BOXES CORE

A LOGISTIC TOWER IN CAMPORA EST

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1. INTRODUCTION

Our project starts during the Final Thesis Studio with prof. Jacopo Leverrato, prof. Alessando Rocca and prof. Andrea Rolando where the topic of the course was to project a new typology of service area and gas station in a specific location in the A7 motorway.
We have been working with prof. Jacopo Leveratto, our supervisor for this thesis, and after the end of the course we decided to continue the project and to develop it in a more prototype approach using the site of Campora Est service station, the base where we have projected the prototype, as a possible location to develop our project.

2. CONTEXT

2.1 GENERAL CONSIDERATIONS

Has first thought we reflected and researched which could be the assumptions that they can satisfy the demand of a new innovative area.
Which have a unique territorial context, similar to the one in Serra Riccò, in particular the service are of Campora Est.

The main issues that affect this area, is the isolation with the neighbouring areas in the territory. This issue makes this service area a strong point on interest due to the location and the connection with the valley, through a small road.

The connection with the Valley, could be a strong` advantage which could benefit the people coming from there are from Genova. Specifically, because this road can't be use a highway exceed following the regulation implemented from " Viabilita Autostradale s.r.l".
Now, keeping in consideration what was just mentioned, we started to work to potential ideas that could improve this area for

different type of circumstances.

Knowing that this road is helpful and important for the viability and the transport, we came proposition that could definitely bring more benefits to the service area.

With the highway theme is implicit to think about the large number of trucks transporting goods all over the country using these roads and and that today the e-commerce shopping with home delivery it's begging to be more frequent, between all generations.

Thanks to these assumptions, we came with the idea of create small sorting centres, semi-automatic, that have the ability to receive and manage hundreds of packages. Sorting them by county in a way that are not required to be handled by the large sorting centre on the big cities.
This system can be more beneficial to the small/medium-sized cities, which are located close to the service's areas.
Another advantage is the performance of e-commerce delivery services and enhancing the parking areas.

2.2 THE LOGISTIC CENTRE

Therefore the logistic center theme fits in. A logistics center or distribution center is a space where goods are stored and orders are prepared which will then be distributed to wholesalers or outlets. In this place, activities are carried out, that process affect the entire logistics chain: receipt, internal handling, storage, preparation and distribution of goods.
To carry out all these operations, the logistics centers must be designed in such a way that the areas of storage, picking, loading and unloading and even the offices, coexist in harmony. In these areas there is a tendency to implement software-driven automatic systems with the aim of speeding up the operational phases:
Receiving of goods: goods arrive daily from production centers or suppliers.
Storage: after the inbound control phases, the goods must be stored in the corresponding storage systems, taking into account their characteristics and rotation rates.
Internal handling and intralogistics: it is essential to design an optimal route for the flow of goods to be fast and efficient. The choice of handling systems (manual and automatic) will also depend on it.
Picking: this is the most complex and expensive operation that takes place within a logistics center. Optimizing picking routes

increases productivity and reduces business costs.
Stock management: stock monitoring is essential to prevent all those errors that could negatively impact the operation of the logistics site.
Shipping Process: Orders are shipped from the fulfillment center to customers.

Big Data and IoT (Internet of Things) devices are revolutionizing the supply chain. Logistics 4.0 is already a reality, in the new 4.0 logistics centers we proceed to digitize processes and improve the analysis of data flows. In this way the systems are better exploited and an exhaustive monitoring of the performance of the center is obtained. This is possible because the management and operational work has been delegated to intelligent systems. So on the one hand we find the software that controls millions of items in real time, on the other there are the robotic storage systems that independently perform the most repetitive operational activities.

2.3 DESIGN PURPOSE

These are the starting requirements to build a logistics center, and they are the minimum requirements that we set ourselves to carry out our project.

After carrying out research on the topic of innovative logistics centers, we decided to use an automated sorting and storage system already present in many storage centers in Europe. This system involves the use of mechanical arms that carry the packs directly to the accommodation provided for their storage. In this way the storage time is significantly reduced and much more organized.

In addition to this important resource, after some research into European standards regarding quality performance to provide sustainable transport solutions, we have decided that the vans serving our logistics center must be electric. We also think that the system should be equipped with drones, increasingly present in the world of
e-commerce, to complement the van service and improve deliveries in areas that are more difficult to reach by other means.

So we have a logistics center that is based on modern

technologies and tries to use environmentally sustainable transport as much as possible.
Precisely on this last issue, we decided to make our entire project and the elements that make it up even more sustainable. We therefore thought of using piezoelectric plates that use vibrations to create energy.
Since the Campora Est service area corresponds to 2 tunnels and being an obligatory point of passage on the Genoa-Milan section, we would like to insert the plates under the asphalt and in correspondence with the entire tunnel, in this way a good Amount of energy that we can accumulate in a generator and use it to power the whole project.

In conclusion, our project will focus on an automated and sustainable logistic centre that exploits modern technologies both to improve the storage process and storage using electrical vehicles.

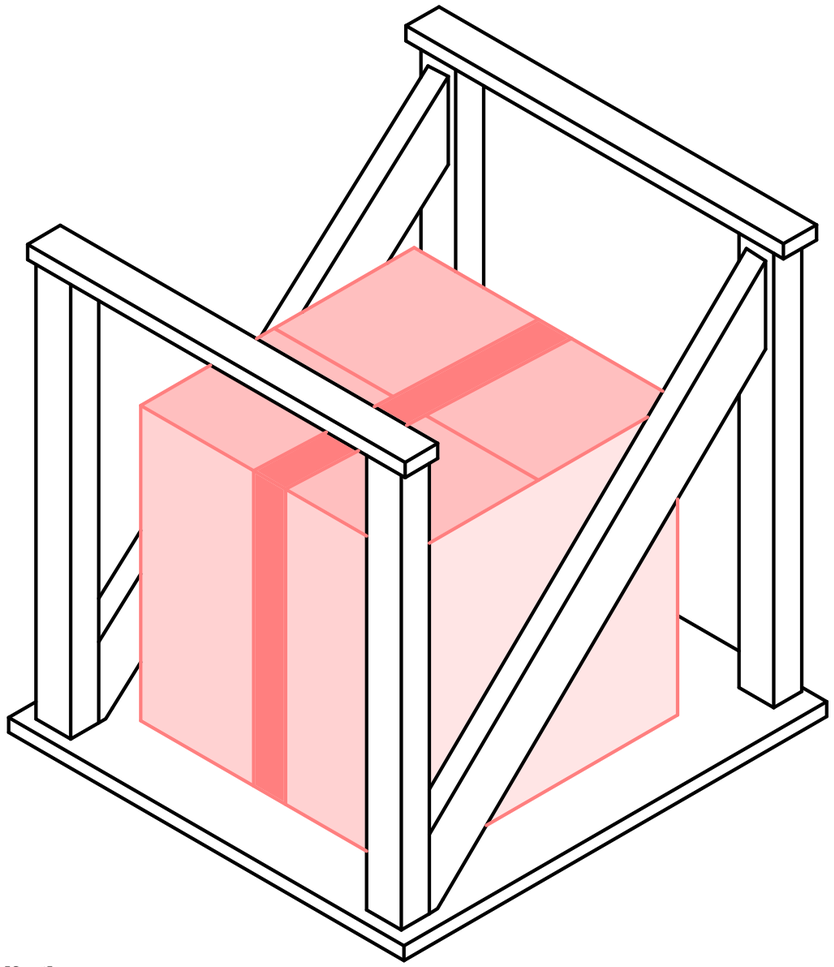
3.PROJECT DESIGN

3.1 MECHANICAL SYSTEM

The topics that emerged from the previous research are the bases that characterized our project design choices and gave the shape to the entire project.

First thing we focused on the warehouse idea of the logistic centre. The existing sorting centers are characterized by a huge space in terms of square meters to host a huge number of spots for the goods where the automated mechanical risers runs in a linear way and lift the boxes up and down.
In Campora Est we didn't have the same amount of square meters to host a large warehouse, also because the viability system in this specific area is quite complex and needed a lot of space.
For this reason we adopted a vertical concept for the storage, in this way we could go vertical and have the same efficiency.
This choice allow us to connect different topics in the same architecture and relate them one to the other.
We thought to have a vertical warehouse provided by spots for the goods that serve the floors running around it, so we designed a cylindrical core of steel CELLS creating a vertical structure. [fig. 1]

Each cells has a dimention of 50 x 60 x 70, are made of steel structure isered inside of the reinforced concrete rings and colums; there are 6 cells' columns each floor. The final number of the cells is 1500 for this tower. [fig. 2]



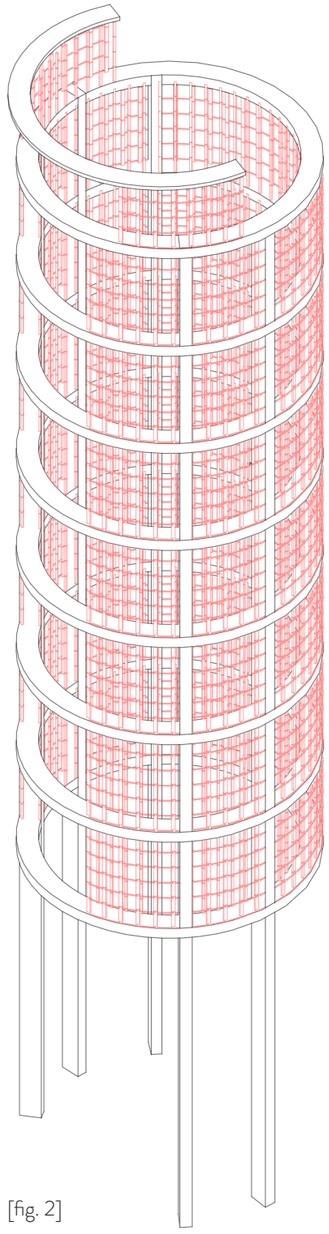
[fig. 1]

The consequence of these choices lead us to adopt a tower concept for the following design options.

To satisfy the needs of a cylindrical tower we adopted a circular rail to run the mechanical raisers that move the boxes all over the cells core. This element is one of the most important of the entire project because set all the primary decisions for the following design process.
We strongly believe that this element is very attractive not only for his functional use but also for his architectural beauty.
The better way to join the aesthetic aspect to the functional one was to insert inside the cells core a glazed elevator to enjoy the view of the mechanical system.
In order to reach the elevator from the outside of the central core we made an opening in the cells to let the people reach the elevator with the landings. [fig. 3].

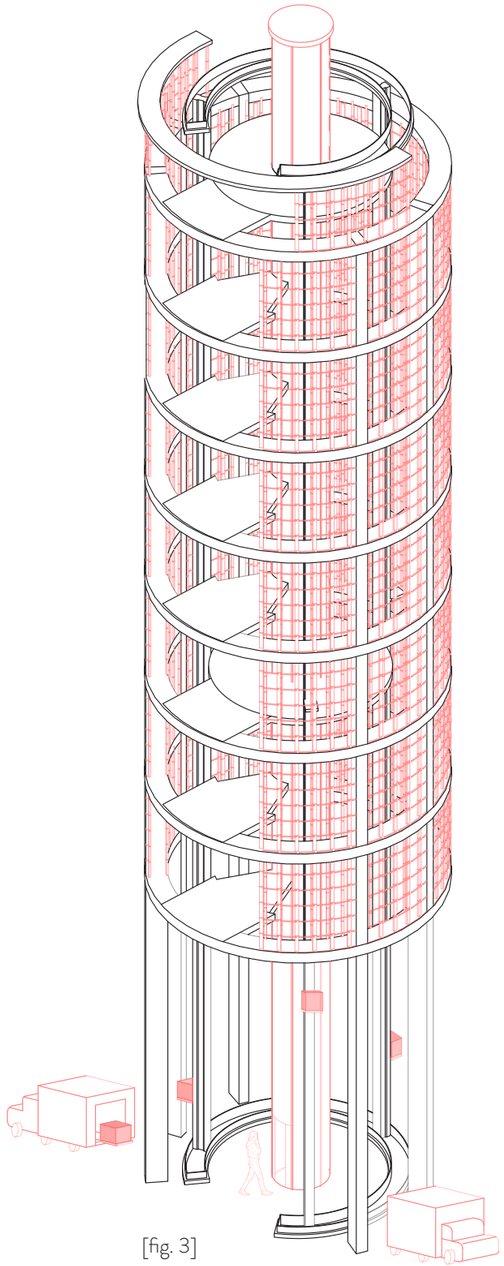
These landings interrupt the circular run of the mechanical raisers and of the cells core so we reduced the rotation of the ring to 290°.
To better reach all the cells we inserted 3 mechanical risers that rotate at the same time ,keeping always the same distance, dividing the ring in 3 sectors. In this way the raisers can run with no interruption with the possibility to lift the boxes up and down independently. [fig. 4]

Once we solved this problem we were able to design the external functions with far fewer restrictions than when we started.



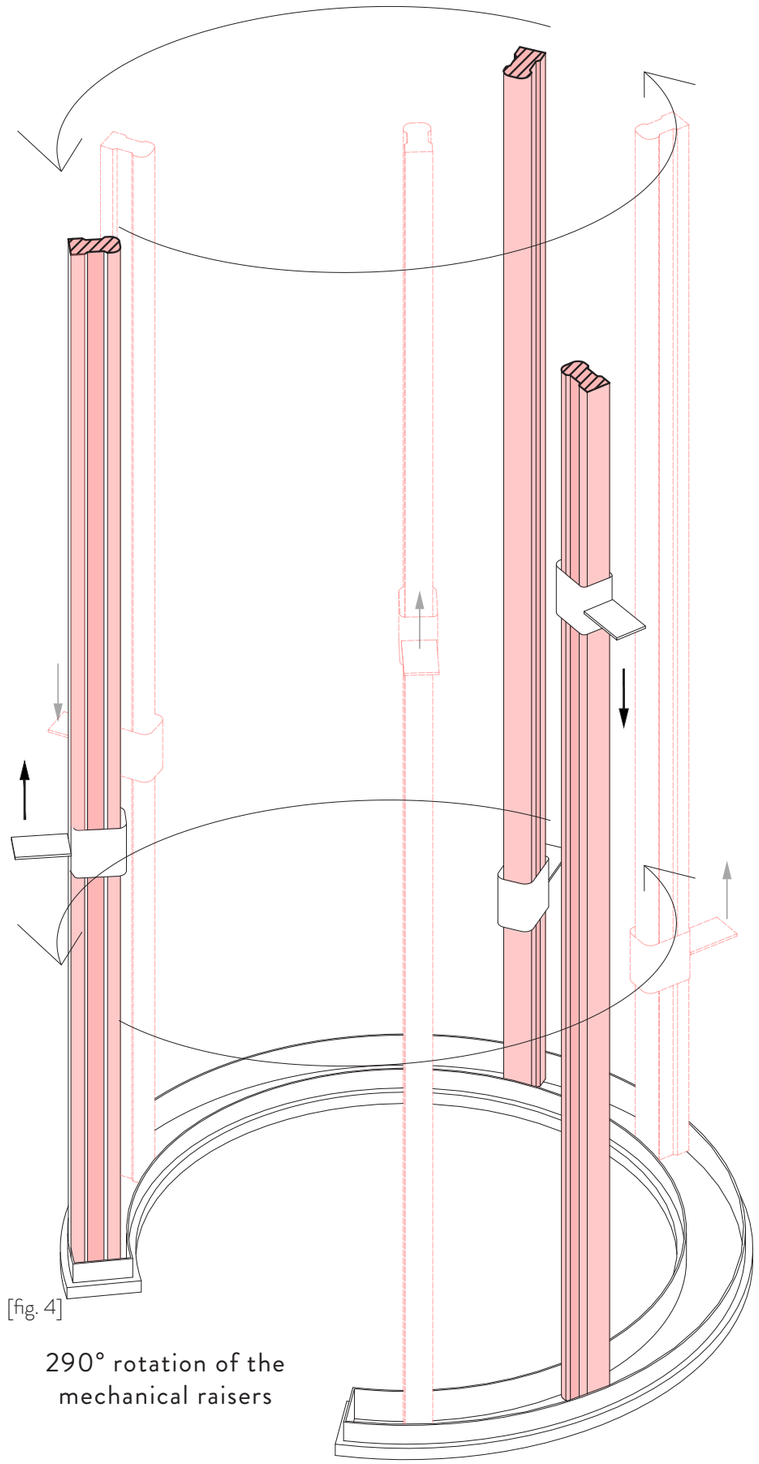
[fig. 2]

Cells and reiforced
concrete elements



[fig. 3]

Landings and ring for
mechanical raisers



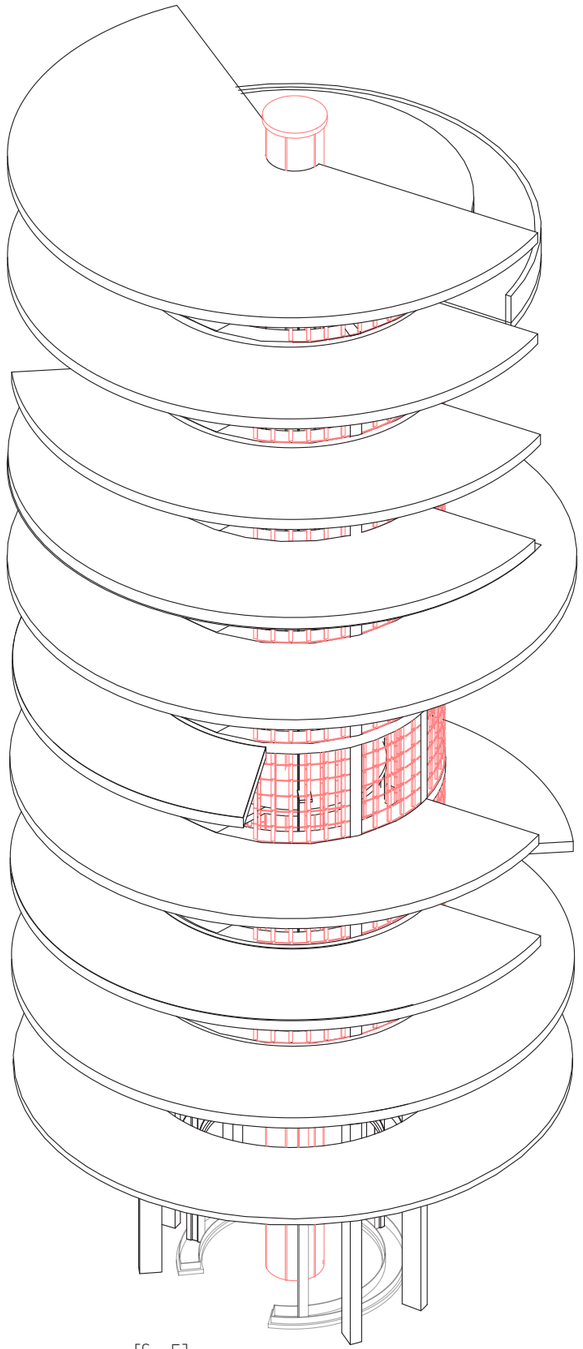
[fig. 4]

290° rotation of the
mechanical raisers

3.2 PLANS DISTRIBUTION

The plans design was related with the research of all the functions that were needed for the logistic centre, and the vertical disposition allowed us not to worry about the square meters issue related to the Campora Est area. Moreover the more we get up with floors distribution more cells number we have.
We set some specific measures to design the jutting elements, first of all they are projecting supported by a cantilever beam proportionate to have a projection of 4 meters, the height is set by a number of 6 cells. We decided to have an offset of only 4 meters for the floors running around the core because we wanted to maintain a certain proportion between the height and the width of the tower. We imposed ourselves the challenge to fill all the floors of all the functions needed in this logistic centre in only 4 meters width.
The entire core structure is made by reinforced concrete columns and rings in which the cantilever beams are inserted to support all the weight of the floors. [fig. 5]

The plans shape is circular and rotates all around the central core, but always have to be connected to the landing for the access. This structural conformation allowed a freedom of the plans design according to their functions. So we never used a 360°



[fig. 5]

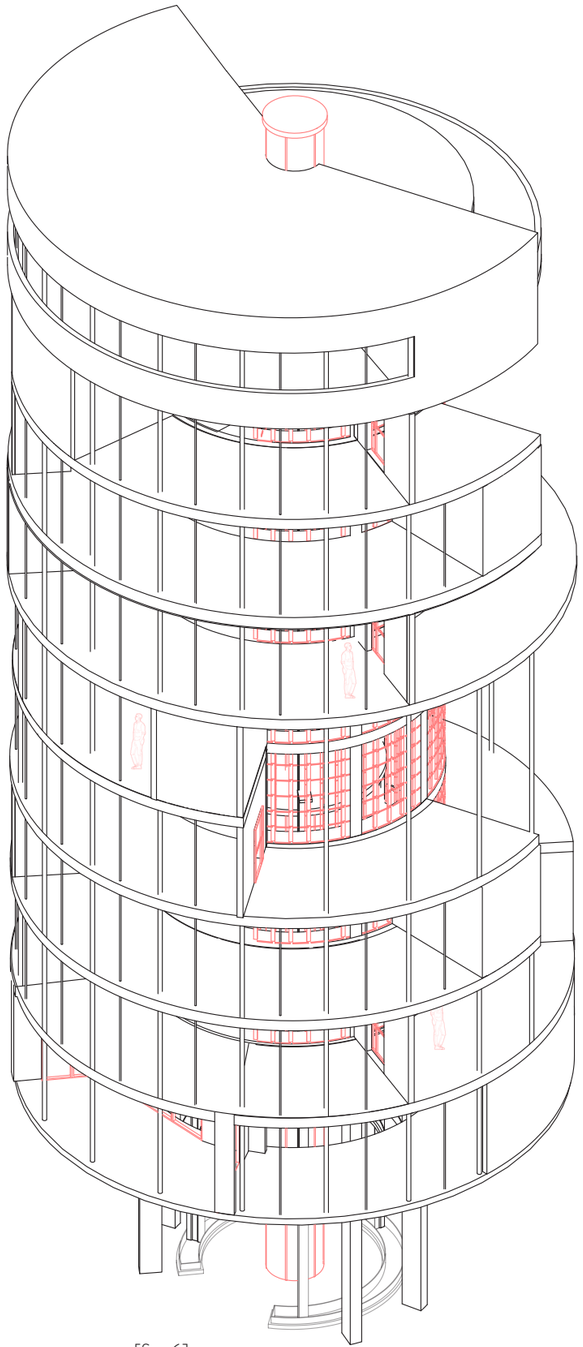
projection elements

plan but we have always opened the single function of each floor with a portion of at lest 60°. In order to let the cells core always visible. Rotating the plans but always keeping the connection with the landing we were able to create different balconies once again connected to the singular function of each floor. [fig. 6]
The last step was adding all the functional elements like staircases, ramps and all the structural elements like columns and bracing elements to reinforce where needed. [fig. 7]

Every floor was used for a specific and needed function both for the logistic centre topic and the service area one. [fig. 8]

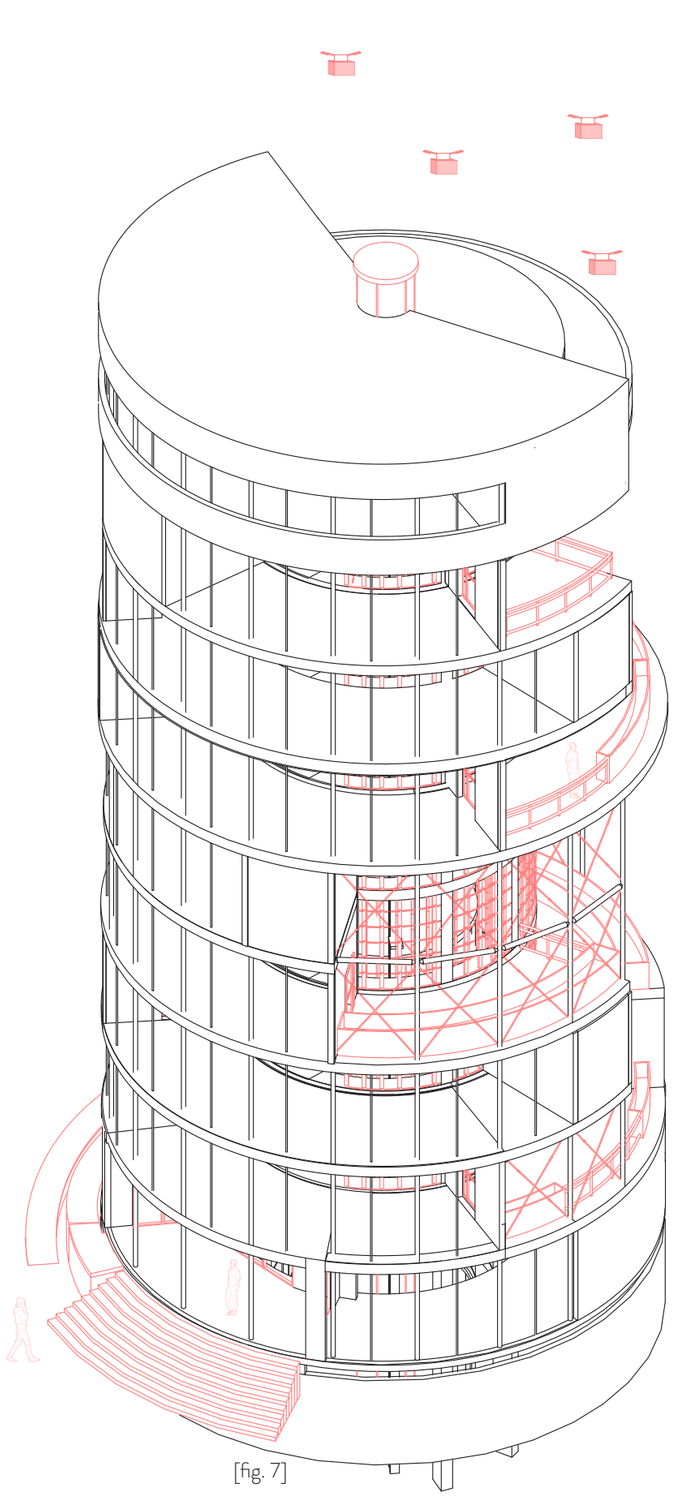
As consequence of the right equilibrium between all the necessary topics and our stylistic choices we obtained a 9 floor tower with almost 1500 cells. Some of the functions inserted in the tower are very peculiar and also very important for the logistic centre concept.
At the first floor for example we have a cashierless mini market that allows customers to pick up all the items they need and then simply walk out the door. Skipping the checkout entirely, shoppers are sent a receipt of their purchases through a specific app (a necessity to enter) after leaving the store. This specific elements has been thought for those costumers that are traveling and doesn't want to spend too much time inside the service area. [fig. 9]

At the second floor there is the logistic locker one of the most important places of the tower. Here the costumers can withdraw their orders previously made or buy new goods directly in place



[fig. 6]

Floors and balconies
conformations



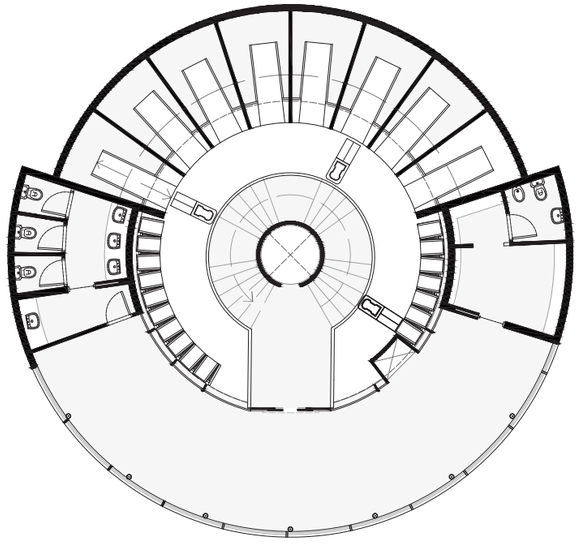
[fig. 7]

Funtional elements

through the mobile-ordering. In this way they can collect the orders they have made or make a new one and make it arrive at the tower before they reach their final destination. So once the costumers arrive in the tower they just have to read on the app the number of the cell of the order location and unlock it to retire the box. The cells are openable from the locker trough some little windows.
When the customers are making a new order directly in place, if the system find a match with it the mechanical raisers take the box wherever it is stored in the tower to bring it directly to the cell selected by the costumer. [fig 10]

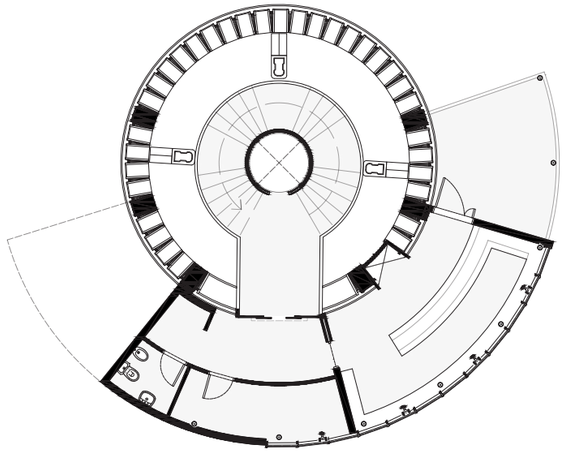
Another important and essential topic that has been inserted in the tower are the offices, throughout the tower there are 4 offices. Two of them (3rd and 5th floor) are used for the maintenance and management of the sorting and shipping system of the tower. The other two (6th and 7th floor) are used for the monitoring of the piezoelectric power supply that makes work all the tower. The offices are those with the biggest balconies.[fig. 11]

The last topic of the tower is the droneport set at the last floor to let the drones fly away without any problems and to do not interrupt the storing process made by the mechanical raisers. This floor is divided in 2 sides, on one side there is a restaurant where you can enjoy the view of the landscape from an high observation point and on the other side there is the droneport where the drones come and go carrying boxes. The restaurant is connected directly with the kitchen on the floor below. [fig. 12]

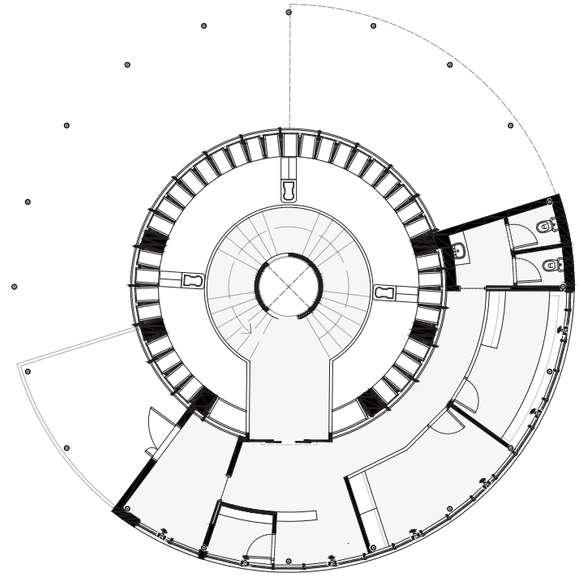


9th FLOOR
drone port/restaurant

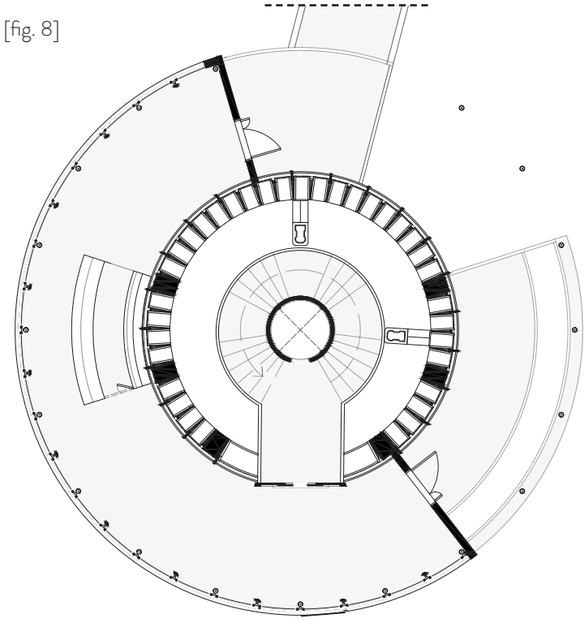
[fig. 8]



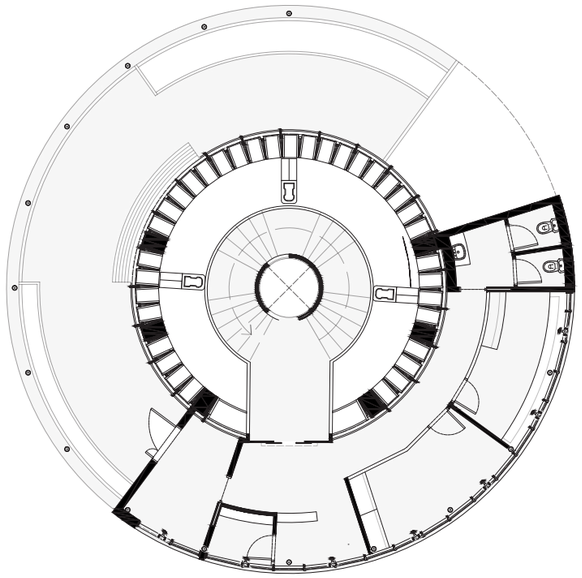
8th FLOOR
kitchen



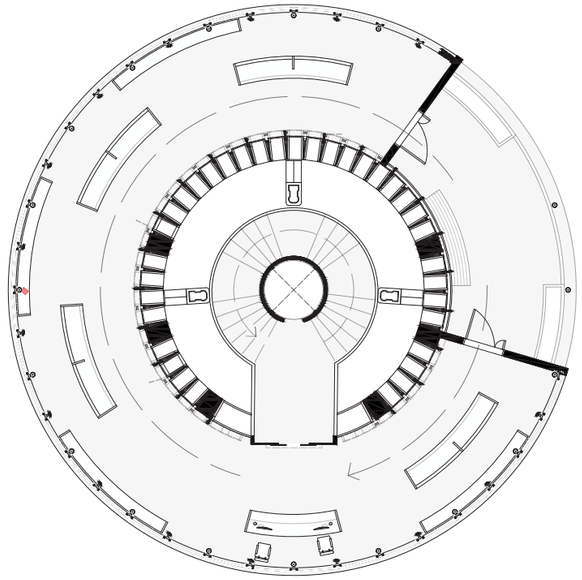
7th FLOOR
piezoelectric office



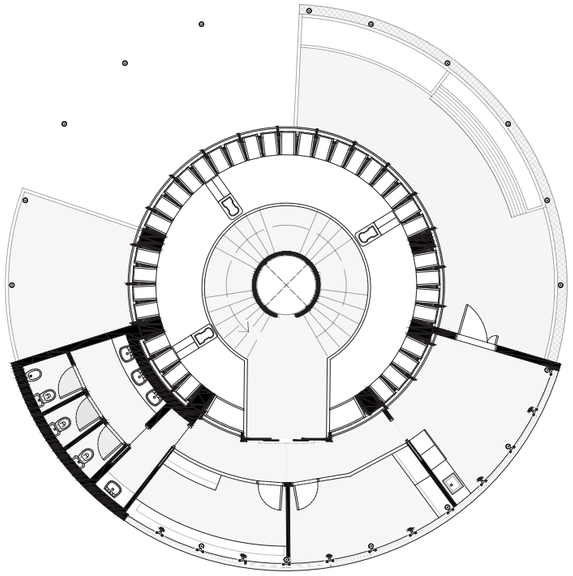
4th FLOOR
bar/bridge



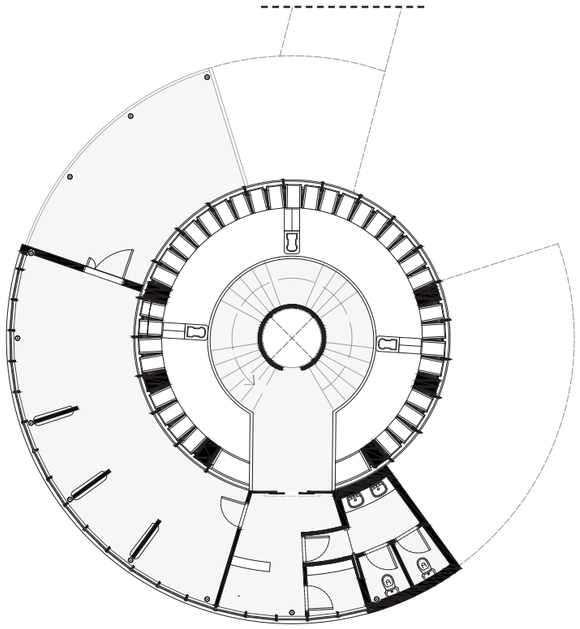
3rd FLOOR
logistic office



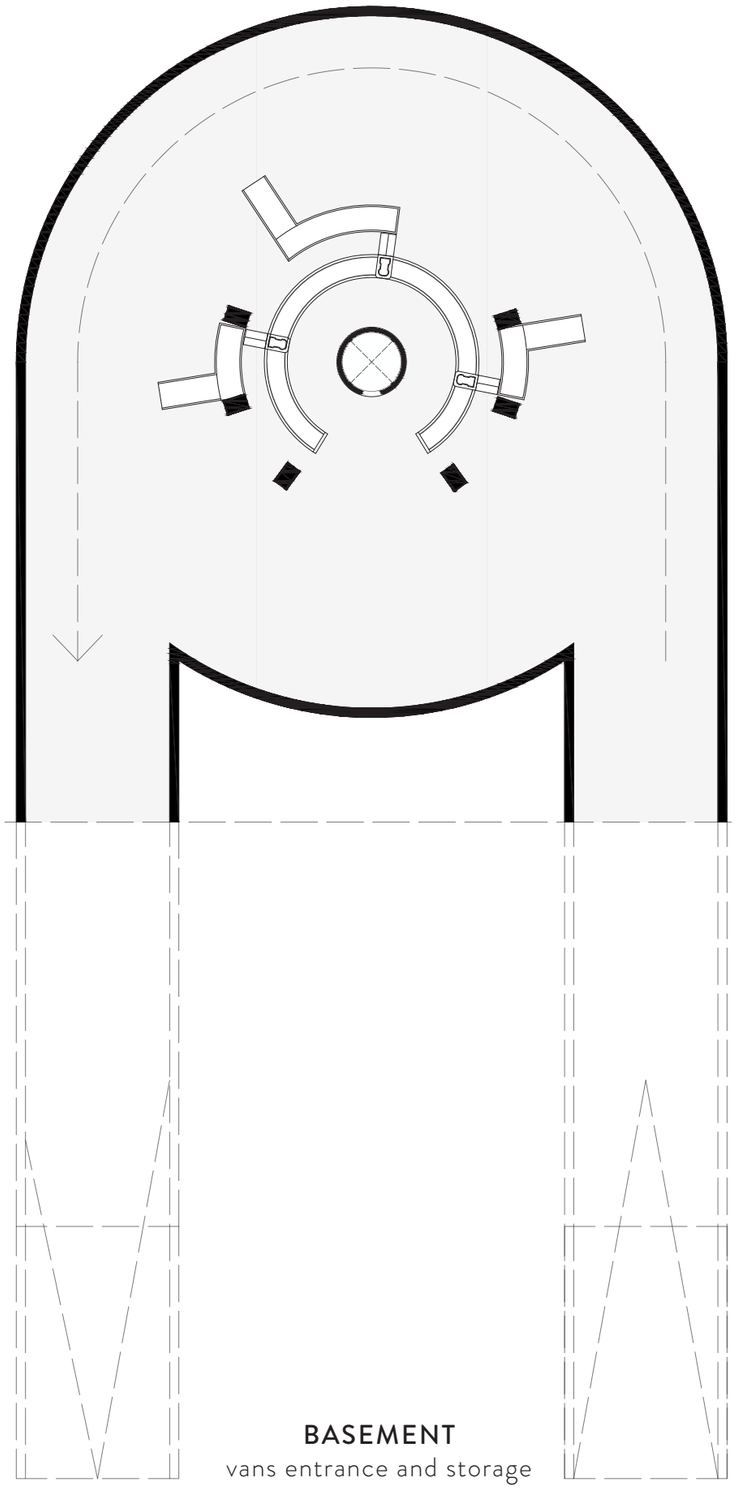
2nd FLOOR
logistic locker



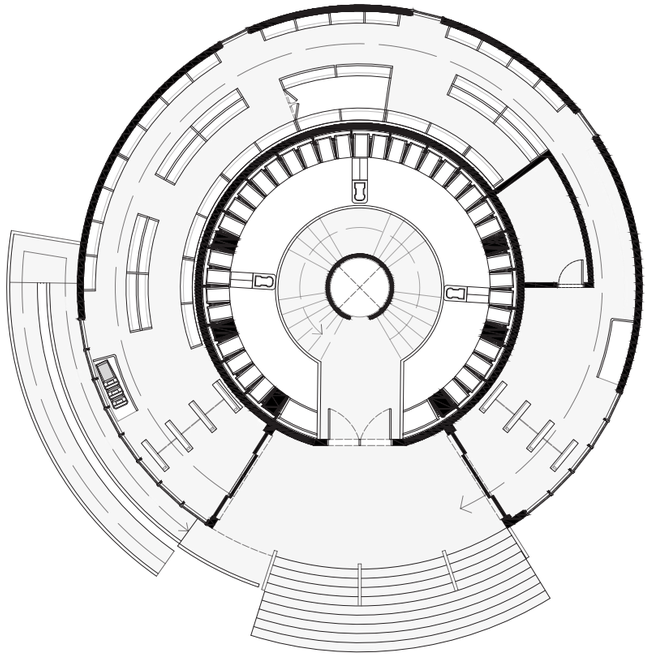
6th FLOOR
piezoelectric office



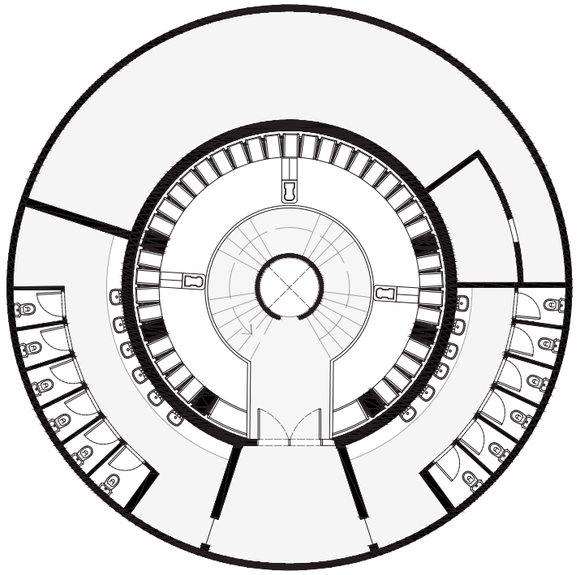
5th FLOOR
logistic office



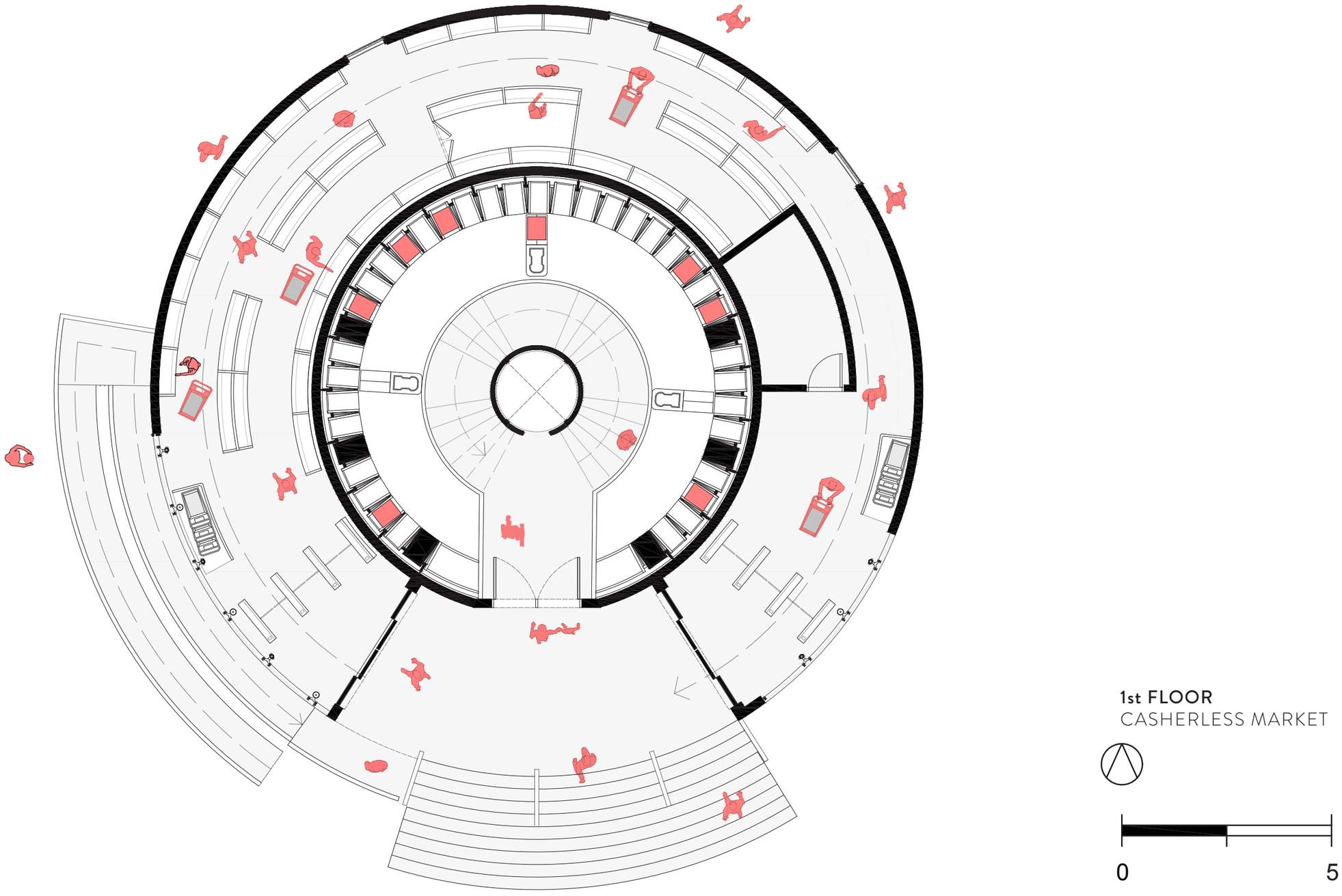
BASEMENT
vans entrance and storage



1st FLOOR
casherless market



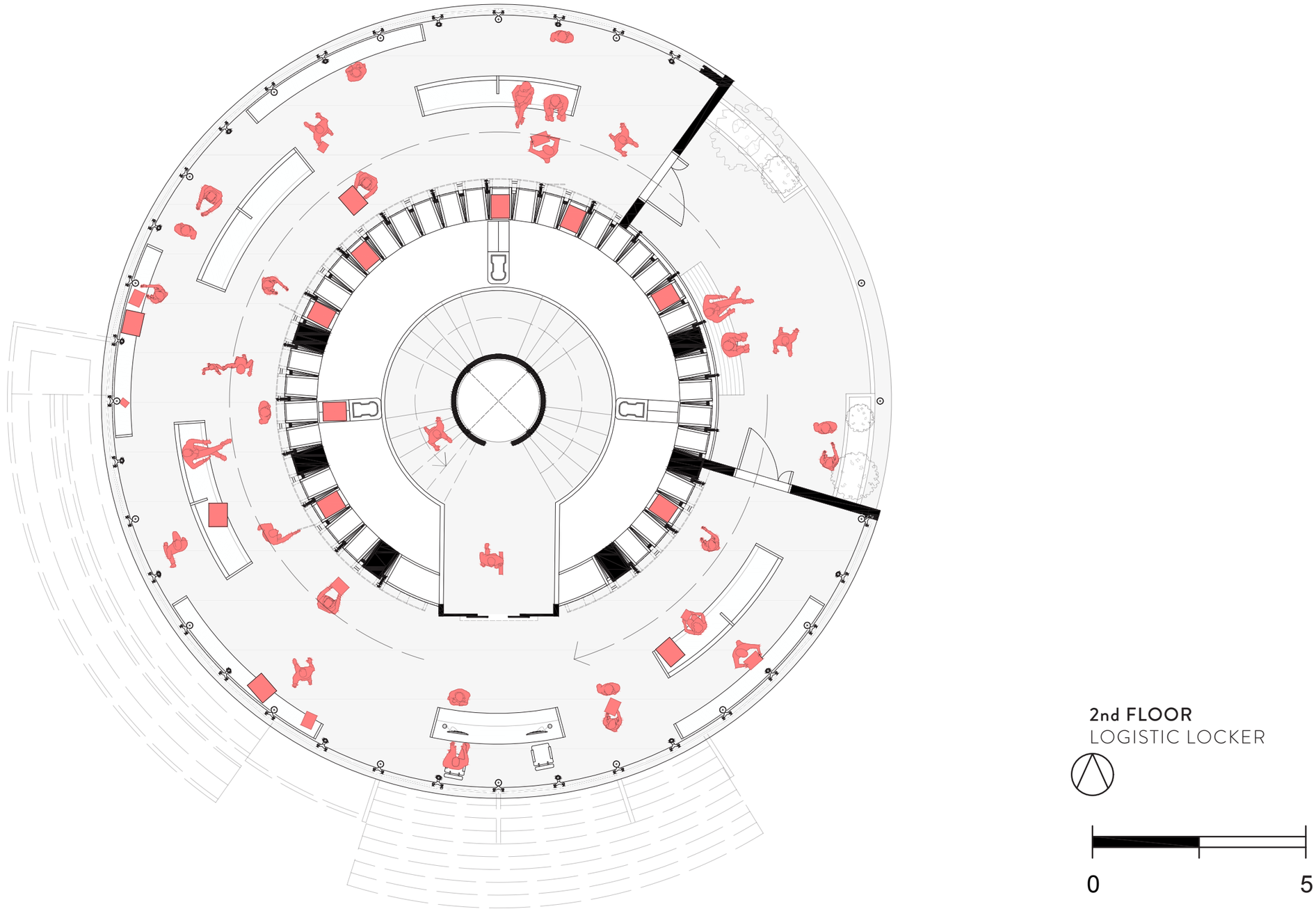
MEZZANINE FLOOR
drone port/restaurant



1st FLOOR
CASHERLESS MARKET

0 5

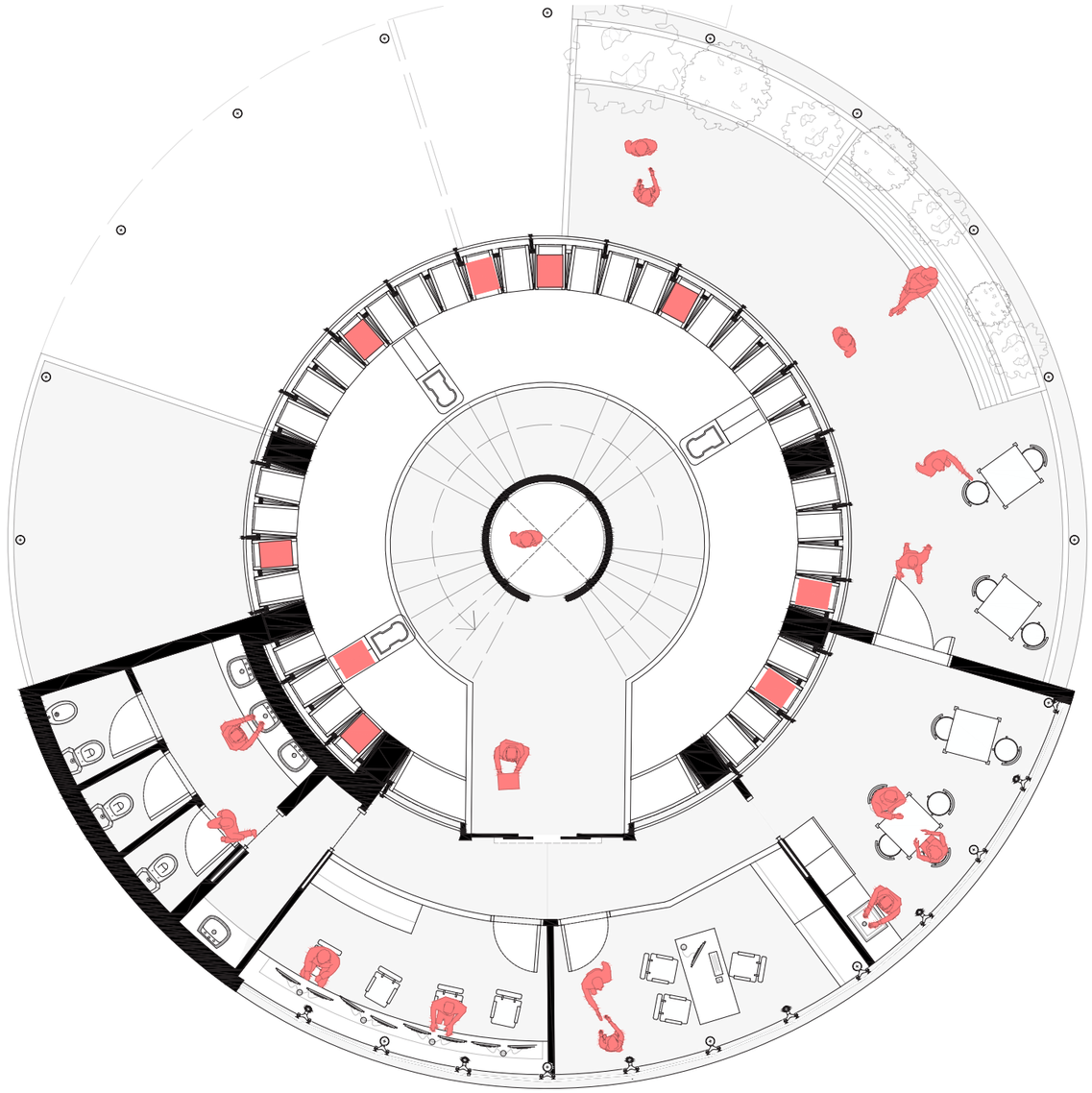
[fig. 9]



2nd FLOOR
LOGISTIC LOCKER

0 5

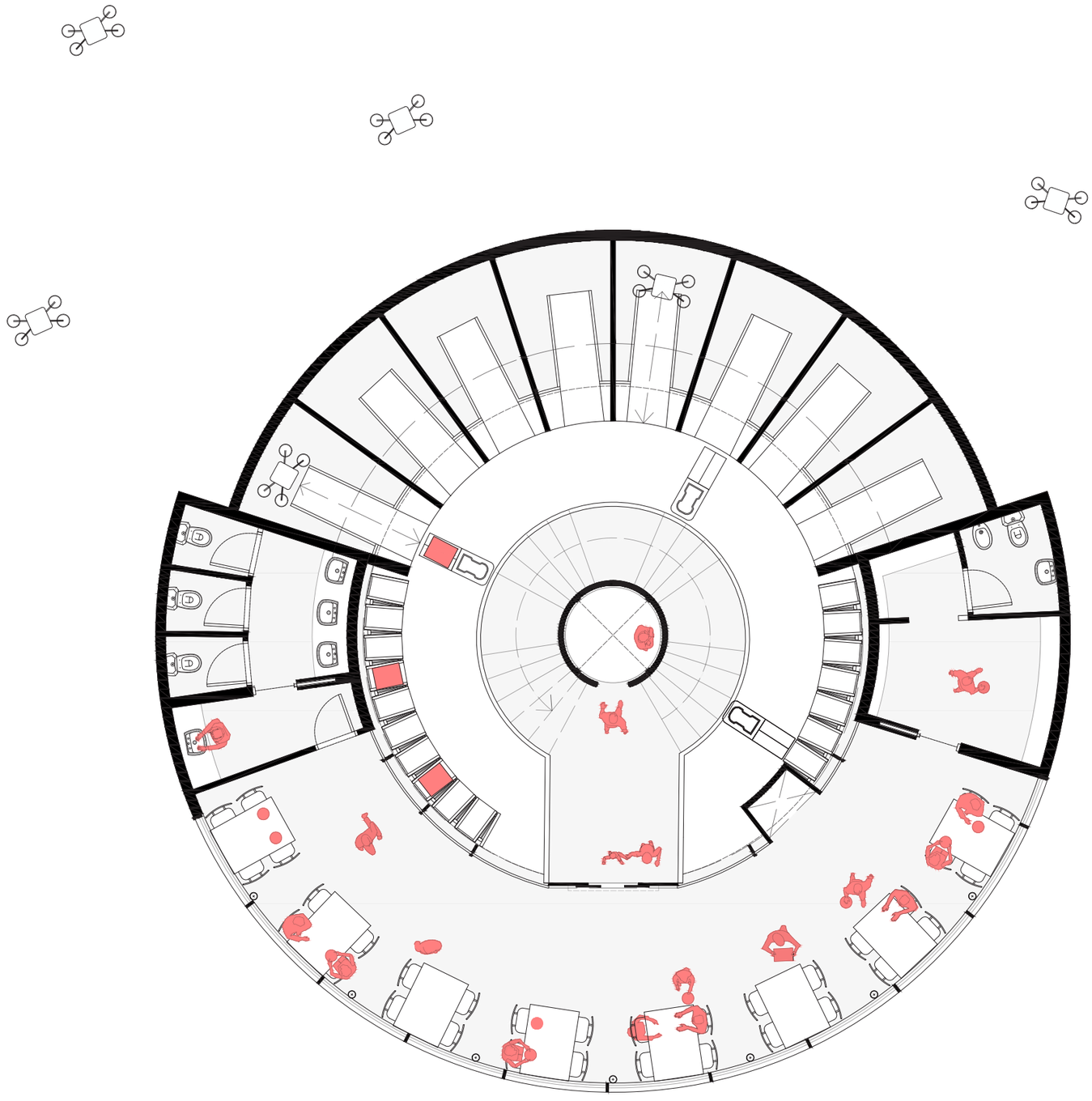
[fig. 10]



6th FLOOR
PIEZOELECTRIC OFFICE

0 5

[fig. 11]



9th FLOOR
DRONE PORT/RESTAURANT

0 5

[fig. 12]

3.3 EXTERNAL COMPOSITION

Once we designed all the interior disposition according to all the functional needs we obtained 11 plans vertically disposed, adding the underground level and the mezzanine one. This disposition creates the final external shape of the tower.

All the plans rotate all around the central core and every entrance has the same position on the floor. The elevator landings is oriented to the South which means that all the jutting bodies are mostly oriented to the South. This gave the tower a specific orientation in which the North facade is completely different from the South facade.

In the North facade, the back part of the tower, the cells core is almost completely visible and a polycarbonate cladding allows to glimpse the boxes in the cells, that, according to their disposition creates a different pattern every time. The polycarbonate cladding is also the room divider between the jutting bodies and the cells

core. In this way the cells and the mechanical system beyond them can be seen all around the tower.

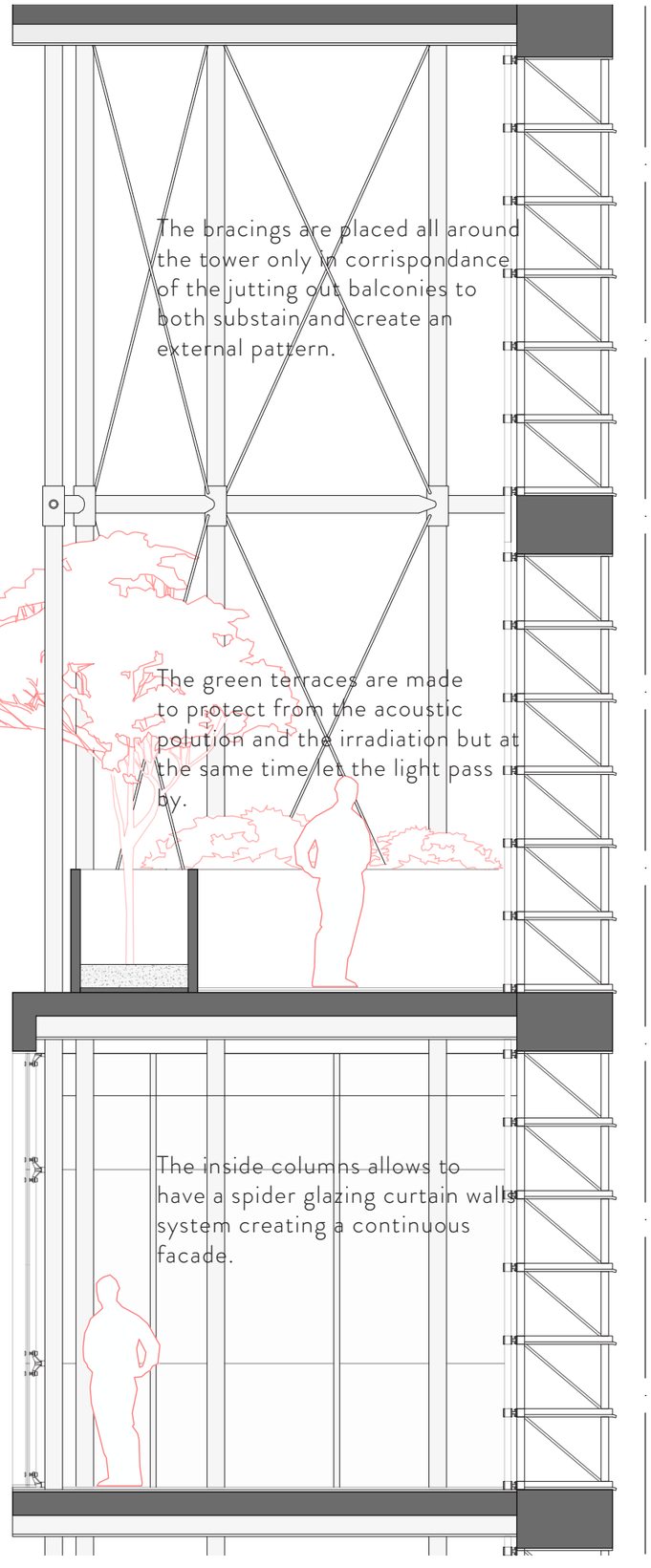
The rotation of the jutting bodies all around the same axe creates some staggered points between them also given by the different length of each floor. These staggered points generate the terraces. [fig. 13]

A very relevant aspect of the terraces is that they are supported by a cantilever beam like the other parts of the structure and their stability is reinforced on the corners by the support of columns. In this way the columns are located only where is structurally needed adding lightness to the whole structure.
The last structural essential part are the bracings, positioned between the columns only in correspondence of the balconies stiffing the “holes” created by the jutting elements; moreover refer to the industrial theme that characterize the rural areas of this part of the highway.

The final result is the combination of different elements that make the structure more resistant and at the same time create an interesting texture.

To complete the external design we added some other elements to better define the entire aesthetic outcome.
On the mezzanine floor we have reinforced concrete walls only interspersed by a ribbon window.
In the other floors we used a spider glazing curtain walls system

[fig. 13]


The bracings are placed all around the tower only in corrispondance of the jutting out balconies to both substain and create an external pattern.
The green terraces are made to protect from the acoustic polution and the irradiation but at the same time let the light pass by.
The inside columns allows to have a spider glazing curtain walls system creating a continuous facade.

that allows a continuous facade. With this option the entire tower assumes a lighter look. The internal disposition creates some concrete walls on the facade that mixed with the full frame windows add an interesting pattern to the entire structure.

In the last floor we had a different approach, we used a 1.60m high continuous ribbon window to focus the view of those entering the restaurant on the horizon line by adding the aspect ratio effect typical of the movie screens that wants to focus the vision in a wider view. We wanted to differentiate the top of the tower with another finishing language.
With all this aspects we obtained a proportioned facade in all the 4 sides defined by full and empty parts that gives movement and depth to the facade.[fig. 14]

We ended the design by adding the aesthetic and finishing elements like the entrance stairs and the ramp on the ground floor and the handrail on the balconies. This last element mixes the normal handrail with plant pots in order to have some green spaces in the terraces.
The plants pots are proportioned to the terrace dimension and to the floor disposition in order to have higher plants only where the space is sufficient high. [fig. 15]
The addition of green elements has been made to protect from the acoustic pollution and the irradiation and at the same time let the light pass by giving vitality to the entire structure.

[fig. 14]

[fig. 15]

3.4 MECHANICAL OPERATION

The entire design of the tower is based on the central core mechanical system, all the design choices were made according to this functional part at the base of the project. The entire system is divided in 3 phases. [fig. 16]

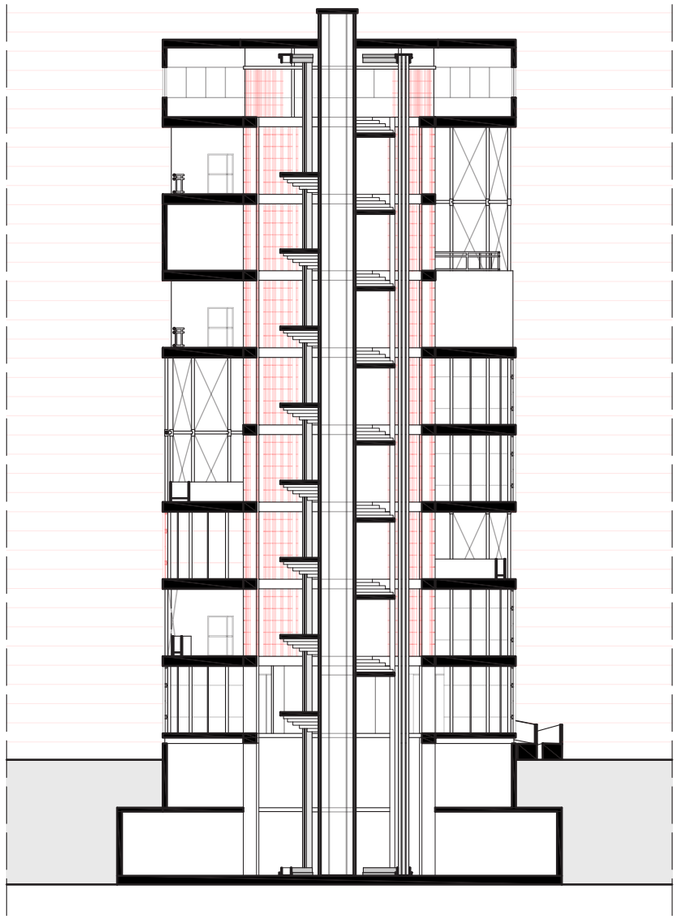
The first phase is located in the underground level, where the electric vans arrive. Here there are 3 spots where the vans can be unloaded. The goods are positioned in one of the 3 conveyor belts that are at the base of the mechanical raisers' ring. These conveyor belts brings the boxes to the mechanical arm which reads the bar code of the box and automatically takes it to the storage cell number entrusted to it by the computer.
The cell number remain registered on the server to be available when it's needed. The 3 mechanical raisers work and rotate at the same time lifting 3 boxes at the time up or down.

The second phase is the storing location. The boxes can be stored in one of the 1500 cells that are in the tower, depending on its

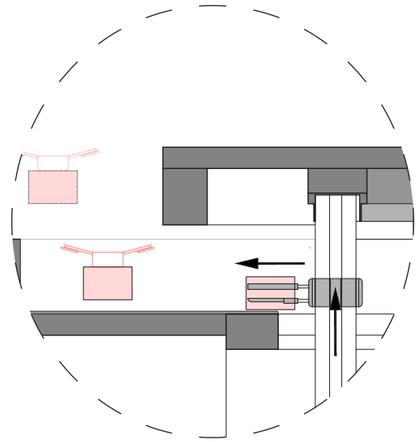
priority.
If a box has to be picked up by a costumer the mechanical raisers take it directly into the locker at the 2nd floor, but if at the moment is not needed it remains stored in the other cells. This concept also allows to have a variety of different goods stored in the tower and this makes possible to shop something directly in place, just checking on the app what is available in the tower.

The last phase is the shipping. When a box has to be shipped it can be done by the vans or with the drones. The selected box is taken from the cells and is brought to the underground level, or to the droneport and picked by one of them.
This system is automatic and it's controlled and monitored by the employers of the logistic centre. The costumers can see the automation process of the mechanical raisers from the inside of the core, in the elevator or in the staircase, and from the inside of each floor and they can see the drones fly away from the outside.

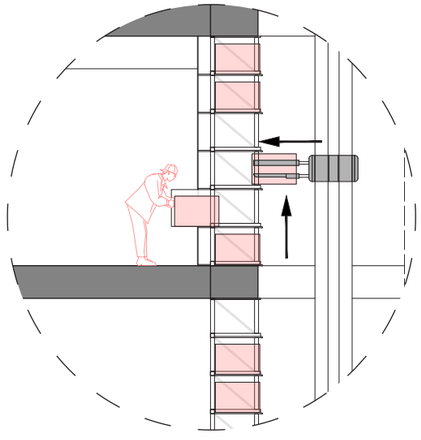
[fig. 16]



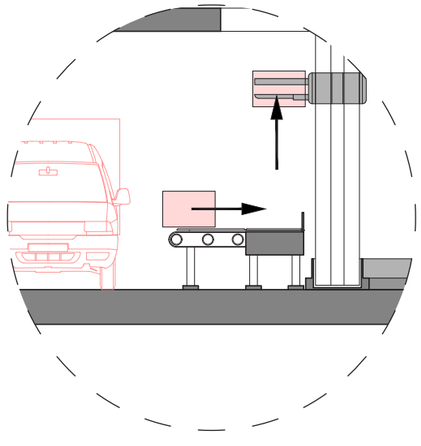
1:200 NORTH SECTION



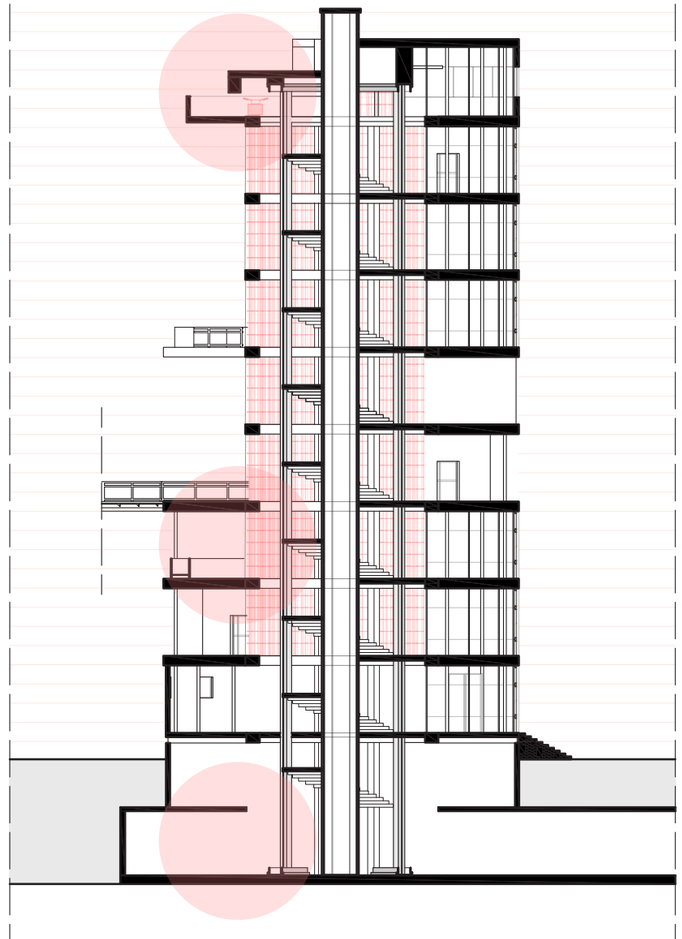
PHASE 3



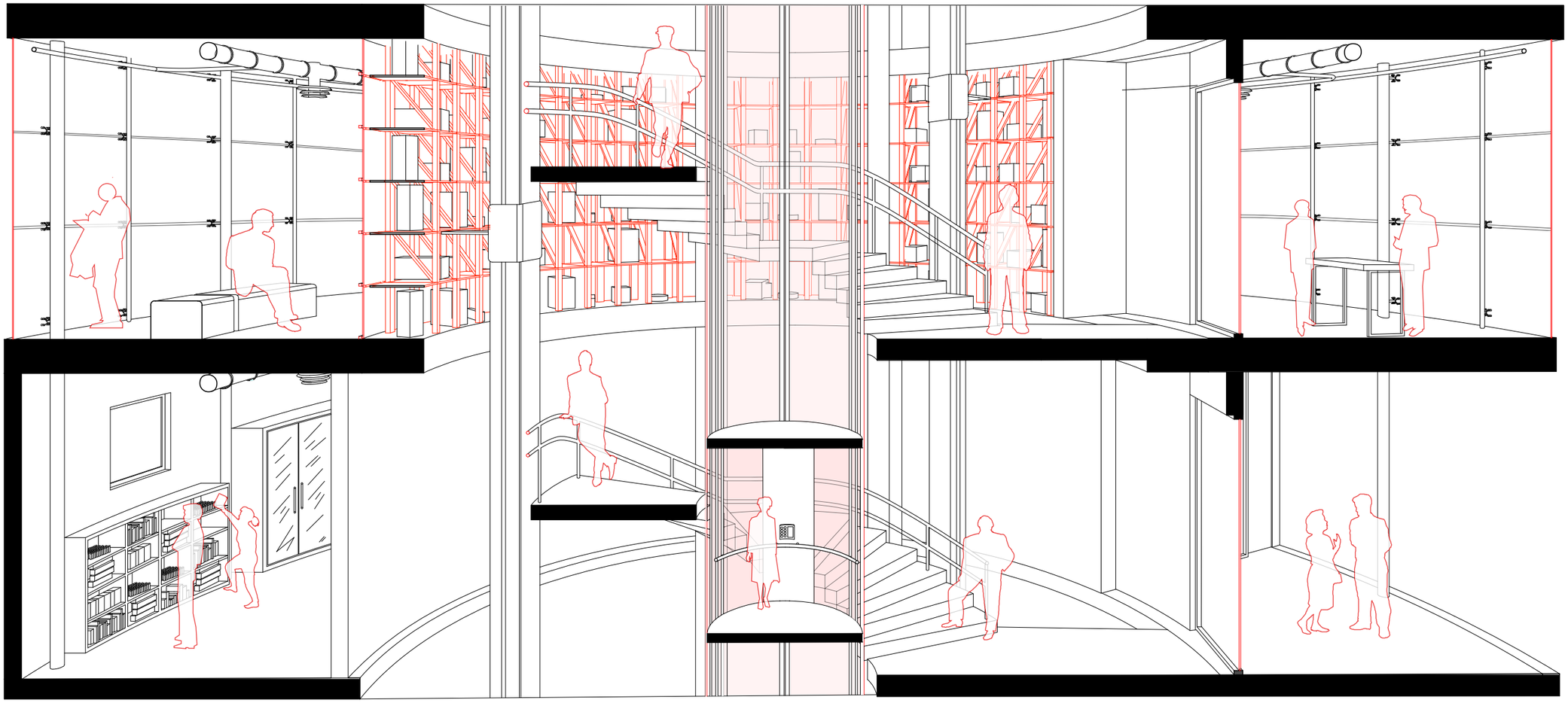
PHASE 2



PHASE 1



1:200 WEST SECTION



[fig. 17]

SCHEMATIC SECTION 1:100
1st floor (casher less mini market) and 2nd floor logistic looker.

4. TERRITORIAL INTEGRATION

4.1 VIABILITY SYSTEM

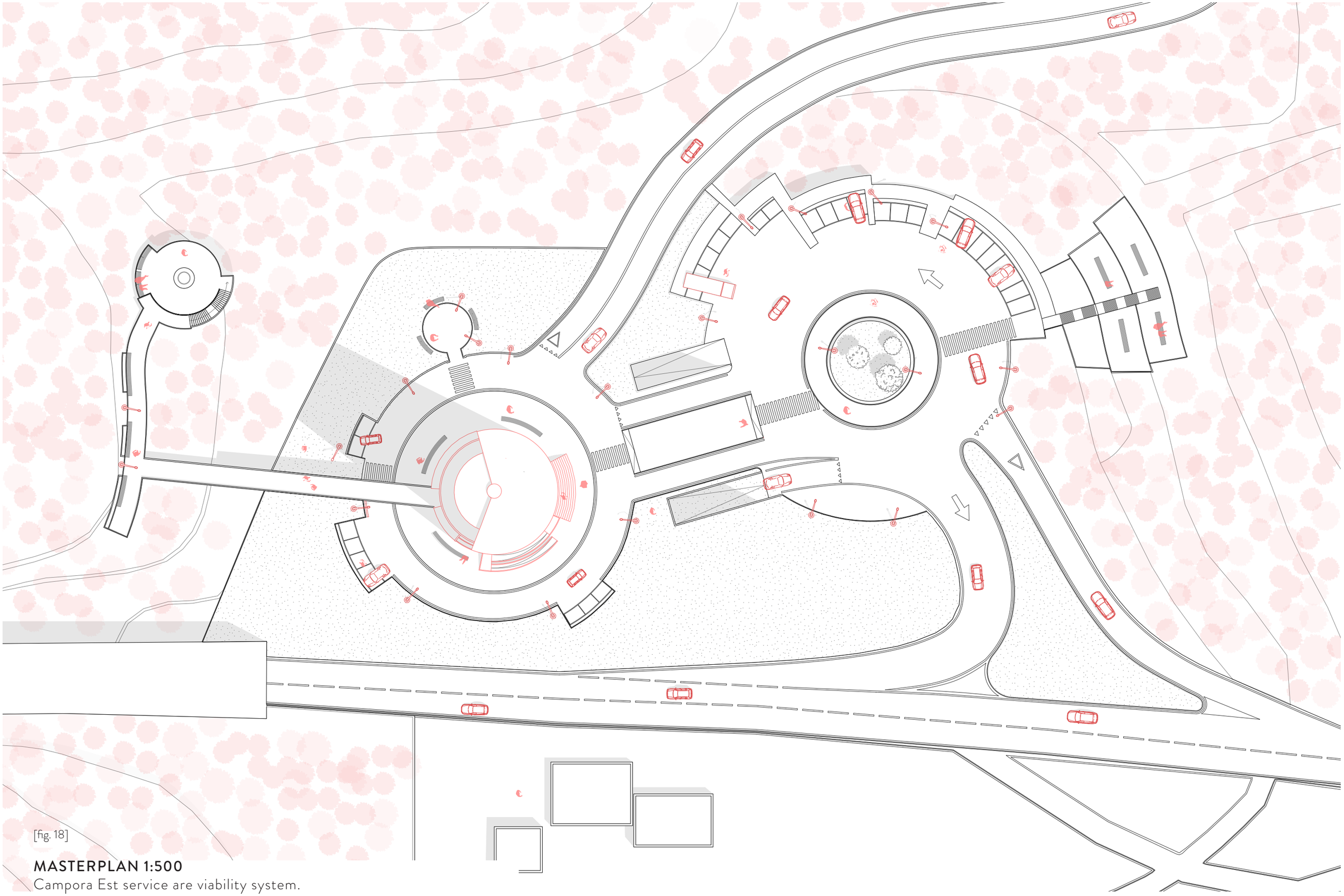
Once all the planning aspects of the tower prototype were finished we focused on the territorial integration into the Campora Est service area.
This specific area has a well structured viability system to remedy the lack of space, furthermore the exit from the service area is very close to the tunnel entrance.

According to the Autostrade s.r.l. viability limits and laws it is mandatory to keep a certain minimum distance between the exit and the tunnel. This means that in order to have a functional system to enter and exit from the gas station we can't completely upset the existing entrance and exit but just arrange them in a way that could fit our project.

For what concerns our project the only aspect related with the viability system is the underground entrance and exit for the electric vans that uses a simple roundabout on the basement of the tower. Here the vans can enter and exit in an easy way without interfering with the viability.

In order to join both the viability system of the high way and the van's viability we designed a double roundabout system that allows to enter and exit from the area in an easy way.
This system finds a way to connect also with the road that is linked with the near areas of Serra Riccò keeping a privileged lane for the electric vans that interact with the tower.

The entire concept was conceived to an moment of the future where all the cars will be electric, so we assumed to have a large number of energy charging towers all over the parking areas instead of a single gas station. [fig. 18]



[fig. 18]

MASTERPLAN 1:500
Campora Est service are viability system.

4.2 PIEZOELECTRIC TECNOLOGY

The final element of territorial integration is one of the main topics of the entire project concept: the piezoelectric plates energy system.

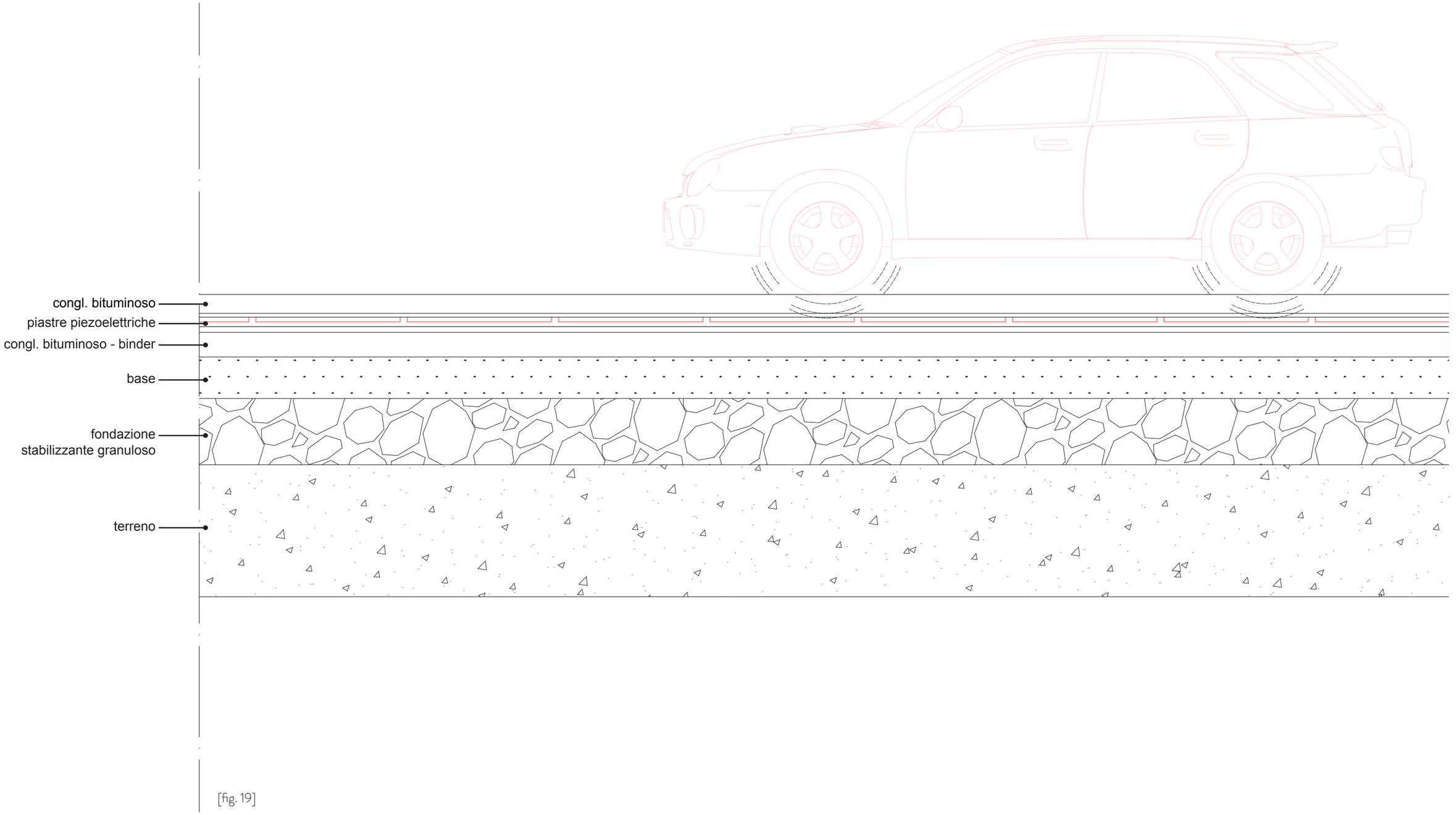
The piezoelectric effect converts kinetic energy in the form of vibrations or shocks into electrical energy.`Piezoelectric generators offer a robust and reliable solution by converting normally wasted vibration energy in the environment to usable electrical energy. They are ideal in applications that need to charge a battery, super capacitor, or directly power remote sensor systems. In the last few year many projects imprinted on the renewable energy have been working on this technology.
These piezoelectric plates in a portion of 10 km highway on which about 600 cars pass per hour, with a theoretical production of five megawatts, generates more or less the energy needed to illuminate 1500-2000 apartments for one hour. The plates are inserted through a double layer of asphalt, inside which there is a “padding consisting of a mixture of quartz, salts, phosphates, piezoelectric minerals and the accumulators connected to the platform, it is possible to obtain a good amount of clean energy.
[fig. 19]

The same concept can be applied inside a tunnel where vibrations resonate through the walls of the tunnels generating an even greater energetic response.

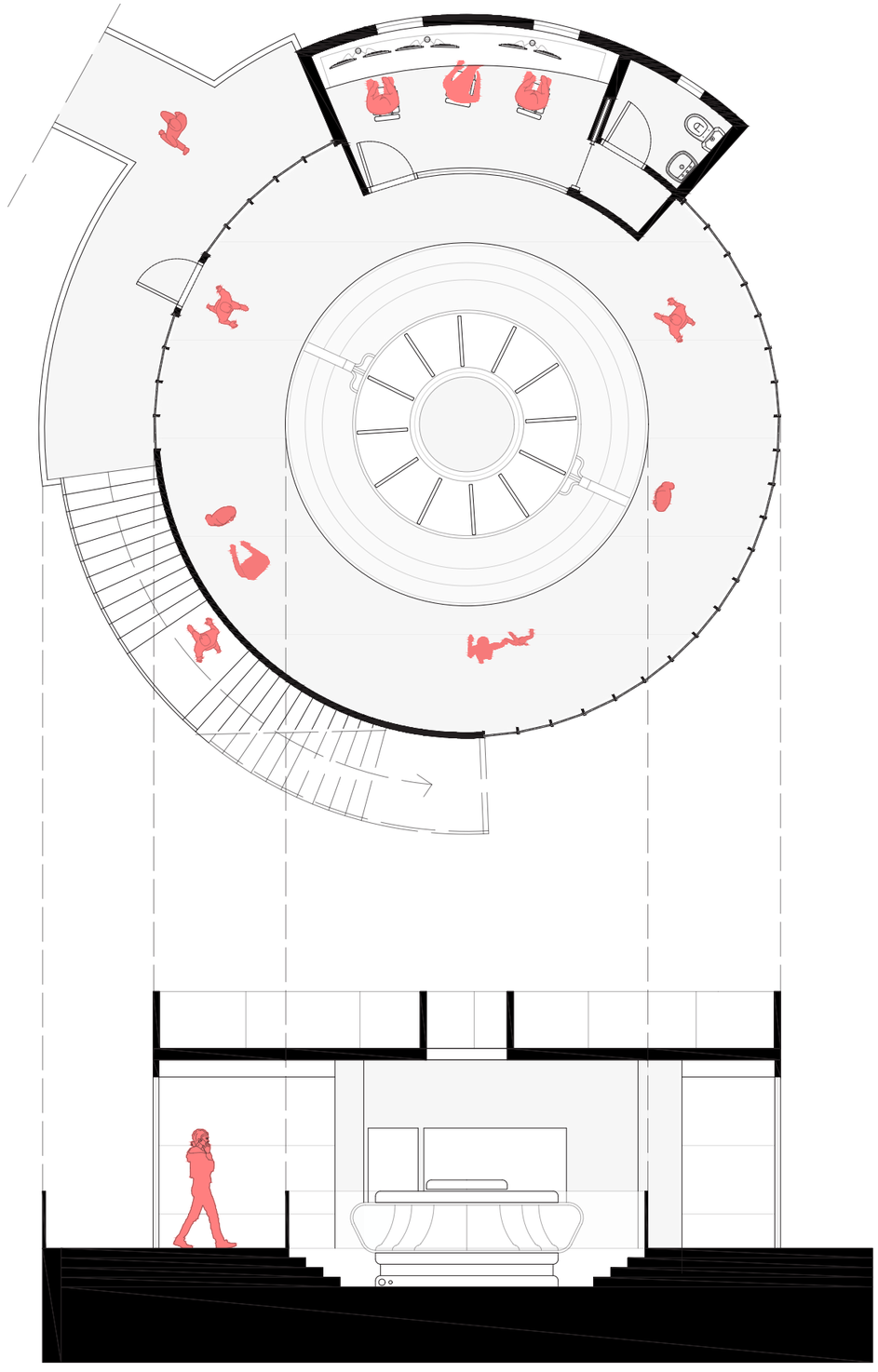
For this reason Campora Est is a perfect spot for this kind of technology and make the tower self-sustainable. Therefore we needed piezoelectric plates under the road surface but also a power capacitor to store the energy arriving by the motorway. On the begging we designed the power capacitor to be inside the tower under the basement, but we though that this element could have been not only a practical functionality but also an attractive point of interest that appeal visitors. [fig. 20]

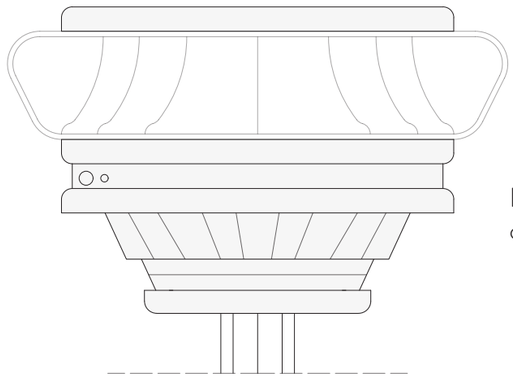
For this reason we decided to locate the power bank station in the hill side of the site reachable by a bridge that directly connects the tower with a path leading to the capacitor location. This idea wants in some way to connect this element of the tower with the environment and invite the visitors of the service area to have a walk in the surrounding nature.

In this way they can observe the piezoelectric capacitor technology and at the same time observe the Boxes Core Tower and the Serra Ricco landscape. [fig. 21]

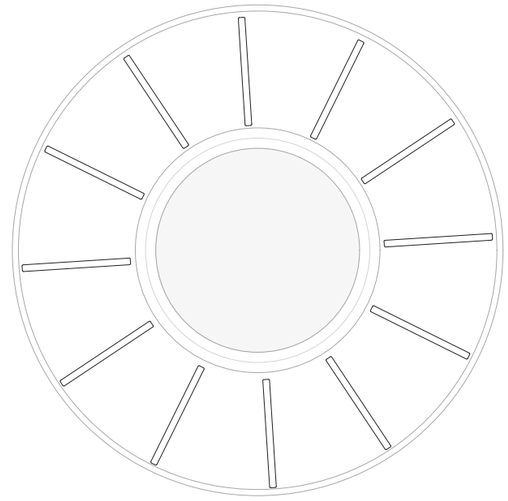

congl. bituminoso
piastre piezoelettriche
congl. bituminoso - binder
base
fondazione
stabilizzante granuloso
terreno

[fig. 19]

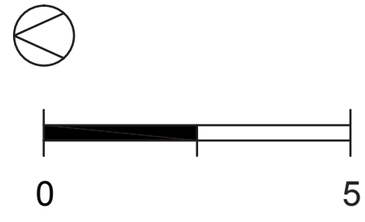




Piezoelectric
capacitor

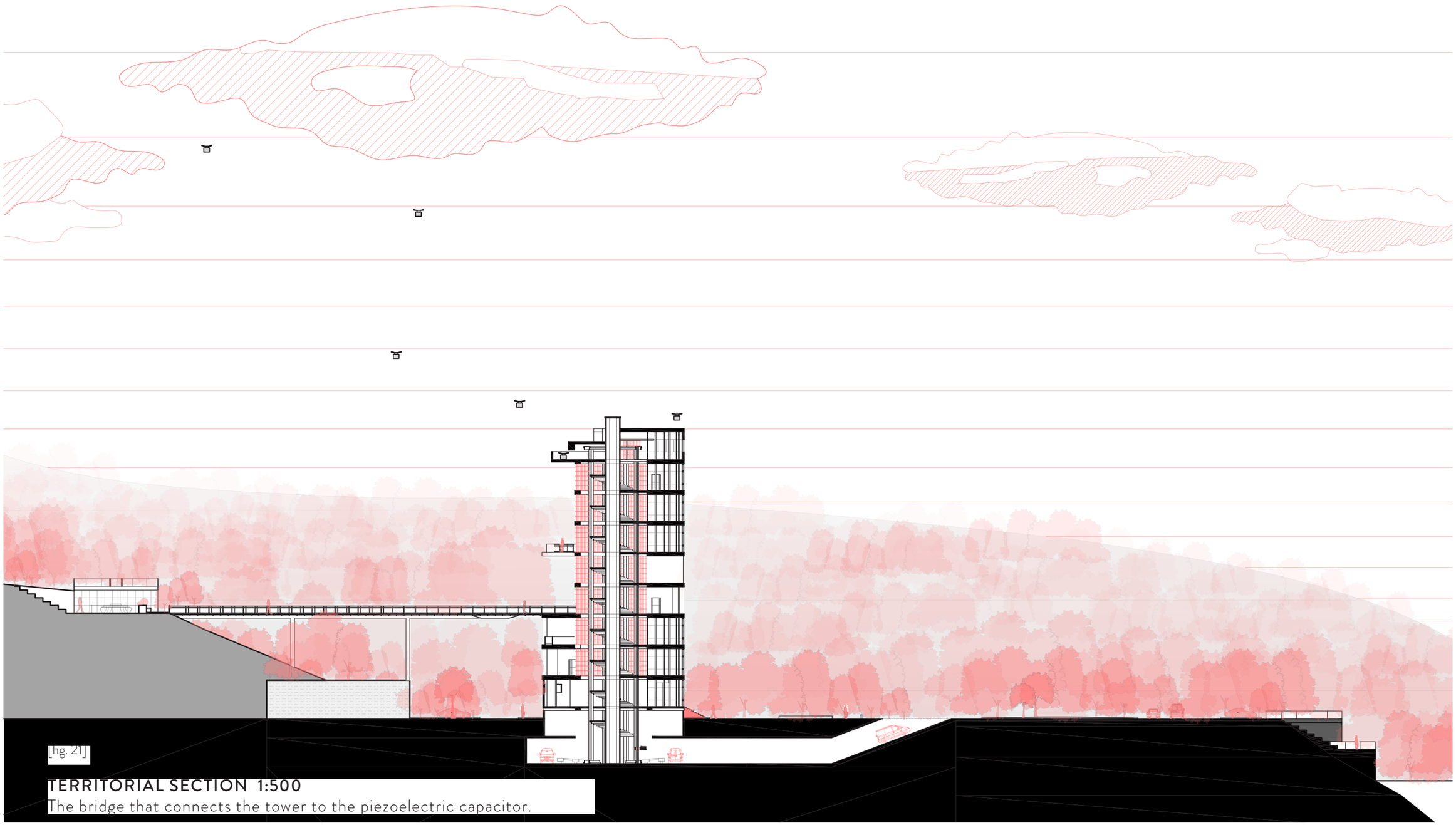


Scale 1:50



[fig. 20]

POWERBANK STATION 1:100



[fig. 21]

TERRITORIAL SECTION 1:500
The bridge that connects the tower to the piezoelectric capacitor.

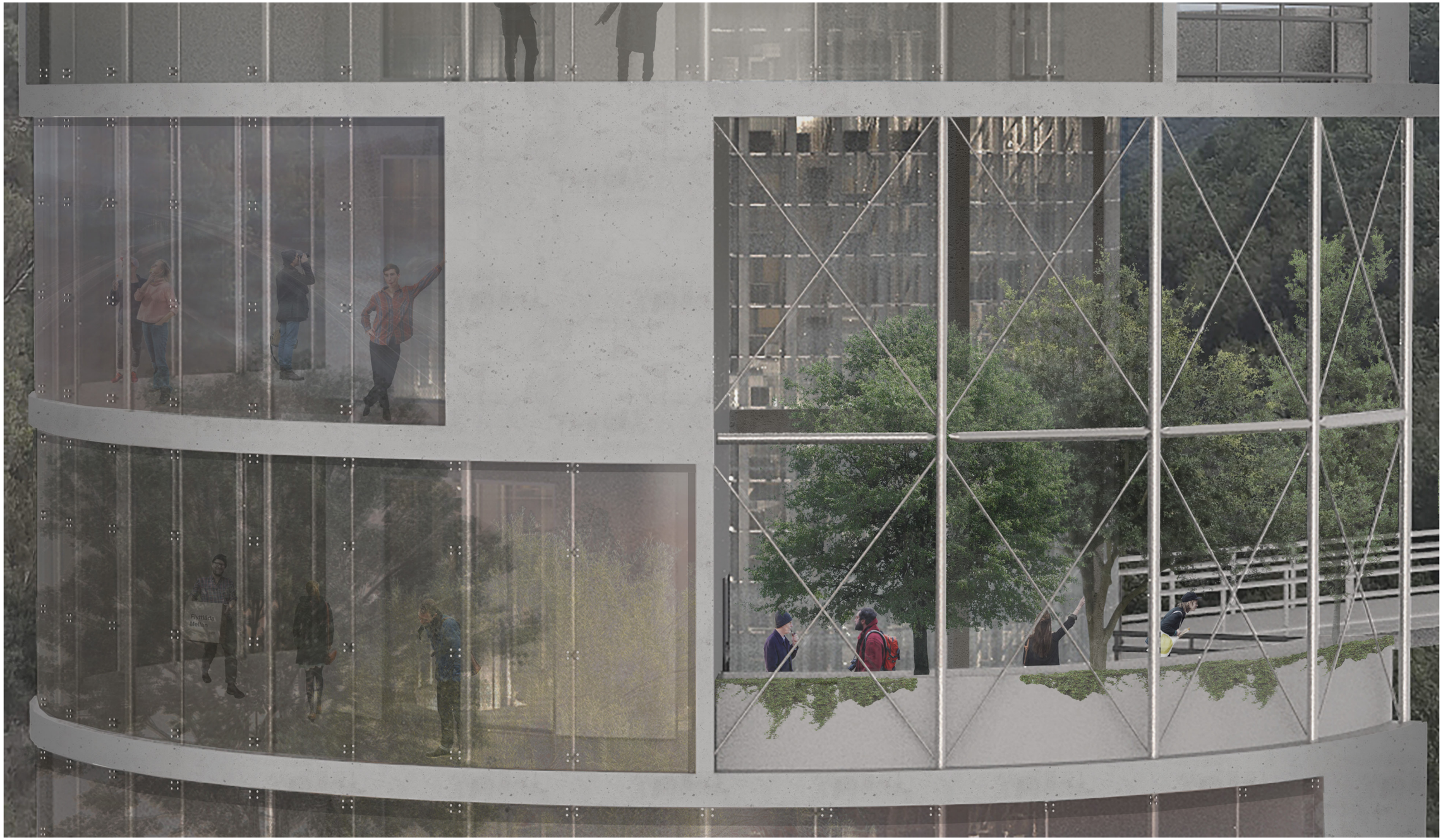
5. CONCLUSION

5.1 THE BOXES CORE TOWER

The Boxes Core Tower is a 37 meters structure set in Campora Est service area that fulfills the role of a modern logistic and sorting centre that serves Serrà Ricco and all the close areas, totally self-sufficient thanks to an innovate piezoelectric plates system that transforms the cars transit into energy.

The project wants to join the architectural element to the pure functional element of the logistic centre topic inserted in the service area context.

LOCKER INTERNAL VIEW



BOXES CORE EXTERNAL VIEW