POLITECNICO DI MILANO
SEDE TERRITORIALE DI LECCO

FACOLTA' DI INGEGNERIA
MSC. ARCHITECTURAL ENGINEERING

NETWORK STATION

Integrated complex within the Central station of Bari

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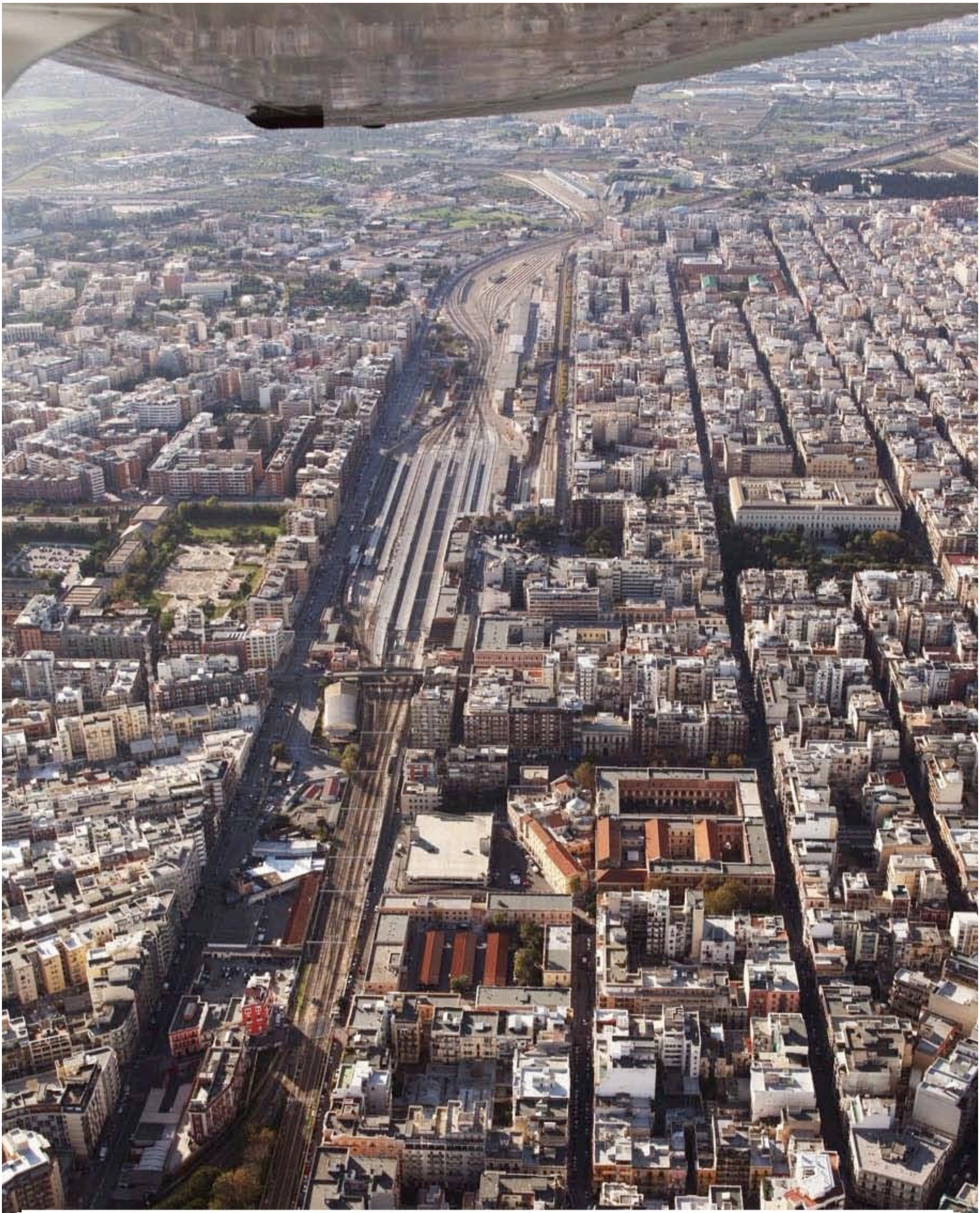

BARICENTRALE

RAILWAY CORRIDOR

COMUNE DI BARI - ASSESSORATO ALL'URBANISTICA E ALL'EDILIZIA PRIVATA -

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1. ANALYSIS

1.1 The Central Station

Bari (latitude 41°7’7’’32 N, longitude 16°51’7’’20 E) is a city in the south of Italy with an area 116 km² and a population of 314.311 inhabitants.

Bari Centrale is a typical transit station near the town center, in the middle of the city.

Historical background

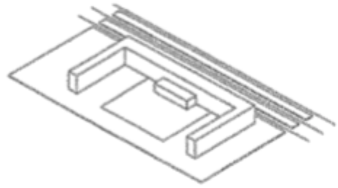
It was built in 1864. Like any transit station was characterized by a roof in flat sheets that covered two-track racing and one crossing with its docks, and architectural forms essential.

From the first years of operation were necessary extensions that invested the area of the tracks and the passenger building.

Between 1865 and 1906 they were added five rails and ancillary buildings were built. The main building was extended towards the square and, at the three central arches, was installed a projecting roof in the Liberty style. Subsequent interventions deeply changed the original shapes and sizes, in 1930 works were carried out which included the raising of a floor of the central spans and closing of the recesses between the main building and the side buildings. In the central atrium the pillars were replaced with Doric columns and marble vaults with coffered ceilings. The last actions foreseen in the plan of 1946 brought the Bari Centrale Station to the current configuration.

In the first years of this century Bari Centrale has been inserted in the program of rehabilitation of the Italian rail yard managed by Grandi stazioni.

Located near the town center, Bari Centrale Station acts as a transit and hub, thanks to its connection with the city's public transport. Characterized by rapid and constant modernizations, the Station offers a selection of shopping range in expansion.



It has an average of 38,000 daily transits and 14 million users a year, with each day arrive and depart about 300 trains and 340 buses ran. The station entrance is located on Piazza Aldo Moro.

The station, founded as a transit, has over the years adapted to the needs of circulation by purchasing a square that provides access to 17 tracks, 10 of which are transit tracks, 6 are head tracks and 1 is between the platform 1 and the track 3, for a total of more than 300 trains stopping at the station every day.

In 2009 began the construction of the rail link (double track electrified) linking Bari Central Station to the airport. The aforementioned service is available from July 2013 and is managed by the Ferrovie Nord Barese. The main beam of the station is also home to two tracks dedicated to the local Ferrovie del Sud Est. The Ferrovie del Nord Barese and the Ferrovie Appulo Lucane are located next to the terminal passenger building, which also overlook Piazza Aldo Moro.

Bari Central is served by long distance trains operated by Trenitalia, by regional services also carried out by Trenitalia, Ferrovie del Sud Est, Ferrotramviaria and Ferrovie Appulo Lucane and by the underground service of Bari. From the 20 September 2015 the high velocity line Frecciarossa is arrived also in Bari, with a direct link with Milano.


Passing trains per day:
300


Users per day:
38 000


Users per year:
14 million

1.2 Urban analysis

The urban context

The urban layout of the city of Bari is configured as the succession of three "urban frames", where the assembly, combines three different stylistic figures, each frame is an image that describes an area of the city.

In order, going from north to south, the Old Village, recounts with its narrow streets and intricate, the Middle Ages an irregular radial that characterizes Bari old, narrow streets converge towards the two main churches of the city, San Nicola and San Sabino and the ancient Bari closes within the thick walls.

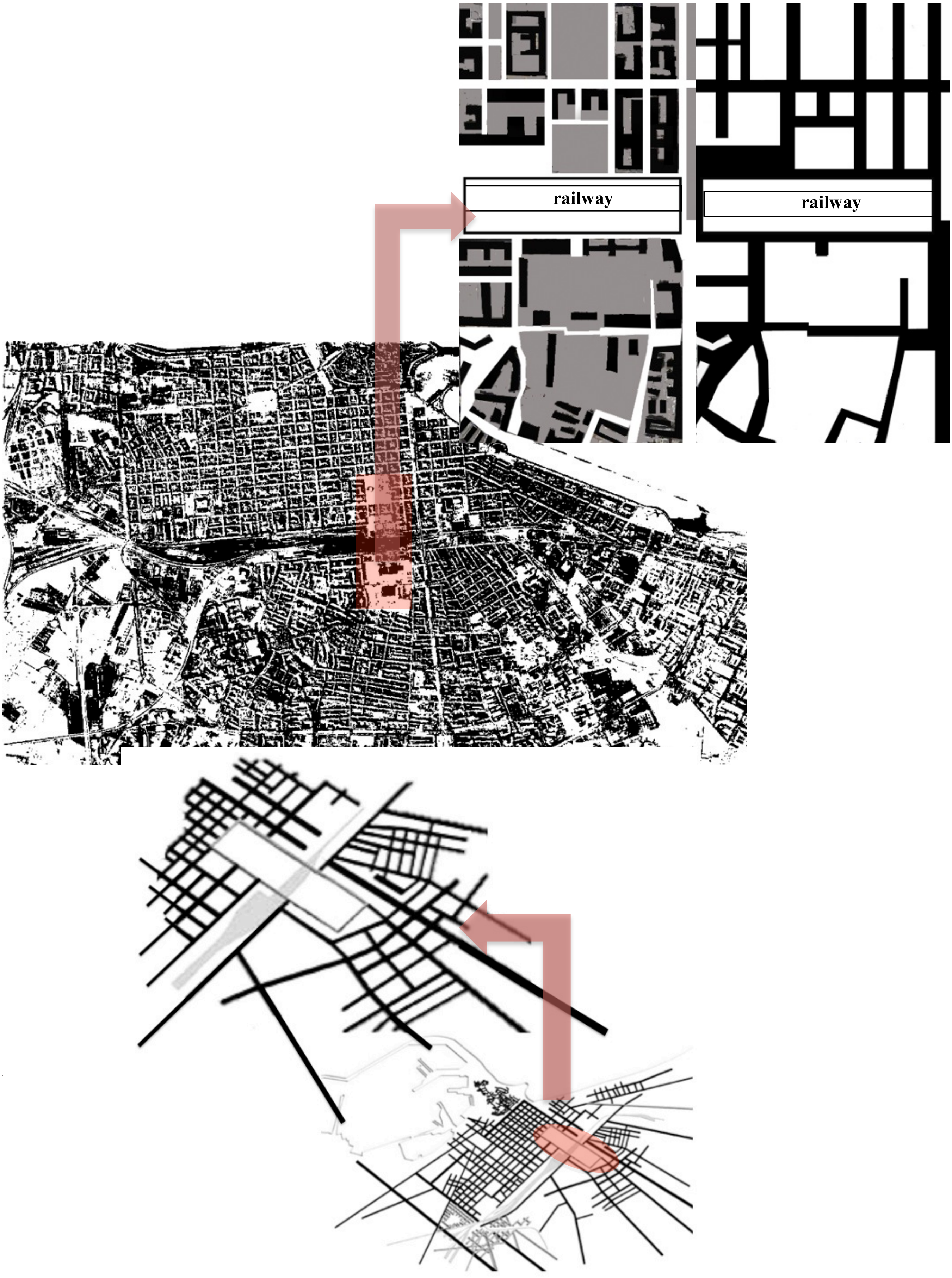
The New Village, the nineteenth-century expansion, a powerful chess offers the city a modern, founded the village Murat, the great urban expansion is named Joachim Murat, who in early 800, he signed a decree for the construction. The board consists of modern perpendicular streets create a regular pattern of blocks intended for residences and trade or buildings necessary for production and for education and the show or urban spaces, squares and gardens. The regular pattern of addition nineteenth century to the train station is the identity of settlements and morphological characteristics of the city as the most modern and alternative variation of habitat historic Old Bari. Until the 20s of last century, Bari is identified in these boundaries, from sea to rail, and expands outside this perimeter only with the extension of the sea to the east of the monumental facades or with the expansion of the first industries to West in the bend Marisabella. The new habitat isolates of Murat, on large open courtyards planted garden, looks civil, healthy and efficient, as long as the proportions are retained in accordance with the original plan conceived by Murat. The planned height of up to three / four levels of the building from the street of the same width ensures a human dimension and balanced. The alterations suffered by demolition and reconstruction of the original volumes in new volumes incongruous as size, proportions and functions, devoid of adequate parking and urban facilities, in addition to a growing process outsourcing (offices and universities) have varied morphological characteristics and identity social. The move to the outskirts of many commercial activities, as well as production, they have become the Murattiano a large outdoor mall widespread, concentrated around Via Sparano. The buildings are the: specialized theatres Piccinni and Petruzzelli, the seat of the University, the Tobacco Factory, and the Central Station. Five blocks of the plan Murat were not built and are squares Umberto I, Garibaldi, etc. The further expansion to the west of the historic grid Murattiana generated the district Libertà, place currently chosen by recent immigrants as a residence and small business. Degradation and social housing currently characterizes this part of the city, as different people and activities from the adjacent urban rich showcase of Murat.

The third and final frame tells a Bari post-war, this period of the city exceeds the railroad to expand, the post-war structure is confusing and irregular, consists of a succession of episodes urban self, comes the contemporary city still evolving.

Different texture of the city.

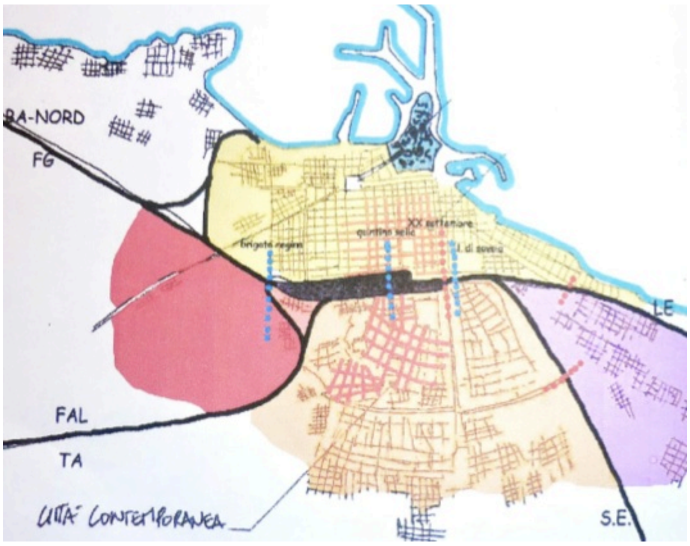
Confining neighbourhoods.

SOLID - VOID ANALYSIS and TEXTURE of the city

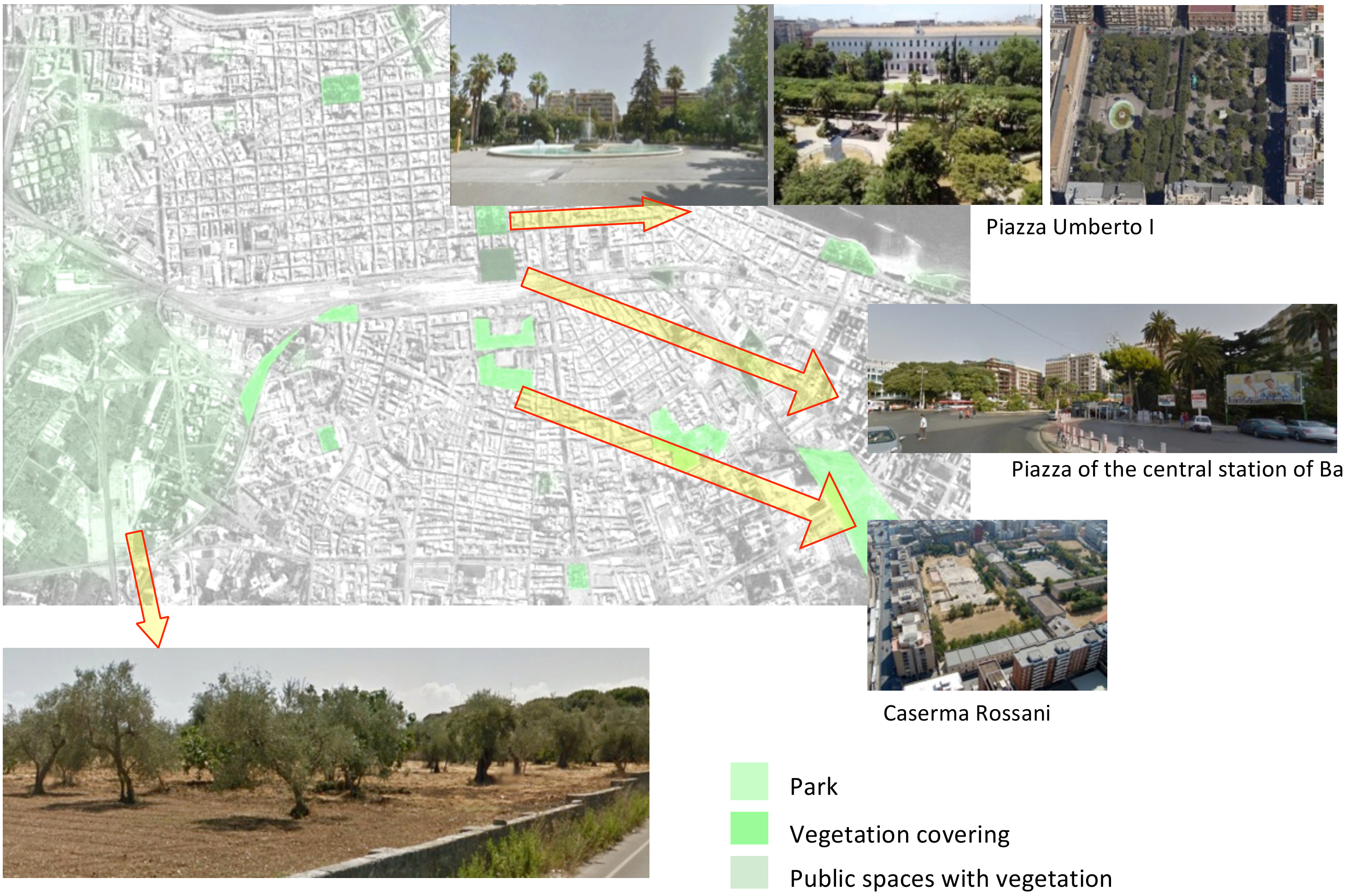


MORPHOLOGICAL and TERRITORIAL CONTEXT

- Historical center
- Consolidated city of historical plant
- Consolidated city after war
- Modern texture not consolidated
- Heterogeneous urban area
- Rural area



GREEN AREAS



Piazza Umberto I

Piazza of the central station of Bari

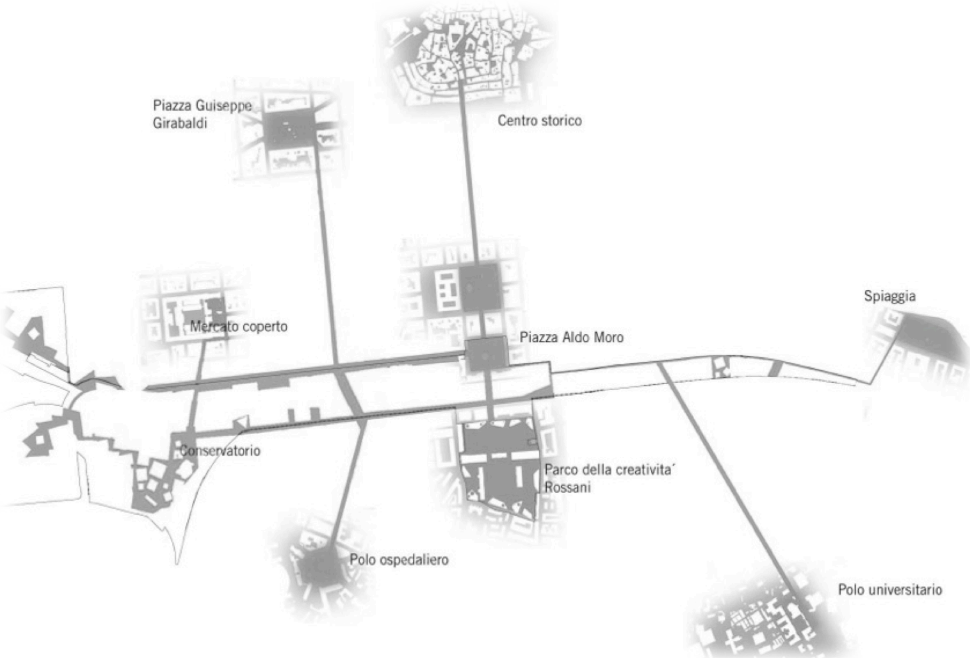
Caserma Rossani

Park

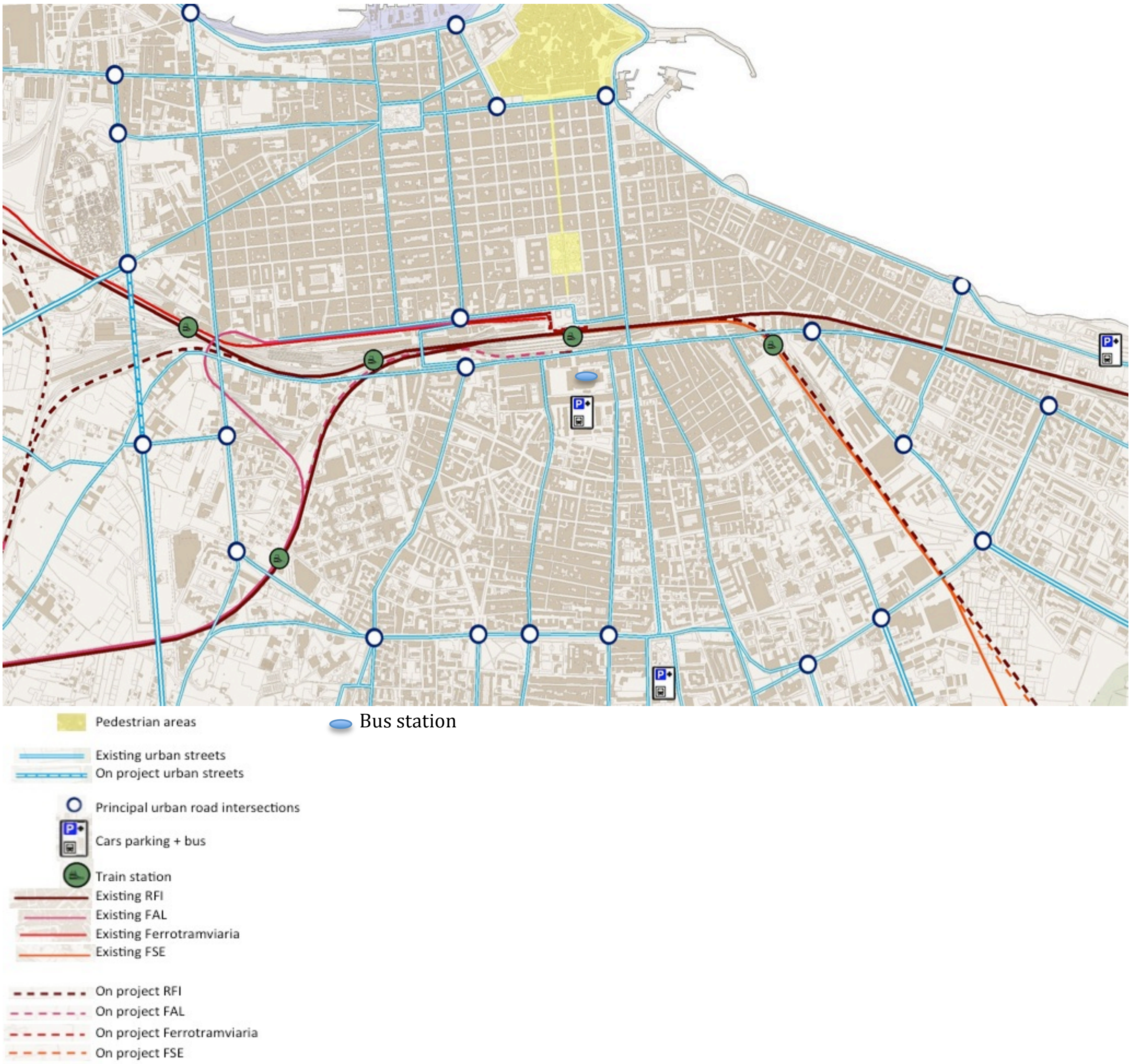
Vegetation covering

Public spaces with vegetation

FUNCTIONAL CONTEXT



MOBILITY

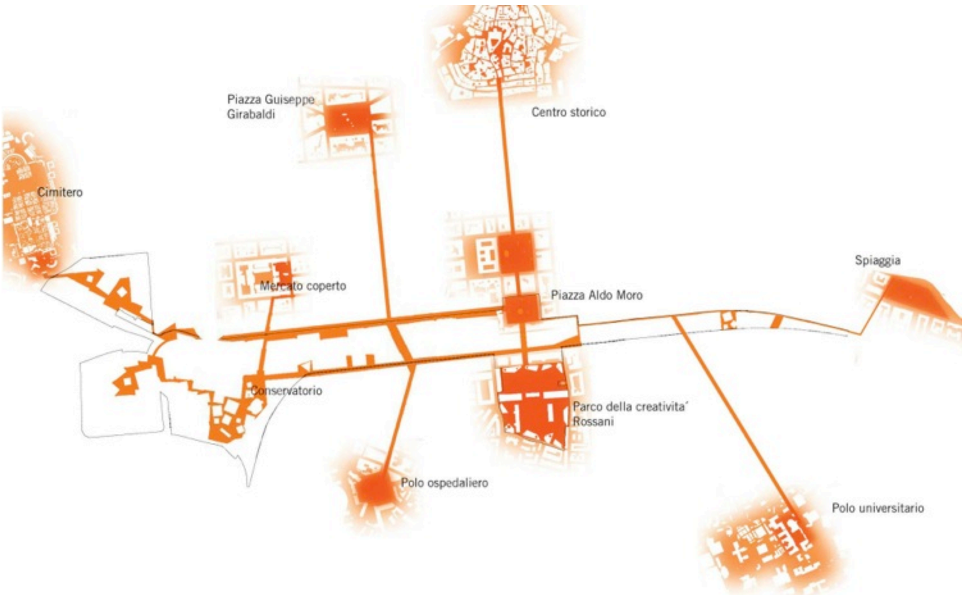


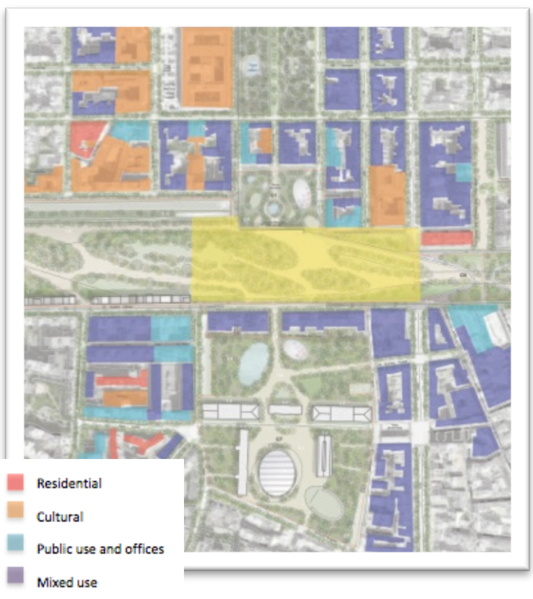
PEDESTRIAN PATHS

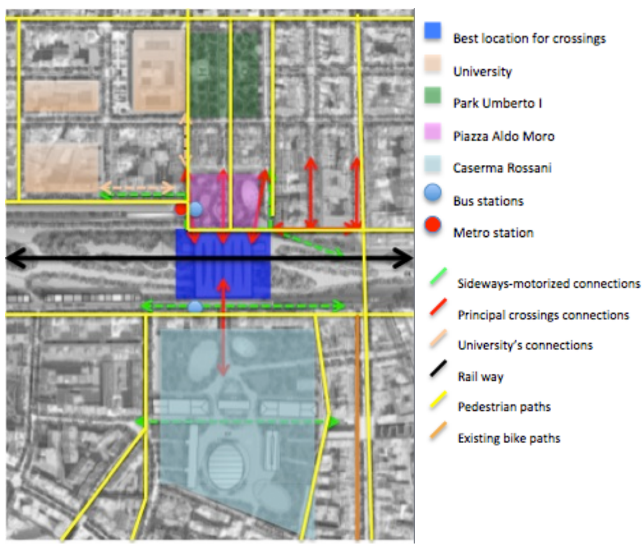
CROSSINGS

The site context

Close to the station most of the buildings has a mixed use (offices, shops, residences), but the point of interest is the nearest university of Bari Aldo Moro, which occupies the wing orange left the station. Annexed to this there is the park of the square Umberto I. In general, the area has a dense presence of buildings and few open spaces and green: the only ones are precisely the Piazza Umberto I and Piazza Aldo Moro, this point is busy of machines, bus, taxis and other public transports, as a place of arrival and departure for those arriving by train; on the other side of the station there is the Caserma Rossani, large unused space. For the rest of the dense network of roads and buildings prevents the opening of more open spaces, combined with the close presence of the tracks of more or less 3 Km of extension.







Piazza Umberto I

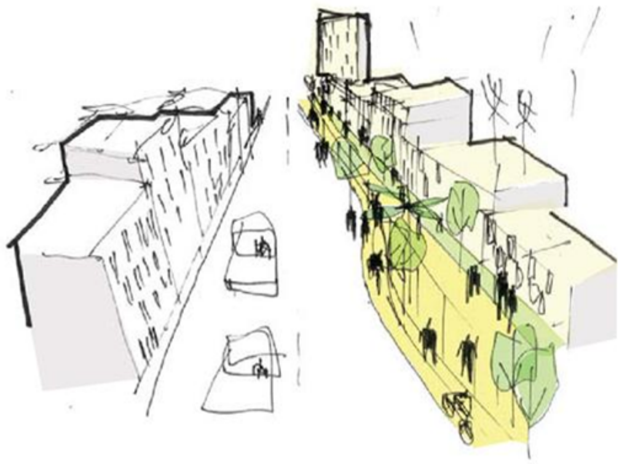
Tracks and rail way

Piazza Aldo Moro and the station

1.3 The vision: the cross-stitch

The aim is to *"restitch"*, to reconnect the "two cities" into "one", by means of two main aspects:

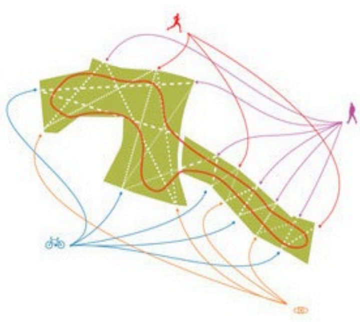
- To produce an lively, green, accessible and diversified urban environment;
- To create new fronts through sustainable urban development.



The idea of reconnection and creation of new sustainable fronts.

How can I do that?

- Improving the accessibility of the existing city;
- Cancelling the border between north and south of the city;
- Providing high quality urban spaces for people and not only for mobility;
- Facilitating the integration of the existing fabric with the new districts, highlighting the gaps and generating a mesh interconnected in a network of spaces;
- Strengthen the identity of existing urban areas.



connection

attivaction

organization

Revitalizing the station is a crucial point for the city life. In fact, the actual social aggregation points are located in the area near the old city, near the sea, and on the other side near the Politecnico. Even in this point of view it is clear the gap that this central area creates between the two parts of the city.
Furthermore, the presence in the proximity of the station of residential areas, university, public offices and most of all, the station itself with its high traffic of people makes the structure a potential social aggregation point. But it is also a potential gate to the cultural public space that the Caserma Rossani could become with its new functions.

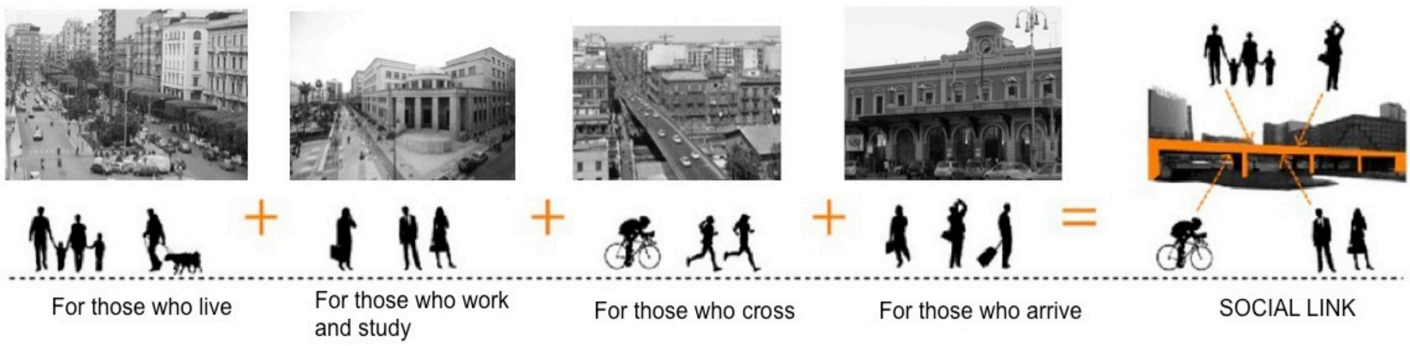
To implement this idea create a SHARED SPACE:
Long more or less 3 Km that connect the sea to the open market, that crosses horizontally the city.
A Shared Space is not merely a design trick. A Shared Space is an urban streetscape in which all boundaries between traffic flows are blurred. Kerbs, traffic signs, signals and cross walks have been removed, resulting in a minimum of regulations on the desired behaviour of pedestrians, cyclists and motorised traffic. Different from what is often thought, Shared Space does not automatically assume right of way for pedestrians, but considers all traffic flows as equal. The main goals of Shared Space are to:

1) improve road safety;
2) increase vitality (e.g. 'the state of being strong and active');
3) reduce vehicle domination and speed. Other institutions also see Shared Space as an excellent opportunity to improve the quality of social life and interaction in public space.

The overall philosophy of Shared Space is that the absence of demarcations forces the users to negotiate their way through the space: they need to make eye-contact with other users instead of assuming safety whilst racing through a green light. Because the streetscape is less defined and will feel less safe to its users, people will compensate these feelings by observing the behaviour of others and responding to that in an appropriate manner (e.g. driving more slowly and carefully). Surprisingly, the most traffic accidents involving pedestrians take place in built-up areas and on marked pedestrian crossings.

ViSION OF THE STATION

The station itself will become, other than a transportation hub, a **social hub**, in order to renew its own identity from *"a place to cross"* to *"a place to live".* In the station of Bari transit everyday many people: who travel for work, who for a holiday. We want to use so this element and join to it the large number of people that hosts Bari and especially in the areas bordering the station to create a focal point for meeting, entertainment, leisure, sports and various activities. This points the goal to LINK ALL THE DIFFERENT PARTS OF THE CITY.



SPACES AND FUNCTIONS: A PLACE FOR ALL!

CASERMA ROSSANI: CULTURE CLUB

This area will be the cultural area. The natural flow starting from Piazza Moro, through the social and transportation hub, will arrive in the green area, filled with different functions, but still remaining the green lung of the project. Its property to being multilevel, assure the connection phase (level -1) and the social phase (level 0).

THE SUSTAINABLE APPROACH

I decided to follow, as a sustainability framework, the **ONE LIVING PLANET** approach. It is an initiative of Bioregional and its partners to make sustainable living a reality. It uses ecological and carbon footprinting as its headline indicators. It is based on *10 guiding principles* of sustainability as a framework.

The idea is to use in our choices these principles in order to get a sustainable, maintainable, always improvable system that can renew itself with the maximum effect over the minimum impact.

1.4 Design brief

In order to attain the goals that we have set, we will follow some minor actions that will lead to a major strategy, according to the following scheme:

Goals	Strategies	Actions
Greening the Area	Enlarge green area	• Use green ways to help cover the railyard area • Multiply the landscape layers
	Reduce pollution	• Confine the motorized viable streets • Introduce thecnologies to filter dust and pollution
	Link green space to local life	• Empower existing cycling roads with green points or greenways • Possibility of introducing social gardening
Recreate a connection with the neighborhood	Maximize the useable time	• Insert functions active at night • Provide more facilities (like Police Station, or Info Point)
	Increase the access points	• Create underground parking areas • Create a cycling/jogging/pedestrians paths • Distinguish fast and normal paths • Provide accessibility for disabled
	Highlight entertainment and culture activities	• Separate the area for children • Diversify the entertainment possibilities (concerts, meetings)
Emphasize the sea as a key element	Improve connections	• In summer, conncect the Station and the sea with extra public courses • Decentralise fountains to give the idea of flow • Multiply the landscape layers
	Integrate with people	• Create common public spaces running from Caserma Rossani to Piazza Moro without interrupting the flow
	Create References	• Use water as a base elements to connect target area and the Sea (use of fountains, Flow paths, little pools, etc.)

PHASING APPROACH

In the *phase 1*, there will be the realization of the intervention in the C7 sector, the Rossani area, in order to give to the community an immediately useable green public space;

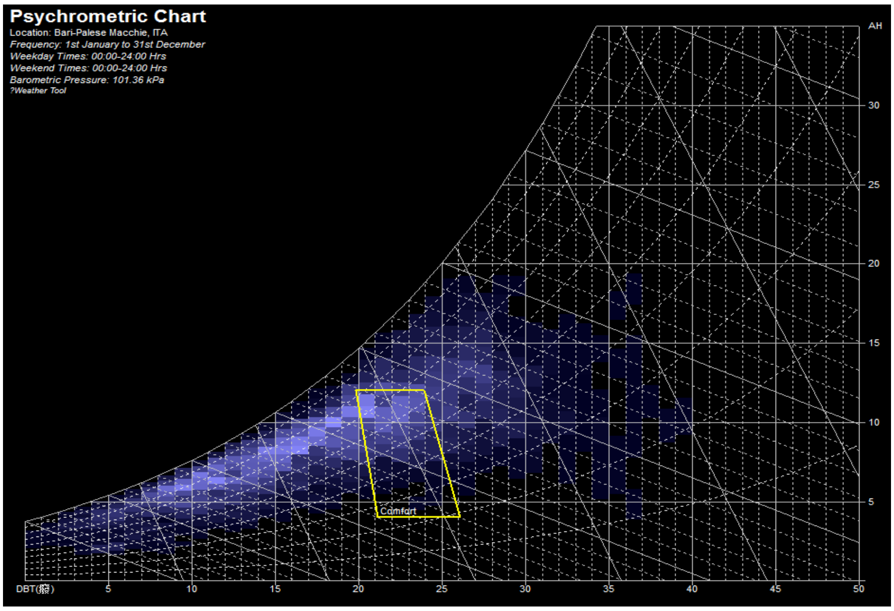
In the *phase 2*, there will be a priority into the realization of the Structure of the Station and the connections between the Rossani area and the Station itself;

In the *phase 3* will be dedicated to the completion of the covering of the railways and the connection to the remaining structure.

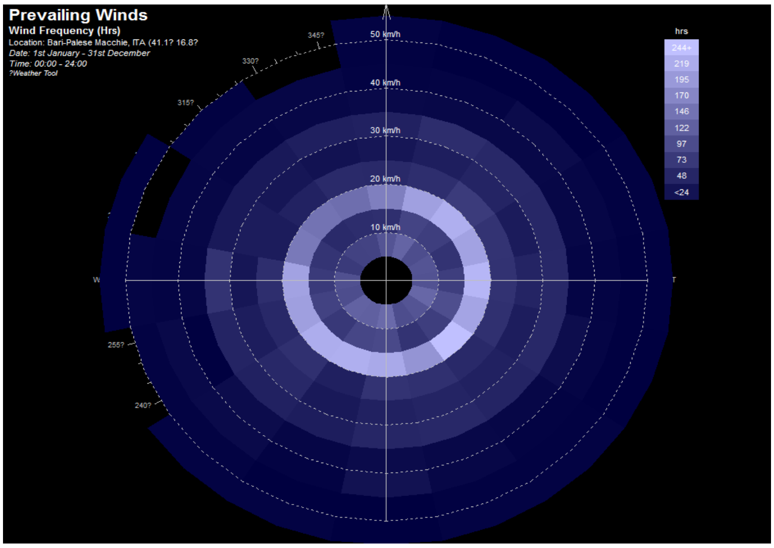
1.5 The environmental analysis

For the environmental analysis I had made a climate analysis with Ecotec to find how the sun, the precipitations and the wind influence the climate in Bari, and to find which climate constraints and potentials we can exploit for the project.

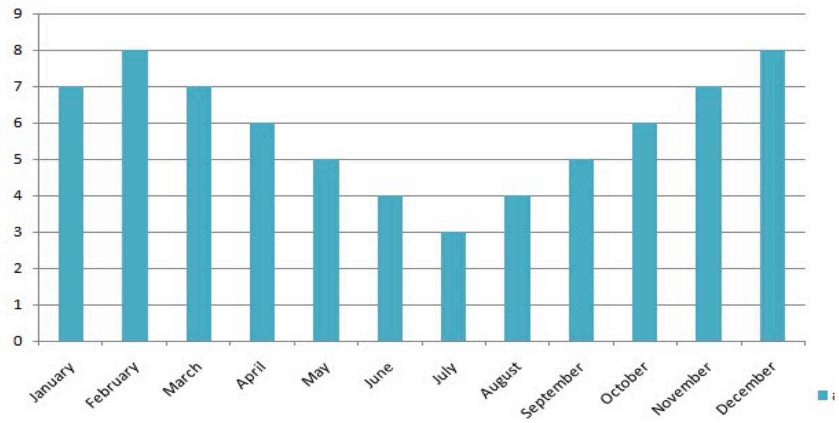
For the HUMIDITY we have found thanks to the psychometric chart that during the year the humidity in Bari is in more or less in the normal range, in the comfort zone, but with peaks of high humidity, values of relative humidity of 80%.



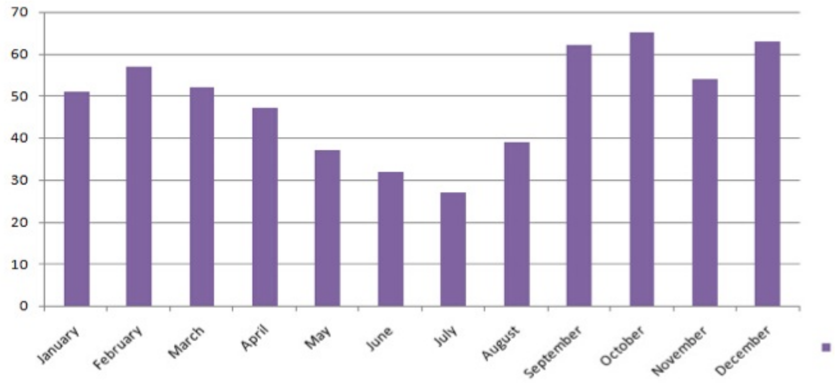
The WIND during all the year has an average speed of 20 Km/h. The analysis show that Bari is characterized by a good average wind speed, so we can use this as a potential source for sustainable energy for example for the production of electricity with the installation of small wind turbines.



The PRECIPITATION in Bari is not so high, the maximum value reached is in October with more or less 65 mm of water, and during the summer the level of precipitation is really low. For these reasons the rain is a climate constraint because we cannot apply in specific systems that use the water of the rainfalls to supply the needs of water of the city. The low quantity of precipitations is visible also in the graph of rainy day, in which only in two months there are 8 days of rain.

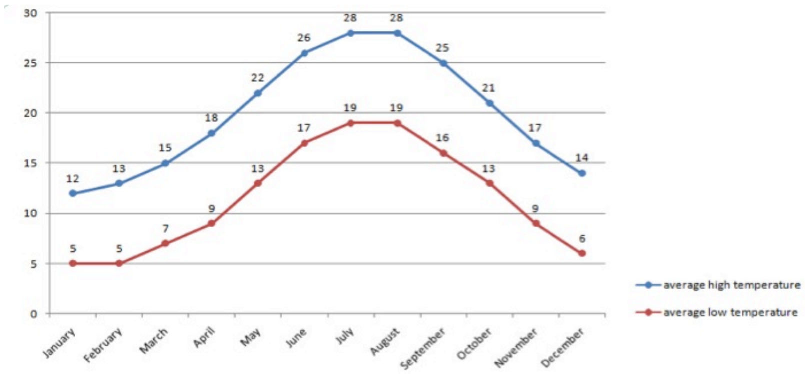


Average precipitation in Bari (mm)

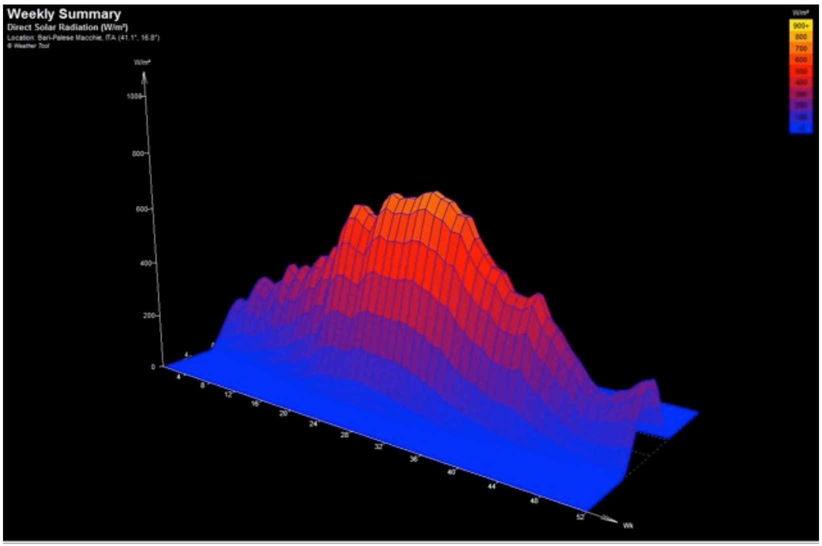


Average rainfall days in Bari (days)

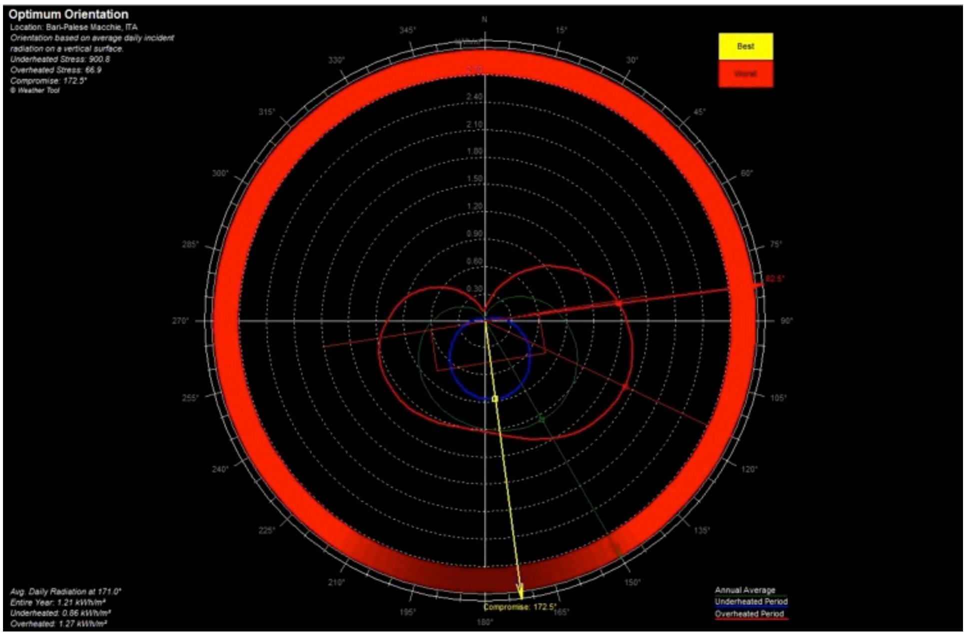
The TEMPERATURE in Bari can reach really high values, as peak was reached a value of 46 °C at 2 p.m. of a summer afternoon. In the graph there are the average temperatures, the most high values are in the months of July and august, but in general during all the year in Bari there is a mild t and comfortable temperature.



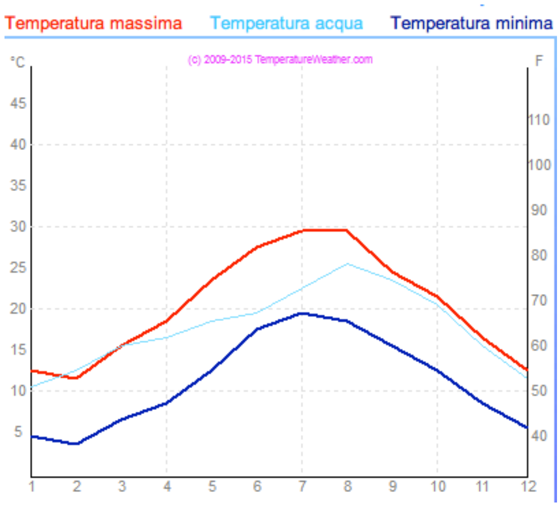
Linked to this there is the study of the GENERAL WEATHER and the SOLAR RADIATIONS. In fact in relation to the high temperature there are the high solar radiations that affect the city of Bari, with a maximum value of more or less 800 /850 W/m2 in the month of august. From this analysis we can use the sun as a potential factor for the use of sustainable systems like the solar photovoltaic panels and the solar tanks that can work in a really good way during all the year, in particular for residential buildings, so as to cover most of the needs of domestic hot water. Photovoltaic could also cover shelters for parking and public transport stops, as well as the covers of some buildings.



From the solar analysis we have found also the best (yellow) and the worst (red) orientations for the building, based on average daily incident radiation on a vertical surface: the best one is more or less direct completely south (172,5°) and the worst one is in the direction N-E (82,5°). For the best orientation during all the year the average daily radiation is equal to 1,21 kWh/m2, for the under heated condition is 0,86 kWh/m2 and for the overheated one is 1,27 kWh/m2.



Another factor that we have to take into account for Bari like a potential factor is the WATER OF THE SEA. An analysis of the average monthly temperatures of the sea, found that the values are between the 12 ° C and the 25 ° C, so it is convenient to use the thermal sea energy, in the winter, and the cooling in the summer, spring and autumn, as energy source heat pumps cooled reversible water. This solution has many advantages from the point of view of energy and environment.



1.6 The sustainability approach

For the sustainability approach we have chose to follow ONE PLANET LIVING that is an initiative of Bioregional and its partners to make truly sustainable living a reality. One Planet Living uses ecological and carbon foot printing as its headline indicators. It is based on 10 guiding principles of sustainability as a framework. The 10 Principles rooted in the science and metrics of ecological and carbon foot printing, 10 One Planet principles are used to structure thinking and inform holistic action. These principles stemmed from Bioregional's experience of working on BedZED, a pioneering eco-village in South London, UK. Together, the principles provide a holistic framework to help organisations and project teams examine the sustainability challenges faced, develop appropriate solutions and communicate the actions being taken to key stakeholders such as colleagues, the supply chain, clients, customers and local and national government.

For the specific city, Bari, we have to follow another line sustainable: **SMART CITY**.

The Municipality of Bari initiated a process aimed at the programmatic presentation of the candidacy to the "Smart Cities" and the implementation of interventions to improve the quality of life for citizens and more sustainable cities in terms of energy. The initiative "Bari Smart city" has the primary objective to inform, engage and mobilize the community, the residents, associations, public and private organizations, in order to develop an effective plan of action in cooperation with the European Commission. The first act of this route has seen the membership of the city to the Covenant in July 2010. The Covenant of Mayors, which sustains and supports the efforts of the local authorities of the European Union, involves for Municipalities members of the drafting and implementation of a Plan of Action for Sustainable Energy (PAES), which set the targets for reducing emissions and how to reach them. The City Council approved the PAES of the city of Bari in its final October 27, 2011.

The PAES has the ambitious goal of reducing emissions by at least 35% by 2020 by implementing 78 actions relating to the following areas:

- Education: promoting interventions aimed at changing consumer habits and lifestyles;
- Energy planning: municipal planning interventions that support the spread of buildings with low environmental impact;
- Network infrastructure: implementing measures to achieve an energy network capable of receiving an increasing share of renewable sources and characterized by low pressure network;
- ICT / TLC: with actions leading to telecommunications networks and systems that enable the ability to generate information, make them available and interpretable to all stakeholders and will facilitate the development of new services with low emissions;
- Sustainable mobility: to facilitate urban mobility and reduce emissions from the public and private transport;
- Building low power: aimed at reducing energy consumption for heating / cooling or lighting for new and existing buildings;
- Renewable sources: for the construction on the urban area of renewable energy plants and / or co-generative small;
- Waste and water: to reduce emissions linked to the collection / management of waste and the collection and distribution of;

- Sustainable public administration: to reduce energy consumption of the local public administration.

Referring to the 10 points of one planet living, and the point of Smart city, my action plan with my proposed strategies is grouped in these specific points for our project:

How renewable technologies we had think to use photovoltaic panels and solar tank, using the radiations of the sun; the small wind turbines and the water of the sea for the energy.

The organic residues could be collected and used in digesters to produce biogas to power partly existing plants or public transport vehicles.

For the use of sustainable transports we want to encourage the use of electric vehicles for public transport and to add a long distance walking and cycling.

How sustainable materials we will use cellular glass and recyclable bio plastic for the construction of the new building of the station and the new ramp, and for the urban objects.

In new cafes and restaurants that will be added in the new building of the new station in multifunctional spaces will be used local foods, also encouraging the creation of local markets.

The water is a key element in Bari, we use the sea water in summer and in winter as a source to create renewable energy, thanks to its temperature between 12 and 25 ° C.

In addition to the new green on the entire strip of the tracks, will be integrated into the new station plants local and indigenous.

In the new Caserma Rossani were constructed buildings for exhibitions, homes for artists; everything will be connected to cultural events, evening events, possible in the new station building.

Bari is supported by the European Union as adhering to Smart City, providing funds for any sustainable initiative. This will give the opportunity, along with local donations to build the new building that will employ many citizens of Bari.

The new station was conceives as a social point for meetings and enjoy yourself, a place where you can do a lot of things always in contact to many people; and the increase of the connections between the city will have a positive effect in terms of socialization.

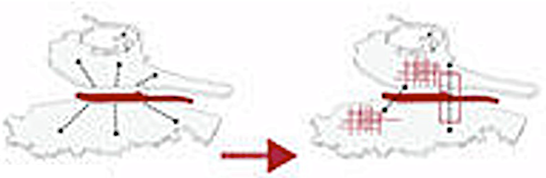
1.7 S.W.O.T. analysis

A S.W.O.T. *(**S**trengths **W**eaknesses **O**pportunities **T**hreats)* analysis is a technique commonly used to assist in identifying strategic direction for an organization or practice. Strengths can be defined as any available resource that can be used to improve its performance. Weaknesses are flaws of any system that may cause to lose a competitive advantage, efficiency or financial resources.

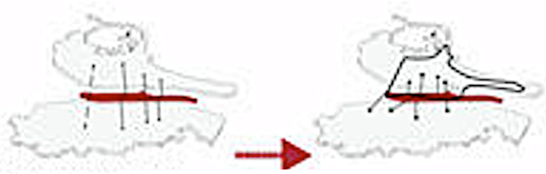
This is the S.W.O.T. analysis of our case study:

STRENGTHS	WEAKNESS
◆ It is in the middle of the city, and it's an important place which a large number of people gathering or passing ◆ There are 2 metro-lines really close to the station ◆ Some Bike-sharing stations near to the stations and to the tracks and yard area ◆ Important investments in infrastructure and rolling stock by Puglia region and the European Union ◆ Network of rail lines that can theoretically provide direct service to most major traffic routes and ensure opportunities for interchanges to intercept flows into the city from the main extra-urban road system. ◆ Big parking close to the station ◆ The reorganization of the railway hub has already been initiated in areas to the north and south of the city centre with a program by the regional government	◆ There is less green area or landscape near an around the site ◆ Presence of the canals perpendicular to the coast ◆ Really few links between the interest points ◆ Lack of connections/passages between the 'two' Bari, the old and the modern ones (both for vehicles and pedestrians) ◆ The compact urban form of the Murat district with its rigid and regular street grid is difficult to overcome without major sacrifices, at least regarding urban quality. ◆ Presence of al lot of private properties (C6) ◆ Because from east to west it is so long. The huge length limit many activities ◆ Lack of the connection with the sea
OPPORTUNITIES	**THREATS**
◆ Bari centrale is the first attraction of Bari. It is a gate and a card of Bari ◆ Restructuring of the railway hub ◆ Acquisition by the Municipality of the Caserma Rossani to create a contemporary and public space (reuse of private properties) ◆ Improved accessibility along with completely rethinking entire areas of the city that today are marginalized or abandoned near the track and yard area improving the quality ◆ It's a zone that combine modern and historic areas	◆ Hydrogeological aspects, proximity to the sea

The most important criticality and the solutions



The fracture of the city



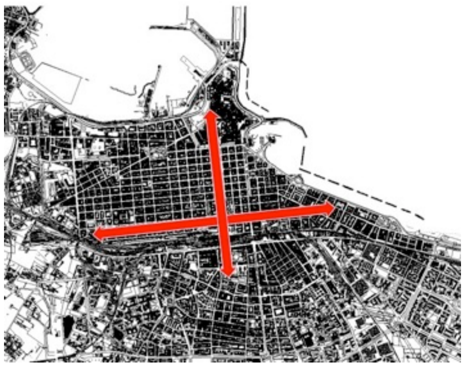
Quality of the crossings

No relation with the sea

Lack of green

By S.W.O.T. analysis showed that the negative factor that most influences the fracture of Bari is the lack of real and strong connections between the main points and the sea, leaving the city to a set full of roads.

For this reason, our project aims to create an horizontal two strong connections with the shared space that connects the sea to the covered market, covering a distance of nearly 3 km, and a vertical ramp and with the station, which connects the ancient and the modern Bari; so as to give the city two reference points and linking the five parts that characterize it: the sea, the west part of the city cultural zone, modern Bari, Bari and the old station.



The shared space as well as to create a real connection between two parts of the city also combats the problem of too much compactness of the district Murat, because you go to create a long corridor that opens the neighbourhood. It also goes to redevelop unused zones, to reduce traffic and accidents and increase green areas by planting new plants that will be the physical divider between the different types of movement.

Thanks to the opportunities that Bari offers and above the site of interest is going to build a new station that will be the business visit Bari, immediately people arriving by train will have the feeling of having arrived in a modern place, near the sea and social connections. In what has been joined by the redevelopment of the railway hub and the Caserma Rossani already implemented by Fuksas.

1.8 References / influences

New central station of Bari by Fuksas

New central train station of Bologna by the studio Performa Architettura +Urbanistica

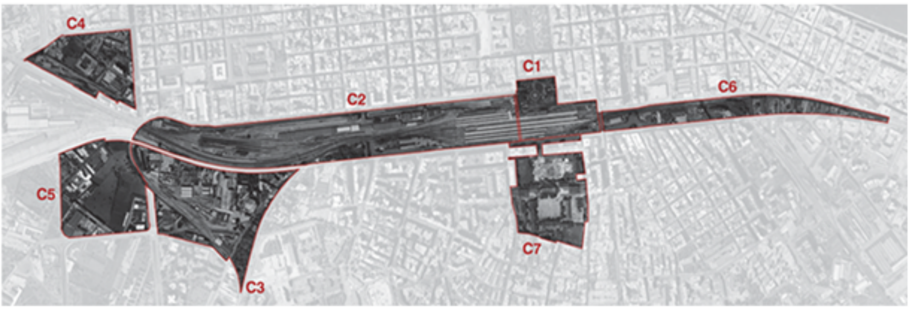
Bussa Milan over bridge

2. PROJECT

2.1 Introduction to the Bari Centrale competition and project area General indications and main goals of the project

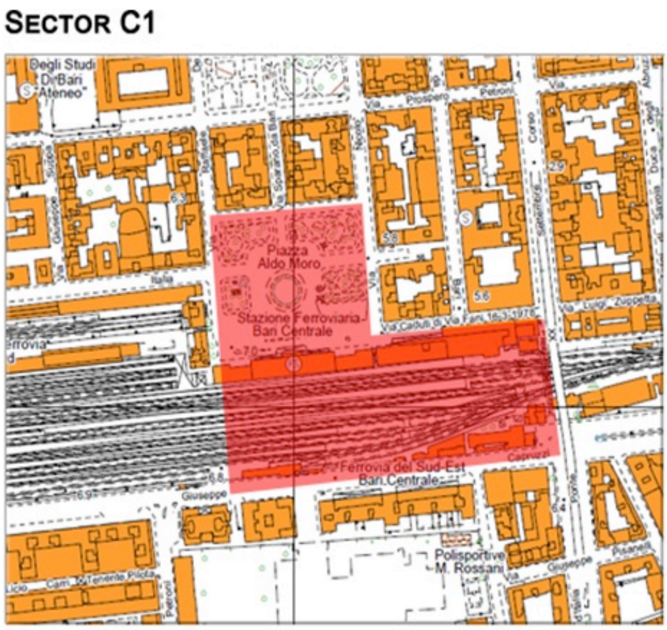
On 2012, the municipality of Bari published a notice for the railway services competition BARICENTRALE, in which has been set a whole new strategy for the urban asset of the city. The actual setup of the station itself is cutting in half the city, touching in all its extension more than 6 neighbourhoods. It is indeed a difficult location, with a challenging demand: to reconnect the two sides of the city, one older and historical, the other newer and compactness. The urge to give to the station and to the rail yard a new identity, plus the annexation by the city municipality of the Caserma Rossani area, makes this competition tempting.

This is a unique occasion to redefine the relationship between old and modern city, but that should begin from a unitary vision of the future role that this urban hinge can play for the entire city. In fact, the project site covers an area of 78 hectares over a length of 3 km, and this made necessary to divide the whole area in seven distinct sectors, in order to facilitate the design processes.



Competition Area: localization of the sectors.

I have chosen to work on the sector C1 (51.079 mq) that coincides with the Bari Centrale station. In recent years, the 'Grand stazioni' program, the introducing of high-speed rail travel and the restructuring of railway hubs have paved the way for large-scale projects for the principal stations in the Italia cities.



Summarizing the main goals for the entire area are:

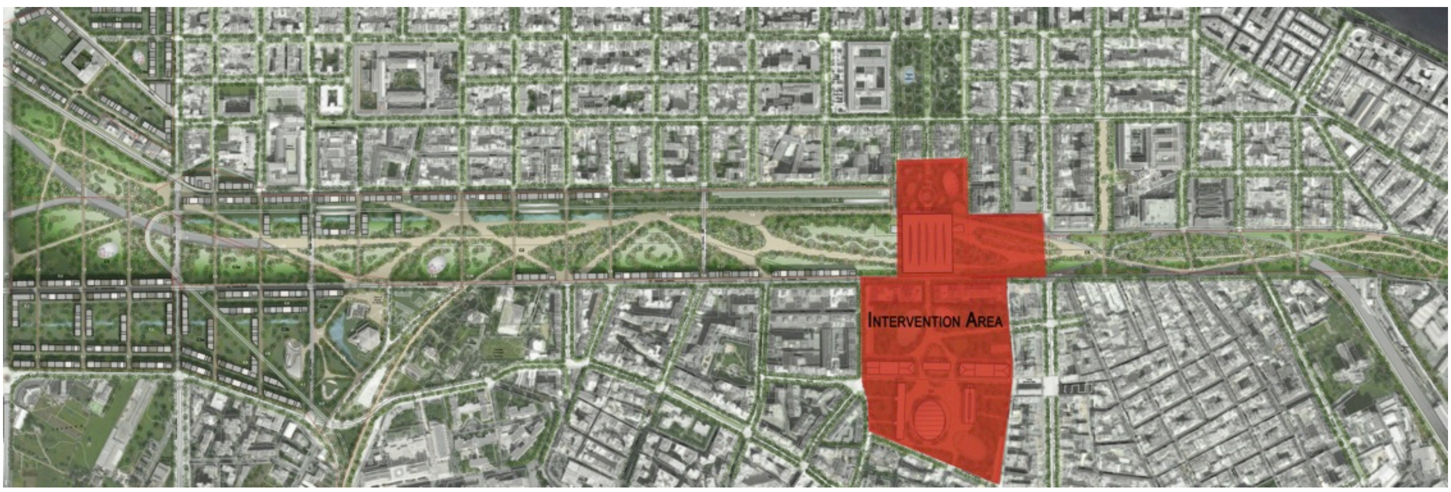
- Create a station as a UNION between the old and the modern city;
- Give a UNITARY vision to this urban hinge, that can play for the entire city of Bari;
- Reduce the discontinuity in the urban fabric and in the daily movement of the city's residents.

For the specific central area C1 the principal goals are:

- Rethink the design of the square;
- Integrate the station with strictures that can facilitate crossing in relationship to the working of the station, passing above and/or below the level of the tracks;
- Create ne street fronts;
- Increase permeability between the two parts of the city through the creation of new crossing.

Choosing this competition is a well-pondered choice, due to the complexity of the location and the aspect of the competition. Renewing an old structure happens all the time, but renewing a transportation center which is so deep placed into the city, means to deal with a lot of constraints: position, density of the existing fabrication, the stiffness of the urban tissue, and so on. In the end, it is the challenge that this project expresses what makes it interesting in our opinion.

On April 24, 2013, has been announced as the competition winner Massimiliano Fuksas and his study, which proposed an advanced city park for the redevelopment of the railway areas of the city, forecasting the intervention in a 15 years multiphasing approach. Since, with the adjudgement of the competition, Fuksas granted himself the possibility to realize a feasibility study, and with that a preliminary project, we are taking the actual design as if it is already realized, to treat it as the base of our design process. In the figure the original masterplan by FUKSAS Studio



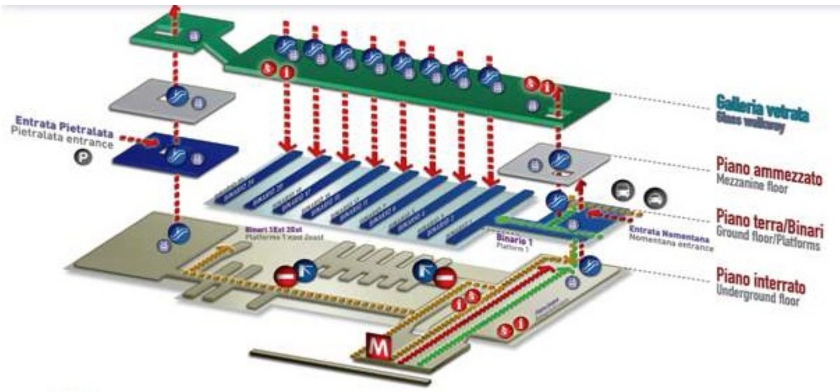
2.2 Functional layout: the new crossing 'flying' platform

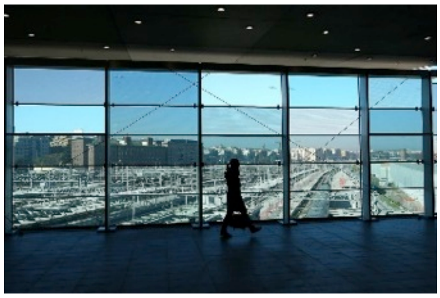
To create the new crossing, between the Aldo Moro square and the Caserma Rossani, the best choice for the station layout is to create a CROSSING-BRIDGE STATION, that let to create a new platform for the crossing of the travellers and the enjoy for the citizens. Add to this on the railway sides are opened two balconies that increase the link between the people and the trains.

The shapes have to be regular, the crossings clear and symmetric, also to remember the absolutely regularity of the pattern of the Murat district.

To start to think to the typical architecture for a bridge station I looking for some example in the world, that can represent that idea:

The new Tiburtina train station





Liege Guillemins station (Belgio)

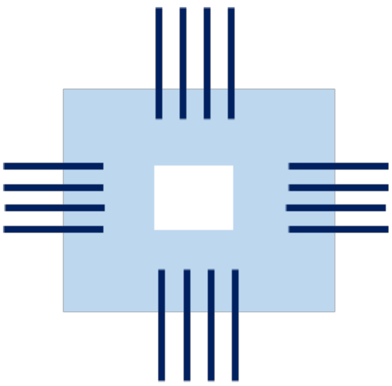
Kenitra railway station (Marocco)

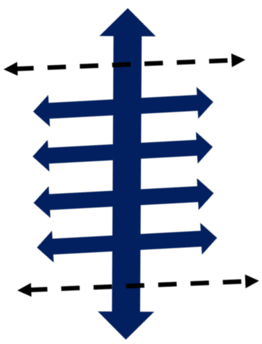
La Reforma tower (Mexico City)

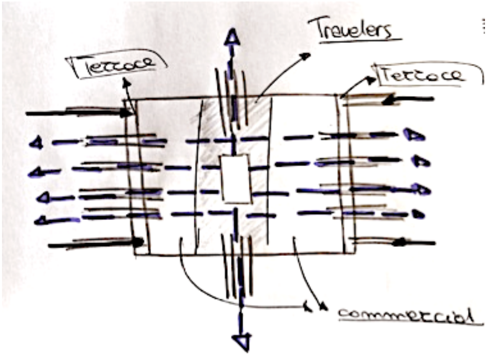
Vasteras transportation hub (Sweden)

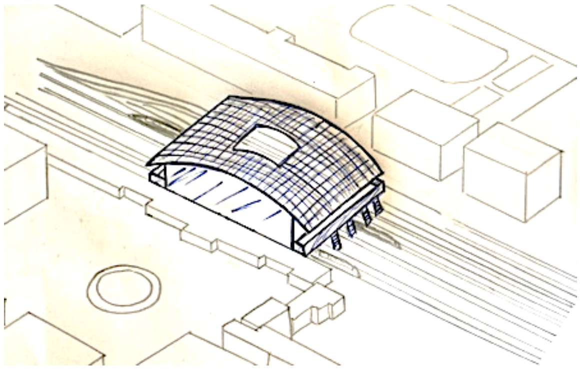
For the new Central Station of Bari, i choose to reuse the idea of the past boulevard to create the GLASS GALLERY-BRIDGE (as Tiburtina station), to create the regular crossings from the train tracks to the platform and viceversa (as the Liege Guillemins station) and to open two urban terraces to link the citizens, the travellers and the other people to the city and to the station. To increase this feeling the material for the platform is the glass, so the tourists when arrive in the station can see immediately the sea and feel the atmosphere of the beautiful Bari.

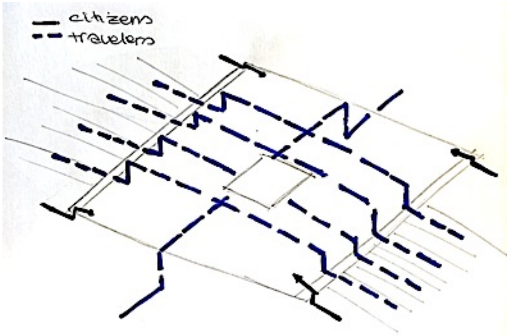
Summing these considerations there are the schematic layout of the station:

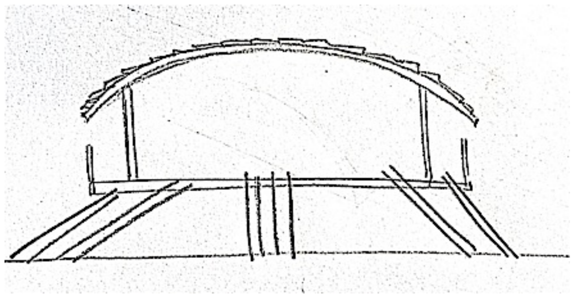






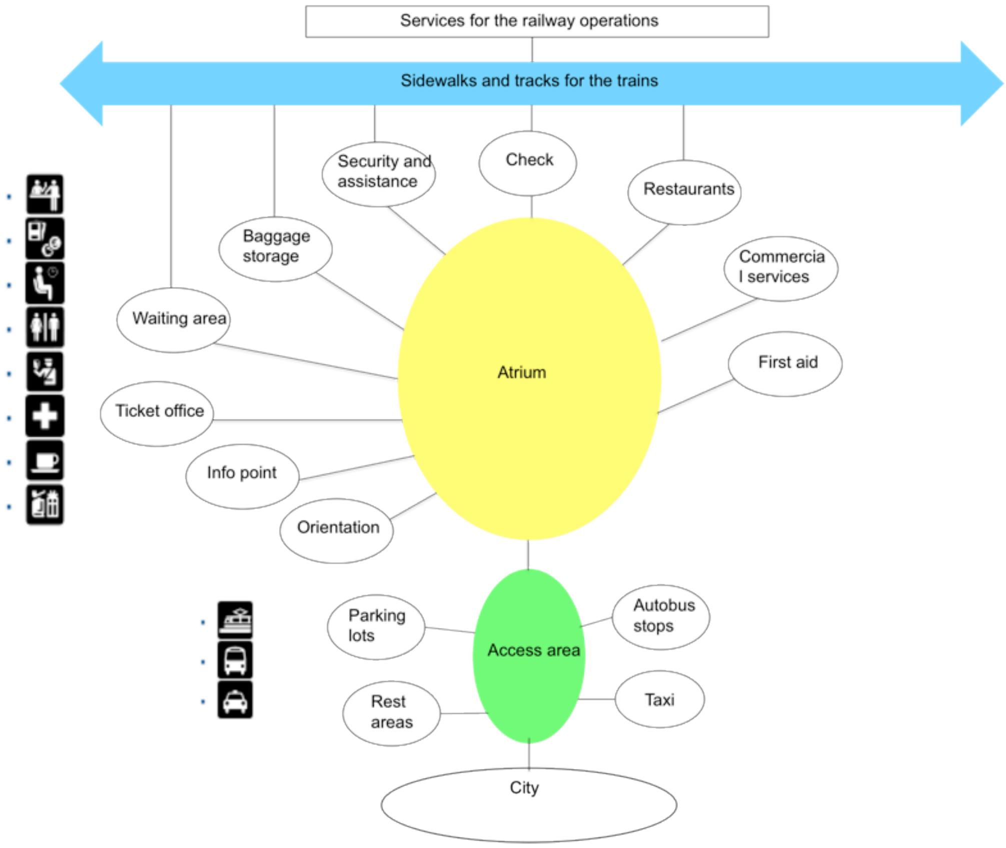




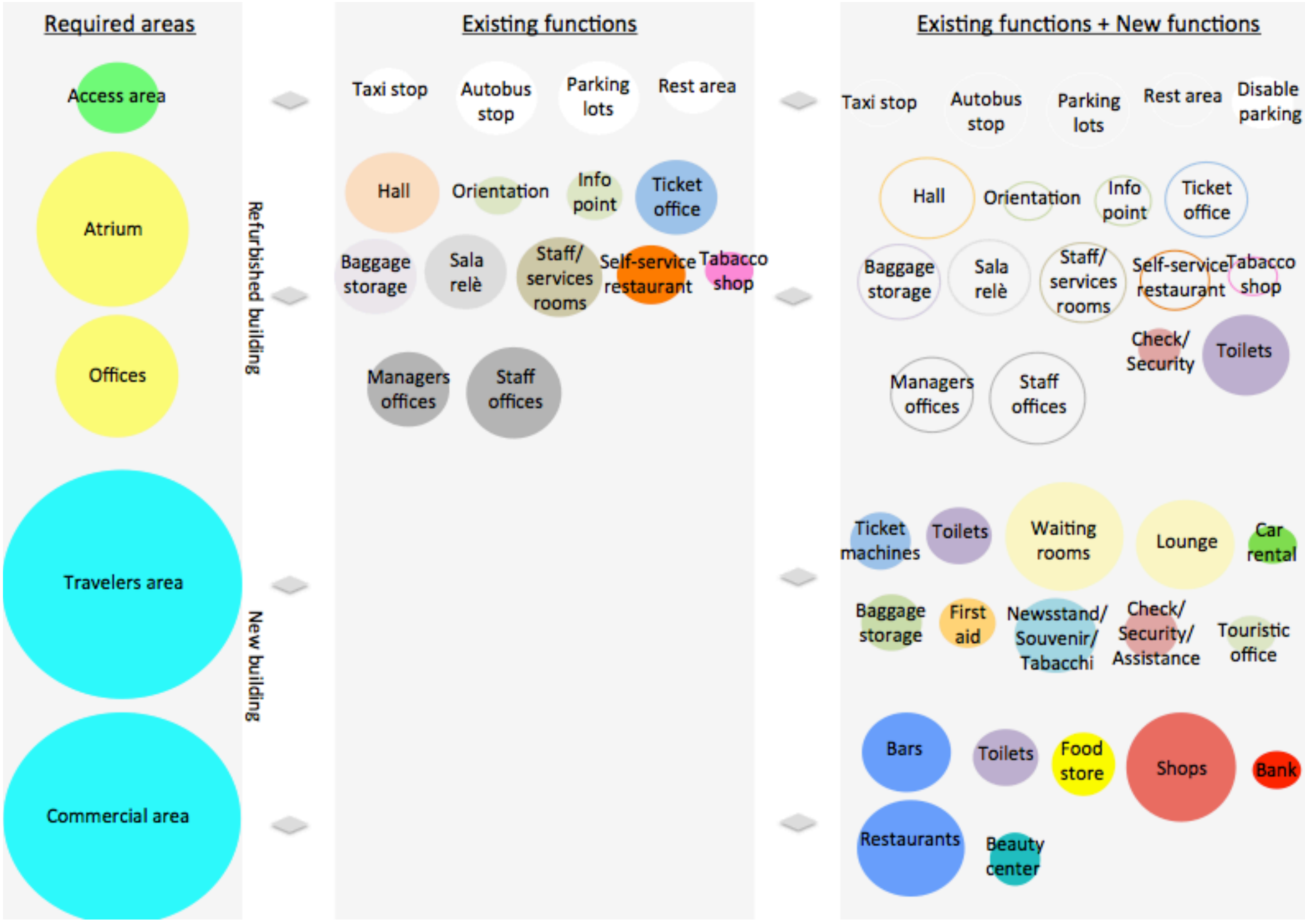


Functions

Choosing the main structure, it has to be study which functions have to be added to the station: for this reason i had followed the national regulation of Grandi Stazioni that expresses the main functions for a big station and how to connect each other for the best crossing of the travellers:



From this scheme it possible to create the new functional layout for the central station of Bari, letting some existing functions and putting some new functions and new connections that are related with the new 'flying' platform.

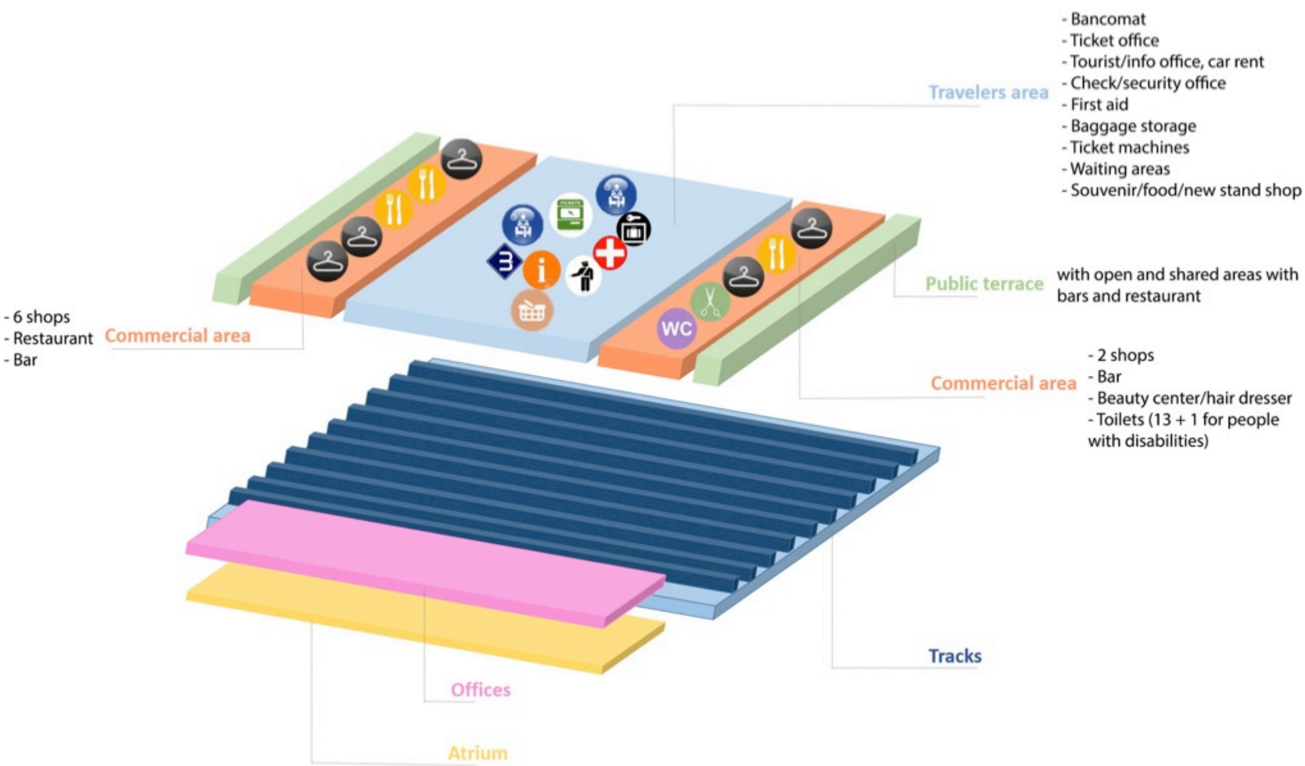


Adding all the requirements the new functional layout is divided as in the figure below.

The existing station, divided in two floors, has maintained its functions but well distributed: in the ground floor there is the main atrium and the ticket offices, toilets and the offices for the station functions; the first floor it remains the same, with the staff and managers offices.

The new platform instead is divided in three areas, to better direct the travellers' traffic:

- The central zone is the TRAVELLERS AREA that creates a direct flux from the entrance to the exit and the train tracks and viceversa. There are the main functions needed for tourists and the travellers as the bancomat area, the ticket offices, the tourist/info office, the car rent, the check/security office, the first aid, the baggage storage, the ticket machines near the sitting areas, the waiting areas and the souvenir/food/new stand shop;
- The lateral areas are the COMMERCIAL AREAS reserved for the shops, restaurant, bars, beauty center/hair dresser and the toilets;
- On the external sides there are the TWO PUBLIC/URBAN TERRACES with spaces shared with the bars and the restaurant and long paths to look the trains and the city.



Connections

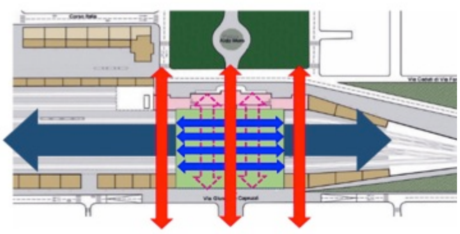
All the functions are linked with direct vertical and horizontal connections:

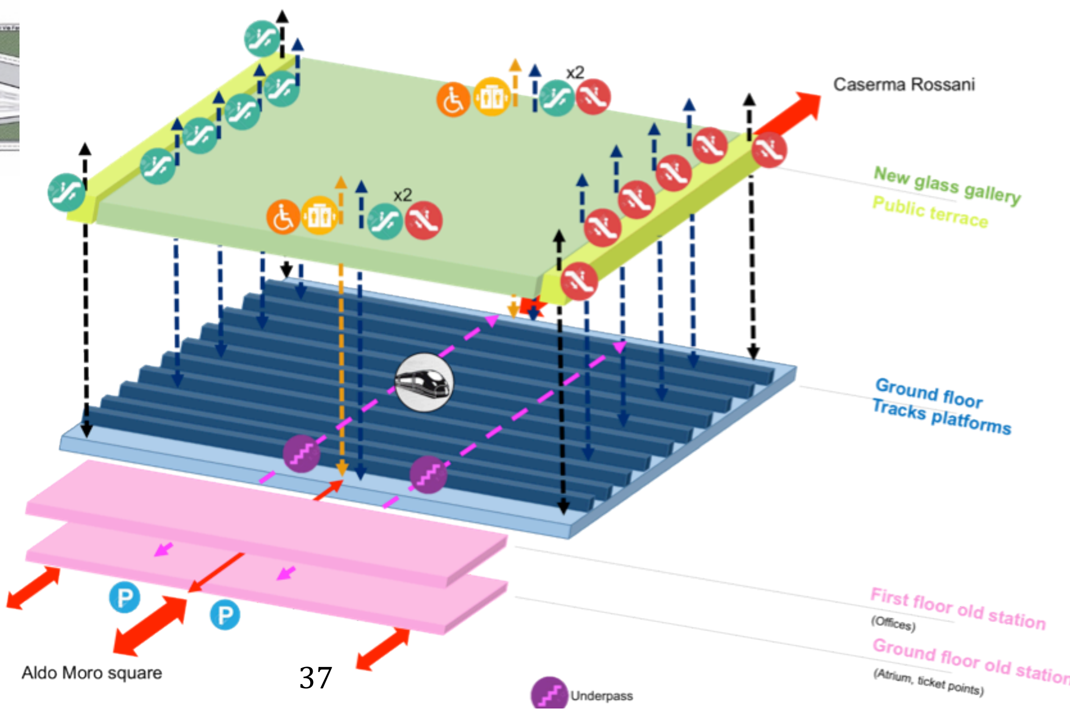
HORIZONTAL:

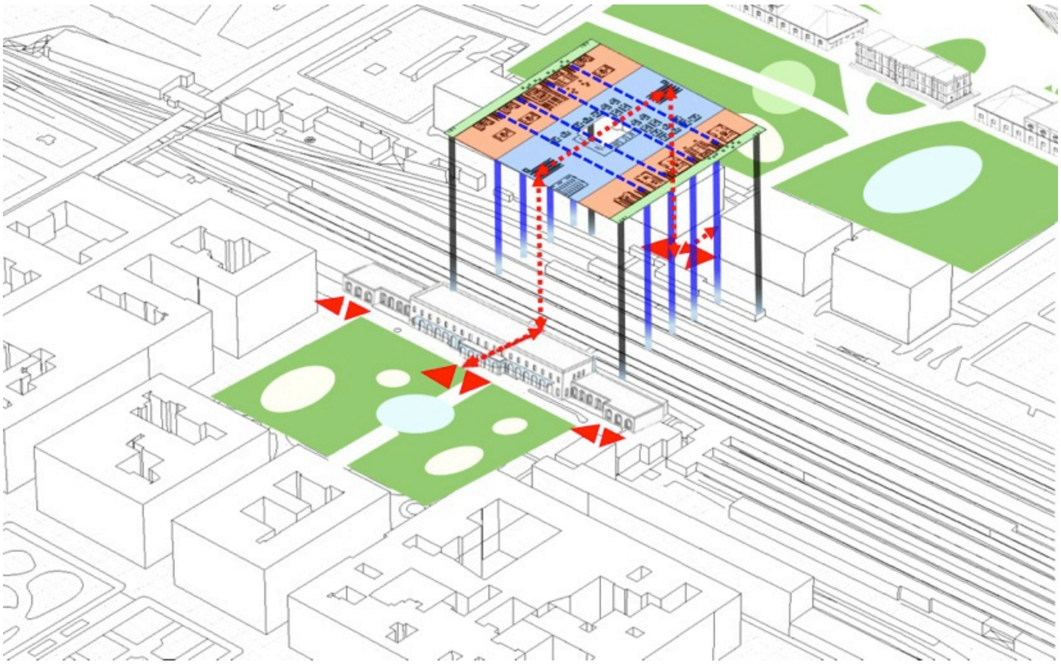
- From/to Aldo Moro square to/from the existing station there are three entrances one in the middle that is used primarily to the travellers and the other two on the lateral sides for the people who don't want to enter to the station but only want to go the platform for the shops and bars or restaurant. In front of the station there are also the bus, taxi and car stops;
- From/to the existing station to/from the other sides of the train tracks and the Caserma Rossani with two underground and pedestrian paths.

VERTICAL:

- From/to the existing station to/from the new platform there are four central escalators and one elevator that arrive directly to the travellers area and four later escalators that arrive/leave on the two terraces;
- From/to the train tracks to/from the platform there are sixteen escalators, eight on the left and eight on the right that arrive on the commercial areas;
- From/to the new platform to/from the Caserma Rossani side there are four central escalators and one elevator and four lateral escalators that arrive/come back on the two terraces.





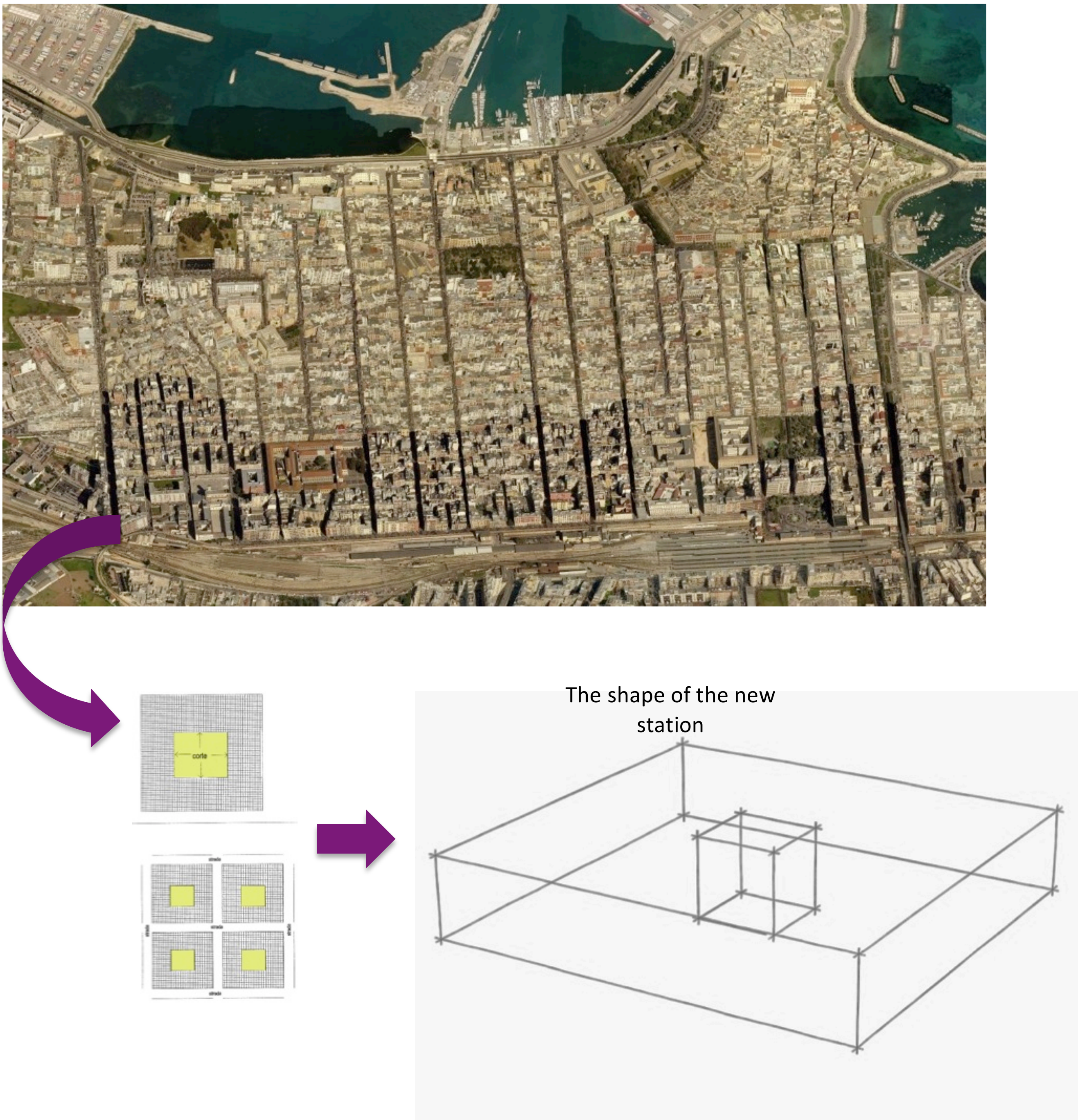


Station's accesses
Aldo Moro square - Travelers area - Caserma Rossani connection
Aldo Moro square - Commercial area- Caserma Rossani connections
Aldo Moro square - Terrace - Caserma Rossani connections

2.3 The architecture

The starting point for the general shape of the new platform station was the idea to maintain the traditional regularity and pattern of the ancient city, really closed to the station.

The Murat district is characterized by the presence of regular and symmetric houses, and by the **COURT HOUSES**. From here starts the idea to create a station with same shape of a **house with the central courtyard**.



Using this shape the all design of the station is clear and linear as well as for the material chosen.

The tradition of the shape is mixed with the modern materials used for the envelope: **GLASS and STEEL** are the main elements that characterize all the structure.

The glass wants to give to the building the idea of a completely open space on the city, the idea that the station is an important part of the city, and to create an important visual connection with the most important element of Bari: the sea.

The steel is present with its color also in the covering, made by big copper zinc panels.

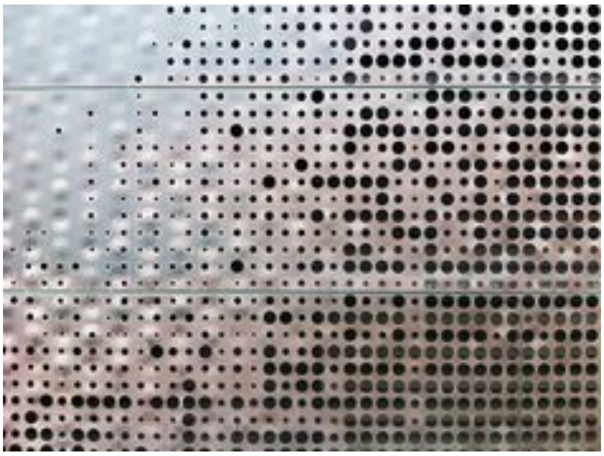
The **COPPER ZINC ROOF** has a really big impact on the all structure, due to its big dimensions and for the big quantity of the copper zinc panel used.

The contemporary architecture benefits from copper, because it complements commonly used materials such as brick, wood, stone and glass, and it is well integrated for a building with the modern style. In addition, copper architecture meets the important requirements of state-of-the-art building design, which demands recyclable and sustainable materials. In existing legislative framework, the production and use of copper products generally safeguards the environment and citizens of Europe, where about 45% of copper demand is met using recycled resources.

Copper is a beautiful material, can have a lot of colours: for the station I don't chose the typical colour of the red copper but I used the Zinc grey copper to have an absolutely continuity with the steel structure and for its appealing look and its long life.

In addition to the duration, the copper has some properties that make it suitable as material for roofs. First, the workability, which allows installers to perform the intricate details, even at low temperatures. A copper roof well laid does not require cleaning and maintenance; thanks to the availability of thin thickness is relatively light.

Copper, and copper alloys, give performance, durability (100+ years), a range of colours, forms and textures, all in a natural, 100% recyclable material.

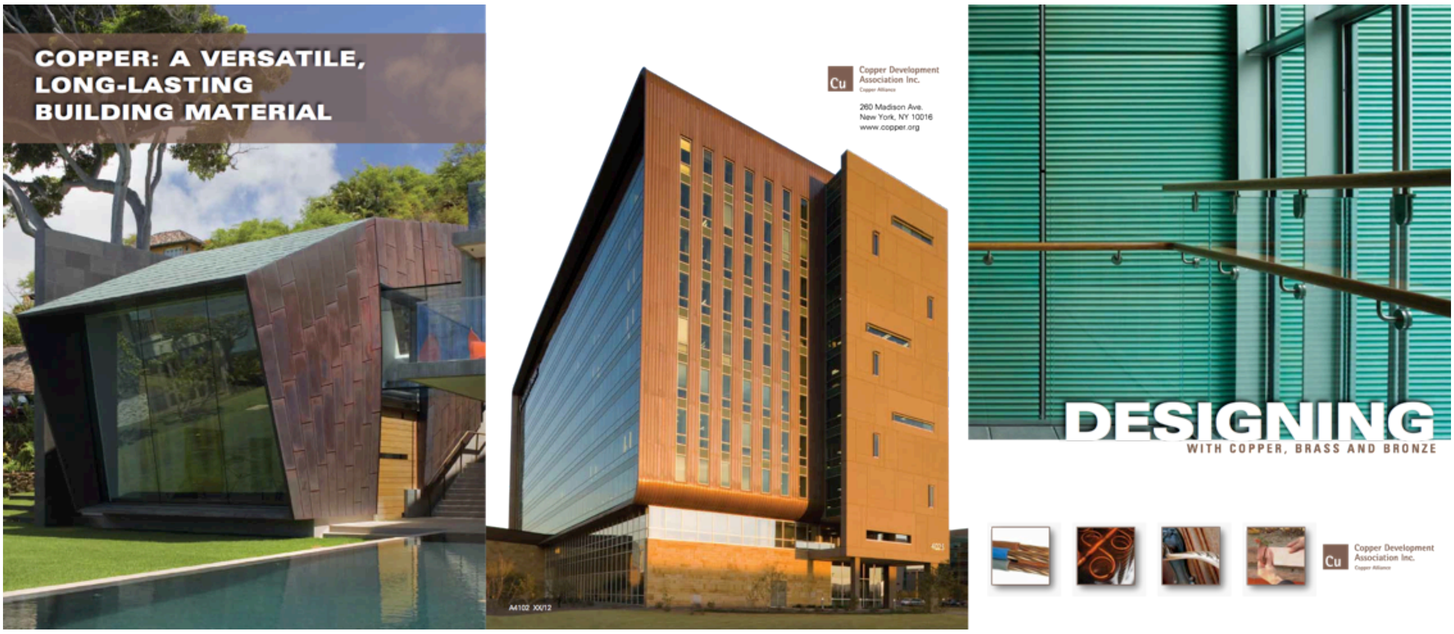


Grey copper: elegance and durability

The discreet and elegant expressivity of this exquisite matt grey surface harmonises excellently with many other building materials. The union of two exceptional metals combines the proverbial longevity of the principal material with a metallic surface, which, although not typical for copper, can give to it the right feeling. During the production of the Zinn copper, the copper strips are specially tinned and surface-treated on both sides. The resulting surface gradually takes on the characteristic colour opaque grey, when exposed to the weathering.

Summarizing the copper is:

- Aesthetic;
- Easy to alloy;
- Antimicrobial;
- Colourful;
- Durable;
- Low thermal expansion;
- Easy to join;
- Essential;
- Malleable and ductile;
- Safe;
- Recyclable;
- Available and Sustainable;
- Tough;
- Easily shaped.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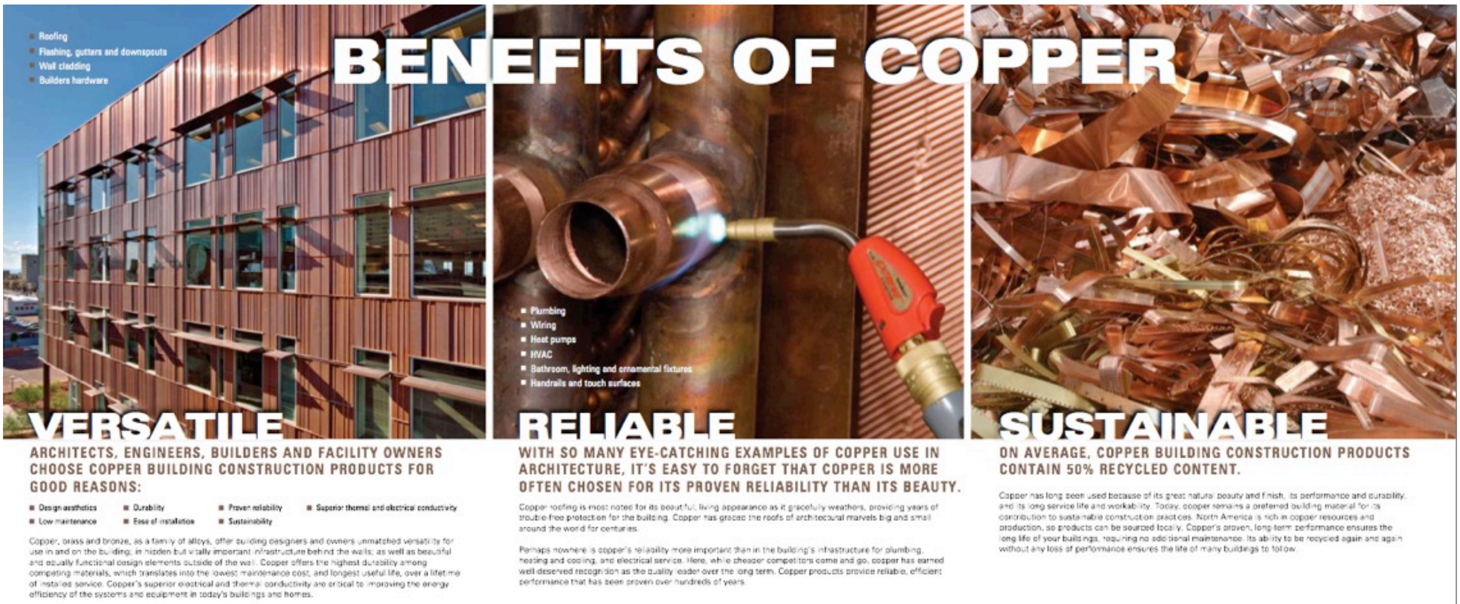
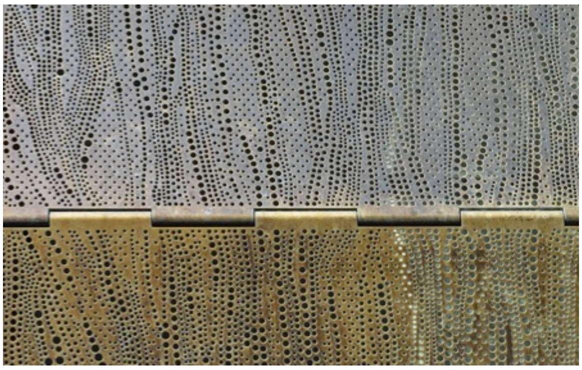
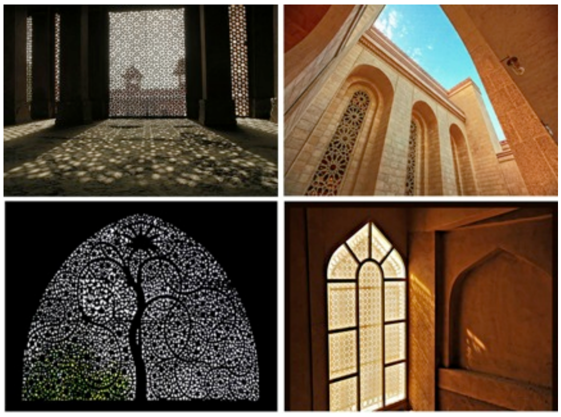

BENEFITS OF COPPER
Roofing
Flashing, gutters and downspouts
Wall cladding
Builders hardware
VERSATILE
ARCHITECTS, ENGINEERS, BUILDERS AND FACILITY OWNERS CHOOSE COPPER BUILDING CONSTRUCTION PRODUCTS FOR GOOD REASONS:
Design aesthetics
Durability
Proven reliability
Superior thermal and electrical conductivity
Low maintenance
Ease of installation
Sustainability
Copper, brass and bronze, as a family of alloys, offer building designers and owners unmatched versatility for use in and on the building; in hidden but vitally important infrastructure behind the walls; as well as beautiful and equally functional design elements outside of the wall. Copper offers the highest durability among competing materials, which translates into the lowest maintenance cost, and longest useful life, over a lifetime of installed service. Copper's superior electrical and thermal conductivity are critical to improving the energy efficiency of the systems and equipment in today's buildings and homes.
Plumbing
Wiring
Heat pumps
HVAC
Bathroom, lighting and ornamental fixtures
Handrails and touch surfaces
RELIABLE
WITH SO MANY EYE-CATCHING EXAMPLES OF COPPER USE IN ARCHITECTURE, IT'S EASY TO FORGET THAT COPPER IS MORE OFTEN CHOSEN FOR ITS PROVEN RELIABILITY THAN ITS BEAUTY.
Copper roofing is most noted for its beautiful, living appearance as it gracefully weathers, providing years of trouble-free protection for the building. Copper has graced the roofs of architectural marvels big and small around the world for centuries.
Perhaps nowhere is copper's reliability more important than in the building's infrastructure for plumbing, heating and cooling, and electrical service. Here, while cheaper competitors come and go, copper has earned well-deserved recognition as the quality leader over the long term. Copper products provide reliable, efficient performance that has been proven over hundreds of years.
SUSTAINABLE
ON AVERAGE, COPPER BUILDING CONSTRUCTION PRODUCTS CONTAIN 50% RECYCLED CONTENT.
Copper has long been used because of its great natural beauty and finish, its performance and durability, and its long service life and workability. Today, copper remains a preferred building material for its contribution to sustainable construction practices. North America is rich in copper resources and production, so products can be sourced locally. Copper's proven, long-term performance ensures the long life of your buildings, requiring no additional maintenance. Its ability to be recycled again and again without any loss of performance ensures the life of many buildings to follow.

On the roof, to create tunnels of natural light, are installed 32 **skylights**, on the most important areas: the two entrances and the two lateral paths near the commercial and waiting spaces.

It is used the **perforated copper**, to create beautiful plays of light inside the station: the copper facade has lends a movement which folds upwards and the perforations create a dialogue with the surrounding buildings. The small perforations on the skylights recreate the Arabian tradition, typical in the Mediterranean area and architecture.

The light is an important factor in architectural design. The most common use of light in architectural lighting internal space needed to carry out activities in accordance with a space. The light in architecture has been responsible for developing and living space. Meaning and symbolism of light is connected with aesthetic sense and have an important role in improving the quality of architectural space





2.4 Technology, Energy and Smart City

For the energy saving demand the principal line that I follow is the Smart City philosophy that resumes in a more specific case all the goals of the One Living Planet framework.

THE SMART STATION

"Smart Cities" is an initiative promoted by the European Union as part of the SET-Plan, the instrument with which the Union defines its policy in the field of energy technologies. SET-Plan traces the logical framework within which to develop actions to achieve the objectives of Agenda 2020, but its period is extended until 2050, the date by which the plan aims to reduce greenhouse gas emissions up to a maximum of 90%, by developing new methods and new technologies for the production and use of energy in low CO2 emissions.

Inside of the SET-Plan, the initiative "Smart Cities" has the strategic objective of improving the quality of life of people living in urban areas, enabling investments to increase the energy efficiency of the city. The initiative aims to reduce by 40% by 2020 CO2 emissions of European cities.

Thanks to "Smart Cities", the European Union intends to engage in pilot projects up to 25 cities/ metropolitan areas, engaging resources for about 12 billion euros to finance actions and interventions in the areas of Construction of buildings with high-energy efficiency, in energy and Sustainable Mobility.

BARI "SMART CITY”

The Municipality of Bari initiated a process aimed at the programmatic presentation of the candidacy to the "Smart Cities" and the implementation of interventions to improve the quality of life for citizens and more sustainable cities in terms of energy. The initiative "Bari Smart city" has the primary objective to inform, engage and mobilize the community, the residents, associations, public and private organizations, in order to develop an effective plan of action in cooperation with the European Commission. The first act of this route has seen the membership of the city to the Covenant in July 2010. The Covenant of Mayors, which sustains and supports the efforts of the local authorities of the European Union, involves for Municipalities members of the drafting and implementation of a Plan of Action for Sustainable Energy (PAES), which set the targets for reducing emissions and how to reach them. The City Council approved the PAES of the city of Bari in its final October 27, 2011.

Premise

The train station is, by its nature, a nerve center of the urban community, the ideal location for transit and terminalisation of networks and / or services, not even closely related to rail transport, as node integration of the different city networks: infrastructure, communication and information.

In this respect, there is the concept of Smart Station, a unique opportunity for the RFI that has in its mission the technological modernization and the development of the lines and the installations.

Smart Station in Smart City

According to the definition of the European Community the degree of "intelligence" of a city (Smart City) can be measured on six dimensions: economy, mobility, environment, living and governance.

Within each area are defined evaluation mechanisms that identify the efficiency and the quality of implementations that using innovative solutions, the optimization of the resources and the integration of the systems, allow the achievement of the objectives of sustainability, liveability and social equity.

The definition of these areas of action can be reported in the railway environment, contextualizing the evaluation mechanisms and the typical solutions of each area within the station, arriving at the definition of Smart Station.

- **Economy:** renew a technological context, bringing it to move with the times, reducing the investment costs and optimizing the maintenance management. Introducing factors as the innovation in areas that until now have been considered complementary with respect to the transport service offered such as comfort, internal mobility, the production and the consumption of energy;
- **Mobility:** provide easy movements both inside and from and to the outside of the station (accessibility), with special attention to people with reduced mobility, and adequate information to the public through the use of advanced mobile information such as information kiosks, audio and video information, etc. Also make available services at intermodal areas equipped with parking control systems, charging equipment for electric vehicles, etc;
- **Governance:** have an overall view of the station and of its development and define, based on this, strategies and lines of action. Identify the best technologies to optimize the functional processes and the services that a station can offer and promote, at the same time, within the company raising awareness on current issues;
- **People:** a smart station offers to the customer a meeting place where the elements of satisfaction of the mobility and the use of technologies that facilitate the identification of the

relevant informations for their journeys, merge with the enrichment of services of high added value. Such as making available comfortable zones and commercials spaces useful in times of interchange/standby and provide connections with Wi-Fi and offering tourist information kiosks;

- **Environment**: promoting a sustainable development that has as paradigms:

  - The rationalization of the consumptions;

  - The reduction of the impact of heating and air conditioning;

  - Reduction of waste production;

  - Strengthening of the collection.

- **Quality of life**: that in a context of station results in quality and comprehensiveness of the services offered by providing an aggregation/displacement center in which the user can, thanks to advanced technological systems, have always available the information requested. Create, through advanced techniques, thematic routes and mappings to make easily accessible the stations themselves.

Objectives of a Smart Station

The primary objective is to get to identify an "horizontal" model on which converge in order to achieve integration, cooperation, inclusion and maximization of the investments and of the objectives of RFI, creating the conditions for wider replicability, scalability and development.

Among the objectives that a Smart Station has to aim there are:

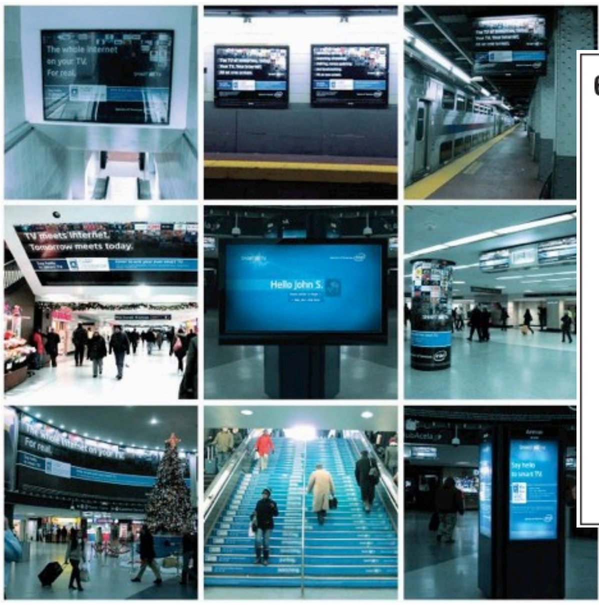
- Environmental sustainability;
- Energy saving;
- Quality of the service;
- Reducing LCC (Life Cycle Cost):
- Design;
- Realization;
- Maintenance;
- Centralization of the information;
- Supervision of the plants;
- Integration with the business information systems.

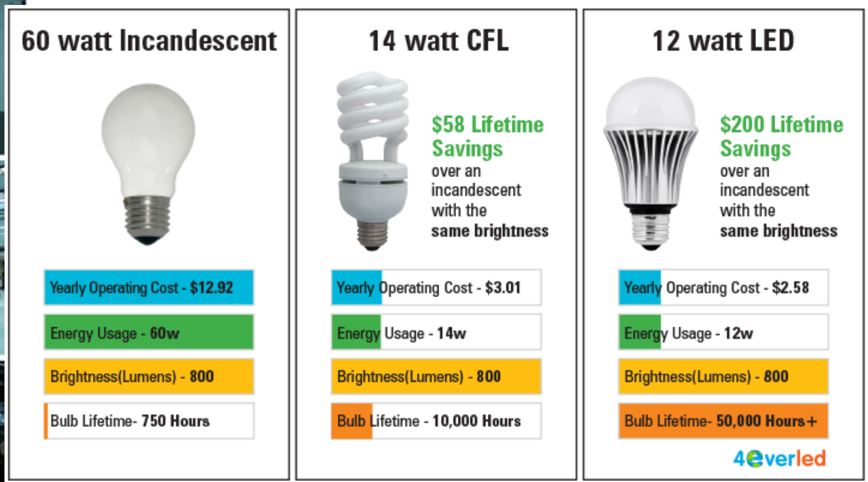
Fields of application

In order to provide a methodological approach to the full implementation of the model "smart" in the sites that are the key elements of the infrastructure network of RFI (such as railway station, bus stops and forecourts), have been identified the thematic areas of intervention.

- **Lighting**

Adoption of LED technology for lighting areas and rooms, combined with appropriate technology of remote monitoring/remote management, optimizing the energy consumptions, leading to lower fuel consumptions and reduced maintenance. In addition adoption of light sensors and motion for the reduction of the luminous intensity in the presence of daylight or in the absence of movement in the night hours.





- **Systems of mobility and accessibility**

Video control and prevention of vandalism in the escalators' areas, in case of failure, diagnostics targeted to the work center responsible.

- **Management of critical issues**

<u>Antifire</u>

Remote monitoring technologies and computerized management of the critical elements of the components making up the system of the fire system.

<u>Water lifting from underpasses</u>

Integration with the lighting and emergency systems and other systems able to acquire alarms about the flooding of certain areas of the station, control of pumps' state.

Auxiliary supplies and electric power machines

Sensor system that allows the check of the status of the systems and the reporting of any failure and/or malfunction.

Electrical panels and switches

Switches monitored resettable.

- **Environmental sustainability**

Before to find the best solutions for each sustainable solution we had make a RISKS' ANALYSIS:

ATMOSPHERICAL AGENTS	DANGERS	AUTUMN/ WINTER	SPRING/ SUMMER
Rain	Direct exposition Flooding Slippery ground	**YES**	**YES**
Snow/ice	Direct exposition Overhead of structures Slippery ground	**YES**	**NO**
Low temperature	Direct exposition	**YES**	**NO**
High temperature	Highlights Heatstroke	**NO**	**YES**
Strong wind	Overhead of structures Separation of materials or of temporary work Dust	**YES**	**YES**

Metering, Saving & Monitoring

Control and monitor of all the utilities (electricity, water and gas) and of the equipments more energy-intensive.

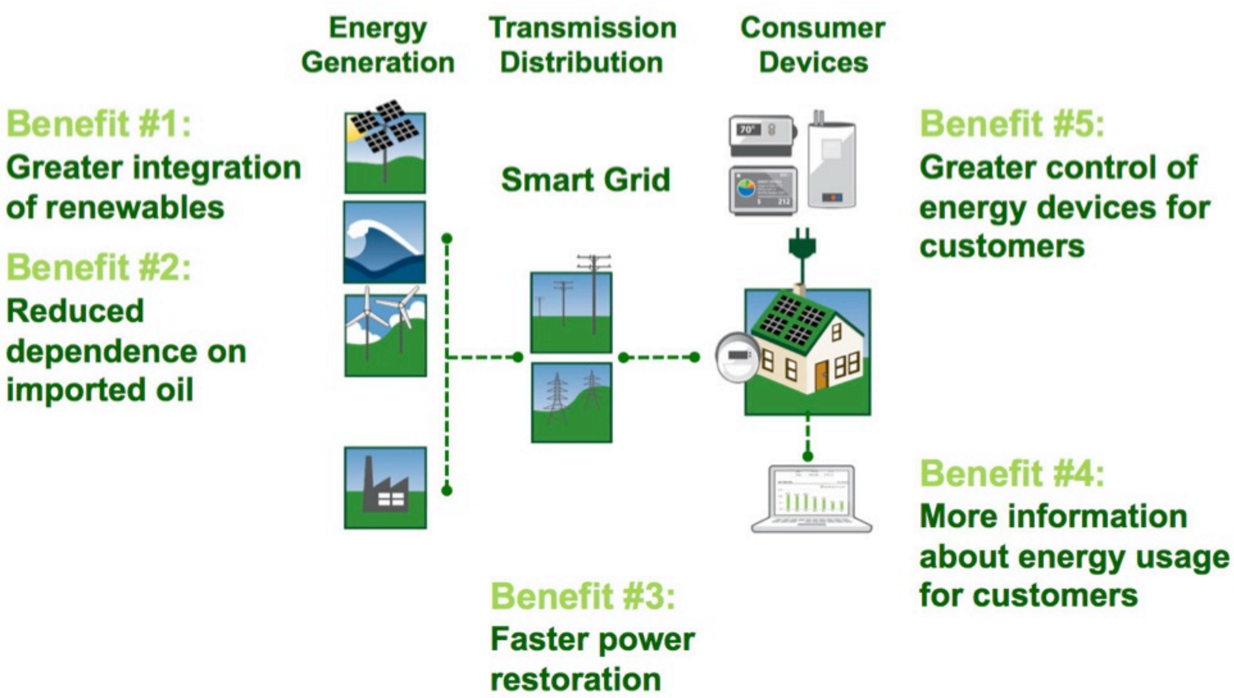
Water treatment

Rainwater collection systems and systems for their subsequent reuse as: irrigation of green areas, supply of heating and cooling systems, supply of the dual networks of supply for exhaust systems in toilets, water Fire integration.

Energy production from renewable sources

Auto-production of energy from wind/micro wind, solar and thermal.

At the base of the energy strategies adopted there will be a Smart grid with which it is possible to manage in real time and in an optimal manner the availability of energy sources and the energy demand, which normally are discontinuous, for example due to the varying of the availability of the sun and energy demand. Smart grid, favouring the system of local generation of renewable energy, enables the intelligent management of these changes and also implies a considerable reduction of distribution losses due to the distance between the central production of electricity and utilities, thus increasing the technological efficiency overall.



Areas that can be equipped

Introducing devices hot-spot to offer to the users an internet connection with free Wi-Fi, recharging stations for electric cars, bicycles, mopeds, battery chargers for mobile phones and personal computers (in 2013 was installed the first charging services: this is the first public charging station in a distribution network that will be comprised of 50 Enel charging points for electric vehicles (EV), located in key areas throughout the city, chosen in conjunction with the Bari municipal government based on a careful analysis of the area and its traffic flows),

parking control systems, information kiosks that provide interactive multimedia services such as real-time informations on the rail and road traffic, public transports available, parking occupancy, weather, tourism, occasional events, etc.

(for this purpose it was created an application for smartphones and iPhone).

- **Comfort**

<u>Production of domestic hot water or for the traditional heating</u>

Correct choice between the instant systems and the systems of accumulation of hot water production, implementation of the systems of heat recovery.

<u>Heating, ventilation and air conditioning (HVAC)</u>

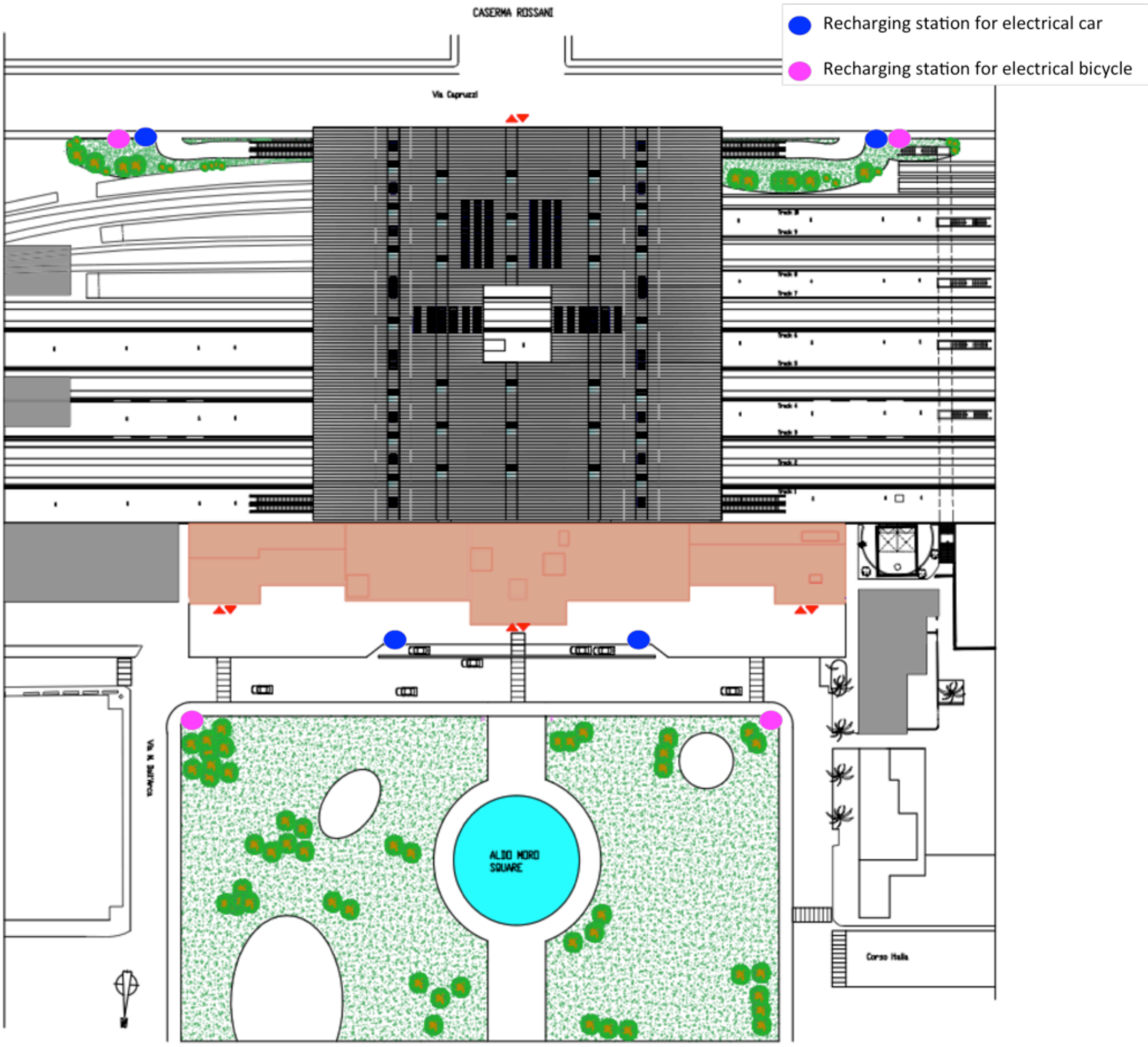
Use of materials with low thermal dispersion, installation of accounts of calories/frigorie.

<u>Toilets</u>

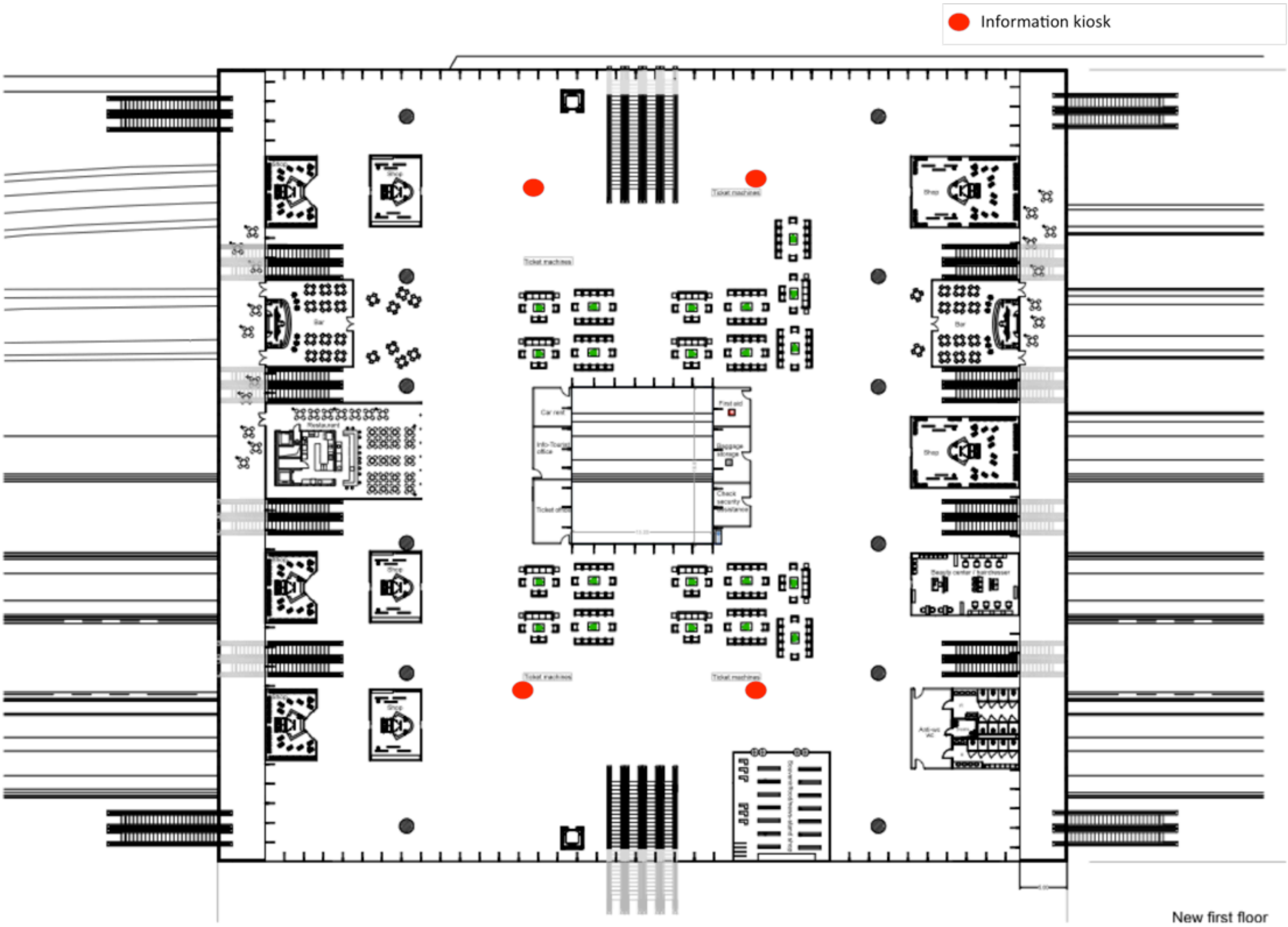
Installing of Automated Toilets in management to companies of the sector.

Below there are the masterplan and the plan on the new station with the location of the information kiosks and the recharging stations.

THE MASTERPLAN



THE FIRST FLOOR



Going more in the detail the principal sustainability technology adopted in the station, that follow the smart grid are:

- Application of PHOTOVOLTAIC and SOLAR PANELS for the energy and hot water needs of the station and the commercial activities. They are installed on the roof in the flat part and on the two slopes, mainly direct to Southeast.
- Exploitation of the NATURAL VENTILATION through the central void and the opening on the external glass façades. That phenomenon is possible thanks to the principal wind that comes from the West-East direction. Through the central opening passes the air, which it has been refresh by the big quantity of trees present on le track area, creating a natural air conditioning for the glass platform. Instead the openings on the top of the glass facades permit to the hot air inside the station to exit. Add to these systems there is also the ventilated roof, with a grid of 5 cm that creates the free space between the layers allows air to pass trough.
- For the human comfort are installed on the all glass facades, HORIZONTAL SHADING DEVICES, to avoid the summer overheating. In fact in the buildings placed in the Mediterranean area is better to use an opaque of covered façade because during the summer the sun has a high radiation.

PHOTOVOLTAIC PANELS (see attached detail)

How do they work?

Electricity is produced from sunlight through a process called solar photovoltaic. Photovoltaic cells are made of semi-conducting materials, so when the sunlight strikes, it is converted into electricity.

The technical part...

The solar cells are made of several thin layers of silicon. When sunlight strikes, the electrons within the cell are knocked loose. By the absorption of a photon (light particle), the negative electron gets shunted away from the silicon atom, and a positive 'hole' remains. The freed electron and the positive hole together are neutral. Therefore, to be able to generate electricity, the electron and the hole need to be separated from each other. This is done by giving layers within the cell opposite charges, so that the freed electrons cannot return to the positively charged holes. When the electrical contacts on the front and rear are connected through an external circuit, the freed electrons can only return to the positively charged holes by flowing through this circuit, thus causing electricity to flow. This means that the greater the intensity of light (larger number of photons), the greater the flow of electricity.

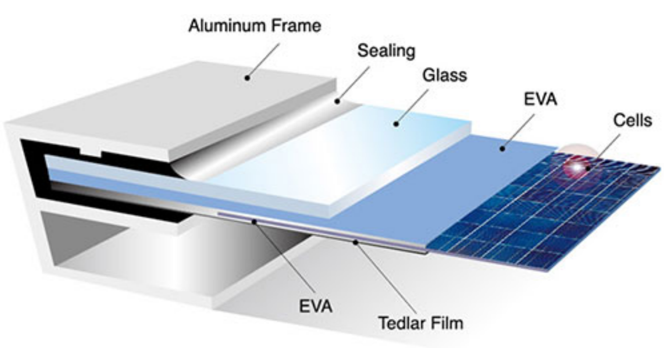
...And what happens if the sun isn't out?

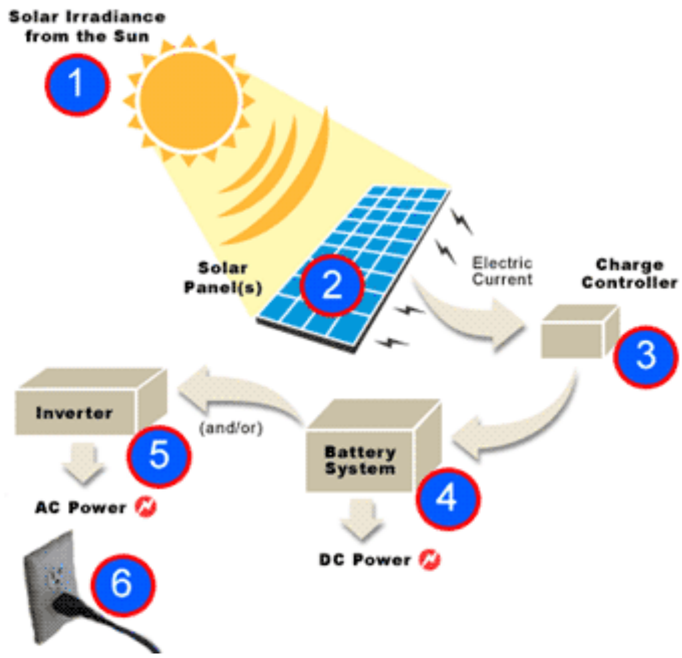
Even if the sky is overcast, PV still produces electricity. This is because PV cells not only use direct sunlight, but also diffuse solar radiation, which is light that has been scattered by dust and water particles in the atmosphere. Obviously the amount of useful electricity generated is proportional to the intensity of light energy, which falls into the conversion area. However, you can still have an electricity supply even without the sun!

To determine the PV electricity generation potential for a particular site, it is important to assess the average total solar energy received over the year.

What about at night?

Despite its advanced technical capabilities, a PV system will not generate electricity at night, but the system is able to store collected energy in a battery for use during non-daylight hours.





The benefit of solar power

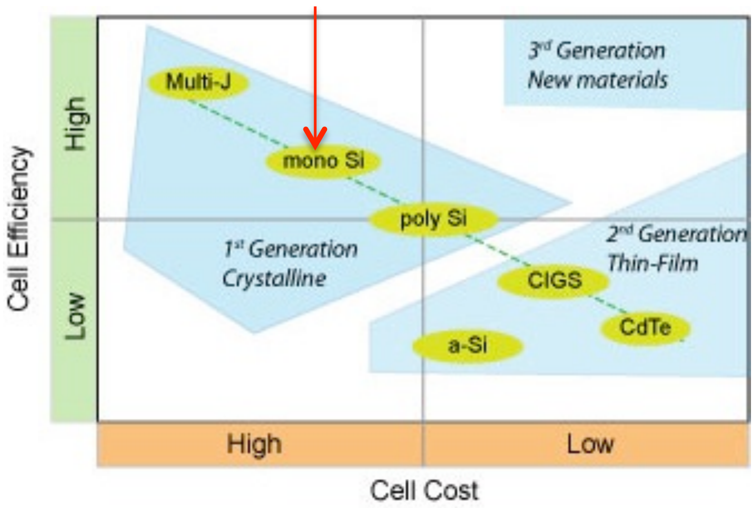
- **Environmentally friendly**: The PV modules are made out of silicon which is entirely benign, and available in abundance. No noise pollution or harmful gases are emitted during the operation.
- **Immediately available**: PV utilises the most abundant energy source on the planet - the sun.
- **No barriers to installation**: PV is not affected by 'Nimbyism' or affected by planning delays.

- **Minimal maintenance**: PV has no moving components and is virtually maintenance free.
- **Flexible**: PV systems can be incorporated into all types of building, and retrofitted on existing roofs, or as part of the building envelope at construction stage. It can be curved and shaped to the building design.
- **Cost effective**: In grid locations where grid connection is too expensive.
- **Reduces energy bills**: Having a solar roof provides you with a power source that can be used to augment your grid connected electricity supply subsequently reducing your electricity bills. In addition, having PV as an energy resource increases your awareness of electricity use and encourages more efficient energy behaviour. This in turn leads to lower energy bills.

For the station are used PV panels with silicon and monocrystalline cells:

The silicon cells are more efficient at converting sunlight to electricity, but generally have higher manufacturing costs.

The crystalline cells have been in service the longest and exhibit outstanding longevity. Cells developed almost 40 years ago are still operating and most manufacturers offer 10-year or longer warranties on crystalline cells. There are two sub-categories of crystalline cells – single crystal and polycrystalline. They both perform similarly. The efficiency of crystalline cells is around 13%.



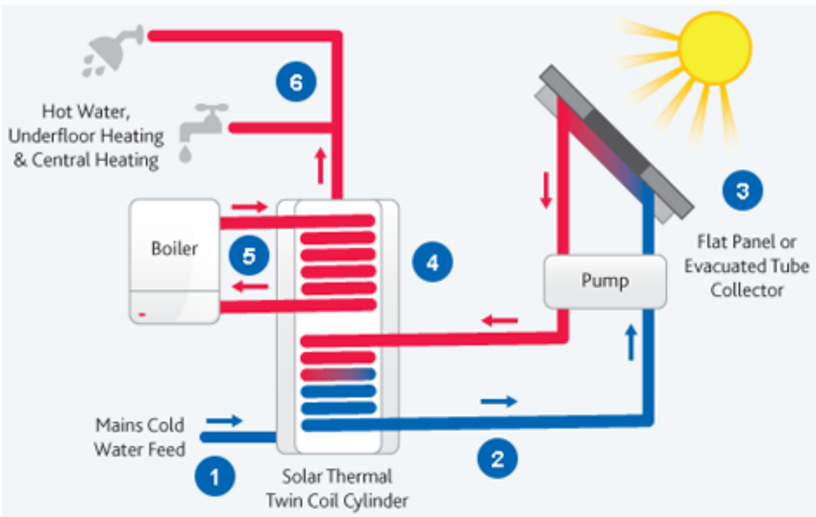
SOLAR THERMAL PANELS

How do they work?

The solar panels produce heat, differently from PV panels that produce energy. The direct systems capture the sun's heat in collectors to directly heat a household's water supply. The system consists of collector pipes filled with water that are linked to an insulated storage tank usually located inside a home. As the sun heats the water inside the pipes, the water flows into the storage tank. Although direct systems are more efficient that indirect ones, they require more maintenance to keep the pipes clear of mineral deposits.

The benefits of solar water heating

- **Hot water throughout the year**: the system works all year round, though you'll need to heat the water further with a boiler or immersion heater during the winter months.
- **Reduced energy bills**: sunlight is free, so once you've paid for the initial installation your hot water costs will be reduced.
- **Lower carbon footprint**: solar hot water is a green, renewable heating system and can reduce your carbon dioxide emissions.



NATURAL VENTILATION: breathe life into the station

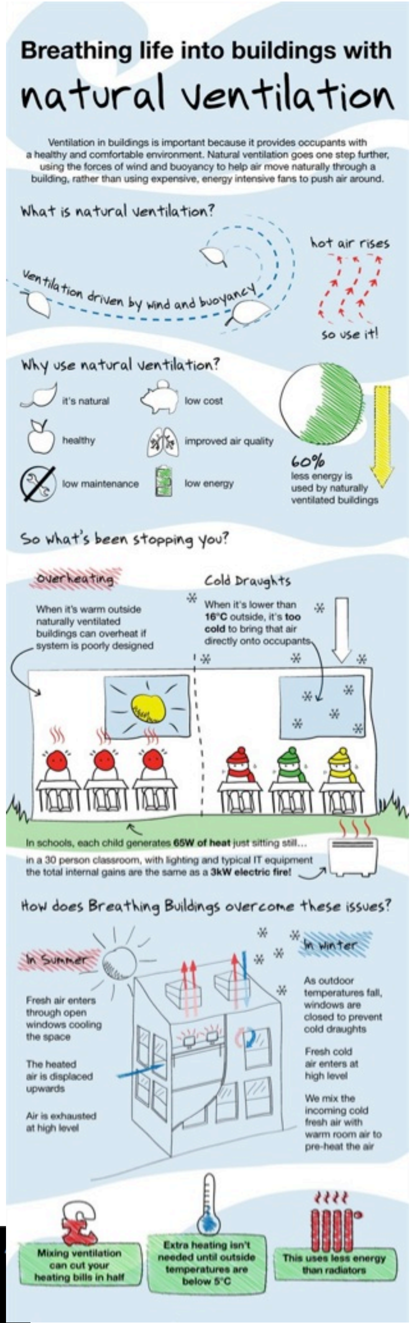
Refresh the building with a natural ventilation system.

As buildings become more contemporary in their design, sustainable strategies, such as natural ventilation, are becoming increasingly important to a structure's core principles.

Not only does such an approach allow for a building to use 60 per cent less energy, it also drastically improves the air quality for the occupants within.

How does it work?

Natural ventilation takes advantage of both wind and difference in temperature in order to drive fresh air through a building. This removes the need for the use of intensive fans, which can often be expensive in terms of energy use and installation.



Using the 'stack effect' this ventilation method makes use of the fact that warm air rises above cold air. Naturally ventilated buildings can utilise this so that an atrium allows warm air from an occupied space to rise and escape through vents situated at the top of the building.

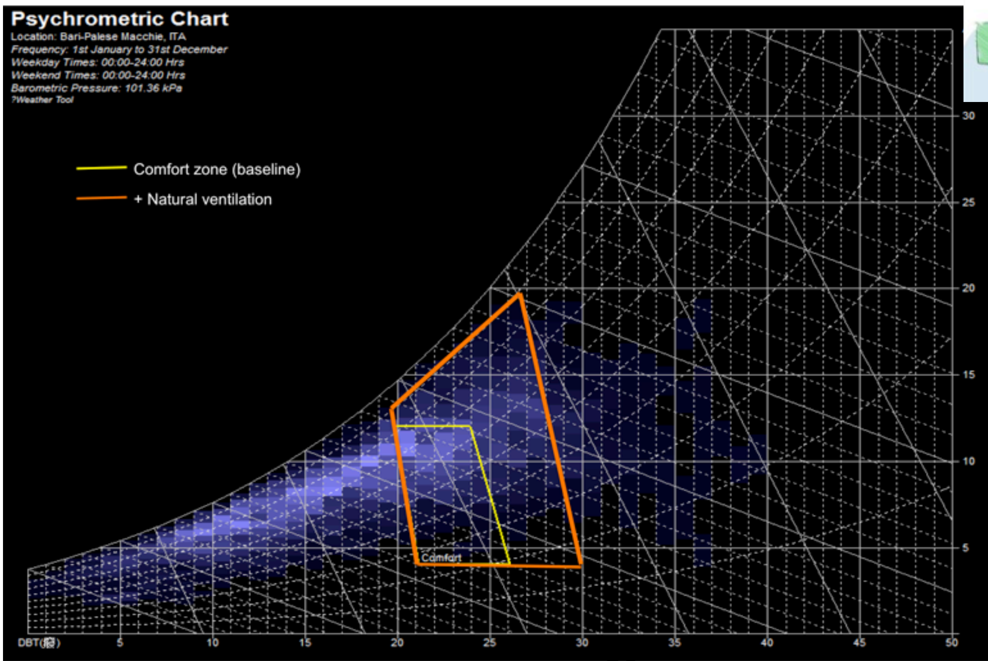
Why use it?

For a start, it costs less to use than some other ventilation methods. By making use of natural elements like the wind these sustainable systems can lead to much cheaper energy bills.

The fact that the buildings will use less energy with a natural ventilation system also means that the amount of carbon emissions that it produces will be significantly reduced as well.

Another added positive of natural ventilation is that it can require much less maintenance than air conditioning. What's more, it gives a building's occupants more control over their surrounding environment, as well as making them more comfortable.

The natural ventilation can also increases the human comfort range inside the station, as it is sown in this chart:

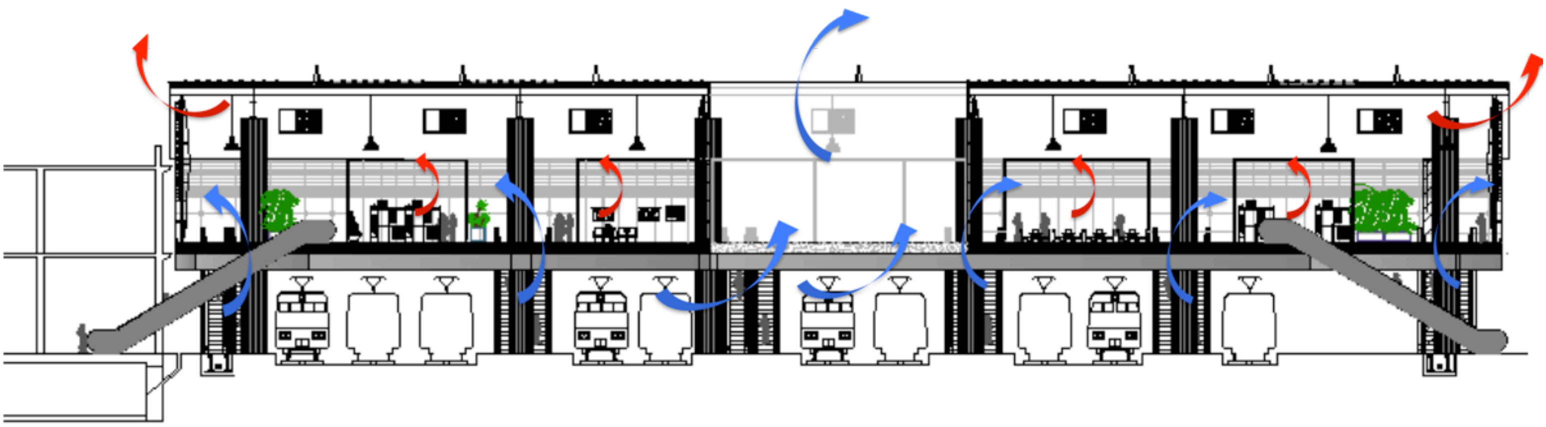


A versatile solution

Most occupied buildings can accommodate for a natural ventilation system. It can work on its own or with other energy-efficient ventilation techniques that a building may have in place. Offices, schools, universities, health care centres and council buildings can all make use of this type of sustainable strategy.

Although it is best to integrate natural ventilation at the earliest possible stage, it can be introduced as a part of a retrofitting project, meaning that existing buildings can still benefit from it on some level.

In the station the natural ventilation in generated by the central void and the voids created by the escalators, by the openings on the top of the glass facades and by the ventilated roof, as it is shown in these figures.



SHADING DEVICES

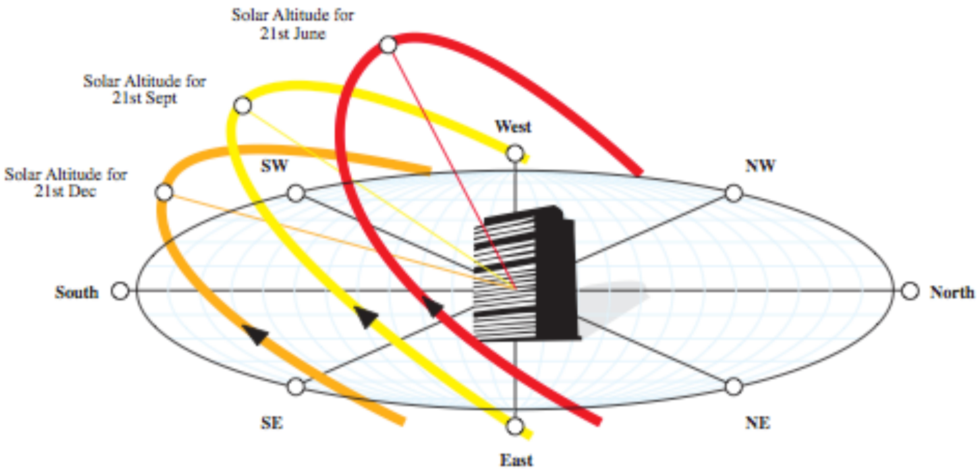
The Mediterranean architecture is confronted in a particular way with the management of the "transparency" of the enclosure. The Mediterranean architecture is characterized by "closed" solutions, where prevail the opaque surfaces and the screen transparencies. Buildings excessively transparent, in Mediterranean climates, create unlivable environments due to the greenhouse: the thermal radiation which passes through the glass is absorbed by materials placed in the indoor environment and it is re-emitted with higher wavelengths, no longer able to cross the glass: the heat is thus captured within the spaces. If this phenomenon can be advantageous in winter, it produces overheating in summer, turning the rooms into real ovens, cooling only with very high-energy costs. The project of the size, orientation and position of windows must therefore deal with several other important aspects: the winter solar gain, the summer sunshine and the resulting overheating, the natural lighting and the possible glare. In the Mediterranean areas, the transparent surfaces of the building are oriented to the south, southeast and southwest to facilitate heat gains in the winter, by ensuring adequate shading devices in the summer. The transparent surface are, however, avoided in the east and west directions because are ineffective in the winter, because not irradiated, and problematic in the summer, since the sun, low in the morning and in the evening, affects in a direct manner such surfaces. The sun in winter is low and does not hit the glass, which becomes, therefore, a dispersing surface even during the day.

For this reason in the station I put on the glass façade the horizontal shading devices that cover a lot of the surfaces, so is avoided in summer the phenomenon of the overheating and in winter the dispersion of the heat.

The Mediterranean architecture is so predominantly opaque because the building is also low isolated and the heat lost (at night and in winter) is very large: consequently, there is the risk that the calories gain during the day are dispersed at night. For this, the Mediterranean architecture is distinguished by the presence of overhangs and shields able to shade, when necessary, the glass surfaces.

The solar geometry

The sun rise in the East and sets in the West, The sun travellers in an arc, reaching its highest altitude in summer and its lowest in the winter.



North facing facade

For the station there are no problems because the north façade is quite completely shaded by the existing station.

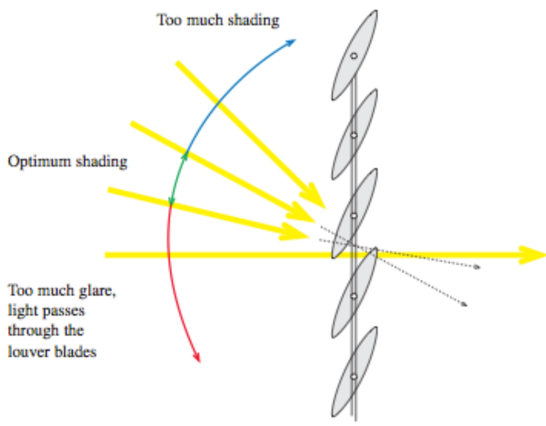
South, East and West facing facade

For a predominately South facing façade, a small amount of solar shading can be achieved using a fixed horizontal brise soleil sunshade. In winter such a device, however, cannot stop direct rays from the sun penetrating the building's windows since the sun is much lower.

While passive solar heating at times is beneficial, some might be surprised to learn that the cooling loads on many southern-facing zones peak in the late fall/early winter due to the solar radiation.

With a predominately East or West facing façade, a fixed system will not perform well throughout the day as the altitude of the sun varies throughout the day.

Effective solar shading on the South, East and West façades can be achieved only by using an operable shading louver system on the building's façade. The angle of the louvers is adjusted throughout the day to provide optimal shading.



Following the considerations before for the station for all the glass façade I choose the OPERABLE HORIZONTAL SYSTEM, so the adjustable louvers will track the position of the sun increasing the systems shading effectiveness and further reducing glare. On overcast days, the operable louvers can be opened to maximize the natural daylight into the building.

It is used the Shadotex system with an operable exterior solar shading louver systems made by PVC- coated polyester, that incorporate a unique, alternate solar shading solution. It consists of a special fabric stretched between two sides of a louver support frame. The fabric is manufactured with a weave to prevent solar glare and solar heat gain. The fabric can also create attractive diffused light and allow a degree of vision. The louvers can be installed either horizontally or vertically on the building's façade.

This type of system is extremely lightweight which allows for very large spans without the need for additional supporting framework.

Features and benefits:

- High solar absorption and high solar reflection.

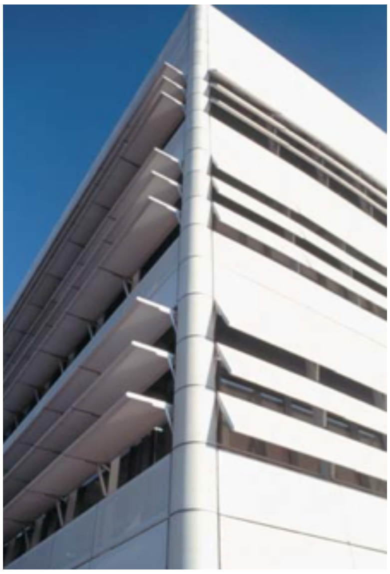
- Lightweight construction, ideal for large spans.

- Good external visibility.

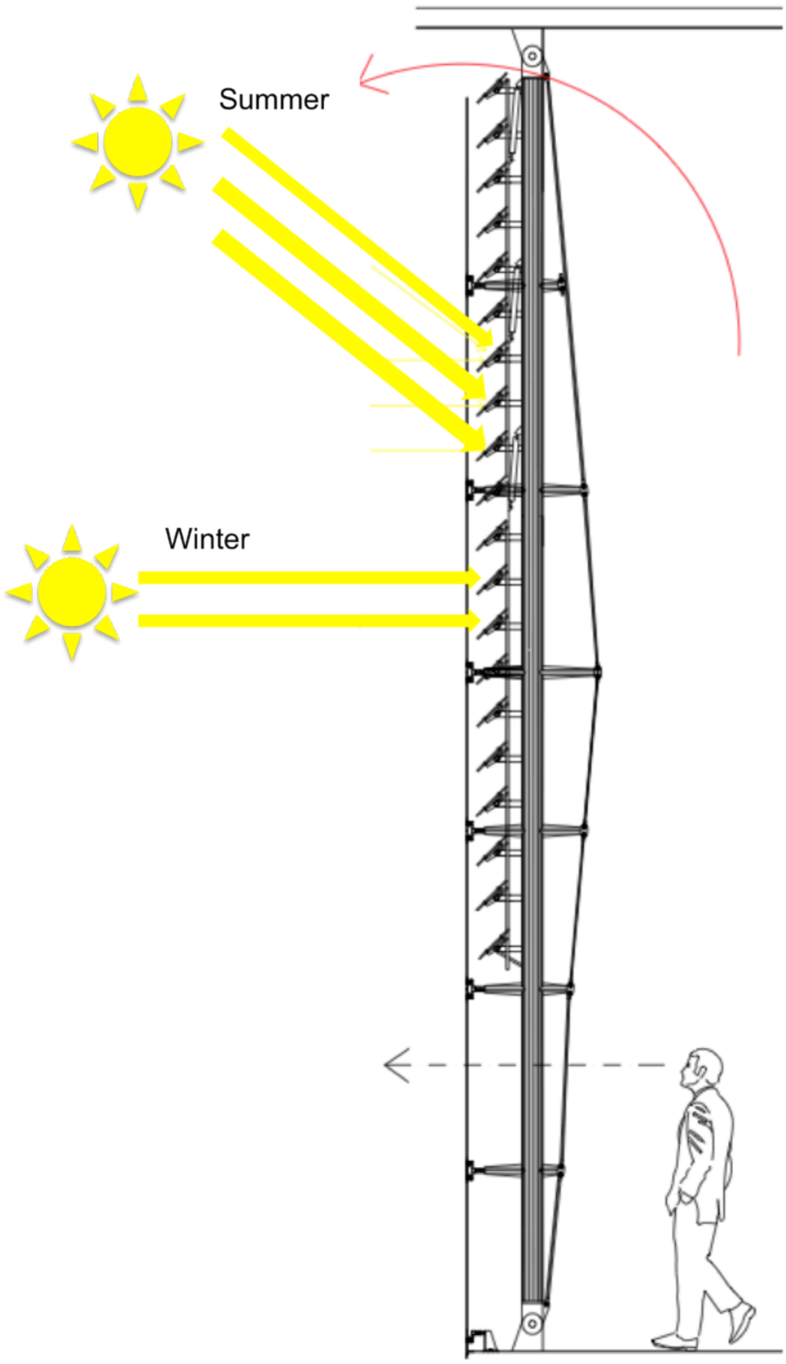
- Easy to clean, as the fabric is typically resin/Teflon coated.

- All principal support components are manufactured from corrosion-resistant extruded aluminium alloy with stainless steel fixings.

- Fully operable or fixed.



The following drawing is the section of all the four facades with the shading system integrated, below the glass.



2.5 **The structure** (see attached drawings)

The structure is made by REINFORCED CONCRETE and STEEL.

CHARACTEISTICS of the MATERIALS:

- CONCRETE C60/75:

  Characteristic cylinder compressive strength: f_{ck} = 60 N/mm2

  Design compressive strength: $f_{cd} = \alpha_{cc} * (f_{ck}/\Upsilon_c)$ = 0,85*(60/1,5) = 34 N/mm2

  Allowable compressive strength under characteristic combination of actions: $\sigma_{c,adm}$ = K1*fck = 0.6*60 = 36 N/mm2

  Medium tensile strength: fctm = 0,3*(fck)^2/3 = 4,59 N/mm2

  Characteristic tensile strength: fctk = 0,7*fctm = 3,21 N/mm2

  Design tensile strength: $f_{td} = \alpha_{ct}*(f_{ctk}/\Upsilon_c)$ = 1*(3,21/1,5) = 2,14 N/mm2

  Secant modulus of elasticity: Ecm = 39000 N/mm2

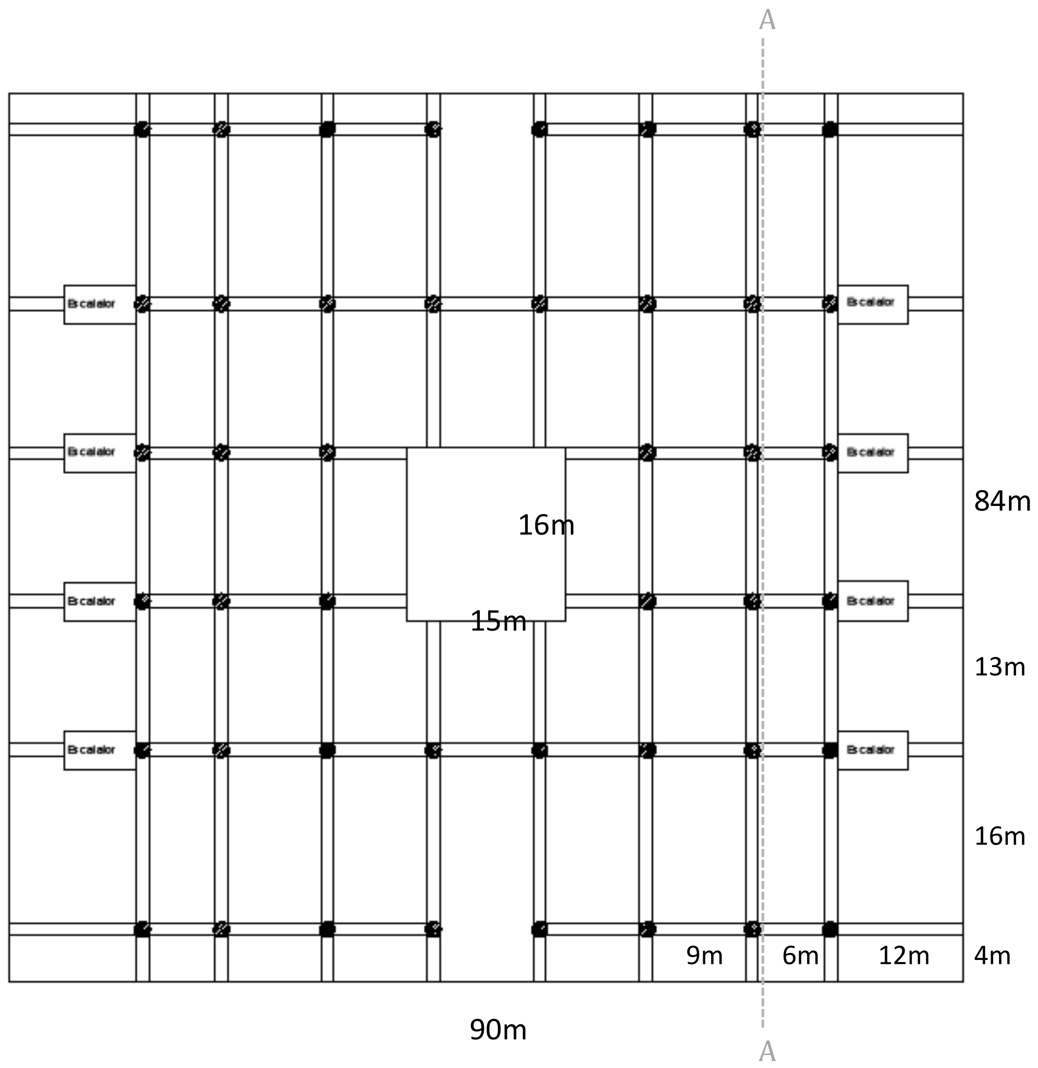
- HIGH DUCTILITY STEEL B450C

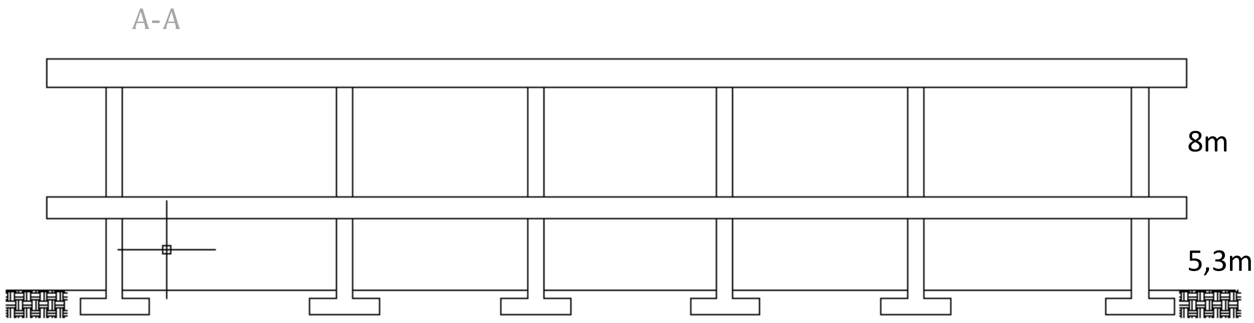
  Characteristic yield strength: fyk = 450 N/mm2

  Design yield strength: $f_{yd} = f_{yk}/\Upsilon_s$ = 450/1,15 = 391 N/mm2

  Admissible stress under characteristic combination of actions: $\sigma_{s,adm}$ = K3*fyk = 0.8*450 = 360 N/mm2

  Modulus of elasticity: Es = 200000 N/mm2


A
Escalator
Escalator
Escalator
Escalator
Escalator
Escalator
Escalator
Escalator
16m
15m
84m
13m
16m
9m
6m
12m
4m
90m
A


A-A
8m
5,3m

LOADS :

- INSIDE PARTITIONS:

Glass inside partition for boxes: 0,29 KN/m2

Plasterboard inside partition for toilets and offices: 0,42 KN/m2

TOT: 0,71 KN/m2

- CELLULAR SLAB:

Layers:
- Stoneware floor: 0,3 KN/m2
- Bedding mortar: 20KN/m3*0,04m = 0,8 KN/m2
- Glass wool insulation: 0,4KN/m3*0,04m = 0,016 KN/m2
- Concrete screed: 24KN/m3*0,06m = 1,44 KN/m2
- Cellular slab: 6,40 KN/m2
- Plaster: 0,4 KN/m2

TOT: structural loads = 1,44+6,40 = 7,84 KN/m2

other layers = 1,516 KN/m2

LOAD ANALYSIS: (Eurocodici 0-1 (parti 1-1,1-2-1-4), Norme tecniche per le costruzioni 2008)

Classification of the actions:

PERMANENT LOADS (G): they are actions that act during the nominal life of the building, whose change in intensity over time is so small and slow that they can be considered with sufficient approximation over time:

• G1 is the weight of all the structural elements;

• G2 is the weight of all the non-structural elements (floor tiles, lean concrete foundation, plaster).

VARIABLE LOADS (Q): actions on the structure or structural element with actual values that may be significantly different from each other in time:

• Long-term: they act with a 'significant intensity, also not continuously, for a time not negligible compared to the nominal lifetime of the structure;

• Short-term: they act for a period of time shorter than the nominal lifetime of the structure.

So they group the overload; the snow load and the wind load.

VARIABLE LOADS:

Cat.	Ambienti	q_k [kN/m²]	Q_k [kN]	H_k [kN/m]
A	**Ambienti ad uso residenziale.** Sono compresi in questa categoria i locali di abitazione e relativi servizi, gli alberghi. (ad esclusione delle aree suscettibili di affollamento)	2,00	2,00	1,00
B	**Uffici.**			
	Cat. B1 Uffici non aperti al pubblico	2,00	2,00	1,00
	Cat. B2 Uffici aperti al pubblico	3,00	2,00	1,00
C	**Ambienti suscettibili di affollamento**			
	Cat. C1 Ospedali, ristoranti, caffè, banche, scuole	3,00	2,00	1,00
	Cat. C2 Balconi, ballatoi e scale comuni, sale convegni, cinema, teatri, chiese, tribune con posti fissi	4,00	4,00	2,00
	Cat. C3 Ambienti privi di ostacoli per il libero movimento delle persone, quali musei, sale per esposizioni, stazioni ferroviarie, sale da ballo, palestre, tribune libere, edifici per eventi pubblici, sale da concerto, palazzetti per lo sport e relative tribune	5,00	5,00	3,00
D	**Ambienti ad uso commerciale.**			
	Cat. D1 Negozi	4,00	4,00	2,00
	Cat. D2 Centri commerciali, mercati, grandi magazzini, librerie…	5,00	5,00	2,00

Up to the four types of representative value may be needed for the variable actions. The types most commonly used for variable actions are:

- the characteristic value: Qk

and combinations of the characteristic value with other variable actions, multiplied by different combination factors:

- the combination value Ψ0Qk: used for checking the Ultimate limit states and the irreversible serviceability limit state; the factor Ψ0 reduce Qk because of the low probability of the most unfavorable values of several independent actions occurring simultaneously;
- the frequent value Ψ1Qk: used for checking the Ultimate limit state involving accidental actions and the reversible serviceability limit states;
- the quasi-permanent value Ψ2Qk: used for checking the ultimate limit states involving accidental actions and the reversible serviceability limit state.

COMBINATION OF THE ACTIONS:

- **Combinazione fondamentale (SLU)**
  - $\gamma_{G1} \cdot G_1 + \gamma_{G2} \cdot G_2 + \gamma_P \cdot P + \gamma_{Q1} \cdot Q_{k1} + \gamma_{Q2} \cdot \Psi_{02} \cdot Q_{k2} + \gamma_{Q3} \cdot \Psi_{03} \cdot Q_{k3} \ldots$
- **Combinazione caratteristica rara (SLE irreversibili, t.a.)**
  - $G_1 + G_2 + P + Q_{k1} + \Psi_{02} \cdot Q_{k2} + \Psi_{03} \cdot Q_{k3} \ldots$
- **Combinazione frequente (SLE reversibili)**
  - $G_1 + G_2 + P + \Psi_{11} \cdot Q_{k1} + \Psi_{22} \cdot Q_{k2} + \Psi_{23} \cdot Q_{k3} \ldots$
- **Combinazione quasi permanente (SLE – effetti a lungo termine)**
  - $G_1 + G_2 + P + \Psi_{21} \cdot Q_{k1} + \Psi_{22} \cdot Q_{k2} + \Psi_{23} \cdot Q_{k3} \ldots$
- **Combinazione sismica (SLU e SLE)**
  - $E + G_1 + G_2 + P + \Psi_{21} \cdot Q_{k1} + \Psi_{22} \cdot Q_{k2} \ldots$
- **Combinazione eccezionale (SLU)**
  - $G_1 + G_2 + P + A_d + \Psi_{21} \cdot Q_{k1} + \Psi_{22} \cdot Q_{k2} \ldots$

For SLU verification:

Carichi permanenti strutturali	favorevoli	γ_{G1}	1,00
	sfavorevoli		1,30
Carichi permanenti non strutturali	favorevoli	γ_{G2}	0,00
	sfavorevoli		1,50
Carichi variabili	favorevoli	γ_Q	0,00
	sfavorevoli		1,50

Action	Ψ_0	Ψ_1	Ψ_2
Imposed loads in buildings category (EN 1991-1.1)			
Category A: domestic, residential areas	0.7	0.5	0.3
Category B: office areas	0.7	0.5	0.3
Category C: congregation areas	0.7	0.7	0.6
Category D: shopping areas	0.7	0.7	0.6
Category E: storage areas	1.0	0.9	0.8
Category F: traffic area, weight ≤ 30 kN	0.7	0.7	0.6
Category G: traffic area, 30kN < weight ≤ 160 kN	0.7	0.5	0.3
Category H: roofs[a]	0.7	0.0	0.0
Snow loads on buildings (EN 1991-1.3)			
• for sites located at altitude H > 1,000m above sea level	0.7	0.5	0.2
• for sites located at altitude H ≤ 1,000m above sea level	0.5	0.2	0.0
Wind loads on buildings (EN 1991-1.4)	0.5	0.2	0.0
Temperature (non-fire) in buildings (EN 1991-1.5)	0.6	0.5	0.0

[a] See also EN 1991-1.1, 3.3.2(1)

SNOW LOAD:

$$q_s = \mu_i \cdot q_{sk} \cdot C_E \cdot C_t$$

dove:

q_s è il carico neve sulla copertura;

μ_i è il coefficiente di forma della copertura, fornito al successivo § 3.4.5;

q_{sk} è il valore caratteristico di riferimento del carico neve al suolo [kN/m^2], fornito al successivo § 3.4.2 per un periodo di ritorno di 50 anni;

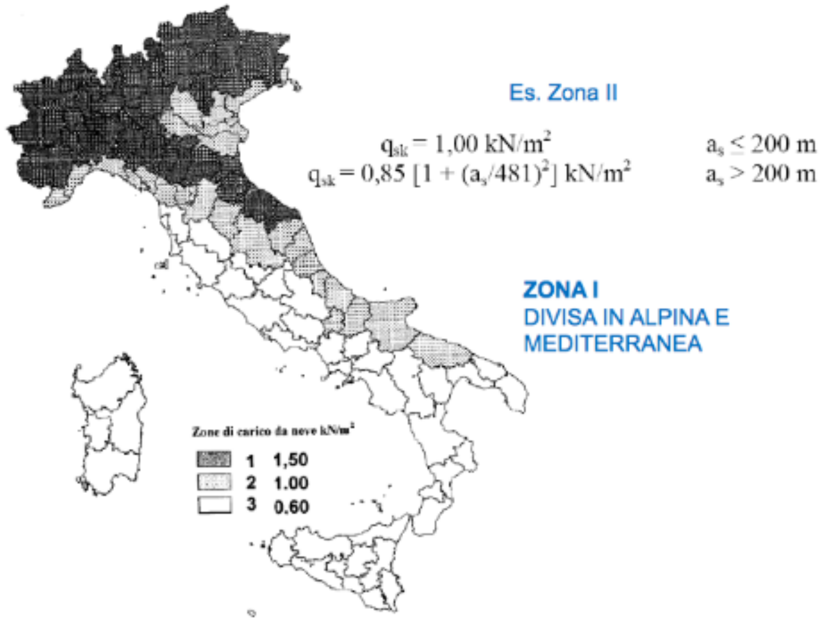
C_E è il coefficiente di esposizione di cui al § 3.4.3;

C_t è il coefficiente termico di cui al § 3.4.4.

CE= 1 for a place with a normal topography

Ct= 1

qsk= 1 kN/m2



qs = 0,8*1*1*1 = 0,8 kN/m2

STRUCTURAL ANALYSIS:

SLAB

For the slab I choose the cellular prefabricated panels.

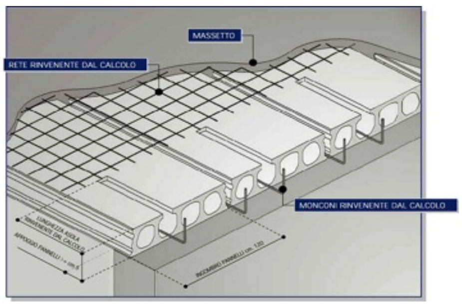
Cellular concretes are used to problem-solve a wide variety of challenges in construction, mining, and manufacturing applications. The breadth of applications results from the ability to precisely control the density of cellular concrete materials and the numerous useful properties inherent in cellular concretes or related to density control.

Beneficial properties associated with cellular concretes include:

• Workability • Flow-ability • Thermal insulating • Sound absorption • Energy absorption • Walkability (in roof deck and flooring applications) • Nail-ability and saw-ability (pre-cast and manufacturing applications) • Stability • Durability • Self-levelling • Self-compaction • Fire resistance • Mould resistance • Seismic resistance • Permeability • Density • Strength.

The physical properties of cellular concrete are closely related to the type, quantity, and quality of the foam liquid concentrate used; the constitution and proper proportioning of the other mix ingredients (including Portland cement and/or supplementary cementitious materials, water, and, if used, sand and/or other aggregates, chemical admixtures, polymers, and fibre reinforcement); the production method employed; and the execution of proper batching, mixing, installation (or moulding), and curing protocols.

Mix design, and batching, mixing, and detailed installation/moulding practices, are beyond the scope of this introductory white paper.



Loads:

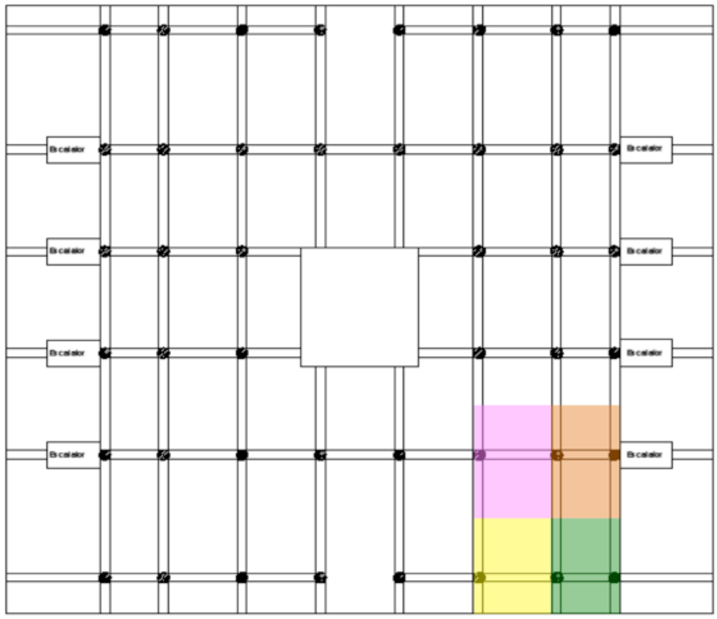
- G1 (cellular slab weight) = 7,84 kN/m^2
- G2 (other permanent loads) = 1,516 kN/m^2
- Q1 (live loads)= 5 kN/m^2
- Q2 (Inside partitions) = 0,71 kN/m^2

Permanent loads: 1,35(G1+G2) = 12,63 kN/m2

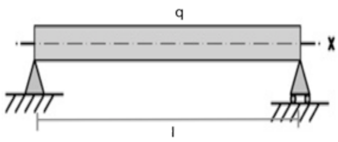
Variable loads: 1,5(Q1+Q2) = 8,565 kN/m2

TOT: 21,195 kN/m2

BEAM



For the dimensioning of the section, consider a doubly supported beam:

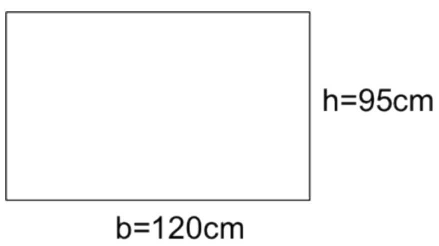


Putting the dimension of the wheelbase and the length of the beam, the first thing is to find the maximum moment M max= (q*l^2)/8.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
interasse (m)	q_s (KN/m²)	q_p (KN/m²)	q_a (KN/m²)	q_u (KN/m)	luce (m)	M_{max} (KN*m)	f_{yk} (N/mm²)	f_{yd} (N/mm²)	f_{ck} (N/mm²)	f_{cd} (N/mm²)	β	r	b (cm)	h_u (cm)	δ (cm)	H_{min} (cm)	H
10,00	7,84	2,23	5,00	210,31	6,00	946,40	450,00	391,30	60,00	34,00	0,57	2,09	120,00	31,79	5,00	36,79	95,00
			plus q trave	247,36	6,00	1113,12	450,00	391,30	60,00	34,00	0,57	2,09	120,00	34,47	5,00	39,47	verificata
10,00	7,84	2,23	5,00	210,31	9,00	2129,39	450,00	391,30	60,00	34,00	0,57	2,09	120,00	47,68	5,00	52,68	95,00
			plus q trave	247,36	9,00	2504,52	450,00	391,30	60,00	34,00	0,57	2,09	120,00	51,71	5,00	56,71	verificata
14,50	7,84	2,23	5,00	304,95	6,00	1372,27	450,00	391,30	60,00	34,00	0,57	2,09	120,00	38,28	5,00	43,28	95,00
			plus q trave	342,00	6,00	1539,00	450,00	391,30	60,00	34,00	0,57	2,09	120,00	40,54	5,00	45,54	verificata
14,50	7,84	2,23	5,00	304,95	9,00	3087,61	450,00	391,30	60,00	34,00	0,57	2,09	120,00	57,42	5,00	62,42	95,00
			plus q trave	342,00	9,00	3462,74	450,00	391,30	60,00	34,00	0,57	2,09	120,00	60,80	5,00	65,80	verificata
				0,00		0,00											

In the table below are shown the calculations for the four types of beams take in consideration.

It is found that the right dimensions for all the beams are **b=120cm and h=95cm**, after verify that the H > Hmin (H min is the useful height of the reagent section of the concrete hu, plus a factor of 5 cm). In the second verification it is add the weight of the beam, and also in this case the dimensions are verified.



SLU VERIFICATION

Mrd > Med

εs > εyd (=fyd/Es)

M=1113,12 kNm

b=1200 mm

d= 635 mm

Reinforcement pre-dimensioning

-Rotational equilibrium: 0,8*b*fcd*(d-0,4*x) = Med

x = 163,9 mm

- Translational equilibrium: 0,8*b*x*fcd-As*fyd = 0

As = 13671,6 mm2

This is the As required.

x/d = ζ = 0,258 < εcu/(εcu+ εyd) = 0,641 OK!

bt = 1000 mm

As,min = 0,26*(fctm/fyk)*bt*d = 1792,6 mm2

As > As,min so for the section of the beam I can use: **As = 15821 mm2**

12ø30+12ø28

Now it has to be verified that the steel is nerveless in such a way as to guarantee a ductile failure:

εs = ((d-x)/x)* εcu = 0,0035 > εyd = fyd/Es = 0,0019 OK!

BENDING ULS VERIFICATION

- Translational equilibrium: 0,8*b*x*fcd = As*fyd

x = 189,52 mm

- Rotational equilibrium: Mrd = As*fyd*(d-0,4*x)

Mrd = 3459,82 kNm

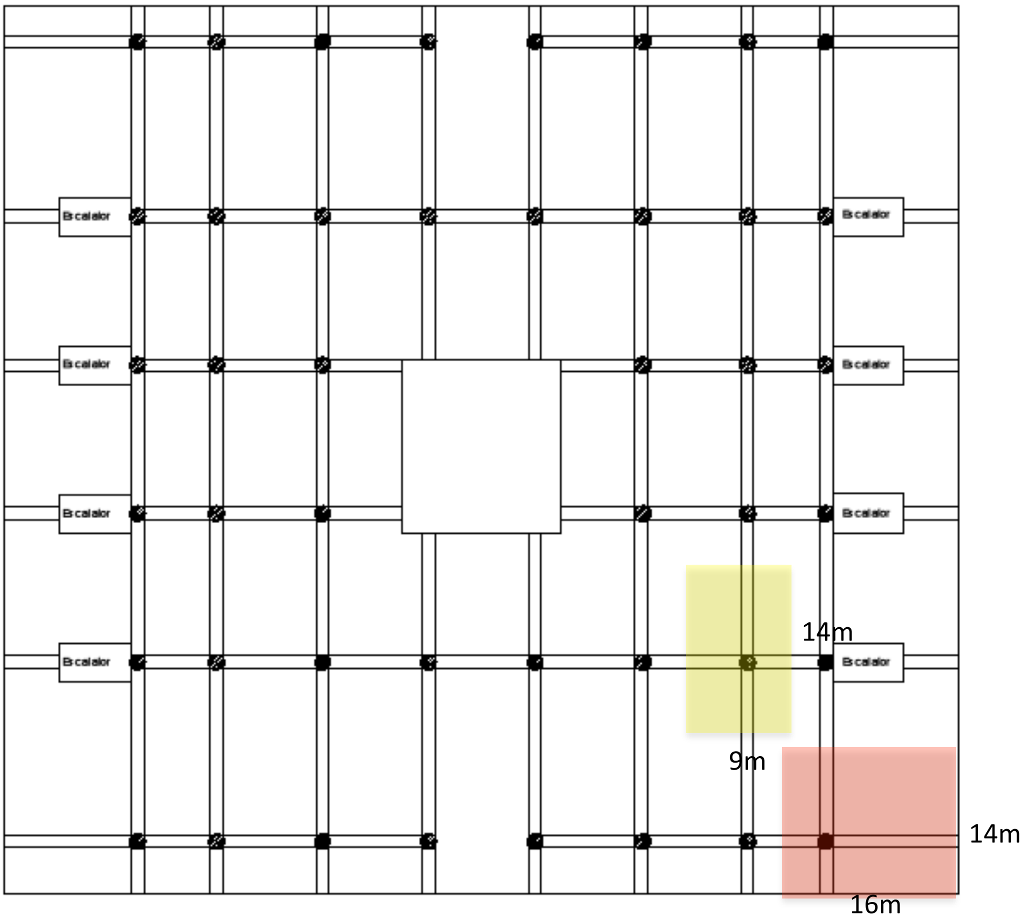
Mrd > M = 1113,112 OK!

εs = ((d-x)/x)* εcu = 0,0082 > εyd = fyd/Es = 0,0019 OK!

All these calculations are made also for the other beams and all the verifications are satisfied.

COLUMN

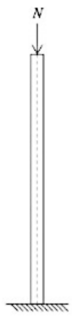
The columns are circular and are made by reinforced concrete; they are the base of the platform and the lateral columns arrive to the covering to sustain the copper roof with its sub-structure.



INFLUENCED AREA:

L_p	L_s	Area
m	m	m2
16,00	14,00	224,00
9,00	14,00	126,00
9,00	14,00	126,00

Lp and Ls are the dimensions of the influenced areas



NORMAL COMPRESSIVE STRENGHT N

Found the total weight of the beams; calculate the total weight of the slab for the SLU:

qslab = (87,84*1,35+2,23*1,5+2*1,5) = 4712,29 kN

N is the compressive force = (qslab+qbeam)*nfloor

L_p	L_s	Area	$trave_p$	$trave_s$	q_{trave}	q_s	q_p	q_a	q_{solaio}	n_{piani}	N
m	m	m2	kN/m	kN/m	kN	kN/mq	kN/mq	kN/mq	kN		kN
16,00	14,00	224,00	28,50	28,50	1111,50	7,84	2,23	5,00	4712,29	1	5824
9,00	14,00	126,00	28,50	28,50	852,15	7,84	2,23	5,00	2650,66	1	3503
9,00	14,00	126,00	28,50	28,50	852,15	7,84	2,23	5,00	2650,66	2	7006

MINIMUM AREA REQUIRED

Having found the value of axial compression can now find the minimum area for the material does not come into crisis.

Amin = N/fcd

L_p	L_s	Area	$trave_p$	$trave_s$	q_{trave}	q_s	q_p	q_a	q_{solaio}	n_{piani}	N	f_{ck}	f_{cd}	A_{min}
m	m	m2	kN/m	kN/m	kN	kN/mq	kN/mq	kN/mq	kN		kN	Mpa	Mpa	cm2
16,00	14,00	224,00	28,50	28,50	1111,50	7,84	2,23	5,00	4712,29	1	5824	60,0	34,0	1712,9
9,00	14,00	126,00	28,50	28,50	852,15	7,84	2,23	5,00	2650,66	1	3503	60,0	34,0	1030,2
9,00	14,00	126,00	28,50	28,50	852,15	7,84	2,23	5,00	2650,66	2	7006	60,0	34,0	2060,5

MINIMUN INERTIA RADIUS, DESIGN AREA AND DESIGN INERTIA

E is the modulus of elasticity

β is the a dimensional coefficient that reflects the influence of the constraints, in this case for the double joints is equal to 1

l is the length of the column

λ is the slenderness of the column

λ min = ∏ √E/fcd

ρ min = (l* β)/ λ min

r min = ρ min*(4)^1/2, then i try to put one value for the **r = 75 cm**

A design = r*r*Π = 17663 cm^2

I design = Π *d^4/64 = 24837891 cm^4

A design > A min OK!

L_p	L_s	Area	$trave_p$	$trave_s$	q_{trave}	q_s	q_p	q_a	q_{solaio}	n_{piani}	N	f_{ck}	f_{cd}	A_{min}	E	β	l	λ_{max}	ρ_{min}	r_{min}	r	d	A_{design}	I_{design}
m	m	m2	kN/m	kN/m	kN	kN/mq	kN/mq	kN/mq	kN		kN	Mpa	Mpa	cm2	Mpa		m		cm	cm	cm	cm	cm2	cm4
16,00	14,00	224,00	28,50	28,50	1111,50	7,84	2,23	5,00	4712,29	1	5824	60,0	34,0	1712,9	39100	1,00	5,30	106,54	4,97	9,95	75,00	150,00	17663	24837891
9,00	14,00	126,00	28,50	28,50	852,15	7,84	2,23	5,00	2650,66	1	3503	60,0	34,0	1030,2	39100	1,00	5,30	106,54	4,97	9,95	75,00	150,00	17663	24837891
9,00	14,00	126,00	28,50	28,50	852,15	7,84	2,23	5,00	2650,66	2	7006	60,0	34,0	2060,5	39100	1,00	13,30	106,54	12,48	24,97	75,00	150,00	17663	24837891

BUCKLING VERIFICATION

The pillar being connected to the beam with a joint, at that node transmits a moment, which could be submitted to the pillar the buckling.

To make the column is not subjected to compressive and bending: σ_{max}≤ fcd

I max= 24837891 cm^4

W max (modulus of bending resistance for circular section) = Π *d^3/32 = 331171,88 cm^3

qt= qsolaio x Ls (distributed load)

Mt= qt x Lp^2 /12 (head moment of the column linked to the beam)

σ max =(N/A) +(M_t/wmax) x 1000

all the σ max < fcd OK!

I_{design}	W_{max}	q_t	M_t	σ_{max}	
cm4	cm3	kN/m	kN*m	Mpa	
24837891	331171,88	294,52	6283,05	22,15	Si
24837891	331171,88	294,52	1988,00	7,91	Si
24837891	331171,88	294,52	1988,00	9,81	Si

Now I made other verifications for the 'red' column:

For ULS is consider a single multiplicative factor ϒf* = (ϒG*Gk+ ϒQ*Qk)/(Gk+Qk) = 1,38

Fk = N =5824 kN

Ned = ϒf* *N = 8037,12 kN

Ac, min = Ned/fcd = 124442 mm2

I use the area found before: **Ac = 1766250 mm2** (Ac>Ac,min)

DIMENSIONING OF THE LONG REINFORCEMENT

Ned = 8037,12 kN

Ac = 1766250 mm2

Limits: - 1 bar ø > 12 mm;

- Minimum number of bar: 6

- Geometrical limits: As > 0,003 Ac

- Static limit As > 0,10*(Ned/fyd)

As,min (0,003Ac) = 5298,75 mm2

As,min (0,10*(Ned/fyd)) = 2055,53 mm2

So the **As = 5429 mm2**

12ø24

COMPRESSION VERIFICATION (SLE)

$N = \sigma c * Ac + \sigma s * As$

$(\varepsilon c=\varepsilon s,\ \sigma s=\alpha e*\sigma c,\ \alpha e=15)$

$N = \sigma c*(Ac+ \alpha e*As) = \sigma c*Aie$

$\sigma c = N/Aie < \sigma c,adm = 0{,}6fck = 36\ N/mm2$

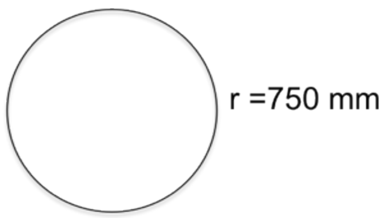
$\sigma c = 3{,}15 < 36$ <u>OK!</u>

(SLU)

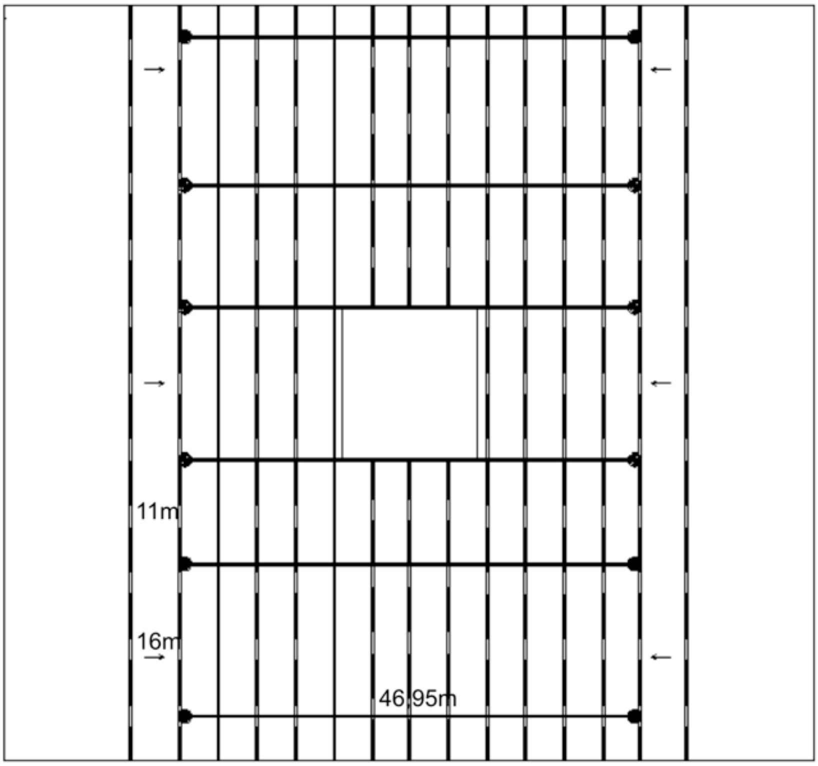
$Ned < Nrd = fcd*Ac + fyd*As$

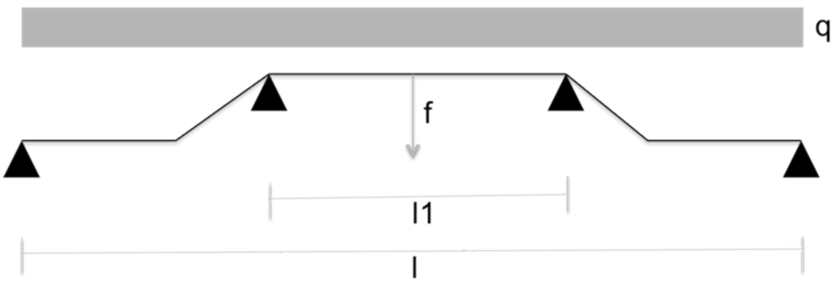
$Nrd = 34*1766250 + 391*5429 = 62175{,}24\ kN$

$Ned = 8037{,}12\ kN < Nrd$ <u>OK!</u>



ROOF





For to support the covering I choose the **steel beam HEM**.

l1 = 46,95m

The freccia limite fmax for general covering is = l/200 = 46950/200 = 234,74 mm

f = (5/384)*(q*l^4/E*I) < fmax

The total load considering the weight of the covering and the snow load is equal to 1,66 kN/mm2

q = 1,66*15m = 24,9 kN/m

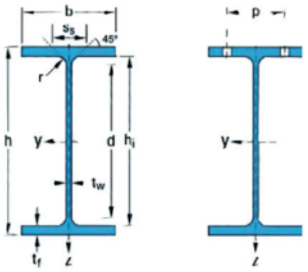
To fine the required inertia based on these dimensions I make the opposite passage: I put the value of the freccia limite into the formula of the f and in this way I can find the right inertia of the steel beam and so the relative dimensions.

234,27 = (5/384)*((24,9 N/mm*46,95m^4)/(2100000 N/mm2*x)

Solving the calculation I find an inertia, considering the ultimate case, of:

I = 3,1954*10^10 mm4

So considering an **HE 1000 M** steel beam (UNI 5397),



Designazione nominale	Massa G kg/m	Dimensioni h mm	b mm	t_w mm	t_f mm	r mm	Area A cm^2	Dimensioni di costruzione h_i mm	d mm	Ø	P_{min} mm	P_{max} mm	Superficie da verniciare A_L m^2/m	A_G m^2/t
HE 600 B	212	600	300	15,5	30,0	27	270,00	540	486	M27	126	198	2,323	10,96
HE 600 M	285	620	305	21,0	40,0	27	363,70	540	486	M27	132	200	2,372	8,308
HE 600 x 337	337	632	310	25,5	46,0	27	429,20	540	486	M27	138	202	2,407	7,144
HE 600 x 399	399	648	315	30,0	54,0	27	508,50	540	486	M27	142	208	2,450	6,137
HE 650 AA	138	620	300	12,5	16,0	27	175,80	588	534	M27	122	198	2,369	17,17
HE 650 A	190	640	300	13,5	26,0	27	241,60	588	534	M27	124	198	2,407	12,69
HE 650 B	225	650	300	16,0	31,0	27	286,30	588	534	M27	126	198	2,422	10,77
HE 650 M	293	668	305	21,0	40,0	27	373,70	588	534	M27	132	200	2,468	8,411
HE 650 x 343	343	680	309	25,0	46,0	27	437,50	588	534	M27	138	202	2,500	7,278
HE 650 x 407	407	696	314	29,5	54,0	27	518,80	588	534	M27	142	206	2,543	6,243
HE 700 AA	150	670	300	13,0	17,0	27	190,90	636	582	M27	122	198	2,468	16,46
HE 700 A	204	690	300	14,5	27,0	27	260,50	636	582	M27	124	198	2,505	12,25
HE 700 B	241	700	300	17,0	32,0	27	306,40	636	582	M27	126	198	2,520	10,48
HE 700 M	301	716	304	21,0	40,0	27	383,00	636	582	M27	132	200	2,560	8,513
HE 700 x 352	352	728	308	25,0	46,0	27	448,60	636	582	M27	138	200	2,592	7,359
HE 700 x 418	418	744	313	29,5	54,0	27	531,90	636	582	M27	142	206	2,635	6,310
HE 800 AA	172	770	300	14,0	18,0	30	218,50	734	674	M27	130	198	2,660	15,51
HE 800 A	224	790	300	15,0	28,0	30	285,80	734	674	M27	130	198	2,698	12,03
HE 800 B	262	800	300	17,5	33,0	30	334,20	734	674	M27	134	198	2,713	10,34
HE 800 M	317	814	303	21,0	40,0	30	404,30	734	674	M27	138	198	2,746	8,655
HE 800 x 373	373	826	308	25,0	46,0	30	474,60	734	674	M27	144	200	2,782	7,469
HE 800 x 444	444	842	313	30,0	54,0	30	566,00	734	674	M27	148	206	2,824	6,357
HE 900 AA	198	870	300	15,0	20,0	30	252,20	830	770	M27	130	198	2,858	14,44
HE 900 A	252	890	300	16,0	30,0	30	320,50	830	770	M27	132	198	2,896	11,51
HE 900 B	291	900	300	18,5	35,0	30	371,30	830	770	M27	134	198	2,911	9,990
HE 900 M	333	910	302	21,0	40,0	30	423,60	830	770	M27	138	198	2,934	8,824
HE 900 x 391	391	922	307	25,0	46,0	30	497,70	830	770	M27	144	200	2,970	7,604
HE 900 x 466	466	938	312	30,0	54,0	30	593,70	830	770	M27	148	204	3,012	6,464
HE 1000 AA	222	970	300	16,0	21,0	30	282,20	928	868	M27	132	198	3,056	13,80
HE 1000 A	272	990	300	16,5	31,0	30	346,80	928	868	M27	132	198	3,095	11,37
HE 1000 B	314	1000	300	19,0	36,0	30	400,00	928	868	M27	134	198	3,110	9,905
HE 1000 M	349	1008	302	21,0	40,0	30	444,20	928	868	M27	138	198	3,130	8,978
HE 1000 x 393	393	1016	303	24,4	43,9	30	500,20	928	868	M27	144	196	3,144	8,006

Designazione nominale	Dati statici I_y cm^4	$W_{el.y}$ cm^3	$W_{pl.y}$ cm^3	i_y cm	A_{yz} cm^2	I_z cm^4	$W_{el.z}$ cm^3											
HE 600 B	171 000	5 701	6 425	25,17	110,80	13 530	902,0											
HE 600 M	237 400	7 660	8 772	25,55	149,70	18 980	1 244											
HE 600 x 337	283 200	8 961	10 380	25,69	180,50	22 940	1 480											
HE 600 x 399	344 600	10 640	12 460	26,03	213,60	28 280	1 796											
HE 650 AA	113 900	3 676	4 160	25,46	90,40	7 221	481,4											
HE 650 A	175 200	5 474	6 136	26,93	103,20	11 720	781,6											
HE 650 B	210 600	6 480	7 320	27,12	122,00	13 980	932,3											
HE 650 M	281 700	8 433	9 657	27,45	159,70	18 980	1 245											
HE 650 x 343	333 700	9 815	11 350	27,62	189,60	22 720	1 470											
HE 650 x 407	405 400	11 650	13 620	27,95	224,80	28 020	1 785											
HE 700 AA	142 700	4 260	4 840	27,34	100,30	7 673	511,5											
HE 700 A	215 300	6 241	7 032	28,75	117,00	12 180	811,9											
HE 700 B	256 900	7 340	8 327	28,96	137,10	14 440	962,7											
HE 700 M	329 300	9 198	10 540	29,32	169,80	18 800	1 237											
HE 700 x 352	389 700	10 710	12 390	29,47	201,60	22 510	1 461											
HE 700 x 418	472 500	12 700	14 840	29,80	239,00	27 760	1 774											
HE 800 AA	208 900	5 426	6 225	30,92	123,80	8 134	542,2											
HE 800 A	303 400	7 682	8 699	32,58	138,80	12 640	842,6											
HE 800 B	359 100	8 977	10 230	32,78	161,80	14 900	993,6											
HE 800 M	442 600	10 870	12 490	33,09	194,30	18 630	1 230											
HE 800 x 373	523 900	12 690	14 700	33,23	230,30	22 530	1 463											
HE 800 x 444	634 500	15 070	17 640	33,48	276,50	27 800	1 776											
HE 900 AA	301 100	6 923	7 999	34,55	147,20	9 041	602,8											
HE 900 A	422 100	9 485	10 810	36,29	163,30	13 550	903,2	1 414	6,50	111,10	736,80	24 960	1	1	1	4	4	4
HE 900 B	494 100	10 980	12 580	36,48	188,80	15 820	1 054	1 658	6,53	123,60	1 137	29 460	1	1	1	3	4	4
HE 900 M	570 400	12 540	14 440	36,70	214,40	18 450	1 222	1 929	6,60	136,10	1 671	34 750	1	1	1	2	4	4
HE 900 x 391	674 300	14 630	16 990	36,81	254,30	22 320	1 454	2 312	6,70	152,10	2 597	42 560	1	1	1	1	2	4
HE 900 x 466	814 900	17 380	20 380	37,05	305,30	27 560	1 767	2 832	6,81	173,10	4 256	53 400	1	1	1	1	1	2
HE 1000 AA	406 500	8 380	9 777	37,95	172,20	9 501	633,4	1 016	5,80	93,15	403,40	21280	1	1	-	4	4	-
HE 1000 A	553 800	11 190	12 820	39,96	184,60	14 000	933,6	1 470	6,35	113,60	822,40	32 070	1	1	2	4	4	4
HE 1000 B	644 700	12 890	14 860	40,15	212,50	16 280	1 085	1 716	6,38	126,10	1 254	37 640	1	1	1	4	4	4
HE 1000 M	722 300	14 330	16 570	40,32	235,00	18 460	1 222	1 940	6,45	136,10	1 701	43 020	1	1	1	3	4	4
HE 1000 x 393	807 700	15 900	18 540	40,18	271,30	20 500	1 353	2 168	6,40	147,30	2 332	48 080	1	1	1	2	4	4

From the inertia formula of this type of beam I can found the total height of the beam required for the inertia calculated before:

H required = 1922 mm = 1,922 m

So I can use two of this beam welded or bolted one over the other to have that height.

Now I recalculate the freccia limite using the inertia of these two beams and adding the weight of the steel beams:

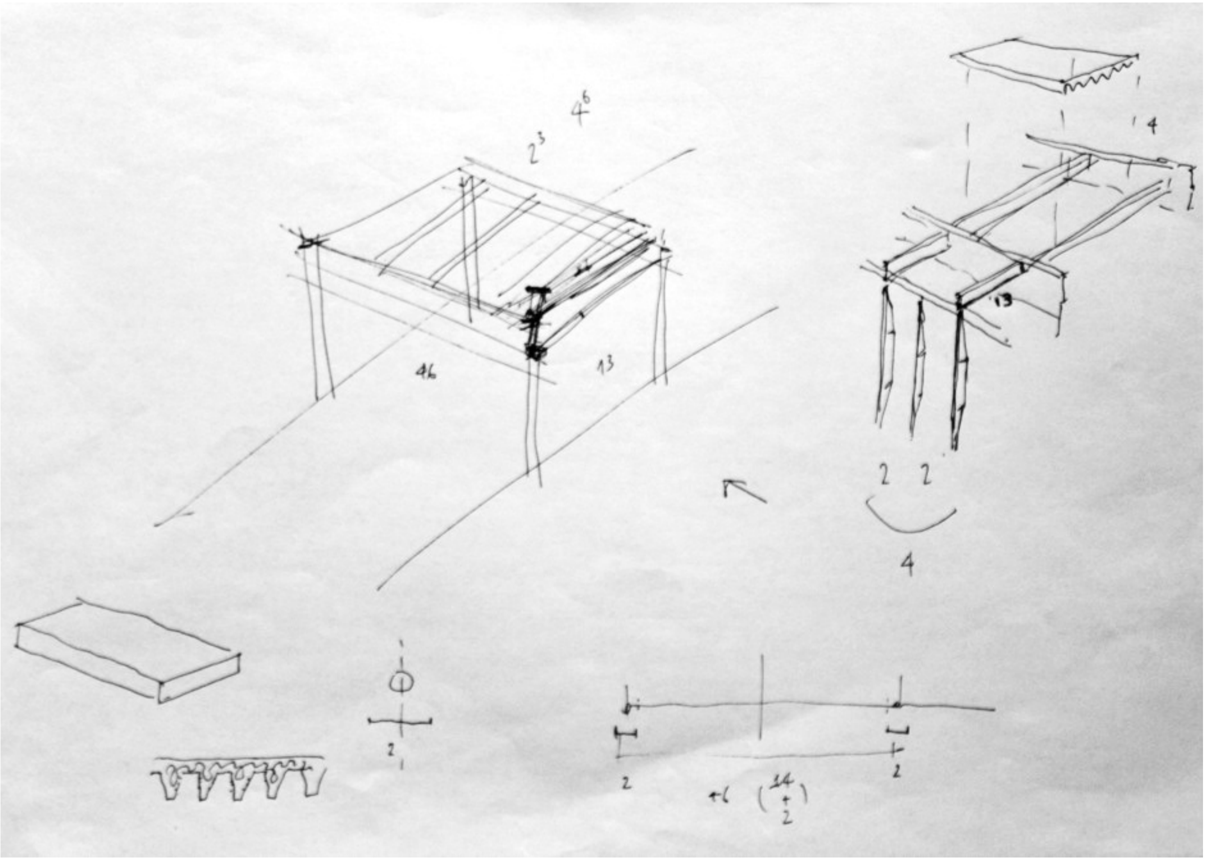
The new total load is: $q = 8,5$ kN/m2

8,5 kN/m2 * 15 m = 127 kN/m

$f = (5/384) * ((127*4695^4)/(210000*1,688*10^{11})) = 225$ mm

$f < f_{max} = 234,74$mm OK!

Under this structure to sustain the paneling of the copper roof is put another sub-structure with steel beam HE 600 M, that form a grid with a step of 4 m, where are included the sandwich panels that create the base for the covering.



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