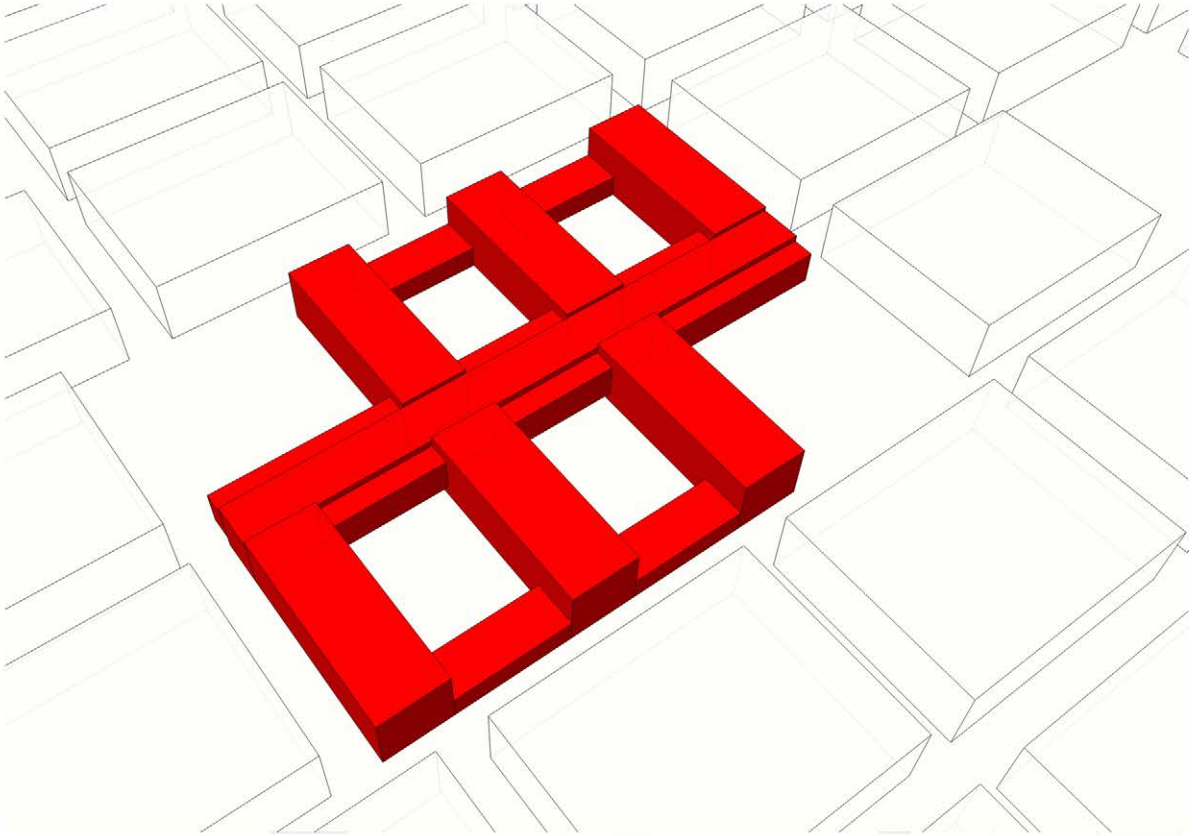
RUSSIAN HOSPITALity.
Strategies for hospital flexibility in urban context.

Politecnico di Milano

Faculty of architecture and society

Master of science in architecture



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Dedicated to T. M.P. P. R.A.A.T.N.V.M....

Abstract.

The aim of this thesis is to analyze capacity of modern hospital, its supplies and demands within urban context. Health care design went through long history in its changes and transformations. Different ages considered place of the hospital within the city in different ways. While in some periods of time, such as Enlightenment, hospital was one of the central and most important facilities in the urban tissue, other ages considered hospital just as utilitarian function, as a machine for patient recovery (Cor Wagenaar, 2006).

Today healthcare design practitioners and theoreticians try to combine most advantageous technologies with spatial quality of hospital in order to bring back phenomenon of healing environment which is made by spatial organization of hospital layout. Modern healthcare technologies play crucial role in recovery process and their rapid development affects hospital in many ways. That is why flexibility, or, in other words, ability of hospital to adapt to these changes, becomes one of the main demands in modern healthcare design.

First chapter of the thesis is dedicated to the short overview of flexibility as theoretical approach and underlines its main characteristic features. Second chapter introduces urban context of the area which was chosen for application of modern and flexible healthcare design principles. The area is Russian city of Pensa, situated 600 kilometers from Moscow which represents typical provincial Russian city requires renovation of healthcare facilities. Third chapter explains in details all aspects of flexibility which were used in this renovation project and shows realization of flexible hospital complex in a bottom-up approach. Fourth and last chapter, modern trends in healthcare design, goes deep in details of different design solutions applied to this design project considering patients, caregivers and visitors as three main groups of hospital users. Special needs of each of these groups as well as their interaction with each other are described in details in this chapter. Thesis ends with the assessment table where different aspects of flexibility are summarized and assessed based on delivered project.

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CHAPTER 1

Hospital flexibility. Theoretical overview.

1.1. Flexibility. Current supply vs future demand

Flexibility in architecture can be viewed as capacity of building to adapt to changing spatial, operational or usage demands whether in a short, medium or long term (Capolongo et al, 2012). Based on this definition, flexibility can be seen as an answer to uncertainty and unability to predict the future. The aim of flexible solutions is to deliver supply which can be adapted, modified or changed in order to meet future needs without demolition of entire structure. Since the life cycle of the standard building is between 70 and 100 years in average, providing flexible design solutions since the moment of creation is a way to extend the use period of the building in a way which meets changing demands (Cor agenaar et al, 2006).

Real estate development process in general, and development of hospital in particular, is a long-term process within changing of economical, technological, political, social and demand-supply ratio situation. Hospital design takes special place while talking about flexibility, since the fact that health care facilities are highly sensible in terms of changing demands because of rapid growth of medical technologies. Hospital has highly technology-oriented environment, which changes rapidly based on supply of new technologies and demand of different user groups of the hospital. Flexibility can be also described as an attempt to match current supply and future demand of the building based on the analysis of future trends, needs and supplies. Figure 1 represents 9-step framework of design an accommodation strategy for analysis, design and elaboration of the real estate development project based on comparison of current demands and future supplies.

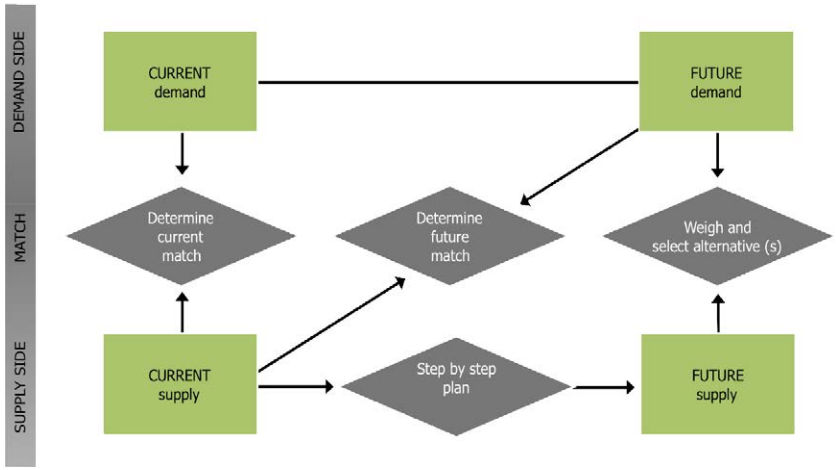


Figure 1. Analysis of demand and supply (Source: De Jonge, 2016)

Based on rapid changes of health care technologies which need to be implemented in hospitals in order to improve the level of treatment and care, which is, after all, the most important indicator of its effectiveness, hospital can be considered as one of the building typologies with the highest demand for flexibility. Figure 2 illustrates the reduce of lifespan of use of health care facilities in retrospective from medieval times till nowadays.

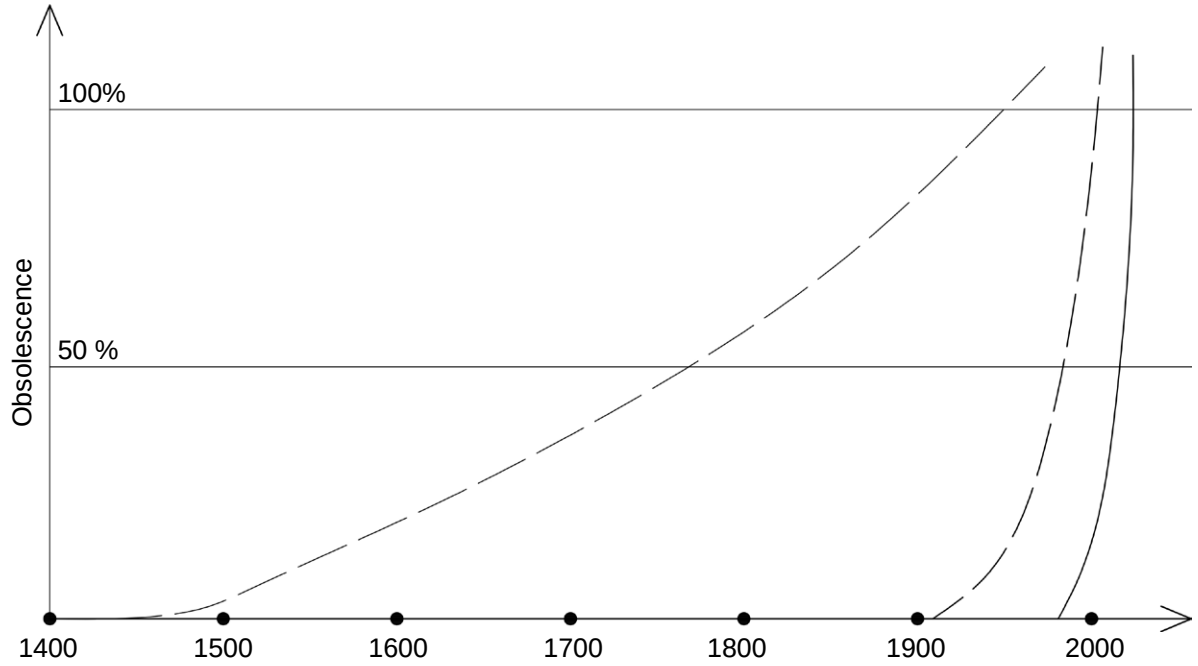


Figure 2. Periods of use of healthcare facilities (Source: Capolongo et al, 2012)

Due to rapid development of medical technologies in the last decades the period of use of health care facilities reduced significantly, as it shown in figure 2. We can conclude that the current supply and future demand of modern healthcare facilities are in conflict with each other. Flexibillity in this case is a tool to get and to consider future demand while design the hospital today. Next paragraph will discover different aspects of flexibility, their interact with each other and their contribution to overall flexibility of the hospital.

1.2. Flexibility of design. Flexibility of use

Another approach of describing flexibility can be explained as possibility for different users to organize and to reorganize their activities freely and according to their own timeframe, without encountering excessive constraints in the structuring of the space and in the installed plant (such as dimentions, distribution, performances, etc) (Capolongo, 2012). In this light it is possible to add that flexibility allows different users to change and

to organize their own layout within the building without disturbing the timeline and layout of other users.
Achieving high level of flexibility requires a lot of design effort on earlier stages of design process. The wide analysis of future needs of the building and demands of its users currently and in the future is needed in order to get flexible spatial layout. One of the main approaches to reach flexibility is standardization of dimentions of different spaces and prefabrication production of elements to construct these spaces. Possibility to change the spatial layout of the space based on predefined number of prefabricated elements is an effective way to reach high level of flexibility. The continuity to use flexibility from design phase to use and operational phase is highly important in this situation. Space designed with needs for flexibility in mind can be than easily adapted for other needs without costly refurbishment or demolition of the building. Basically, there are three transformation cycles exist.

- Daily / weekly usage transformation cycles
This cycle offers possibility to use the same place during the day or the week for different purposes. For example, consultancy room can be used for its primary function during the week and for office or meeting room during the weekend. This strategy can reduce the demand for office spaces and consultancy rooms in the hospital by careful management of working timetable and exchanging spaces and user flows.

- Medium usage transformation cycles
These cycles refer to seasonal or medium time changes in spatial layout based on natural insolation, amount of sun light and other seasonal or cyclical factors in the work of the hospital

- Long usage transformation cycles
This transformation cycle is similar to daily one, but the change of the function of the space takes long-term charcter. For example, practitioner room can be changed to office or surgery room for a long time without costly refurbishement of the space by using identical prefbrication elements which are common for the entire hospital building (Capolongo, 2012).

1.3. Types and levels of flexibility

Flexibility in general and flexibility of hospital in particular can be structured by levels and types of flexibility. There are 3 types of flexibility:

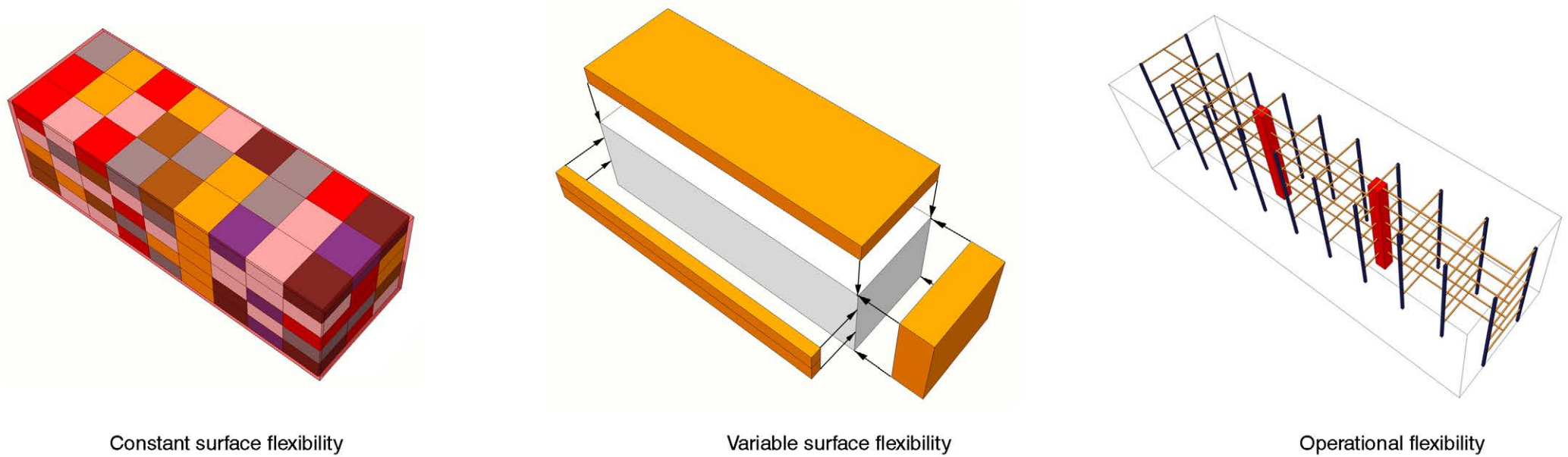
Constant surface flexibility

Variable surface flexibility

Operational flexibility

Constant surface flexibility includes the possibilities to change and to adapt the existing facilities (rooms, units or buildings) to the user needs within

initial floor area can be increased (or decreased) by adding additional parts to the existing building. These parts can be modular cantilevers which are hanging to the facade and increasing the floor area of the unit, or entire segment of the building which can be added to it in a modular or prefabricated way. The possibility of this type of flexibility should be designed in advance in order not to disturb the daily activities of entire hospital. The third type, operational flexibility, is meaning to adapt one or another unit (or indidual room, or entire building) according to user's needs and demands as well as flexibile operational and technical services and easy access to them. Figure 3 illustrates all three flexibility types.



Constant surface flexibility

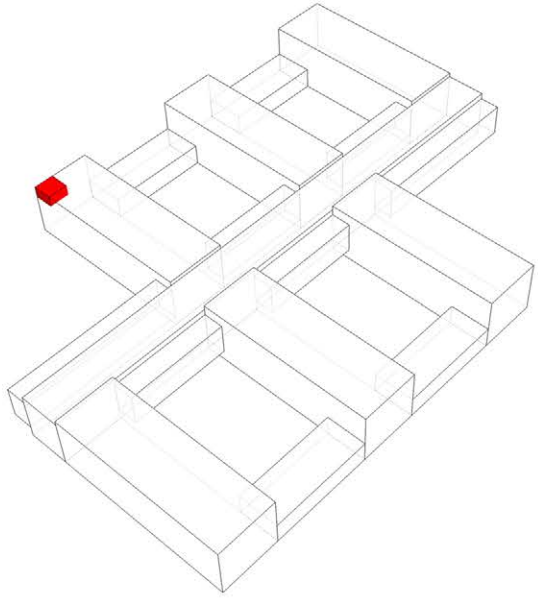
Variable surface flexibility

Operational flexibility

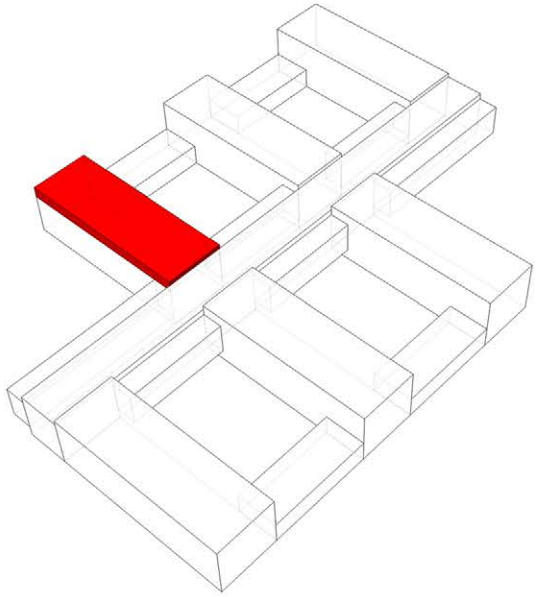
Figure 3. Types of flexibility

In addition to three types there are four levels of flexibility in hospital design (Capolongo, 2012). The first level is individual room, which can be adaptable to the user's needs. The second one is functional unit, which can be combined from the set of individual rooms and be able to accomodate any hospital department. Third one is a building level, in which different hospital departments can be accomodated in one building; they can be changed based on current demand or even converted into another function, such as offices or housing. Finally, the fourth level is a hospital complex level, which is combined from identical buildings and accomodates the entire hospital. Due to rapid changes in healthcare technologies the function of total complex can be changed from hospital to housing or office functions in case of proper applicability of flexibility concepts on the previous levels. Figure 4 represents four levels of hospital flexibility.

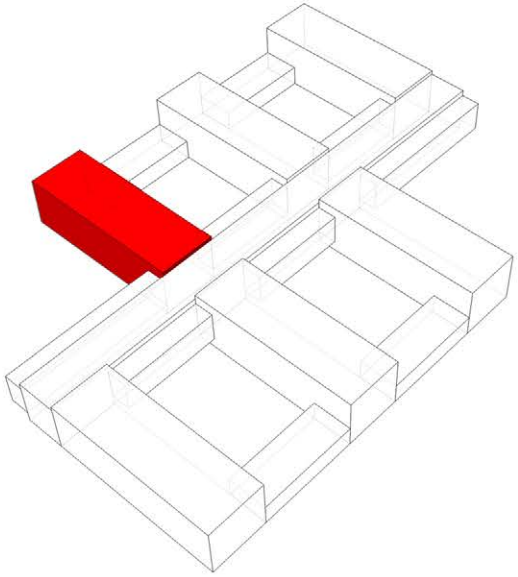
Figure 4. Levels of fleibility



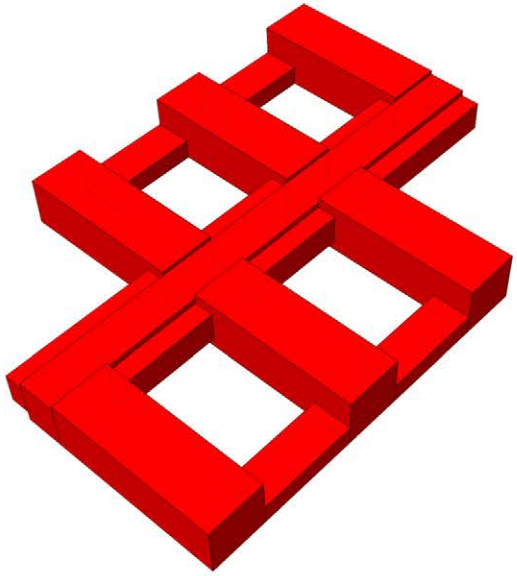
1 level: Individual room



2 level: Functional unit (floor department)



3 level: Building



4 level: Hospital complex

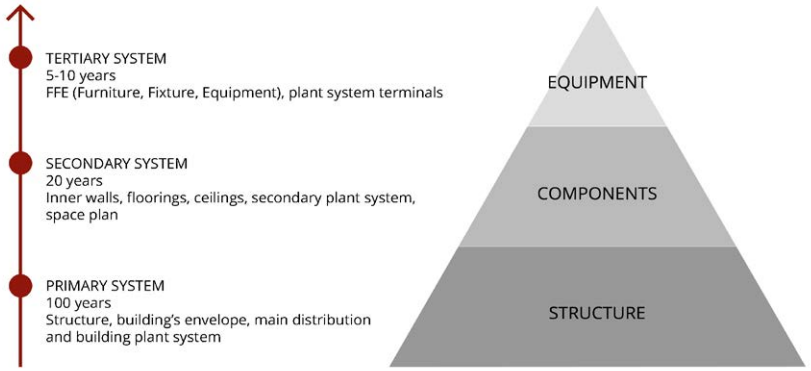
Another subdivision of functional units of the hospital in terms of flexibility can be found in Cor Wagenaar research book «The architecture of hospitals» (Cor Wagenaar, 2006). They are:

Site of the building

Primary structure

Secondary structure

Tertiary structure



Three systems of hospital flexibility

The location of the hospital is crucial for its operation and future extension. The reconstruction of existing hospital which is still in use is complicated task, which demands a lot of management approach while the normal work of hospital will be sill reduced. That is why the site for the future hospital should be big enough to accommodate additional structures. When the current hospital will be obsolescent the new building can be built firstly on the same plot, and the original building can be refurbished or demolished after. Possibility to modify existing hospital while it is in use, is more complicated but possible solution. Here we are going back to three types of flexibility, and particularly to variable surface flexibility, when the part of the building can be added or eliminated without disturbing the whole complex. In this light it is important to design flexible layout on the earlier stages of the project.

Primary structure is the main skeleton and structural frame of the hospital with lifespan of 50 - 60 years (Cor Wagenaar et al, 2006). Primary structure of the hospital mainly consists of structural skeleton with the usual span of 7.2 to 7.2 meters. There is an ongoing debate regarding the effectiveness of increasing the span of primary structure. The promoters of wider spans argue that this increases the flexibility within the floor and allows to adapt the building to the future needs more easily. The opponents of wide spans say that despite the fact that wider spans can facilitate the planing of one or another department within the floor, it brings much more technical and structural difficulties in reality. Structures with wider spans are more difficult for technical installations because any whole decreases the stability of the structure. Since the fact that hospital contains a lot of vertical communications and installations, which demand a lot of technical wholes and shafts, the increasing of the span in structural grid makes the installation of these communications difficult. That is why for the reasons of structural stability as well as for easier technical installations, the optimal span of structural grid in hospital usualy equal to 7.2 x 7.2 meters (Wagenaar, 2006). On the other hand, in recent years the structural grid of modern hospitals is slightly increasing 7.2 m span based on higher complexity of technical installations. In any case, the choise of one or another span for hospital structural grid is based on individual characteristic features of the project.

Secondary structure mainly includes installations and technical systems of the hospital, such as steam, ventilation, cooling, water, electrical lines, heating systems, ICT communications, etc. The lifespan of secondary structure is 15-20 years. Measures for increasing flexibility of secondary structure include:

- Larger story heights in order to increase the amount of technical communications above the ceiling or under the floor

- All installations are located above the main corridors in order not to disturb different departments while maintenance process and to simplify it.

- No bypassing of room units to reach other departments

Tertiary structure mainly includes finishings of interiors, lighting, furniture and other equipment. The use of prefabricated and standardized elements for finishing interior design can siginicantly increase flexibility and process of maintenance. Movable walls with fast fixing systems can siginificantly increase constant flexibility of the hospital by subdivision or unification of the space depends on current needs. Grouping of hospital departments by classes, such as ward cluster, emergency department, surgery block, etc gives possibility to change equipment and installations in particular department locally without disturbing other departments. The spatial needs of one or another cluster can be considered in advance and different supply can be provided in the design phase based on its special needs. Tertiary structure also includes micro-extensions, when territory of existing hospital can be adapted or modified within its current boundaries.

Figure 5 represents summary of different types, levels and aspects of flexibility which can be used for checking and assessment of hospital flexibility.

Levels of flexibility	Types of flexibility	Typological-spatial strategies	Levels of flexibility	Types of flexibility	Typological-spatial strategies
Hospital complex	Constant surface flexibility	Flexibility of access systems	**Building**	Constant surface flexibility	Existence of shell space for expansion
		Functional flexibility of the system			Structural flexibility
		Reuse of hospital complex			Oversizing of load-bearing structure
		Redundancy of space for plant			Modifiability of the envelope
	Variable surface flexibility	Existence of unused building land			Presence of spaces for building plant infrastr.
		Strategies for increasing volume of buildings		Variable surface flexibility	Oversizing of load-bearing structure
	Operational flexibility	Modular, replaceable and maintainable plant			Possibility of modular expansion
		Presence of networked informational systems			Tiered building
		Use of automation and control systems		Operational flexibility	Modular, replaceable, maintainable plant
		Use of flexible contractual/financial arangements			Efficient programmed maintenance
		Outsourcing of support facilities			Life cycle cost

Levels of flexibility	Types of flexibility	Typological-spatial strategies
Functional unit	Constant surface flexibility	Use of internal dry partition walls
		Use of moveable internal walls
		Use of moveable internal partitions
		Presence of spaces for service building infrast.
	Variable surface flexibility	Possibility of extending entire unit upwards/sideways
		Presence of verandas / setbacks
	Operational flexibility	Plant with flexibility of use
Individual room	Constant surface flexibility	Functional flexibility of the room
	Variable surface flexibility	Possibility of extensions upward / sideways
	Flexibility of use	Providing multifunctional rooms
		Plant for multifunctionality
		Information systems services for multifunc-ty
	Adaptivity of the user	Use of moveable furniture and vertical screening
		Customisable humanisation of the room

Figure 5. Flexibility matrix of healthcare facility
(Source: Capolongo, 2012, Astley et al, 2015)

Above table represents general assessment of the flexibility of hospital. Each parameter can be checked for particular hospital project and total persentage of flexibility can be calculated. This method will be used at the end of the project in order to assess flexibility of design project.

1.4. Organizational structure of the thesis

The aim of this work is to analyze and to understand modern principles of health care design with flexibility as the main approach. For this reason sufficient number of existing hospitals was analyzed in order to understand main principles of their spatial organisation, daily functioning and capacity of flexibile renovation. The final table of the examples which were analized and those parts of them which were used in my hospital design project is represented in figure 7. Chapter one, in this case, reviews main aspects of flexible health care design and gives an overview of the modern existing hospitals.

In order to implement the main principles of flexibility in health care design and to test the latest trends in this field, the existing general hospital for 300 beds in Russian city of Pensa was choosen for flexible renovation and revitalization. Choosing this particular hospital for meta-design project has two main reasons. First one is the approach to renovate the hospital in Russian province instead of design the project for one of the Moscow hospital sites. While situation with health care in the capital of Russia can be assessed as sufficient based on high amount of financial,

technological, managerial and political resources, the state of regional hospitals around the country is relatively poor based on high centralization of the administrative system of health care, negative financial balance of the budgets of many Russian regions and depreciation of communications of technological plants (Sidorkova, 2011). Second reason is related to the first one and has an aim to design universal model of extension of existing Russian hospitals with possibility to apply it to the number of them in order to reduce the time of design and approval of the project as well as to simplify the construction process and to reduce financial costs of the overall process. Burdenko hospital in Pensa, choosen for renovation design project for this thesis, is a general hospital for 300 beds with standard set of medical departments, such as surgery department, emergency and reanimatology department, out-patient clinic, therapeotic and physiotherapy departments as well as research laboratories. Burdenko hospital has classical pavillion system of spatial organisation, when different departments are situated in different buildings and connected to each other by ground or underground connections. Second chapter, in this case, describes current situation and state of the art of Burdenko hospital, analyzes its urban context and gives main data regarding its current capacity. This chapter also shows morphological scheme of extension and renovation of Burdenko hospital choosen for this project.

Since the flexibility of health care design is the main focus of this thesis, chapter three is fully dedicated to flexibility aspects of renovation of Burdenko hospital. All aspects, types and levels of flexibility described in chapter one, are implemented step-by-step in this renovation project. Bottom-up approach of implementation is choosen and the flexibility of individual room continuously goes into flexibility of the hospital floor through standard hospital building to the flexibility of entire hospital complex at the end. The possibility of conversion of hospital into other functions based on its technological obsolescence is also demonstrated in this chapter.

Fourth and last chapter of the thesis describes different aspects of Burdenko renovation hospital design project based on subdivision into three main groups of hospital users. These three groups are patients (in- and out-), caregivers and visitors. Since the fact that each of these groups has their own demands and supplies, while they need to interrelate with each other at the same time, this chapter shows design solutions which help to achieve high level of comfort and flexibility for each of these groups.

Thesis ends with the final assessment table of all aspects of flexibility used in the desgin project. Conclusions, summaries and evaluations of the project done in this work are presented in this last section of the thesis as well as areas and fields for further research and elaboration.

Figure 6 contains infographical representation of the thesis structure.

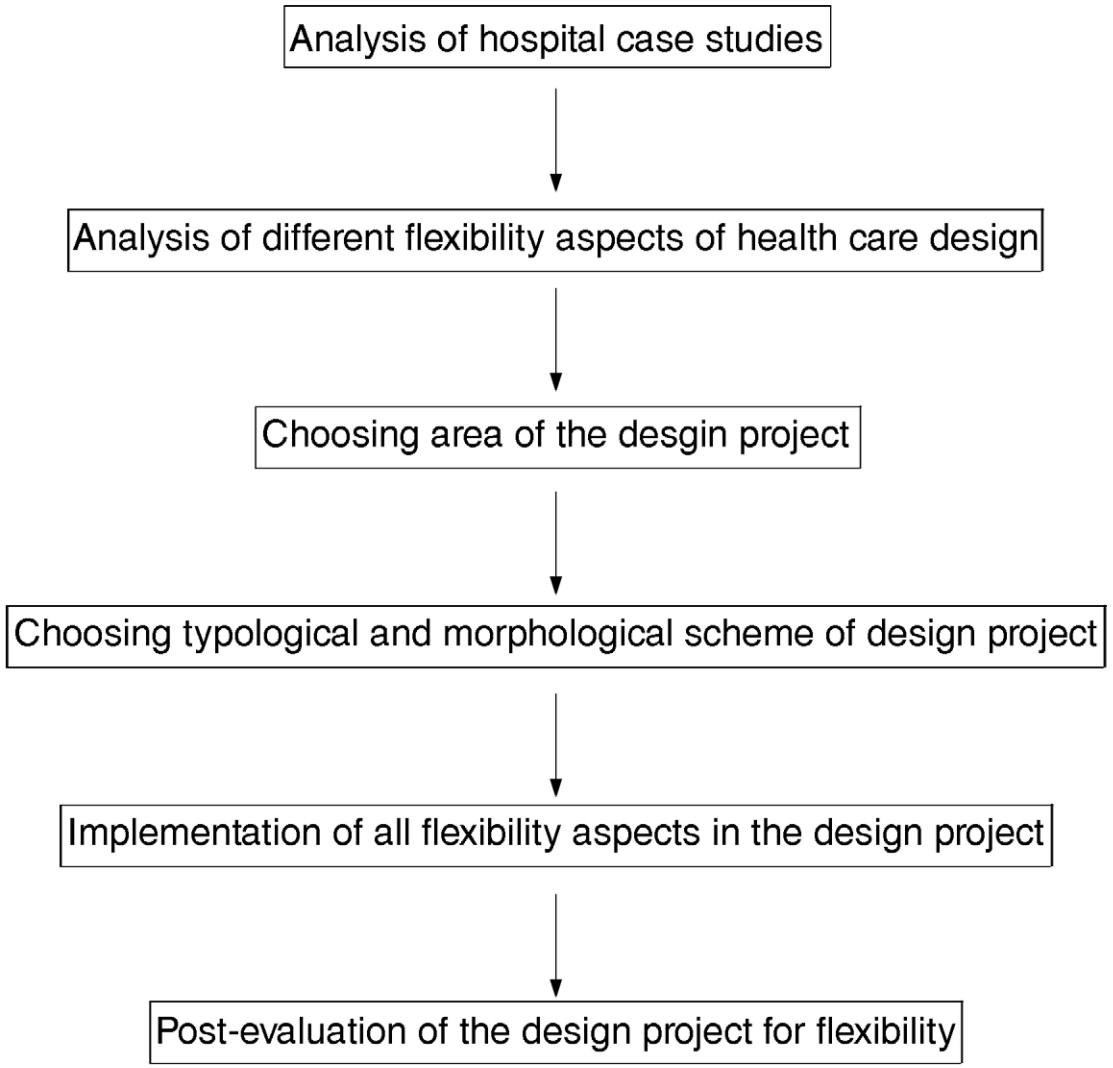
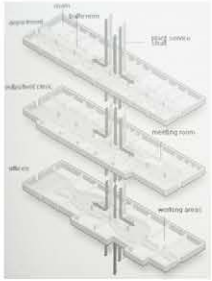
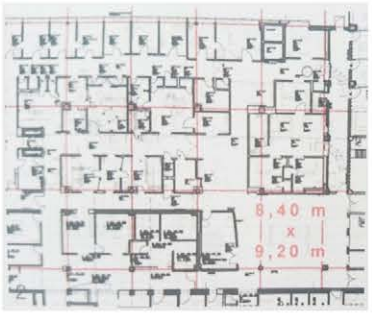


Figure 6. Flowchart of the thesis structure

Flexibility level	#	Hospital example	Aspects of analysis	Description	Overview
Individual room	1	Forta Medical prefabrication hospital units / Miami Valley Hospital, USA, 2011	Prefabricated methods for health care modular units	Forta medical is a company located in Latvia and specialized in design and production of prefabricated health care facilities in a modular way. The characteristics of the details of the modules as well as their quintitative and qualitative parameters were analyzed in this case study (Source: www.fortamedical.com)	 
	2	Patient room “2020”	Structure of the modern patient ward	Modern patient wards are subdivided into 3 main areas and each of them are dedicated to particular hospital user, which are patients, caregivers and visitors. This 3-part concept of the patient ward was analyzed and used in the design project for this thesis (Source: wardconcept2020.com)	
	3	Friedrichsdorf Hospital, Germany (2014)	Foldable furniture in the ward	Foldable and movable furniture is one of the essential components which provides flexibility on the level of individual room. Friedrichsdorf hospital contains foldable visitor beds in the wards and was used as an example of this type of flexibility in hospital design project for this thesis (source: author, 2015).	
	4	Georgetown Hospital, USA, 2014	Visibility of the ward from corridor (visual connections)	Visibility of the ward from corridor for checking the sate of the patient is important for caregivers. That is why spatial layout of the ward need to be organized in a way when visibility of the patient bed from corridor is provided (source: www.healthcaredesignmagazine.com).	

Flexibility level	#	Aspects of analysis	Hospital example	Description	Overview
Individual room	5	Access of natural light and provide a view from the room	Houston hospice, Texas, USA, 2009	Natural daylight as well as nature views speed up the recovery period fo the hospital patients (Cor Wagenaar, 2006). These two factors reduce stress and negative emotions of the patients. That is why provide an access of the daylight and nature views are impoerant part of healing environment.	
	6	Individual room as basic health care unit	University hospital of Arkansas, USA, 2009	Individual room is considered as basic unit in modern hospital design (Cor Wagenaar, 2006). Individual patient ward reduces the risk of infection and amount of transfers, which positively influence the recovery process of the patient.	
	7	Possibility of extension individual room upward / sideways	Martini hospital, Netherlands, 2007	Variable flexibility, when the initial space can be adjested in a modular way is important part of hospital flexibility. The concept of cantilevered modules which are hung on the facade and increase the operational surface of the wards was used in design project of this thesis as efective way of local expansion of the hospital and increasing its capacity (Capolongo et al, 2012).	
	8	Multi-functional rooms	Miami Valley Hospital, USA, 2011	Multi-functionality and adaptability of the room is another component of flexible health-care design. Based on uiversal dimentions and uniformed spatial layouts any room can change its function depends on the current needs of the hospital (Cor Wagenar, 2006).	

Flexibility level	#	Aspects of analysis	Hospital example	Description	Overview
Hospital floor	9	Arranging of any department within the hospital floor	Martini hospital, Netherlands, 2007	Arranging of different departments within the same hospital floor is continous part of flexibility which goes from individual room to the hospial complex (Capolongo et al, 2012).	
	10	Re-use of hospital building	Mary Immaculate Hospital, NY, USA, 2011	Re-use of hospital building due to its obsolescense is another part of flexible lifecycle process. In order to extend the lifecycle of the building it could be converted to another functions (apartments or offices) based on spatial flexible layout designed in advance (source: Cor Wagenaar, 2006).	
	11	De-centralized nursing stations in hospital floor	Smyth County Community Hospital, Maryland, USA,	De-centralized nursing stations in the ward floor reduce the transfer of the patients, allow each of caregivers to concentrate on smaller number of patients and give them higher level of care, while patients can interact with the personnel more actively (Cor Wagenaar, 2006). Moreover, it reduces the daily walking distances of caregivers	
	12	Possibility of upward / sideway extension of the floor	Martini hospital, Netherlands, 2007	Along with the concept of increasing the area of the individual room, hospital floor can be extended in the same way based on concept of variable flexibility (Capolongo et al, 2012). Martini hospital in The Netherlands illustrates this concept by hung of external modules on the facade.	

Flexibility level	#	Aspects of analysis	Hospital example	Description	Overview
Hospital floor	13	Installation of technical plants	Martini hospital, Netherlands, 2007	Grouping of vertical technical plants and installations in several places in the hospital floor instead of spreading them through the entire floor facilitates the process of maintenance and increases flexibility of the floor in general, because most of the space a free from plants and available for adaptation.	
Hospital building	14	Re-use of hospital building	Mary Immaculate Hospital, NY, USA, 2011	Re-use of hospital building due to its obsolescense is another part of flexible lifecycle process. In order to extend the lifecycle of the building it could be converted to another functions (apartments or offices) based on spatial flexible layout designed in advance (source: Cor Wagenaar, 2006).	
	15	Uniformity of spatial layout	Martini hospital, Netherlands, 2007	Uniformity of spatial layout and standardization of the elements allow to reach high level of flexibility within hospital building (Capolongo et al, 2012). Exchanging of the functions within hospital building, in this case, is much more easy which is increase overall flexibility of the hospital.	
	16	Oversizing of load-bearing structure	General hospital Forchheim, Germany, 2010	Oversizing of load-bearing structure for posible enlargment of facilities within the building i one of the flexibility concepts for health care design (Capolongo et al, 2012). Despite the higher loads and difficulties in vertical communications this concept is used in modern hospitals (Cor Wagenaar, 2006).	

Flexibility level	#	Aspects of analysis	Hospital example	Description	Overview
Hospital building	17	Modifiability of envelope	General hospital del Mar, Spain, 2006	Easy access and possibility of modification of the hospital envelope allow to adapt to the current needs without disturbing of the daily work process of the hospital (Capolongo et al, 2012).	
	18	Presence of free land on the plot for extension	Kortrijk hospital, Belgium, 2005 - 2018	Presence of the land available for the future expansion of hospital building on the plot is important factor of flexibility concept (Cor Wagenaar, 2006). It allows to plan and to design hospital extension in a smart way at the beginning of the project.	
	19	Access of natural daylight	Zorgboulevard-Hospital, Rotterdam, NL, 2012	Access of daylight to the most of hospital facilities is important component of healing environment in the hospital (Prasad, 2010). This factor affects the configuration and spatial layout of the building in a way that its thickness fluctuates between 16 and 24 metters, which allows to incorporate hospital building in urban context.	
	20	Hospital building as universal part of hospital complex	Jeroen -Bosch Hospital, Netherlands, 2010	Since the fact that each part of hospital, such as individual room, hopital floor as well as hospital building is the part of flexibility of the hospital on a larger level, universality and standardization of hosipital builing allow to use it as universal component of the hospital complex (Cor Wagenaar, 2006).	

Flexibility level	#	Aspects of analysis	Hospital example	Description	Overview
Hospital complex	21	Healing gardens as part of recovery process	New hospital of North Zealand, 2015 -	Healing gardens in hospitals are considered as essential component of healing environment and recovery process (Cor Wagenaar, 2006). They are used by all groups of hospital users, such as in- and out-patients, caregivers and visitors.	
	22	Hospital street as main communication of the hospital complex	New Akershus University hospital, Norway, 2010	Hospital street in modern hospitals plays a role of main communication and connection for all facilities of the complex (Capolongo et al, 2012). On the ground floor hospital street contains health care related facilites such as farmacies, shops, gyms, etc, while on upper floors it connects all hospital units.	
	23	Flexibility of hospital complex	Maasstad hospital, NL, 2011	Hospital complex is the last and most complicated level of health care flexibility (Capolongo et al, 2012). Universal principles of design and construction, including standardization and unification of elements, multi-functional character of all spaces, accessibility and interchange of plants and services - all these aspects are combined into flexible hospital complex.	
	24	Automatization of delivery and maintenance services within hospital complex and outsourcing of services	Orbis Medical Park, The Netherlands, 2010	Automatical vechicles are used in modern hospital complexes nowadays (Cor Wagenaar, 2006). Undeground floor of the hospital contains all supported facilities such as laundries, cantins, sterelization stations, etc. At the same time, hospital outsource some of their functions (laundries, for instatce), which were solely hospital funcions previously.	

Flexibility level	#	Aspects of analysis	Hospital example	Description	Overview
Hospital complex	25	Presence of additional free land on the hospital plot	Rehabilitation center, ReHAB, Switzerland, 2007	In line with hospital building, the extension of hospital complex requires additional land. The entire lifecycle of the hospital with planned extensions can be predicted and designed t the beginning of design process in order to build, use, maintain and operate hospital in a flexible and sustainable way (De Jonge, 2016).	
	26	Existing of non-hospital functions in hospital complex	Karolinska Hospital Institute, Stokholm, Sweeden, 2011	Inclusion of the hospital into urban tissue instead of making it an island in the city requires to add additional functions in hospital complex in order to attract visitors and customers (Cor Wagenaar, 2006). Farmacies, conference rooms and offices, sport centers and shopping malls - all of them can revitalize hospital and make it viable.	

CHAPTER 2

MASTERPLAN

Location

Russian Federation consists of 85 regions in terms of administrative division. Each region has the main city, or capital of the region, where most sophisiticated facilities are situated. Historicaly, Russia was quite centralized country, and because of this main cities still play most important role on the regional scale.

Russia is very unevenly developing country. Some sociologists even say that Russia consists of three countries: Moscow, Saint-Petersburg and the rest of the country. As it was already mentioned above, for centuries Russia was highly centralized country, and its capital was the main place where decisions took place. That is why for the last two hundred years Moscow and Saint-Petersburg, as two Russian capitals, were much more developed rather than other regional cities. As a result, today most sophisticated hospitals and clinics are situated in Moscow, and people from other regions of the country should travel there in order to get adequate medical assistance, because regional hospitals do not have modern equipment in some cases.

Pensa is a typical Russian regional center. It is situated in European part of Russia, in 650 km from Moscow. Pensa contains several hospitals, which were built in Soviet times. These hospitals belong to pavilion system, when different departments are situated in different buildings and connected to each other by ground or underground tunels.

One of the Pensa's hospitals, Regional Hospital of Burdenko, which is the example of typical Russian regional hospital, was choosen as a case study for renovation and implementation of the ideas of flexibility and other modern trends in hospital design. By developing step-by-step renovation strategy, hospital area is going to be unifyed and work as one entire organism.

Pensa city on Russian Federation map

Pensa city

Foundation: 1663

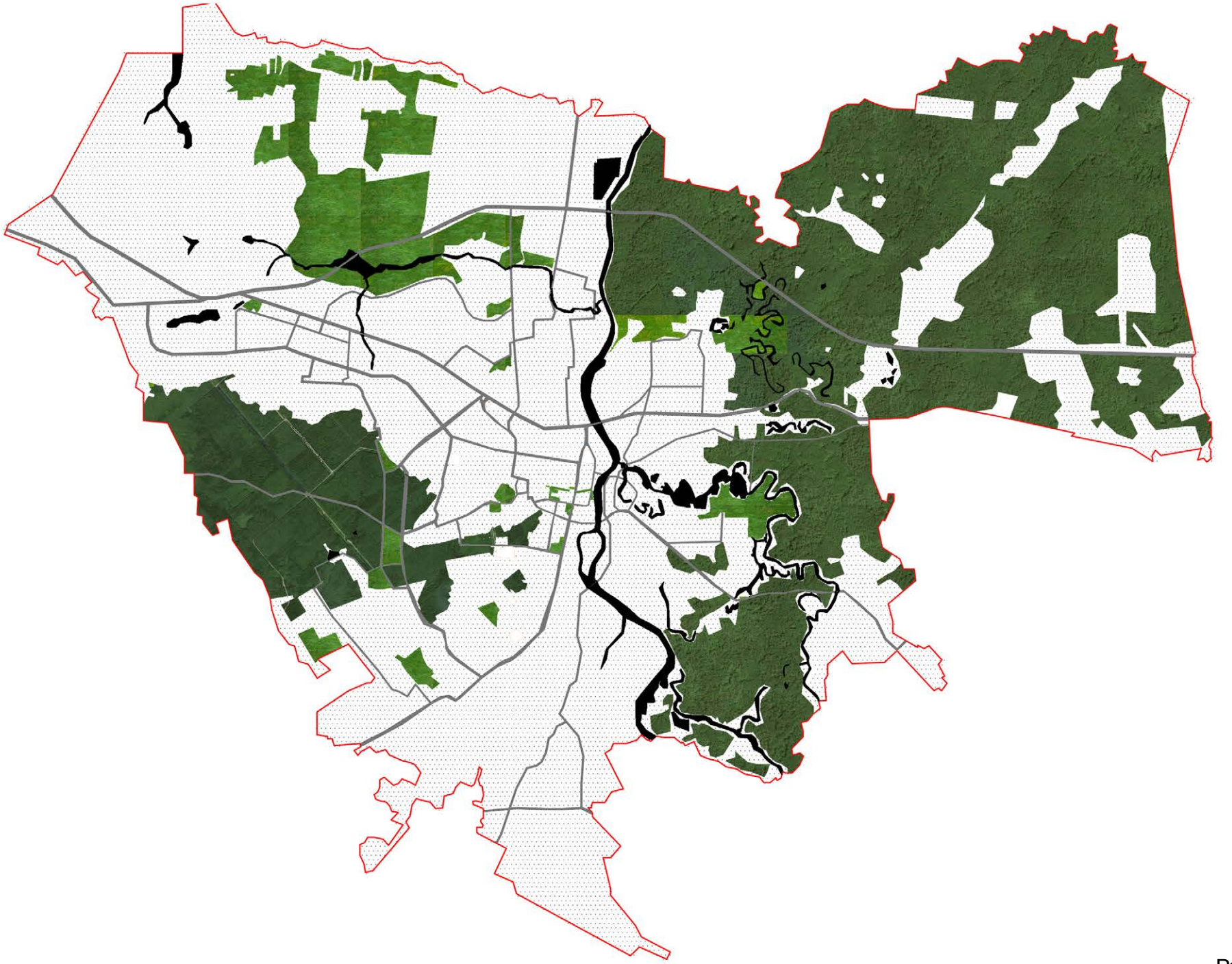
Population: 522.823 people (2015)

Area of the city: 304,7 km2

(Source: www.pensa-gorod.ru).

Pensa average climate (1981 - 2015)

Index	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Max temperature, C	7,0	8,5	17,3	31,1	35,6	37,7	39,3	40,4	33,6	25,6	16,1	11,0	40,4
Average max, C	−5,5	−5,1	1,0	12,4	20,8	24,8	26,6	24,7	18,2	9,9	0,6	−4,4	10,3
Average temperature, C	−8,7	−9,1	−3,4	6,8	14,3	18,5	20,4	18,3	12,5	5,6	−2,1	−7,4	5,5
Average min, C	−11,9	−12,5	−7,2	1,9	8,1	12,7	14,7	12,8	7,7	2,2	−4,6	−10,3	1,1
Absolute min, C	−39,9	−40	−31,1	−20	−5,6	−1,1	4,7	0,0	−6,4	−17,2	−31,1	−40,5	−40,5
Precipitation rate, mm	38	31	35	33	42	65	59	51	52	47	48	41	542



Pensa existing hospitals

1. **Burdenko regional hospital**

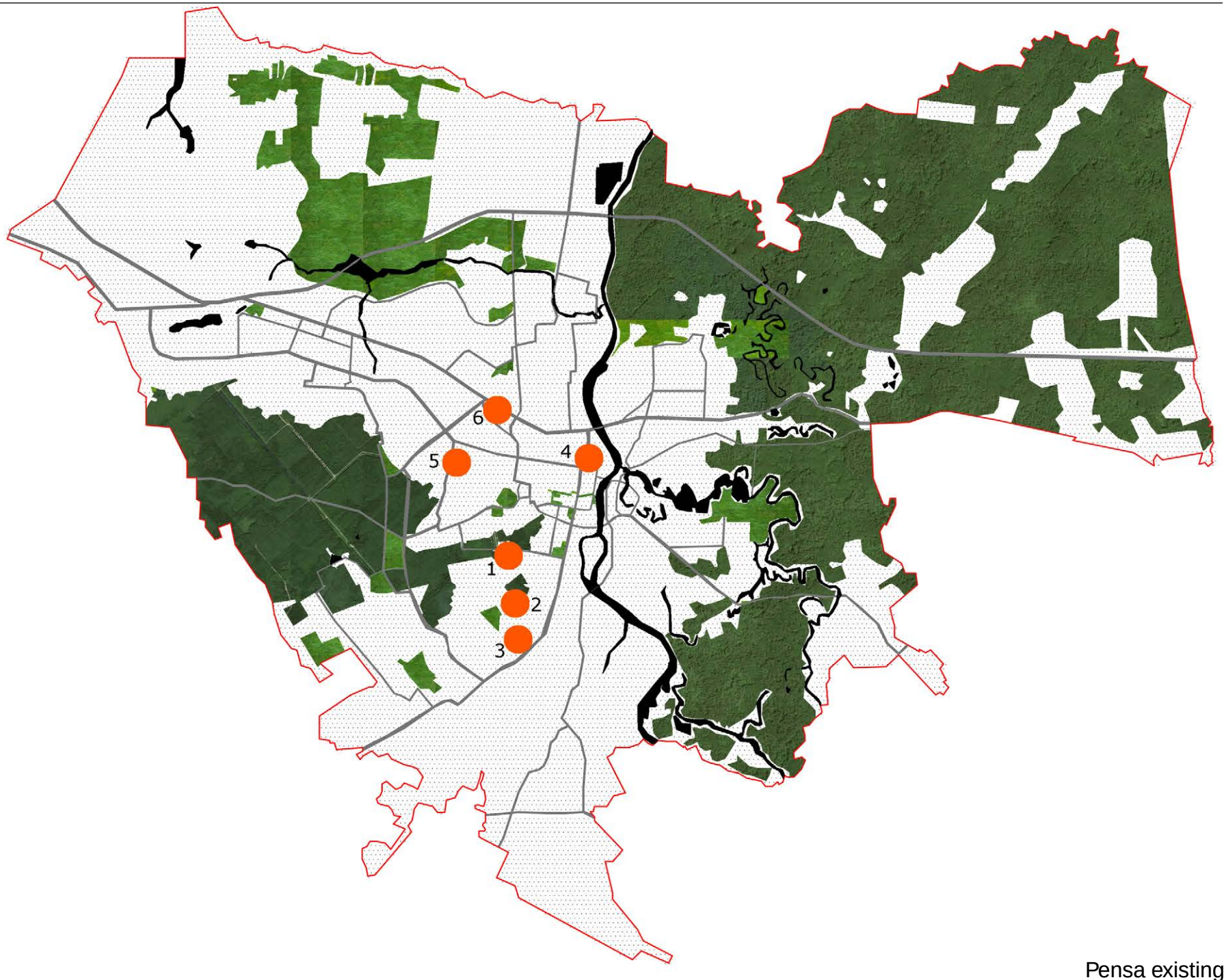
2. TB dispanser

3. City hospital # 1

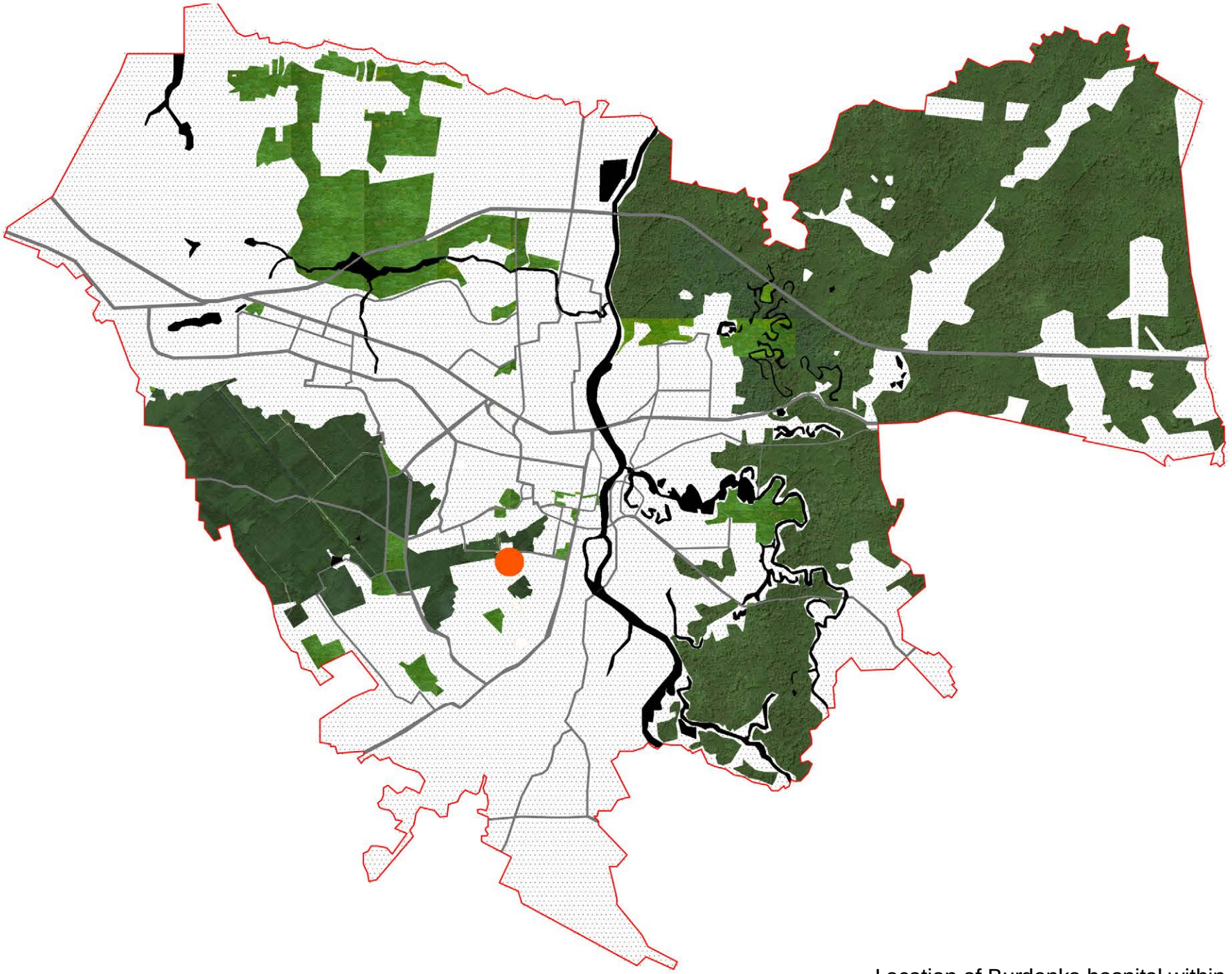
4. Railway hospital

5. Filatov regional children hospital

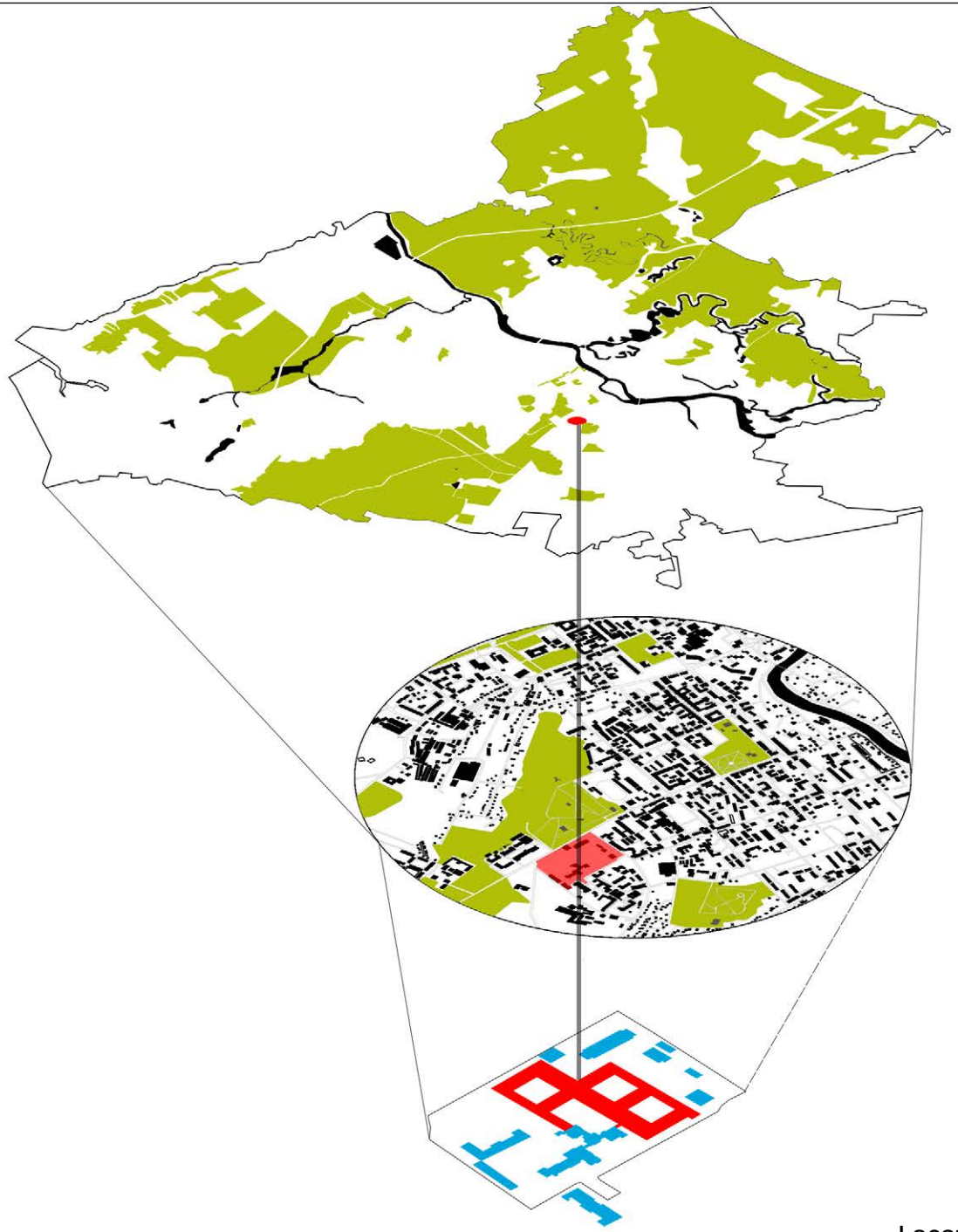
6. Emergency hospital



Pensa existing hospitals



Location of Burdenko hospital within Pensa city



Location of Burdenko hospital within Pensa city

Plot area

The area of the project is situated in the center of Pensa. The total area of the plot is equal to 7,5 Ha. Dimensions of the plot are 341 x 210 m. Existing buildings of Burdenko hospital are arranged in «Pavilion» system, when different departments are spread around the plot and could be connected to each other by ground or underground tunels.
Plot area is situated in the center of Pensa urban tissue. It is surrounded by botanical garden, Pensa state university, sport area and city zoo.

Botanical garden

Botanical garden of Belinsky is the central park of the city. The park contains a lot of public spaces, playgrounds and green areas. The park is very popular among citizens and proposes activities for every season.

University area

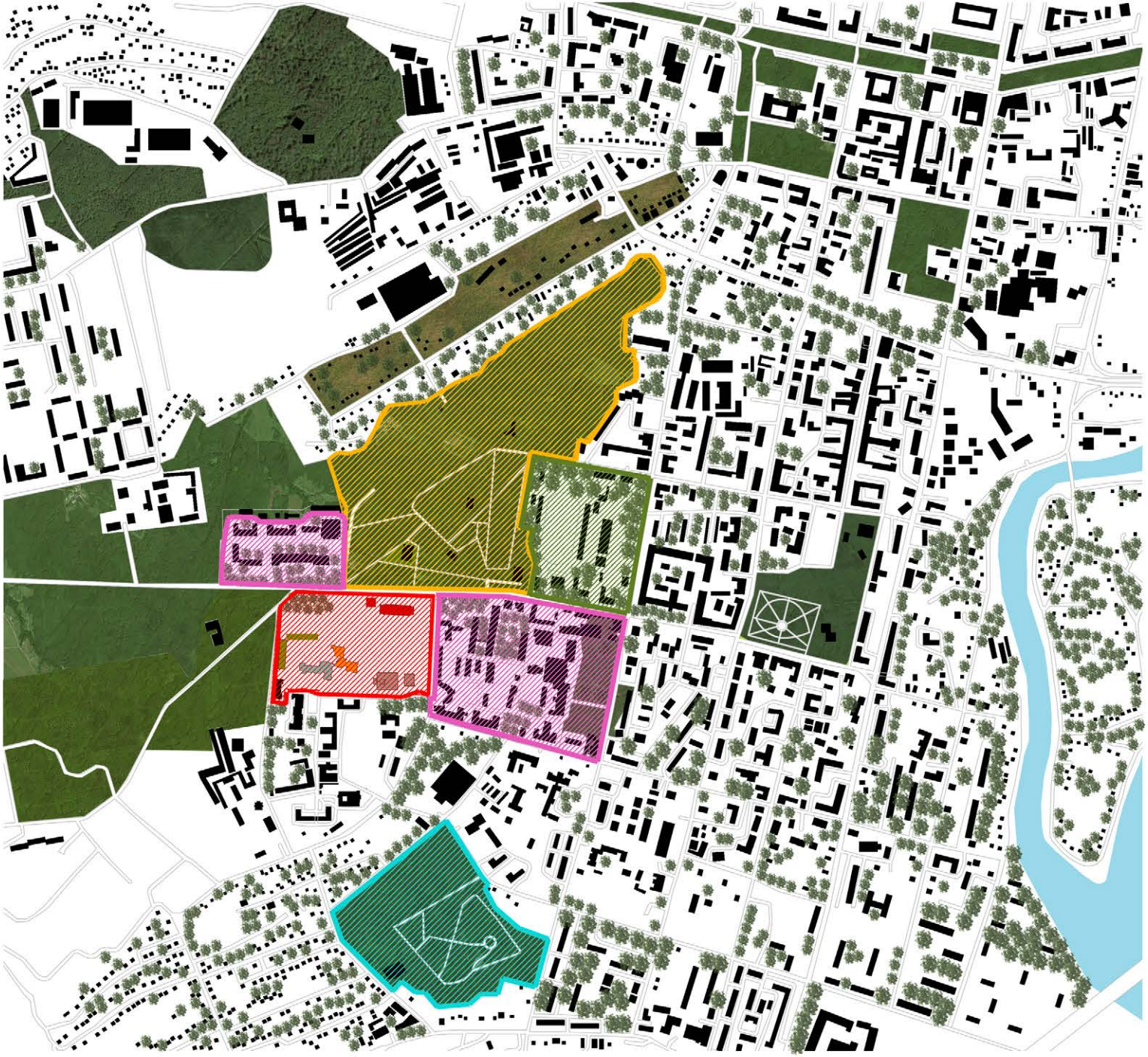
Pensa state university is the main university of the region. There are several departments within the university, in particular, law department, pedagogical department, medical department, department of physical culture and politechnical department.

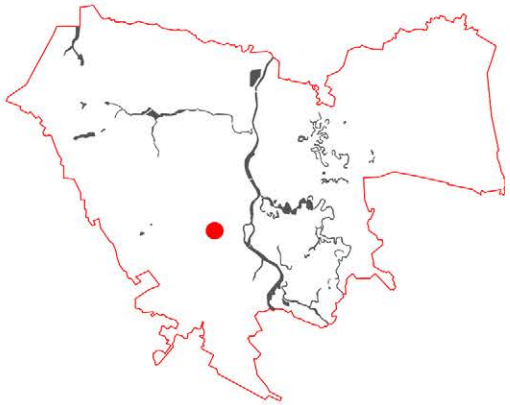
Sport area

Sport area consists of stadium for athlethic sports and several gym buildings

City zoo

Pensa zoo is another green area in the city center. The zoo contains several zones with different animals as well as public and trading areas.





Plot area

Public garden area

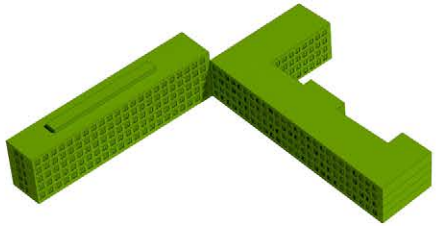
University area

City Zoo area

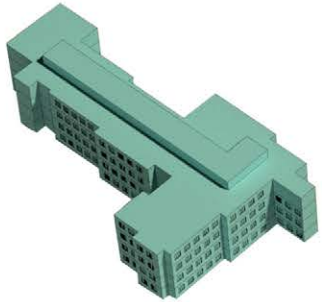
Sport area

Zonning plan of Burdenko hospital area

Burdenko hospital current situation



Policlinic, 5 floors



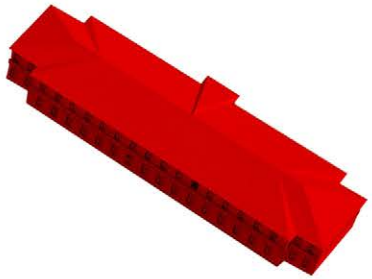
Surgery block, 4 floors

Wards’ tower, 11 floors

Nutrition department, 2 floors

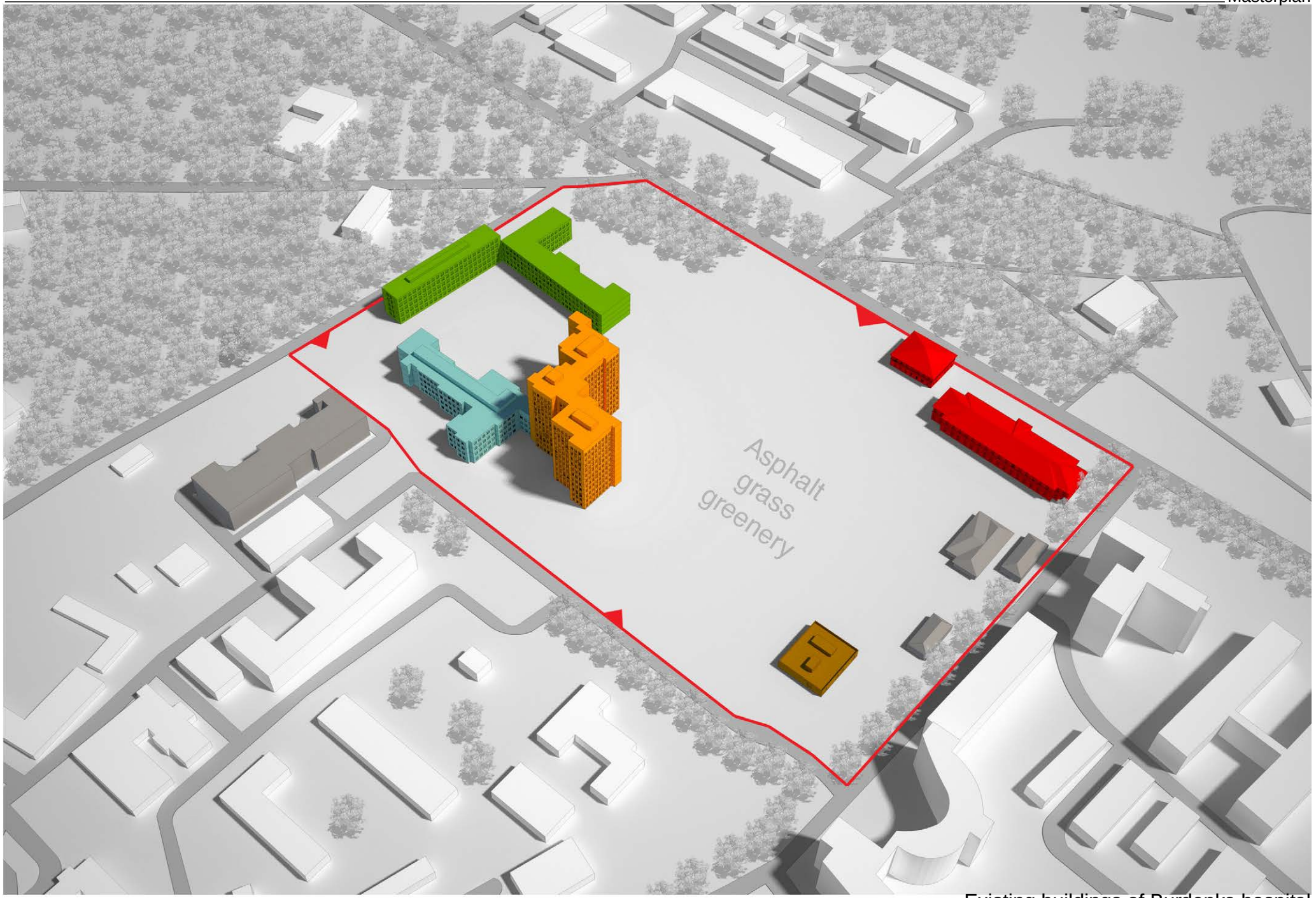
Storage building, 1 floor

Supporting buildings, 2 floors



Administrative building, 2 floors

Administrative building, 2 floors



Existing buildings of Burdenko hospital

Morphological scheme of renovation of Burdenko hospital

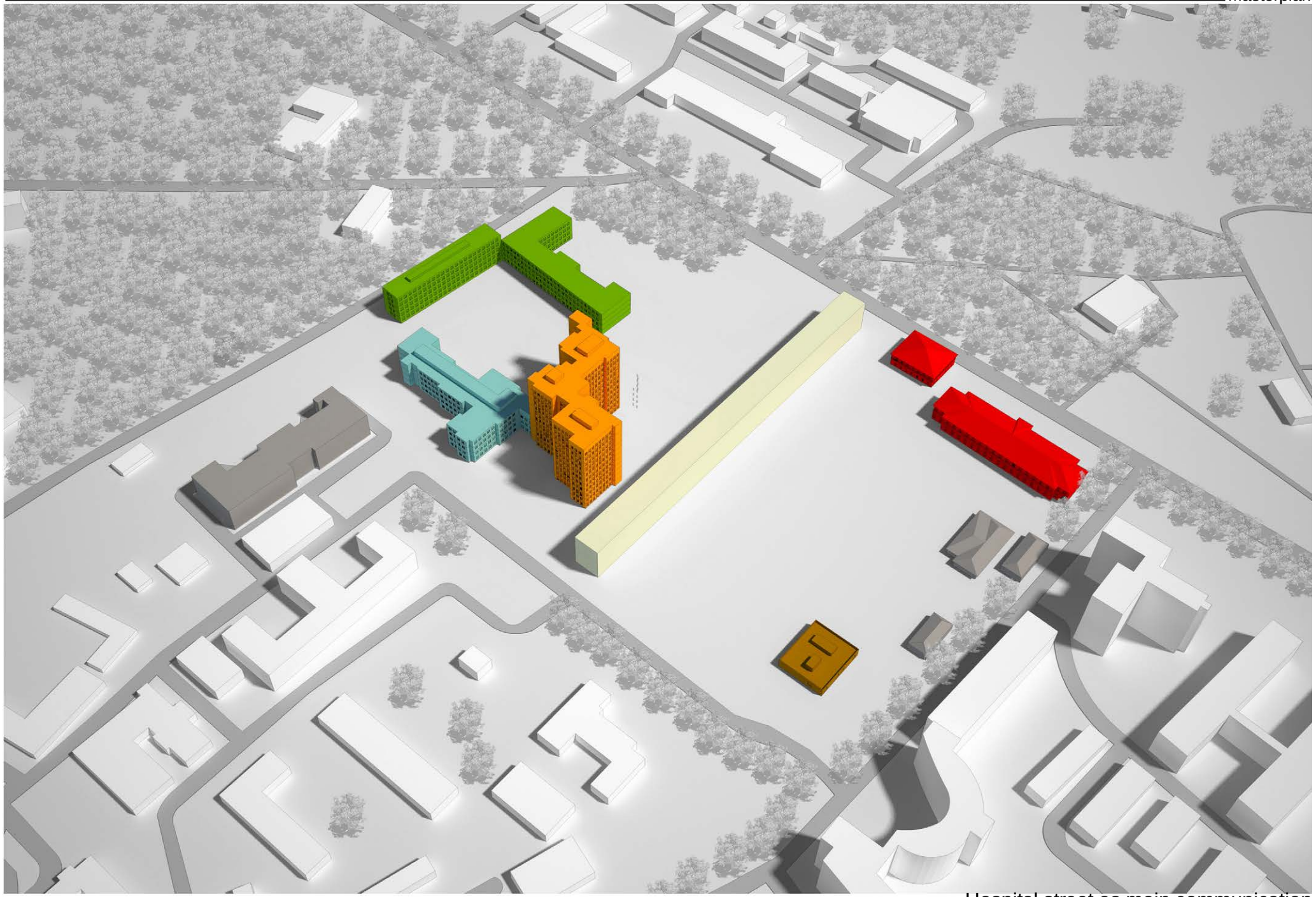
- Research facilities
- Policlinic
- Surgery block
- Wards
- Healthcare related facilities
- Administration
- Nutrition unit
- Technical facilities
- Internal green yards
- Visitors' hotel
- Office

Parameters of current facilities of Burdenko hospital before and after renovaion:

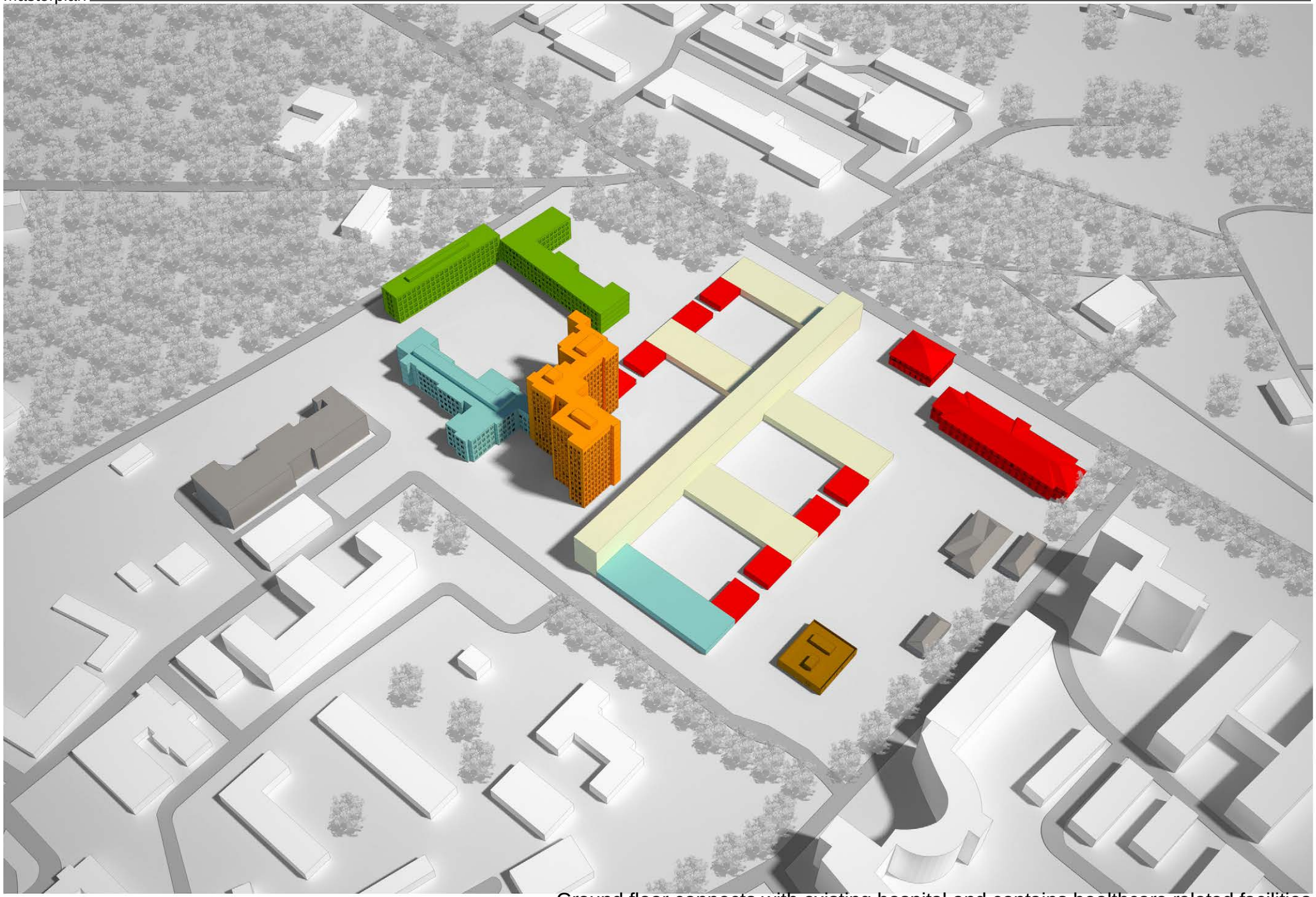
Index	Current situation	Extension	After renovation	
Size of the plot	10,2 Ha	10,2 Ha	10,2 Ha	
Footprint	14.200 m2	18.600 m2	32.800 m2	→ Growth 76%
GFA (Gross Floor Area)	80.450 m2	48.842 m2	129.300 m2	→ Growth 60%
FAR (GFA / size of the plot)	0.79	0.48	1.27	→ Growth 60%
COV (Footprint / size of the plot)	0.14	0.18	0.32	
HEI (FAR / COV)	5.67	2.67	3.97	
Number of beds	300	350	650	→ Growth 85%

Departments of Burdenko General Hospital:

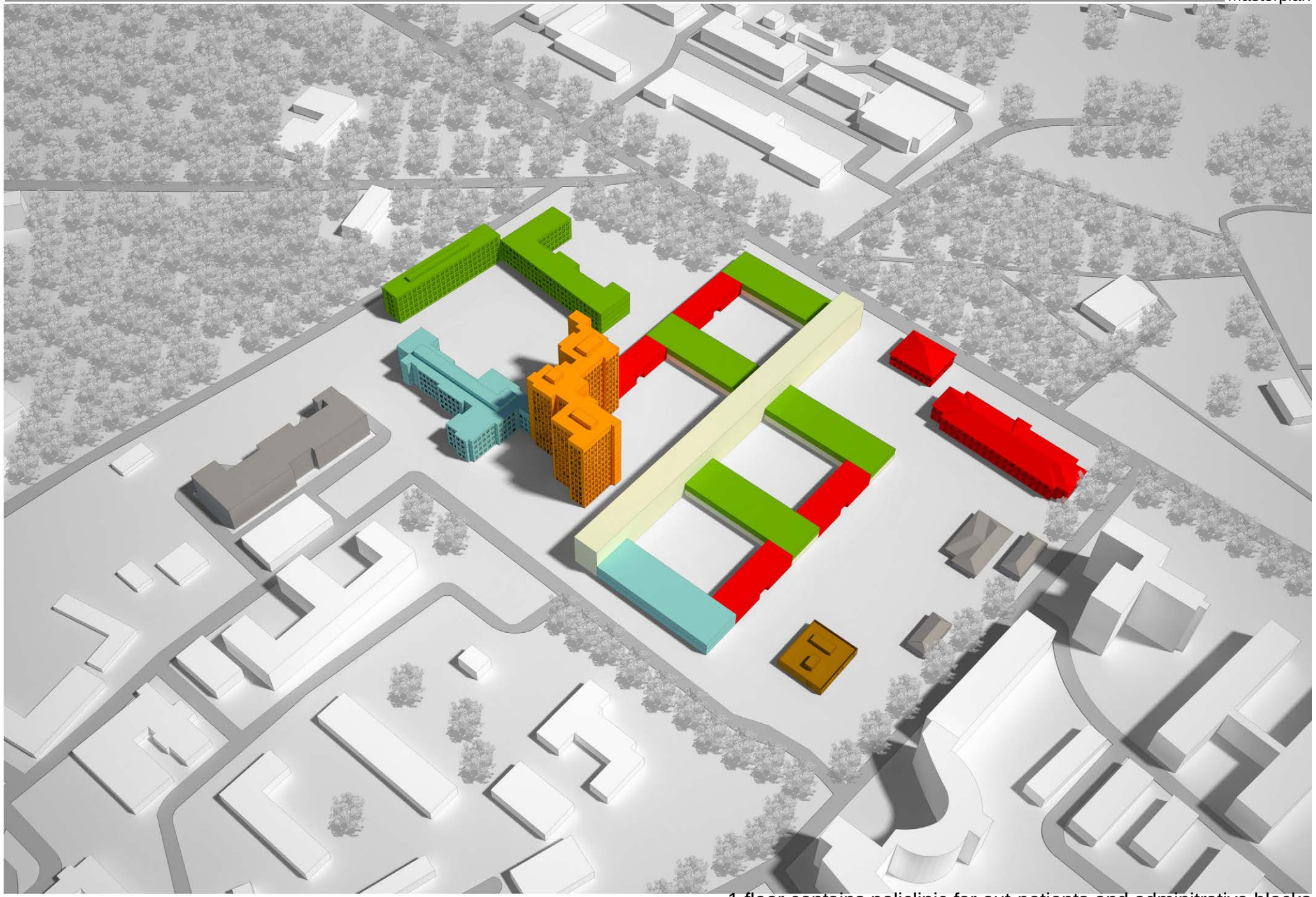
1. Surgery department
2. Traumatology and orthopedics department
3. Reanimatology department
4. Out-patient clinic department
5. Emergency department
6. Cardiology department
7. Research laboratories
8. Neurology department
9. Therapeotic department
10. Functional diagnostic department
11. Physiotherapy department



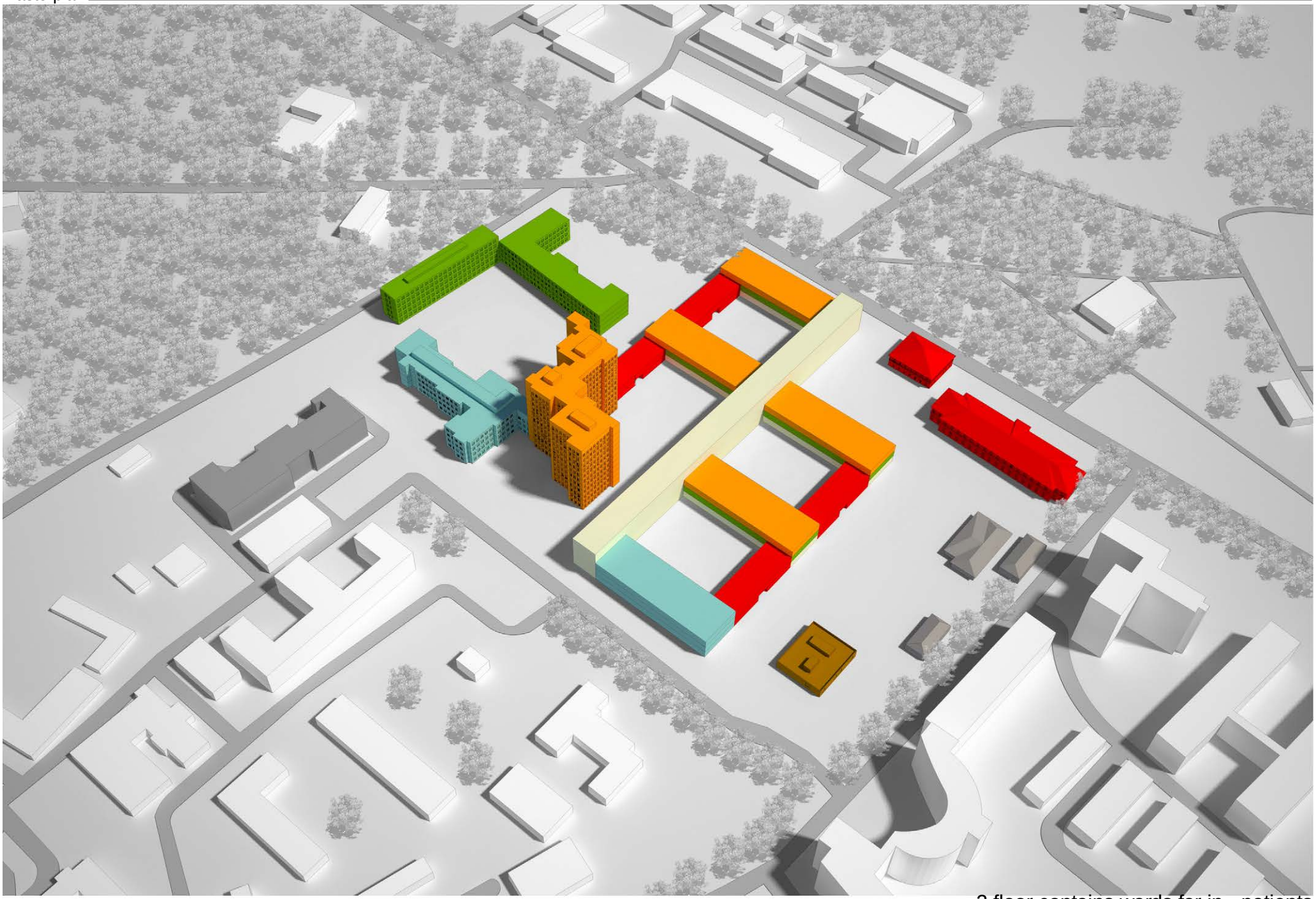
Hospital street as main communication



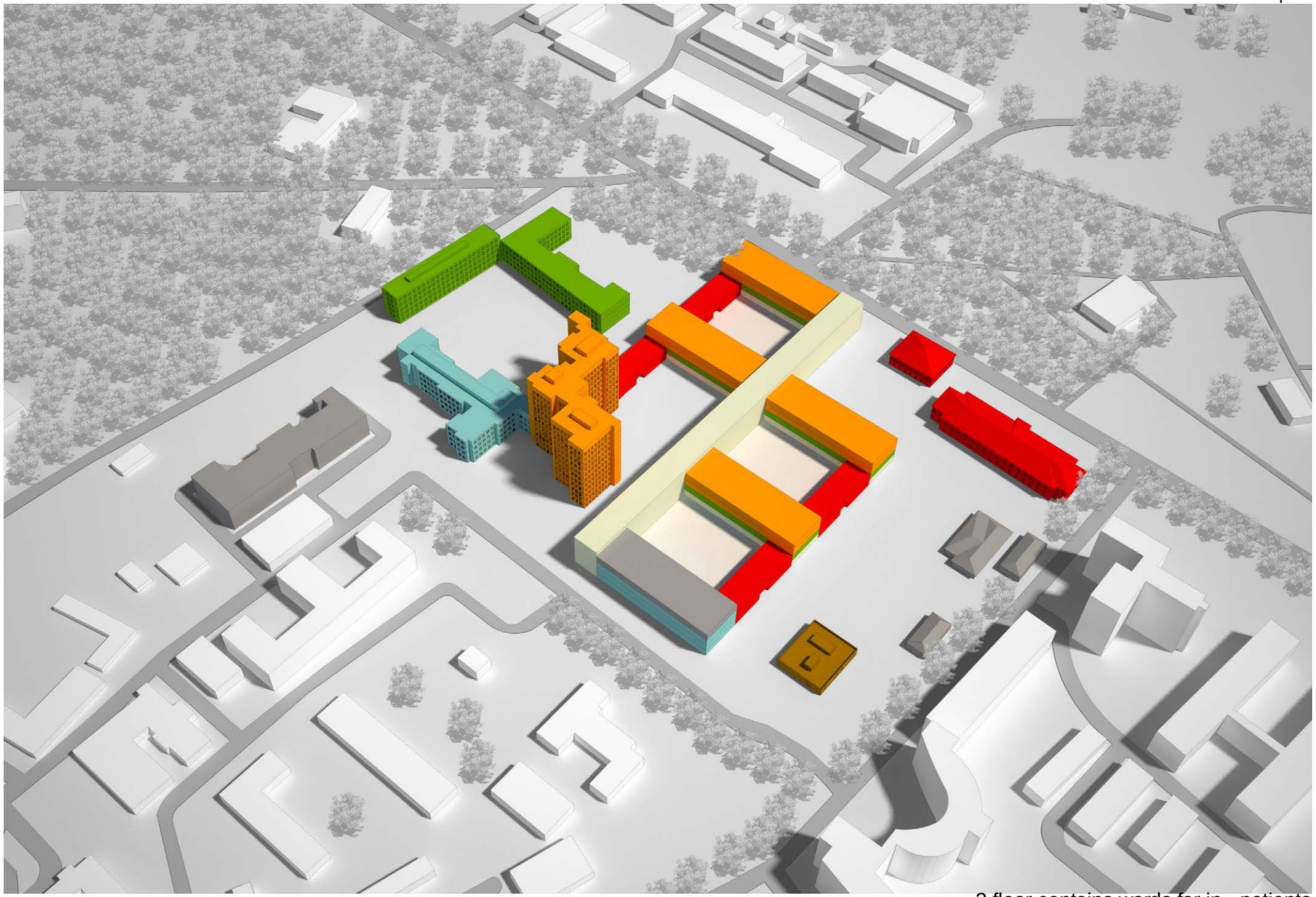
Ground floor connects with existing hospital and contains healthcare related facilities



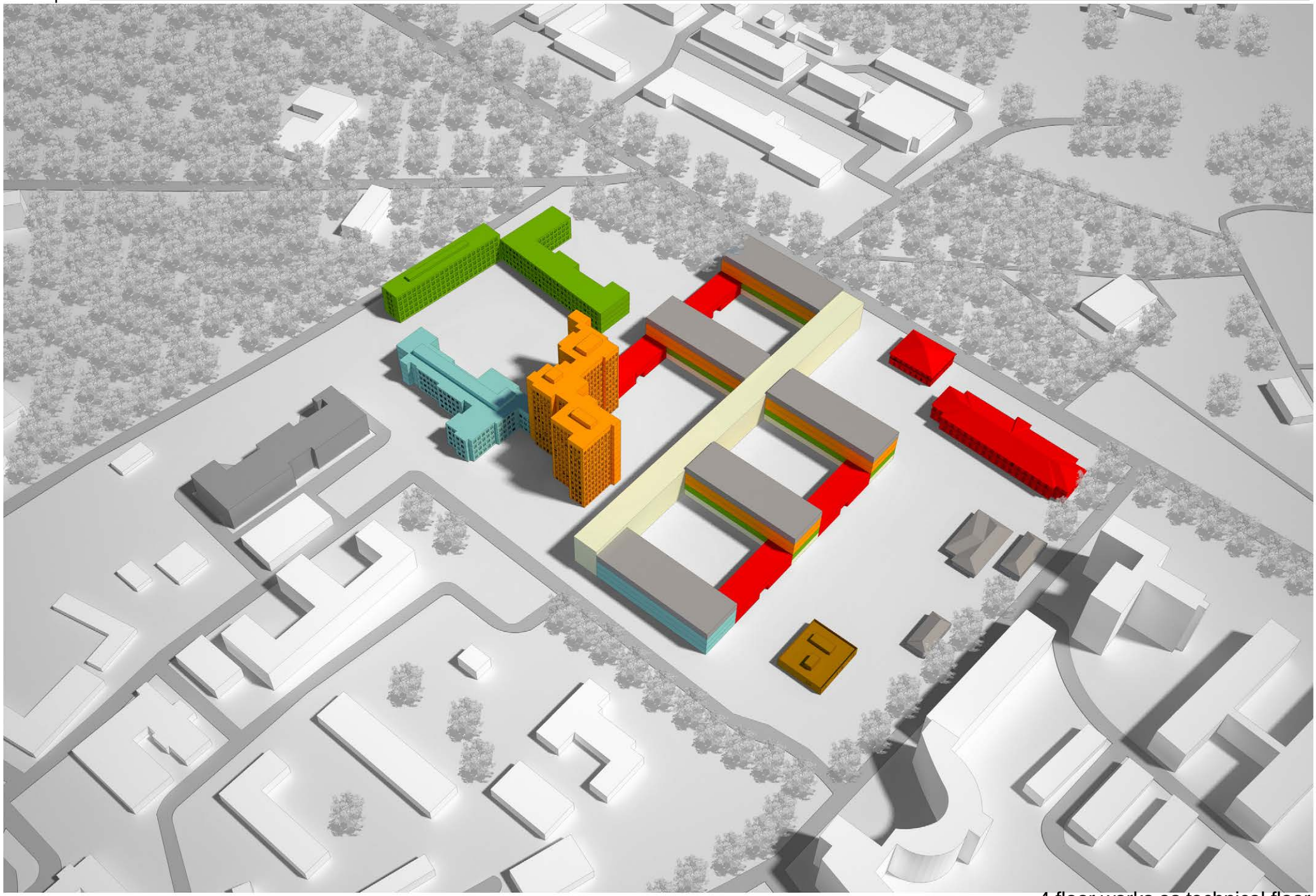
1 floor contains policlinic for out-patients and adminitrative blocks



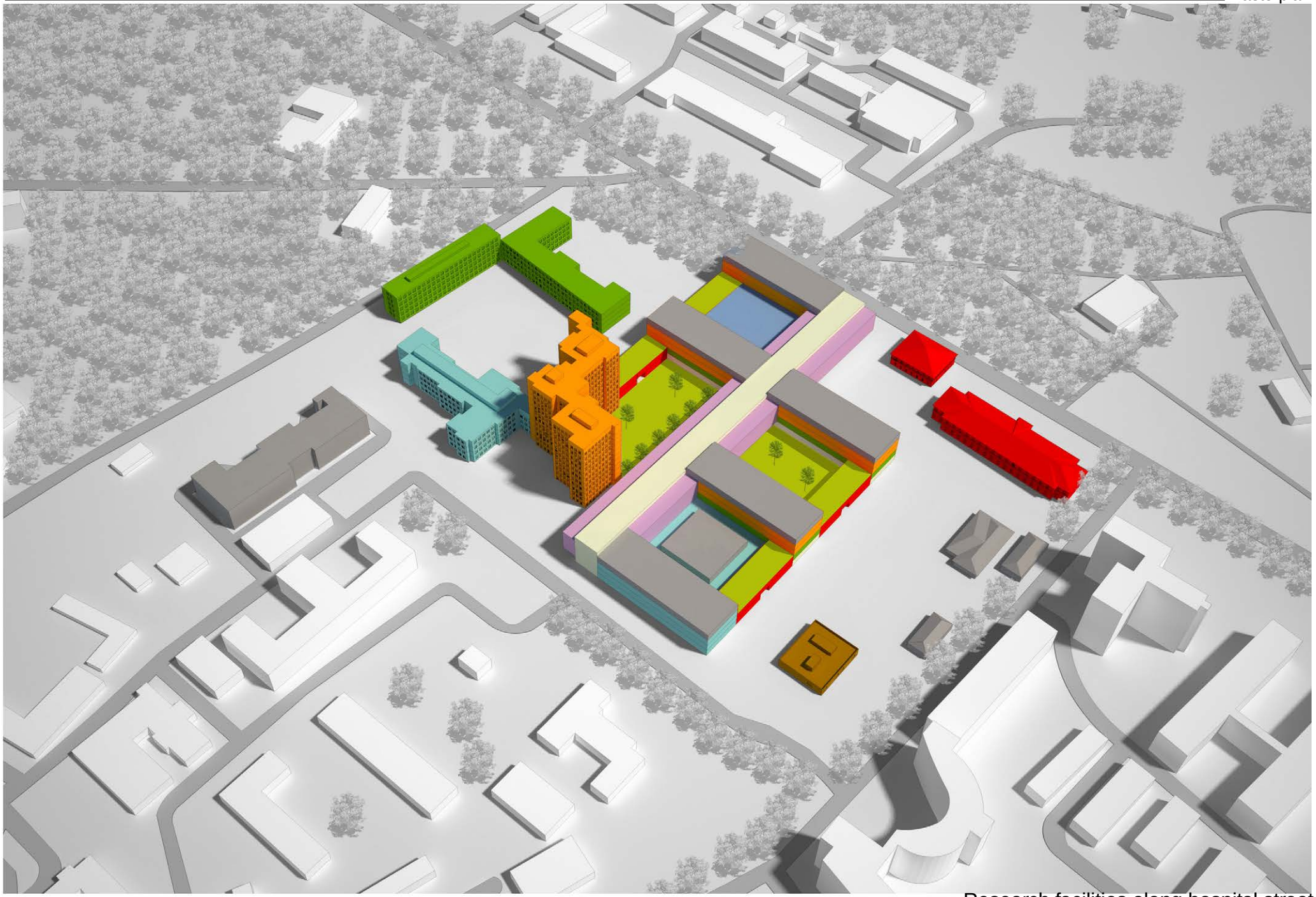
2 floor contains wards for in - patients



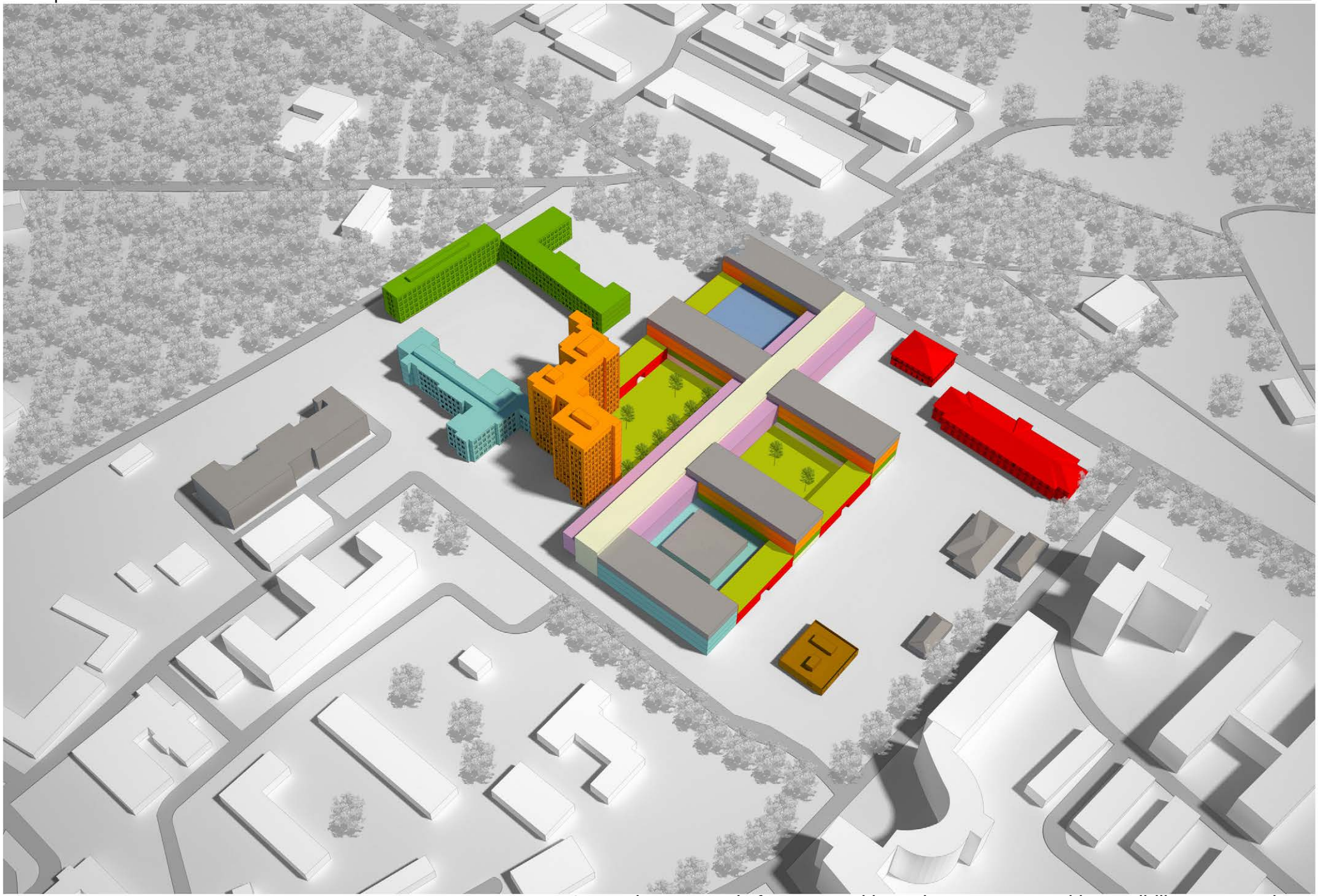
3 floor contains wards for in - patients



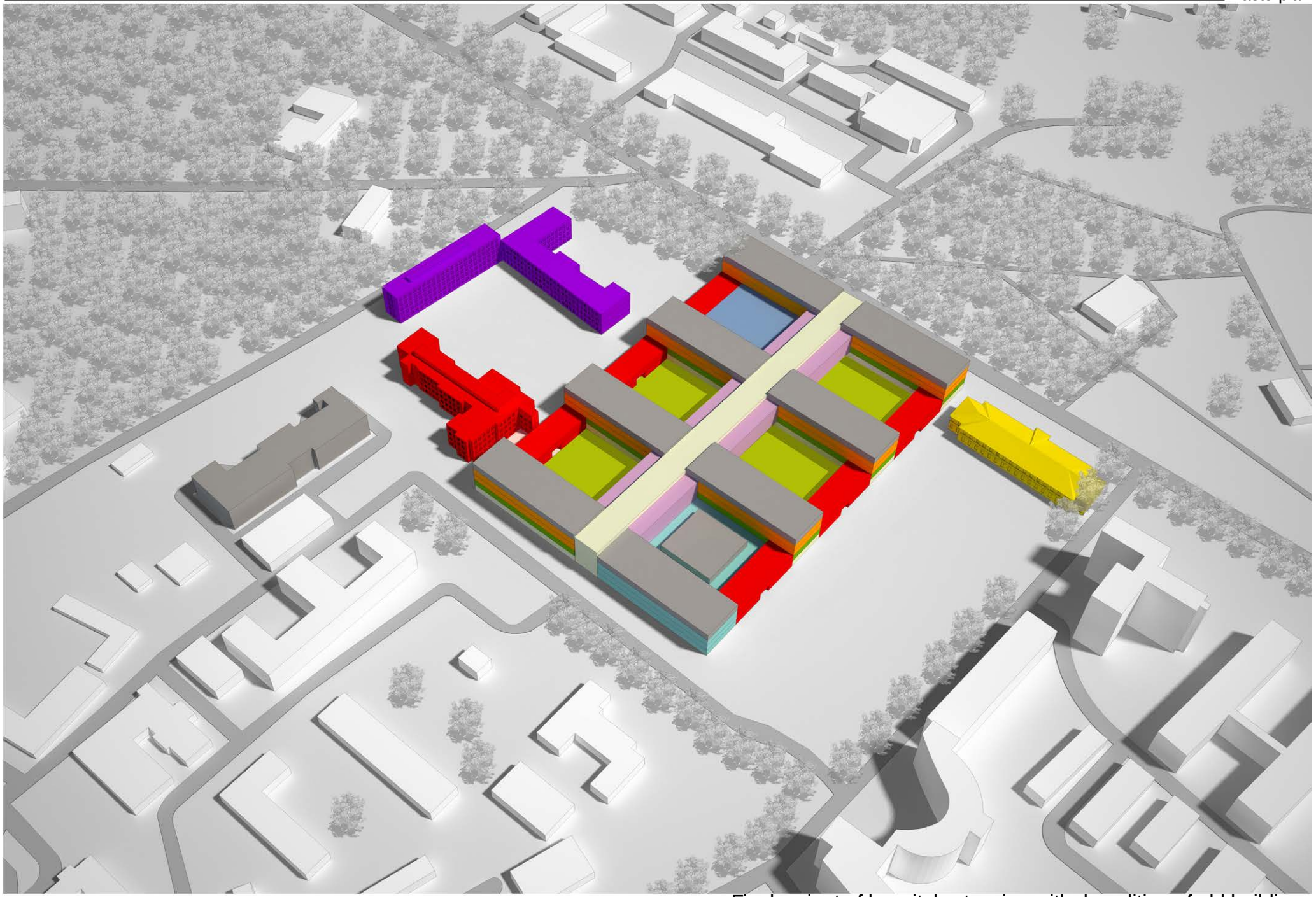
4 floor works as technical floor



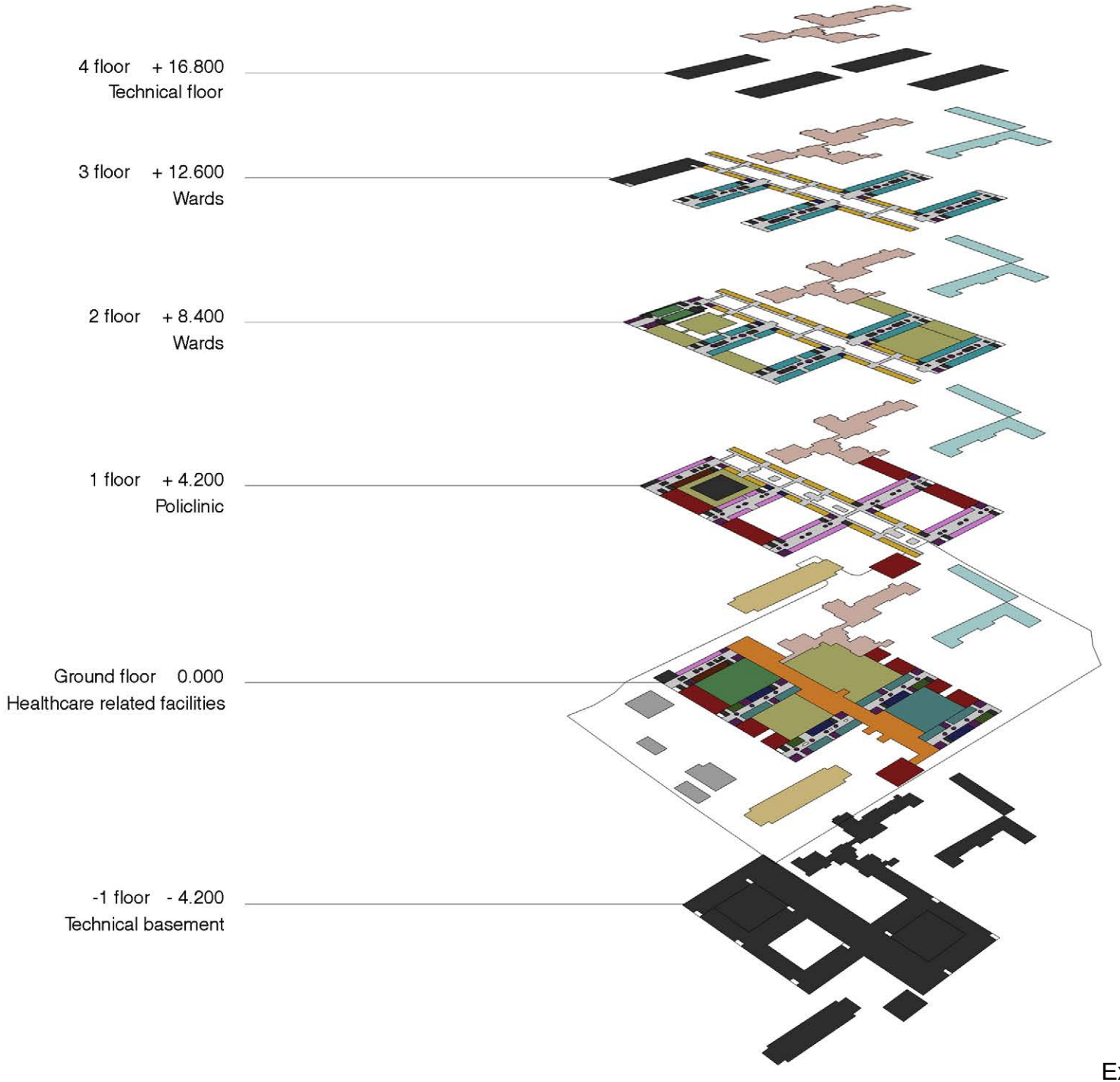
Research facilities along hospital street



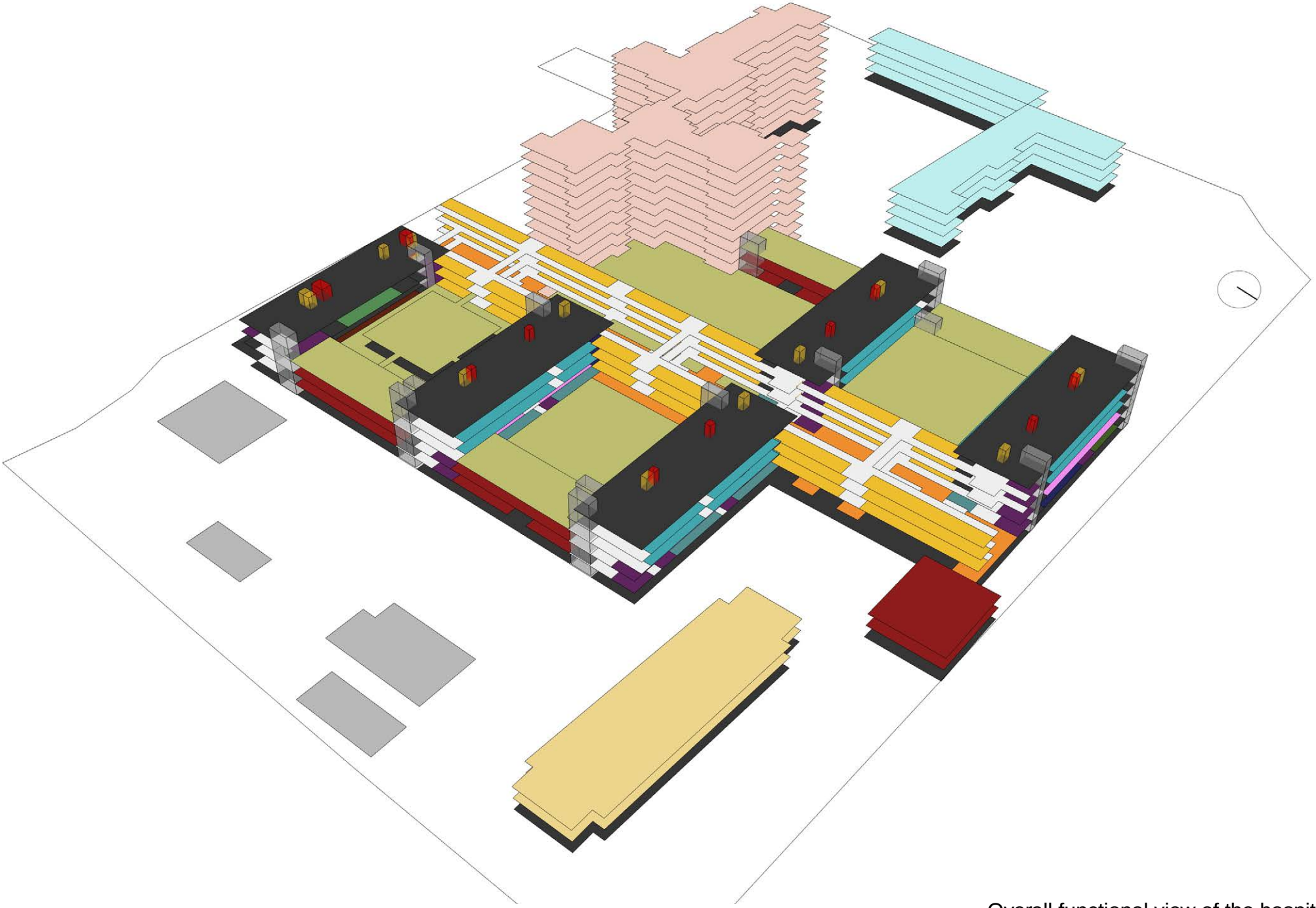
Internal green yards for out - and in-patients recovery with possibility to cover them



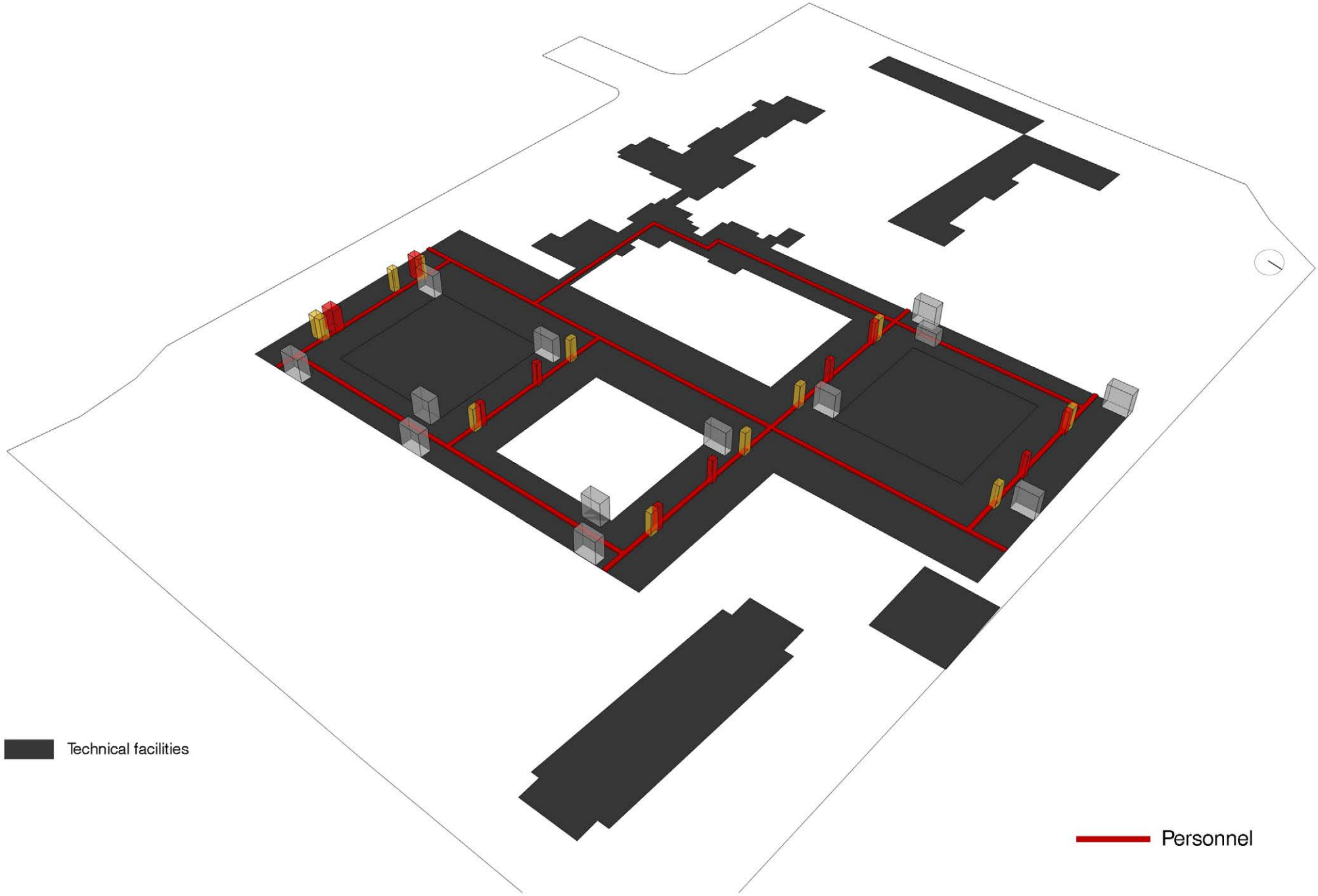
Final variant of hospital extension with demolition of old buildings



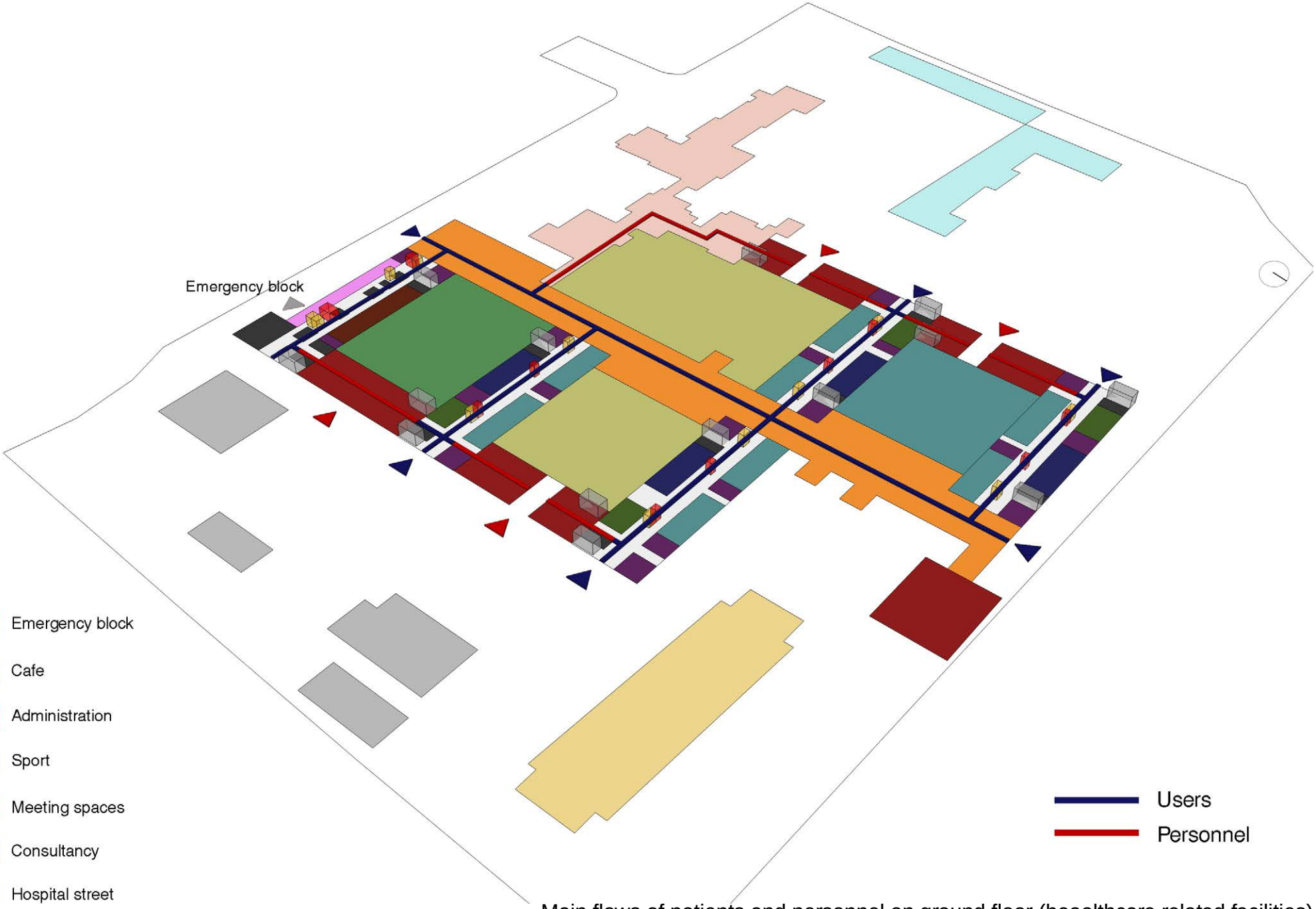
Explosion scheme of the hospital



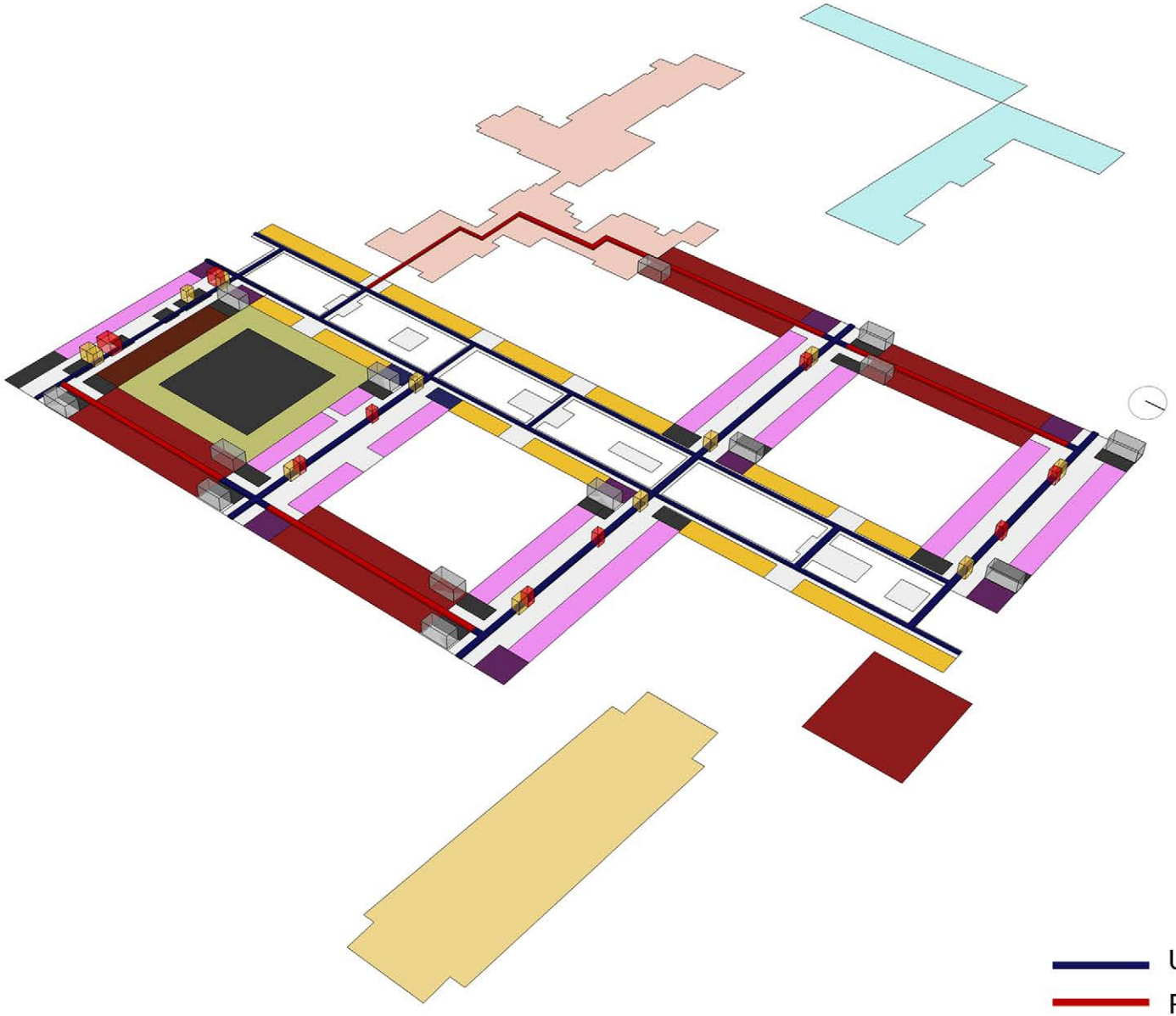
Overall functional view of the hospital



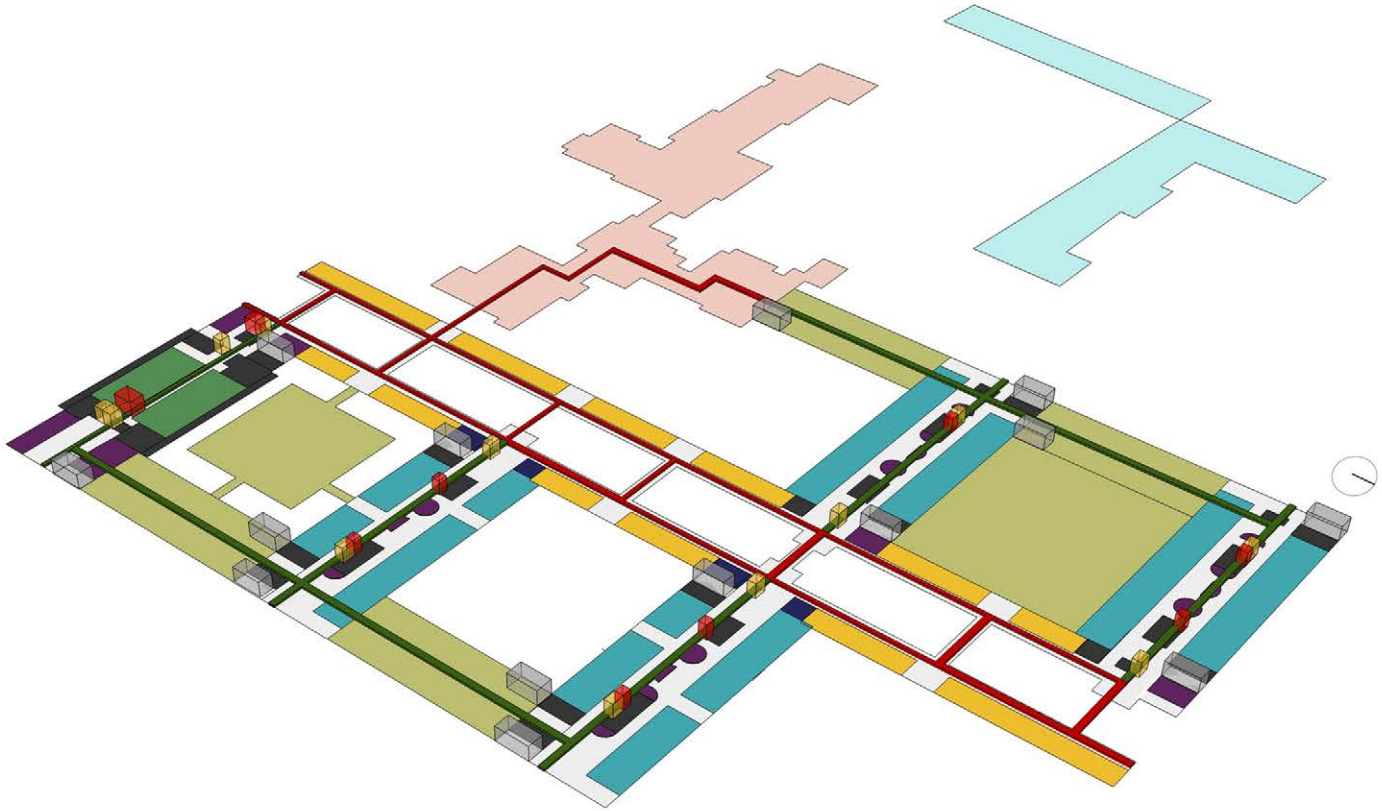
Main flows of patients and personnel on underground floor (technical basement)



Main flows of patients and personnel on ground floor (heaalthcare related facilities)



Main flows of patients and personnel on first floor (Policlinics)



Roof gardens

Patient ward

Support facilities

Meeting places

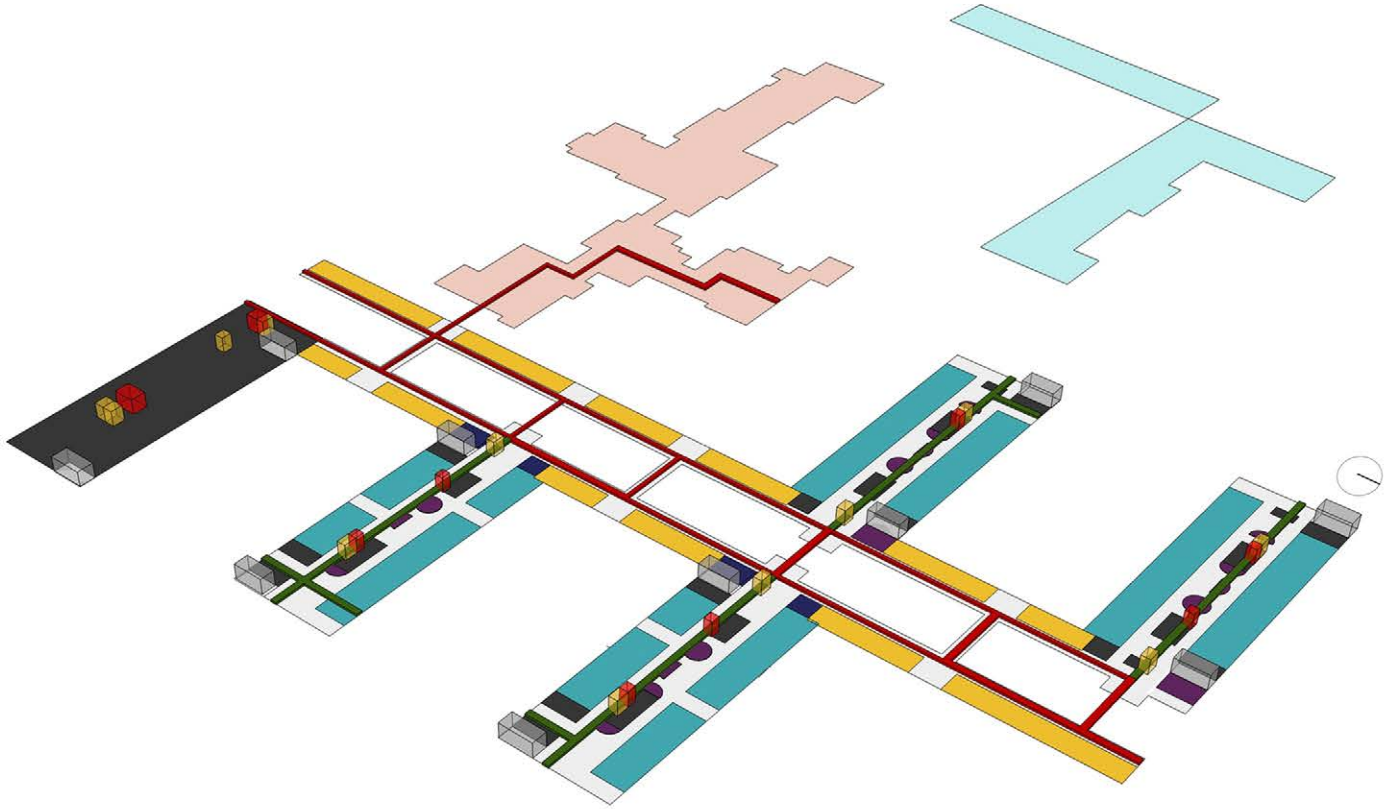
Personnel facilities

Surgery floor

In-patients

Personnel

Main flows of patients and personnel on second floor (wards)



Patient ward

Support facilities

Meeting places

Research facilities

In-patients

Personnel

Main flows of patients and personnel on third floor (wards)

Masterplan and ground floor

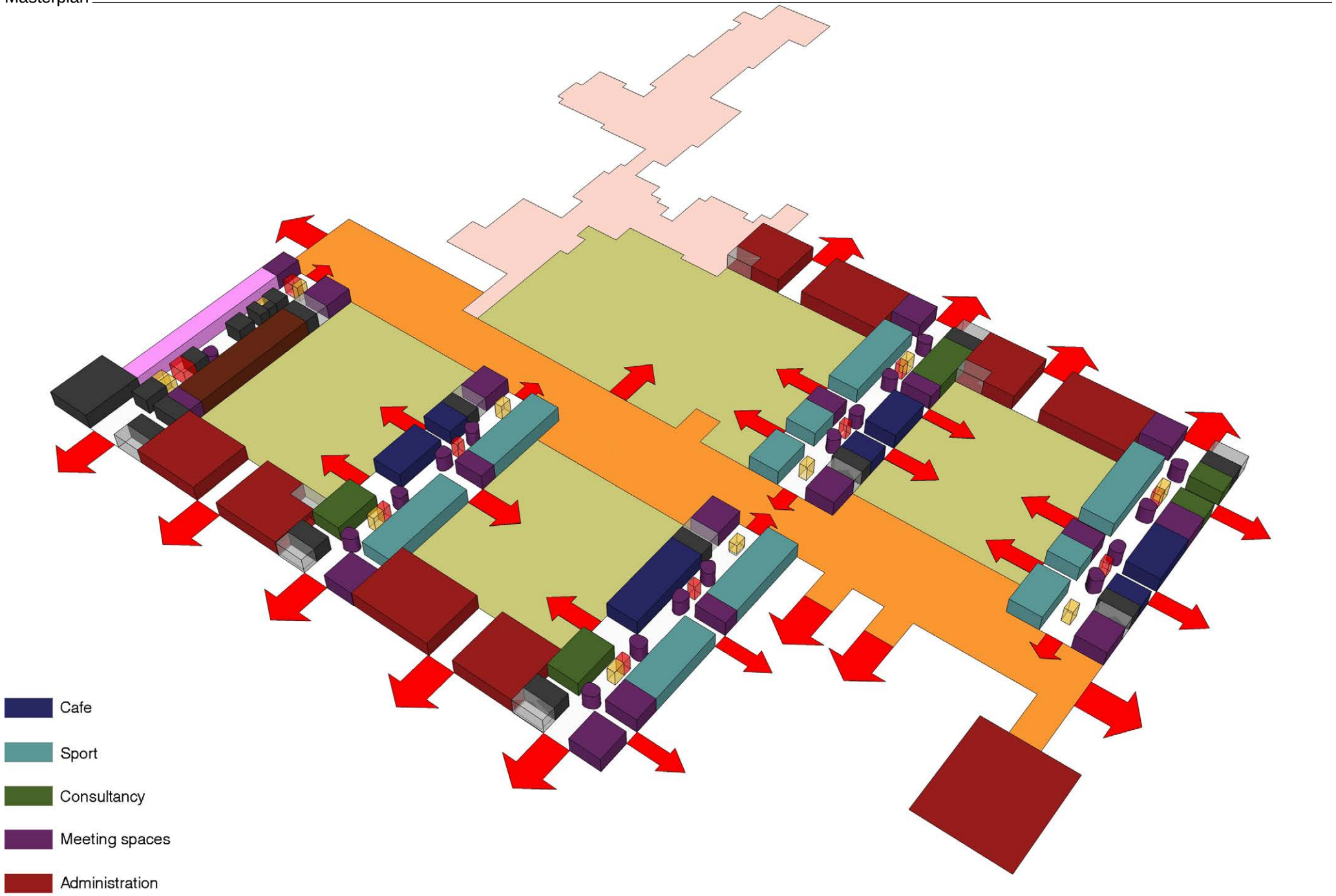
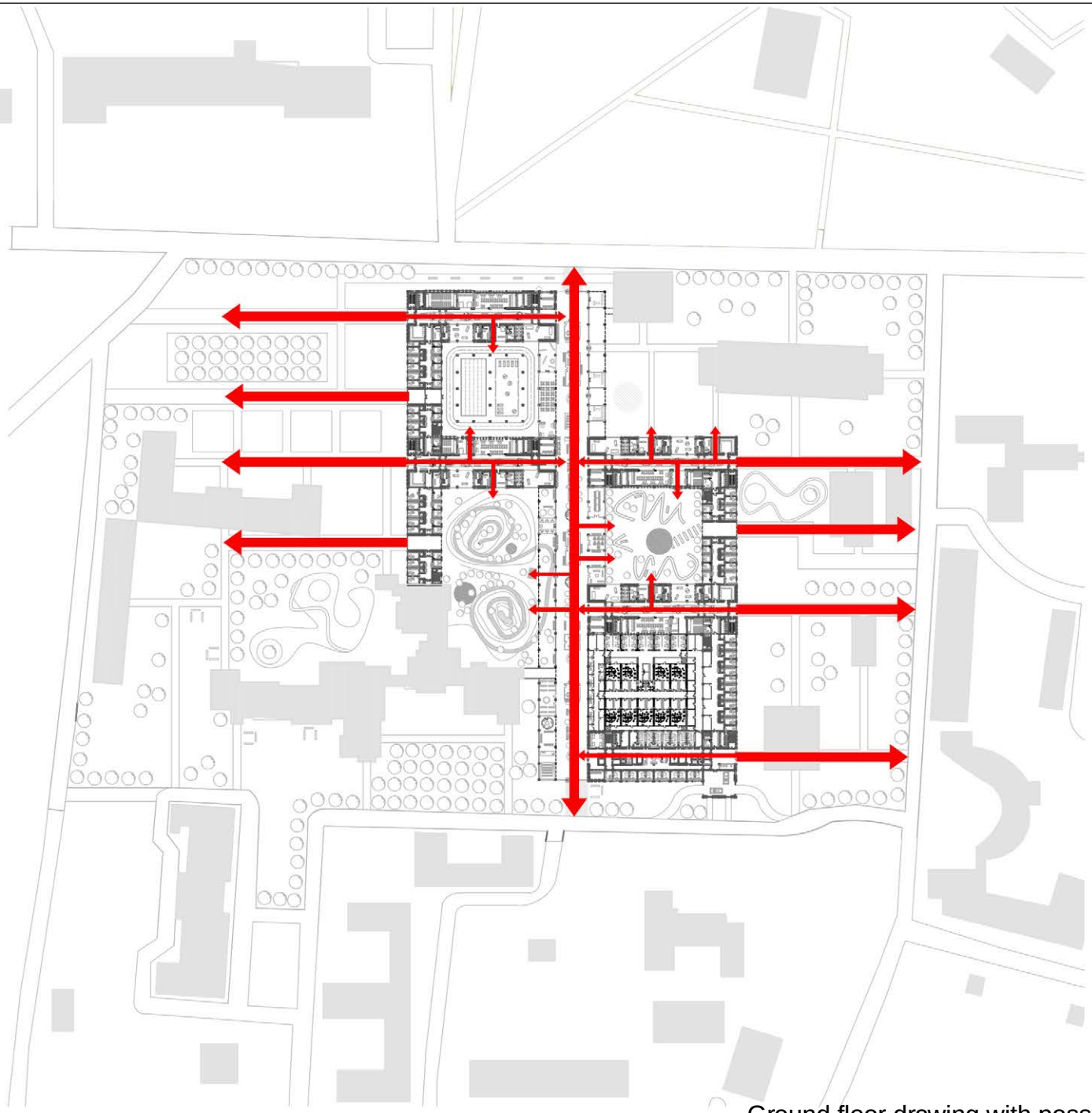
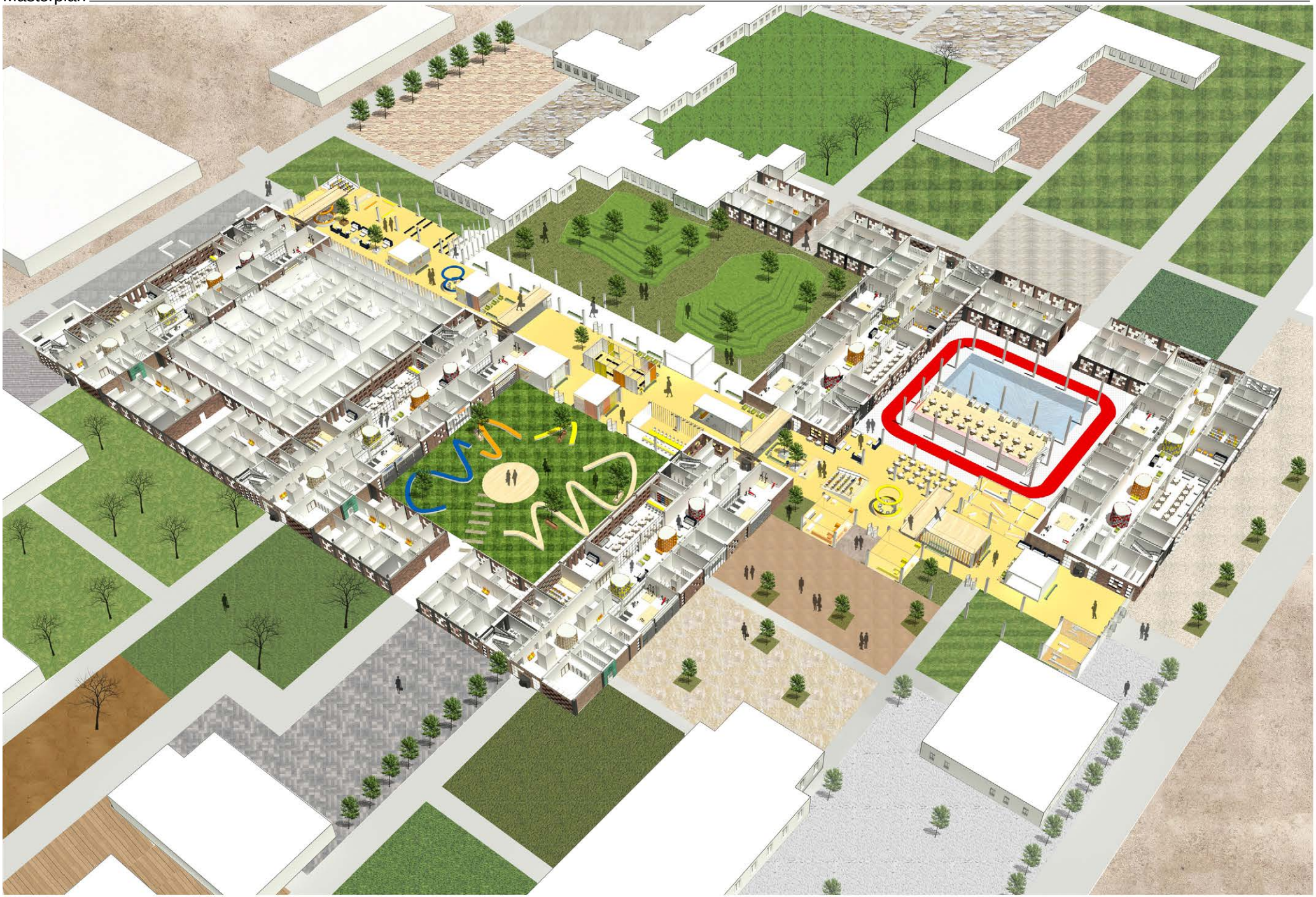


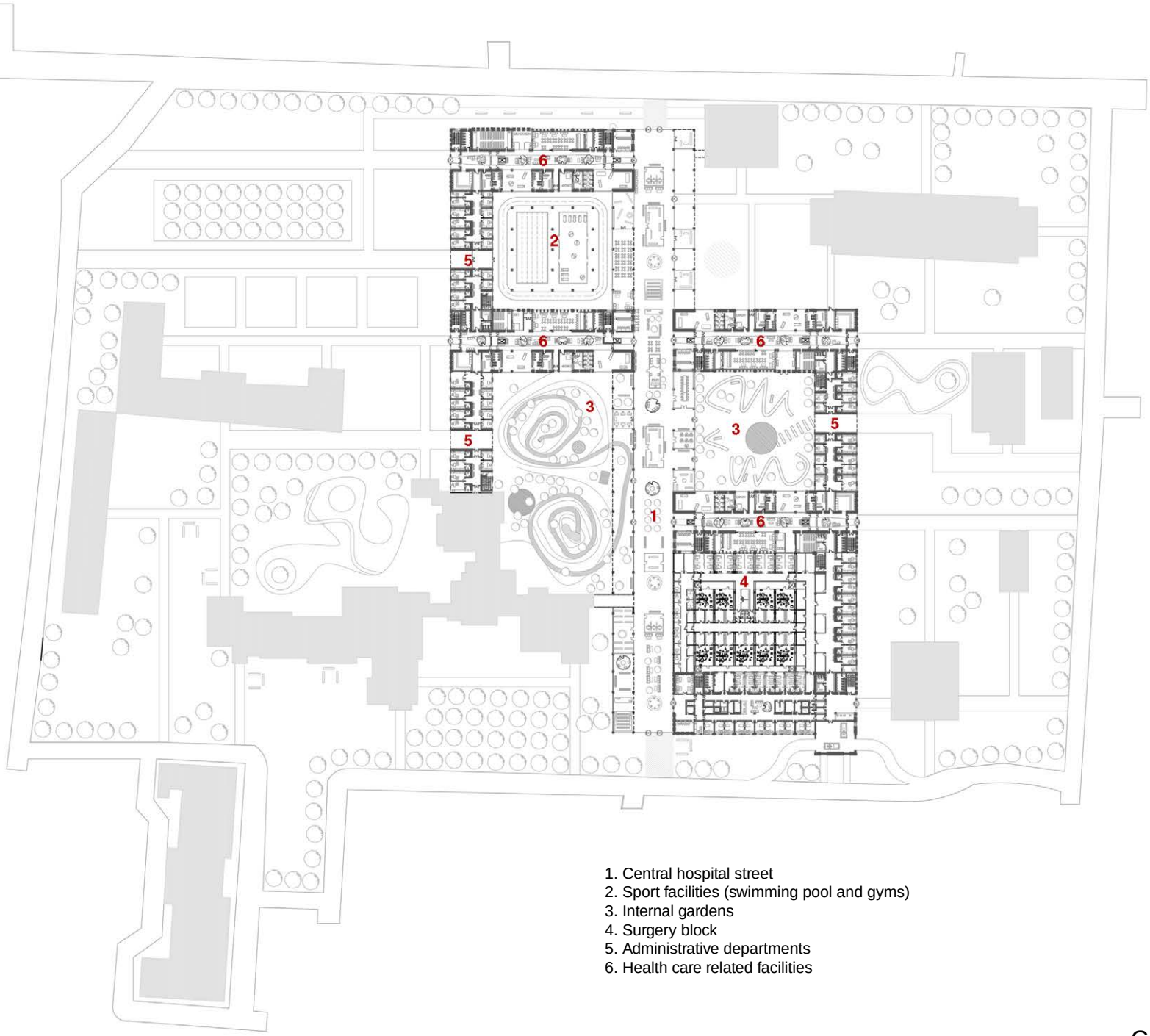
Diagram of permeability of ground floor



Ground floor drawing with possibilites for permeability



3d diagram of ground floor with healthcare related facilities



1. Central hospital street
2. Sport facilities (swimming pool and gyms)
3. Internal gardens
4. Surgery block
5. Administrative departments
6. Health care related facilities

Ground floor plan

CHAPTER 3

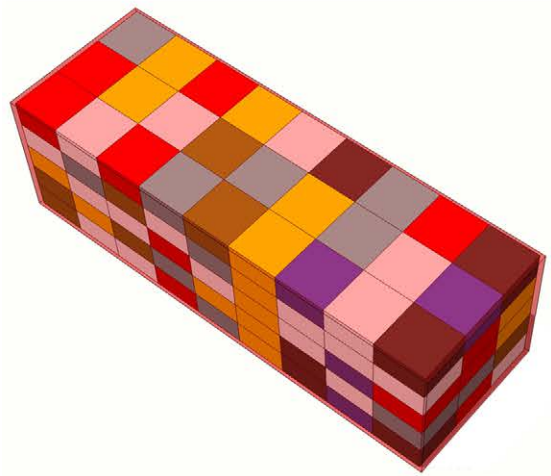
FLEXIBLE RENOVATION OF BURDENKO HOSPITAL

Types of flexibility

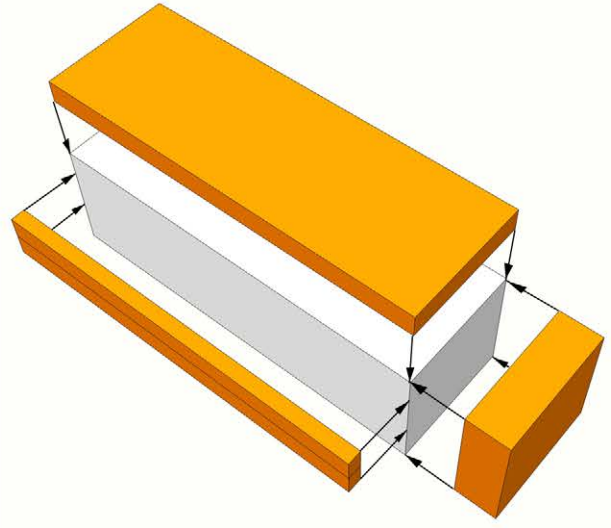
In addition to four levels of flexibility there are three types of flexibility exist. These are constant surface flexibility, variable surface flexibility and operational flexibility. Constant surface flexibility includes the possibilities to change and adapt the existing facilities (rooms, units or buildings) to the user needs within the boundaries of the building, which means that the initial floor area is constant. Variable surface flexibility, on the other hand, means that the initial floor area can be increased (or decreased) by adding additional parts to the existing building. These parts can be modular cantilevers which are hanging to the facade and increasing the floor area of the unit, or entire segment of the building which can be added to it in a modular or prefabricated way. The possibility of this type of flexibility should be designed in advance in order not to disturb the daily activities of entire hospital. The third type, operational flexibility, is meaning to adapt one or another unit (or indidual room, or entire building) according to user's needs and demands.

Levels of flexibility

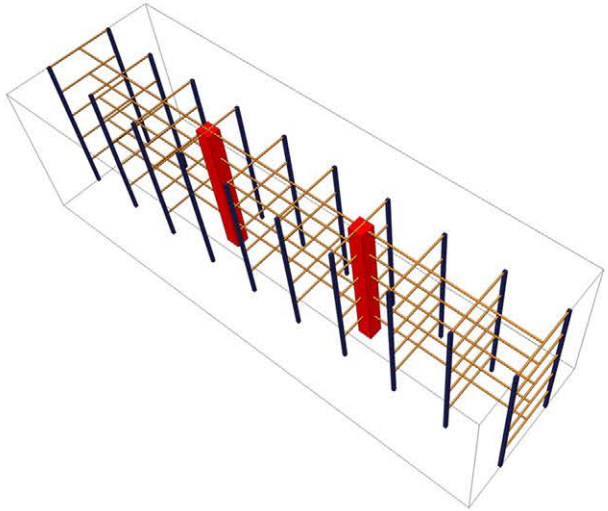
There are four levels of flexibility in hospital design (Capolongo, 2010). The first level is individual room, which can be adaptable to the user's needs. The second one is functional unit, which can be combined from the set of individual rooms and be able to accomodate any hospital department. Third one is a building level, in which different hospital departments can be accomodated in one building; they can be changed based on current demand or even converted into another function, such as offices or housing. Finally, the fourth level is a hospital complex level, which is combined from identical buildings and accomodates the entire hospital. Due to rapid changes in healthcare technologies the function of total complex can be changed from hospital to housing or office functions in case of proper applicability of flexibility concepts on the previous levels.



Constant surface flexibility

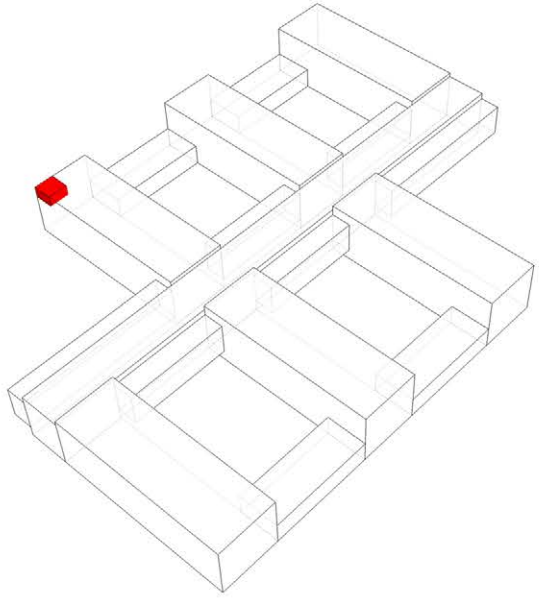


Variable surface flexibility

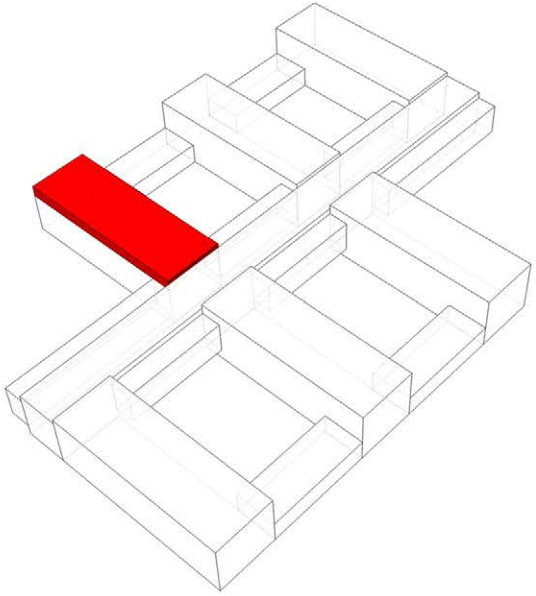


Operational flexibility

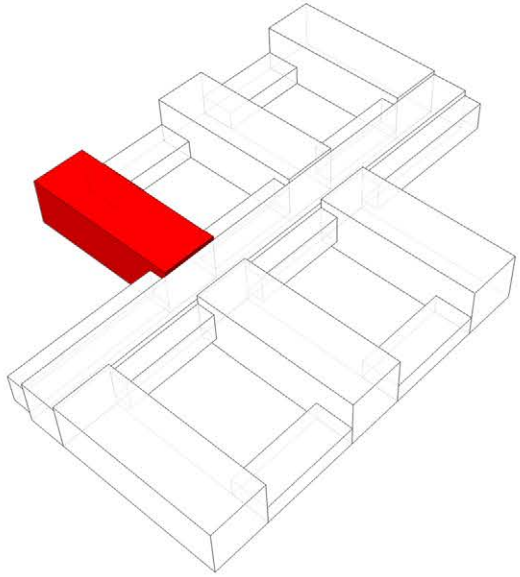
3 types of flexibility



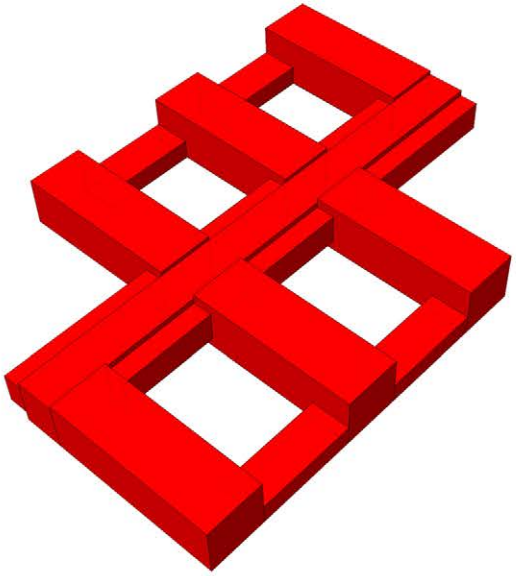
1 level: Individual room



2 level: Functional unit (floor department)



3 level: Building



4 level: Hospital complex

4 levels of flexibility

Structuring the chapter

The way of representation of material in this chapter will follow the two schemes presented on two previous pages. The chapter will cover all four levels of flexibility which were used in renovation of Burdenko hospital. The explanation will start from justifying the span of structural grid which was chosen for primary structure of the hospital. Then the flexibility of single room and prefabrication method of its assembling will be explained. Third part of the chapter will cover the flexibility of functional unit, while the fourth one will explain the flexibility of entire building which was designed as a modular part of entire hospital complex. The fifth part will cover the flexibility of entire hospital complex, its role in revitalization of the city area and possibilities of applying this flexible system for the extension of existing healthcare facilities in Pensa city. Last part will explain the possibilities of conversion of the hospital into other functions due to relatively quick process of outdatin the ehalthcare facilities based on rapid development of technologies.

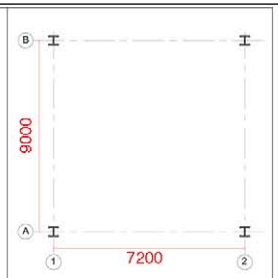
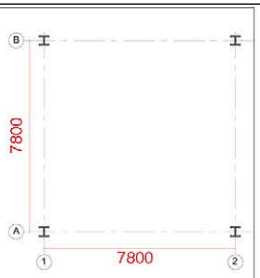
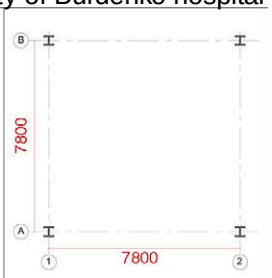
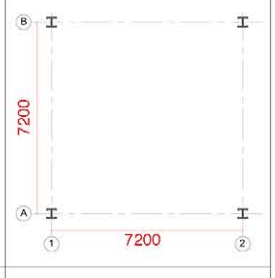
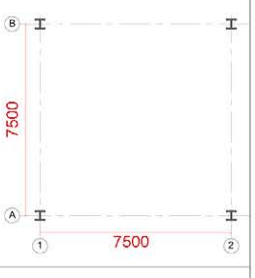
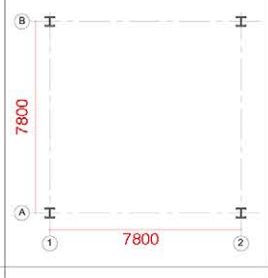
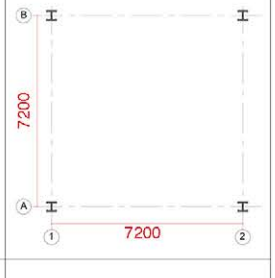
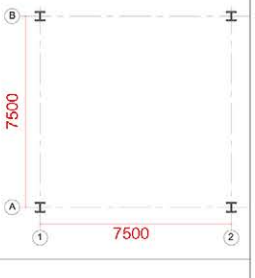
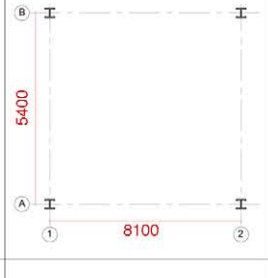
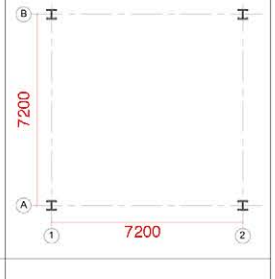
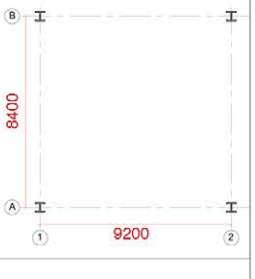
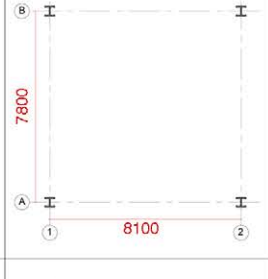
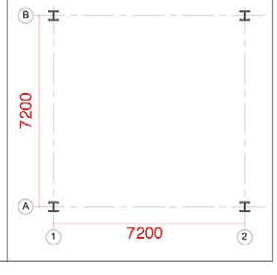
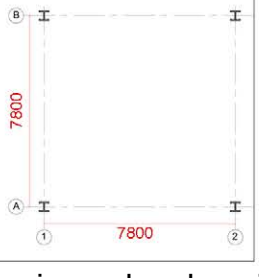
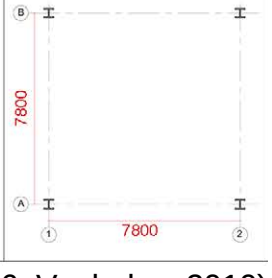
3.1
Structural grid

Structural grid is the first and foremost element of flexibility in hospital. All medical facilities, floor circulations, technical installations exist within this primary skeleton structure. Flexibility of structural grid plays crucial role in all other levels and types of flexibility mentioned in the first chapter.

Different practitioners as well as theoreticians give reasons for wider or smaller spans speaking about structural grid in hospitals. The promoters of wider spans argue that this increases the flexibility within the floor and allows to adapt the building to the future needs more easily. The opponents of wide spans say that despite the fact that wider spans can facilitate the planing of one or another department within the floor, it brings much more technical and structural difficulties in reality. The structures with wider spans are more difficult for technical installations because any whole decreases the stability of the structure. Since the fact that hospital contains a lot of vertical communications and installations, which demand a lot of technical wholes and shafts, the increasing of the span in structural grid makes the installation of these communications difficult. That is why for the reasons of structural stability as well as for easier technical installations, the optimal span of structural grid in hospital usualy equal to 7.2 x 7.2 meters (Wagenaar, 2006).

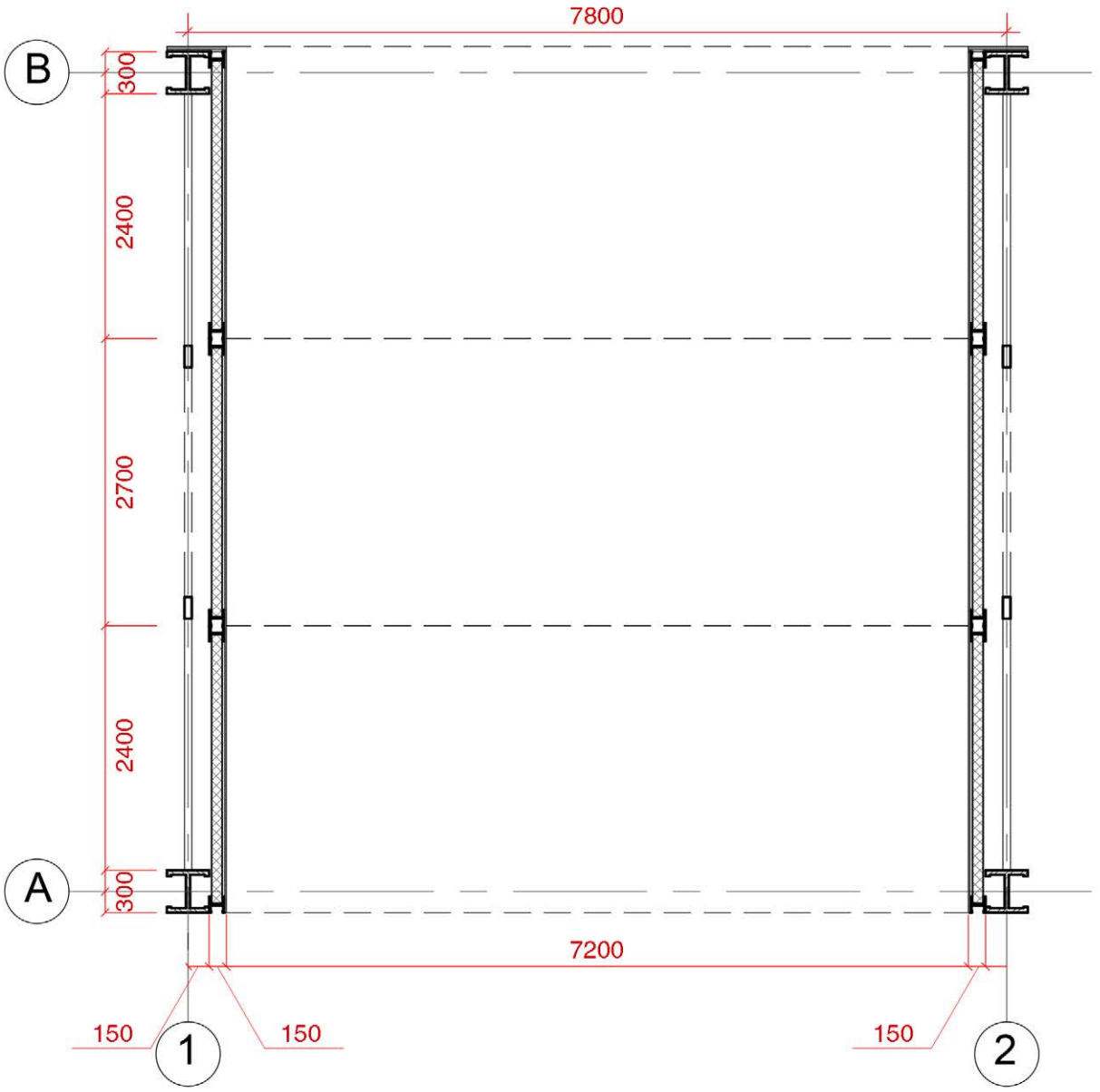
On the other hand, in recent years the structural grid of modern hospitals is slightly increasing 7.2 m span based on higher complexity of technical installations. In any case, the choise of one or another span for hospital structural grid is based on individual characteristic features of the project.

Another aspect which needs to be taken into account when choosing hospital structural grid is re-use of hospital building in the future. Since the fact that hospital complexes become outdated relatively soon after their completion because of rapid changes in technologies, the hospital complex should have possibility for conversion into other functions in case of being outdated. The table on the right page gives some examples of structural spans in different hospitals which were studied in order to chose proper span for Burdenko hospital expansion.

Martini hospital, Groningen, The Netherlands, 2007		Ludwigshafen clinic, Germany, 2004		Maasstad Hospital, Netherlands, 2009	
Clemente Alvarez Emergency Hospital, Rosario, Argentina, 2007		Seattle medical center, USA, 2004		Rijmond Zuid Medical Center, Netherlands, 2011	
Brandenburg University clinic, Germany, 2008		Seattle medical center, USA, 2004		Kortrijk Hospital, Belgium, 2005-2018	
Halle University clinic, Germany, 2004		Forchheim General Hospital, Germany, 2008		Karolinska General Hospital, Stockholm, 2010	
Karlsruhe University clinic, Baden, Germany, 2004		Geroen Bosch Hospital, Netherlands, 2010		New Akershus University Hospital Oslo, 2011	

Overview of different spans in modern hospitals (Source: Cor Wagenaar, 2006; Verderber, 2010)

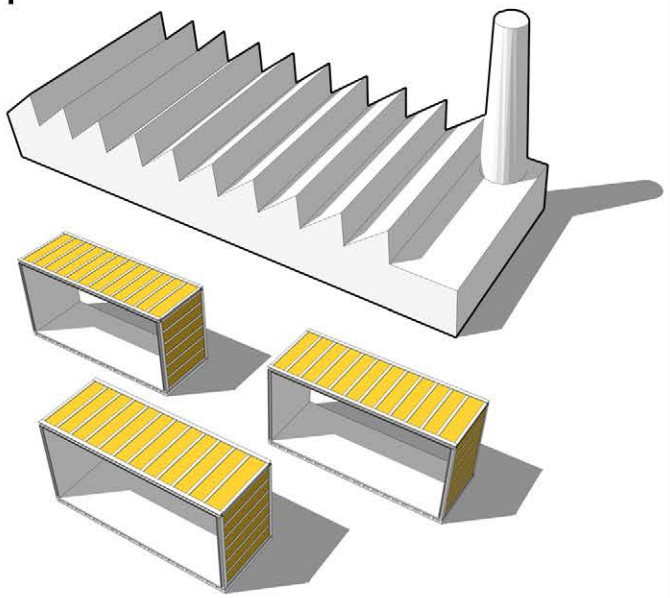
Primary structural grid of 7.8 x 7.8 meters was chosen for the extension and renovation of Burdenko hospital as a good compromise. Since the fact that main structural grid serves as primary skeleton structure which contain secondary structure with different hospital departments, primary structural grid of 7.8 x 7.8 meters allows to set up the secondary structure consists of prefabricated modules within 7.2 x 7.2 meters, which is usual and most suitable for hospital design.



Span of primary skeleton structure chosen for the project

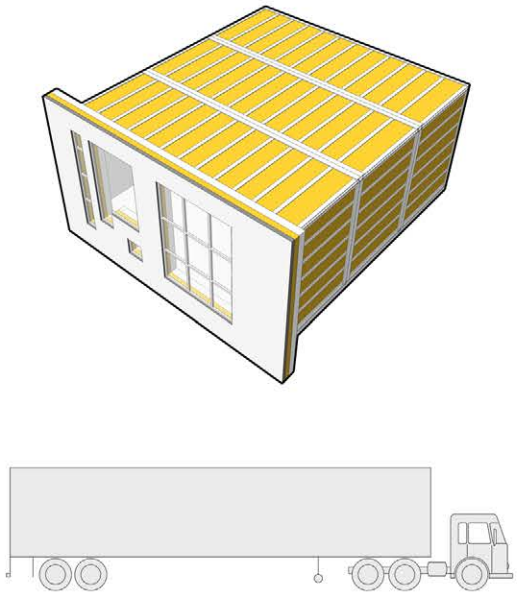
3.2
Technical assembling of the module

1



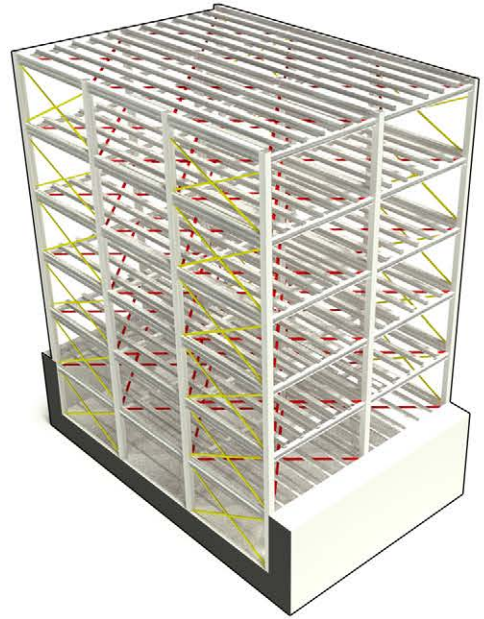
Producing of prefabricated parts of modules in a factory

2



Transporting parts of modules by truck to construction site

3

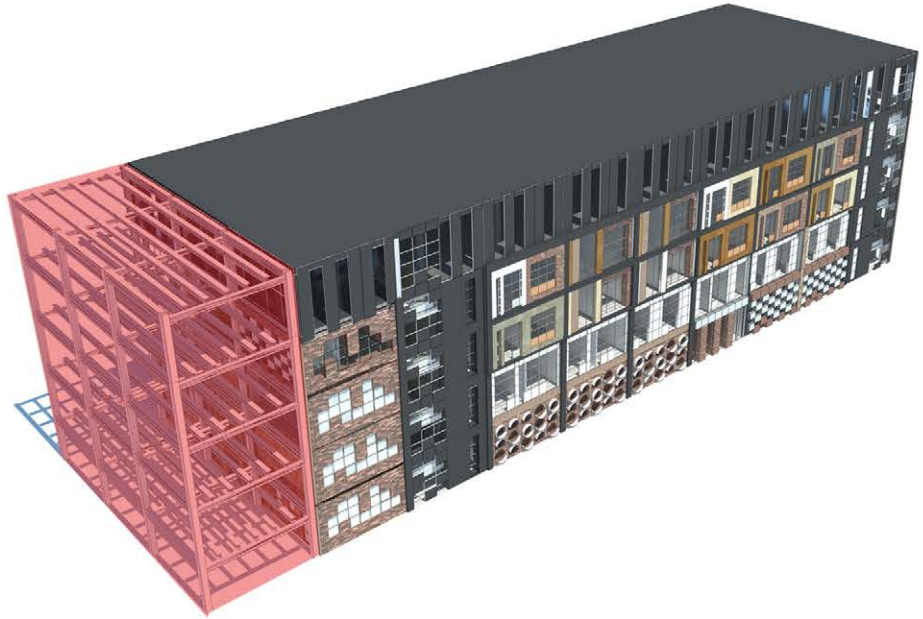


Construction of primary skeleton on construction site

4

Inserting of prefabricated modules into primary skeleton

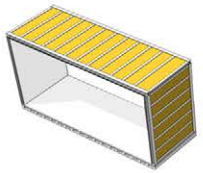
5



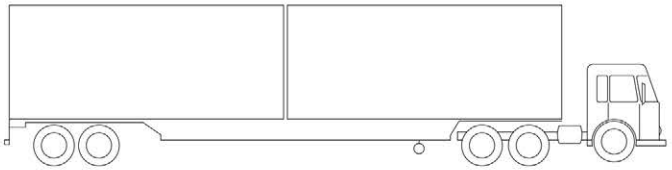
Possibility of extension for completed hospital building

Processing scheme of production, transportation and construction of prefabricated modules

Project life process scheme



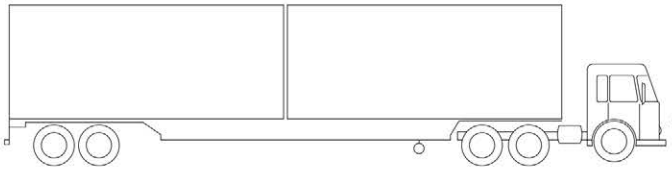
X 2 =



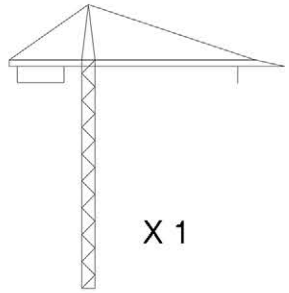
X 1

1/3 part of the module

= 150 modules =



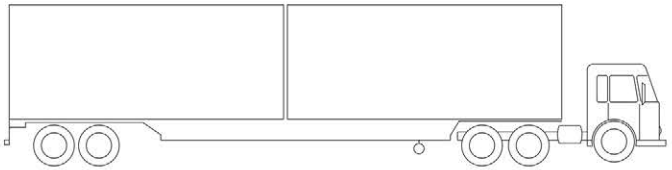
X 75 +



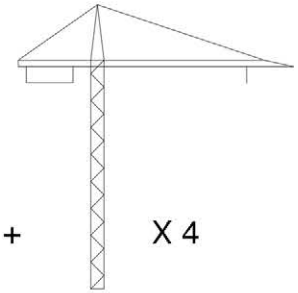
X 1

Standard 5-storey block

= 832 modules =



X 375 +



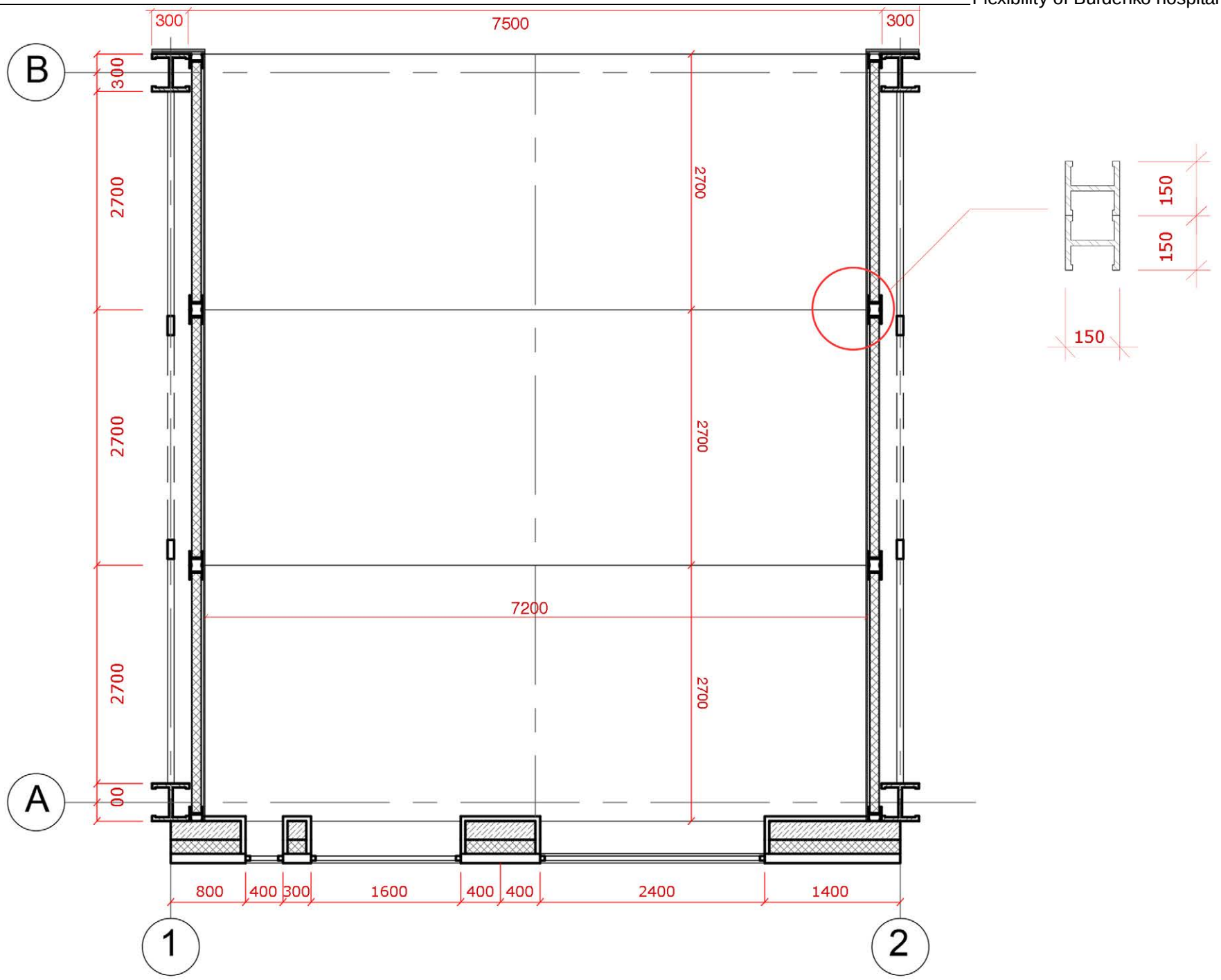
X 4

5 standard blocks + 4 administrative units + hospital street

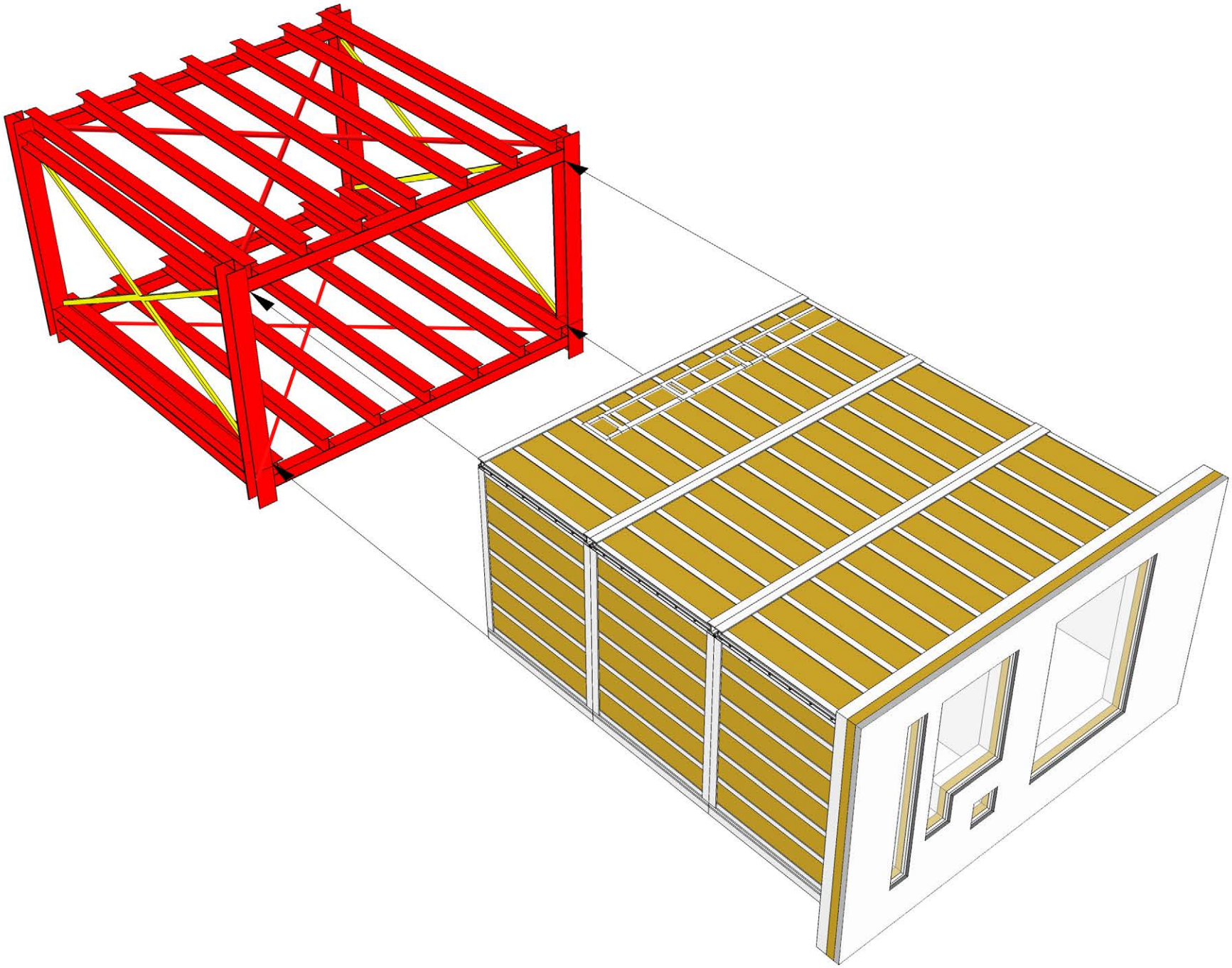
Project life cycle scheme of construction and utilization of the modules

3D scheme of assembling modules into hospital building

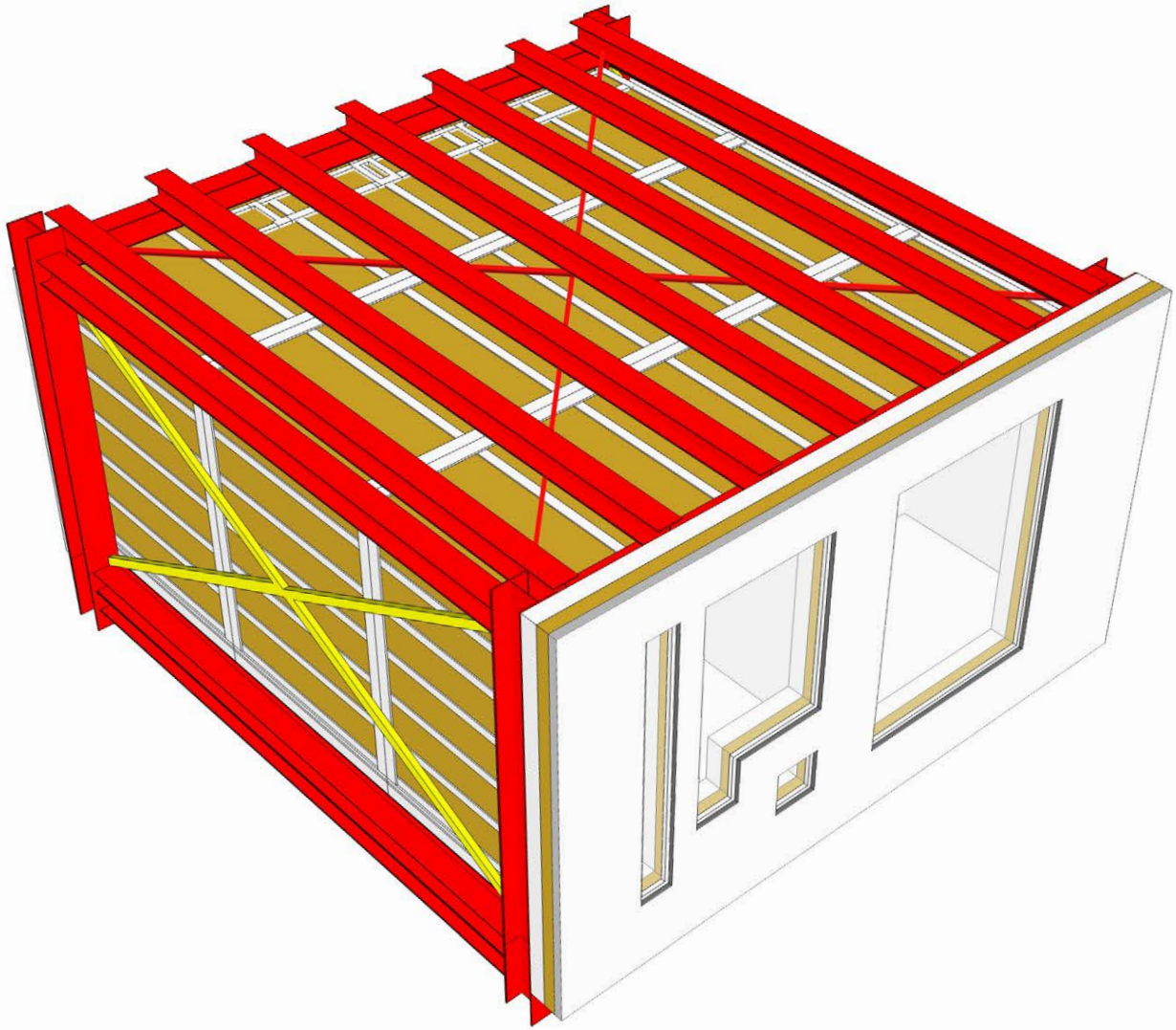
3D scheme of assembling modules into hospital building



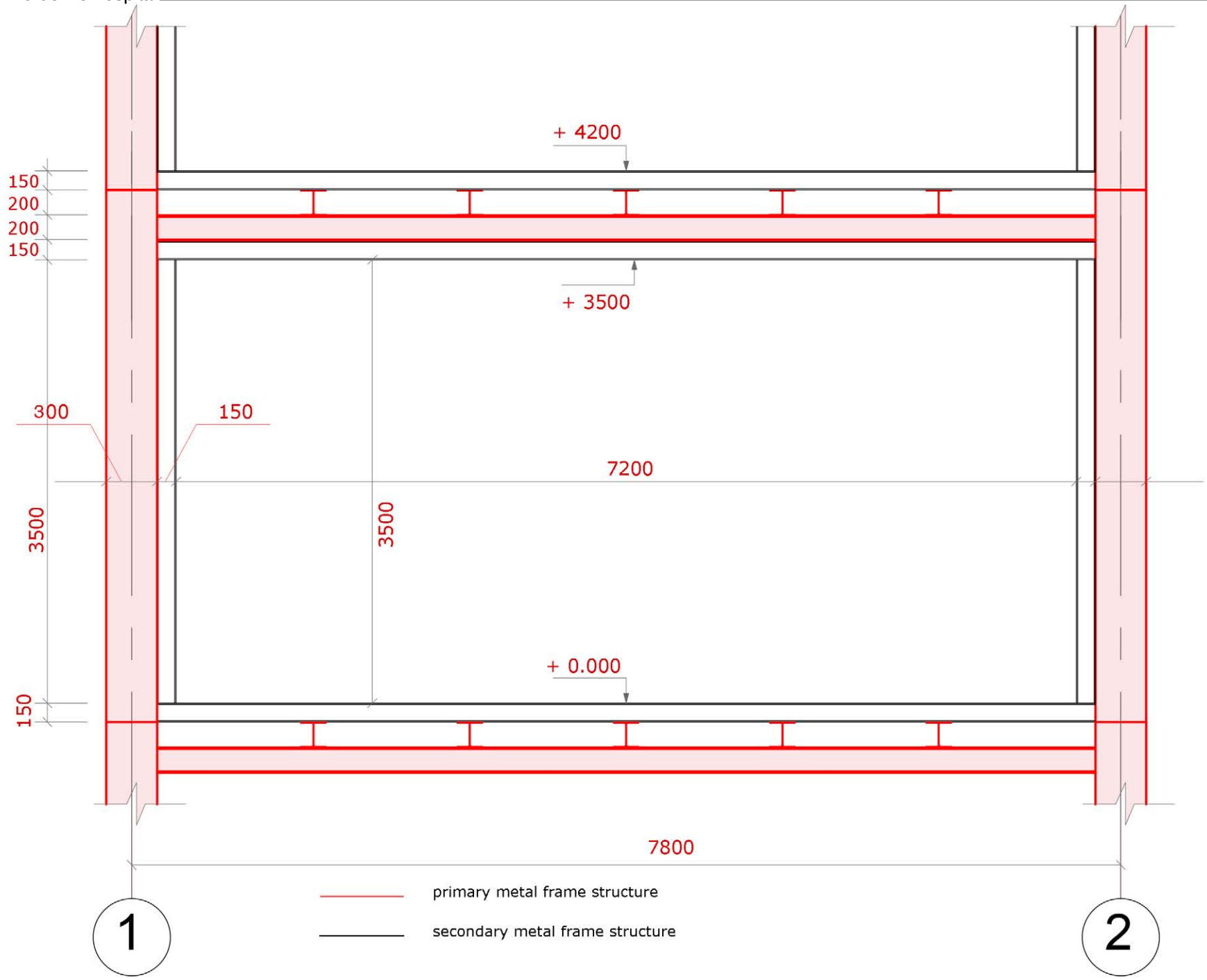
Detailed plan of primary structure together with inserted prefabricated module



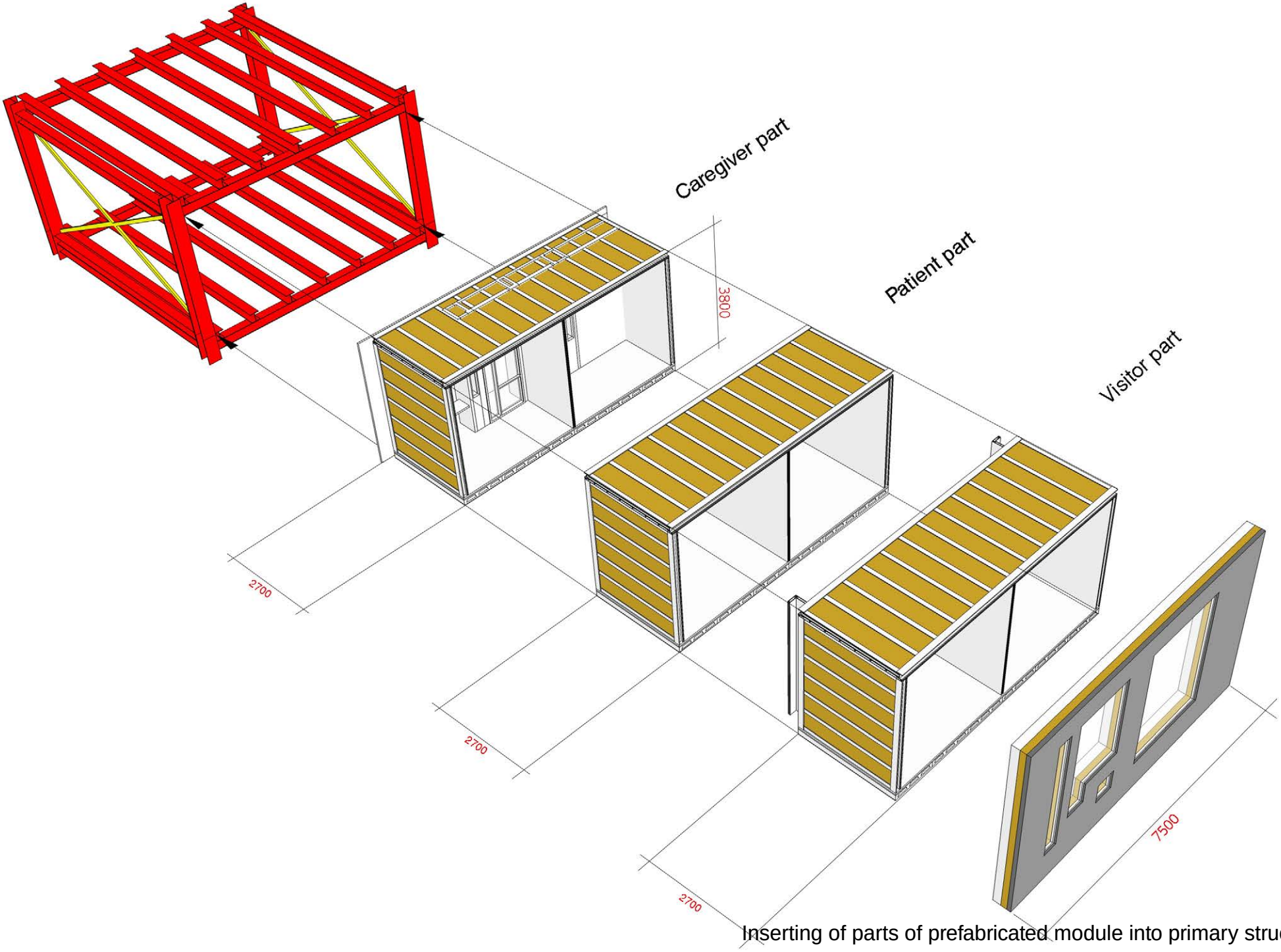
Insterting of prefabricated module into primary structure



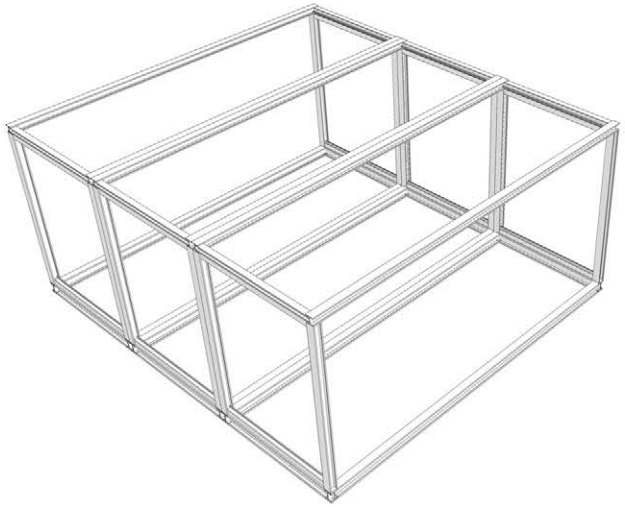
Assembled structure



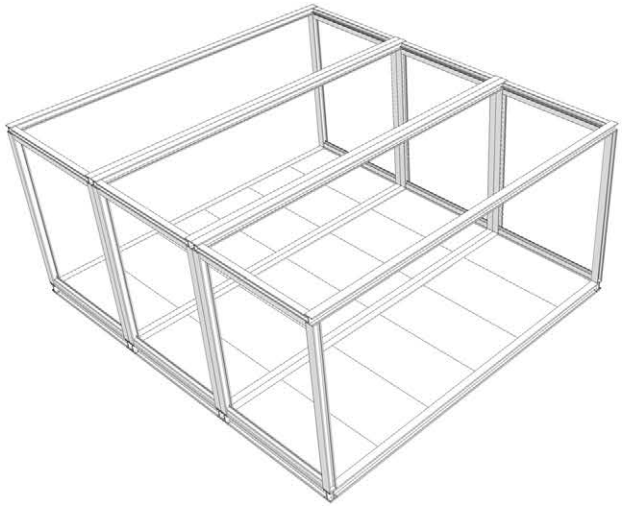
Ortogonal drawing of primary and secondary strycture with dimentions



Inserting of parts of prefabricated module into primary structure

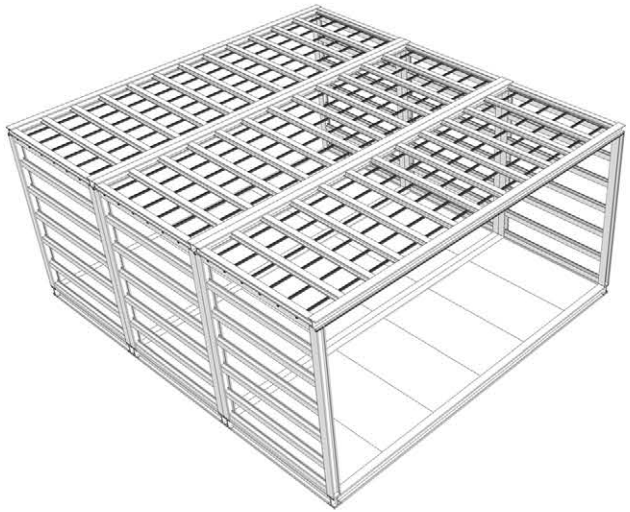


3 segments of metal frame 150x150 mm

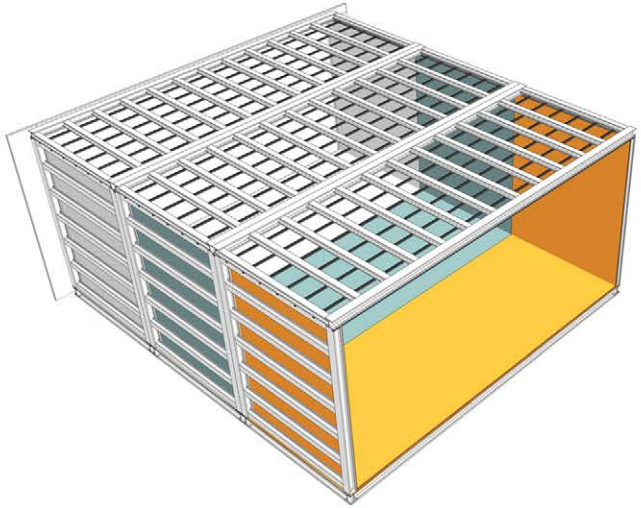


Concrete floor slab panels

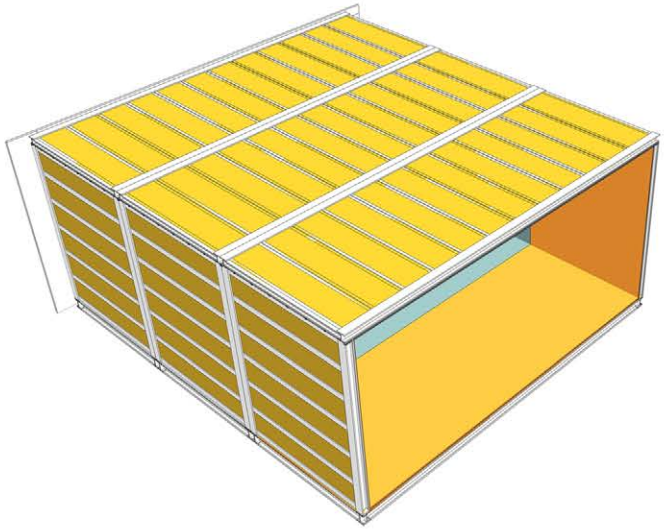
Additional metal elements



Metal railings for finishings

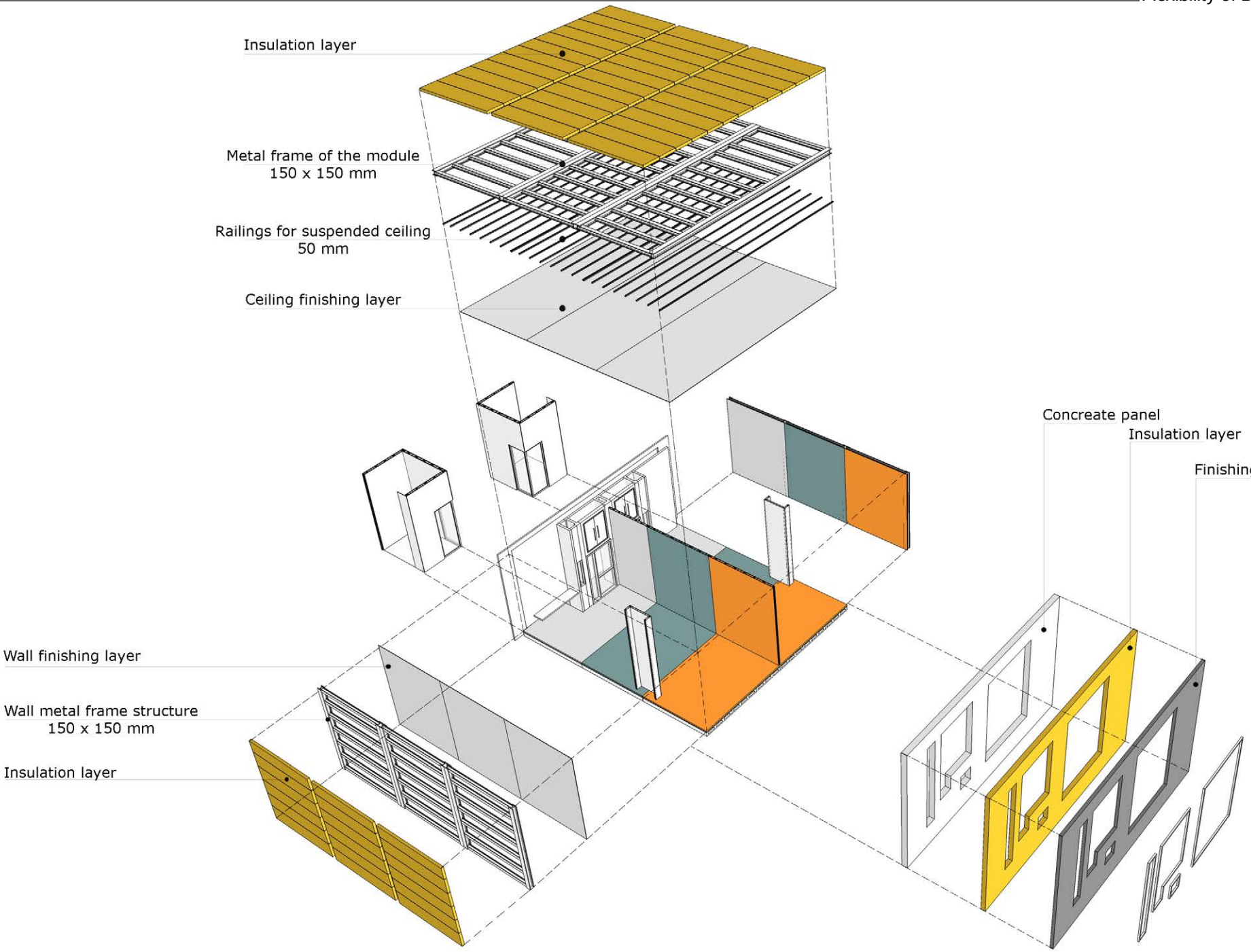


Finishing walls

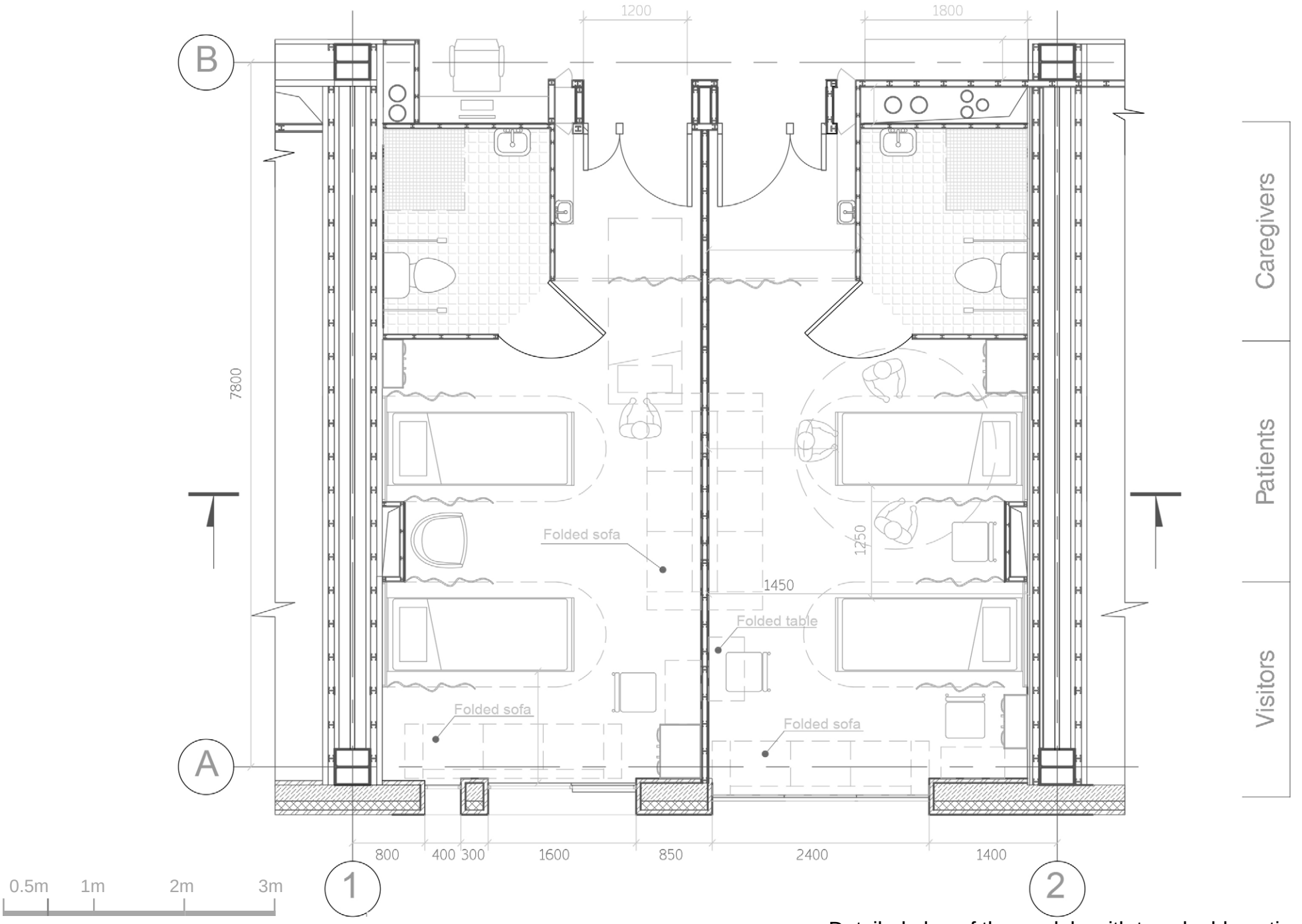


Insulation layer

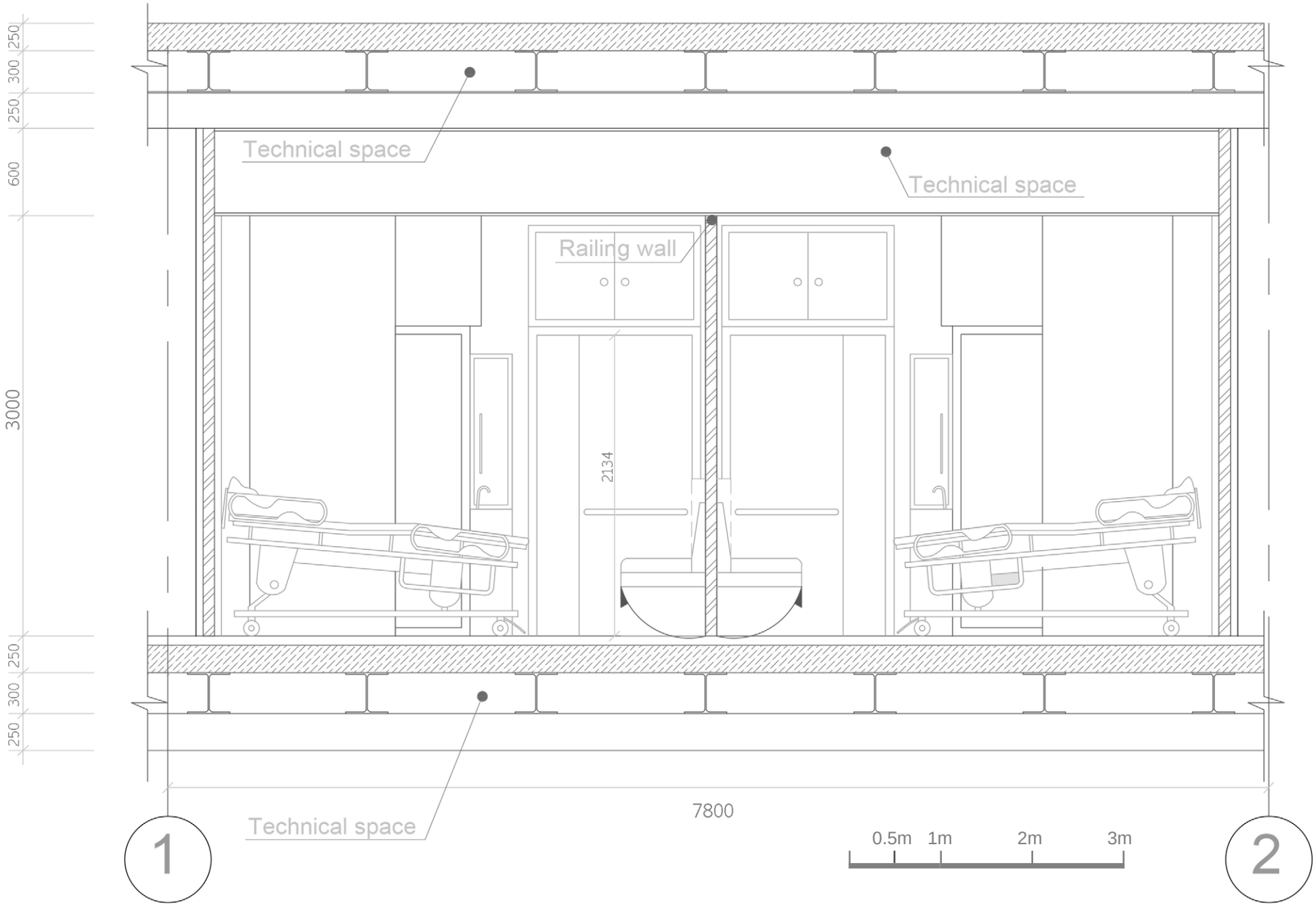
Assembling scheme of the module



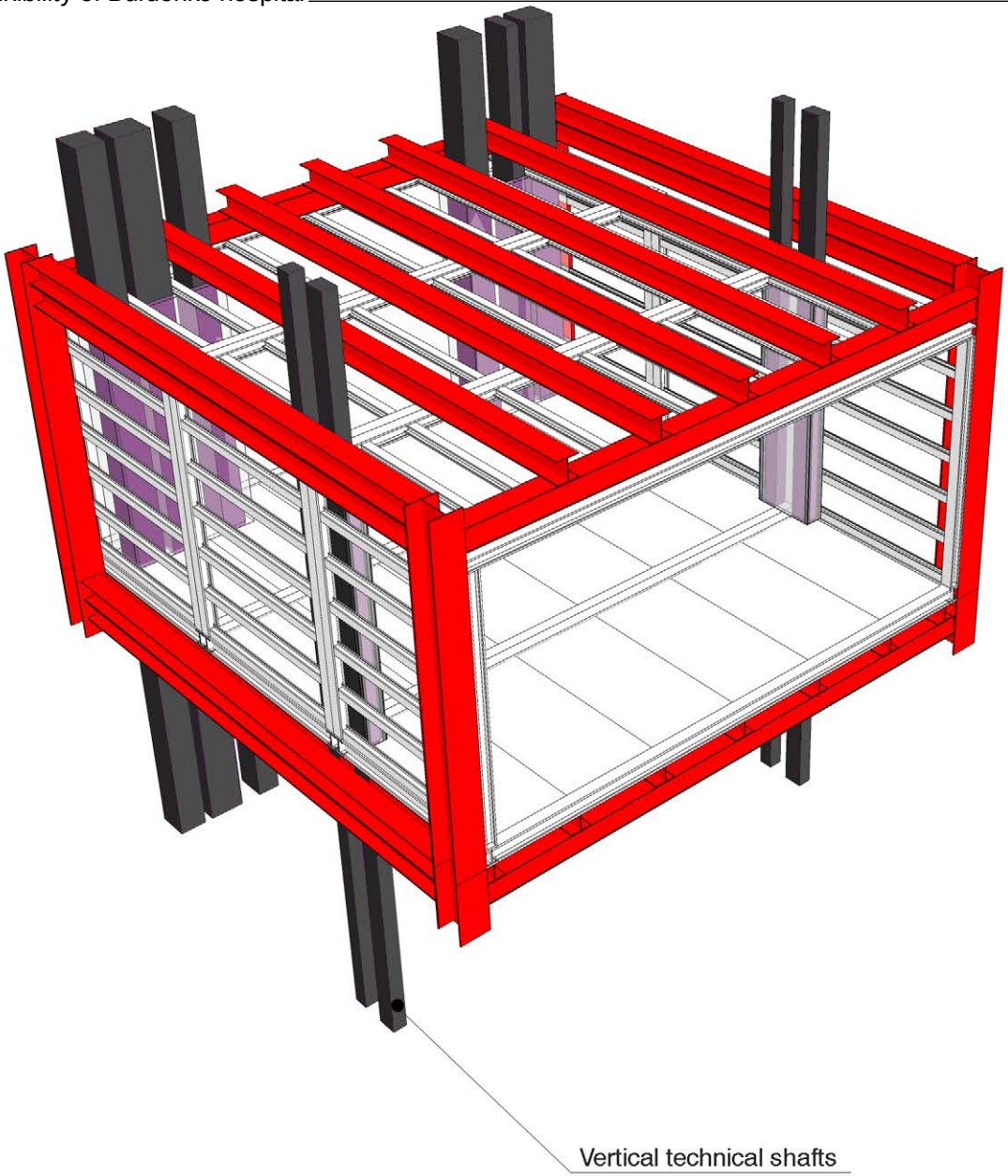
Explosion scheme of structural layers of the module

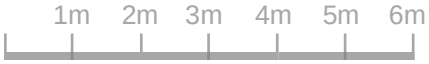


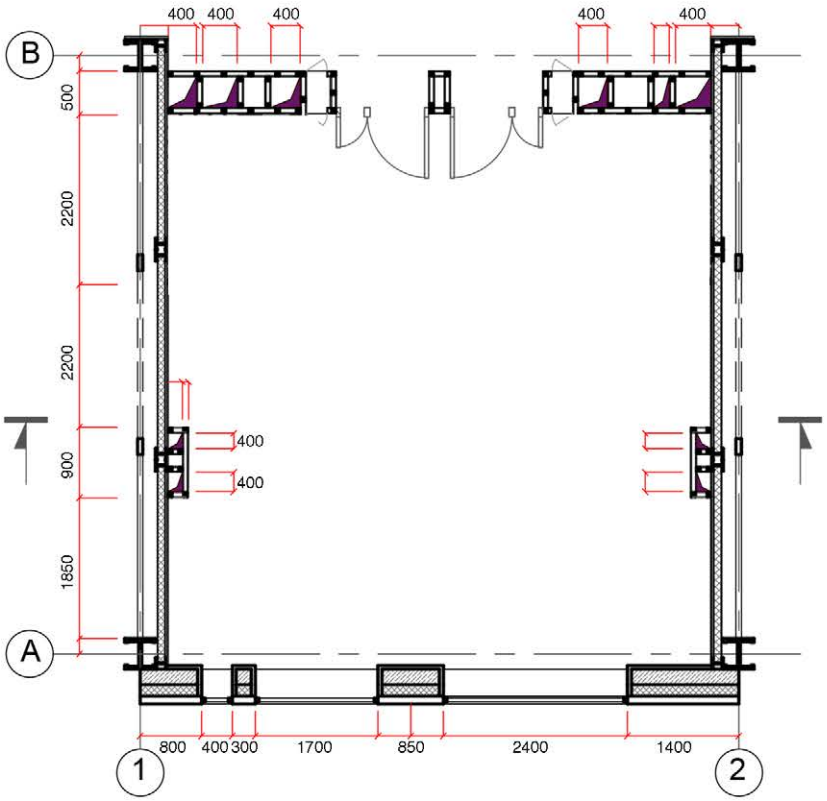
Detailed plan of the module with two double patient wards

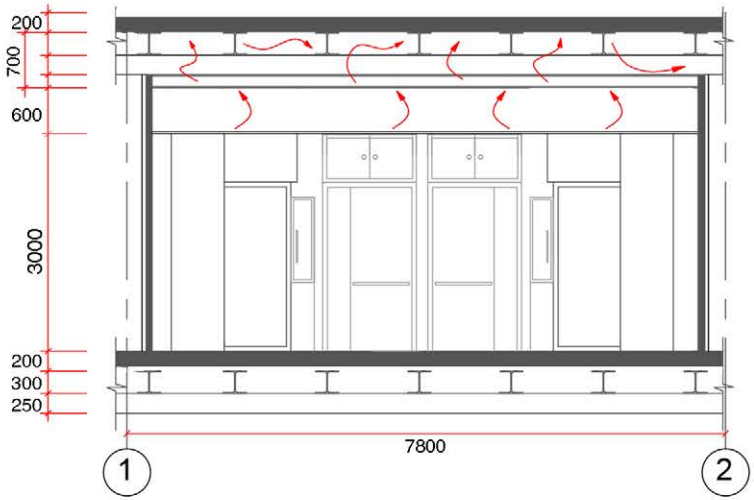


Detailed section of the module with two double patient wards

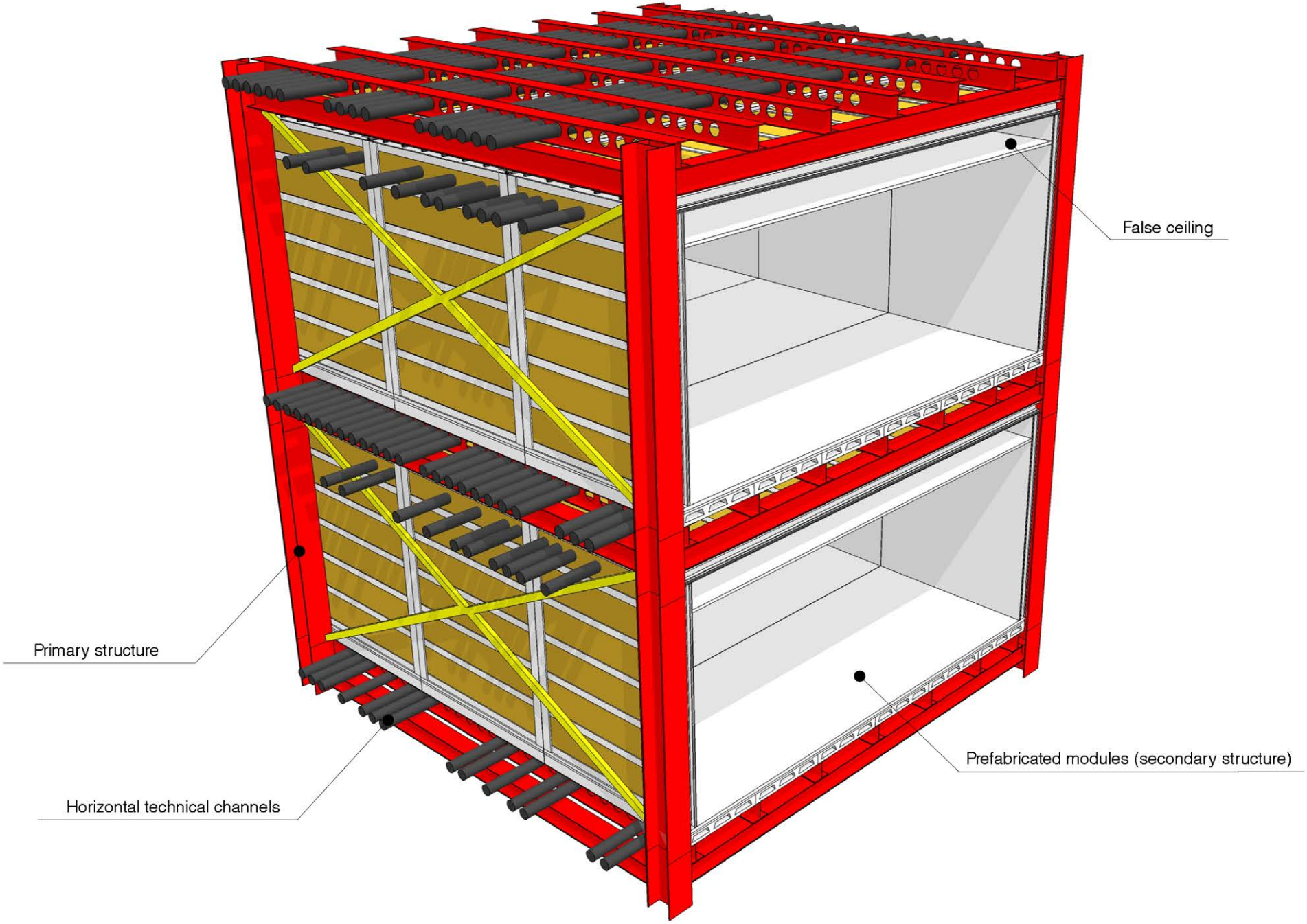




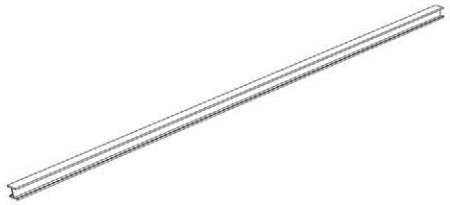
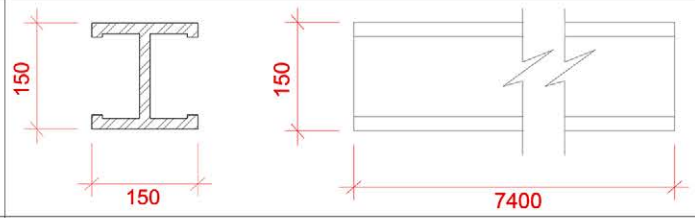
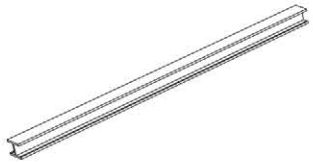
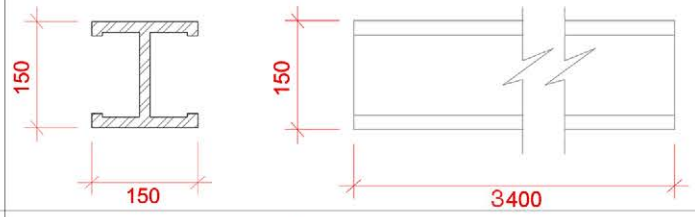
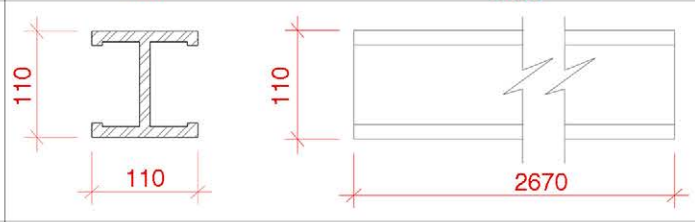
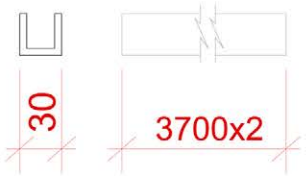
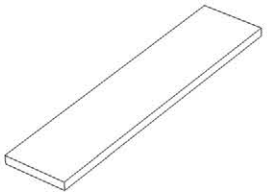
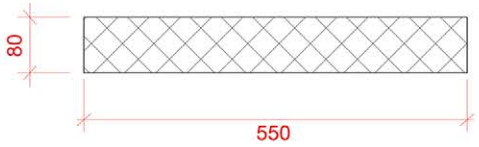
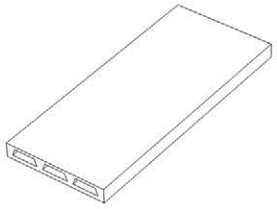
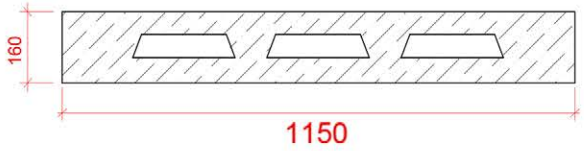


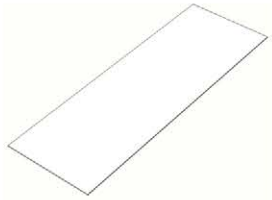
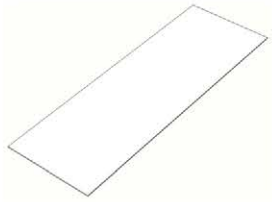
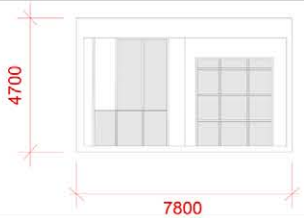


Vertical technical communications in the module

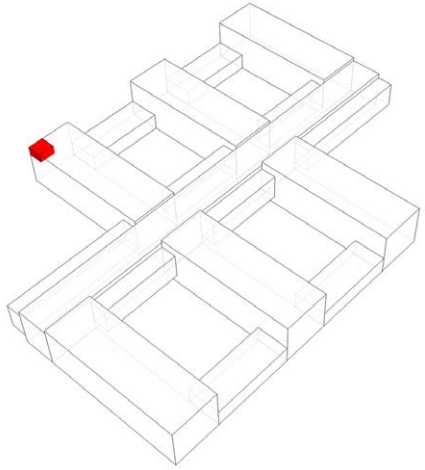


Horizontal technical communications in the module

Type of element	3D view	2D view	Quantity
I - beam type 1			12
I - beam type 2			12
I - beam type 3			62
Guide rail for ceiling			24
Insulation layer			108
Precast floor concrete slab			18

Type of element	3D view	2D view	Quantity
Floor finishing (Mormoleum FORBO Real 3075)			55 m2
Wall finishing (DuPont Korian)			56 m2
Ceiling finishing (DuPont Korian)			55 m2
Facade panel			1

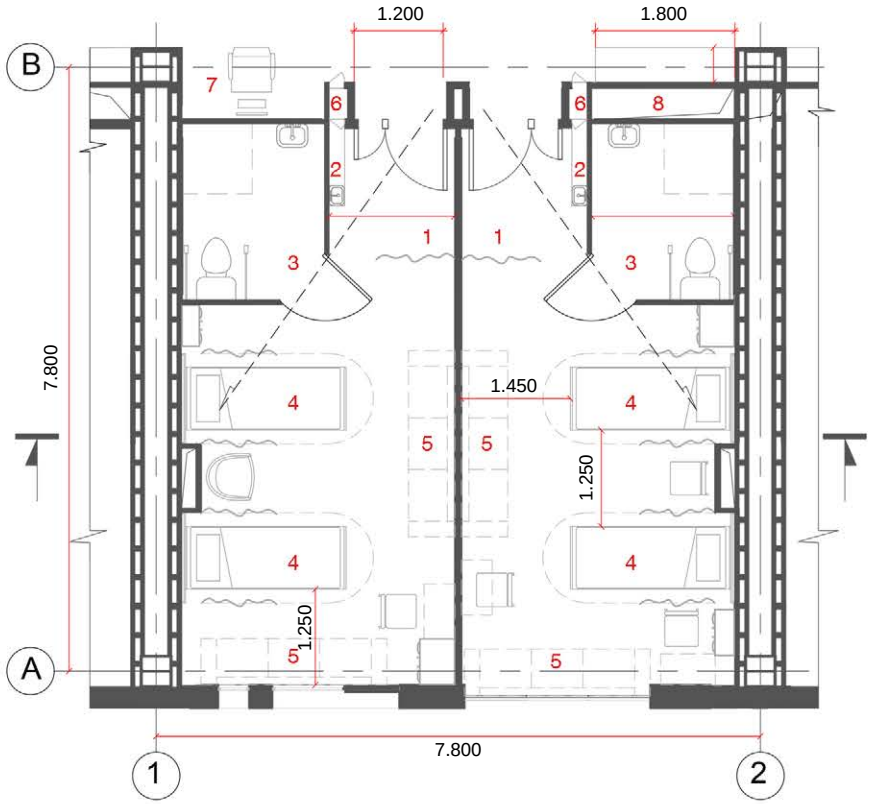
3.3
Individual room. Arranging of different functions into the module

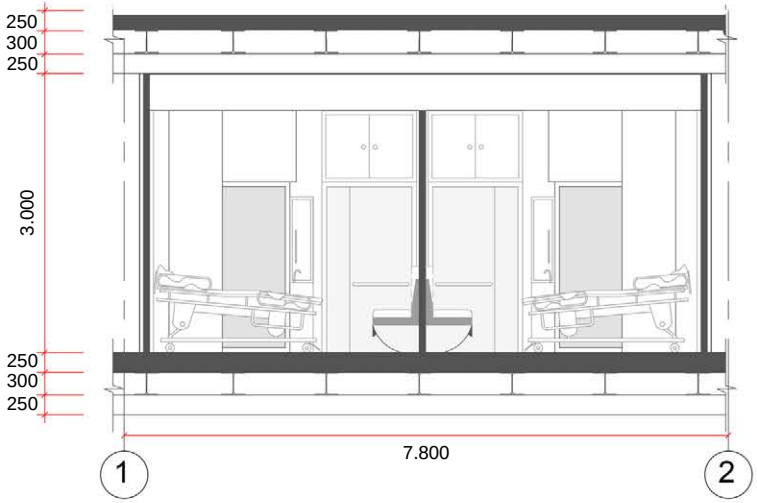


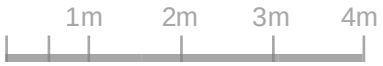
Two double-person wards

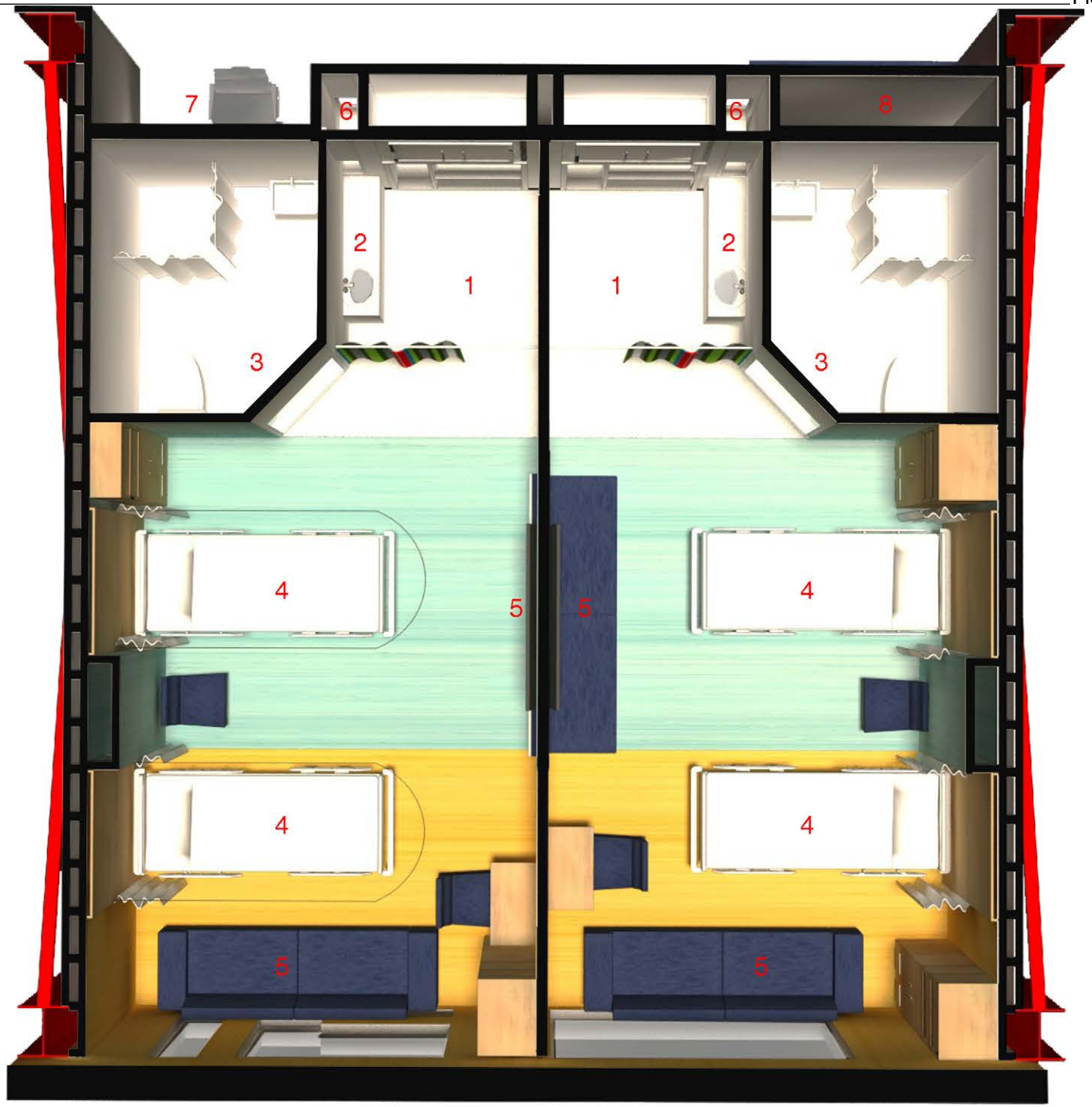
1. Gateway
2. Sink
3. Bathroom
4. Patient bed
5. Sofa
6. Capboard for medication
7. Nurse station
8. Technical shaft

S of the ward: 22 m2
S of the bathtoom: 4.1 m2







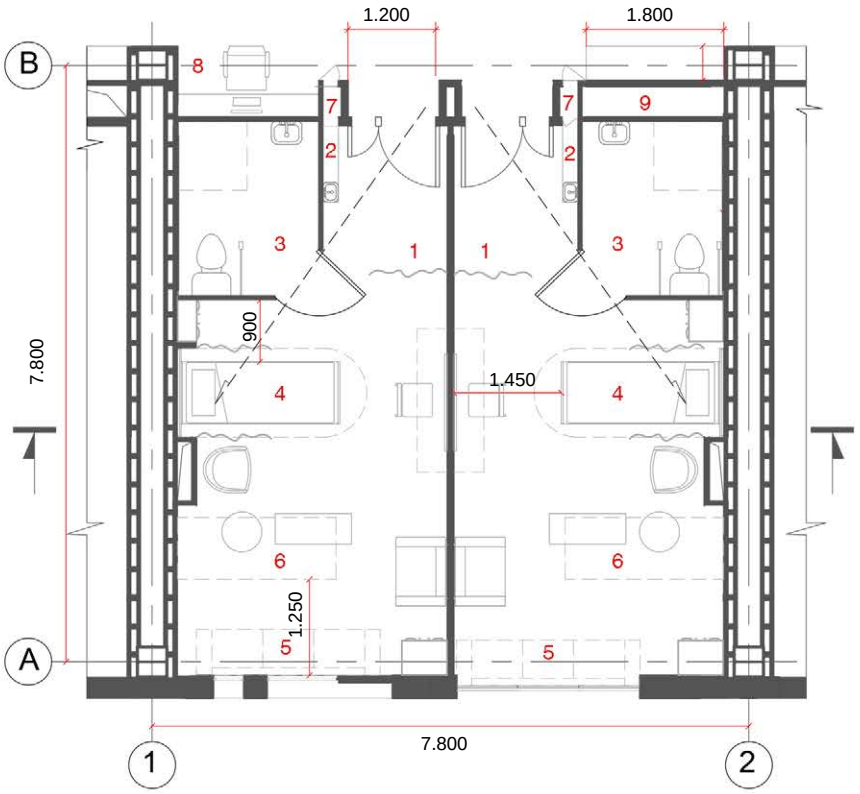


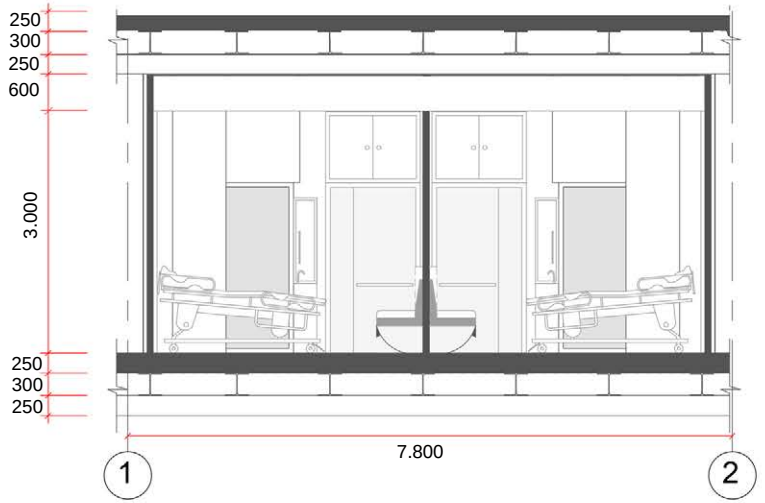
Two double-person wards

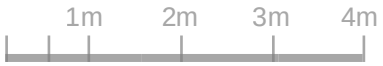
Two individual wards

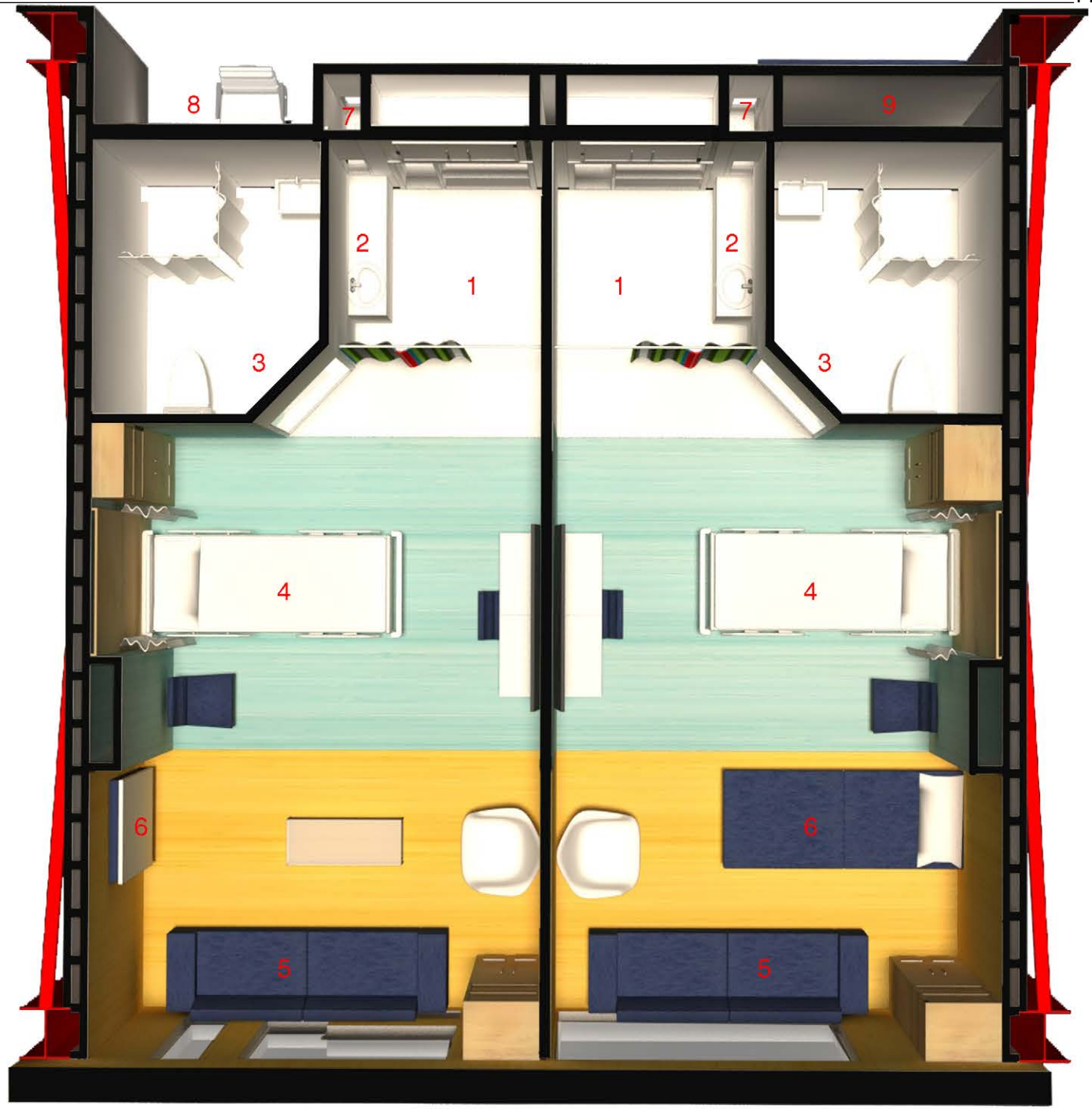
1. Gateway
2. Sink
3. Bathroom
4. Patient bed
5. Sofa
6. Visitor's bed
7. Capboard for medication
8. Nurse station
9. Technical shaft

S of the ward: 22 m2
S of the bathtoom: 4.1 m2







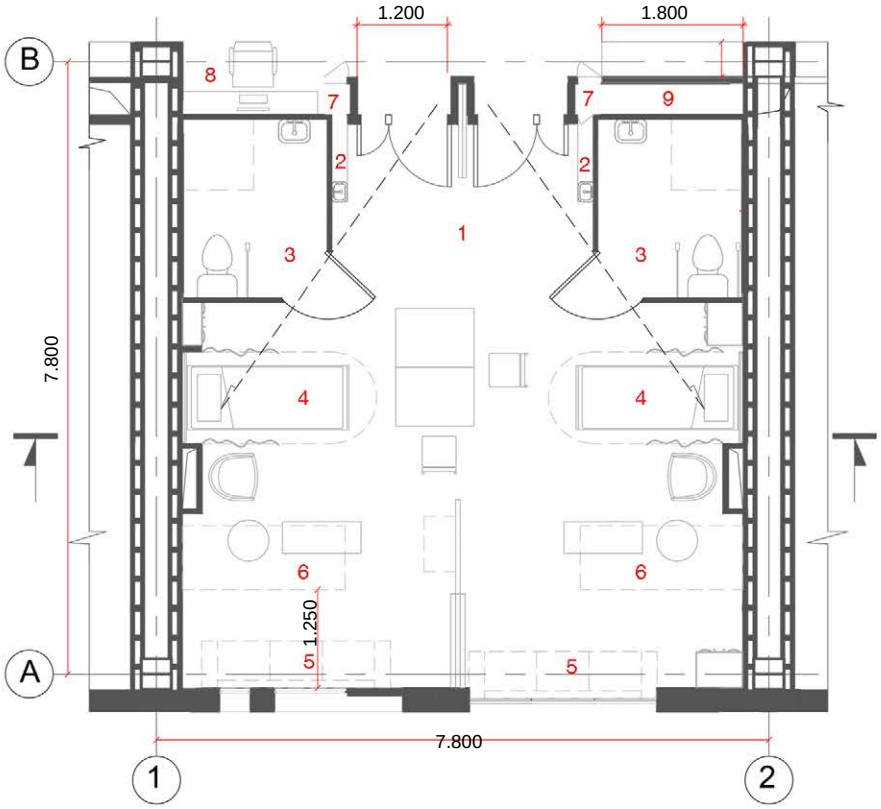


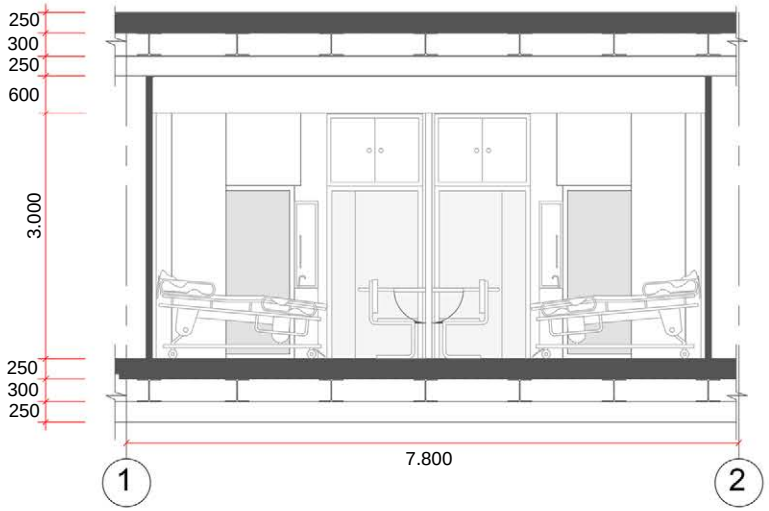
Two individual wards

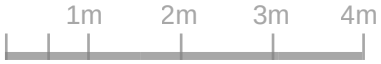
Double-patient ward with movable internal wall

1. Gateway
2. Sink
3. Bathroom
4. Patient bed
5. Sofa
6. Visitor's bed
7. Capboard for medication
8. Nurse station
9. Technical shaft

S of the ward: 44 m2
S of the bathtoom: 4.1 m2





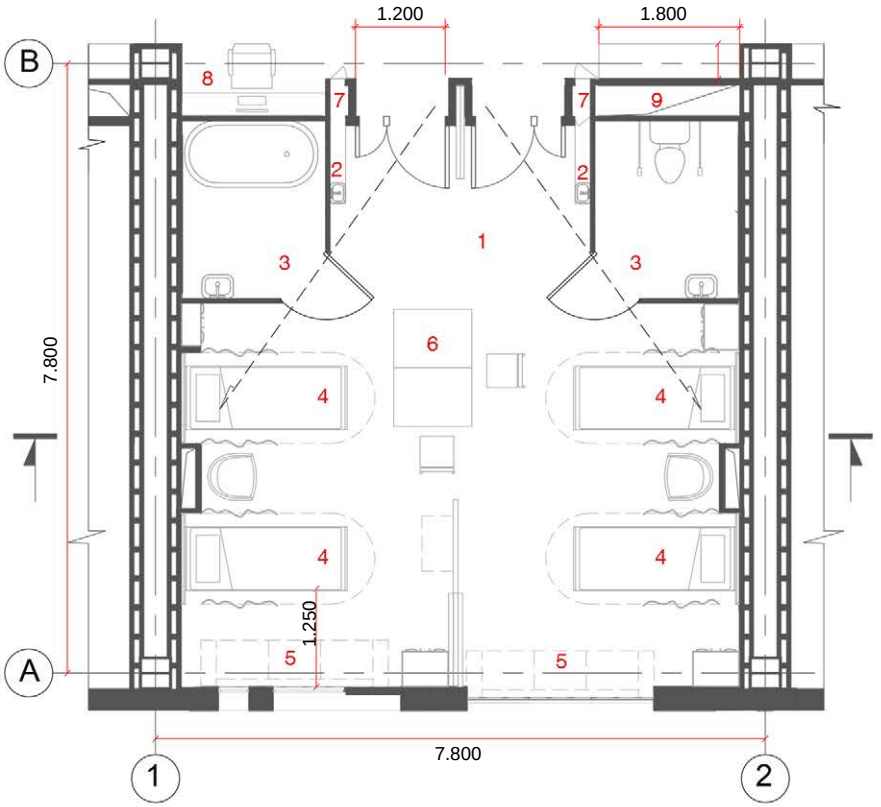


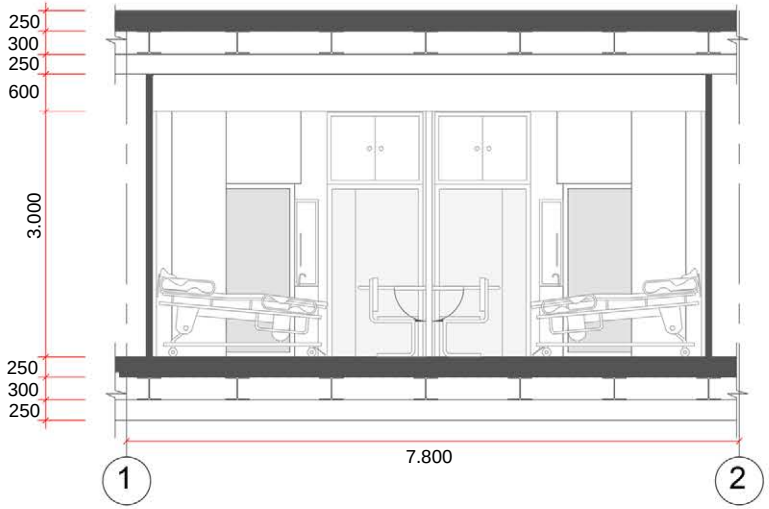
Double-patient ward with movable internal wall

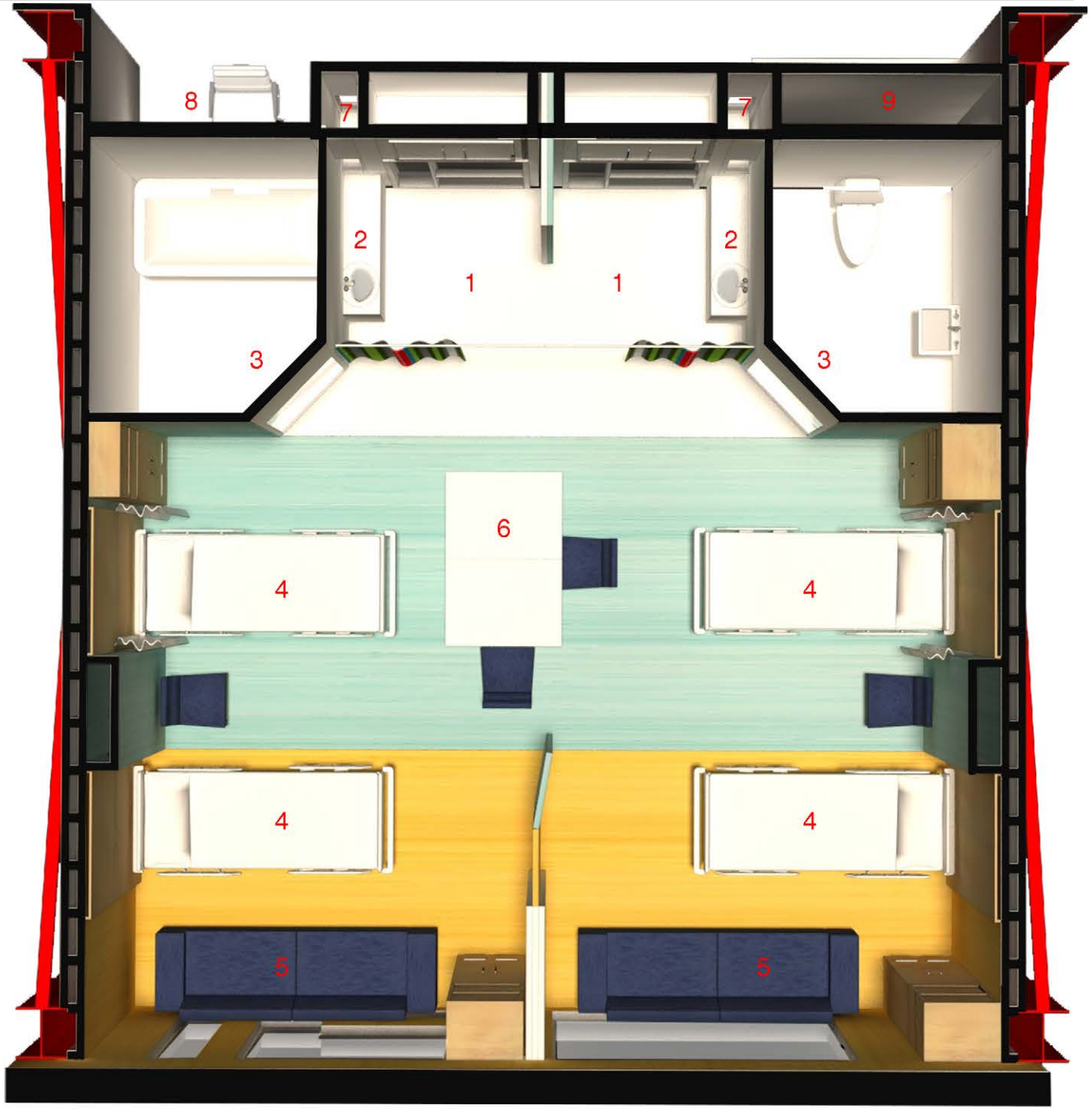
Four-patient ward with movable internal wall

1. Gateway
2. Sink
3. Bathroom
4. Patient bed
5. Sofa
6. Common foldable table
7. Capboard for medication
8. Nurse station
9. Technical shaft

S of the ward: 44 m2
S of the bathtoom: 4.1 m2





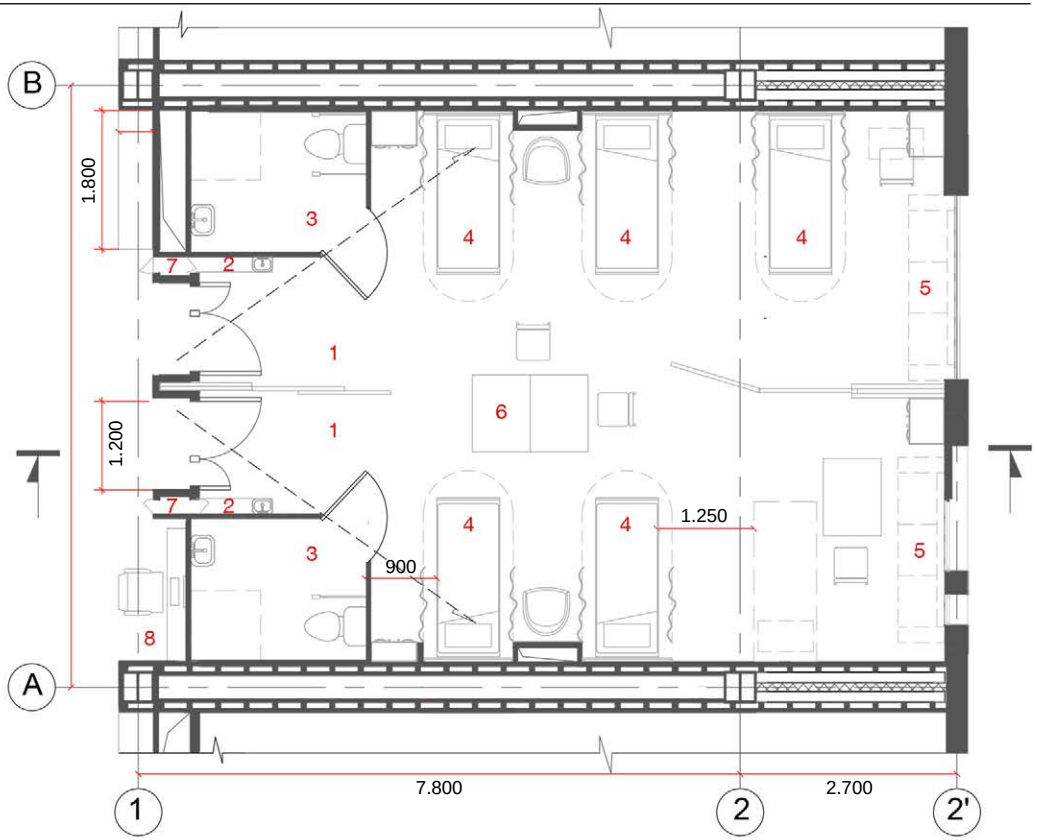


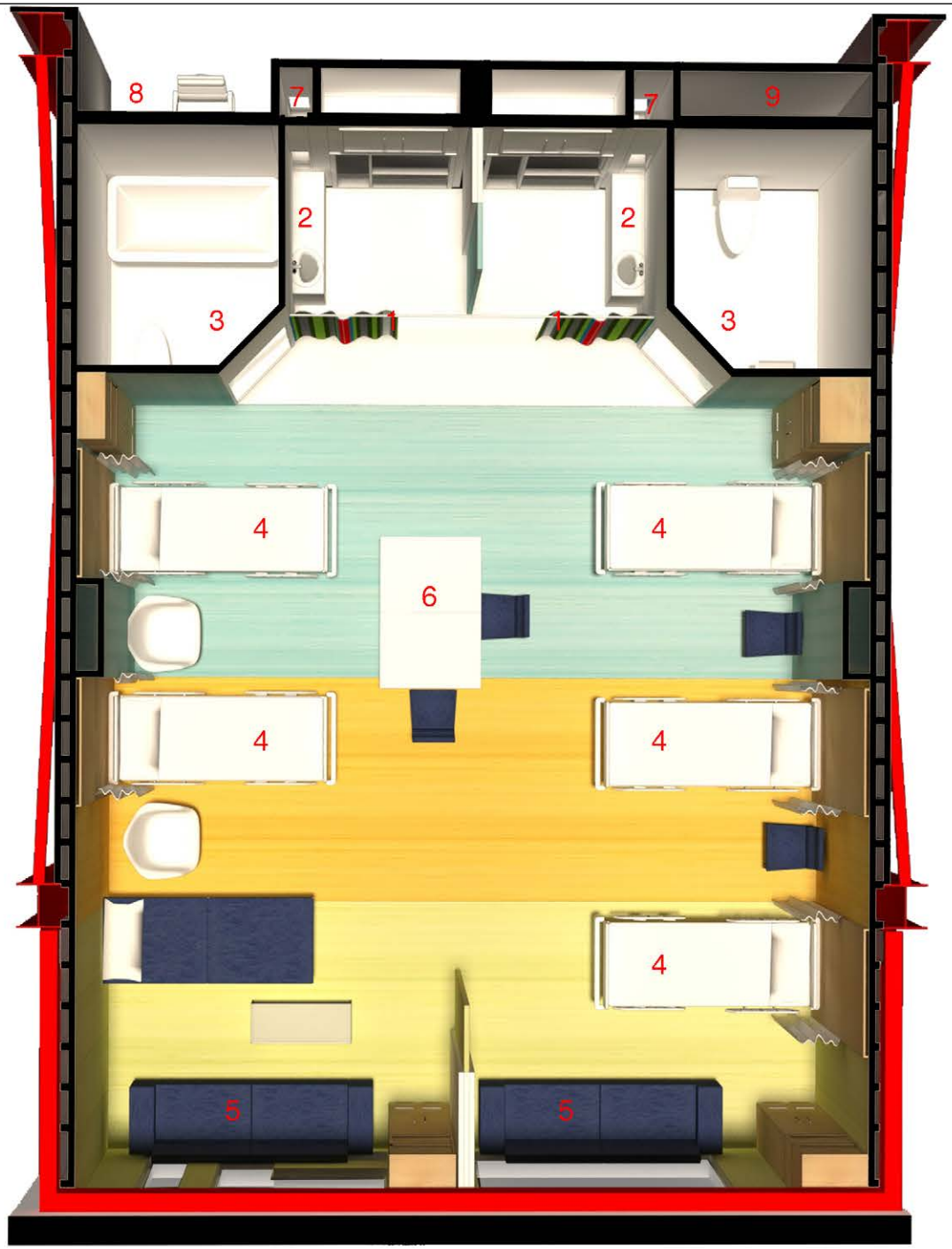
Four-patient ward with movable internal wall

Five-patient ward with cantilevered part of module for increasing surface area of the ward

1. Gateway
2. Sink
3. Bathroom
4. Patient bed
5. Sofa
6. Common foldable table
7. Capboard for medication
8. Nurse station
9. Technical shaft

S of the ward: 61 m2
S of the bathtoom: 4.1 m2



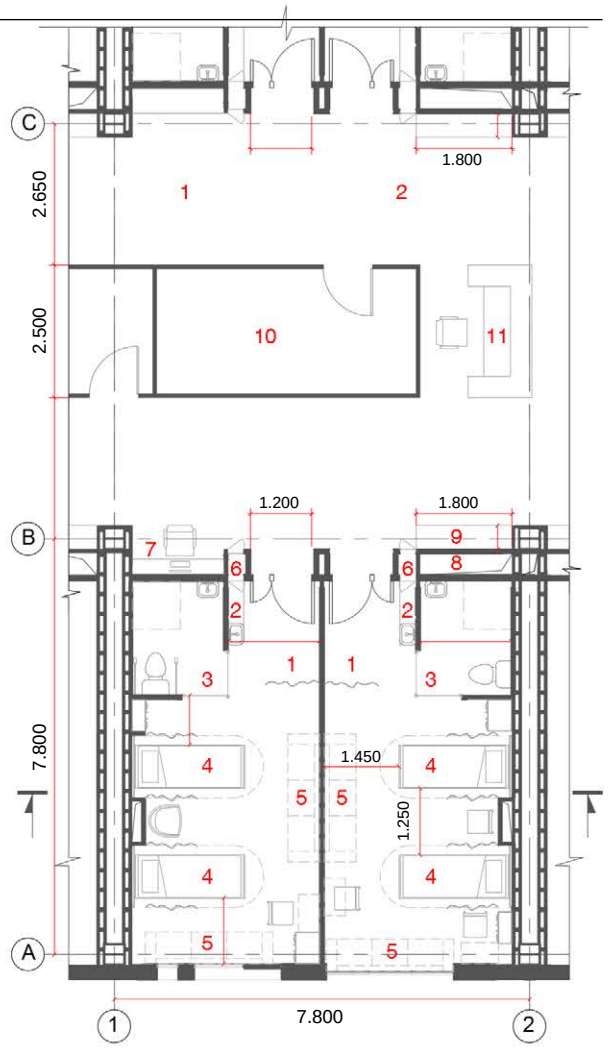


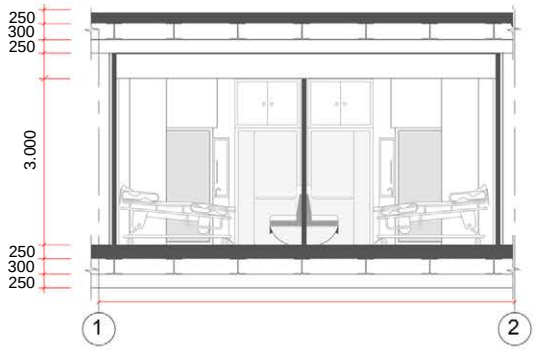
Five-patient ward with movable internal wall and cantilevered part of module for increasing the surface area of the ward

Two 2-patient wards with personnel support facilities in corridor which are also part of prefabricated module

1. Gateway
2. Sink
3. Bathroom
4. Patient bed
5. Sofa
6. Capboard for medication
7. Nurse station
8. Technical shaft
9. Corridor sofa
10. Personnel facilities
11. Central nurse station

S of the ward: 22 m2
S of the bathtoom: 4.1 m2



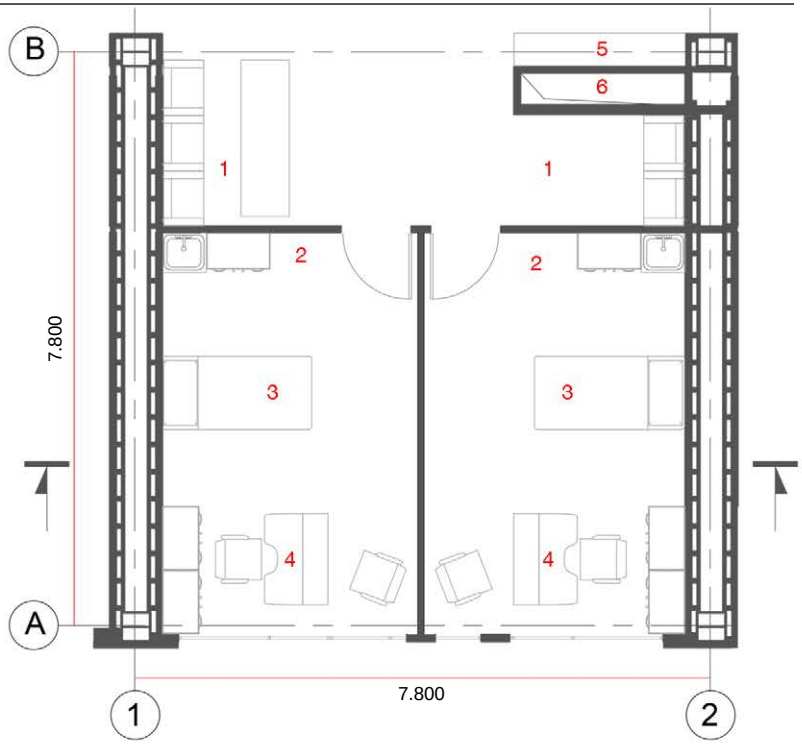


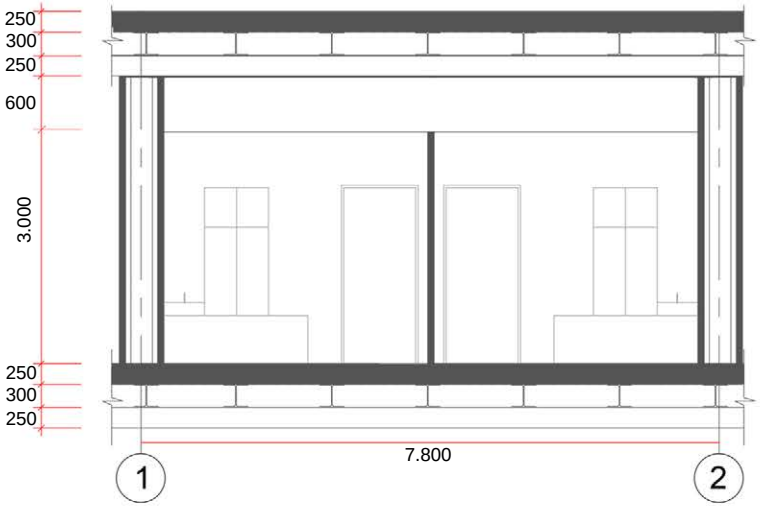
Two 2-patient wards with personnel support facilities in corridor which are also part of prefabricated module

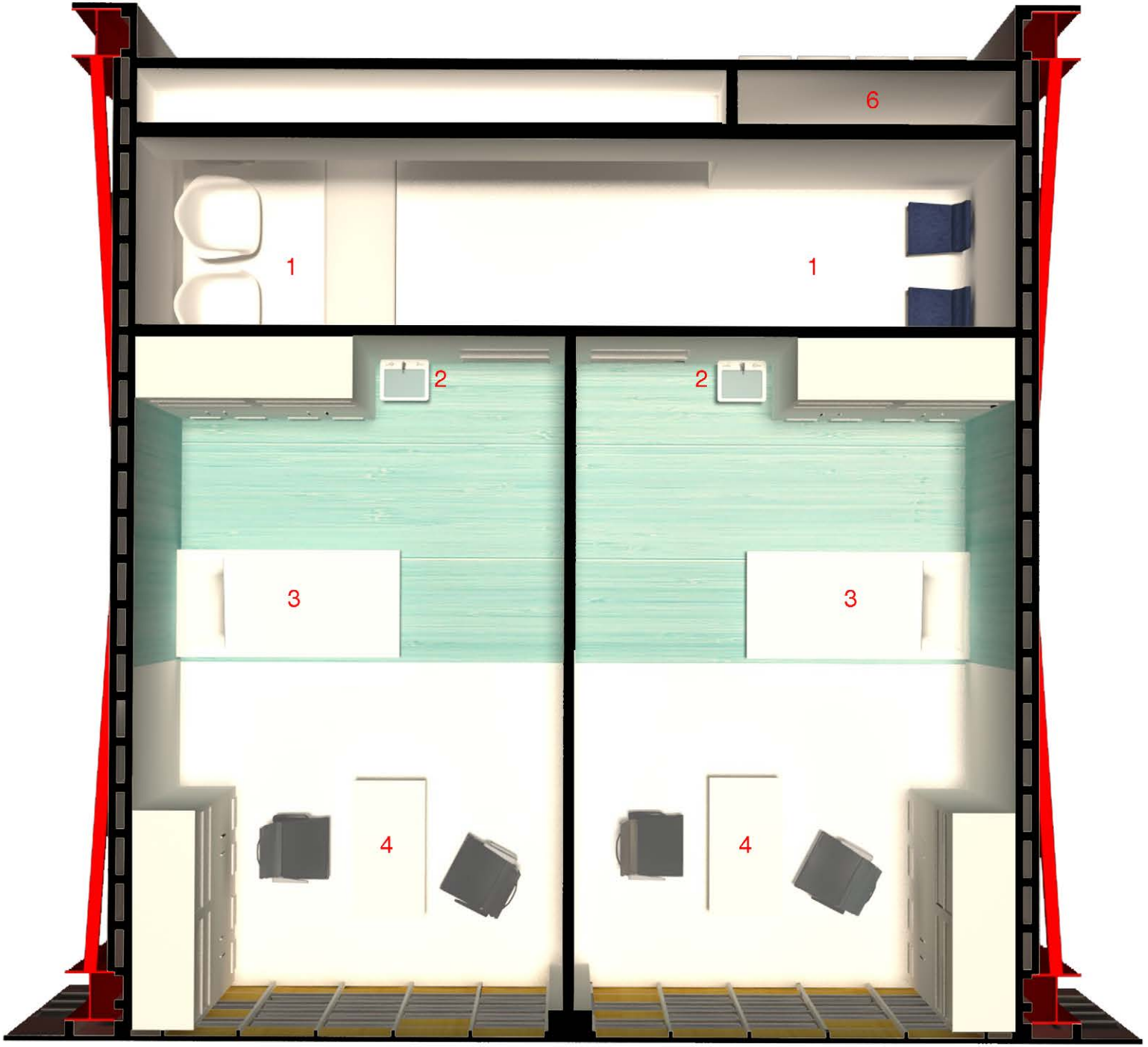
Consultancy office of practitioner with patient waiting area

1. Patient waiting area
2. Sink
3. Patient bed
4. Practitioner's table
5. Corridor sofa
6. Technical shaft

S of the cabinet: 19 m2





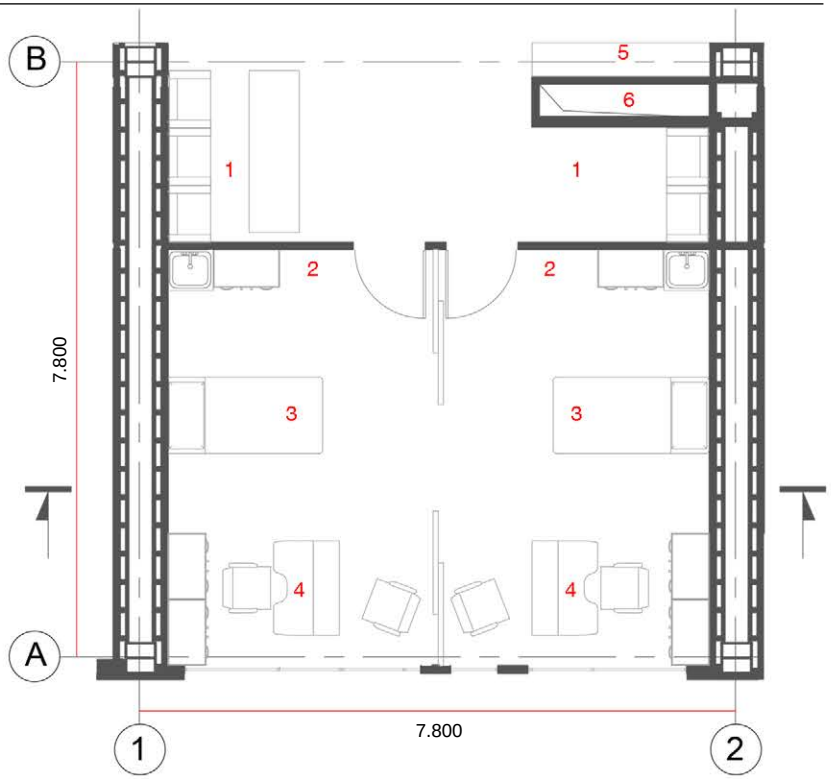


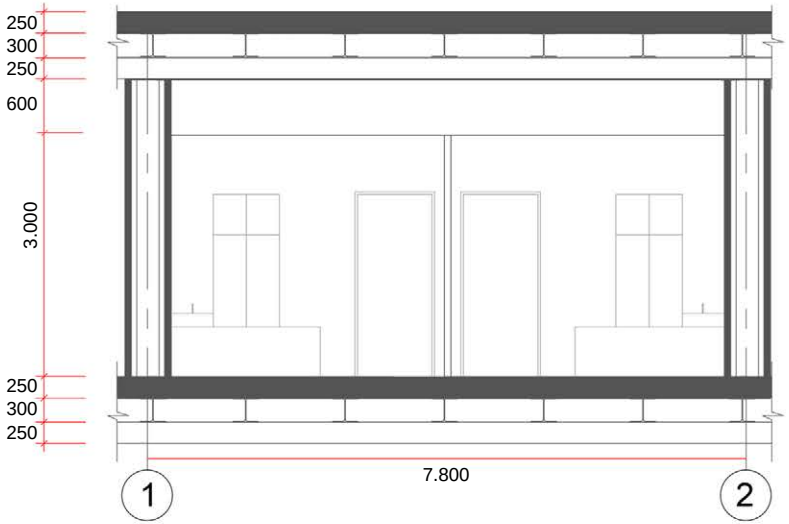
Consultancy office of practitioner with patient waiting area

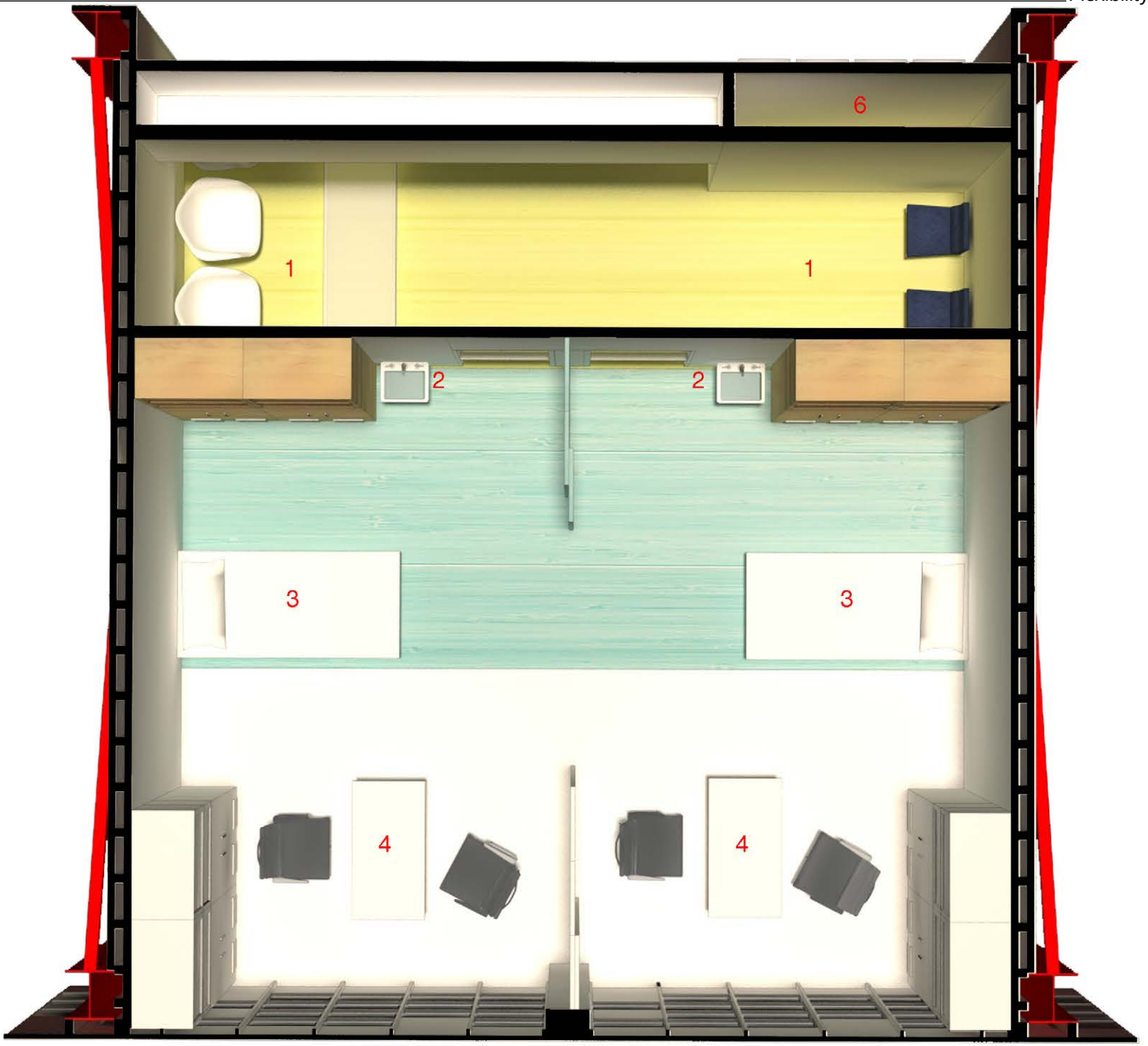
Consultancy office of practitioner with movable internal wall

1. Patient waiting area
2. Sink
3. Patient bed
4. Practitioner's table
5. Corridor sofa
6. Technical shaft

S of the cabinet: 38 m2





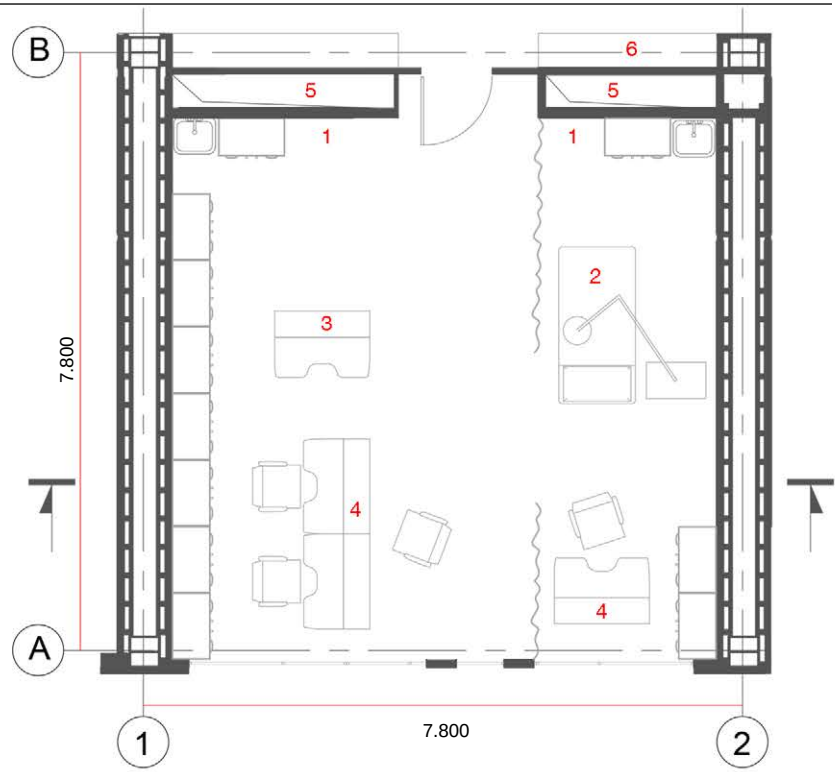


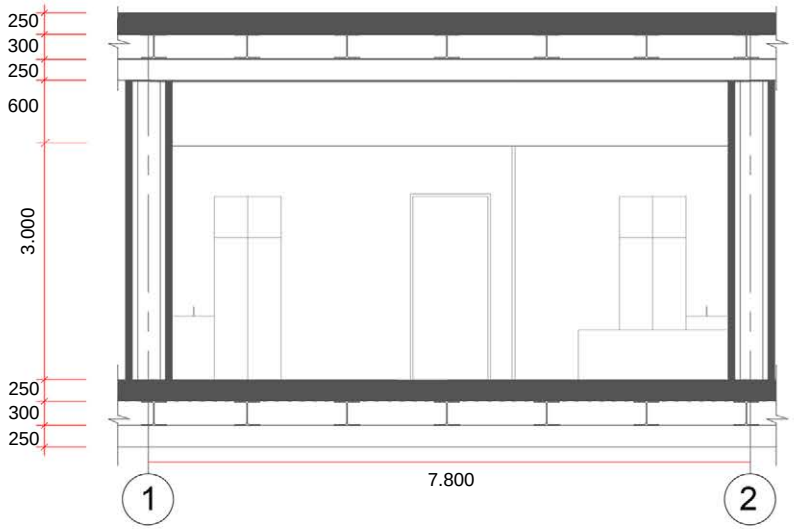
Consultancy office of practitioner with movable internal wall

Consultancy office of practitioner

1. Sink
2. Patient bed
3. Table
4. Practitioner’s table
5. Technical shaft

S of the cabinet: 50 m2



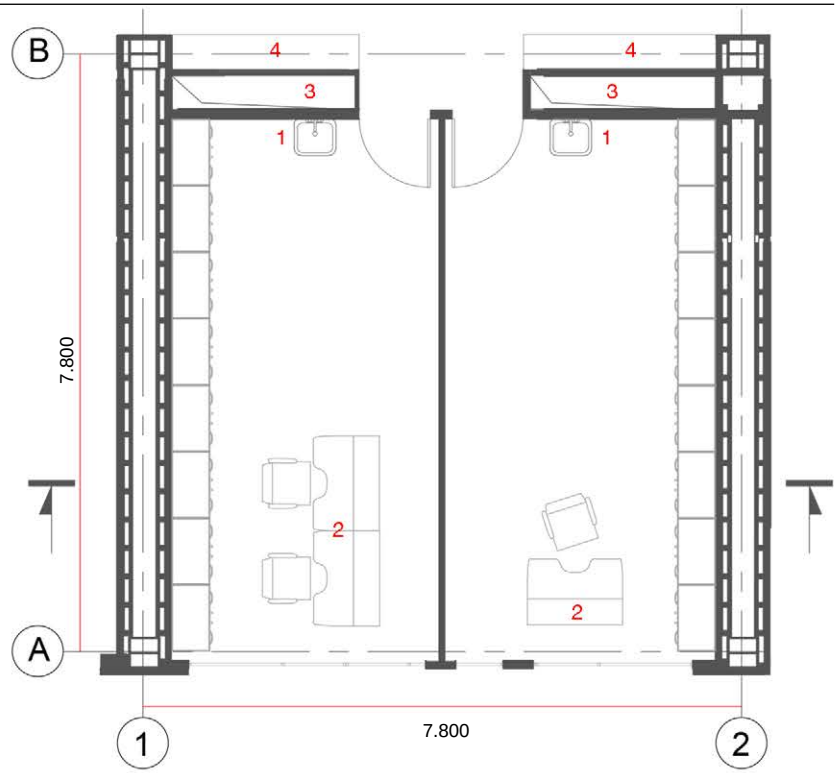


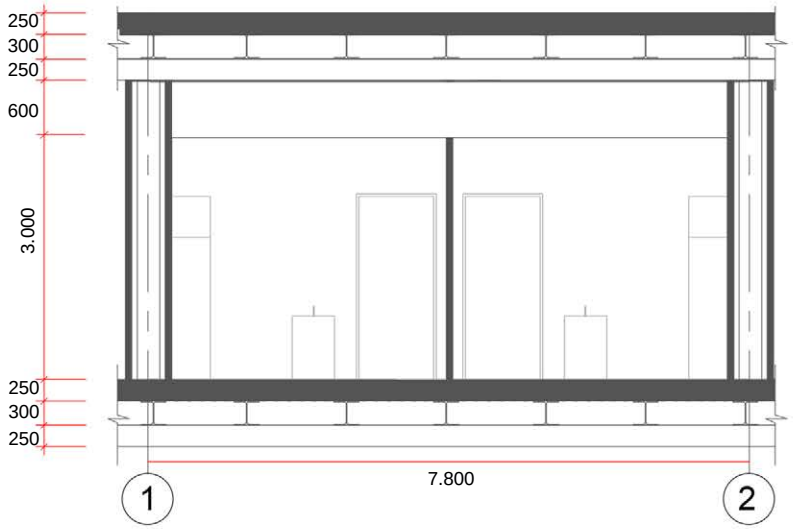
Consultancy office of practitioner

Consultancy office of practitioner

1. Sink
2. Office table
3. Table
4. Technical shaft
5. Corridor sofa

S of the cabinet: 24 m2



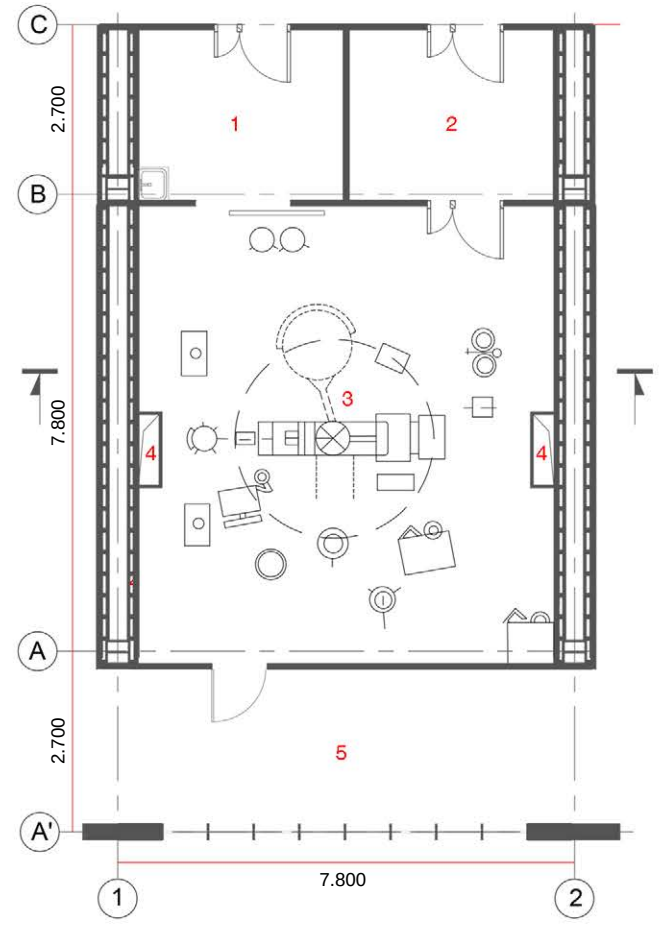


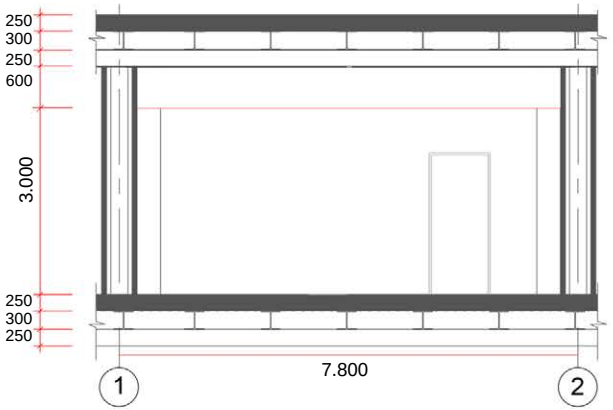
Administrative office

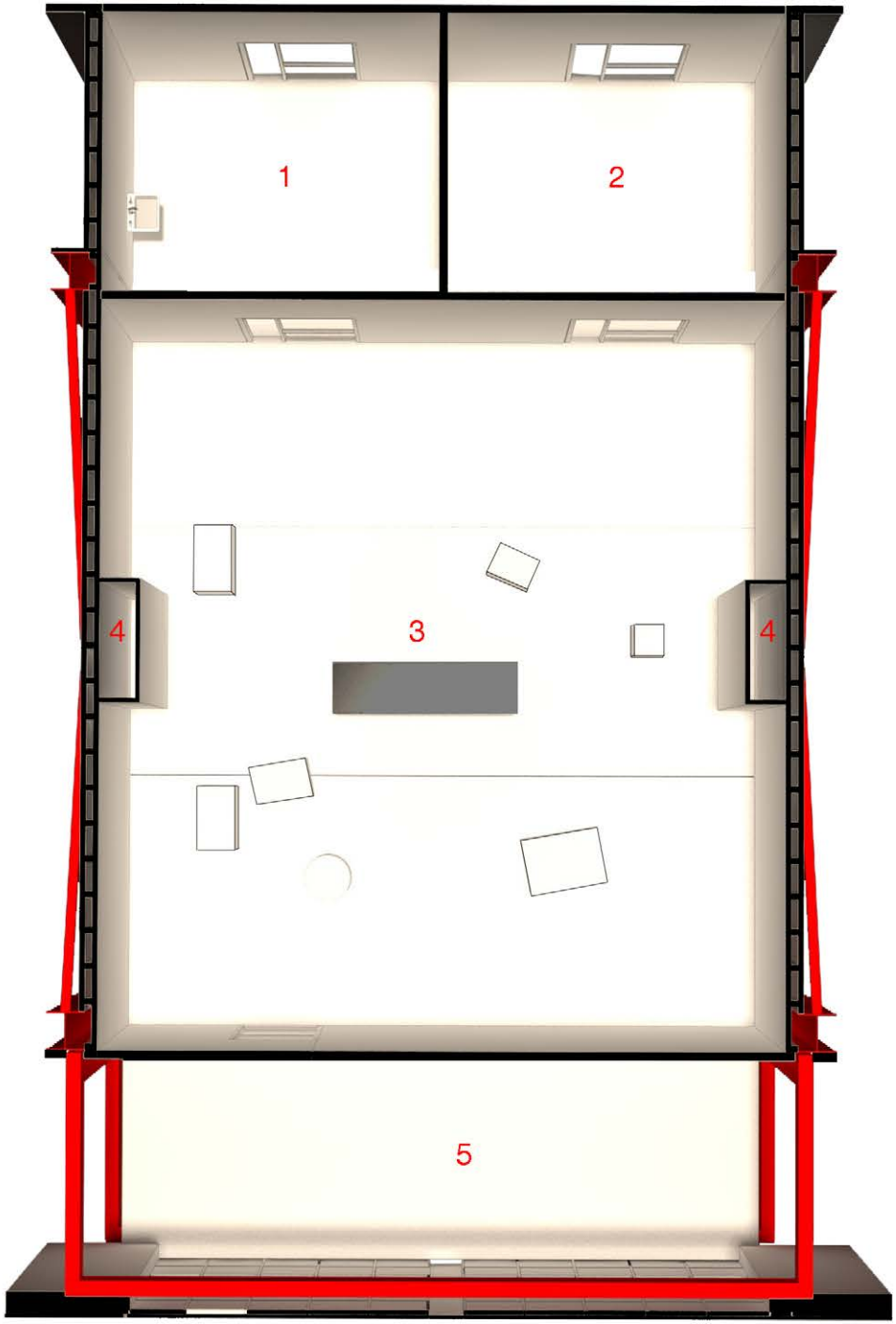
Surgery room

1. Anesthetic room
2. Pre-operative room
3. Surgery table
4. Technical shaft
5. Dirty corridor

S of surgery room: 55 m2





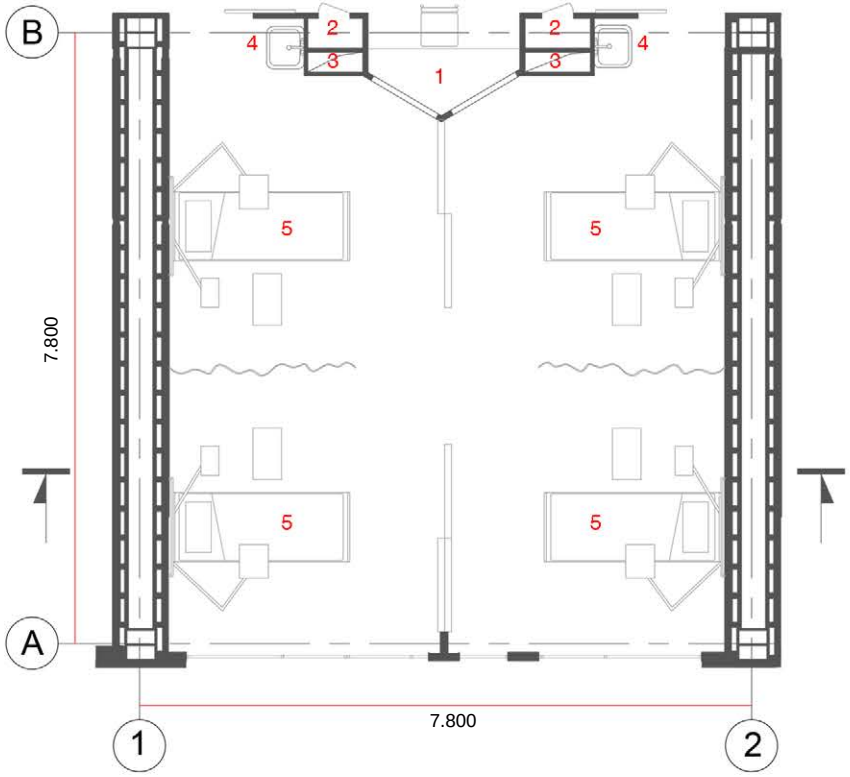


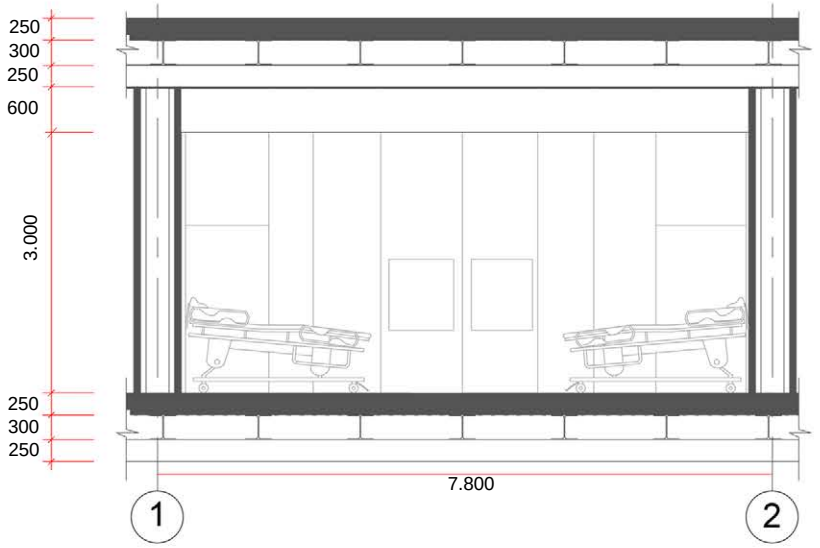
Surgery room

Intensive care unit

1. Nurse station
2. Personnel storage place
3. Technical shaft
4. Sink
5. Patient bed

S of the unit: 52 m2



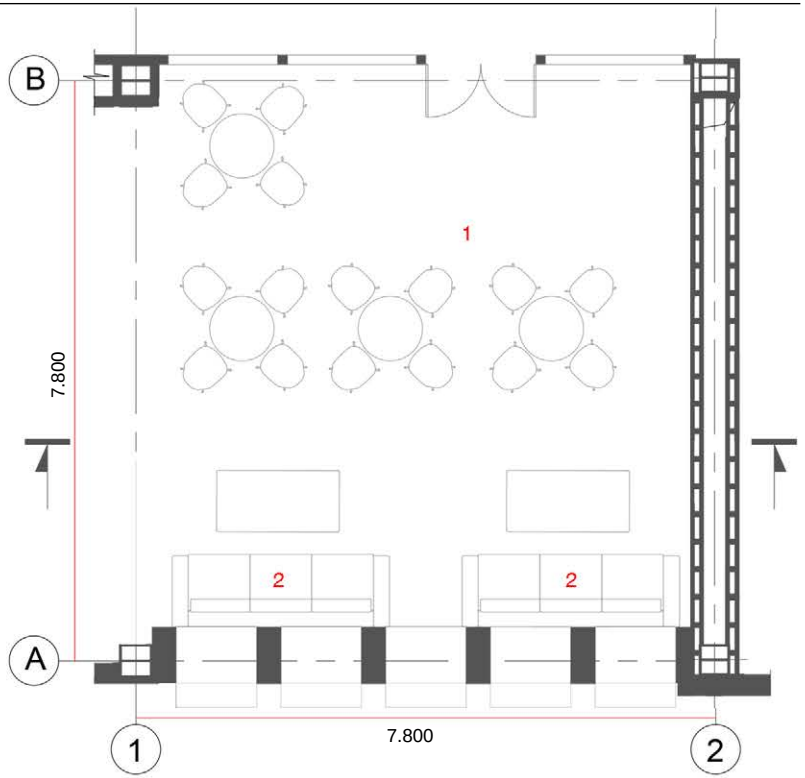


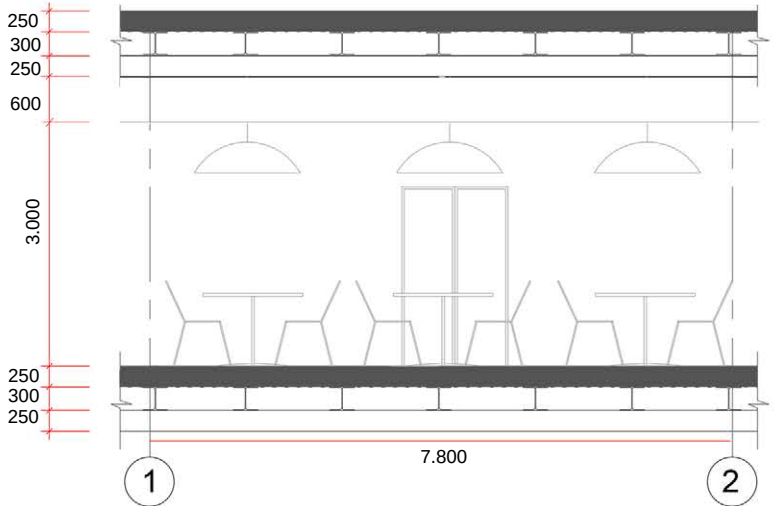
Intensive care unit

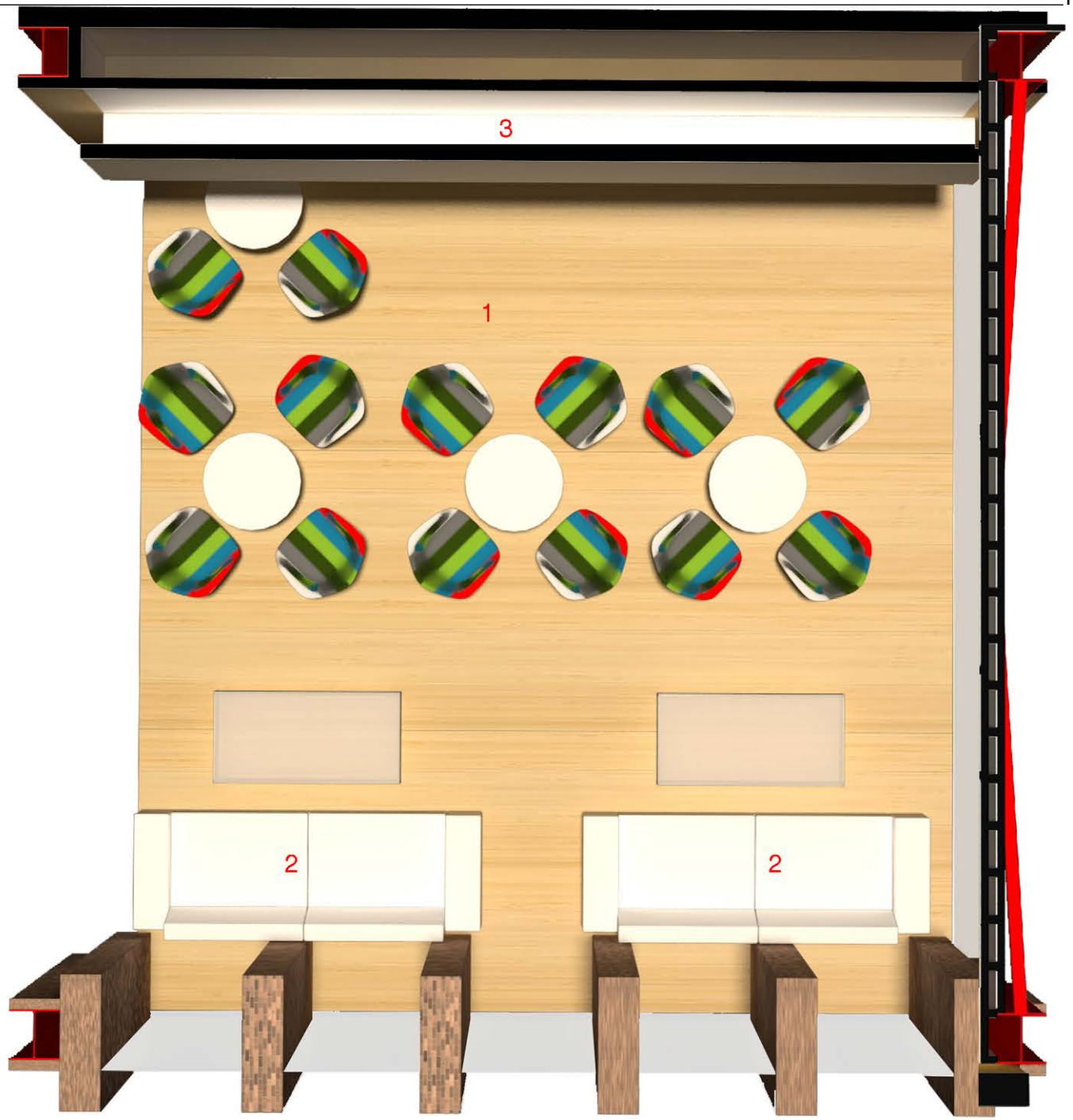
Public space

1. Cafe area
2. Lounge area

S of the unit: 52 m2

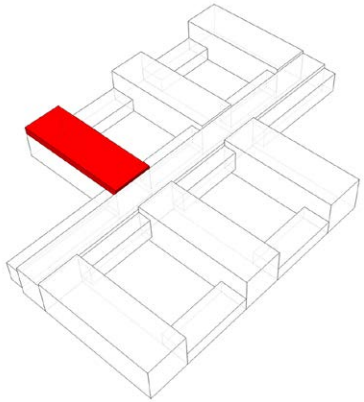




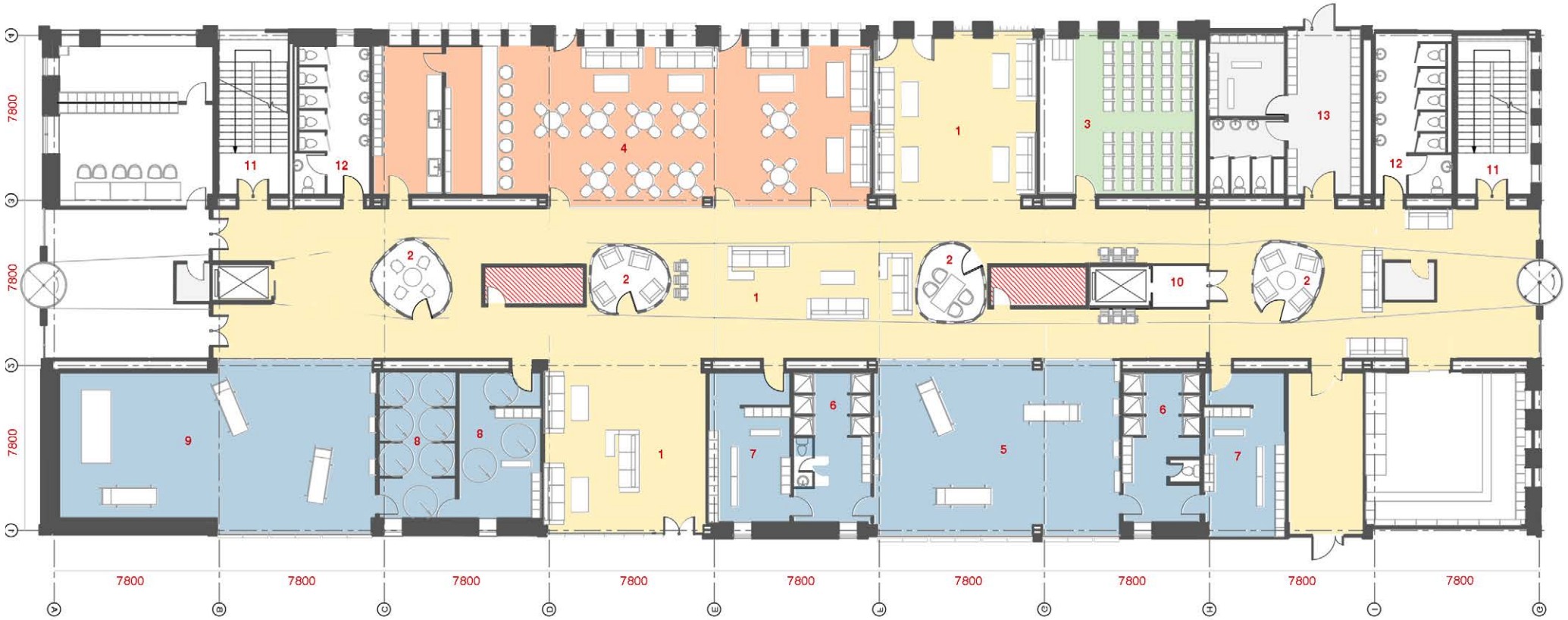


Public space

3.4.
Functional unit. Arranging of different departments within one floor. (constant flexibility)



Healthcare related facilities



Waiting area

Cafe

Sport hall

Conference hall

Main technical shafts

1 waiting area
2 private meeting areas
3 Conference hall
4 cafe
5 sport hall
8 cloak room for disable people
9 sport hall for disable people
10 elevator hall
11 emergency stair
12 toilets
13 personnel support area

Emergency department

1 practitioner room
2 intensive care ward
3 emergency stair
4 toilets
5 common waiting area
6 reception
7 sanitary gateway
8 personnel support area
9 nurse station
10 private meeting space
11 personnel sanitary gateway
12 reception

Surgery block

Clean corridor

Dirty corridor

Surgery room

Main technical shafts

1 surgery room

2 anesthetic room

3 doctor's preparation room

4 dirty coridor

6 office

7 toilets

8 emergency stair

9 elevator hall

10 sanitary gateway

Policlinic department

Waiting area / common space

Practitions rooms

Personnel support area

Main technical shafts

1 practitioner rooms

2 private waiting areas for each room

3 Personnel support area

4 private meeting areas

5 main waiting area

6 personnel cloak room

7 toilets

8 emergency stair

9 elevator hall

10 sanitary gateway

Ward floor with support facilities in corridor

In-patient common space

Wards

Personnel zones

Main technical shafts

1 Individual ward

2 two patient ward

3 nurse central station

3' nurse local station

4 personnel technical area

6 hall

7 toilets

8 emergency stair

9 out-patient common space

10 sanitary gateway

Ward floor with support facilities situated in sectional way

In-patient common space

Wards

Personnel zones

Main technical shafts

1 Individual ward

2 two patient ward

3 nurse central station

3' nurse local station

4 personnel technical area

6 elevator hall

7 toilets

8 emergency stair

9 out-patient common space

10 sanitary gateway

Administrative block

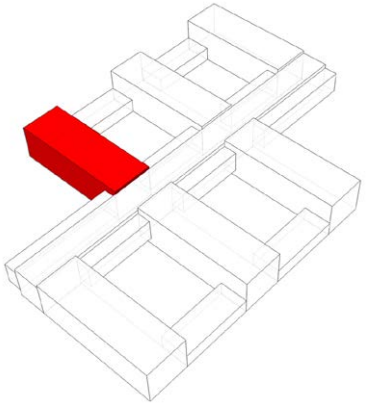
office

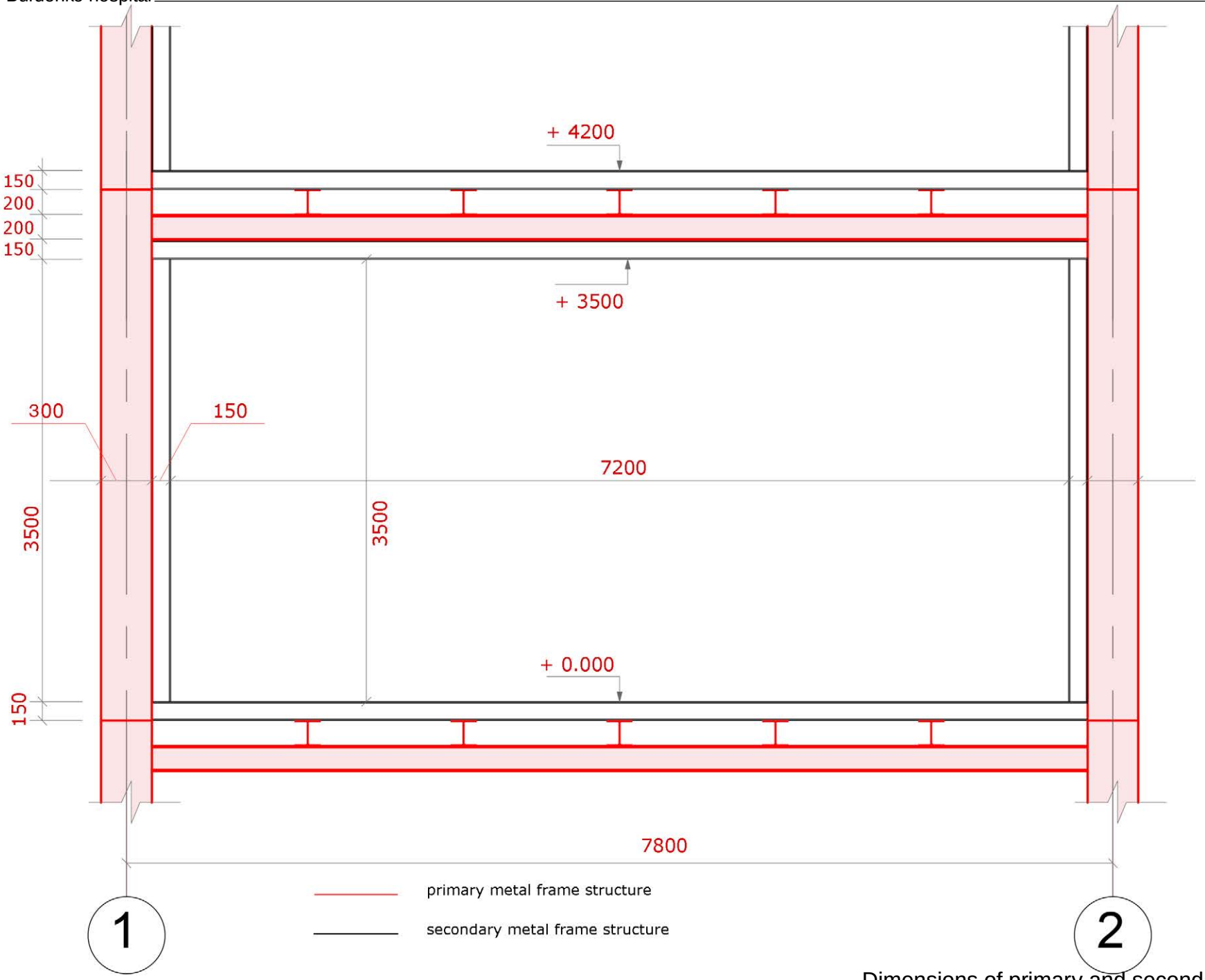
1 office

2 common space

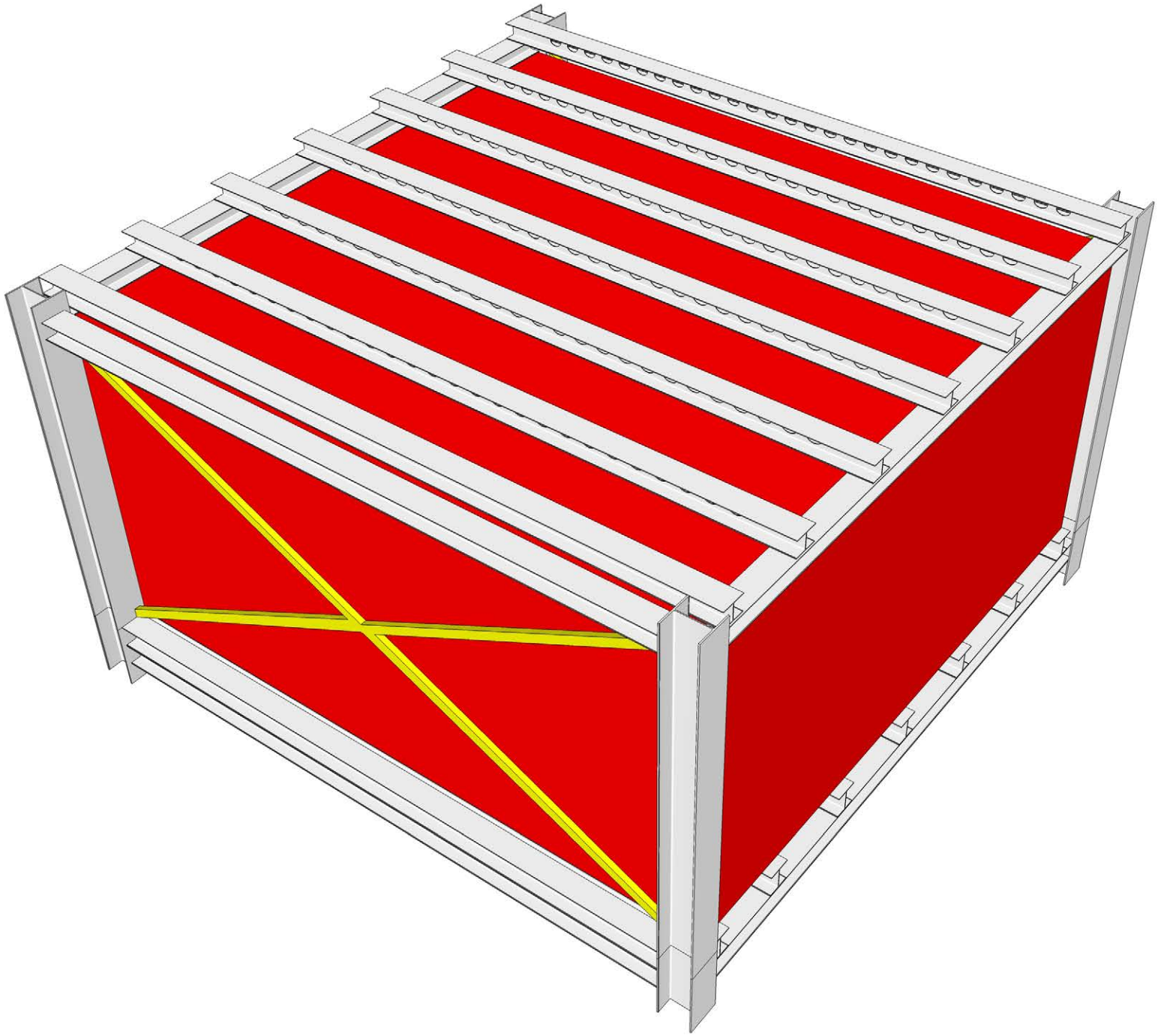
3 emergency stair

3.5
Building. Standard block as universal part of hospital complex

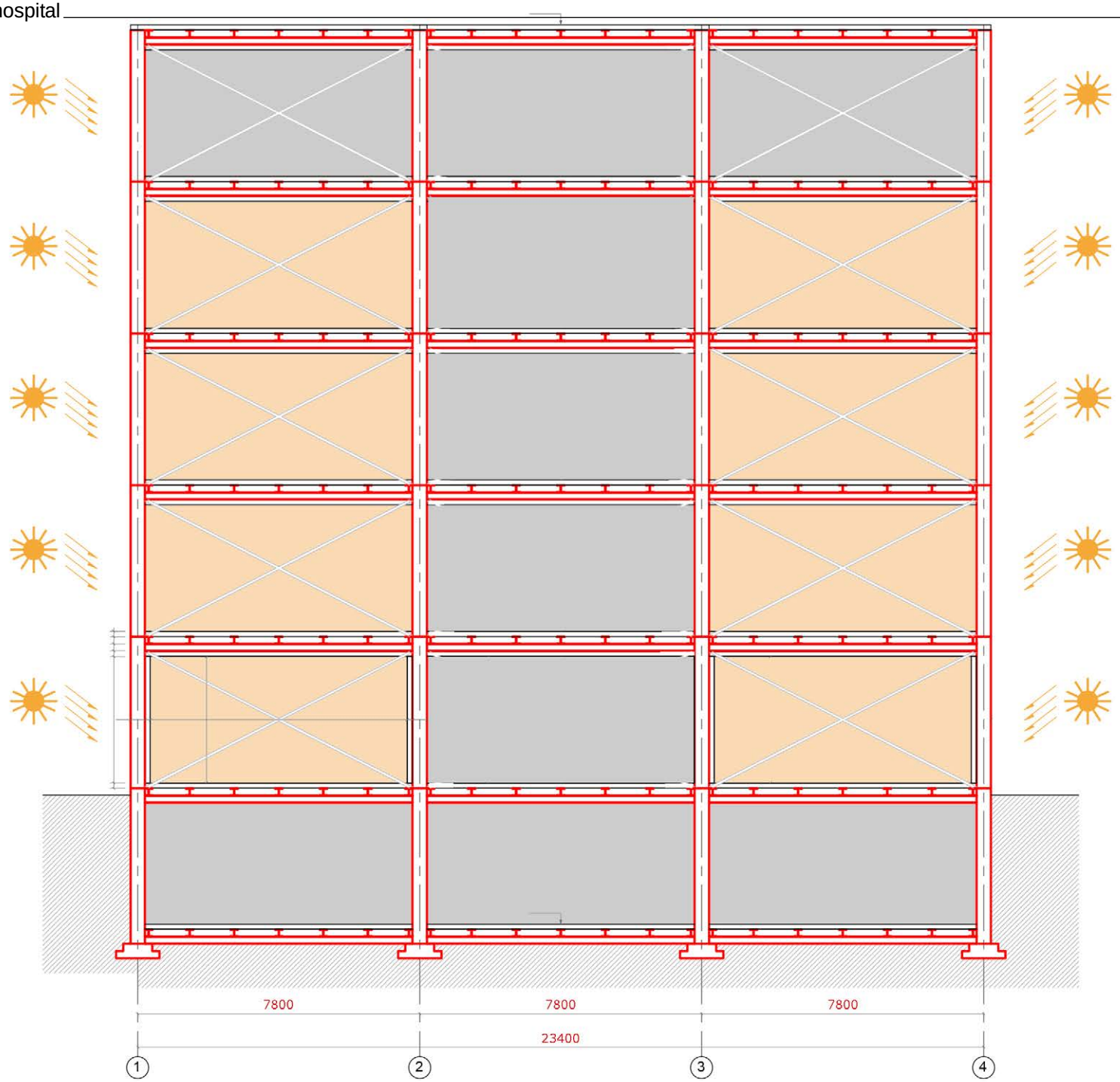




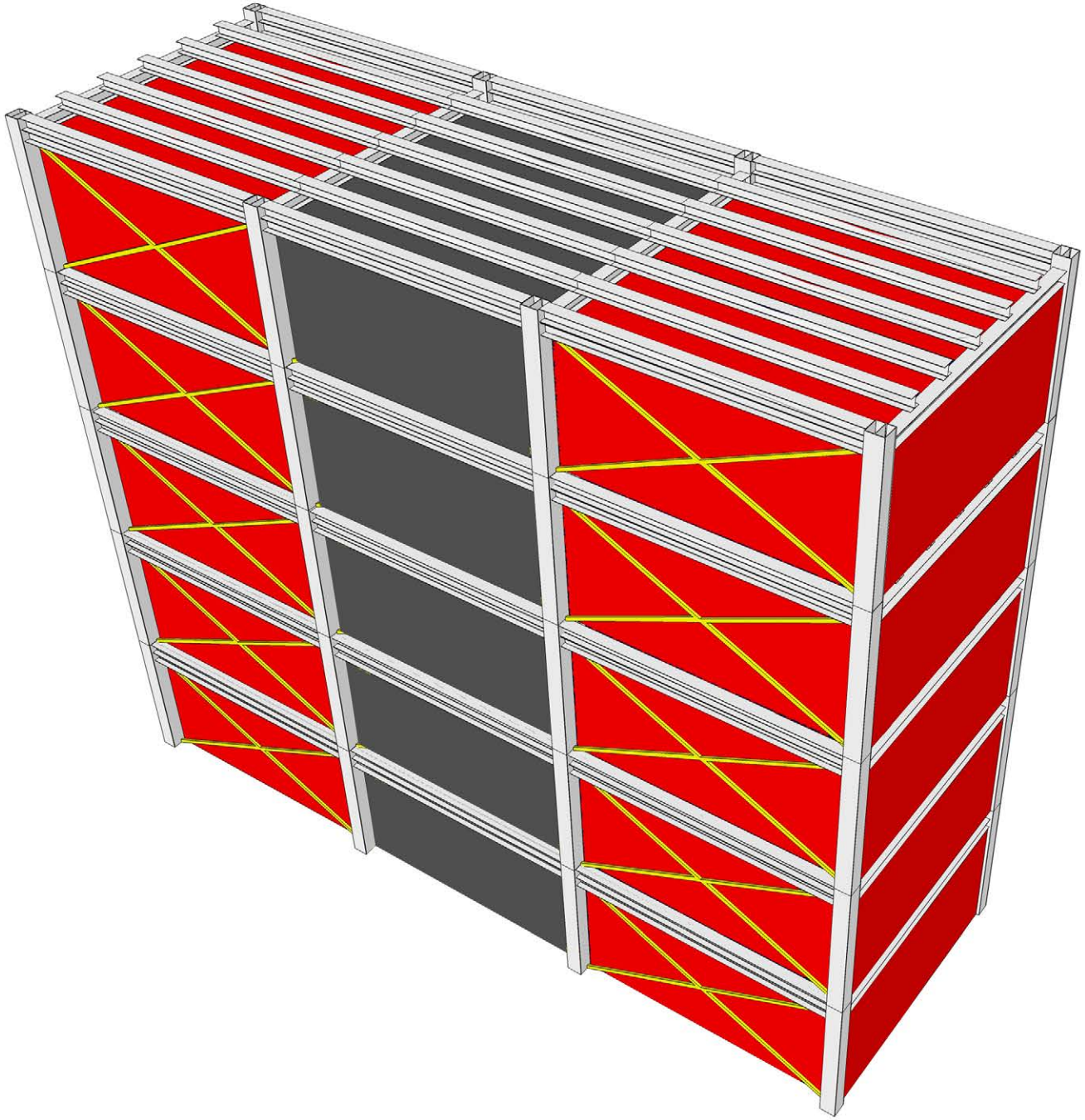
Dimensions of primary and secondary structure



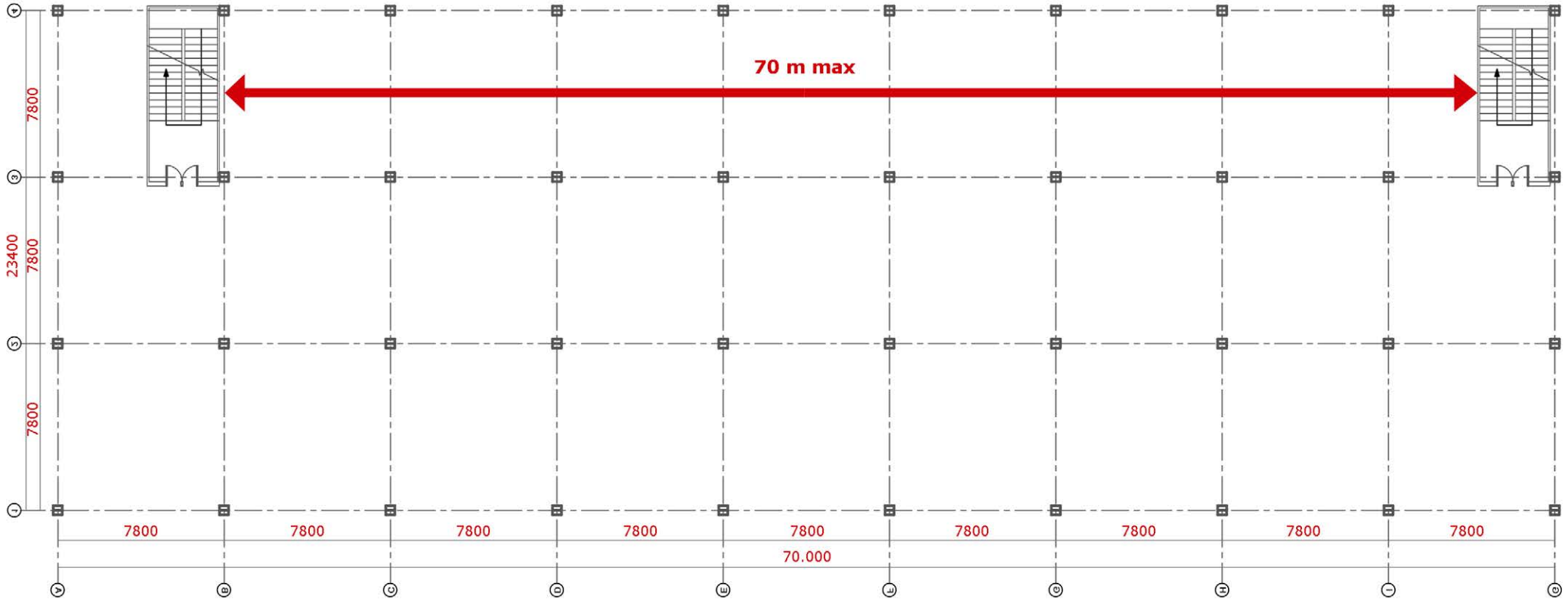
Universal module inside primary structure



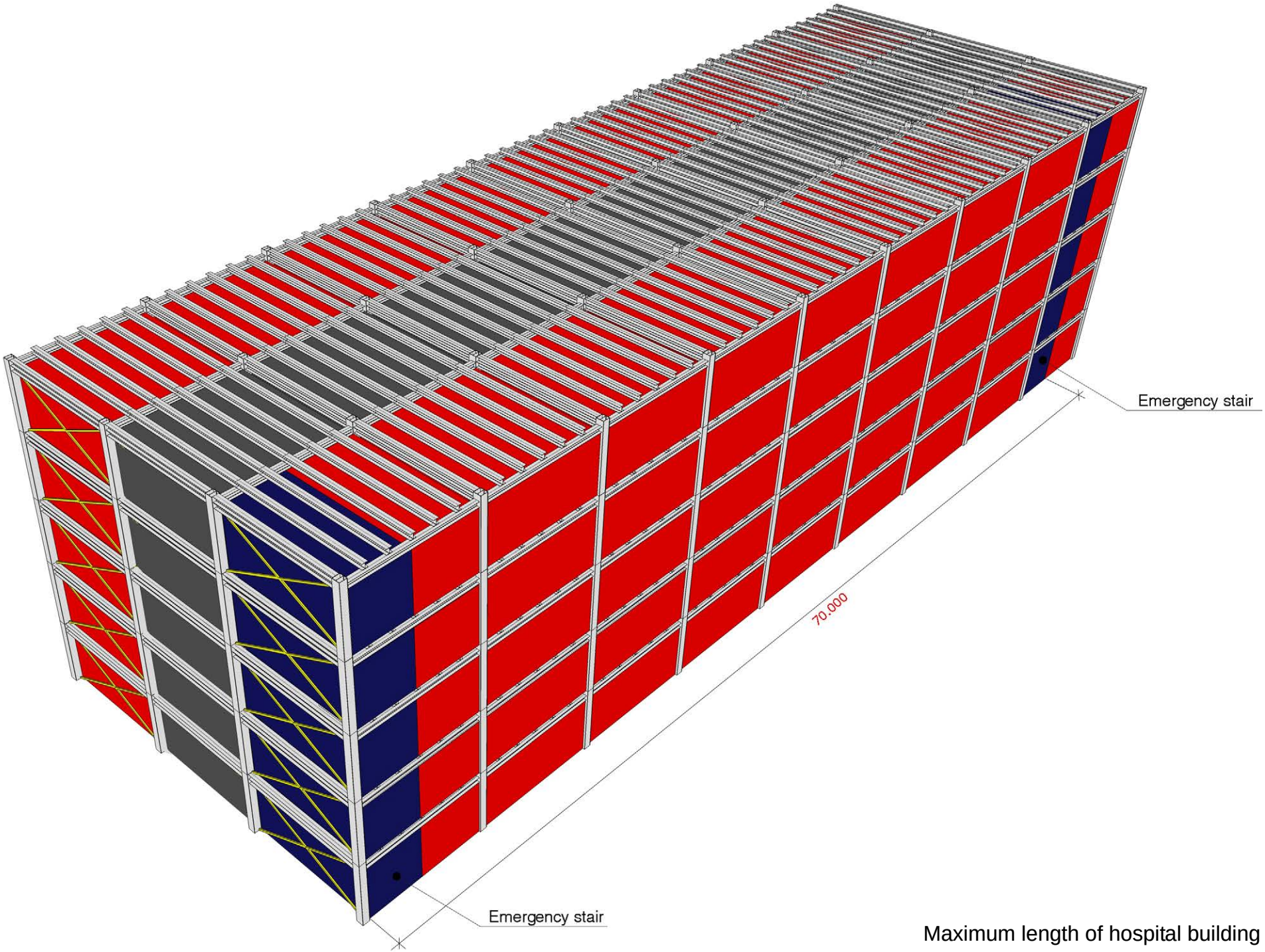
Three-part section



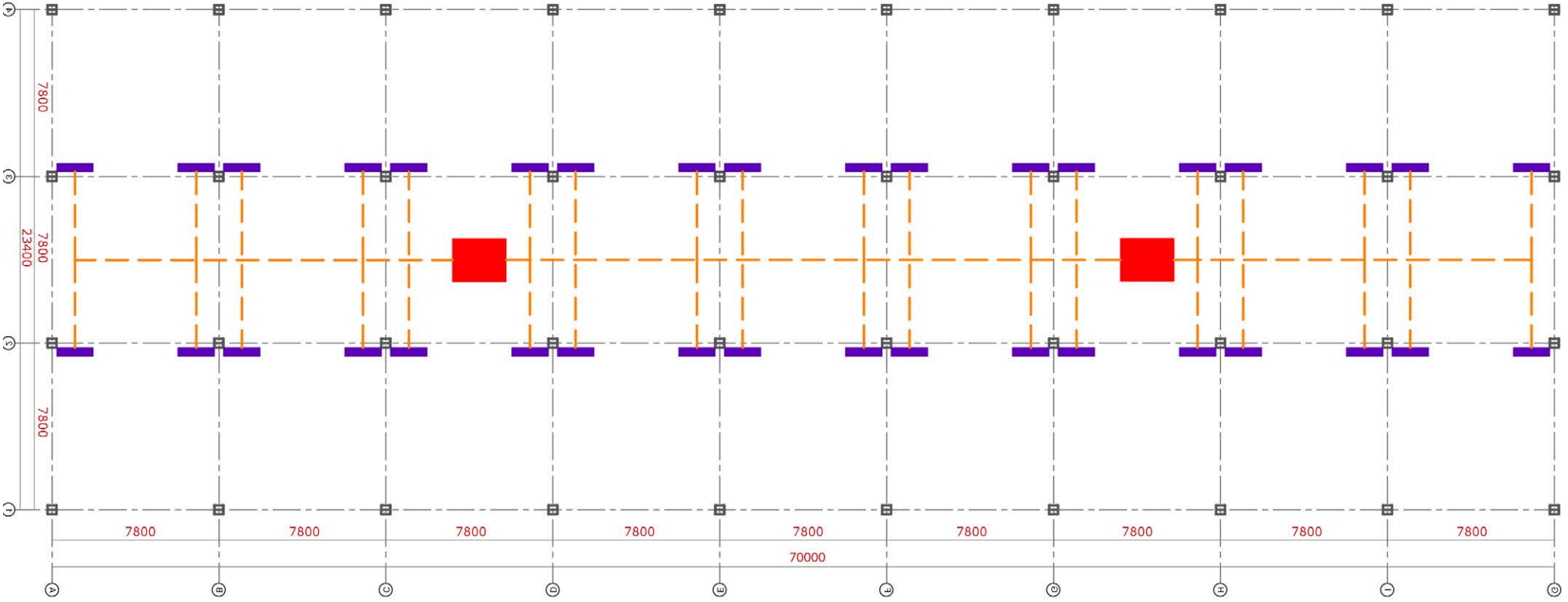
Three-part section



Maximum length of hospital building



Maximum length of hospital building

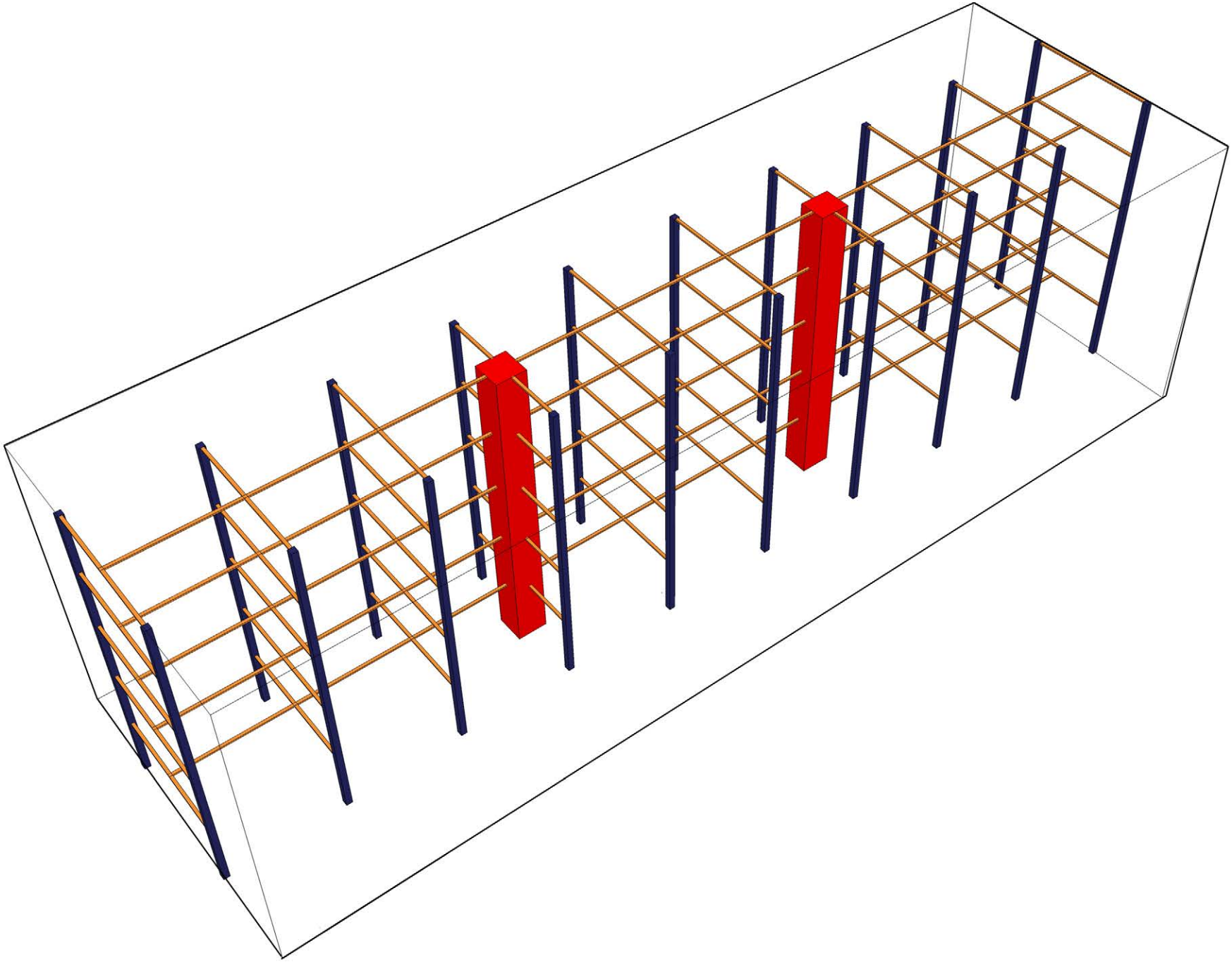


2 main shafts for vertical technological installations

Local installations of vertical shafts

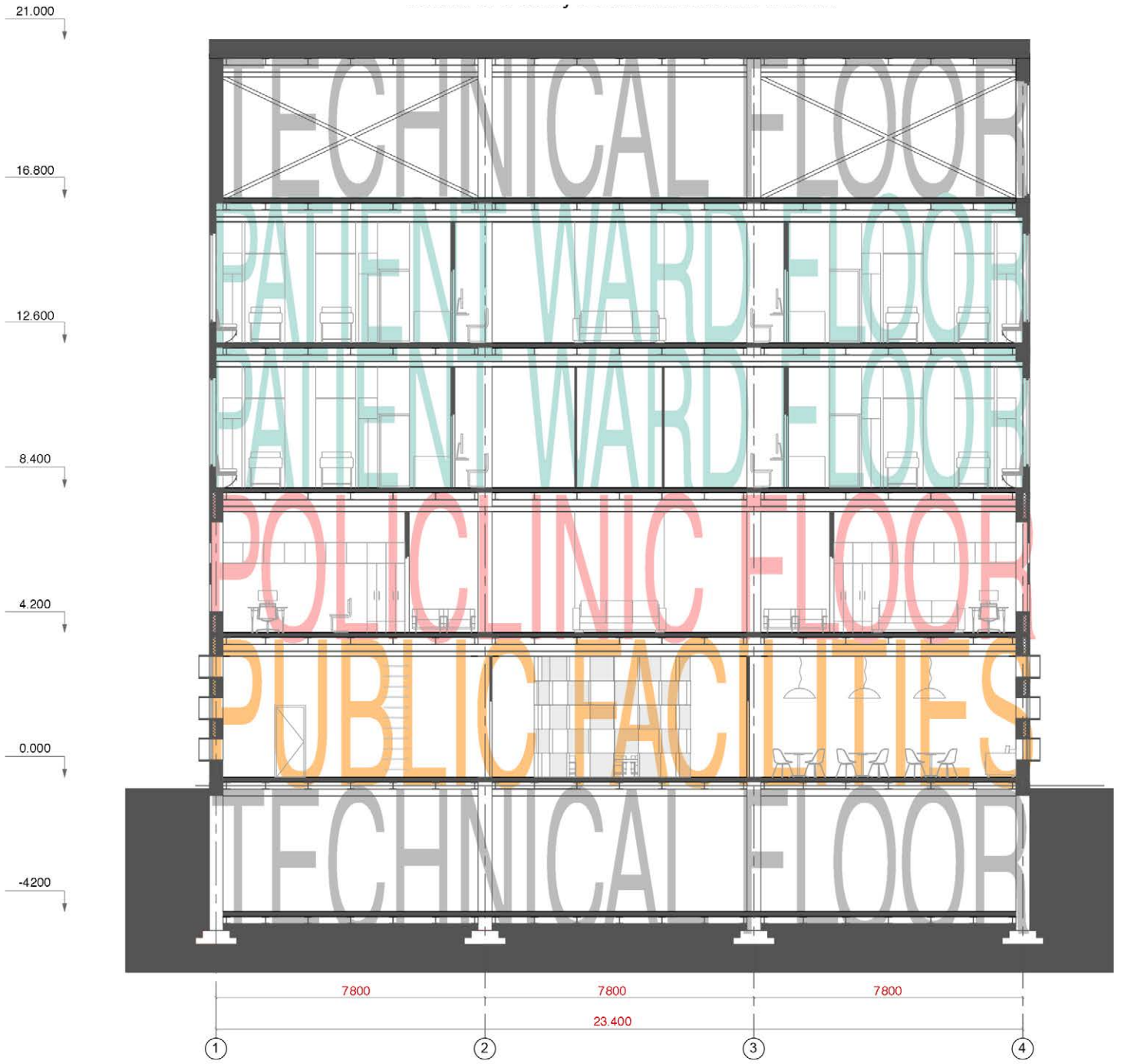
Horrizontal technical connections

Spread of technical communications within hospital building

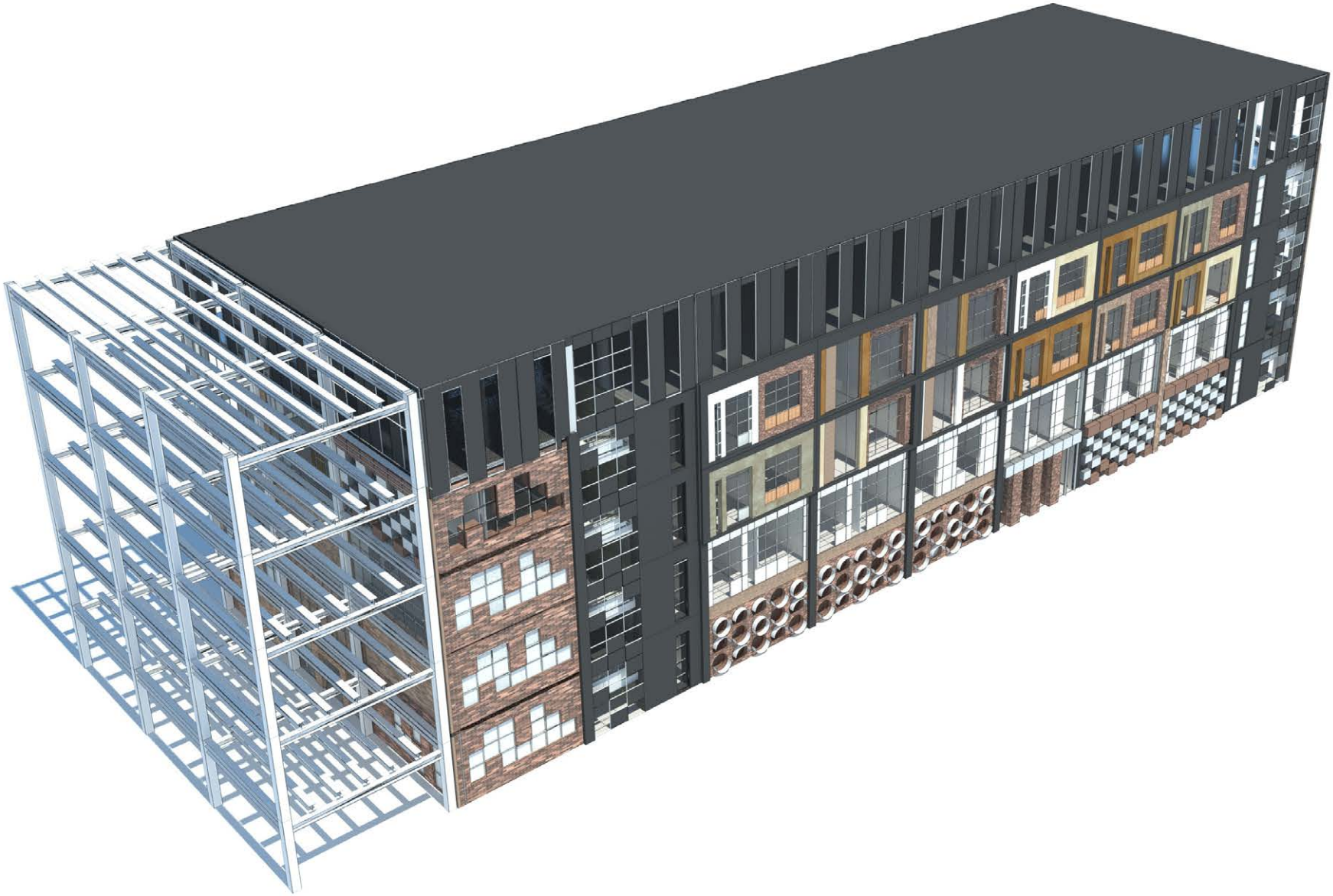


Spread of technical communications within hospital building

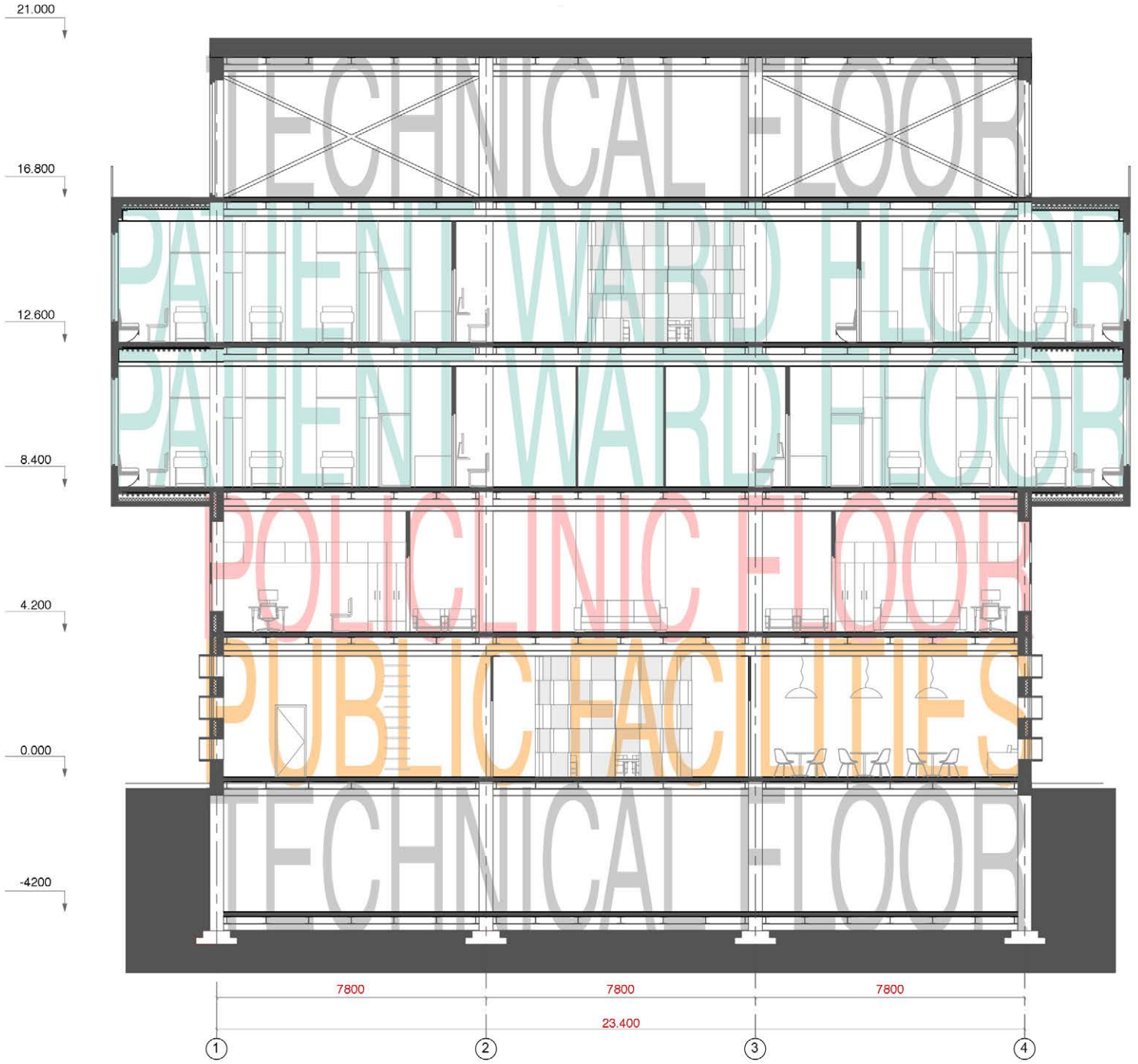
3.6.
Variable flexibility of standard block



Standard 5-storey block with possibility to increase its length

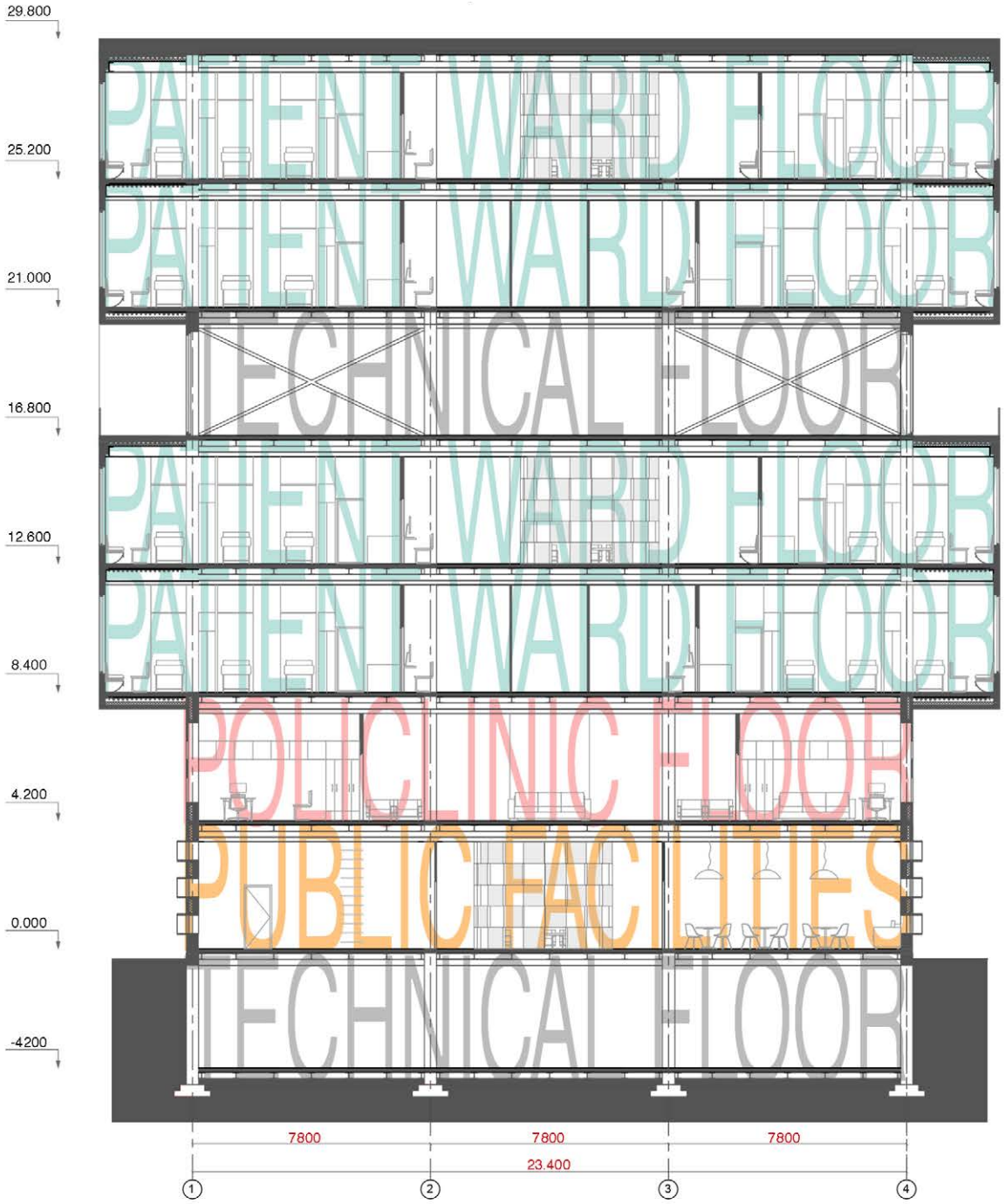


Standard 5-storey block with possibility to increase its length

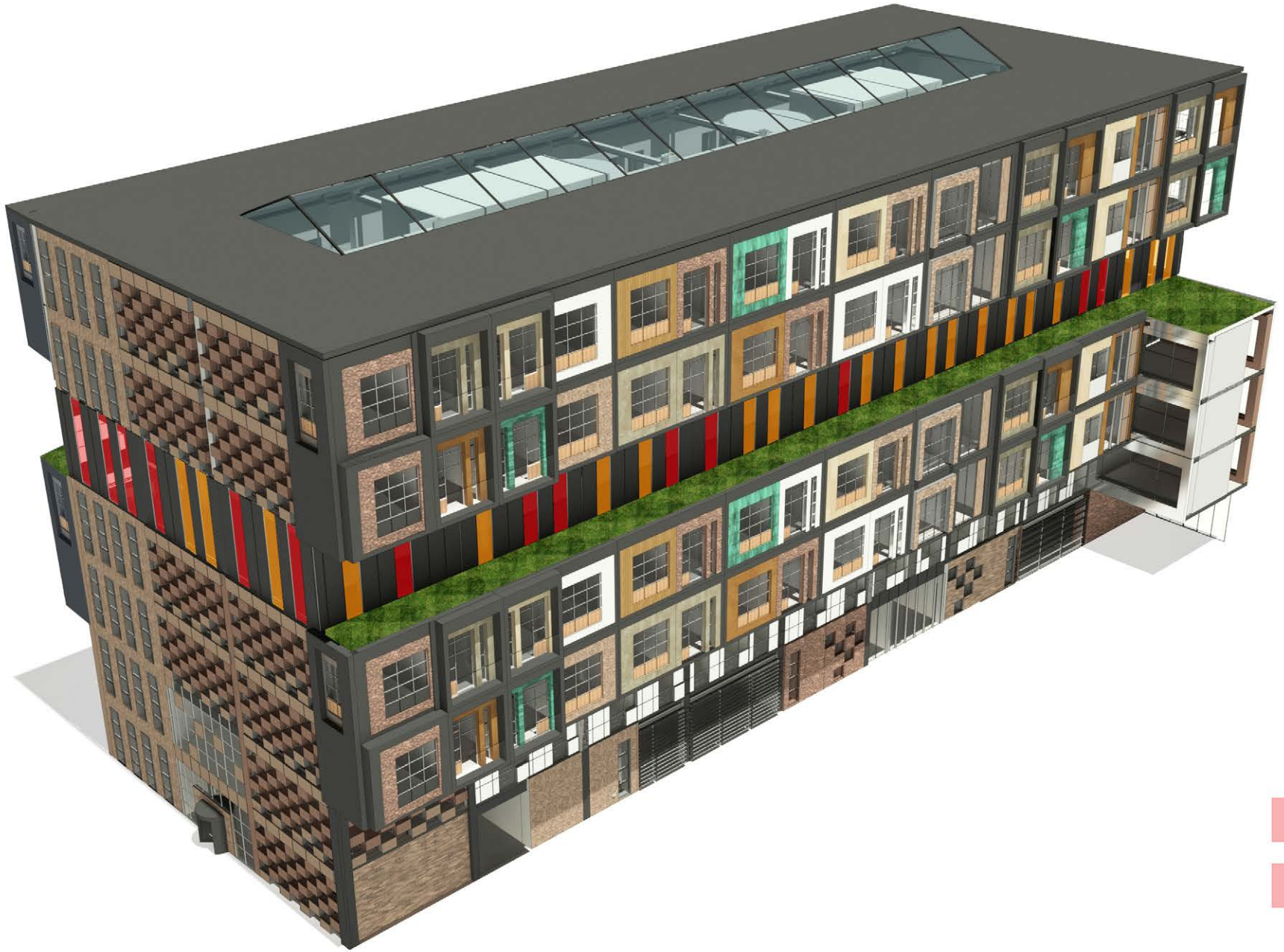


Standard 5-storey block with possibility to hang 1/3 part of prefabricated module on the facade as cantilever

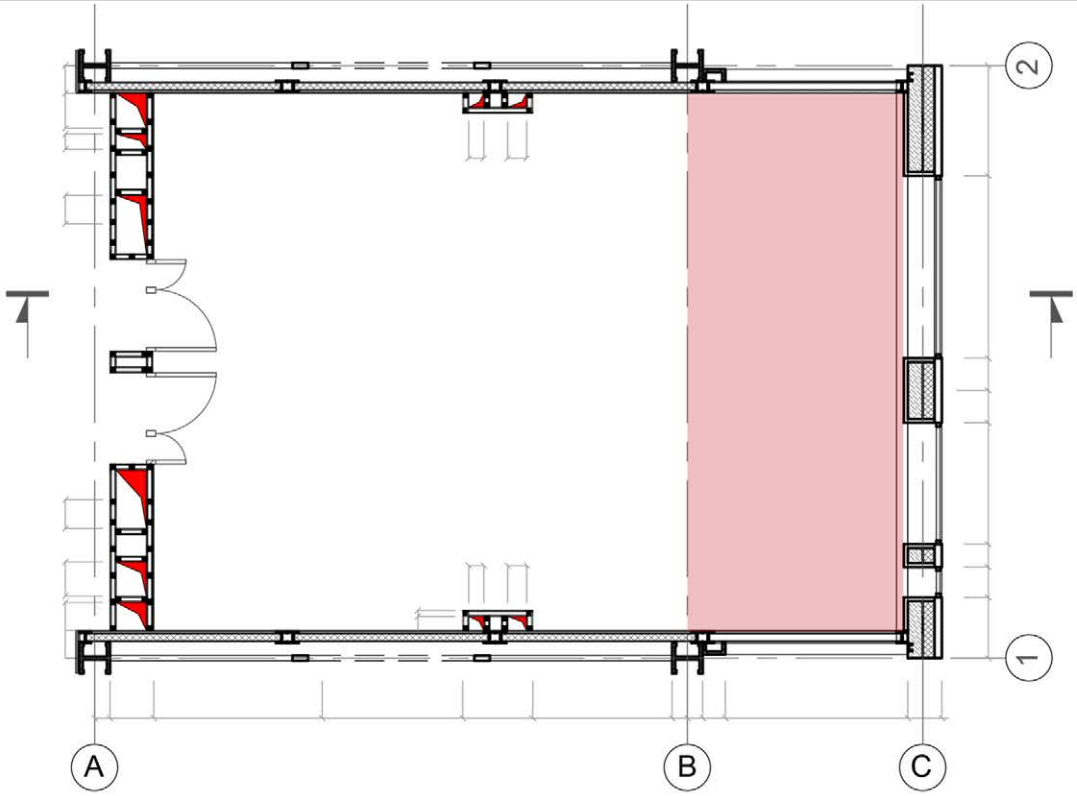
Standard 5-storey block with possibility to hang 1/3 part of prefabricated module on the facade as cantilever



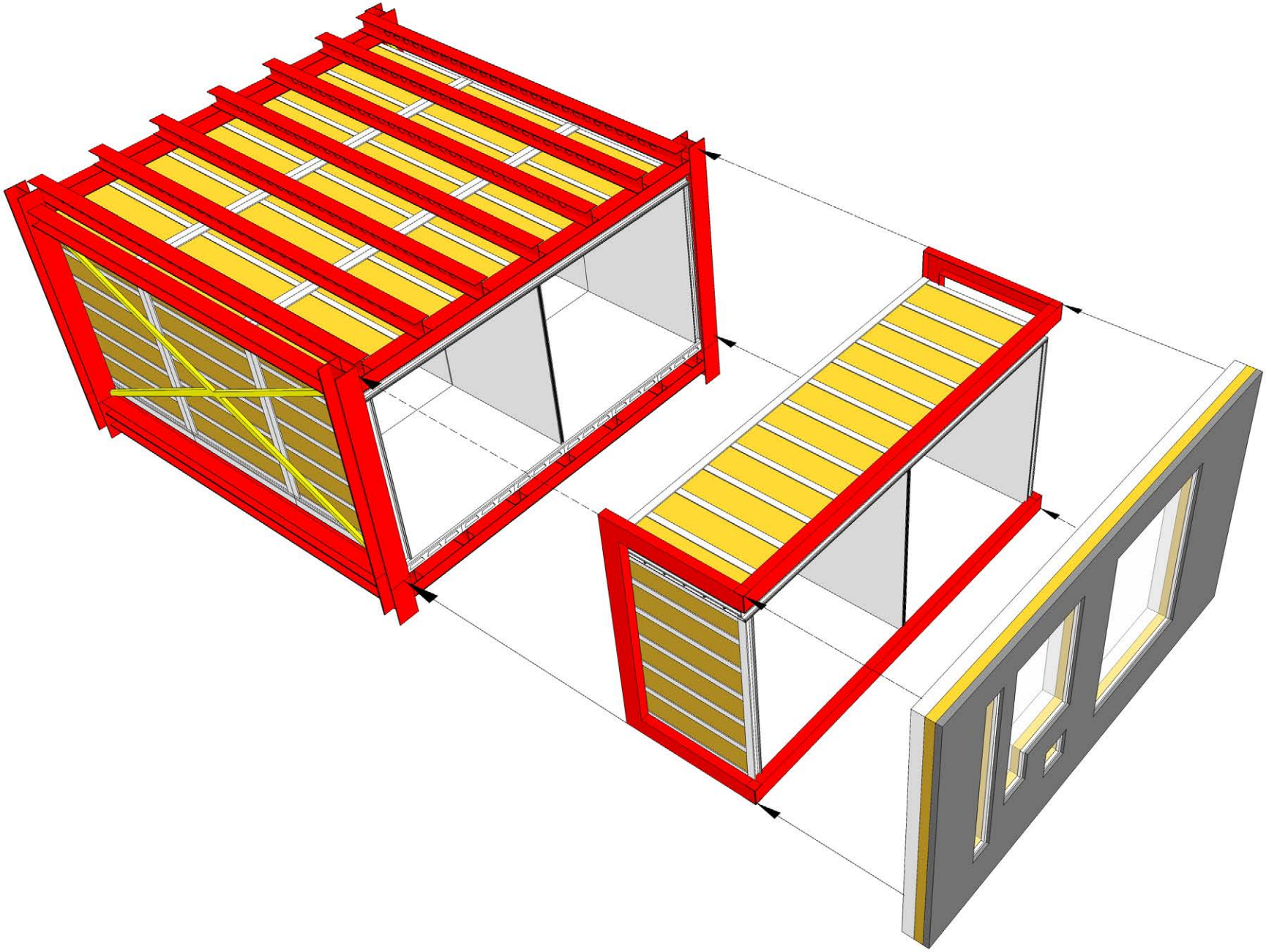
7-storey block with possibility to construct another 2 floors and to hang 1/3 part of prefabricated module on the facade as cantilever



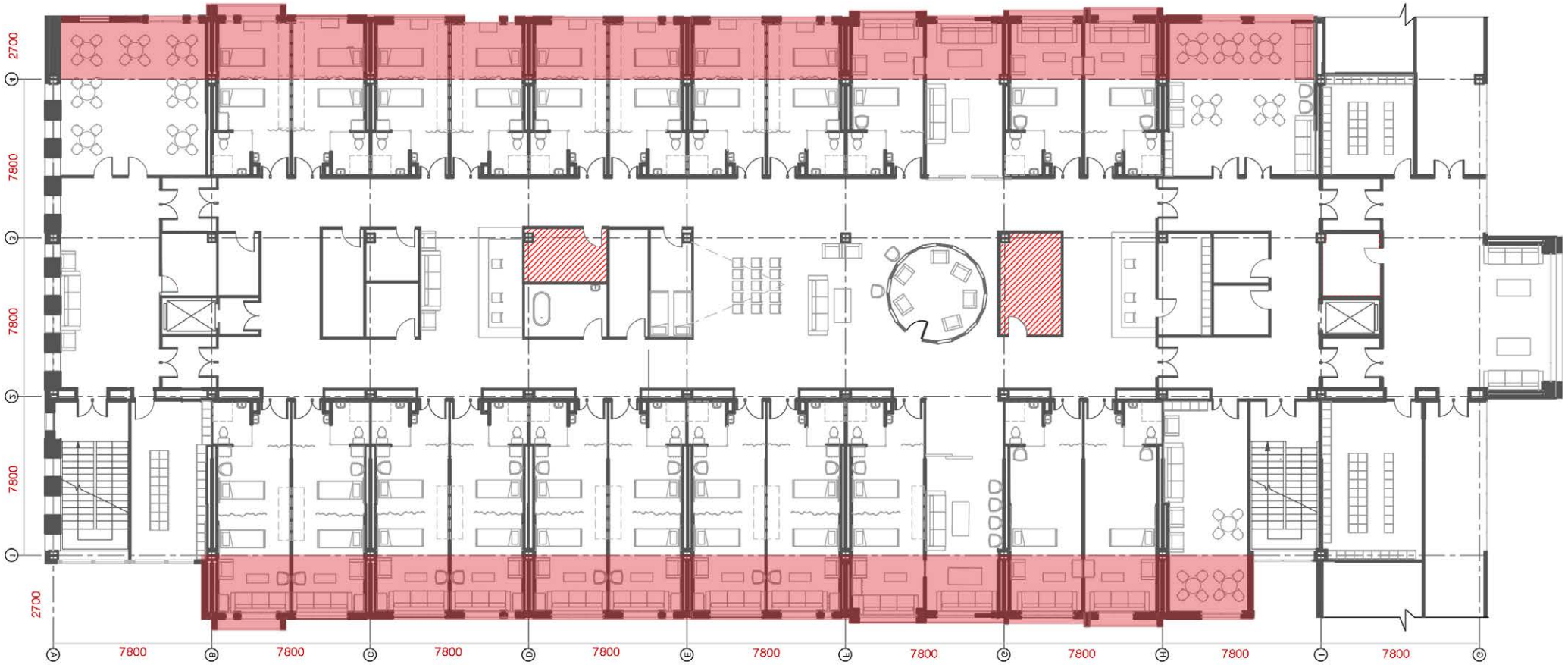
7-storey block with possibility to construct another 2 floors and to hang 1/3 part of prefabricated module on the facade as cantilever



Inreasing the surface area of the module by hanging 1/3 part of prefabricated module on the facade as cantilever



Inreasing the surface area of the module by hanging 1/3 part of prefabricated module on the facade as cantilever



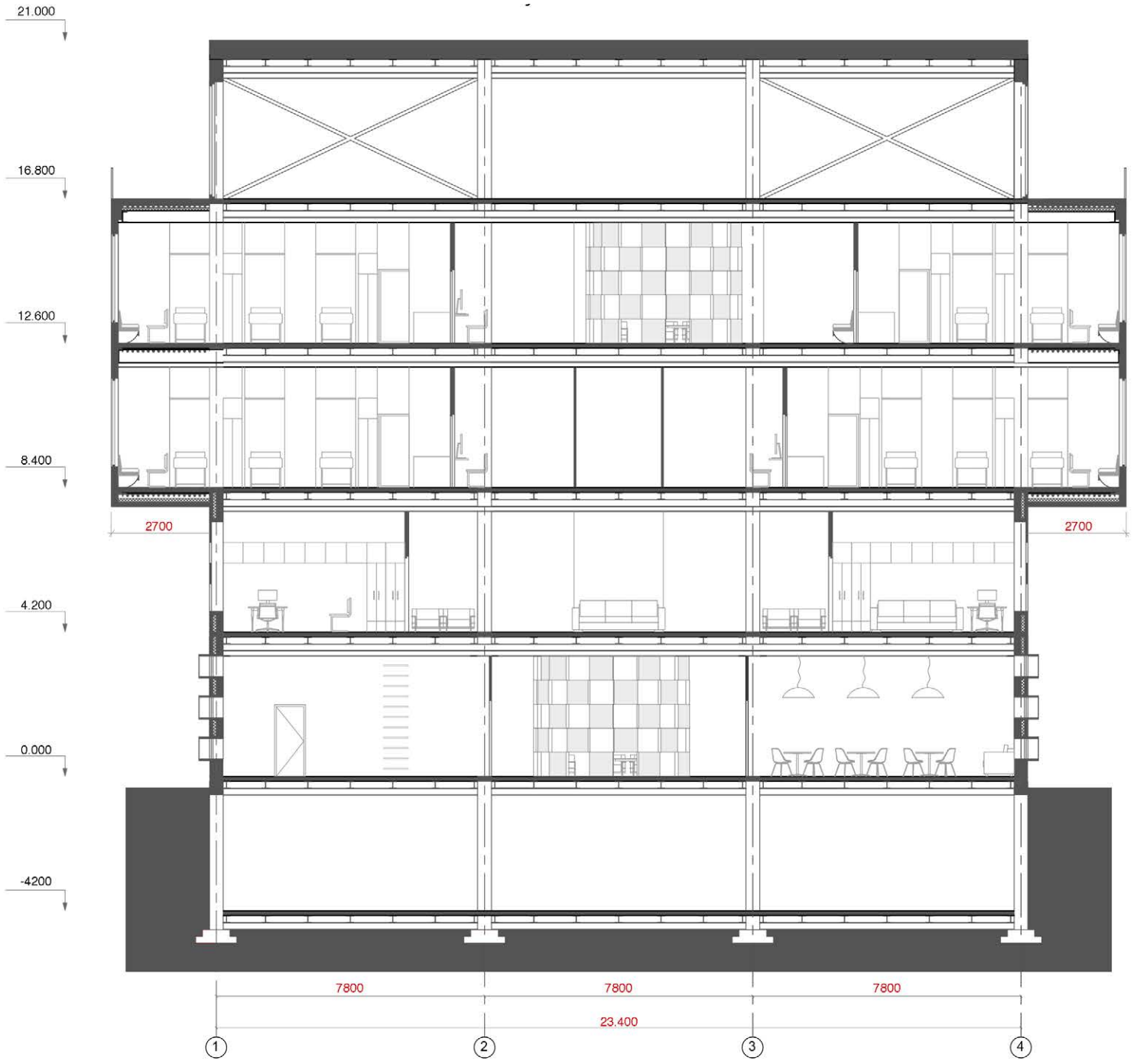
Plan of ward floor with cantilevered modules

The area of the floor can be enlarged by adding cantilevered modules for 10 % from the original floor area

Possibility of increase the surface of the ward floor with cantilevered system

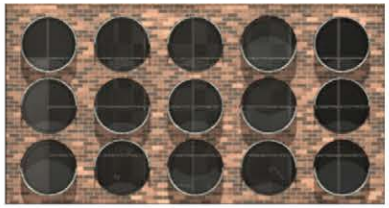
Possibility of increase the surface of the ward floor with cantilevered system

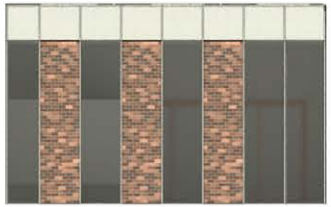
Longitudial section of standard block

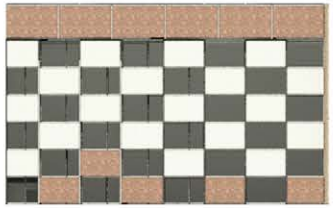


Cross-section of standard block


Technical floor


Public space


Public space


Waiting area


Sport halls


Policlinic floor


Technical space


Emergency stair


Research facilities


Waiting area


Ward facades


Ward facades

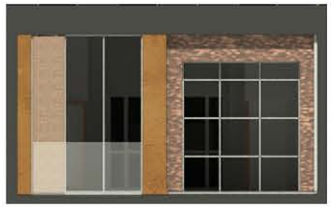

Ward facades


Ward facades


Ward facades

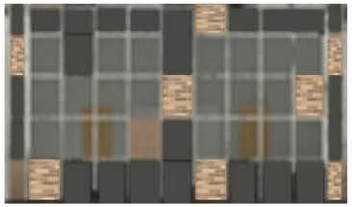

Ward facades


Ward facades


Ward facades

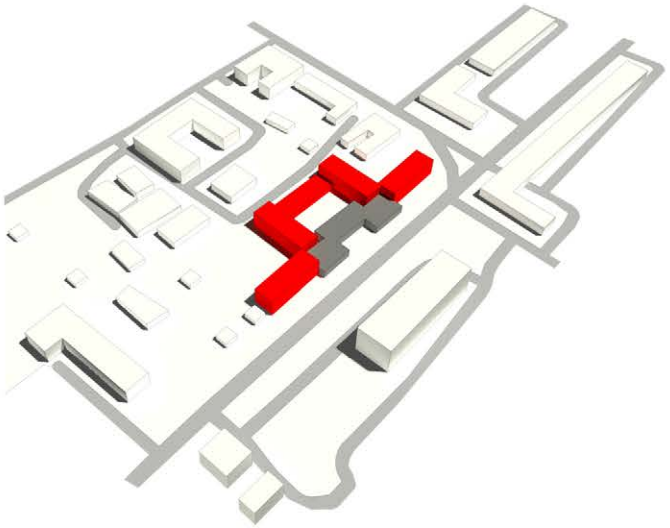

Ward facades


Ward facades

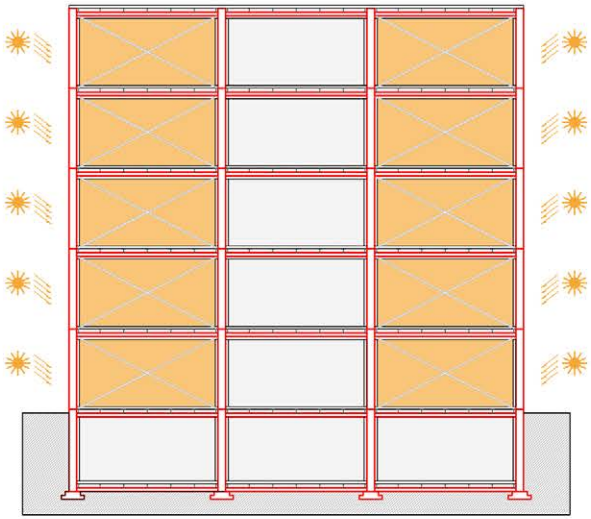

Office floor

Different facades for different hospital functions

Pluses of standard building block



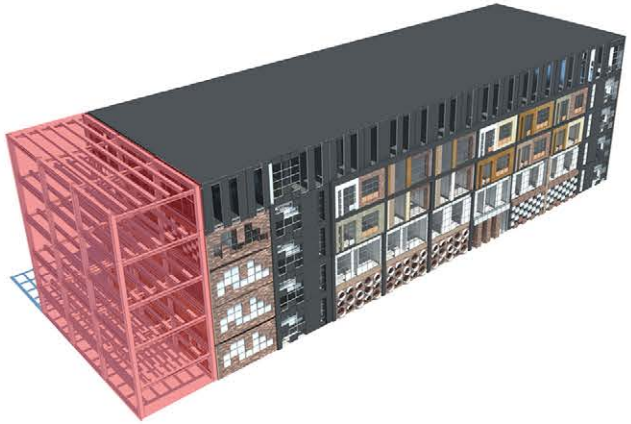
Inscribing of standard block into urban context



insolation of all facilities which demand a daylight

Simplicity of assembling the structure due to partially prefabricated method

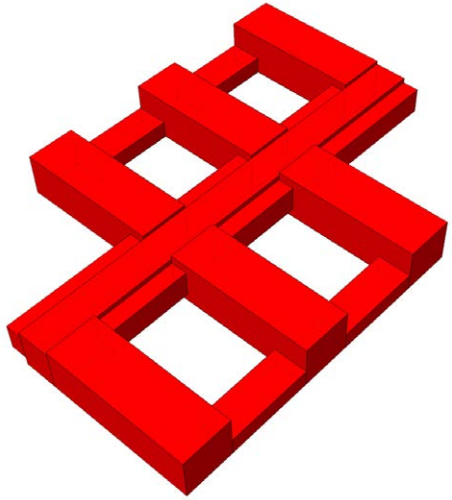
Possibility to put any functional unit within standard block



Possibility of extension of standard block

Human scale and creation of environment

3.7
Hospital complex



Hospital complex is the final and larger part of construction of hospital in general and renovation of Burdenko hospital in particular. The variant of renovation presented on the right side is a general hospital with all medical facilities and departments within. Standard hospital buildings (or blocks) presented in previous section are situated along the main communication - main hospital street. The street contains public and healthcare related facilities on the ground floor and personnel facilities on upper floors. Two storey administrative blocks together with standard blocks and personnel facilities organise internal yards which are used mostly for out-patients, while exploitated roofs of administrative blocks are used for in-patients recovery. Some of internal courtyards are covered and contain different functions such as sport cluster and surgery block.

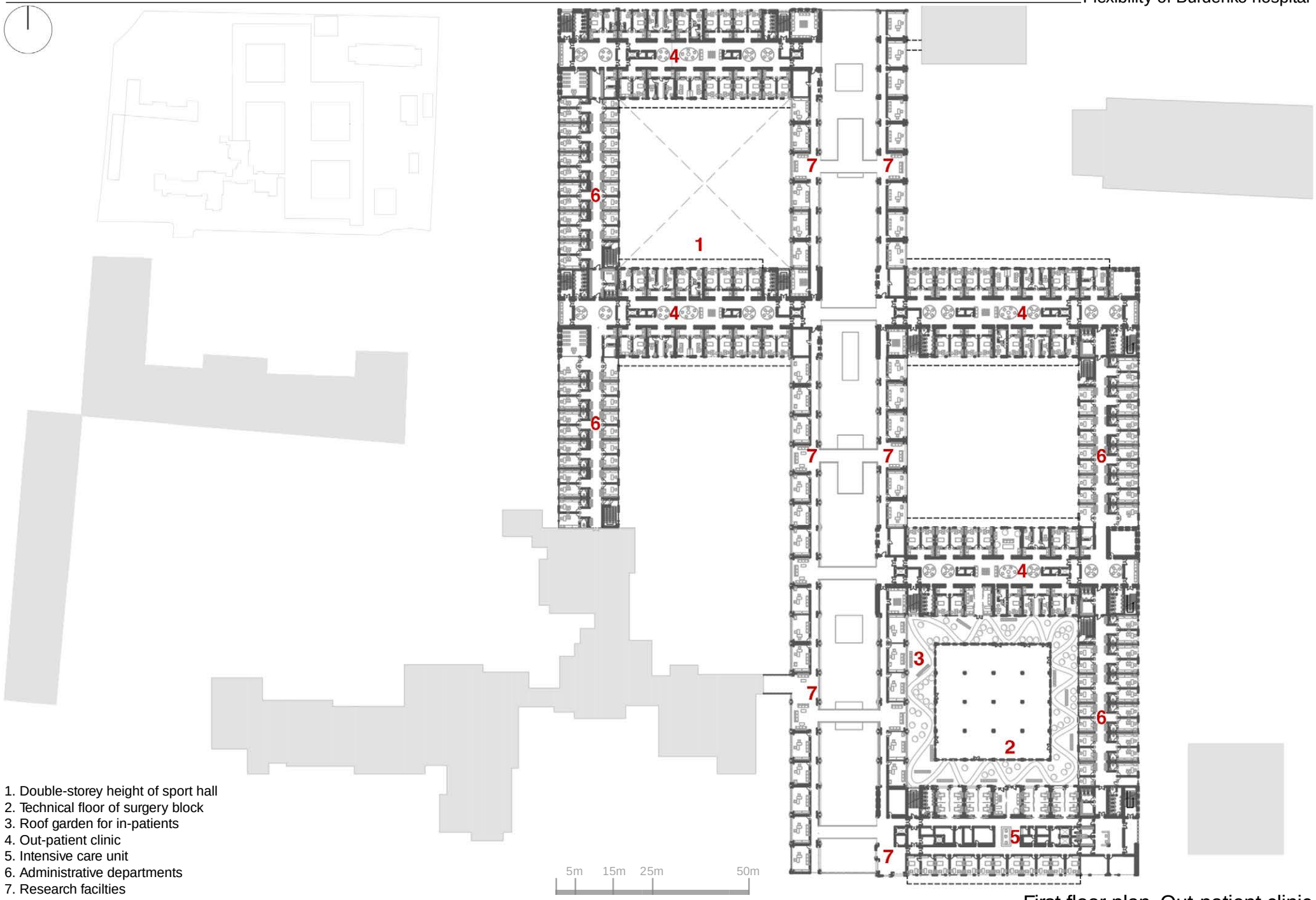
The entire flexible system, from srandard prefabricated module to entire hospital complex, can be used for extension and renovation of any healthcare facilities (from city policlinics to the general or university hospitals). Some of these examples will be demonstrated in this section.

Due to rapid development of technologies hospitals become outdated relatively soon. The problem of renovation or even conversion of hospitals to other functions is really important one. The characteristics of standard hospital building (or block) demonstrated in previous section are valuable for this kind of conversion. At the end of this section the possibilities of conversion of standard hospital building as well as entire hospital complex will be demonstrated.

Burdenko hospital bird’s eye view

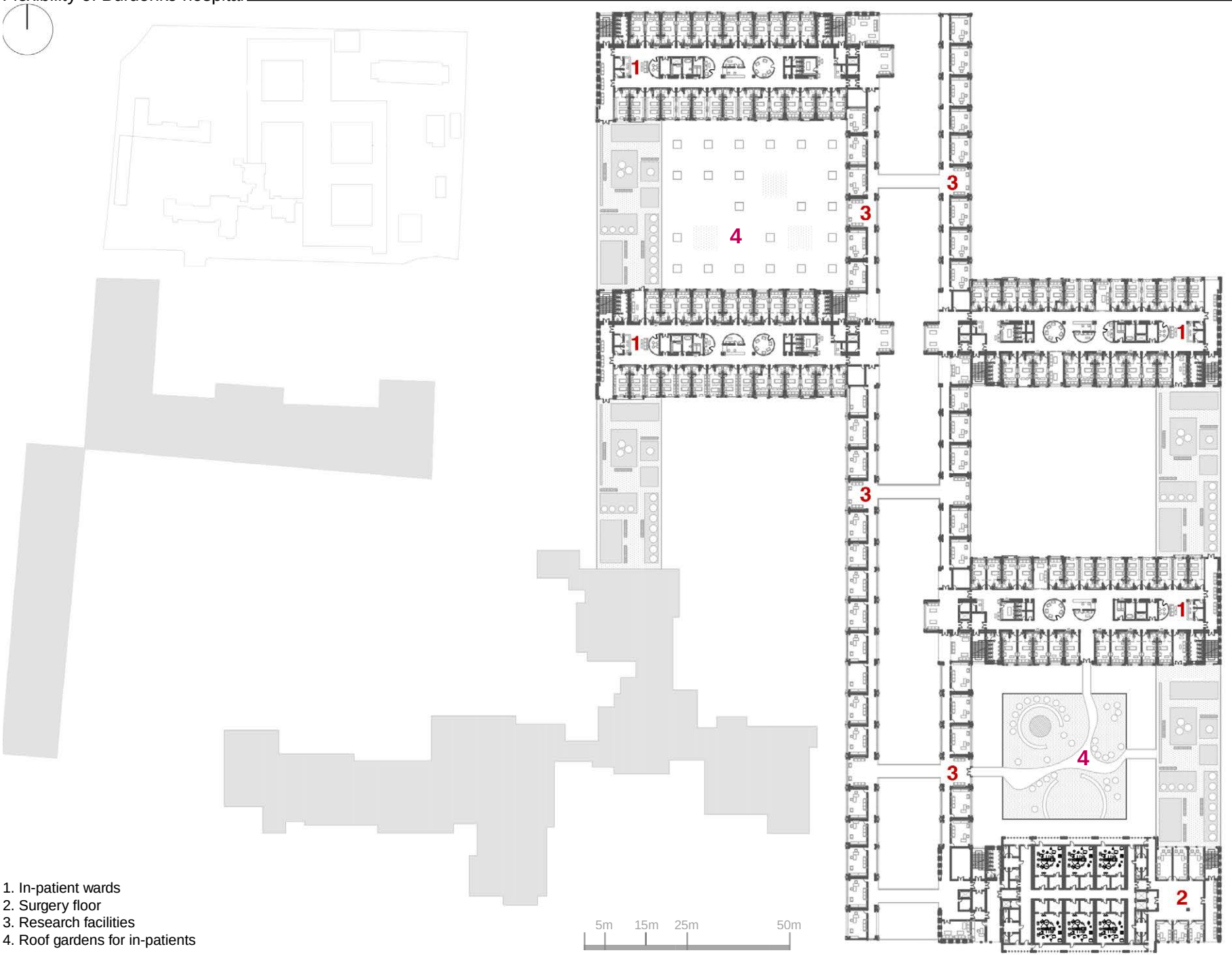
1. Central hospital street
2. Sport facilities (swimming pool and gyms)
3. Internal gardens
4. Surgery block
5. Administrative departments
6. Health care related facilities

Ground floor plan. Health care related facilities



1. Double-storey height of sport hall
2. Technical floor of surgery block
3. Roof garden for in-patients
4. Out-patient clinic
5. Intensive care unit
6. Administrative departments
7. Research facilties

First floor plan. Out-patient clinic



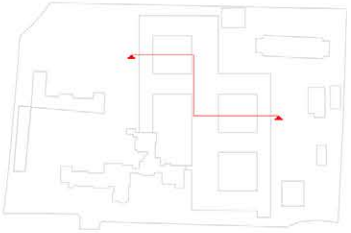
1. In-patient wards
2. Surgery floor
3. Research facilities
4. Roof gardens for in-patients

Second floor plan. In-patient wards

1. In-patient wards
2. Technical floor of surgery block
3. Research facilities

Third and fourth floor plans. In-patient wards

Longitudial section of hospital street



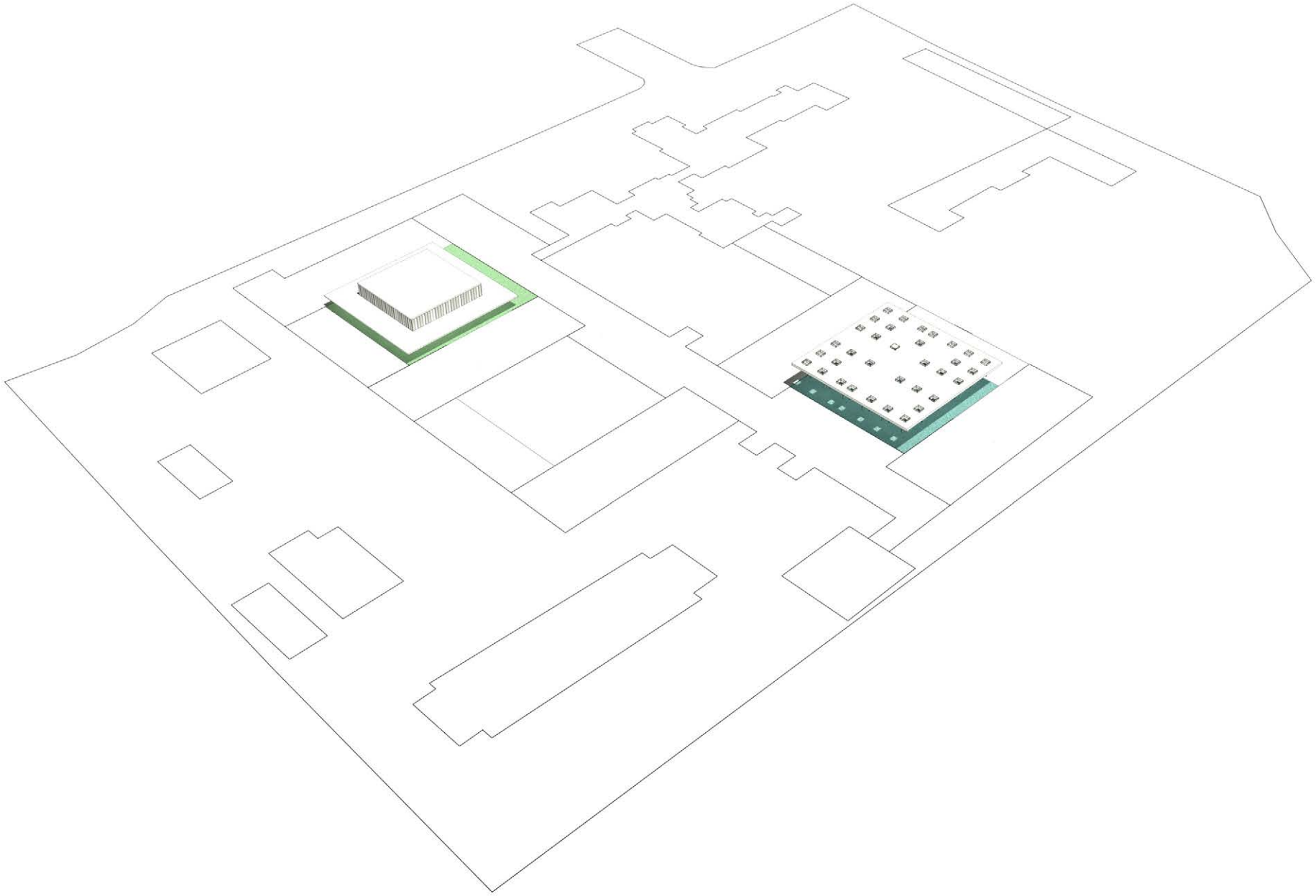
Cross- section of covered and open internal yards

Eastern (up) and western (bottom) facades of the hospital complex

Northern (up) and southern (bottom) facades of the hospital complex

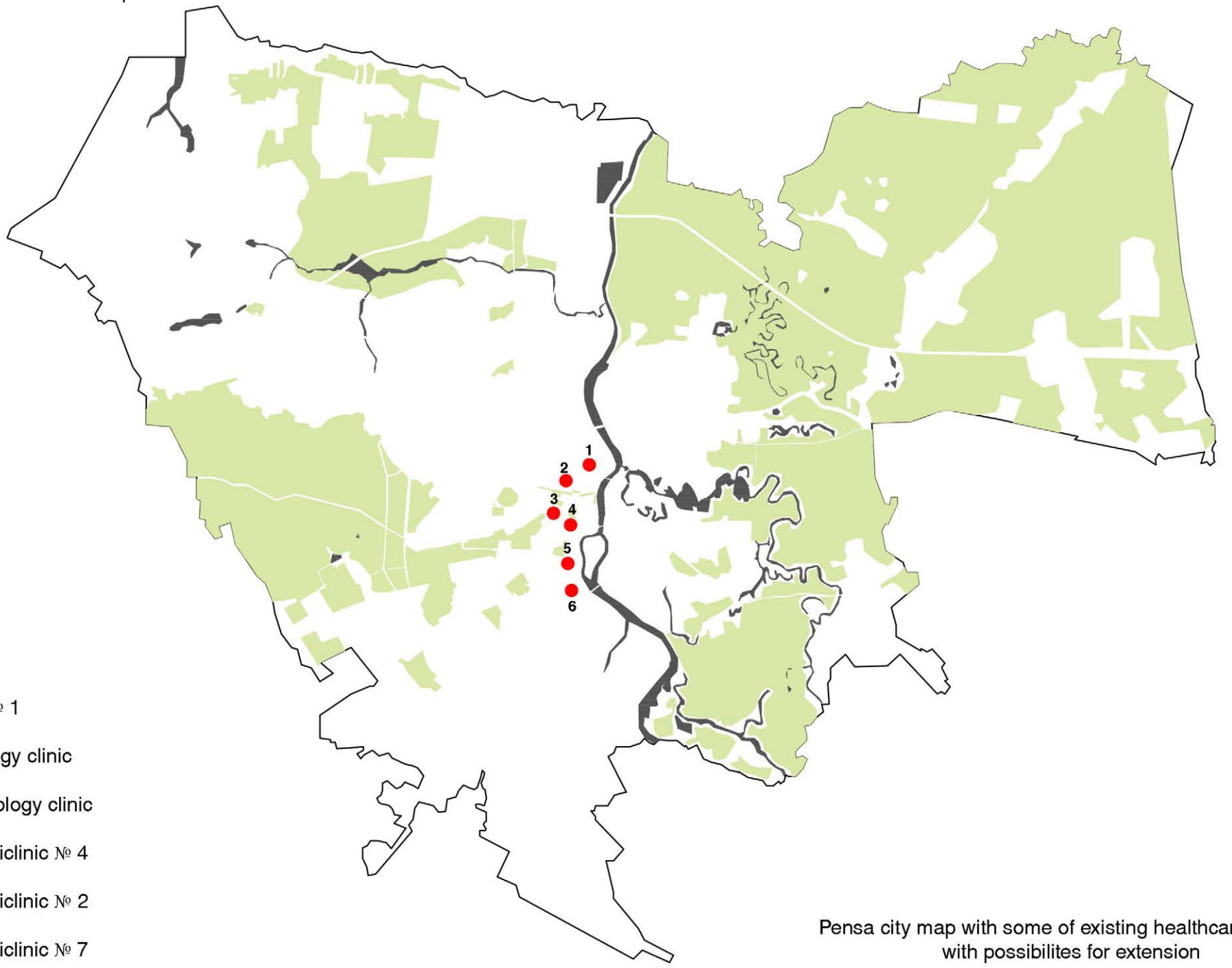
Covered internal yards with diferent functions

Functions of covered internal yards



Functions of covered internal yards

3.8.
Extension of current healthcare facilities of Pensa within urban context



1 Clinic № 1

2 Narcology clinic

3 Stomatology clinic

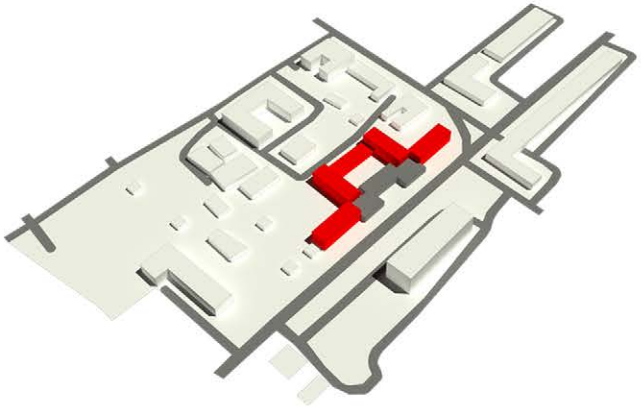
4 City policlinic № 4

5 City policlinic № 2

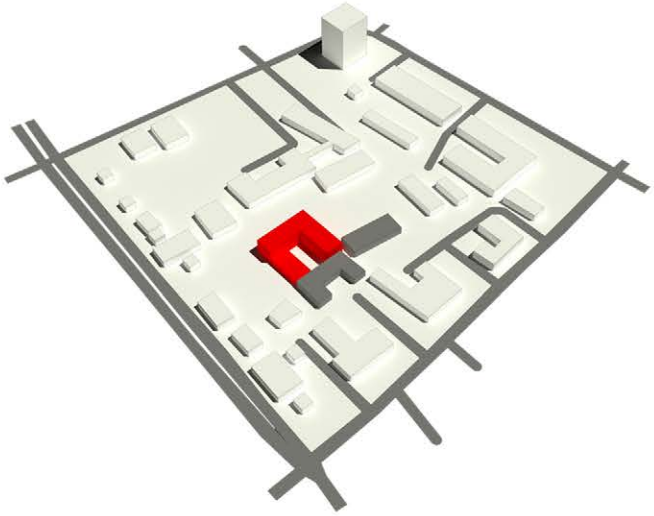
6 City policlinic № 7

Pensa city map with some of existing healthcare facilities with possibilites for extension

Pensa city with position of current healthcare facilities which can be extended by this system



1



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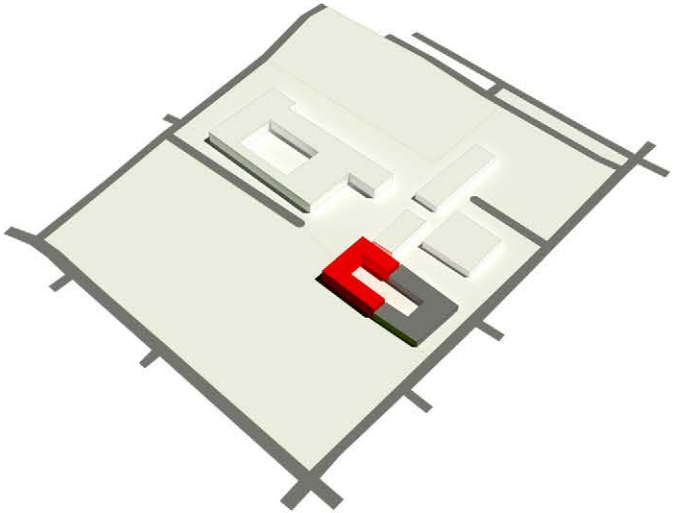
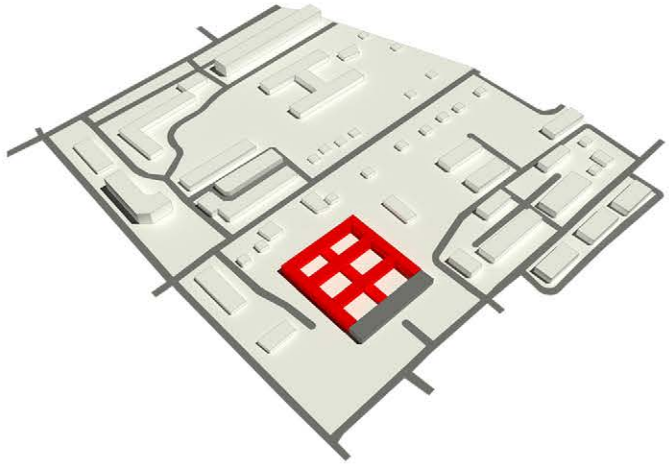


3

Typical existing healthcare facilities in Pensa
and their possible extensions by modular system



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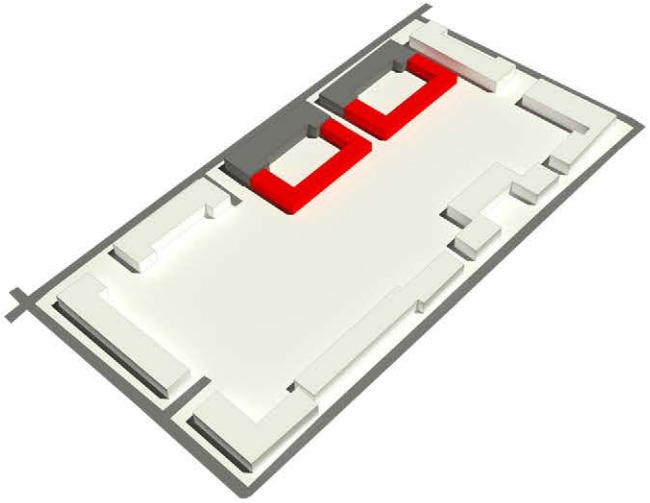

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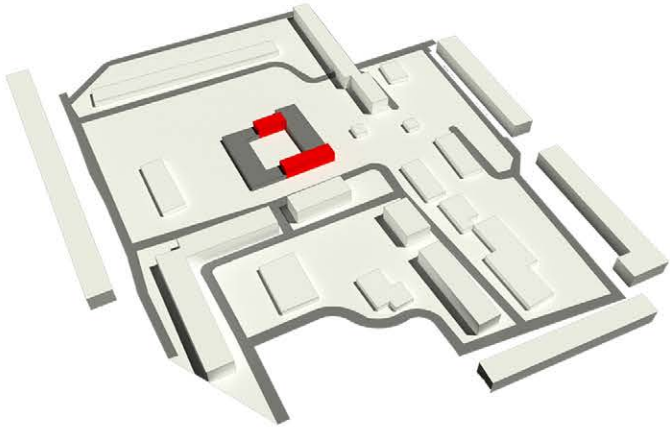
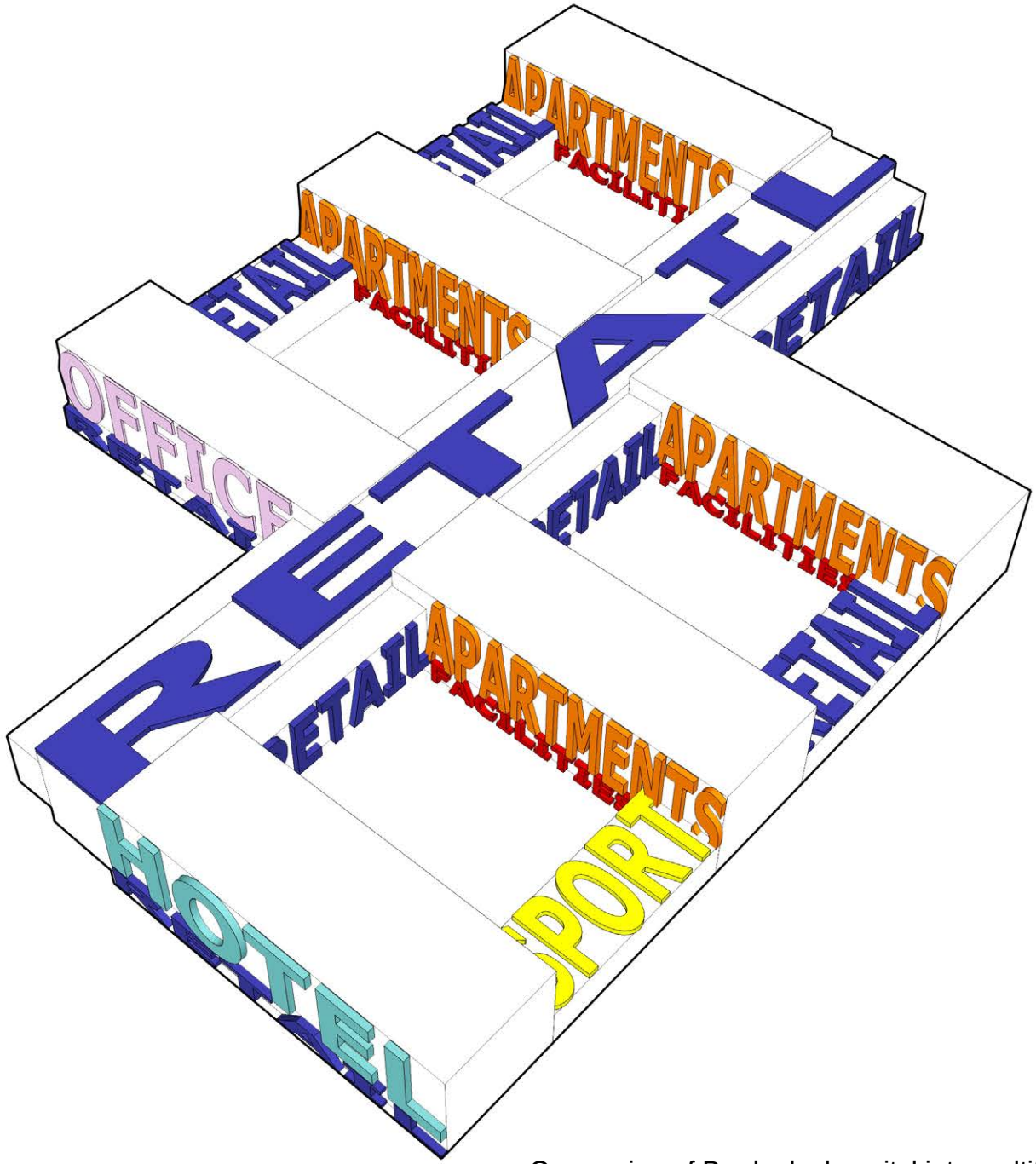


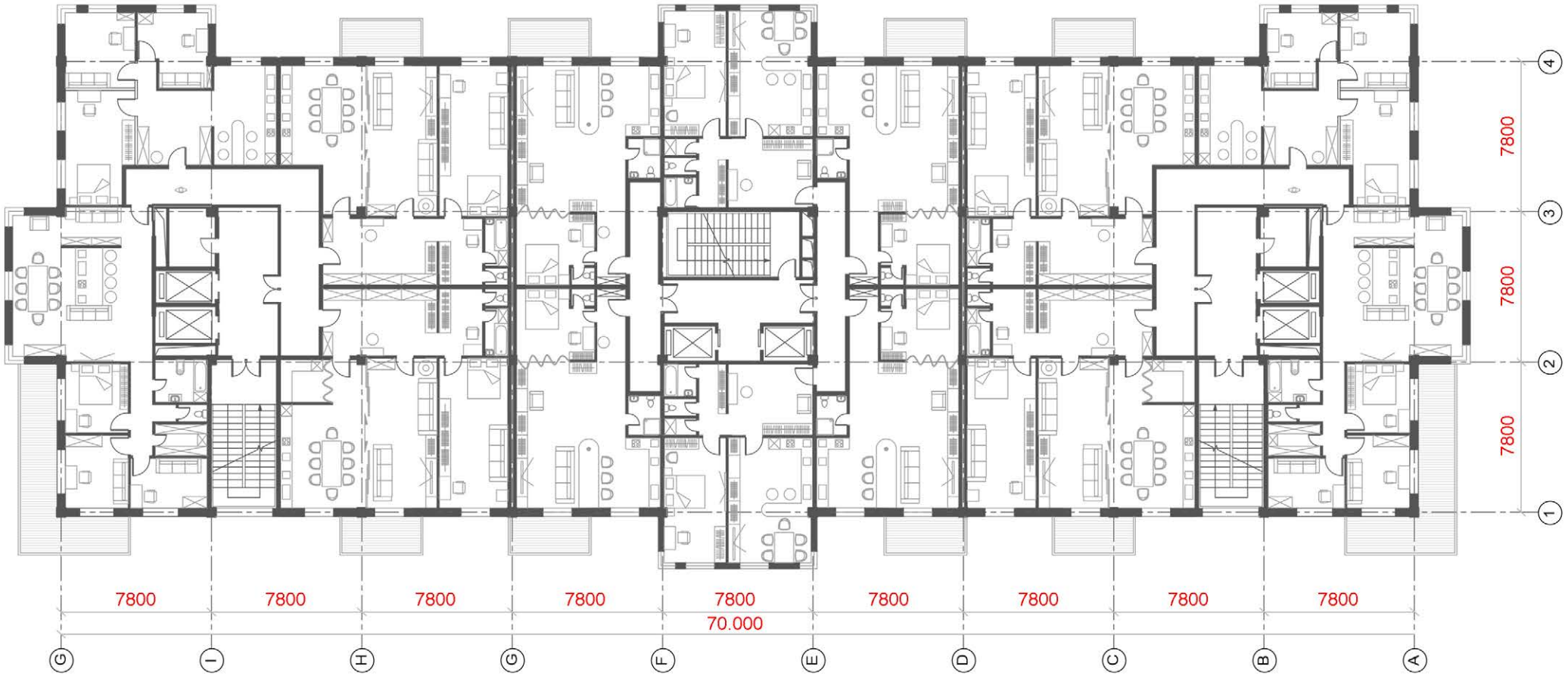
6

Extension of current Pensa healthcare facilities

3.9.
Conversion of hospital complex into other functions due to its obsolescence

Current functional division of Burdenko hospital


APARTMENTS
FACILITIES
RETAIL
OFFICE
HOTEL
SPORT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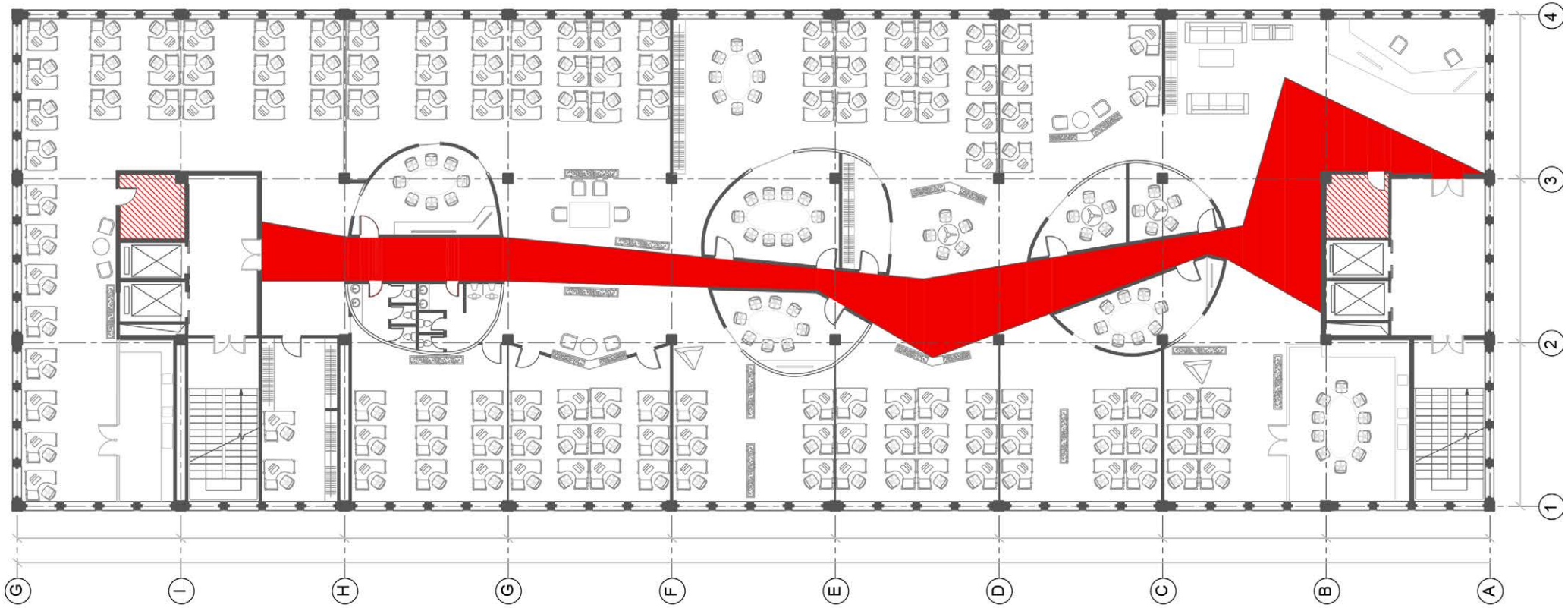


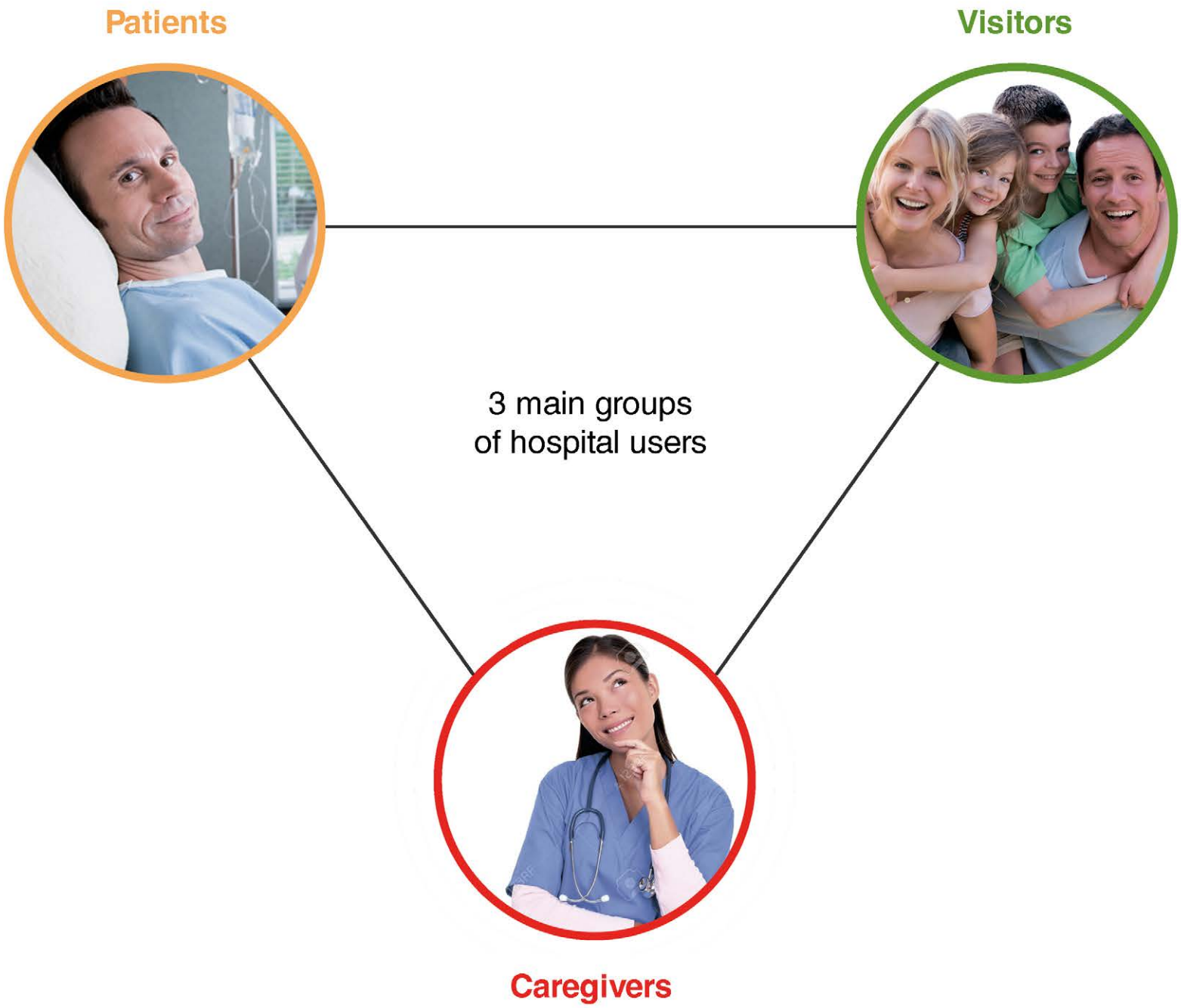
Conversion of standard hospital buildig into office

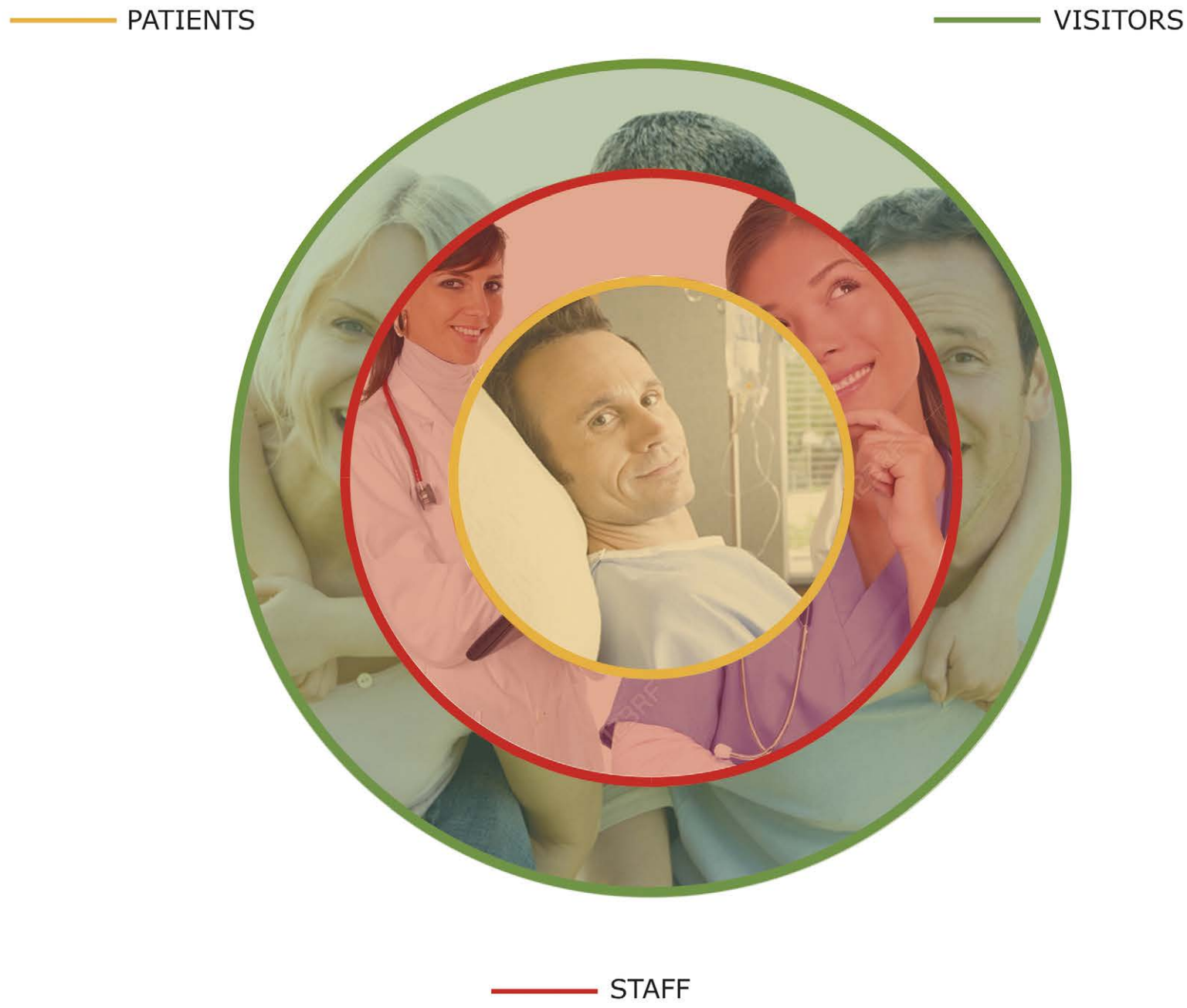
CHAPTER 4

Overview of modern hospital trends
and
their application in Burdenko hospital renovation project.

One of the most important trends in modern health care design, flexibility, was described in detailes in previous chapter since it is focus of the thesis. Meanwhile, hospital design contains much more trends which are used in hospitals and related to the latest solutions for increasing effectiveness, efficiency as well reducing recovery time and, overall, improve spatial quality of the hospital.

There are three main groups of users can be identified in the hospital. They are patients, caregivers and visitors (Verderber, 2010). Each of these groups have their own special needs regarding hospital environment and spatial solutions. The most important trends for each group will be described in this chapter by using theoretical description and demonstrating the application of these trends in renovation project of Burdenko General Hospital.

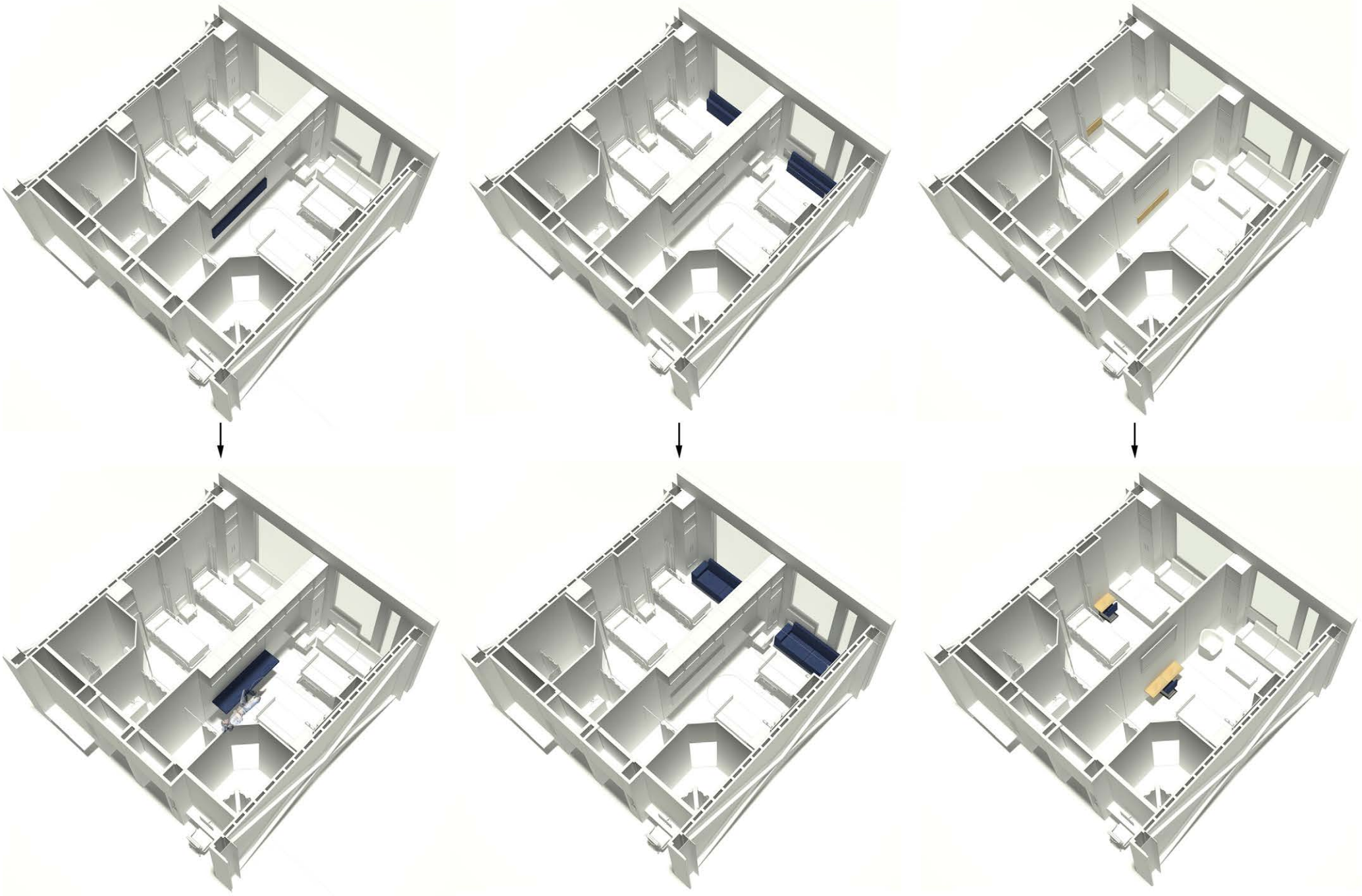

Patients
Visitors
3 main groups
of hospital users
Caregivers


PATIENTS
VISITORS
STAFF

4.1. Patients

4.1.1. Ward flexibility

Ward flexibility is the basic and at the same time most important level of flexibility for the patient. The adaptation of individual room to individual needs of the patient is the crucial part of healing environment in the hospital and trend to individualization of the place of stay for the patient (Capolongo et al, 2012). SInce the fact that all types of transformations of the wards were demonstrated in previous chapter, here the summary of transformations of the patient ward will be shown.



Folded sofa

Folded sofa for visitors

Folded table

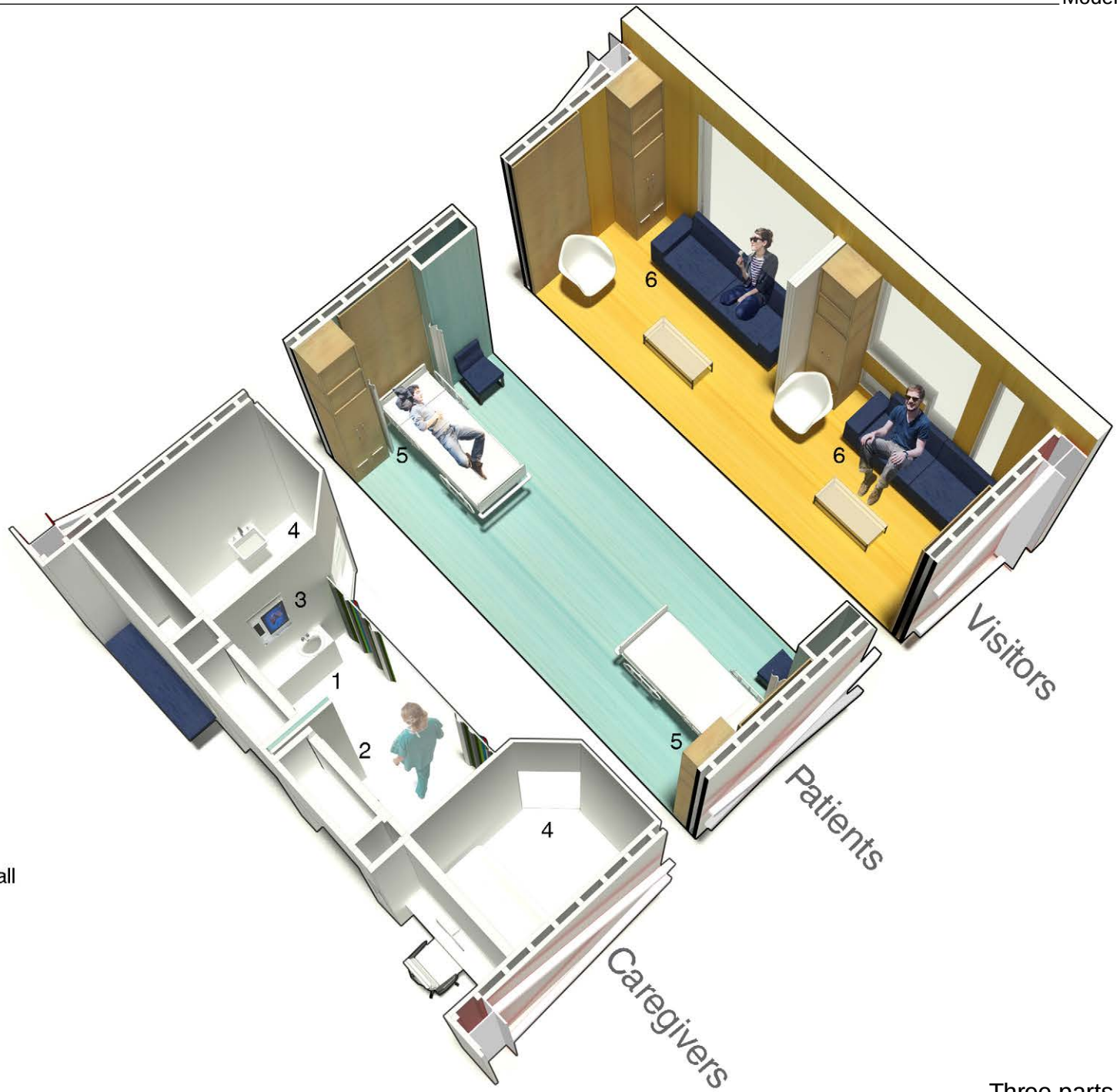
Folded guest's bad instead of 2d patient bed

Movable partition wall

Curtains around the bed

4.1.2. Zonning of the ward

According to the last tendencies in hospital design, patient ward is divided into three parts: caregiver part, patient part and visitor part. Each part has its own characteristic features and suites best to the particular needs of one or another user (Prasad, 2008).
Caregiver segment, the first one from the entrance, contains sink for washing hands, monitor for checking the current state of the patient, cupboard for medication and curtain which subdivides caregiver part from patient part.
Patient segment, in the middle of the ward, contains patient bed with curtain around it for making privacy, patient cupboard and all related medical devices.
Visitor part, close to the window, contains guest sofa (preferably folded for higher level of flexibility), foldable table, chair and newspaper table.
All these three segments follow the structural scheme of assembling the ward room presented in chapter «Flexibility».



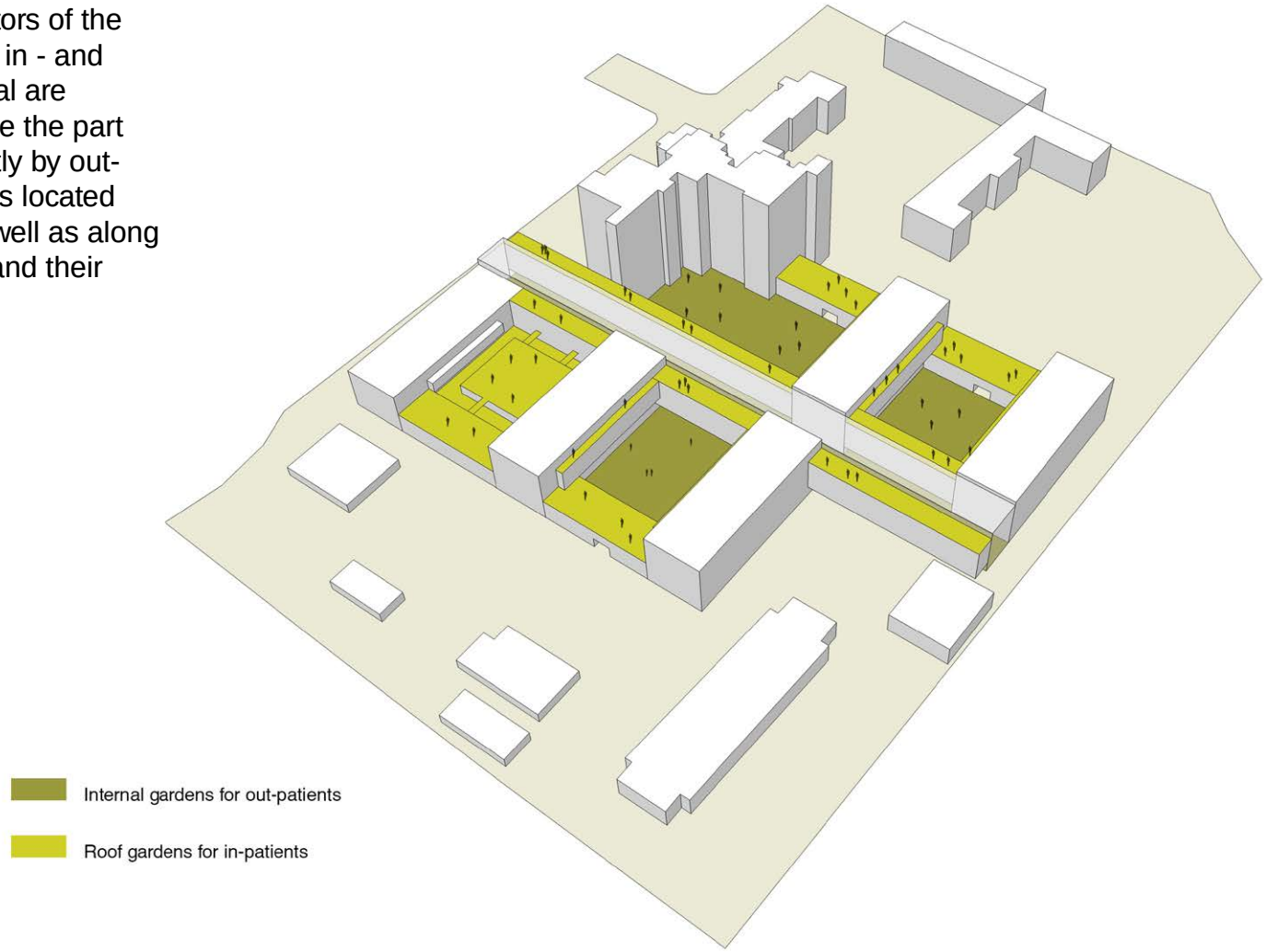
1. Sink for caregivers
2. Movable partition wall
3. Care monitor
4. Bathroom
5. Patient bad
6. Visitor sofa

Three parts of standard patient ward

Interior of the standard patient ward

4.1.3. Internal gardens for in - and out-patients

Internal gardens for recovery of in- and out-patients are the inherent part of modern hospital (Zeinstra, 2016). Healing environment as important part of quick and sufficient recovery is known for centuries as efficient treatment for not only the patients but also personnel and visitors of the hospital as well. In order to separate the flows of in - and out-patients internal gardens of Burdenko hospital are subdivided by levels. Gardens on ground floor are the part of healthcare related facilities and are used mostly by out-patients and visitors of the hospital. Roof gardens located above the administrative and surgery blocks as well as along the main hospital street are used by in-patients and their visitors.



3D scheme of internal gardens for in - and out-patients

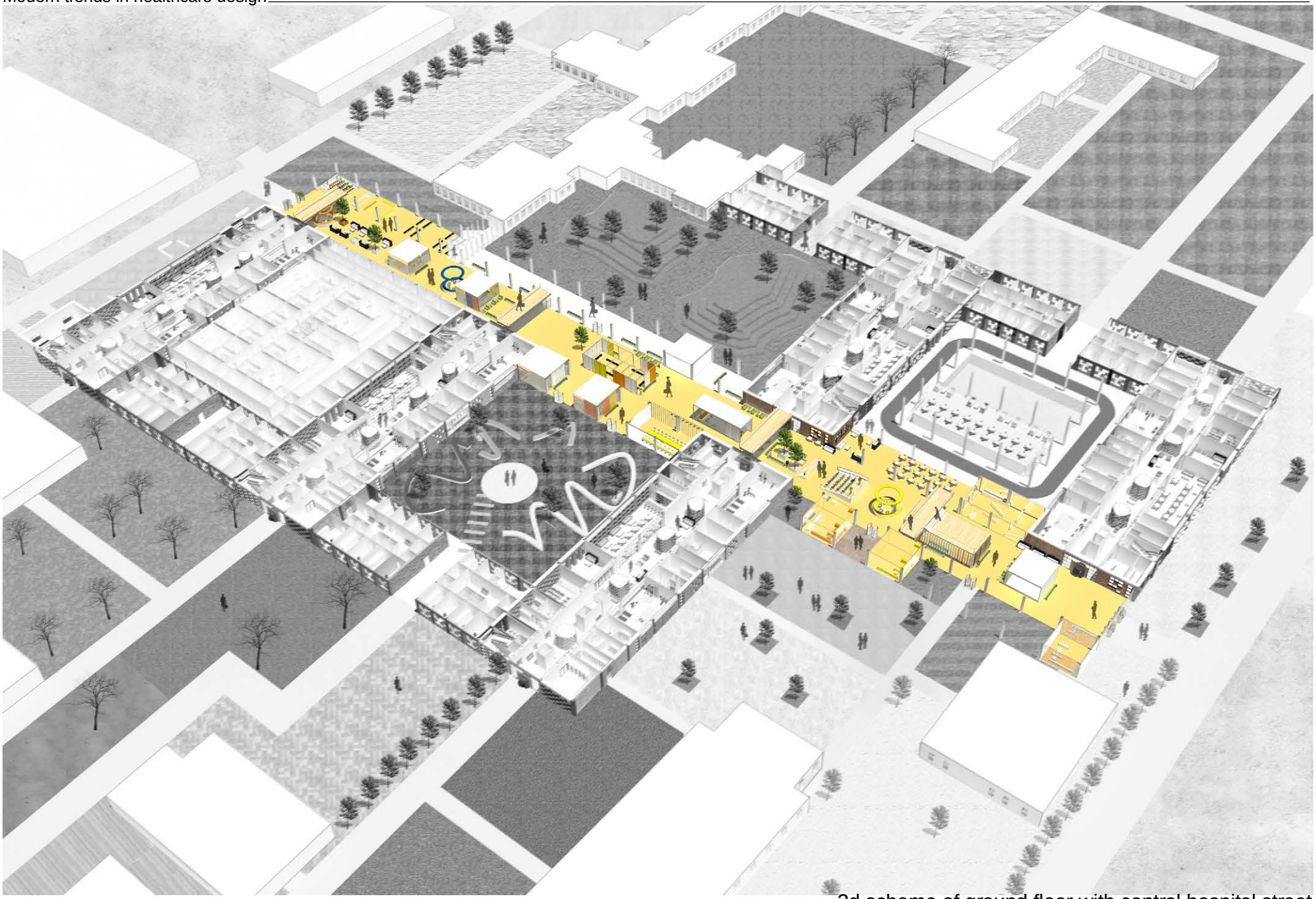
View of the roof garden for in-patients above swimming pool

View of internal garden for out-patients on the ground level

View of the roof garden for in-patients above surgery block

4.1.4. Central hospital street as active user place

Hospital street is the main and central communication of the hospital for all three types of users - patients, caregivers and visitors (Cor Wagenaar et al, 2006). Hospital street provides an access to all departments of the hospital which are connected to it from both sides at all floors. Along the hospital street the personnel and research facilities are situated started form the first level. At the ground level hospital street contains healthcare related facilites such as farmacies, shopping pavilions, meeting rooms, informational points and public spaces for all types of users. The internal gardens on the ground level are also accessible from hospital street.

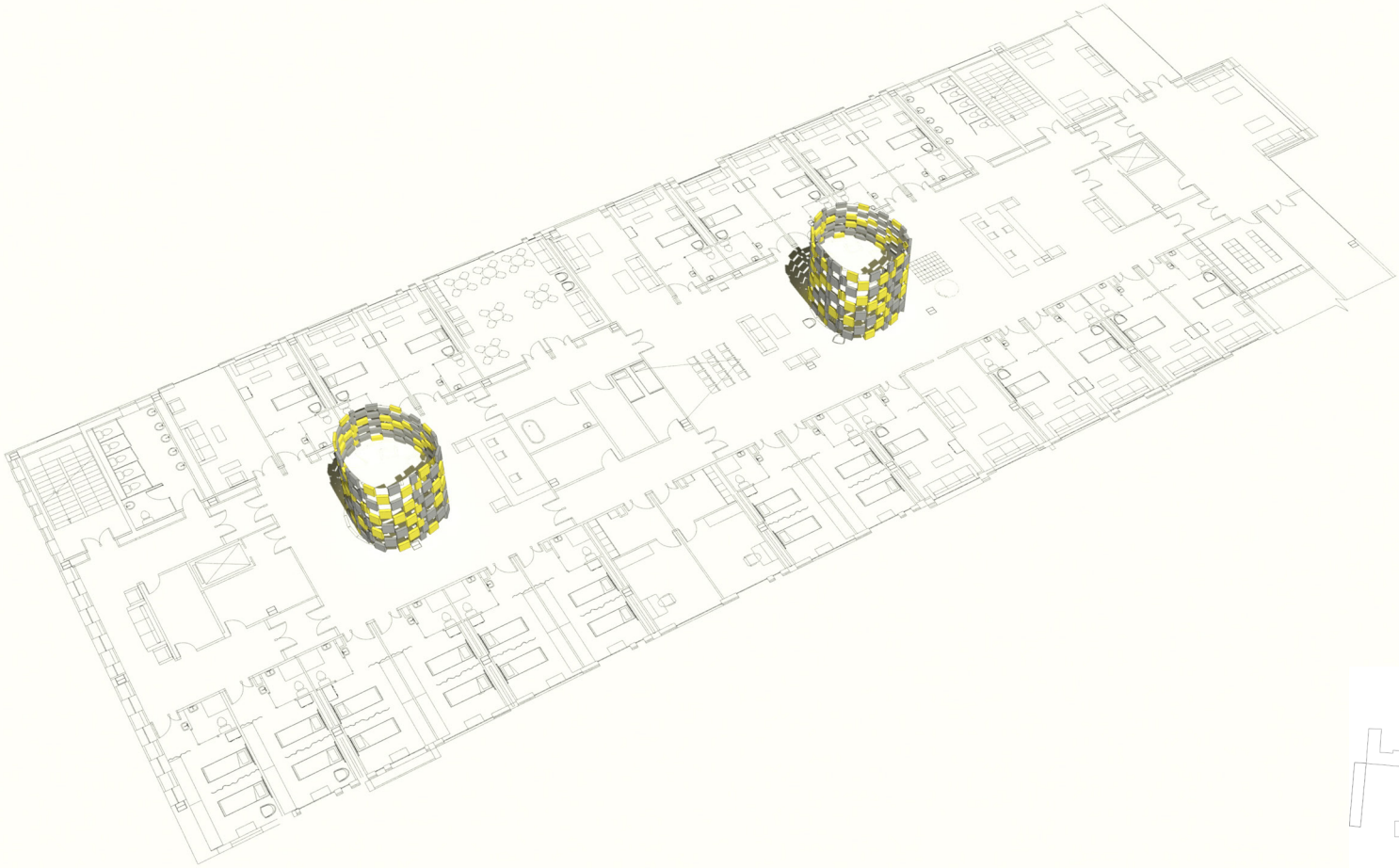


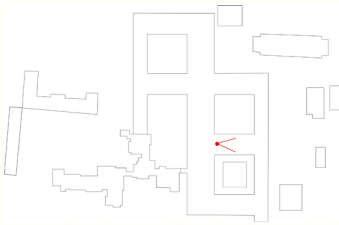
3d scheme of ground floor with central hospital street

Central hospital street view

4.1.5. Places for private meetings

At some moments in hospital doctors, patients and their visitors as well as medical personnel need a closed place for private conversation tet-a-tet in order to present some news which should only be shared between them and should not be announced loudly. For this reason each floor of standard hospital building (as well as other places in the hospital) contains closed private spaces for small number of people where they can discuss important things privately. Being semi-transparent, with possibility for day light to be inside and being really private meeting rooms at the same time, these spaces are perfect for small conversation between different users within the hospital when privacy is the most important thing.

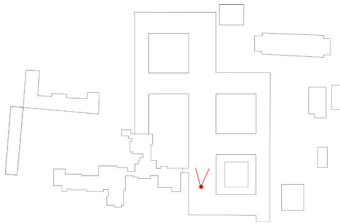




View of the middle space of standard hospital building with space for private meetings

4.1.6. Digital application for navigation in hospital

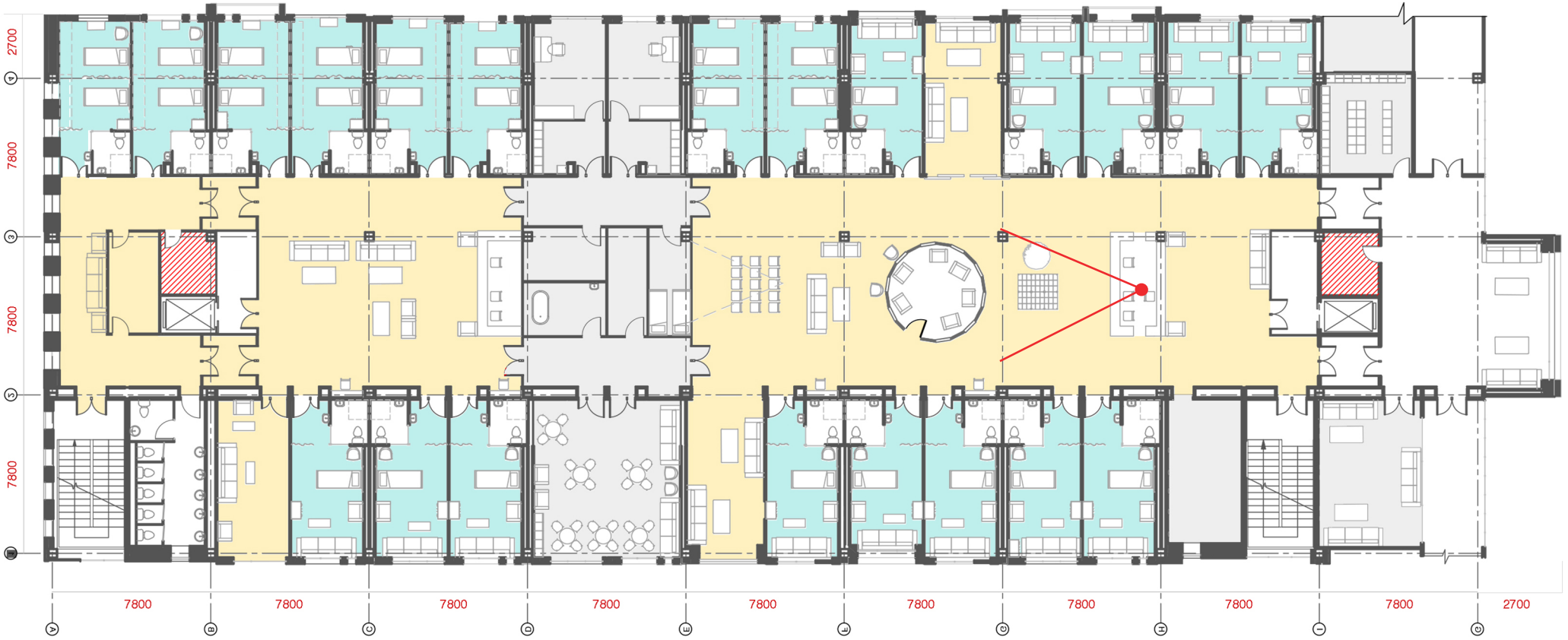
Since the fact that hospital in general and Burdenko hospital in particular are complicated spatial structures, the problem of quick and efficient navigation is rising (Day N. J., 2016). In order to facilitate navigation within the hospital for all groups of users the digital application was elaborated. There are two functions of this app. First one is to position the user on the 3d hospital spatial scheme and make a shortest route from current location to desirable one. Second function of the app is to inform all groups of users about upcoming activities and appointments. For example, the patient can get a notice about upcoming reception to the doctor and check the shortest way to get it. Personnel can use this app as daily and weekly planner were all upcoming activities will be visible. Visitors can use it in order to find the ward or room where their relative or friend is at the moment.



Digital application for navigation within the hospital

4.1.7. Common spaces instead of corridors

Corridors are the essential and at the same time one of the most useless, unfriendly and even scared spaces in the hospital (Cor Wagenaar, 2006). While in some places such as surgery units, corridors cannot be excluded from the layout because of the strict technological rules, in some other places such as ward or policlinic floors coridors can be replaced by common meeting areas with the access of natural day light and comfortable environment for users. The picture on the right side represents this type of common space in the in-patient ward floor. The entire ward floor is subdivided into several sections and personnel related facilities are situated between them where they occupy the entire width of th floor. Consequently, personnel related facilities in the middle of the floor are excluded or minimized.

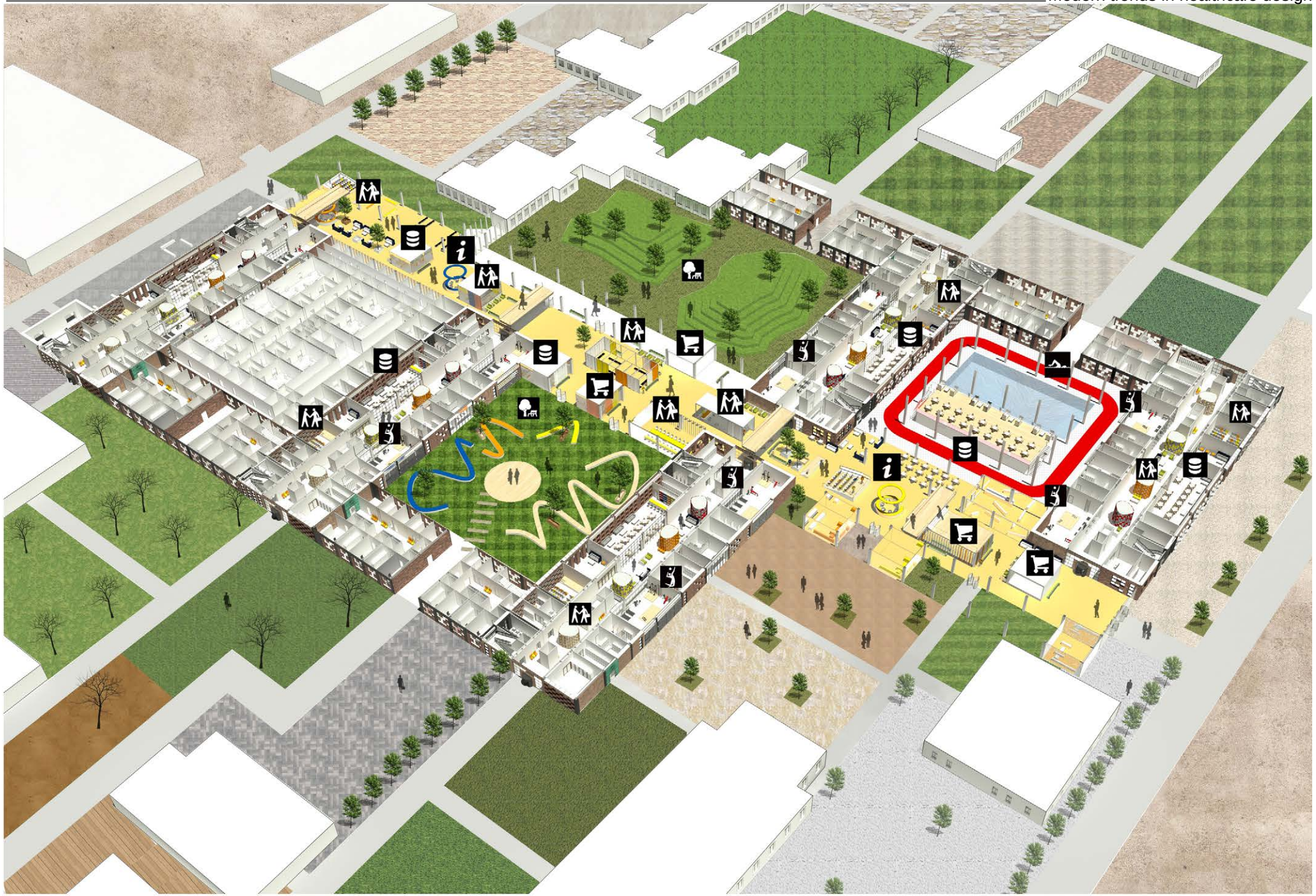


View of the common space in ward floor

4.1.8. Healthcare related facilities as driver and source of income

There is no doubt that the core function of the hospital is to treat the patients. But the hospital should be considered not as an island within the city or medical anclave but the useful part of urban tissue which are incorporated into it. For these reasons healthcare related facilities, especially on the ground floor, can be added to the core function of the hospital and bring added value into it.
Farmacies, consultancy rooms for different medical products, healthcare insurance offices, meeting and office rooms, green spaces and internal gardens, cafes and restaurants, perfume shops, sport halls and swimming pools, etc. - all these functions can be accomodated on the ground floor of the hospital and can be combined into one big healthcare mall - the place where people can use their time and not just spend it.

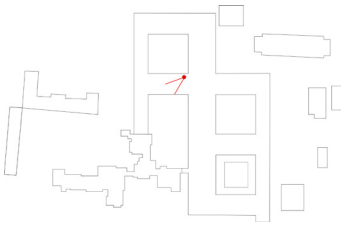
The accommodation of healthcare related activities on the ground floor of the hospital around the main street change the phylosophy of visiting the hospital. Instead of boring and endless waiting for the appointment visitors can use the waiting time for shopping, business, sport or rest activities on the ground floor. The application specifically designed for the hospital and available by Internet will help people not miss the actual time of their appointment while they can do a lot on the ground floor before or after it. By using this strategy hospital not only becomes valuable and inclusive part of urban tissue but also generates additional income by accommodating of all these healthcare related services and facilities (Franzen et al, 2011).



3d scheme of ground floor plan of the hospital with locations of healthcare related facilities

4.1.9. Natural light as essential component of healing environment

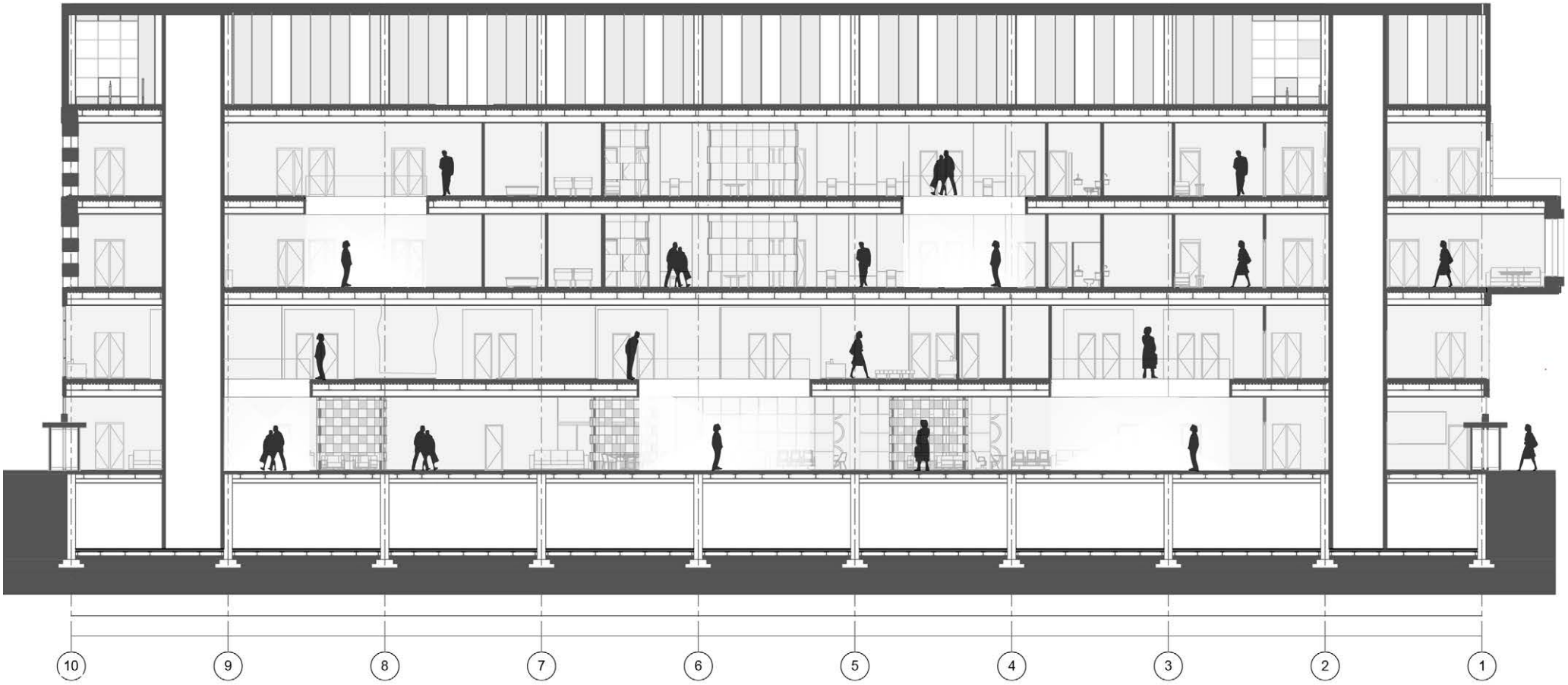
Natural light is the vital part healing environment in the hospital (Mens, 2014). The spatial configuration of standard hospital block which has a width of 23,4 m allows to bring natural dailight in all rooms and spaces of the building. Moreover, light holes between two floors lying one above the other do not only bring additional light into middle spaces of the block but also make the waiting areas higher, more sociable and inter-connected and eliminate narrow lightless corridors (Gola, 2012).



Meeting area with access of the natural daylight

Common space in the out-patient clinic floor with access of the natural daylight

Double-story waiting area in the middle of the floor with light hole



Longitudial section of standard hospital building showing light holes in waiting areas

Plan of the policlinic floor with light holes in the middle areas

4.2. Caregivers

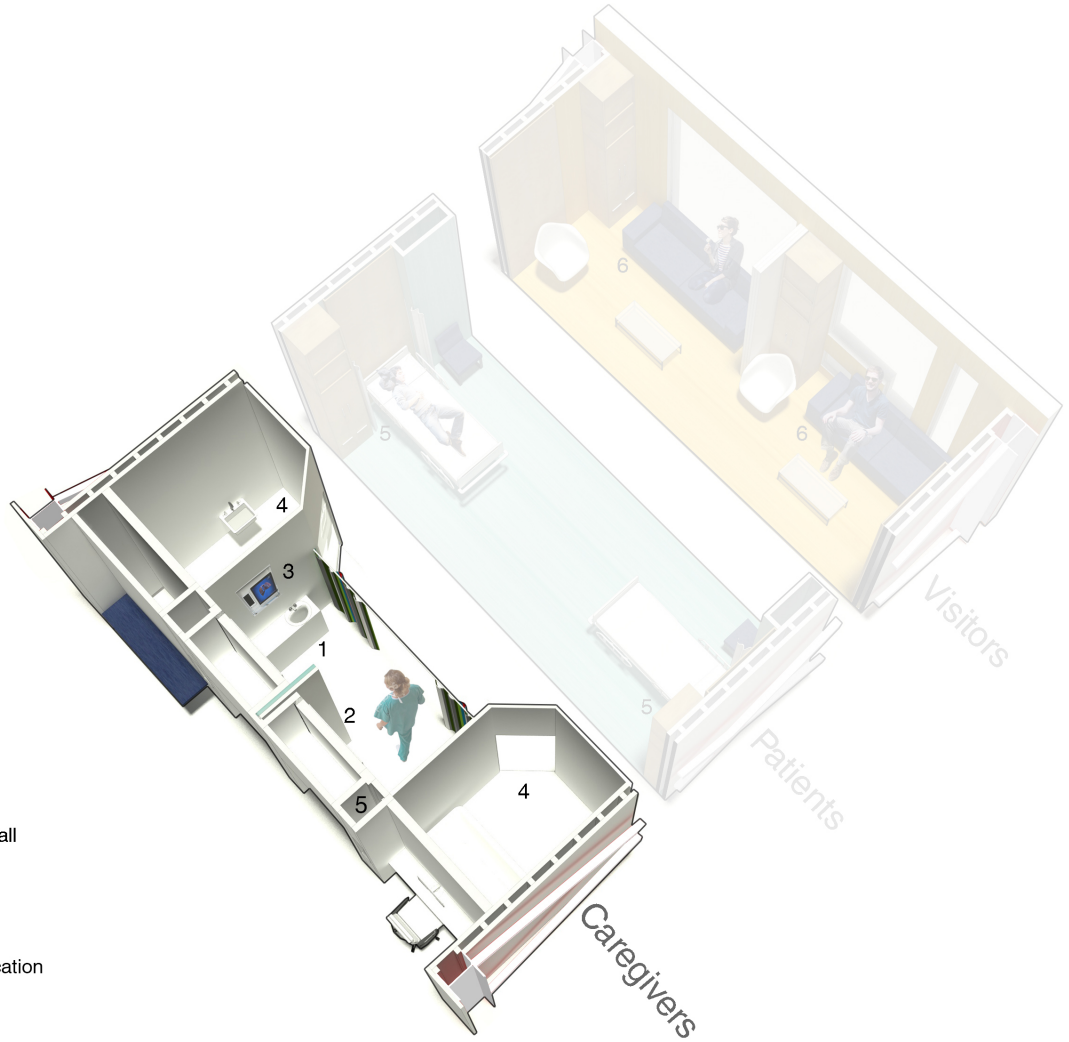
4.2.1. De-centralized nursing stations

Nurse station in the ward floor is a crucial component of daily health care process in the hospital. All information regarding curent state of the patients in the wards comes and accommodates here. Moreover, emergency calls and signals from the wards are also come here. Traditionally, each hospital floor has one or two central nursing points. These points are fixed in spatial layout of the floor (Wagenaar et al, 2006). Decentralized nursing stations, or, in other words, presence of several of them spreadrd on the ward floor, allow to reduce the daily walking distance of the personnel while be concentrated on smaller number of patients which guarantee higher level of care (Capolongo et al, 2012).

Ward floor with desentralized nurse stations

4.2.2. Caregiver equipment in the ward

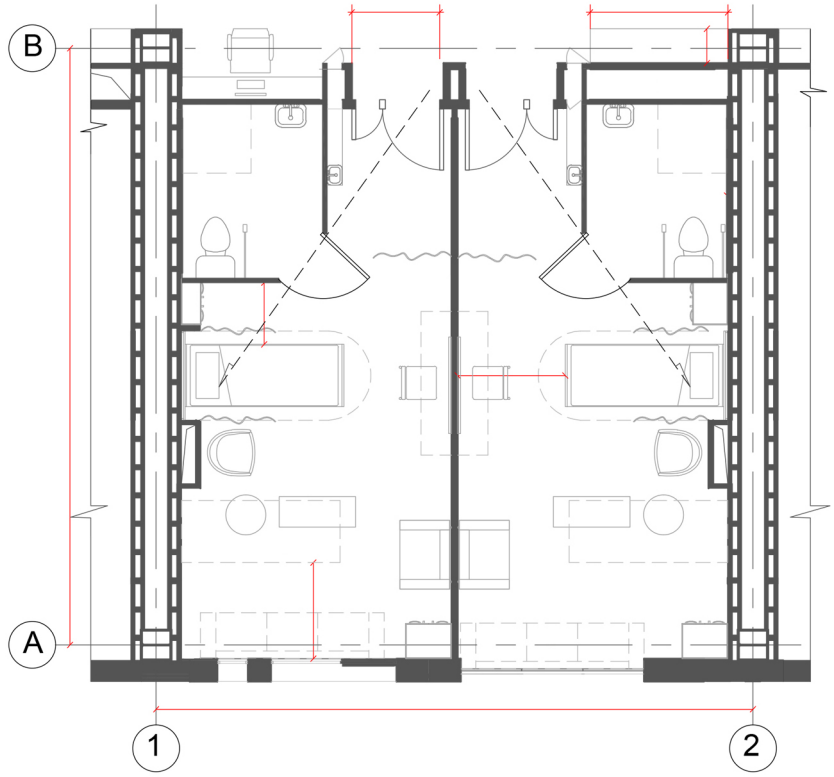
The devision of the ward into three segments - caregiver part, patient part and visitor part, was already described previously. Caregiver part of the standard ward includes sink, monitor with all parameters of the patient health, place for puting medication for current patients without entering to the ward, and curtain which can seprate patient's part of the ward from caregiver's part. Location of prefabricated bathroom which is connected to the corridor wall and also situated in caregiver's part of the ward, allows to maintain or change it in effective way without disturbing the daily work of the hospital floor.

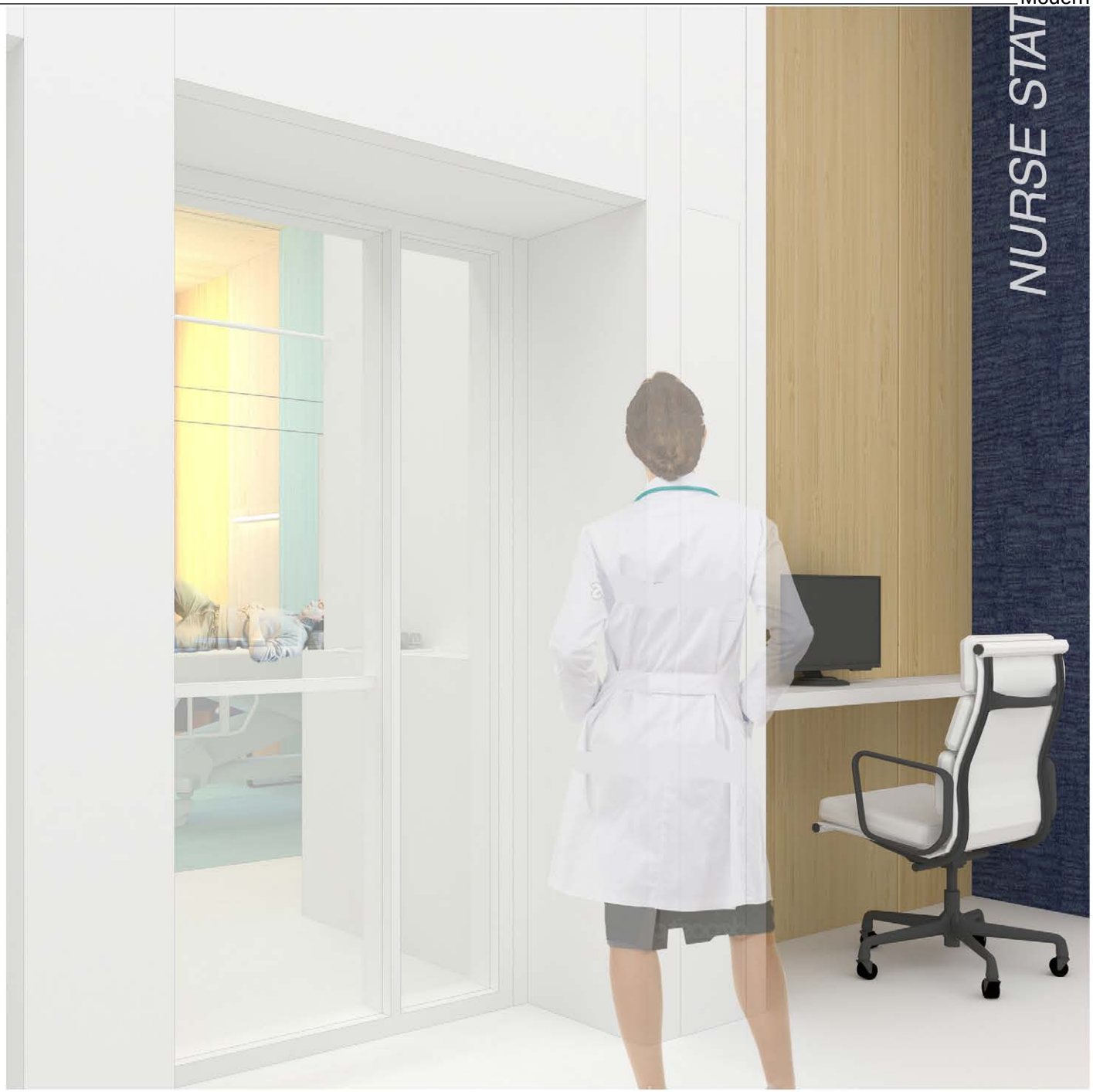


Caregiver’s part of the ward

4.2.3. Visibility of the patient bed from the corridor

Visibility of the ward from the corridor is important component of daily communication between caregivers and patients (Capolongo et al, 2012; Gola, 2012). Visual checking of the ward from corridor by the staff allows them to control patients without entering to the ward and disurbing them. The location of the bathroom in this case is debatable question. On the one hand, location of the bathroom near corridor wall reduces visibility of the ward from the corridor. On the other hand, positioning of the bathroom near external wall reduces the amount of sun light passing to the ward as well as makes technical difficulties based on climate conditions in Russia. Finally, the positioning of the bathrooms in the middle of the ward reduces flexibility because in this case ward cannot be united. Based on this analysis the position of the bathroom near corridor wall was choosen. In order to provide better visibility of the ward from corridor one corner of it is bevelled.

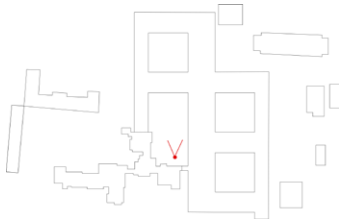




Visibility of the ward from corridor

4.2.4. Internal gardens

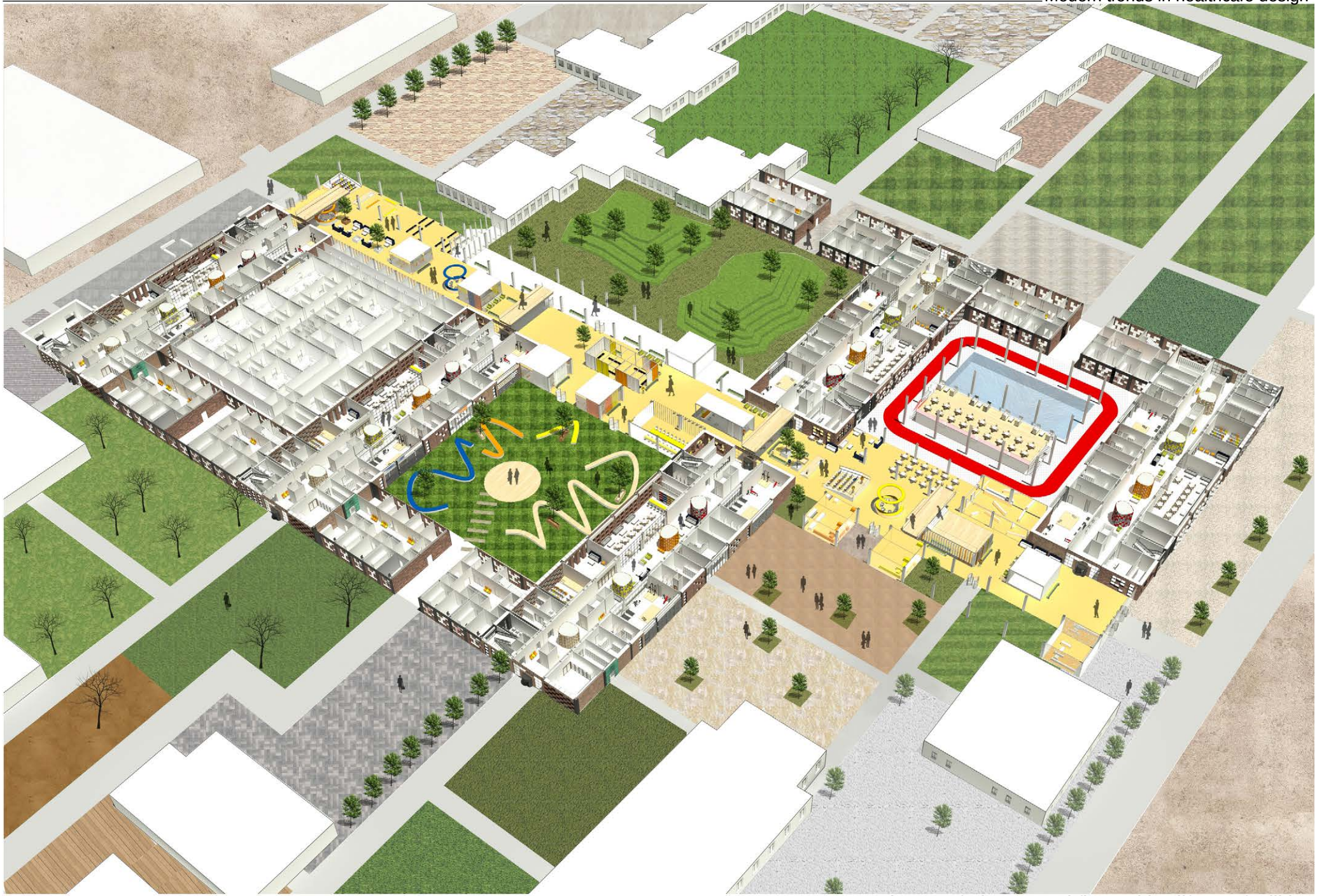
Gardens are used not only by in- and out-patients, but also by the staff. Beside the work with the patients in an open air, gardens are designed for the rest of caregivers during the shift. Healing environment provided by green spaces in the hospital reduces stress which takes place during the shift of the personnel and allow different user groups of the hodpital to communicate in a friendly and natural environment (Wagenaar et al, 2006).



Internal garden on the ground floor

4.2.5. Staff facilities on the ground floor

Ground floor of the hospital as well as hospital street is a multi-functional place where all users are met. Caregivers can use this level during the shift and all its facilities, such as sport facilities, food courts, office and meeting spaces, etc. The use of these facilities are included in the social package of the caregivers and they can use them for free while working.

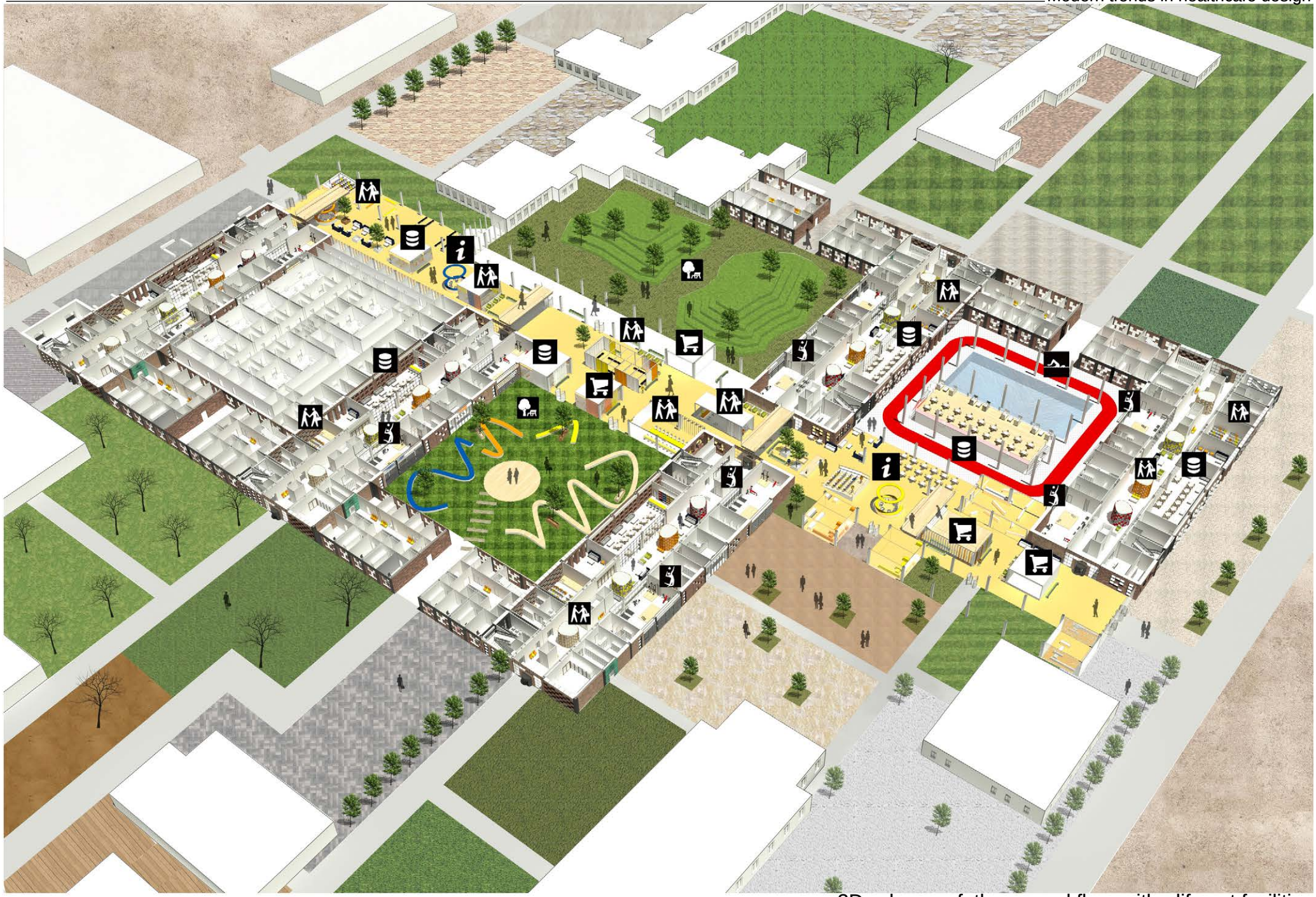


3D scheme of the ground floor with diferent facilities

4.3 Visitors

4.3.1. Hospital street. Place where you can use time, not spend it

Ground floor as multi-functional space fo all types of users was already described previously. Visitors can use all facilites while waiting their appointment or meeting with in-patient relative. Based on a lot of activities presented on the floor, visitor can use the waiting time in effective way. It can be office and meeting spaces for business cases, or taking lucn in cafeteria, walking in the park with their relatives or even using of sport fcilities.

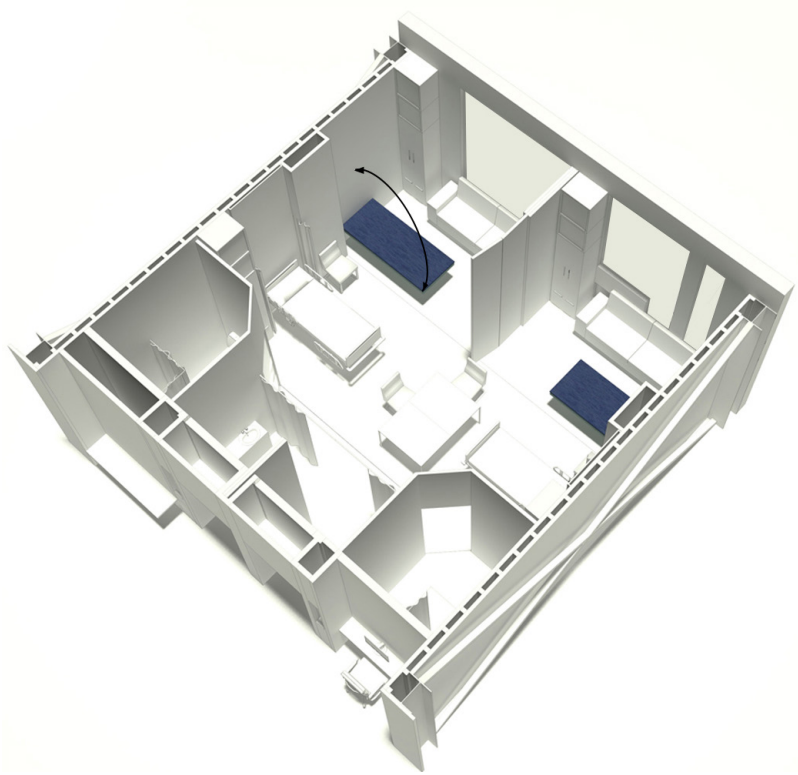


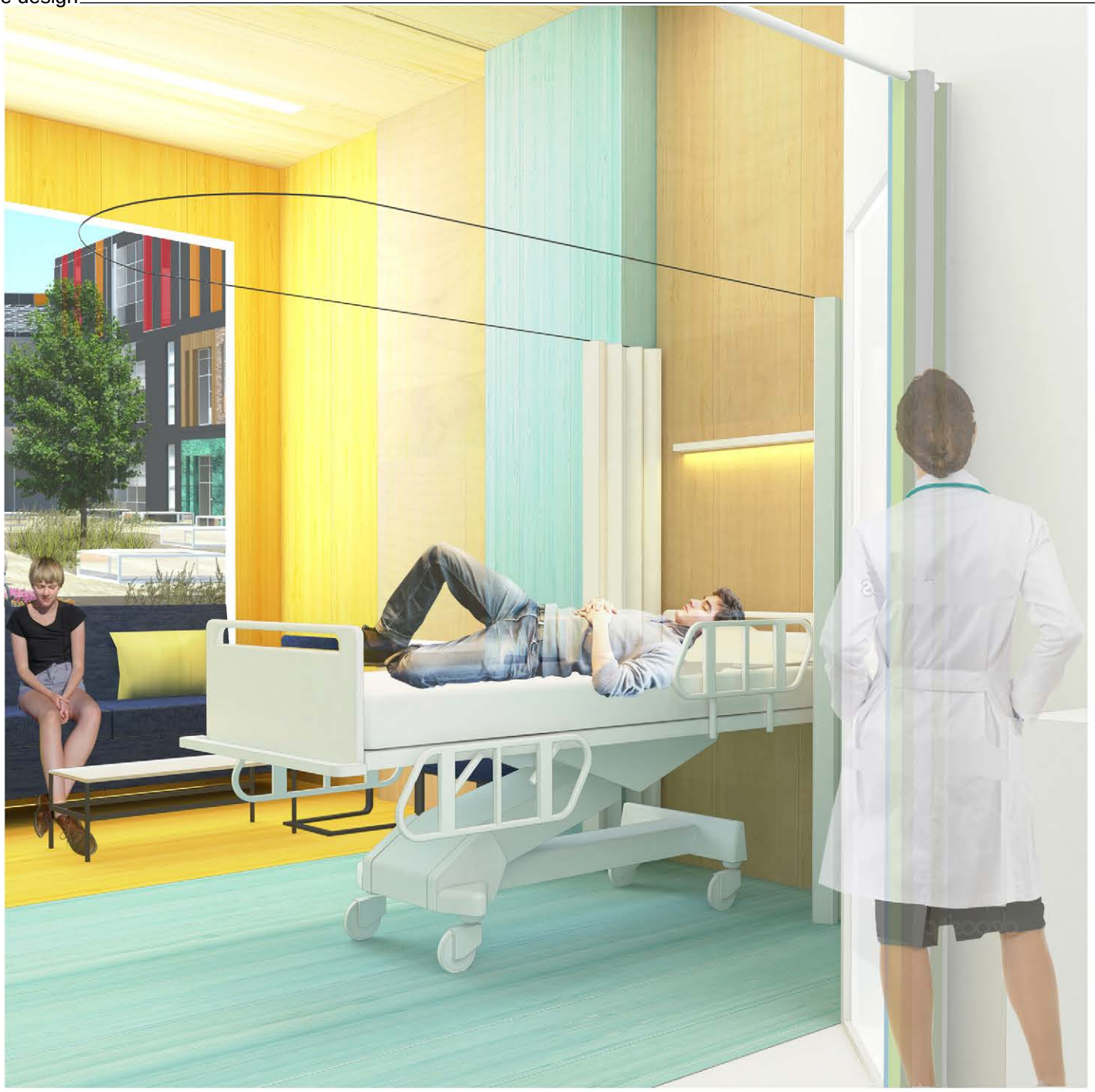
3D scheme of the ground floor with diferent facilities

3D view of the sport hall in one of the covered internal yards on the ground floor

4.3.2. Visitor’s part of ward

Visitor’s part of the ward contains folded sofa, cupboard, table and chairs for comfortable communication witht he patient and staying in the ward for a period of time. Depends on the layout of the ward, second folded sofa instead of patient bed can be added in order to provide an accommodation for additional visitor.

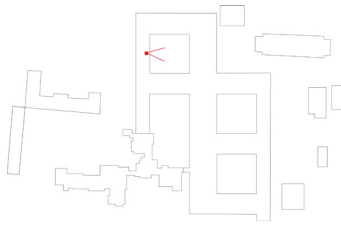




Standard patient ward

4.3.3. Internal gardens

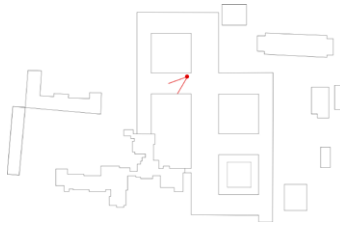
Ineternal hospital gardens were already described in details as place for interaction of all groups of hospital users. Visitors of the hospital can use these gardens and green spaces as well while walking with their relatives who stay in the hospital or while consulting with caregiver regarding health conditions.



Internal roof garden

4.3.4. Space for family's communication

Family-oriented environment is important component of modern hospital. One of its components is private meeting places, where family members can meet each other, or, where doctors can speak with them privately (Wagenaar et al, 2006). That is why presence of small and private spaces for tet-a-tet conversation is important part of hospital environment. Next page represents one of the common spaces in the ward floor with area for private meetings.



Common place on ward floor with area for private metings

4.4.
Final flexibility assessment

Bird’s eye view of the hospital

Levels of flexibility	Types of flexibility	Typological-spatial strategies		Levels of flexibility	Types of flexibility	Typological-spatial strategies	
Hospital complex	Constant surface flexibility	Flexibility of access systems	✓	**Building**	Constant surface flexibility	Existence of shell space for expansion	✓
		Functional flexibility of the system	✓			Structural flexibility	✓
		Reuse of hospital complex	✓			Oversizing of load-bearing structure	✓
		Redundancy of space for plant	✓			Modifiability of the envelope	✓
	Variable surface flexibility	Existence of unused building land	✓			Presence of spaces for building plant infrastr.	✓
		Strategies for increasing volume of buildings	✓		Variable surface flexibility	Oversizing of load-bearing structure	✓
	Operational flexibility	Modular, replaceable and maintainable plant	✓			Possibility of modular expansion	✓
		Presence of networked informational systems	✓			Tiered building	✓
		Use of automation and control systems	✓		Operational flexibility	Modular, replaceable, maintainable plant	✓
		Use of flexible contractual/financial arangements	✓			Efficient programmed maintenance	✓
		Outsourcing of support facilities	✓			Life cycle cost	✓
Macro-area assessment			100 %	Macro-area assessment			100 %

Levels of flexibility	Types of flexibility	Typological-spatial strategies	
Functional unit	Constant surface flexibility	Use of internal dry partition walls	✓
		Use of moveable internal walls	✓
		Use of moveable internal partitions	✓
		Presence of spaces for service building infrast.	✓
	Variable surface flexibility	Possibility of extending entire unit upwards/sideways	✓
		Presence of verandas / setbacks	✓
	Operational flexibility	Plant with flexibility of use	✓
Macro-area assessment			100 %

Levels of flexibility	Types of flexibility	Typological-spatial strategies	
Individual room	Constant surface flexibility	Functional flexibility of the room	✓
	Variable surface flexibility	Possibility of extensions upward / sideways	✓
	Flexibility of use	Providing multifunctional rooms	✓
		Plant for multifunctionality	✓
		Information systems services for multifunc-ty	✓
	Adaptivity of the user	Use of moveable furniture and vertical screening	✓
		Customisable humanisation of the room	✓
Macro-area assessment			100 %

Source: Capolongo et al, 2012).

Conclusions and further research.

The purpose of this thesis was to analyze the main aspects of flexibility in health care design and to test them in reality by design a renovation project of real hospital. The process started from deep analysis of case studies of different existing hospitals as well as design proposals in order to understand main principles of spatial, organizational, structural and urban structure of the modern hospital. SInce the accent of this thesis was focused on hospital within an urban context, sufficient number of hospital extension and renovation projects were studied in order to find an optimal solution and efficient spatial structure. Summary of this analysis is presented in section 1.5.

Russian city of Pensa was choosen as an area for design project based on actual re-development process of one of its hospitals (Burdenko General Hospital) as well as possibility to desgn a meta-project which can be used for renovation and extension of health care facilities in different Russian cities. Morphological scheme proposed for the meta-project was choosen based on the analysis of case-studies mentioned in chapter one. This scheme, called fabrics, is used as main spatial layout in modern hospitals since the beginning of 2000s (Cor Wagenaar et al, 2006). Steb-by-step proposal for extension of Burdenko General Hospital demonstrates flexible meta-project with possibility for further extension on the plot as well as use of the parts of the project for extension of other existing health care facilities in different cities based on modular design.

Different aspects, levels and types of flexibility described in chapter one were used and tested in meta-project of renovation of Burdenko General hospital in order to design flexible and long-term strategy of its extension. Bottom-up approach, which starts from choosing the structural grid and ends with possibility of conversion hospital complex into other functions due to its obsolescence, allowed to test and to demonstrate all parameters of flexibility in this particular project.

Modern hospital trends which were applied to the renovation project of Burdenko General Hospital are described in details in chapter four and subdivided by three main groups of hospital uers - patients, caregivers and visitors. Final assessment table of different parameters of flexibility used on meta-project of renovation of Burdenko General Hospital is presented at the end of the thesis and allows to check which parts of flexible healthcare design were used in this meta-project.

Further research

Additional and deeper research is needed to test flexibility in health care design. This thesis overviewed different instruments for flexible hospital design in a brief way in order to give the reader possibility to see the entire process of implementation flexibility in healthcare design on different levels. Economical and financial aspects of prefabrication in hospital design were not described in this thesis while they require additional calculations and elaboration. On the one hand, production of prefabricated modules with pre-installed technical equipments is considered as sustainable and cost-efficient based on easier installation process on construction site and higher level of assembly works in the factory.

On the other hand, transportation costs of the modules to construction site can reduce economical benefits of prefabricated production method (Capolongo et al, 2016).

Healthcare facilities is one of the building typologies which demonstrate growing demand for modular construction (Forta Medical, 2011). Creation of standardized, prefabricated and unified solutions in health care design is one of the approaches to get high quality and operability in this field together with variety of spatial and architectural solutions. Continuous research for organisation of health care facilities in a modular way requires additional cost analysis, improving of standard elements as well as closer attension to technological plants and installations which require more and more space in hospital layout (Cor Wagenaar, et al, 2006).

The spatial layout of the meta-project presented in this thesis can be a basis for further work and research in this field in order to deliver high spatial quality of hospital complex together with adaptable installation systems and sufficient cost-benefit analysis of modular construction.

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