POLITECNICO DI MILANO

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MASTER SCIENCE OF ARCHITECTURAL ENGINEERING

MASTER THESIS

A RECREATION HUB

New Hotel + Health Club in Liberec, Czech Republic

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YU Jianghao

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ARCHITECTURE STATEMENT

Why is history no longer a point of reference for contemporary architects? It is now generally understood by those in my generation, and even more so by subsequent generations, that with regard to architecture history has largely supplanted geography.

This evolution of theoretical approaches and sensibilities is laying the foundation of the architecture of tomorrow which will focus primarily on places, strategies, systems and voids, in a word on the neutralization of form.

The disciplinary field of building walls, inserting doors, designing windows and roofs was once sufficient for the architect's role. Today, under the pressure of another essential parameter - the incessant transformation of territories - it has become obsolete. Territories are ever more complex, disparate, fragmented, dense and polluted. A figurative architecture whose terminology is limited to the words "walls," "doors," "facades," and "roof" cannot adequately fulfill their needs.

Now we must think about architecture in terms of landscapes, meaning that we must be fully aware of the face that we are creating artificial landscapes, that the nature in which we live is more artificial. Today, all our efforts consist of attempting to modify the urban fabric, more precisely what we could call the urban substance, a challenge just as jubilatory as it is disturbing, Architects have to cooperate with society to achieve framework of urban planning. Sometimes they can no longer take on the city as a whole. They must give up the quest for the utopian ideal of being able to determine its configuration.

Still we will continue to build more buildings, infrastructures and cities. Rapid urbanization accelerates predatory of city resources. Peter Eisenman said: "***Before becoming 'predatory' as it is today, the city was first and foremost a protective place, a place of birth, development and rootedness***" (Expert form Dominique Perrault's conference, during the EURAU'08 January 19, 2008). It has always carried its own memory within it, as well as the outline of its near future. But how can the city be reconciled with the idea of civilization, of which it is a cornerstone? Part of the answer lies on the relationships we establish between the place, on the one hand, and the building on the other. The concept of the envelope stands at the intersection of these two considerations: it links them. This interface can be context, between the artificial and the nature.

The objective of this procedure is to obtain a transmutation of the part (architecture) into the whole (landscape). More than a mere blurring of perception, the envelope leads to a sort of vanishing of the building, to its gradual disappearance. Whatever motives justify its construction whether to delimit, protect or isolate, the wall create separation - the forbidden.

Once full aware of this limitation, the challenge consists of transfiguring the object that separates in order to substitute with something that links, binds and creates interrelation and exchange; of imagining walls that are more than themselves, that is to say to create places of transition between the outside and the inside, between the public and the private between the urban magma and the intimate sphere; of substituting the wall with an "in between," a new kind of space, one that stimulates the curiosity of users, strikes their emotional being and, the circumventing the filer of the intellect, directly touches their brain.

GOALS

Now the problem between buildings, building and environment, environment and human being is harmonization.

How do we get the relationship between new and old architecture?

How can we replace confrontation with dialog and merge into an organic whole between artificial volume and natural terrain?

How can we strike a balance between population of high-speed growth and sustainable environment?

INDEX

List of figures

1.0 Chapter

2.0 Chapter

3.0 Chapter

4.0 Chapter

5.0 Chapter

List of tables

4.0 Chapter

5.0 Chapter

1.0

INTRODUCTION

Big Liberec!

Liberec when you say, most people remember the center of Babylon and Jested.

The North Bohemian district town of Liberec, which you are most welcome to visit, is located in the valley between the Ještěd Ridge and the Jizera Mountains. Its history goes back to the times of merchant paths leading through this area. As the crossing of the Ještěd Ridge was highly demanding, it was necessary to create a resting place for travelling merchants. Therefore Liberec was gradually established as an open market settlement and it was this fact which determined the character of the town. The first stone edifices were built then and for a long time characterized the town.

New, more prominent changes took place in the second half of the 18th century. At this time, the centre of Liberec consisted of brick houses in the classical style. The beginning of the 19th century saw the growth of the textile industry which brought about the development of industrial architecture. This fact leads to the town acquiring independent status.

Web sources: http://www.infolbc.cz/en/liberec/historie.html

Nowadays, Liberec offers many interesting sites. In downtown there are many buildings which are the pride of the town - for example, the town hall built in neo-renaissance style, a symbol of wealth and the economical as well as cultural development of the town. Behind the town hall, there is the Theatre of František Xaver Šalda dating from 1893. A museum, chamber of commerce and a building society originating from 1901-02, with their grandeur and clarity of style, form the jewels in the crown of the historical part of the town. The rarest jem is the villa quarter from the turn of the 20th century which by its uniqueness attests to the wealth of Liberec at that time.

Liberec may be a big city by Czech standards, but stepping off the bus at the main station you can immediately tell you're out of the capital as the air is remarkably fresher than Prague.

Memory

In September 2009, there is an international workshop was organized by Polytechnic of Milan (Italy) and Technical University of Liberec (Czech Republic). The location is Liberec. It is a happy and memorable experience. Liberec is charming place: a harmonious merger of classic and modern; enthusiasm and preciseness. Perhaps it is the result of North Bohemian culture.

Project

Because I am interesting in the distinctive cultural background, I chose the project in Liberec as my diploma project.

Competition

The project also is a competition which is organized by ECE Projekt management Praha s.r.o and Technical University of Liberec.

The goal of competition is: **the design of a building/structure or complex of buildings without further functional specification or proposal of a different use of the given area**

Site

The location of site is close to historical centre. As mentioned above, the excavation works have been already done, but the company ECE did not get the further permit of construction, so they had to backup from the intention.

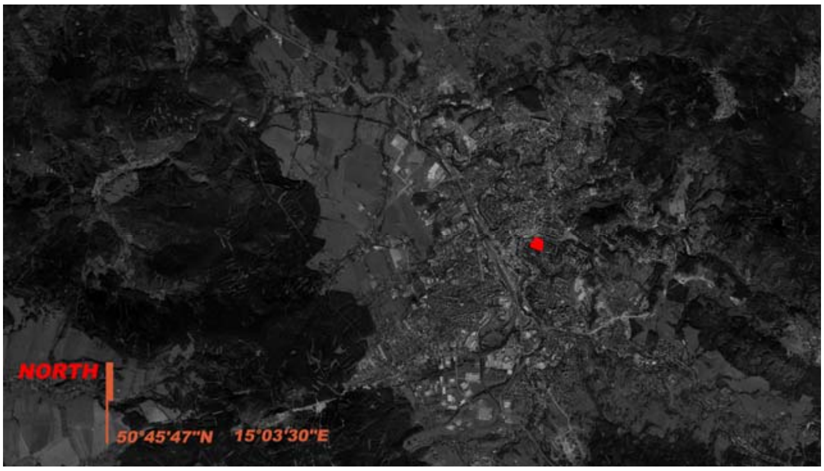


Figure 1.1 Liberec map

In the following chapters I will present my thesis in detail from these aspects: Urban Analysis, Urban design, Architecture design, structure design and Technology design.

1.1 Czech Republic

1.1.1 Geography

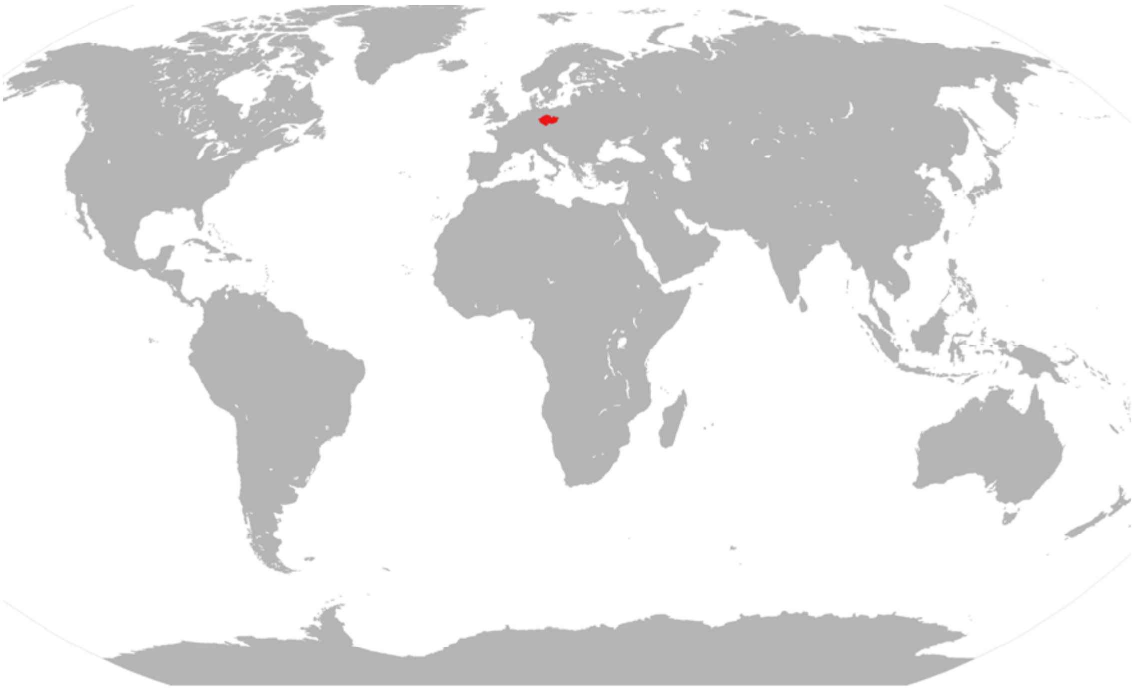


Figure 1.2 World map

Figure 1.3 Location of Czech Republic

Location: Central Europe

Area: 78.864 square km

Borders with countries: Germany, Poland, Austria, Slovakia

Population: 10,300,000 inhabitants

Capital: Prague with 173 000 inhabitants

Administrative language: Czech

Climate: Mild continental, four seasons, changeable winters, warm summers

Time zone: Central European Time

Currency: Czech Crown – CZK 1 = 100 haler

Largest cities: Prague, Brno, Ostrava, Plzen, Olomouc, Liberec

Political system: democratic republic with two legislative chambers – The Chamber of Deputies and Senate

1999, March 12 the republic has become a member of NATO

2004, May 1st, entry of the Czech republic to European union

1.1.2 History and development

Czech Republic is a landlocked country in Central Europe.

Web sources: http://www.international.ucla.edu/euro/countries/easteurope/index.asp

The country is bordered by Poland to the northeast, Slovakia to the east, Austria to the south, and Germany to the west and northwest.

The Czech Republic has been a member of **NATO** since 1999 and of the **European Union** since 2004. The Czech Republic is also a member of the **Organization for Security and Cooperation in Europe (OSCE)**. As an OSCE participating State, the Czech Republic's international commitments are subject to monitoring under the mandate of the U.S. Helsinki Commission. From 1 January 2009 to 30 June 2009, the Czech Republic held the Presidency of the Council of the European Union.

The Czech state, or Lands of the Bohemian Crown as it was known until 1918, was formed in the late 9th century.

The country reached its greatest territorial extent during the 13th and 14th century, under the rule of the Přemyslid and Luxembourg dynasties. Following the Battle of Mohács in 1526, the Kingdom of Bohemia was integrated into the Habsburg monarchy as one of its three principal parts[citation needed] alongside Austria and Hungary. The independent Republic of Czechoslovakia was formed in 1918, following the collapse of the Austro-Hungarian empire after World War I. After the Munich Agreement (signed by Nazi Germany, France, Britain and Italy), Polish annexation of Zaolzie and German occupation of Czechoslovakia and the consequent disillusion with the Western response and gratitude for the liberation of the major portion of Czechoslovakia by the Red Army, the Communist party won plurality in the 1946 elections.

In a 1948 coup d'état, Czechoslovakia became a communist-ruled state. In 1968, the increasing dissatisfaction culminated in attempts to reform the communist regime. The events, known as the Prague Spring of 1968, ended with an invasion by the armies of the Warsaw Pact countries (with the exception of Romania); the troops remained in the country until the 1989 Velvet Revolution, when the communist regime collapsed. On 1 January 1993, Czechoslovakia peacefully dissolved into its constituent states, the Czech Republic and Slovakia.

The Czech Republic is a pluralist multi-party parliamentary representative democracy. President Václav Klaus is the current head of state. The Prime Minister is the head of government (currently Petr Nečas). The Parliament has two chambers: the Chamber of Deputies and the Senate. It is also a member of the Organisation for Economic Co-operation and Development (OECD), the Council of Europeand the Visegrád Group.

1.1.3 Economy

The Czech Republic made economic reforms such as fast privatizations. Annual gross domestic product (GDP) growth stood at around 6% until the outbreak of the recent global economic crisis. The country is the first former member of the Comecon to achieve the status of a developed country according to the World Bank (2006).

In addition, The Czech Republic has the highest human development in Eastern Europe, ranking as a "Very High Human Development" nation. It is also ranked as the most democratic, peaceful and healthy (by infant mortality) country in the region.

1.2 Liberec

1.2.1 Geography

Figure 1.4 Czech Republic map

Liberec region

It locates in North Bohemia on the borders of Saxony and Poland, neighboring the regions Hradec Králové, Central Bohemia & Ústí nad Labem. Its area is just 3,163 km^2 or 4.0 % of the national territory. As of H1 2009 the region had 437,168 inhabitants, which was about 4.2 % of the population of the Czech Republic, one of the smallest among all regions in the country.

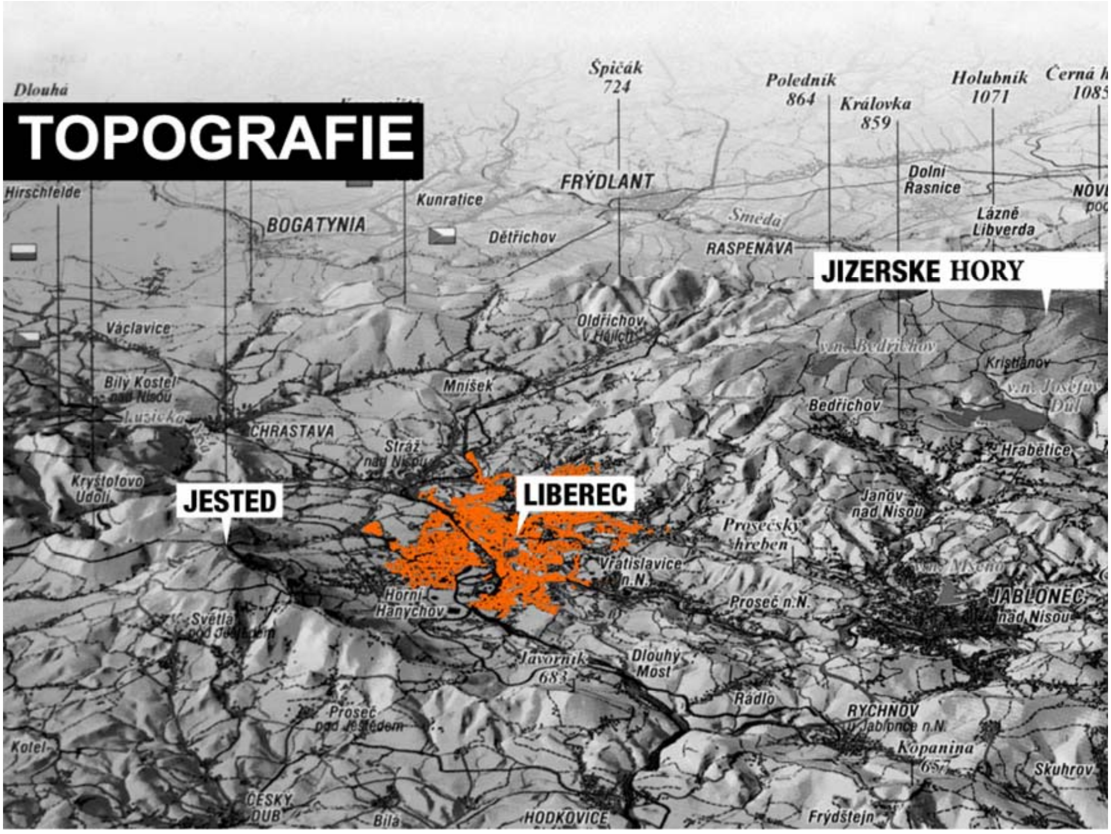


Figure 1.5 Topography of Liberec 1

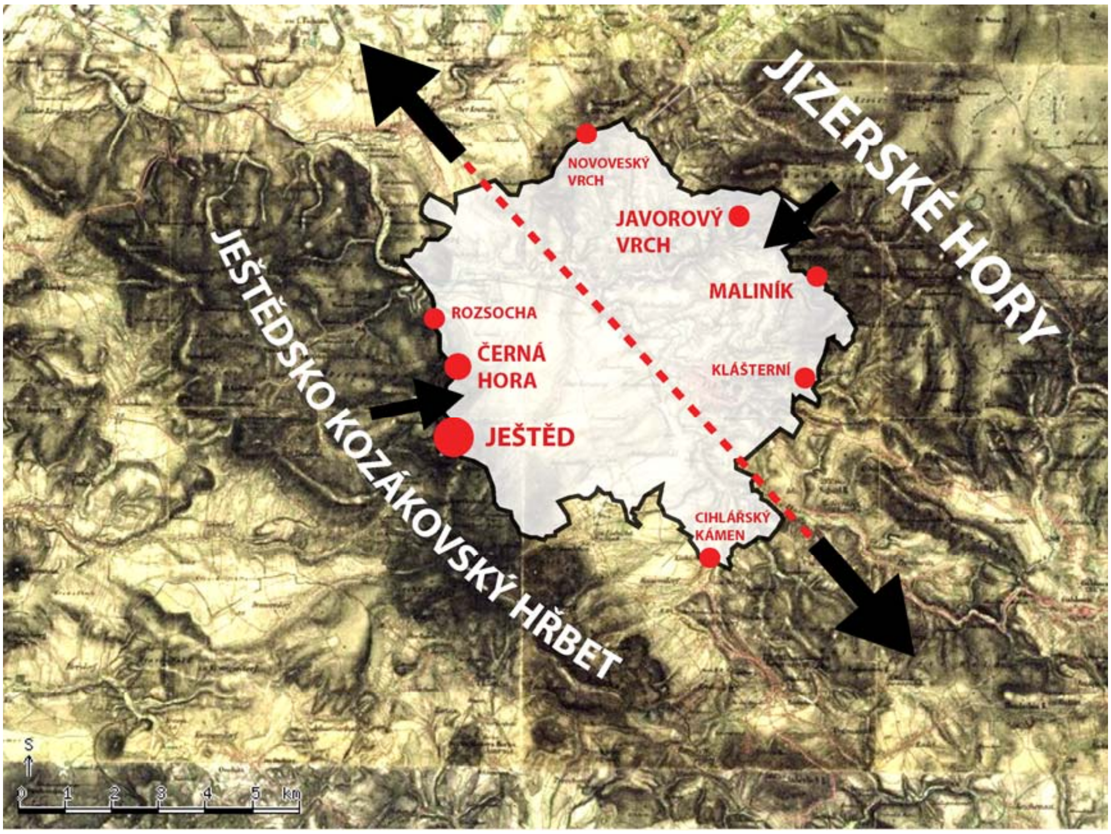


Figure 1.6 Topography of Liberec 2

Figure 1.7 Liberec region

The region is composed of 4 districts - **Česká Lípa**, **Liberec**, **Jablonec nad Nisou** and **Semily**

The regional capital of Liberec district

Land area: 925 km2

Population: 99721

Climate: Great Inland Ocean aptitude is the transition temperate climate. Annual average temperature is 6.5 ℃, annual precipitation volume 700 mm.

Liberec is traffic hub among European cities as well as in Czech Republic.

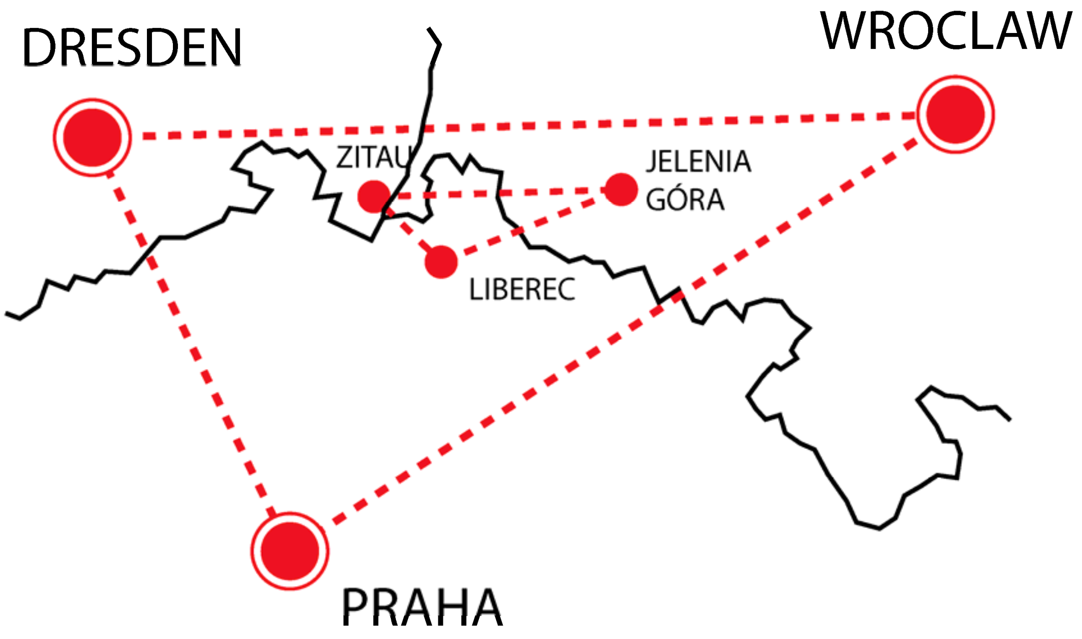


Figure 1.8 Relationship among cities 1

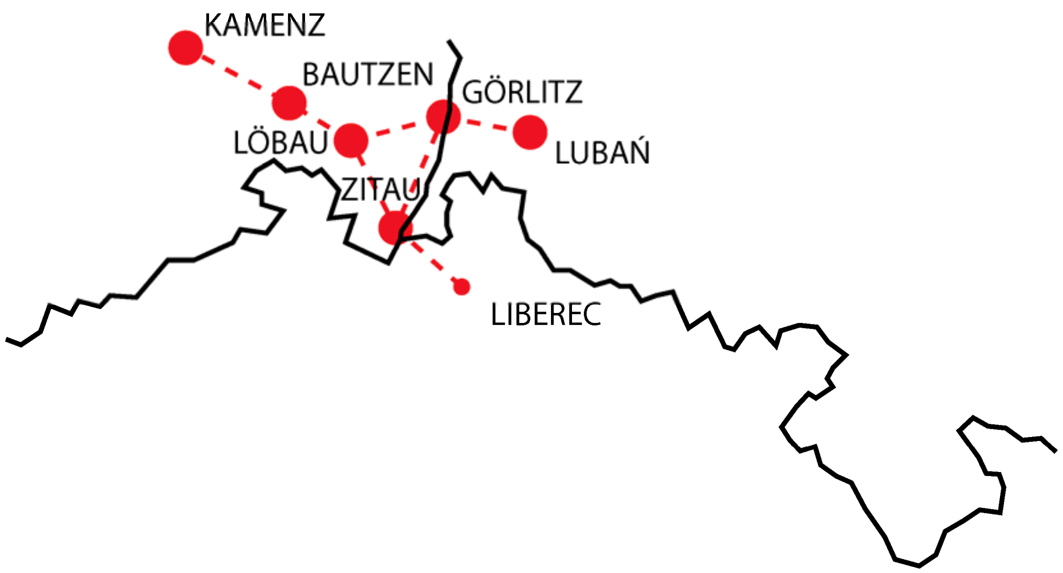


Figure 1.9 Relationship among cities 2

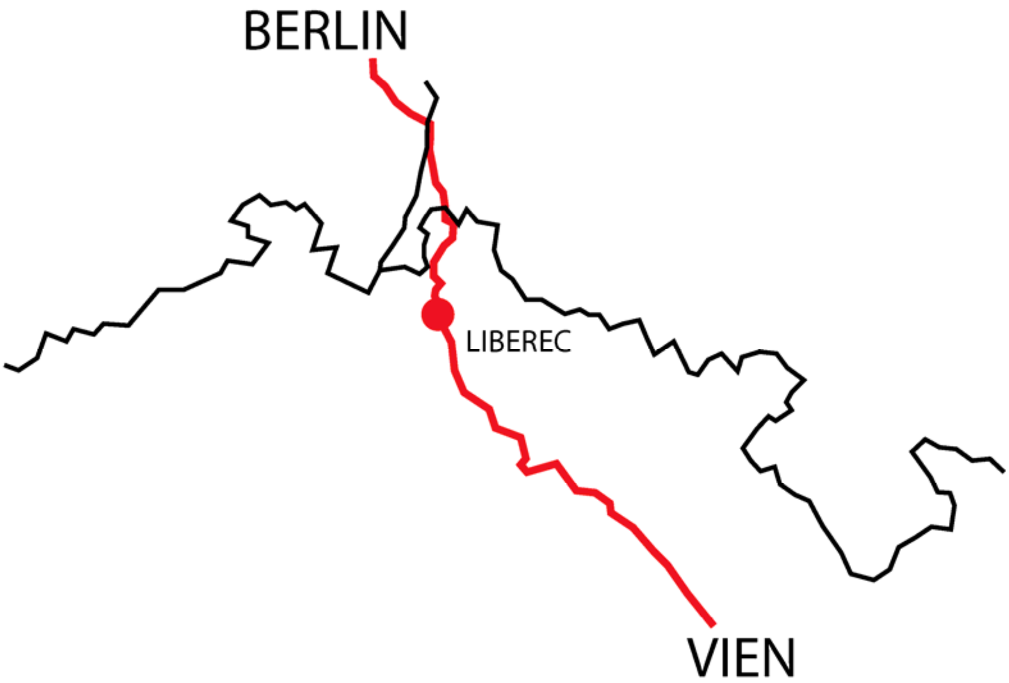


Figure 1.10 Relationship among cities 3

COMPARISON TRAVEL TIME BY TRAIN AND BUS BETWEEN LIBEREC AND SELECTED CITIES

	PRAHA	BRNO	OSTRAVA	ÚSTÍ n L	HADEC	PLZEŇ	DRÁŽĎANY
train	2:36	4:47	5:47	2:14	2:33	4:53	2:13
bus	1:05	5:00	7:45	2:00	1:50	3:00	6:45

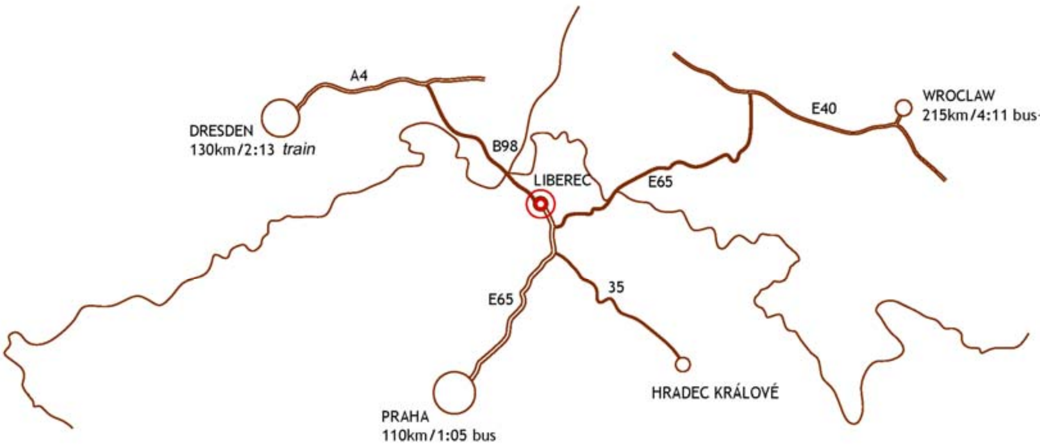


Figure 1.11

Comparison travel time by train and bus between Liberec and selected cities

1.2.2 History

Web sources: http://en.wikipedia.org/wiki/Librec

Liberec was first mentioned in a document from 1348, and from 1622 to 1634 was among the possessions of Albrecht von Wallenstein. After his death it belonged to the Gallas and Clam Gallas families. The cloth-making industry was introduced in 1579. The prosperous local industry was interrupted by the Thirty Years' War and a great plague in the 1680s. The Battle of Reichenberg between Austria and Prussiaoccurred nearby in 1757 during the Seven Years' War.

At one time the second city of Bohemia, the city developed rapidly at the end of the 19th century and as a result has a spectacular collection of late 19th century buildings; the town hall, the opera house, and the Severočeské Muzeum (North Bohemian Museum) are of significant note. The Opera House has a spectacular main curtain that was designed by the Austrian artist Gustav Klimt. The neighborhoods on the hills above the town center display beautiful homes and streets, laid out in a picturesque Romantic style similar to some central European thermal spas.

After World War I, the Lands of Crown of Bohemia, consisting of Bohemia, Moravia and Silesia one of the parts of Austria over throwed the Hapsburg rule to became independent. All those lands had mixed population of Czech and German language; some Germans refused to be incorporated into Crown of Bohemia, citing Woodrow Wilson's Fourteen Points and the doctrine of Self Determination. An independentSudeten German provinces of Austria was briefly formed with Reichenberg as the nominal Capital. Therefore, Czechoslovak Army occupied with no military clashes the whole area of the secessionist provinces and reintegrated them into Crown of Bohemia which was renamed to Czechoslovakia.

During the 1920s and 1930s, Liberec became unofficial capital of Germans in Czechoslovakia. This position was underlined by foundations of important institution, like Buecherei der Deutschen, a central German library in Czechoslovakia, and by failed effort to relocate German (Charles) University from Prague to Liberec.

The World Crisis devastated the economy of the area with its textile, carpet, glass and other light industry. High number of unemployed people, hunger, fear of future and ignorance of Prague government led to the flash rise of populist SdP Party founded by Konrad Henlein, born in the suburbs of Liberec. However he declared fidelity to the Republic, he secretly negotiated with Adolf Hitler. In 1937 he radicalized his views and became voluntarily Hitler's puppet in order to destabilise and occupy the Czechoslovakia, which was an ally of France and was one of the leading weapon producers in Europe. The city became the centre of Pan-German movements and later the Nazis especially after the 1935 election, despite it had an important democratic major Karl Kostka (Deutsch-demokratische Freiheitspartei). The final change came in summer 1938, after the radicalisation of the terror of the Sudeten German Party (SdP), whose death threats forced Karl Kostka and his family to flee to Prague.

In September 1938, after two SdP's unsuccessful attempts of Nazi coup in Czechoslovakia which were suppressed by police and army, finally the Munich Agreement of 1938 changed the city to the capital of the Sudetengau within Nazi Germany. Most of the large city's Jewish and Czech population fled to the rests of Czechoslovakia or were expelled. Precious synagogue was burned down. After the World War II, the liberated town became again a part of Czechoslovakia and nearly all of the city's German population was expelled following through the Beneš decrees. The region was then resettled by the Czechs. Until today, the city has an important German minority, consisting of anti-nazi Germans active in struggle against Hitler as well as Germans from Czech-German families and its descendents. Liberec has also a Jewish minority with a newly-build synagogue and Greek minority of Communist refugees settled here after Greek Civil War in 1949.

Historical names

1352	Reychinberch
1369	Reychmberg
1385–99	Reichenberg
1410	Rychmberg

1545 Rychberk

1592 Lychberk

1634 Libercum

1790 Reichenberg, Liberk, Habersdorf

1834 Reichenberg, Liberk

1845 Reichenberg, Liberec

1.2.3 Culture

1.2.3.1 Custom

North Bohemian and East Bohemian influence Liberec

Many towns in the region also have a rich glassmaking tradition and visitors can see with their own eyes how world-renowned Bohemian glass is made.

Figure 1.12 Custom pattern

1.2.3.2 Feature

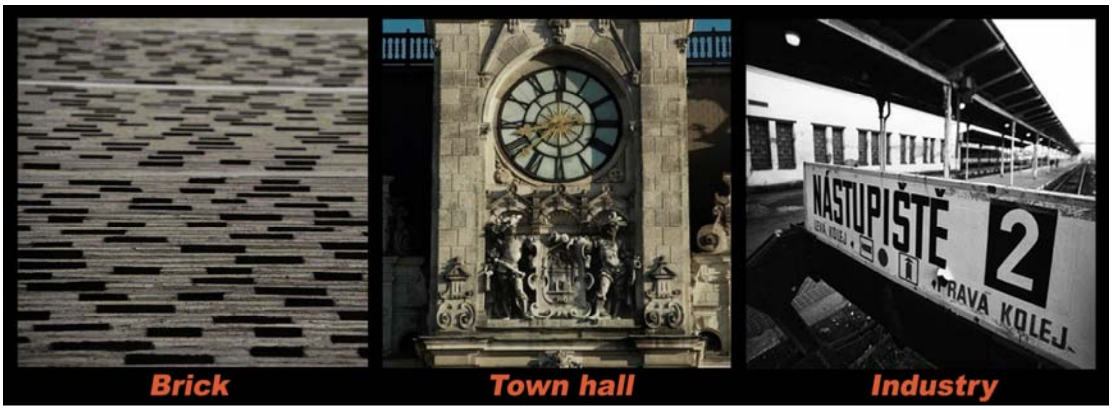


Figure 1.13 Feature

In 2nd half 1900's, the center of Liberec consisted of brick houses in the classical style.

Industrial architectures are due to the growth of the textile industry.

Landmark Town hall is Neo-Renaissance style.

1.2.4 Tourist resources

1.2.4.1 Natural resources

Liberec region divides 3 landscape regions

Figure 1.14 Landscape region

The bohemian Paradise (Český ráj)

A romantic region where diverse natural beauty combines with rich historical monuments.

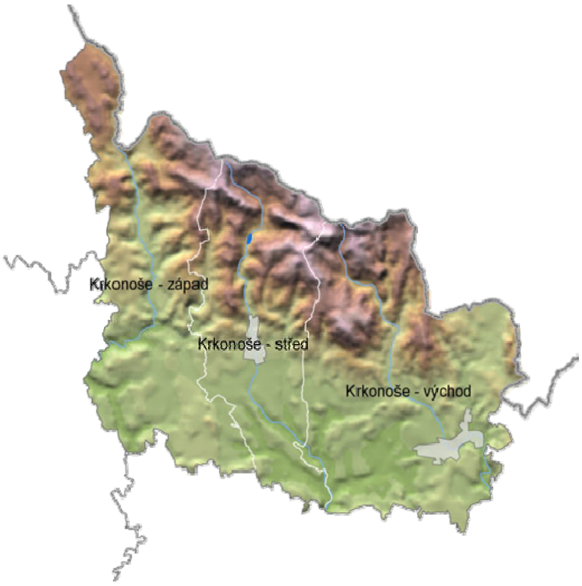
Figure 1.15 Bohemian Paradise

North Bohemia

A region with an extraordinarily valuable cultural landscape which is attractive to tourists in both summer and winter.

Figure 1.16 North Bohemia

The Giant Mountains (Krkonoše)



The best known and highest Czech mountains are of interest both in summer and in winter.

Figure 1.17 Giant mountain

1.2.4.2 Sports

Figure 1.18 Sport activities

The Liberec Region is ideal for an active holiday. Those interested in swimming or winter sports will find all they need at Mácha's Lake or in the Holany Ponds area. The area is also interwoven with a number of marked cycling paths. Meanwhile, the Jizera Mountains are home to one of the best known cross-country skiing tracks in the country, the Jizera Mountain Cross-Country Track.

Winter sports

- Downhill skiing in Jested
- Cross-Country skiing areal in Vesec

Summer sports

- Tourist pedestrian / cycling

Sport events

Liberec has hosted two European Luge Championships, having done so in 1914 and 1939 when the city was then known as Reichenberg. In 2009, it hosted the FIS Nordic World Ski Championships.

Web sources: http://wn.com/Liberec

- EYOWF 2011

  The 10th European Youth Olympic Winter Festival 2011 (EYOWF) was solemnly opened on Saturday, 13 January, in the Liberec ice hockey arena.

- World championship in classic skiing in Liberec 2009
- Jizera 50 Cross-Country skiing competition
- Hockey: Bily tygri club and football: Slovan club in Liberec

  FC Slovan Liberec a football club founded in Liberec and currently playing the highest division (Gambrinus liga). FC Slovan Liberec is one of the most successful clubs in the Czech Republic (2 league titles). HC Bílí Tygři Liberec finished top of the Extraliga (the highest national ice hockey league) in 2007-8.

This map shows that distribution of sport and recreation points and area within the city.

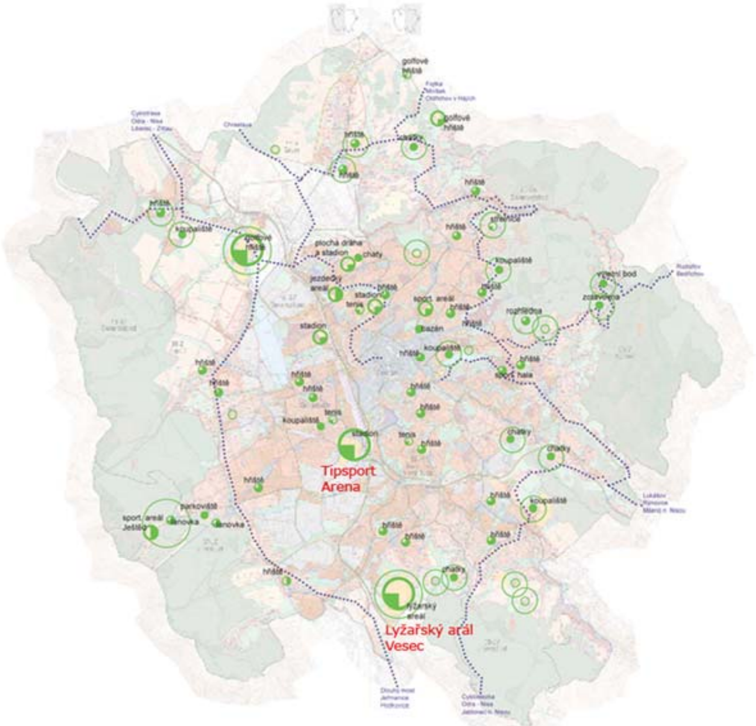


Figure 1.19 Sports and recreation points within Liberec

This map shows that distribution of sport and recreation points and area close but out of the city.

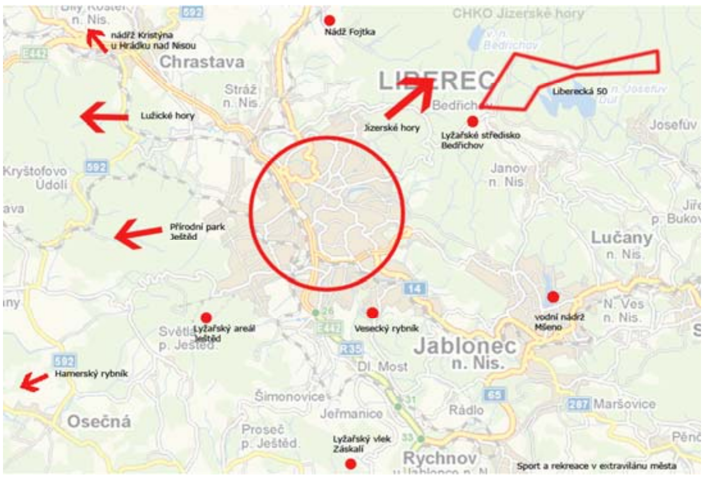


Figure 1.20 Sports and recreation points out of Liberec

1.2.4.3 Attractions

The Liberec Region has a rich tradition represented by many historical buildings and monuments, such as the North-Bohemian Museum in Liberec, the Regional Gallery in Liberec, the State Scientific Library in Liberec, the F. X. Šalda Theatre, the Naive Theatre, or the Zoological and Botanical Gardens in Liberec. A number of museums and galleries are scattered about the Region. Those interested in tradition of glass and artificial jewellery can visit, for example, museums of glass making in Nový Bor, Kamenický Šenov and Železný Brod or the Museum of glass and artificial jewellery in Jablonec nad Nisou, the Czech Paradise Museum in Turnov with collections from the area of geology, mineralogy and documentation of goldsmith's art and jewellery making, which are unique not only within the Czech Republic but also as in Europe.

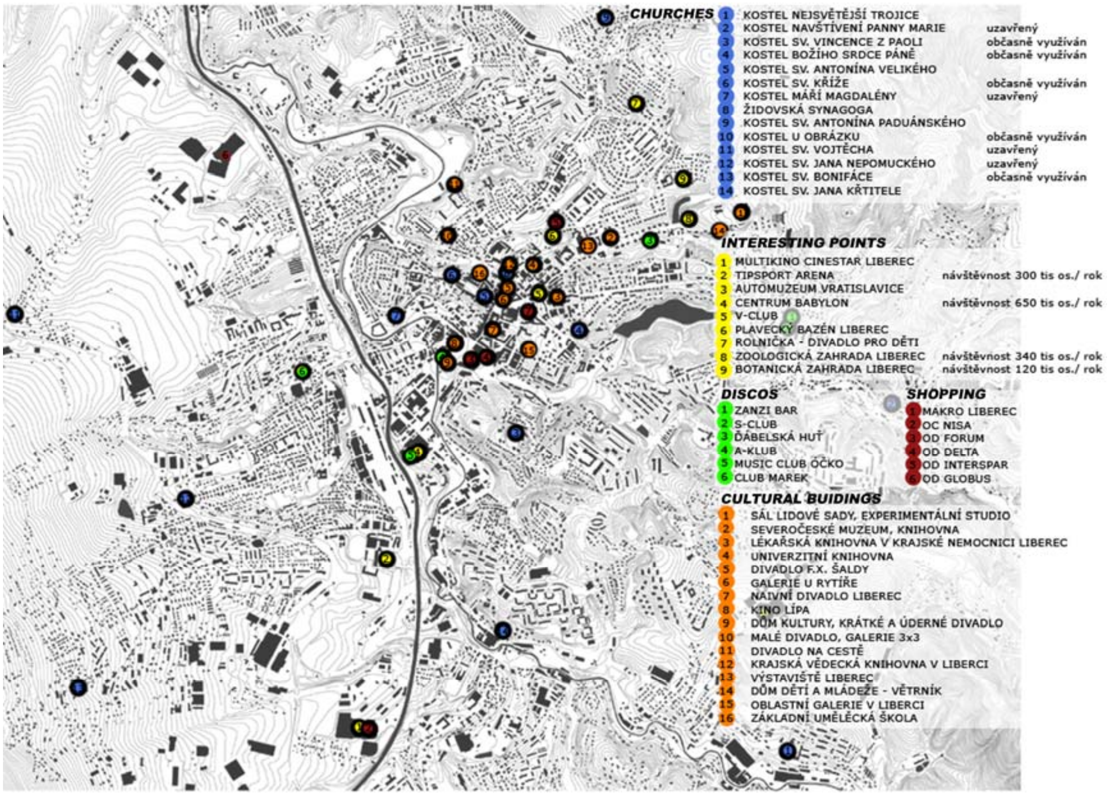


Figure 1.21 Distribution of tourist points

From this map, we can understand the distribution of tourist points around city center such as churches, recreation facilities, cultural buildings, shopping centers and so on.

Figure 1.22 Tourist points

1.2.5 Economy

Czech Republic

The Czech Republic has one of the most developed industrialized economics in Europe. GDP per capita at purchasing power parity was $26,800 in 2008, which is 82% of the EU average.

The principal industries are heavy and general machine-building.

Liberec

The history of the textile industry in Liberec stretches back more than 500 years, but it wasn't until the second half of the 1800's that the region began to thrive both culturally and economically.

The most famous products are costume jewellery and high quality glass from Jablonec nad Nisou. Textile is the main pillar industry in the Liberec, and also is the dominating economic resource. Tourism becomes more and more important sources of economic growth. The principal industries are heavy and general machine-building.

1.3 Current condition of site

Figure 1.23 Design site 1

Figure 1.24 Design site 2

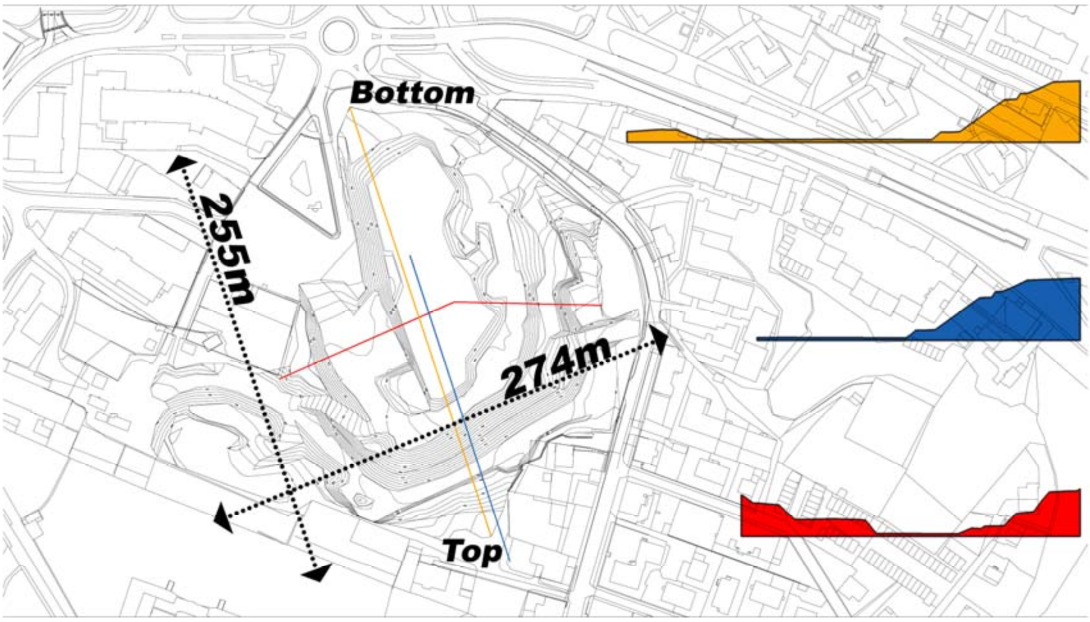


Figure 1.25 Measure of site

The basic measurement helps me to study complex terrain.
Site area is 5 ha. The altitude difference is 28 m from bottom to top.

According to the complex terrain after excavation and the objective of competition, I hope give the best proposal to suit this skin texture.
Let us repeat the objective of competition: **the design of a building/structure or complex of buildings without further functional specification or proposal of a different use of the given area.** It means we need to represent new definition for the site in a particular way by ourselves. The basic idea is as possible as to keep the original landform after excavating and the new volume adjust to existing environment to create new communication between them, then form new city focus in Liberec.

2.0

URBAN DESIGN

An important element of Liberec's sustainable Urban Plan is what is known as the "urban voids". These will be turned into truly collective places for socialization, flexible spaces that relate to their immediate urban surrounds.

The proposed extensive and intensive service provision delivered by these "urban voids" is key to the city's future development. Urban voids will constitute the green backbone of the new urban vision, varying-scale series of pedestrian walkway, squares, open spaces, cycle paths, circulation routes (for collective and private traffic), new services provision centers for the local and wider communities, neighbourhood shops and so on.

The backbone structure confirms the overall strategy of the development plan whose underlying objective is to create new impression of city that will in turn raise the overall quality of people's lives.

2.1 Analysis of city

2.1.1 Urban morphology

2.1.1.1 Expansion of city

It is settled by German and Flemish migrants since the 14th century

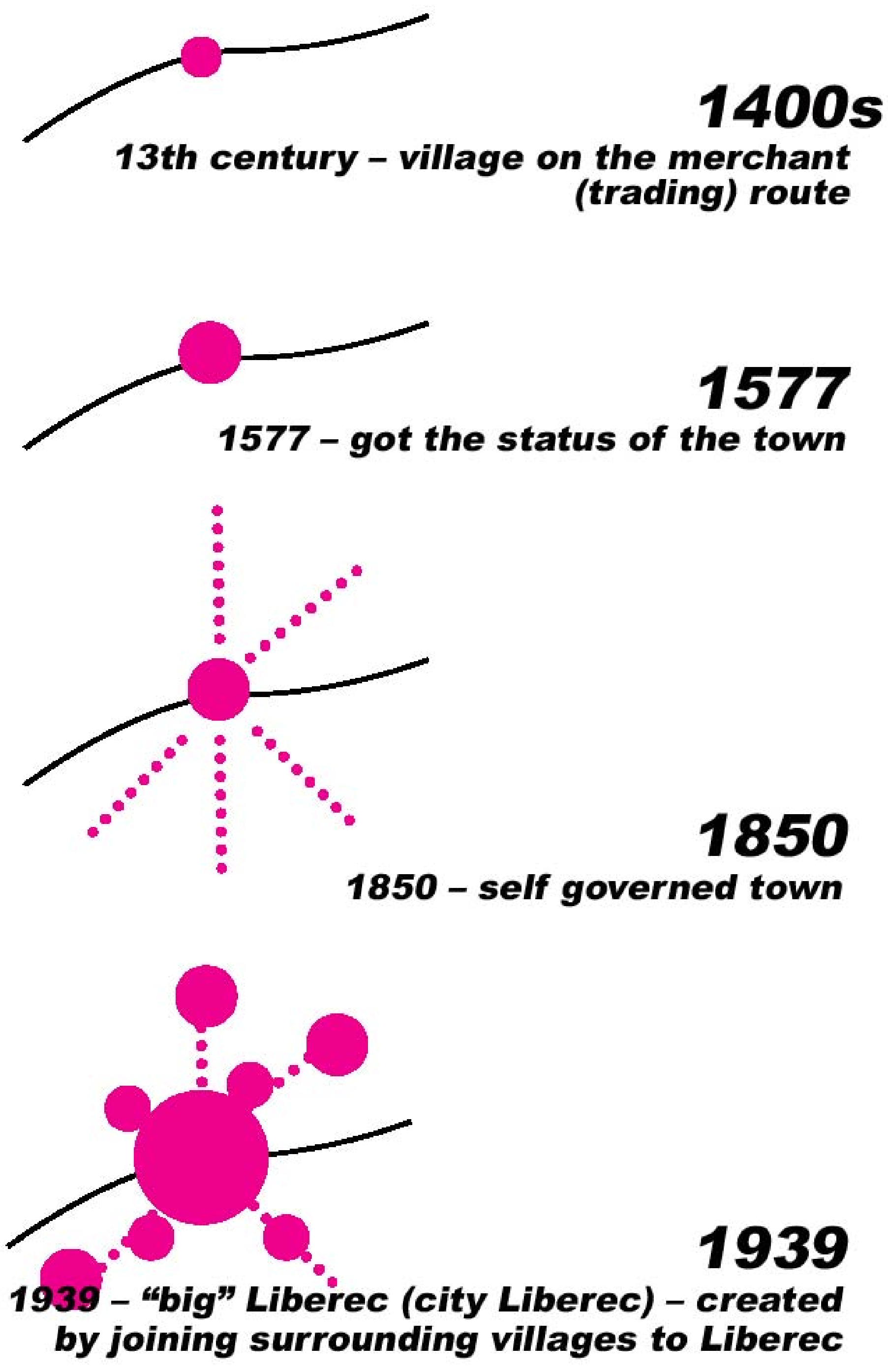


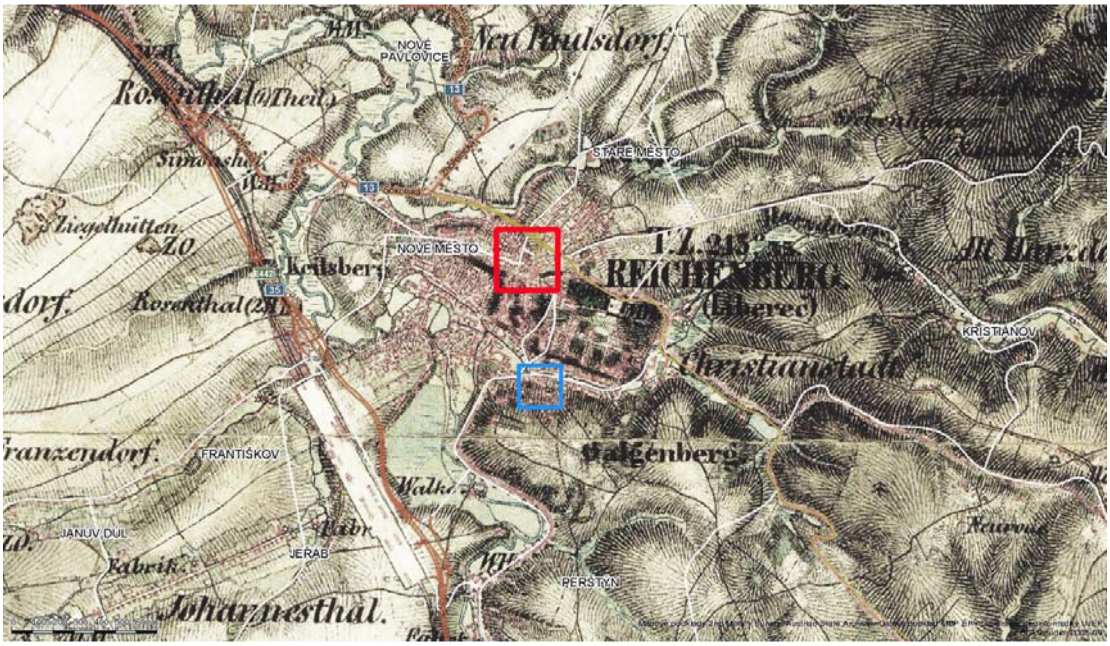
Figure 2.1 Expansion of Liberec

2.1.1.2 Evolution of city

1764 The texture of urban-morphology doesn’t formed.

Figure 2.2 1764 Liberec map

1836 The basic urban-morphology begin to form and city center appeared.



Historical centre Design site

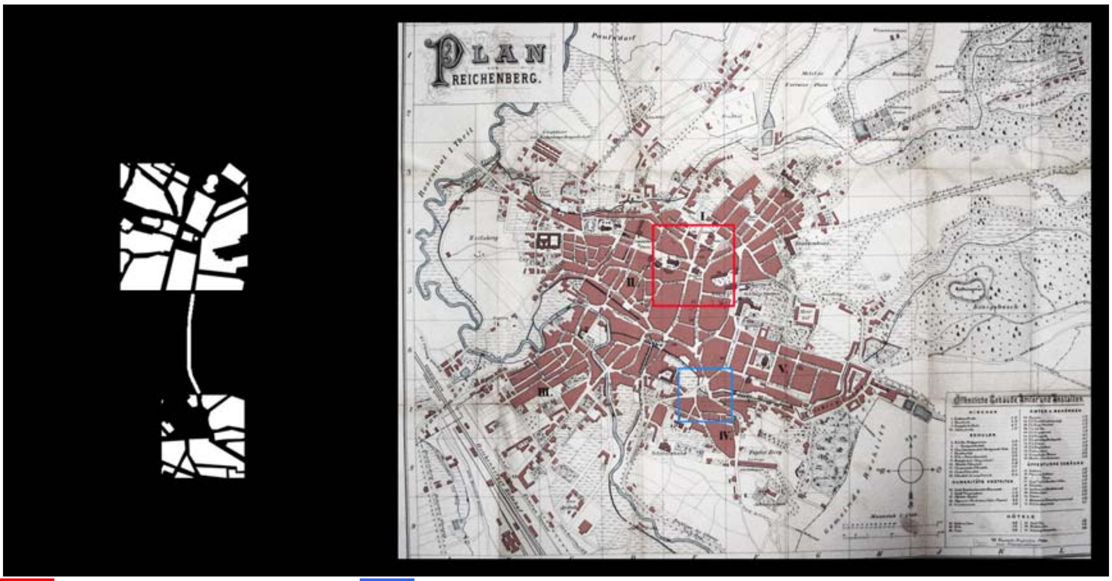
Figure 2.3 1836 Liberec map

1858 Historical map of Liberec

Historical centre   Design site

Figure 2.4 1858 Liberec map

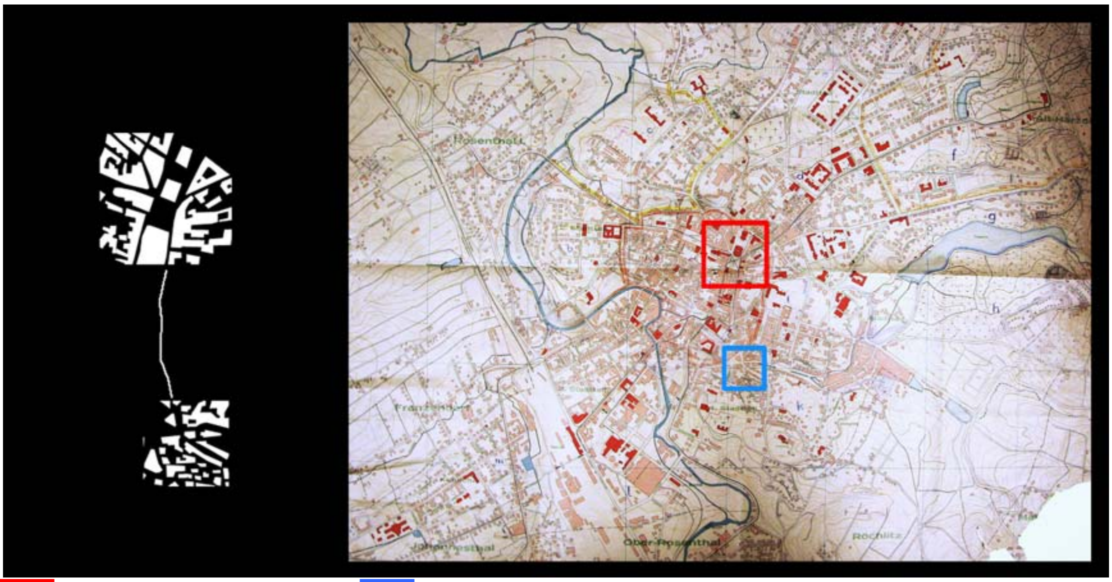
1882 Historical map of Liberec



Historical centre   Design site

Figure 2.5 1882 Liberec map

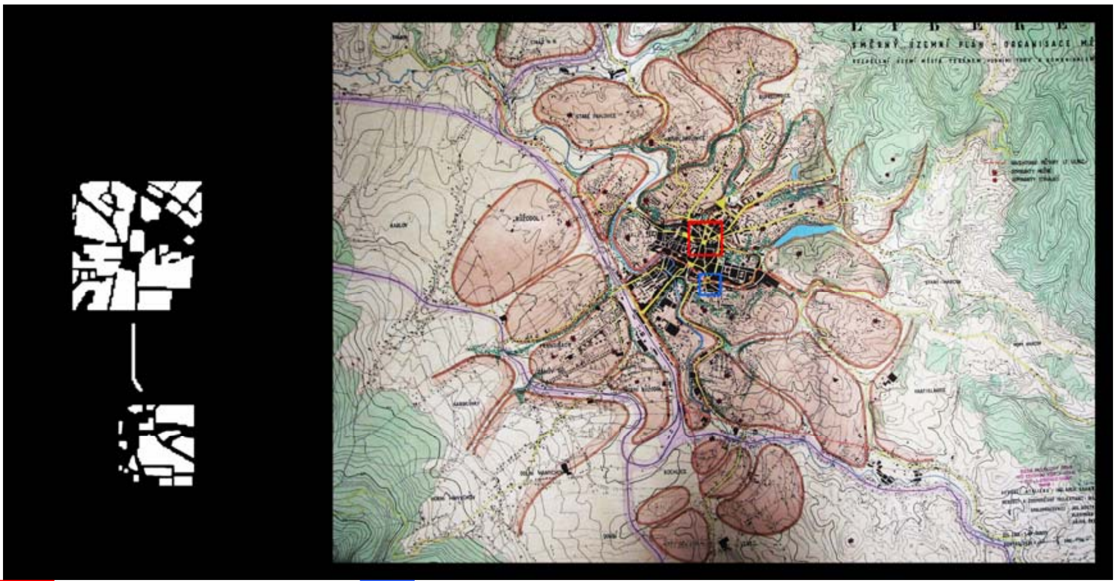
1932 Historical map of Liberec



Historical centre   Design site

Figure 2.6 1932 Liberec map

1956 Historical map of Liberec



Historical centre   Design site

Figure 2.7 1956 Liberec map

2.1.2 Transportation system

Main road system

Figure 2.8 Main road system

57716 passenger cars on 105 000 inhabitants

43 km of roads on the city territory (roads of 1st (best) and 3rd (worst) class – almost none of 2nd class)

60 percent of roads are not in good shape (not well maintained)

Railway system

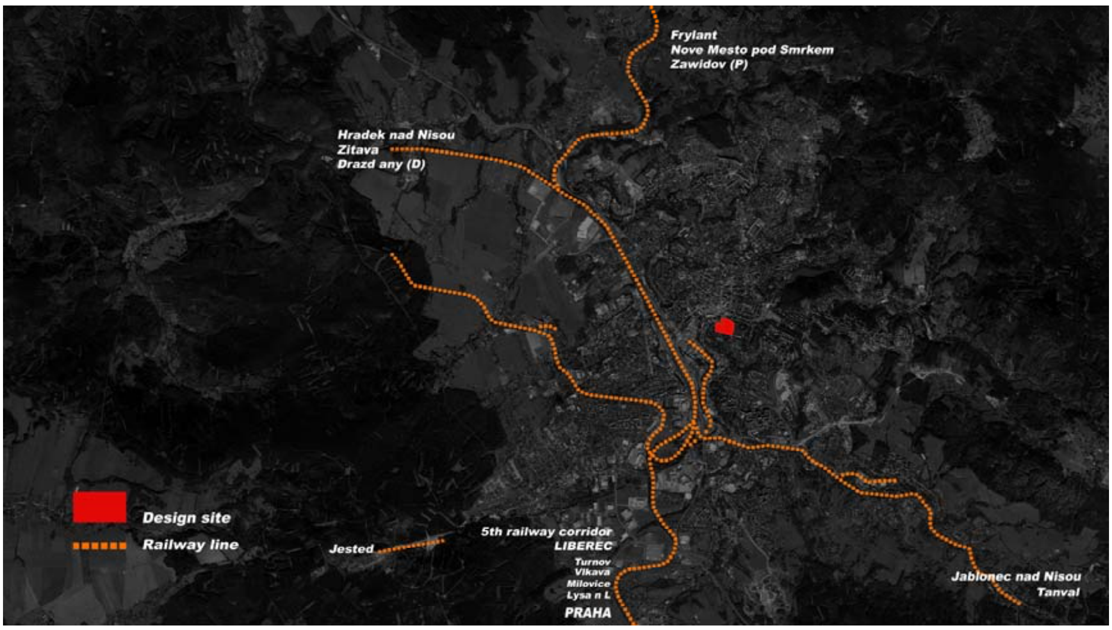


Figure 2.9 Railway system

The 5th railway corridor – planned from Liberec to Prague to shorten the travel time from 2,5 hours by train today to about 1 hour. It is an official plan, but probably will not be realized. Between Liberec and Prague, there are 4 stops: Turnov, Vlkava, Milovice and Lysa n L.

Public transportation system

Tram system (MHD)

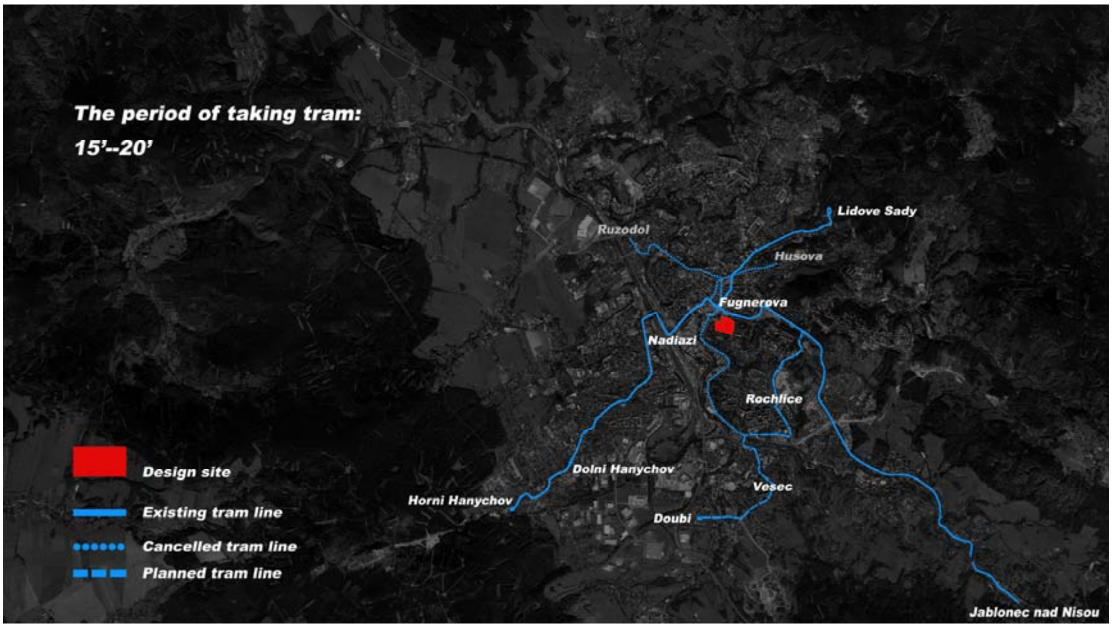


Figure 2.10 Tram system

Bus system

Figure 2.11 Bus system

Tram lines 34 km； Bus lines 309 km

In 2005, 3 081700 passengers used the public transport in Liberec

Trams: 1 140 200 passengers； Buses: 1941500 passengers

2.1.3 Solid and Void

SOLID

City block density

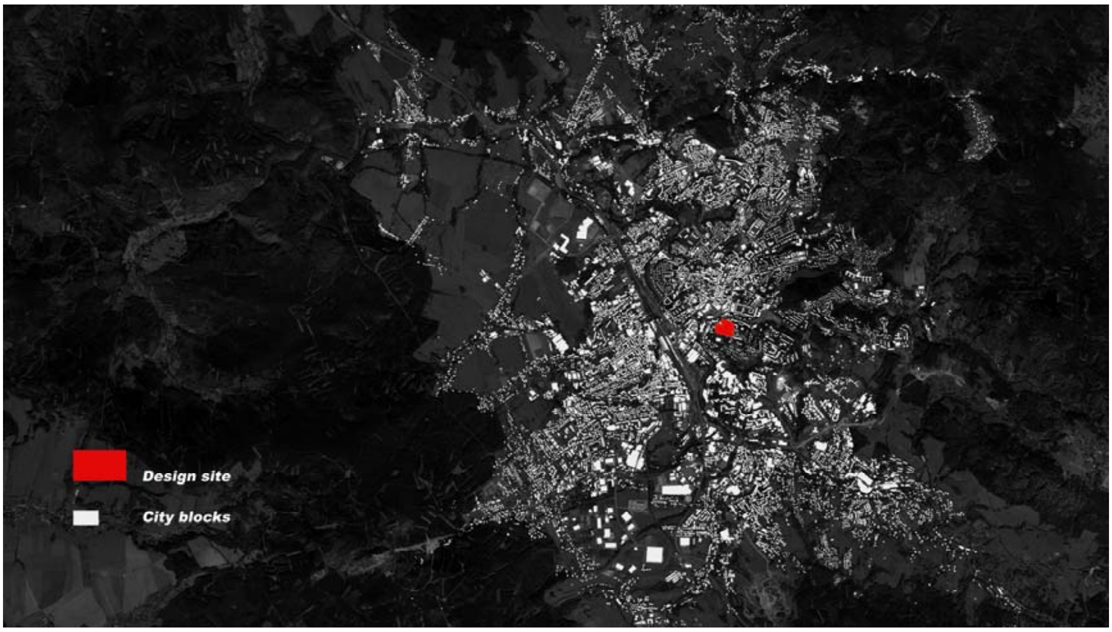


Figure 2.12 City blocks

City centre

Figure 2.13 City centers 1

The big pink area is the main city centre and the small ones are the local centres of some city quarters. There are either some shops there or some spaces like squares etc... So it is possible to call those places “local centre” to attract people.

Historical centre

Figure 2.14 City centers 2

Local centre example

Figure 2.15 City centers 3

The red words indicate names of local city squares and centers.

Housing

Figure 2.16 Housing 1

Housing area examples

Figure 2.17 Housing 2

Figure 2.18 Housing 3

The red words indicate names of housings and residential areas.

Sídliště- prefab concrete panel residential blocks

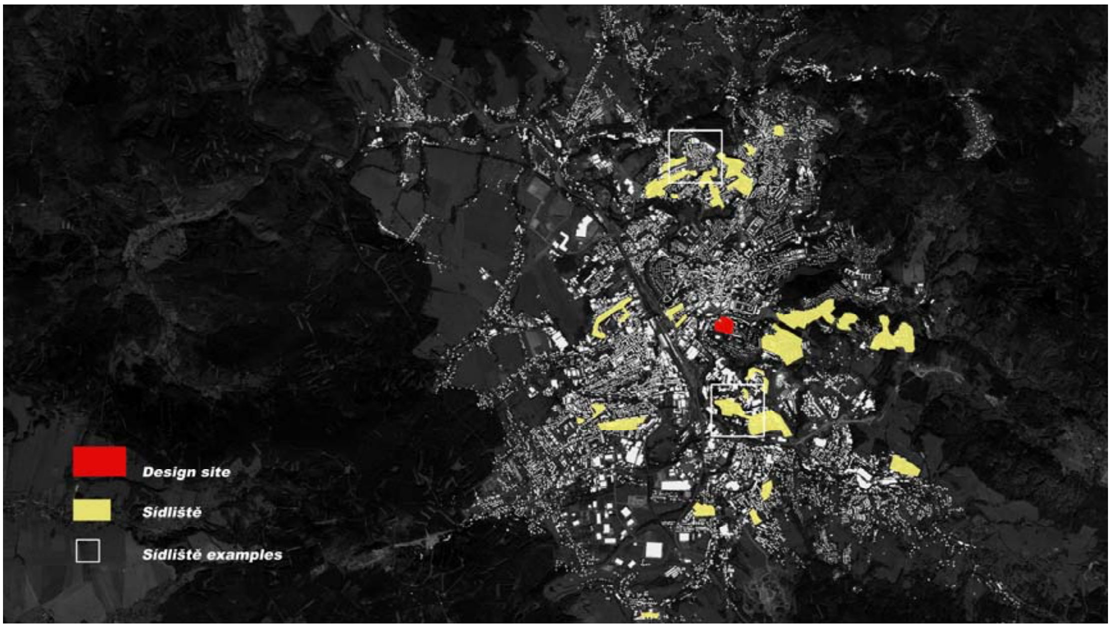


Figure 2.19 Sidliste 1

Sídliště means especially a specific type of residential blocks – prefab concrete panel blocks built during communist era from 60s to 90s. These blocks form such neighborhoods which are not very popular, but people need to live somewhere. Usually people try to move out from there if they have money to build a single family home.

We can see it also on the urban layout -those long lines on the left picture (simply all bigger buildings, small ones are family houses) are big blocks of flats. Sometimes they are even more than 500m long and usually 6-12 floors tall.

Figure 2.20 Sidliste 2

The red words indicate names of housings and residential areas.

The blocks on the left picture are again these prefab buildings (called “panelaky” in Czech) – again long blocks and they form big internal green yards.

Figure 2.21 Sidliste 3

The red words indicate names of housings and residential areas.

Industrial area around river

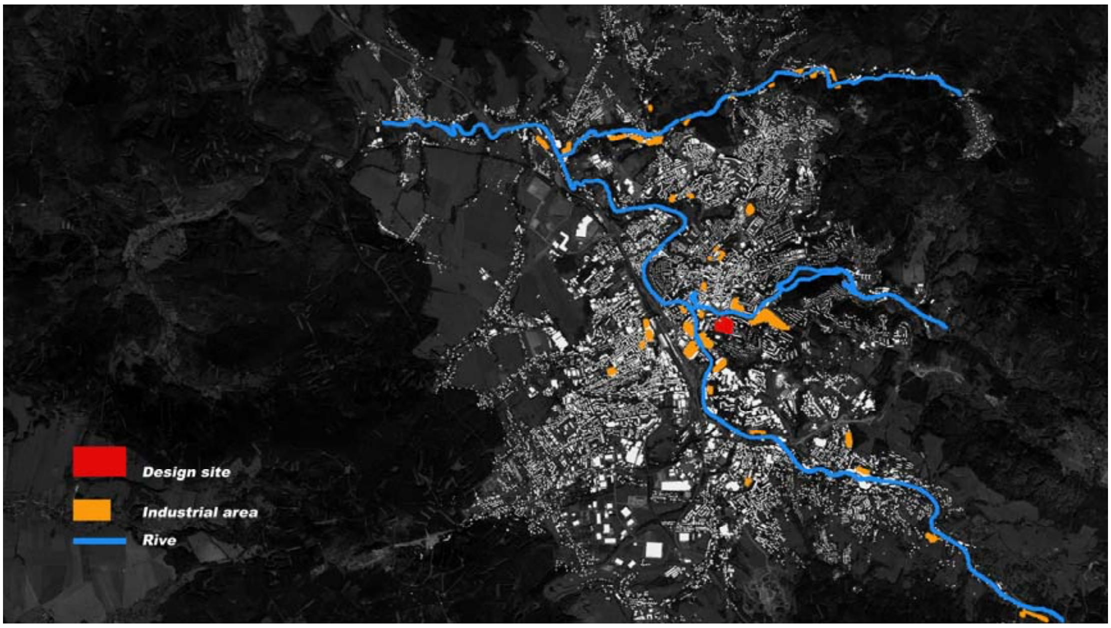


Figure 2.22 Industrial areas 1

Industrial area around main roads

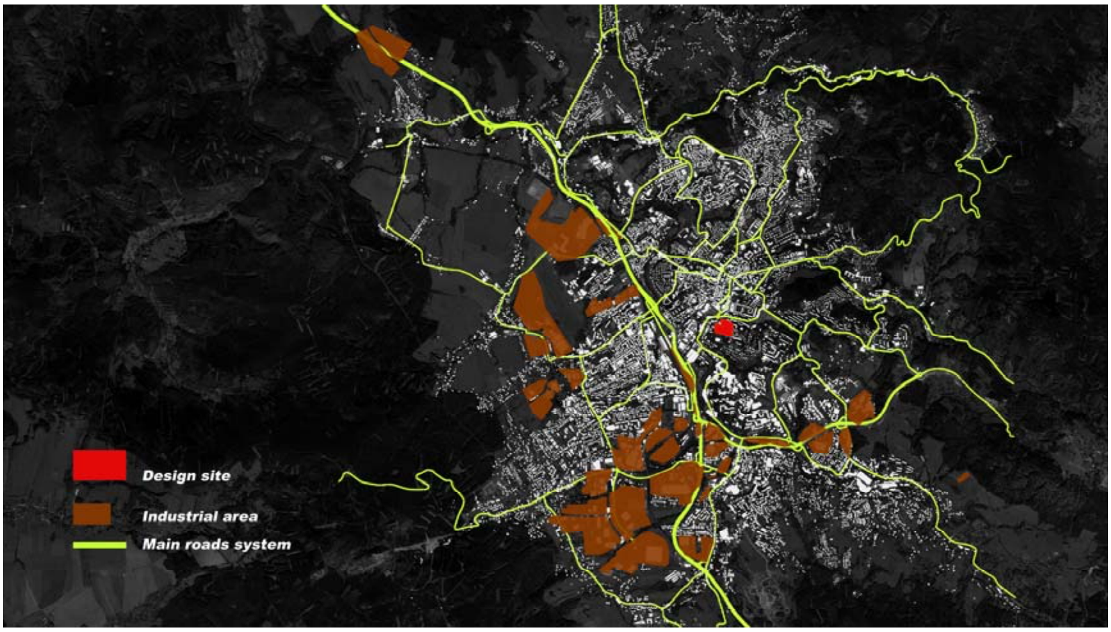


Figure 2.23 Industrial areas 2

VOID

The void means different used space. The term "urban open space" stands for green areas for recreational uses. They are natural and cultural resources.

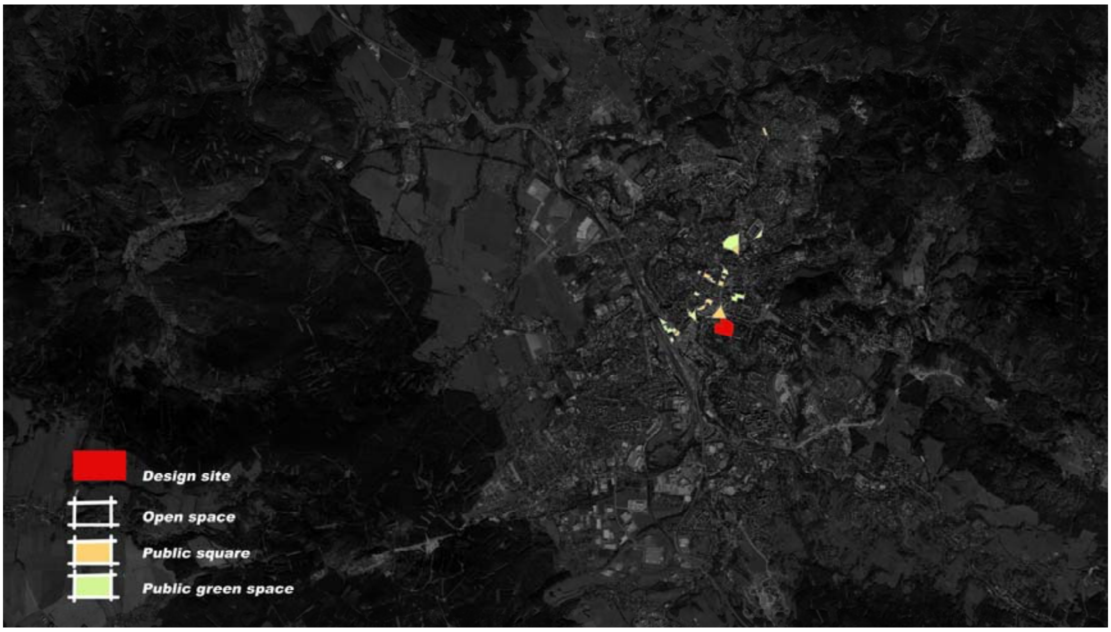


Figure 2.24 Void

2.1.4 Landscape

Green space

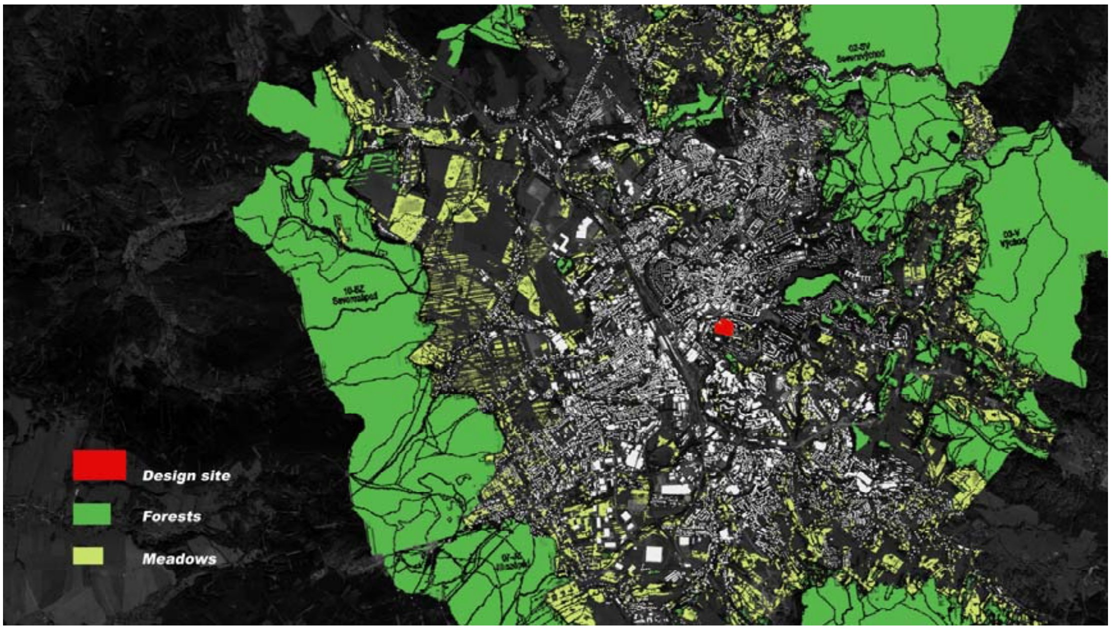


Figure 2.25 Green spaces

Water economy

Three springs of Nisa river (Lucanska, Novoveska, Bila) and Cerna Nisa form together the Nisa river which flows through Liberec (length 53km, flow 5,4m3/s, flow in Liberec 2,2 m3/s). Watershed (dividing) between Baltic Sea and North Sea (some water from Liberec – behind Jested flows to North Sea, the rest to Baltic sea – also Nisa river)

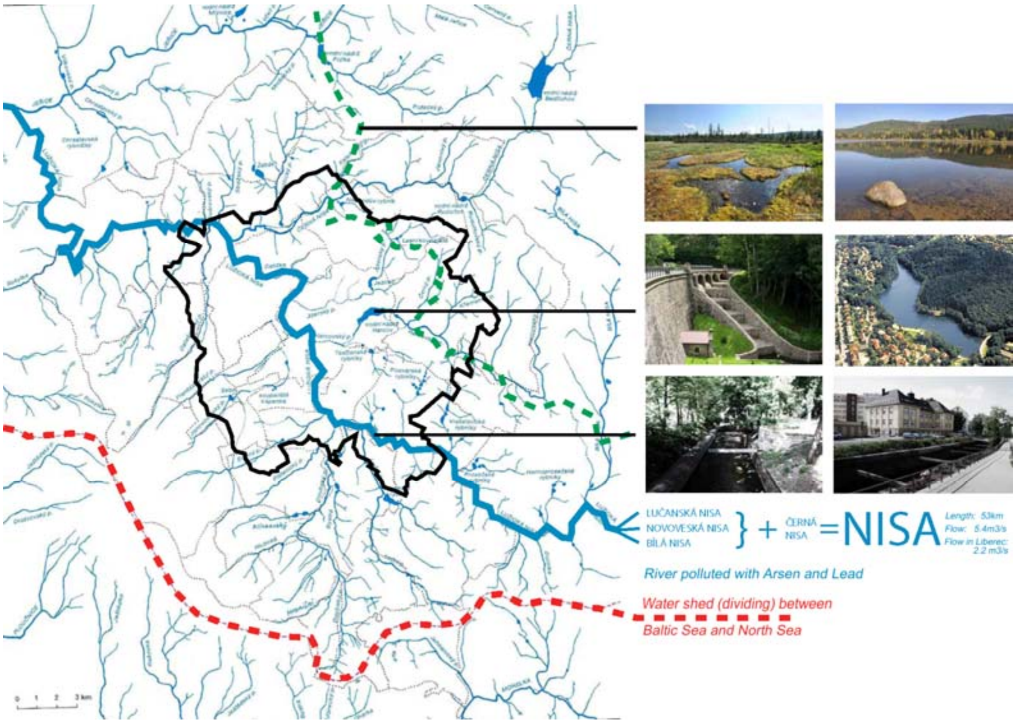


Figure 2.26 Water system 1

Distribution of water system

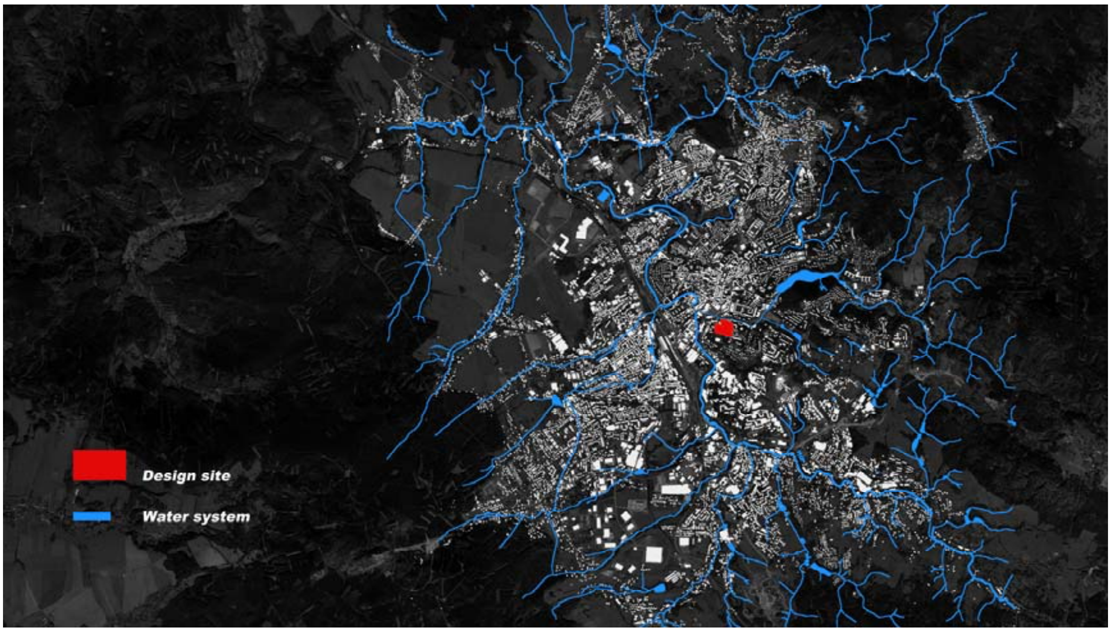


Figure 2.27 Water system 2

2.2 Concept

2.2.1 Choose study area

Focus on 3 interesting parts

After analysis of Liberec city, we find 2 interesting parts around design site.

For the urban design, the basic idea is to **connect the 3 parts mentally or physically**.

The 3 parts are **DESIGN SITE**, **ABANDONED INDUSTRIAL AREA** and **KRISTIANOV MOUNTAIN**.

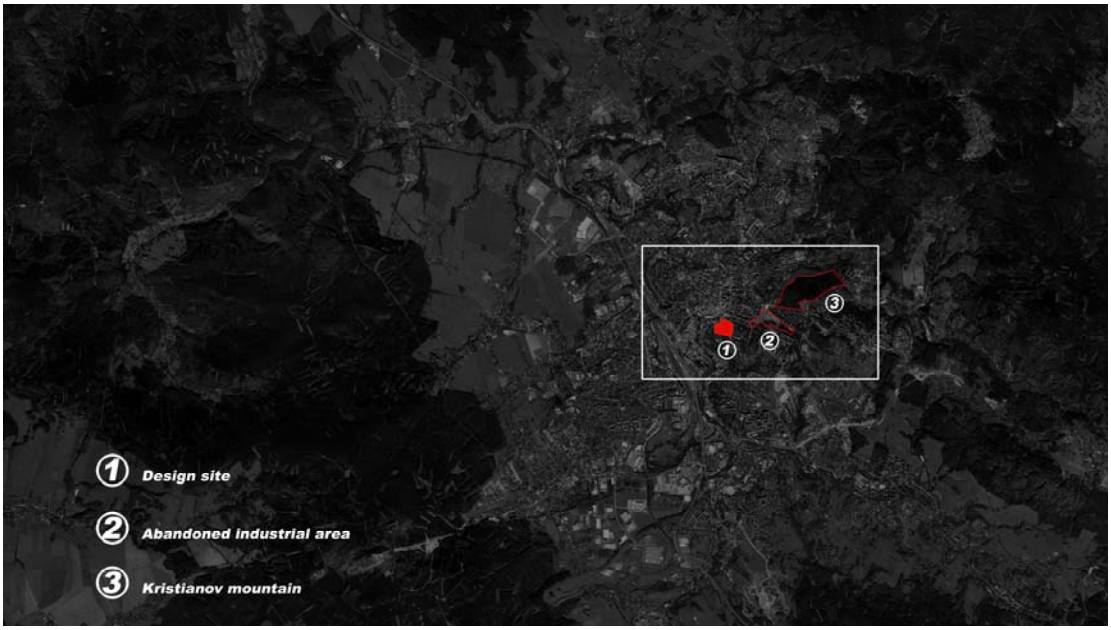


Figure 2.28 Study area

DESIGN SITE

This part is the competition site. We need to reshape and redefine a new function.

ABANDONED INDUSTRIAL AREA

The factory was built at the end of 19/beginning of 20th century and was producing textiles. The name of the factory was **TEXTILANA**.

The investor who bought the factory tore it down about 5 years ago. Investors wanted to build some entertainment centre there, but then they changed their mind and then the **Global Financial Crisis** came in 2008, so they have to pigeonhold the plan. Now the whole area is free to be used for anything, because the factory is gone.

KRISTIANOV MOUNTAIN

It is natural mountain which faces to **Harcov** lake. It can be regarded as another new landmark of Liberec.

2.2.2 Analysis of study area

Traffic hub stations

The traffic hubs are so close to the design site.

Figure 2.29 Traffic hub (MHD: Bus and tram terminal station)

Transportation system

Figure 2.30 Traffic line

Public space

Public Square means social public space including piazza in front of church, open space, parking area and so on.

The Public Green spaces were organized so as to give configuration to present.

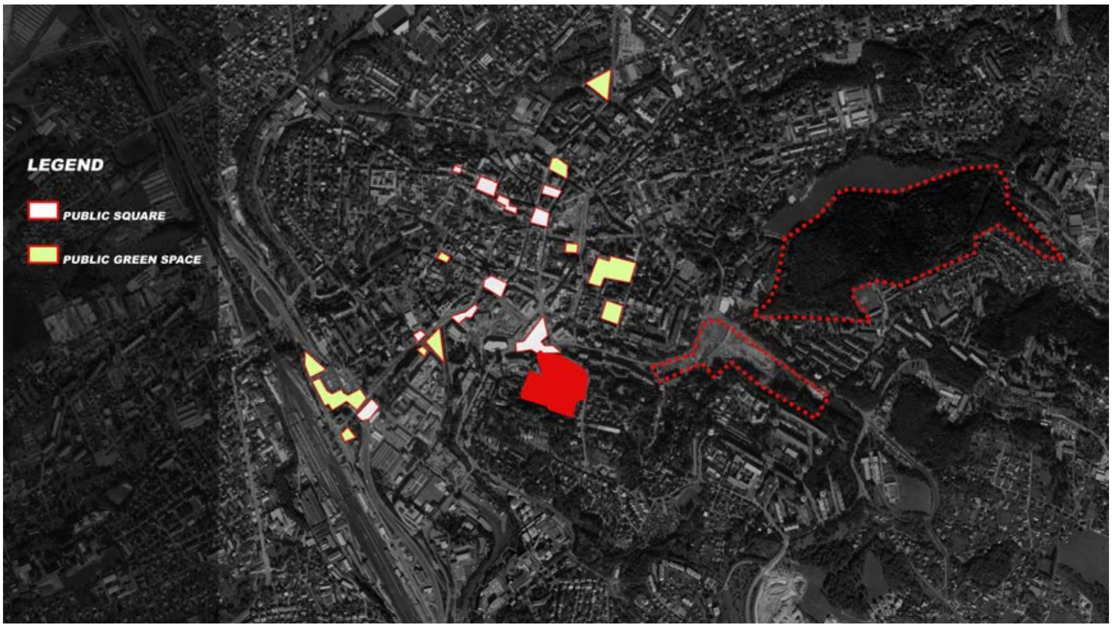


Figure 2.31 Public space

Land use

Residential area: private housing, apartment, social housing, etc.

Commercial area: shops, shopping mall, office buildings, etc.

Public buildings: theatre, cinema museum, castle, school, universities, municipal buildings, etc.

Religion: church, tempo, monastery or convent, etc.

Industrial area: factories.

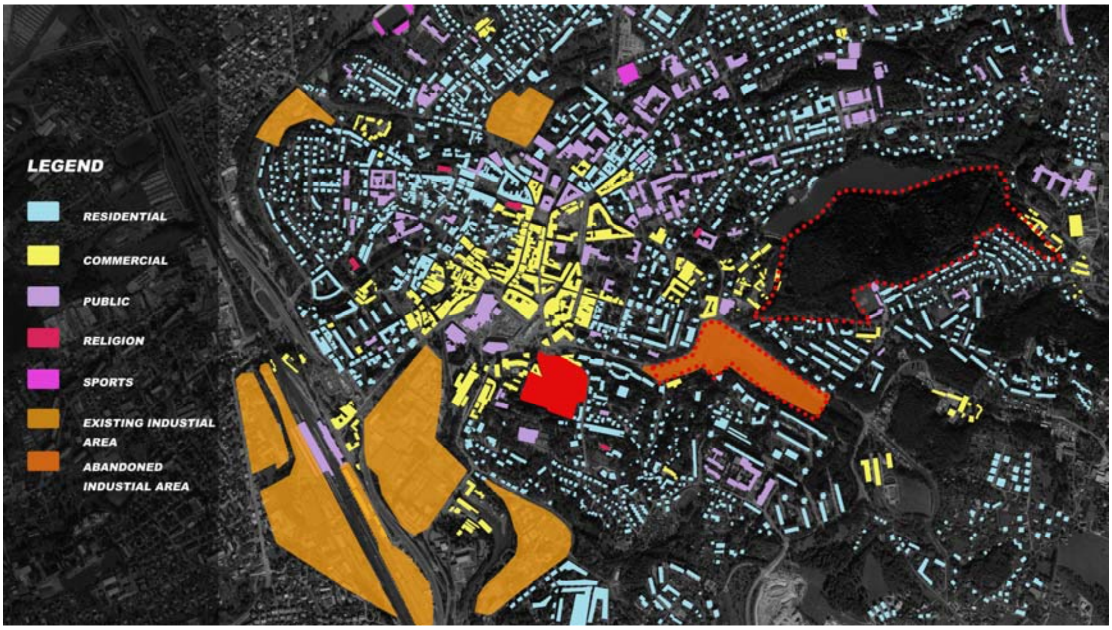


Figure 2.32 Land use

Landscape

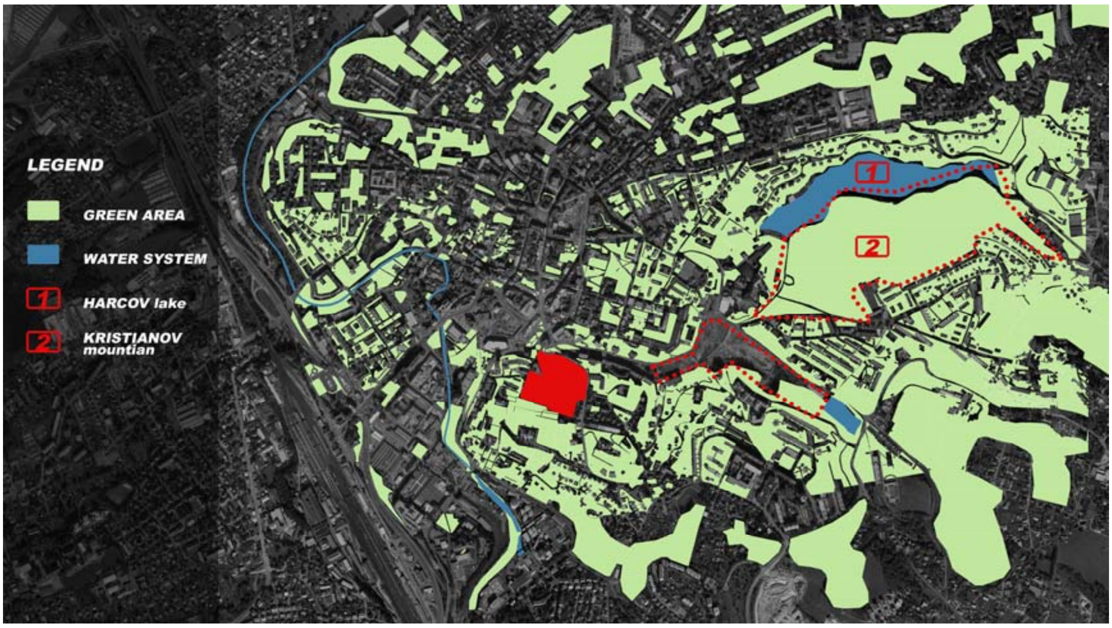


Figure 2.33 Landscape

Tourist attractions

We can see from below map, there are most tourist attractions around city centre and so closing to study area which I have chosen.

Figure 2.34 Main tourist points

2.2.3 Positive vs. negative analysis

Positive

- Good sports resource for tourism
- Good natural landscape for tourism
- Convenient traffic: railway, tram and other traffic facilities
- Presence of many investments
- Many attracted points: historical buildings and monuments
- International sports events and competitions
- Historical value

Negative

- City grid is disordered and urban environment is not well organized.
- Abandoned textile industrial areas form partial pollution of soils.
- Poor pedestrian connection
- Lack of big social green space for local citizens and tourists
- The mass sports activities have not promoted well

2.2.4 Definition of function

Idea of design site: Hotel + Health Club

Now Let us go back to the objective of competition: the design of a building/structure or complex of buildings without further functional specification or proposal of a different use of the given area. So any reasonable proposal can be accepted. It is an open topic for the competition.

After urban analysis, we draw a conclusion: the tourism has become the new ways to change economic growth in Liberec because its function on optimizing industry construction, widening market scale and elevating city quality etc. So we can consider tourism industry as the new motive power or new path to change economic growth ways in the Liberec Region. Another aspect, sports is very popular in Liberec. It depends on special natural resource. There are some important sports events specially winter sports events which are hosted in Liberec.

But according to analysis above, the situation of Liberec has not provided essential condition or facilities to promote tourism industry and mass sports activities.

Due to the reasons mentioned above, I will give new definition for this site as a new recreation and sports center: **Hotel + Health Club.**

Idea of abandoned industrial area: Post-Industrial Eco-park

Post-Industrial Landscape is a Contemporary Issues and Strategies for Industrial Heritage Site Reclamation and Landscape Regeneration;

The reclamation and conservation of post-industrial landscapes constitutes an important cultural objective which is inherently sustainable in that it encourages the positive re-use of redundant fields and facilities that are part of our industrial and commercial heritage.

It addresses the urgent need to reclaim these landscapes, influenced both by two different tendencies connected with the abandonment of industrial landscapes. On one hand, the urban pressure related to the city’s administration and stakeholders’ will to urbanize those areas and on the other hand, the increasingly public awareness of the necessity to protect industrial heritage. Often in advantageous locations near city centres, situated along waterways, supported by existing infrastructure, and adjacent to residential communities, these landscapes are environmentally impaired assets that need to be returned to productive uses, and reintegrated into the surrounding community.

According to the situation, I give the new definition of **TEXTILANA:**

Post-Industrial Eco-park

Idea of linking 3 parts: Tourist route

Let us go back to problem which is mentioned earlier, how to get the uniform of the 3 parts (design site, abandoned industrial area and Kristianov moutain) in the urban scale, then relating each other by mentally or physically in a certain way.

The goal is to create a visible linear relationship among 3 parts: **Tourist route**

2.3 Design process

2.3.1 Organizing tourist route

2.3.1.1 Methodology: Image of the city

People who move through the city engage in way-finding. They need to be able to recognize and organize urban elements into a coherent pattern. In the process of way-finding, the strategic link is the environmental image, the generalized mental picture of the exterior physical world that is held by an individual. This image is the product both of immediate sensation and of the memory of past experience, and it is used to interpret information and to guide action. Lynch proposes that these mental maps consist of five elements (from his book "**Image of the city**"):

(1) **Paths**: routes along which people move throughout the city;

(2) **Edges**: boundaries and breaks in continuity;

(3) **Districts**: areas characterized by common characteristics;

(4) **Nodes**: strategic focus points for orientation like squares and junctions;

(5) **Landmarks**: external points of orientation, usually an easily identifiable physical

object in the urban landscape.

Of these five elements, paths are especially important according Lynch, since these organize urban mobility.

The tourist route attract people from **Railway station** to the **HOTEL + HEALTH CLUB** along the tram line, then pass **Post-Industrial Eco-Park**, finally extending to **Kristianov mountain**.

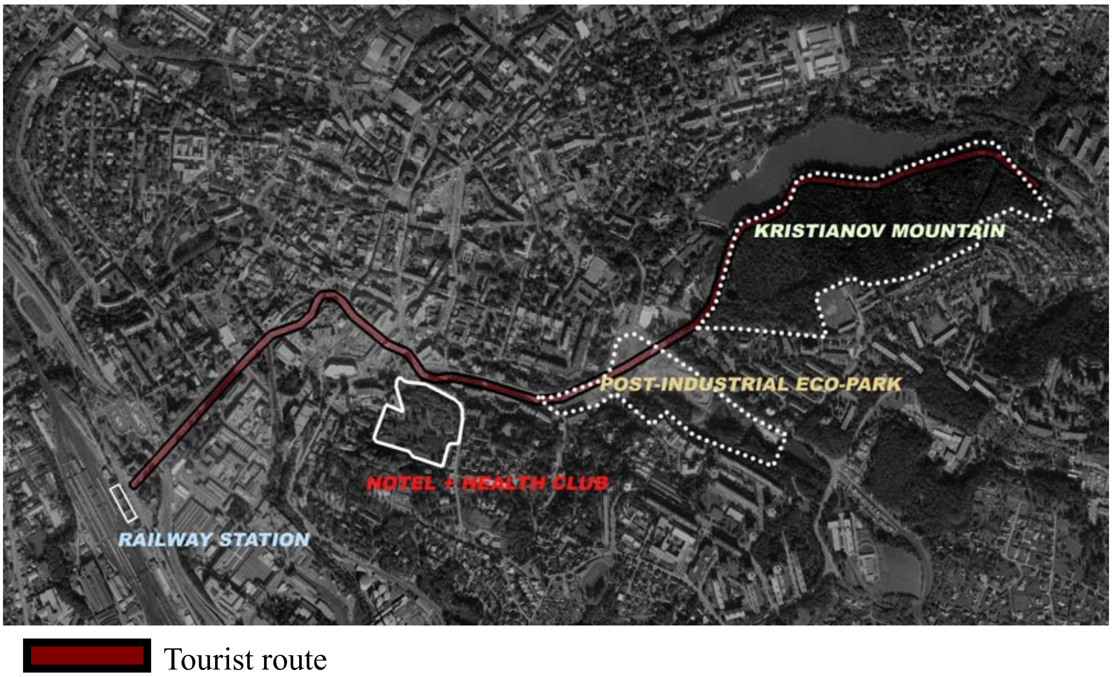


Figure 2.35 Functional map

So I will analysis urban tissue along the tourist route with the 5 elements of city

Paths_ familiar routes followed

The paths are most direct element of city image. It has strong identify and inherent indexicality.

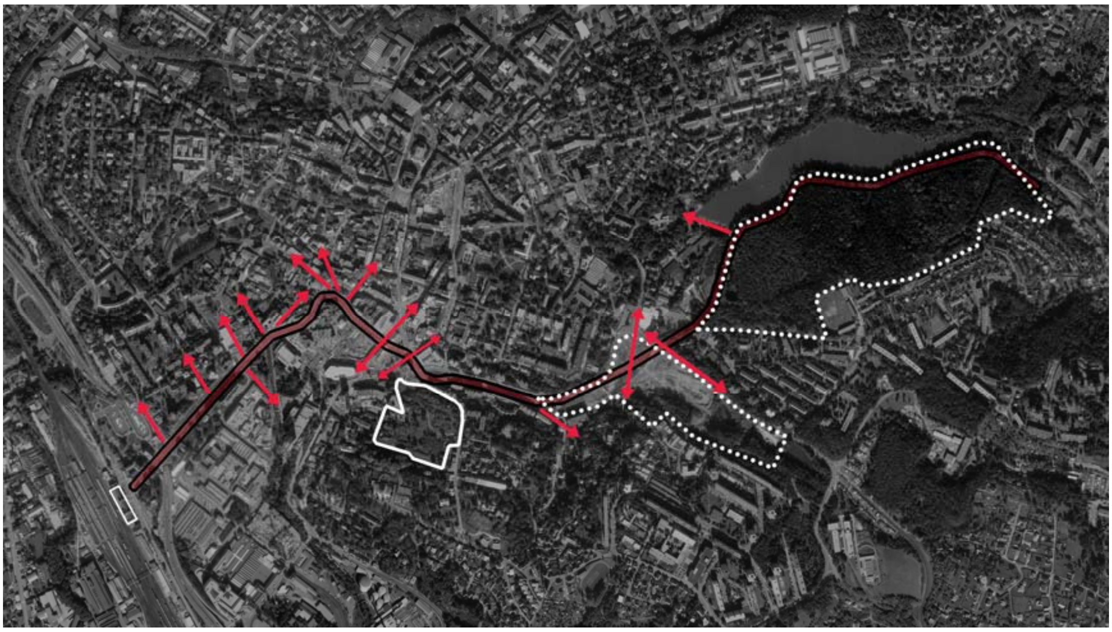


Figure 2.36 Paths map

Edges_ dividing lines between districts

They are the boundaries between two phases, linear breaks in continuity: shores, railroad cuts, edges of development, walls and so on. These elements, although probably not as dominant as paths, are for many people important organizing features, particularly in the role holding together generalized areas, as in the outline of a city by water or wall.

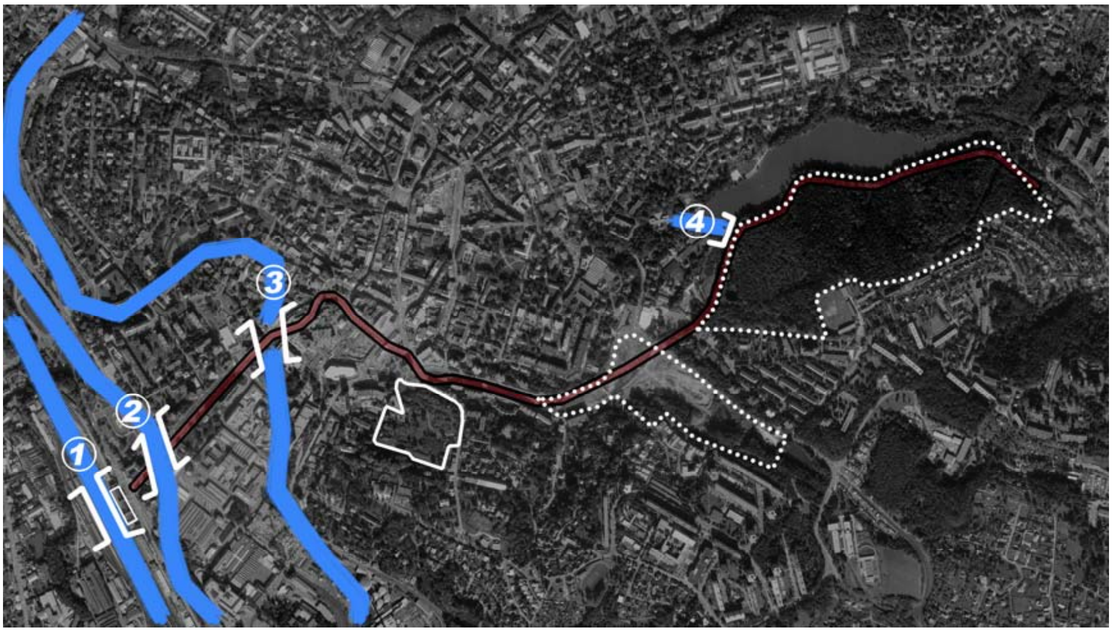
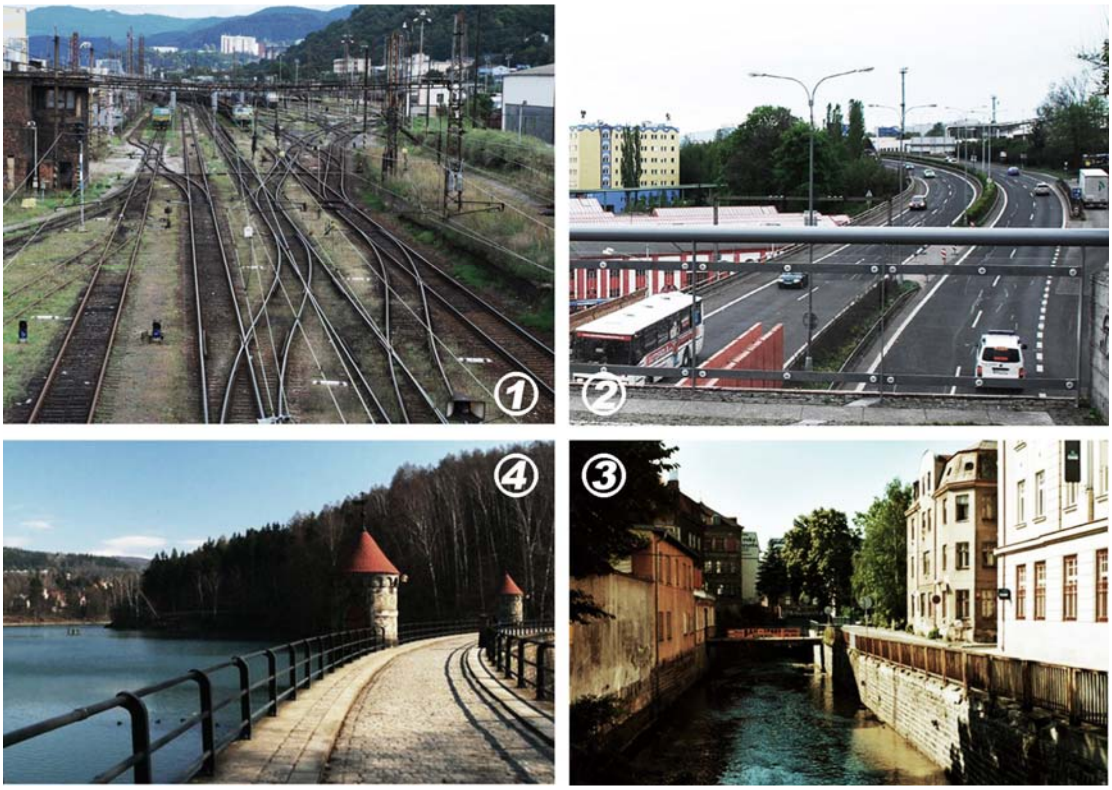


Figure 2.37 Edges map



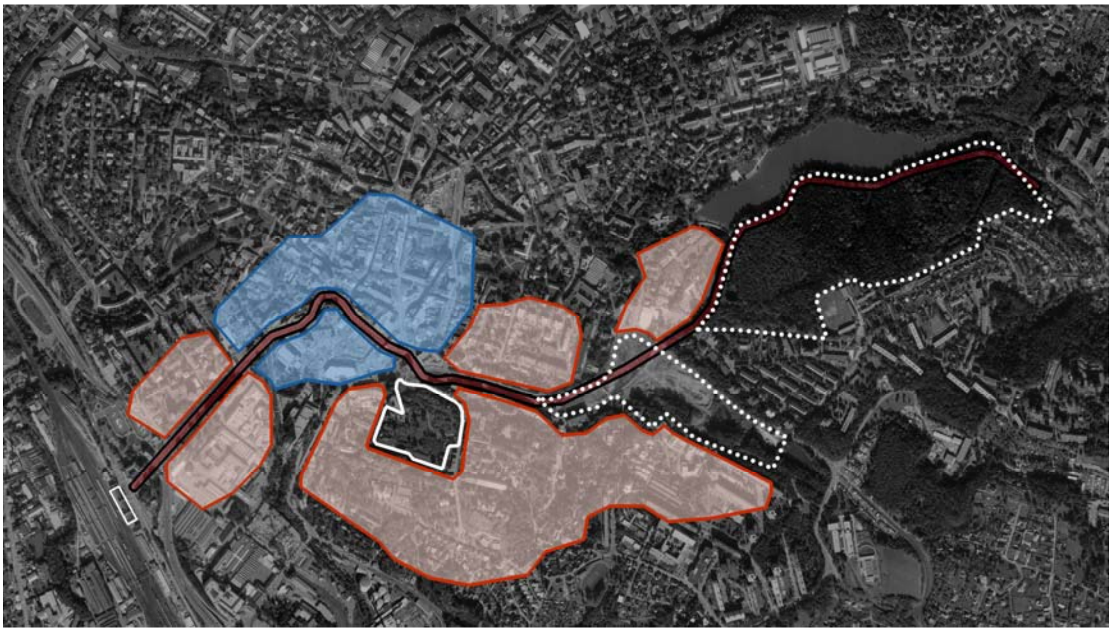
① Railway line ② Motorway ③ Nisa river ④ Harcov Dam

Figure 2.38 Edges images

Districts_ areas with perceived internal homogeneity

From a macroscopic perspective, they divide two sections: **Public** and **Private.**

The public section includes commercial, cultural, municipal buildings or fields also some public space or natural landscape and so on. The private section includes office buildings, residential area, personal farm or factories and so on. Though distributing different functional area by similar properties, people can recognize easily where they are.



Private districts Public districts

Figure 2.39 Districts map

Nodes_ centres of attraction that you can enter

They may be primarily junctions, places of a break in transportation, a crossing or convergence of paths, moments of shift from one structure to another.

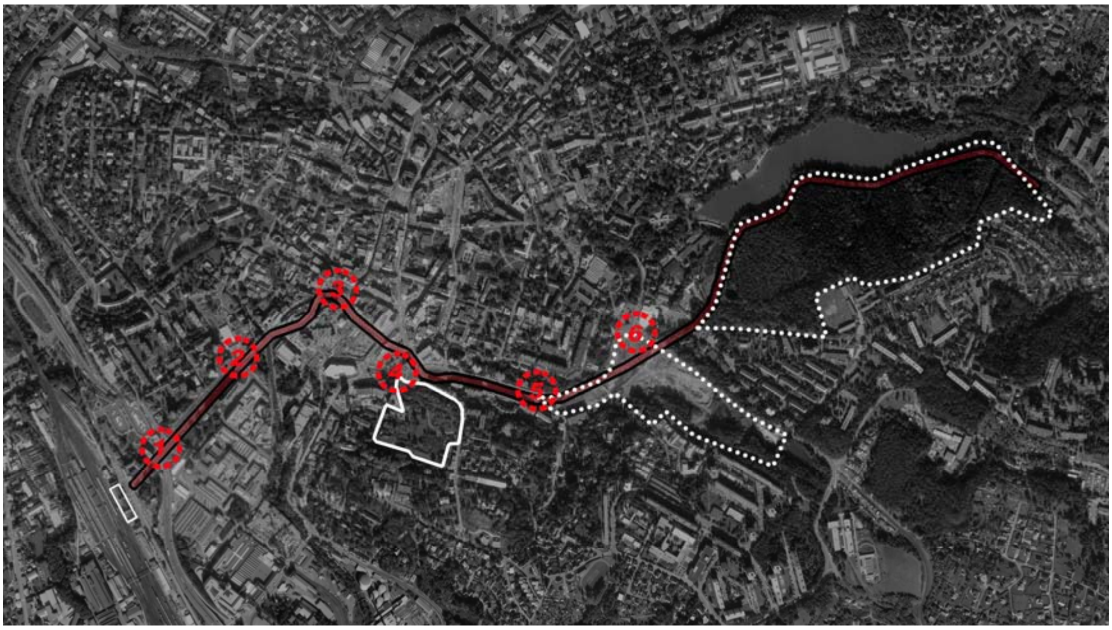


Figure 2.40 Nodes map

Figure 2.41 Nodes images

Landmarks_Point of reference

They are another type of point-reference and usually a rather simply defined physical object: buildings, signs, stores, or mountains. The prominent visual features of the city are its landmarks. Landmarks are an important element of urban form because they help people to orient themselves in the city and help identify an area.

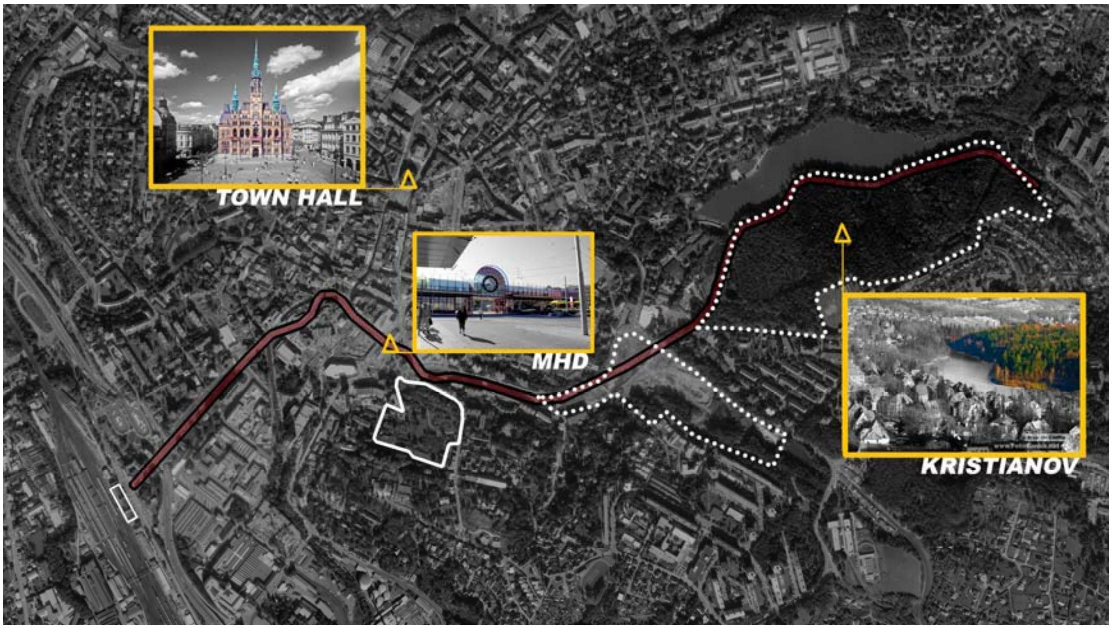


Figure 2.42 Landmarks map

2.3.1.2 Tourist route design

Definition of dimension for tourist route design

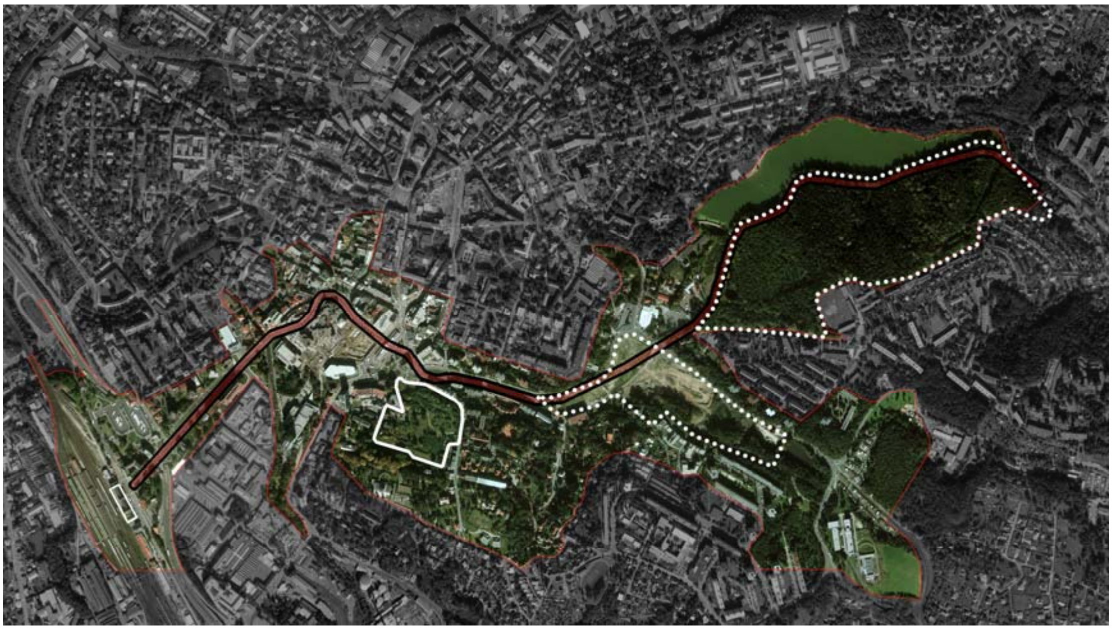


Figure 2.43 Tourist route area

Urban Solids

The existing of architecture assumes a certain form in urban.

Traffic hub   Solid   Tourist route

Figure 2.44　Urban solids

Urban Voids

It presents a kind of filling type between solids. They can consist of open space such as green space, public space, parking, water system and so on.

Void   Tourist route

Figure 2.45　Urban voids

Spacing points

Following the tram stops, I create a series of urban spaces for local citizen and tourists. The spacing between 2 urban spaces about 250~300meters.

Open space (square, parking…) Tram stops

Figure 2.46 Spacing points

Definition of urban outline-reorganization of pedestrian

I provide 2 alternative traveling way: by tram or by walking and recover the tram stops with steel frame to get the same image of the city as well as giving the uniform of urban fabric.

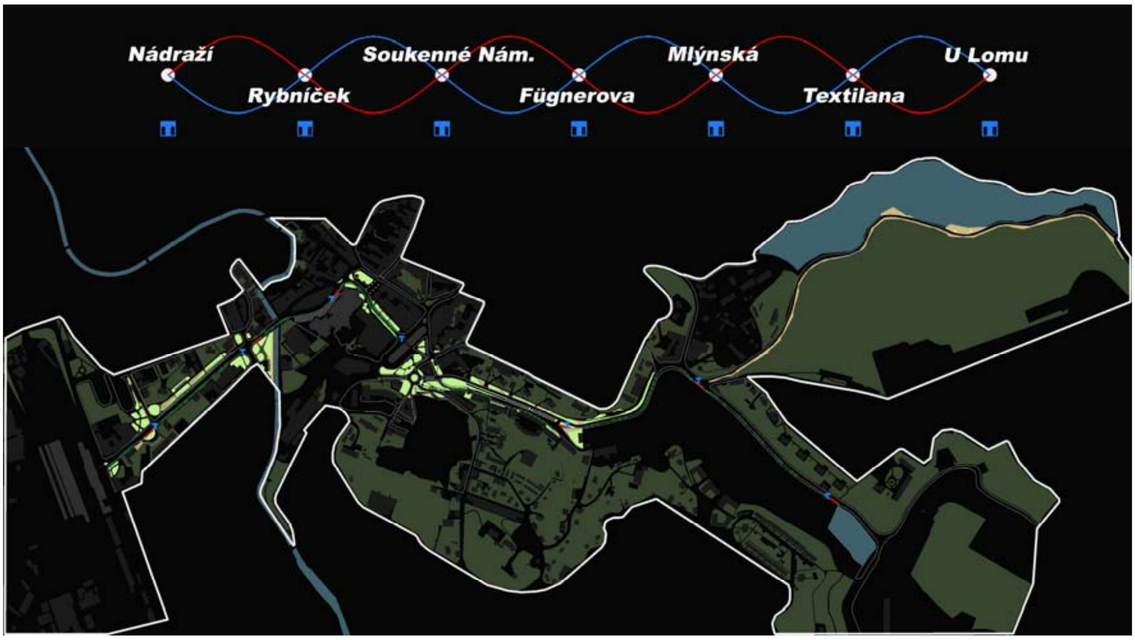


Figure 2.47 Figuration of tourist route

2.3.2 Definition of architecture Form: Recreation hub (Hotel + Health Club)

Figure 2.48 Location of Recreation hub

1st step: compare between Town hall piazza and design site.

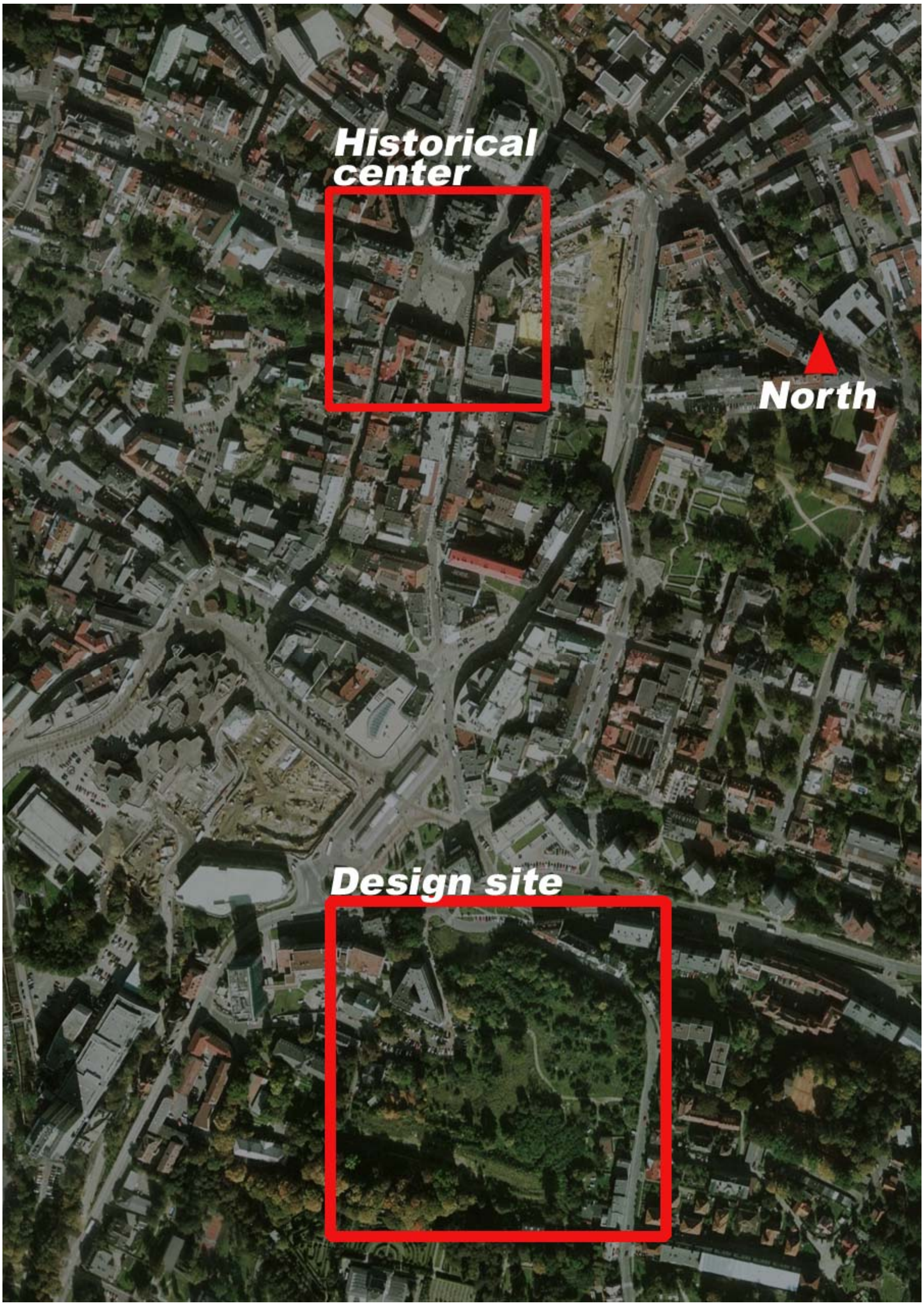


Figure 2.49 Location of historical center and design site 1

I have represented historical evolution of the historical center (Town hall plaza) during different period from 18th century to 19th century.

We could see very clearly evolution process and development trend of historical square from this diagram. In 20th century, the form of square id defined. (Red area is historical square.)

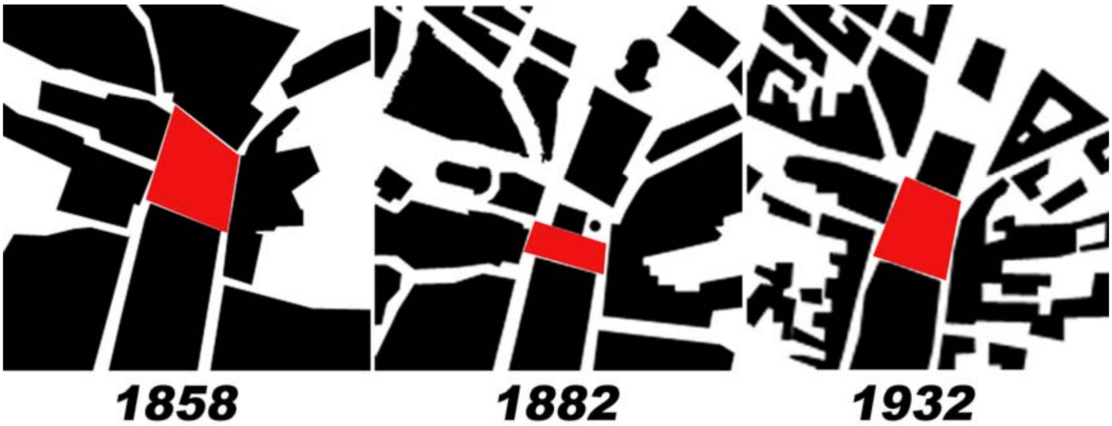


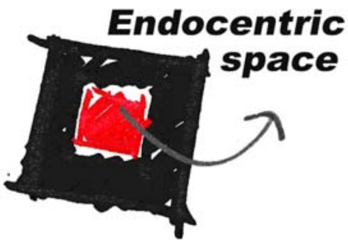
Figure 2.50 City evolution map

The definitional geometrical feature of square is rectangle which is enclosed by buildings. We also can say that void is embraced by solid. According to the method, void creates an endocentric space in the city.

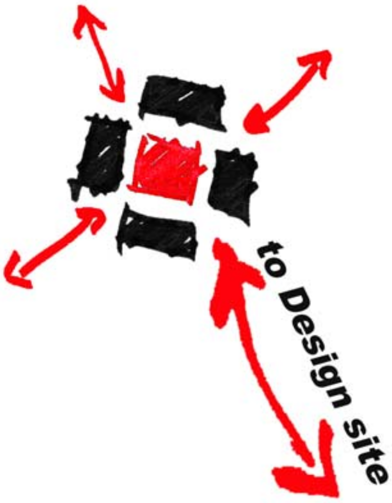
2nd step: Extraction of elements from historical plaza

A circumscribed space or area is created by buildings.

The solid creates the void.



Using simple geometrical feature summarize this type of form circumscribing space. We can call the void as **Endocentric space**.



Opening up four corners.

So void can bring people in inside or take them outside.

Figure 2.51 Concept sketch of architectural form 1

3rd step: Application of extracted elements to design site

According to analysis above, we can understand clear that the inherent property of circumscribed space is **ENCLOSING.** We find the design site is similar form and angle of inclination with historical plaza. Between them, there is a clear path.

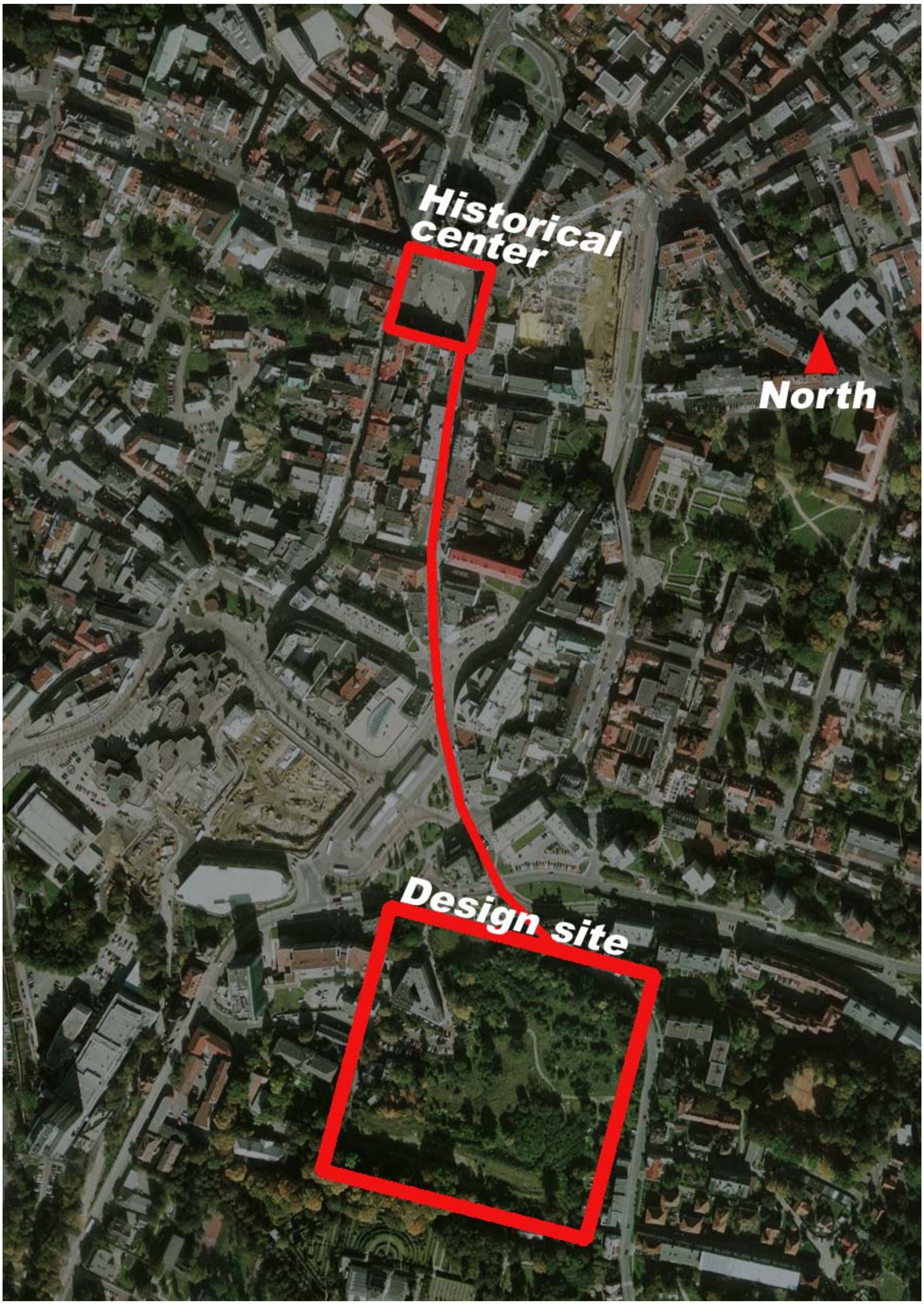
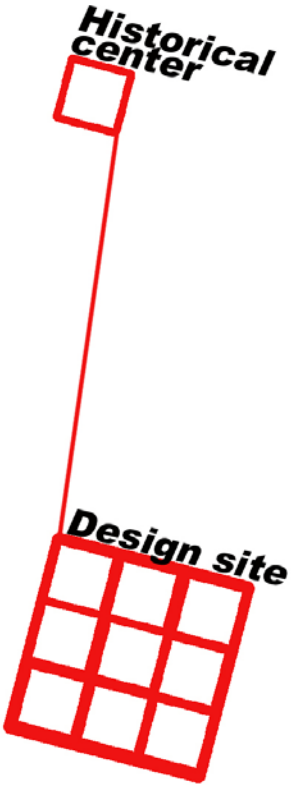


Figure 2.52 Location of historical center and design site 2

I have mentioned above that solid create a void with enclosing form to get an **Endocentric space.** With this original concept, I will start to defend the architectural form.



- Put the **9 Matrix modules** of historical plaza to Design site.
- we can compare the dimension of design site with historical plaza.

Figure 2.53　Matrix module

I mentioned above that the excavation works of design site have been already done, so there is a big "hole" in middle of site. Due to subterranean outflow, the hole looks alike a "pool". I want to keep this "hole" regarding as **Endocentric space**.

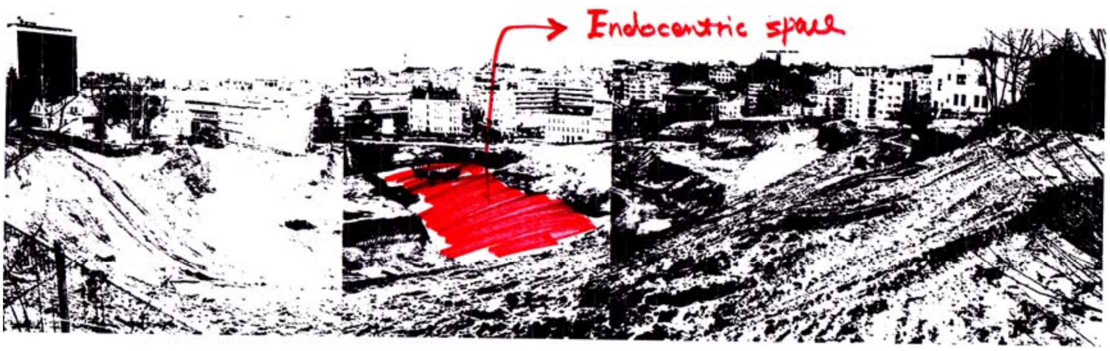
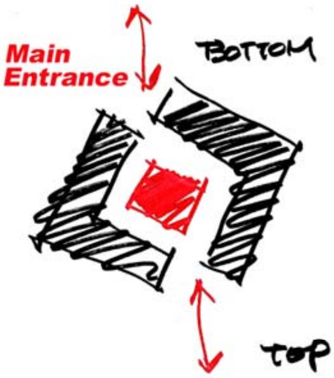


Figure 2.54　Endocentric space

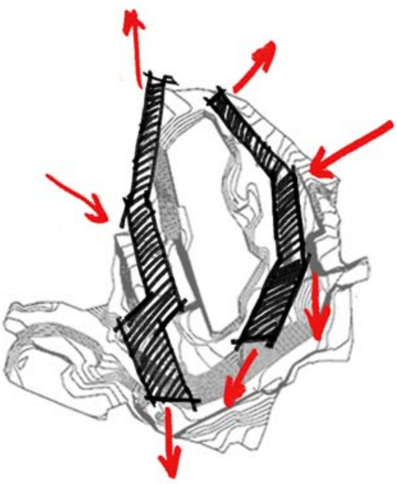
Enclosing the design site by matrix

The hole is regarded as **Endocentric space**

Solid encloses the **Endocentric space** and a new void is created.



Open up 2 corners of block: bottom point and top point that bring people inside or take them outside. The bottom point is close to MHD station and traffic node, so it is regarded as main entrance of **Hotel + Health Club.** The top point establishes the identity of landscape with bottom point. The matrix is separated into 2 volumes.



Bending and extruding shape of volume is to adapt special terrain which is excavated.

Figure 2.55 Concept sketch of architectural form 2

4th step: Prioritization scheme

Survival –In order to survive, human being need adapt the society and environment. From "the outside (appearance)" to "the inside (internal mechanism)" and then to "the cause," we can understand the "law" of the existence of all things? **Balance**.

The way of architectural survival is the same. We need consider under the pressure from the surrounding, how the architecture survive.

Basic architectural shape is defined. Two volumes embrace the **Endocentric space** (the red area) to create a new mental and physical void.

Figure 2.56 Architectural prioritization sketch 1

The pressure comes from traffic network.

The main entrance is close to MHD station and traffic point (the red circle). I try to incise to open up the matrix volume from bottom to top with a linear sighting.

The people can see the open landscape from bottom to top standing on the entrance square

Figure 2.57 Architectural prioritization sketch 2

The pressure comes from green space.

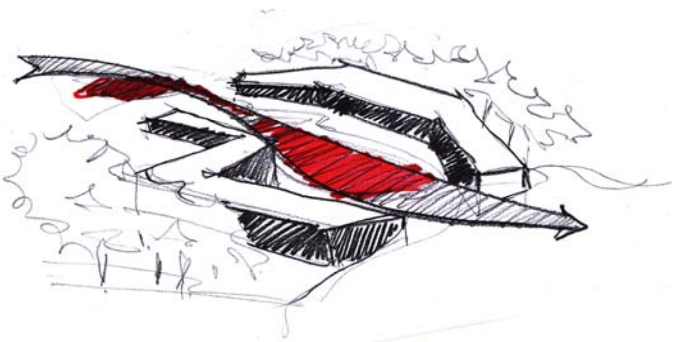
We can see that the design site has been enveloped by green space. How to bring natural landscape inside and take the **Endocentric space** outside to share between interior and exterior space?

Figure 2.58 Architectural prioritization sketch 3

The **Green pocket** draws the surrounding landscape into Hotel and Health Club.

Let outside and inside landscape blend and merge each other.

Figure 2.59 Architecture prioritization sketch 4



Following 4 analysis diagrams, the figures have already been laid in.

Figure 2.60 Volume sketch

Finally I hope to connect the 2 separated volumes by a certain way.

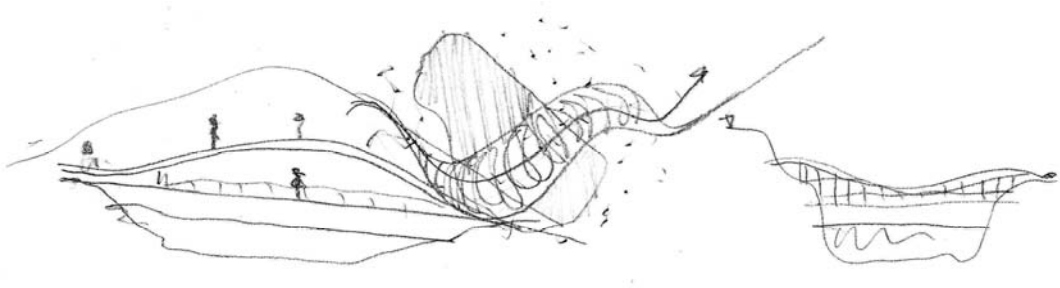


Figure 2.60 Bridge sketch 1

The idea is to make a multilayer bridge to link the 2 volumes. The bridge passes above the endocentric space and connects directly 2 interior public spaces of Hotel and Health Club between different levels.

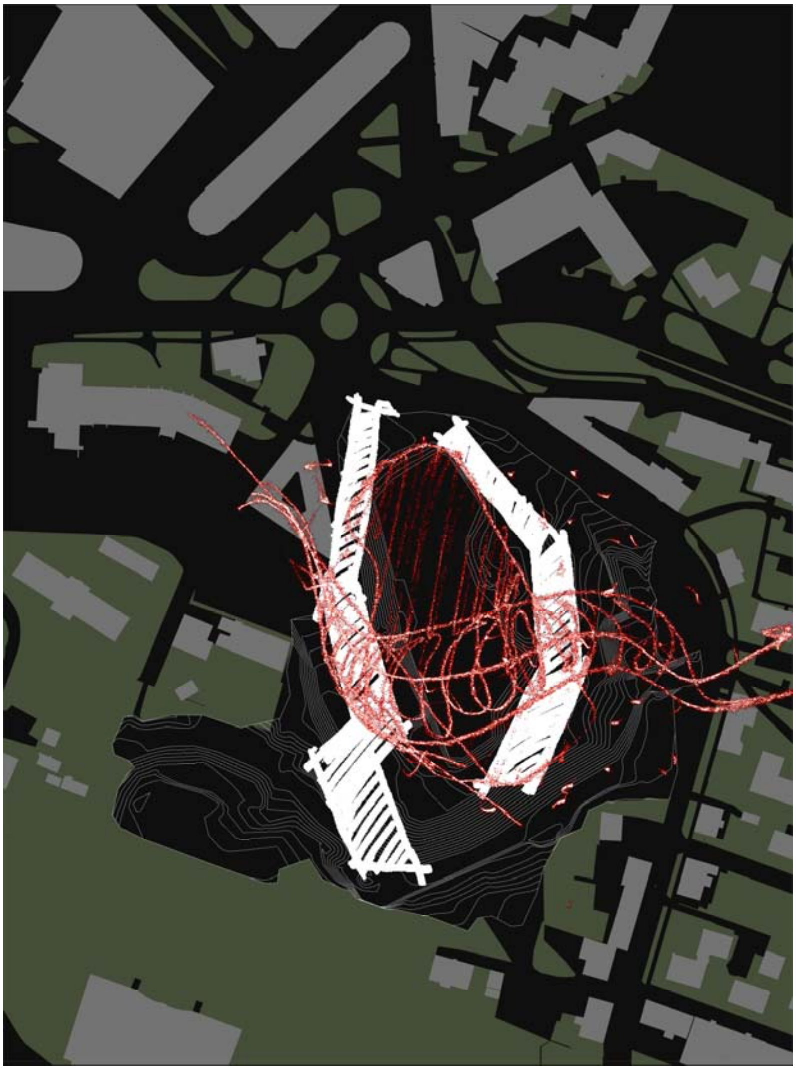


Figure 2.61 Bridge sketch 2

MASTER PLAN of RECREATION HUB

Figure 2.62

MASTER PLAN of RECREATION HUB

Figure 2.63

2.3.3 Post-Industrial Eco-Park

What is the Post-Industrial Park? Post-Industrial Landscape design is a new paradigm of landscape design, which emerged in 1960's~1970's, and quickly developed in the 1990's. With the transformation from Industrial Society to Post-Industrial Society, the western countries encountered the decline of traditional industry, consequently there came out a mass of industrial dereliction and wasteland. Beyond the restoration of ecosystem and landscape regeneration, they carefully preserved set of theories and methodology, and reused the industrial heritage. Post-Industrial Landscape design had become a new paradigm of landscape design with its own object and a completion of theories and methodology.

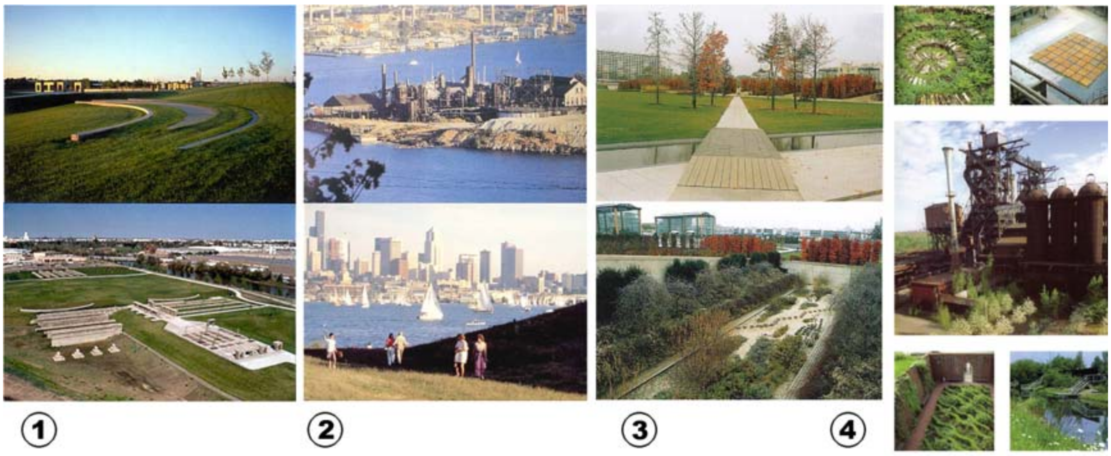


Figure 2.64 Case study images

① Northside Park, Denver ② Gasworks Park, Seattle ③ Parc Andre- Citroen, Paris ④ Duisburg- Nord Landscape Park

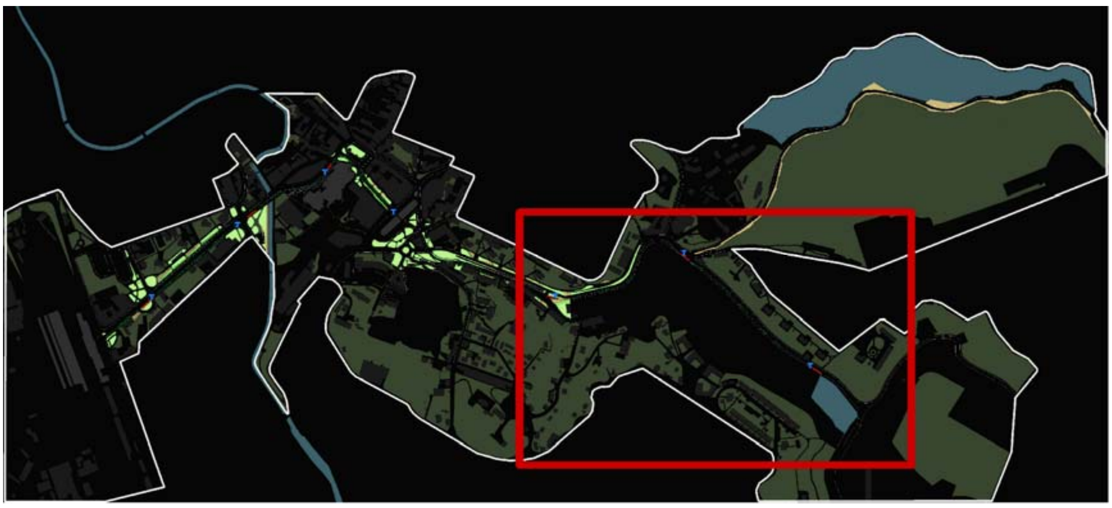
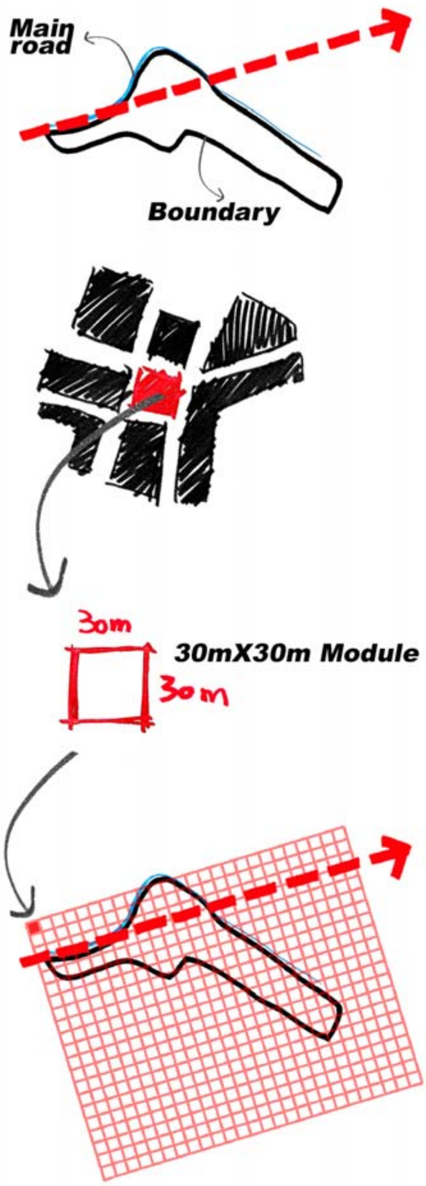


Figure 2.65 Location of post-industrial eco park

Definition of boundary



Definite a new axis

Extend the main road into the area and regard as an axis.

We need find a methodology of designing process. According to analysis above, I choose the void of historical plaza regarding as a module. The dimension of module is 30m*30m. Then I use the 30m*30m module as a single element to lay out a grid system for abandoned industrial area. It has the same incline angle with axis which is defined above.

Figure 2.66　Concept sketch of park 1

The position of the abandoned industrial area locates between two green spaces.

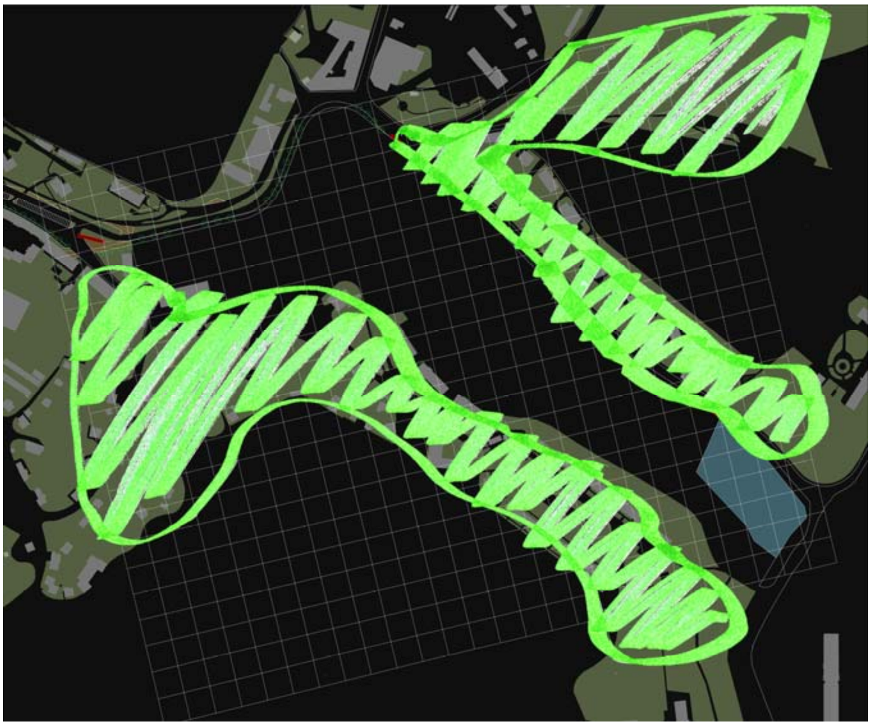


Figure 2.67 Concept sketch of park 2

Hope try to link the two green space.

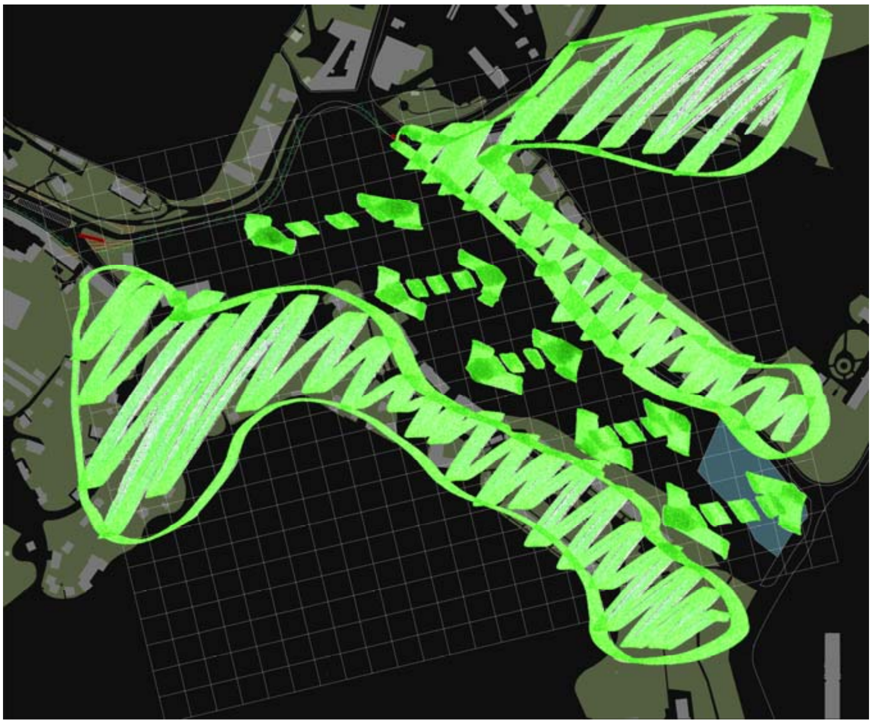


Figure 2.68 Concept sketch of park 3

Definition of **Green Matrix**

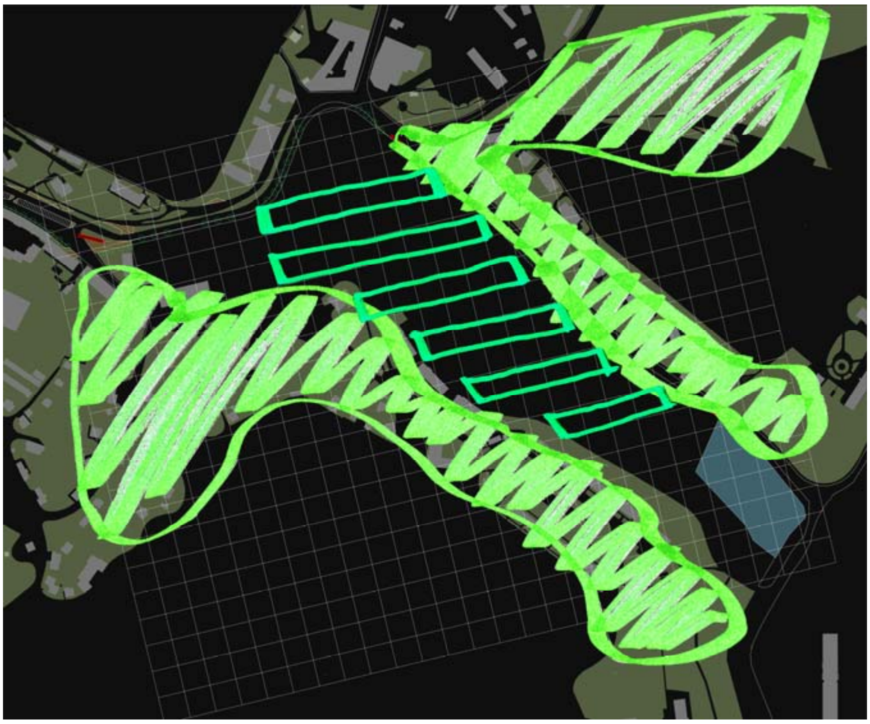


Figure 2.69 Concept sketch of park 4

We will find 2 inflection points. One trends to park and another one trends to Kistianov Mountain.

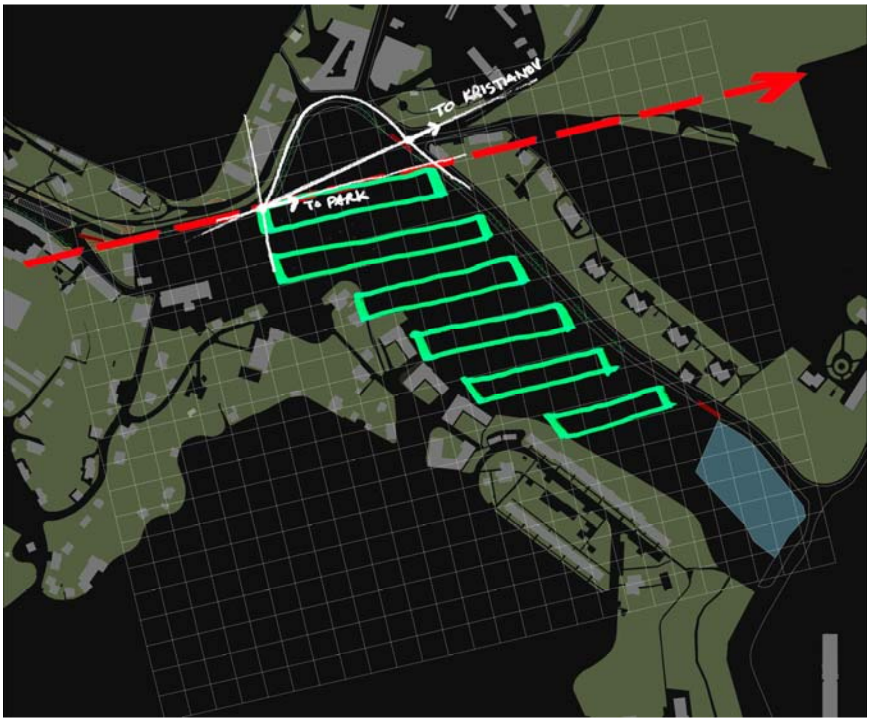


Figure 2.70 Concept sketch park 5

Paths incise to open up the **Green Matrix.**

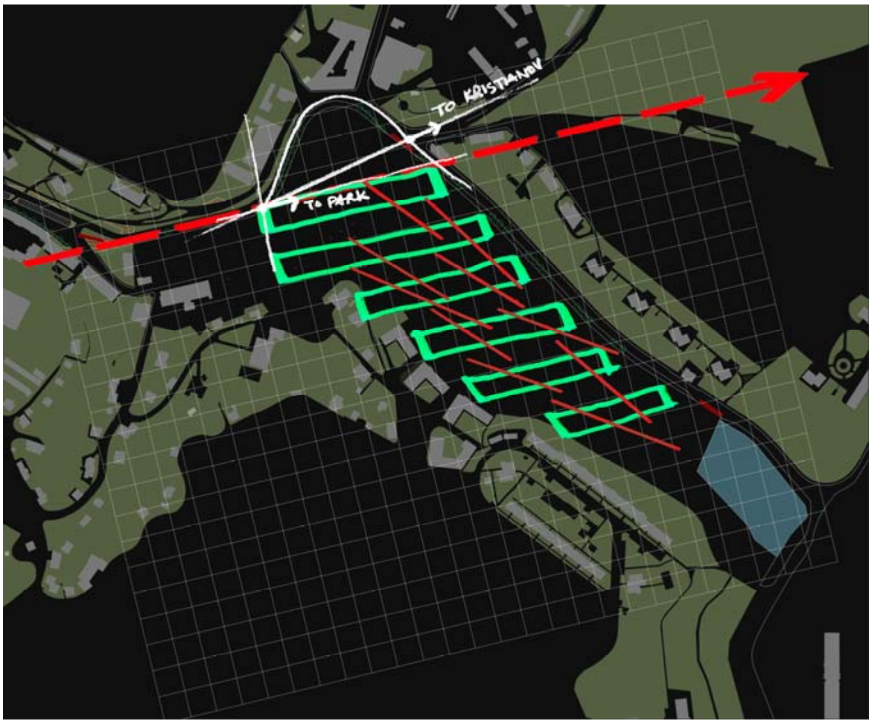


Figure 2.71 Concept sketch of park 6

Keep and reshape the existing pool

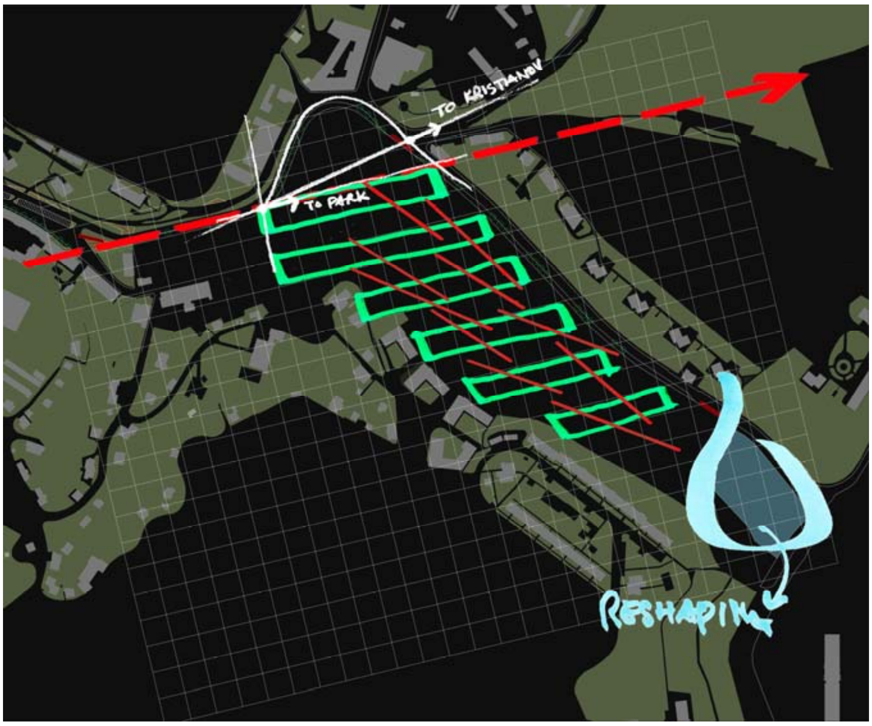


Figure 2.72 Concept sketch opf park 7

Purification System

The reuse of urban recycling water-Water quality standard for scenic environment use.

1. Water for aesthetic environment use: PH 6~9; BOD5<6;
2. Water for recreational environment use: PH 6~9; BOD5<4.

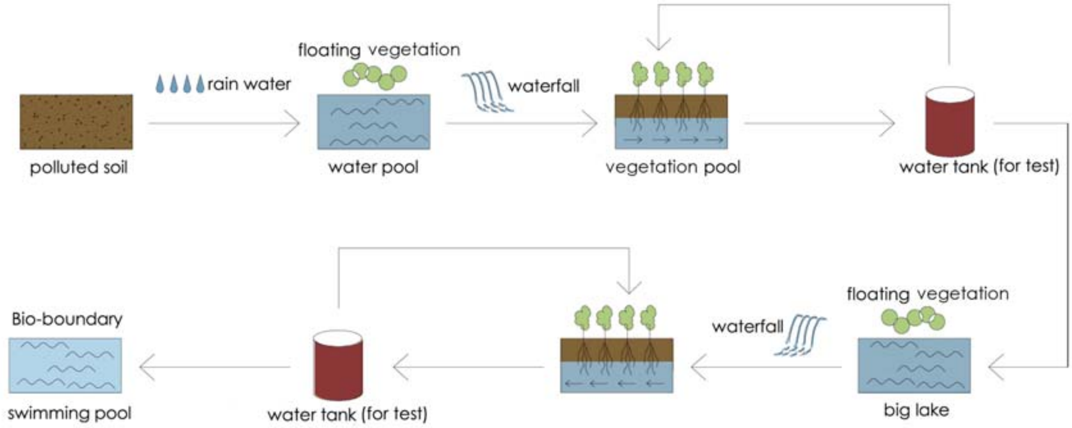


Figure 2.73 Purification system

Plant-purification—horizontal sub-surface flow

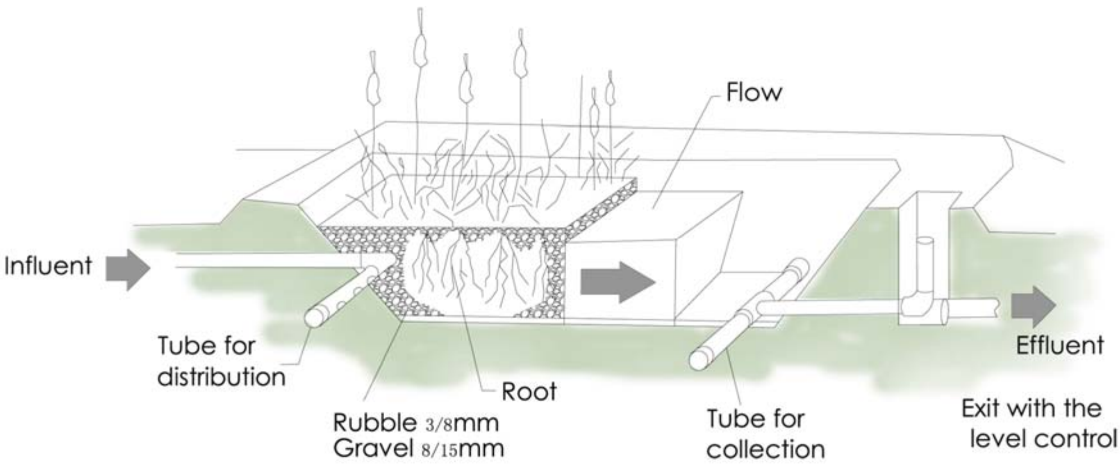


Figure 2.74 Plant-purification

Master plan

Figure 2.75

Park of Post_industrial & ECO

Figure 2.76

Figure 2.77

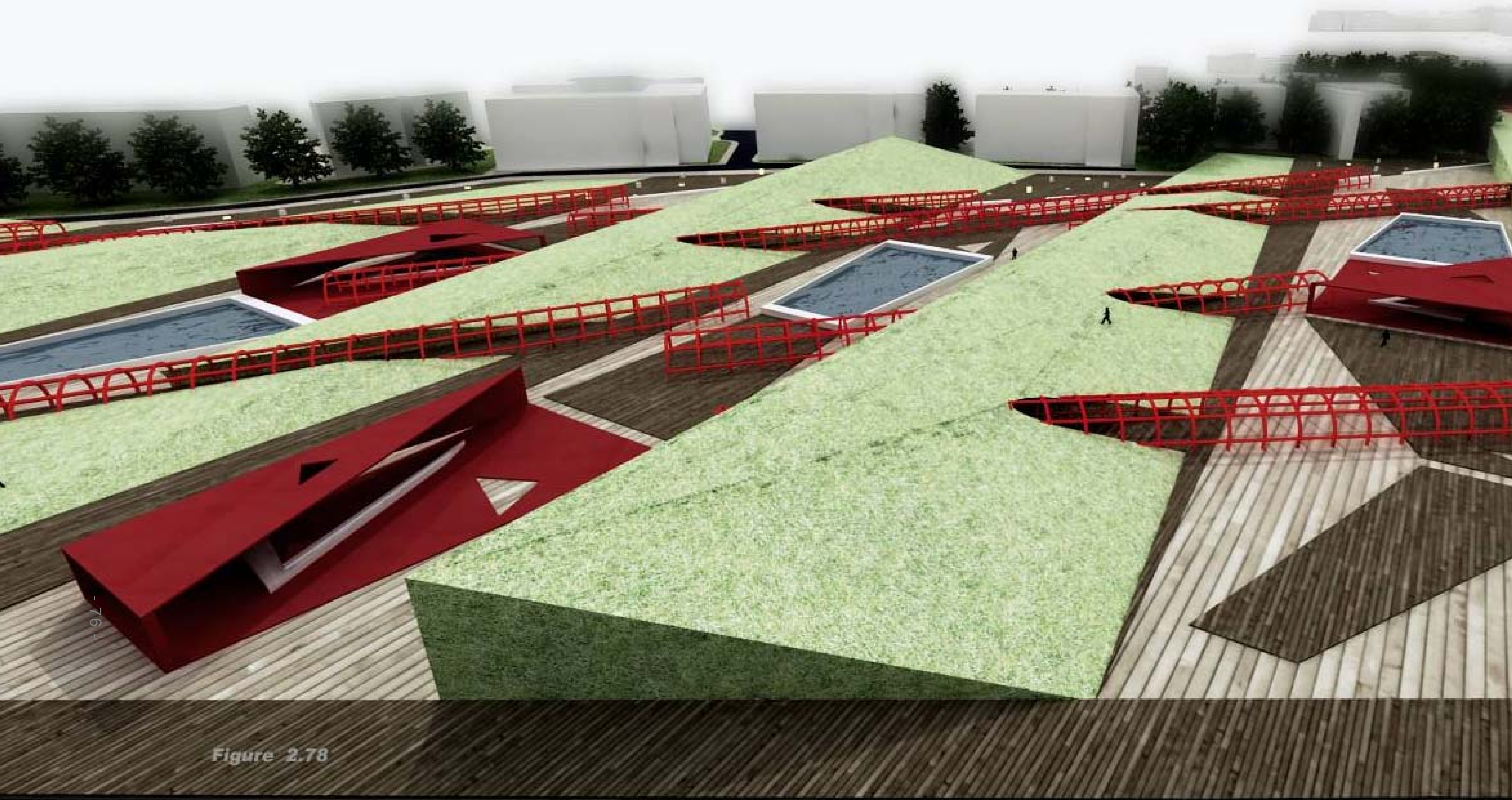


Figure 2.78

Park of Post_industrial & ECO

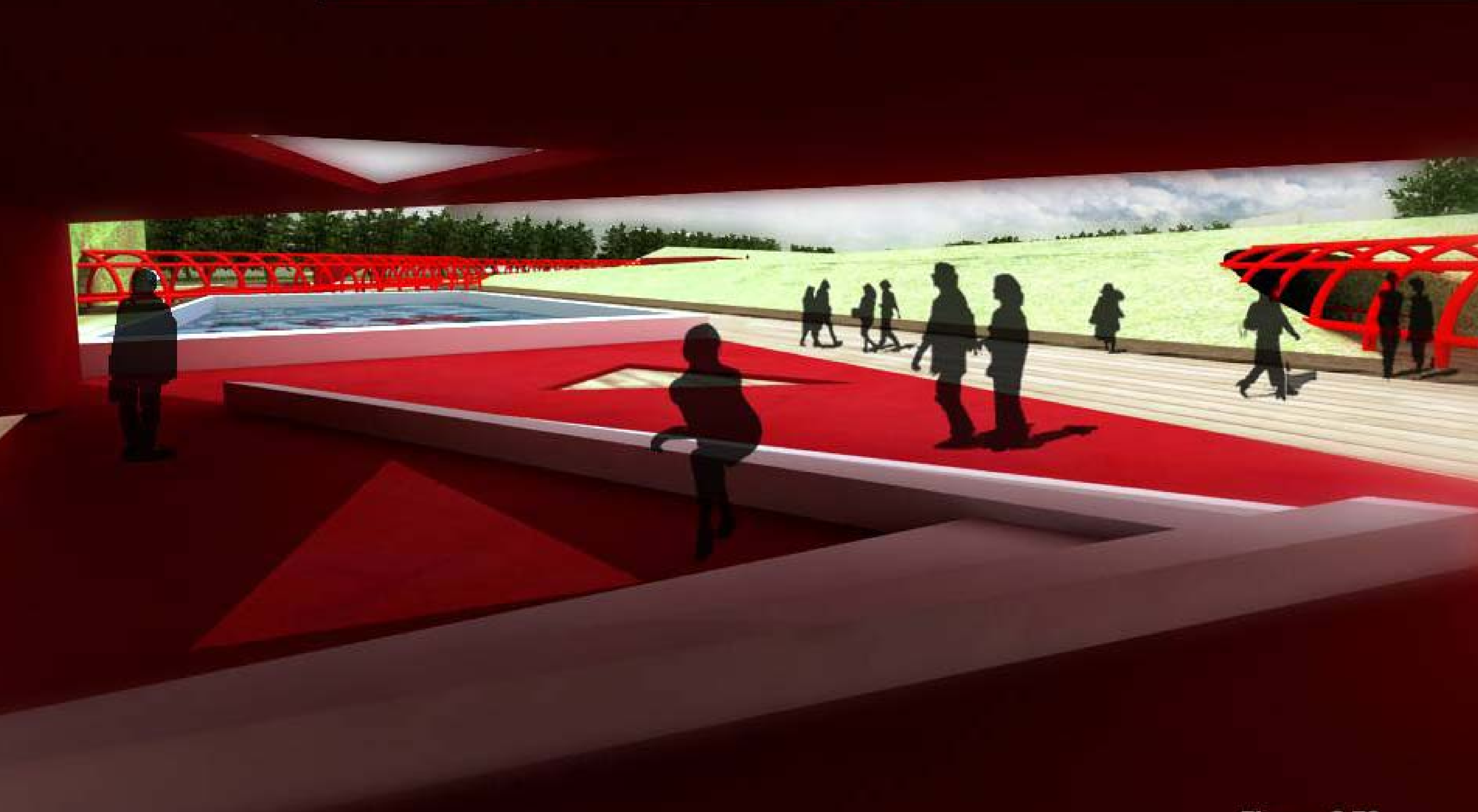
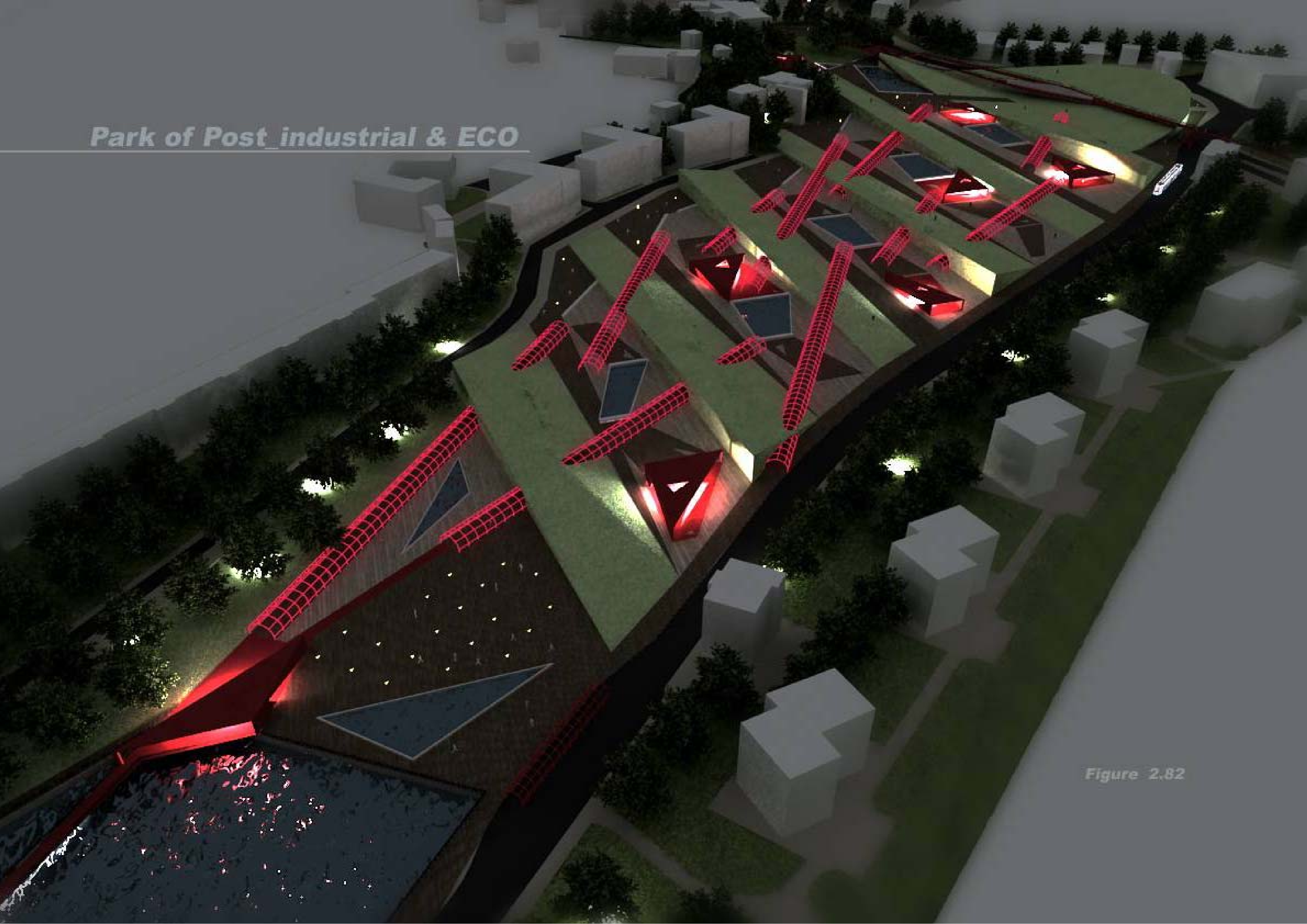


Figure 2.79

Figure 2.80

Figure 2.81



Park of Post_industrial & ECO

Figure 2.82

2.3.4 Global Master plan

URBAN MASTERPLAN

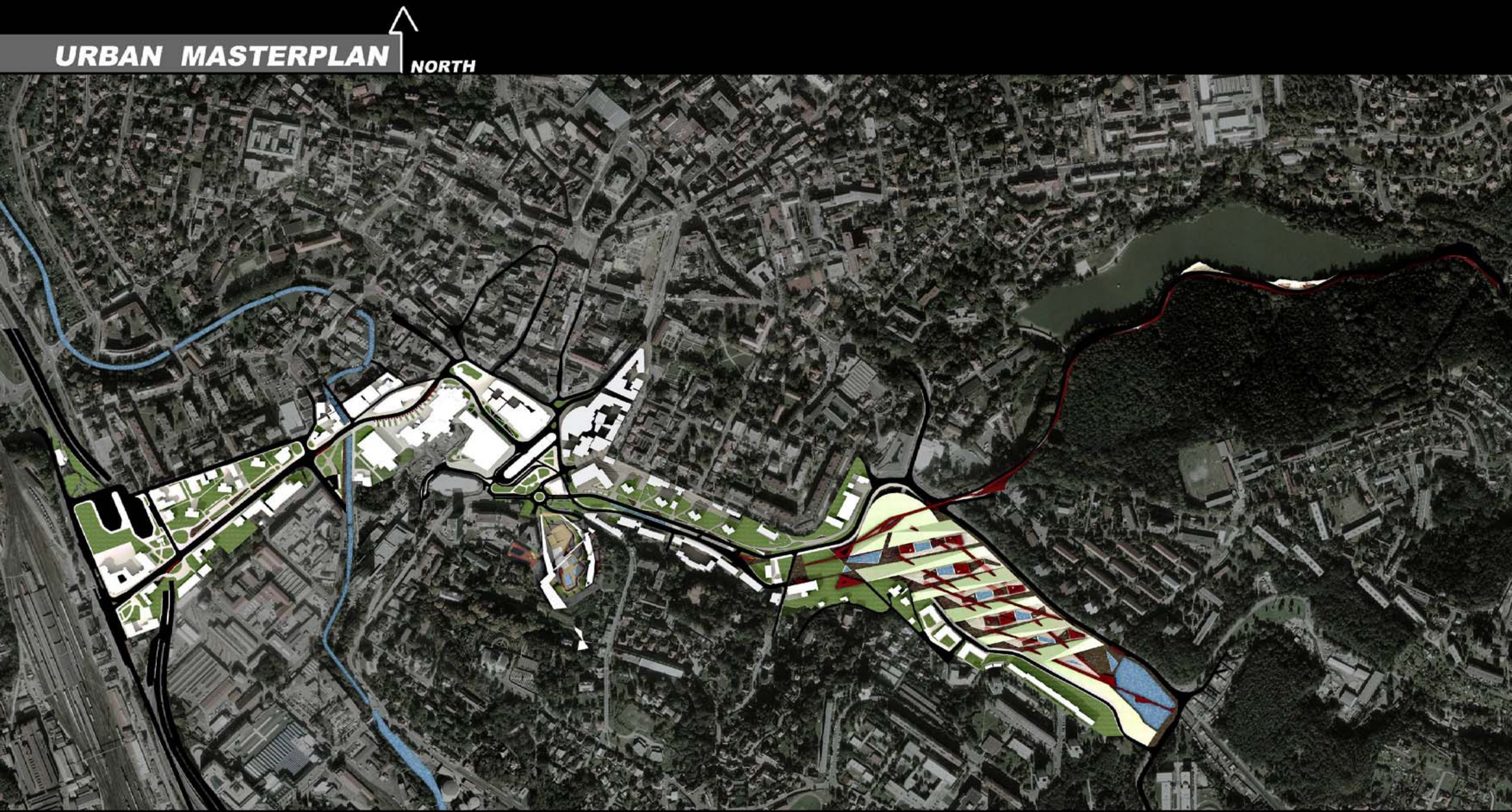


Figure 2.83

2.4 Impression of Liberec

Impression of Liberec

Figure 2.84

Impression of Liberec
Figure 2.85

Impression of Liberec

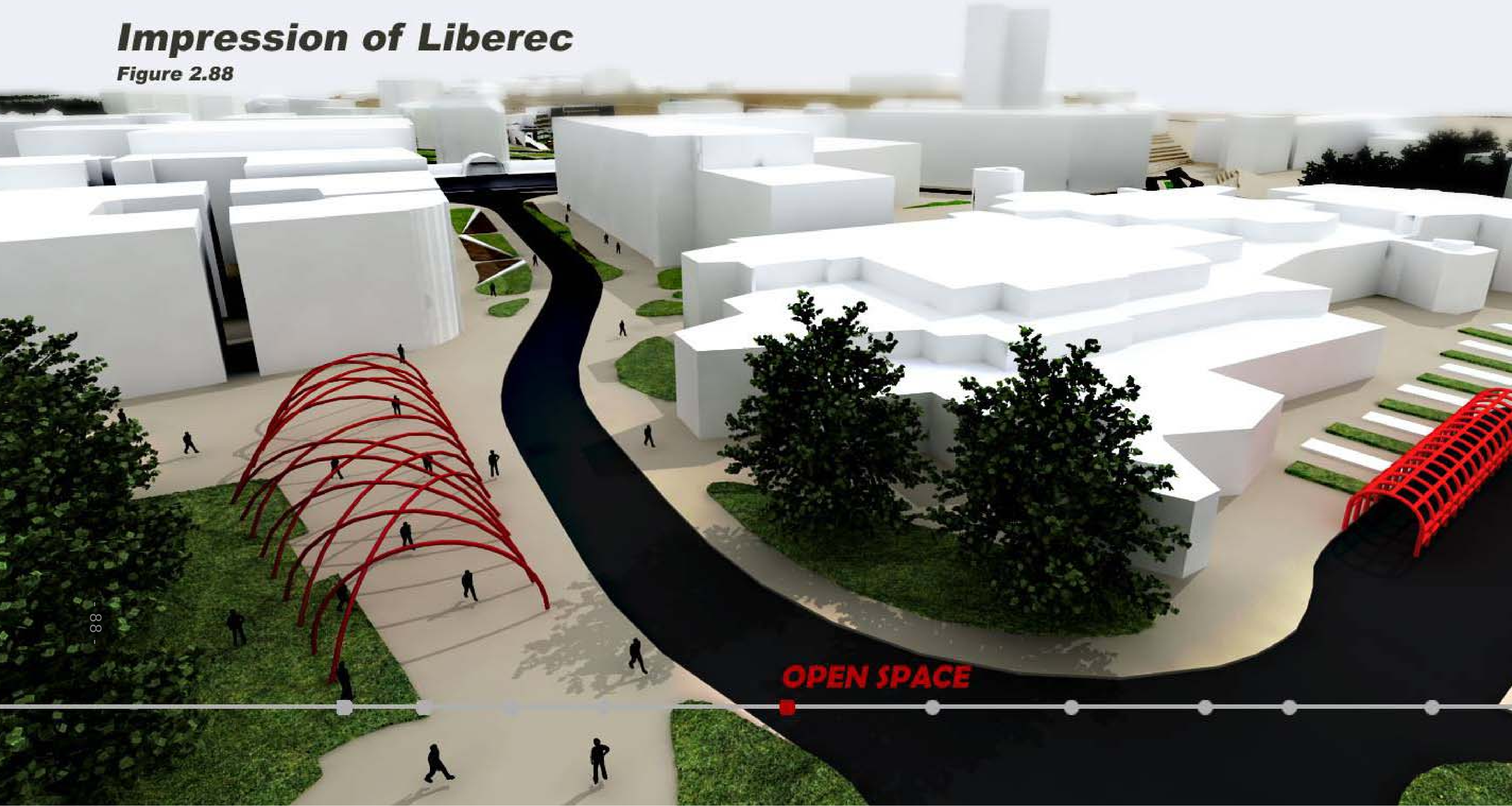
Figure 2.86

Impression of Liberec

Figure 2.87

Impression of Liberec

Figure 2.88



Impression of Liberec
Figure 2.89

Impression of Liberec

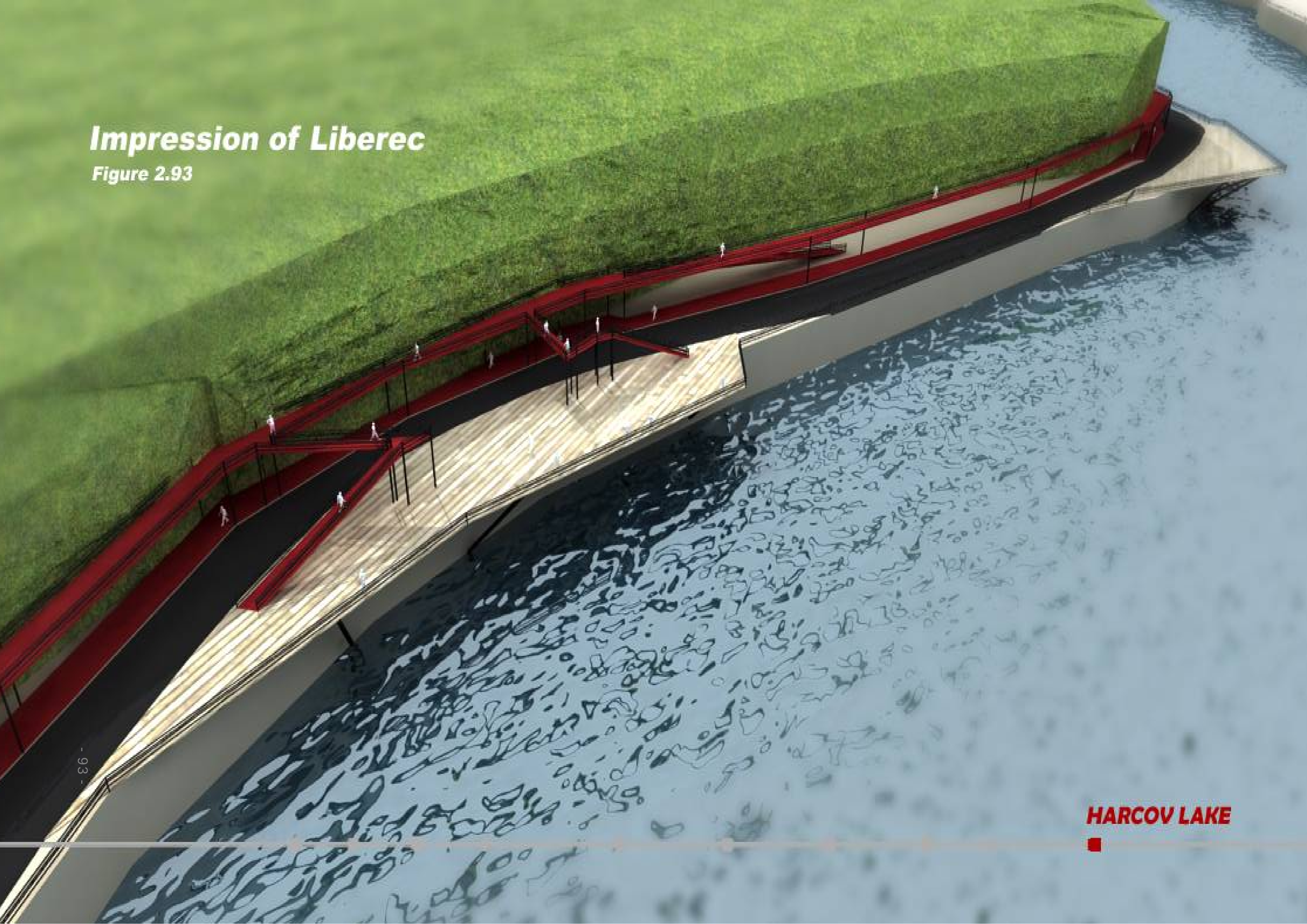
Figure 2.90

Impression of Liberec

Figure 2.91

Impression of Liberec

Figure 2.92



Impression of Liberec

Figure 2.93

3.0

ARCHITECTURE DESIGN

The Relation between Human Activities and Landscape Architecture: The first impression of designing constructions and places in the field of landscape architecture seems to create a particular space where people can display their activities efficiently. This creating job is not only to influence on human activities as performing our daily lives, but also to impact on society, politics, economy, and culture as a whole, which are associated with the track of human civilization. Thus, the significance of landscape architecture should be focused on how to fulfill needs of human and society as well as to maintain the beauty of nature.

Traveling, Leisure and Innovation come together to create an environment that will attract people and families to the new recreation hub of Liberec, with compelling leisure programme and events offerings onsite.

On the other hand, this chapter concerns the relationships between the physical form of the urban environment and leisure activities. It examines how architectural space morphology - i.e. spatial patterns and formal patterns - may have an impact on tourists' attraction and preferences in the contemporary cultural context of urban tourism.

3.1 Health club

3.1.1 What's the Health Club?

This is fashion word. A health club (also known as a fitness club, fitness center, and commonly referred to as a gym) is a place which houses exercise equipment for the purpose of physical exercise.

3.1.2 Facilities and services

Main workout area

Figure 3.1 Main workout area

Most health clubs have a main workout area, which primarily consists of free weights including dumbbells, barbells and exercise machines. This area often includes mirrors so that exercisers can monitor and maintain correct posture during their workout. A gym which predominately or exclusively consists of free weights (dumbbells and barbells), as opposed to exercise machines, is sometimes referred to as a black-iron gym, after the traditional color of weight plates.

Cardio area/theater

Figure 3.2 Cardio area/theater

A cardio theater or cardio area includes many types of cardiovascular training-related equipment such as rowing machines, stationary exercise bikes, elliptical trainers and treadmills. These areas often include a number of audio-visual displays (either integrated into the equipment, or placed on walls around the area itself) in order to keep exercisers entertained during long cardio workout sessions.

Group exercise classes

Figure 3.3 Group exercise classes

Most newer health clubs offer group exercise classes that are conducted by qualified fitness instructors. Many types of group exercise classes exist, but generally these include classes based on aerobics, cycling (spin cycle), boxing, high intensity training, regular and hot (Bikram) yoga, pilates and muscle training. Health clubs with swimming pools often offer aqua aerobics classes.

Sports facilities: Some health clubs offer sports facilities such as a swimming pools, squash courts or boxing areas. In some cases, additional fees are charged for the use of these facilities.

Personal training

Figure 3.4 Personal training

Most health clubs employ personal trainers who are accessible to members for training/fitness/nutrition/health advice and consultation. Personal trainers can devise a customized fitness routine, sometimes including a nutrition plan, to help clients achieve their goals. They can also monitor and train with members. More often than not, access to personal trainers involves an additional hourly fee.

Other services: Newer health clubs generally include health-shops, snack bars, restaurants, child-care facilities, member lounges and cafes. It is not unusual for a sauna, steam shower, or wellness areas to be present. Health clubs generally charge a fee to allow visitors to use the equipment, courses, and other provided services.

3.1.3 Health Club case study

Sports and Leisure Center

Location: Saint-Cloud, France

Designed for festive celebrations and entertainment and featuring the ‘coolest’ indoor climbing wall in France, the vibrant hues from the outside of the building correlate via color coding to the interior areas — enabling spatial orientation for young people. Environmentally aware KOZ architects made ‘green’ the standout color in their project by implementing eco-aspects into their design. The openings in the roofs and the glass facades allow for maximum natural lighting and limit electrical consumption, and they used prefab concrete slabs to reduce waste, pigment infused concrete to reduce paint use, and installed a solar heated hot water system.

Figure 3.5 Sports and Leisure Center in Saint-Cloud

Undena Multifunctional Sport & Wellness

Location: Anupriškės vill., Trakai dist., Lithuania

Complex consist of 27 buildings: outdoor amphitheater, outdoor volleyball, basketball and tennis courts, 20 hotel-type little houses, two sauna, restaurant with conference hall, two buildings with banqueting hall, kitchen, hotel rooms and sauna. There are two storage buildings and one fishing storage building. The area is a big hilly forest bordering the lake. The aim of a complex is a recreation in a nature for individuals, families, organizing labor groups from the big cities.

Figure 3.6 Undena Multifunctional Sport & Wellness

Orhidelia Wellness

Location: Podčetrtek, Slovenia

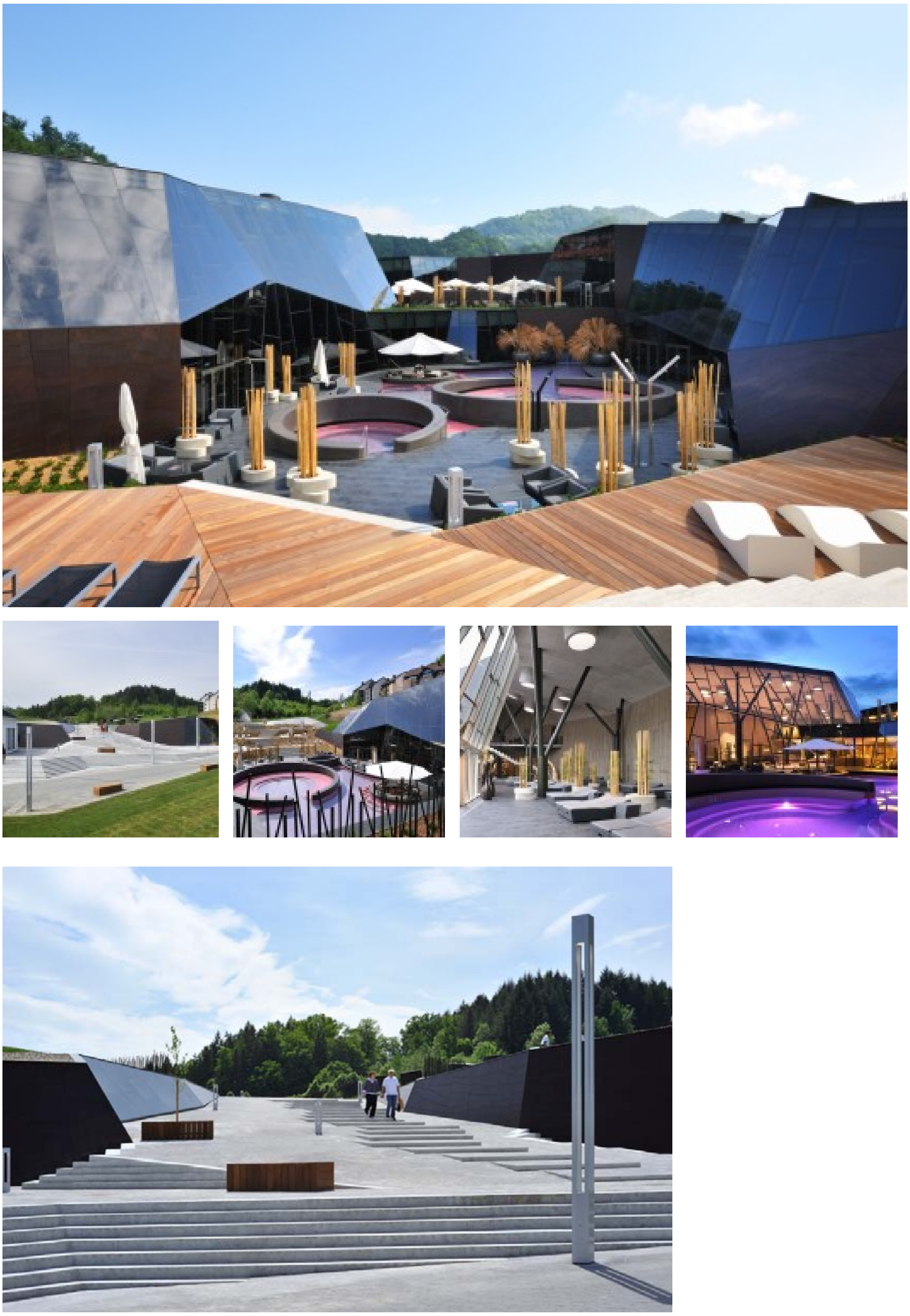


Figure 3.7 Orhidelia Wellness

3.2 Hotel

3.2.1 What's the Hotel?

As business and leisure travel become more intertwined, today's hotels must accommodate the overlapping desires and needs of the traveler. Hotels need to provide more things to more people—a place to work, relax, gather, entertain the family, eat, drink and shop. Modems, computers, wireless phone and fax machine are becoming room standards while entertainment expectations are now greater than just a tennis court or indoor pool. The convergence of the themed hotel has brought increased competition to the hotel industry.

But whether it is an urban high-rise or a remote retreat, human experience ultimately determines a hotel's success. What are travelers looking for? After all, they are not a homogeneous group. It is crucial that hotel designs take into account this diversity. Our designs must reflect the image of the owner and operator along with the nature of local surrounding—and produce space that embraces these factors. The architect's job is to create wonderful destinations of preference that provide the right financial returns for the owner and operator.

3.2.2 Second homes for tourists

We should try to make hotels, especially urban, suburban, and convention hotels, feel like second homes for tourists. Hotels should offer a full range of business and leisure amenities. We will create a collaborative learning environment—a place where people from throughout the company could come together to exchange information and redesign processes—to learn to think differently.

3.2.3 Resort place

Travelers expect today's hospitality facilities to reflect and enhance the environment in which they are located. This is especially true with resorts. The architect must understand the land, site and environmental considerations in addition to the culture. The challenge for the architect is, first, to identify what's special about the location and, second, to capitalize on its strengths without mimicking other places.

3.2.4 Environmental and cultural sensitivity

I want emphasize the importance of environmental and cultural sensitivity. We recognize that working in different countries requires an appreciation for different criteria. Unspoiled beauty and natural environments draw today's tourists—It's both responsible and great business.

The most effective way we have about found to take advantage of environmental assets, local customs and cultures is to use the owner's and operator's wealth of knowledge. We also from collaborative relationship with local design professionals, manufacturers and suppliers to make sure that we incorporate indigenous materials throughout

3.2.5 Hotel case study

Atra Doftana Location: Prahova, Romania

The building is situated nearby a mountain lake and is configured with two major volumes, taking advantage of the natural form of the site, which presents two major level drops intercalated with two approximately flat areas: one volume that houses the rooms and reception, and the second volume that contains living and dining spaces, the restaurant kitchen and technical spaces, both volumes are thus articulated as to exploit at maximum the geometric configuration of the land, orientation and views the site has, considering the insertion in site and how the building creates a dialogue with the environment

Figure 3.8   Atra Doftana Hotel

Camélia

Location: Guimarães, Portugal

An irregular plot where it seemed too tight to fit what the architects proposed to design, with some existing constructions from the 19th Century they wanted to keep and that strongly had to relate to the new building. It is an extensive program with several function related requirements, but without being complex.

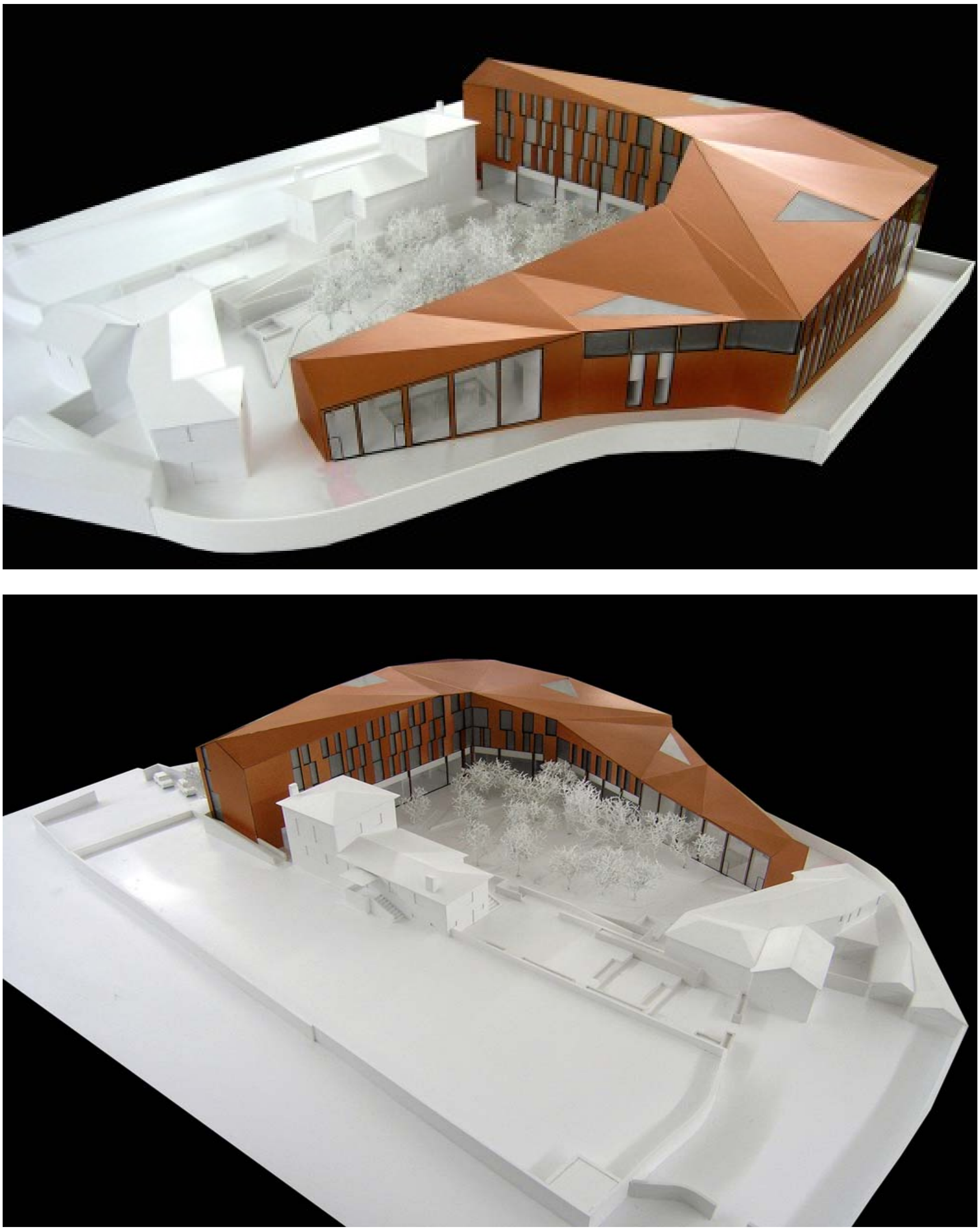


Figure 3.9 Camélia Hotel

3.3 Abstraction

3.3.1 Environment

The Liberec Region includes the areas of Český ráj, Jizérské mountains, Krkonoše, Lužické hory, Máchuv kraj and Frýdlantsko.

The region is home to the protected landscape areas of the Jizera and Lužice mountains and the Krkonoše Mountain National Park. Unique timber-framed structures have been preserved in many places in this mountainous landscape.

3.3.2 Sports and Leisure

Liberec interested in swimming or water sports will find all they need at Mácha's Lake or in the Holany Ponds area. The area is also interwoven with a number of marked cycling paths. Meanwhile, the Jizera Mountains are home to one of the best known cross-country skiing tracks in the country, the Jizera Mountain Cross-Country Track.

Extreme Games

Bungee jumping‖ Rock climbing‖ Snowboarding ‖ Zorbing ‖Mountain boarding‖ Grass skating ‖Ski ‖Ballooning ‖ Skateboard ‖Tandem skydiving ‖ Skating ‖ Snowboard ‖ Bobsleigh ‖Dive ‖ Rafting ‖Ski Jumping ‖

Competitive sports Games

Badminton ‖Football ‖ Swimming‖ Beach volleyball ‖ Track ‖Athletics ‖ Taekwondo ‖ Judo ‖ Volleyball ‖ Tennis ‖Cycling ‖Gymnastics Trampoline ‖ Softball ‖

Others:

SPA ‖ Fitness ‖Ballet‖ Squash ‖ Shooting ‖ Fencing ‖ Yoga ‖

3.3.3 Activities

The Liberec Region is ideal for an active holiday. Many towns in the region also have a rich glassmaking tradition and visitors can see with their own eyes how world-renowned Bohemian glass is made.

3.3.4 Situation

The plot is located in the southern center of Liberec. It forms a transition between two types of buildings, from the north adjacent to the city center from the south Perštýn neighborhoods with predominantly family houses. After the previous plan to build on it a large commercial center, from which it was abandoned, there remained a huge construction pit. It covers almost the entire territory and the highest point of elevation is 20 meters.

3.3.5 Basic concept

Due to the reasons mentioned above, the function of the project is a **RECREATION HUB** including **HOTEL** and **HEALTH CLUB.**

The idea is to create a formal continuity between architecture and terrain resulting in a system of overlapping artificial and natural landscapes.

Preserving the existing void (the hole after digging) enclosed by two linear form buildings. My desire is to maintain and reuse the existing void and turn it into a new landscape point. The form of the linear building is my approach to a project, especially when, as in this case, the building comes into dialogue with complex terrain.

As possible as it can be, keep continuity of the roof for walking around following the terrain shape. Also the people can get on the top of the roof, and from there experience and observe the surrounding landscape.

I reuse the “hole” after digging and defining new meaning: water landscape and skating rink for different seasons for the customs who are living in the hotel and do the exercise in the health club. The pedestrian bridge which is steel structure above the hole links two buildings: Health club & Hotel.

By using the buildings I designed, I want to provide a new life style for local inhabitants as well as tourists in the dynamic modern metropolis.

3.4 Process

3.4.1 Solid and void

Figure 3.10 Recreation hub layout

1. Open Opera 2. Grass pedestrian 3. Wooden circulation platform

4. Skating rink 5. Swimming pool (outdoor)

The project for the **Recreation center** clearly expresses the main features of the site. The form emerges from a delicate understanding of the territory and its interesting topography. It creates a kind of dialogue between solid and void such as building and environment. Two dynamic volumes embrace inner space to create a semi-public center. The form of inner space which also can be called as Endocentric space responds to historical center. It generates a new landscape, an environment that lays between artificial and the natural.

3.4.2 Dynamic volumes

Main goal while designing the building was to diminish as much as possible its presence in the surroundings. The linear distribution of units, it is a resultant of a topological answer to the picturesque typologies frequently built in the area.

From applying the logic of topographical mapping i.e. the indexing of horizontal sections as continuous lines, the volume is formed as a series of strata that as an artificial entity maintains a dialogue with its natural environment.

Architectural Shape tries to merge into organic whole with the terrain. They look like as two branches to set around inner space. A multilevel bridge over the inner space establishes relationship between 2 volumes.

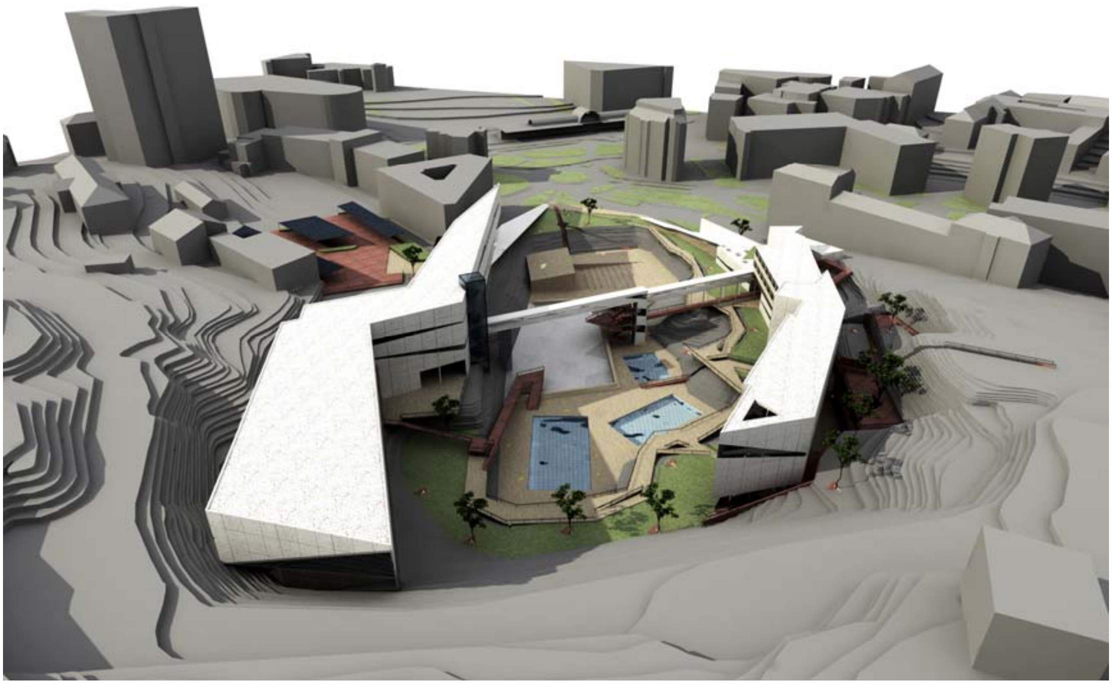


Figure 3.11 Dynamic volumes 1

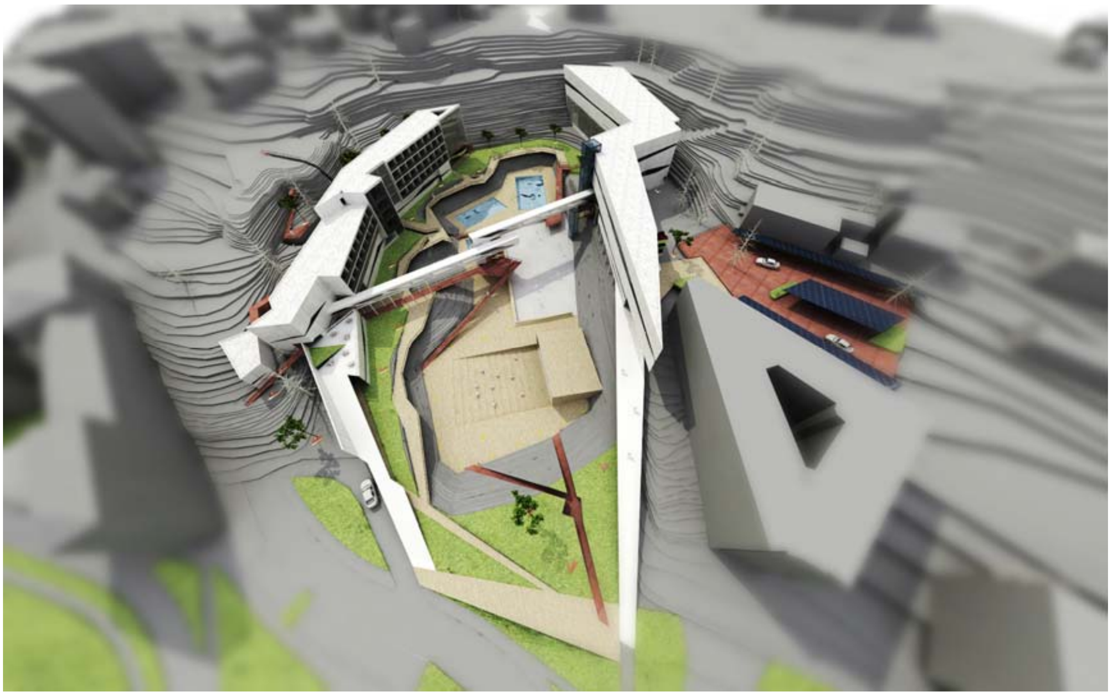


Figure 3.12 Dynamic volumes 2

3.4.3 Indicative windows

I try to create a dynamic facade. According to local bohemia culture, the whole skin has been cut in stretched zig-zag pattern with the “scissors”.

Figure 3.13 Bohemia Zig-zag pattern

The indication of window shape absorbs not only the people into the inner space also the landscape. Another reason of facade design is reducing the area of windows to keep the heat gain in winter according to low temperature in Liberec.

Figure 3.14 Zig-zag windows 1

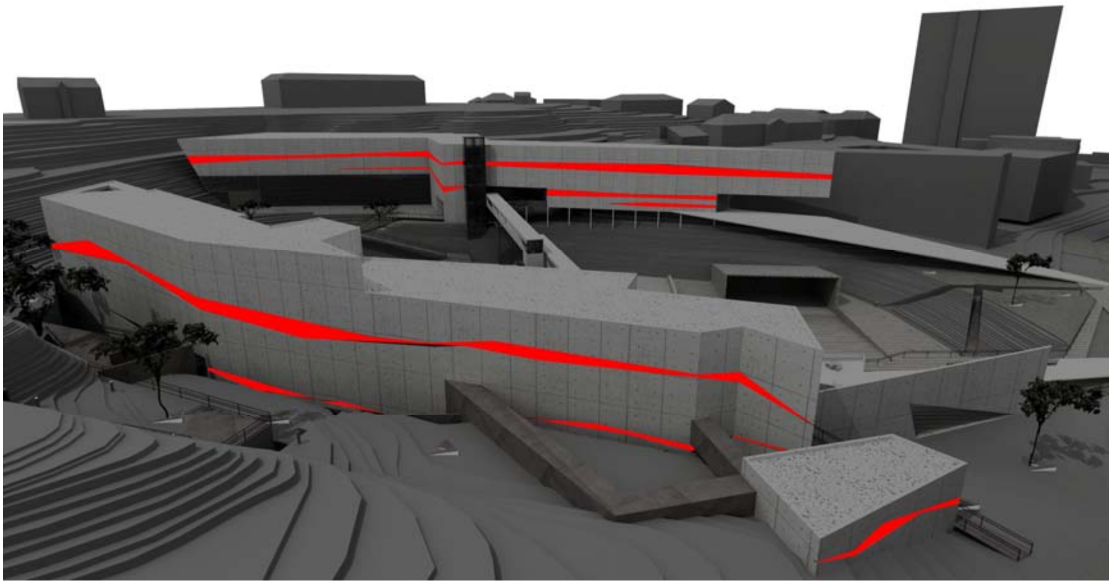


Figure 3.15 Zig-zag windows 2

3.4.4 Interactive landscape

1st, to keep the strong natural terrain character of the place;

2nd, to build spaces for the guests;

New recreation center is consecutively designed rather like a landscape arrangement then a building. The circulated platform embraces a sank square space including swimming pools and open opera. The whole plot has been connected by different level ramps and steps. I try to enunciate that linear landscape ecology plays a crucial part in the landscape of hilly terrain.

The largest part of the new built space, with underground and semi-underground levels, will be for a tourist transfer station and related activities.

Figure 3.16 Landscape of Recreation hub 1

Figure 3.17 Landscape of Recreation hub 2

Figure 3.18 Landscape of Recreation hub 3

Figure 3.19 Health Club courtyard

Figure 3.20 Entrance square

3.4.5 Open opera

The playing and singing under the open sky on a gentle summer night, far away from the noise of the street is an experience that even the average visitor who is not too much into opera and passion plays will find overwhelming.

Figure 3.21 Open opera

3.4.6 Balcony: "Thermal obstruct volume"

Sometime we need skylight without solar heat (during summer). Sometime we need skylight and solar heat (in winter). We can achieve these goals by balcony. In summer, the balcony likes as a thermal obstruct volume to stop almost solar radiation into guest room due to the higher solar altitude. In winter, according to lower solar altitude, the guestroom as much possible as absorb the solar radiation during the day time.

Figure 3.22 Balcony facade

3.4.7 Wooden shading slats

Some parts of external elevations are enveloped by splint to form an elegant outer envelope of sun-shading slats system. The natural ventilation is sufficient especially in summer. The wooden shading slats system is translucent not transparent. It creates fantastic internal lighting features.

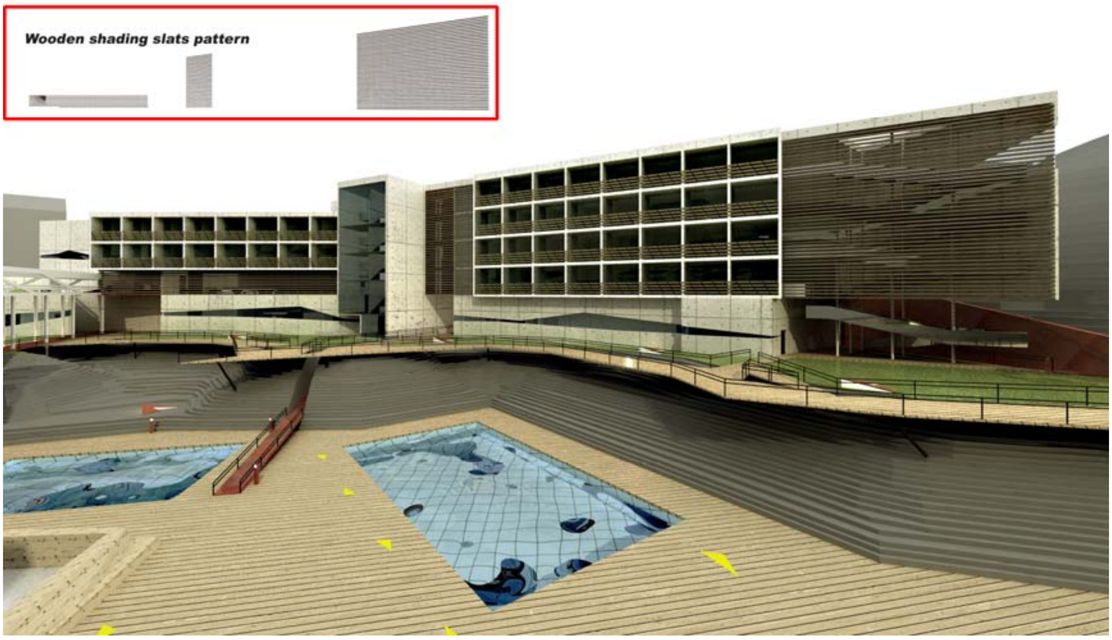


Figure 3.23 Wooden slab façade of hotel

Figure 3.24 Wooden slab façade of health club

3.4.8 Semi-Enveloped courtyard

I hope to create an interaction space between artificial and natural environment. The Semi-Enveloped courtyard is conceived as a flowing spatial continuum. People will find themselves in a mysterious and illusive universe while walking in

Figure 3.25 Facade of Semi-Enveloped courtyard

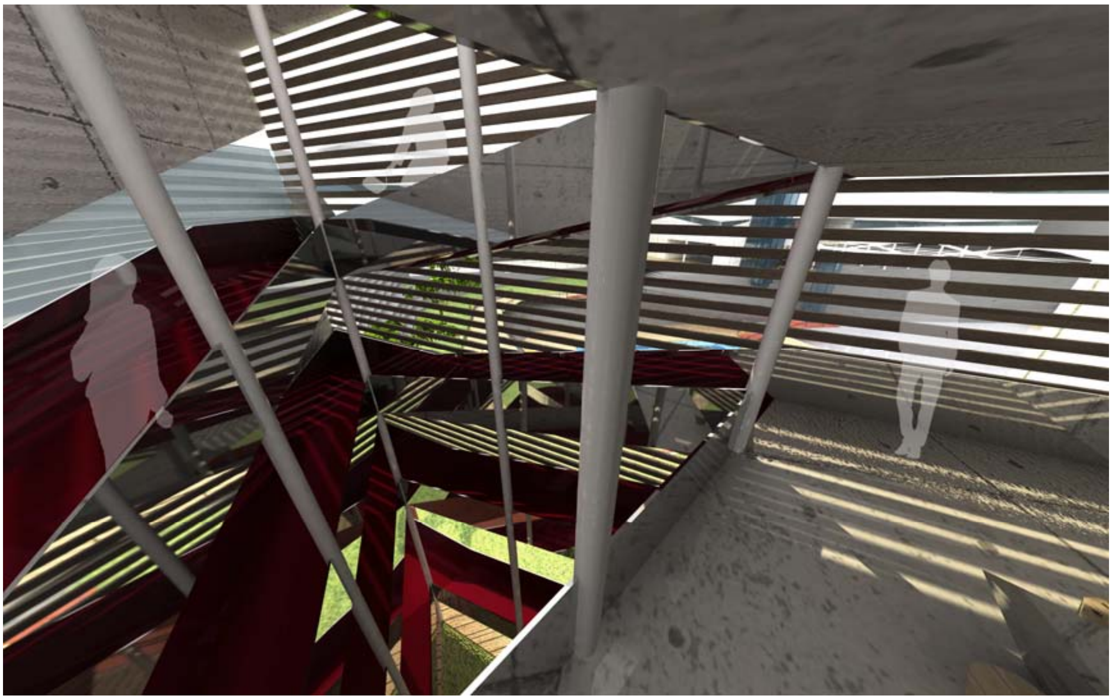


Figure 3.26 Ramp of Semi-Enveloped courtyard

3.4.9 Twin Bridge

The Twin Bridge is medium between health club and hotel. It overcomes the great span (inner landscape space). People can shuttle between two volumes freely. So it likes a hub of horizontal and vertical communication. Considering visual continuum, the bridge is hollowed out and it creates a sense of dynamic rhythm.

Figure 3.27 Twin bridge 1

Figure 3.28 Twin bridge 2

3.5 Interior design

3.5.1 Hotel

Guest room

Many hotels operators believe that the guestroom and guest bathroom make a more lasting impression on the lodging guest than does the exterior architecture or the lobby or other single interior space. Design of the individual guestrooms and suits, while clearly more an interior layout problem than an architectural one, is still an important part of the architect's responsibility.

I design 3 types of guestroom:

Type A: **Suite**; Type B: **Standard room B**; Type C: **Standard room C**

Figure 3.29 Type of guestrooms

Figure 3.30 Plan of type A: Suite

Figure 3.31 Plan of type B: Standard room B

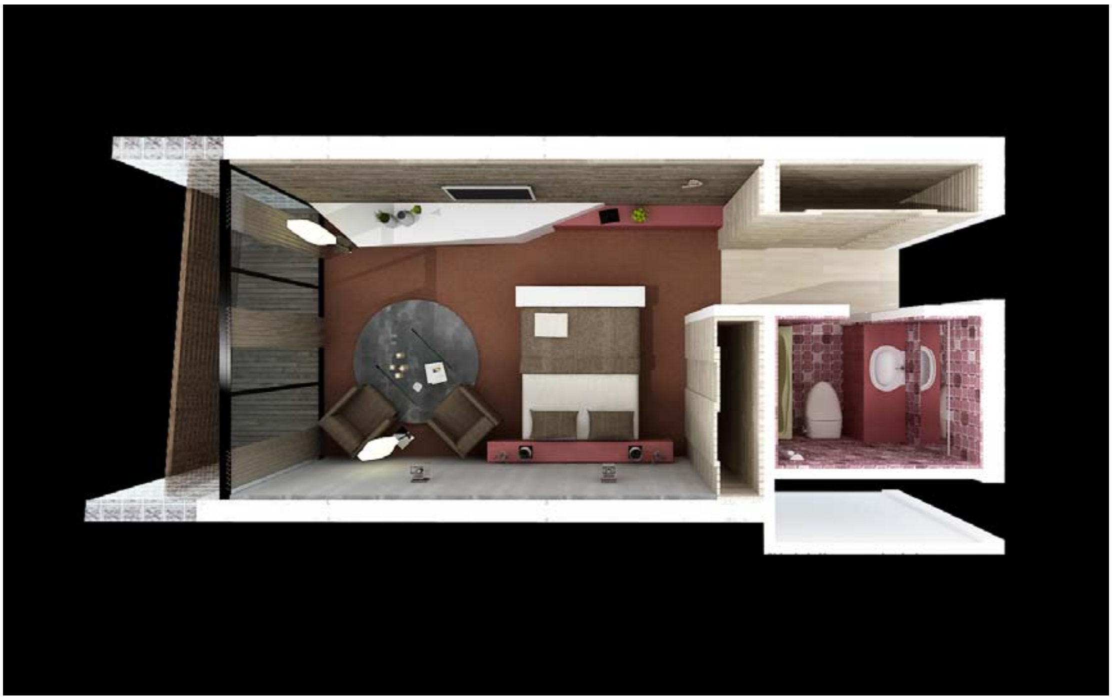


Figure 3.32 Plan of type C: Standard room C

Figure 3.33 Living room of suite

Figure 3.34 Bed room of Standard room B

Figure 3.35 Leisure space of Standard room C

Relax space

The restaurant and bar not only provide the relaxing space for the people, also create a new landscape between inside and outside.

Figure 3.36 Restaurant of hotel

Staircase

The staircase is not only a vertical traffic system but it creates a new landscape point which provides spatial indicative mark for the people. The half-space landing also creates a new communication space for the guests.

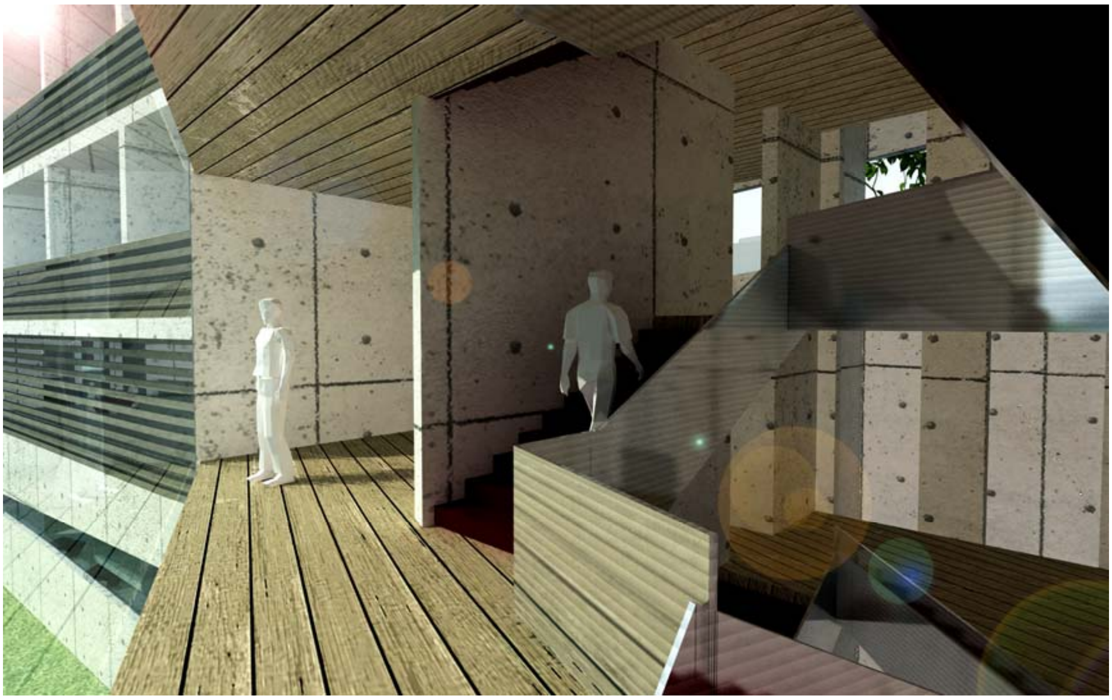


Figure 3.37 Staircase of hotel

3.5.2 Health club

SPA

A principal of Minimalism Aesthetic, where the space design emphasizes on extreme leisure and comfort, have an experience of a journey from body relax to soul touch. This is a new SPA center in Liberec. Space is invisible, integrated with the function of spa through the natural elements, and created a sense of chic, comfort and silent.

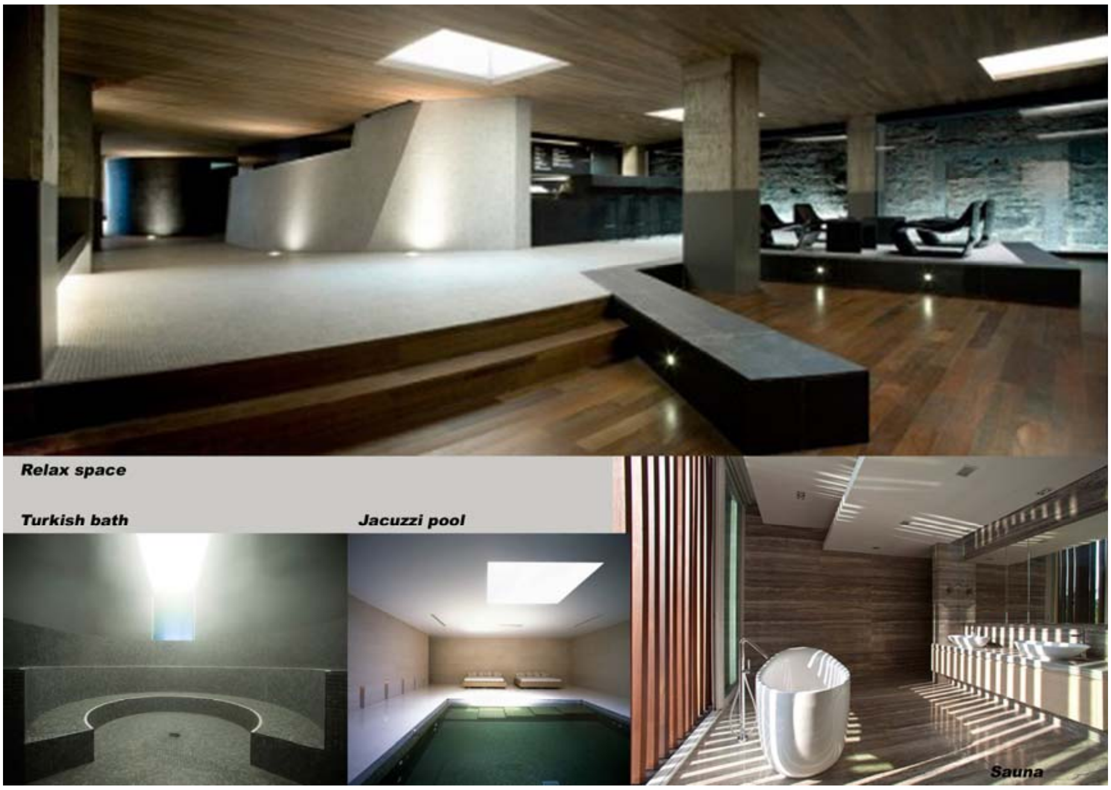


Figure 3.38 SPA of health club

Corridor lobby

People will pass through a long corridor before entering the sport centre, so attaching interestedness to long path is important. I put the coffee house along the corridor to organize two streams of people, one is from parking and another is from park of entrance, then extending to reception desk and the style of interior decoration achieves to theme of sport.

Figure 3.39 Corridor lobby

Reception desk

The reception desk will give the fist impression of Liberec to people. Let the tourists feel the special sport culture in Liberec.

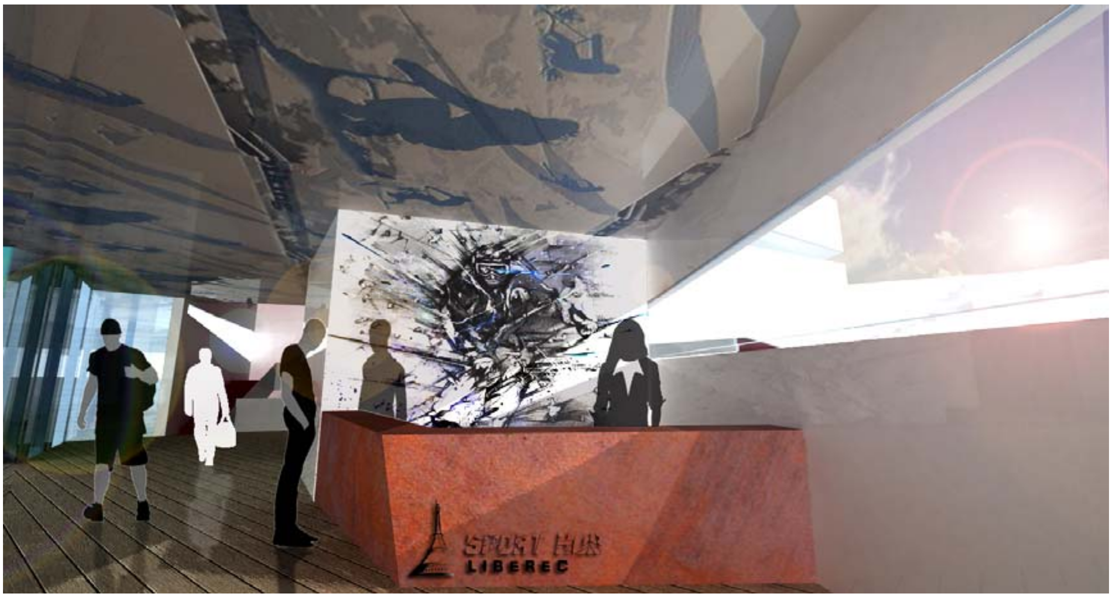


Figure 3.40 Reception of health club

Extreme sports

The skateboard and rock climbing is poplar extreme sports in Liberec.

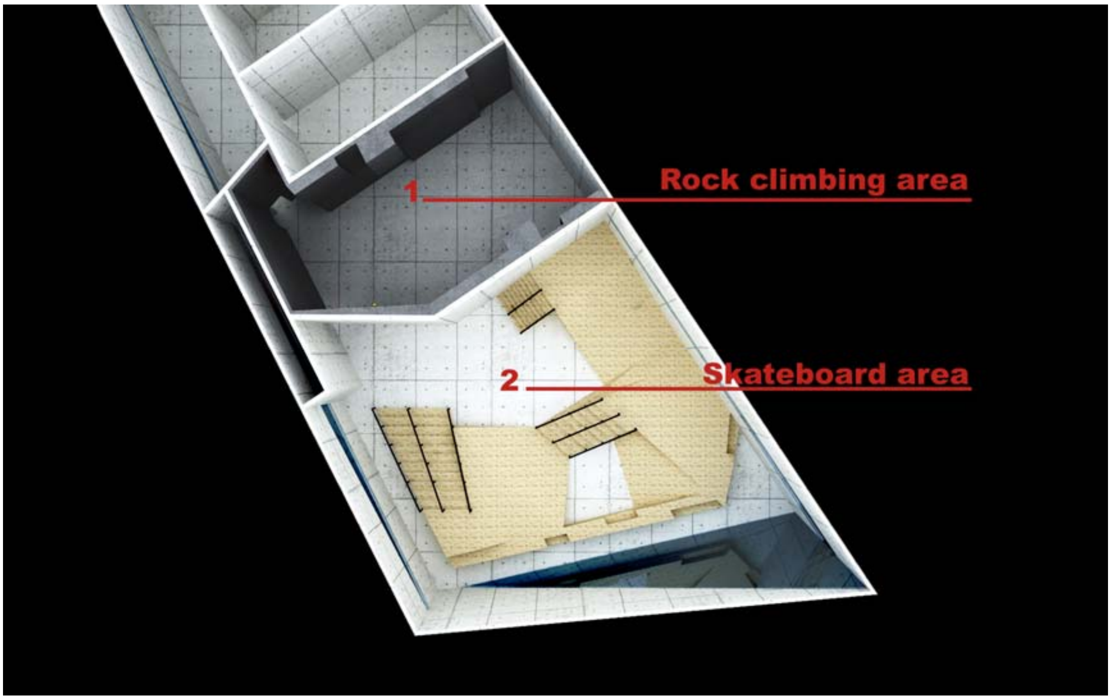


Figure 3.41 Plan of extreme sports area

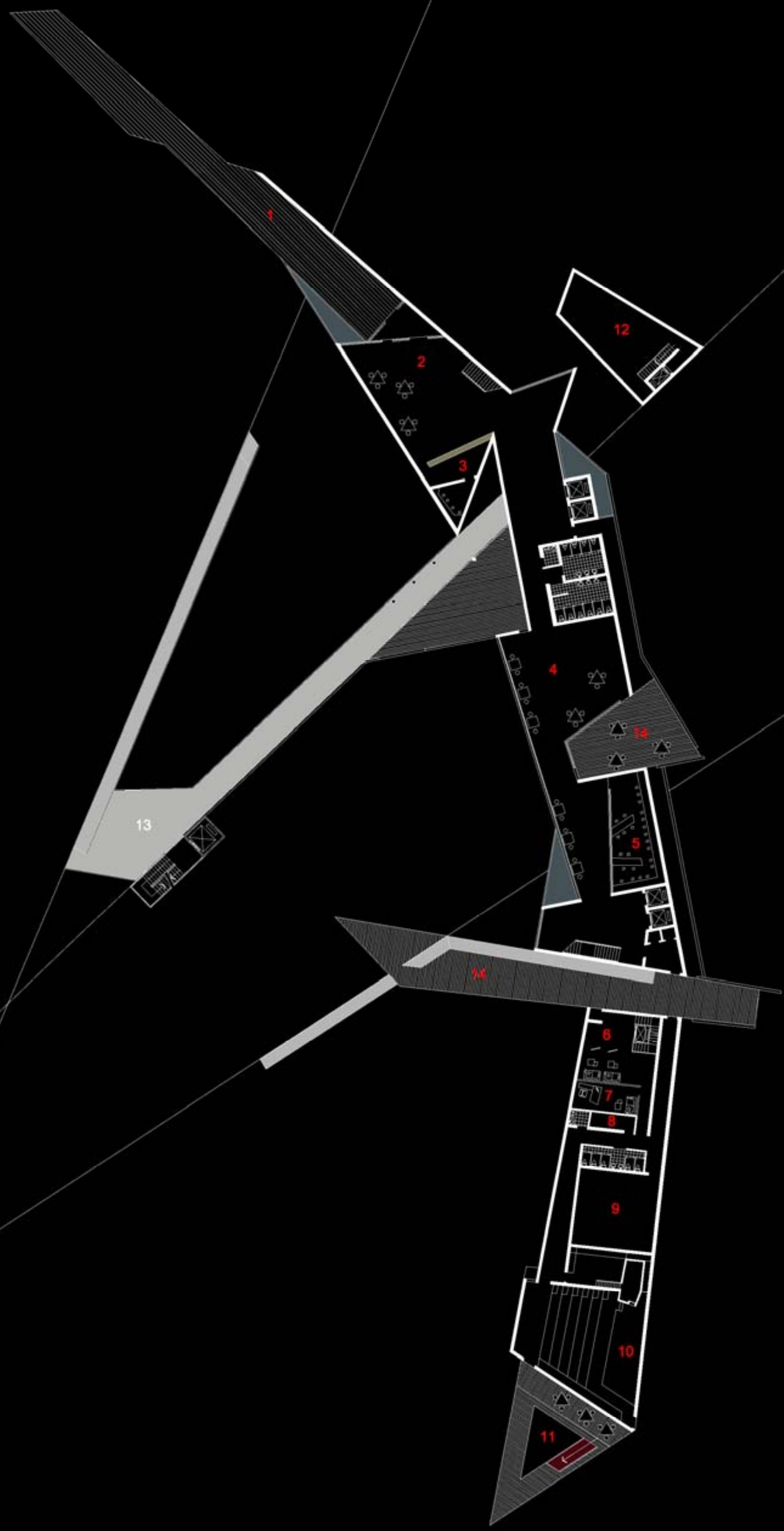
Renders of extreme sports rooms

3.6 Drawings

3.6.1 Plans

LEGEND

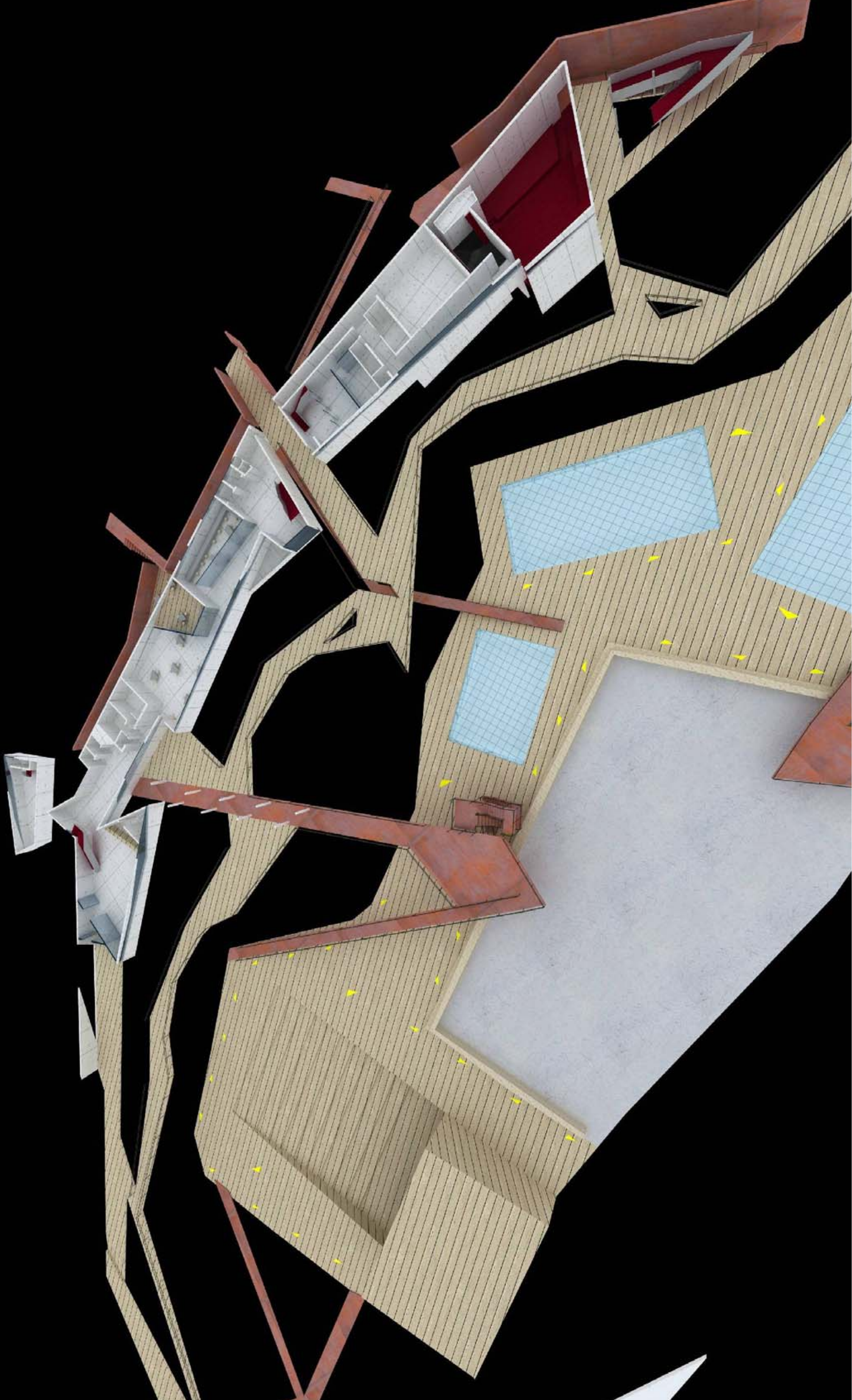
1. Hotel entrance platform
2. Hotel lobby
3. Reception
4. Business corridor
5. Information center
6. Office room
7. Managing director's office
8. Storage room
9. Multifunctional space
10. Small theatre
11. Green lobby outside
12. Kitchen (food storage)
13. Ramp to open Opera
14. Relax platform



LEVEL 0 PLAN

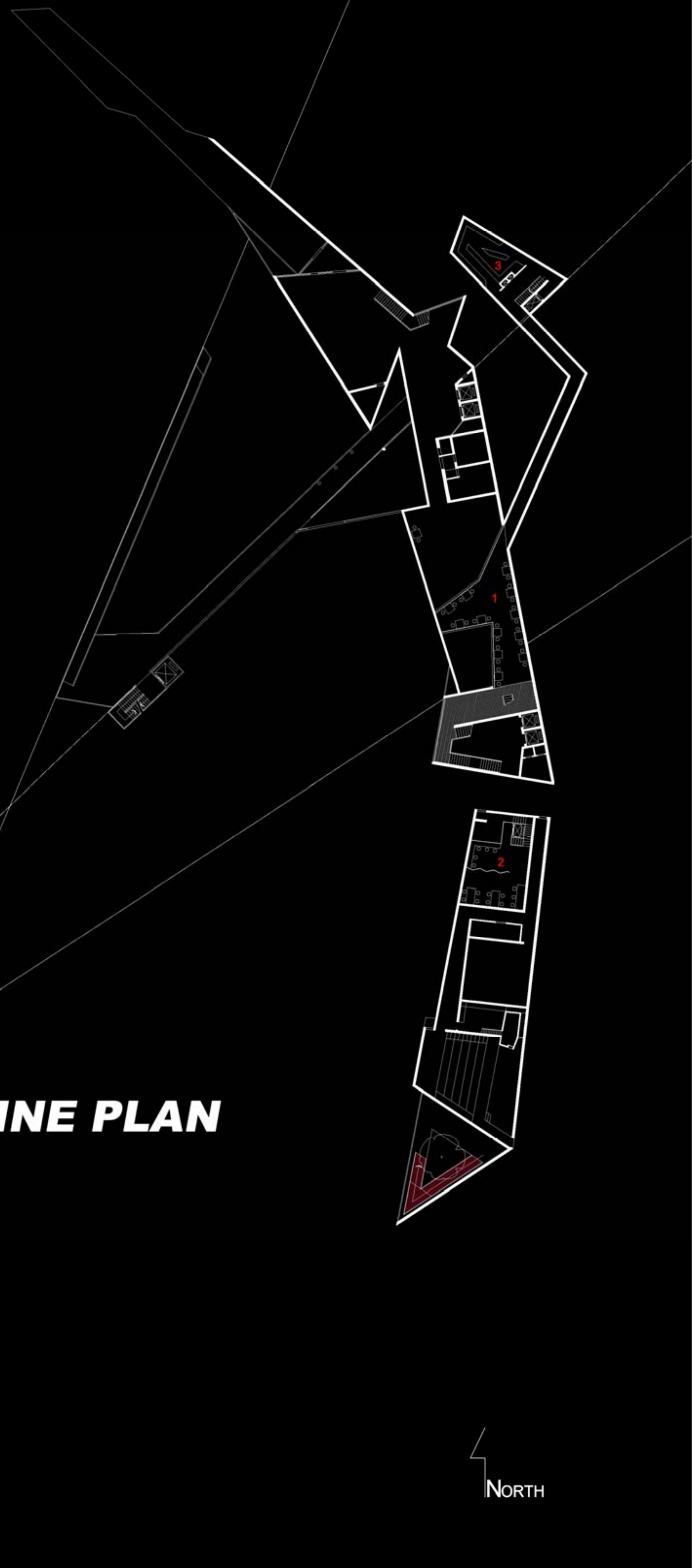
Hotel ±0.000

NORTH



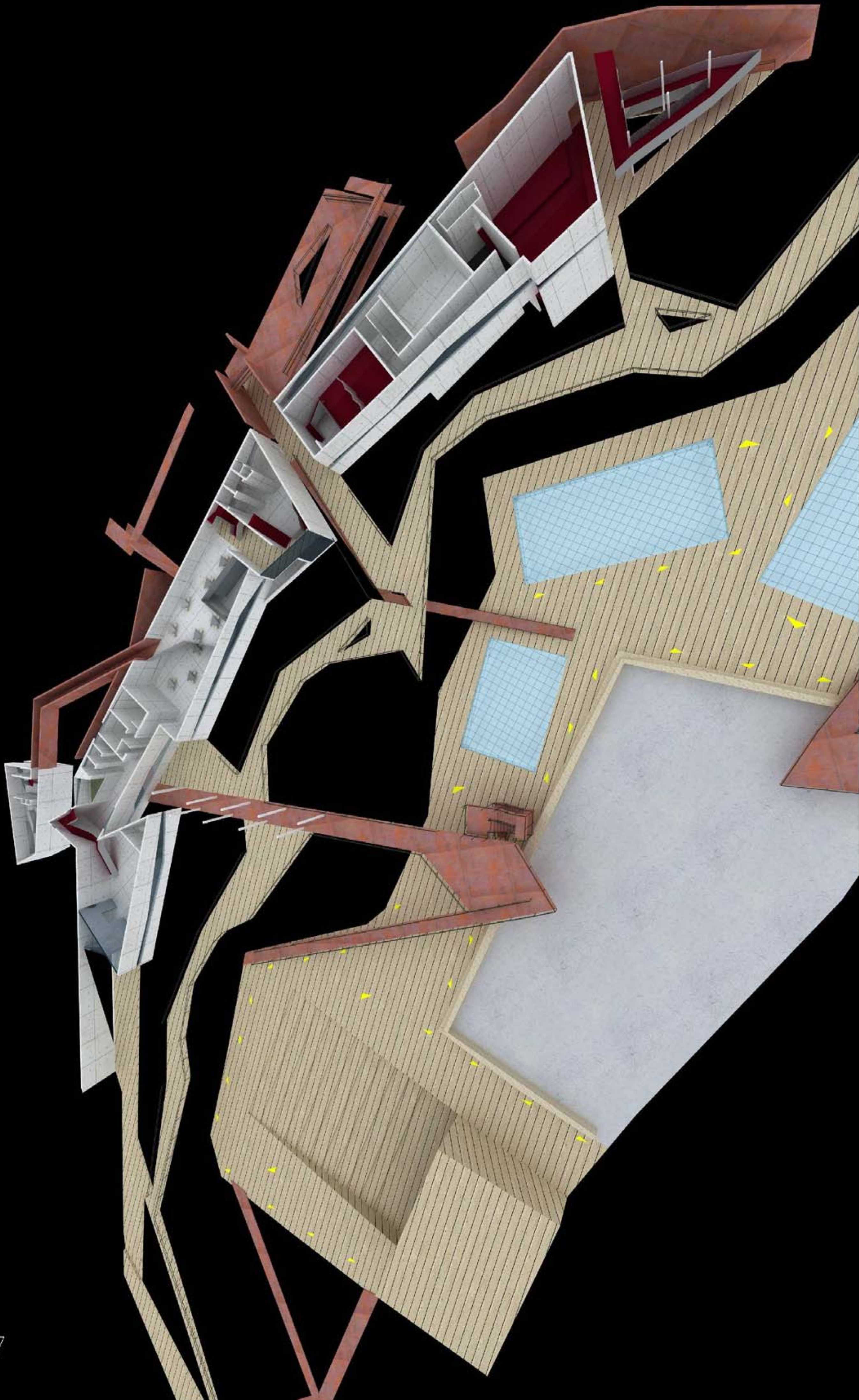
LEGEND

1. Restaurant
2. Office room
3. Kitchen (work space)



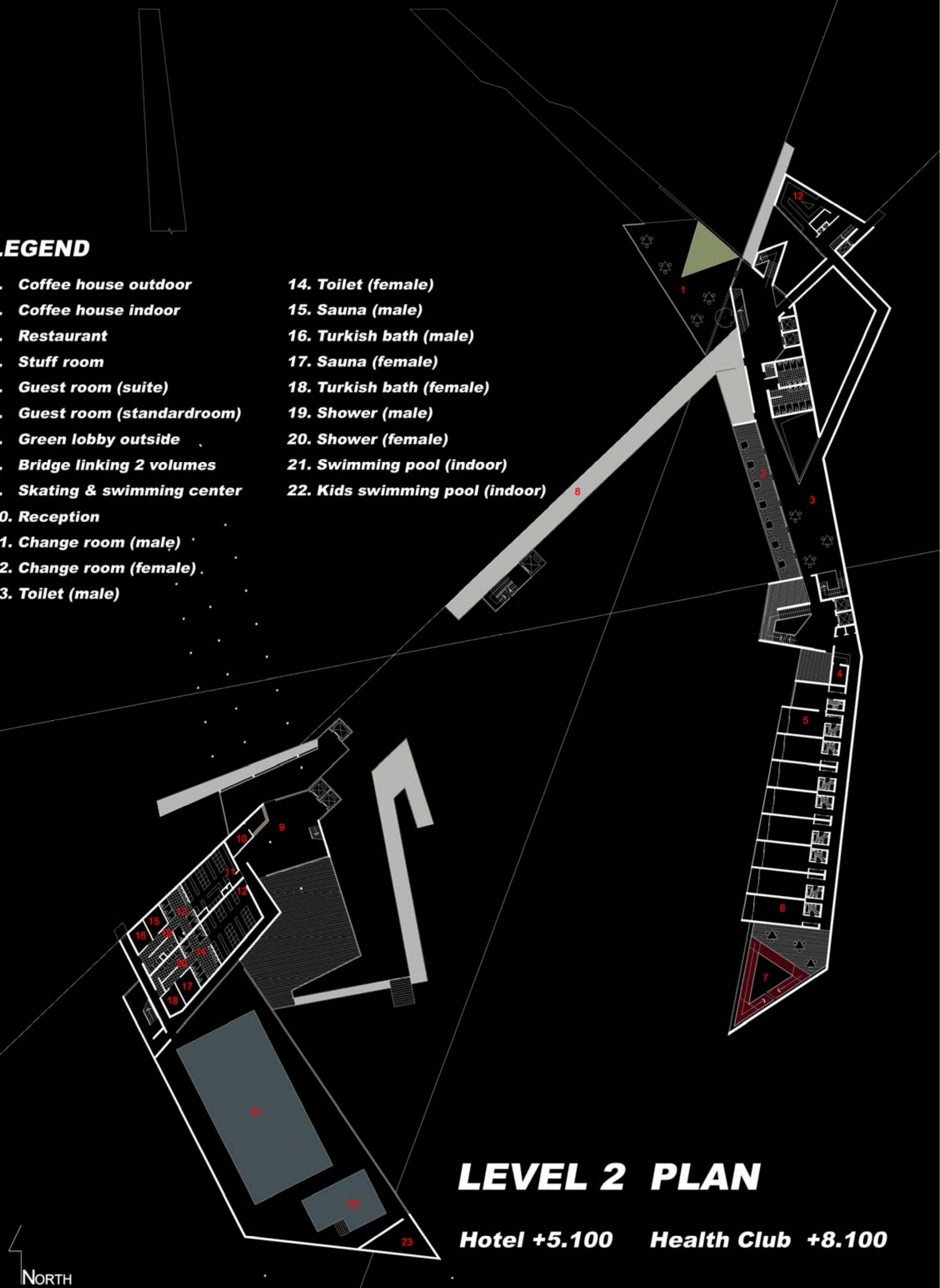
LEVEL 1 MEZZANINE PLAN

Hotel +2.700



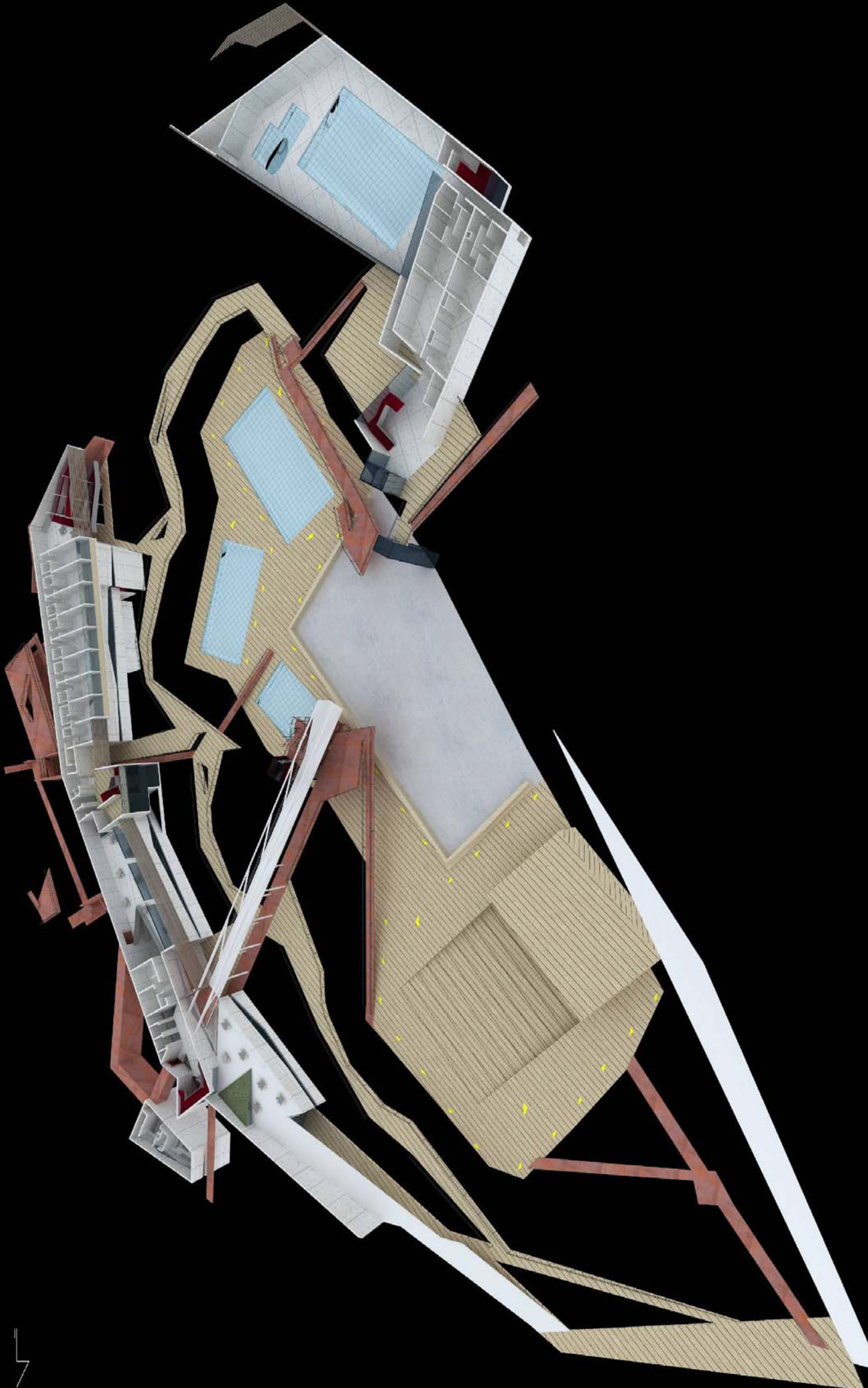
LEGEND

1. Coffee house outdoor
2. Coffee house indoor
3. Restaurant
4. Stuff room
5. Guest room (suite)
6. Guest room (standardroom)
7. Green lobby outside
8. Bridge linking 2 volumes
9. Skating & swimming center
10. Reception
11. Change room (male)
12. Change room (female)
13. Toilet (male)
14. Toilet (female)
15. Sauna (male)
16. Turkish bath (male)
17. Sauna (female)
18. Turkish bath (female)
19. Shower (male)
20. Shower (female)
21. Swimming pool (indoor)
22. Kids swimming pool (indoor)



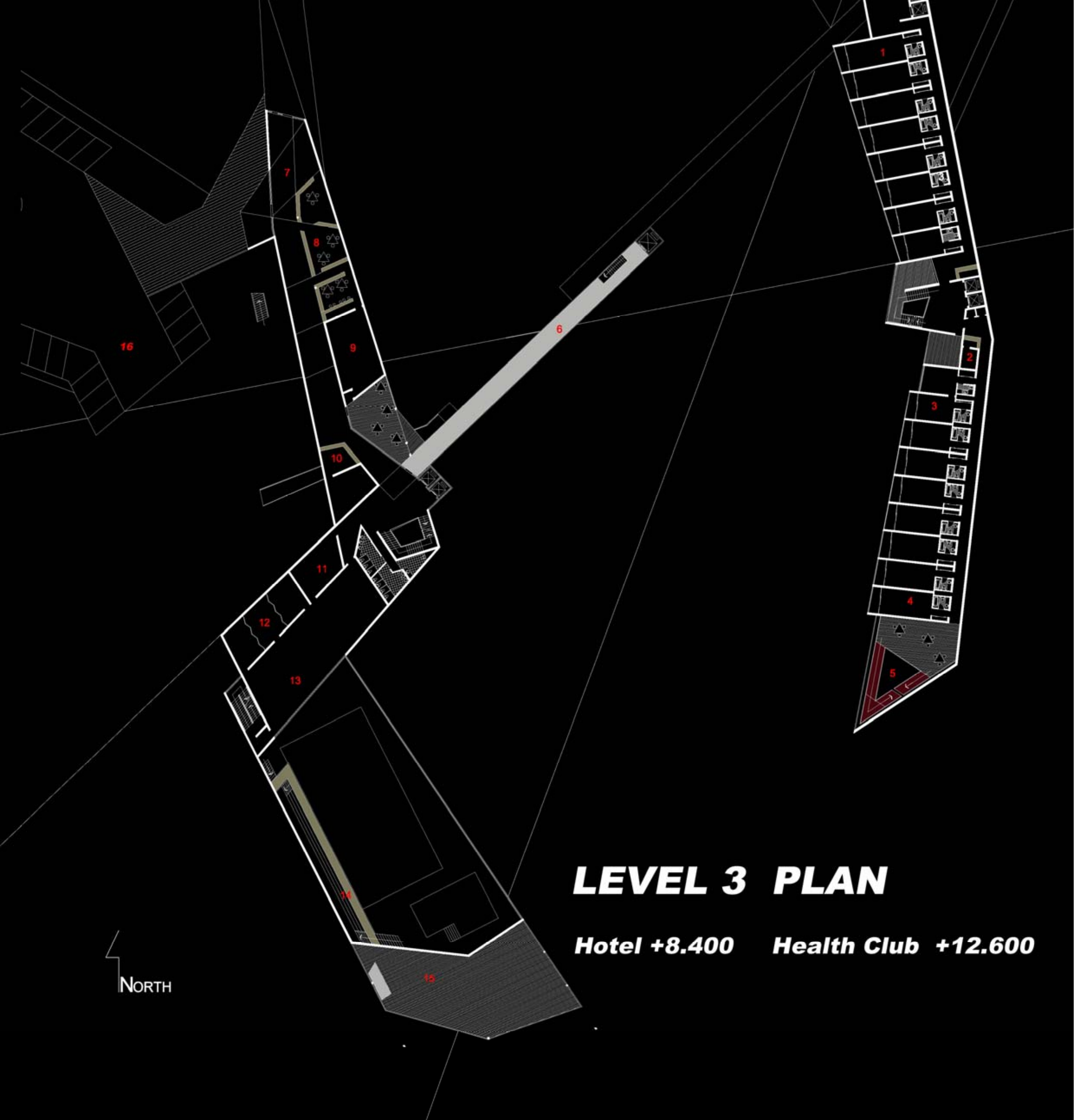
LEVEL 2 PLAN

Hotel +5.100 Health Club +8.100



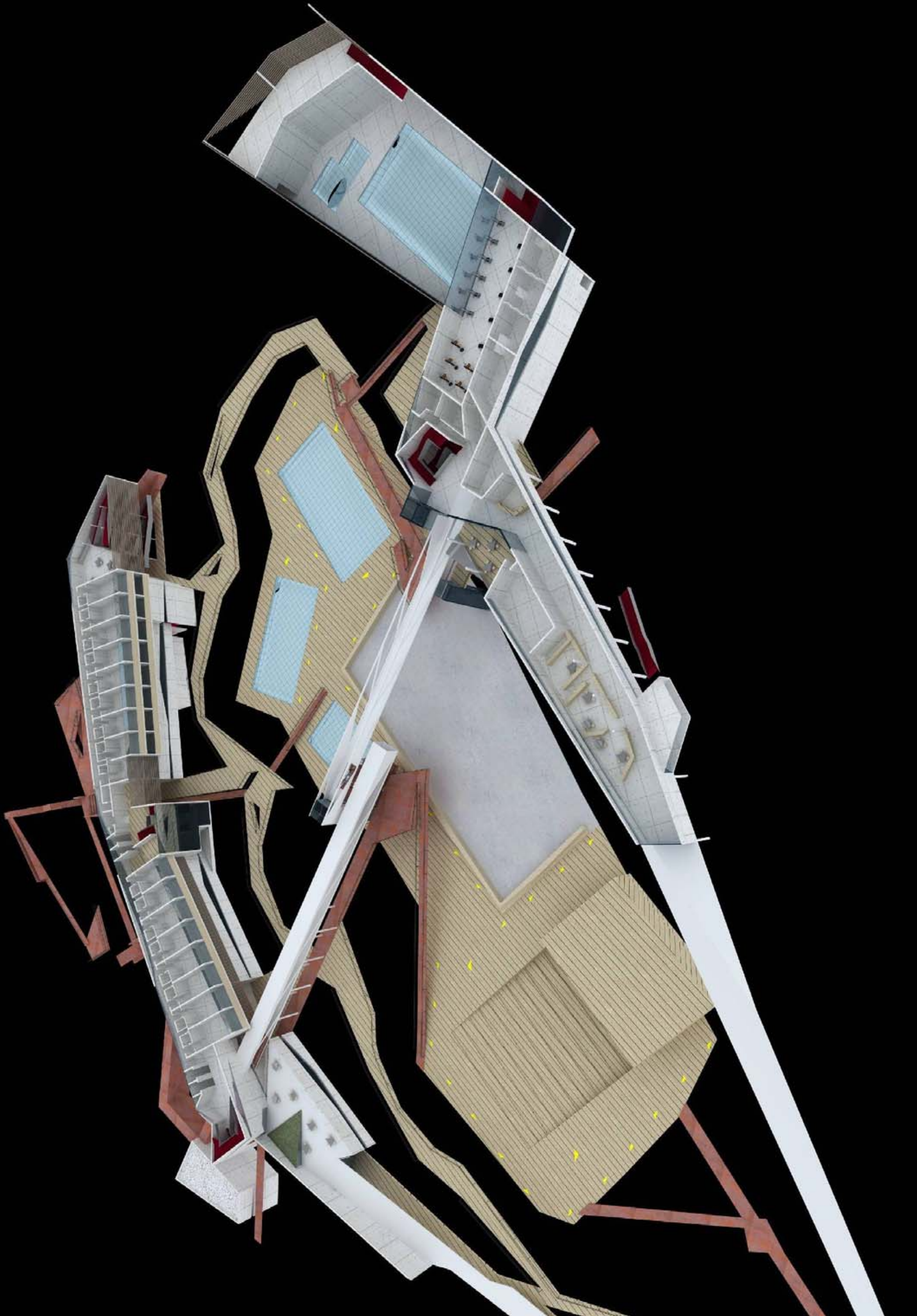
LEGEND

1. Guest room (standardroom)
2. Stuff room
3. Guest room (suite)
4. Guest room (standardroom)
5. Green lobby outside
6. Bridge linking 2 volumes
7. Health Club entrance and lobby
8. Health Club cafe bar
9. Kitchen
10. Health Club reception
11. Class room A
12. Class room B
13. GYM
14. Grandstand
15. Rock climbing (outdoor)



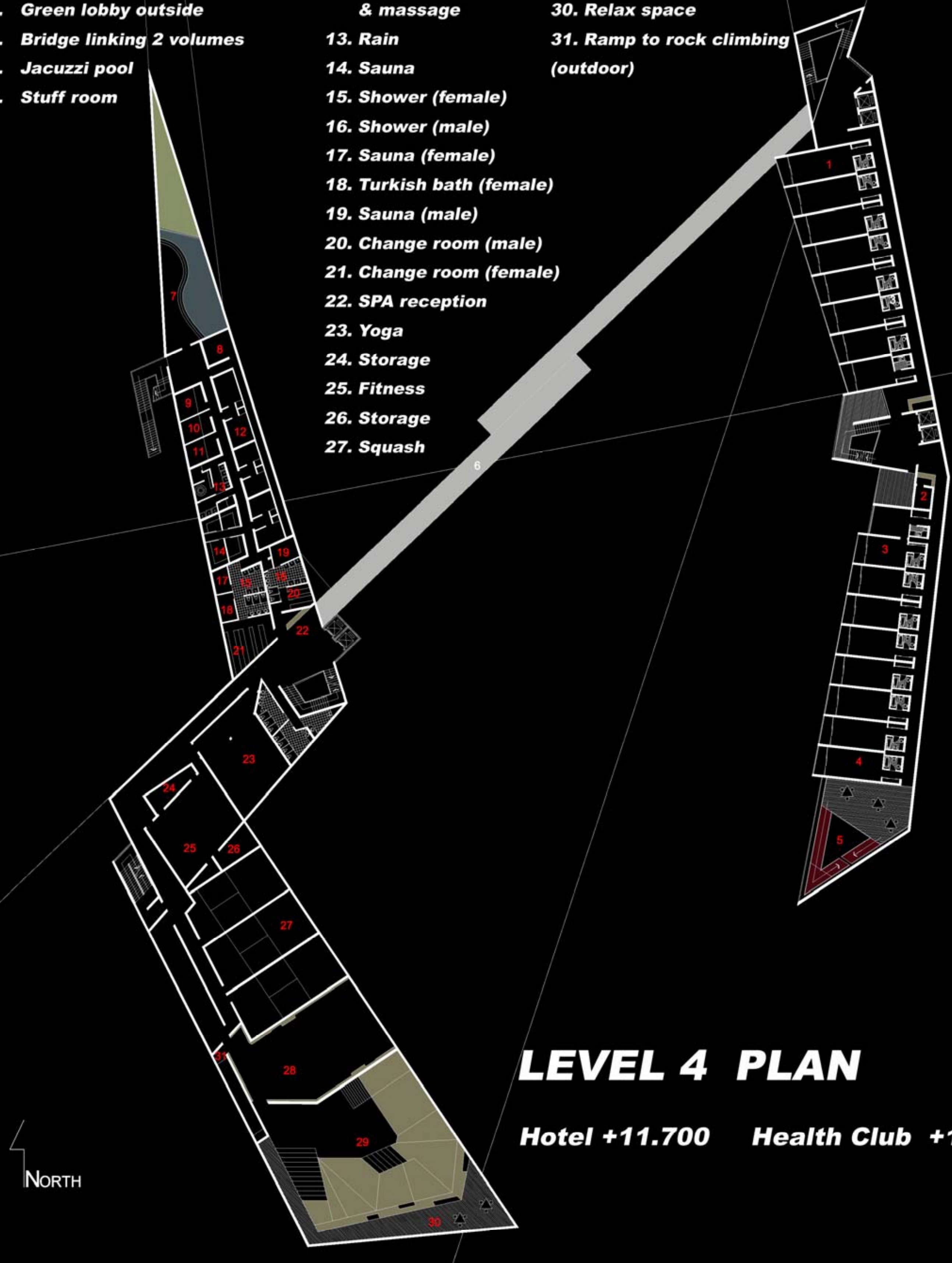
LEVEL 3 PLAN

Hotel +8.400   Health Club +12.600



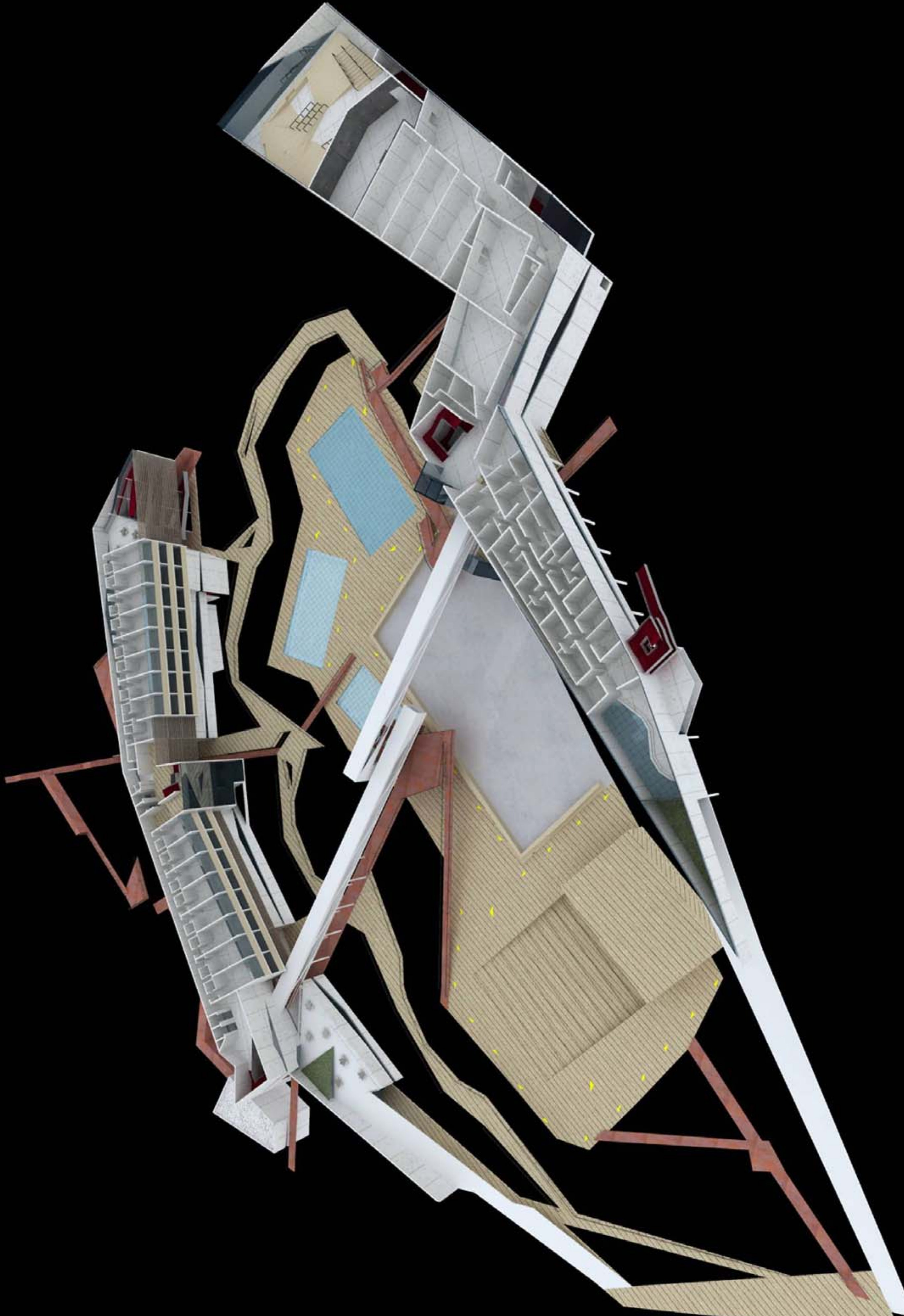
LEGEND

1. Guest room (standardroom)
2. Stuff room
3. Guest room (suite)
4. Guest room (standardroom)
5. Green lobby outside
6. Bridge linking 2 volumes
7. Jacuzzi pool
8. Stuff room
9. Cold / hot water
10. Wood aroma
11. Flower aroma
12. Body treatments & massage
13. Rain
14. Sauna
15. Shower (female)
16. Shower (male)
17. Sauna (female)
18. Turkish bath (female)
19. Sauna (male)
20. Change room (male)
21. Change room (female)
22. SPA reception
23. Yoga
24. Storage
25. Fitness
26. Storage
27. Squash
28. Extreme sports Rock climbing (indoor)
29. Extreme sports Skate-boarding (indoor)
30. Relax space
31. Ramp to rock climbing (outdoor)



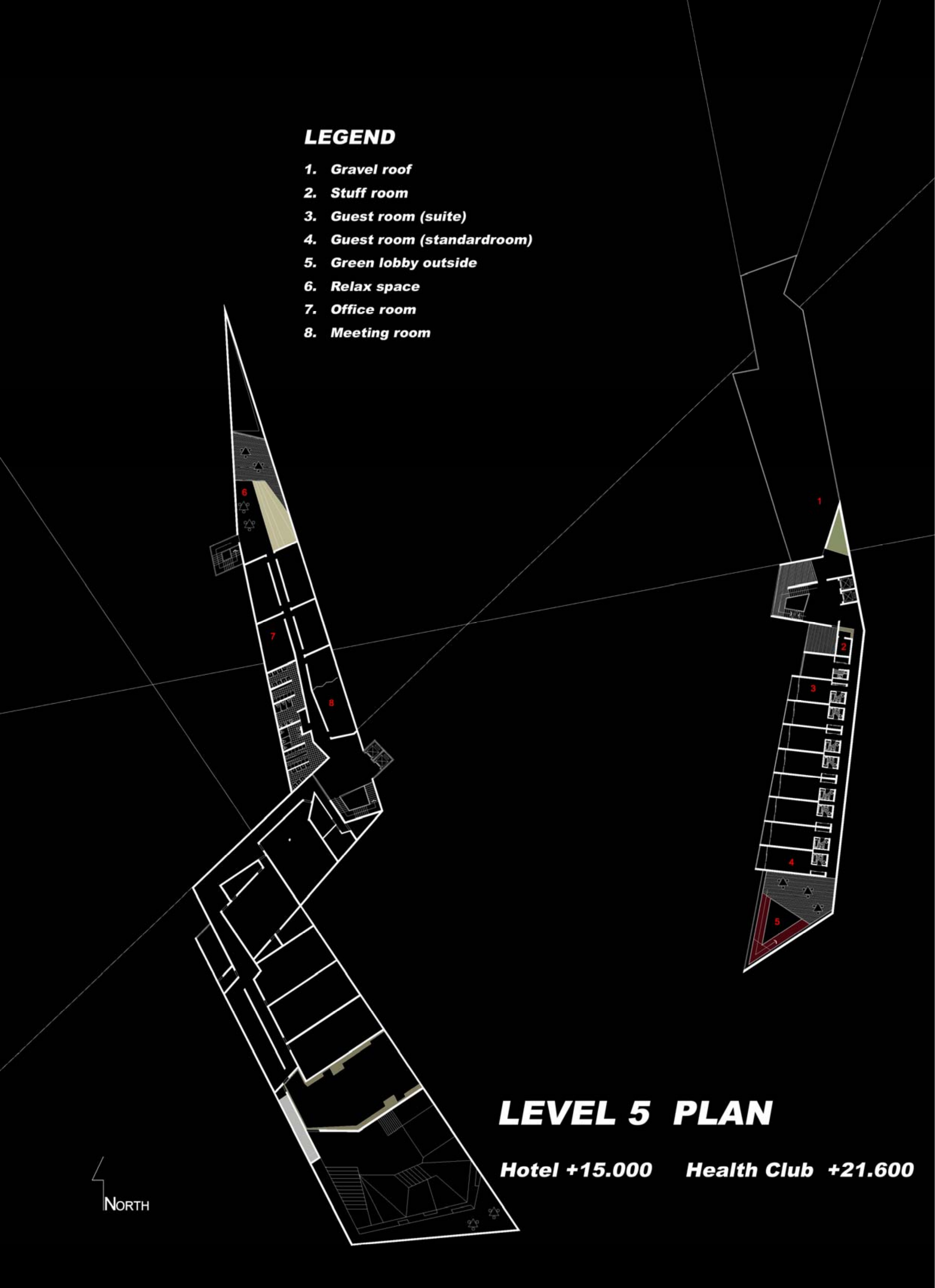
LEVEL 4 PLAN

Hotel +11.700 Health Club +17.100



LEGEND

1. Gravel roof
2. Stuff room
3. Guest room (suite)
4. Guest room (standardroom)
5. Green lobby outside
6. Relax space
7. Office room
8. Meeting room



LEVEL 5 PLAN

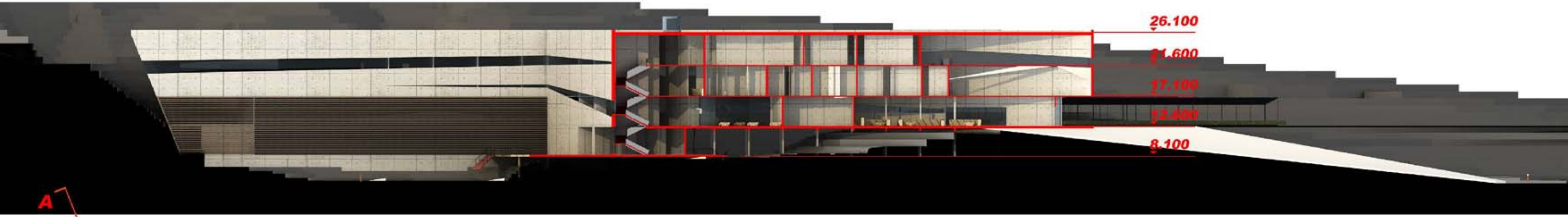
Hotel +15.000   Health Club +21.600

3.6.2 Facades

NE FACADE *Health club*

SW FACADE *Hotel*

3.6.3 Sections



A-A SECTION Health club

B-B SECTION Hotel

C-C SECTION Hotel

3.6.4 Impression

4.0

STRUCTURE DESIGN

With the development of the times, the **Steel structure** is more and more widespread. I choose it as my structure system of project. Steel, strong and stiffs, is a material of slender towers and soaring spans. Precise and predictable, light in proportion to its strength, it is also well suited to rapid construction, highly repetitive building frames, and architectural details that satisfy the eye with a clean, precise elegance. Among the metals, it is uniquely plentiful and inexpensive.

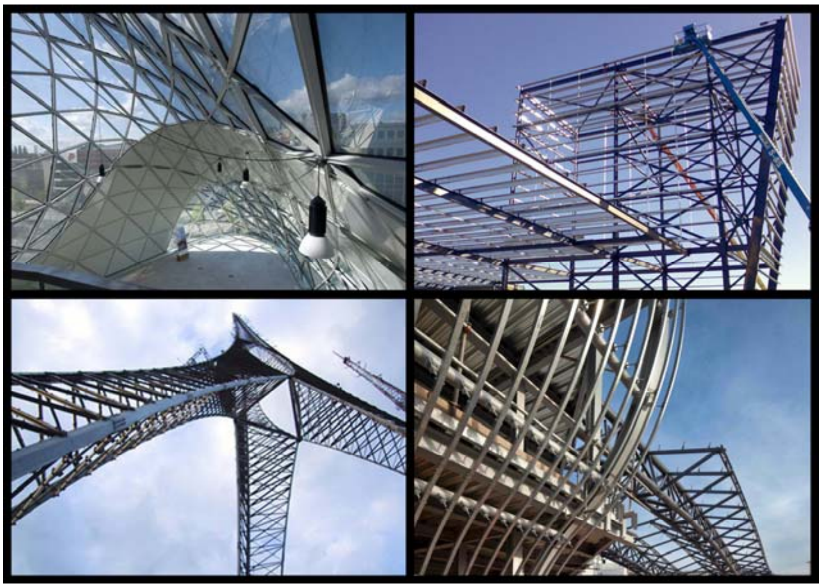


Figure 4.1 Steel structure

Its great strength, uniformity, light weight, ease of use and many other desirable properties makes it the material of choice for numerous structures such as steel bridges, high rise buildings, towers, and other structures. Steel exhibits desirable physical properties that make it one of the most versatile structural materials in use.

The many advantages of steel can be summarized as follows:

High Strength:

This means that the weight of structure that made of steel will be small.

Uniformity:

Properties of steel do not change as oppose to concrete.

Elasticity:

Steel follows Hooke's Law very accurately.

Ductility:

A very desirable of property of steel in which steel can withstand extensive deformation without failure under high tensile stresses, i.e., it gives warning before failure takes places.

Toughness:

Steel has both strength and ductility.

Additions to Existing Structures:

Example: new bays or even entire new wings can be added to existing frame buildings, and steel bridges may easily be widened.

Although steel has all this advantages as structural material, it also has many disadvantages that make reinforced concrete as a replacement for construction purposes.

Some disadvantages of steel can be summarized as follows:

Maintenance Cost:

Steel structure is susceptible to corrosion when exposed to air, water and humidity. They must be painted periodically.

Fireproofing Cost:

Steel is incombustible material, however, its strength is reduced tremendously at high temperature due to common fires.

Susceptibility to Buckling

For most structures, the use of steel columns is very economical because of their high strength-to-weight ratios. However, as the length and slenderness of a compressive column is increased, its danger of buckling increases.

Fatigue:

The strength of structural steel member can be reduced if this member is subjected to cyclic loading.

Brittle Fracture:

Under certain conditions steel may lose its ductility, and brittle fracture may occur at places of stress concentration. Fatigue type loadings and very low temperatures trigger the situation.

In this section I will explore steel structure as structural solution to resolve the problem of long span for the project.

4.1 Structure concept

The **Recreation Hub** is composed of two parts which are **Hotel** and **Health Club.**

In this chapter, I will choose the **Hotel** volume for structure design.

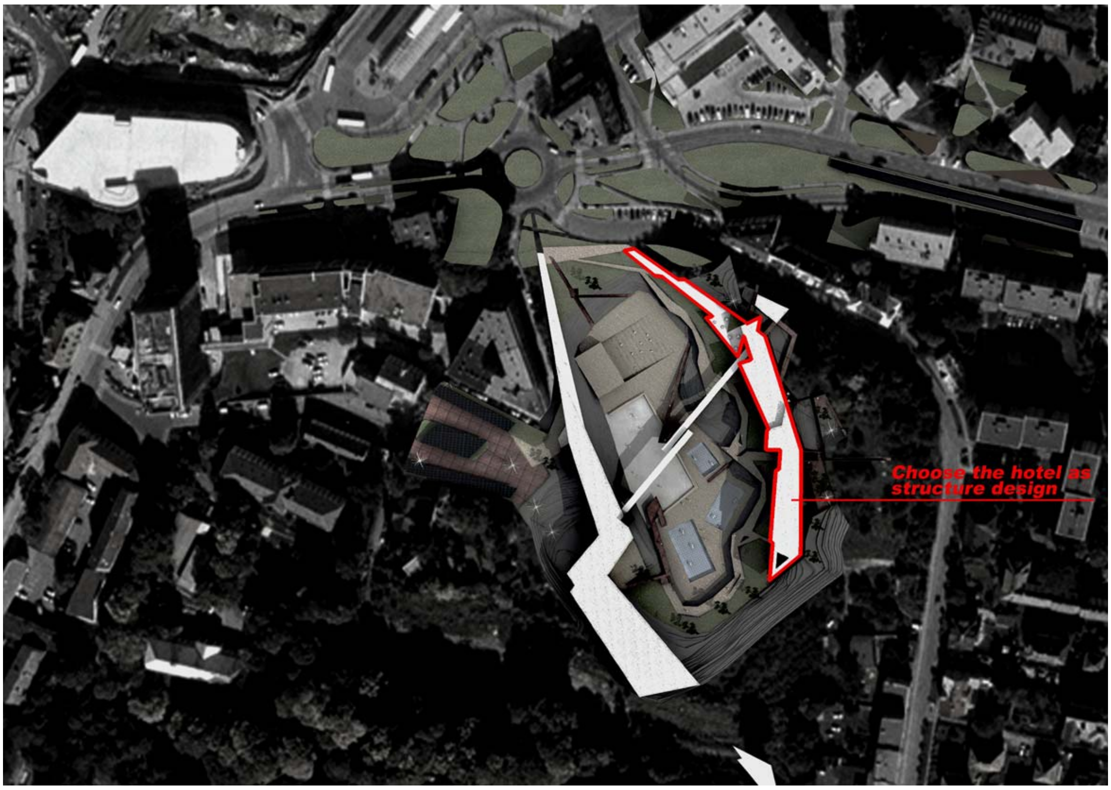


Figure 4.2 Recreation Hub

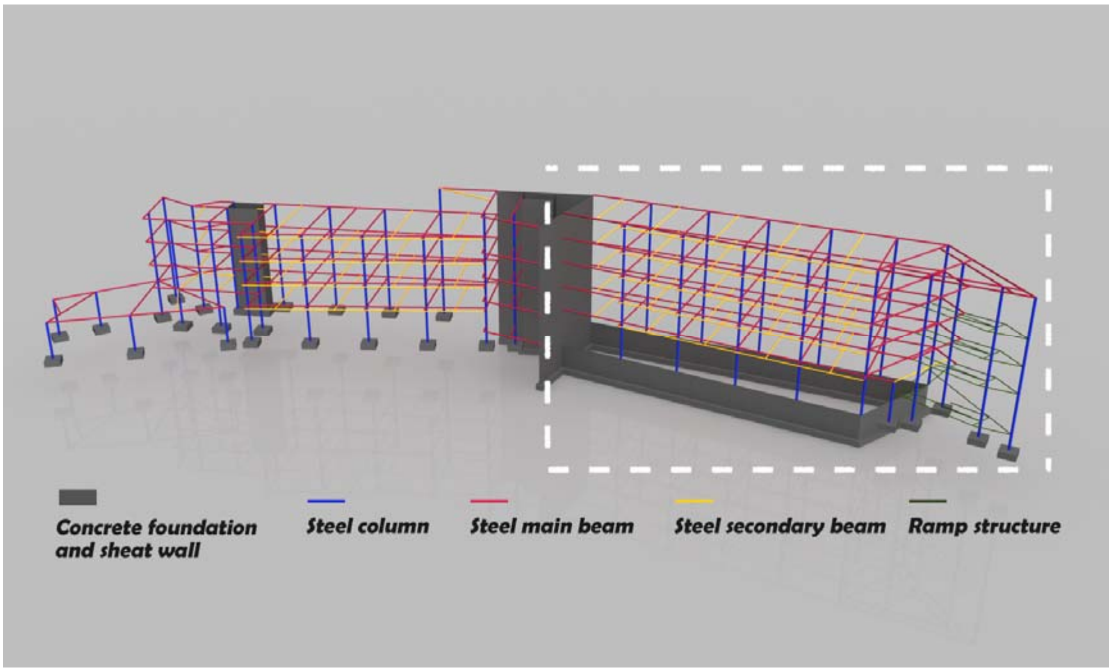


Figure 4.3 Structural model

Because the building geometry is too long about 120 m, I divided two single structure systems and chose the dash line area for calculation.

From structural design point of view, the building has 5 stories and one storey basement. For the ground level, the floor height is 5.1m. For the upper floors, the floor height is 3.3m.

In the structure plan showing below, the bracing system is placed around the corner of steel structure in order to resistant the lateral force.

Structure 3d model with indication of beam and column

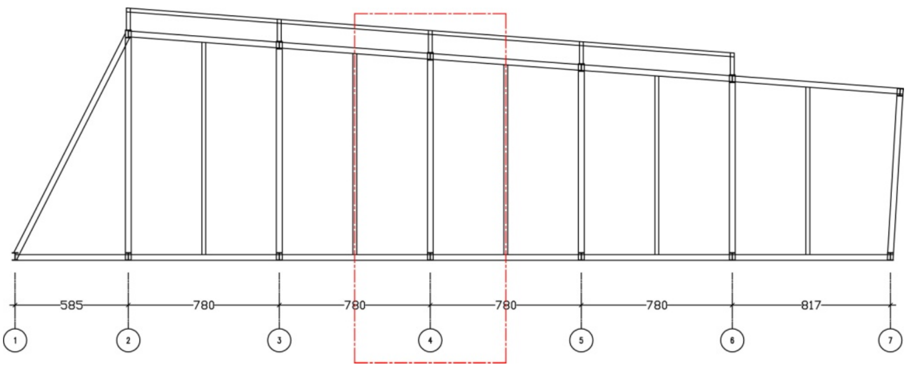


Figure 4.4 Structural plan

Steel frame structure is applied for the structure system with shear walls on the basement. The floor slab and roof slab is casted by the composite floor with profiled steel sheet.

To choose the steel profiles to be used in the project, first it was considered the maximum allowable deflection under serviceability limit state, as:

$$\delta_{\max} = \frac{l}{200}$$

Where:

$\delta_{\max}$ = maximum allowable deflection

l = beam/column length

Which has to be compared to the equation:

$$\delta = \frac{5}{384}\frac{pl^4}{EI}$$

Where:

δ = deflection on the element

p = distributed load on the element

l = element length

E = Young modulus of the material (For steel: $0.2E^{09}$)

I = inertia moment of the element's cross section

Obtaining:

$$\delta = \frac{5}{384}\frac{pl^4}{EI} \leq \delta_{\max} = \frac{l}{200}$$

From where, the term "I" can now be isolated to get the minimum inertia moment required for the element in order to comply with the maximum deflection allowed under serviceability limit state, obtaining the equation:

$$I \geq \frac{5}{384} 200 \frac{pl^3}{E}$$

Where:

I = inertia moment of the proposed cross section

The structure element can now be chosen, and is defined as follows:

Main Beam:

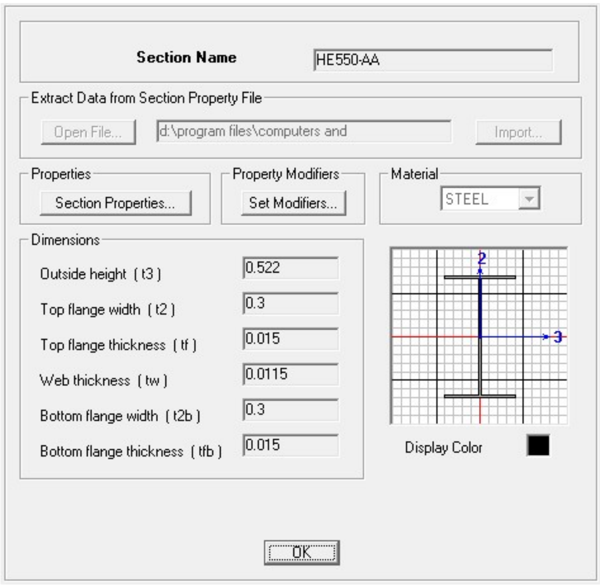


Figure 4.5 Steel main beam section

Secondary Beam:

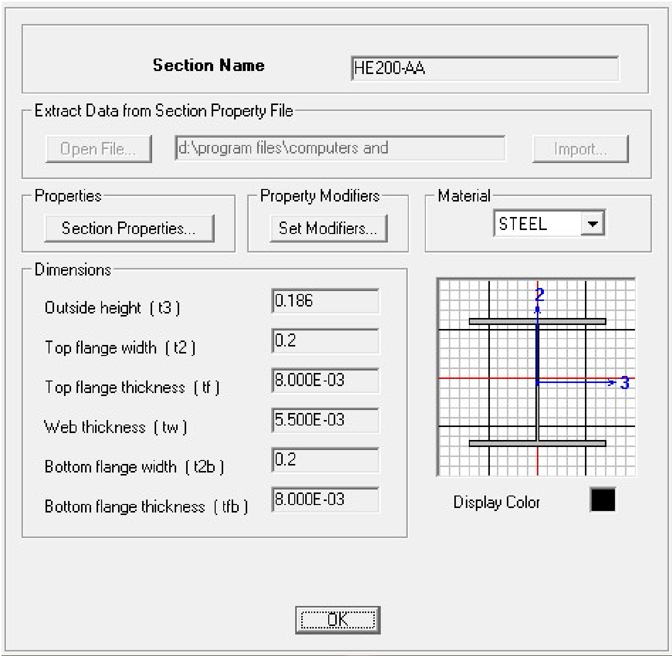


Figure 4.6 Steel secondary beam section

Column:

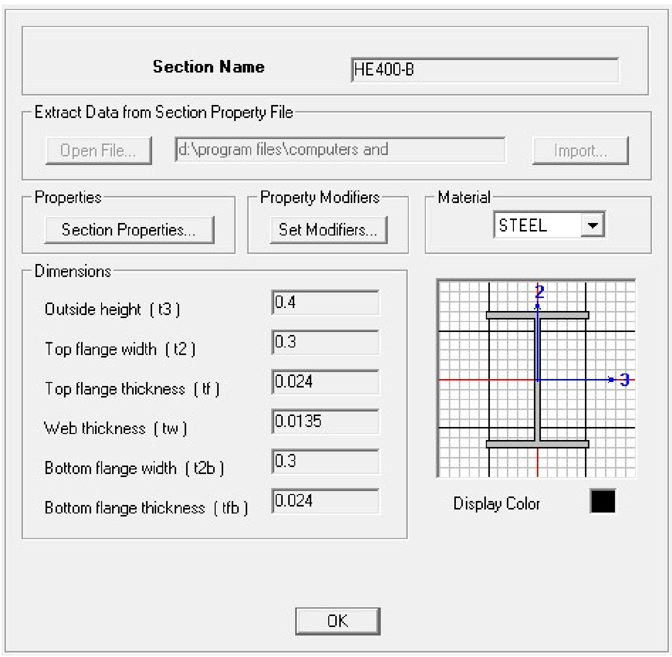


Figure 4.7 Steel column section

The foundation is continuous soft foundation under the shear wall on the basement. As the steel column is connected with the shear wall by screw bolt on the ground floor level, the ground floor column calculating height is considered the same as the floor height which is 5.1m. The simple calculation diagram of transverse frame (governed by axis 4) is shown as figure below.

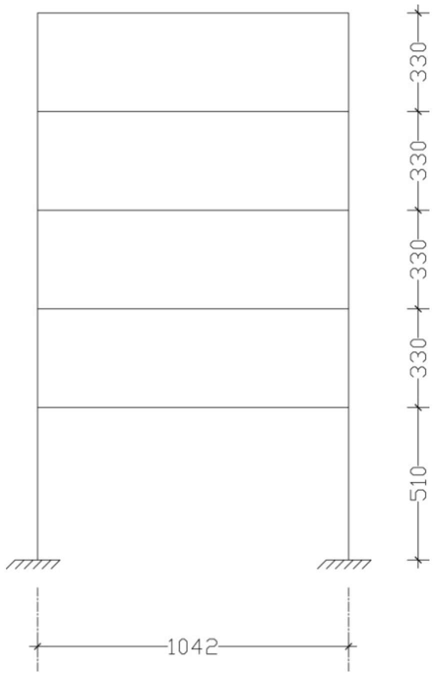


Figure 4.8 Transverse frame

4.2 Load calculation

4.2.1 External wall

layer	Specific weight(kN/m3)	Thickness (mm)	Height (m)	Weight (kN/m)
Interior finishing with a double layer of plaster board	12.5	25	3.3	1.03125
Technical panels (type OSB)	0.07	15	3.3	0.003465
Wooden plank	-	-	3.3	-
Air space for interior ventilation	-	-	3.3	-
Technical panels to protect insulation	0.07	15	3.3	0.003465
Insulation(polystyrene) interposed to wooden uprights	0.03	200	3.3	0.0198
Wooden plank	-	-	3.3	-
Ventilation gap	-	-	3.3	-
Precast concrete panel	6	50	3.3	0.99
Total				2.04798

Table 4.1 Load division_External wall

4.2.2 Internal wall

layer	Specific weight(kN/m3)	Thickness (mm)	height(m)	Weight (kN/m)
Interior finishing with a double layer of plaster board	12.5	25	3.3	1.03125
Mineral wool insulation	0.03	100	3.3	0.0099
Air Gap	-	50	3.3	-
Mineral wool insulation	0.03	100	3.3	0.0099
Interior finishing with a double layer of plaster board	12.5	25	3.3	1.03125
Total				2.0823

Table 4.2 Load division_Internal wall

4.2.3 Parapet wall

layer	Specific weight(kN/m3)	Thickness (mm)	Height (m)	Weight (kN/m)
Bituminous Felt	17	3	0.3	0.0153
Polystyrene Expanded	0.25	40	0.3	0.003
Bituminous Layer	17	3	0.3	0.0153
Concrete	24	150	0.3	1.08
Wooden plank	-	10	0.3	-
Ventilation gap	-	10	0.3	-
Precast concrete panel	6	50	0.3	0.09
Total				1.2036

Table 4.3 Load division_Parapet wall

4.2.4 Floor

layer	Specific weight (kN/m3)	Thickness (mm)	Weight (kN/m2)
Wooden floor	6.5	10	0.065
heating radiation layer	0.3	50	0.015
Rockwool acoustic insulation in rigid panels	5	20	0.1
Waterproof	0.25	2	0.0005
Leveling layer	19	25	0.475
Concrete composite floor	24	100	2.4
Wooden panel	6.5	15	0.0975
Rockwool thermal insulation	0.03	100	0.003
Gypsum Plaster Board	20	30	0.6
Total			3.756

Table 4.4 Load division_Floor

4.2.4. Roof

layer	Specific weight (kN/m3)	Thickness (mm)	Weight (kN/m2)
Gravel	18	50	0.9
Bituminous Felt	17	3	0.051
Polystyrene Expanded	0.25	80	0.02
Bituminous Layer	17	3	0.051
Slope Concrete	19	30	0.57
Concrete composite floor	24	100	2.4
Wooden panel	6.5	15	0.0975
Rockwool thermal isolation	0.03	100	0.003
Gypsum Plaster Board	20	30	0.6
Total			4.6925

Table 4.5 Load division_Roof

4.3 Internal force calculation

4.3.1 Wind load

EN 1991-1-4 gives guidance on the determination of natural wind actions for the structural design of building and civil engineering works for each of the loaded areas under consideration.

4.3.1.1 The fundamental value of the basic wind velocity vb,0, is evaluated

Where:

vb,0 is the characteristic 10 minutes mean wind velocity, irrespective of wind direction and time of year, at 10m above ground level in open country terrain with low vegetation, such as grass and isolated obstacles with separations of at least 20 obstacle heights. Where the influence of altitude on the basic wind velocity vb is not included in the specified fundamental value vb,0 the National Annex may give a procedure to take it into account. In the National Annex, the followings are applied:

$v_{b,0} = \bar{v}_{b,0}$ when $a_s < a_0$,

$v_{b,0} = \bar{v}_{b,0} + k_a \left(a_s - a_0\right)$ when $a_0 \le a_s \le 1500m$.

For Barcelona, $a_s \le a_0 = 1000m$, and the fundamental value of the basic wind velocity is 5.68m/s.

$v_{b,0} = \bar{v}_{b,0} = 5.68m/s$

According to EN 1990 4.1.2(7)P and EN 1991-1-4 3.4(1) the fundamental value of the basic wind velocity is a characteristic value and it refers to an annual probability of exceedance of 2%, which is equivalent to a mean return period of 50 years, as assumed for the design working life of the building.

4.3.1.2 Starting from the fundamental value the basic wind velocity, by means of two multiplicative coefficients cdir and cseason, which respectively take into account the influence of wind direction and seasonal weather factors respectively, the basic wind velocity can be calculated as follows:

$$v_b = c_{dir} c_{season} v_{b,0}$$

where:

vb is the basic wind velocity, defined as a function of wind direction and time of year at 10 m above ground of terrain category II,

vb,0 is the fundamental value of the basic wind velocity,

cdir is the directional factor,

cseason is the season factor.

The recommended values cdir=1.0 and cseason=1.0 are used here in accordance to the National Annex. Therefore, the basic wind velocity is:

$$v_b = v_{b,0} = 5.68 m/s$$

4.3.1.3 The mean wind velocity vm(z) at a height z above the terrain can then be calculated and it depends on the terrain roughness and topography and on the basic wind velocity vb:

$$v_m(z) = c_r(z) c_0(z) v_b$$

Where:

c0(z) is the topography coefficient, taking as 1.0 (recommended value). Where topography (e.g. hills, cliffs etc) increases wind velocities by more than 5%, the effects should be taken into account using the topography factor c0 which can be calculated following the procedure given in Annex A.3 , or correspondently in the National Annex.

cr(z) is the roughness coefficient. It accounts for the variability of the mean wind velocity at the site of the structure due to the height above ground level and the ground roughness of the terrain upwind of the structure in the wind direction considered.

The recommended procedure for the determination of the roughness factor cr(z) at height z is based on a logarithmic velocity profile and is given by the following expression:

$c_r = k_r \cdot \ln\left(\frac{z}{z_0}\right)$ for $z_{\min} \le z \le z_{\max} = 200m$,

$c_r = c_r\left(z_{\min}\right)$ for $z \le z_{\min}$

where:

z0 is the roughness length

kr terrain factor depending on the roughness length z0 calculated using:

$$k_r = 0.19 \cdot \left(\frac{z_0}{z_{0,II}}\right)^{0.07}$$

where:

z0,II = 0,05 m

zmin is the minimum height defined in table

zmax is to be taken as 200 m, unless otherwise specified in the National Annex

Recommended values for z0 and zmin are given in the following table depending on five representative terrain categories.

Terrain categories and terrain parameters

Terrain category	z0 (m)	zmin (m)
0 Sea or coastal area exposed to the open sea	0.003	1
I Lakes or flat and horizontal area with negligible vegetation and without obstacles	0.01	1
II Area with low vegetation such as grass and isolated obstacles(trees, buildings) with separations of at least 20 obstacle heights	0.05	2
III Area with regular cover of vegetation or building or with isolated obstacles with separations of maximum 20 obstacle heights(such as villages, suburban terrain, permanent forest)	0.3	5
IV Area in which at least 15% of the surface is covered with buildings and their average height exceeds 15m	1	10

Table 4.6 Terrain categories and parameters

This building is located in the urban centre of Barcelona, after referring the terrain categories illustrated in Annex A.1. The terrain condition of our project belongs to category IV.

So z0 =1.0m, zmin=10m,

$$k_r = 0.19 \cdot \left(\frac{z_0}{z_{0,II}} \right)^{0.07} = 0.19 \cdot \left(\frac{1}{0.05} \right)^{0.07} = 0.234$$

$$c_r\left(z_{\min}\right) = k_r \cdot \ln\left(\frac{z}{z_0}\right) = 0.234 \times \ln 10 = 0.539$$

$$c_r\left(z\right) = 0.234 \times \ln\left(z\right)$$

4.3.1.4 The turbulence intensity Iv(z) at height z can be evaluated with the following formula:

$$I_v\left(z\right) = \frac{k_1}{c_0\left(z\right)\ln\left(z / z_0\right)} \quad \text{for} \quad z_{\min} < z < z_{\max}$$

$$I_v = I_v\left(z_{\min}\right) \quad \text{for} \quad z < z_{\min}$$

where,

kl is the turbulence factor. The value of kI may be given in the National Annex. The recommended value is kI=1.0,

c0 is the orographic factor,

z0 is the roughness length.

4.3.1.5 The peak velocity pressure qp(z) at height z, which includes mean and short-term velocity fluctuations, can then be determined:

$$q_p\left(z\right) = \left[1 + 7I_v\left(z\right)\right]\frac{1}{2}\rho v_m\left(z\right)^2 = c_e\left(z\right)q_b$$

Where,

$\rho = 1.25 kg / m^3$ is the air density (recommended value),

$q_b = \frac{1}{2}\rho v_b^2$ is the basic velocity pressure,

$c_e(z) = [1 + 7I_v(z)] c_r(z)^2 c_0(z)^2 = k_r^2 \ln(z/z_0)[7 + \ln(z/z_0)]^1$ is the exposure factor.

4.3.1.6 Wind pressure on surfaces

The wind pressure acting on the external surfaces, we, can be obtained by the following expression:

$$w_e = c_{pe} q_p(z_e)$$

Where:

ze is the reference height for the external pressure,

cpe is the pressure coefficient for the external pressure that will be specified later on,

qp(ze) is the peak velocity pressure.

4.3.1.5. Wind force

The wind force, Fw, acting on a structure or structural element may be determined by Victoria summation of the forces acting on their reference surfaces.

$$F_w = c_s c_d \sum_i w_{ei} A_i$$

where,

cscd is the structural factor (separated into a size factor cs and a dynamic factor cd), taken as 1.0 as for framed buildings which have structural walls and which are less than 100 m high and whose height is less than 4 times the in-wind depth,

Ai is the reference area of the individual surface,

Wei is the external pressure on the individual surface at height Ze,

4.3.1.7 Wind pressure on the northwest façade

As the structural ground floor is basement, we should consider the wind action starting from the structural first floor when calculating the building height of windward side.

$b = 45.22m$
$h = 5.1 + 3.3 \times 4 + 0.3 = 18.6m$
$d = 10.42m$

where,

h is the height of the building,

b is the building dimension in the horizontal direction perpendicular to the wind direction,

d is the structural depth.

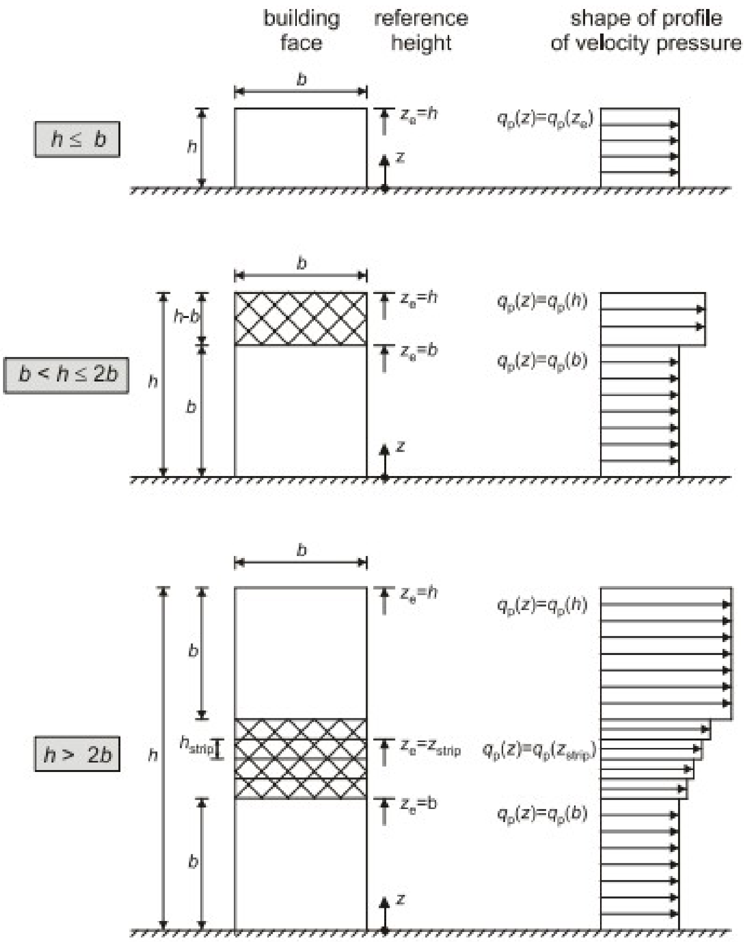


Figure 4.9 Wind pressure diagram

Reference height, ze, depending on h and b, and corresponding velocity pressure profile

According to EN1991-1-4 7.2.2, and given that the building height (h=18.6m) is less than the building dimension in the direction perpendicular to the wind direction (b=45.22m), the building may be considered to be one part, and the pressure distribution on the windward side is same. And the reference height is equal to the height of the building (ze=h=18.6m), shown in figure.

Details of the calculation of the wind pressure are shown below.

$h = 18.6m < b = 45.22m$

$z_e = h = 18.6m$

$z_{\min} = 10m$

$z_{\max} = 200m$

$z_{\min} < z_e < z_{\max}$

$c_r(z_e) = 0.234 \times \ln 18.6 = 0.684$

$$I_v(z_e) = \frac{k_1}{c_0(z)\ln(z_e / z_0)} = \frac{1}{\ln 18.6} = 0.342$$

among which, $k_l = c_0(z)$=1.0 , $z_0 = 1m$

$$c_e(z_e) = [1 + 7I_v(z_e)]c_r(z_e)^2 c_0(z)^2 = (1 + 7 \times 0.342) \times 0.684^2 = 1.588$$

$$q_b = \frac{1}{2}\rho v_b^2 = \frac{1}{2} \times 1.25 \times 5.68^2 = 20.16 N / m^2$$

$$q_p(z_e) = c_e(z_e) q_b = 1.588 \times 20.16 = 32.01 N / m^2$$

Details of the results in procedure of calculating the wind pressure at reference height are listed in the table:

z_e (m)	$c_r(z_e)$	$I_v(z_e)$	$c_e(z_e)$	q_b (N/m2)	$q_p(z_e)$ (N/m2)
18.6	0.684	0.342	1.588	20.16	32.01

Table 4.7 Wind pressure calculation at reference height

As the structure is arranged in a longitudinal direction, the consideration of only single wind direction which is longitudinal façade windward could be applied.

4.3.1.8 Wind load

We can deem that the wind force on the surface can be transferred into the concentrated force at the nodes of each floor of the structural frame.

The wind force Fw acting on a structure or a structural component may be determined directly by using Expression below:

$$F_w = c_s c_d \cdot c_f \cdot q_p(z_e) \cdot A_{ref}$$

where:

cscd is the structural factor,

cf is the force coefficient for the structure or structural element,

qp(ze) is the peak velocity pressure at reference height ze,

Aref is the reference area of the structure or structural element.

The details of the calculation are listed in table. The result of calculation of wind force is shown in figure.

wind force calculation

Floor level	cscd	cf	qp(z) /N/m2	Aref/m2	Pw/kN
5	1	1	32.01	28.08	0.898841
4	1	1	32.01	25.74	0.823937
3	1	1	32.01	25.74	0.823937
2	1	1	32.01	25.74	0.823937
1	1	1	32.01	39.78	1.273358

Table 4.8 Wind force calculation

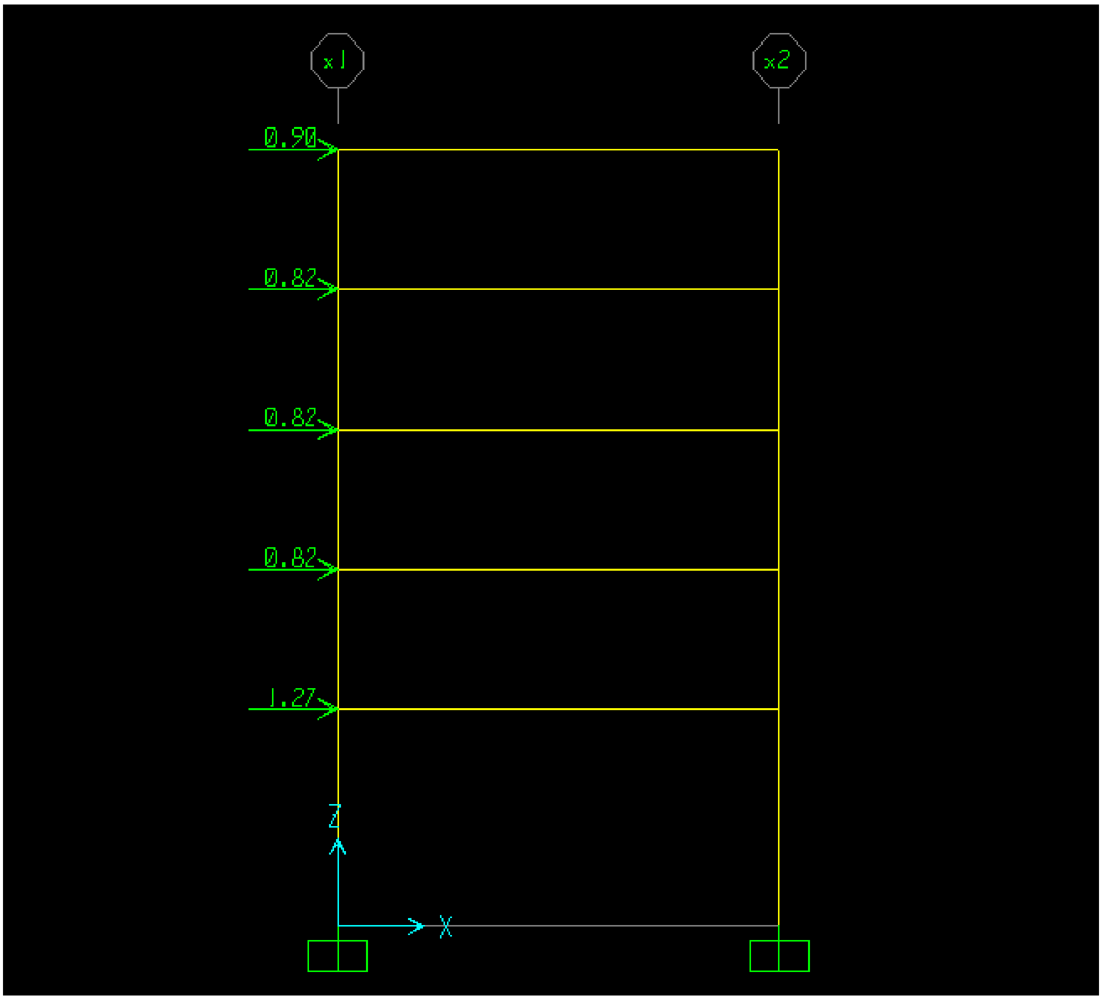


Figure 4.10 Wind action frame diagram

4.3.1.9 Internal force analysis under wind action

After the internal force analysis in Sap2000, we can get axial load diagram, shear force diagram and bending moment diagram.

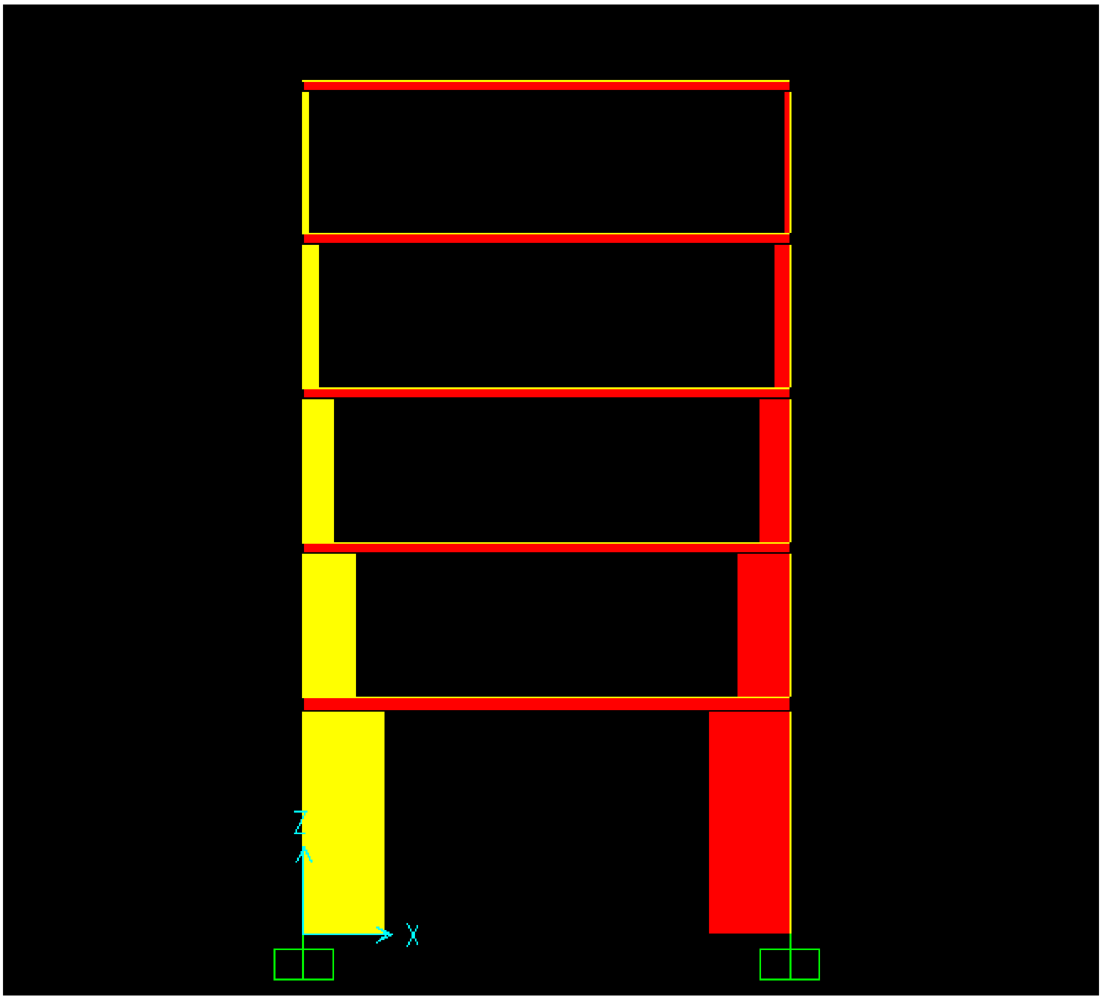


Figure 4.11 Axial load under wind action diagram

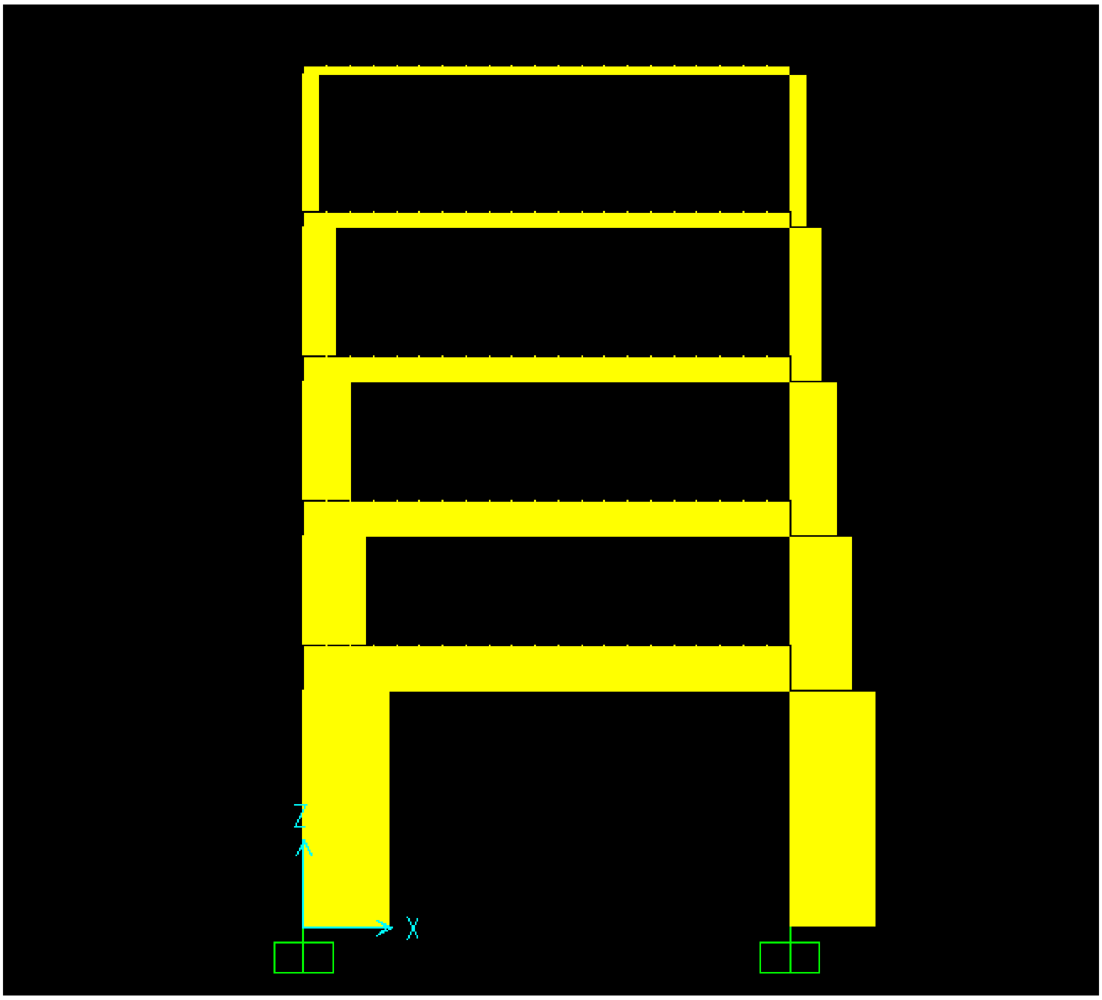


Figure 4.12 Shear force under wind action diagram

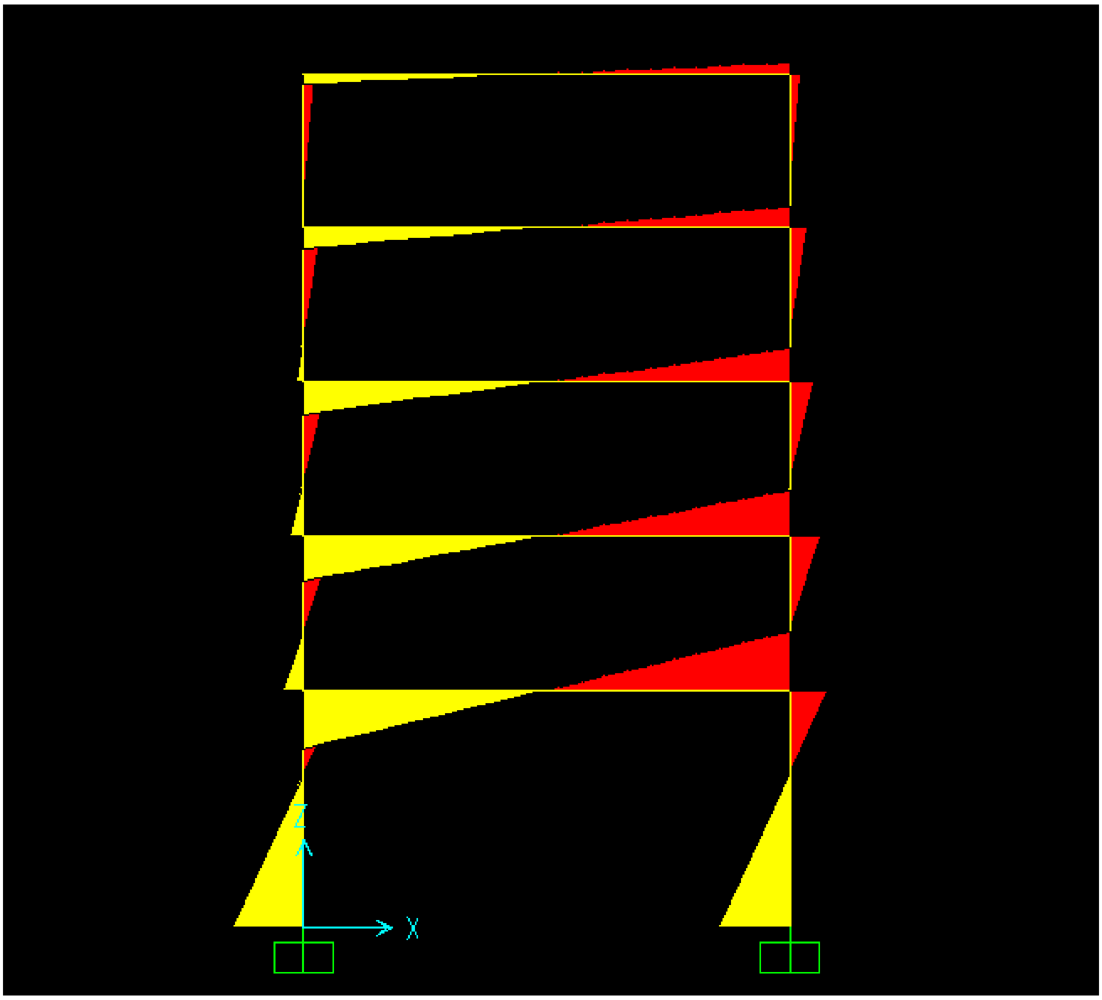


Figure 4.13 Bending moment under wind action diagram

4.3.2 Vertical load action

4.3.2.1 Calculation unit

As having described before, we take the transverse frame of axis 4 in plan to calculate. The depth for calculation is 7.8m, as shown in figure. The central line of outskirt beam is not combined with the central line of column. So we should calculate the concentrated bending moment at frame node. From figure below we can find that the load area covered by horizontal line delivered to longitudinal beam, and the load area covered by dot delivered to latitudinal beam.

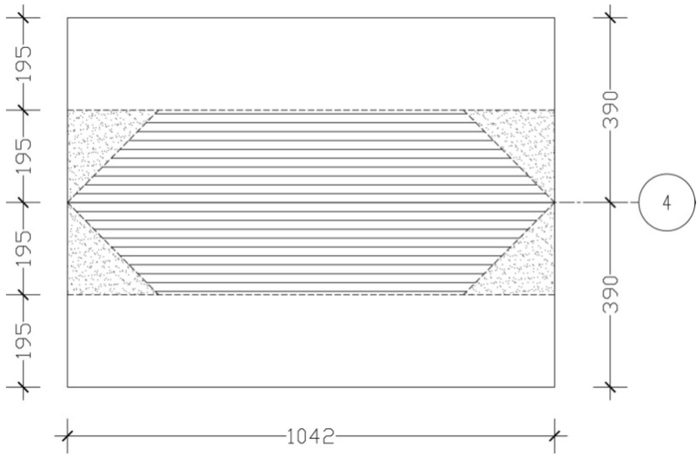


Figure 4.14 Load distribution area at the longitudinal beam

4.3.2.2 Dead load

As we calculate the internal force by Sap2000, the self weight of frame column and beam need not to be considered into dead load calculation. The load distribution under dead load action is shown in figure below.

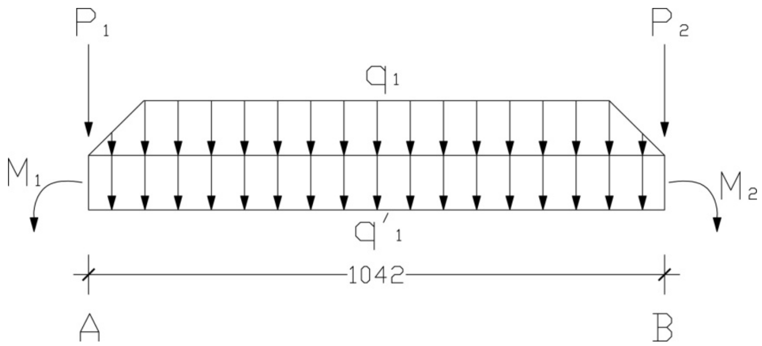


Figure 4.15 Dead load on each floor of the transverse frame

In figure, q_1' is the uniform distributed load of internal wall applying on the main beam,

1st – 4th floor: $q_1' = 2.08kN/m$

5th floor: $q_1' = 0$

q1 is the trapezoid distributed loads applying on the main beam delivered from the slab,

1st – 4th floor: $q_1 = 3.76 \times 3.9 = 14.66 kN/m$

5th floor: $q_1 = 4.69 \times 3.9 = 18.29 kN/m$

P1, P2 are the concentrated loads applying on the columns delivered from the gravity load of floor or roof slab weight, internal wall and parapet wall resistant on secondary beam and main beam.

1st – 4th floor:

$$P_1 = P_2 = 1.95 \times 10.24 \times 3.76 + 0.5 \times 1.95 \times 1.95 \times 2 \times 3.76 + 94.2 \times 9.8 \times 7.8 / 1000$$
$$+ 0.5 \times 34.6 \times 9.8 \times 10.24 / 1000 + 2.05 \times 7.8 = 114.3 kN$$

5th floor:

$$P_1 = P_2 = 1.95 \times 10.24 \times 4.69 + 0.5 \times 1.95 \times 1.95 \times 2 \times 4.69 + 94.2 \times 9.8 \times 7.8 / 1000$$
$$+ 0.5 \times 34.6 \times 9.8 \times 10.24 / 1000 = 120.42 kN$$

As beam width is 0.3m, the length of side column cross section is 0.4m, so the concentrated bending moment at frame node is:

1st – 4th floor: $M_1 = M_2 = P_1 e_1 = 114.3 \times \frac{0.4 - 0.3}{2} = 5.72 kN \cdot m$

5th floor: $M_1 = M_2 = P_1 e_1 = 120.42 \times \frac{0.4 - 0.3}{2} = 6.02 kN \cdot m$

We can summarize the results of calculation in table.

Results of dead load calculation for transverse frame

Floor level	q1	q_1'	P1	P2	M1	M2
5	18.29	0	120.42	120.42	6.02	6.02
1-4	14.66	2.08	114.3	114.3	5.72	5.72

Table 4.9 Results of dead load calculation for transverse frame

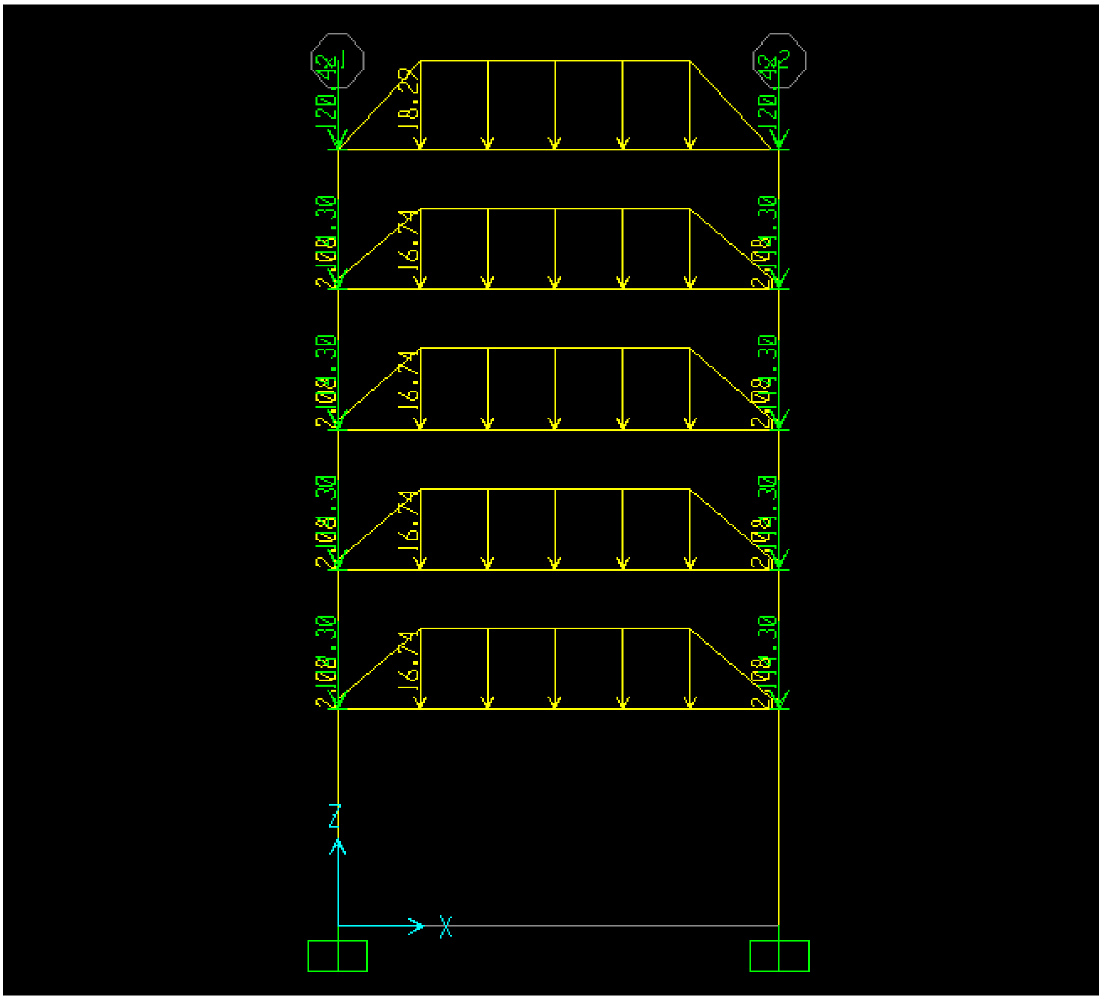


Figure 4.16   Dead load diagram

4.3.2.3 Internal force analysis under dead load action

After the internal force analysis in Sap2000, we can get axial load diagram, shear force diagram and bending moment diagram.

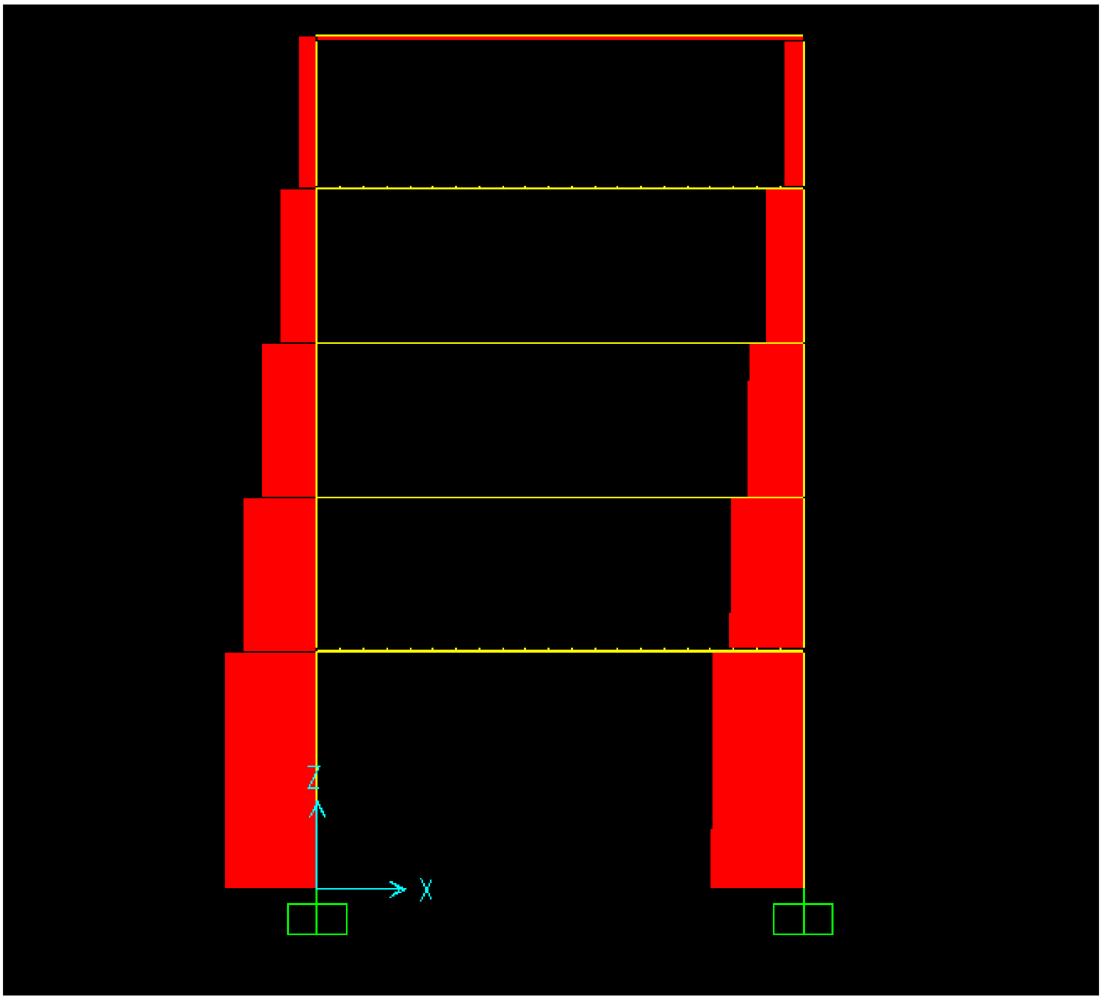


Figure 4.17 Axial load under dead load action diagram

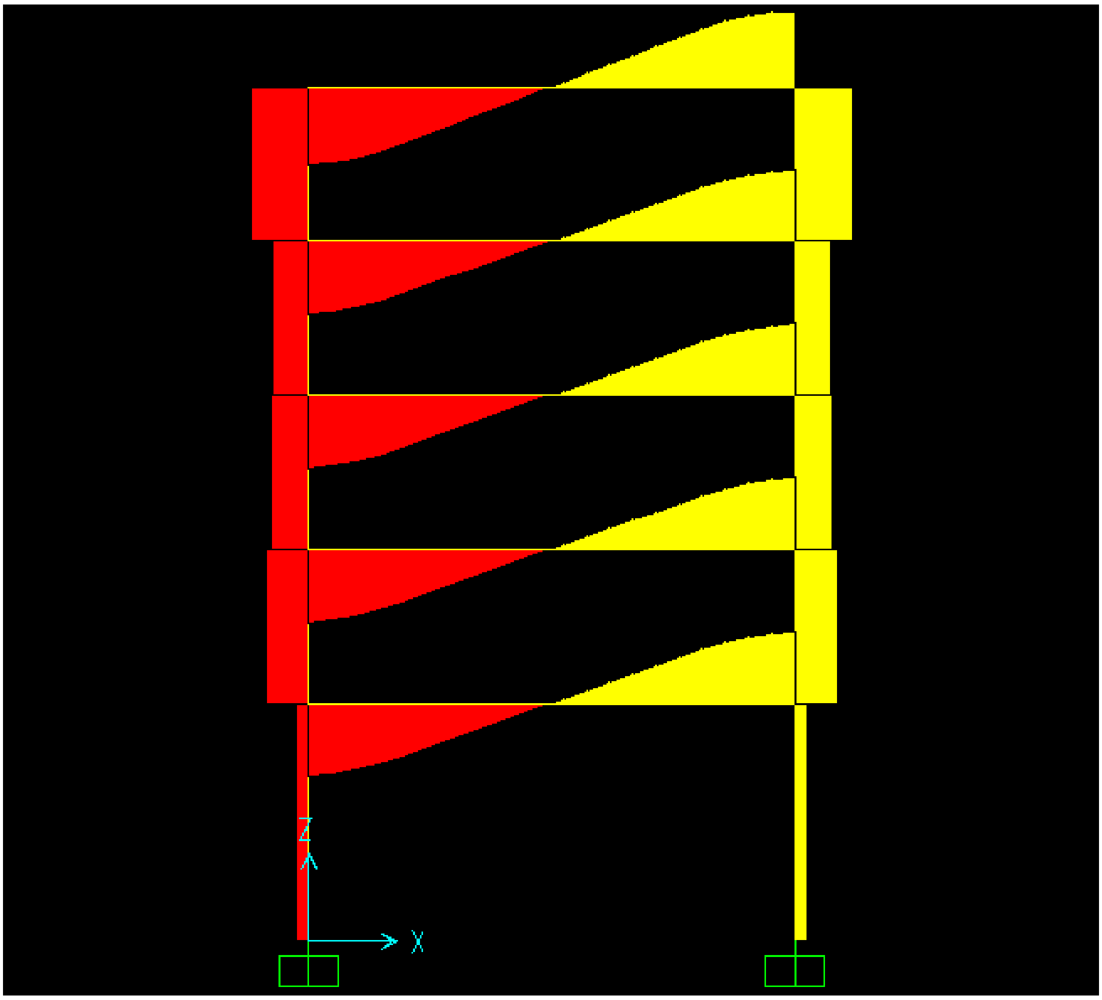


Figure 4.18 Shear force under dead load action diagram

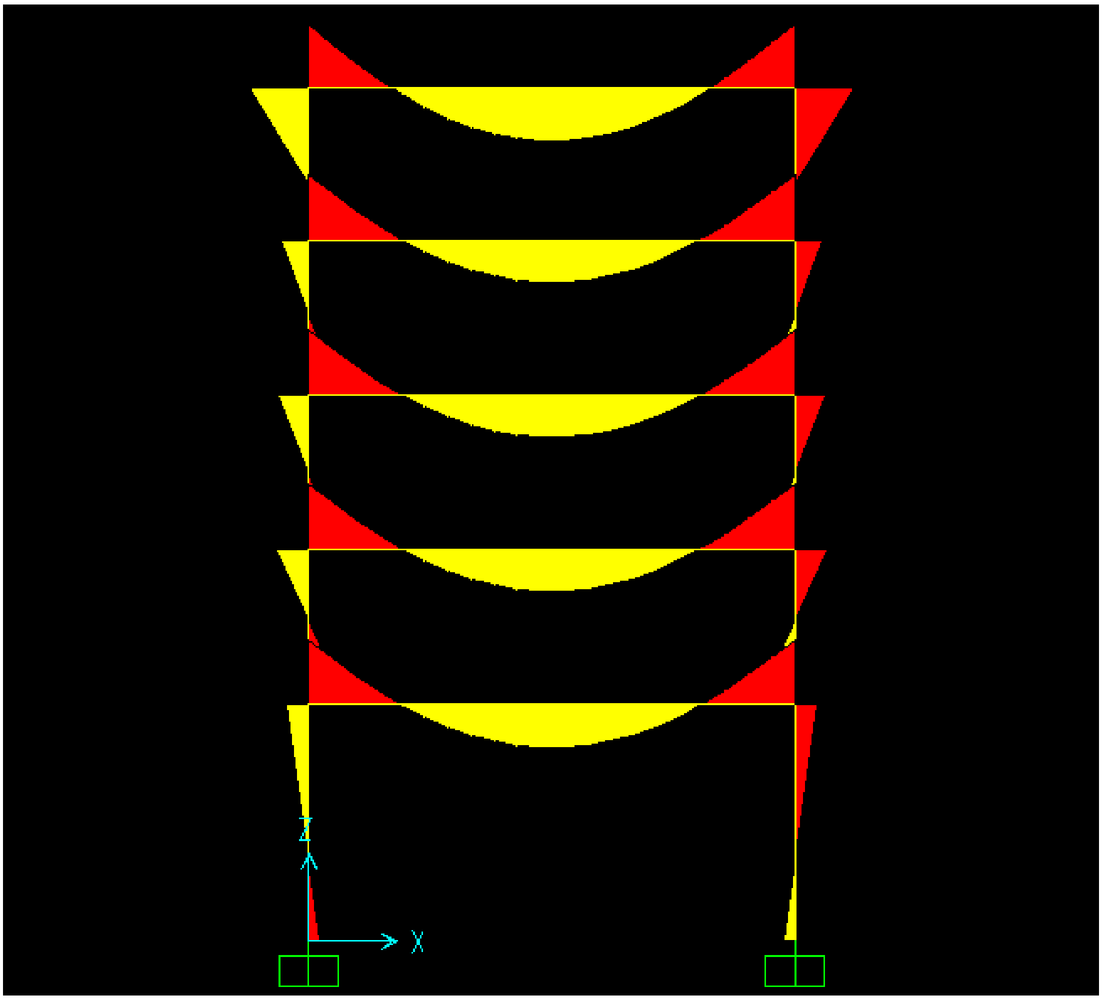


Figure 4.19 Bending moment under dead load action diagram

4.3.2.4 Live load

The load distribution under live load action is shown in figure.

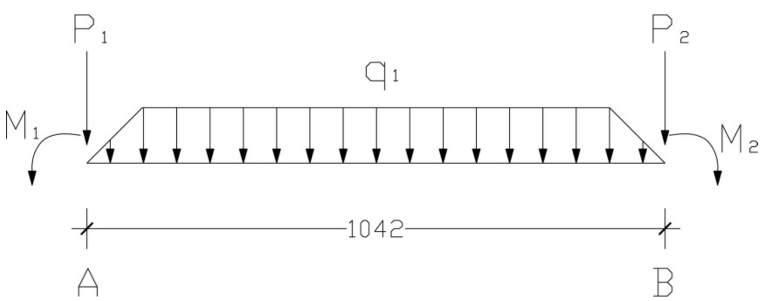


Figure 4.20 Live load on each floor of the transverse frame

In this building, ground floor is mainly used for restaurants and the upper floors are used for offices. The imposed loads for floors and accessible roof [EN1991-1-6 §6.3.1.2, Tab.6.1 and 6.2] are Qk=3.0kN/m2 and Qk=3.0kN/m2 respectively.

In figure, q1 is the trapezoid distributed load applying on the main beam respectively delivered from the room live load,

1st – 5th floor: $q_1 = 3 \times 3.9 = 11.7kN/m$

P1, P2 are the concentrated loads applying on the columns delivered from the live load resistant on secondary beam and main beam.

1st – 5th floor:

$$P_1 = P_2 = 1.95 \times 10.24 \times 3 + 0.5 \times 1.95 \times 1.95 \times 2 \times 3 = 71.31kN$$

As beam width is 0.3m, the length of side column cross section is 0.4m, so the concentrated bending moment at frame node is:

1st – 5th floor: $M_1 = M_2 = P_1 e_1 = 71.3 \times \frac{0.4-0.3}{2} = 3.57kN \cdot m$

We can summarize the results of calculation in table.

Results of live load calculation for transverse frame

Floor level	q1	P1	P2	M1	M2
1-5	11.7	71.31	71.31	3.57	3.57

Table 4.10 Results of live load calculation for transverse frame

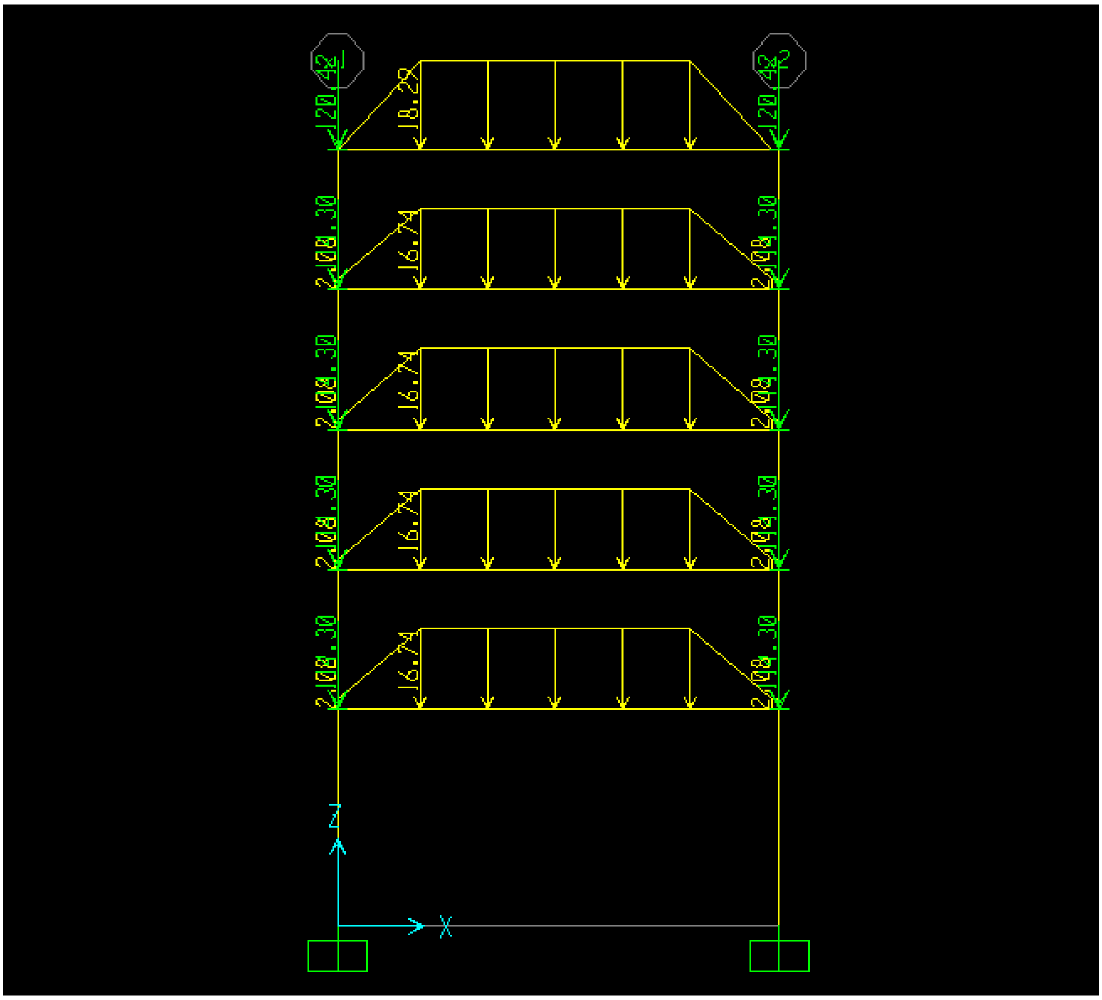


Figure 4.21 Live load diagram

4.3.2.5 Internal force analysis under live load action

After the internal force analysis in Sap2000, we can get axial load diagram, shear force diagram and bending moment diagram.

Figure 4.22 Axial load under live load action diagram

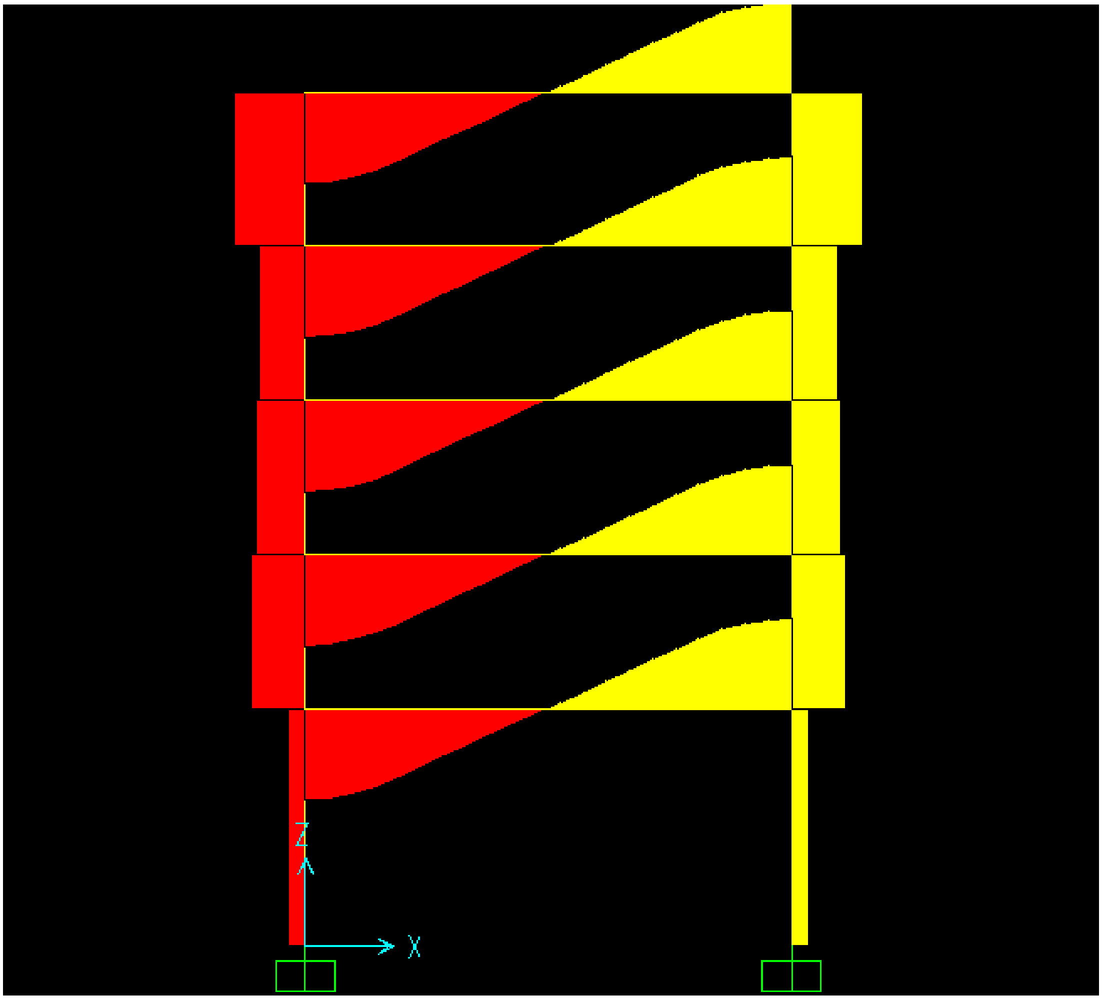


Figure 4.23 Shear force under live load action diagram

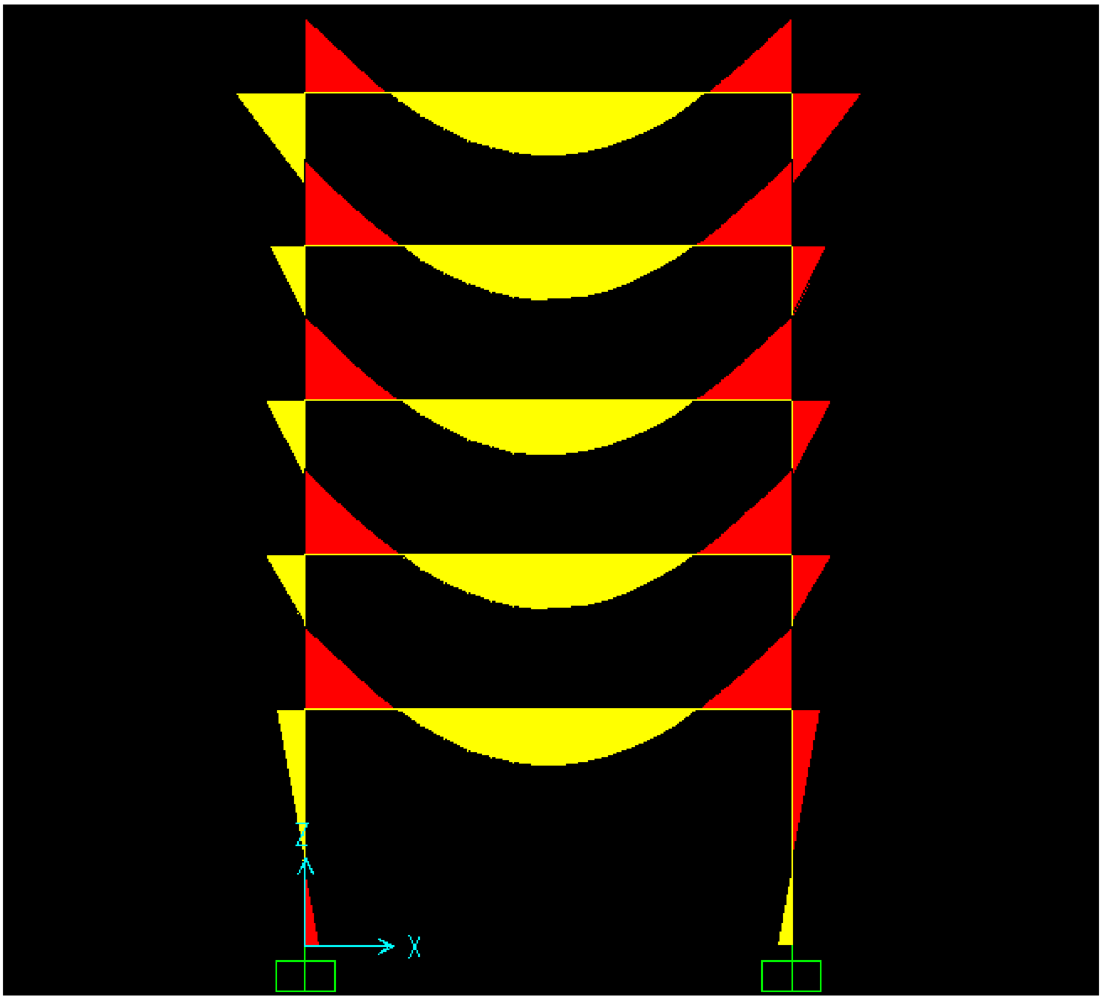


Figure 4.24 Bending moment under live load action diagram

4.3.3 Snow load

For the persistent design situation, the formula to calculate the snow load [Expression 5.1-EN1991-1-3] is:

$$s = \mu_1 \cdot C_e \cdot C_t \cdot S_k$$

Where:

μ1 is snow load shape coefficient. Here, it is taken as 0.8 for a roof with angle less than 30° [EN 1991-1-3.§5.3.(2)-Fig 5.1].

Ce is exposure coefficient. Here, it is equal to 1.0 for normal topography [EN 1991-1-3.§5.2.(7)-Tab 5.1].

Ct is thermal coefficient. Here, it is equal to 1.0, unless other specifications [EN

1991-1-3.§5.2.(8)and National Annex].

Sk is the characteristic value of snow load on the ground, equal to 2.25 kN/m2 (refer to figure) for Liberec for a design working life 50 years [EN 1991-1-3 and National Annex].

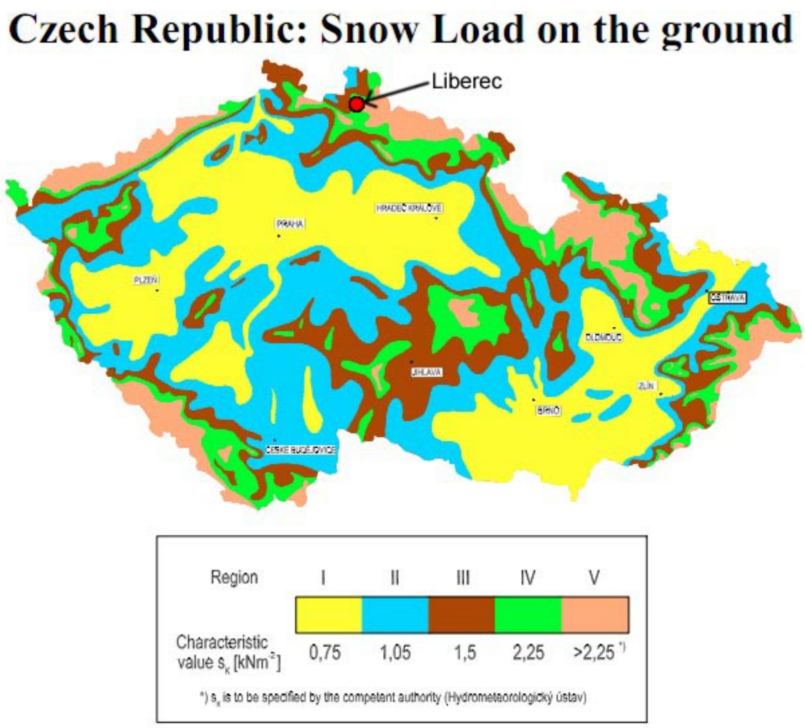


Figure 4.25 Snow load distribution in Iberian Peninsula district

So,

$$s = 0.8 \times 1.0 \times 1.0 \times 2.25 = 1.8 kN / m^2$$

As a result, the snow load (1.8kN/m2) on the roof is lower than the live load (3kN/m2) on the roof. So, we only take into account the live load for the roof during the structure design.

4.4 Load combination

The load combination conditions applied are shown in table.

Load combination conditions

Combination 1	1.35 DL
Combination 2	1.35 DL+1.5 LL
Combination 3	1.35 DL+1.35 LL+1.35 WL
Combination 4	1.35 DL+1.35 LL-1.35 WL
Combination 5	1.35 DL+1.5 WL
Combination 6	1.35 DL-1.5 WL
Combination 7	1.0 DL+1.5 WL
Combination 8	1.0 DL-1.5 WL

Table 4.11 Load combination conditions

Note: Dead Load, Live Load and Wind Load are abbreviated as DL, LL and WL respectively.

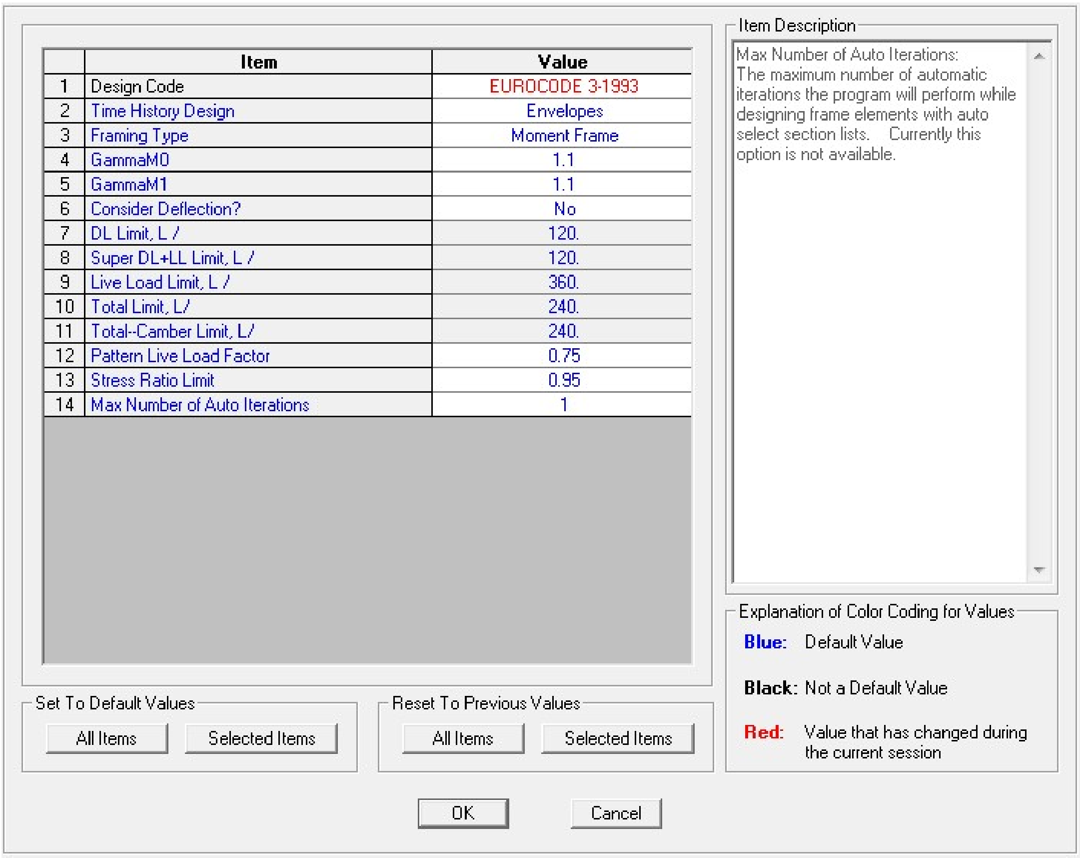


Figure 4.26 Load combination_1

According to these response combinations, we can define a new combination called "ENVELOPE" to envelop all the 8 combinations, so that we can find the max and min value of each elements of the structure.

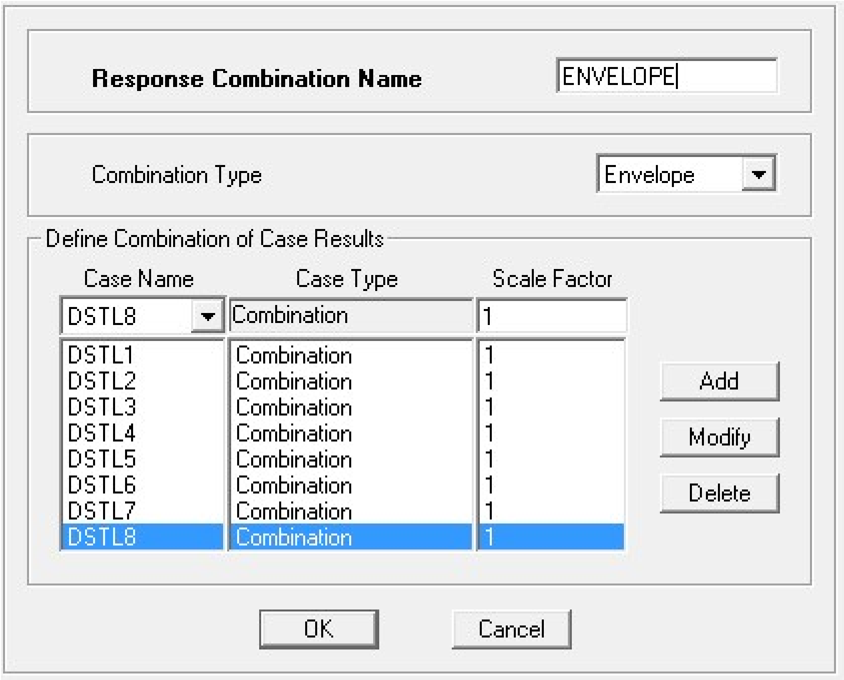


Figure 4.27 Load combination_2

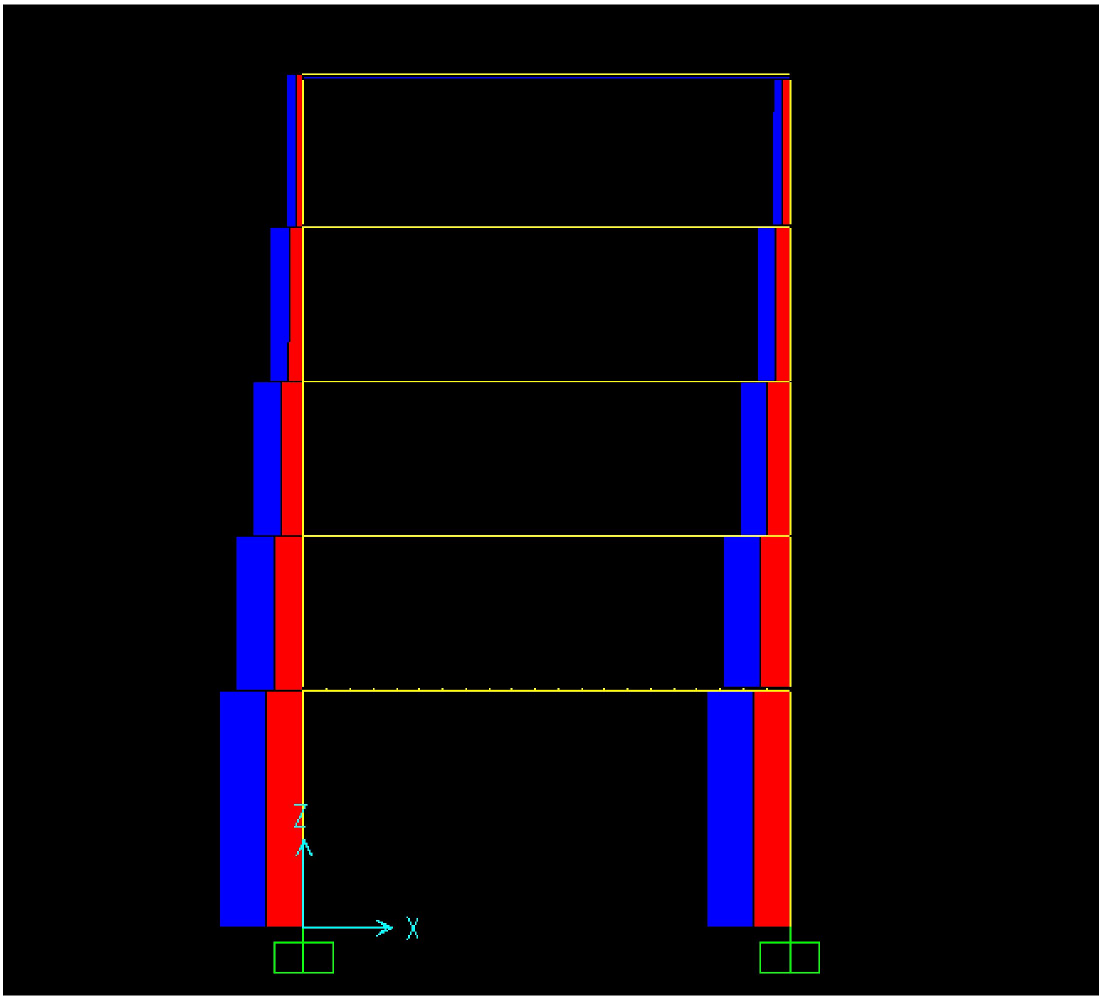


Figure 4.28 Axial load under new load combination diagram

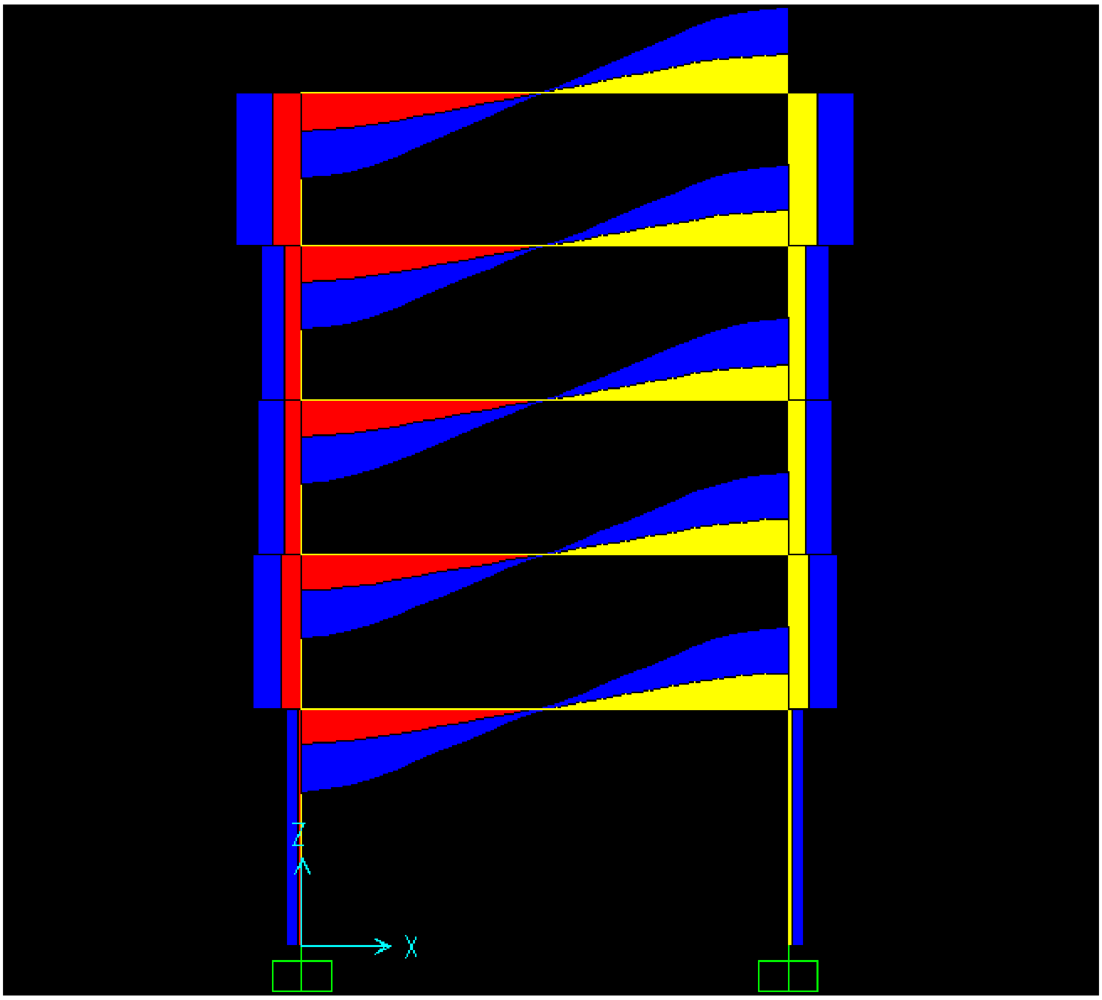


Figure 4.29 Shear force under new load combination diagram

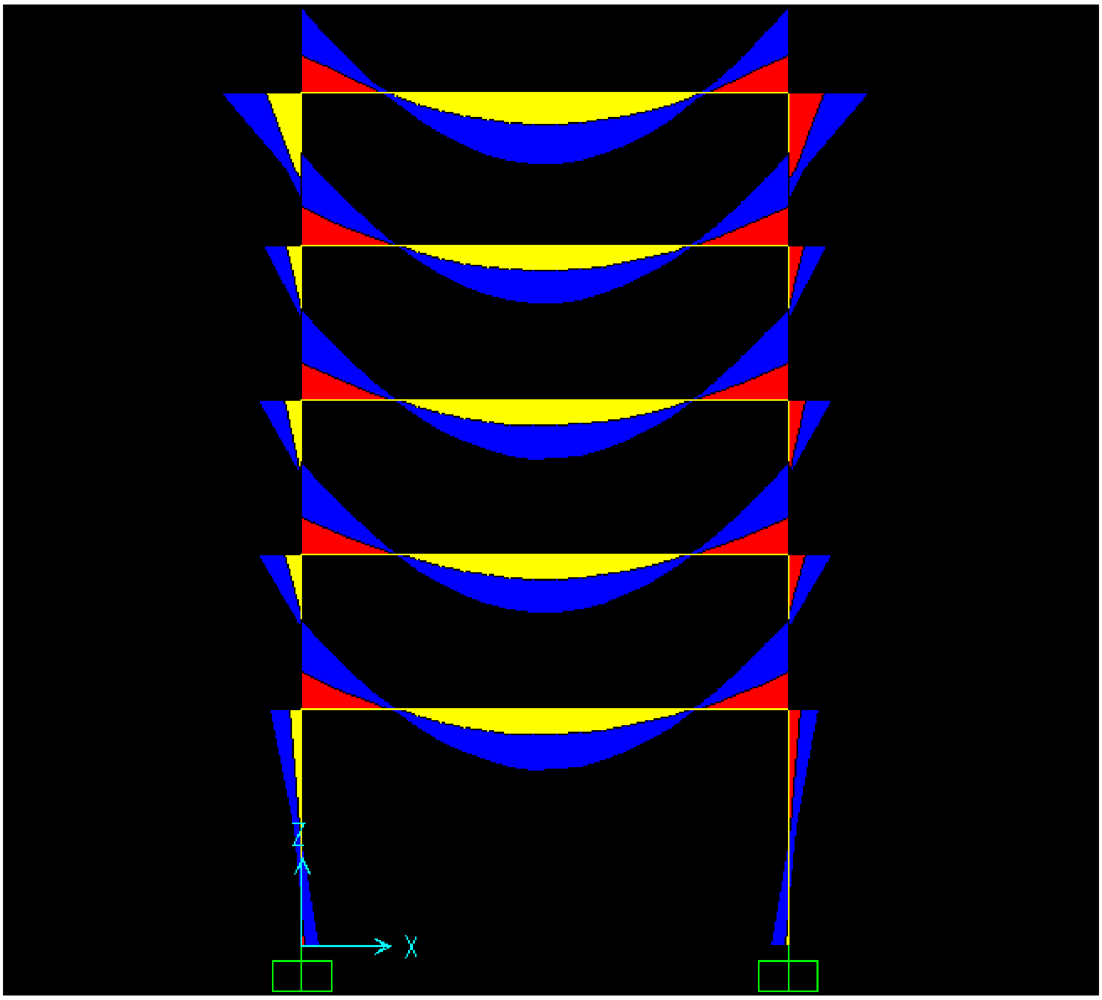
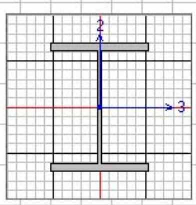


Figure 4.30 Bending moment under new load combination diagram

We take one element from each kind of beam and column as example to show the detailed data under the effect of 8 combinations.

Units KN, m, C

EUROCODE 3-1993 STEEL SECTION CHECK
Combo : ENVELOPE
Units : KN, m, C



Frame	: 1	Design Sect: HE400-B			
X Mid	: 0.000	Design Type: Column			
Y Mid	: 0.000	Frame Type : Moment Resisting Frame			
Z Mid	: 2.550	Sect Class : Class 1			
Length	: 5.100	Major Axis : 0.000 degrees counterclockwise from local 3			
Loc	: 5.100	RLLF : 1.000			

Area	: 0.020	SMajor	: 0.003	rMajor	: 0.171	AVMajor:	0.005
IMajor	: 5.768E-04	SMinor	: 7.213E-04	rMinor	: 0.074	AVMinor:	0.012
IMinor	: 1.082E-04	ZMajor	: 0.003	E	: 199947978.80		
Ixy	: 0.000	ZMinor	: 0.001	Fy	: 248211.284		

STRESS CHECK FORCES & MOMENTS

Location	P	M33	M22	V2	V3	T
5.100	-2248.012	114.373	0.000	-34.332	0.000	0.000

PMM DEMAND/CAPACITY RATIO

Governing Equation	Total Ratio		P Ratio		MMajor Ratio		MMinor Ratio	Ratio Limit	Status Check
(5.5.4)	0.846	=	0.679	+	0.167	+	0.000	0.950	OK

AXIAL FORCE DESIGN

	Fc or Ft Force	Nc.Rd Capacity	Nt.Rd Capacity	Nb33.Rd Major	Nb22.Rd Minor
Axial	-2248.012	3308.467	4467.803	4056.584	3308.467

MOMENT DESIGN

	M.Sd Moment	Mc.Rd Capacity	Mv.Rd Capacity	Mb.Rd Capacity
Major Moment	114.373	729.290	729.290	689.215
Minor Moment	0.000	249.114	249.114	

	K Factor	L Factor	k Factor	klt Factor	C1 Factor
Major Moment	1.642	1.000	1.062	0.965	2.021
Minor Moment	1.000	1.000	1.500		

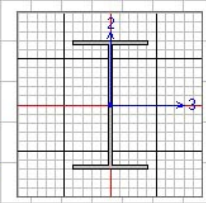
SHEAR DESIGN

	V.Sd Force	V.Rd Capacity	Stress Ratio	Status Check	Tu Torsion
Major Shear	34.332	703.497	0.049	OK	0.000
Minor Shear	0.000	1563.326	0.000	OK	0.000

Figure 4.31 Data under the effect of 8 combinations_1

Units KN, m, C

EUROCODE 3-1993 STEEL SECTION CHECK
Combo : ENVELOPE
Units : KN, m, C



Frame	: 48	Design Sect:	HE550-AA
X Mid	: 5.200	Design Type:	Beam
Y Mid	: 0.000	Frame Type :	Moment Resisting Frame
Z Mid	: 5.100	Sect Class :	Class 2
Length	: 10.400	Major Axis :	0.000 degrees counterclockwise from local 3
Loc	: 0.000	RLLF	: 1.000

Area	: 0.015	SMajor	: 0.003	rMajor	: 0.218	AVMajor:	0.006
IMajor	: 7.287E-04	SMinor	: 4.511E-04	rMinor	: 0.067	AVMinor:	0.008
IMinor	: 6.767E-05	ZMajor	: 0.003	E	: 199947978.80		
Ixy	: 0.000	ZMinor	: 6.990E-04	Fy	: 248211.284		

STRESS CHECK FORCES & MOMENTS

Location	P	M33	M22	V2	V3	T
0.000	30.647	-315.038	0.000	-180.092	0.000	0.000

PMM DEMAND/CAPACITY RATIO

Governing Equation	Total Ratio		P Ratio		MMajor Ratio		MMinor Ratio	Ratio Limit	Status Check
(5.5.4)	0.931	=	0.009	+	0.922	+	0.000	0.950	OK

AXIAL FORCE DESIGN

	Fc or Ft Force	Nc.Rd Capacity	Nt.Rd Capacity	Nb33.Rd Major	Nb22.Rd Minor
Axial	30.647	910.132	3452.393	3152.811	910.132

MOMENT DESIGN

	M.Sd Moment	Mc.Rd Capacity	Mv.Rd Capacity	Mb.Rd Capacity
Major Moment	-315.038	705.823	705.823	336.668
Minor Moment	0.000	157.727	157.727	

	K Factor	L Factor	k Factor	klt Factor	C1 Factor
Major Moment	1.000	1.000	0.994	1.000	1.001
Minor Moment	1.000	1.000	0.920		

SHEAR DESIGN

	V.Sd Force	V.Rd Capacity	Stress Ratio	Status Check	Tu Torsion
Major Shear	180.092	782.054	0.230	OK	0.000
Minor Shear	0.000	977.079	0.000	OK	0.000

Figure 4.32 Data under the effect of 8 combinations_2

4.5 Structure check

After calculating the forces and moments of the elements, we use SAP2000 to check whether all the sections of the elements in this structure system can reach the strength demand.

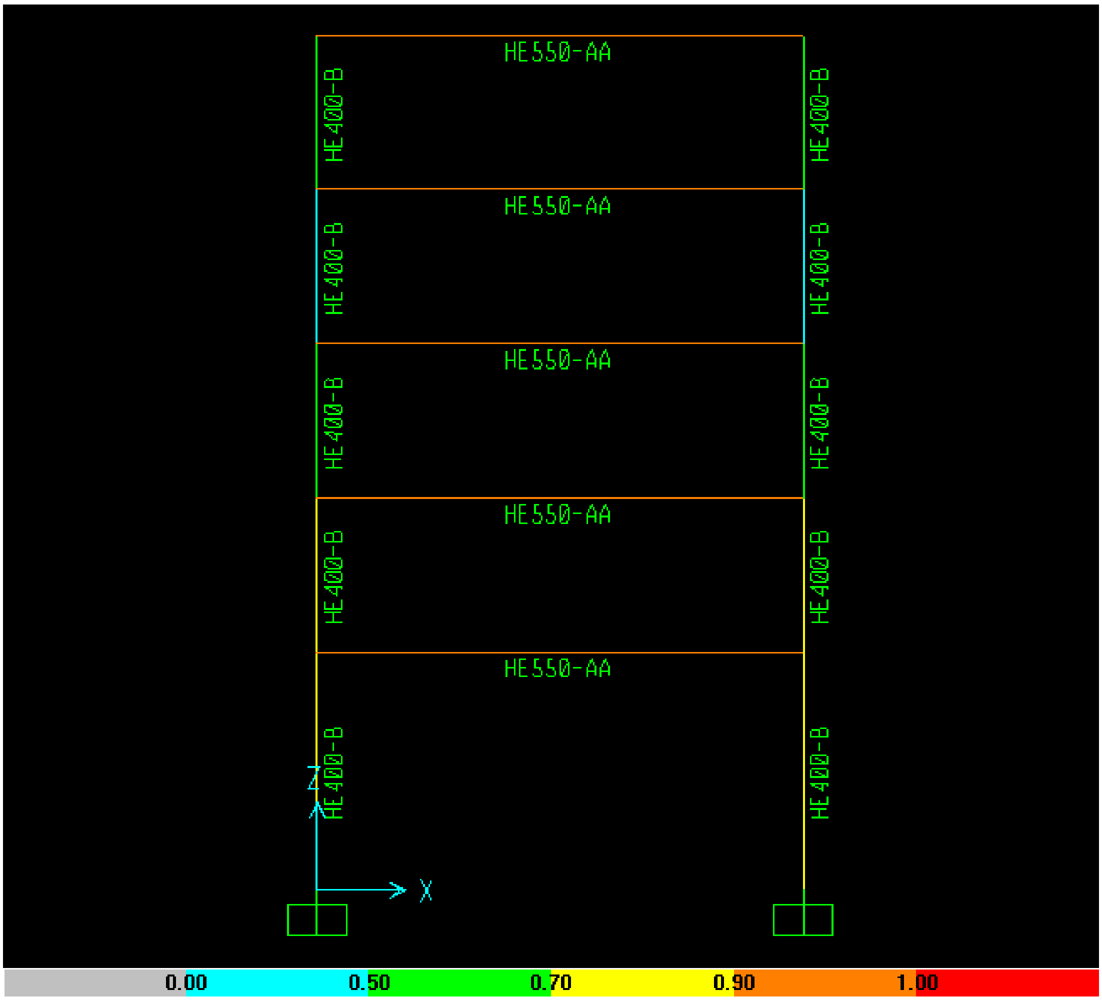


Figure 4.33 Structural system check

Without seeing the red color in the diagram, we conclude that analysis and design sections match all steel frames and all steel frames pass the stress/capacity check.

4.6 Connection design

4.6.1 Point 1: Connection between main bean and secondary beam

If primary beam and secondary beam are connected by hinge, the torsion effect of primary usually can be neglected and only need to consider about the shear effect at the connection.

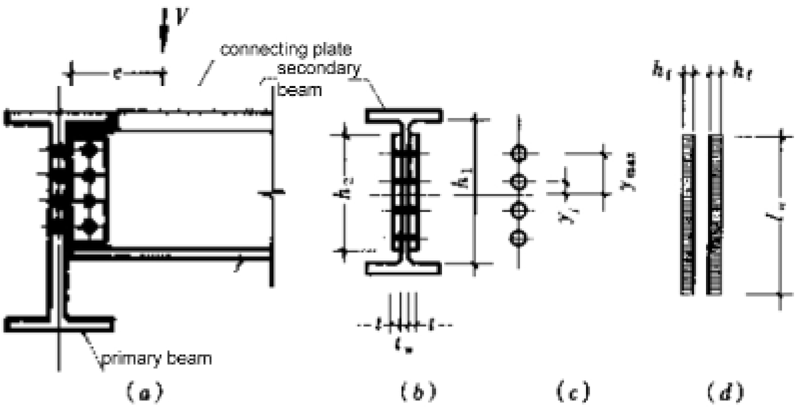


Figure 4.34 Type of joint between main beam and secondary beam

When the high-strength bolt friction type connection between primary beam and secondary beam is applied, the bolt can be design as following steps.

1. Under effect of shear force at the edge of secondary beam, the force resisted by one high-strength bolt is:

$$Nv = V / n$$

2. Under effect of eccentric bending moment Me=V · e, the maximum force resisted by

side row high-strength bolt is:

$$N_M = \frac{M_e y_{\max}}{\sum y_i^2}$$

3. Under the combined effect of shear force and eccentric bending moment, the maximum force resisted by side row high-strength bolt is:

$$Ns\max = \sqrt{(N_v)^2 + (N_M)^2} \le N_v^{bH}$$

Where, N_v^{bH} is the design value of single side shear resistance of one friction type high-strength bolt.

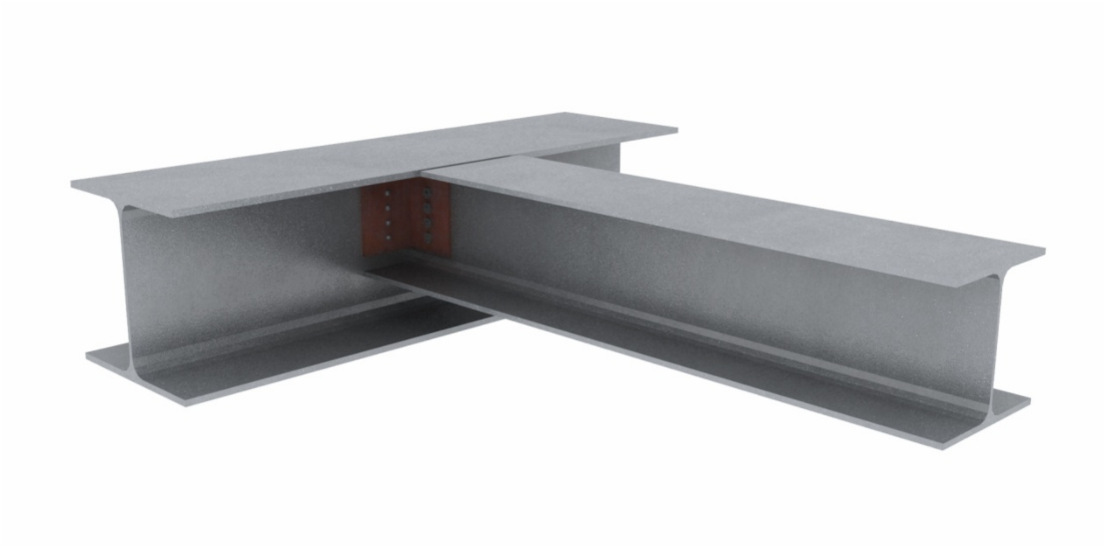


Figure 4.35 Connection of main beam with secondary beam

4.6.2 Point 2: Connection between column and beam

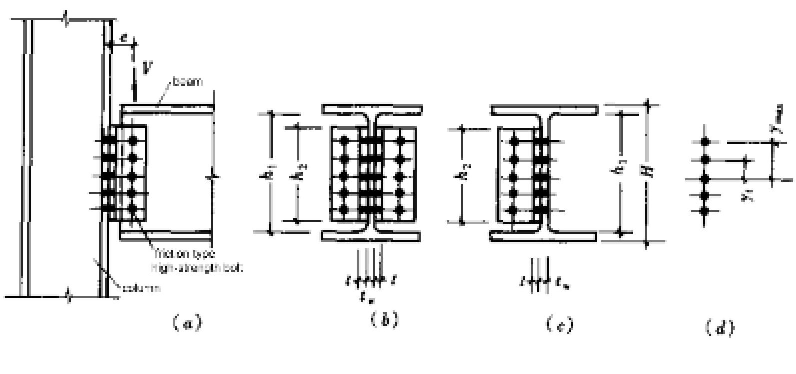


Figure 4.36 Type of joint between column and beam

1. Joint between beam and column is consisted with connection profiles (angle steel ,etc). The parameters used are as follows:

(1) Geometry parameters of Beam and column

H (height), B (width), T (flange thickness), t (web thickness), R (fillet radius of flange-web) (subscript 1 means beam, subscript 2 means column)

(2) Material parameters

Fu (tensile stress)= 345 MPa , Fy (Minimum yield stress)= 510 MPa ,

(subscript 1 means beam, subscript 2 means column, subscript 3 means angle steel)

(3) Parameters of connecting bolt

D (diameter of bolt), DL (diameter of bolt hole = D+2 or D+1.5),

LL (spacing of bolt), S (boundary spacing of bolt), G (track line spacing of bolt),

P_b (minimum pre-tensile of bolt), H_b (allowable tensile load = 0.8 P_b),

V_b (allowable sheer load = 0.9*f* P_b), f (Coefficient of friction).

(4) Geometry parameters of angle steel

t_3 (thickness of angle steel), H_3 (width of angle steel),

L (length of connecting angle steel)

(5) Joint load

H (Axial force along the beam direction), V(shear force along column direction)

2. Number of bolt on one side

As it is required in design codes, the length of angle steel should not be shorter than the half- height: 2S + (LL -1) N ⩾ Ht /2, as

$$n_1 = \frac{(H_1 / 2) - 2S}{LL - 1} \qquad (1)$$

Based on shear stress conditions,

$$n_2 \geq \frac{V}{2V_b} \qquad (2)$$

Based on tensile stress conditions,

$$n_3 \geq \frac{H}{2H_b} \qquad (3)$$

Based on compression stress of supporting profiles conditions,

$$n_4 \geq \frac{V}{2 * 0.9 * F_{y2} * T * D} \qquad (4)$$

At the joint of the beam- column web, $T=t_2$; At the joint of beam- column flange, $T=T_2$.

$$n_5 \geq \frac{V}{2*V_b*[1-H(2*N*P_{b2})]} \quad (5)$$

or $$n_5 \geq \frac{V+2.25H}{1.8f*P_b} \quad (5)$$

Number of bolts

$$N = \max(n_1, n_2, n_3, n_4, n_5) \quad (6)$$

Use the following equation to check if the structural length to meet the requirements of beam height:

$$(N-1)LL + 2S \leqslant H_1 - 2(T_1 + R_1) \quad (7)$$

If equation (7) is satisfied, then the number of bolts is N, otherwise bolts are set in two rows.

3. Dimension of angle steel

Thickness of angle steel

compression stress of angle steel

$$t_a \geq \frac{V}{2*N*D*0.9*F_{y3}} \quad (8)$$

shear stress of angle steel

$$t_b \geq \frac{V}{2[(N-1)*LL+2S-N*DL]*0.4*F_{y3}} \quad (9)$$

tensile stress of angle steel

$$t_c \geq \frac{H}{2[(N-1)*LL+2S]*0.6*F_{y3}} \quad (10)$$

spacing of bolts

$$t_d \geq \frac{V}{(LL-D/2)*N*F_{u3}} \quad (11)$$

spacing of angle steels

$$t_e \geq \frac{V}{S*N*F_{u3}} \quad (12)$$

thickness of angle steel

$$t_3 = \max \{t_a, t_b, t_c, t_d, t_e\} \quad (13)$$

Width of angle steel

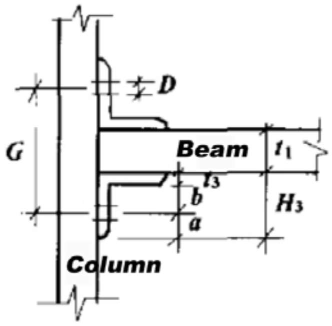


Figure 4.37 Beam-column connecting node

Based on thickness of angle steel, $a = H_3 + t_1/2 - G/2$, $b=G/2- t_1/2 - t_3$, and $a \leqslant 1.25b$,

$$H_3 \le \frac{9(G-t_1)}{8} - \frac{5t_3}{4} \quad (14)$$

The result should be multiple of ten.

Figure 1 Beam - column connecting node

As $b' = b - D/2$, $a' = a + D/2$, $r = b' / a'$, $\delta = 1 - DL/LL$,

$$B = (1 - \frac{V}{2*N*V_b})P_b \quad (15)$$

If $B \leqslant H_b$, the width is got from equation (13);

If $B>H_b$,width and thickness can be got as follows:

As $B=H_b$, $T=H / (2N)$, $\beta = (B/T - 1)/r$,

$$\alpha = \begin{cases} 1 & (\beta \ge 1); \\ \min\left(1, \frac{\beta}{\delta(1-\beta)}\right) & (\beta < 1). \end{cases}$$

so $$t_r = \sqrt{\frac{8*T*b'}{LL*F_{y3}*(1+a\delta)}} \quad . \quad (16)$$

(1) If $t_r \leqslant t3$, the requirements of width from equation (12) is satisfied;

(2) If $t_r > t3$, and equation (7) is satisfied, then N=N+1, return to 3 recalculate dimension of angle steel;

(3) If $t_r > t_3$, and equation (7) is not satisfied, then the thickness of angle steel

$$t_3 = t_r \; ; \qquad (17)$$

(4) If t_r >maximum thickness of angle steel, joints should be edge-connection instead of bolts.

Figure 4.38 Connection of beam with column

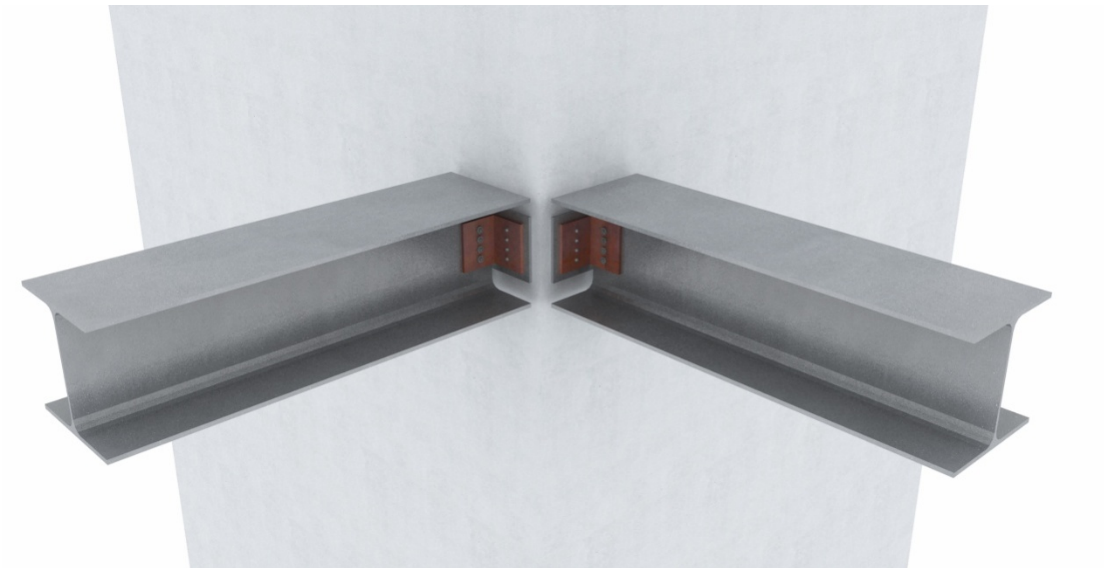


Figure 4.39 Connection of beam with shear wall

4.6.3 Point 3: Connection between column and foundation

The design for base plate is according to the maximum load that has been derived from the structure analyses by Sap2000 and the building supports are fixed supports, which they can take axial load, shear and moment. The reason for using this kind of support is that the building will be able to withstand more vertical forces. We take HE600 column on ground level as an example to describe the process of designing base plate.

Initial design information

Column section: h × b × tw × tf = 600×300×15.5×30 mm

Material strength: Steel grade S 335H: fy = 335 N/mm2

Concrete grade C30: fck = 30 N/mm2

The column is supported concentrically on a part of 2000×2000×800 mm deep reinforced concrete mat foundation.

Design loads from Sap2000

Design compressive force: Nsd= 3419.32 kN

Design Shear force: Vsd = 16.36 kN

Following the procedure in Spain national annex of EUROCODE 3:

Column flange thickness: tf = 30 mm

Column web thickness: tw = 15.5 mm

Axial resistance

The thickness of base plate should not be less than the thickness of the column flange.

Therefore use base plate thickness, t > tf, ie 35.00 mm.

The maximum potential effective bearing width, c, of the plate:

$c = t\,[\,fy/(3 \times fj \times \gamma M0)\,]^{0.5}$

Where the bearing strength:

$fj = \beta j\ kj\ fcd$

Where,

fcd = fck / ɣc = 30/1.5 = 20 N/mm2

βj = 0.67 (from EUROCODE)

concentration factor: kj = [a1 × b1 /(a × b)]0.5

If we assume that the base plate has 700×400×35 mm dimension to provide adequate space for the locating the holding down bolts and setting stiffer plate, then:

a = 700 mm, b = 400 mm

a1 = b1= a + h (effective depth of foundation) = 700 + 800 = 1500 mm

b1= b + h = 400 + 800 = 1200 mm

kj = (1500× 1200 /700 × 400)0.5 = 2.54

fj = 0.67 × 2.54 × 20 = 34.03 N/mm2

fy = 355 N/mm2

ɣ M0 = 1.0

Therefore, c = 35× {355/(3×34.03×1.0)}0.5 = 65.3 mm

Effective area: Aeff = (600 + 2 × 65.3) (300 + 2 × 65.3) = 314.6 × 103 mm2

Design bearing pressure: Nsd/Aeff = 3419.32 × 103 / 314.6 × 103 = 10.87 N/mm2

Bearing strength, fj = 34.03 N/mm2 > 10.87 N/mm2 (satisfied)

Shear resistance

Where the applied shear force is less than 20% of the applied vertical load, no special provisions are necessary for the transfer of the shear load from the base plate to the foundation

Nsd = 3419.32 kN

Vsd = 16.36 kN < Nsd/5 = 3419.32/5 = 683.9 kN (satisfied)

Design of plate dimensions

Minimum width of plate required:

b + 2c = 300 + 2 × 65.3 = 430.6 mm ≈ 450 mm

Minimum depth of plate required:

$d + 2c = 600 + 2 \times 47.9 = 730.6$ mm $\approx$ 750 mm

So: 750 × 450 × 35 mm grade S 335H steel base plate is used.

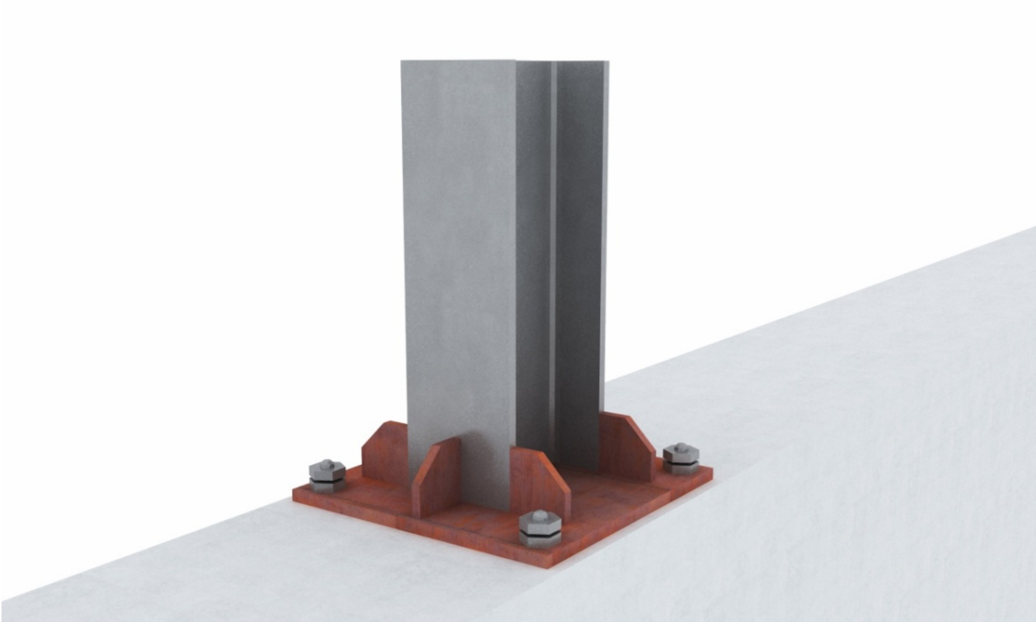


Figure 4.40 Connection of column with foundation

5.0

TECHNOLOGY DESIGN

From the viewpoint of human comfort and energy use, the climatic condition of a place can be divided broadly into negative and positive effects. In general, the aim of climate-conscious architecture is to provide protection from the negative factors and take advantage of the positive ones in order to meet the comfort requirements of the people and secure an economical level energy consumption.

A year-round analysis is required. Buildings have to perform appropriately in summer, winter and intermediate seasons. The latter are often characterized by great day-to-day variability, demanding flexibility of operation. To allow the architect to analyse the climate at a particular site, the climatic factors need to express quantitatively. The key factors are the position of the sun, the amount if solar energy, the air temperature, long wave radiation and wind condition. Humidity, best assessed as the water-vapor pressure, is also an important factor in hot weather.

The geometric range if the sun's position throughout and particular day determines the directly-radiated surfaces. The range changed from season to season. The strength of the direct solar beam on a specific surface is described by its beam irradiance. This is the heat flow per unit area and is expressed in watts per square meter(W/m2). In Europe at low level sun, the beam irradiance seldom exceeds 900W/m2. As well as the direct solar beam, building surface also receive diffused solar radiation scattered by the particles in the sky and reflected from clouds, ground, adjacent buildings, etc. If the solar energy reaching a surface is summed over a stated period of time, the irradiation is obtained.

The outdoor air temperature describes the thermal ambience of a place. It can be measured using thermometers shaded by a well-ventilated whitened meteorological screen mounted at a standard height. Air temperature is a major factor in determining thermal comfort.

Knowledge of wind conditions makes it possible to assess the impact wind can have on ventilation and heat loss. Information on typical wind speeds and directions is needed to devise protection against winds in winter. In summer, positive use of wind for natural cooling is important, especially in southern Europe. Wind speeds are very dependent in height above ground. Substantial deflections are caused by buildings

The humidity of the air exerts strong influence in comfort in hot weather. High water vapor pressure makes it difficult for the body to evaporate sweat at adequate rates to stay cool.

The available observed values of the above climatic factors are those measured at meteorological stations where the instruments are mounted under standardized conditions at standard heights above level, grass-covered ground. These measured values provide the macroclimate database for the area. Sometimes, access to more local data can help the architect to understand the conditions of the site more fully.

The architect must always interpret the required climate data according to the place where he wants to build. He or she must consider the mesoclimate-the modifications which topography and vegetation make to the macroclimate of the region. He or she must also take into account the microclimate-the effect on the mesoclimate of what man does to the local environment.

Wind flow is strongly affected by topography-for instance, by the shelter provided by hedgerows and trees, by the surface properties of features such as lakes or shrubs, and by the shape of the ground. Wind flow is also affected by nearby buildings: in towns, it can be highly perturbed. The temperature microclimate is influenced by the wind microclimate. It is also affected by the nature of the ground cover. For instance, dark pavements heat up in the sun whereas green grass produces a much cooler environment. The solar radiation climate at the site is affected by the presence of pollution.

5.1 Climate in Liberec

5.1.1 Basic information

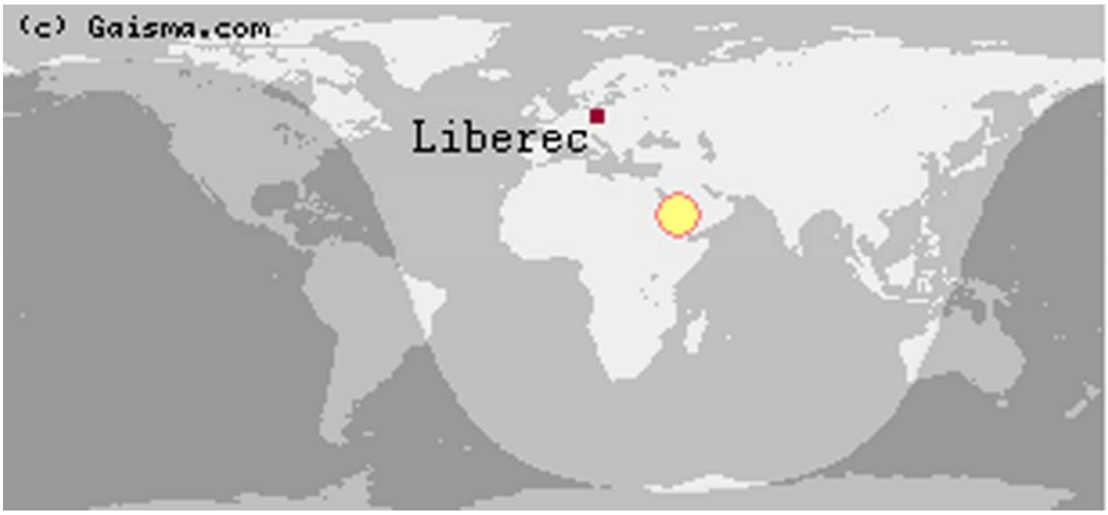


Figure 5.1 Location map of Liberec in the world

Latitude: +50.78 (50°46'48"N)

Longitude: +15.06 (15°03'36"E)

Time zone: UTC+1 hours

Climatic characteristics: Mild continental, four seasons, changeable winters, warm summers.

5.1.2 Natural conditions

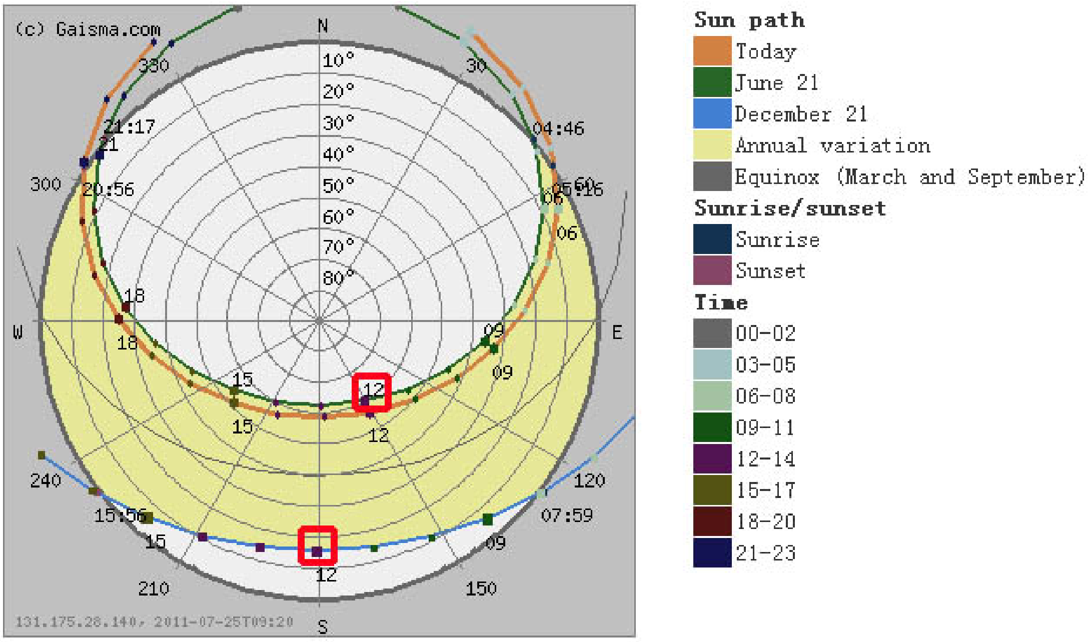


Figure 5.2 Solar path

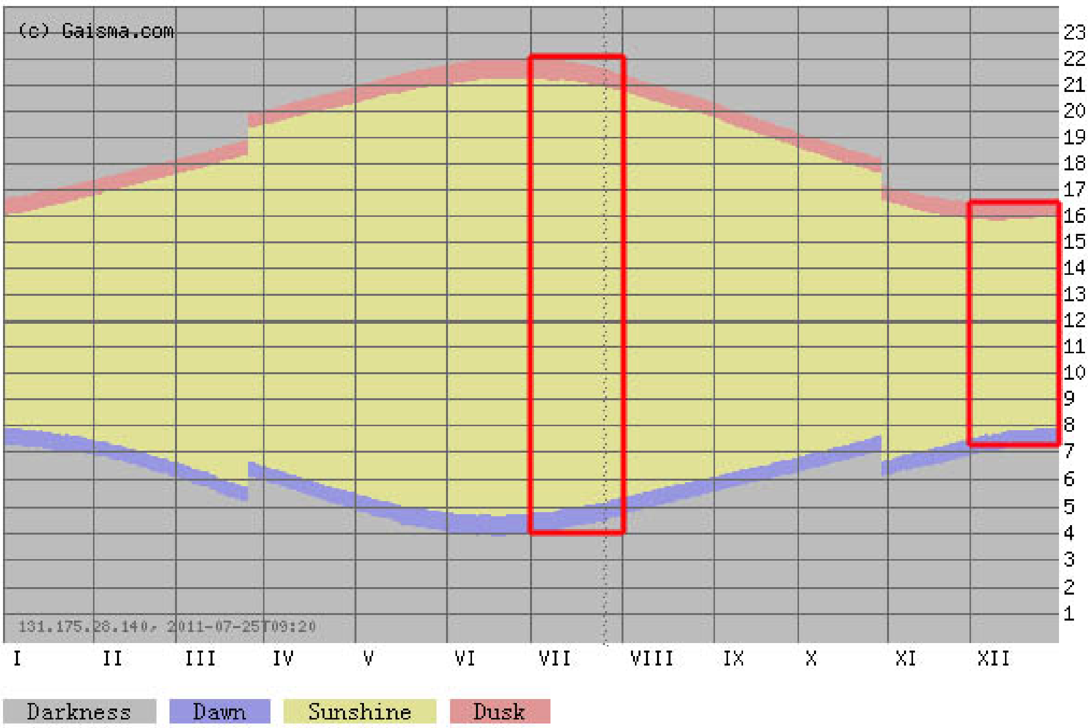


Figure 5.3 Sunrise sunset dawn and dusk times

Variable	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Insolation, kWh/m²/day	0.79	1.45	2.46	3.72	4.77	4.72	4.82	4.34	2.84	1.65	0.87	0.63
Clearness, 0 - 1	0.34	0.38	0.40	0.43	0.45	0.41	0.44	0.46	0.40	0.36	0.32	0.33
Temperature, ° C	-1.09	-0.23	3.28	8.73	14.50	17.14	19.54	19.53	14.48	9.61	3.17	-0.32
Wind speed, m/s	6.46	6.01	5.98	5.08	4.89	4.92	5.24	5.20	5.86	5.90	6.25	6.42
Precipitation, mm	65	53	56	59	81	89	92	90	68	63	70	81
Wet days, d	14.7	13.5	13.4	13.8	14.4	15.1	15.0	14.2	13.0	12.2	14.9	16.3

Figure 5.4 Solar energy and surface meteorology

Psychrometric Chart

From this diagram, the primary building system is **heating system**.

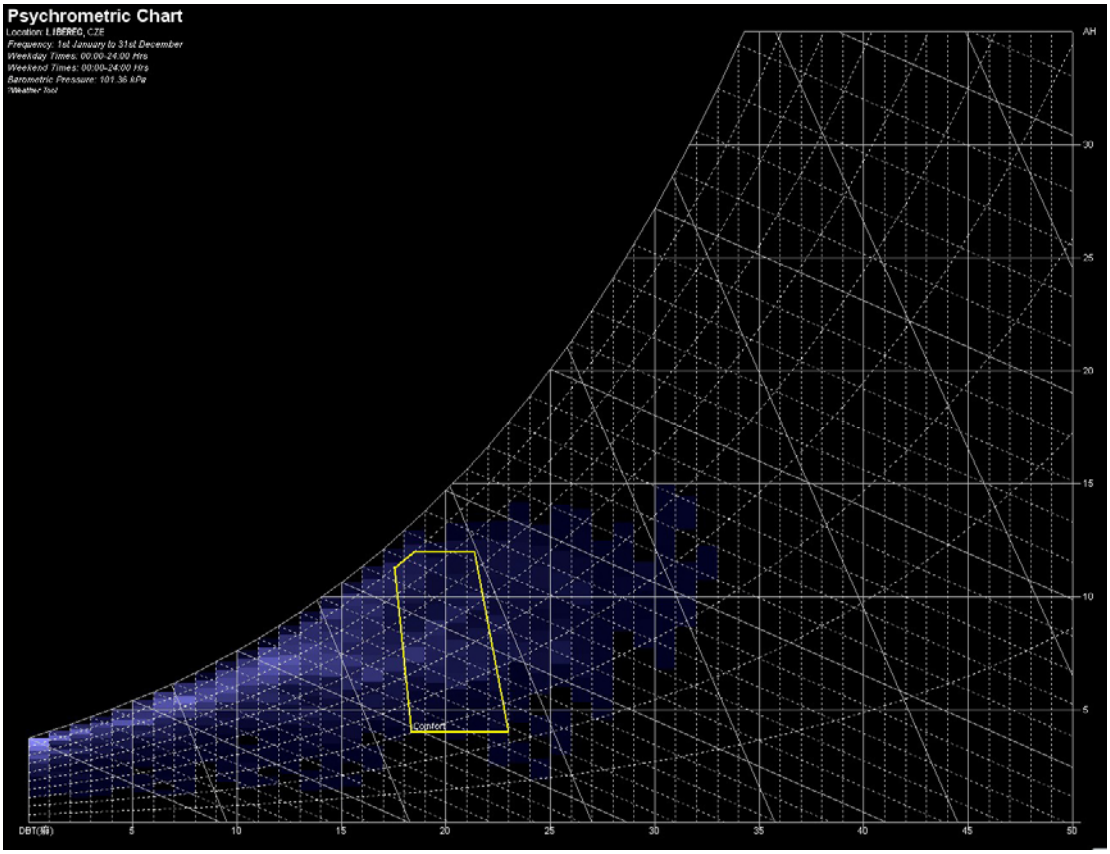


Figure 5.5 Psychrometric Chart

Hottest and coldest day conditions in Liberec

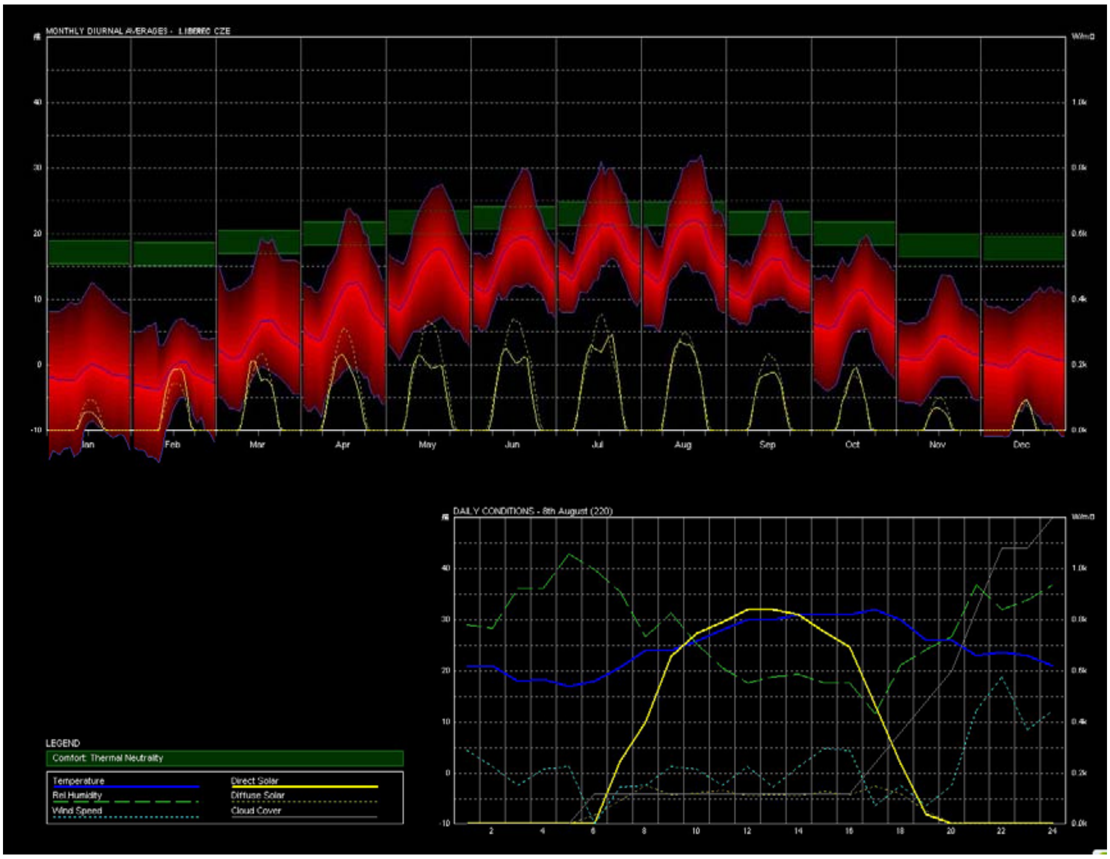


Figure 5.6 Coldest day data

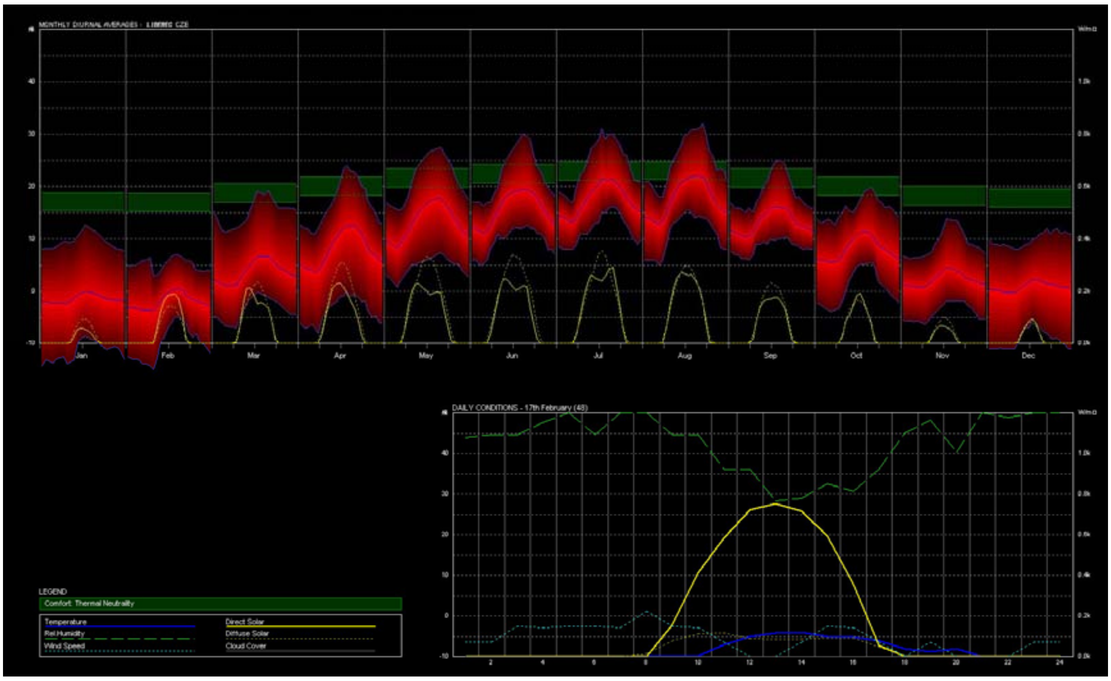


Figure 5.7 Hottest day data

Comparation

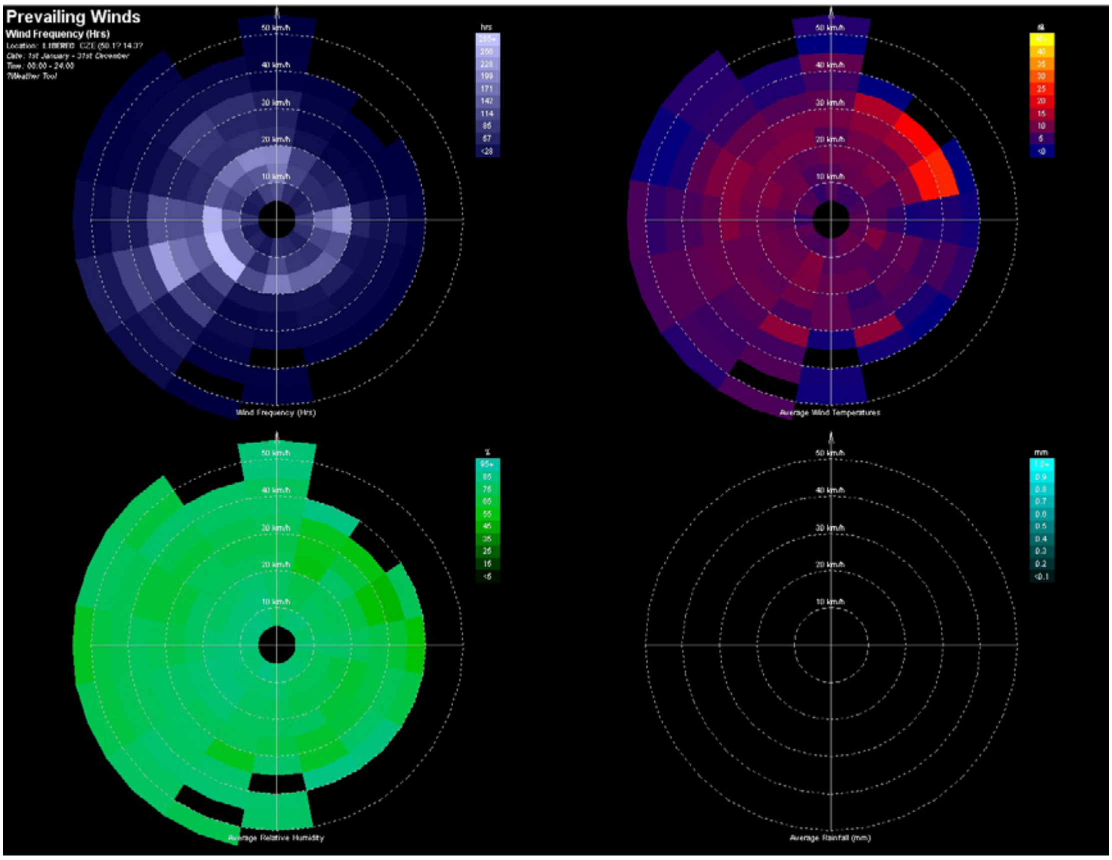


Figure 5.8 Prevailing winds

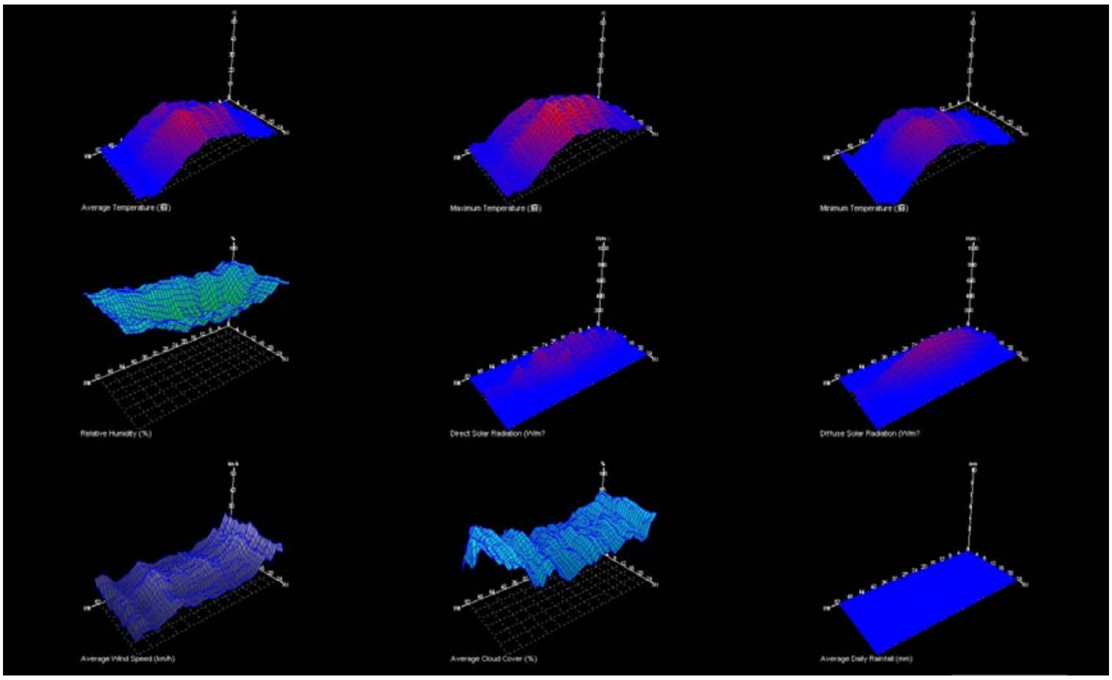


Figure 5.9 Weather conditions weekly

This is the monthly total of sun hours

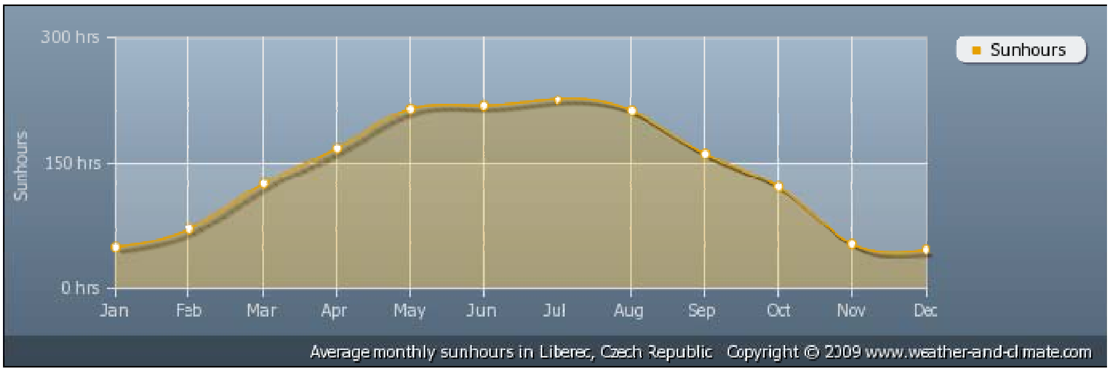
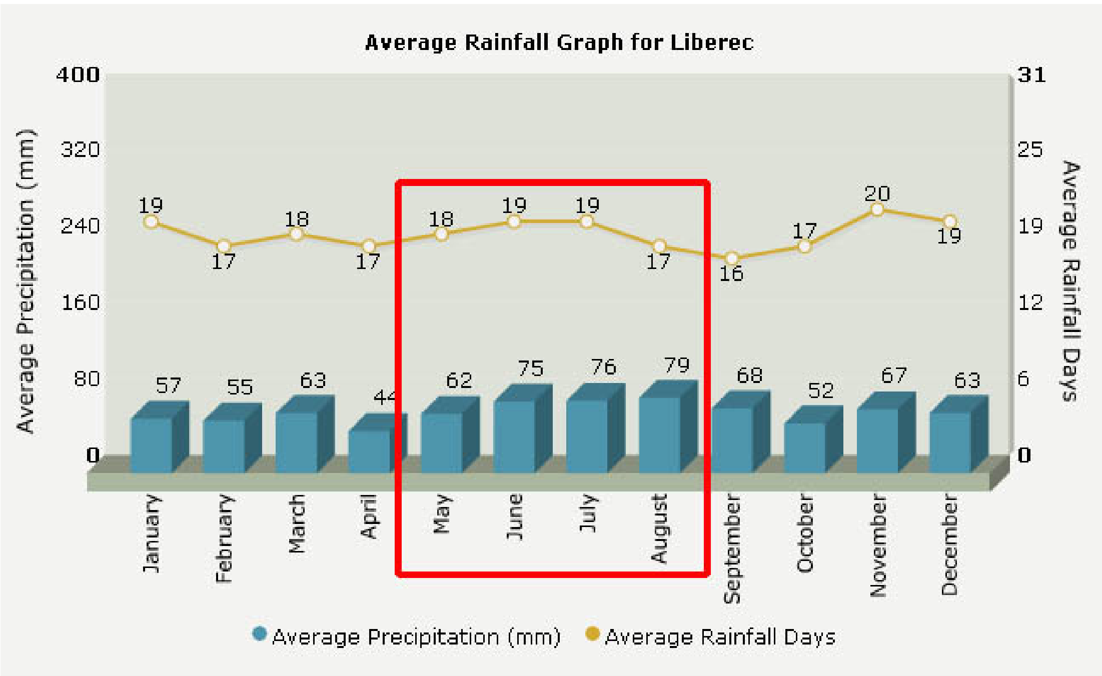


Figure 5.10 Sun hours monthly

This is average rainfall in Liberec



Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
57mm	55mm	63mm	44mm	62mm	75mm	76mm	79mm	68mm	52mm	67mm	63mm
19	17	18	17	18	19	19	17	16	17	20	19

Figure 5.11 Average rainfall

5.2 Climate analysis

5.2.1 Global shadow analysis

Firstly we will find the performance of solar shadow at the hottest day in summer.

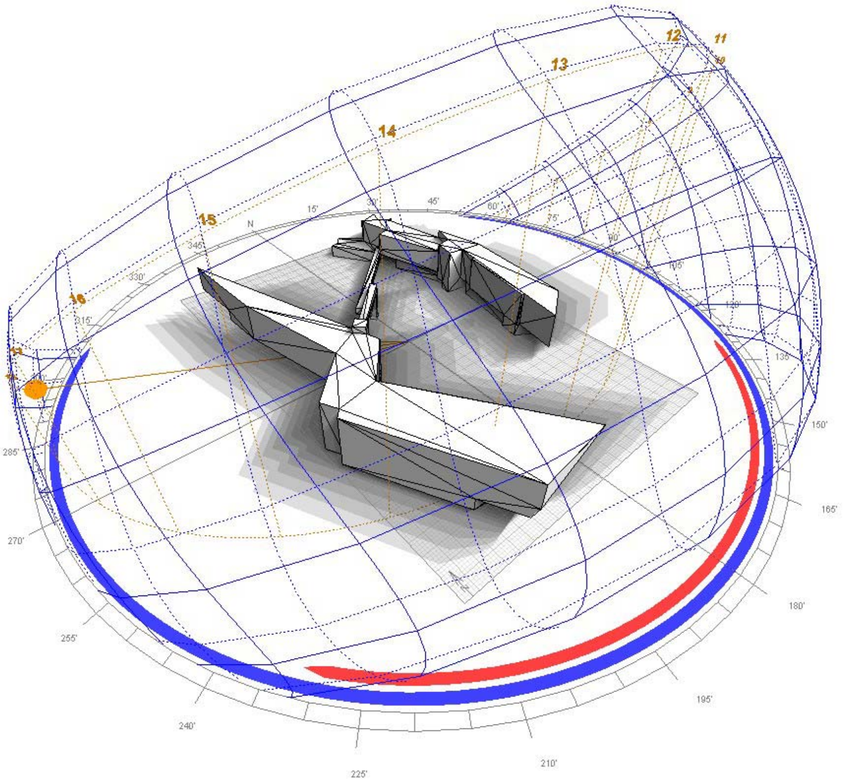


Figure 5.12   Performance of global shadow at the hottest day

From the following the diagram, we can find the direct solar lighting performs on red area (the guest room spaces) from 13:00 to 18:00 at the hottest day in summer. Because the highest temperature focuses on 12:00 to 15:00, we need to consider how to cool the guest room spaces during this period.

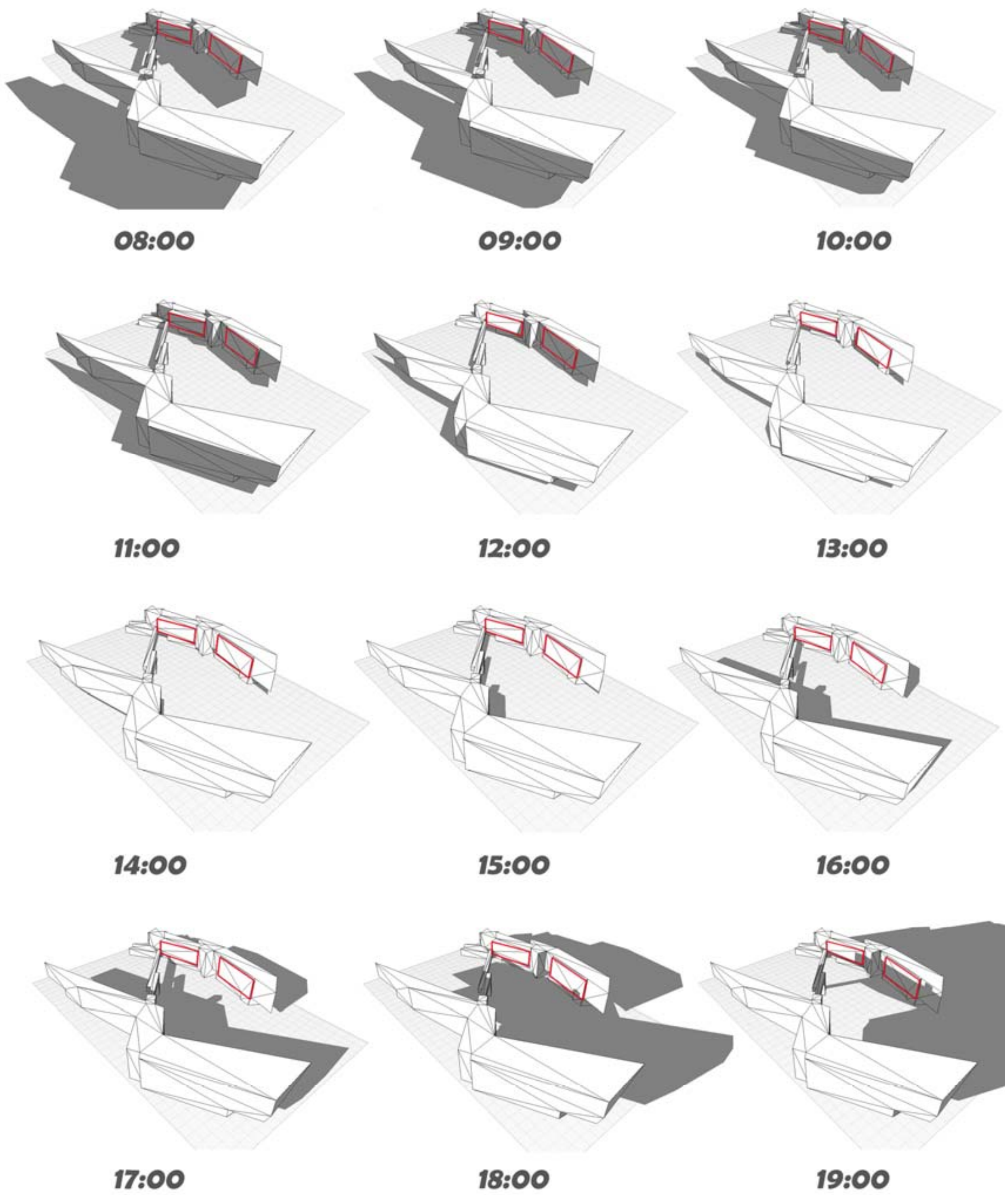


Figure 5.13 Building shadow between 08:00 and 19:00 at the hottest day

Secondly, we will find the performance of solar shadow at the coldest day in winter.

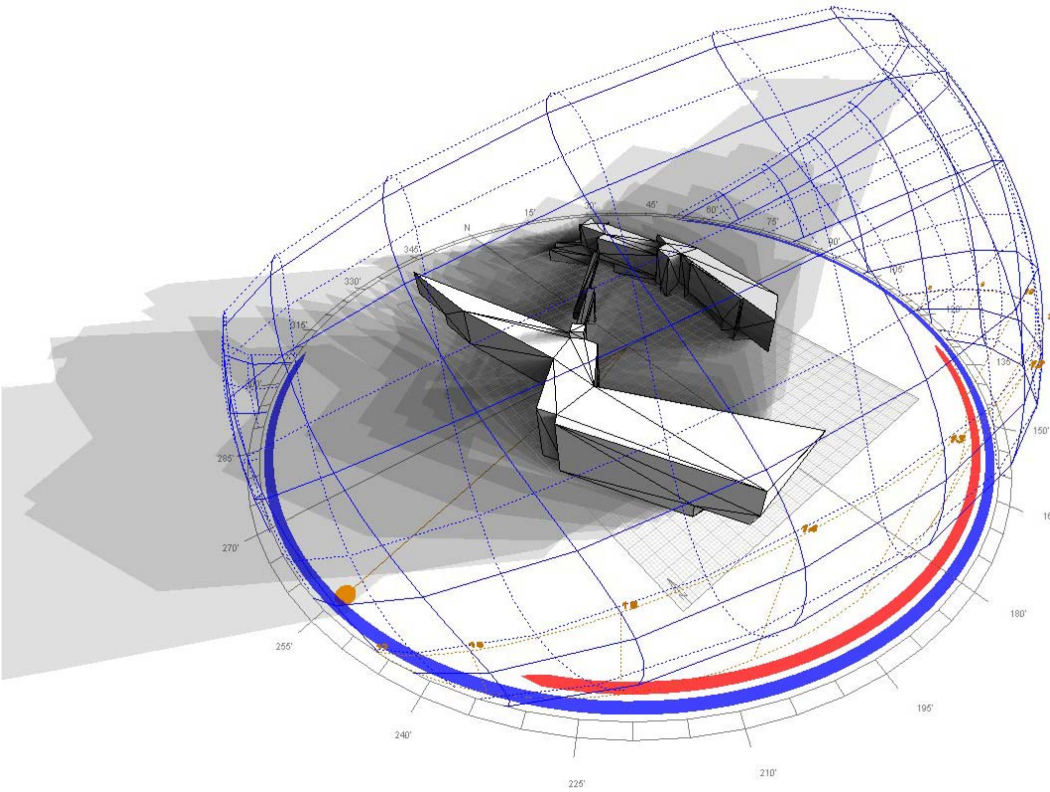


Figure 5.14 Performance of global shadow at the coldest day

From the following the diagram, we will find the direct solar lighting performs on red area (the guest room spaces) from 12:00 to 16:00 at the coldest day in winter. We know the effective sunshine time is from 9:00 to 15:00 in winter. So, the guest room spaces can get the effective solar thermal for 4 hours.

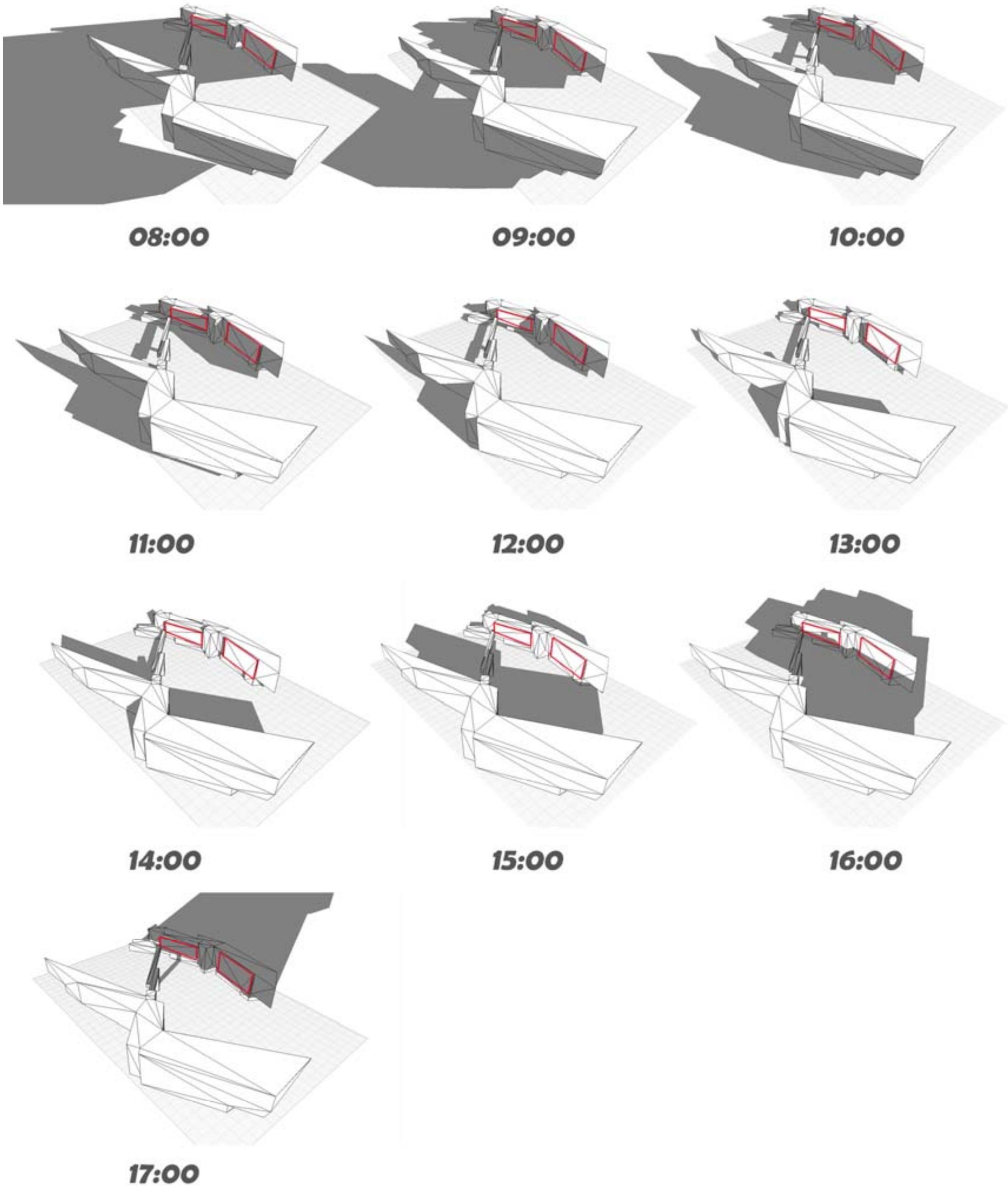


Figure 5.15 Building shadow between 08:00 and 17:00 at the coldest day

For a hotel, the thermal comfort of guest rooms is very important. Now I will choose a part of guest room spaces (colorful area) to analysis.

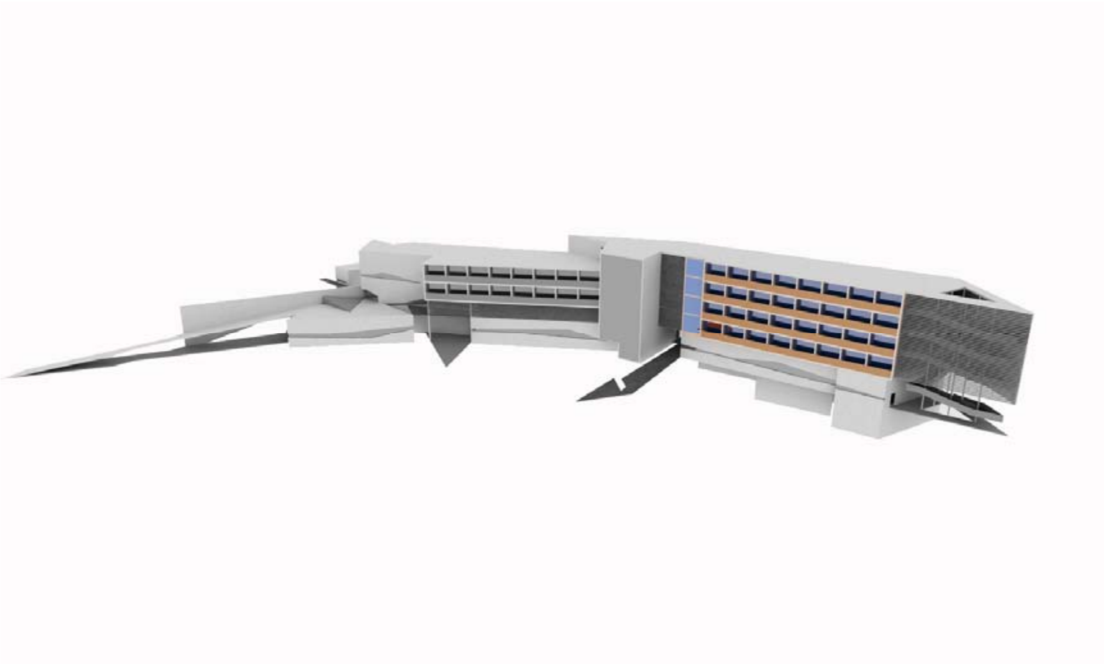


Figure 5.16 Hotel volume

5.2.2 Balcony design

Now we need to define the depth of balcony. How to get the maxim natural light during the daytime?

From figure 5.2 & 5.15, we know that solar altitude is much lower (15°---5°) in winter (12:00---16:00), so the depth of balcony has not big influence on nature light.

From figure 5.2 & 5.13, we know that solar altitude is higher (70°---18°) in summer (12:00PM---19:00PM). The changeable range of solar altitude is large. So natural light of guest room depends on reasonable dimension of balcony during daytime.

From figure 5.7 & 5.13, we know the highest temperature at 13:00 and the guest room area get direct solar lighting beginning with 13:00.

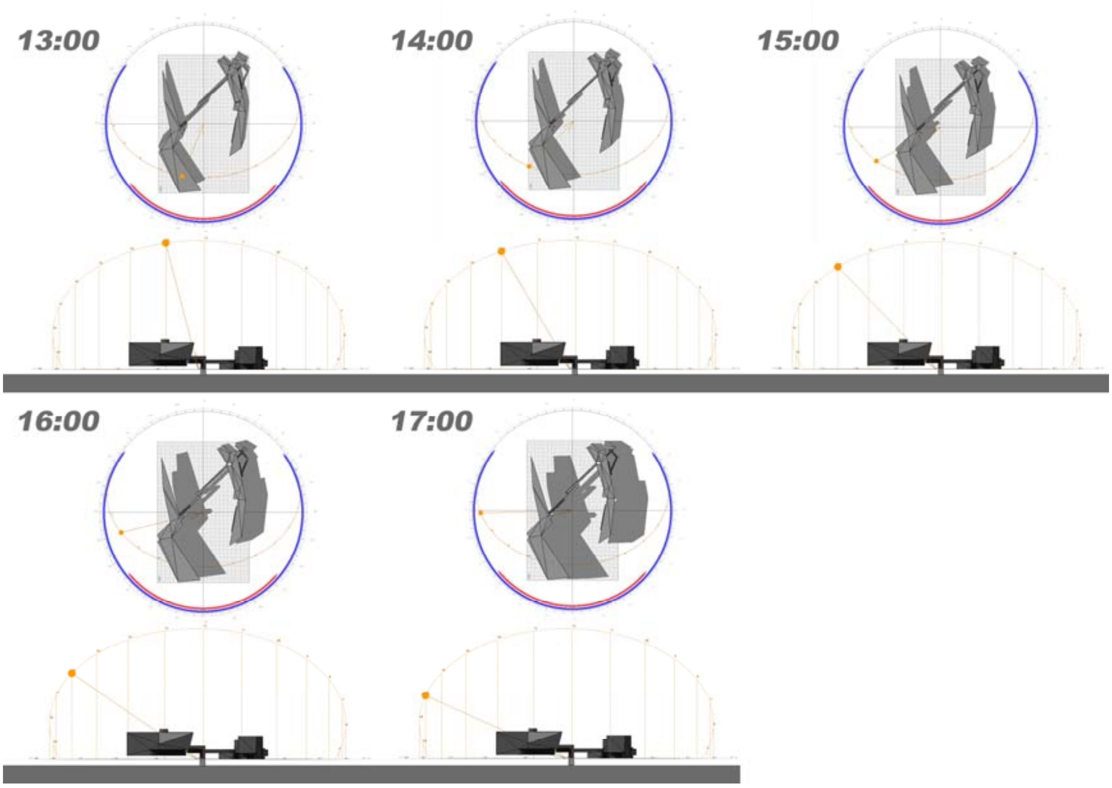


Figure 5.17 Range of solar attitude between 13:00 and 17:00 in summer

This diagram shows range of solar attitude from 13:00 to 17:00. It gets biggest solar attitude angle 65° at 13:00 and gets the lowest solar attitude angle 30° at 17:00. So the aim of balcony design is to obtain the skylight without solar radiant in summer.

I choose the 13:00 as a reference point for balcony design because it is highest temperature during the daytime.

I will define appropriate dimension of balcony by comparing 3 diagrams.

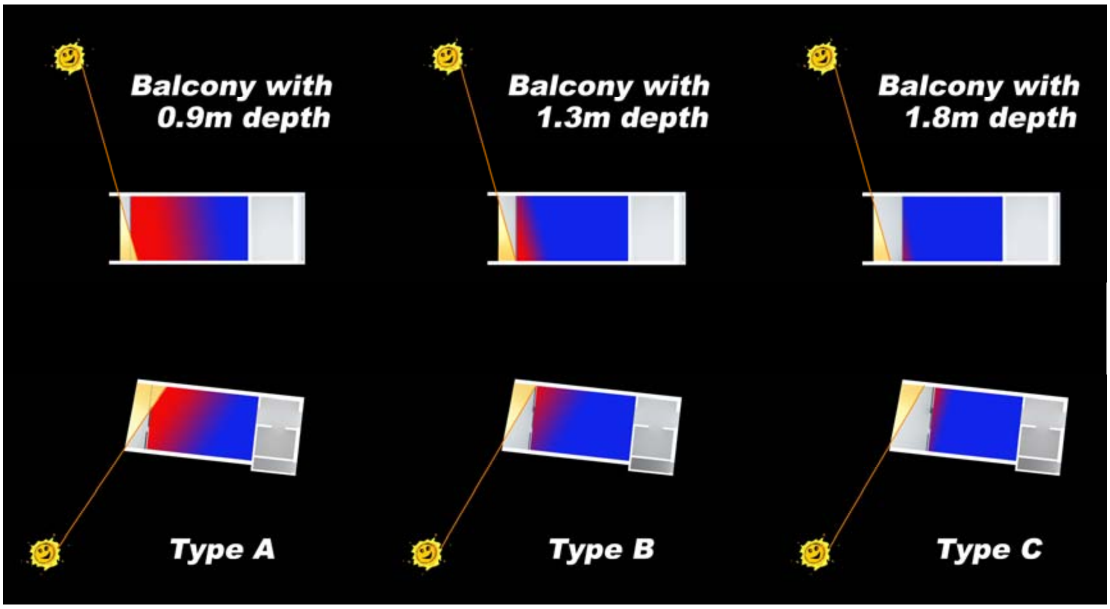


Figure 5.18 Comparison of balcony types

From the 3 types of balcony with different depth, we can find

Type A: the depth of balcony is 0.9m. It is too narrow. The guest room can get enough sunlight, but it also gets much more solar radiation and it will lead to higher indoor temperature.

Type B: the depth of balcony is 1.3m. It is proper dimension. The direct sunlight mainly localizes distributions within balcony area. So guest room obtains appropriate natural light and the balcony prevents some of solar radiation from reaching into guest room.

Type C: the depth of balcony is 1.8m. It is too broad. The guest room can not get good natural light.

So we can come to a conclusion: Type is appropriate dimension of balcony for the guest room. The daylighting through the balcony, interior space of guestroom can get diffuse light.

In order to get maximum use of daylighting and assure privacy of each guestroom unit, each balcony is divided by glass block.

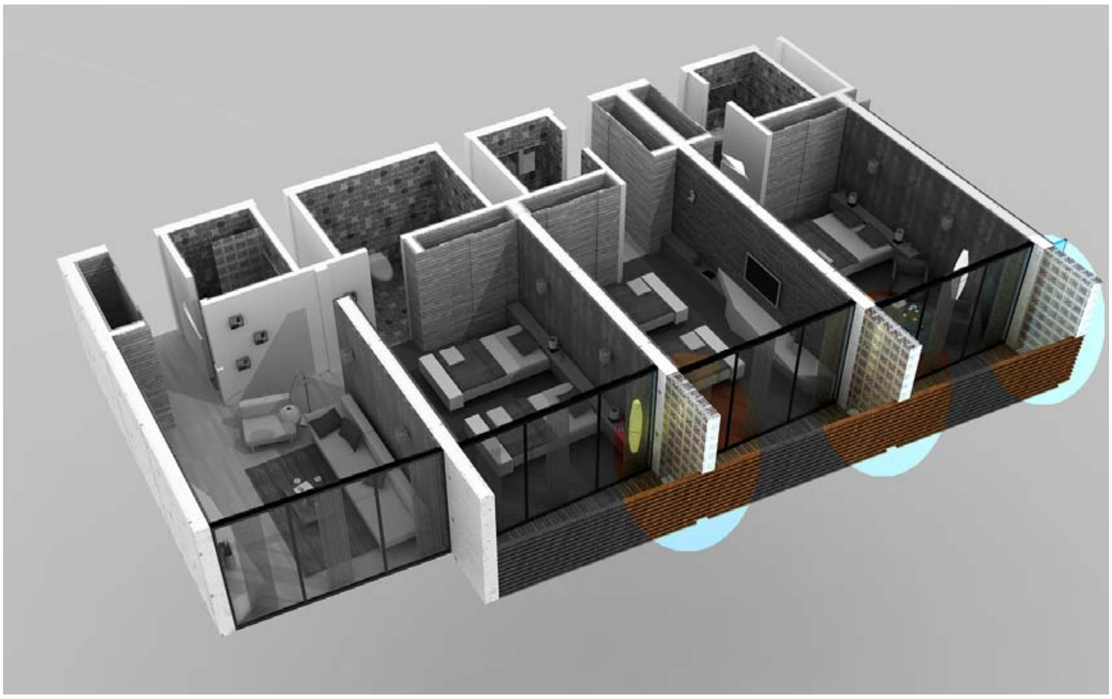


Figure 5.19 Model of balcony

The glass block is translucent, but not transparent.

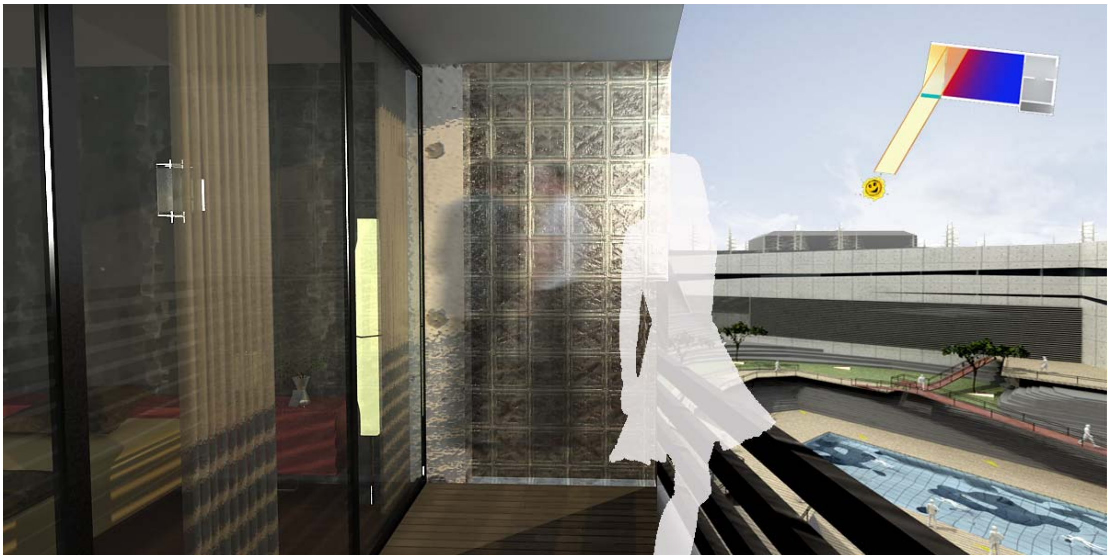


Figure 5.20 Impression of balcony with glass block

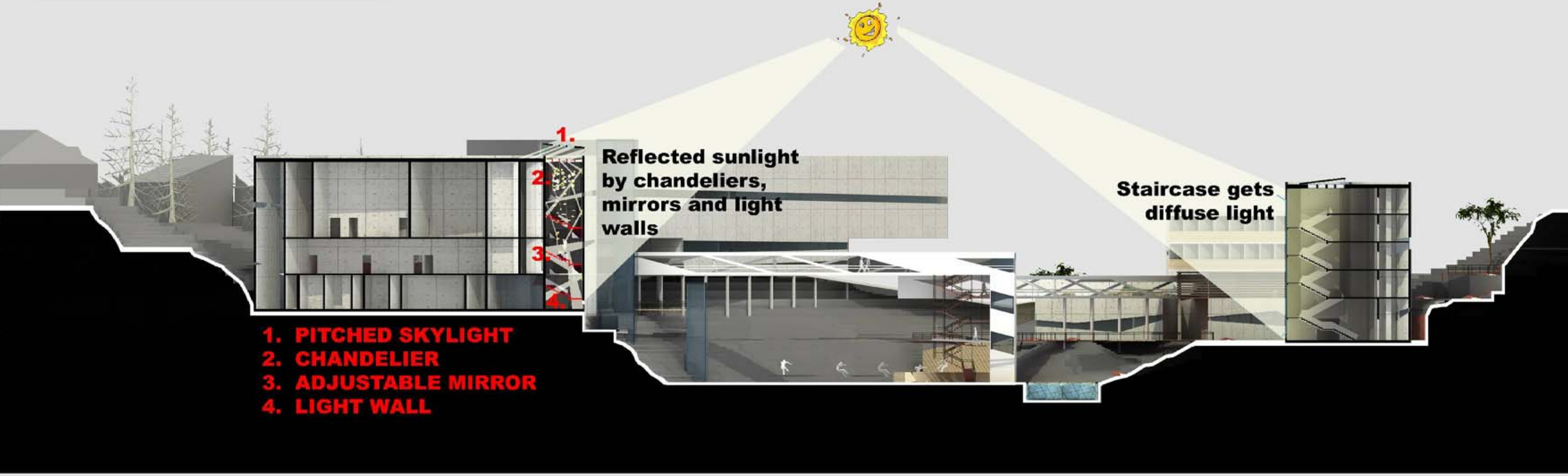
5.2.3 Daylighting Design

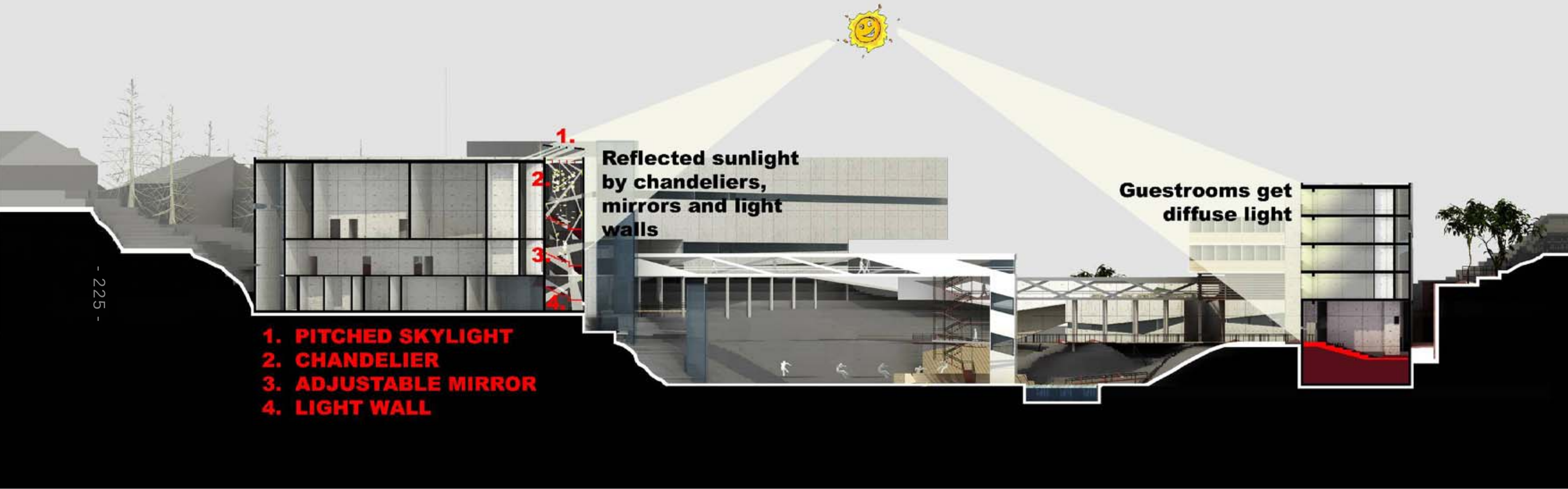
In the traffic hall of the **Health Club** and **Hotel** two climatic oases have been developed – two atriums, which extend over the full height of the multi-storey volume, branching like two trees, creating spatial situations with different functional identities. The atrium of **Health Club** connects the various areas of the building, which is organized like a “lighting box”. A pitched skylight filters the daylighting downward, reducing glare, but not the amount of light. The filtered sunlight is then further dispersed into the interior of the building through artificial “chandeliers” and reflective “light-wall”. The chandeliers, made of high quality acrylic prism plates, animate the atrium with shifting patterns of iridescent light. Their appearance is that of a cloud of light moving and changing with different light patterns throughout the day. The lighting of the atrium is further enhanced through a sunlight redirection system (heliostats and adjustable mirrors).

The sunlight through the triple glazing wall of **Hotel** atrium, interior space of staircase can get diffuse light.


LIGHTING BOX_staircase

LIGHTING SYSTEM





5.2.4 Solar radiation analysis

According to analysis above, we know that solar altitude is high in winter and low in summer. So the guest room get more sunlight in winter and in summer, the balcony can block some part of radiation such as “thermal obstruct volume”

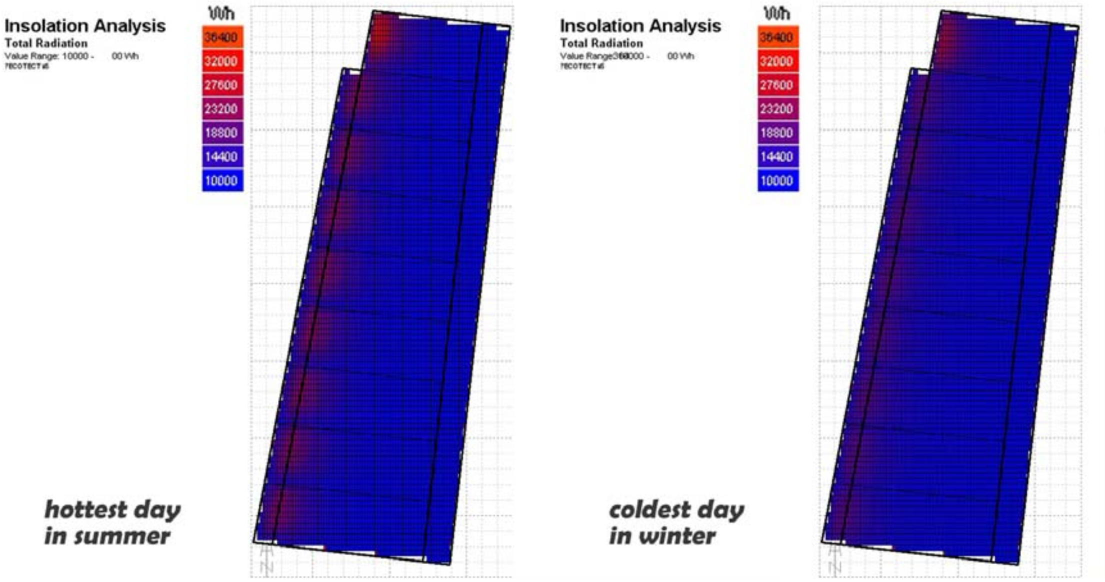


Figure 5.21 Solar radiation analysis

This diagram shows during the summer and winter, the guest rooms get lower solar radiation and in particular during the summer, the balcony block up to 90 percent of this heat from the solar radiation. So the main tasks are how to heat in winter for guest rooms and providing good ventilation in summer.

5.2.5 Goals

From above charts, we can understand clearly daytime is shortest in December about 8 hours and a longest in July about 16 hours.

At the Solar path diagram shows, the sun angle at noon on June 21st reaches 60° and on December 21st at 16°. We find, so we can adjust the building geometry to reach to indoor thermal comfort.

The coldest month in winter January whose temperature is from -5°C to 0°C and the warmest month is August in summer whose temperature is from 10°C to 30°C. The rainy seasons are May, June, July and August whose average precipitation is from 62mm to 79mm.

So we can get these conclusions:

- **The best time to travel to Liberec is June, July and August.**
- **The solar angle in summer is high and in winter is low**
- **Liberec has dry periods in January, February and December**
- **On average, the weather is so comfortable in summer**
- **On average, the coldest month is January no less than -5°C**

According to above conclusions, the goal of building service and technology design:

- **Try to adjust building geometry to reach to thermal comfort due to great difference of solar angle between summer and winter.**
- **Try to reduce thermal loss in winter and design heating system**
- **Natural ventilation**

5.3 Heating load

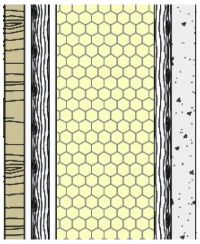
5.3.1 Building geometry design

Liberec, the fifth largest city in Czech Republic is a charming place for tourists all over the world due to its nice climate and natural resources. In summer, the highest temperature is around 25℃ and the balcony block up most of solar radiation. In winter, the temperature is around 0℃ and the guest room spaces can get the effective solar thermal for 4 hours. So, we only calculate the heating load in the building system design.

5.3.2 Basic data

VERTICAL ELEMENTS

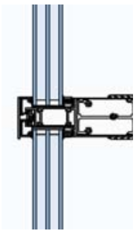
External wall "Aria" panel wall



Layer	Density Kg/m3	Thermal Conductivity W/mk	S m	R m^2k/W
Double plaster board		0.160	0.025	0.156
Technical panels (type OSB) Birch plywood		0.147	0.015	0.102
Air interspace		0.024	0.035	1.458
Insulation (mineral wool)		0.035	0.200	5.714
Ventilation space		-	0.035	-
Precast concrete panel		0.190	0.050	0.263
Internal	Hi	7.7 W/m^2K		0.130 m^2K/W
External	He	25 W/m^2K		0.040 m^2K/W
ΣR				7.863 m^2K/W
U				0.127 W/m^2K

Table 5.1 Basic data_ External wall

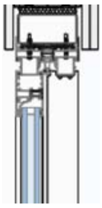
External triple glazing wall



Layer	Density Kg/m3	 W/mk	S m	R m^2k/W
Low-E glass		0.980	0.006	0.006
Argon		0.016	0.012	0.750
Low-E glass		0.980	0.006	0.006
Argon		0.016	0.012	0.750
Low-E glass		0.980	0.006	0.006
Internal	Hi	7.7 W/m^2K		0.130 m^2K/W
External	He	25 W/m^2K		0.040 m^2K/W
ΣR				1.688 m^2K/W
U				0.592 W/m^2K

Table 5.2 Basic data_ External triple glazing wall

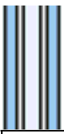
External double glazing sliding door



Layer	Density Kg/m3	W/mk	S m	R m^2k/W
Low-E Glass		0.980	0.006	0.006
Argon		0.016	0.012	0.750
Low-E Glass		0.980	0.006	0.006
Internal	Hi	7.7 W/m^2K		0.130 m^2K/W
External	He	25 W/m^2K		0.040 m^2K/W
ΣR				0.932 m^2K/W
U				1.073 W/m^2K

Table 5.3 Basic data_ External double glazing sliding door

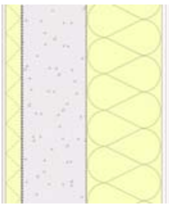
Internal double glazing wall



Layer	Density Kg/m3	W/mk	S m	R m^2k/W
Glass	2400	1.500	0.0125	0.008
Glass	2400	1.500	0.0125	0.008
Internal	Hi	7.7 W/m^2K		0.130 m^2K/W
External	He	25 W/m^2K		0.040 m^2K/W
ΣR				0.186 m^2K/W
U				5.376 W/m^2K

Table 5.4 Basic data_ Internal double glazing wall

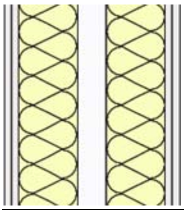
Basement surrounding wall



Layer	Density Kg/m3	W/mk	S m	R m^2k/W
Double plaster board		0,160	0.025	0.156
Mineral wool insulation		0.035	0.240	6.857
Vapor barrier		0.036	0.002	0.056
Concrete wall		0.510	0.200	0.392
Waterproofing membrane		0.036	0.005	0.139
Insulation (Polystyrene)		0.035	0.050	1.429
Cavity drainage membrane			0.010	
Internal	Hi	7.7 W/m^2K		0.130 m^2K/W
External	He	25 W/m^2K		0.040 m^2K/W
ΣR				9.199 m^2K/W
U				0.109 W/m^2K

Table 5.5 Basic data_ Basement surrounding wall

Internal non-glass wall

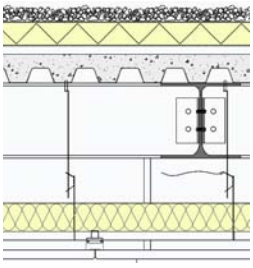


Layer	Density Kg/m3	W/mk	S m	R m^2k/W
Double plaster board		0.160	0.025	0.156
Mineral wool insulation		0.035	0.100	2.857
Gap			0.050	
Mineral wool insulation		0.035	0.100	2.857
Double plaster board		0.160	0.025	0.156
Internal	Hi	7.7 W/m^2K		0.130 m^2K/W
External	He	25 W/m^2K		0.040 m^2K/W
ΣR				6.196 m^2K/W
U				0.161 W/m^2K

Table 5.6 Basic data_ Internal non-glass wall

HORIZONTAL ELEMENTS

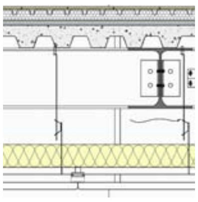
Roof



Layer	Density Kg/m3	W/mk	S m	R m^2k/W
Gravel		0.700	0.050	0.071
Bituminous		0.500	0.003	0.006
Expended polystyrene insulation		0.035	0.080	2.286
Bituminous		0.500	0.003	0.006
Slope concrete		0.190	0.030	0.158
Concrete composite floor		0.340	0.100	0.294
Wooden panel		0.140	0.015	0.107
Rockwool thermal isolation		0.045	0.100	2.222
Plaster Board		0.160	0.025	0.156
Internal	Hi	7.7 W/m^2K		0.130 m^2K/W
External	He	25 W/m^2K		0.040 m^2K/W
ΣR				5.476 m^2K/W
U				0.183 W/m^2K

Table 5.7 Basic data_ Roof

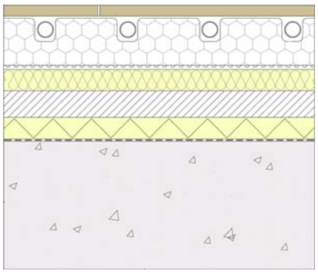
Floor



Layer	Density Kg/m3	W/mk	S m	R m^2k/W
Wooden floor		0.140	0.010	0.071
heating radiation		0.029	0.050	1.724
Rockwool acoustic insulation in rigid panels		0.045	0.020	0.444
Water proof		0.036	0.002	0.056
Leveling layer		0.360	0.025	0.694
Concrete composite floor		0.340	0.100	0.294
Wooden panel		0.140	0.015	0.107
Rockwool thermal isolation		0.045	0.100	2.222
Plaster Board		0.160	0.025	0.156
Internal	Hi	7.7 W/m^2K		0.130 m^2K/W
External	He	25 W/m^2K		0.040 m^2K/W
ΣR				5.938 m^2K/W
U				0.168 W/m^2K

Table 5.8 Basic data_ Floor

Basement floor



Layer	Density Kg/m3	W/mk	S m	R m^2k/W
Wooden floor		0.140	0.010	0.071
heating radiation		0.029	0.050	1.724
Rockwool acoustic insulation in rigid panels		0.045	0.020	0.444
Leveling layer		0.360	0.025	0.694
Expanded polystyrene insulation		0.035	0.120	3.429
Waterproof		0.036	0.002	0.056
Concrete composite slab		0.340	0.200	0.588
Internal	Hi	7.7 W/m^2K		0.130 m^2K/W
External	He	25 W/m^2K		0.040 m^2K/W
ΣR				7.176 m^2K/W
U				0.139 W/m^2K

Table 5.9 Basic data_ Basement floor

Components	**Thermal transmittance** W/m^2K
External wall “Aria” panel wall	0.127
External triple glazing wall	0.592
External double glazing sliding door	1.073
Basement surrounding wall	0.109
Internal non-glass wall	0.161
Internal double glazing wall	5.376
Roof	0.183
Floor	0.168
Basement floor	0.139
Window	2.200

Table 5.10 Thermal transmittance of components

Thermal bridge coefficient

Corner between equal walls TB1, Ψ=0.100 W/mK

Corner between floor and walls TB2, Ψ=0.450 W/mK

Junction between windows and walls TB4, Ψ=0.000 W/mK

5.3.3 Calculating the heating load

Design external temperature is assumed to be 8℃

Design internal temperature is assumed to be 22℃.

5.3.3.1 Calculating the temperature in basement (T_x)

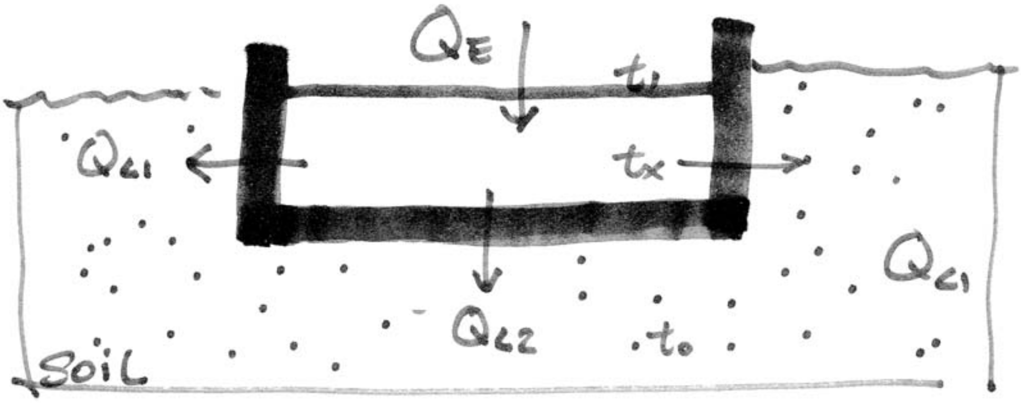


Figure 5.22 Sketch map of heat loss in the basement

In the basement, heat will transfer from inside to outside by 2 ways: heat loss from basement surrounding walls $\mathbf{Q_{L1}}$ and heat loss from basement floor $\mathbf{Q_{L2}}$.

Calculating heat loss from basement surrounding walls

$$\mathbf{Q_{L1} = S_1 \times U_1 \times (T_x - T_0)}$$

$\mathbf{S_1}$ = 100.769m × 3m = 302.307m^2

$\mathbf{U_1}$ = 0.109W/m^{2}K

$\mathbf{T_0}$ = 8℃

$\mathbf{S_1}$ Surface area of perimetric surrounding walls in basement

$\mathbf{U_1}$ Thermal transmittance of perimetric surrounding walls in basement

$\mathbf{T_x}$ temperature inside the basement

$\mathbf{T_0}$ temperature outside the basement

So we can get

$$\mathbf{Q_{L1} = S_1 \times U_1 \times (T_x - T_0)}$$

$$\mathbf{Q_{L1}} = 302.307 \times 0.109 \times (\mathbf{T_x} - 8) = 32.951(\mathbf{T_x} - 8)$$

Calculating heat loss from basement floor

$$\mathbf{Q_{L2} = S_2 \times U_2 \times (T_x - T_0)}$$

$\mathbf{S_2} = 417.661\text{m}^2$

$\mathbf{U_2} = 0.139\text{W/m}^2\text{K}$

$\mathbf{T_0} = 8℃$

$\mathbf{S_2}$ Surface area of basement floor

$\mathbf{U_2}$ Thermal transmittance of basement floor

So we can get

$$\mathbf{Q_{L2} = S_2 \times U_2 \times (T_x - T_0)}$$

$$\mathbf{Q_{L2}} = 417.661 \times 0.139 \times (\mathbf{T_x} - 8) = 58.055\ (\mathbf{T_x} - 8)$$

In sum heat loss in basement $\mathbf{Q_L}$

$$\mathbf{Q_L = Q_{L1} + Q_{L2}} = 32.951(\mathbf{T_x} - 8) + 58.055\ (\mathbf{T_x} - 8) = 91.006(\mathbf{T_x} - 8)$$

Because the heating resource in basement in only transferred from the ground floor, we can get the equation

$$\mathbf{Q_E = S_G \times U_G \times (T_1 - T_x)}$$

S_G = 1308.319m^2

U_G = 0.168W/m^{2}K

T_1 = 22℃

S_G Surface area of ground floor

U_G Thermal transmittance of ground floor

T_1 Temperature in ground floor

$Q_E = S_G \times U_G \times (T_1 - T_x) = 1308.319 \times 0.168 \times (22 - T_x) = 219.798\ (22 - T_x)$

Due to the energy equilibrium, we get $Q_E = Q_L$,

$219.798\ (22 - T_x) = 91.006(T_x - 8)$

So we get the temperature inside basement $T_x = 18$ ℃

5.3.3.2 Calculating the heat loss in ground floor

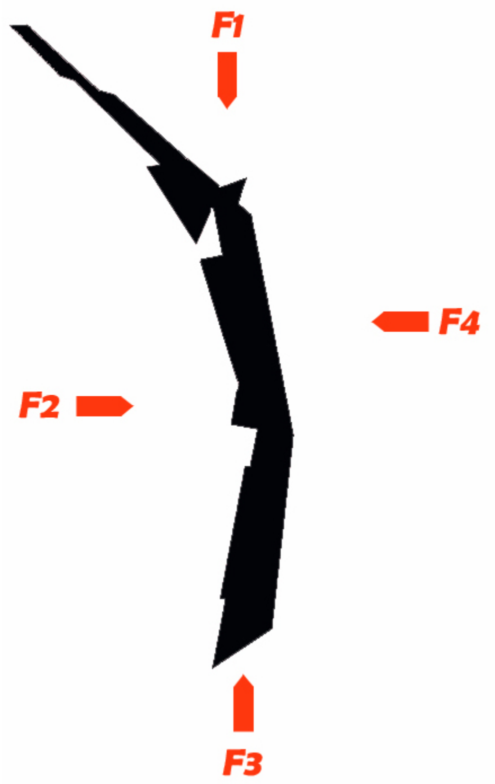


Figure 5.23 Sketch map of heat loss

We need consider the heat loss from roof to external environment and heat loss from ground floor to basement.

I divided 4 facades and roof of outdoor restaurant of the 1st floor in this hotel then calculate the each component surface area of 4 facades and ground floor area.

Components		Perimetric walls	External doors	Window	Floor	Roof
Surface area m^2	F1	0	4.500	40.300	-	-
	F2	671.633	10	84.444	-	-
	F3	55.186	2.500	0	-	-
	F4	590.140	10	84.882	--	-
	Horizontal	-	-	-	273.275	172.651

Table 5.11 Basic data of ground floor

Then we calculate the HTC (heat transfer coefficient) and T.B.HTC (thermal bridge heat transfer coefficient).

Heat transfer coefficient HTC

HTC =A×U

A Surface area though which the heat loss transfer

U Thermal transmittance of related elements

Components		Perimetric walls	External doors	Windows	Floor	Roof	Total
Heat transfer coefficient W/K	F1	0	4.829	88.660			93.489
	F2	85.297	10.730	185.770			281.797
	F3	7.009	2.683	0			9.692
	F4	74.948	10.73	186.740			272.418
	Horizontal				45.910	31.595	77.505

Table 5.12 Data_ HTC in ground floor

Thermal bridge heat transfer coefficient T.B.HTC

T.B.HTC =L×TB

L Length

TB Thermal bridge value

Components		Perimetric walls	External doors	Window	Floor	Roof	Total
Thermal bridge heat transfer coefficient W/K	F1	4.971	-	-	-	-	4.971
	F2	68.651	-	-	-	-	68.651
	F3	7.450	-	-	-	-	7.450
	F4	45.084	-	-	-	-	45.084
	Horizontal	-	-	-	-	22.985	22.985

Table 5.13 Data_ T.B.HTC in ground floor

Finally, I calculate the heat flux though each facades and roof

The equation:

$$\Phi = f \times (HTC + T.B.HTC) \times \Delta T$$

Φ heat flux

f exposition correction factor

ΔT different temperature between internal and external environment

	f	HTC	T.B.HTC	ΔT	Φ
F1	1.15	93.489	4.971	30	3396.870
F2	1.08	281.797	68.651	30	11354.515
F3	1.02	9.692	7.450	30	524.545
F4	1.06	272.418	45.084	30	10096.560
Horizontal	1	77.505	22.985	30	3014.700

Table 5.14 Data_ Heat flux in ground floor

The heat loss by transmission in the sum of above heat flux

$$Q_{loss,\ trans} = \Sigma \Phi_i = 28387.190W = 28.39\ kW$$

Heat loss by ventilation:

We need calculate m'_V mass transfer velocity,

$$m'_V = \rho_{da} \times V' = \rho_{da} \times V \times n$$

$\rho_{da} = 1.2\ kg/m^3$ the density of air in ventilation process

$$V = 1127.653 \times 5.1 = 5751.030\ m^3$$

volume of the space undergoing the ventilation process

$n = 0.5/h = 0.5/3600/s$ ratio of volume which proceeds the air ventilation in particular time

$$m'_V = \rho_{da} \times V' = \rho_{da} \times V \times n = 1.2 \times 5751.03 \times 0.5/3600$$

$$= 0.958505 \text{ kg/s}$$

The heat loss by ventilation equation

$$Q_{loss,\ vent} = m'_V \times c_{p,da} \times \Delta T$$

$c_{p,da}$ **= 1006 J/kg.K** the thermal capacity of the air

ΔT **= 30K** the different temperature between internal and external environment

Finally, the heat loss by ventilation

$$Q_{loss,\ vent} = m'_V \times c_{p,da} \times \Delta T = 0.958505 \times 1006 \times 30$$

$$= 28927.6801 \text{ W} = 28.93 \text{ kW}$$

The total sensible heating load in the sum of heat loss by transmission and the heat loss by ventilation as following equation:

$$Q_{SL} = Q_{loss,\ trans} + Q_{loss,\ vent} = 28.39 + 28.93 = 57.32 \text{ kW}$$

5.3.3.3 Calculating the heat loss in 1st floor

Because of the same temperature at both sides of the ground and 1st floor slab, we do not need to calculate the heat loss from the upper floor and the below floor.

I will calculate the heating load in 1st floor with the same method.

I divided 4 facades in this hotel then calculate the each component surface area of 4 facades.

Calculate the surface areas of 4 facades

Components		Perimetric walls	External doors	Windows
Surface area m^2	F1	0	3	12.437
	F2	81.131	81	12.517
	F3	39.273	4.5	0
	F4	343.804	6	10.028

Table 5.15 Basic data of 1st floor

I have described how to calculate the heat transfer coefficient (HTC) and thermal bridge heat transfer coefficient (T.B.HTC) in ground floor as mentioned above

Now we calculate the two terms in 1st floor

Heat transfer coefficient HTC

HTC =A.U

A Surface area though which the heat loss transfer

U Thermal transmittance of related elements

Components		Perimetric walls	External doors	Windows	Total
Heat transfer coefficient W/K	F1	0	3.219	27.361	30.580
	F2	10.304	86.913	27.537	124.754
	F3	4.988	4.829	0	9.817
	F4	43.663	6.438	22.062	72.163

Table 5.16 Data_ HTC in 1st floor

Thermal bridge heat transfer coefficient T.B.HTC

T.B.HTC =L.TB

L Length

TB Thermal bridge value

Components		Perimetric walls	External doors	Windows	Total
Thermal bridge heat transfer coefficient W/K	F1	2.783			2.783
	F2	39.959			39.959
	F3	6.015			6.015
	F4	41.781			41.781

Table 5.17 Data_ T.B.HTC in 1st floor

Finally, I calculate the heat flux though each facades and ground floor

The equation:

$$\Phi = f \times (HTC + T.B.HTC) \times \Delta T$$

Φ heat flux

f exposition correction factor

ΔT different temperature between internal and external environment

Calculate the heat flux though 4 facades

	f	HTC	T.B.HTC	ΔT	Φ
F1	1.15	30.580	2.783	30	1151.024
F2	1.08	124.754	39.959	30	5336.701
F3	1.02	9.817	6.015	30	484.459
F4	1.06	72.163	41.781	30	3623.419

Table 5.18 Data_ Heat flux in 1st floor

The heat loss by transmission is the sum of above heat flux

$$Q_{loss,\ trans} = \Sigma\ \Phi_i = 10595.603\ W = 10.60\ kW$$

Heating loss by ventilation

We need calculate m_V mass transfer velocity,

$$m'_V = \rho_{da} \times V' = \rho_{da} \times V \times n$$

$\rho_{da} = 1.2\ kg/m^3$ the density of air in ventilation process

$V = 903.181 \times 3.3 = 2980.497\ m^3$

volume of the space undergoing the ventilation process

$n = 0.5/h = 0.5/3600/s$ ratio of volume which proceeds the air ventilation in particular time

$$m'_V = \rho_{da} \times V \times n = 1.2 \times 2980.497 \times 0.5/3600$$

$$= 0.4967495\ kg/s$$

The heat loss by ventilation equation

$$Q_{loss,\ vent} = m'_V \times c_{p,da} \times \Delta T$$

$c_{p,da} = 1006\ J/kg.K$ the thermal capacity of the air

$\Delta T = 30K$ the different temperature between internal and external environment

Finally, the heat loss by ventilation

$$Q_{loss,\ vent} = m'_V \times c_{p,da} \times \Delta T = 0.4967495 \times 1006 \times 30$$

$$= 14991.89991\ W = 15\ kW$$

The total sensible heating load in the sum of heat loss by transmission and the heat loss by ventilation in 1st floor as following equation:

$$Q_{SL} = Q_{loss,\ trans} + Q_{loss,\ vent} = 10.60 + 15 = 25.60\ kW$$

5.3.3.4 Calculating the heat loss in 2nd floor

Because of the same temperature at both sides of the 1st and 2nd floor slab, we do not need to calculate the heat loss from the upper floor and the below floor.

I will calculate the heating load in 2nd floor with the same method.

I divided 4 facades of 2nd floor in this hotel then calculate the each component surface area of 4 facades.

Calculate the surface areas of 4 facades

Components		Perimetric walls	External doors	Windows
Surface area m^2	F1	31.723	0	3.922
	F2	128.733	81	34.172
	F3	39.273	45	0
	F4	321.842	0	15.045

Table 5.19 Basic data of 2nd floor

Calculate the heat transfer coefficient (HTC) and thermal bridge heat transfer coefficient (T.B.HTC) in 2nd floor

Heat transfer coefficient HTC

HTC =A.U

A Surface area though which the heat loss transfer

U Thermal transmittance of related elements

Components		Perimetric walls	External doors	Windows	Total
Heat transfer coefficient W/K	F1	4.029	0	8.628	12.657
	F2	16.349	86.913	75.178	178.44
	F3	4.988	48.285	0	53.273
	F4	40.874	0	33.099	73.973

Table 5.20 Data_ HTC in 2nd floor

Thermal bridge heat transfer coefficient T.B.HTC

T.B.HTC = L.TB

L Length

TB Thermal bridge value

Components		Perimetric walls	External doors	Windows	Total
Thermal bridge heat transfer coefficient W/K	F1	4.986			4.986
	F2	52.970			52.970
	F3	6.015			6.015
	F4	46.599			46.599

Table 5.21 Data_ T.B.HTC in 2nd floor

Finally, I calculate the heat flux though each facades and ground floor

The equation:

$$\Phi = f \times (HTC + T.B.HTC) \times \Delta T$$

Φ heat flux

f exposition correction factor

ΔT different temperature between internal and external environment

Calculate the heat flux though 4 facades

	f	HTC	T.B.HTC	ΔT	Φ
F1	1.15	12.657	4.986	30	608.684
F2	1.08	178.44	52.970	30	7497.684
F3	1.02	53.273	6.015	30	1814.213
F4	1.06	73.973	46.599	30	3834.190

Table 5.22 Data_ Heat flux in 2nd floor

The heat loss by transmission is the sum of above heat flux

$$Q_{loss,\,trans} = \Sigma \Phi_i = 13754.771\ W = 13.75\ kW$$

Heating loss by ventilation

We need calculate m_V mass transfer velocity,

$$m'_V = \rho_{da} \times V' = \rho_{da} \times V \times n$$

$\rho_{da} = 1.2\ kg/m^3$ the density of air in ventilation process

$V = 1006.599 \times 3.3 = 3321.777\ m^3$

volume of the space undergoing the ventilation process

$n = 0.5/h = 0.5/3600/s$

ratio of volume which proceeds the air ventilation in particular time

$$m'_V = \rho_{da} \times V \times n = 1.2 \times 3321.777 \times 0.5/3600$$

$$= 0.5536295\ kg/s$$

The heat loss by ventilation equation

$$Q_{loss,\,vent} = m'_V \times c_{p,da} \times \Delta T$$

$c_{p,da} = 1006\ J/kg.K$ the thermal capacity of the air

$\Delta T = 30K$ the different temperature between internal and external environment

Finally, the heat loss by ventilation

$$Q_{loss,\,vent} = m'_V \times c_{p,da} \times \Delta T$$

$$= 0.5536295 \times 1006 \times 30 = 16708.5383\ W = 16.71\ kW$$

The total sensible heating load in the sum of heat loss by transmission and the heat loss by ventilation in 1st floor as following equation:

$$\mathbf{Q_{SL} = Q_{loss,\ trans} + Q_{loss,\ vent} = 13.75 + 16.71 = 30.46\ kW}$$

5.3.3.5 Calculating the heat loss in 3rd floor

Because of the same temperature at both sides of the 2nd and 3rd floor slab, we do not need to calculate the heat loss from the upper floor and the below floor.

We need consider the heat loss from the roof to external environment

I divided 4 facades and roof in this hotel then calculate the heat load of each component .

Components		Perimetric walls	External doors	Windows	Roof
Surface area m^2	F1	31.723	0	0	
	F2	128.733	81	26.278	
	F3	39.273	45	0	
	F4	276.508	0	60.379	
	Horizontal				460.831

Table 5.23 Basic data of 3rd floor

Calculate the heat transfer coefficient (HTC) and thermal bridge heat transfer coefficient (T.B.HTC) in 3rd floor

Heat transfer coefficient HTC

HTC =A.U

A Surface area though which the heat loss transfer

U Thermal transmittance of related elements

Components		Perimetric walls	External doors	Windows	Roof	Total
Heat transfer coefficient W/K	F1	4.029	0	0		4.029
	F2	16.349	86.913	57.812		161.074
	F3	4.988	48.285	0		53.273
	F4	35.117	0	132.835		167.952
	Horizontal				84.332	84.332

Table 5.24 Data_ HTC in 3rd floor

Thermal bridge heat transfer coefficient T.B.HTC

T.B.HTC =L.TB

L Length

TB Thermal bridge value

Components		Perimetric walls	External doors	Windows	Roof	Total
Thermal bridge heat transfer coefficient W/K	F1	4.986				4.986
	F2	52.970				52.970
	F3	6.015				6.015
	F4	46.599				46.599
	Horizontal				52.110	52.110

Table 5.25 Data_ T.B.HTC in 3rd floor

Finally, I calculate the heat flux though each facades and ground floor

The equation:

$$\Phi = f \times (HTC+T.B.HTC) \times \Delta T$$

Φ heat flux

f exposition correction factor

ΔT different temperature between internal and external environment

	f	HTC	T.B.HTC	ΔT	Φ
F1	1.15	4.029	4.986	30	311.018
F2	1.08	161.074	52.970	30	6935.026
F3	1.02	53.273	6.015	30	1814.213
F4	1.06	167.952	46.599	30	6822.722
Roof	1	84.332	52.110	30	4093.230

Table 5.26 Data_ Heat flux in 3rd floor

The heat loss by transmission in the sum of above heat flux

$$Q_{loss,\ trans} = \Sigma \Phi_i = 19976.209\ W = 19.98\ kW$$

Heat loss by ventilation:

We need calculate m'_V mass transfer velocity,

$$m'_V = \rho_{da} \times V' = \rho_{da} \times V \times n$$

$\rho_{da} = 1.2\ kg/m^3$ the density of air in ventilation process

$V = 1006.599 \times 3.3 = 3321.777\ m^3$

volume of the space undergoing the ventilation process

$n = 0.5/h = 0.5/3600/s$ ratio of volume which proceeds the air ventilation in particular time

$$m'_V = \rho_{da} \times V' = \rho_{da} \times V \times n = 1.2 \times 3321.777 \times 0.5/3600$$
$$= 0.5536295\ kg/s$$

The heat loss by ventilation equation

$$Q_{loss,\ vent} = m'_V \times c_{p,da} \times \Delta T$$

$c_{p,da} = 1006\ J/kg.K$ the thermal capacity of the air

$\Delta T = 30K$ the different temperature between internal and external environment

Finally, the heat loss by ventilation

$$Q_{loss,\ vent} = m'_V \times c_{p,da} \times \Delta T = 0.5536295 \times 1006 \times 30$$
$$= 16708.53831\ W = 16.71\ kW$$

The total sensible heating load in the sum of heat loss by transmission and the heat loss by ventilation as following equation:

$$\mathbf{Q_{SL} = Q_{loss,\ trans} + Q_{loss,\ vent} = 19.98 + 16.71 = 36.69\ kW}$$

5.3.3.6 Calculating the heat loss in 4th floor

Because of the same temperature at both sides of the 3rd and 4th floor slab, we do not need to calculate the heat loss from the upper floor and the below floor.

We need consider the heat loss from the roof to external environment

I divided 4 facades and roof in this hotel then calculate the heat load of each component area.

Components		Perimetric walls	External doors	Windows	Roof
Surface area m^2	F1	53.269	4.5	0	
	F2	65.604	81	26.278	
	F3	39.297	45	0	
	F4	106.248	0	94.570	
	Horizontal				607.457

Table 5.27 Basic data of 4th floor

Heat transfer coefficient HTC

HTC =A.U

A Surface area though which the heat loss transfer

U Thermal transmittance of related elements

Components		Perimetric walls	External doors	Windows	Roof	Total
Heat transfer coefficient W/K	F1	6.765	4.829	0		11.594
	F2	8.332	86.913	28.196		123.441
	F3	4.991	48.285	0		53.276
	F4	13.493	0	101.474		114.967
	Horizontal				111.165	111.165

Table 5.28 Data_ HTC in 4th floor

Thermal bridge heat transfer coefficient T.B.HTC

T.B.HTC =L.TB

L Length

TB Thermal bridge value

Components		Perimetric walls	External doors	Windows	Roof	Total
Thermal bridge heat transfer coefficient W/K	F1	7.924				7.924
	F2	29.902				29.902
	F3	6.015				6.015
	F4	28.044				28.044
	Horizontal				65.669	65.669

Table 5.29 Data_ T.B.HTC in 4th floor

Finally, I calculate the heat flux though each facades and ground floor

The equation:

$$\Phi = f \times (HTC + T.B.HTC) \times \Delta T$$

Φ heat flux

f exposition correction factor

ΔT different temperature between internal and external environment

	f	HTC	T.B.HTC	ΔT	Φ
F1	1.15	11.594	7.924	30	673.321
F2	1.08	123.441	29.902	30	4968.313
F3	1.02	53.276	6.015	30	1814.305
F4	1.06	114.967	28.044	30	4547.750
Roof	1	111．165	65.669	30	5305.020

Table 5.30 Data_ Heat flux in 4th floor

The heat loss by transmission in the sum of above heat flux

$$Q_{loss,\ trans} = \Sigma \Phi_i = 17308.759\ W = 17.31\ kW$$

Heat loss by ventilation:

We need calculate m'_V mass transfer velocity,

$$m'_V = \rho_{da} \times V' = \rho_{da} \times V \times n$$

$\rho_{da} = 1.2\ kg/m^3$ the density of air in ventilation process

$V = 607.457 \times 3.3 = 2004.608\ m^3$

volume of the space undergoing the ventilation process

$n = 0.5/h = 0.5/3600/s$ ratio of volume which proceeds the air ventilation in particular time

$$m'_V = \rho_{da} \times V' = \rho_{da} \times V \times n = 1.2 \times 2004.608 \times 0.5/3600$$
$$= 0.3341\ kg/s$$

The heat loss by ventilation equation

$$Q_{loss,\ vent} = m'_V \times c_{p,da} \times \Delta T$$

$c_{p,da} = 1006\ J/kg.K$ the thermal capacity of the air

$\Delta T = 30K$ the different temperature between internal and external environment

Finally, the heat loss by ventilation

$$Q_{loss,\ vent} = m'_V \times c_{p,da} \times \Delta T = 0.3341 \times 1006 \times 30$$
$$= 10083.138\ W = 10.08\ kW$$

The total sensible heating load in the sum of heat loss by transmission and the heat loss by ventilation as following equation:

$$Q_{SL} = Q_{loss,\ trans} + Q_{loss,\ vent} = 17.31 + 10.08 = 27.39\ kW$$

We can get the conclusion

$$Q_{SL\ total} = 57.32 + 25.6 + 30.46 + 36.69 + 27.39 = 177.46\ kW$$

Heating loss per square meter $Q_{average}$

= 42.31 W/ m² $= 42.31\ W/m^2$

5.4 System

5.4.1 Geothermal system for buildings

What is the geothermal energy?

Geothermal energy uses heat from the earth for electricity and direct heat application, and is viewed as an indigenous, sustainable, competitive, environmentally and socially acceptable source of energy. Resource of geothermal energy range from the shallow ground to hot water and hot rock found a few miles beneath the Earth's surface, and down even deeper to the extremely high temperatures of molten rock called magma.

Almost everywhere, the shallow ground or upper 3 metres of the earth's surface maintains a nearly constant temperature between of 10℃ and 16℃.

How to work?

Geothermal heat pumps can tap into this resource to heat and cool buildings.

A geothermal heat pump system consists of a heat pump, an air delivery system (ductwork), and a heat exchange.

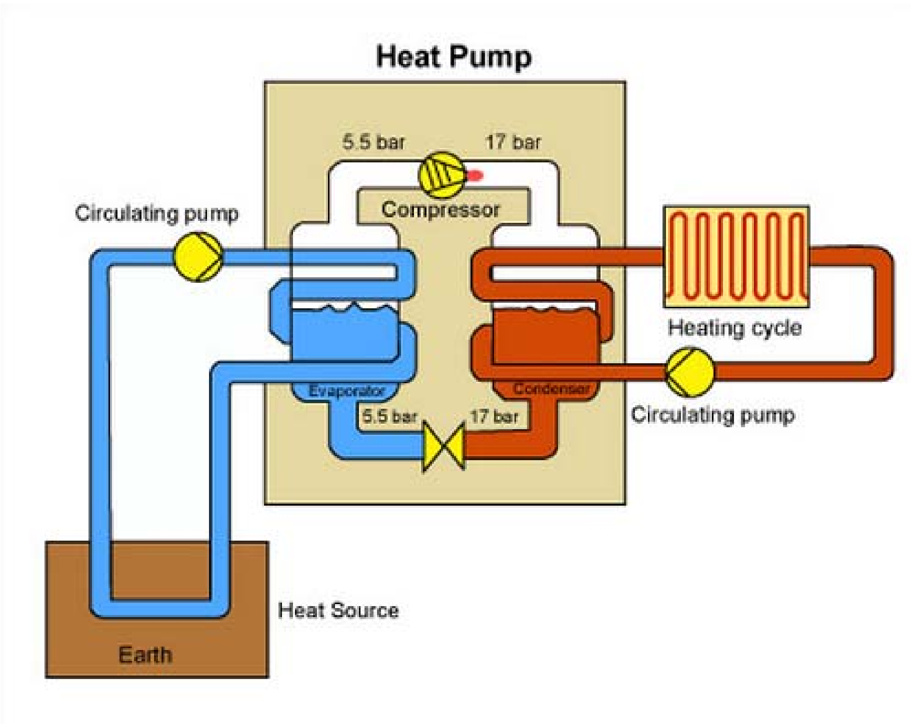


Figure 5.24 Geothermal heat pump system

In the summer, the earth acts as a cooling tower. The Heat Pump loads the loop with heat, sending warmed water to be cooled by the earth.
In the winter, the earth acts as the boiler. The Heat Pump extracts heat from the loop, sending cooled water to be warmed by the earth.

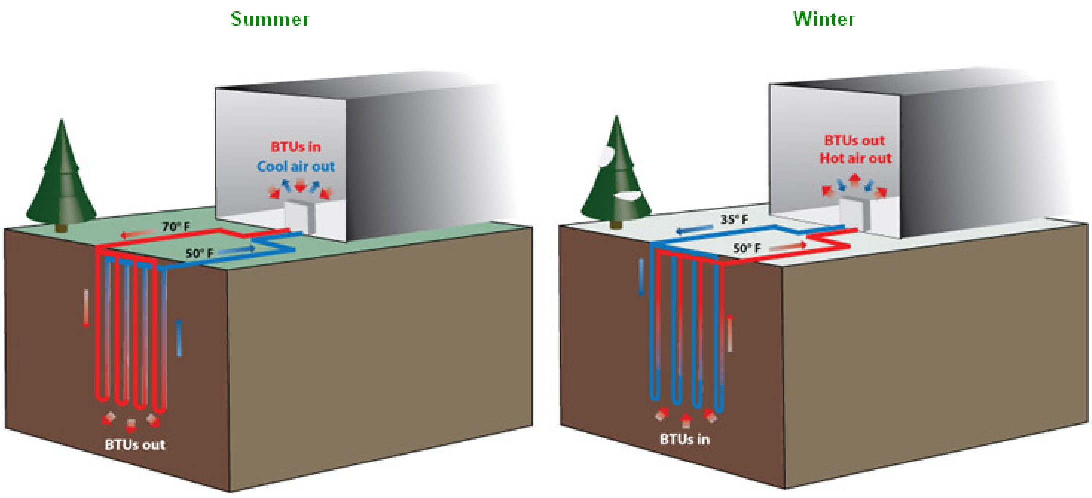


Figure 5.25 Work system of geothermal heat system in summer and winter

Geothermal pump systems exchange thermal energy between a building and the ground. When the building needs heating, the system extracts heat energy from the ground, and pumps it into the building where it is boosted by the heat pump to a comfortably warm temperature. Conversely, when the building needs cooling, the heat from the building is collected by the heat pumps and sent into the ground, much as a refrigerator's compressor transfers heat from inside the refrigerator to the outside. This exchange of thermal energy makes the system efficient. Rather than creating heat by burning a fuel on site, or chilled water by rejecting heat to the hot summer air, the geothermal heat pump system moves thermal energy between the ground and the building using heat pump technology.

Resources Potential

Geothermal energy comes from the natural heat of the earth primarily due to the decay of the naturally radioactive isotopes of uranium, thorium and potassium.

Because of the internal heat, the Earth's surface heat flow averages 82 mW/m^2 which amounts to a total heat loss of about 42 million megawatts. The total heat content of the Earth is of the order of 12.6 x 10^{24} MJ, and that of the crust, the order of 5.4 x 10^{21} MJ (Dickson and Fanelli, 2004). This huge number can be compared to the world electricity generation in 2007 of 7.1 x10^{13} MJ (IEA, 2009). The thermal energy of the Earth is therefore immense, but only a fraction can be utilized. So far utilization of this energy has been limited to areas in which geological conditions permit a carrier (water in the liquid or vapor phases) to 'transfer' the heat from deep hot zones to or near the surface, thus giving rise to geothermal resources.

5.4.1.1 Geothermal power project in Liberec

Figure 5.26 Geothermal power project in Liberec

Within the Czech Republic about 60 sites have been identified with a theoretical electricity potential of 250 MWe and a heat supply capacity of about2 000 MWt-. The resulting electricity generation has been estimated to be some 2 TWh and usable heat, 4 TWh. It is considered that, if successful, further exploration could lead to higher production. At the beginning of 2009 ČEZ, the country’s largest power company, issued a tender for a survey to determine the feasibility of constructing a geothermal power plant in Liberec, north Bohemia

It is a necessary step for the country's goal to increase reliance on renewable energy, say those connected with the project. Czech energy company.

CEZ has launched a tender for an amount of 250 MCZK (about 880 Keuros) to conduct an exploratory drilling to determine whether the subsurface geological near Liberec had good conditions required for a geothermal power plant is built. If results are positive, the plant considered, which will "draw on" earth heat to several kilometers from the surface, should be able to provide heating and electricity to nearly half the population of the city, is approximately 50,000 inhabitants.

This facility contributes only 0.3% of total energy production in the Czech Republic. However, it represents a milestone in the country's energy policy, which aims to achieve, by 2020, the bar 13% of its total energy production from renewable resourcesissue. In a country where such resources are relatively limited, geothermal energy has a major role to play. Currently, 5-6% of energy is from renewable sources, including hydroelectric and wind energy.

5.4.1.2 Application of geothermal system for the building

Now I will calculate the **q** (water flow rate) during the heating system.

The geothermal system composed of some bore holes. We assume the power of each bore hole as 5.8 kw.

$$N= Q_{SL\ total}\ /5.8 = 177.46 / 5.8 = 30$$

The number of borehole is 30

The formula of water flow rate:

$$q= Q / (4.187\times\Delta T)$$

Q = 177.46 kW the heating load

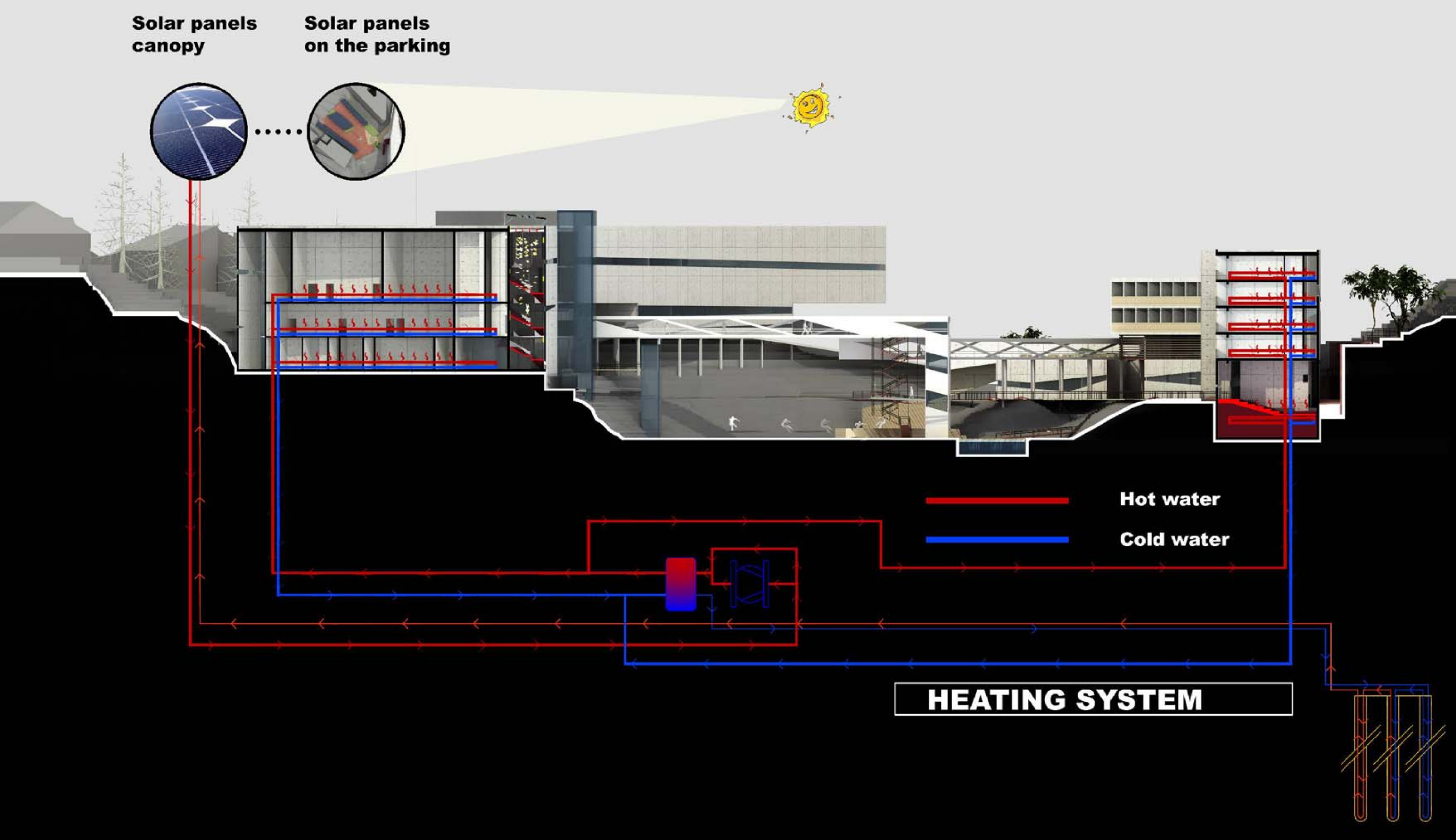
ΔT different temperature between the supplying and returning water.

$\Delta T = 5$℃

$$q= Q / (4.187\times\Delta T) = 177.46 / (4.187 \times 5) = 8.476\ kg/s$$

$$q= 8.476 \times 3600 kg/h = 30516.17\ kg/h$$

The water is supplied from underground bore holes. After heated, they are transferred to each floor by a serious of tubes.


Solar panels
canopy
Solar panels
on the parking
Hot water
Cold water
HEATING SYSTEM

5.4.2 Ventilation system

The basic idea is trying to provide the natural ventilation for the building to keeping cooling in summer.

5.4.2.1 Vertical ventilation

3 staircases provide good vertical natural ventilation for the hotel such as "ventilation box"

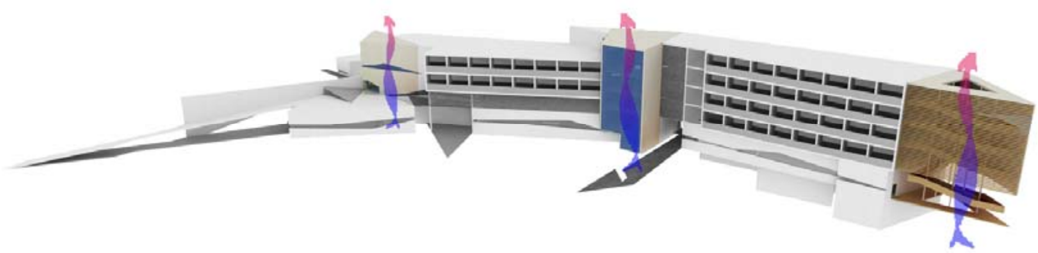


Figure 5.27 Hotel_ Vertical natural ventilation

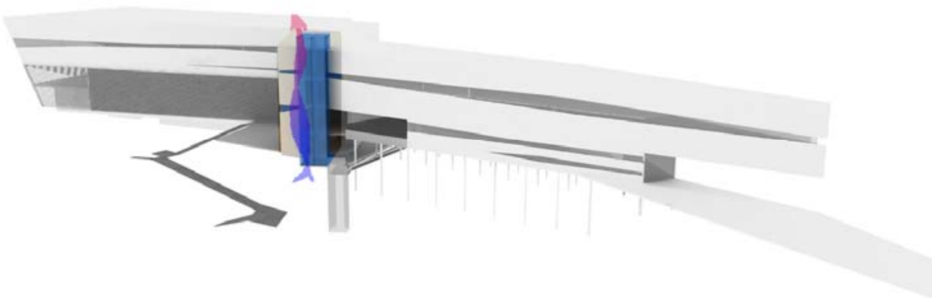


Figure 5.28 Health club_ Vertical natural ventilation

5.4.2.2 Horizontal ventilation

One corridor incises to open up the oblong hotel. It brings the natural ventilation though the hotel.

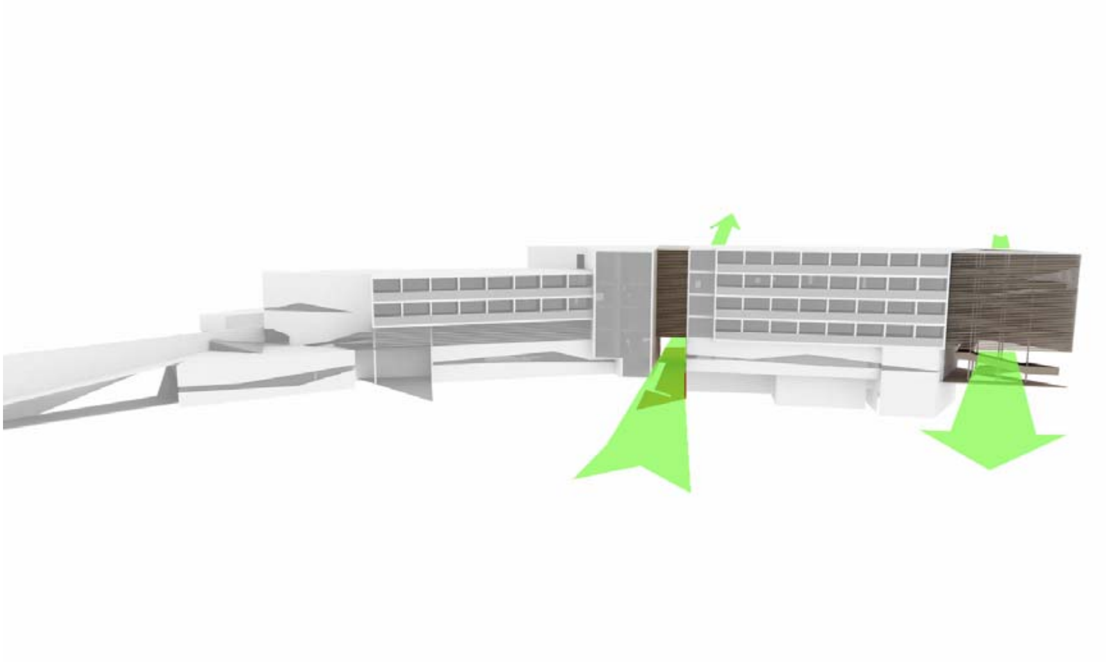


Figure 5.29 Hotel_ Horizontal natural ventilation

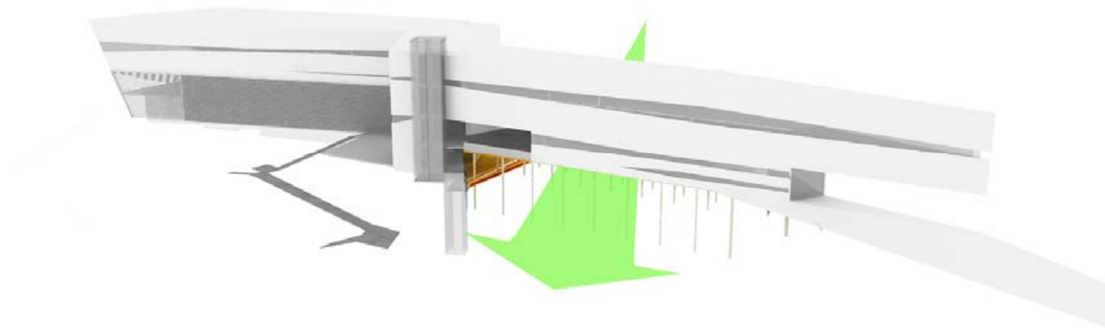


Figure 5.30 Health club_ Horizontal natural ventilation

We can see following image that the natural ventilation passes though the design site. It creates a "Microclimate" for the tourists and local citizen. It forms a new morphology of Eco-landscape.

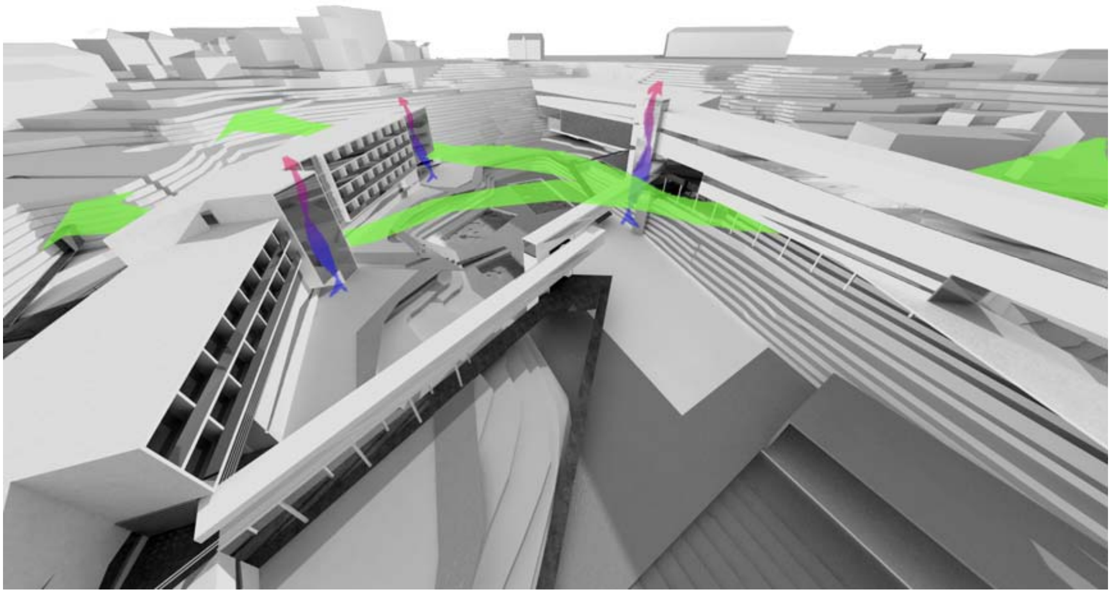


Figure 5.31 Recreation hub_ Natural ventilation system

5.4.3 Fresh air supplying system

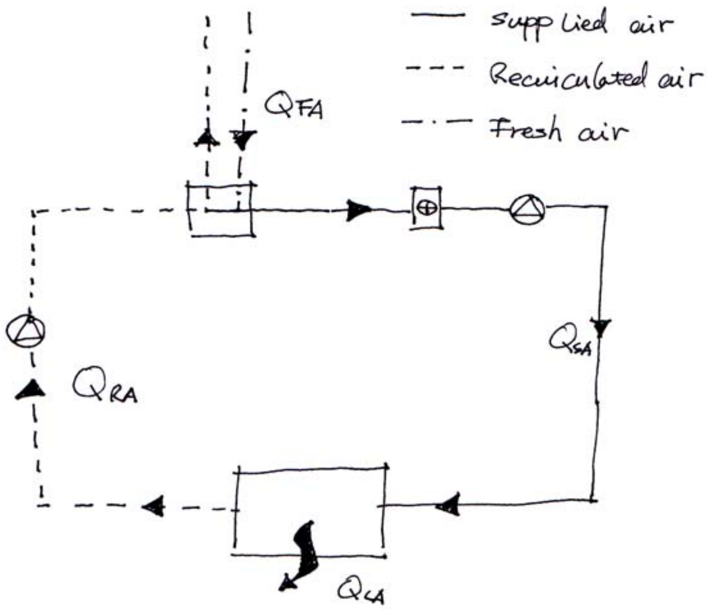


Figure 5.32 Sketch map of fresh sir supplying system

Calculating the fresh air needed for people

Requirement of indoor suitable fresh air for each people is 11 L/s.

I assume the maximum number of guests existing in the hotel at same time is about 80.

So, $\mathbf{Q_{pFA} = 80 \times 11 = 880\ L/s = 1.056\ kg/s}$

Calculating the fresh air leaked in linkage Q_{LA}

First we need to calculate the **v**, the velocity value of leaked air

$$\Delta P = v^2 \times \rho / 2$$

$$v = \sqrt{\frac{2\Delta P}{\rho}}$$

$\rho = 1.2 kg/m^3$ the density of leaked air

$\Delta P = 1\ P_a$ the pressure difference between indoor and outdoor

v the velocity value of the leaked air

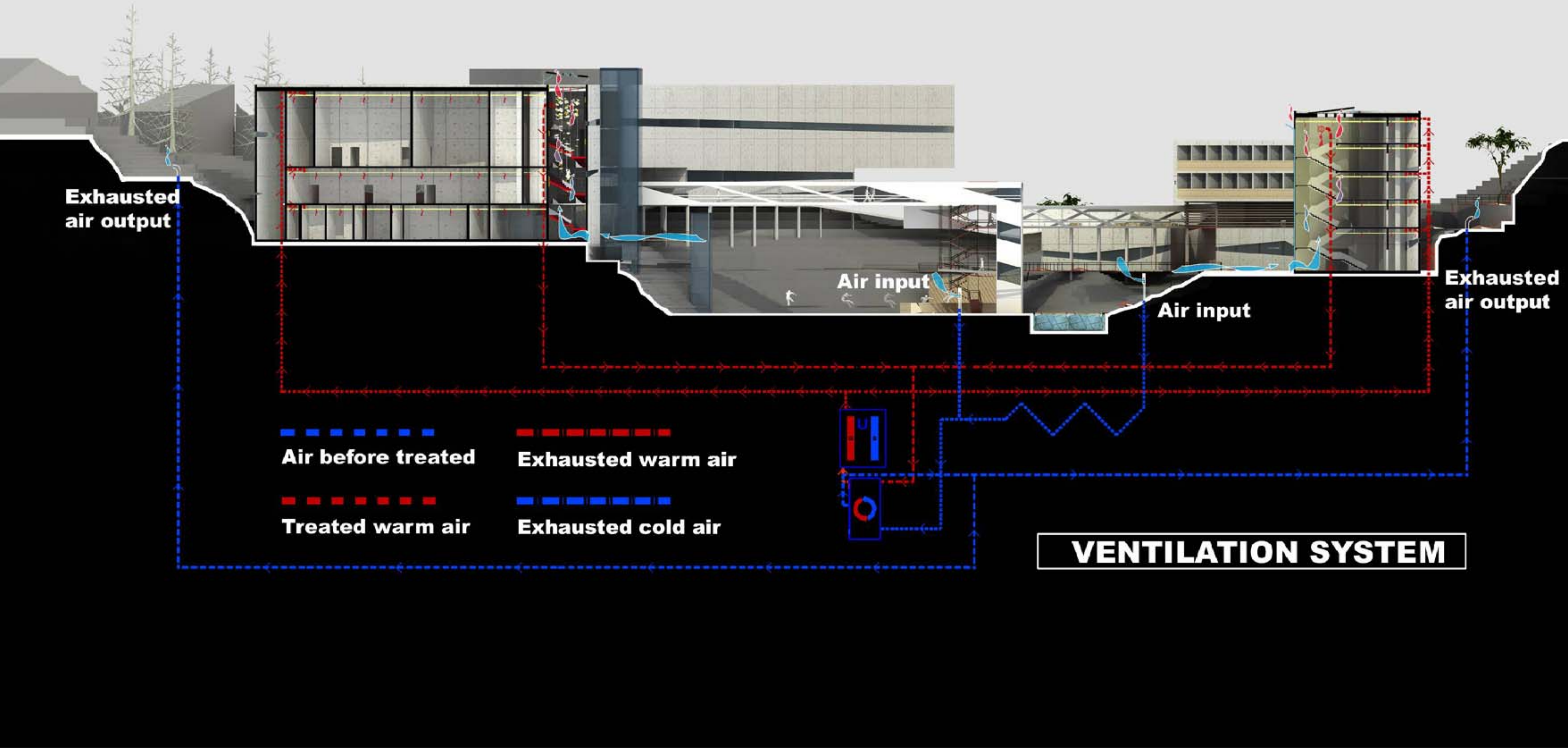
$$v = \sqrt{\frac{2\Delta P}{\rho}} = \sqrt{\frac{2}{1.2}} = 1.29\ m/s$$

$$Q_{LA} = \rho \times v \times S$$

$S = 0.374\ m^2$ (assuming the depth of the linkage is equal to 1mm) the total area of the leakages, including those between windows framed and doors.

$$Q_{LA} = \rho \times v \times S = 1.2 \times 1.29 \times 0.374 = 0.577\ kg/s$$

$$Q_{SA} = Q_{pFA} + Q_{LA} = 1.056 + 0.577 = 1.633\ kg/s$$



VENTILATION SYSTEM
Exhausted air output
Air input
Air input
Exhausted air output
Air before treated
Exhausted warm air
Treated warm air
Exhausted cold air

5.4.4 Splash pool in summer and skating rink in winter system

I try to keep the landscape pond in summer to provide a good view for people and tourists and also turn the pond into skating rink in winter.

ISAAC Solar Ice Maker

The ISAAC Solar Icemaker is an intermittent solar ammonia-water absorption cycle. It uses a parabolic trough solar collector and a compact and efficient design to produce ice with no fuel or electric input, and with no moving parts.

Solar Icemaker Up to 1000 pounds of ice per day. There is low cost and reliable source of ice for situations requiring 25 to 1000 pounds of ice per day (12-450kg).

"Isaac" is the acronym for Intermittent Solar Ammonia Absorption Cycle. Ammonia absorption refrigeration technology was developed in the 19th century and is still used in industrial applications. Energy Concepts has adopted this technology to a machine which uses the sun as the only energy output. The particular advances in the design and configuration have resulted in a low cost and reliable method of making significant quantities of ice in areas without electricity.

How ISAAC works?

During the day the solar collector focuses the energy of the sun onto the ammonia generator in the collector trough. Solar heat distills pure ammonia vapor from the water-ammonia solution in the generator. The vapor condenses in the cooling coils and collects as liquid ammonia in the receiving tank in the evaporator.

At the end of the day, the user switches three valves from the Day to Night position to allow the ammonia to evaporate in the ice compartment, providing the refrigeration to freeze the water. The resulting vapor is absorbed back in the generator. Critical to the operation of Isaac is a passive thermosyphon that operates in the Night mode to remove the heat from the generator and allow the ammonia vapor to absorb into the solution at lower pressure and temperature.

At the beginning of the day, the operator harvests the ice from the ice trays, operates a drain sequence to remove traces of absorbent from the evaporator, and places the unit back into Day mode to begin the next cycle.

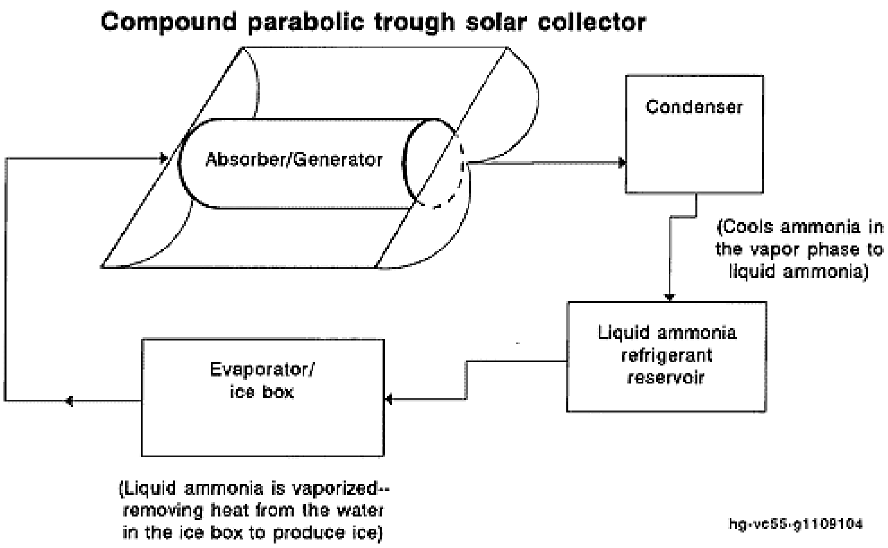


Figure 5.33 Compound parabolic trough solar collector

Skating rink detail

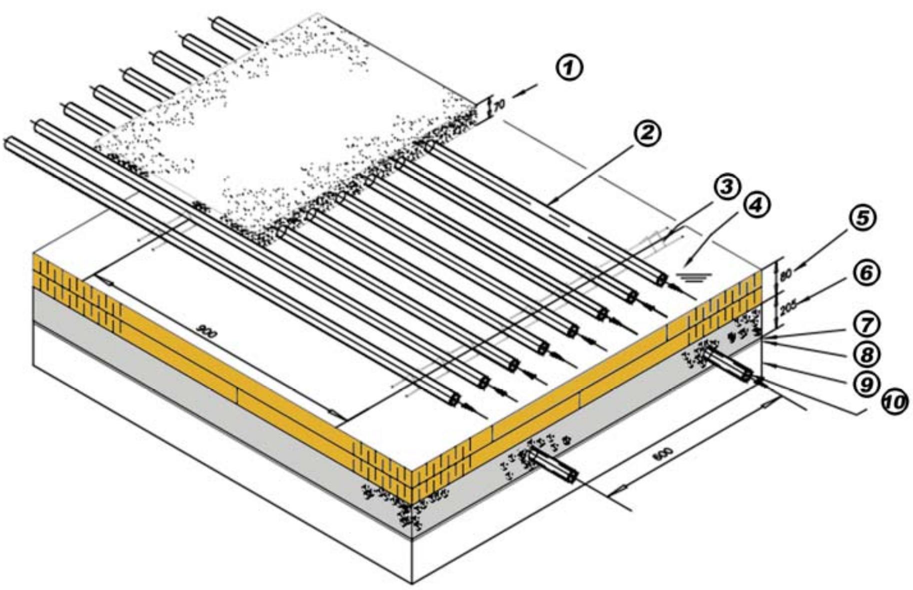


Figure 5.34 Skating rink detail

① 75 mm sand layer was compressed to 70 mm

② Polyethylene refrigeration pipe of skating rink @ 90 mm

③ Pipe saddle @ 900 mm

④ 0.15 mm Polyethylene film, damp proof

⑤ 80 mm insulation layer

⑥ 205 mm cleaning sand, density is 92%, smoothness: ± 5 mm

⑦ 20 mm cement mortar screed-coat

⑧ 1.5 mm polyurethane waterproofing coating

⑨ Concrete layer

⑩ Ø 32 mm Polyethylene heat pipe @ 600 mm

5.4.5 Water balance system

The project in Liberec has the ability to dramatically reduce its demand for potable water and the subsequent burden to the city's sewage system through water-efficiency measures, rainwater harvesting and grey water reuse without any reduction in quality to the users. This project will be a model of sustainable urban water resources management.

Water-efficiency measures

Significant water-use reduction can be realized at very low costs by simply installing water-conserving toilet fixtures and appliances. A second component of water efficiency is user education. Dedicating a modest budget to user education regarding excessive water use can generate additional, significant reductions.

Rainwater-harvesting

A rainwater-harvesting system will capture runoff from roof surface and store it in tank for recirculation to flush toilets and to irrigate landscaped area.

Grey-water reuse

A grey-water reuse system will harvest the grey-water "resource" from the two buildings (flow from sinks, showers and laundry), filter and treat it and then store it in a tank for recirculation to flush toilets and irrigate landscaped areas. Grey water has the potential to provide almost 10 times as much water as rainwater harvesting.

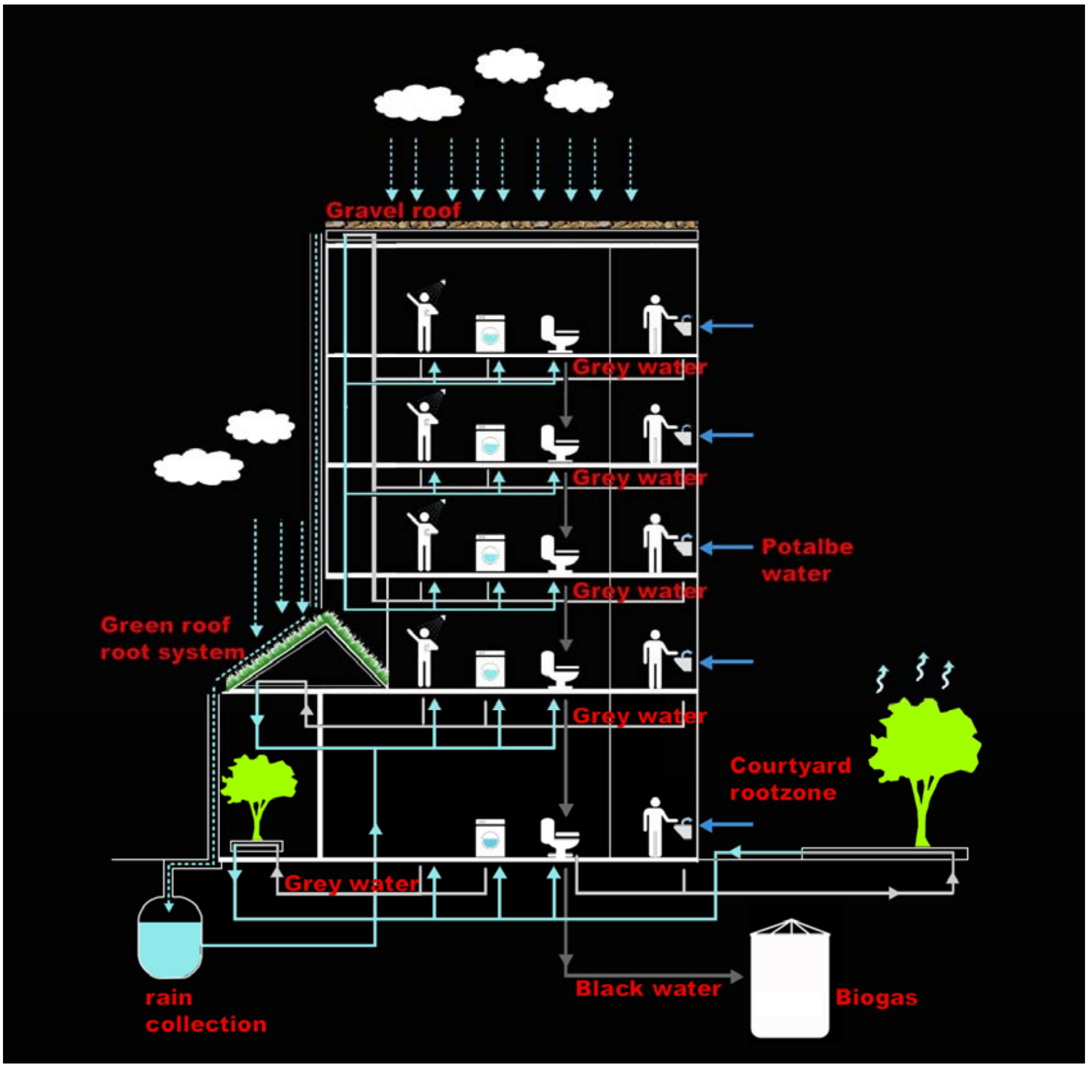


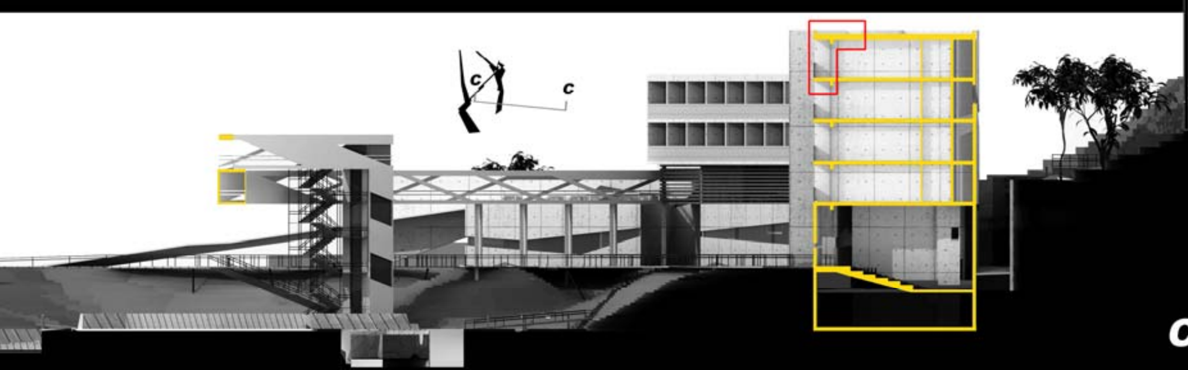
Figure 5.35 Water balance system

5.5 Details

DETAILS _ 1 2

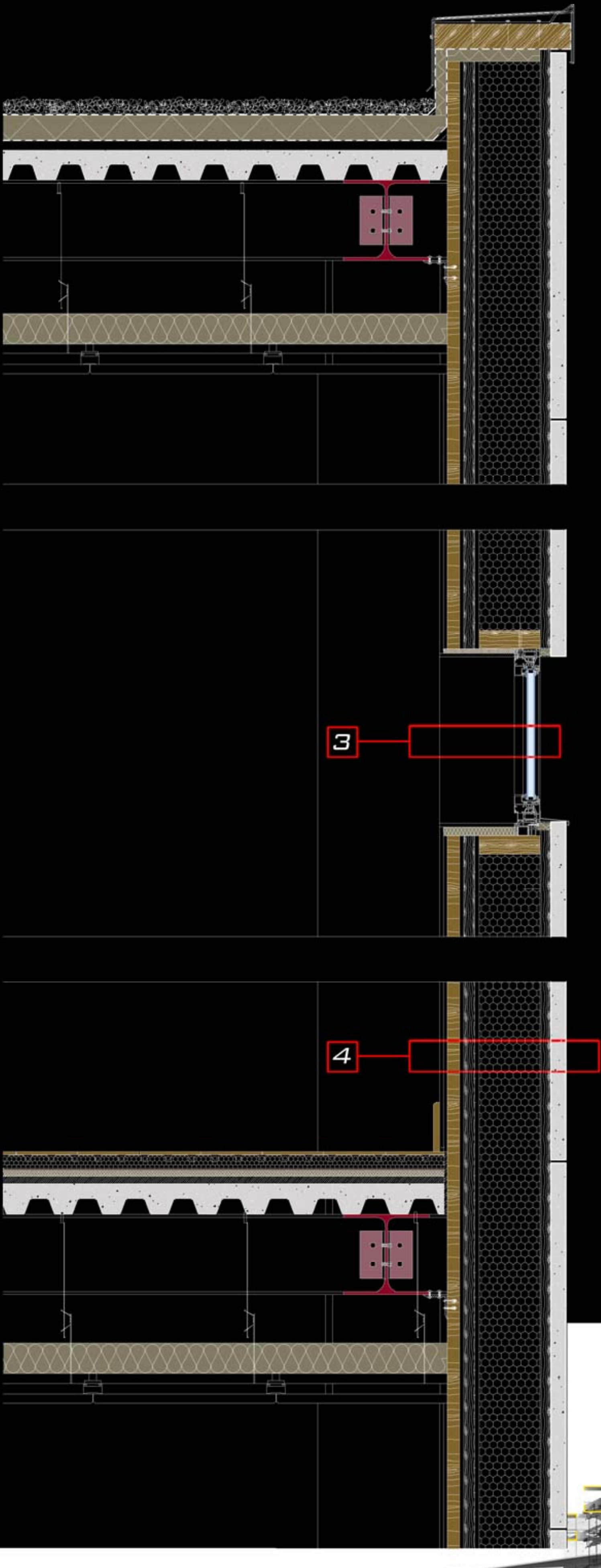
1. Gravel, 5cm
   Bituminous Felt, 0.3cm
   Polystrene Expanded, 8cm
   Bituminous Layer, 0.3mm
   Slope Concrete, 3cm
   Composite floor 100mm

2. Wooden floor
   Media polystyrene 3 cm for heating
   radiant water and screed cls in thickness. 5 cm
   Rockwool acoustic insulation in rigid panels 20 mm
   Waterproof 2mm
   Leveling layer 25mm
   Concrete composite floor 100mm
   HE beam 280mm
   250*70*3 C Steel profile
   Rockwool thermal isolation 100mm
   Suspended ceiling 30mm
   Gypsum Pluster Board 30mm

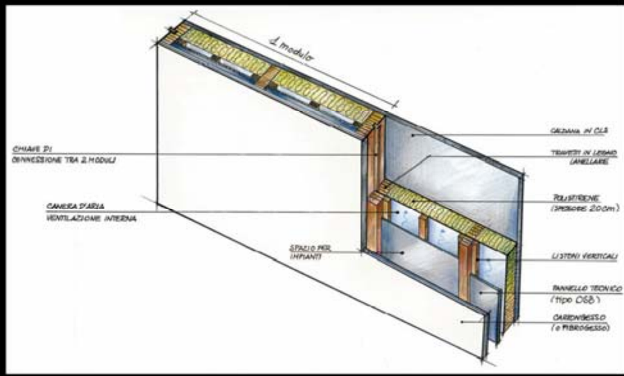


C-C SECTION Hotel

DETAILS _ 3 4



Breathing skin
_"ARIA" Panel external wall



3 Double glazing window (6/12/6mm)

4 HE 400 column

Interior finishing with a double layor of plastic board (12.5mm)

Technical panels (type OSB) 15mm

Wooden plank (35*40mm)

Air space for interior ventilation

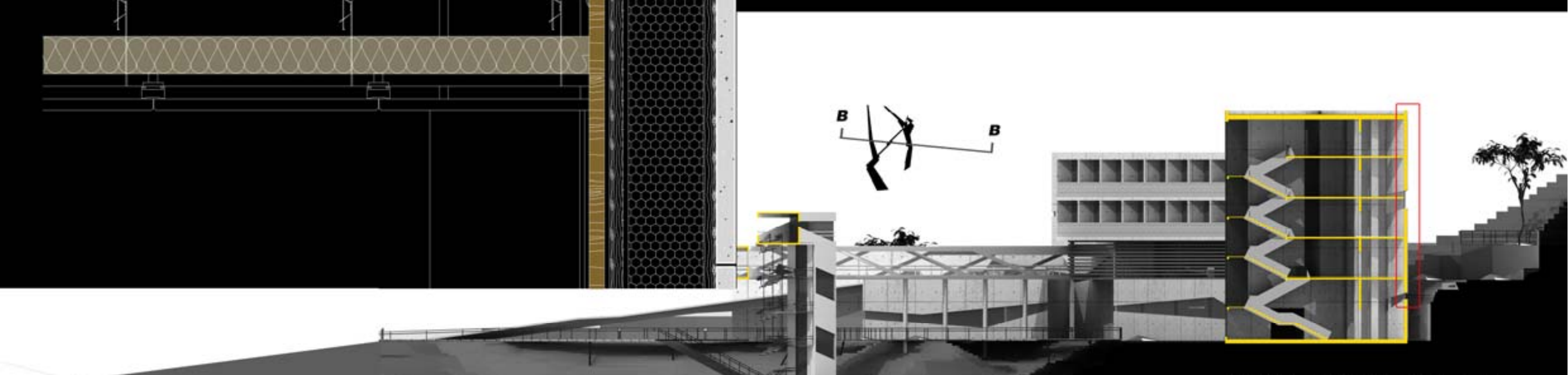
Technical panels to protect insulation 15mm

Insulation(polystyrene) interposed to wooden uprights (200mm)

Wooden plank (35*40mm)

Ventilation gap

Precast concrete panel(50mm)



B-B SECTION Hotel

DETAILS _ 5 6 7

5 Polysulphite Layer

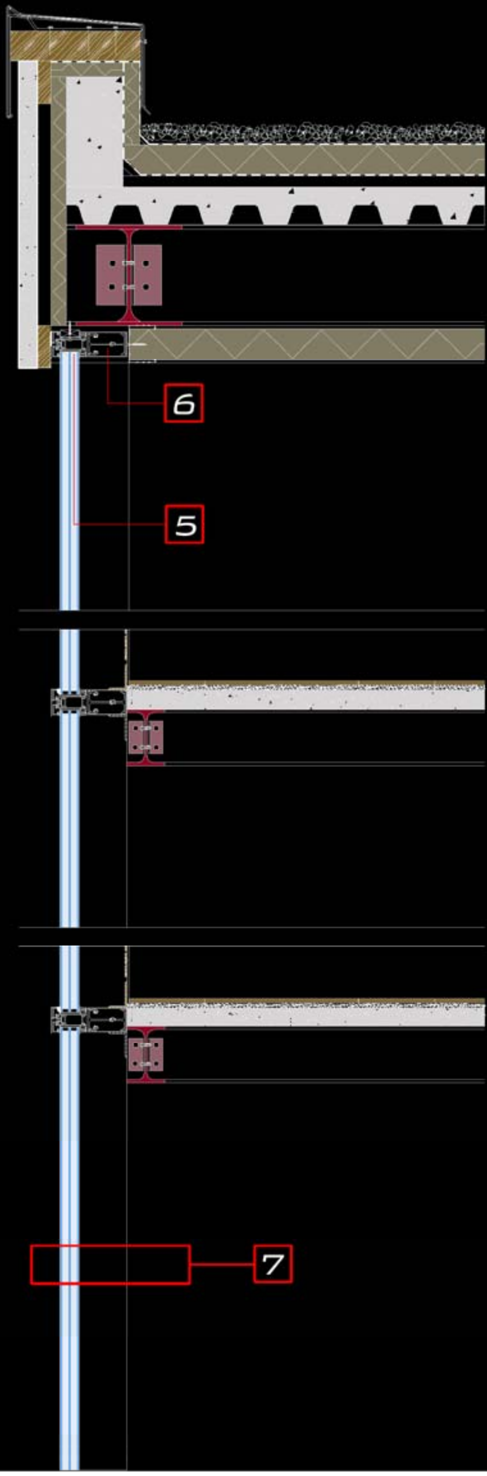
6 Kawneer Aluminium Transom Skyline

7 Innerpane solar control toughened safety glass (t=6mm)

Air cavity filled with Krypton

Middle solar control toughened safety glass (t=6mm)

Outerpane low-E solar control toughened safety glass (t=6mm)



B-B SECTION Hotel

6.0

CONCLUSION

This thesis was intended to study the relationship between social impression and human behavior; urban spatial pattern and morphology of architecture as well as utilization of regenerated energy and architecture design.

Urban design chapter:

Though studying “Image of the city” by Kevin Lynch, I created a visible linear system to link each part in the city.

Reorganization of pedestrian and driveway formed a kind of multi-layered urban traffic system.

Architecture and landscape design chapter:

The main idea is to retain the original landform after excavating and the new volume adjust to existing environment to create new communication between them, then form new city focus in Liberec. It is similar that a group of architectural organisms grown from land. The architectural volumes merge into the terrain and environment and it creates a new morphology of landscape.

Structure design chapter:

Compared to the concrete structure, the steel structure system has these characteristics: light-self weight, large span and easily to be assembled.

Technology design chapter:

The **“Breathing skin”-“ARIA” Panel external wall** performs a good natural ventilation for the building envelope.

Make full use of local geothermal resources and use it as primary building system-Heating system

The modern architecture is no longer expressed in a single form, it is a contradictory mixture of urban and society.

During the design, we need to consider all aspects of project including urban planning, architectural form, structure system and sustainable technology.

The thesis attempts to provide a methodology，which can resolve the problem between stability of architecture and instability of urban.

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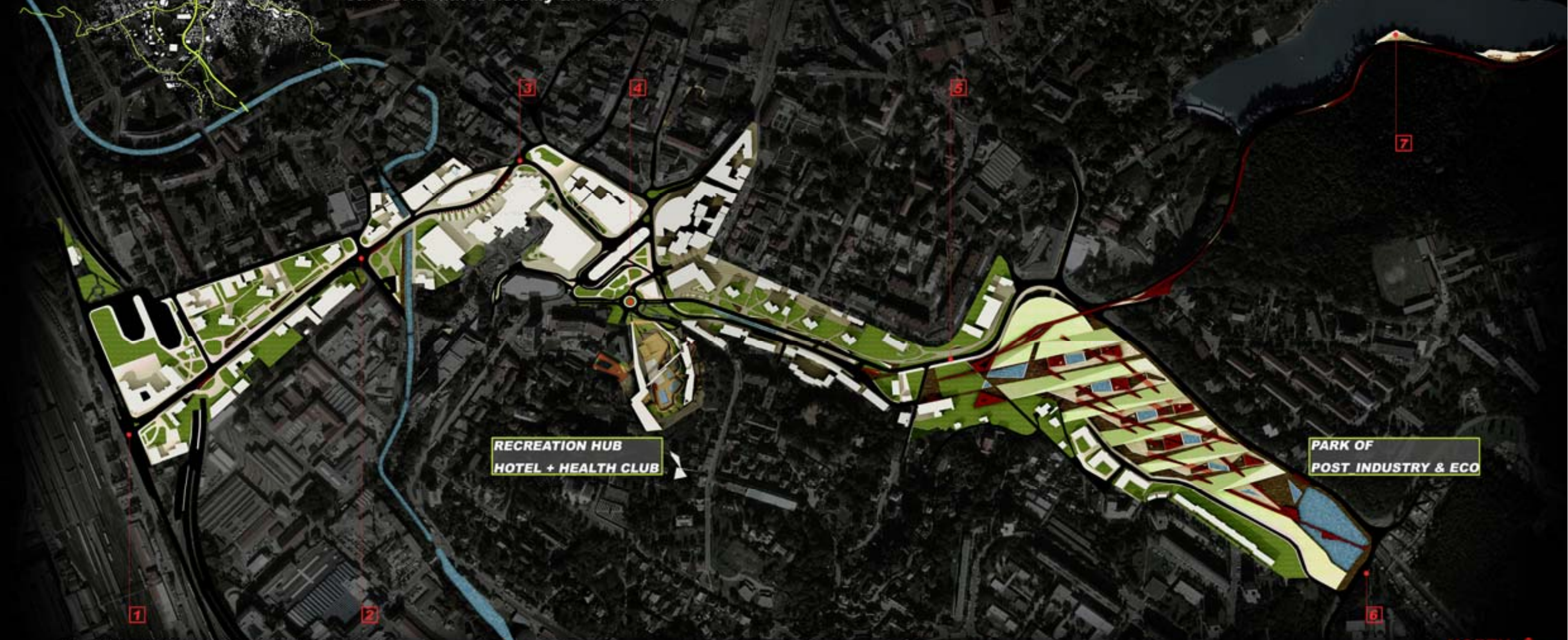
POSTERS

A RECREATION HUB
NEW HOTEL + HEALTH IN LIBEREC, CZECH REPUBLIC

REORGANIZATION OF A TOURIST ROUTE

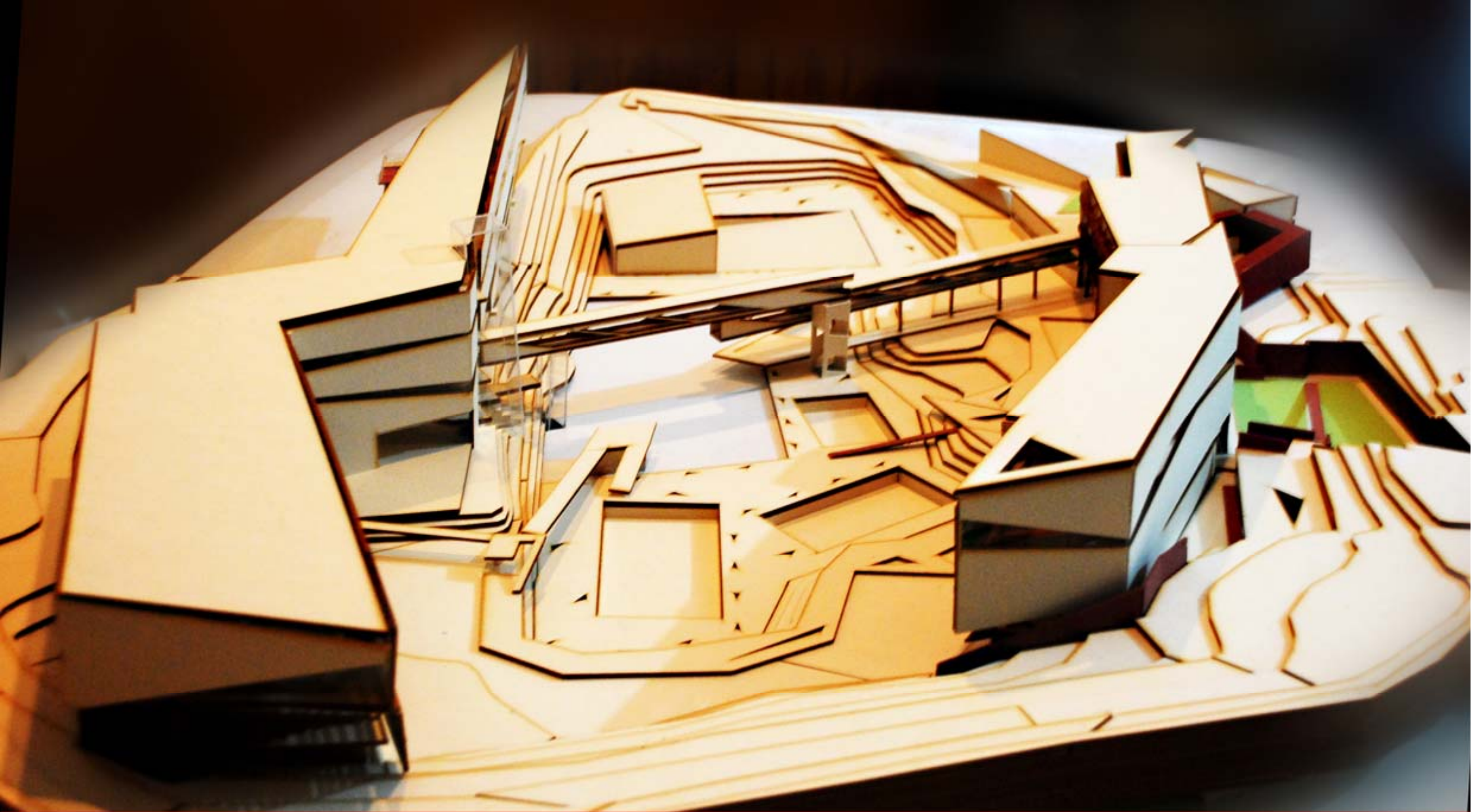
People who move through the city engage in way-finding. They need to be able to recognize and organize urban elements into a coherent pattern. In the process of way-finding, the strategic link is the environmental image, the generalized mental picture of the exterior physical world that is held by an individual.



IMPRESSION OF LIBEREC

POLITECNICO DI MILANO
POLO REGIONALE DI LECCO

MASTER COURSE OF ARCHITECTURAL ENGINEERING
RELATORE PROF. MASSIMO TADI
THESIS BY YU JIANGHAO MATR. 722786



POLITECNICO DI MILANO

A RECREATION HUB

NEW HOTEL + HEALTH IN LIBEREC, CZECH REPUBLIC

POLO REGIONALE DI LECCO

MASTER CPURSE OF ARCHITECTURAL ENGINEERING

RELATORE PROF. MASSIMO TADI

THESIS BY YU JIANGHAO MATR.722786