extra resources to use electric grids in opposite direction.

Any geographical location has its own specific features, so to create the principles of self-sufficient development in Moscow, the environment and the building were examined in different layers:

- Urban Design
- Design Ecology
- Housing typology
- Building facade
- Wood Structure and Building materials
- Parametric design

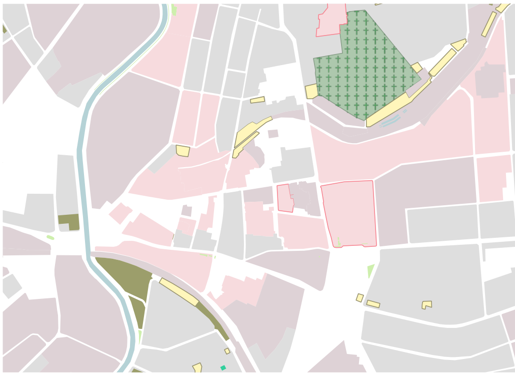
Research of each layer allows to take into account all aspects of building production from preparation of materials to creating efficient system. Urban environment, availability of materials, ecological aspects, including noise pollution and wind impact create framework, where suitable typology and multifunctional facade apply. Building shape is proven by methodology, developed in parametric design section. In this work, attention was also paid to the implementation of the zero mile strategy, which will allow to produce construction components in the immediate vicinity of the construction site, which reduces transportation costs and reduces emissions to the atmosphere.

URBANITY

INTRODUCTION

Urban context is a set of parameters, often physical, for which a certain territory can be classified within the chosen typology. The importance of context is expressed in the philosophy of the new urbanism, where the environment has an important role in determining the functional purpose and the choice of the appearance of the building. In the modernist school, however, the definition of typology does not play such an important role in the creation of the project, although they are enshrined in the idea of zoning of the city's territories according to the functional purpose of the buildings located there. Moscow is filled with various functions that vary from district to district, industrial zones alternate with residential areas, and high-rise buildings adjoin historical low buildings. However, the stage-by-stage development during the 20th century, with pronounced approaches, makes it possible to unify the territory into belts, each with its own function and planning ideas.

URBAN DESIGN



The creation of a residential building on the territory of Moscow is closely connected with the environment, which affects the size, shape and method of erection. Typologizing Moscow, it is possible to distinguish a residential zone, industrial, mixed, as well as recreational and abandoned zones. Within the analysis of residential areas, the following were taken into account:

Figure 1.
Fragment of Moscow's zoning plan.

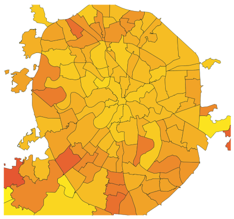


Figure 2.
Height map, 2018.

Analysis of building height - the average height rises from the center to the periphery, which is interconnected with the inter-house distance, which creates a more sparse environment on the outskirts with separately-standing buildings than in the central areas with a visible street front.

The period of development - most of the buildings in Moscow was built during the reign of Khrushchev, when the problem of resettlement of barracks and communal apartments was solving, thus the huge spaces of the city were built up with typical solutions presented in the mid-fifties of the last century.

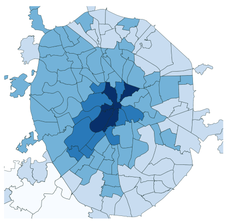


Figure 3.
Renovation map, 2018.

The renovation program is a reaction to the state of the housing stock, which was created in the middle of the last century and is considered morally obsolete, on the renovation map it is clear which areas are more affected by the launching program.

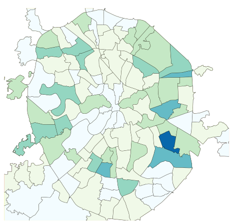


Figure 4.
Cost map, 2018.

The economic factor is an unphysical factor that expresses the residents' demand for real estate in one or another part of Moscow, partly dictated by the desire to live closer to the center in order to reduce commute, partly dictated by the established opinion about the ecological purity of the western regions associated with the location of the dirty production in the southeast of city and a rose of winds, with prevailing western winds.

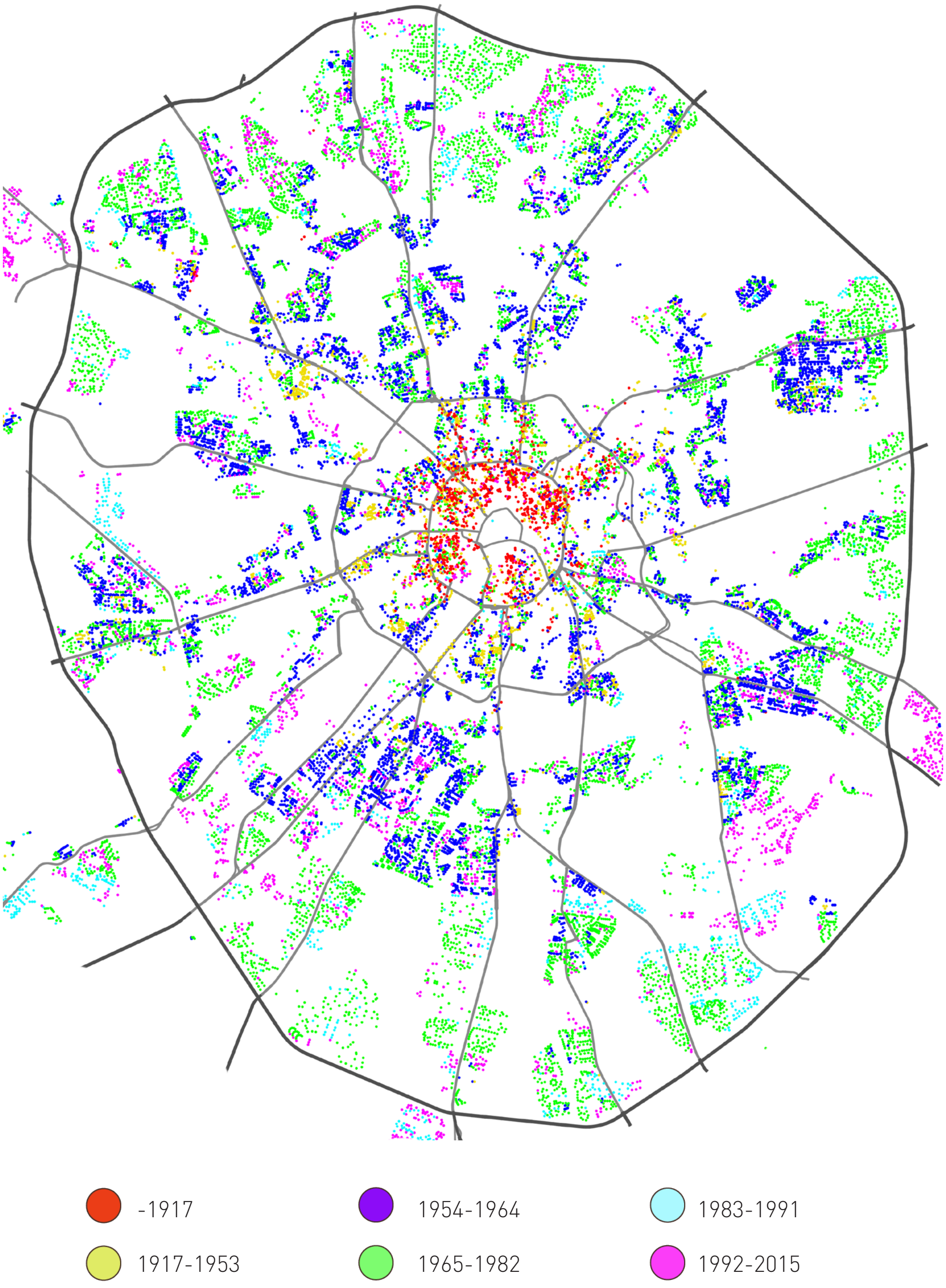


Figure 5.
Historical map.

In addition to residential areas, industrial zones were also considered, which can be conditionally divided into 2 types - industrial zones and brownfields.

Industrial zones - during the analysis of industrial zones, there were allocated functioning plots in the city, which do not always perform the function of production, but there may be garages, warehouses, car-care centers, etc. Their territories are often impassable, the physical and legal structure of such places remains unclear.

Brownfields are zones different from industrial ones in that their status is approved by the city authorities. The existing structure is also not clear, some of them continue to function, some are turned into landfills, but the existing government is deploying a revitalization program for 18,000 hectares.

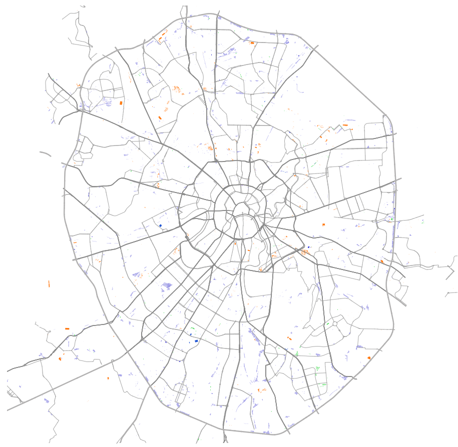


Figure 6. (left)
Industrial zones map.

Figure 7. (right)
Brownfields map.

CYCLE IMPLEMENTATION

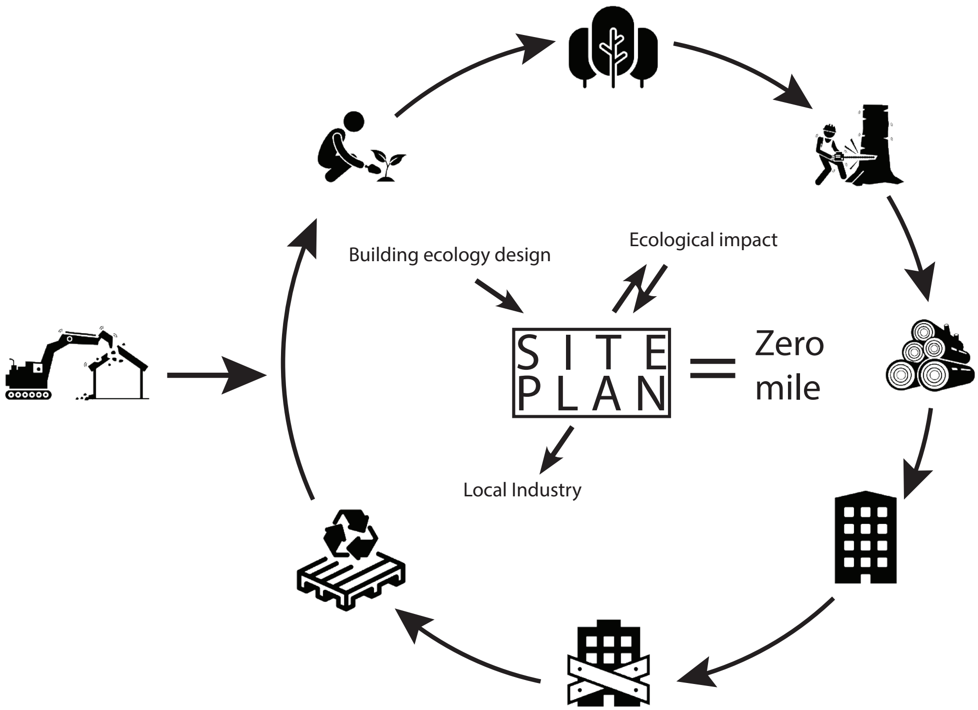


Figure 8.
Cycle implementation scheme.

The process of creating self sufficient buildings can be divided into its operation and the production process. And if the principles of self-sufficiency are considered in the following sections, the process of building production takes place in an urban environment.
The task is to reduce the impact on the environment in the process of creating a new building on the site in Moscow.
Transforming of 18800 Hectars of brownfields into forest framework in next decades will give 1,23*18800=23000 cubic meters of wooden material annualy. Distribution of brownfields around Moscow allows to create Zero km program of urban development, where construction parts are growing and assembled very close to the site.
Urban block for 1000 people requires about 8000 cubic meters of timber for construction, it means that anually, this wooden framework can produce timber for 3 such blocks.

LOCAL MANUFACTURING

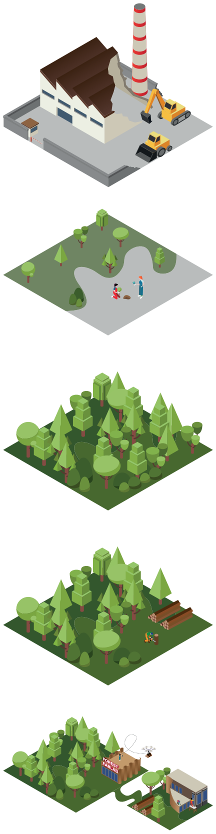


Figure 9-13.
Stages of implementation cycle.

The design of a self-sufficient building should be associated with the local production of resources necessary to reduce the environmental load during the transportation of building structures. Due to intensive industrial development, large industrial clusters located in the immediate vicinity of the center were formed in Moscow. Abandoned territories can be used to create a green framework, where forest is growing, collecting and processing on the territory of several hundred hectares. Also manufactures and fablabs can be located there for producing prefabricated constructions.

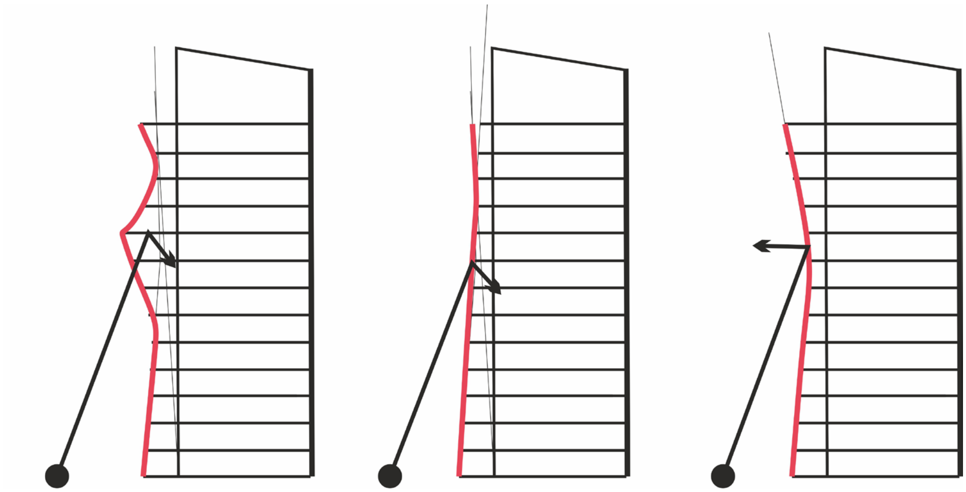
The advantage of such an idea is the replacement of a linear process by a cycle. With the existing model, previously components are mined in quarries or other forms of the deposit, transported to the plant for the production of reinforced concrete, where the finished structures are transported to the construction site. With this model, a large part of the costs goes to transportation, and a building constructed of concrete is a polluting atmosphere at all stages, from the extraction of components to the demolition of the building.

The introduction of the same cycle can significantly reduce transportation costs, using the principle of Zero mile, which in the context of the construction of the building means the transition from the concrete structure to the wooden ones. The launch of the cycle consists of the demolition of existing workshops and the planting of forests in these areas. Over time, the forest will allow harvesting up to 1.23 cubic meters of wood per hectare or about 20,000 cubic meters per year from the territory of Moscow, not including the region. In the process of tree growth, they intensively consume carbon dioxide from the atmosphere, thereby improving the ecological situation in Moscow. Much more slowly the wood does it as a part of the structures, however there is the process of carbon consuming, rather than it's production. Growing timber for industrial purposes will positively affect the creation of jobs, training new personnel, as well as the development of the production of wooden structures.

Figure 14.
Demonstration of an integrated cycle

BUILDING ECOLOGY

INTRODUCTION



How to create energy-efficient building in Moscow taking into account wind direction, climate changes, solar energy from particular side of urban area, underground conditions, moisture level, noise level in particulat area, natural landscape conditions, rainwater amount, etc.

taking into account Moscow region natural resources features as well

using active and passive energy-efficient technologies

The ecological challenges in the rapidly developing world have been reaching critical levels. Sustainable development requires more transformative changes and solutions of the future problems. The major driving forces are the continuous population growth and changes in economy of region, which requires more water for more people, as well as for new cultural, economic, industrial and other activities (Bourouni and Chaibi, 2007).

The Design ecology is overall strategy to integrate the metabolic, social and environmental requirements. It is related to sustainable development concept with empahasis on distribution of natural resources, close relationship between people and their environment. On the other hand, this is connected with the architectural topology concept as a method of spatial-ecological formation.

Thus, the basic concepts related to design ecology strategy will be considered in this work, then they will be analyzed in relation to Russia and, in particular, to Moscow. It is necessary to take into account wind direction, climate changes, solar energy from particular side of urban area, underground conditions, moisture level, noise level in particulat area, natural landscape conditions, rainwater amount, etc. Thus, to provide solutions for energy-efficient block in Moscow region focused natural resources features (for example, wood) as well.

INTRODUCTION | CONTENT

The Design ecology is overall strategy to integrate the metabolic, social and environmental requirements. It is related to sustainable development concept with empahasis on distribution of natural resources, close relationship between people and their environment. On the other hand, this is connected with the architectural topology concept as a method of spatial-ecological formation. Thus, sustainable development is most common concept, urban metabolism is related to techological communication processes in buildings, architectural topology is method of ecological-spactial form making, ecological design inclused both aspects in relatoin to particular building.

Climate-responsive design are evident in indigenous and traditional architecture throughout the world. Bioclimatic design has developed out of a sensitivity to ecological and regional contexts and the need to conserve energy and environmental resources. Bioclimatic approaches to architecture offer a way to design for long term and sustainable use of environmental and material resources.

Metabolistic approach in architecture fuses the architectural structure and the concept of biological growth into one. It is a framework for modeling complex urban systems' flows – water, energy, food, people, etc.

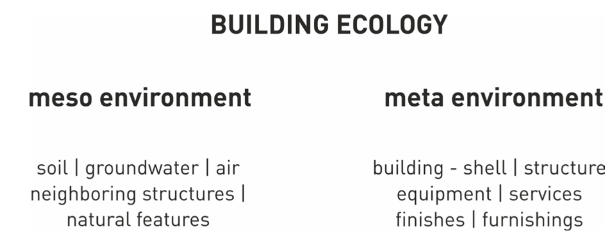


Figure 16 .
Environment components scheme.

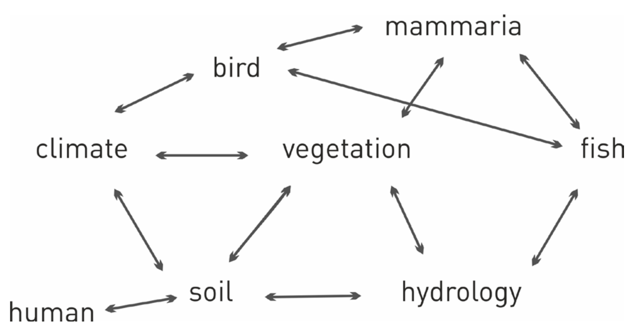


Figure 17.
Ecology components scheme.

Building ecology related to:

- "meso environment" is the environment in which the building is located. It includes the soil, groundwater, air, and neighboring structures and natural features

- "meta environment" is the building itself. It includes the building shell or envelope, the structure, equipment, services, finishes, and furnishings.

According this, two aspects of building ecology will be considered - urban environment (meso) and buiding design inself (meta).

Air quality | wind rose

The wind from the north-west in July, south-west wind - in January in Moscow.

Due to the wind pattern, flow direction of the Moskva River, northwestern and southwestern districts of Moscow are considered to be more ecologically favorable areas. On the contrary, the east and southeast Moscow are ecologically unfavourable, which is aggravated by the concentration of production industries and constantly congested traffic in this part of the city.

Water quality

The water quality has been measured by the comparative analysis of each housing groups in all Moscow areas. The water is better in places with the largest Moscow's westewater treatment stations (Lubertskaya and Kuryanovskaya).

Forests and nature conservation areas

As per space requirements for a 1000 block residence if considered to be constructed solely of wood as the building material, it would require approximately 8300 cubic metre of wood in volume. This data can have a significant impact on the environment if this wood was to be obtained from the forest.

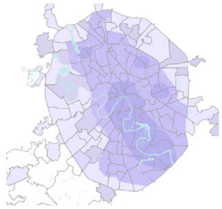


Figure 18.
Wind map of Moscow.

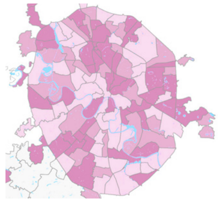


Figure 19.
Water quality map of Moscow.

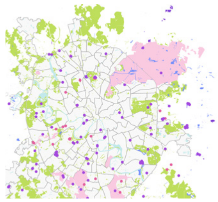


Figure 20.
Forest map of Moscow.

DESIGN STRATEGY

Noise level

noise protection

Activities to reduce and suppress noise in the complex:

- a complex layout of the complex, where the noise "fades"

- green spaces

- temporary prefabricated - dismantled lattice and tent structures, fences.

Measures to reduce and suppress noise in the building:

- plan arrangment

- the use of sound-insulating and sound-absorbing materials and structures

- screens and the acoustic center of the noise source.

Wind direction

streamline shape

If the building is above 40 m, the dynamic component of the wind load is taken into account. Thanks to a streamlined form and engineering genius, the wind accelerates from the bottom up and with great force, passes through the "upper energy beacon".

wind turbines

Should be arranged on the top of the building in the area of the highest wind flows. The funnel crowning the top of the building is specially designed for the greatest accumulation of wind energy and its transformation into electricity. Thanks to this power plant, the building is able to provide electricity, 25% of the required.

Water

water protection

Water protection zones are the territories adjacent to the shoreline (boundaries of the water body) of the seas, rivers, streams, canals, lakes, reservoirs and on which a special regime of economic and other activities is established to prevent pollution, contamination, siltation of these water bodies and depletion their waters, as well as the conservation of the habitat of aquatic biological resources and other objects of the animal and plant world.

The width of the water protection zone of the rivers is up to 10 kilometers - 50 meters.

zero waste water cycle

Black wastewater (51 thous.lit.) can be compensated by grey water from crane and shower (44 thous.lit.) and precipitation. The least amount is on March - 7.7 thous.lit., i.e it covers wastewater. Exceed precipitation (0.35 thous.-7.8 thous.lit.) can be used for irrigation or washing.

water collecton

Shower's hot water allows melting snow - being stored this freshwater can be used for irrigation green roof and food production in summer.

The building can also include a system of internal and external watershed precipitation, from where rainwater or melted snow enters the collector.

Moisture collection panels can be oriented on the river according to wind direction as well.

Climate

Design in the cold climate

Energy-efficiency of block form, composition based on energy saving, wind assessment, solar energy, etc.

Use of land energy. underground spaces

Active and passive technologies

Multi-layers construction solutions | Design with wide insulation and 2-3 glass windows

Building composition with protected areas

Snow melting

Shower's hot water allows melting snow being stored this freshwater can be used for landscape irrigation outside in summer.

The average annual snow reserves in recent years are about 2.3 thousand km³. In the winter period 2017-2018 more than 14.4 million m3 of snow mass were recycled at snow melting stations. As a thawed water it comes to sewage treatment facilities for disinfection before descent into water receivers.

Solar energy

Solar panel

Production of energy, energy consumption reduction

maxumum orientation to the south

The most efficient way of light capturing

bevels of the rood and glass upper farms

More light for light-loving plants and food production

Landscape natural habitat existence

Glazed winter gardens

Building a glazed winter garden can maintain a pleasant temperature and this glass building can maintain the thermal mass within it using residual distinct heat from the flats. It could serve new common meeting point for the block that would be created for local residents and allowing them to afford new recreational opportunities.

Green rood

Influence on climatic conditions in building and fuctioning as food prduction place | terrace | garden, etc.

green yard with diversity of plants

Site both for rest - aestetics and social garden for growing plants

inner pond and water purification

Use for water collection, water distribution, irrigation, purification and for aestetics and social garden

thermal mass and timber construction

Since timber has a larger specific heat capacity than dense concrete, use of prefabricated timber components with an increasing application of solid, as opposed to frames, floors and walls. And "Stacked Plank" is ine such technique which will provide a considerable amount of thermal mass as well as the ability to absorb and transmit water vapour.

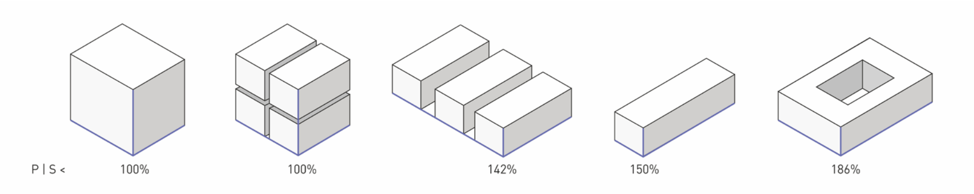


Figure 21.
Dependence of building shape
on non-energy consumption.

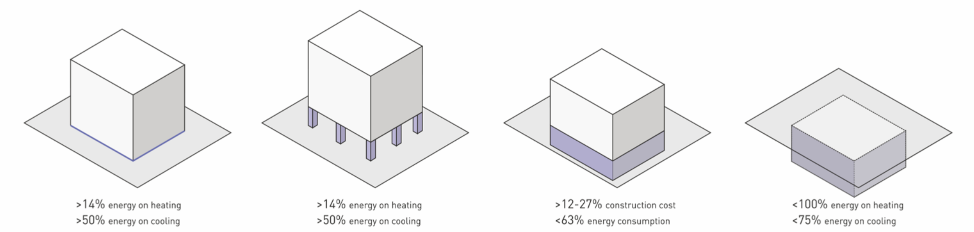


Figure 22.
Dependence of building shape
on non-energy consumption.

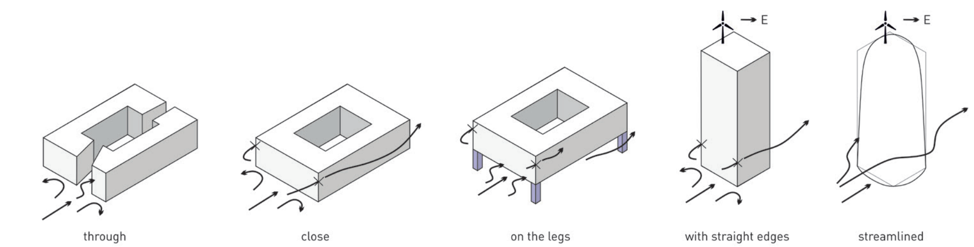


Figure 23.
Responce to wind | protection
and energy use.

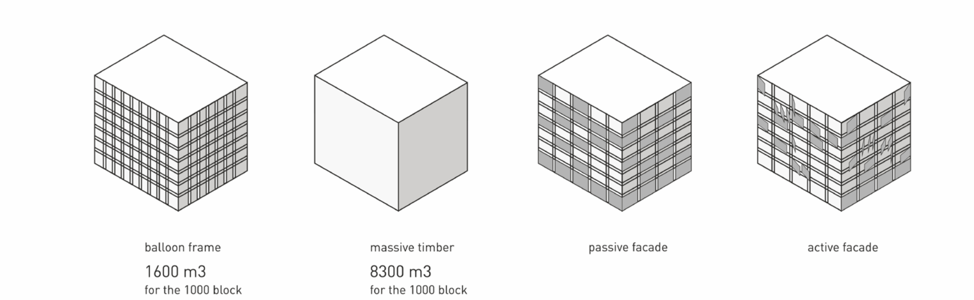
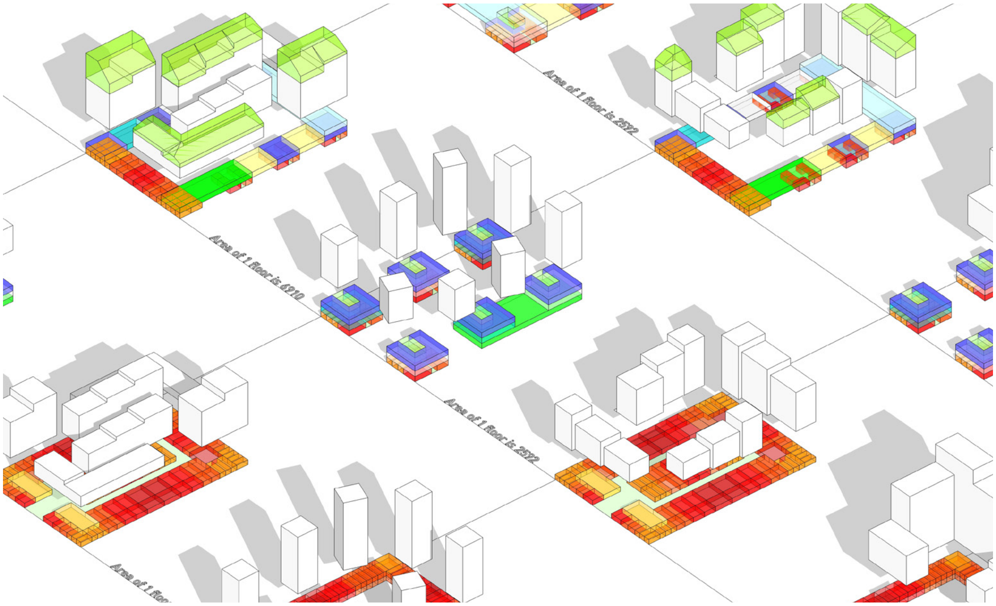


Figure 24.
The structural system
of block.

Features: The smaller the ratio between the perimeter of the building and its area, the higher the energy efficiency. Above the ground block increase the energy demand of 14% for heating and 50% for cooling in comparison with the partially underground solutions. It is necessary that the building is located end to the direction of the wind. The structural wood is much more economical and visually facilitates the construction of high-rise towers

BUILDING TYPOLOGY

INTRODUCTION



Typology (from the Greek typos - imprint, form, sample, logos - concept, teaching) is a scientific method that is used for comparative study of essential features, relationships, functions, relations and levels of organization of objects. The basic logical forms used by the typology are type (pattern), classification (a means of expanding the relationships between object classes), and taxonomy (hierarchical subordination). The architectural typology of buildings and structures, representing one of the most important sections of architectural science, systematizes and develops the basic principles of the formation of buildings and structures, taking into account their preferred features and characteristics. It reveals the social, ideological, functional, constructive-technical, economic, town-planning and architectural-artistic requirements, determines the classification and nomenclature of types and types of buildings, corresponding to the basic parameters of design standards, composition, size, nature of technological links and their equipment. Typology studies the influence of climatology, architectural lighting and acoustics, sanitary hygiene and safety requirements on the architecture of buildings and structures; determines the quantitative and qualitative parameters of buildings and structures that correspond to the current level, the material and cultural needs and opportunities of society. New town-planning ideas and trends, the creation of group settlement systems, agglomerations, etc. also have a significant impact on the principles of organization and the system of cultural and consumer services and the types of buildings and structures.

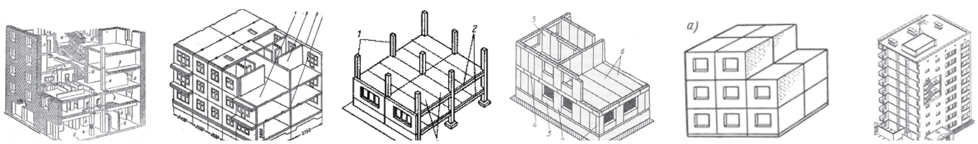
MAIN CLASSIFICATION CRITERIA

- purpose: time and nature of residence
- number of storeys
- spatial planning structure
- constructive solutions
- materials of enclosing structures

All the buildings can be classified to many goups by different criterias. It could mainly be divided into five perspectives, those to be: purpose according to time and nature of residence, number of storeys, spatial planning structure, constructive solutions and materials of enclosing structures.
The purpose of the residencies on the one hand vary considerably due to time people are planning to live in an appartment , i.e. some families need temporary use dwellings, when others live in a house for their entire life. On the other hand the nature of residence- how people use it, make a new branch in design typology. people can use the space individually as well as sharing it together with others.

Constructive solution

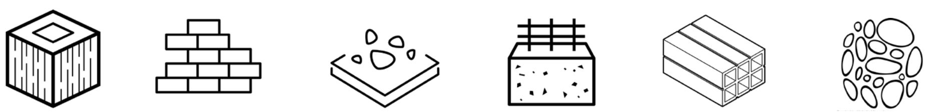
Figure 25.
Responce to wind | protection and energy use.



of piece materials | panels | frame-panels | large-block | volume-block | monolithic

Materials of enclosing structures

Figure 26.
The structural system of block.



wood | bricks | concrete | reinforced concrete | silicate materials | local materials

Buildings can be also divided according to their height, but more principal here would be the vertical connection of the floors, because it is crucial if the building has a lift or the only communication is a stairway.
In case with stairs as a main upright communication there are low-rise buildings (up to 3 storeys) and the average height buildings consisting of 4-5 storeys. While looking at building blocks with elevation system, we see a bit broader range: multi-storey (6-9 storeys), buildings with increasedd number of storeys (9-16) and high-rise buildings (over 16 storeys).
Spatial planning structure.
Corridor construction of an apartment house is considered the most economical for multi-storey apartment houses. This is quite natural, given that in the corridor houses every square foot of the corridor serves two apartments instead of one in the gallery houses. The economic feasibility of a corridor house becomes even more obvious if we compare it with a one-section house. In the first one, the maximum floor area per elevator and staircase is reached, in the second - the area of the floor is limited.
The gallery house is a type of multi-storey residential building in which access to apartments is provided from open galleries on one side of the building. Galleries are connected by at least two staircases (two ways of evacuation), sometimes by elevators.
Galleries are usually located on the shady side of the building. In the gallery house there can be only small apartments.
The advantages of a gallery house consist in saving space (you can use fewer staircases), while the apartments have an orientation to two sides, which can not be achieved in a house with a corridor. However, an apartment of the same quality in a sectional house with two apartments on the floor is usually cheaper. Other shortcomings of the gallery house and did not find any convincing solutions. The path from the apartment to the stairwell is usually in the open air. Entrance doors usually open outwards, and apartments can be viewed.
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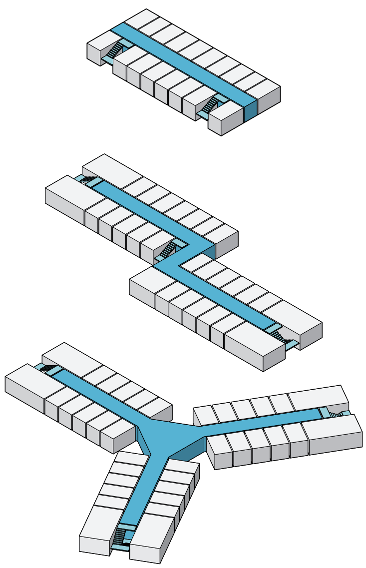


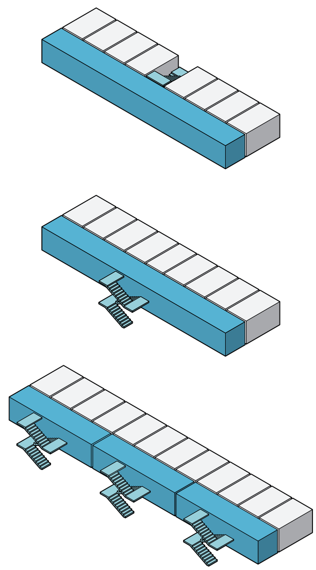


Figure 27. (left)
Gallery type
a. the stairs are located in the house's overall dimensions
b. ladders removed from the overall dimensions of the house.
c. gallery-sectional house

Figure 28. (right)
Corridore type
a. rectangular
b. with a shift for lighting and airing corridor-moat
c. three-beam houses

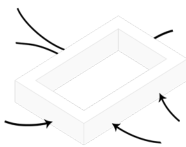
Designing new urban typologies, we have to bear in mind the existing standards and regulations for urban development. Here are the norms and standards for living apartments:

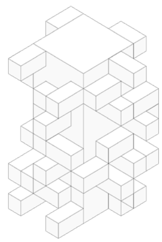
Building norms for apartments

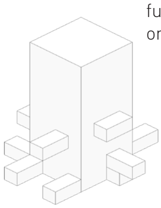
Table 1.
Calculation of apartments.

Household	Members, %	Members	Numbers of flat	Dormitory	n=k-1	n=k	n=k+1
	29,9%	299 people	299	50% / 150	0%	50% / 149	0%
	28,7%	288 people	144	20% / 29	30% / 47	70% / 100	0%
	25,4%	254 people	84	6% / 5	0%	83% / 70	11% / 9
	15,9%	159 people	40	0%	0%	100% / 40	0%

Typology of blocks







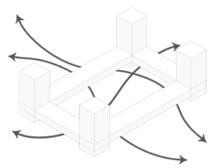


Figure 29.
Diversity of block typology

RESIDENTIONAL PART TYPOLOGY

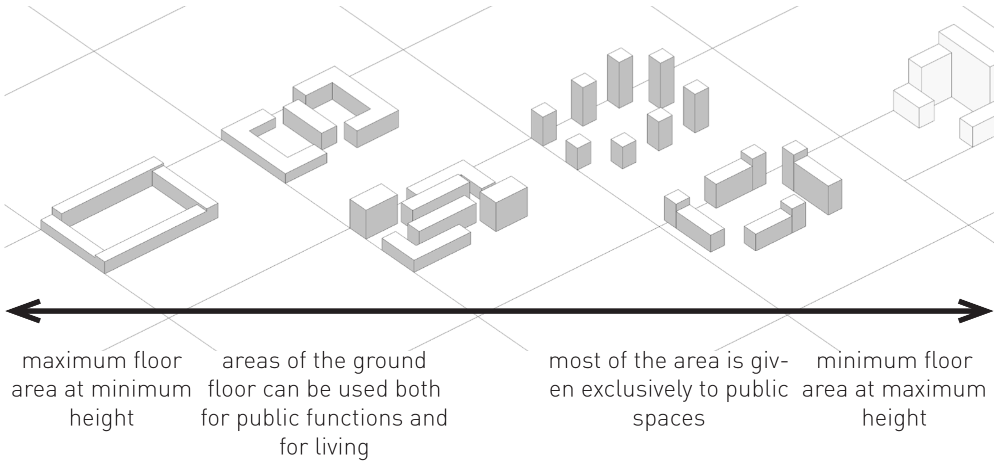


Figure 30.
Typology of residential space in residential building, depending on the area of the floor

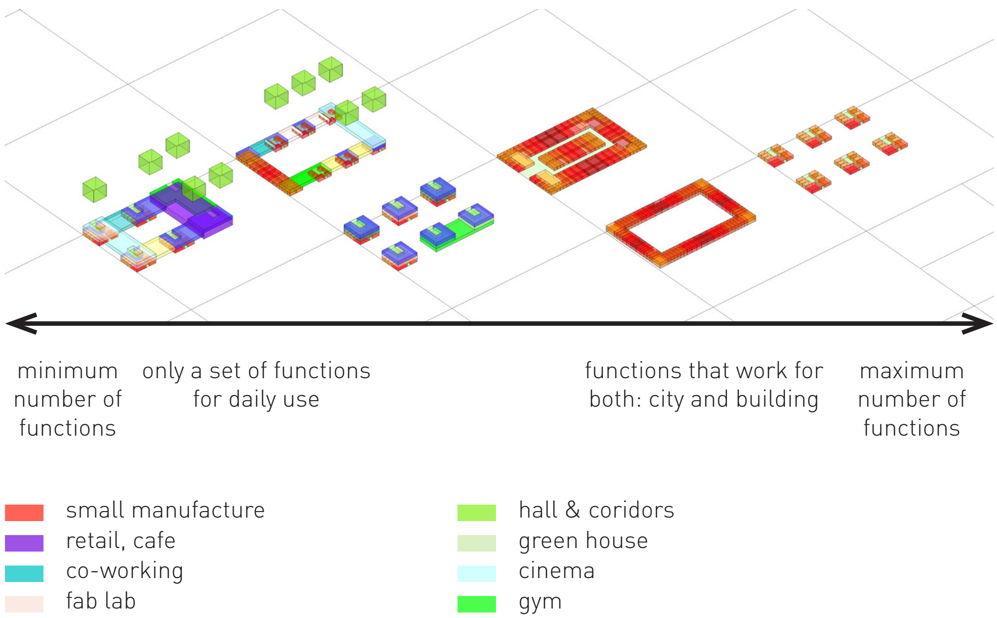


Figure 31.
Typology of public function in residential building in gradation by actinality

Figure 32.
Parametrization of residential buildings with public functions

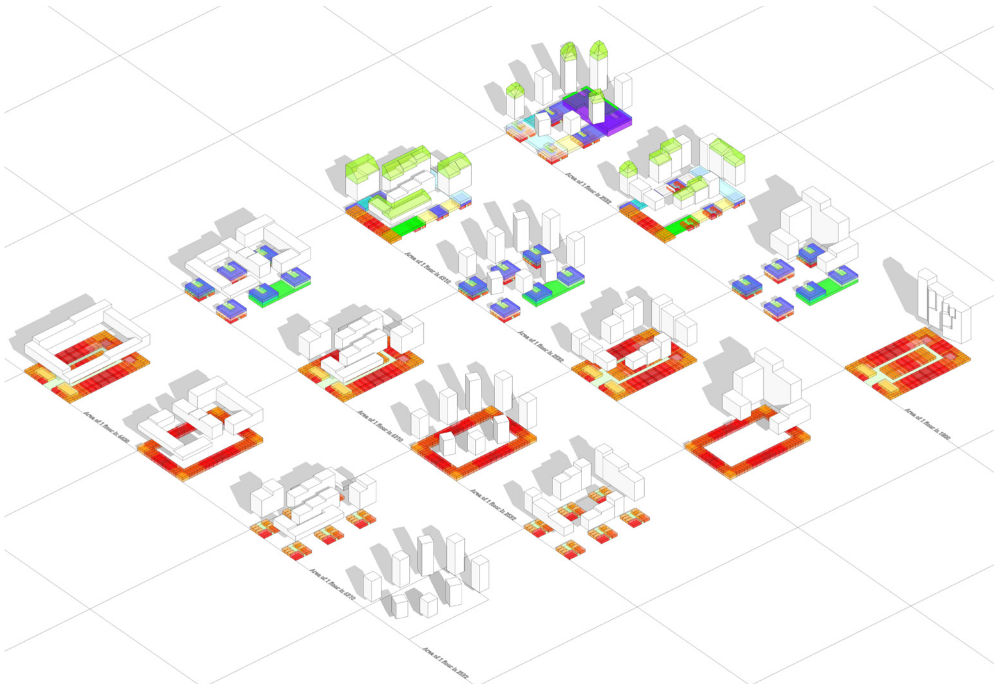


Figure 33.
Parametrization of residential buildings with public functions, taking into account the peculiarities of insolation

BUILDING FACADE

INTRODUCTION

Typology (from the Greek typos - imprint, form, sample, logos - concept, teaching) is a scientific method that is used for comparative study of essential features, relationships, functions, relations and levels of organization of objects. The basic logical forms used by the typology are type (pattern), classification (a means of expanding the relationships between object classes), and taxonomy (hierarchical subordination). The architectural typology of buildings and structures, representing one of the most important sections of architectural science, systematizes and develops the basic principles of the formation of buildings and structures, taking into account their preferred features and characteristics. It reveals the social, ideological, functional, constructive-technical, economic, town-planning and architectural-artistic requirements, determines the classification and nomenclature of types and types of buildings, corresponding to the basic parameters of design standards, composition, size, nature of technological links and their equipment. Typology studies the influence of climatology, architectural lighting and acoustics, sanitary hygiene and safety requirements on the architecture of buildings and structures; determines the quantitative and qualitative parameters of buildings and structures that correspond to the current level, the material and cultural needs and opportunities of society. New town-planning ideas and trends, the creation of group settlement systems, agglomerations, etc. also have a significant impact on the principles of organization and the system of cultural and consumer services and the types of buildings and structures.

FUNCTIONS OF FACADE

The building facade basically does four types of function, those to be:
- first is limitation of the space, enclosing the structure to certain closed volume and protecting it from surrounding;
- second is ,sort of counterwise to the upper one, connecting the INterior with the environment OUTside the shelter
- and third is constructive function- to carry the load of the building, this function does not necesserily obey first two statements, but it can change according to material set chosen for the construction.
- design

Protection

• Mechanical protection
• Protection from rain
• Windproofing
• Reflection of light radiation and thermal
radiation
• Absorption of thermal radiation
• Reflection of electromagnetic radiation

Connection

• Visual contact
• Light
• Air permeability/ Natural ventilation
• Solar radiation
• Heat gain
• Storage of heat

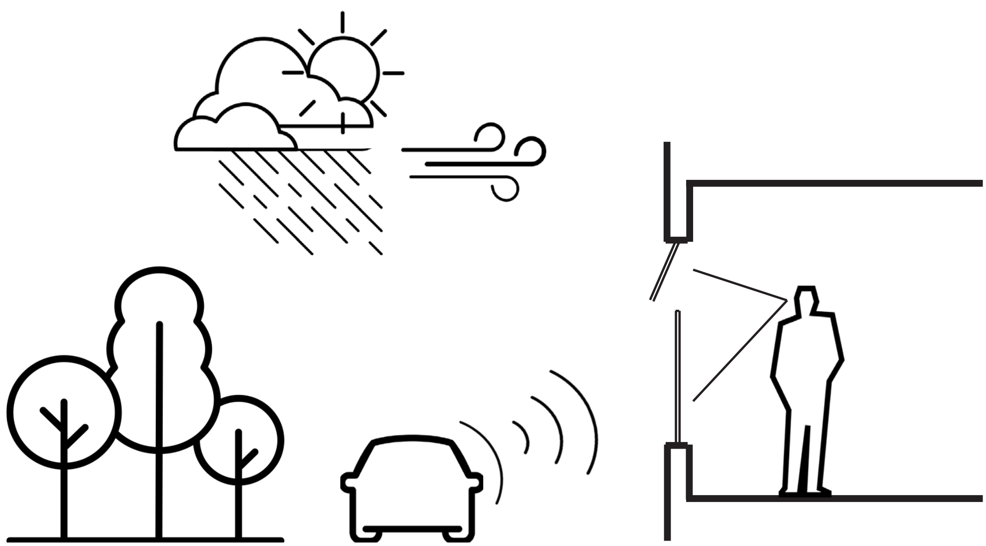
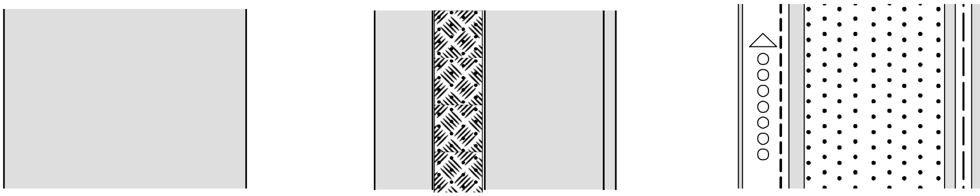


Figure 34.
Facade functions illustrations.

FUNCTIONS OF FACADE

The taxonomy of building facade contains of three main categories, that are based on a complexity of different parameters, such as:
material, type of production and design.
There are many different materials used for building facades, but all of them fall under monolayer, multilayer or hybrid constructive systems.



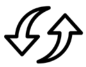
Monolayer Hybrid Multilayer

Figure 35.
Facade sections typology.

Monolayer

This particular group is specific with its usage of only one type of material for its outer wall and mostly it is used for load-bearing wall system. For example materials used here would be bricks, concrete or wood. This type of construction gives a lot of benefits.

Wood

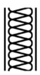
- Materials are reusable 

- Resource is renewable 

- No need on transportation 

- No CO2 emissions 

- On cite fabrication/ prefabrication 

- Great insulation 

- Physical properties 

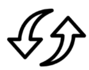
Concrete

- Physical properties 

- Flexible design 

Bricks

- On cite fabrication/ prefabrication 

--Materials are reusable 

- Physical properties 

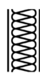
- Great insulation 

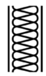
Figure 36.
Material properties

Multilayer

The possibility of having several layers united to one is also very profitable,but only in terms of facade's performance. Basically you can reach any configuration of a structure choosing the components of the wall. Usually this type of construction is applied for only enclosing function. However due to modern technologies there is a long list of different materials used for insulation, covering, etc. For each aspect of functionality there is a bunch of different solutions within this layering system. Below we can see tendencies that are currently predominant in multilayer facade structures:

• Increasing performance of functional layers
• Reducing the space required for layers (e.g. vacuum insulation) through to miniaturising of functional structures (e.g. prismatic light deflection systems less than 0.1 mm high)
• Surface coatings using nanotechnology
• Combination of several functions in a single polyvalent layer

Wood

- Great insulation 

- Customization 

- Flexible design 

- Price range 

Figure 37.
Multilayer facade properties

Hybrid

There were different variations of hybrid systems even a long period of time ago in history of architecture, but now it got a new breath with CLT (cross laminated timber). Because timber itself having very outstanding physical proper ties, when combined with steel for example, gives even more effective and efficient results. Using hybrid technology is very logical when a building requires more load resistance: vertical, horizontal and bending forces. This can improve wooden structure by ten times.

Hybrid wood-steel construction

- Physical properties 

- All of the wooden structures advantages 

Figure 38.
Hybrid facade properties

WOOD MATERIAL

INTRODUCTION

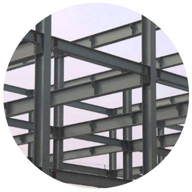
One of the oldest materials for construction is a tree. Can the buildings of the tree be modern? Today, numerous architects and designers compete in the skill of using wood for building and finishing a variety of buildings. For many centuries the tree has been used in construction in various weather conditions and climatic zones, and new ways of processing and using this material are emerging every year. There are many creators who use wood as the basis for self-expression and creativity, but even those who once resort to this material perceive this as a challenge and an opportunity for creativity. The tree is a unique material that, due to its properties and features, influences the architectural form and design as a whole, thus forming a separate discipline. Thanks to the new generation technologies, the tree becomes the main trend among construction materials, bringing a significant contribution to modern architecture.

The ability of the wood to resist the main mechanical effects - compression, bending, stretching, makes it suitable for most structures within the carrying capacity of the material. In the fifties of the last century, in connection with the discovery of new chemical means of protecting wood from decay, giving it fire resistance and the invention of particularly strong adhesives, the possibilities of using wood in construction were significantly extended. The wide use of glued wood in architecture is facilitated by such qualities as high strength, low weight, bio-and fire resistance, industriality, economic efficiency and high aesthetics. This material is used to build public and industrial structures.

Table 2.
Comparative analysis of structure materials.

	Material	Floor span capability	Heigh capability
1	Steel frame	6-7 m for composite steel/concrete floors	>100 storeys
2	Concrete frame	8-12 m for solid, prestressed, troughed and robbed slabs	>20 storeys
3	Platform timber frame	5-6 m for engineered timber joists	7 or 20m
4	CLT construction	6-8 m	>17 storeys

1



2

3

4

Disadvantages

Moisture
Moist conditions can, over time, even soften wood treated to withstand moisture, making it susceptible to wet rot and fungus. Such problems can be very expensive to treat, and often the best preventative measure is simply to use a material that does not have this vulnerability. Plastics and nonporous materials are frequently used in applications where high moisture is a consideration.

Burning
Wood, of course, can burn-- making it a less than ideal material to use in applications where fire safety is a concern. Even worse, some types of treated wood can emit toxic chemicals such as arsenic, which can be fatal in closed spaces.

Warping
Depending on conditions, wood may warp by swelling, shrinking, or twisting. This means that in many fine-calculation applications -- such as in doorways and around window-frames -- the choice of wood may reduce functionality if the environmental conditions do not meet requirements.

Benefits

Enviromental friendliness
Using wood in construction, whether it's a complete construction of just the wooden frames, really does have a positive impact on climate change.

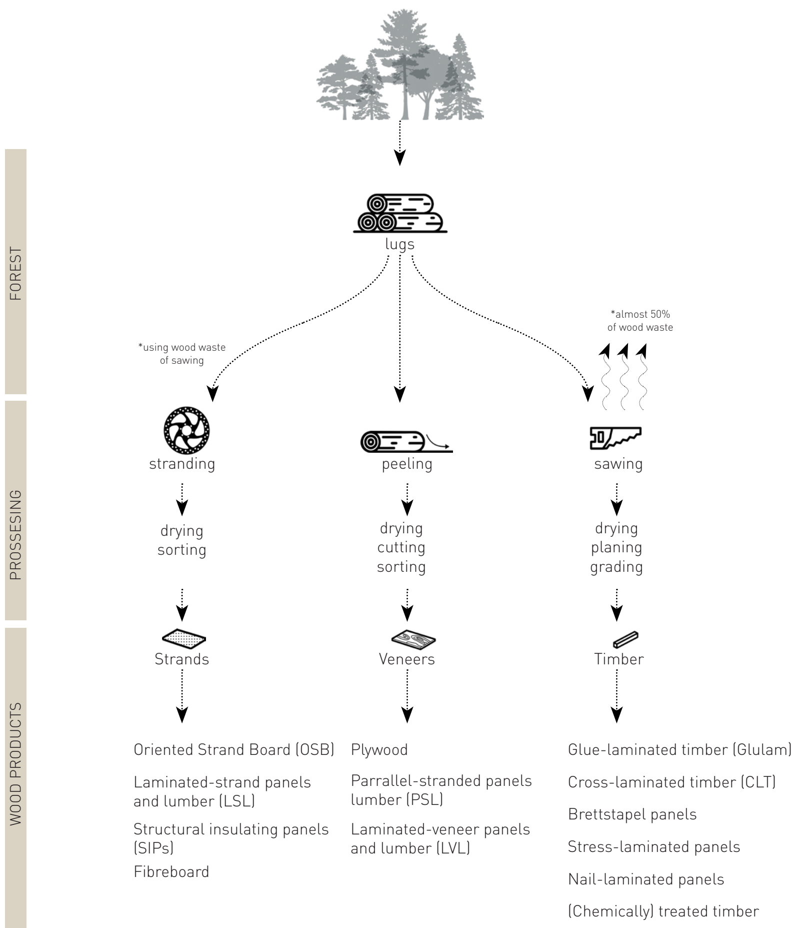
Resourse renewability
The increased demand for responsibly sourced wood products that store carbon can result in an increase in well-managed forests and plantations on marginal or cleared land.

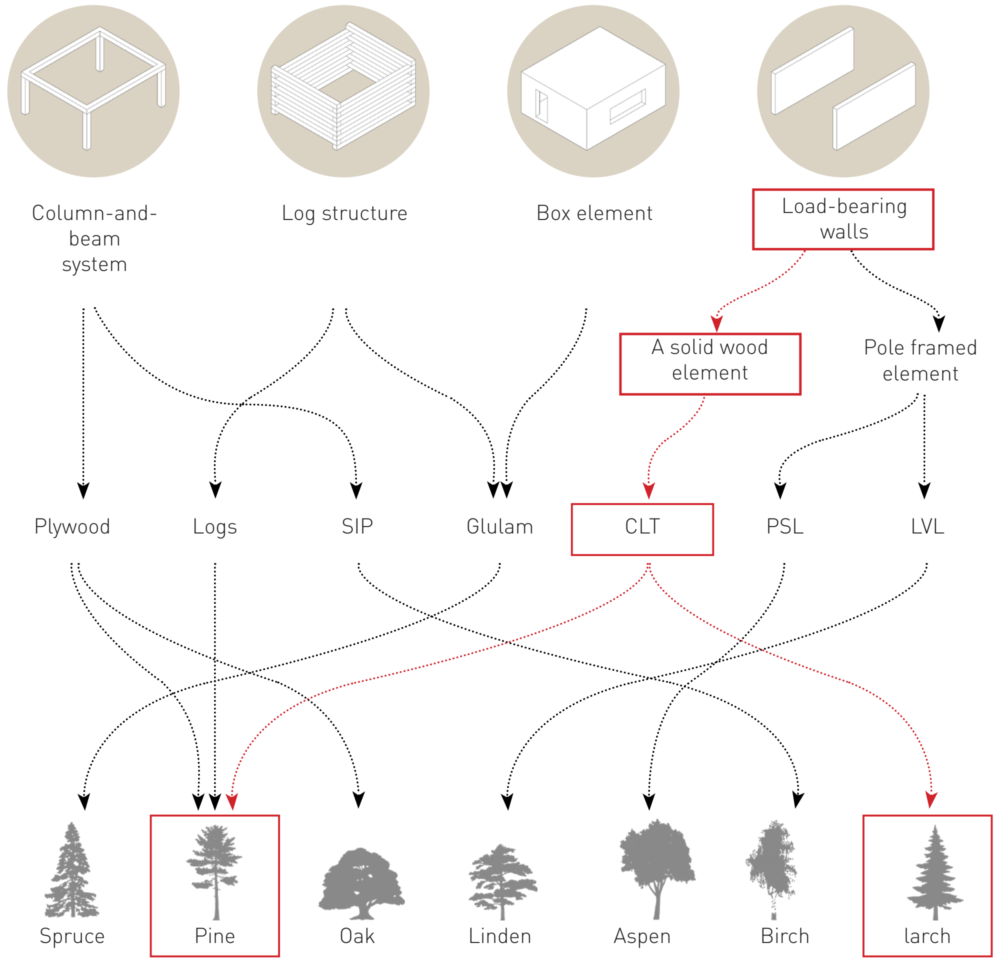
Flexibility
Wood mats also offer a slight degree of flexibility in the field, which can be a useful trait in some applications. Mats are built using high-quality hardwoods, but not varieties that can snap when weight is too extreme.

Insulting properties
A thick wall is formed by the large amount of air in cellulose, acting as a barrier to outside heat. Imagine an excellent insulating material tightly surrounded by a hard outer shell. Wood is twelve times more insulating than concrete.

Wood is living material. Untreated wood usually has low characteristics and can not compete with other building materials. The process of processing wood allows it to obtain good material properties.
The properties of the material that need to be improved for wood include durability, biodegradability, fire resistance, mechanical properties, etc. Wood is a natural material, the main feature of which is increased absorption of moisture. When humidity or temperature drops, the tree breaks down. This process is manifested by swelling, shrinkage, cracking or decay of wood products. The tree is sensitive to various microorganisms: mold fungi, insects, algae. The first signs of damage to the tree by microorganisms are dark, gray spots on the surface or mold. The most terrible enemy for a tree is a white house mushroom that destroys wooden products in a very short time. Wood is also sensitive to fire. Therefore, in order that a wooden house has served more than a decade, it is necessary to protect the tree from destructive factors.

Figure 39.
Wood flows scheme.





	Spruce	Pine	Oak	Linden	Aspen	Birch	larch
	27%	**23%**	**2%**	**0,3%**	**9%**	**35%**	**5,7%**
	5 884 380 ga	**5 012 620 ga**	**435 880 ga**	**65 382 ga**	**1 961 460 ga**	**7 627 900 ga**	**1 242 258 ga**
TYPE OF WOOD	softwood	softwood	congenital hardwood	congenital hardwood	diffuse-vascular hardwood	diffuse-vascular hardwood	diffuse-vascular hardwood
DENSITY, KG / M3	450	520	700	530	510	650	660

Table 3.
Structural systems and local wood products.

	Spruce	Pine	Oak	Linden	Aspen	Birch	larch
BASIC PROPERTIES	One-sidedness of the structure, long fibers, stable white color, low resinity, high ability to resonate.	Wood of medium density, high enough strength, resistant to decay, well processed.	Has a beautiful texture and color, high strength against decay, as well as good bending ability	Soft, light, ogosho is sharpened, little cracks and weakly warped.	It has a homogeneous structure, it is easily peeled, impregnated and does not give much smoky flame.	Wood is characterized by high strength, homogeneous structure and color, but low resistance against decay.	Larch wood does not rot and does not turn blue, relative biological resistance
APPLICATION	Congenital building structures operated in dry conditions	Bearing wooden structures, various joiner's products, plywood, etc.	High-quality parquet, plywood, furniture.	Facing material, lining, interior finishing	Rafting system, interior partitions, floor	Plywood, construction parts, slabs, parquet, furfural, furniture manufacture, production of construction parts	Plywood, construction parts, slabs, parquet, furfural, furniture manufacture, production of construction parts

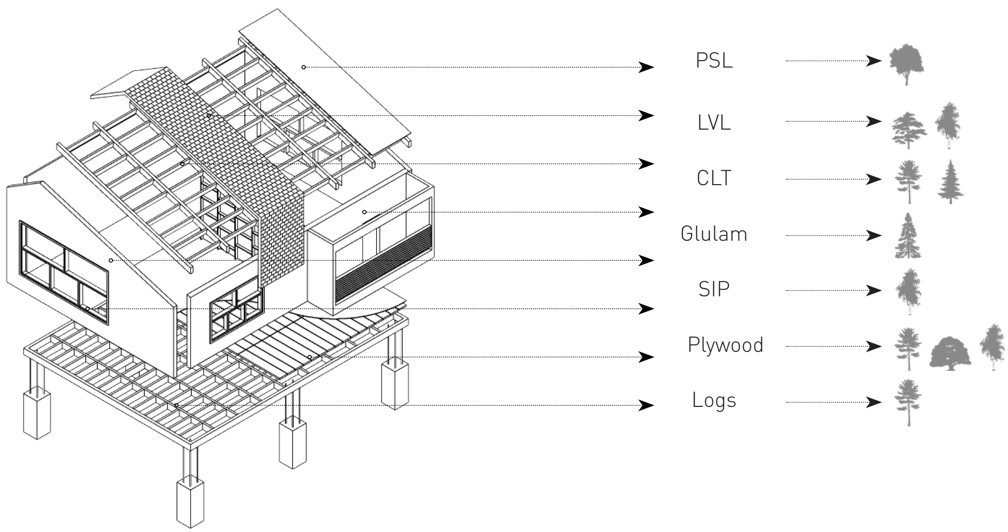
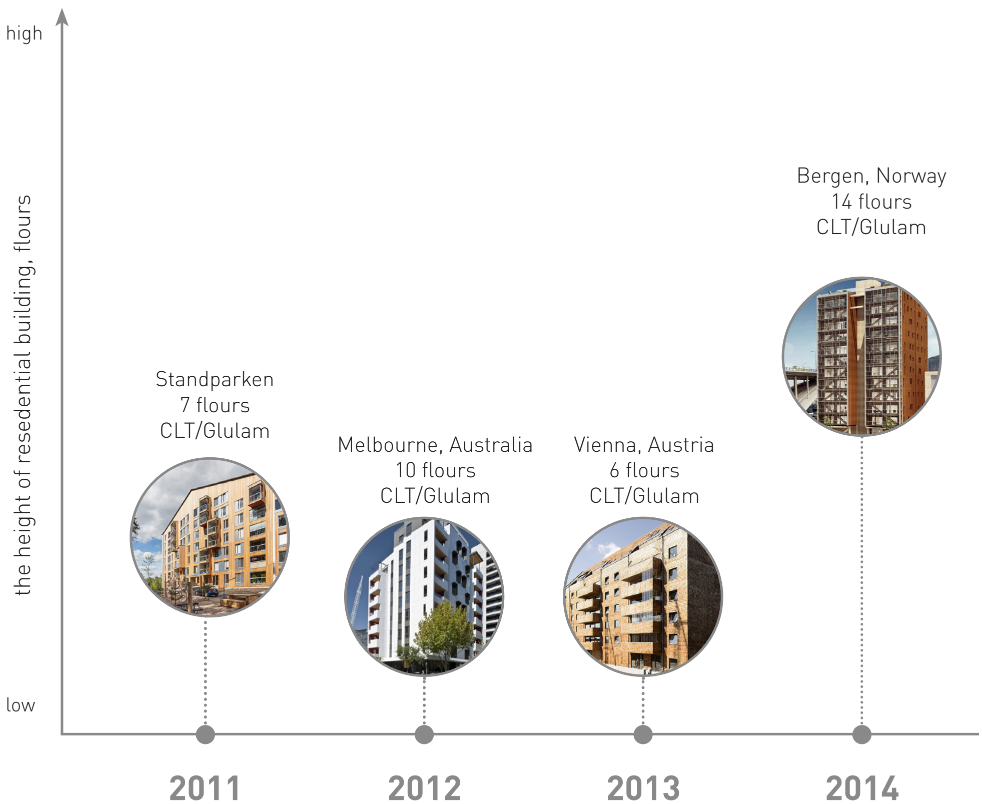


Figure 40.
Applications of wood products.

TIMELINE | WOODEN RESEDENTIAL BUILDING FOR THE LAST 10 YEARS

The past century has become a time of abandonment of wood as a key building material. The main reason for this situation is concrete. In the new century, the tree gradually began to return to people in a new quality. No one is surprised by its use in multi-storey architecture. Modern technologies have given the construction wood new properties that allow creating unparalleled architectural and constructive solutions, forming a new, high-quality, ecologically clean living environment. Wooden multi-storey apartment houses, business centers, public facilities, airports were built. Architects have already swung to wooden skyscrapers. Technology CLT panels, created in the 1970s and received rapid development in the early 2000s, gave birth to a new trend, aimed at building multi-storey apartment buildings.



The high strength and fire resistance of these panels created a technological basis for such construction and the aggravation of environmental problems caused by reinforced concrete construction forced a closer look at the potential of multi-storey timber-based construction.
As a result, in 2009, the first 9-storey residential building appeared, built entirely of wooden CLT panels. In the future, this trend began to grow rapidly. In Canada, England, Australia, France, Sweden, Norway, 12 or even 18-storey houses based on wooden structures began to be designed. Architects began to think about the construction of wooden skyscrapers and for such construction began to develop hybrid design solutions.

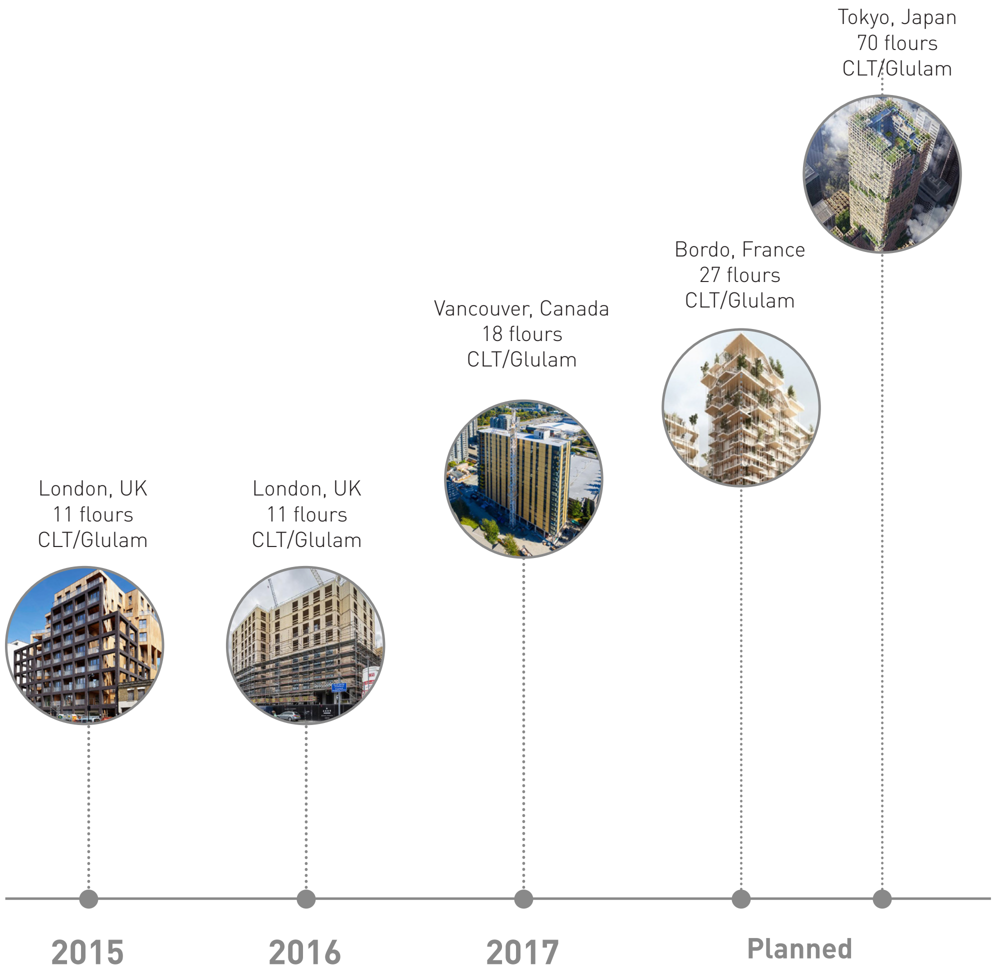
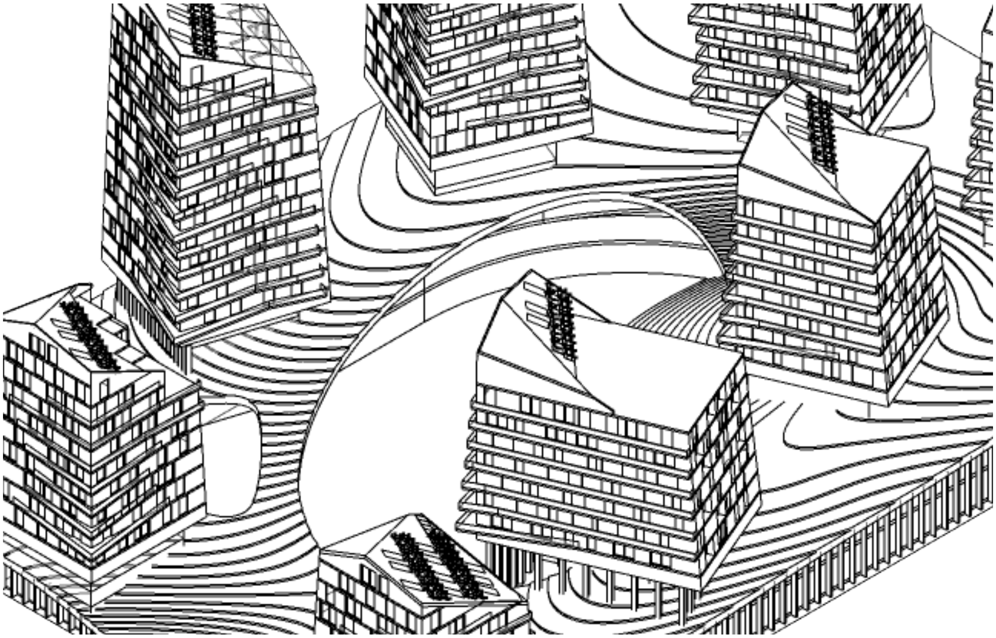


Figure 41.
Wooden resedential buildings timeline.

PARAMETRIC DESIGN

INTRODUCTION



Parametric design is has over the last few years become synonymous with some of the most iconic buildings, bringing to mind shattered undulation of forms and of asymptote. This is achieved with computational software which regulates the relationships between the various aspects of the project form.
This process of automated implementation to changes in the building form allows for massive cost saving. The ability to change entire series of window, doors and facade materials by alteration of single variables; perform analysis on several iterations of the derives models; all the while maintaining the connectivity between parameters, variables and the resultant forms, thereby allowing for real-time application of changes to the design. The sinuous organic nature of the works done by parametric architects is what makes their works stand out from the rest. Parameters subject to variation include elements or parts of the building that are subject to geometric variation. such components include windows, doors, walls, finishing tiles, columns and so forth. Variations in the patters can be generated as a modular unit and the same are used to populate the entire building form with variations of the same modular unit.

CONTENT

CONCEPTS IN PARAMETRIC DESIGN PROCESS:

1. Variables
   Driving geometric variations (dependent & independent - l-w-h vs area)
2. Constraints
   Establish range of variations for model.
3. Dependencies
   Equation driven dependencies for example a circle defined by C = 2Pi*r
4. Components
   Variables & Constraints define geometric elements called components
5. PowerCopies (with power features)
   Grouped components with parameters that can be transfered and adapted to variable contexts.
6. Rules
   Input types ranging from geometric and numerical variables to constraints and other components, forming rules by which the design theme takes shape.

- Standardized blocks in existing facade systems are dicated by the materials from which they are made. Form is dictated by materials.
- Using parametrics, the variations in materials and form can be increased and the most aesthetic can be chosen from a range depending on prioritized parameters.
- Whereas the changes in form may vary depending on the parametric inputs being considered, eventually the form will depend on the optimization process - impacting the form of the structures.
- The modules used to parametricize the single facade panels are then applied on the overall building as a system and this is then re-analyzed and optimized to scale.

GENERAL APPLICIABILITY

1. Architectural Design Considerations:
Design of Spaces:
- 1.1 Floor Area (Gross Area)
- 1.2 Floor - Cieling Height
- 1.3 Communication and Corridors
- 1.4 Number of Rooms (by function)
- 1.5 Room dimensions (by function)
- 1.6 Number of floors
- 1.7 Roofing form

Design of Facade:
- 1.8 Facade Finish
- 1.9 Fenestration

2. Structural Design Considerations:
Design of slabs;
- 2.1 Slab material
- 2.2 Slab thickness
- 2.3 Slab finishes

Design of Structural Elements;
- 2.4 material
- 2.5 thickness of walls
- 2.6 wall finishes

1. Versatile building typology
   - 1.1 Establishing parameters by modular units
   - 1.2 Adjustment of building parameters to the site situation
   - 1.3 Optimization of building component forms
   - 1.4 Creation of versatile building templates

2. Relationships between form and function
   - 2.1 Allows for maintenance of links between parameters (
   - 2.2 Functional optimization - during design

3. Fluidity of Forms
   - 3.1 As defined upon execution of adjustments to building components. This allows for changes in the form simultaneously
4. Regulatory constraints
   - 4.1 Dimmensions by codes and standards

5. Analysis of Building Performance
   - 5.1 Building parameters optimization to per formance criteria.

APPLICATION

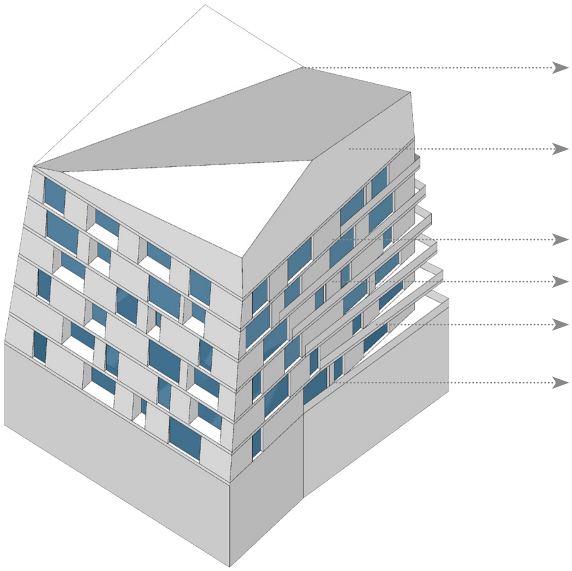


Figure 42.
Parametric design application
in building block.

The use of parameteric design is instrumental in rolling out context based forms adapted to the specifications of a site. These forms can then be optimized to suite the site conditions through various iterations. Such processes can be conducted on platforms like grasshopper using plugins like galapagos which will run through various iterations of which the optimal versions will be retained. Thus the resultant architectural forms will have been customized to the site. The process increases workflow efficiency while maintaining links between the parameters and the forms being generated. This allows for changes to be made to the model in single sessions - the modular units can be edited individually and the modifications are propagated to the copies of the same unit. Furthermore, the hierachical nature of the components is maintained and this allows designers to maintain the logical thought processes and ensure that centralized changes are applied throughout the model. Given that this process is only as new as the software used to generate parametric models, it is evident that there is still a long way to in parametricism, nontheless the wide range of applications at the moment are are not diminished in their efficacy with regards to instantaneous generation of variants of the same project.

Key principles, represented in this work demonstrate how step-by-step self-sufficient building can be designed. To create not a dwelling, but a complex residential building it is very important to observe it's life cycle from different points – to understand benefits and limitations of site, how to use those exact ecological aspects, that are represented. To choose solar panels, or wind turbines? should the building be protected from noise or not? All these questions are described in ecological design part. Another crutial characteristic is the typology of building; usually buildings were topologized by height, or shape, or initial function, but how to combine these characteristics together? What should be the shape and height of building to provide diverse scenarios of living? The coherence between building characteristics and better-living was also observed. All these functions should be envelopped by facade, which function is not only protection of internal content, but also a connection of external environment with building systems. How to maintain the balance between energy conservation and openness and accessibility is described in the building facade design section.

Any shape chosen has to be created using technologies and materials. How to choose a material and why timber again relevant are the questions discovered in another part of this work. There are represented benefits and disadvantages of wood as building material, its properties, and all the cycle of creation and implementation. There are different methods how to prove the shape of the building. We suppose that using parametric design approach we can make buildings more sufficient. parametric design is not only smooth biomorph forms, but also mathematical model, applied to calculate solar exposure, best rotation angle, slopes of the roof and so on. Original model, after parametric design become more responsive to external factors.

All these steps help to create the set of components and factors, which connected together create self-sufficient building in a specific location.

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