KBC

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Expansion of the Clinical Center in Podgorica, Montenegro
Design proposal for the Oncology and Radiology Hospital

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I would like to thank my family for always being there for me. My mama and tata. You are my rock. To Jojki, to omiljeni tetak Veseljko and my Bejbs. You are the OGs.

Hvala mami i tati na naizmjernoj podrsci. Ne znam ko bih bila bez vase ljubavi.

CONTENTS

ABSTRACT

This thesis is about an Oncological Hospital in Podgorica, Montenegro. As the first hospital specializing in cancer treatment, it was crucial to provide a complete service to patients. The hospital wpuld be the only oncological center for the entire country. Taking into consideration the importance of such a building, it was very important to be respectful to the environment at the same time. Equal attention was given to both built and natural environments.

By focusing on innovative construction methods such as modular building and circular economy, this project is an attempt to design a sustainable hospital. Ensuring the future reuse of materials is an expression of being aware that building has a lifetime, especially healthcare institutions that demand constant upgrading and modifying. A modular construction can easily be adapted to alternating needs. It can also be completely relocated, dismantled and reused according to the needs. By circulating the materials, we are making sure to value the resources consumed. The consumption, in this case, is not singular, but it is to be repeated as long as the materials permit.

Building for healthcare by ensuring the Earth is taken care of, is a way of ensuring this generation leaves the world a bit better for the future ones to come.

The purpose of this master thesis is to examine the effect of a design that puts the user and the environment in the focus, without compromising anyone, respectfully. It is the application of the concept of sustainable design and an enjoyable hospital. The goal to be reached is a hospital designed for the overall wellbeing of the patients, with minimal consequences on the environment.

INTRODUCTION

WHAT ?

General Definition: Design of an Oncology and Radiotherapy Hospital in Podgorica, Montenegro . The Hospital is an extension of the Clinical Center dating back to 1970s.It will be the first upgrade since the contruction of the original complex.

Issue: There have been no major upgrades to the Clinical Center following its inauguration in 1974. The Hospital will be the center for oncological treatment in the realm of healthcare of Montenegro, as the only public and free-of-charge institution offering said services.

WHY?

General Objective: The population of the Podgorica has doubled since the construction of Clinical Center in ‘70s. However, the Clinical Center has not seen any expansions. With growing demand, as well as being the only healthcare center providing full service in the entire country, the pressure to accommode everybodies needs is rising.

Targeted Objective: Design the oncological hospital providing both day care and intensive care units. The hospital will include the operational block as well as the radiotherapy treatments. Additionally, the hospital will focus on the overall wellness of the occupants. The hosital aims to become the first example of sustainable constructive metods - circular economy and modular building, in the region.

HOW?

Methodology:

Understaing the context: How the history and the geography of the country influenced the fact that there is only one Clinical Center in the country.

Defining key concepts of the design through case studies: modular construction and circular economy.

Design Proposal: why the proposal offers a complete answer to the demands of a contemporary oncological clinic at while relying on the most up to date methods of sustainable construction

CONTEXT

Montenegro
image source: google images

The country

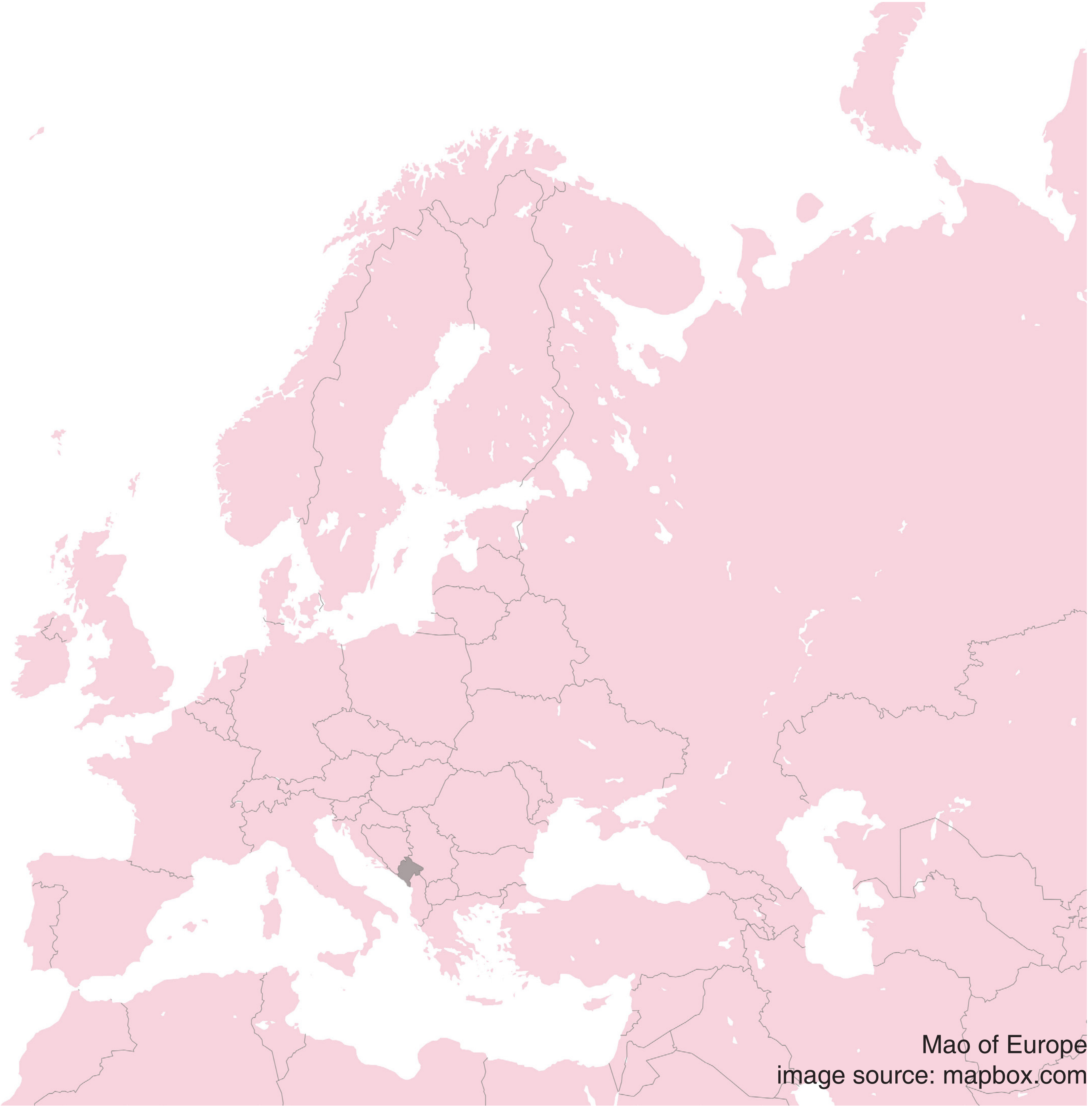
MONTENEGRO

Montenegro is a country located in Southeast Europe, on the coast of the Balkans. Montenegro is bordered on the east and northeast by Serbia, on the west and northwest by Croatia and Bosnia and Herzegovina, on the east by Kosovo and on the southeast by Albania. In the southwest, the Adriatic Sea creates a natural border with Italy.

The country's names came from the dark, mountain forests that cover the surface of the state. Just about 60% of the country is at the elevation of more than 1000 meters, compared to the level of the sea.

The mainland borders of Montenegro are 625 km long, while the coastline length is 293.5 km. Montenegro has an area of 13,812 square kilometers and a population of 620,079 as per census done in 2011. The capital city is Podgorica. Cetinje is the Old Royal Capital.

MONTENEGRO



Mao of Europe
image source: mapbox.com

Due to its geographical position, Montenegro belongs to the central Mediterranean. Although Montenegro has a small total area, it is a land of exceptional natural beauty and incredible contrasts. The country is characterized by the diversity of climates, terrain configurations, natural resources. Diversity of flora and fauna make it extremely attractive. Montenegro is home to one of two European rainforests, the southernmost fjord in the world, the largest lake in the Balkans (Skadar Lake), river with the deepest canyon in Europe and second in the world (Tara). It is a country of wild beauty.

Montenegro became the first country to identify as an ecological state, officiated by the addition of said epithet to the Constitution on 20 August 1991. It was confirmed by the new Constitution following the country's separation from Serbia. Said act was settled in order to protect the natural resources and preserve the identity of its particularity.

Although the country restored its independence in 2006, Montenegro is one of Europe's oldest states. In its centuries-old existence, Montenegro has survived and celebrated itself with its feats of the struggle for freedom and its own existence. Many civilizations of Illyrian, Slavic, Byzantine, Turkish, Christian and Islamic civilizations merged in this region, leaving Montenegro a crossroads of culture and history. Thanks to all the civilizations mixing, it became a mosaic of civilizatios.

SUMMA SUMMARUM

Capital
Podgorica

Number of citizens
625,266

Area (in km2)
13,812 th most common

Area (square miles)
5,333 th most common

Official languages
Montenegrin, Serbian, Bosnian, Croatian and Albanian

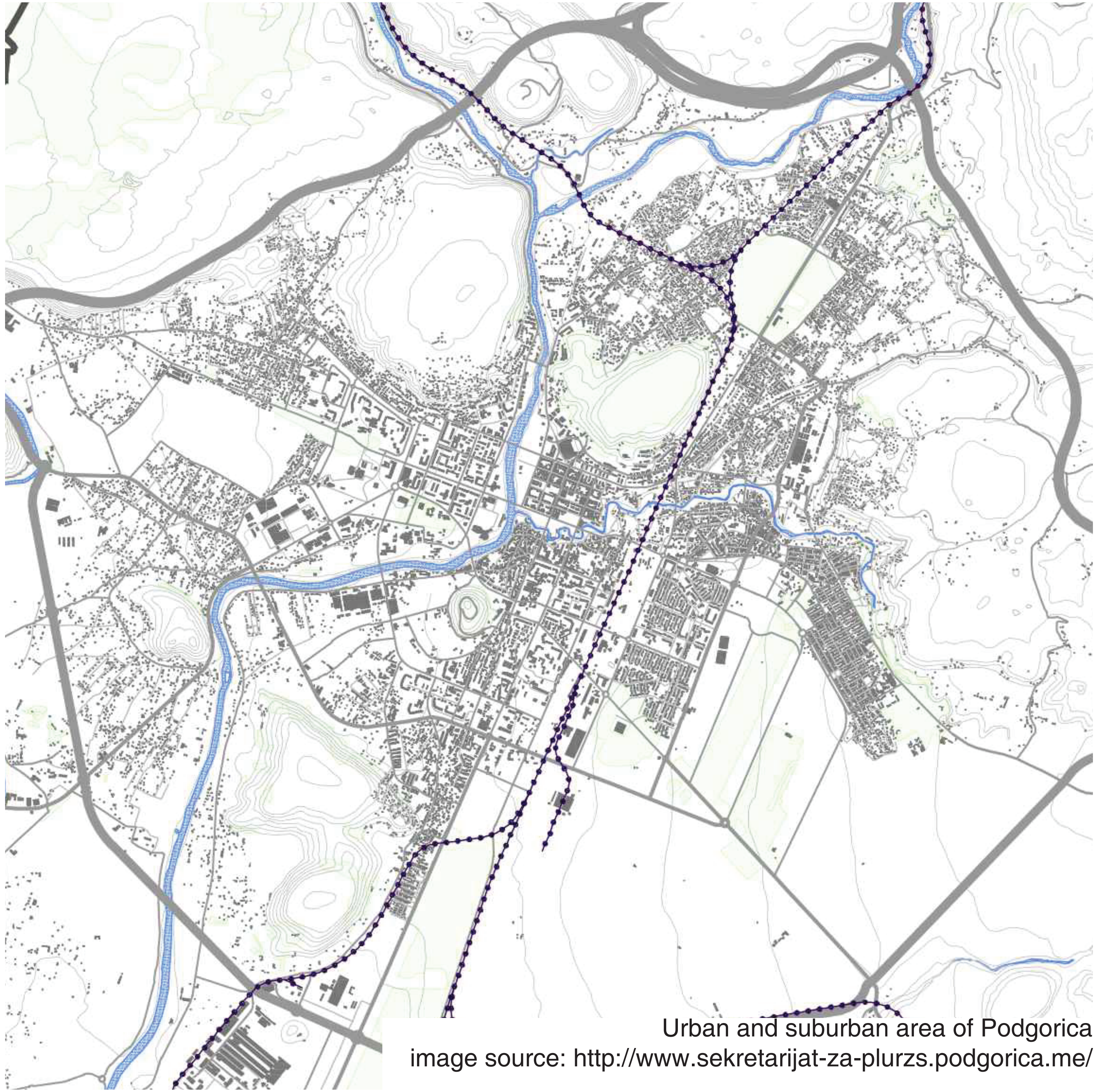
Poverty rate
9.3%

Per capita income
$ 13,130

Human development index
0.828

Podgorica
image source: google images

The city



Urban and suburban area of Podgorica
image source: http://www.sekretarijat-za-plurzs.podgorica.me/

PODGORICA

Podgorica is the capital as well as the largest city of Montenegro. It derives its name from the hill overlooking the city - Gorica. The literal meaning is ‘bellow Gorica’. Hitherto, the city was known as Titograd, during the period Montenegro was the Socialist Republic in the Socialist Federal Republic of Yugoslavia. The name was in honor of Josip Broz Tito and stayed from 1946-1992.
The junction of rivers Ribnica and Morača creates a very advantageous location for the capital. The meeting-point of the fertile Zeta Plain and Bjelopavlići Valley has encouraged settlement historically. Besides the favorable geographical characteristics of the city, it is a crossroads to norther mountainous regions and southern beaches and cultural heritage sites.
Podgorica Municipality has a population of 185,937 as per the 2011 census. Approximately 30% of the total population of Montenegro lives in Podgorica. It is the nation’s administrative base, as well as an economic, cultural, and educational center.
In contrast to most of Montenegro, Podgorica lies in a plain, at an elevation of 47 m. It is locked in itself by surrounding hills. Although some are partially urbanized, most of the terrain is too steep for development. Hence, it limits future expansion, especially in the northern direction. Podgorica city has an area of 108 square kilometers, while the actual area that is urbanized, is significantly smaller.

PODGORICA

Podgorica is a city that best presents the tumultuous heritage of Montenegro. As one governing regime succeed the other, architectural styles stands as a testimony to as every new epoque. During the Ottoman reign of the Balkans, which lasted close to 500 years, until 1878, Podgorica was the capital of the occupating forces. Stara Varoš (Old town) and Drač, the oldest surviving parts of the city, were established during this period. Two mosques, a Turkish clock tower - Sahat kula and narrow, winding streets witness the former Turkish settlement in the city.
Following the departure of Ottomans, Podgorica was reincorporated in Montenegro. The urban core of the city was moved to the other bank of the Ribnica River, where the town developed in a more European style: wider streets with an orthogonal layout. This neighborhood of the city is now regarded as the city center. It is called Nova Varoš, roughly translating to New town.(Official data by Podgorica municipality, 2019)

Panorama of Podgorica (fig. 3)
image source: google.images

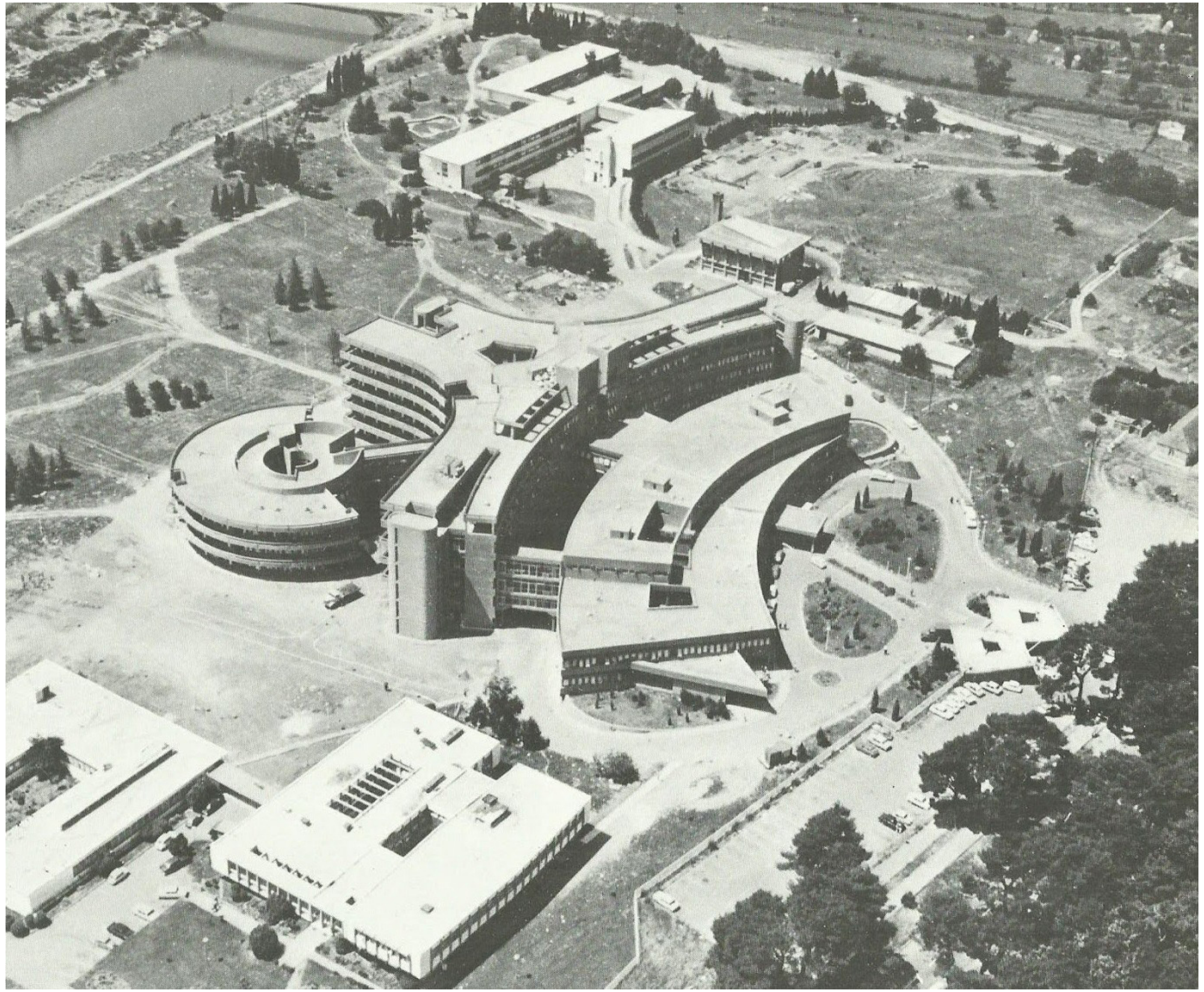

Mass residential blocks erected during communist rule (fig. 1)
image source: google.images


Residential zones built in the late 1990s (fig. 2)
image source: google.images

PODGORICA

The Second World War left Podgorica in almost complete ruins. The city was bombed more than 70 times, razing it to the ground. After liberation, rebuilding began. The architecture was heavily controlled. The style of building is very socialist and brutalist. A true representation of the communist-ruled SFRY. Mass residential blocks were erected, with very simple, modular designs. The part of the city that lay on the right bank of the Morača River was built this following this philosophy. (fig. 1)The main traffic arteries were laid out during this period, and as still being used at this time. Expansion of the city followed the established grid, to the south and west. Developments of the city's infrastructure and the construction of the residential blocks during the time of SFRY continue to shape the city's layout in present times. It was a necessary action in order to provide housing for the unmatched population growth in the city following the end of World War II.

The pivotal point in the city's architecture came in the late 1990s. This marked the rapid changes the city is about the face in the following period. Residential and business blocks were built expeditiously (fig. 2). New constructions followed the current glass-and-steel trends in architecture. In an effort to rebrand Podgorica as a modern state capital, and create notable spaces, the city officials invested significantly in the city's public spaces. Brand new squares, parks, and monuments were constructed. The city has since gained numerous new landmarks. They include the Hristovog Vaskrsenja, an orthodox temple as well as the Millennium Bridge, the most prominent feature of the Podgorica skyline. (fig 3.) (Official data by Podgorica municipality, 2019)


Aerial view of then-newly constructed Clinical Center, 1974
image source: https://www.facebook.com

The Clinical Center

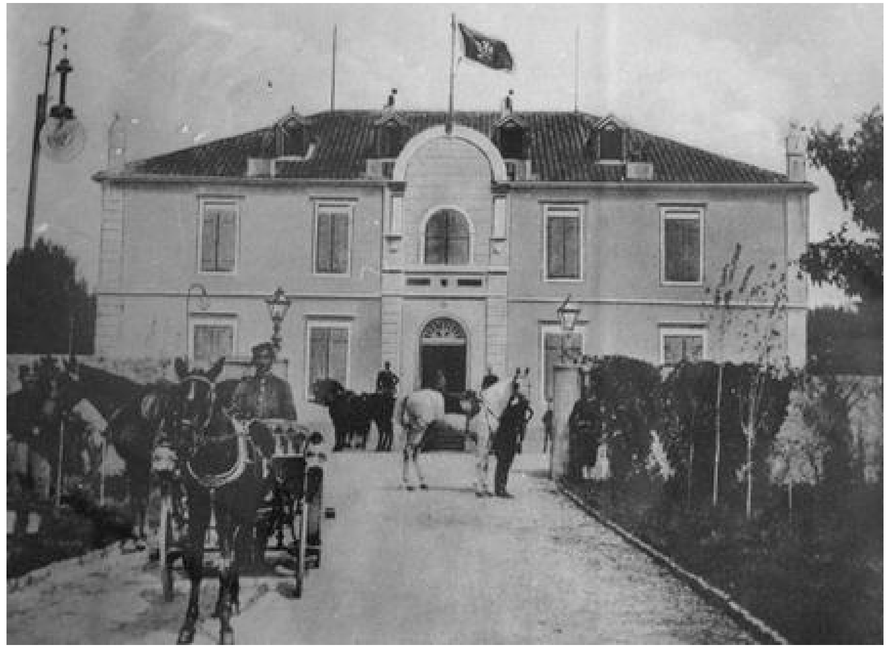
Aerial view of the Clinical Center
image source: http://plavazvijezda.com/prosetajte-podgoricom/

South facade of the main hospital of the Clinical Center, 2019
image source: google images

The Clinical Center - KBC

The Clinical Center is a unique health care facility providing secondary health services to citizens - as a general hospital for the municipalities of Podgorica, Danilovgrad, and Kolašin and at the tertiary level of health care for the whole of Montenegro. As a reference institution of Montenegrin healthcare, the Clinical Center conducts highly specialized diagnostics, treatment, and consultative specialist and subspecialist health care activities.The Clinical Center is also a medical scientific research center and teaching base of the Faculty of Medicine of the University of Montenegro. In the long tradition of the Clinical Center, much has been done to improve the health and use of new technologies in diagnosis and treatment. Ensuring optimal health care at the Clinical Center requires the continued development of professional and technological capabilities.
The planned investment in medical education and the development of focused vocational education programs significantly raised the level of total knowledge and skills and achieved the development of highly specialized medical services provided at the Clinical Center. With the technological expansion, which is a necessary condition for quality health service, the Clinical Center keeps pace with modern medical trends. The priority development goal of the institution has three focuses, which include the introduction of new medical technologies, with the education of staff and investment in modern medical equipment.
The organizational structure of the Clinical Center consists of more than 30 organizational units, including the Institute for Diseases of Children with two clinics, 14 clinics, 11 centers, Operation block, 6 intensive care units, two specialist clinics in the fields of medicine and dentistry, as well as administrative and technical -Engineering services and services. The clinical center has more than 2,200 employees, of whom 1,448 are healthcare professionals, with 55 doctors subspecialists and 272 doctoral specialists. (Clinical Center of Montenegro, 2019)

Pediatric Hospital,
part of the Clinical Center,
early 70s'
image source: http://plavazvijezda.com/prosetajte-podgoricom/



The offical hospital until 1974.
image source: http://plavazvijezda.com/prosetajte-podgoricom/

The Clinical Center - KBC

The increasing population of the capital, new methods of diagnosis and treatment require new staff, space, equipment, and new organization. In accordance with the strategic plans of the Ministry of Health and the Health Insurance Fund of Montenegro (HIF), the management of the Clinical Center recognized the problems and weaknesses of the existing institutions and launched a series of projects to improve working conditions and raise the level of health services.

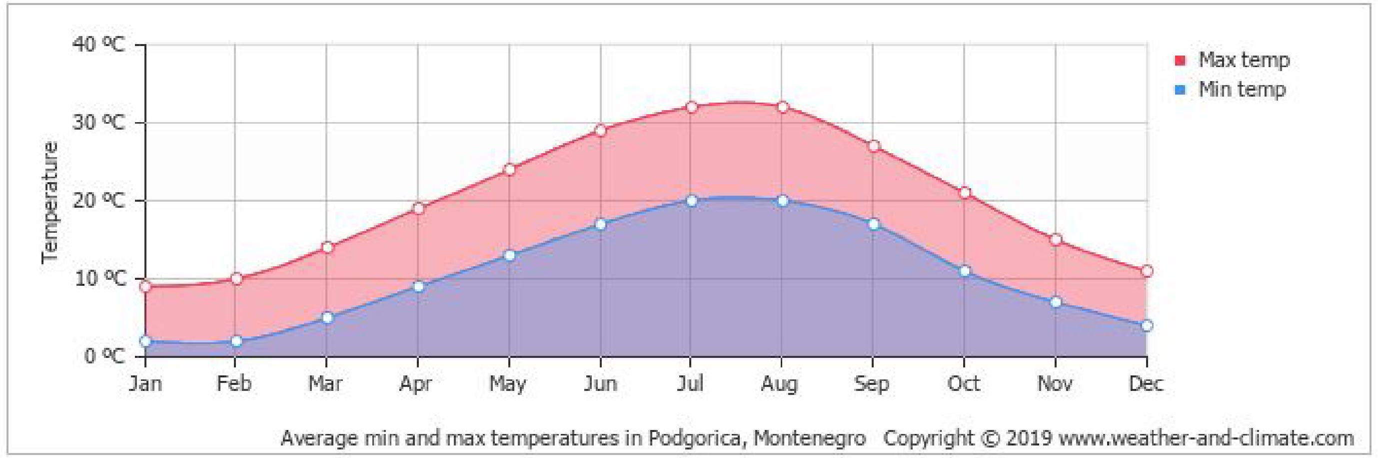
Since the establishment of the Clinical Center of Montenegro in 1974, and since then there have been no major investments in the adaptation of the Clinic.

Before 1920, the hospital was in a one-story building (fig.1). It shared a building with an elementary school. The building was located next to the Clock Tower. After 1920, the hospital was transferred to King Nikola's Castle in Krusevac. As an addition to the castle, a pavilion for infectious diseases was built, followed by two similar constructions, for other diseases.

The imposing building complex of the Clinical Center of Montenegro was officially opened in 1974, and the designers of this magnificent, unusual and complex structure are Božidar Milić and Milan Popović. Before the construction of the new clinical center even started, in 1941, Podgorica had seven physicians. At the time of the opening of the hospital, there were about 150 of them. (Burzan, D, 2017).

AVERAGE MINIMUM AND MAXIMUM TEMPERATURE OVER THE YEAR

The monthly mean minimum and maximum daily temperature. Show in Fahrenheit »

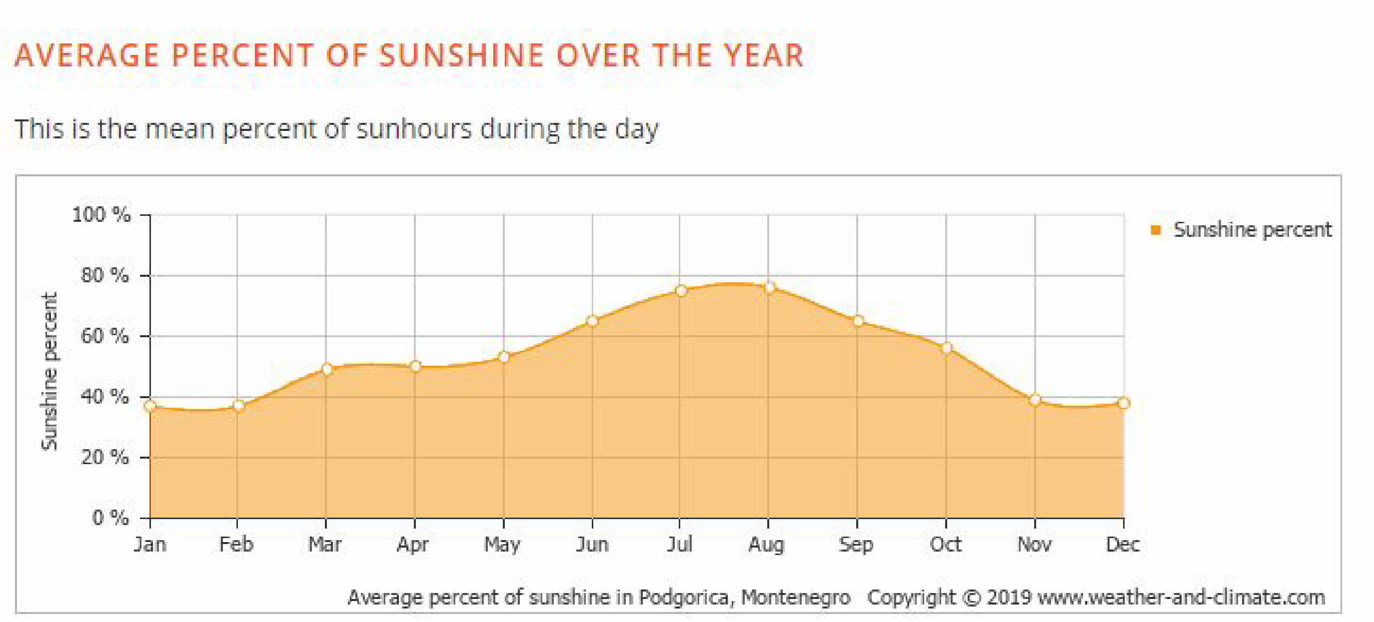


Analysis of the natural characteristics of the area

The granular sediments of the terrains are mainly of carbonate origin. These sediments are partially bound also by carbonate binders. This attachment is expressed in the overlying zone and especially in the wetting zone of surface waters and waters of the Moraca River in the flanks of its riverbed.
Quaternary granular sediments were finely sorted during deposition, gradually settling and subsequently more or less cemented, making real conglomerates somewhere. The terrain formed by these sediments is almost straight, with a slope below 100 (except those just past the edge of the Moraca and the very flanks of that trough). This kind of slope makes the terrain stable.
Good sorting, settling and sometimes more or less cementation of these granular sediments make terrains that build considerable payloads that can go as high as 500 kNm2 (5 kg/cm2) In some locations.

Hydrogeological features of the terrain and hydrology of Moraca

The data indicate that the Moraca water level at the station goes over 36 m above sea level. As the angles of the terrains (farther from the edge of Moraca riverbed by 5-10 m) are about 45 m above the sea level, it means that the groundwater level in the aforementioned terrains is below the terrain surface and at maximum water levels are 5-8 m.



Topography

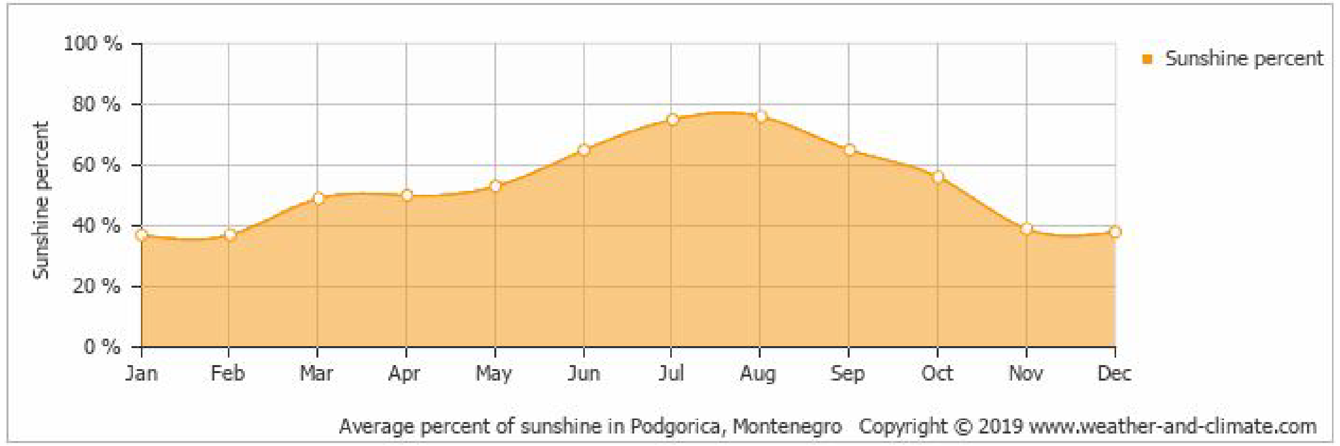
The complex of the Clinical Center engages in the morphological sense of the plateau field on the right bank of Moraca. The plateau of the field is at an elevation of approximately 42.00 m.
The Moraca bed in this segment has a characteristic notched profile with “caves”. The upper part of the coast is steep and difficult to reach and partly raised by an embankment

Climate

The urban area is characterized by a slightly modified maritime influence of the Adriatic Sea. Winters are mild, with rare frosts, while summers are hot and dry.
Specific microclimate characteristics are in the area of the city, where the anthropogenic influence of the industry on aeronautics is much greater, as well as the overall urban morphologies on air currents, humidity, solar, thermal radiation and more. In terms of microclimatic conditions, the location n of the Clinical Center, as well as the proximity of the Moraca River, have a share in the reduction of extreme temperatures, and the height and density of the plantations in the nearby park softens the strength of the north wind. (Secretariat for Spatial Planning and Sustainable Development, 2011)

AVERAGE PERCENT OF SUNSHINE OVER THE YEAR

This is the mean percent of sunhours during the day



Air temperature

The average annual temperature in Podgorica is 15.5 ° C. On average, the coldest month is January, at 5 ° C, and the warmest is July with median temperature at 26,7 ° C. The maritime influence of the sea is reflected in the warmer autumn than spring by 2.1 ° C, with milder temperature transitions between winter and summer from summer to winter. The average time period required for heating residential and other premises extends from November 10 to March 30, for a total of 142 days.

Humidity, fog, hail

The average relative humidity is 63.6%, with a maximum in November of 77.2% and a minimum in July of 49.4%.
The average annual fog frequency is 9 days, with ecstasy from 1 to 16 days. They do from December to June. Thunderstorms occur on an average of 53.7 days during the year.

Sunrise

The average annual amount of sunshine is 2,465 hours. The sunniest month is July, and the month with the least sunny days is December.

Cloudy

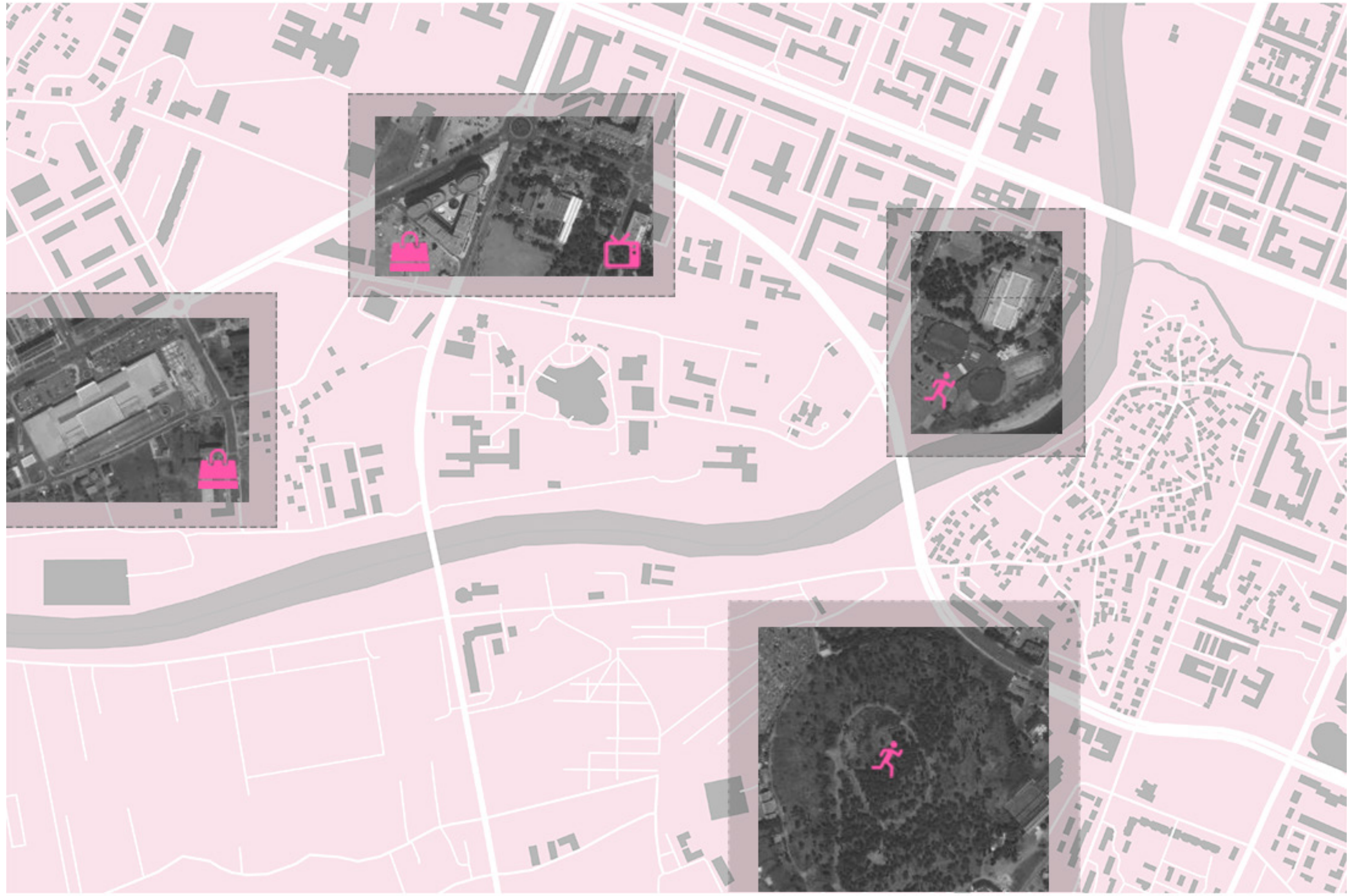
The annual cloud flow has an average value of 5.2 (one-tenth of the sky). The highest clouds are in November and the lowest in August.

Precipitation

The annual average rainfall in Podgorica is 169 mm, the highest in December and at least in July.

Winds

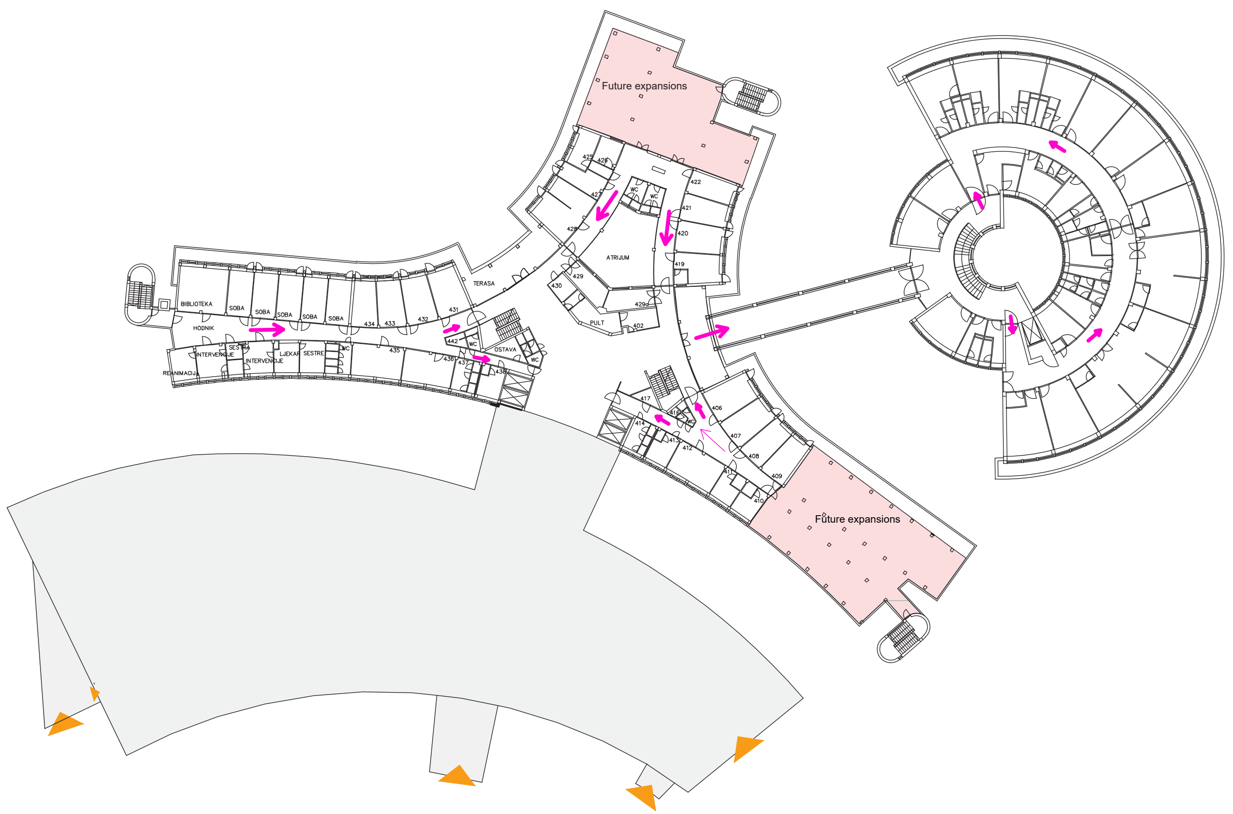
The highest wind frequency occurs. Stronger winds usually occur in the winter period.



Schematic representation of the contact zones

Analysis of the context on the subject space and vice versa

On the north side of the block is the complex of the Radio and Television building, a city park with a playground for children. The Atlas Capital Center complex is being built diagonally from the subject area on the northwest side, which is mainly a business building with a luxury residential part of the apartment type. On the west side, the plan is bordered by an apartment block, while on the east side is part of the Krusevac Park. This part of the park currently houses a Clinic for Psychiatry and Skin and Venereal Diseases, for which a new location within the boundaries of this urbanization plot has been designated. On the east side, a facility of the Secondary Medical School was constructed within the State Park “Kruševac Memorial Park”, and therefore the need to retain the old school building, which is still within the boundaries of this urbanization plot, ceased completely. On the south side of the block is the Moraca River, as the natural boundary of this complex, that is, the zone “Čepurci” on the south side of the river bed. The level of construction in the contact zones is such that it does not allow the expansion of the hospital complex beyond the defined boundaries of the current urban plan, therefore all solutions related to the future development of the clinical center must be sought precisely by the planning documentation. (Secretariat for Spatial Planning and Sustainable Development, 2011)



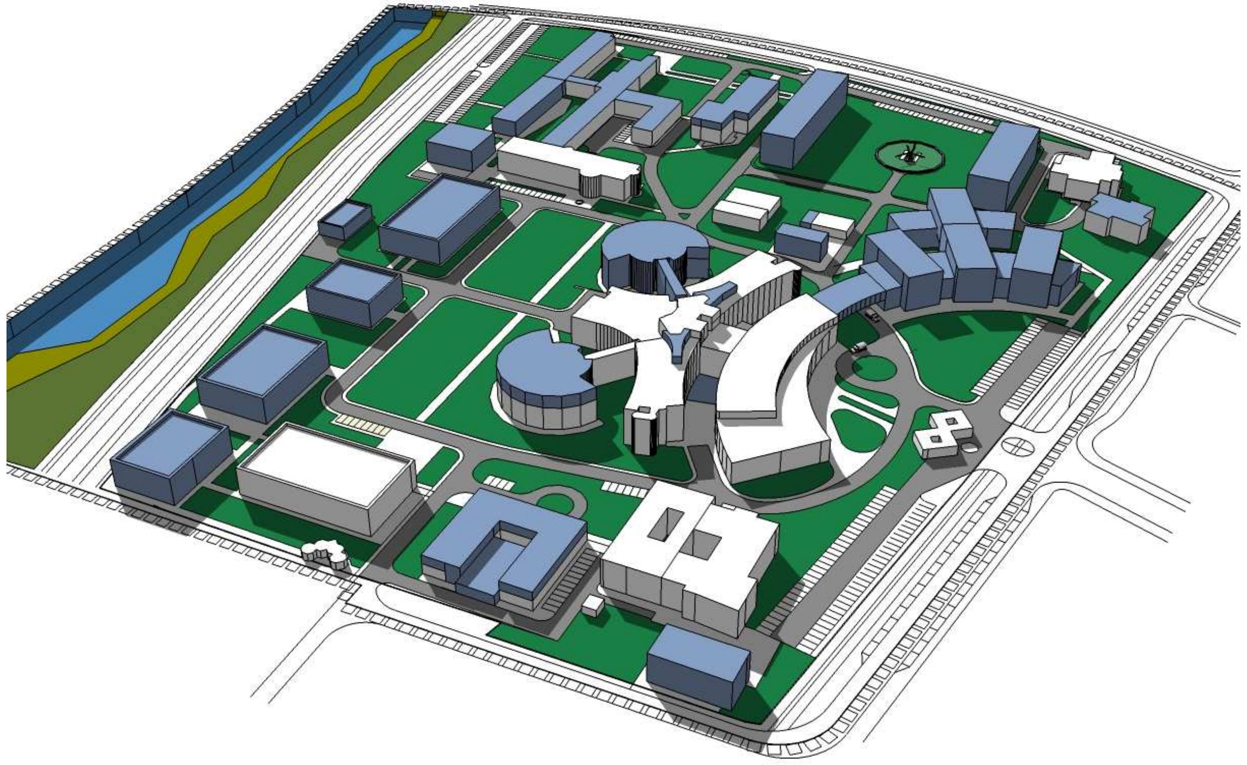
Main building expansion plans highlighthed in pink, scale 1:2000
plans source: http://www.sekretarijat-za-plurzs.podgorica.me/

General Objective:
Future Expansions of the Complex

The amendments to the urban plan for the ciry envisage new facilities as well as the upgrading of the existing ones, both content and capacities in accordance with the needs of the space users.
The Clinical Center Main Facility Complex will be complemented by new functional facilities:
Annex of the Clinical Center Main Facility is located in the proximity of the current Main Facility, within the entrance plaza. The access to the building, as well as the communications around the building, are adapted to the inherited condition while being up-to-date and functional. The Annex is connected to the Main Facility of the Clinical Center, at the level of the operating block on the second floor. In its shape, the annex supports the rounded front of the existing Main Clinical Center Facility and frames the entrance square space on the west side.
In contact with the described Annex of the Main Facility of the Clinical Center, but as an independent facility on the plot, the facility of the Institute for Blood Transfusion of Montenegro was planned. Particular attention has been paid to the design of this facility since it is intended as a separate facility, which will after the Annex has been built, be physically connected to the second-floor level (connection to the OP block of the main building).
In this sense, the form chosen had to be functional and acceptable both as a separate entity and as part of a complex. When positioning the facility, the requirement to provide 3 separate entrances to the facility was complied with - for patients of the clinical center on the northeast side, for employees on the east side and for blood donors on the southwest side. The circular annex of the Clinical Center Main Facility is located between the existing building and the Faculty of Medicine. The form of the annex attached is identical to that of the existing part of the facility where the internal clinic is currently located.

Current Clinical Center(white) with planned expansion marked in blue
image source: http://www.sekretarijat-za-plurzs.podgorica.me/

It is planned to upgrade the facilities of the Clinic of the Institute for Children's Diseases and the Institute for Children's Diseases following the existing dimensions.
On the south side of the Institute for Children's Diseases, a single track is planned for the Center for Neonatology, floors basement + ground floor + 2 floors above the ground level, which would form a functional unit with the existing facility, but the possibility of independent entrance on the south side has also been left. In the immediate vicinity of these facilities is planned a facility for the possible use of the Administrative Service, ground-level topped with two additional floors. A basement or basement floor is allowed below the property.
The facility of the gynecological-obstetric clinic is located in the area between the heliport and the Clinic of the Institute for Children's Diseases. When locating the facility, care was taken to observe the required distances from the hospital heliport, so as not to interfere with the manipulative landing and take-off space.
Contemporary and functional performance of the activity performed in the existing facility of the Department of Pathology and Forensic Medicine, and out of the expressed needs, contents within the complex of Clinical Center are planned, which, by its function, is not a medical facility, but is a link between the health care activities and communal functions.



Current Clinical Center(white) with planned expansion marked in blue
image source: http://www.sekretarijat-za-plurzs.podgorica.me/

The morgue will be located in the urban area, close to the existing Pathology facility. The object is oriented to provide direct traffic to the perimeter road to evacuate the deceased as soon as possible. Bearing in mind the planned contents of the hotel in the contact zone, the morgue facility is located on the south side of the Pathology facility, in order to make the necessary distance between the two facilities. The building is ground-floor with the possibility of building a basement. When drafting the project documentation, it is obligatory to anticipate the possibility of a driveway to the basement floor.
The planned building is on the ground floor, with a planned underground garage in the basement or basement floor, which enters laterally, on the south or east side. The location of the current garage and morgue, is planned to accommodate the facility of the Technical Service of the Clinical Center. The location of today's waste disposal site, on the south side of the complex, on the coast of Moraca, is planned to house the Medical Waste Management and Treatment Facility.
The projected floor is a high ground floor, which in this case implies a floor height of up to 7m. The facility would operate on the principle of a cold store and could receive waste disposal vehicles, which would approach the facility from the perimeter road along the Moraca River. In this way, disposal, storage, and loading towards the final disposal site will be done indoors, air-conditioned, thus avoiding the possibility of medical waste in any way coming into contact with the environment and thereby causing negative environmental effects. The location of the facility within the complex has been determined at the most functionally appropriate location and is located in the immediate vicinity of the bypass, which will allow waste vehicles not to enter the hospital complex itself. Since it is a properly insulated object, there can be no negative effects on the immediate environment.
(Official Statement by Clinical Center of Montenegro, 2011)

Targeted Objective:
Construction of the first national hospital specialized in cancer treatmentt

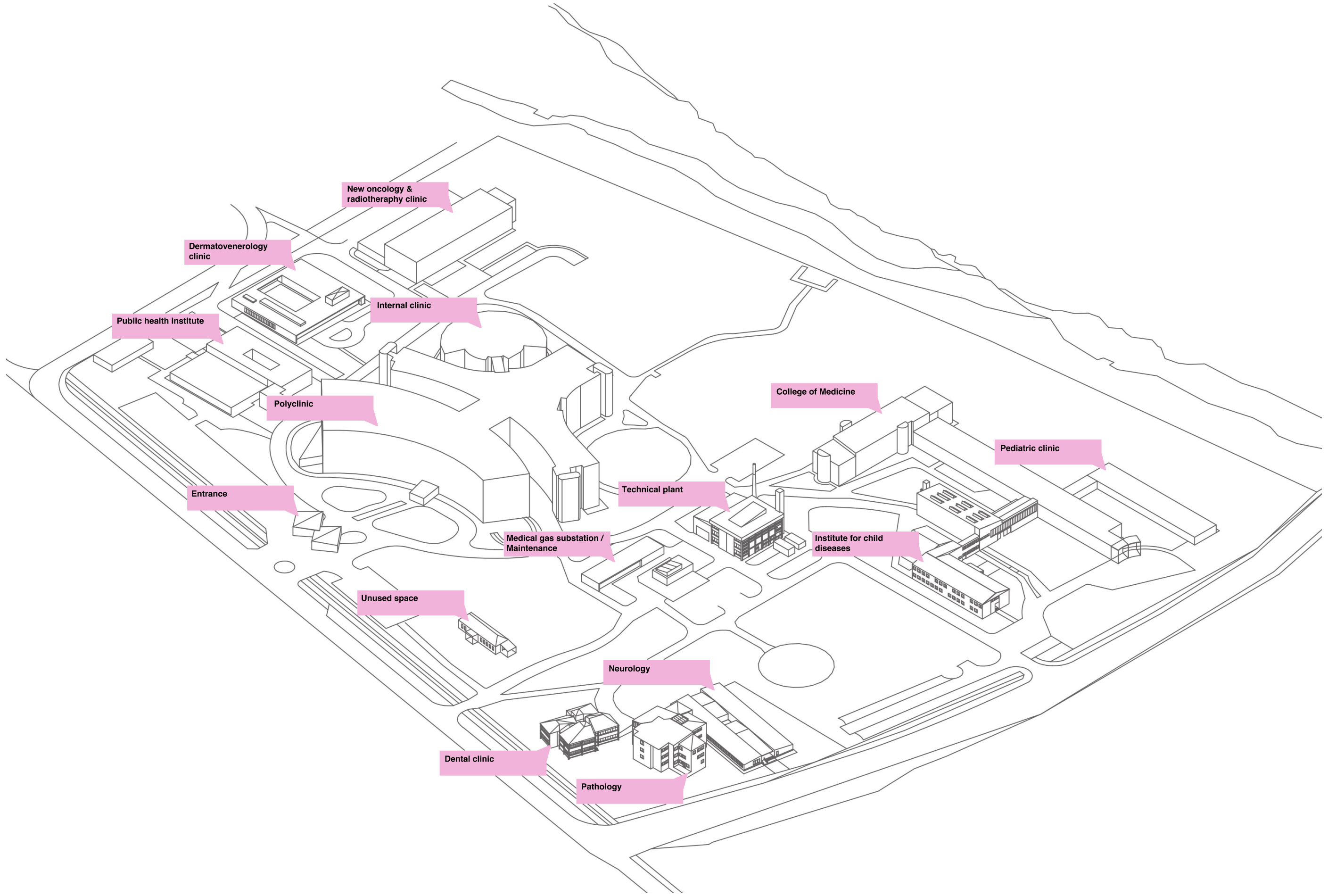
Hospitals provide health protection services at various scales. The Clinical Complex of Montenegro (fig. 1) is the only medical center providing free healthcare for every diagnosis. The numerous hospitals part of the complex, vary in size. From the smallest (50 beds), small (150 beds). to standard-sized hospitals (600 beds). At the time of the construction in 1968, there was no need for a large hospital (over 600 beds).
The hospital can have diverse functions: general, university and specialist hospital. KBC has all three types on its premises. The University is a stand-alone building, but within the complex, enabling students to have practical lessons in the nearest vicinity. General Hospital is the biggest one in the center. It an example of socialist architecture with a complex but yet modest modular constructive system. It administers health care at the level of consultations, extended stays, and operational units and therapy.
All successful hospitals have good planning, good design and good administration in common. By making sure the traffic is directed to separate different types of visitors and users, creates more comfortable zones. It minimizes the crowds to prevent distractions and create a more tranquil space. It is critical to keep communications efficient. Stairs, elevators, entrances, and exits are to the connection with the shortest route executable.

Giving privacy to important functions such as intensive care, operation blocks, and radiotherapy, by making sure to protect the users from the ever interest prying eyes of passers-by is another mean of client service and good planning.
The hospital should be very accessible no matter the size as it will be used by people that are most often spending a very short amount of time there or it is their first visit. In such circumstances, the users are not familiar with space. It means that the organization should be easily understood to prevent the users from getting lost and thus causing distress.
Not only should it be a pleasant stay for visitors, but it should also be an enjoyable space for the staff. Very regularly the staff is working long hours, spending both day and night in the workplace. Providing areas that are private and closed from the visitors and patients, is very important. These zones are meant for healthcare workers to feel like they are just as important as the patients.
Hospitals as such are very complex structures. Making inclusivity and individuality the priority, with no compromises in the comfort aspect makes a hospital a more humane environment.

Cancer is a disease that can affect a person at any age. It is unpredictable and in some cases, unfortunately, incurable disease.
Unofficial data states that there are now more than 3,000 cancer cases in Montenegro, and this vicious disease takes about 1,300 lives in the country annually. Currently, there are about 2,000 oncology patients being treated, up three times more than nine years ago when there were 650.
The idea of architecture curing cancer may seem unthinkable. However, designing spaces focused on wellbeing is a treatment in itself. “It relies on research and data to create physical spaces that will help achieve the best possible outcomes. In the context of cancer care, this means designing environments that are not only places where people can receive the highest quality medical care, but also places for them to heal.” (Bauer A, 2014)

A most prominent example are Maggie’s centers throughout the United Kingdom. They offer a solution to the misery of an intense hospital stay by humanizing the space. They give hope through architecture. The life of a patient in a cancer-treating institution is often solitary. Visits are limited to a few hours, hence the isolation is an everyday norm for the patients. There is an absence of external factors, such as society, music, art, and culture. Common spaces for socializing are few. There are even fewer spaces for contemplation Meditation is not very widespread in Montenegro. Treating illness by healing the mental state is almost unheard of. Maggie, who passed away from cancer a year prior to the opening of the first center, understood the healing process differently. It is not restricted to the physical space. She proposes natural, organic spaces enabling healing on every level. The patients are surrounded by friends and family for support. The common areas are full of sunlight. The hospitals feature personal space reserved for patients to focus on themselves.
Hospitals are undoubtedly medical institutions, but they tend to be one-dimensional. Healing from disease as complex as cancer requires so much more than what contemporary mainstream Western medicine gives at the moment. (Medina, S, 2014)

Guidelines



Isometric view of the current services provided by the Clinical Center

The south side of the plot is planned for the purpose of the Oncology and Radiology Clinic. It was conceived as a separate entity, but not isolated from the rest of the complex. Consideration was given to the need to create a more comfortable environment for the patients, which implies the possibility of organizing landscaped green spaces housed in separate microbial. The facility for the possible Clinic has the permitted height of Ground + 2 floors. A basement floor is allowed below the property.
Future expansions envision the hospital to feature space for at least 50 beds for the hospital stay. The rooms are equipped with single beds while being spacious enough to accommodate an additional one in case of dire need. Dimensions are uniform with the minimum square area of 18 m2. Bathrooms have to be at least 3.5m m2. The hospital should include at least 6 doctors' offices, and 6 nurse stations. The height of the rooms is suggested to be 2.8m.
The building is restricted to the ground and 2 floors above ground. There should also be an underground floor with technical rooms and a depository. The ground floor should include counseling, an office for the head of the hospital, administration, ambulatories, main entrance with an information desk, as well as day hospital. The communication is to be done predominantly with elevators. There are staircases in case of emergency. The first and second levels should include doctor's offices, nurse stations, intensive care units, special treatment rooms, presentations and meeting rooms. Communications should continue in the same manner as conducted on the ground level. An oncological hospital should include both operation block and radiotherapy rooms.
The Oncological center will be offering both daycares, ambulatory consultations, intensive care units for extended stays. The hospital has a radiotherapy unit and operation block.
The positive location of the new hospital within the complex guarantees the patients are taken care of. The University of Medicine on the ground of the KBC provides direct contact for the students with the practical work. The location of the hospital is by every means very central in the city. It ensures the users, both staff and the patients are staying in an environment that is not secluded, as not to cause unpleasant or uncomfortable stay.(Official data by Clinical Center of Montenegro, 2011)

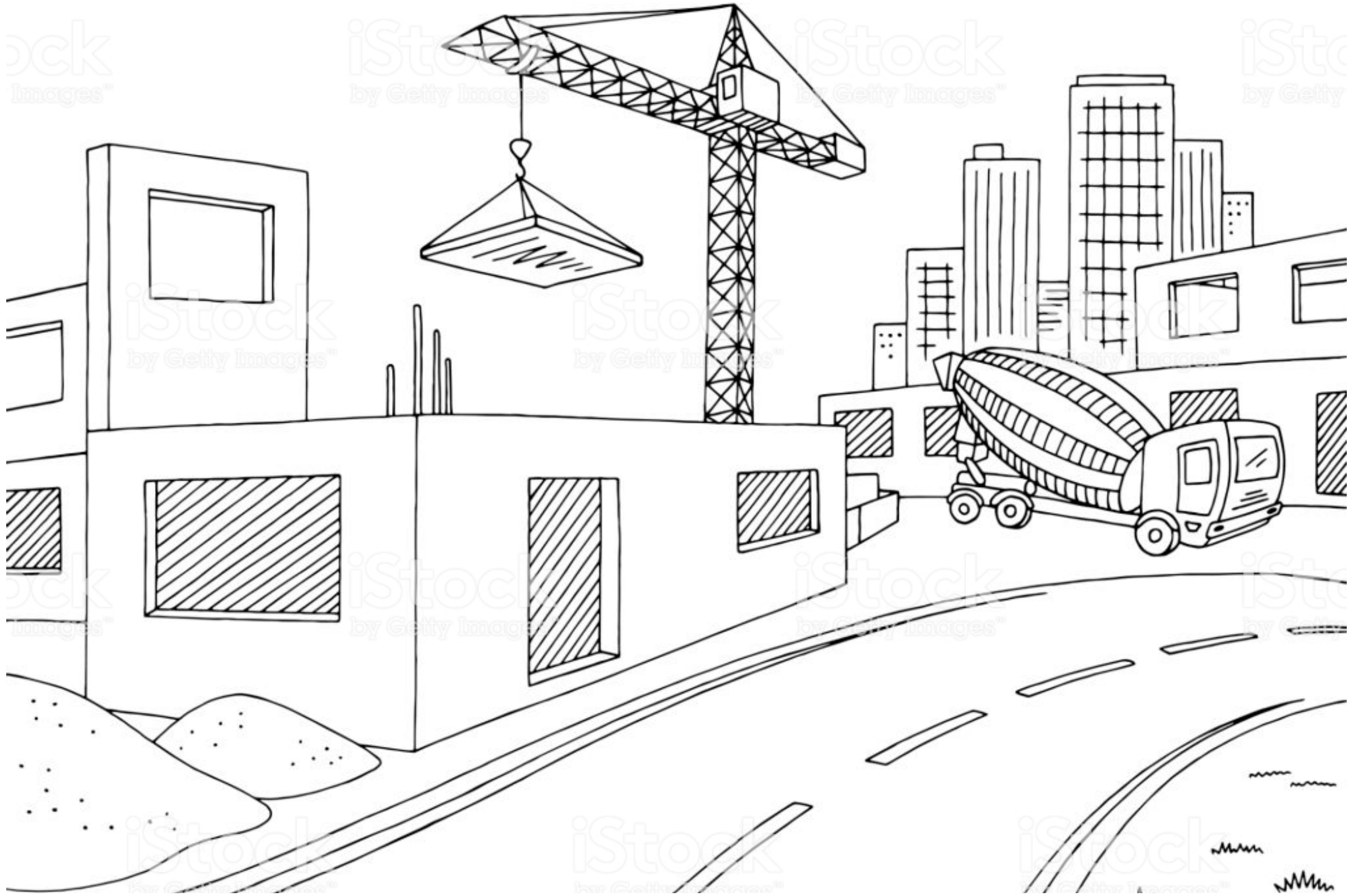


image source: google images

TECHNOLOGY

2.1 Modular (Off-Site) Construction

Modular is any system composed of separate components that can be connected together. The advantage of modular architecture is that we can replace or add any module without affecting the rest of the system. On the contrary, integrated architecture means there are no clear divisions between components. “A modular system is characterized by functional partitioning into discrete scalable and reusable modules, rigorous use of well-defined modular interfaces and making use of industry standards for interfaces.”() One of the highlights of the application of modular design is the flexibility in design and reduction in costs it offers. Examples of modular systems are everywhere. It ranges from modular buildings to smaller scale items like solar panels, wind turbines, etc. Modular design combines two very polarizing aspects. It takes the advantages of standardization while leaving space for customization. (Swiszczowski, M, 2020)

fig. 5 - Blok V, Podgorica, Montenegro, 1984.
image source: google.imagest

Origins of modular construction

The first modular design can be considered as Buckminster Fuller. Fuller experimented with flexible housing in the early decades of the 20th century. The most famous example is the Dymaxion House. It came equipped with a prefabricated bathroom module. US military would later use these modules during World War II. The first fully modular home was constructed in 1933. It was built using the newly patented exterior finishing material called Cemesto. Cemento was a panel board made partly of sugarcane, It was crafted by the John B. Pierce Foundation. The first modular house consisted of several modules-rooms, with a 'service core'. The bathroom, kitchen, plumbing, and heating systems were attached to the core. In 1942, the US Government used a similar Cemesto prefabrication system to build a completely new town - Oak Ridge, in Tennessee, location of the Manhattan Project. The town was built practically overnight. Perhaps the most famous example of the modular construction to date is Habitat 67, built for the 1967 Expo in Montreal. It was a graduate project by Moshe Safdie. Habitat 67 consists of identical prefabricated concrete modules. Modules served as apartments. They were arranged in variations. On the other side of the world, Japan developed an architectural style of Metabolism. It is an architecture focused on flexibility and modularity. The most known Metabolist structure is the 1972 Nagakin Capsule Tower, by Kisha Kurokawa. The Nagakin Capsule tower is made up of 140 prefabricated capsules. The capsules were complete with bathrooms, cabinetry. The modules are tiny, designed to be removable and replaceable. They are a predecessor to contemporary micro-apartments. (Wagner, K, 2016)

An example of modular construction in Montenegro is Blok V (fig. 5). A mass housing block built in the late 70s, as a part of the city expansion plans. The buildings have a service core. Much like the one seen in the first modular house built in 1933. It consisted of a bathroom and kitchen attached to a bearing wall. Every other wall in the apartment was removable and it could be replaced and repositioned as to the wishes of the inhabitants. The architect had strict state-order rules that had to be followed. This made prefabrication much more difficult. But as Habitant 67 mixed the modules, the architect of Blok V – Mileta Bojovic, made every room according to the standards. These modules would later be moved like Tetris block to fit in the pre-determined sizes of a one-, two-, or three-bedroom apartments. They were extravagant in the time of the construction. They still stand as one the most prominent examples of the possibilities with modular construction in the restricted context.

Though mass modular housing has had a few successes such as Habitat 67, there is still hope. The rise of new forms of housing combined with a highly technological age, create perfect conditions for the expansion of affordable modular housing.

Prefabricated modules, brought to the construction site
image source: cadolto.com

The Challenge of Modularity

Modularity means using the same module in variations permitting a broad variety of designs by minimizing the number of component types. It is especially advantageous when the scale and scope of the project are relatively big. Modules provide a more practical and economical option. “Through modularity, you can achieve various designs, while achieving low-cost for development, as well as, cost-saving in design and construction. “(McCluskey, 2000).
On the contrary, modularity may lead to excess cost due to over-design, inefficient performance, and too many common modules that may result in loss of design identity.

Modular Design Approach

Modular design is characterized by upgradability, serviceability, flexibility, etc. The way we use modularity and the objectives of modular systems is how this particular system of design could influence architecture. There are infinite numbers of architectural designs and forms potentially generated with a basic set of modules.

2.2 Upgrading To The Next Generation Of Design

The architecture of most personal computers allows you to easily replace an older hard disk drive with a new one, because the interfaces between the hard disk drive and the rest of the computer have been defined to allow a range of variations in hard disk drives. (Sanchez R, 2000)

Architecture has a two-part definition. The first part is a decomposition of the overall functionality of an item into an array of defined functions and the components of the product that are going to provide those functions. The second part of the definition is the specification of the interface between the components, in other words, how components are going to interact together in the product as a system. The specification of the interface is critical to the design of flexible architectures that allow you to substitute component variations within a product without having to make adjustments in other components. “For example, the architecture of most PCs allows you to easily replace an older hard disk drive with a new one because the interfaces between the hard disk drive and the rest of the computer have been defined to allow a range of variations in hard disk drives.” (Sanchez R, 2000)

The expansion of modularity can in effect allow the locus of a product definition to shift from producers to consumers. Designers were historically in charge of the product alterations and upgrades - decisions on product functions, features, and performance levels, and which is to be modified was always in the hands of the designers. They had to recognize what would sell and then offer a competitive product to the market. All in hopes that the product they have designed will have a positive response within the audience. Modularity is already happening in a number of industries. It is not exclusively tied to the computer industry. Modularization is an established method in the global bicycle industry. A bicycle can be assembled with the components that are chosen by the customer, made by different suppliers. All the components are made to fit standard measures. This is also happening in clothing. When a firm uses modular architectures to personalize product personalization, consumers can choose between a variety of components, but the final call in the specifics of component variation is still the firm’s decision. (Swiszczowski, M, 2020)

Taylor Chapman’s project for a hotel completely constructed of recycled shipping containers
source: http://www.chapmantaylor.com

Cadolto's module production is entirely exectude in a factory
source: http://www.cadolto.com

The modules are completely prefabricated in factories

Standardizing the elements of an architectural component, either completely or partially, it results in the creation of an open market. Companies interested in producing the component have to be creative in the manner of design and production of the component, by first getting to know and understand the use and application of the components.
Cadolto is an example of successful entry of a company into the prefabricated modules market. Citing noise, dust, emissions, weather impact, delays, trouble with trades and inefficiency as some of the reasons to go modular, Cadolto suggests using their modules as a more reliable and proficient constructive system. The modules are completely prefabricated in their factories. As everything is built in a sheltered space, the construction is not reliant on the external factors as the weather. Not only is it very efficient, but it also permits the construction to stay on time and on budget. One modular construction plan is complete with all the technical systems and equipment. Hence the modules come equipped with heating, air conditioning, electric plugs, manufacturing a completely modular structure. To respond to any specific target, modules may also include medical, laboratory and building technologies. Finishes such as tiles, window coverings, furnishings, and exterior cladding. As it is completely independent, construction of the building structure can begin at the site, while the modules are produced. As soon as the structure is built, modules are inserted, a totally time-efficient and time-saving construction method.
Modular construction makes it possible to complete relocate the building to another site. It would not be possible to so with conventional construction methods such as concrete structures. Modular buildings can last for as long as conventional buildings. As a matter of fact, they can even last longer. All building materials can be sorted and reused in new constructions. Giving everything a new life while being sustainable and protecting the environment from excess garbage and saving resources. (Cadolto, 2019)

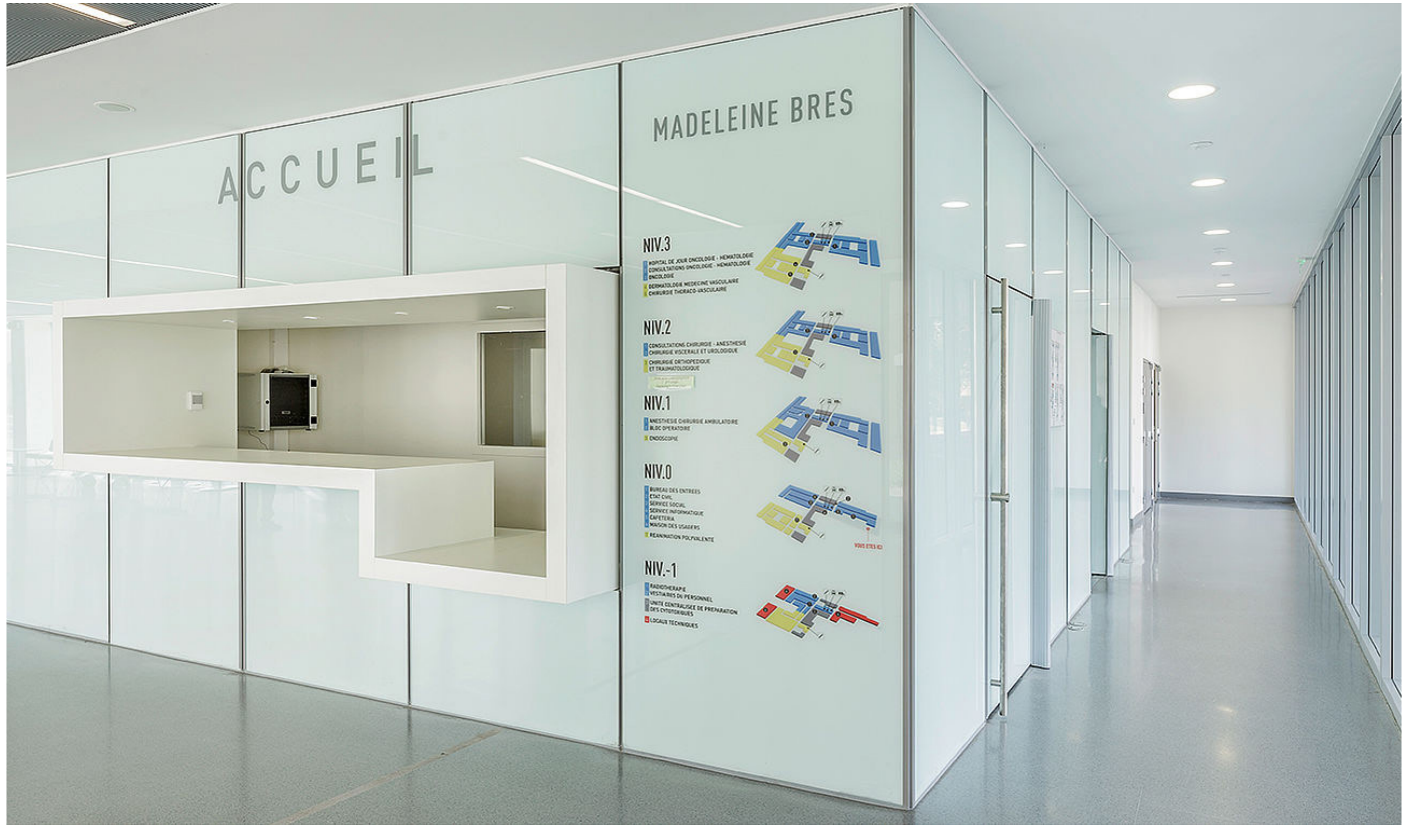
2.2.1 Case Study: Centre Hospitalier D’Argenteuil

Paris, France

Centre Hospitalier D’Argenteuil
image source: http://www.cadolto.com

Conventional building meet modular construction

The advantages of modular constructions for hospital architecture is shown in the case of another Cadolto project. A hospital in Paris, which is a combination of both conventional construction and the modular building. Underground and ground levels were erected in a traditional manner, but moving on to the upper levels. From first to the final, third floor Cadolto’s modules were inserted. The total count of modules sums up to 330, with various uses. The majority are ward units, followed by operational units, with functional units coming last. The project it the biggest modular construction in Europe, with a total gross floor area of almost 13000 m2. (Cadolto, 2013)
This particular Parisian hospital follows the current trends in architecture. A lot of experiments, particularly in hospital constructions have been tested. Modular building permits an easy expansion in both horizontal and vertical levels. Modular constructions gain particular leverage for all the advantages it ensures in comparison to traditional buildings. A significant time saving is guaranteed as the modules are completely prefabricated independently from the structure. Module manufacturers certify that the units are only to be inserted with no major construction work on sire. A process is a very simple assemblage of the units in the structural skeleton. This system allows for more precise project management in the time aspect. It is also advantageous in terms of workers’ security by minimizing the tasks of the construction site workers. Every module satisfies specific quality control laws. Everything can be modified in case of conflict with regulations of specific sites. This also means that every module can be easily replaced in the maintenance stage of the project’s life cycle. It can be replaced, fixed and dismantled without affecting the surrounding modules. By knowing the exact materials and equipment used, later reuse of the forementioned is facilitated.



Interior of the Centre Hospitalier D'Argenteuil
image source: http://www.cadolto.com

First modular constructions were criticized for the lack of protection in case of seismic and risks of fires. But newer modules are designed to follow the demanded regulations, as well as make sure to satisfy hygienical standards. Modules have to allow natural insolations, along with necessary shading and noise cancellation to enable a pleasurable stay for the users.
Some of the limitations with modular construction may include the need to design everything in advance, as the project needs to be managed according to the production of the modules. Necessary information and expansive analysis of the modules need to be finished in the early stages of the project. By entrusting the module manufacture to a certain company, it automatically excludes the possibility of another contractor taking over the production and implementation as every production is company-specific. This is quite constrictive especially in the case the company is unable to finish the production. Another potentially compromising aspect is the limited number of companies, producing prefabricated modules, on the market today.
Particular attention is to be paid to the dimensions of the modules as the bugger units could significantly increase transportation costs and logistics.
The use of typical and repetitive units means a compelling reduction in the construction costs, as well as the elimination of the competition, as only the manufacturing company can do maintenance work on the modules. Modules are to be inserted in an autonomous static load-bearing structure that is in protocol with fire and seismic regulations. (Desideri E, 2011)

2.3 Circular Economy in Architecture

In a report released in 2014 by the European Commission, construction and use of buildings in the EU represent 40% of final energy use, 35% of greenhouse gas emissions, 50% of all extracted material, 30% of water use and 35% of all generated waste.

In the face of increasingly scarce raw materials, the reuse of raw materials, with undiminished quality, is becoming increasingly important. Current ways of raw material recovery (recycling) are often based on the linear model in which profit maximization and not the actual preservation of raw materials are central. That is why valuable raw materials are still being massively and irrevocably destroyed.
To prevent the depletion of the earth's resources, it is necessary to conserve resources and to use them again and again for new generations of products. This can only be achieved through social & economic change. We must switch from a linear to a circular economy. This marks a fundamentally different approach to a housing challenge; not resulting in a self-contained building but as an active element in a circular system. At the area level, energy level, material level, social level, and realization level: boundaries are blurring and synergy is created.
The entire life cycle of a project is taken into account, from design to demolition and all phases in between, nothing is left to chance. The exact data on which and how many materials are used in a project comes in handy when maintenance is to be carried out and the situation when the building is to be dismantled.

Reusability

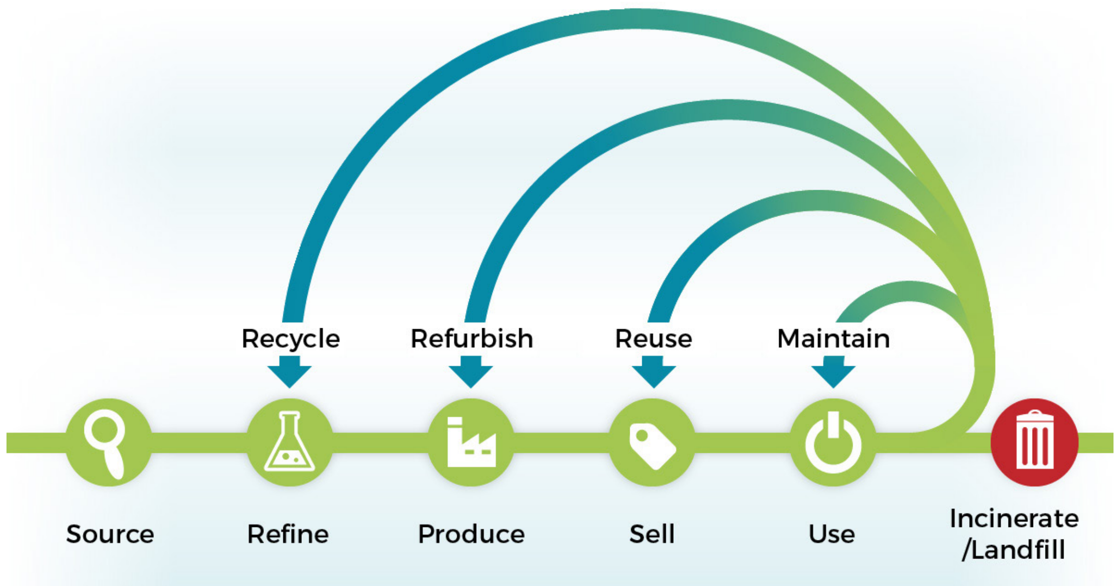


Diagram showing the circulation of the constructive materials
image source: https://circulartayside.co.uk/circular-construction/

Modularity can facilitate the operation of the production company. By making use of the fast upgradability of a modular architecture, it will create an advantage for the company in the market place. By opening up to modularity and transferring the benefits of it, one can configure product variations and offer diverse upgrades to various customers.
Reusability is a key element. Especially for the user who will save money by choosing to reuse the materials. The reusability of components and processes has become a central issue for a lot of companies in their design strategies. There are a number of reasons for this. The cost of developing a product versus manufacturing is starting to shift progressively to greater investments in development. By producing one component design and creating a component design that can be used in a number of product variations or across product generations, or preferably both, it saves tremendous amounts of money on development costs. This can also speed up the delivery of improved products based on selectively upgraded components to the market in the future. The second benefit of reusing components are the possibilities to understand and control the quality improvements at the component level. With time, it will lead to the smarter reuse of the components. Smarter in the sense that it will be cheaper and better. One of the principal approaches to improve the reliability of products is the commitment to the reuse of the components. The more a component is reused, the more that it is worked with leads to it incrementally improving. The component and its production process will progress, and thus make the component more reliable. "Embracing and correctly implementing a circular economic model—a philosophical change in how one conducts business—can solve current problems with immediate and long-term benefits. Instead of the traditional "take, make, and waste" system, the circular economy is a closed-loop regenerative approach of "take, make, and reuse." This can help all supply chain entities—from sourcing, manufacturing, and operations to end-consumers—become more prosperous." (R. Sanchez, 2000)

2.4 Circularity in Construction

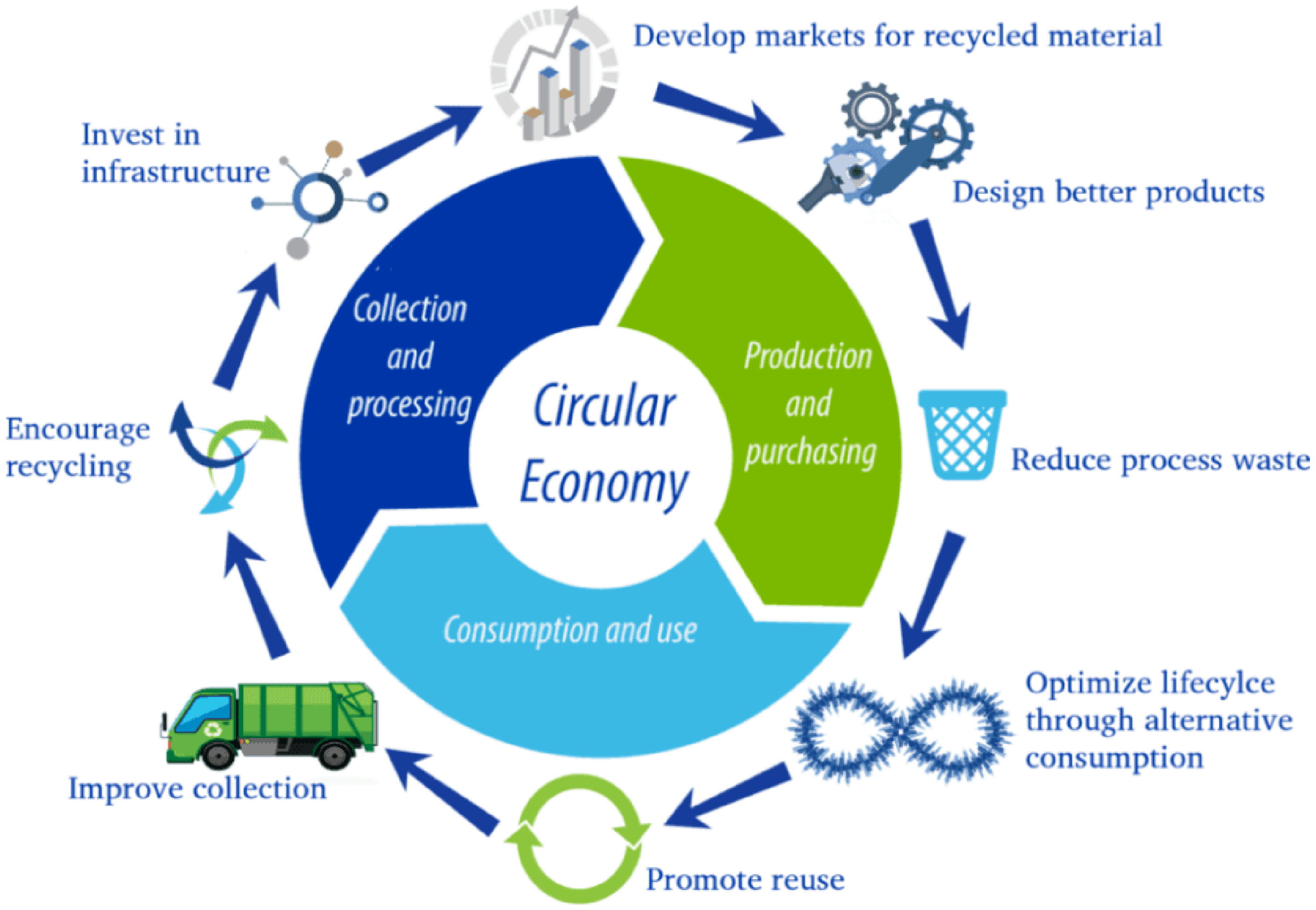


Image: Sustainable Global Resources Ltd. Recycling Council of Ontario

Consciously choosing better-performing technologies

The goal of constructions in the new millennium is to accord to certain standards while choosing the best performing technologies. The buildings are made sustainability or environmental guidelines leading to more nature-friendly architecture.
Starting with system optimization, the construction industry ought to adapt its practices. Prolonging products' use period through repair/maintenance, as well as the encouragement of design for durability and upgradability as prevention of mindless wastefulness. Another action is decreasing resource usage by either increasing efficiency or designing out waste. Optimizing the logistics system through the implementation of reverse logistics, meaning that we need to start thinking about what happens at the end of building life-cycle, and design in reverse.
In a building environment, circularity can be enhanced with prefabrication, or production that is executed off-site. Smart urban design - sustainable and growth-enhancing planning, along with energy efficiency achieved with a particular design of building envelope. Other ways include conscious water use - water re-use and circulation of water in the building. Reduction in transport-related to construction as well as material efficiency are the main paths to establish a more circular construction project.
The loop of building materials can be encouraged by remanufacturing, refurbishing and recycling of the forementioned. Remanufacturing and refurbishing can be further stimulated by designing products that are easier to dismantle and disassembly. Piece-by-piece demolition, material banks, stock management are also remanufacturing techniques. Making a conscious choice to implement products that can be recycled is crucial. Optimizing the end-of-life of building products such as durability, maintenance, re-use are all forms of circularity. The modularity of the building specifically modular building techniques, multi-purpose volumes, and flexibility in buildings are another means. Selecting resources and technologies wisely by shifting to renewable energy and material sources, using alternative material inputs, replacing traditional with advanced technical solutions (e.g. 3D printing), replacing product-centric delivery models with new service-centric ones. On the other hand, choosing better-performing materials (advanced materials discovery), better-performing technologies (e.g. 3D-printing, building management systems, electric engines), new products and services (e.g. multi-modal transport) are choices made on construction site. (Tikkanen, S, 2019)

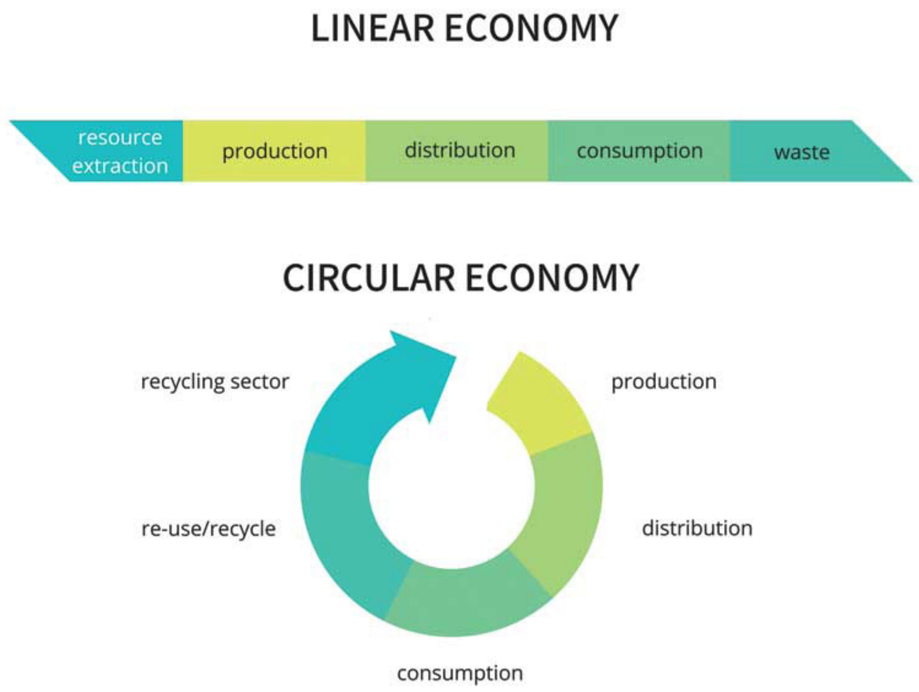


image source: https://www.constructionspecifier.com/the-circular-economy/

The reign of the conventional building is crumbling

Formerly mentioned modular construction company Cadolto is encouraging the circular economy of the buildings with its construction approach. “More than 70% of our construction projects are as much in use today as they were back then. The rest are being used in other forms. That is one of the ways we define “sustainability”.” (Cadolto, 2019)

This is made clear - the reign of the conventional building is crumbling – literally. While 70 % of the elements used in construction projects by Cadolto are still in use for their initial purpose at the moment, the remaining 30 % are repurposed and reused in new projects, either in their entirety or in parts. It is a form of modular up-cycling. And if the life cycle of a module should come to an end one day, 100 % of the construction materials can be reused.

Off-site prefabrication is a through-and-through sustainable modular construction approach. It gives an additional advantage: flexibility. Every building can be expanded, relocated, dismantled, or have stories added to it. Everything can be executed in minimum time. Sustainability implies efficiency: from the planning stage to final construction. The local environment also benefits from the prefabrication approach. Cadolto states that by using the prefabrication approach they minimize the quantity of packaging materials and emissions at the construction site. They cite “80 % less construction site traffic than conventional construction sites.” This potentially means fewer environmental risks and an all-round advancement in the environmental balance.

2.4.1 Case Study: Brummen Town Hall
Brummen, Netherlands

“The Brummen Townhall was the first building in the world conceived as such a materials depot.” (Rau T, 2016)

Brummen Town Hall post-intervention
image source: http://www.bamstudio.it/en/

The Town Hall is designed to be dismantled in 20 years. It is a completely innovative design process, by thinking backward. How can the materials be used again after the current use is abolished. It is the reasoning that places importance in knowing how things will finish before starting them.

Brummen is located in the Netherlands that is currently undergoing a process of merging neighboring municipalities. Hence the current Town Hall may no longer be the municipality center. The expansion was planned in consideration of this outcome. The new addition is made for dismantling and continuous use of reusable and renewable materials, that are of very high quality.

The existing Town Hall dates back to the 1890s. The historic landmark was left intact, with only necessary restorations being done. A new glass roof connects the new extension to the building. The designers predict 90% of the materials will be reusable after the end of the service life. Dismantling will leave the original structure uninterrupted.

Materials used in the construction all have a passport, with the specification on each product used including a secondary destination for some. The concept of a town hall as a raw materials depot - a temporary construction - made it a necessary and logical step to create a raw materials passport in order to enable the reuse of all components after the dismantling of the building. All details of the building are known and documented, including their destination in second life. The novelty of the concept made it a challenge to convince the client of the necessity of a materials passport and to obtain all the necessary data from suppliers.

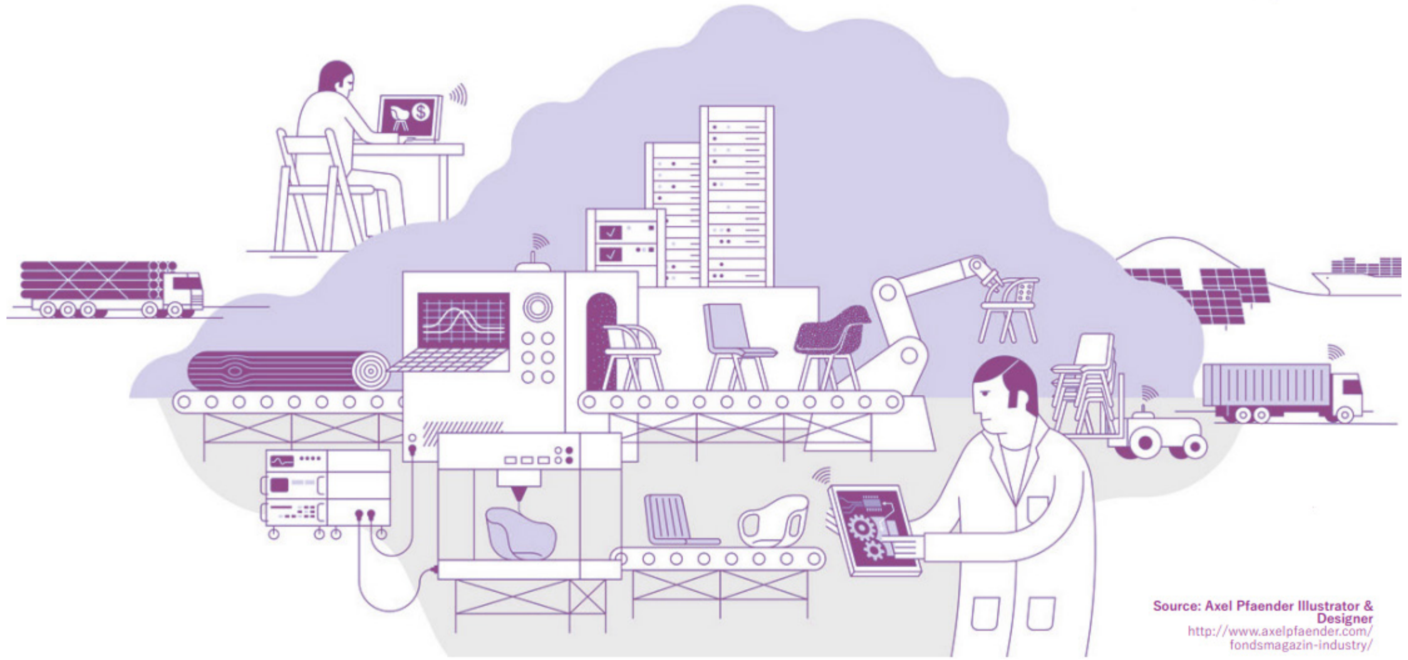
This project presents a completely new way of imagining and designing buildings. It leads to new considerations of the temporary function the buildings offer, and how can it be facilitated through a modular and circular building techniques.

The project was awarded the Dutch Award for Sustainable Architecture in 2013. (CE100, 2016)

Modular Elements meant for reuse in Brummen Town Hall
image source: http://www.bamstudio.it/en/

The fact that the wooden beams were made larger, not thinner, made the team realize that Key Performance Indicators (KPI) in the circular economy are not necessarily the same as in a linear model, where less, not more material would have been considered an achievement.

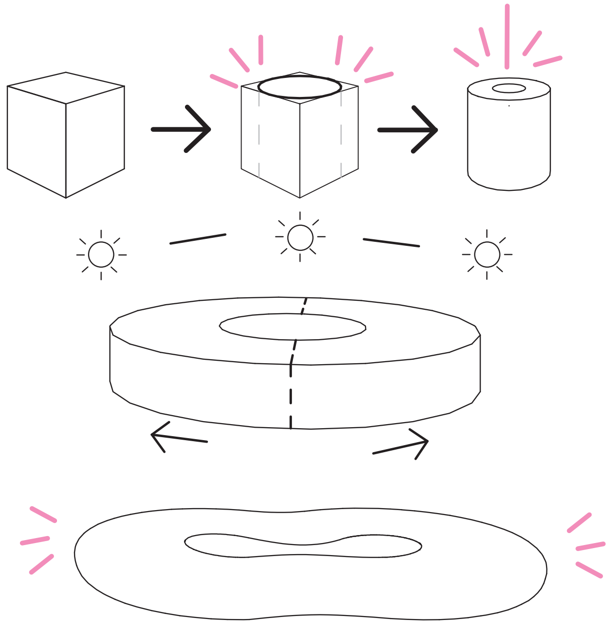
The expansion is a modular construction that greatly reduces construction costs. By saving on the excessive money loss for on-site construction, it provided a bigger budget for using higher quality materials. The use of concrete was minimal. Instead, reusable materials were preferred with the planned secondary utilization in the future. All the pictured wooden components are prefabricated off-site and can be used in a new building after dismantling. Interestingly, manufacturers asked for several minimal, yet very intentional, design changes so that the components would have an easier case for their second-life application. The timber supplier wanted to provide timber of larger dimensions because it will be easier to reuse in 20 years when the materials are set to be returned. Co-operation with manufacturers alleviated the future handling of the resources utilized.
The modular design not only saved time but minimized potential failures in the construction process.
An undoubtedly visionary approach to design was challenging to manage, as it required intense involvement of architects, circular economy specialists, and builders in order to ensure the execution of the envisioned design. The design and construction process needed particular guidance. Initially, suppliers needed a bit of reassurance and convincing on the part of the design team, but this cooperation assures a very high degree of circularity of the building.
The fact that the wooden beams were made larger, not thinner, made the team realize that KPIs (Key Performance Indicators) in a circular economy is not necessarily the same as in a linear model, where less, not more material would have been considered an achievement.(CE100, 2016)



Source: Axel Pfaender Illustrator & Designer
http://www.axelpfaender.com/fondsmagazin-industry/

03 THE PROJECT

3.1 Design Process



Concept evolution

The design concept evolved from a simple form placed on the plot as indicated by the urban plan of the city adopted in 2011. Located in a city characterized by strong winds in the winter, the curvaceous form imposed itself as the most organic. Proposed guidelines for the new hospital aim for a more grounded structure. They are less then 100 days per year is without the Sun in Podgorica. Sun is the main actor as it is proved to aid in not only psychological but physical amelioration of people. Opening up the building with an atrium allows for the sun to penetrate an otherwise too closed off construction. The final design presents a very unconventional form for a hospital. The idea is the hospital not only to be placed for a physical ailment but mental as well. It is a space that is able to transcend the walls it is enclosed with. This hospital shows different ways in which architectural design can reflect, invigorate, and direct daily experiences.
By mixing local culture with the natural environment, the oncological center acts as a microcosm, encouraging an organic passage between interior and exterior.
The rooms offer visual access to the outdoors. Some are facing the atrium, other face the context of the clinical center. With a large indoor space, patients are encouraged to find solace in the spacious room together with their families, as well as in the grandiose sunny spaces for social exchange.
The approximately 2000 cancer patients that will potentially visit the hospital does not include temporary visitors. The user of the space come in for various motivations. Some are here to find treatment, some for support and others for guidance.
Not every patient will walk out as a survivor, but while providing treatment, the hospital is designed to give safe, healing spaces. Spaces that will encourage hope and improve sometimes insufferable conditions that patients face in treatment facilities. This highlights the importance of architecture and design in everyday life.
It is crucial for the design to follow the vision in order to reach the ultimate objective. Health care facilities are often designed to deliver more health care rather than more health. As noted in the first chapters of the thesis, hospitals are typically divided by the terms of bed occupancy. This results in a hospital designed to accommodate as many private rooms as possible, leaving minimal space for walking. Recent studies highlight the importance of getting up, walking around, and interacting with the environment is just as essential for recovery as medical treatment. The traditional hospitals are delivering health care, forgetting the main objective is the overall improvement of health, not just treatment of the problem.

Patients and their families, along with hospital staff: physicians, nurses, administrators, and architects on the other side comprehend the issues differently. They are all key factors in understanding why the order of things, they orchestrate the movement and communication in the hospital. Typical hospital room has patients lying with their heads to the exterior wall while doctors and visitors can look out the windows. Changing the narrative is an innovative way of improving hospital stay. Orienting the beds in a way the hospital patients get the view of nature instead of seeing other sick people is a passive form of treatment.
Mapping the invisible to ensure better understanding. By making maps and drawing out the movement of the people, who communicate with each other and those who don't, spaces where social interaction happens and the room where the medical work is conducted. Understanding that different users are seeing the same thing, but grasp it distinctly. It uncovers the hidden dynamics that influence the behavior of the users. This can ensure the more natural design, that will facilitate movement and make users more feel more at ease as they can follow their instinct and move in the space.
Planning is about constant innovation. Planning in assumptions that the future is uncertain is very present in the design of the hospital. It unfreezes the design. The modular design enables the circulation of the materials at any given moment in time. It does not put an end to transformation. It encourages it, rather. If at any time, there is a need to repurpose the hospital to something else, or to another specialization, the materials are reusable and recyclable. Such an option is key to unlock various doors. It is not to be understood as infinite reuse, but rather once the need arises, the hospital elements are available to answer to the cause of redevelopment.
Considering the social aspects in design does not only lead to improved results in terms of patient health, but it also prompts hospitals to become more lucrative in the era when patients seek information to a greater extent, in order to decide on the choice of the health care institution. Aspects such as design is an important factor in decision making. Although patients and families may not phrase them as design, it inherently is. By taking into consideration whether the hospital has enjoyable waiting areas, livable rooms, easily orientable spaces is an unspoken pivotal point in the decision. Some consumers better understand their deliberations by preferring the facilities with better relations with its environment and its reputation for promoting health, not just providing health care. (Gould, R, 2017)

Project Break Down

All said factors are taken into consideration to design a hospital that is enjoyable for extended stays, comfortable to work in and easy to move around.
It is a two-story building. The underground floor is operational bock with magazines. The ground level is ambulatory and daycare floor, while the first floor is intensive care and overnight stay area. The internal courtyard is an escape of the city that surrounds the hospital.
The rooms are modules premade off-site. Every room in the hospital has the same dimensions. The ostentatious appearance of the building hides a quite modest interior. Every element used is prefabricated and embedded in the structure of steel pillars with a reinforced concrete core. Prefabricated modules come in standard dimensions as per the national guidelines for healthcare institutions.
The floors are divided into wards. Wards on the first-floor amount up to 6. Every ward is featuring all necessary elements for individualized patient care. There are doctors' offices, nurse stations, reception areas, public toilets, medication storage, as well as a laundry room. Each ward is dotted with vertical communications, both staircases as well as elevators. This way there is no need for the users to move a lot to get the care they need. It provides privacy and prevents intrusion of visitors that are not family. More frequent movement is guaranteed on the ground floor. It is the space for daycare and ambulatory consultations. Though it is more lively, the corridors segregate more permanent users such as the medical staff from the visitors and their company.
The underground floor communicates with the exterior through the car driveway. It provides direct contact with the ambulance vehicles with the hospital. The patients are brought directly to operational block minimizing the time spent moving in emergency cases. The patient's experience is put into focus. Every room has an opening to the environment, to make patients feel less secluded. The areas for socializing are located in every ward, even in intensive care. Ambulatory visits are made easier with spacious waiting areas. Communication is efficient and quick.
The hospital is designed for every user. Medical staff, visitors and long term patients are the elements that orbit the design while making sure the environment is not jeopardized.

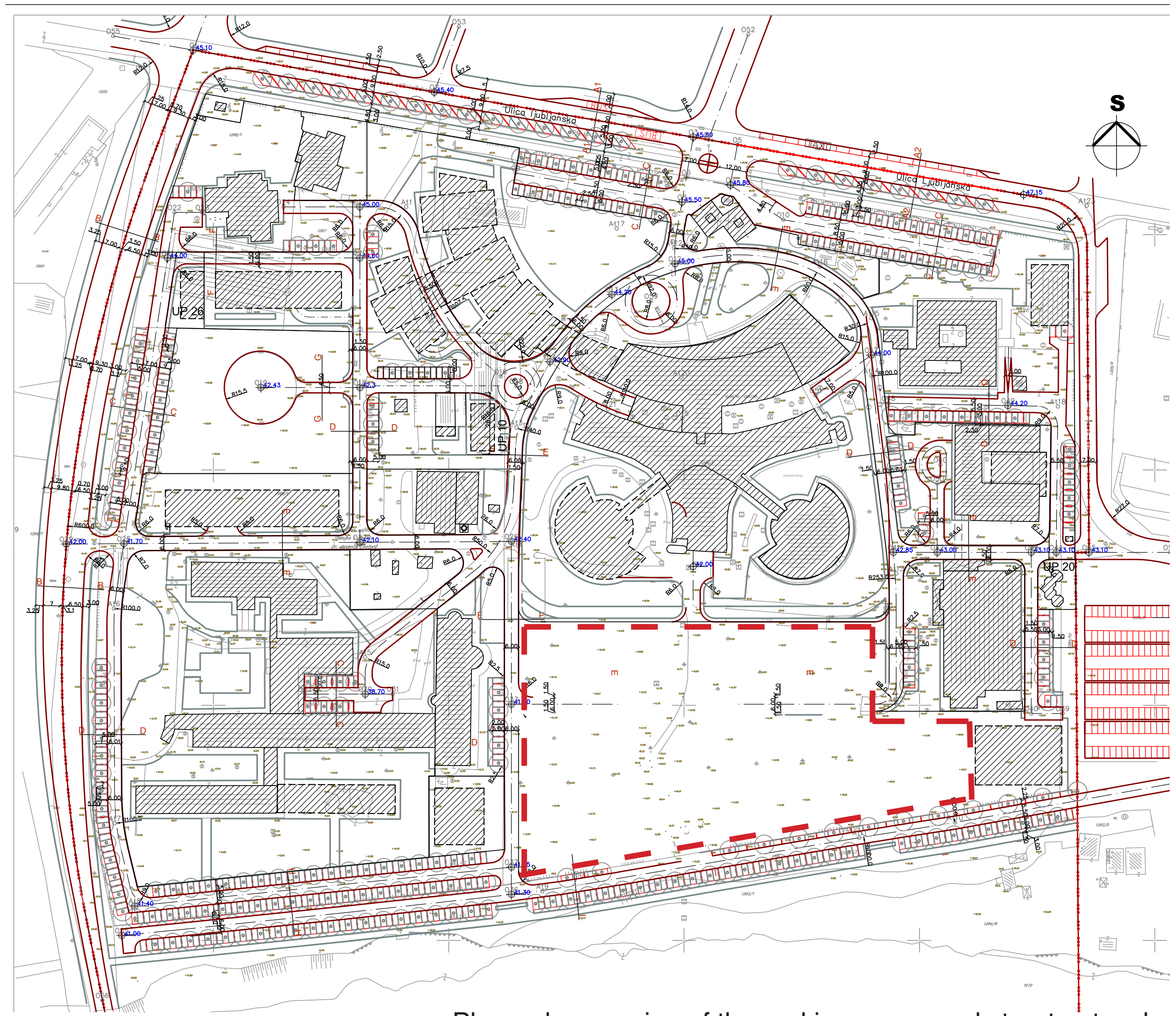
3.2 Project As An Open System - Comforting To The Environment

The oncological clinic is part of the expansion plans of the clinical center. It is located on the southern part of the parcel, overlooking the river. The hospital is located on the part of the plot formerly occupied by a parking lot. It has a very favorable position by the riverbanks, but it is unfortunately dismissed because it is isolated from the vital street, passing by the other side of the clinical center plot. There is no direct connection with the current traffic. The new street will connect the oncological center with the preexisting streets, and provide easy access to the hospital.
Hospitals are very busy areas. There is a high number of daily users, between workers, visitors, and patients. Ensuring the building is well-connected and comfortably accessible by public transit or that it has pathways that facilitate the access by foot reduces the energy usage. The facilities' accessibility determines its subsequent maintenance. The facilities allow expansion and modification with a modular structure that permits repurposing should there be a need. The building's development should be predicted.
Not only is the hospital an active component in the clinical center complex, it is an unique building with function that make it completely independent from the Main Hospital building. It is connected with the system either by short walking distance or by an internal system of streets providing easy communication in the case of patient transportation to different buildings on the complex premises.
The new Oncological hospital is built with the principal idea being that it will be dismantled, reused or repurposed some time in the future. Such a mobile structure opposes the permanent concrete structures of the complex. It provides treatment for the patients that have so far been constricted to few rooms in the main building with no consideration to the sensitive stage of life such as cancer treatment. Space is provided for very individualized and personalized treatment.

The health care institution such as Clinical Center deals with a lot on a daily basis. It is the provider of national health care, meaning that people from every part of Montenegro are to come to Podgorica, to KBC in order to get the treatment they are prescribed. By building specialized institutions, such as the oncological center it reduces the pressure from the staff at the Main Hospital and by reducing occupancy it encourages more personal contact between the patient and the doctors and nurses.
The building also supports the use of the students of the near-by Medical Faculty and makes space for promotional and educative workshops, seminars and meetings.
gn is firstly determined by urban regulations. The second priority are the norms that the building must conform to. These parameters can be either the typology, distribution, or volume of the spaces needed. The final characteristic to be considered is the exterior, and factors like sustainability, etc.
The design is very self-aware. the hospital can be repurposed and materials can be reused. In the case of population growth, everything can be remade to accommodate new needs. It can be dismantled in case of relocation. Modules that make up the interior can be moved to another location, to another building on the suite, or simply redesigned for varying treatments.
By not considering itself as a permanent element of the center, the buildings' size is justified as the materials are later to be reused. In the case of reuse, some modifications are to altered. By using more material, thicker glass, or better steel for the skeleton, it leaves space for the elements to be adjusted. Changes are considered as standard and expected.
Oncological Hospital is an open system. The inner atrium opens the building to the environment but making it an axis of the project. The natural flow of light is enhanced by the atrium. This also incorporates the elements of nature that are more private for the users, and it does not give the sensation of exclusion from the outside world, as it creates a private garden for the users. At any moment, the building is isolated from and open to the environment.

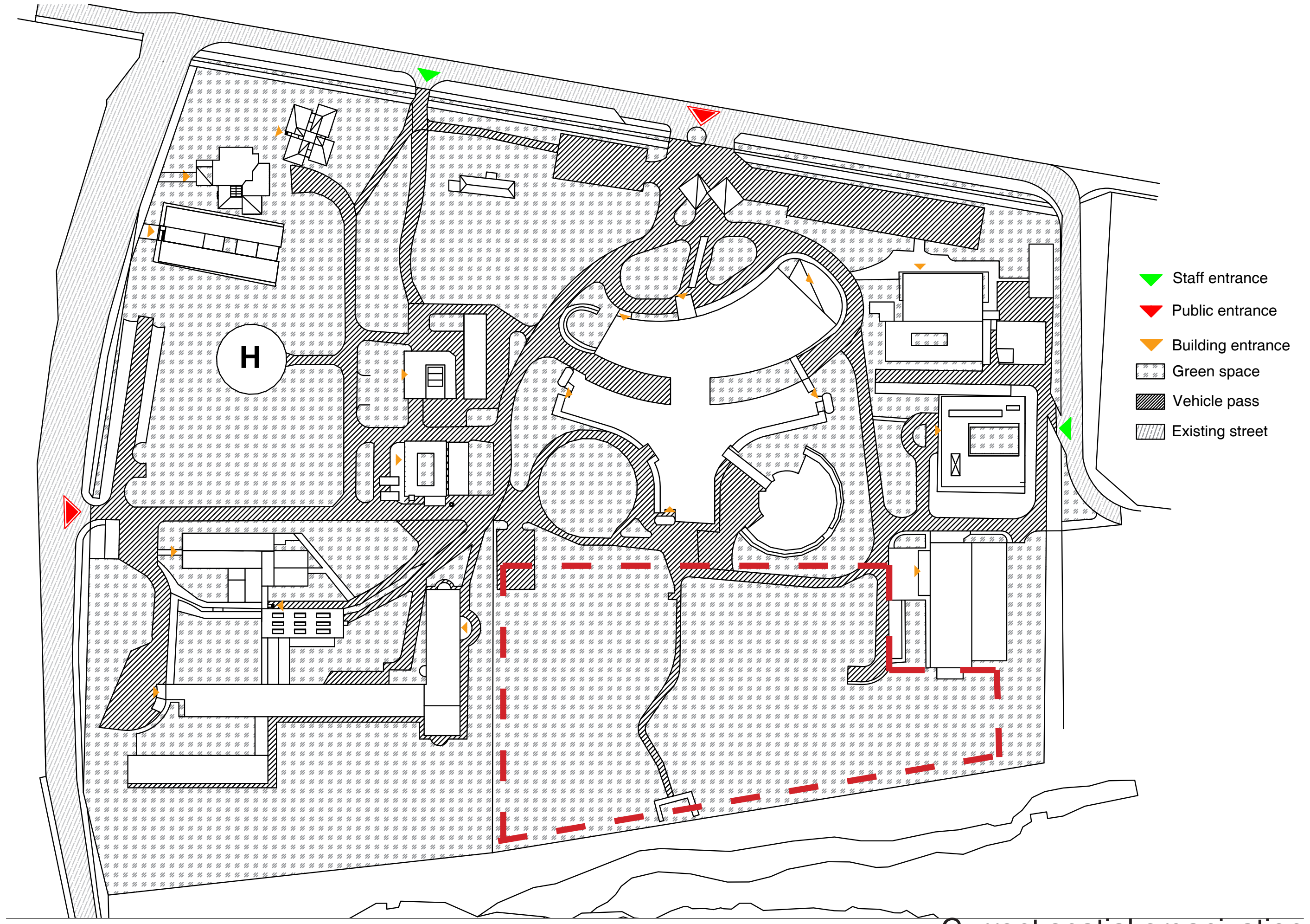
Project in the Clinical Center Context

The Oncological Center is located on the south part of the Clinical Center parcel. It is connected by the pedestrian paths and vehicle street with the rest of the complex. It is very important to provide quick and easy access within the center. Not only does it as such, make building more part of the entity, but it is a mean of security. Formerly a parking lot, the space of the new Oncological clinic was cut off from the currect traffic network. Construction of the new hospital envisions the building of the new street. Said street will connect a very busy alley on the west, with not as congested street on the east. This provides a direct entry to the hospital. It also reduces the stress on the main entrance of the building. New parking space is planned on the eat part of the lot, where there is less traffic. By enlarging the network of connection from and to the complext, there is less traffic concentrated in one area. Knowing that there is a way to enter from north, east, west and south will create a decentralized system of communication with the complex. Ambulance cars can reach desired area easily, while families will be able to find parking spot within acceptable walking distance.



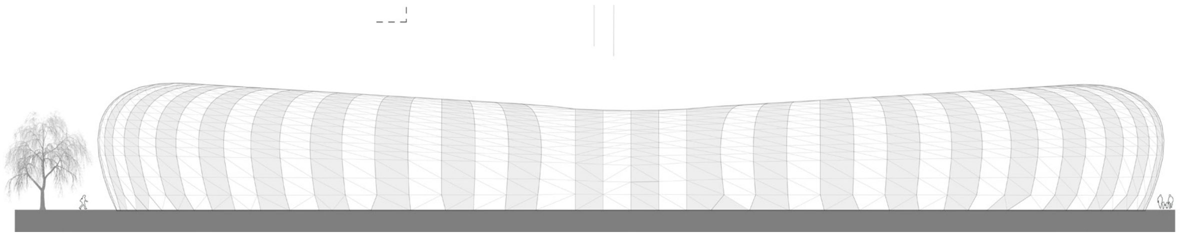
Planned expansion of the parking space and street networks

Planned plot area for the new clinic



Current spatial organization

Planned plot area for the new clinic



South facade of the new Oncological hospital

Observation Of The Operation

An Oncological Hospital in Podgorica, Montenegro is the first hospital specializing in cancer treatment. The hospital is the only public oncological center in the entire country. The scale of the project made it very important to pay special attention to the environment. Not just the environment in terms of the complex it is a part of. Nature is the aspect that is most oftenly neglected in favor of providing more health protection.
Hospitals are one of the biggest consumers of energy. Coming second only to food industry. By being considerate of the nature that surrounds it, this hospital is a project that explores temporary. Combating the permanent, unchanging concrete blocks it is surrounded with. The project is about reuse. It is about repurpose and recycling. It relies heavily on the main principles of sustainablity. Architects of the complex, have left the Clinical Center practically prohibited to the touch of the future generations. The Oncological hospital is aware of the temporary time it will be used for. Every element is chosen with the idea that it will continue its life somewhere else. What may be erected as a cancer treatment center, can be remade into any other specialized clinic. Not exclusively a healthcare facility on the exact premises, modules can be moved anywhere. They can be remade into a completely different building. The design of the hospital is eccentric. It is eclectic in choices. It is a contemporary solution to the rising issue of cancer in the world. By chosing to shift the perspective from the illness treatment, to overall wellness, this hospital is a sore thumb. Not striving to become Montenegro's first Maggie's center, but rather the first public institute that focues on the human, not on the disease.

Search For The Best Solution

Search for the best answer to the question of the sustainable hospital was in modular construction and circular economy approach. By valuing the resources used in the prefabrication of the modules, the project envisions the later repurposing of the materials used in the production of the aforementioned.
Currently, architectural projects include a detailed breakdown of the design, from the predesign phase to building operation and maintenance. The Internet of Things and Building Information Modeling make achieving greater operational reliability, it also reduces maintenance costs, and improves the system's energy efficiency more plausible.
The biggest consumers of energy in public buildings are predominantly air conditioning and lighting. These areas can also be the areas of the biggest possible energy optimization. By keeping the width of the building rational, and including rather large windows in room design, permits the optimal insolation of the interior by natural means. Not only does it reduce electricity usage, using natural light sources has proven to speed up patient recovery. It also improves productivity and response times of the hospital staff.

Prefabrication Modules in the Healthcare Environment

The interior of the hospital is completely furnished with modules. Units are made off-site and brought to the construction site. In such a manner there are savings in the time. By correctly managing the construction, building structure can be erected while at the same time modules are produced in the factory. Not only does it save time, but it also leads to a project that is more likely to keep within the predicted budget.
By minimizing the on-site construction, there is less havoc and distress caused in the zone. Building the modules in the factory means there the exact quantity of the materials used is known. Thus reducing waste of supplies. It inherently reduces the waste and the residue on the construction site.
The modules are made to fit the standard dimension. In this case, the entire hospital is equipped in modules of the same dimension. Every function is realized in a box of following dimensions 4.2mx7mx3m. Keeping the dimensions uniform, it left the interior of modules to the creative freedom to accommodate the needs and functions indicated in the project. Relatively small dimensions of the modules make transportation easier and more economic.
Modular interior ensures the ease of maintenance in case such a situation arises. The maintenance is facilitated as the materials and building methods are known and company-specific.
Should there be a need, the modules can be easily replaced.
Healthcare construction is particularly sensitive as it is under constant watch. Not uncommon are the frequent change of norms and regulations. Different contents for different functions under ever-changing laws make hospitals a constant playground. Modular elements facilitate should movements. Every modification can be easily executed.
Extremely easy to manage, modular designs impose themselves as the most suitable for constructions such as healthcare institutions. Oncological Hospital in Podgorica has a very irregular form. Such a grandiose structure was kept humble by using prefabricated modules.
Production of the modules off-site the construction ensures the noise and the chaos is kept on the minimum on the premises of the Clinical Center. This a guarantee for the normal functionality of the hospital. The waste is in negligible amounts as not to disrupt the movement of the staff, visitors and vehicles on the complex. Modular construction is a better solution for the management of the buildng. Not only enabling a more punctual construction, but it also leaves morespace for maintenance of the modules and later reuses of the materials.

Circulation of the materials after the end of building life cycle

A circular economy is an approach that believes in a sustainable understanding of the constructive industry. It relies on the key point of reuse, recycling and reducing. Materials are not for a single-use. They can and should be reused, recycled or repurposed according to the situation.
Biophilic design is a design that mimics some of the natural occurrences. By adopting one of the principles of biophilic design known as resilience, we ensure the circular economy of constructive materials. Every element of nature is keen to change and evolve, in order to better face new challenges. Designing buildings to mimic the resilient seen in nature is possible by considering if the entire life of the building. Constructive elements, unused and leftover materials can be reused for new construction. In such a case there is a limit the amount of waste produced. The Oncological hospital is built to last. It is then planned to be reused in a manner that is deemed suitable for current needs, once the present useful life is over. By being aware of the building's life cycle, we delve in the prospects of more sustainable design. The project of the hospital bears on its shoulders both ecological and social responsibility.
One of the ways explored in the case study of Town Hall in Brummen, Netherlands is the materials passport. By being aware that the design project is not a permanent element of the context it is located in, we rationalize the design process. The materials are chosen more sensibly. By using more we choose to extend the life of the materials. Such a decision leads to easier manipulation in the later stages of life. The Oncological Hospital is made of prefabricated modules by using the highest quality materials. It is an investment in the future. The overall structure is supported by steel columns that can be later cut and repurposed incoming projects. Even the facade is made of smaller elements, which when dismantled can be translated into another design.

By being transparent of the transitory nature of contemporary construction, the Oncological Hospital bears in mind the ever-changing today. What is now deemed as urgent and necessary may seem insignificant in 20 years. The modular design of the hospital makes internal modification very feasible. Interior spaces designed to provide multiple uses, promises the longevity of the useful life of the building. Every module is dotted with standard furnishings for a hospital. Designed as Oncological Hospital, it can be repurposed to fit any other type of general or specialized healthcare institution.
Creating material passports at the initial stages of construction provides a guarantee for later reuse. Not only are the information such as the quality and the quantity of the product crucial for the reuse, but they also give an insight into the maintenance process.
Circulation of the materials used in the building process, or change of principal use of the space, is a reality in modern construction. By building a hospital that can potentially accommodate not only healthcare but the repurposed into a complete building, makes the complete circle in an attempt to promote a circular economy in the construction sector.
The Living Building Challenge is a push for designers to “reconcile the built environment with the natural environment.” The goal is for every design and building constructed to be an act in making the world a better place (Living Building Challenge, 2014). Beauty is part of the design project by choosing to focus on the aspects that bring joy to people and celebrate life and the environment.

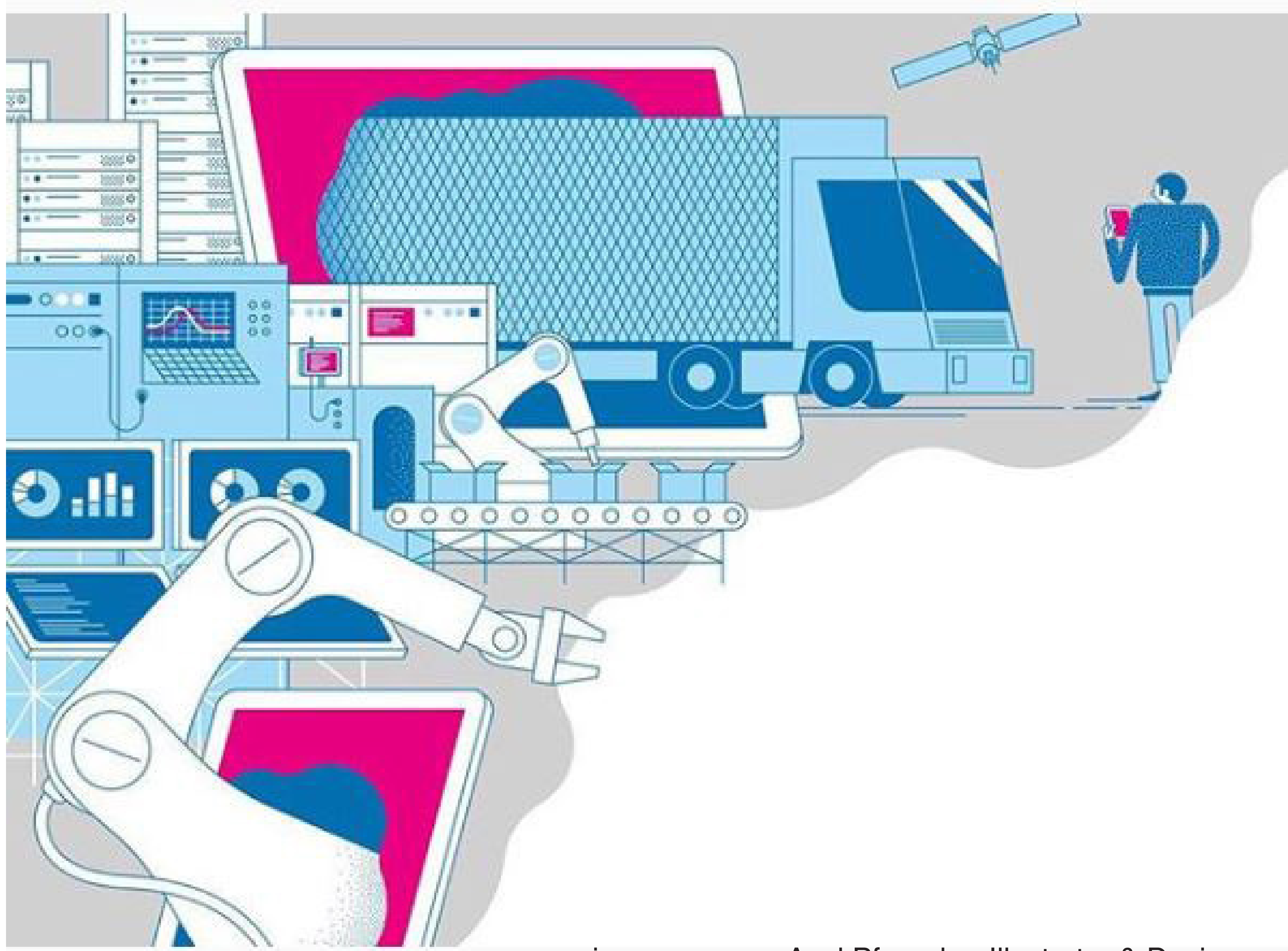


image source: Axel Pfaender, Illustrator & Designer

Sustainable Design for Healthcare Institutions

Hospitals consume two-and-a-half times more energy than other commercial buildings and produce 30 pounds of Carbon Dioxide per square foot (American Hospital Association, 2015).

Sustainable Design is a design considerate of the environment. It is a method of construction that put much attention on the social, economic, and environmental aspects of the project. By being considerate of the location and context of the project. The project as such is not to disturb any natural process or ecosystems, Sustainable project plans the consumption of energy, water, and other resources throughout the life cycle of the building. Observed from a social viewpoint, the sustainable design places special attention to the welfare of both present and future generations of the space occupant. The Oncological Hospital in Podgorica aims to minimize the life cycle and maintenance costs of a building. By opting for prefabricated modules as interior elements, it reduces the negative impact of on nature. This, along with the circular plans for material reuse make this project a one that strives to have a positive impact on the environment.
It has been found that hospitals consume up to two-and-a-half times more energy compared to other commercial buildings. Hospitals also produce 30 pounds of Carbon Dioxide per square foot (American Hospital Association, 2015). Its numbers are justified by the technology used on a daily basis in these institutions, and the sheer size of the medical industry. By taking into consideration varying elements, the Oncological Hospital focuses on sustainable energy sources, while being rational with energy use, thus lowering energy consumption.
Designing for the level of stress, urgency, and uncertainty is a healthcare environment is challenging. To address the psychological needs of patients and staff, the design of the Oncological hospitals looks to nature. For the majority of history, nature provided everything needed for survival. Thus, humans associate nature with wellbeing. The Oncological hospital aims to create a more comfortable and relaxing environment. It is an attempt to address the need for emotional comfort found through the sensory experience of the space. The hospital focuses on the promotion of wellness, instead of solely and singularly preventing the illness. Facilities are designed to be beautiful and comfortable. They are an environment where the patients, visitors, and staff of the institution can come to feel well, not just get better.

Facade design process

“BIM or Building Information Modelling is a process for creating and managing information on a construction project across the project lifecycle. One of the key outputs of this process is the Building Information Model, the digital description of every aspect of the built asset. This model draws on information assembled collaboratively and updated at key stages of a project. Creating a digital Building Information Model enables those who interact with the building to optimize their actions, resulting in a greater whole life value for the asset.” (NBS, 2016)

Building Information Modeling (BIM) makes the design process more efficient and less time-consuming. The tasks are automatized. The computational design is a rising asset of BIM. It is the idea that every element of the design can be split into the task, with logical guidelines. The tasks can be executed using computation. This gives quick solutions for design needs.
Dynamo is an extension of Revit. It is a visual programming plug-in that helps create and update models. This in effect saves a lot of time, as one can take an idea and quickly create variations, with no need to manually make and save the changes.
One real-life example of this type of productivity is the automatization of the workflow at NBBJ. Using Dynamo to extract data from a client’s DWG files and bring them into Revit, NBBJ estimates to have saved about 1,650 hours of work. (NBBJ, 2015)
One of the best options for Dynamo is the high degree of interoperability. Dynamo can support multiple file-formats and it has design tools that can bring all the tasks together. So instead of using different applications for design, visualization, simulation, and fabrication, every modification can be made with Dynamo.
Visual programming enables the design of very parametric shapes and forms. By diving the task in mathematical formulas, the software generates complex geometries. Applications like Dynamo, enable easy modifications of the parameters that are the line guides of the model, thus instantly displaying the modification applied. The use is easy, and intuitive. The benefit of visual programming is the possibility to generate data about the module too.
Having in mind all these benefits Dynamo is an obvious choice of innovation in the architectural design process. It provides designers with a tool to explore parametric designs and efficiently automate tasks, Dynamo can undoubtedly help a designer work smarter. Smarter work gives freedom and flexibility needed for: an efficient way to get things done. (Santos, S, 2015).

Complexity Of The Design

The form of the facade is conceived of simple circle forms. Dynamo nodes generated circles with input information on the radius and a center point of the circle (fig. 1). There is additional information on the height of the floor as it will later enable the software to create a surface y doing a cross-section of all the points of the elements in question. The base parameters are the ground floor height, slab of the ground floor, as well as the summed value of the second floor. slab and roof height, as to minimize the parameters. The code blocks connected to the aforementioned values and point node generate the sum that is the base of the later cross-section sourced surface.

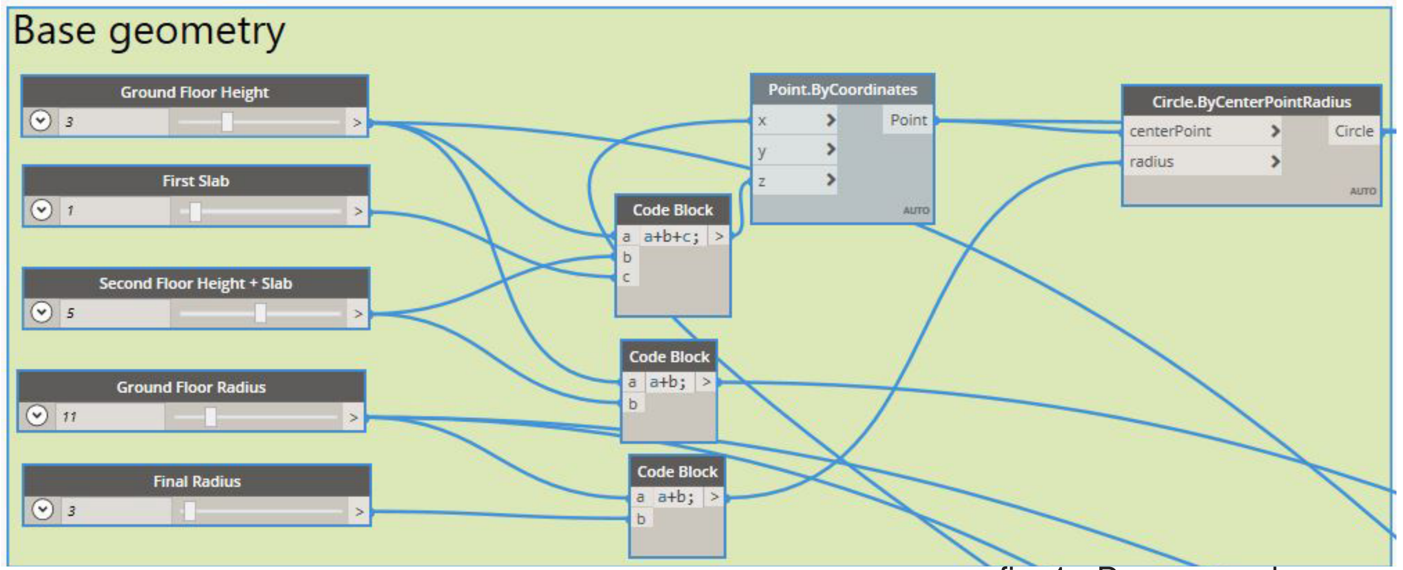


fig. 1 - Dynamo node group

Rotation of the slab node group creates the volumes of the facade. It is a curved form that by rotating the slabs creates a curve, raised upwards on the borders. Dynamo nodes rotate the circles that are the bases of the floors (fig. 1). Parameters as the floor rotation is a simple number value that can be adjusted by a slider button. This is one of the biggest advantages of Dynamo. Easy modifications are automatically visible in the model. Geometry node is defined by the following arguments: geometry rotated, origin, the axis of the rotation and the degrees of the rotation. The geometry parameter is the circle that is the base of the floor slab. The origin parameter is the origin point of the aforementioned circle.

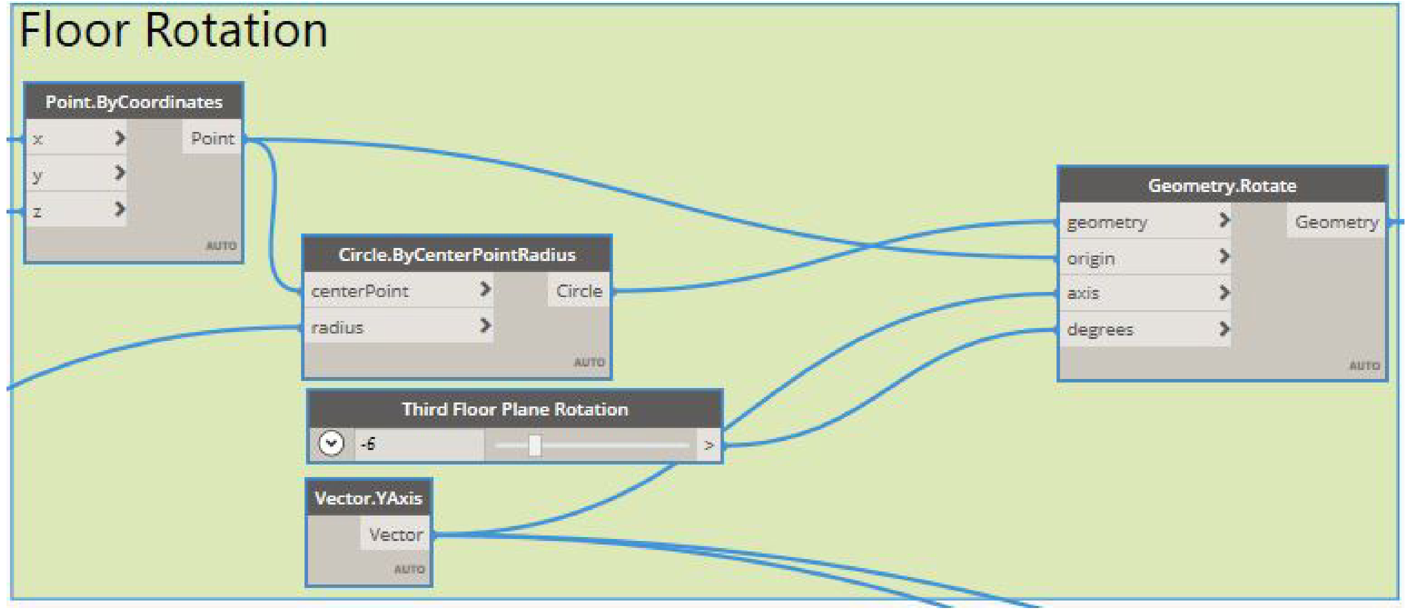


fig. 2 - Dynamo node group

The scaling node group modifies the size of the facade. The curve is enlarged or shank according to the floors' slabs in the interior construction. Dynamo nodes alter the size of the floor circles (fig. 3). Scaling node is defined by the following arguments: point of the origin, plane determined by the origin point, and geometry scale node. The geometry scale parameter is a node controlled by the input geometry, the plane of the geometry, and the value of the axis parameter. There is the same origin point for the planes generated by the origin point. These planes are the reference for the scaling of the geometry. The topic of the issue is the facade modifications to adjust to the slabs, the value used is x scale value. The scaling node group is the horizontal modification feature. The interior construction houses modules that are cantilevered by differently on the first and ground floor. Such a dynamic character of the building elements creates a curved form that is more top-heavy. The first floor has a significantly bigger radius than the ground floor. The Rotation node (fig. 2) curved the facade to conform to different radiuses, and the Scaling node will make it a suitable fit for the building.

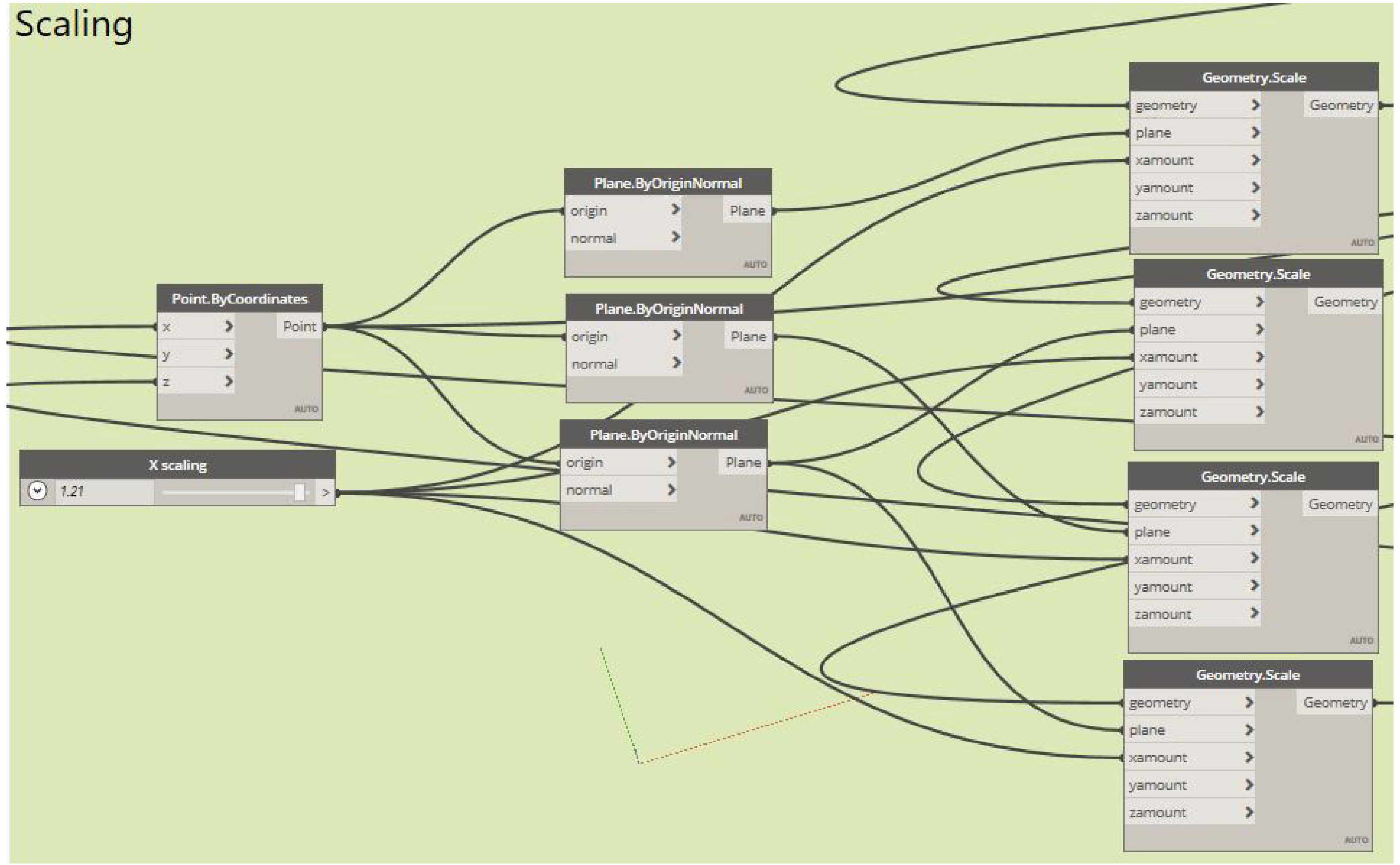


fig. 3 - Dynamo node group

Facade material

Facade material is the ETFE. ETFE is short for Ethylene Tetrafluoroethylene. Originally invented by DuPont as an insulation material for the aeronautics industry, ETFE was not initially considered as a mainstream building material. As the building industry is always looking for more budget-friendly solutions, ETFE imposes itself as the contender with its features.
ETFE was developed in the 1980s' by DuPont. It was invented as an insulation material. One of the most famous and among the first application of the ETFE in building design is the Allianz Arena Football Stadium in Germany.
Properties of ETFE
ETFE is extendable into thin transparent sheets that can be used as roofing, cladding, and façade systems. This unique material is very resilient, yet light in weight. It is not affected by UV light, nor does it corrode in contact with air pollution. ETFE has a very low coefficient of friction, making water and snow slide off of it easily. ETFE is also very light in weight. on the other hand, it is so strong that it ensures significant savings in money terms. This is possible because the surrounding structure does not have to support a heavy load of the traditional cladding finishes. ETFE can be stretched up to three times its length. The deciding factor for the choice of this material is the fact that it is easily recyclable, It can be completely re-used in case of building dismantling. This, in effect, lowers the environmental impact of the material dramatically, especially compared to the typical materials used. The material shows as superior in terms of its extraordinary tear resistance, long life, and transparency to UV light. One of the main advantages of ETFE is its high translucency. It typically transmits up to 95% of the light that hits the surface. This allows the full spectrum of natural light to penetrate the building. Sunlight is essential to hospital occupants' health. ETFE facade can be made with a shading coefficient. During the manufacturing, multi-layer cushion systems are installed. One outer and one inner layer of ETFE foil can be printed to allowing the variety of light transmission.

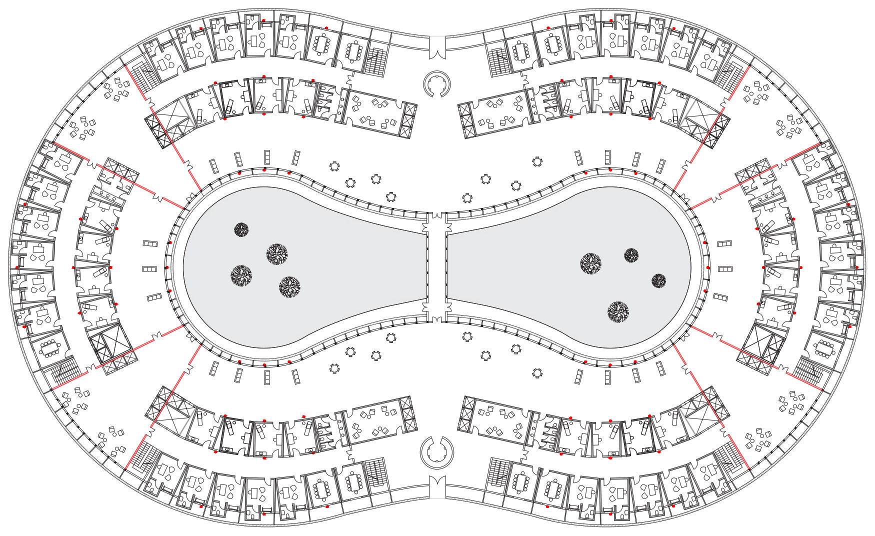
fig. 1 - ETFE Foil close up
image source: google.images

Unaffected by UV light, nor atmospheric pollution or other forms of environmental weathering, ETFE is an extremely durable foil. While there are no ETFE structure older than twenty-five years, tests performed in stimulated conditions suggest the material has a life span of more than 40 years. ETFE is 100% recyclable. It requires minimal amounts of energy for transportation and installation means that it makes a significant contribution to the move towards green construction and sustainability. However, the material is in its infancy in terms of development. The makings of ETFE as a long term construction material will lie in the development of various high-tech coatings and methods of printing which will modify the translucency, along with thermal and acoustic properties of the fabric. There is much more potential to tap into. The advantageous characteristics of the ETFE foil will ensure the designers increasingly decide on the use of EFTE in the architectural sphere in the coming period.

image source: Axel Pfaender, Illustrator & Designer

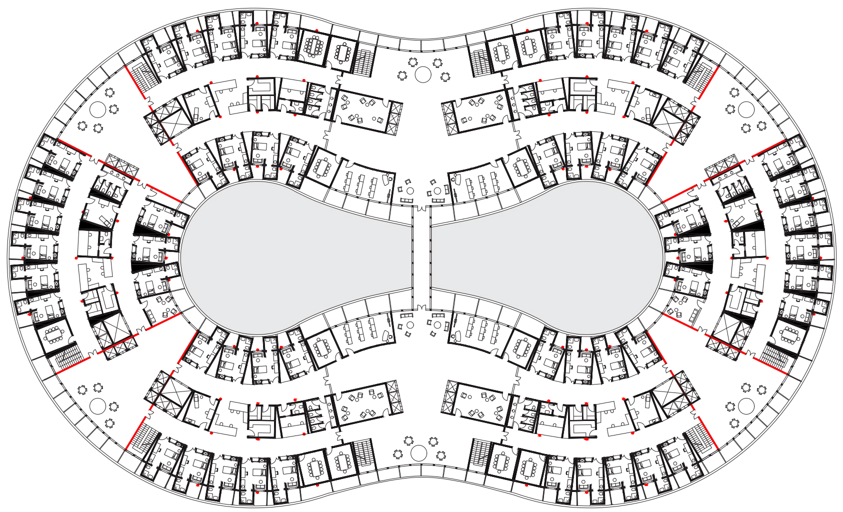
Construction

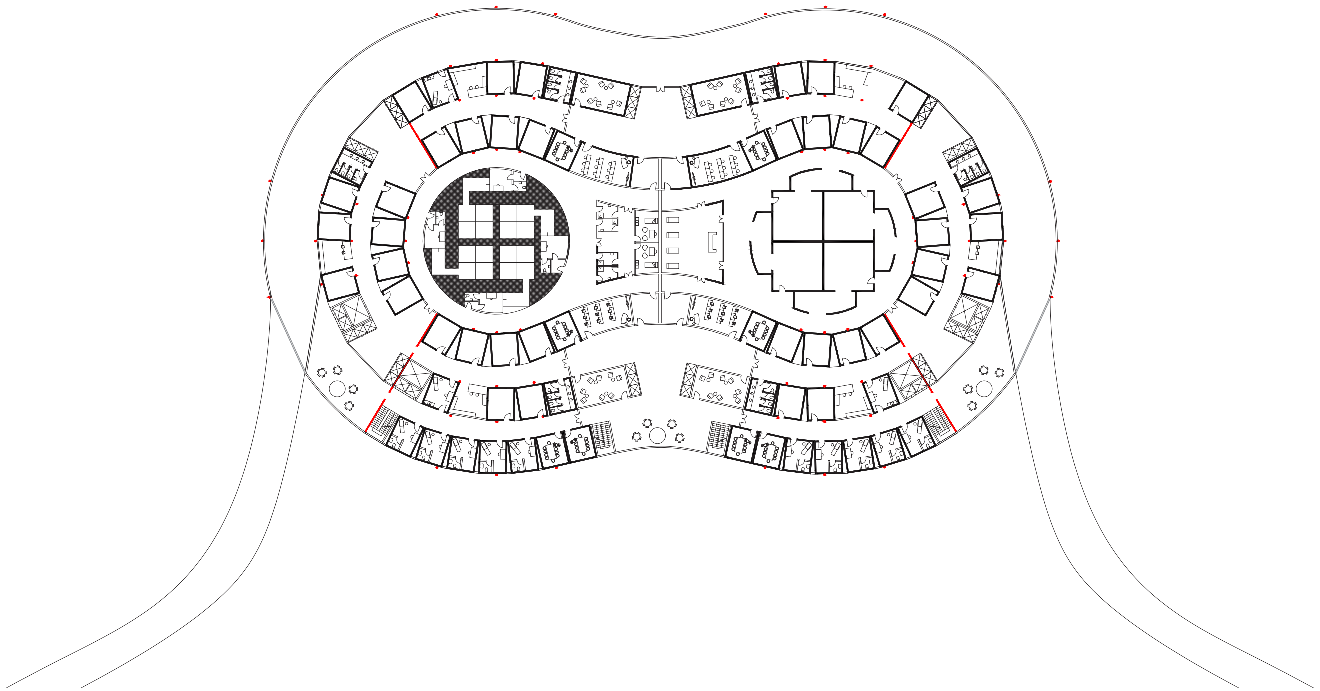
The contruction begins with structural part. Steel sceleton is contructed and the rough outline of the building is formed. The modules are delivered to the site, and inserted in the building with a crane. Securiity at construction site is guaranteed, as the distance of the contructive elements conforms to the norms set by law. The distance between on each site of the module and pillars is 60cm.
Circual approach gives the project a sustainable air, as in case of redesing or demolishment, all the material can be reused and repurposed.
While the project has irregular shape for a hospital and uncanny facade design, it has all led to a more cohesive constructive object. The irregular shape has led to very design specific problems as to organization of the space, while raising the question on the adapt of an all-prefabricated interior in the a circular base.



System

The project is located on a urban plot occupied by the Clinical Center and all the complementary buildings and spaces. The Oncological hospital reaches the southern edges of the site. Considering the location in a built environment, with very frequent and important daily trafic, make the lot area a construction site is impossible. It is a rather logistical challenge. The solution to this was the choice to use prefabricated modules as room in the object.
The concrete frame and a steel support system allow the structure to grow at a very fast rate. It is very important to keep the disruptions to a minimum. Daily resposabilities of a Clinical Center and the Medical Faculty are to performed as regular.
Concerning both clinical and nonclinical services, everything is prefabricated. The modules are delivered as a whole unit with ducts, cables and pipes pre-fitted in ceiling frames. They are connected up on site.
Once the shell and core are completed, the constructon of the facade can start.
The facade is broken down in smaller elements, all uniform in size, with three basic types repeated throught the construction. It is assembled on the site, and connected to the building with a special support system.
By enabling continuous operation of the Clinical Center, the Oncological Hospital is built silently and efficiently. It is stand-alone project connected to the context, by seemlessly blending in.





Columns as the main load-bearing element of the support
system of the Oncological Hospital

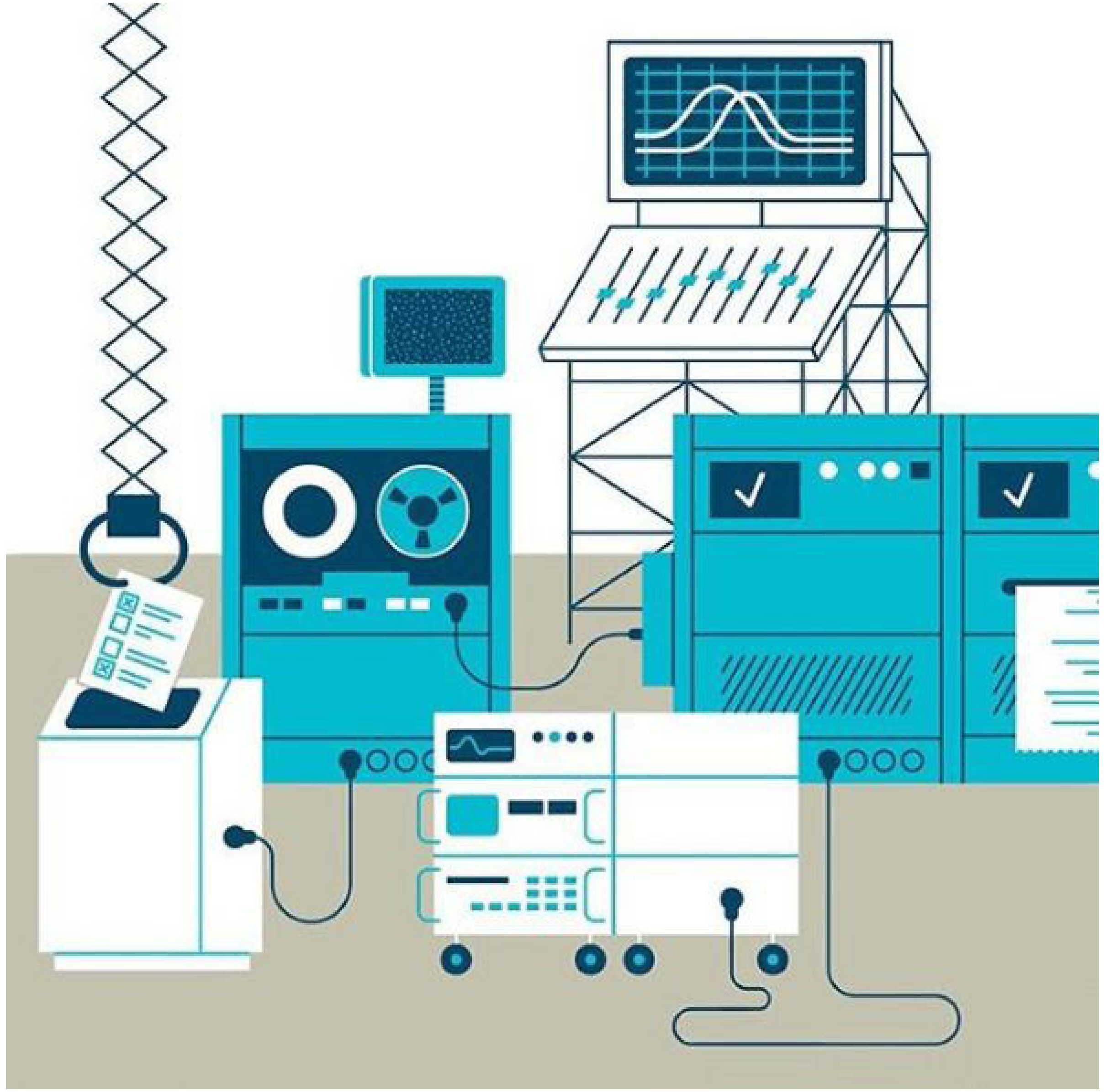


image source: Axel Pfaender, Illustrator & Designer

Hospital as a self-sustainable system

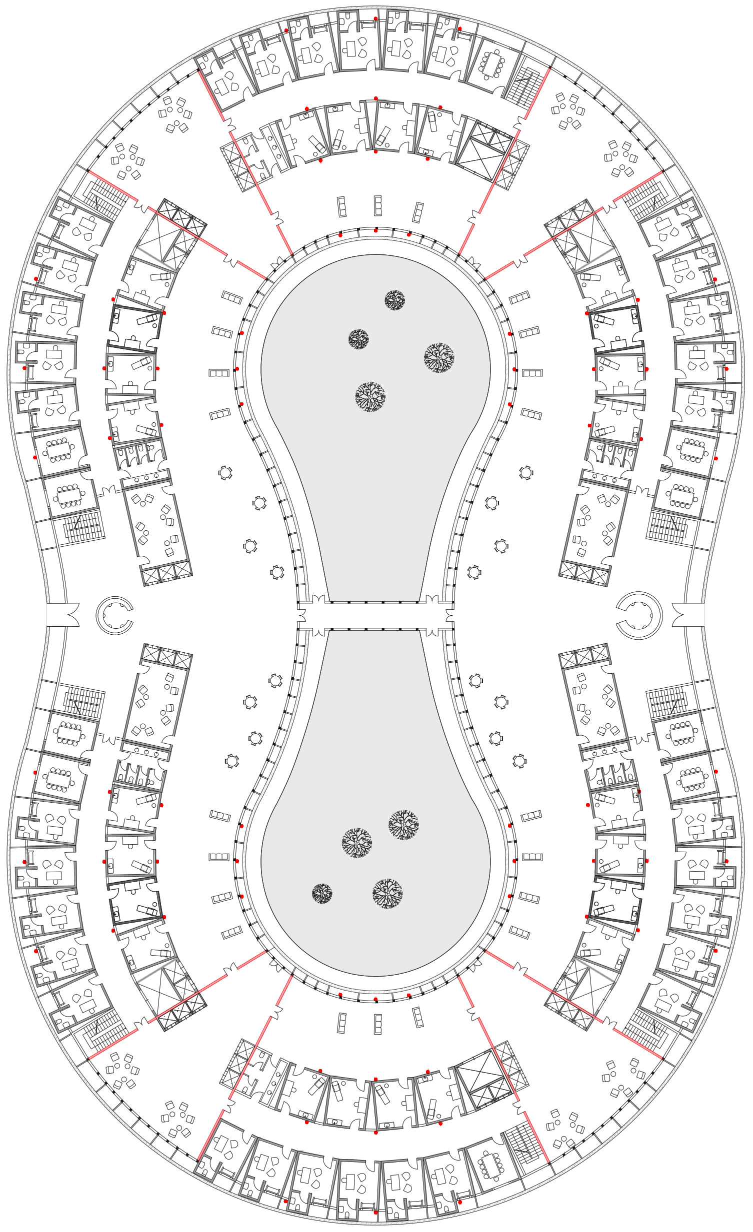
The Oncological hospital has all the necessary elements to function as an independent system. It is a wholesome canceer treatment center. The Hospital is dotted with spaces for extented stay, intensive care, operational block. The services are divided on various levels according to the guidelines set by the urban planning department of Podgorica. The technical rooms on the underground level store supplies for any needed situation. On the first floor there are ambulatories and daycare rooms. There are food courts, kitchens, bathrooms. In aim to more the stay at the institution more comfortable both for the patients and the staff, there are multiple relaxation zones.
The areas for the staff are separeted from the public ones, and the treatment blocks. It will give the doctors and nurses a piece of quiet in an often hectic and quite anxious environment. The waiting areas are spaces of uncertainty and overthinking, hence making them very sunny and spacious makes the patients more at ease. By offering spacious zones during the stay in the hospital, patients are not constricted in the environment. They are made aware that the disease will not make them at disease in the given space.
The first floor is the area of intensive care units. Patients are given privacy from the traffic of the ground floor. Every ward is a fully operational block that has ambulatories and nurse station. Medical supplies and storage of all neccesities.
Communal spaces are very sunny and offer a freedom of movement for the patients who do not have to walk far away from the room to find themselves in a social context.
By providing enough indoor spaces for normal social interaction of the users, the users feel like a part of community. The hospital places special importance on the environment. The atrium opens up the building to a internal court that is very much garden like.
It is a self-sustainable system that functions as a separate entity from the Main Hospital Building. Every diagnosys and treatment can be done completely independenly in the Oncological hospital. The services and comfort it provides to the user make it a complete unit.
It must always be taken into account that, for the building's proper operation, functionality and comfort must be the most important criteria.

Giving the control to the user

The principal elements in every hospital design should first and foremost be the functionality and comfort. The buildings are designed for people. To promote occupant comfort, the design includes areas that give patients a sense of control over their environments. A sense of control is especially important in the healthcare environment because, often, patients may feel out of control and anxious in their surroundings. By giving patients a choice, is to offer them control of their circumstances. By providing multiple levels of social interaction for occupants, and leaving them the choice of the amount of interaction they have. Areas of quiet and refuge are helpful for people who need space, and areas of collaboration and social engagement are important for people who crave interaction and community.
Because everyone is different, individuals should have access to heating and cooling controls. This will ensure the patients and workers direct benefit from the control over their comfort levels. Lighting is another system that users should have control over, and by incorporating dimmable, energy-efficient lighting in spaces and adjustable shades on daylighting windows, occupants can determine the amount of light they need in a space. The designer is providing patients with a sense of dignity. It reminds the occupants that they have autonomy and independence. Self-esteem and independence are major contributors to a sense of wellbeing, and they promote recovery in a hospital setting. Acoustics are a major concern in the healthcare environment, first because of proprietary information and patient privacy, and second because the noise that is carried can create discomfort and dissatisfaction in patients. If the sound levels are higher than the level of comfort, it will inhibit communication between the institution staff. It can also create anxiety and distrust in the patient. Poor acoustics in a healthcare facility is dangerous because it can potentially hinder the concentration of healthcare workers. Daylight has quantitative and measurable effects on human health and wellbeing. By careful design, and good organization of spaces in healthcare facilities, passive solar design can be used to offset the heating and cooling costs of a building.

Many individuals find peace and solace when looking near a natural environment. In the Oncological Hospital suggested by this thesis, the garden atrium aims to create a sense of ease and relief for patients. Green space opens up the hospital to the user while shielding it from the urban noise. The main goals are to lower stress levels and aid in mood improvement.
One major issue in the healthcare industry is the high amounts of waste that are produced in the building. According to the American Hospital Association, hospitals generate close to 7,000 tons of waste per day. Much of the waste is carefully regulated and expensive to dispose of, not to mention hazardous to human health and the environment. Medical waste incinerators are a major source of mercury in the outdoor environment (American Hospital Association, 2015). Better waste management in healthcare is crucial for environmental protection. Water is another waste issue of healthcare facilities, and it may be the most pressing. The hospitals are one of the biggest consumers of water. This calls for sustainable measures in the spending control.
Beautiful environments that calm and heal keep workers and patients coming back. Natural elements that help to fight fatigue also raise productivity and efficiency of workers, so that they get more done in less time. (Gould, R, 2017)

System Program - How Will the Hospital Operate

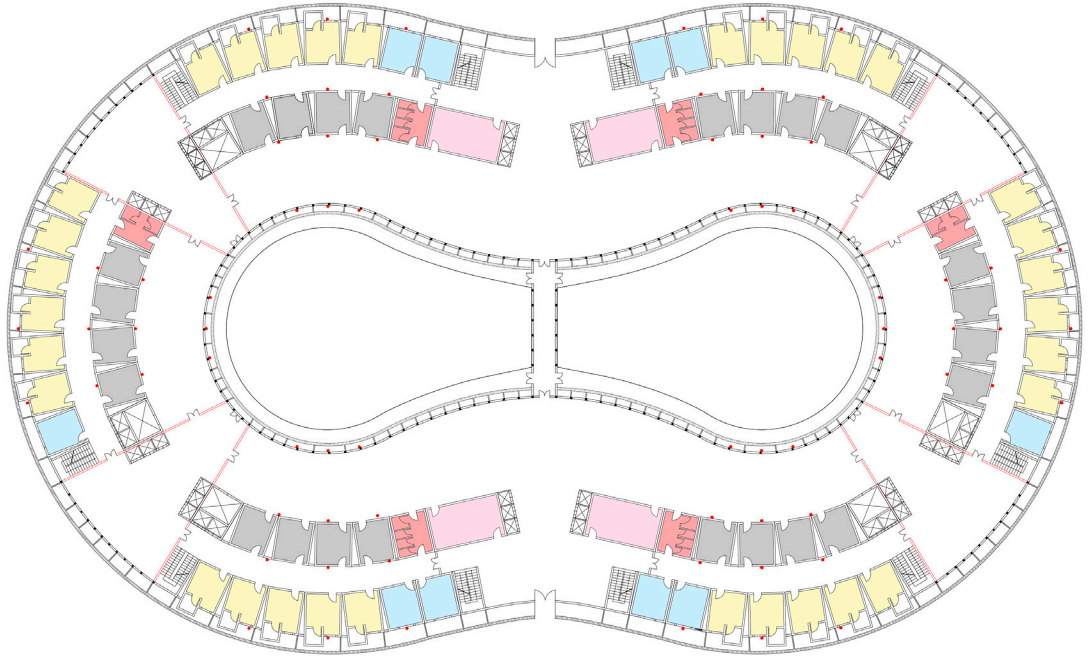


Ground Floor Plan +0.00m
*out of scale

Ground Floor Organization

Ground floor is the entry level. It features daycare spaces and ambulatories. The community areas for the hospital users are located on the parts that have a direct exposure to the environment. There is enough privacy for the staff and enough space for the daily visitors not to feel constricted in space. The prominent entrances to the hospital are via Main Entrance, located on the south. A secondary entrance, on the north facade, faces the Main Hospital building. It provides quick access from the neighboring building. The emergency entrance is on the underground level. It is exclusive for ambulance cars and emergency patients arriving to the hospital. The service entrance is the zone around the atrium. It is separated from other entrances as not to distrupt the established flow. Every entrance is distanced and unrelated to the other. This means that there will interrupt the movement of different users and slow down the work process. The corridors connecting the building horizontally are wide enougn to enable a continuous movement, and not create congestions. There is enoug space for wheelchairs, hospital beds and users to move without bumping into each other. The hospital is designed as the the 'corpo quintuplo'. This means there are separate corridors leading to different services. Visitors never have to meet the intensive care patients, or doctors. Entrance foyer is spacious as to enhance the feeling of welcome to the visitors. By opening up the space and stepping away from narrow hallways, the visitors are welcome to a reception desk. The reception desk with guide them to other functions located in different parts of the hospital. The reception desk is large enough to impose itself as the information point. It does not shield the view of the rest of the hospital. There is a clear view of vertical communications and hallways. This enable the users to understand the pathways and find their ways quicker. In effect, the users feel more at ease in the space, and it minimizes the need for direction signs. Administration offices are also located on the ground floor. As per standard, they are fit into prefabricated modules. Daycare services are increasingly more common. Patients who come for radiotherapy treatment stay to be monitored for the rest of the day. In cases there is no need for the patient to have an extended stay at the hospital, daycare rooms are provided. There is enough space for the relaxion and companions of the patients.The cental connection is also a staff zone, at the same time. It hides the offices, meeting rooms, cantees and relaxation areas to the overwhelmed medical staff. This is an oasis for trom the constant buzz and movement in the hospitaly, especially on the ground floor, that sees more traffic than the rest of the hospital. While waiting for the consultaion, therapy or simply waiting for the patient to get the treatment, waiting zones are separed from the corridors. As not to create too much commotion, waiting areas are secluded rooms, that offer companions to wait respectfully and not to be disturbed by the sights of the patients or illness. The social zones are located between every ward. It is a space for the interaction. It is a space to communicate with other patients, or institutions' staff. It offers a confortable space for companionship.

Ground Floor Functions

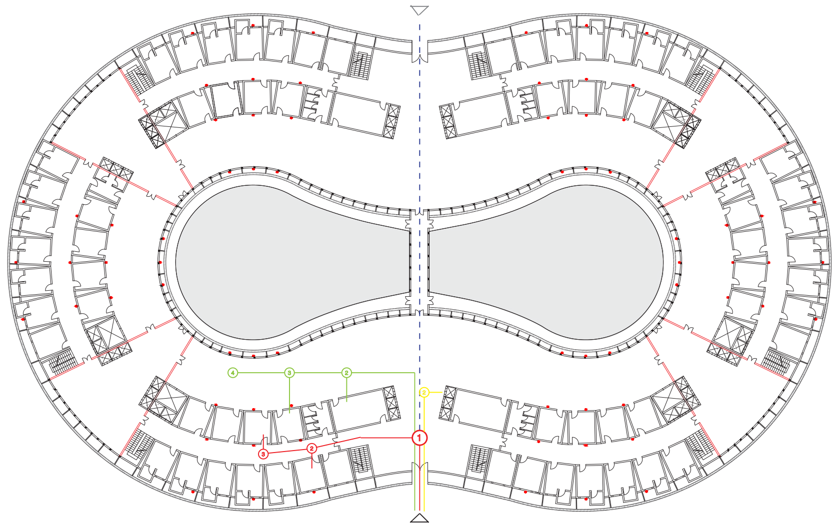


- Ambulatories
- Public Bathrooms
- Offices
- Meeting Rooms
- Waiting Rooms

room type	area in m^2	total number of rooms
ambulatories	23	24
waiting rooms	50	4
meeting rooms	21	6
doctors' offices	21	32
toilet	21	6

Ground Floor Movement Map

GROUND FLOOR MOVEMENT MAP
1:500

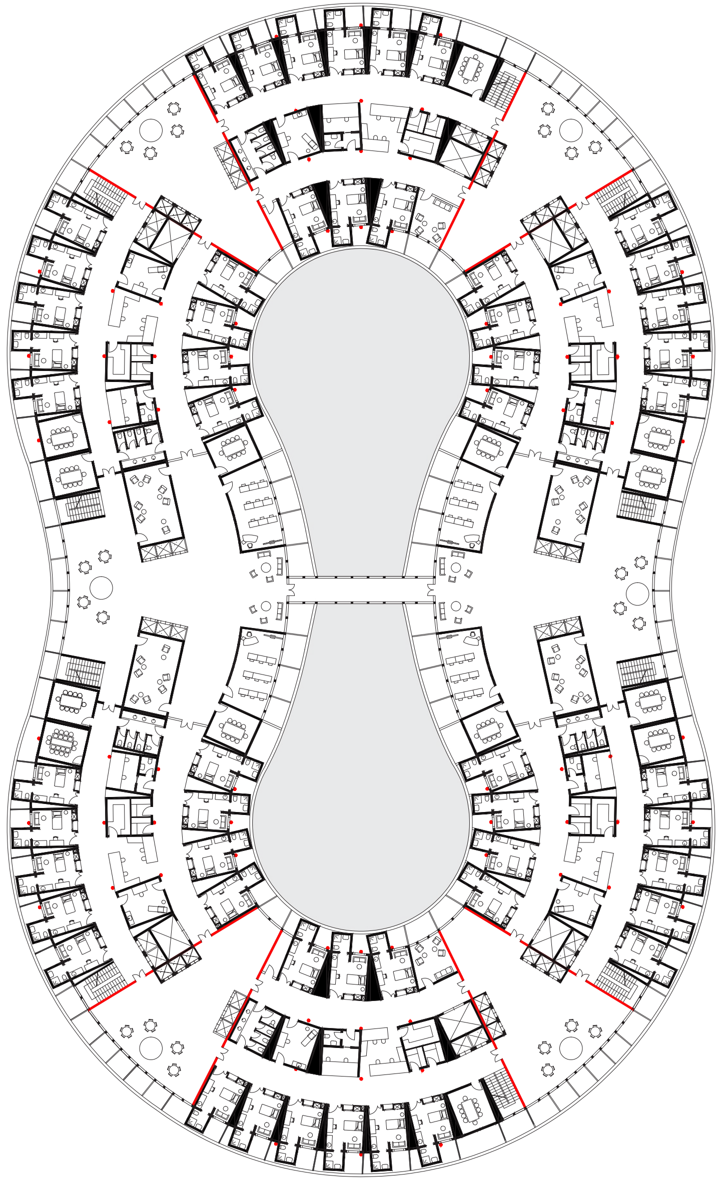


Entrance
Back entrance
1 Reception
Doctors' movement
2 Office
3 Ambulatory

Patients' movement
2 Closed waiting area
3 Ambulatory
4 Ambulatory waiting area

Visitors' movement
2 Elevators to First Floor

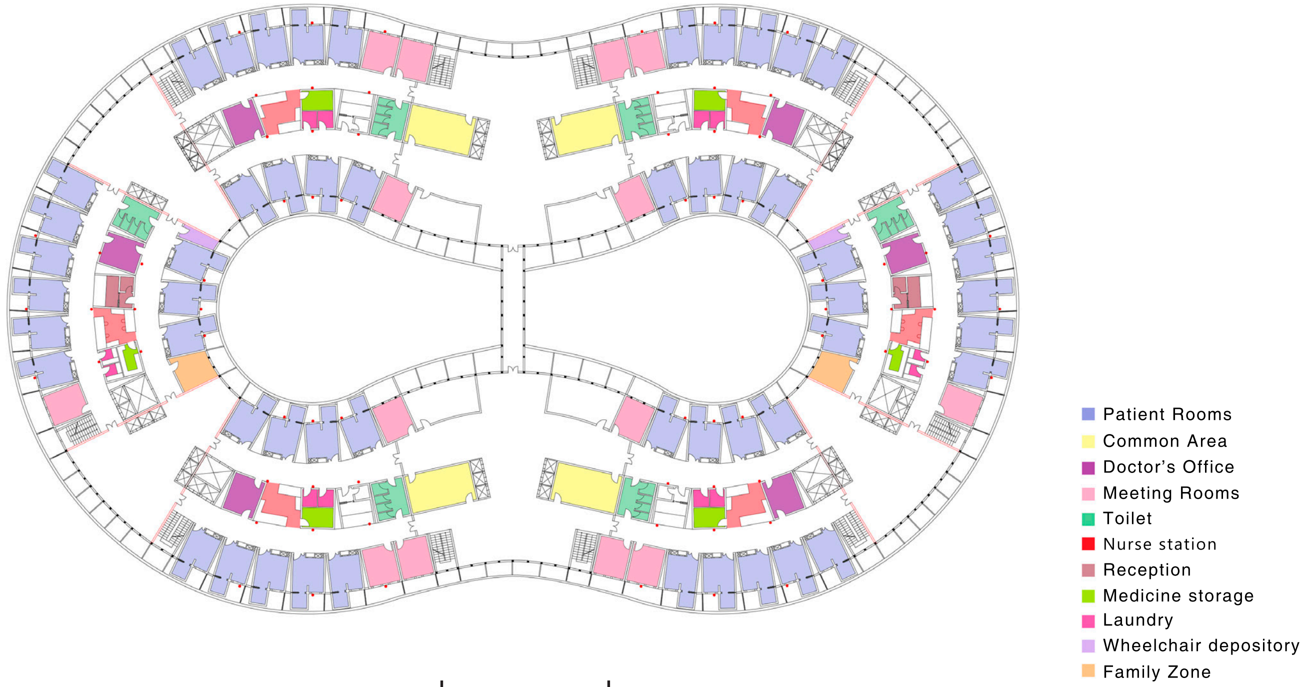
First Floor Organization



First Floor Plan +5.00m
*out of scale

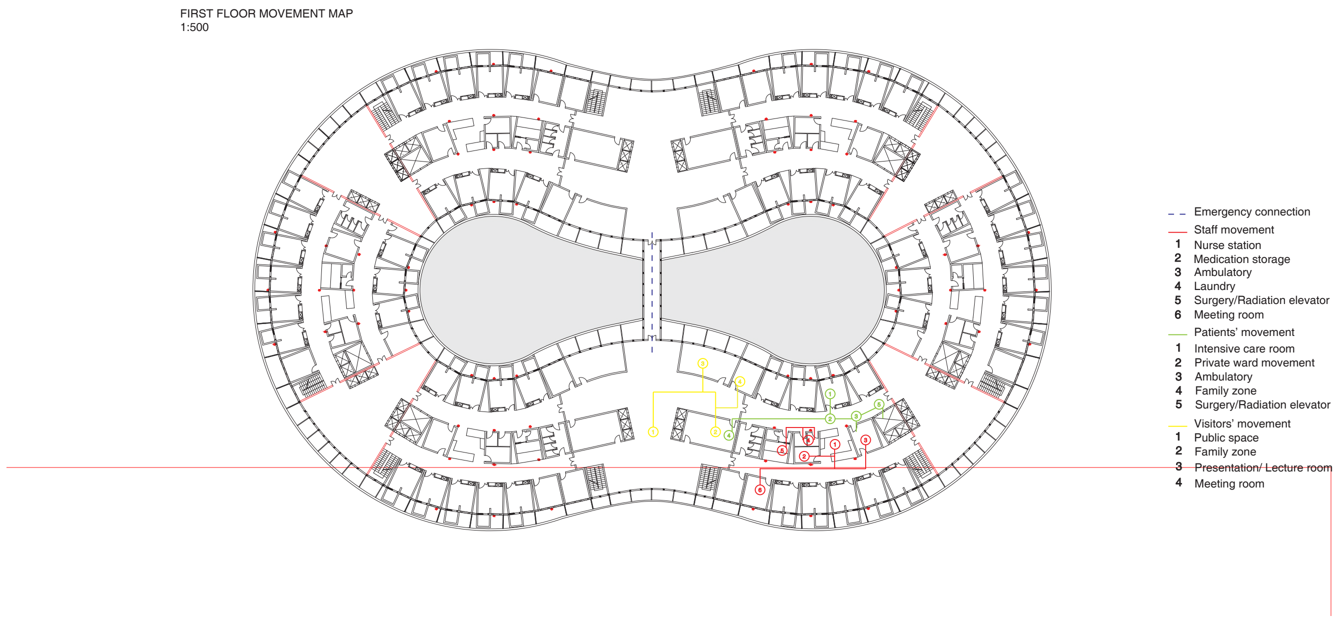
First floor is the intensive care unit level. There are six wards. The wards are spaces for the patient that require constant supervision or a continuous treatment. The wards feature private rooms. Rooms are big enough to accommodate another bed in case of emergency. The rooms are spacious enough to include the family zone as well. Besides the private rooms, the wards have multiple services. Every ward is a separate unity. There is a reception desk that will take care of check-in and check-out of the patients. The nurse station is in the center as to provide quick access to every room. The floor follow the ‘corpo quintuplo’ organization of the space seen on the lower level. This means that there are corridors on both sides of the nurse station. By opening it up, means that there is a fast connection to both sides of the ward. Nurse station is connected to the medication storage. Communication in vertical direction are provided by both elevators and staircases. The elevators are multiple. There are three public elevators coming from the ground floor. Every ward has an elevator for food delivery, another one for laundry. FInally there is an elevator big enough to trasnport hospital beds to operation block and vice versa. Considering the amount of users, there is a public bathroom in every ward.
Communal spaces are located between wards. This way patiens go out and socialize in a more dynamic environment. There is no need to walk far away for the occupant to feel more humane and not as orchistrized from the world. The clear view of both atrium and the urban context, is a nice change from the often depressing solitary room.
By taking into consideration the hospital is located in the near vicinity of the medical faculty, there are classrooms located on the first floor. They provide an educational space for students to have lectures or the hospital to organize seminars and presentations.

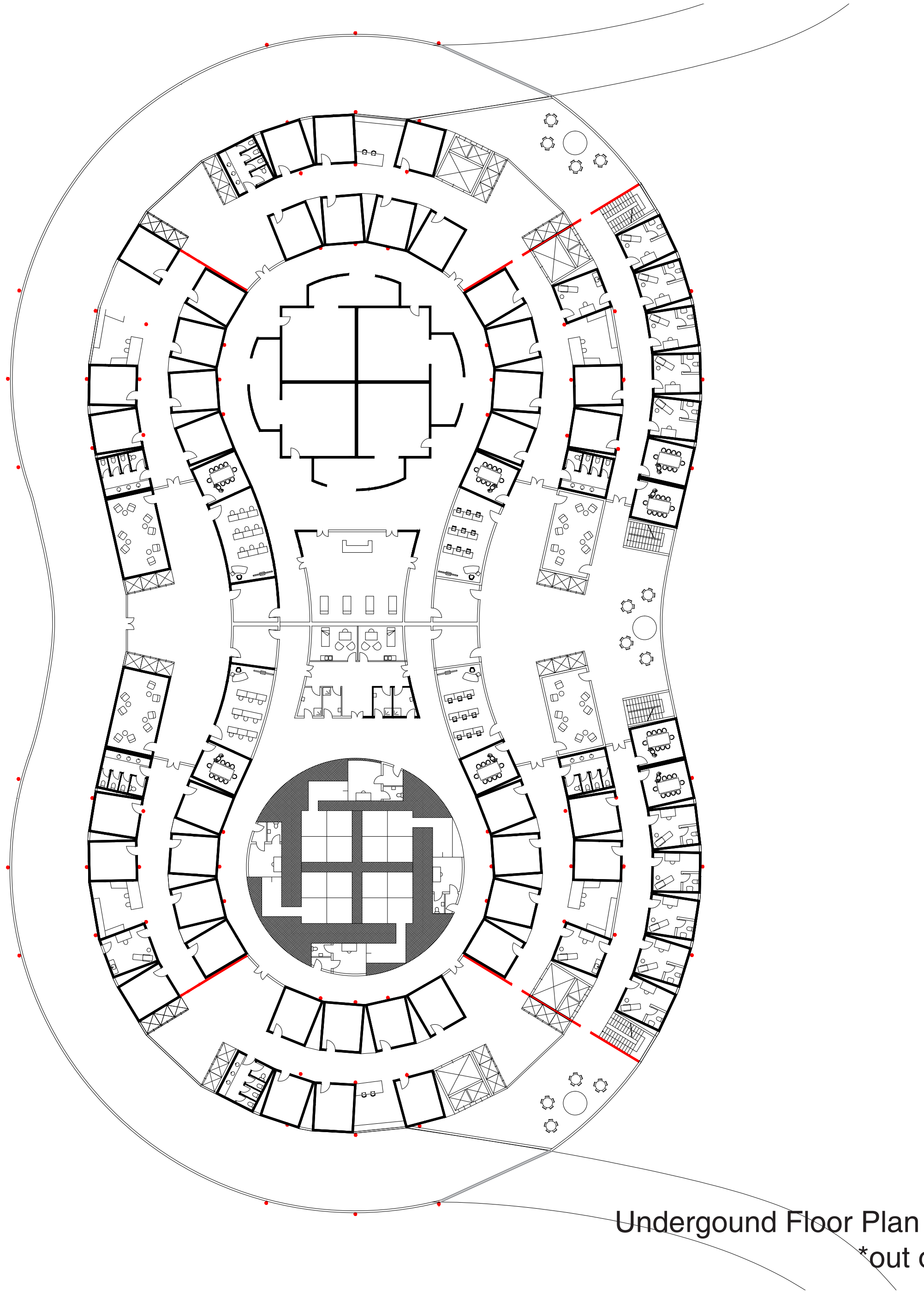
First Floor Functions



room type	area in m^2	total number of rooms
patients' rooms	25	28
common areas	50	10
meeting rooms	21	14
doctors' offices	21	6
toilet	21	6
nurse station	25	6
laundry	21	6
wheelchair depo	10	6
family zone	23	6

First Floor Movement Map



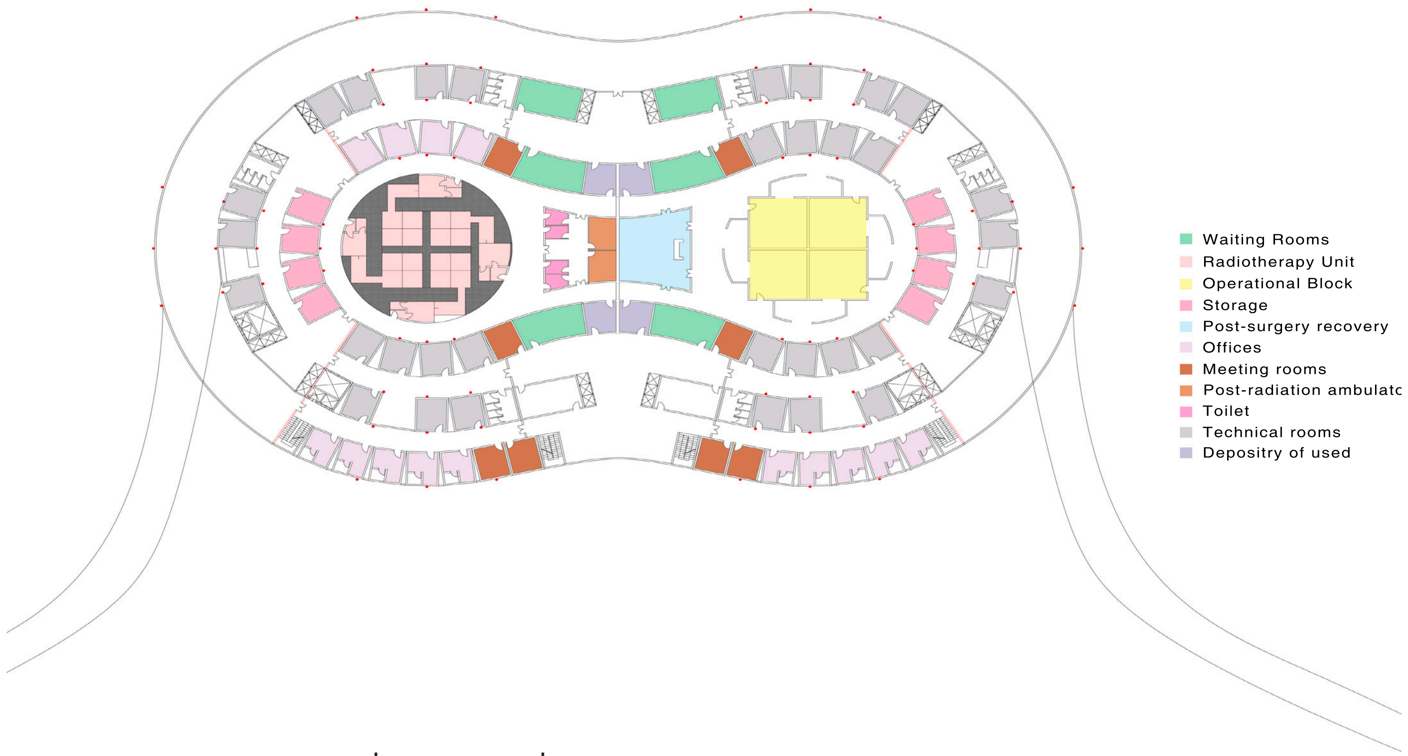


Undergound Floor Plan -6.00m
*out of scale

Underground Floor Organization

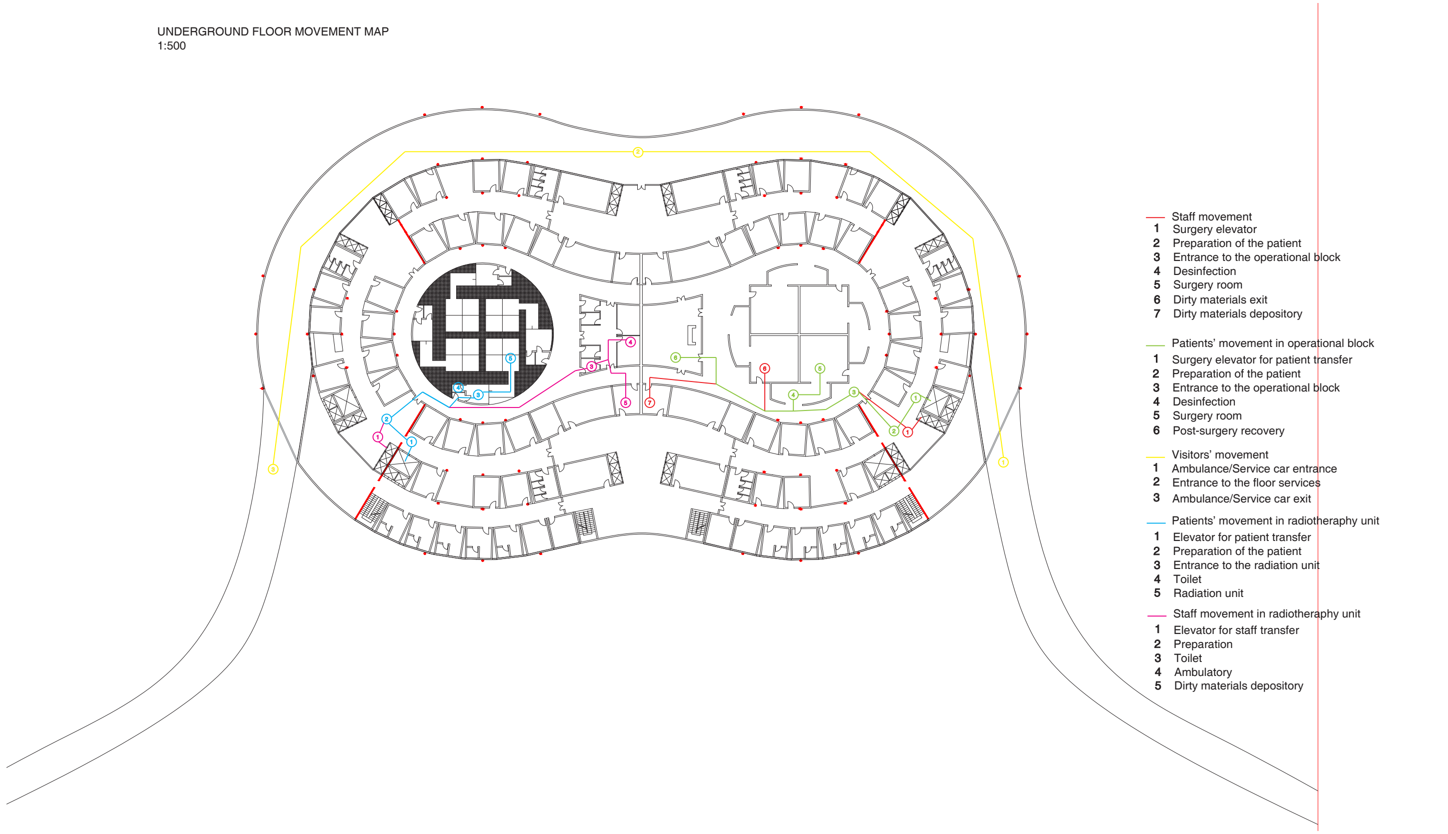
Underground floor situated operation block and readiotherapy. The emergency entrance is from the underground floor. The ambulance car circles the building on a ramp that has small inclination of 5%, as to make it safer in case of snow and ice in colder winter months.
The spatial organization mimics upper floors with the exection of the last row of the rooms. They have been abolished in order to make space for the driveway. The driveway leads out of the underground level, back to the street level.
The floor is sepated into two distinct units. Operation block and Radiotherapy unit.
Radiotherapy unit is the location for the treatment of the conditions diagnosed as cancerous.The radiotherapy department has different rooms. There are reception, console room, machine room, Treatment Planning System(TPS) and Uninterruptible Power Supply (UPS) room. Room vary in size. There is a standarn norm to be followed that is to have enough space for normal movement of commercial machinery.
Radiation is very harmful to human. As such, radiotheraphy unit is planned underground. Treatment room is solitified by thick concrete walls. It minimizes the external effect of the radiation. By keeping it underground, portion of the radiation is absorbed by the earth. Other fuctions in the near proximity of radiotherapy unit are kept to minimum.
The Operation block is a complex zone with a predetermined map of movements.The block is made up of administration area, scrub area, as well as work and supply room. There is a laboratory, a recovery room, lounge for the staff. There are lockers and toilets.
In Oncological hospital, there are four operational room. They are of same dimensions. Every operational unit has three zones for different types of activities. To ensure the sterility is pristine, there are certain paths of circulation to be followed. There is an outer zone with basic control, where the personnel enters the block and patients are received. Next level of sterility is intermediate zone. it is a work and storage area. Supplies are delivered to this zone, but moved inside from external corridor, as not to come across the more sterile interior. The recovery unit is considered as intermediate zone. The highest level of sterility is the inner zone. It is the zone of the operating room. This includes scrub area, patient holding and induction area. External traffic is prohibited. The conditions need to be septic.
The operating room establishes a pattern of minimal circulation between area. The patients is quickly transported to other hospital areas. The patients are moved back to their rooms on the first floor after waking up in the recovery room.
The patterns are strict and must be followed to ensure the most precise and efficient operation of the hospital. This is all in aim to provide the ultimate health protection.

Underground Floor Functions



room type	area in m^2	total number of rooms
technical rooms	21	28
offices	21	10
meeting rooms	21	8
waiting rooms	50	6
operation rooms	54	4
radiation rooms	26.6	4

Underground Movement Map



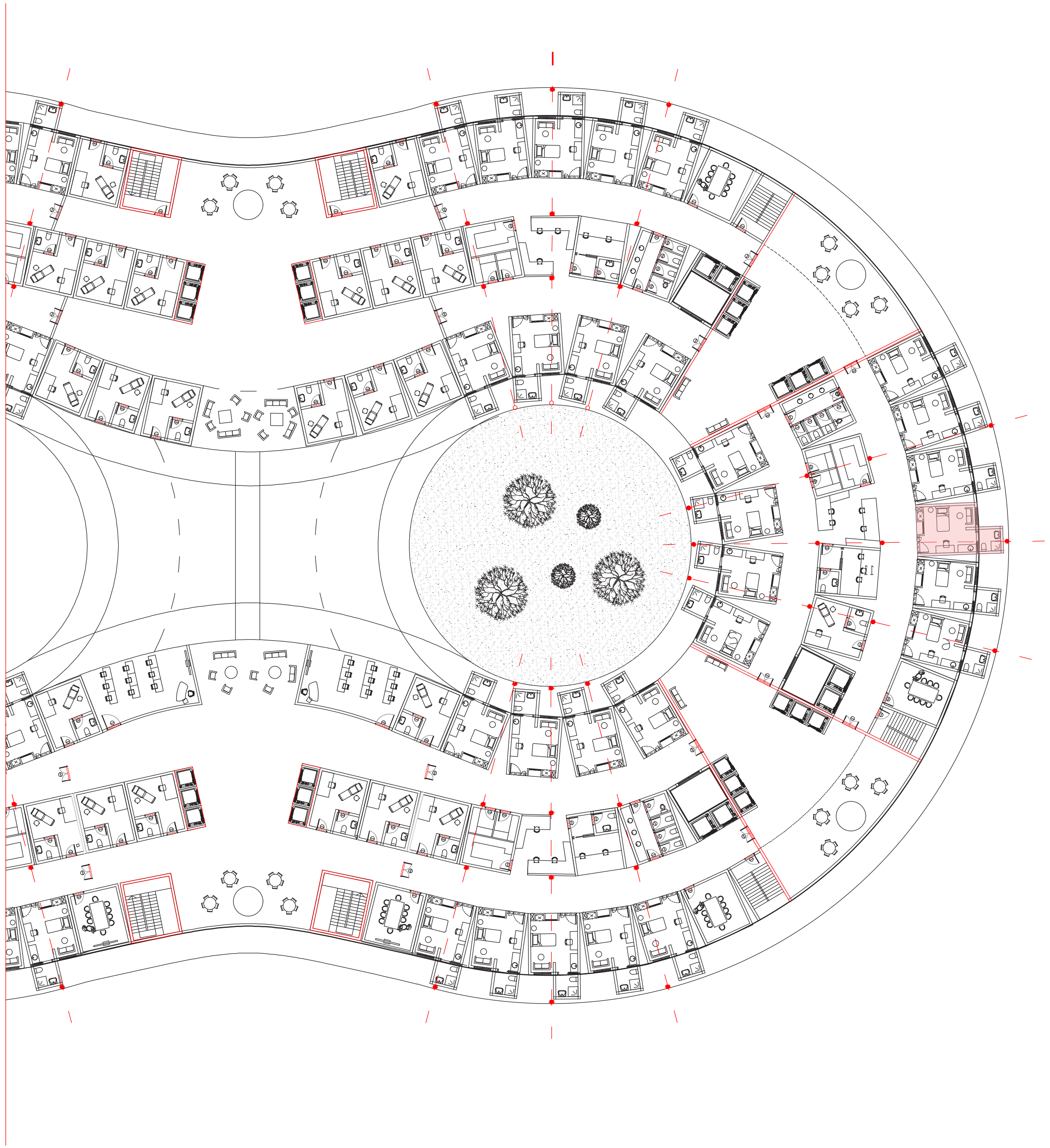


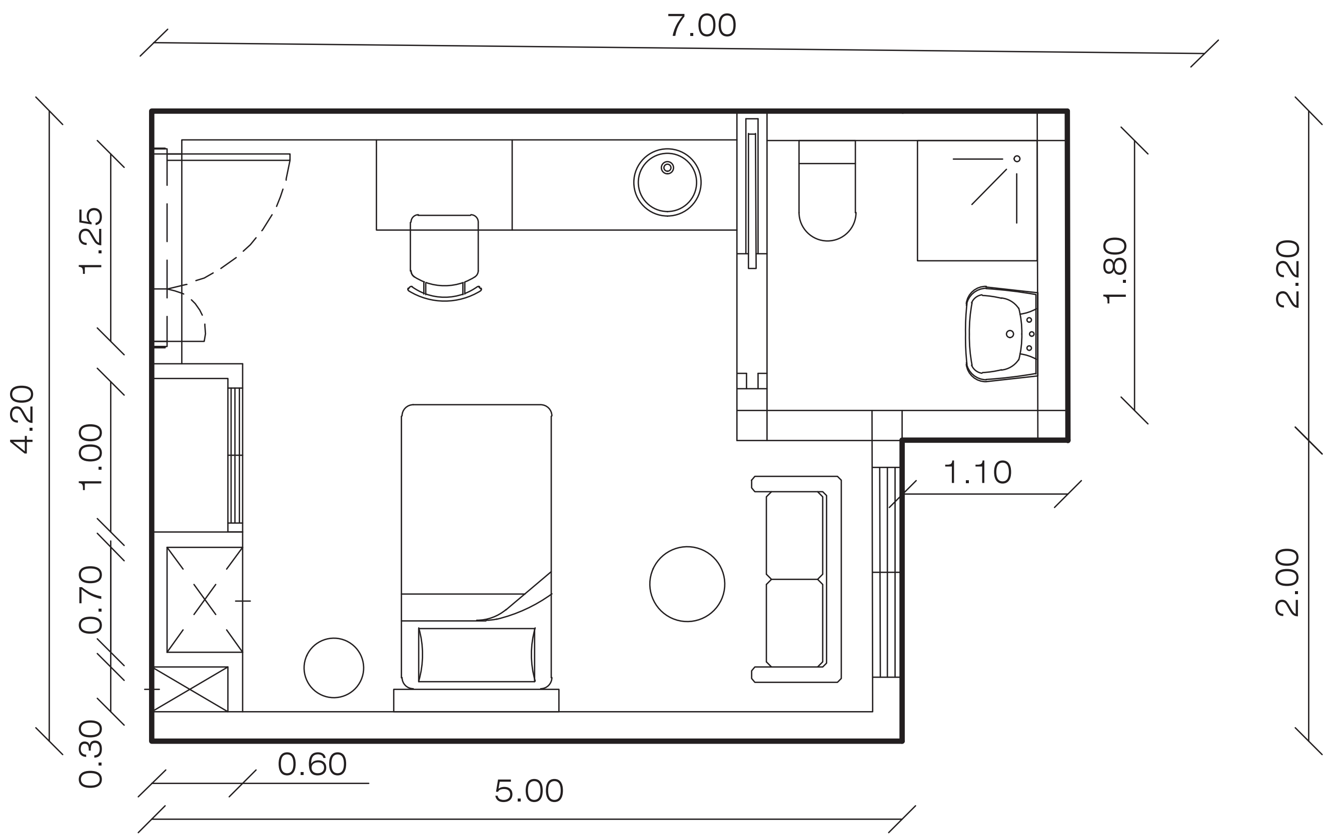
fig. 1

Functional Equivalence - How The Users Will Interact With The Poject

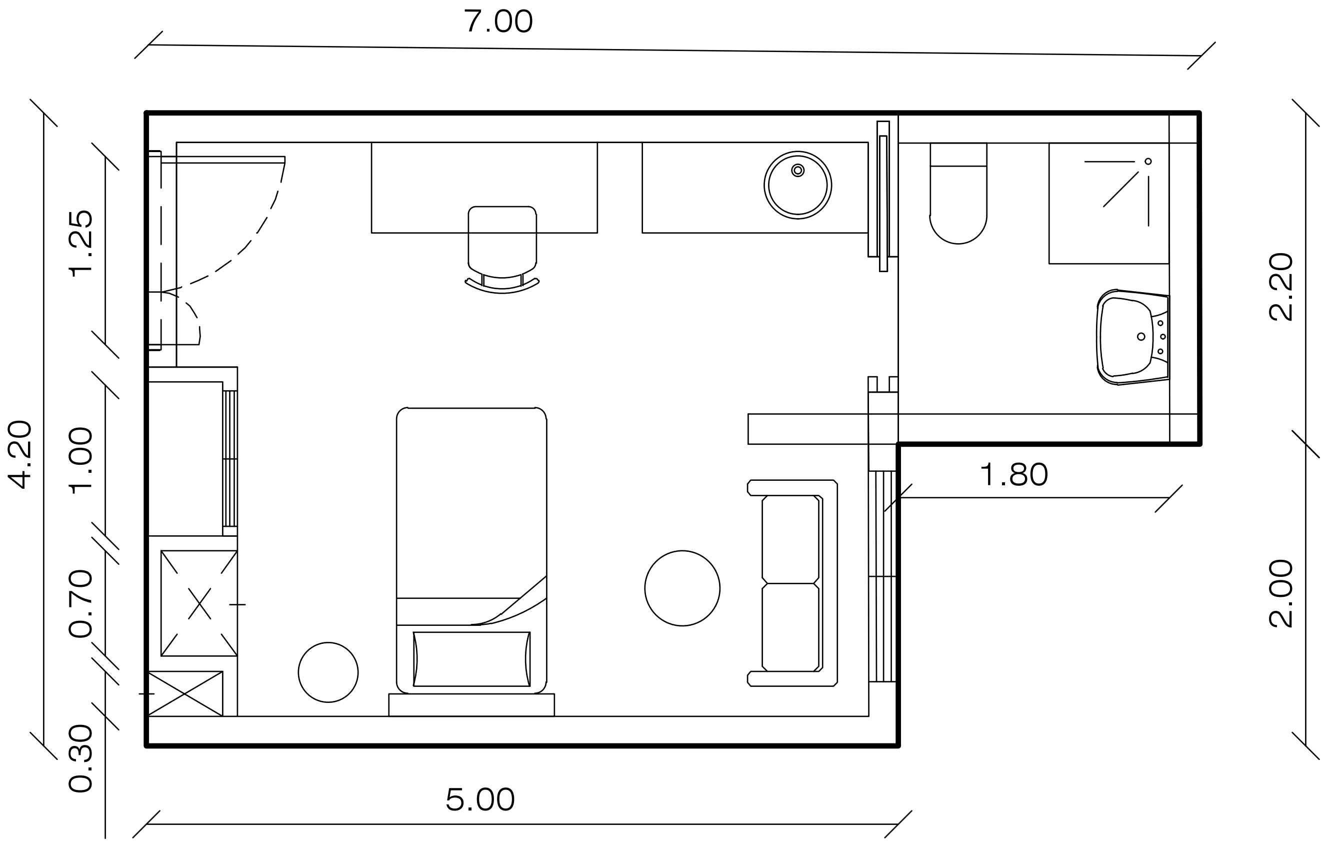
Healthcare buildings are notorious for making the patients anxious. Multiple pieces of research have proven that a more sustainable design will improve health. It will minimize the environmental impact while keeping the operational costs of a healthcare facility lower than average. The major cause of disease among patients is the lack of a quiet and healing environment. People use healthcare facilities in some of the most stressful and fearful times of their life.

Healthcare facilities are also one of the most stressful workplaces because the staff daily takes other people's lives into their hands. Whether administering medication or taking care of a patient experiencing trauma all workers are put under pressure. they experience more stress due to the responsibility their work carries.

The organization of the hospital follows a rule known as 'corpo quintuplo'. It is the organization of the layout featuring double corridors.This creates five sections. it is often used in order to lower the pressure and traumatic experiences of the health institution occupants. By separation movement paths of the patients, doctors and visitors, there is less anxiousness among staff. They suffer from extreme stress and seeing patients and family at every given moment heightens the sense of responsibility. Meanwhile, a separate pathway for patients means privacy. They are often under a constant watch from both the medical practioners and their family. Leaving them the freedom to move on their own, gives back the sense of control a disease can take away. By separating wards from the main circulation, it shields the patients from the unwanted looks from passerbys.



Patient’s room on the ground floor, scale 1:50 (fig 1, pg 134)



Patient’s room on the first floor, scale 1:50 (fig 1, pg 134)

The occupant's experience

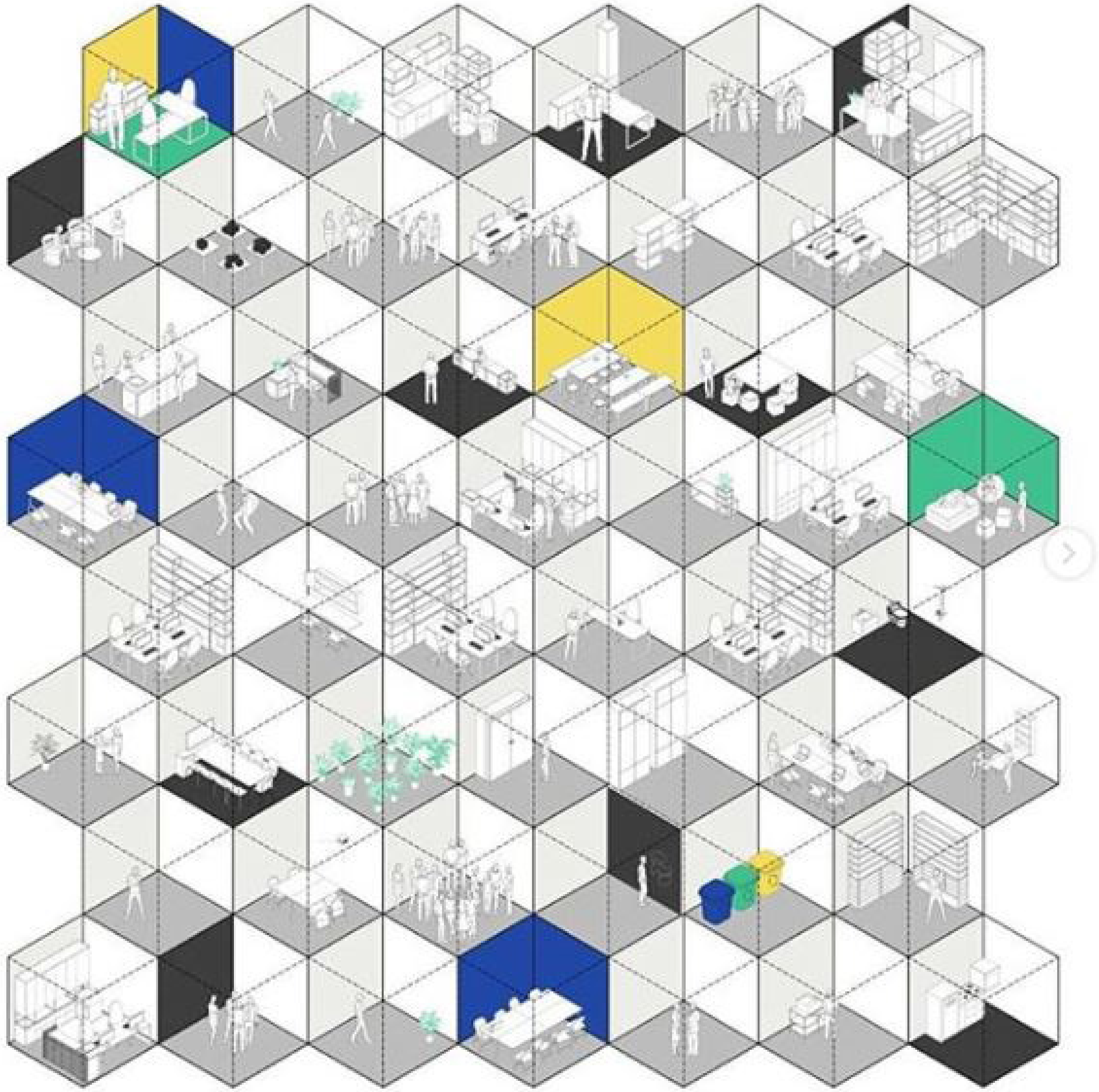


image source: instagram.com

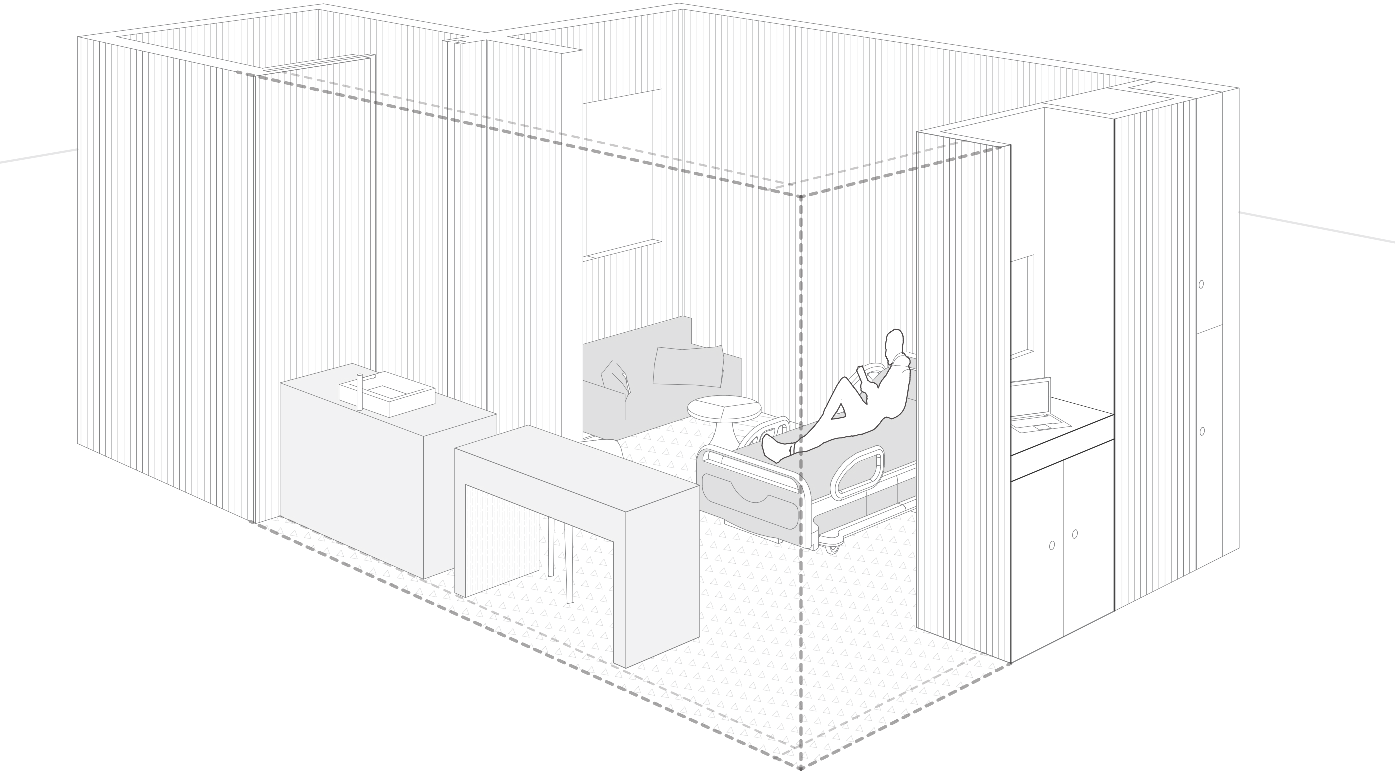
The patient is the central figure in health care institutions. It means that the individuality and humanization have gained importance in recent times. Not only is the aesthetic of the hospital very important, but the design should also consider the emotional and social aspects, as well as the patient's personal experience of everything that surrounds them.

Some examples that are being experimented with consist of improving the user's experience in waiting rooms. It means converting the patients' downtime together with their visitors, into useful time/ Designing hospitals that are easy to move around, facilitates the mobility for the people in the hospital. It in effect reduces the levels of uncertainty and anxiety among patients and visitors.

Interventions are already taking place. By creating an environment that supports the patient's individuality. There is an array of functional spaces for the patient to feel at ease during the hospital stay. By not separating the ill from the city, the Oncological Clinic translates the liveliness of the context is located in. Patients no longer need to feel like the disease is isolating them from the world. Today, the patient has a voice. Their opinions and experiences are a means of understanding how to better improve the hospital stay. The hospitals have evolved in a complete circulation system accessible to patients, families, and experts.

A new movement in the design of the hospitals by giving patients single-bedrooms raises the question of where do patients meet for socializing. There is a rising danger for the patients to feel lonely, isolated. Single bedrooms may also mean isolation. Previous research studies have already certified a relation in the patient's level of socializing and the actual time spent in the hospital.

Considering socialization as the crucial parameter for future patients, the project addresses one of the neglected areas in current hospital projects – the spaces for social support. Common zones, waiting areas, corridors, and daycare rooms are designed in the same way as bedrooms and treatment rooms. This creates a sterile and what is often used in a negative connotation clinical atmosphere in the institution. It means they are basically unattractive to stay in. The project of Oncological hospital establishes three pivotal points of the design of the community zones: spaces that reenact daily life, creation of the homely atmosphere and making sure the interior design project is executed in the human scale.

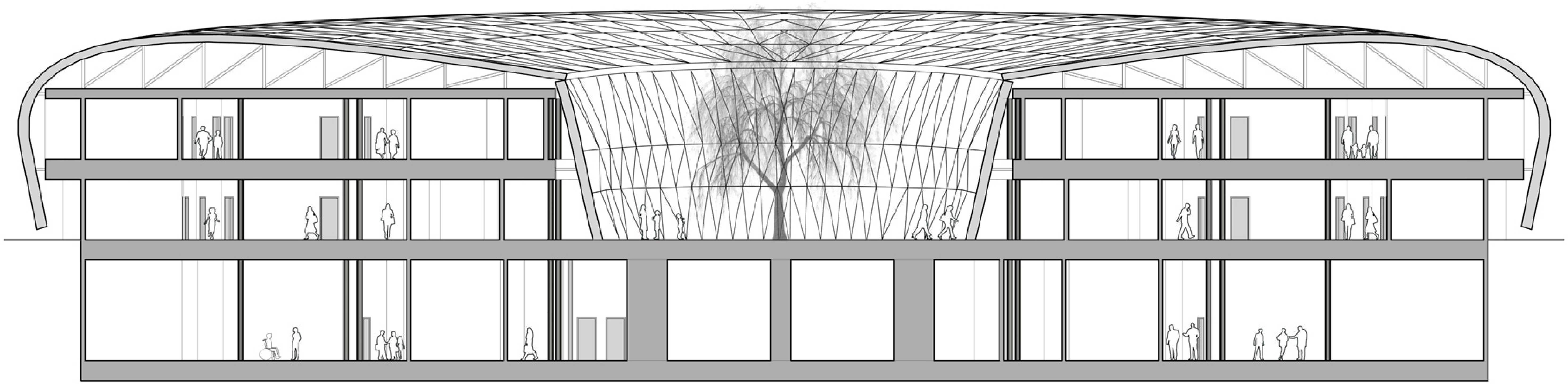


3D respresentation of patient’s room

The design of the Oncological hospital aims to create a calm, healing environment. The patient’s room is a private space for the ill and the family. A healing environment is the one that is not necessarily focused on medication. There is an dire need to establish a connection with nature. “A view to the outdoors and of nature is very important to healing,” (Dr. Fisher, Ellen, 2014).
By orienting the bed in a position to provide a direct view of the outdoors, speeds up the recovery process. There is an increase in the amount of daylight penetrating the room, as a result. Reducing noise, a major source of stress is another way of creating a more enjoyable hospital stay.
Hospital rooms are very modern and spacious. There is space for a bed, that is easily moved around and brought out of the room. Another very contemporary detail is the ‘family zone’. Patients in intensive care often suffer from loneliness. Depression is not uncommon. Making sure to include familiar faces in an unfamiliar environment, creates a more enjoyable stay for the ill. The bathroom is private for every room. Another innovative addition to the overnight room modules is the outer wall. The door opening is 125cm, in two wings. Both wings are to be opened in case of bed transfer. The modules’ walls are equpped with a desk and medicine cabinet. A desk is installed as a stop for the doctors to have a look at the patient’s files or to have a moment for themselves after the visit. There is an additional storage cabintet under the desk. Another small cabinet for medical equipment occupies space in the wall. This helps maximize the space available.
The room has a desk corner and another point for medical staff. There is enough space and equipment for every need of a modern hospital. There is a healing space personalized for the patients going through an intesive tratment. The needs of hospital staff are considered as well. The need for privacy and rest in needed in such emotionally demanding situations, for both patients and staff likewise.

Operational project

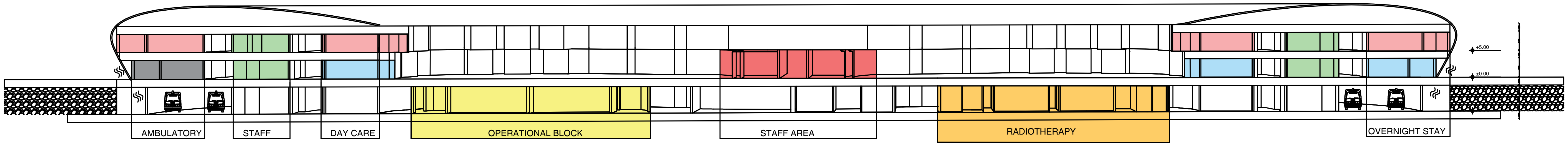
The building is designed to provide comfort and make the hospital stay more pleasant as most of the patients are in intesive care. The Oncological hospital has a very complex facade. It is attached to the building with particular and carefully placed elements. In order not to disrupt the openings of the hospital to the exterior, there are verious levels of privacy. Privacy is provided with the variation between elements that provide clear view of the environement, or elements that shield the interior modules from the public eye.
Facade, although of complex form is assembled by smalled triangual elements. They have three variations in size. As such they can follow and shape the different degree of curves in the exterior envelope od the building.



cross section of the hospital with the central atrium

The building is completely furnished by modules produces off-site. This means they are of standards dimension. The extravagant form of the facade, hides a modest interior. Every modules is identical in size. By careful placement and choice of the purpose of the module. The scheme hightlights the use of the spaces on different levels. Different floors hold different functions. Ground floors is the public floor. It is the space for daycare patients, ambulatory visits, as well as administrative and staff areas.
First floor is the zone of the intesive care. Special attention is put on the comfort of patient staying for extended periods. The design proposes boh private and public common areas. Underground floor is a way for the emergency entrance to the hospital. It houses thickly confined radiotherapy and large operating block. This is the service block. It is not accessible to general public.

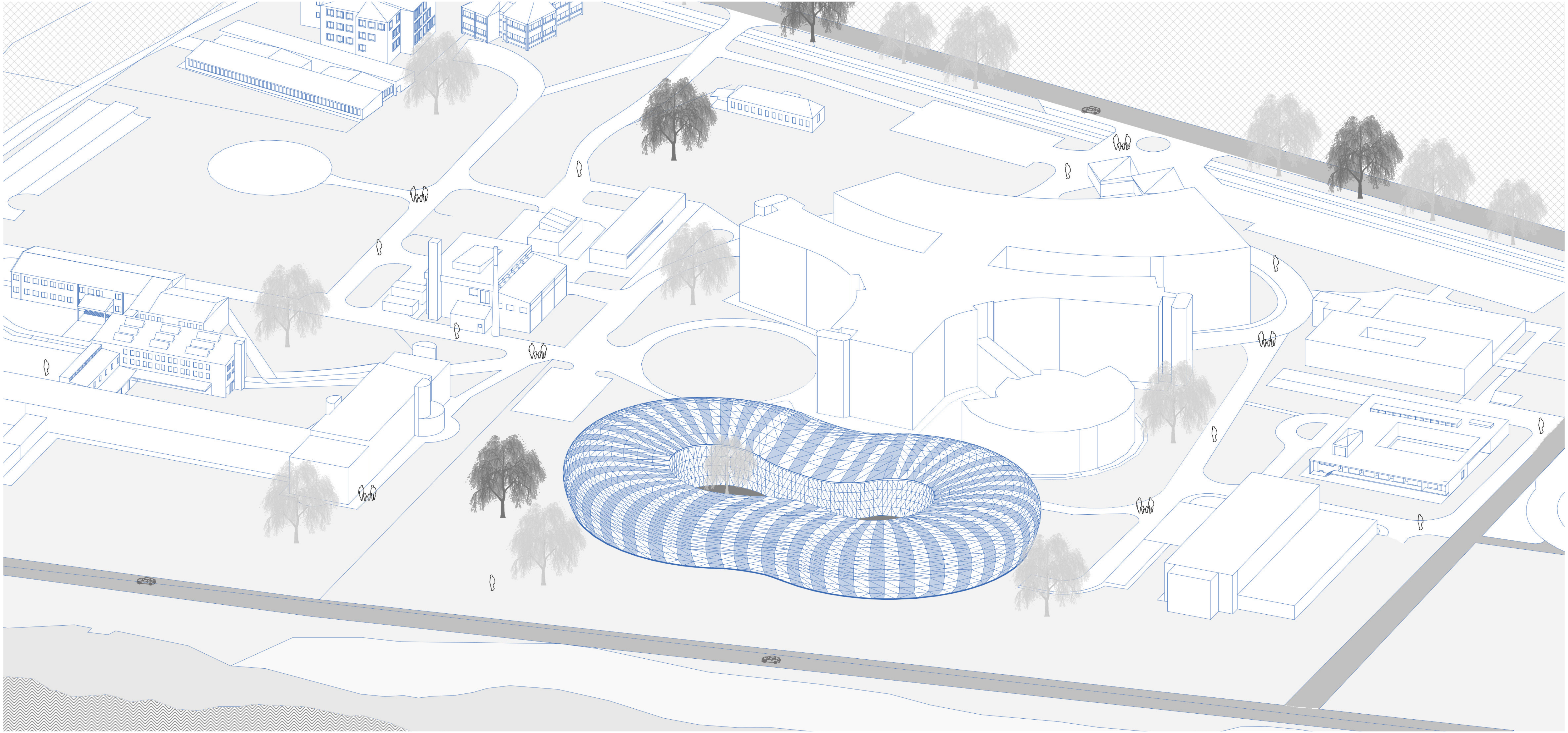
By playing with the position of the identical modules, there is a dynamic in the space. This does not implies difficulties in the orientation of the users. The corridores confined by wards, later open up to common spaces. These spaces are lightly furnished. The careful choice of the materials and the facade allow maximum penetration of the sunlights in the bulding. These are the spaces of comfort and relaxation for patients and staff likewise. The facade encloses a set of modules that are cantilevered. The first floor more than the ground. The first floor is overhung by 1.8m. The ground floor is overhung by 0.9 m. These dislocations are what gives the elasticity to the facade. It is a not linear form. The cantilevered part is the bathroom. The opaque elements of the facade cover the function of the contact spaces. All these disharmonies join in a particular form of a curve of the new oncological hospital.



transversal section highlighting the different uses of space within the hospital

Final Observations

Oncological Hospital is located on the brims of the river Moraca, in Podgorica, Montenegro. It classifies as a small hospital, counting 60 beds.
A very sensitive type of treatment as the cancer treatment is one of the demands of the project. Another one is the location of the building in the bigger complex of Clinical Center. There is an existing system. Conforming to the system and bringing new services.
As the only public cancer treatment hospital, the building includes a radiotherapy unit and an operational block. These services constitute the core medical zone. The underground floor is joined by a united medical and technical service zone.
The design of the hospital, from the whole hospital, divides into wards. This provides the separation of doctor and patient, private and public zone.
While taking advantage of the horizontality of the hospital space, the center area of the building offers a safe and comfortable evacuation square for medical workers and patients.
The project design takes full advantage of the natural conditions, such as the very sunny climate, strong winds, the shape of hills surrounding the city and the river system. The design successfully provides a comfortable and enjoyable hospital.
An innovative material used for the facade manages the sunshade. It offers soft lighting and a private atmosphere indoors. The scenery surrounded by the hills, the urban zone, and the river brings the patient a sense of safety and liveliness.



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Slatkice, muchas gracias for being there.