Reviving the hospital building

A sustainable renovation of the AMC

Architectural Engineering

Graduation Studio

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P5 Presentation

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Context: AMC Hospital
Amsterdam

Sustainability

- 70% of 2050 european building stock already exists

- In the Netherlands

  - 50% built between 1945 and 1985

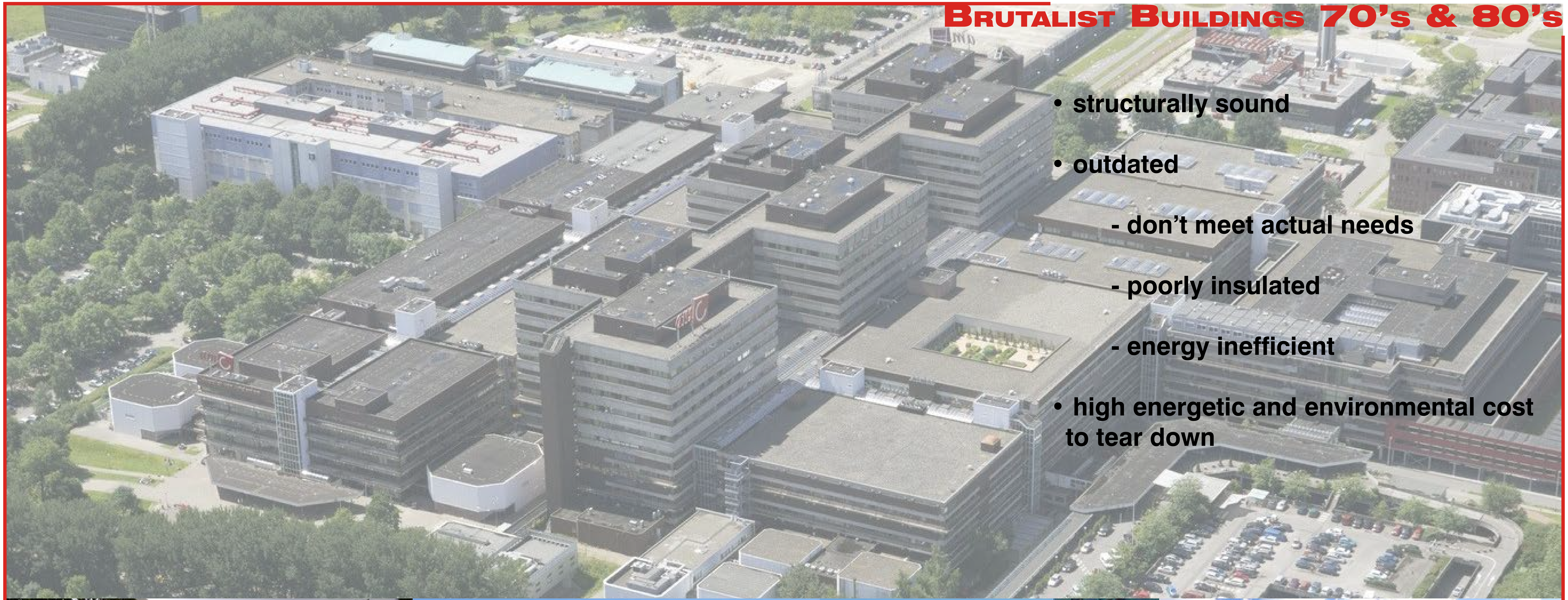
  - large amount of buildings 1970's and 1980's

  - buildings outdated according to today's standarts

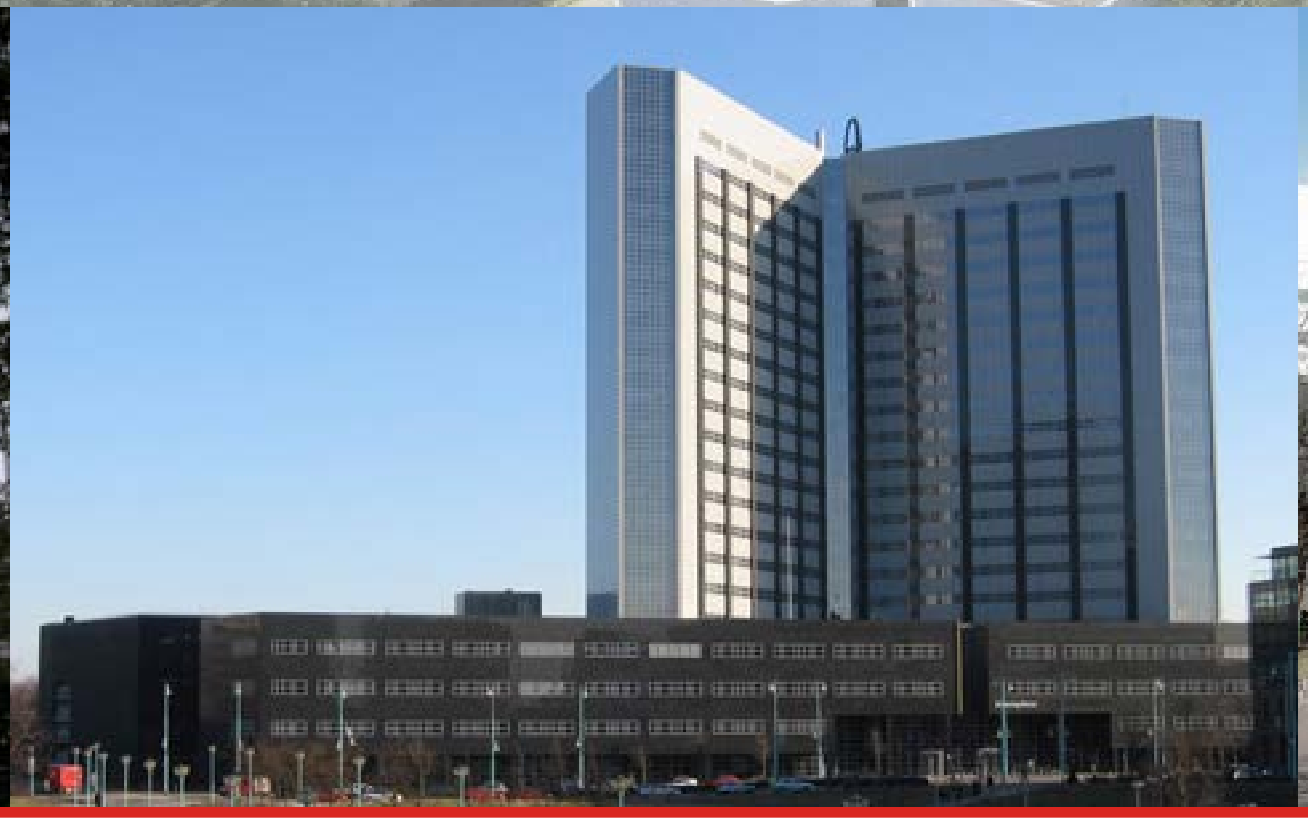
"The most sustainable building is the one that has already been built"

Sustainable upgrade of existing buildings = highly relevant task

Brutalist Buildings 70's & 80's



- structurally sound
- outdated
  - don't meet actual needs
  - poorly insulated
  - energy inefficient
- high energetic and environmental cost to tear down



Amsterdam Medisch Centrum

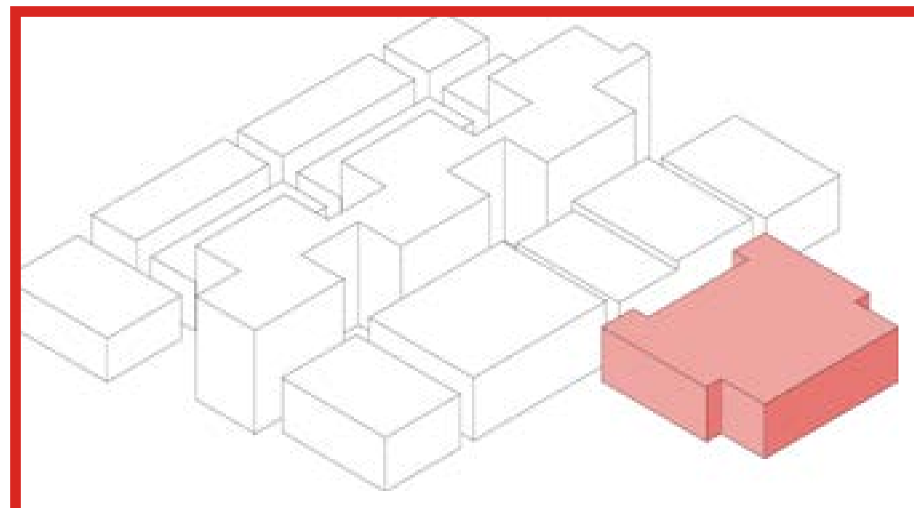
Dick van Mourik, Marius Duintjer | 1983

- Largest concrete structure by delivery
- ±$^1/_2$ million m² of floor
- 60.000 m² of facades needing replacement
- Teaching hospital
- Design according to basic philosophy of a group of critic architects on the role of an hospital

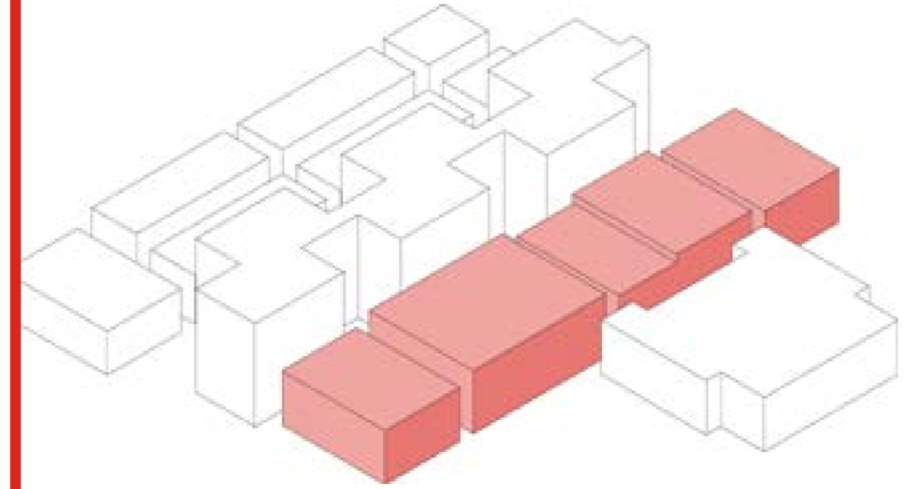
= 2 specificities

The Building City

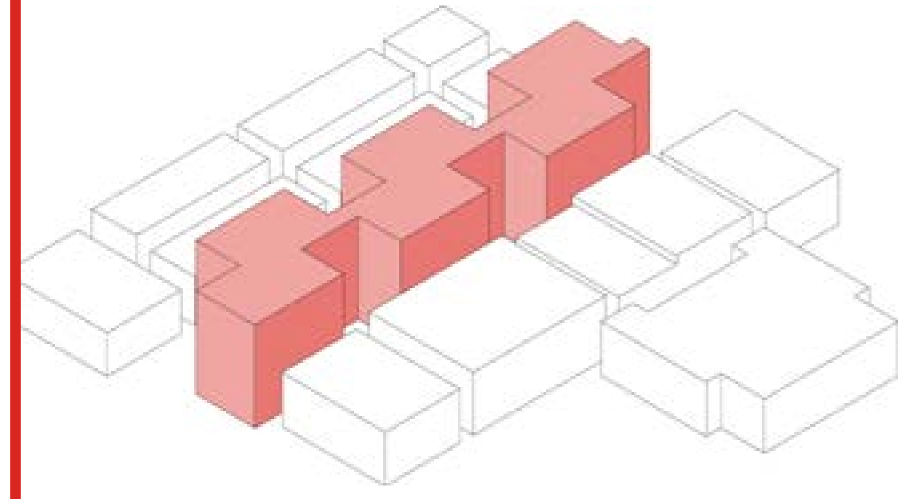
Inner street and atria



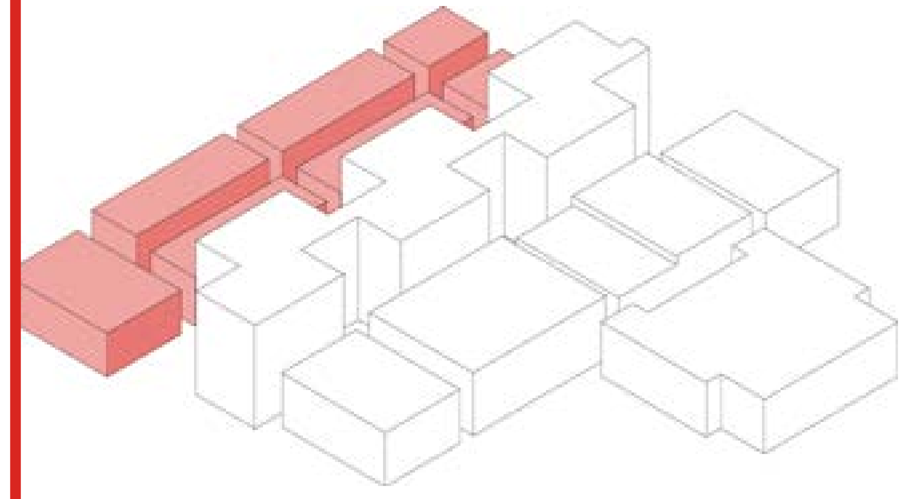
Polyclinics



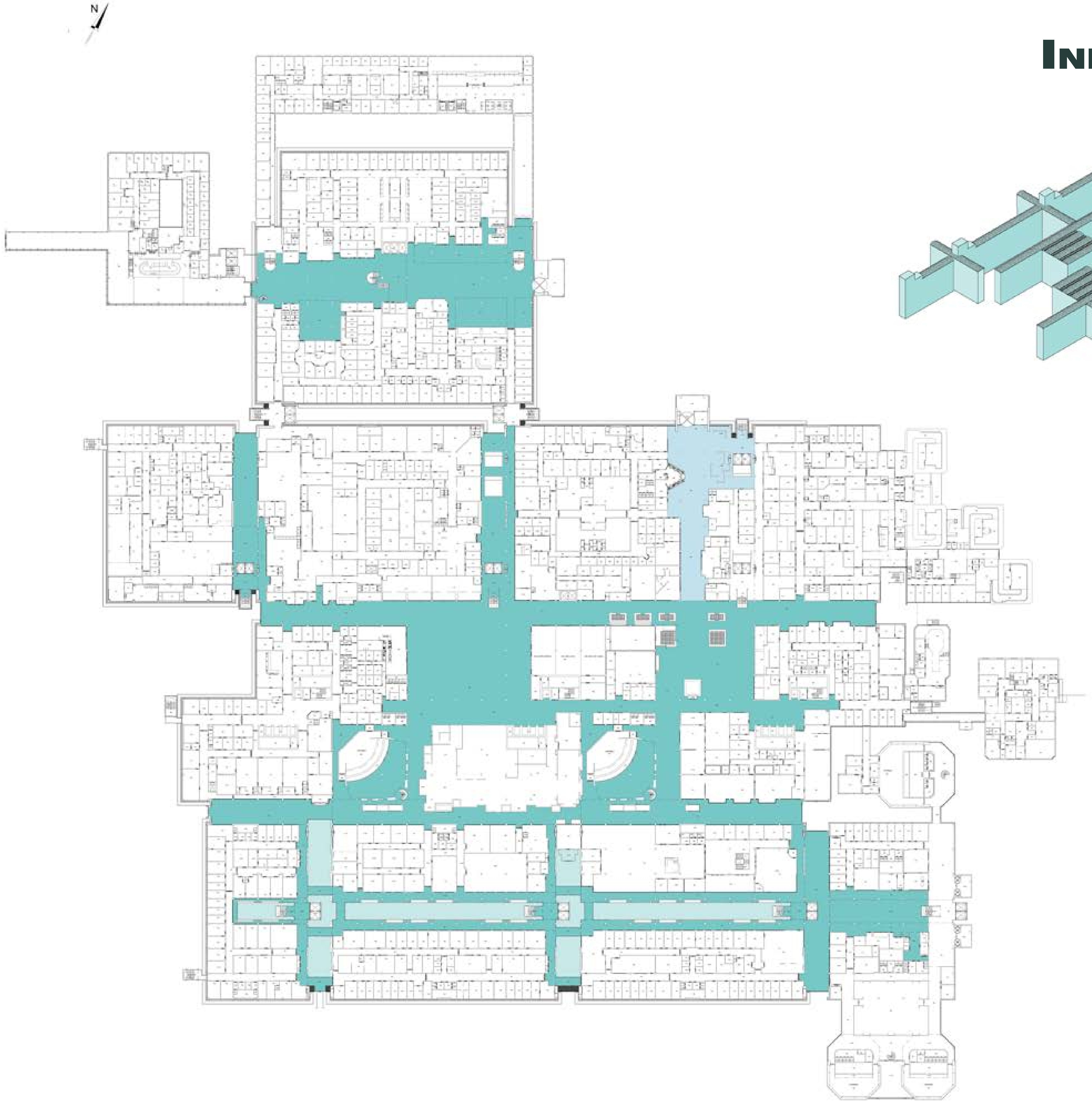
"Hot floors"
ER, IC, OR, imaging, treatment...

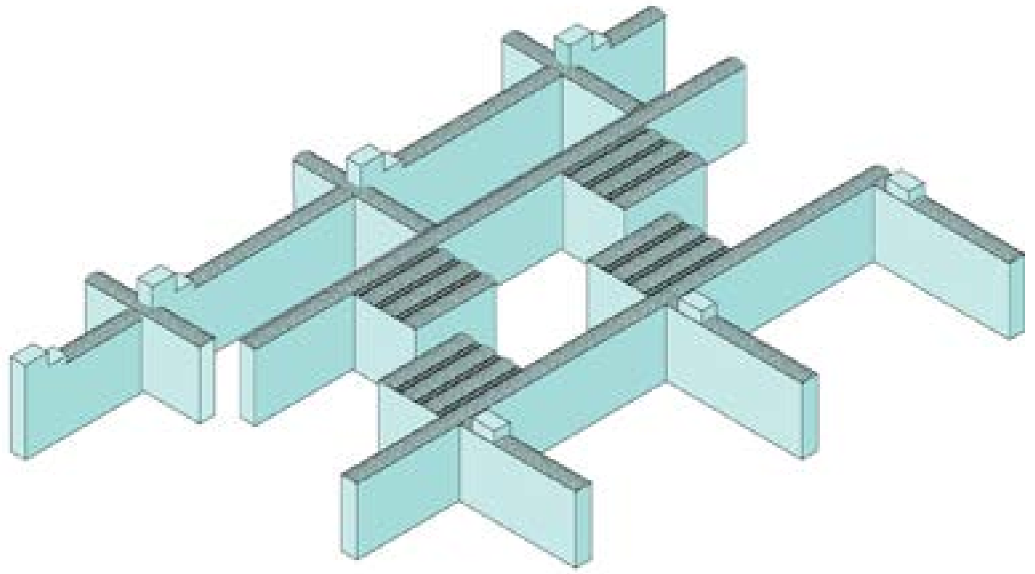


Bed Towers
Nursing wards



Faculty of Medicine
Lecture halls, library, research facility





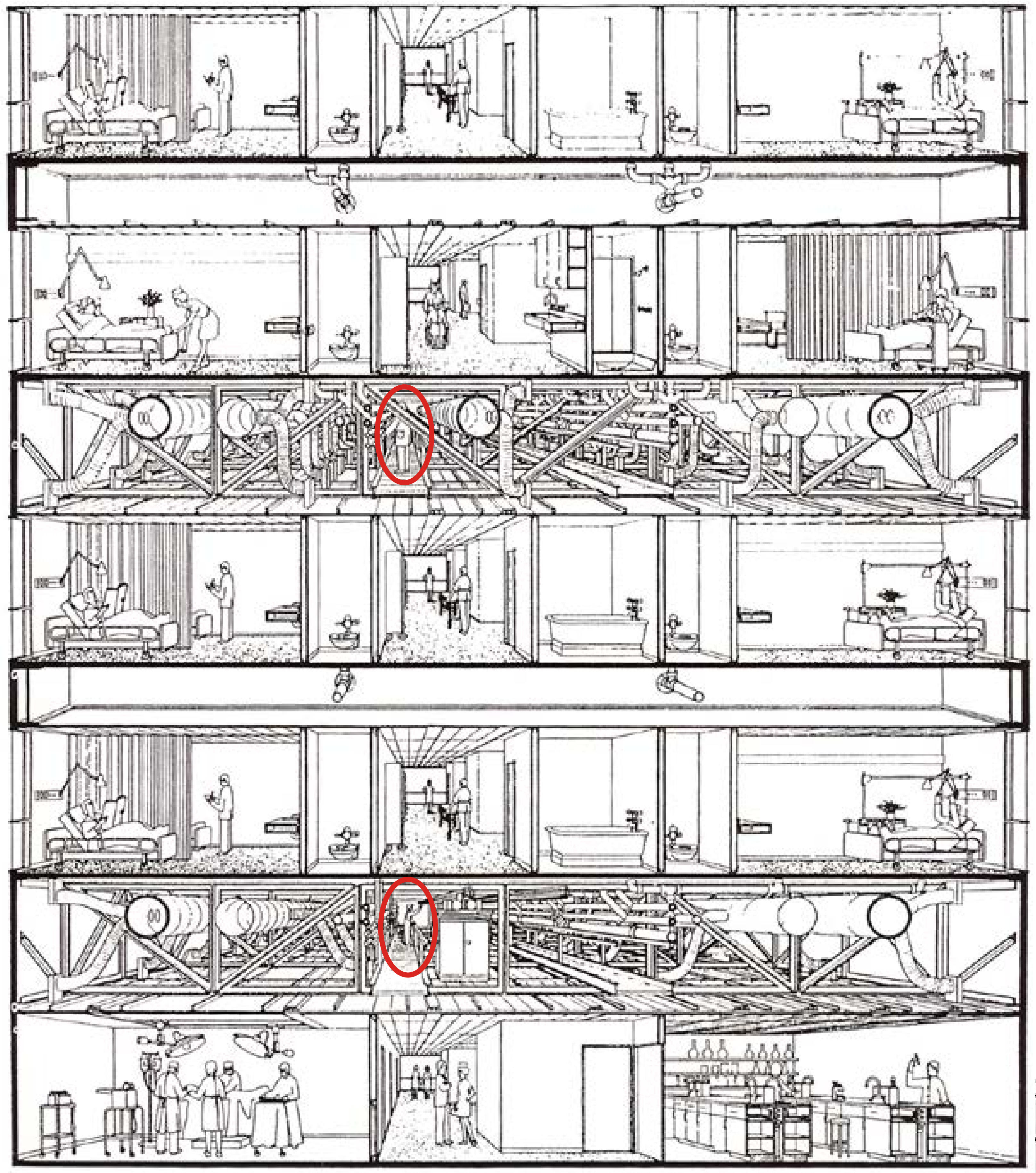
Interstitials
Structuralism

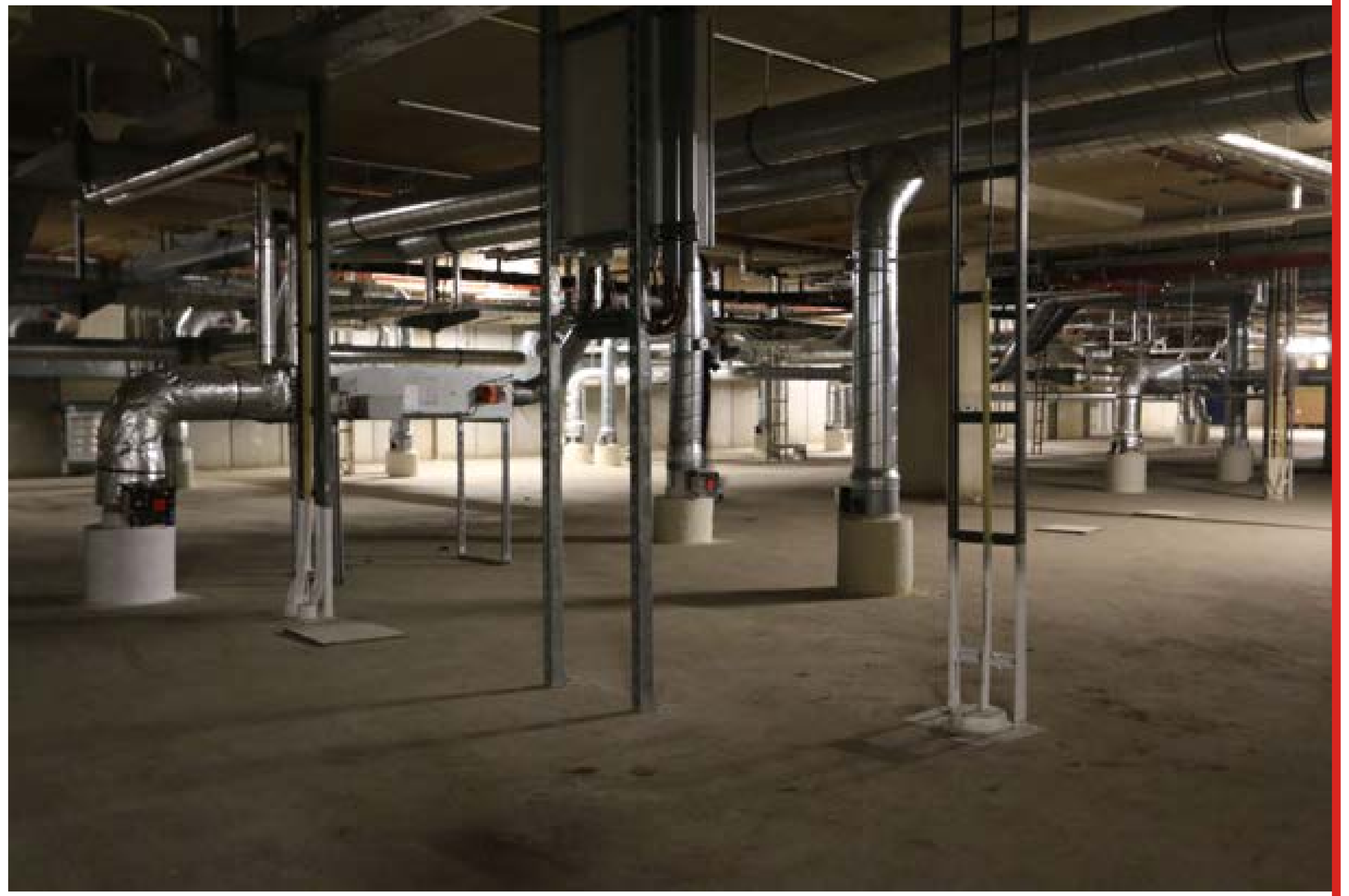
Structuralisme

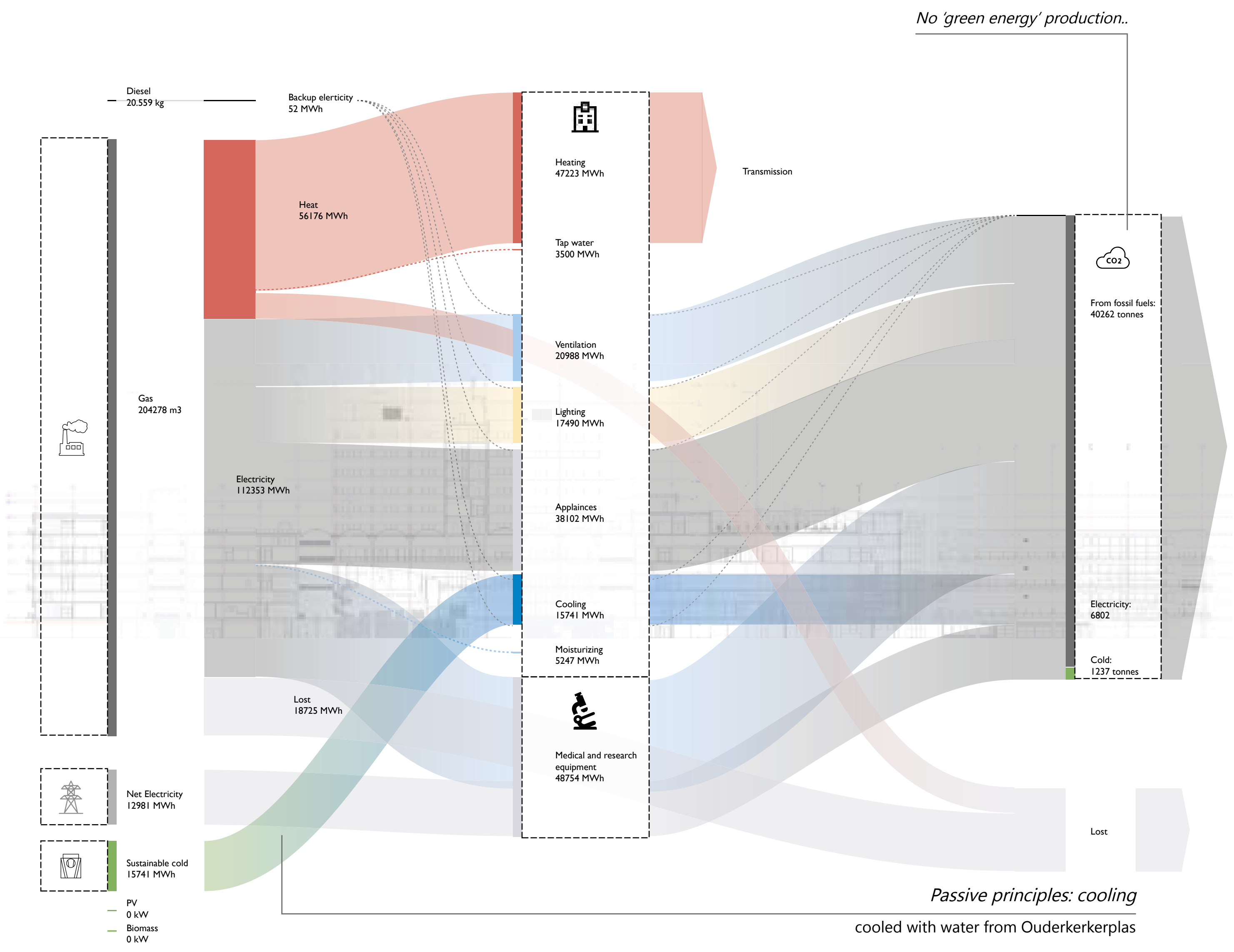
a permanent bearing structure, combined with elements that can be easily replaced by others.

To be able to adapt to the rapidly changing technologies typical of healthcare

- building adaptable in technical way
- without major disruptions during work
- with limited cost during exploitation







Energy demand AMC = 75 GWh

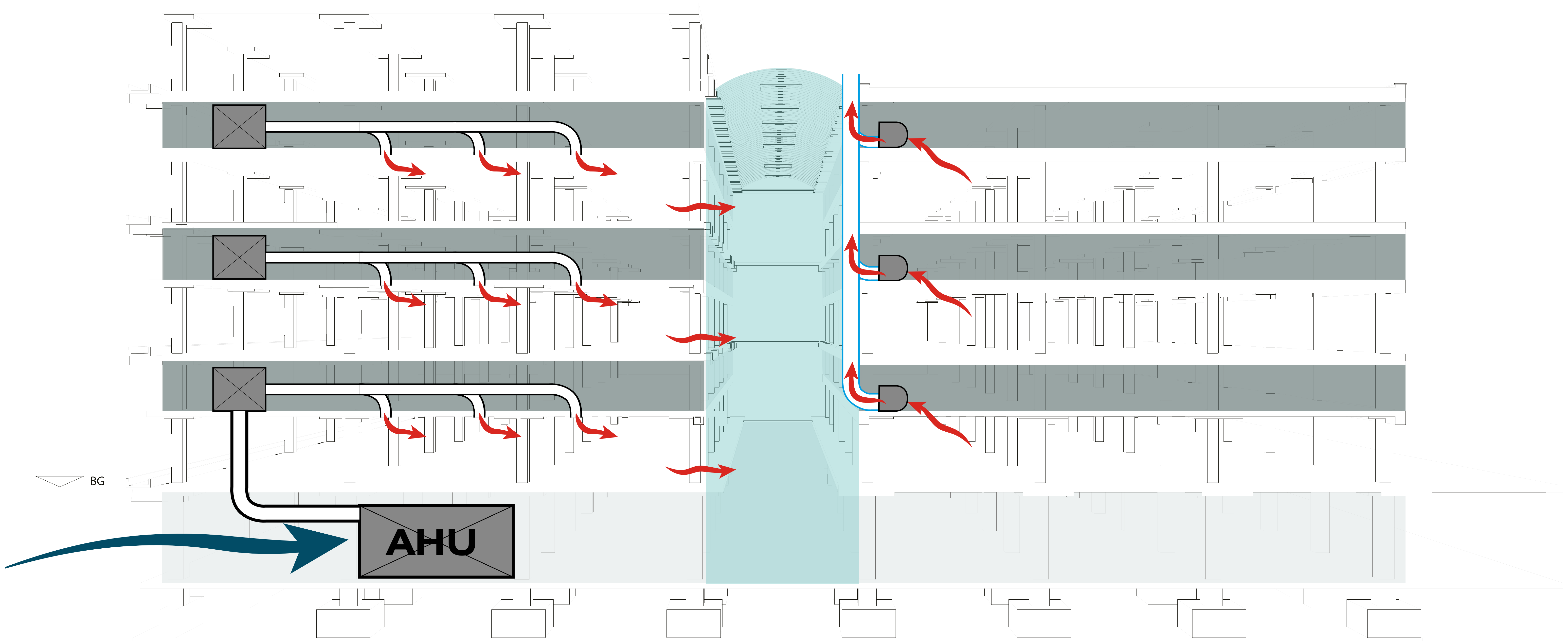
± the yield of 100.000 PV panels
± usage of Schiedam or Lelystad

- **45% related to ventilation and thermal comfort**
- **Atria and streets only benefit from "leaked" air from buildings => increased usage**

All-air system with central AHU

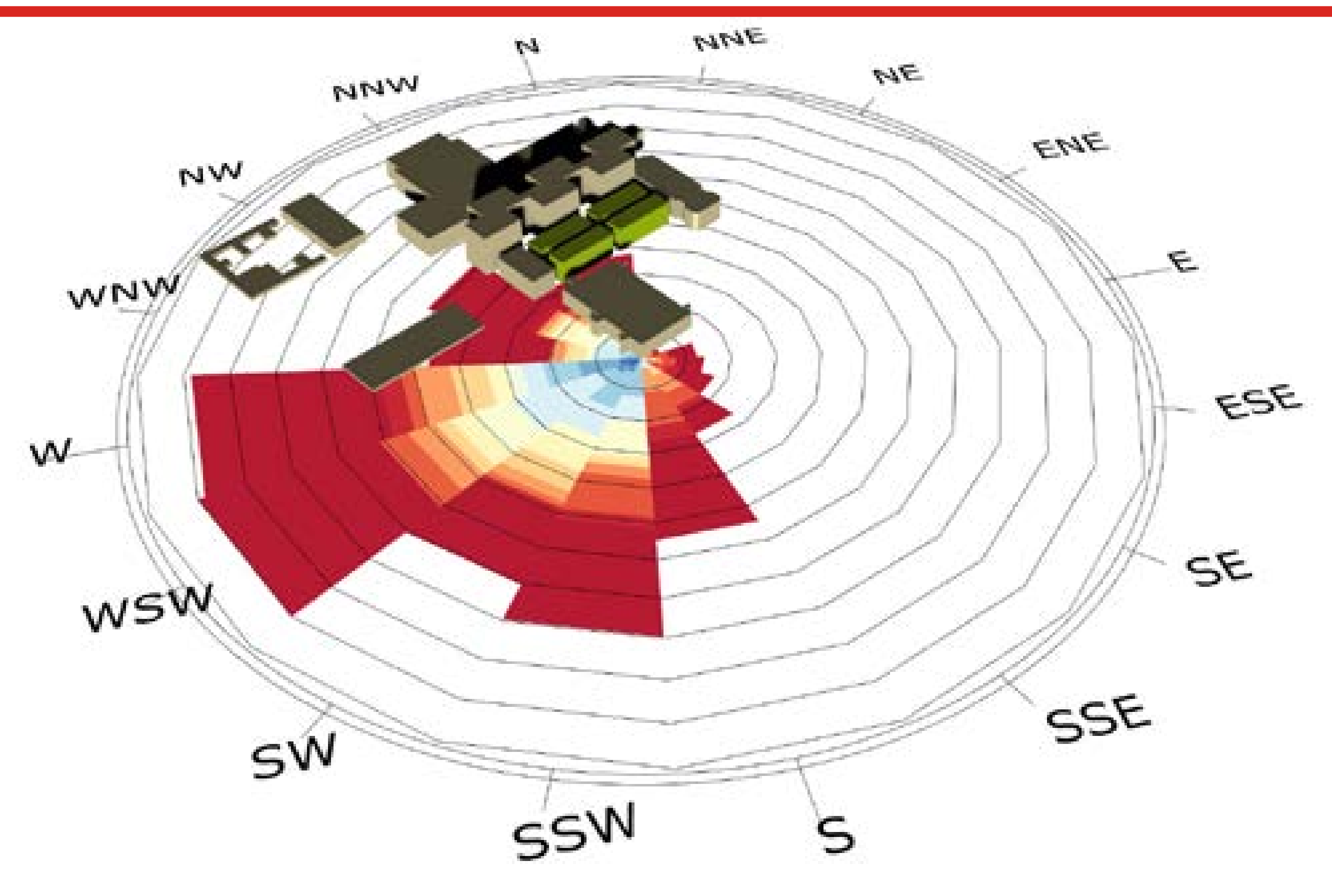
Air Handling Unit

- **fixed temperature and flow**
- **adjustment painstaking and sometimes inaccurate**
- **central system with pressured air = infection spreading risk**



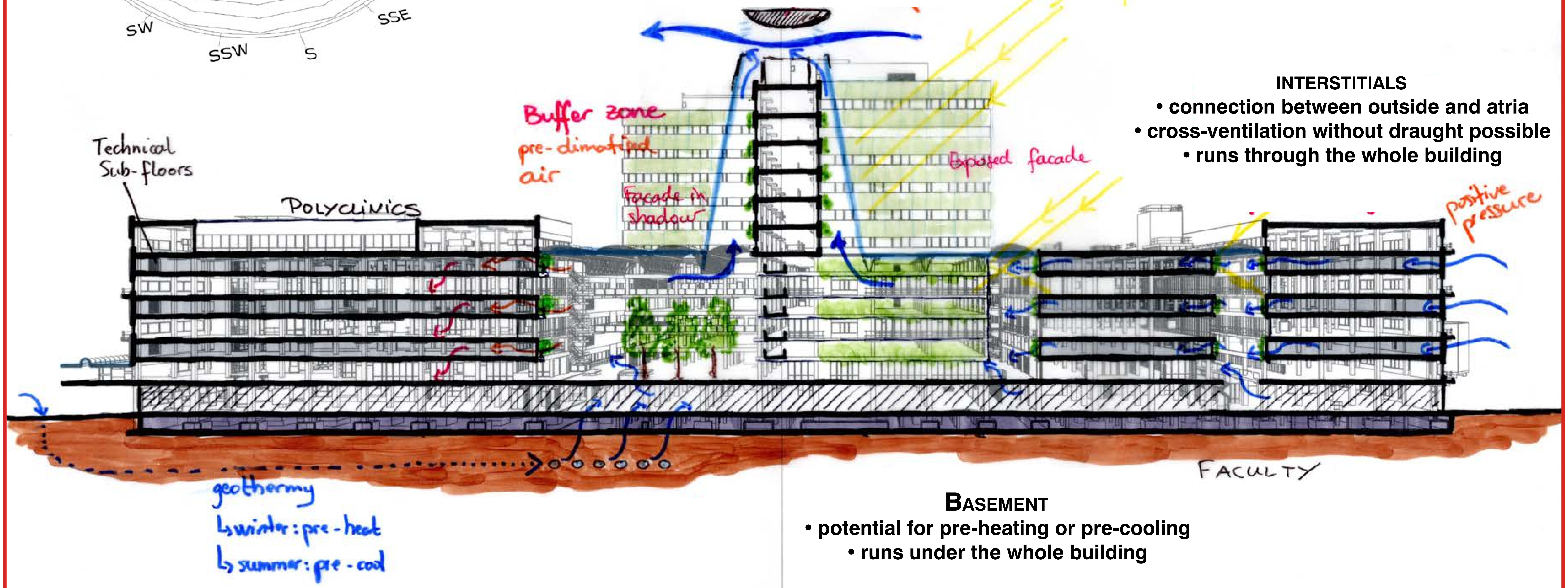
Climate System
Simplified schematic

Sustainable climate design
Potentials of the AMC

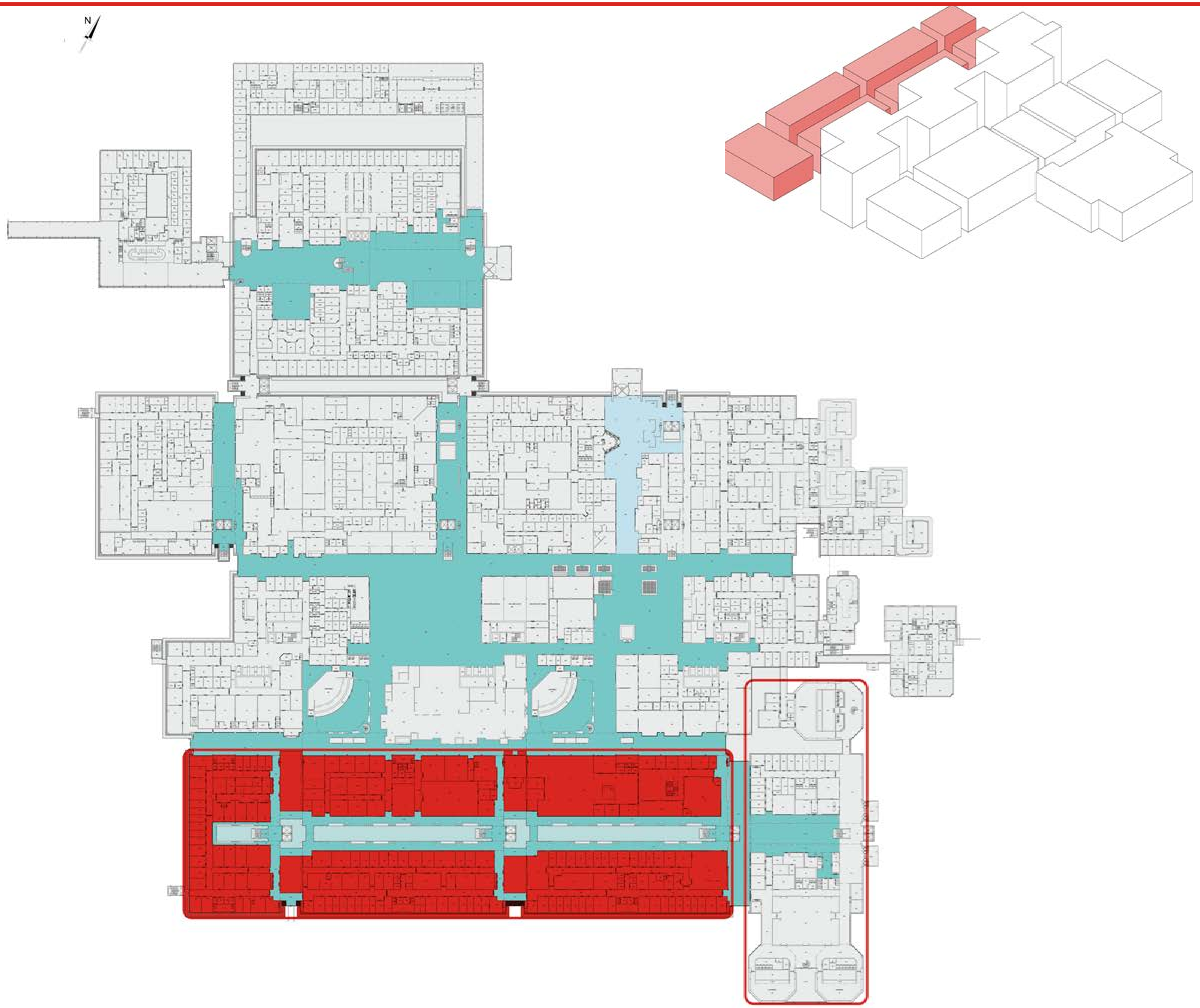


Bed towers
• height for buoyancy driven exhaust
• can be supported by Venturi wing
• limited depth: suitable for cross- or even single-sided ventilation

INTERSTITIALS
• connection between outside and atria
• cross-ventilation without draught possible
• runs through the whole building



Basement
• potential for pre-heating or pre-cooling
• runs under the whole building



All specifics elements of the AMC
= possible extension of concepts to the rest

- **3 blocks divided by inner street**
- **interstitials**
- **less strict requirements than hotfloors**
- **Outer facade**

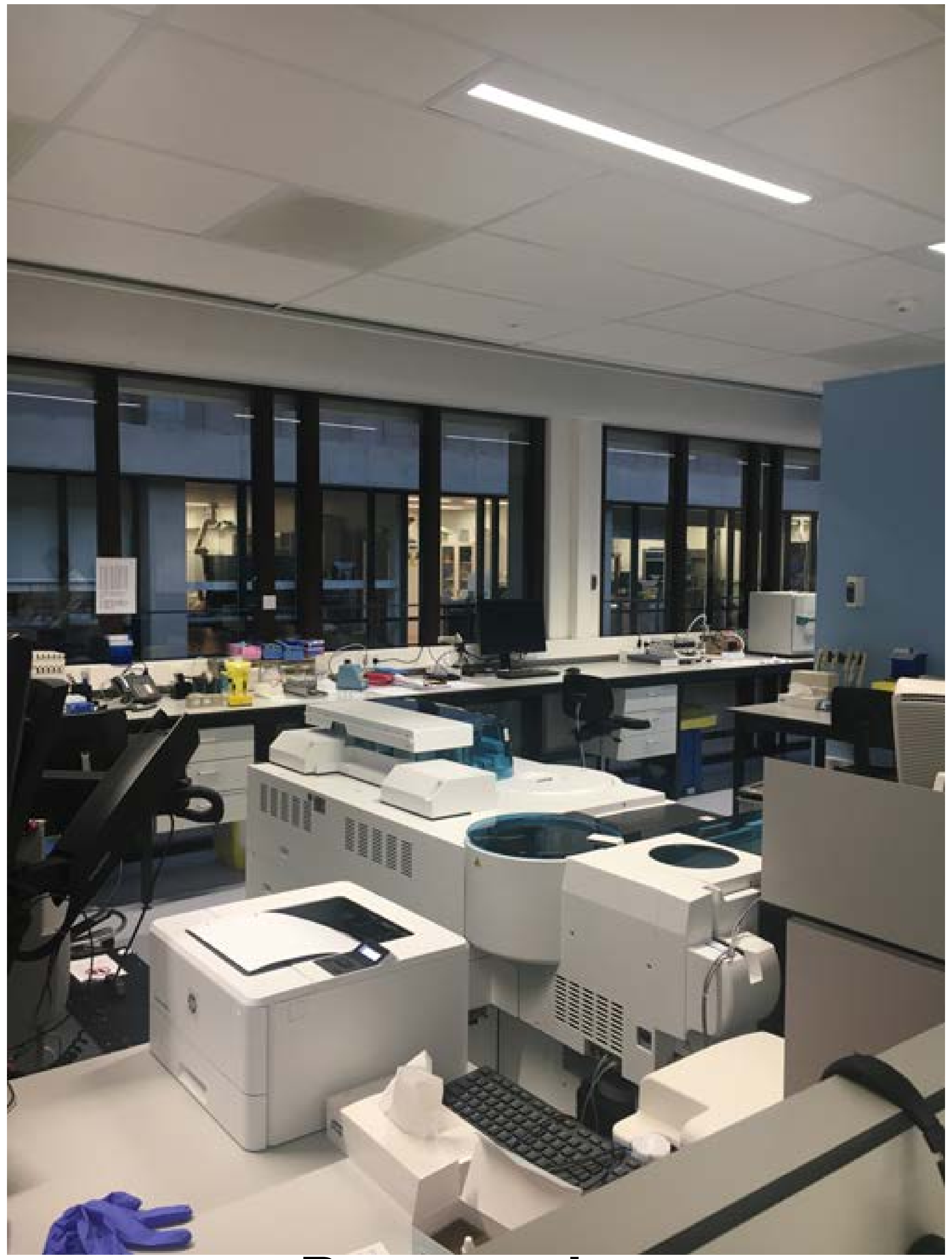
  + favourable orientation (South)

OLD LAB
Fixed work surfaces, rigid layout

Changed lab standarts
since the construction

- **less need for work surface**
- **more space needed for machines**

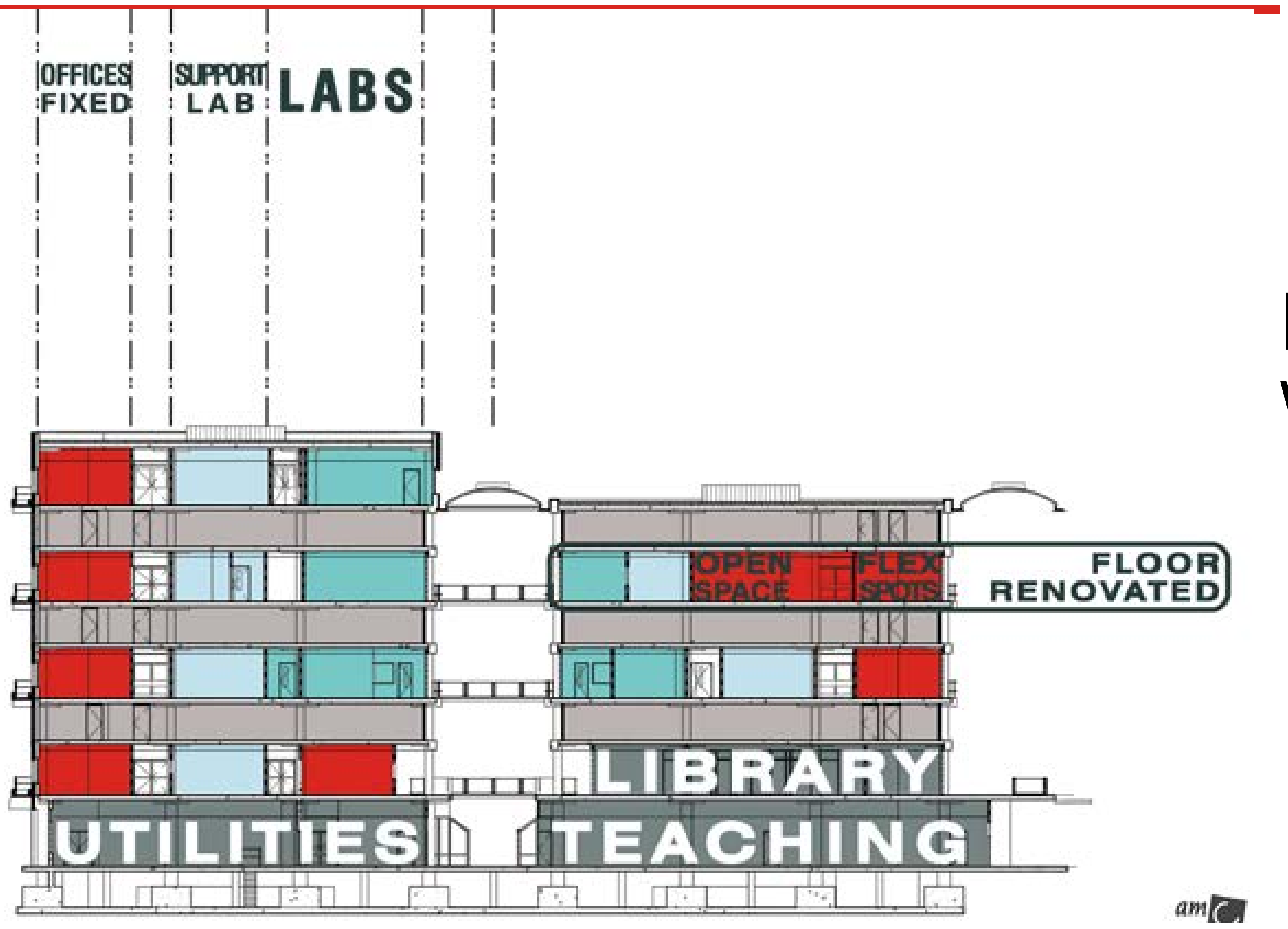
=> layout too rigid and ill adapted



RENOVATED LAB
Work surfaces on the side, open layout for machines

Old Lab

- Labs ±50%
- Support labs
- Offices ±30%
- Facilities (WC, storage, technical)



Renovated Lab

Wing K - 2nd floor

- Labs ±30%
- Support labs
- Offices ±30%
- Facilities (WC, storage, technical)

=> introduction of an open space

=> offices are not assigned anymore

Changed work standards

since the construction

- more time spent processing that data than collecting it
- ratio labs/offices not in proportion with use
- more need to use several labs for one research

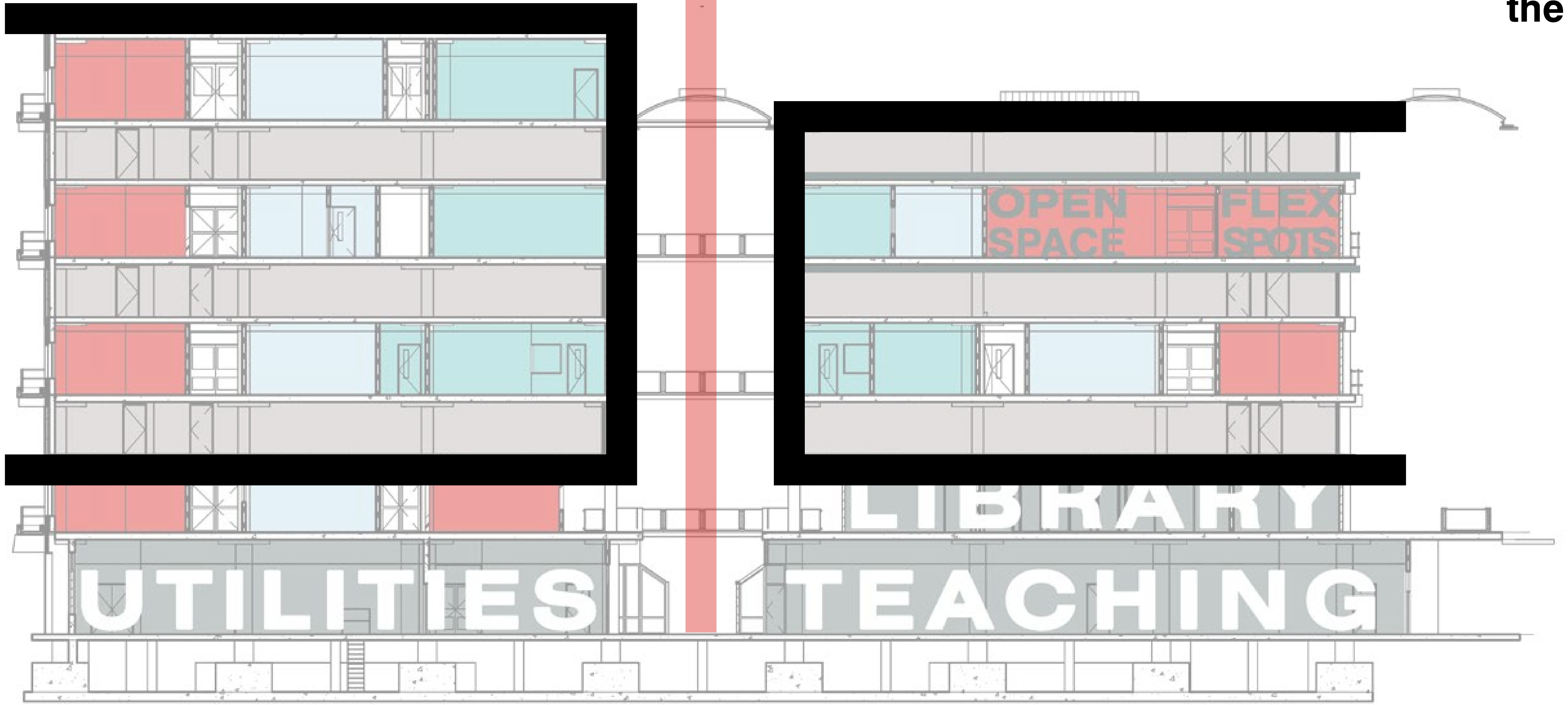
New insights on education and research
for better results

- cross-disciplines exchange important
- work in too big groups also ill-advised

=> spontaneous contact in small groups

Actual layout does NOT meet the requirements

- actual structure with assigned individual desks isolates researchers.
- seldom places to spontaneously meet and discuss findings
- Available places can be quite a distance



The street as a barrier
despite the openness and source of daylight

- **Only labs are facing the inner street**
- **No circulation in street except for level 1**
- **Offices facing the other way increasing the isolation**

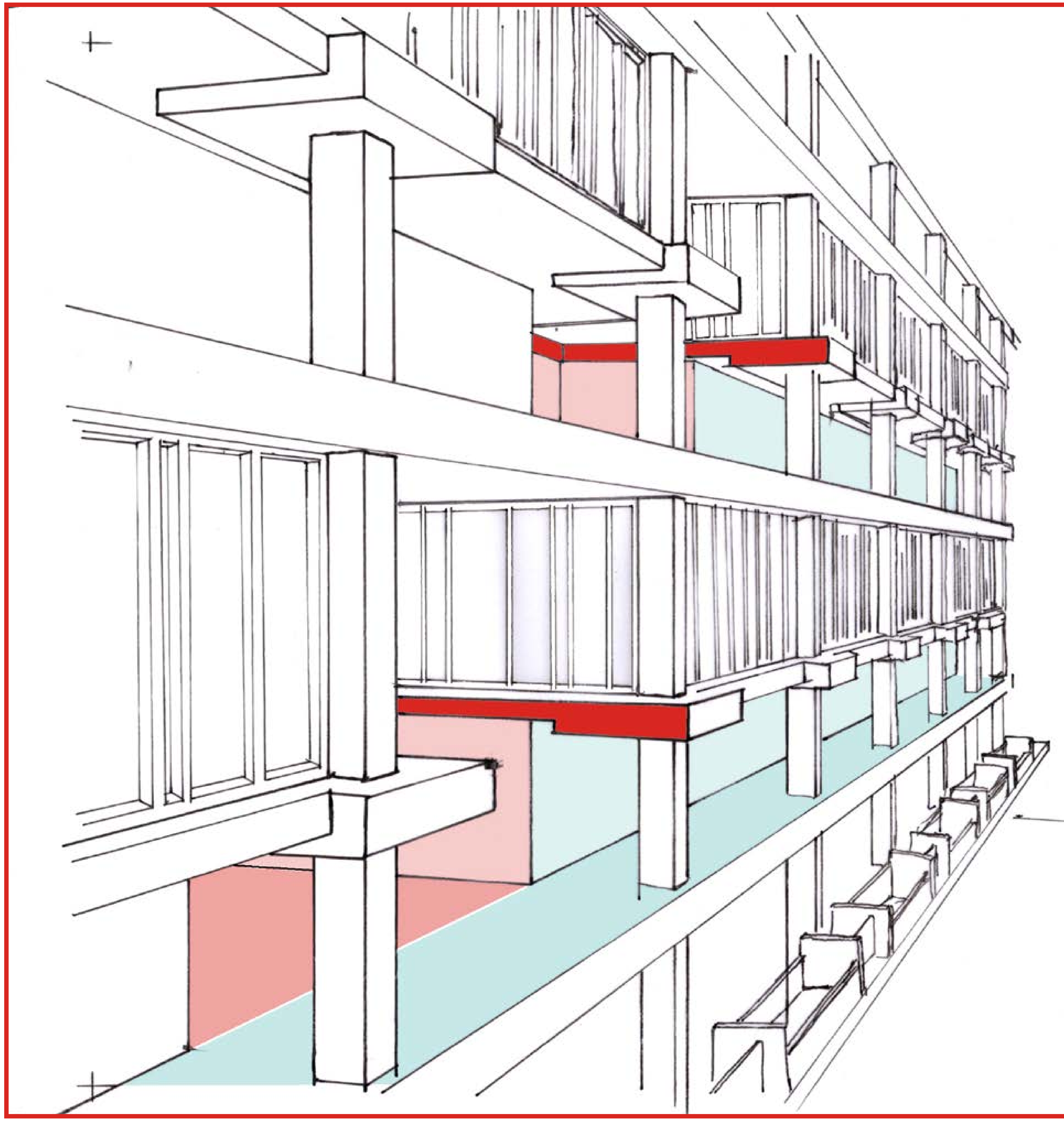
Giving shape to the connection

- Creating informal meeting areas in the street

- Re-designing the work floors' layout
-
- Creating an inviting route to connect work spaces to meeting areas

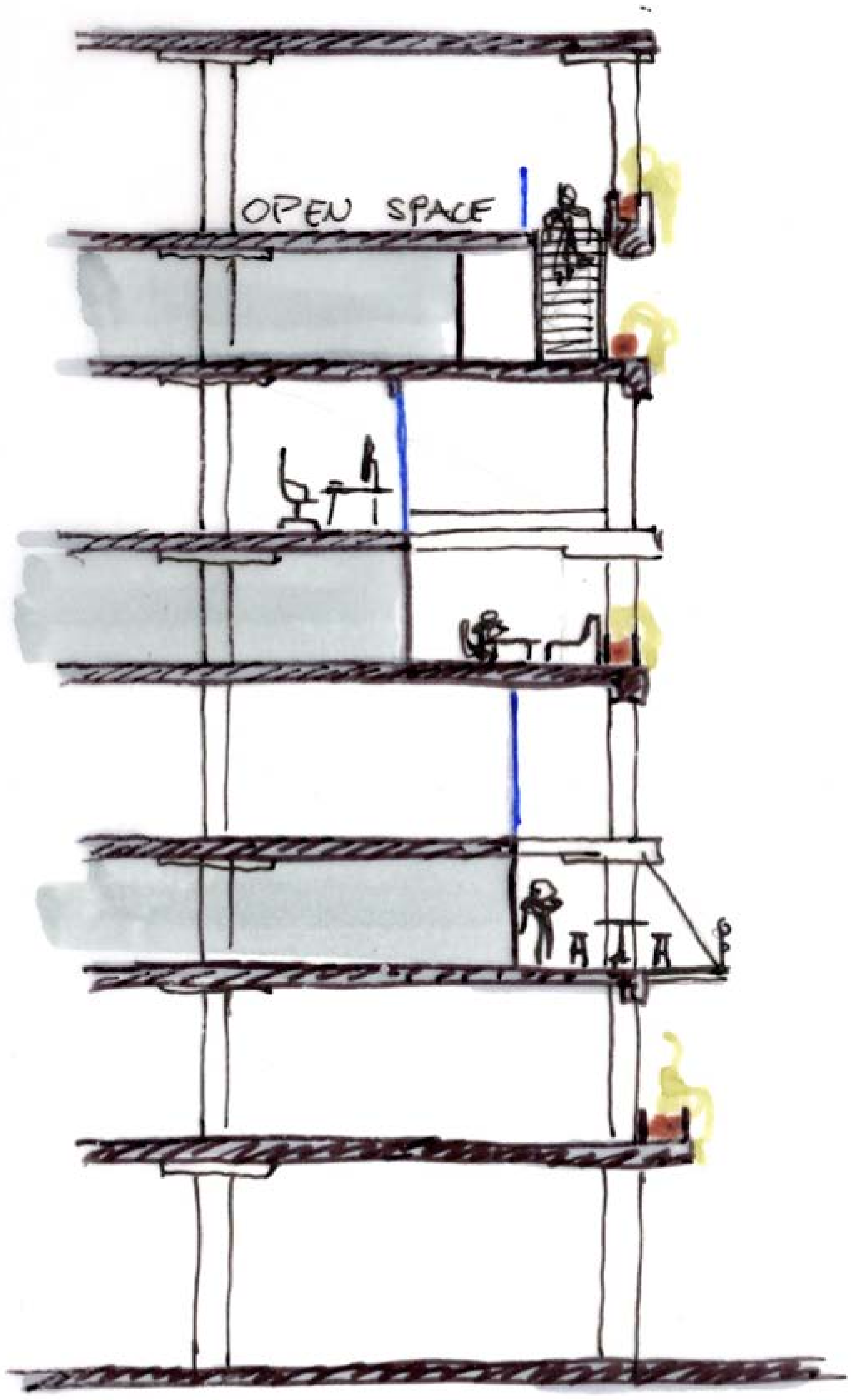
Walkways and Loggia's

CLAIMED ON SUBFLOORS



Walkway
- high enough to stand
- not for staying area

Loggias
- concrete slab cut between capitals of two columns
- semi private sitting area open on street



Green "railings"

Introduction of plant life
despite the openness and source of daylight

- **Soften hard character of concrete**

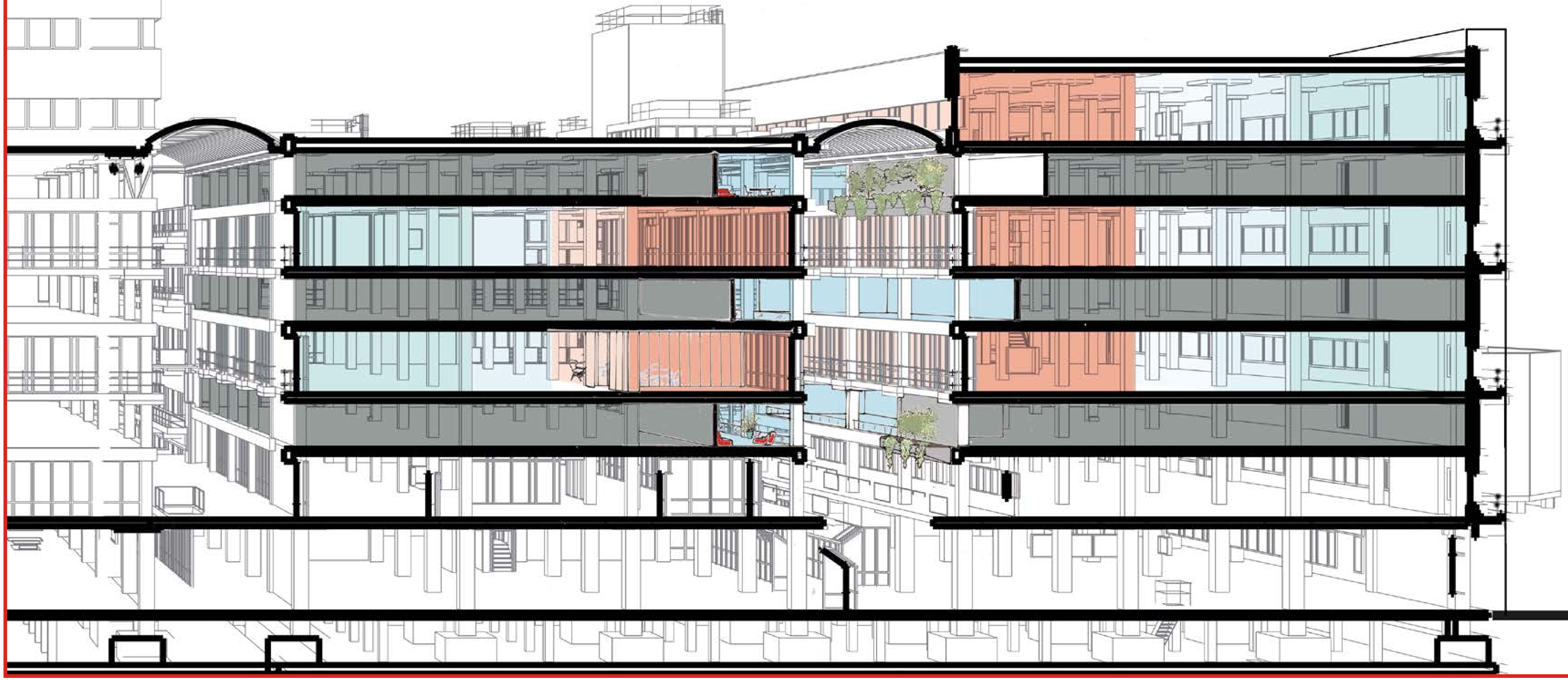
- **Air quality improvement:**
  - **filtering**
  - **evaporative cooling**

- **Beneficial effect on patients' recovery**
  - **healing period reduced**

The data processing at the centre

what researchers have to share

- **Offices and open spaces facing each other**
- **Labs spread around where researchers exchange**



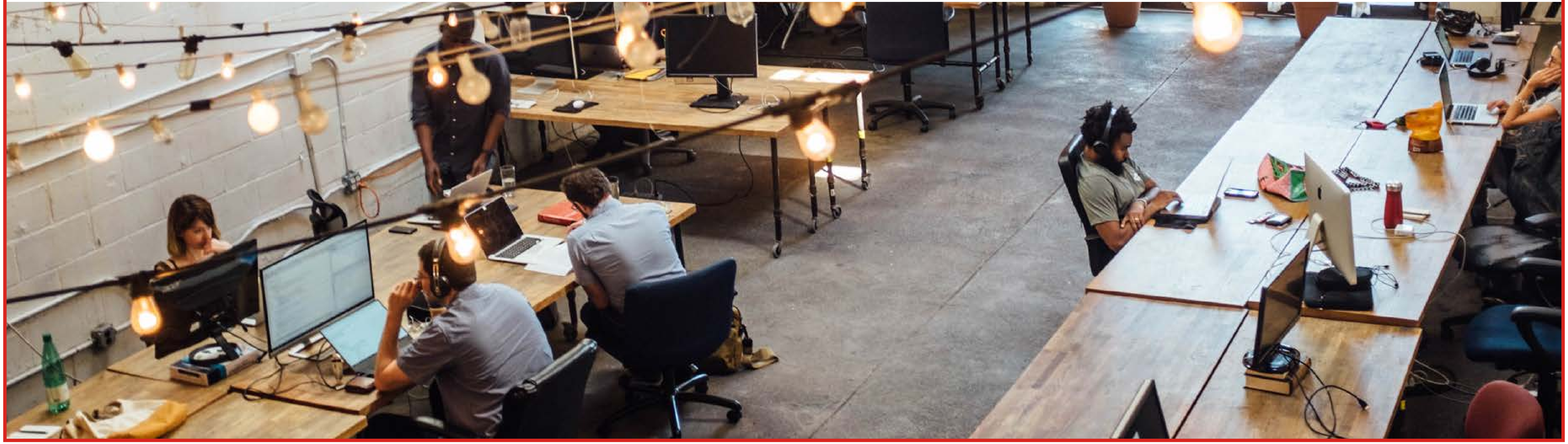
The impact of the 'open' workspace on human collaboration
Bernstein, E., Turban, S. | 2018 | in Philosophical Transactions B

Results of study astounding

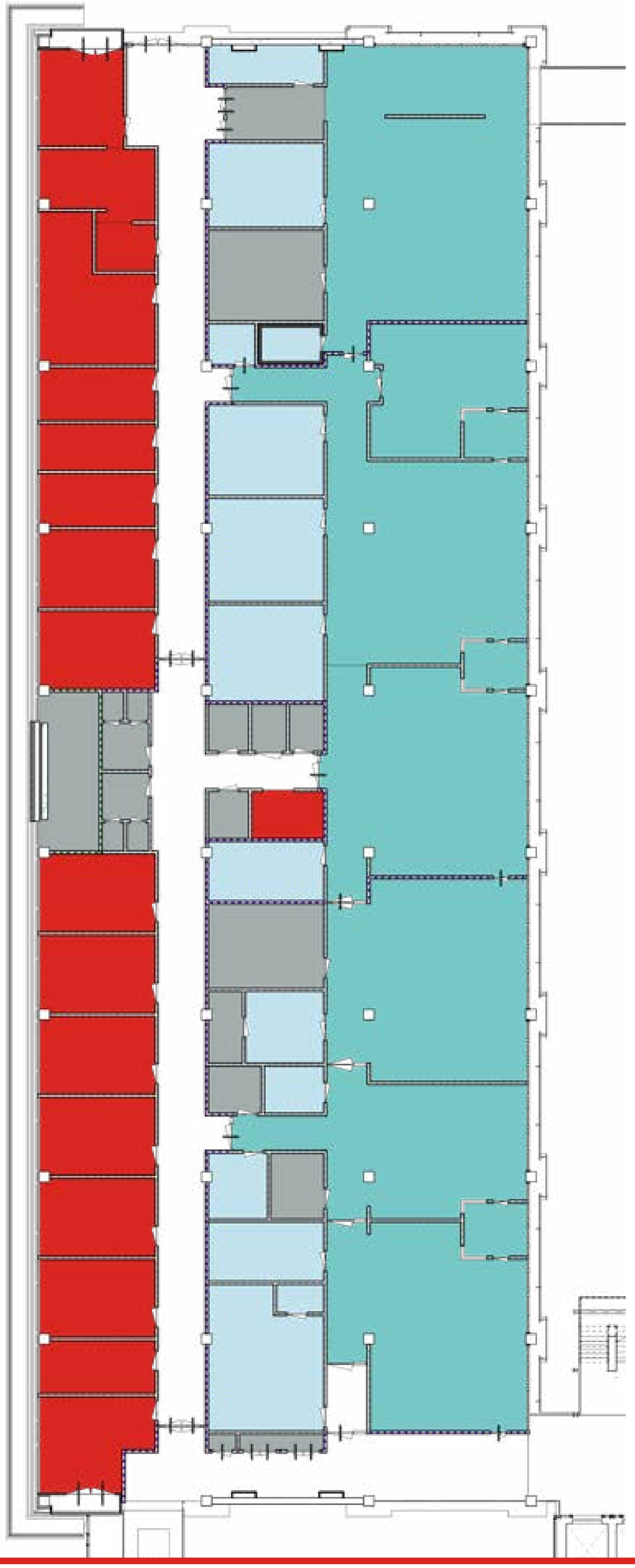
combining double-skin facade and atrium

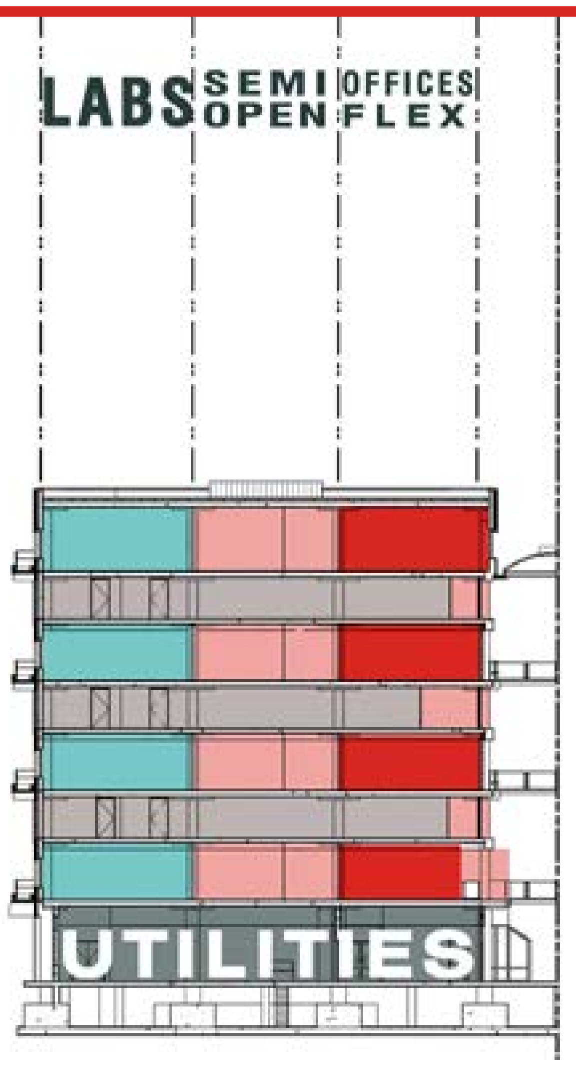
- **Face-to-face interaction decreased by 70%**
- **Mailings increased by 56%**
- **Copying in mailing increased by 41%**
- **Use of internal IM increased by 67%**

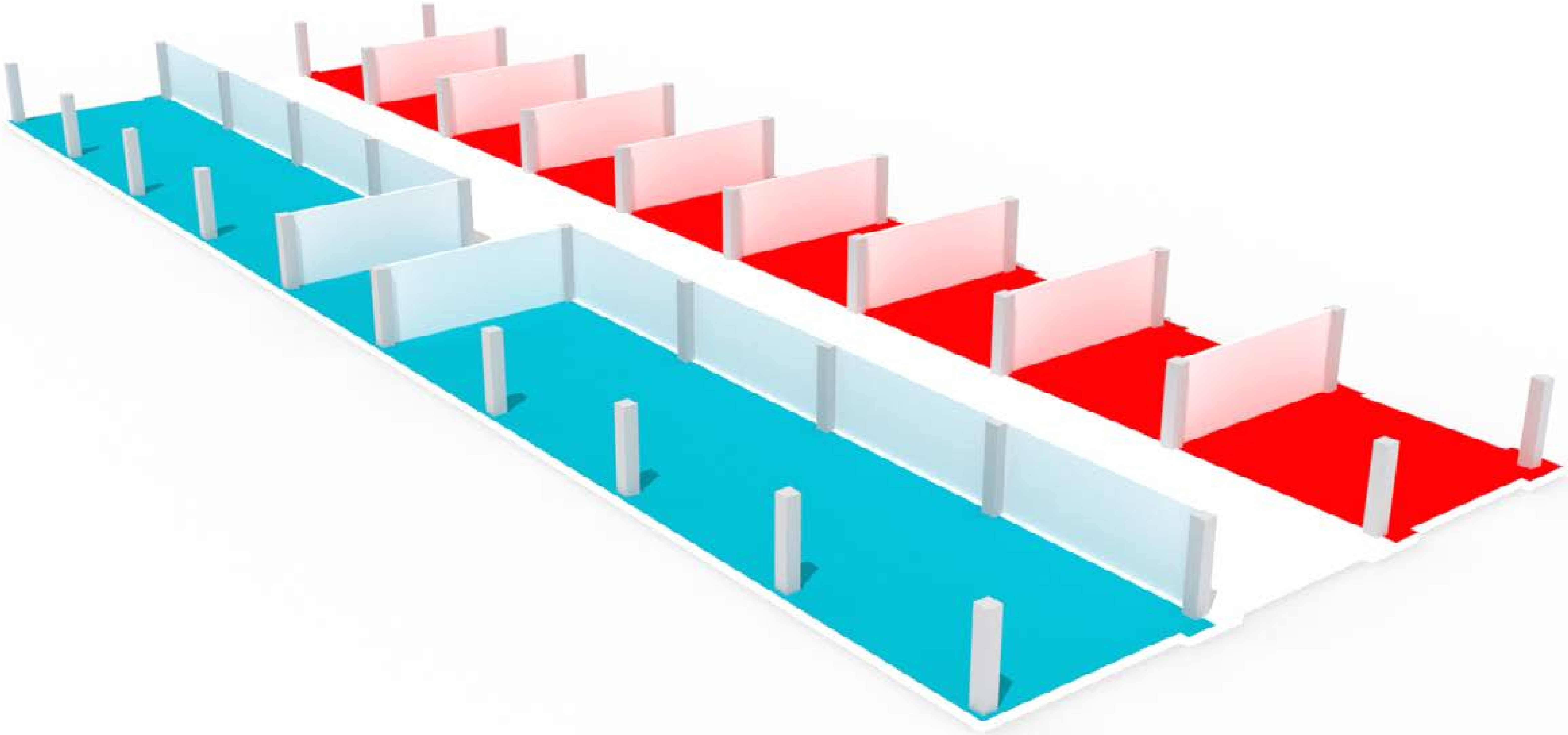
=> open workspace does not increase human interaction
=> reduces interaction and productivity

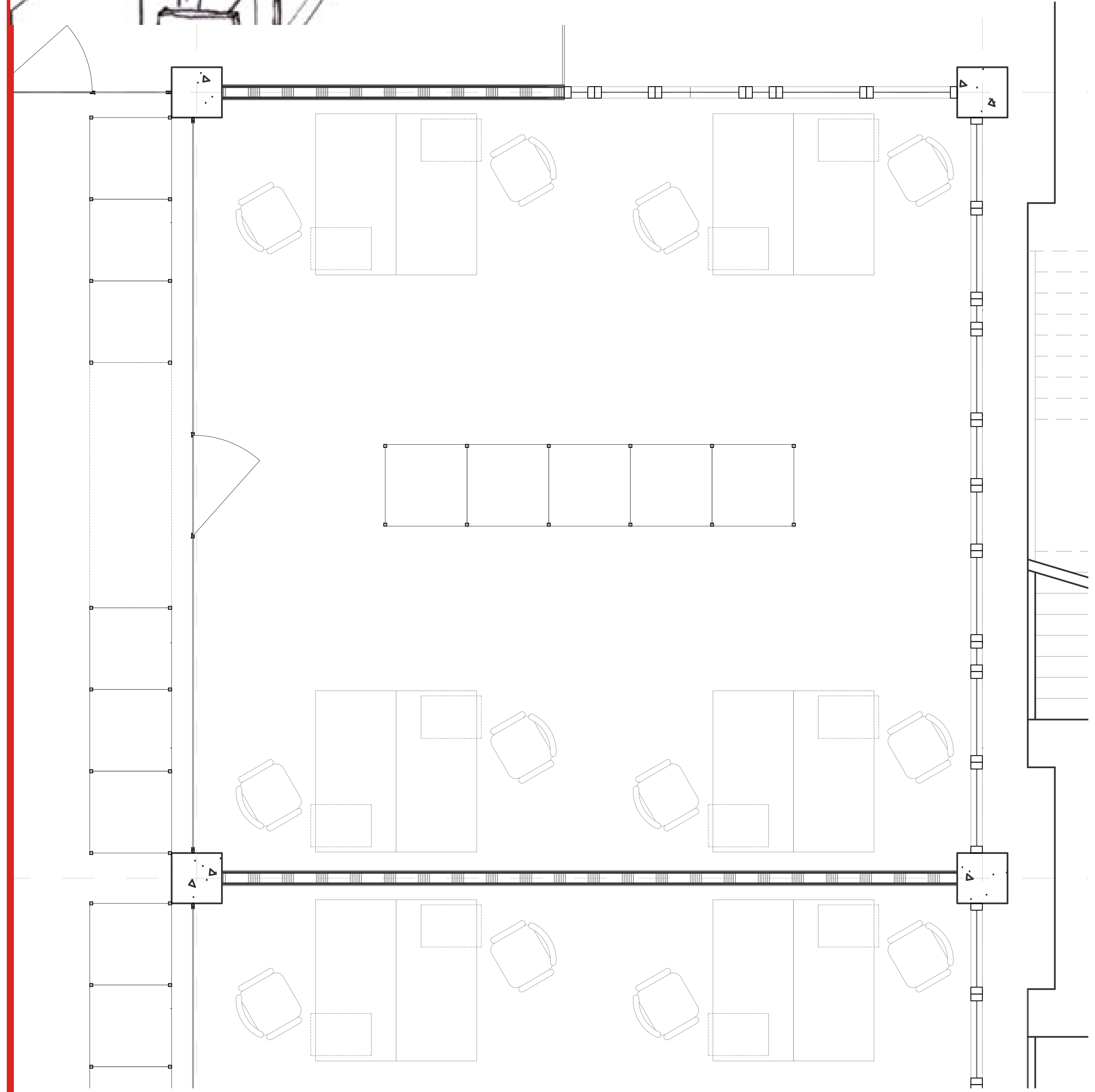


Existing



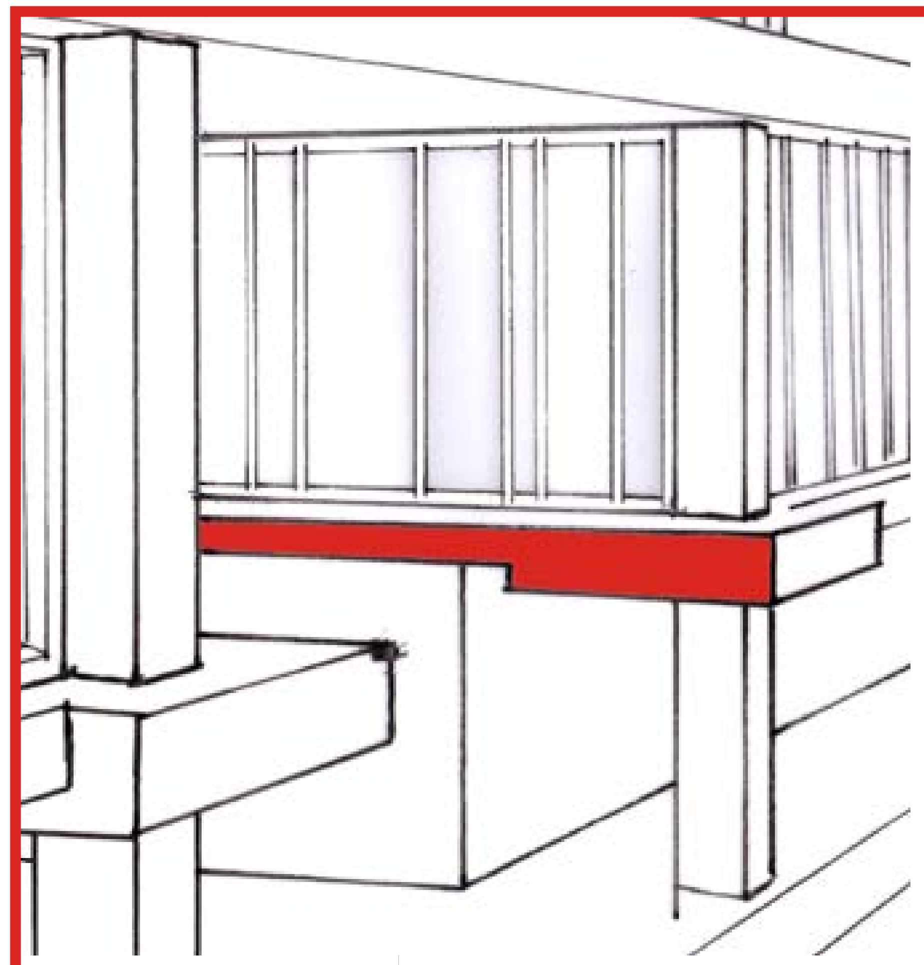






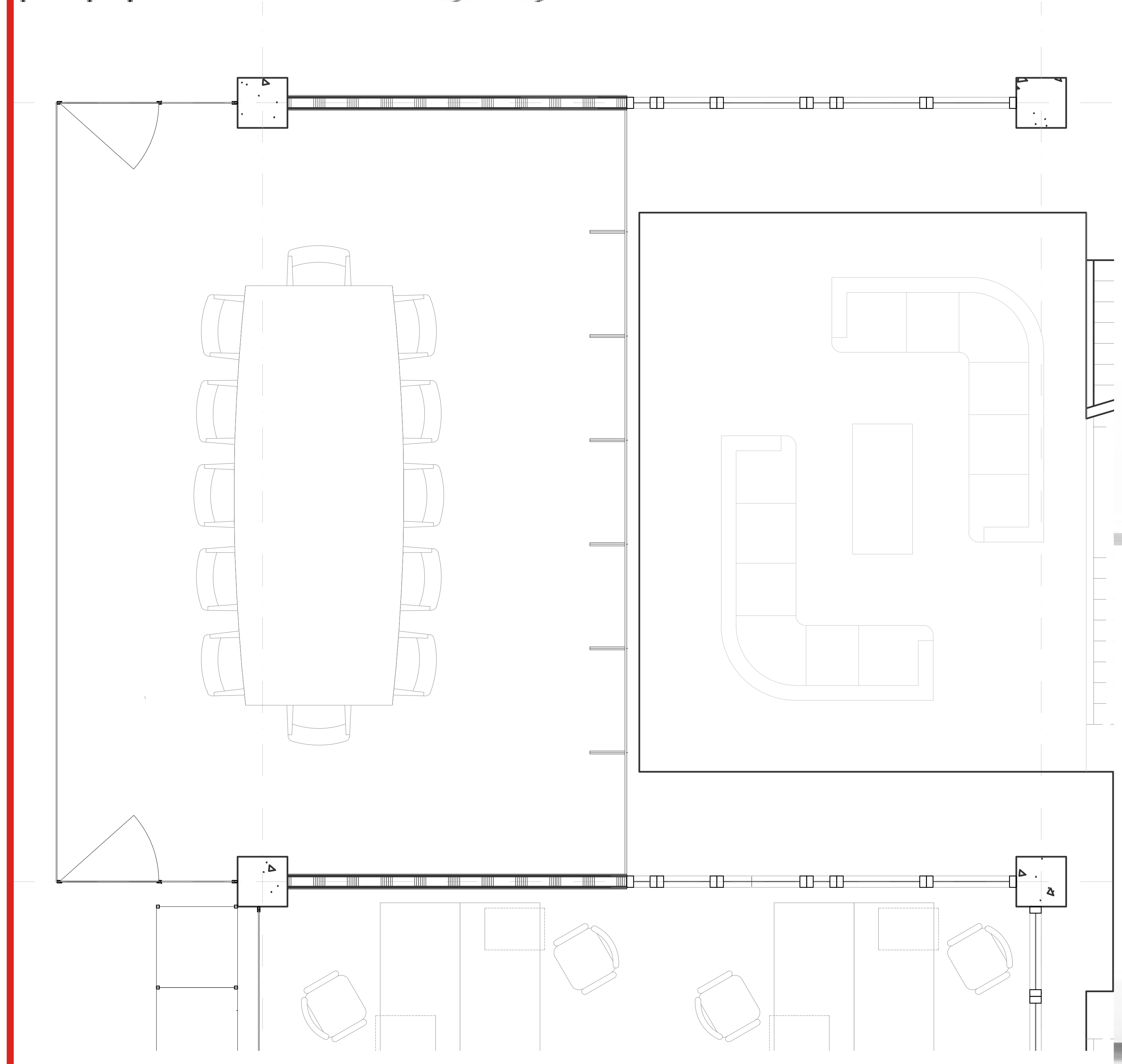
- **Office block**

Retains exisiting facade
8 work spaces

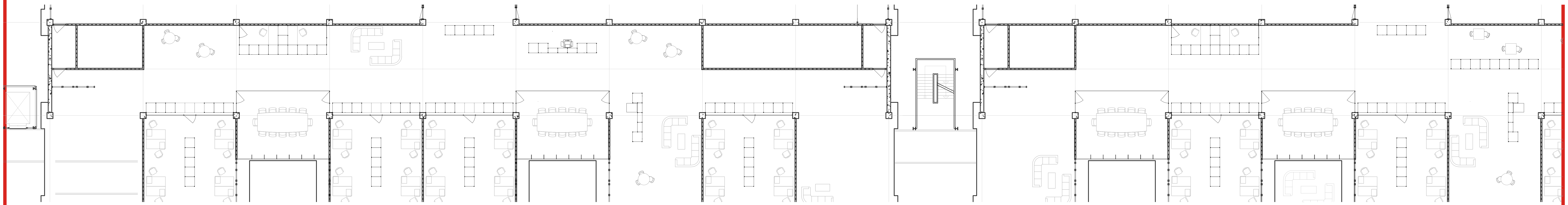


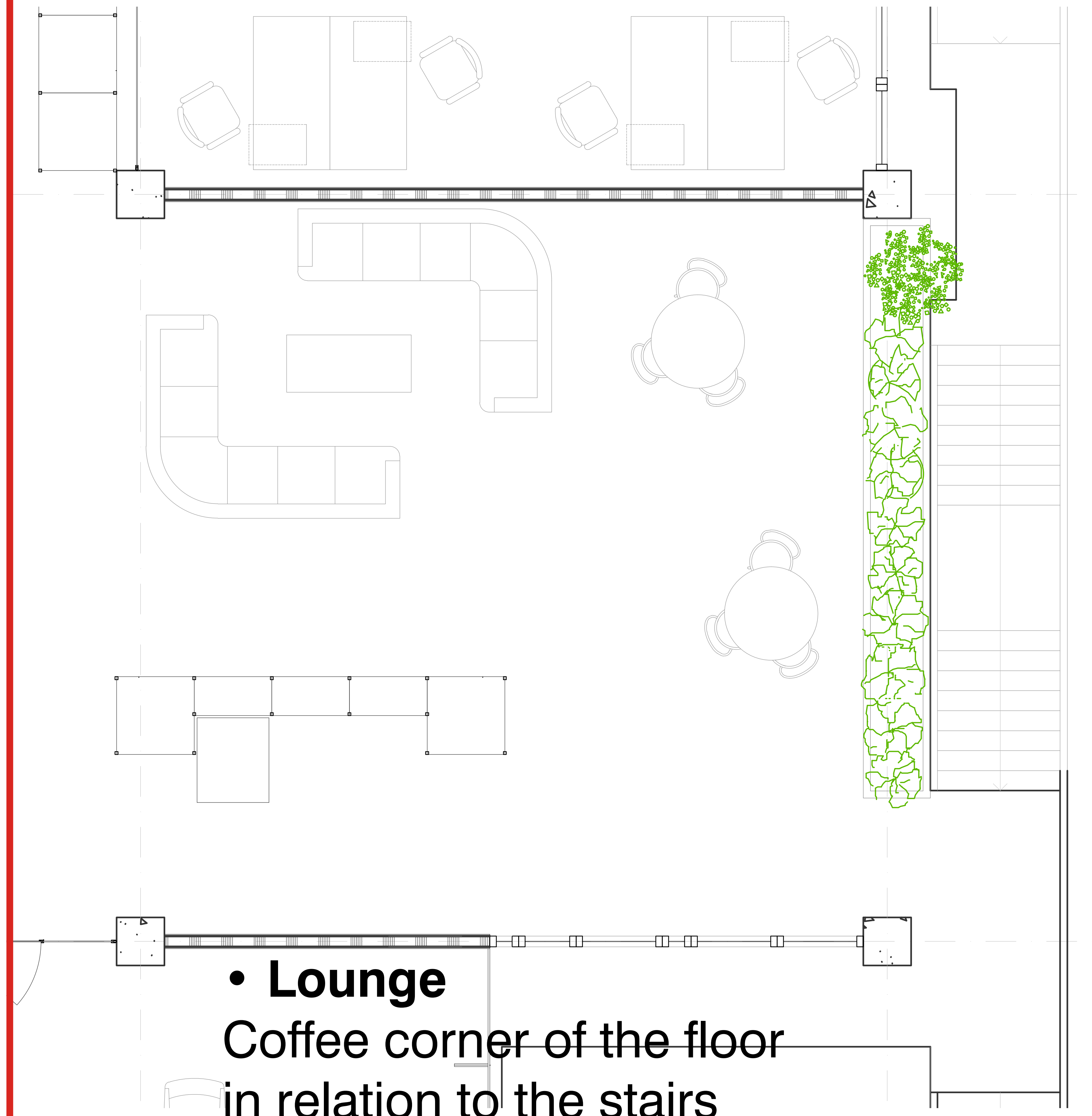
- **Meeting room**

Slides inside wing to create space for cut in slab



Quality of the middle space





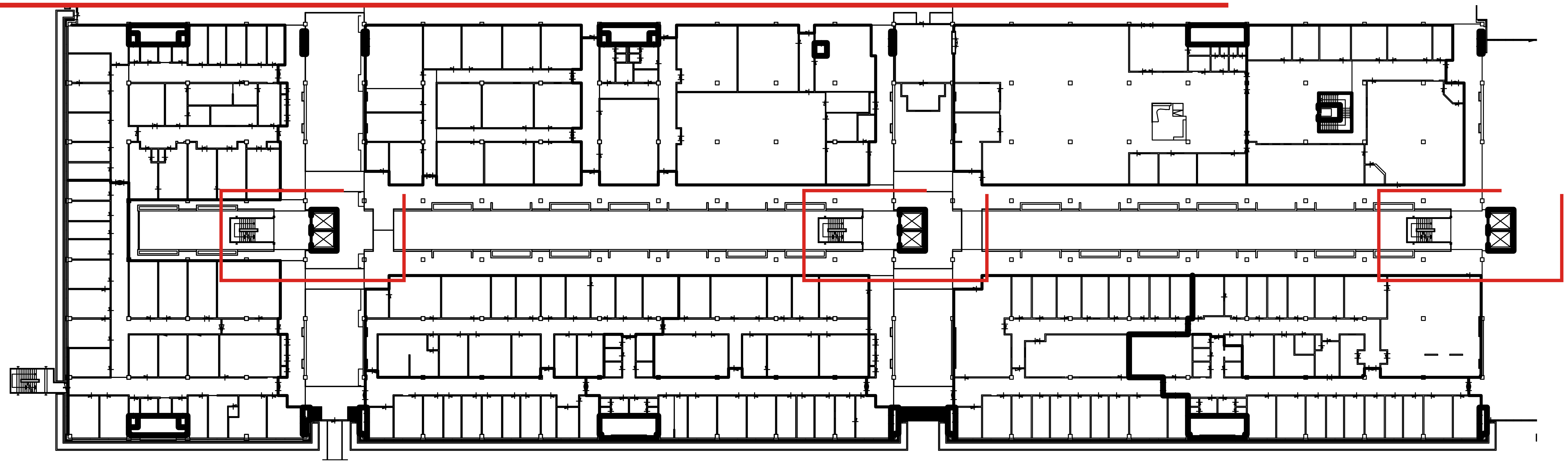
- **Lounge**

Coffee corner of the floor in relation to the stairs

Vertical Circulation

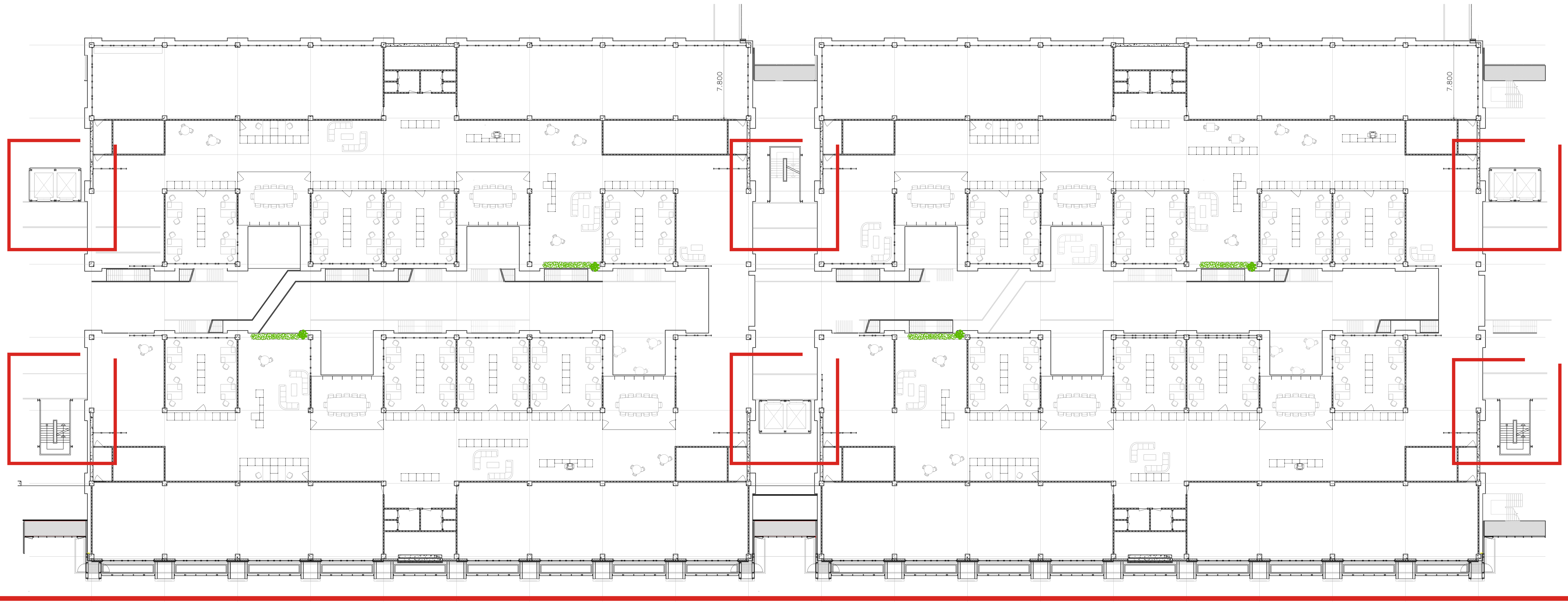
- **Existing**

Blocking view atrium



- **New**

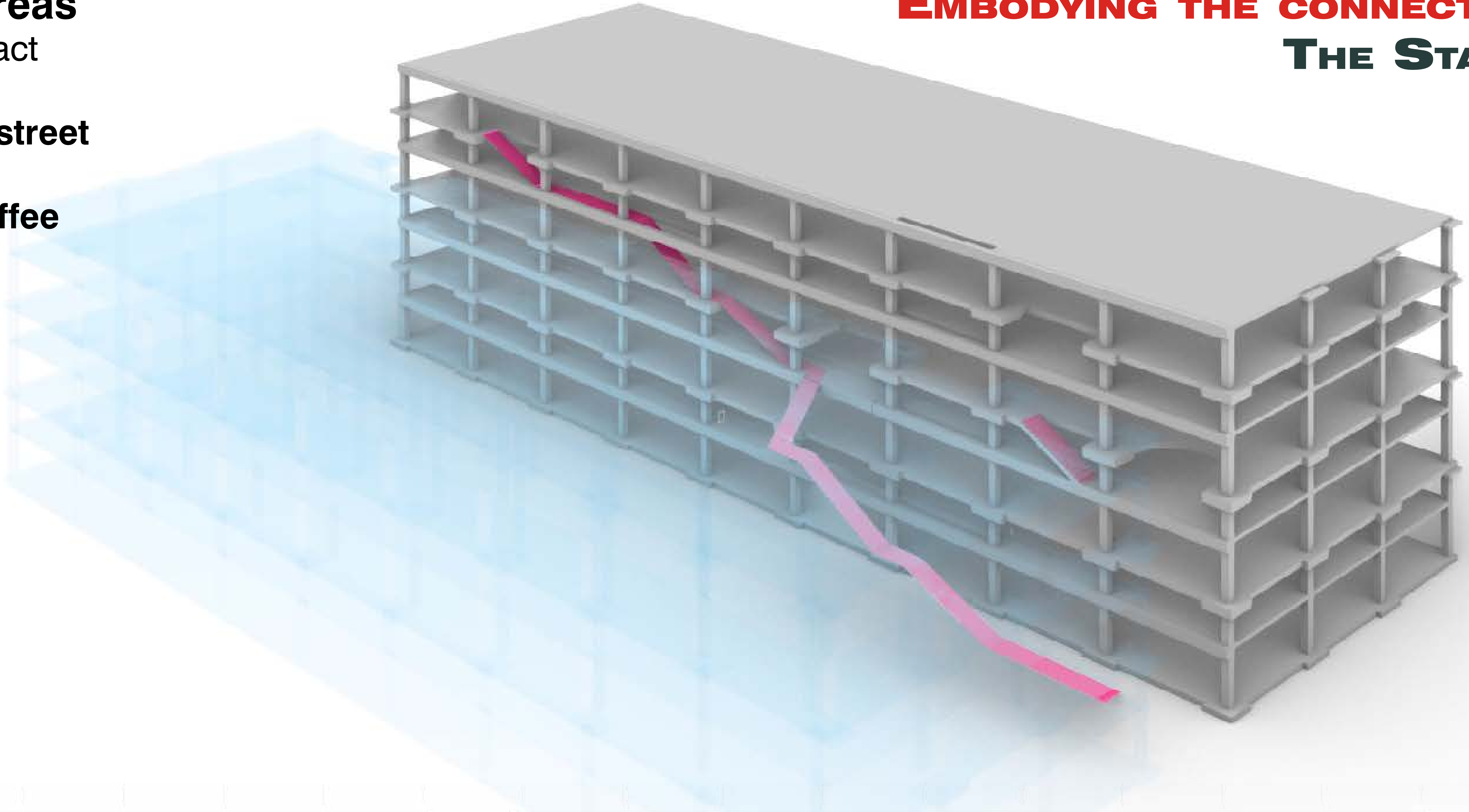
Pushed to the side



Touristic way to the meeting areas

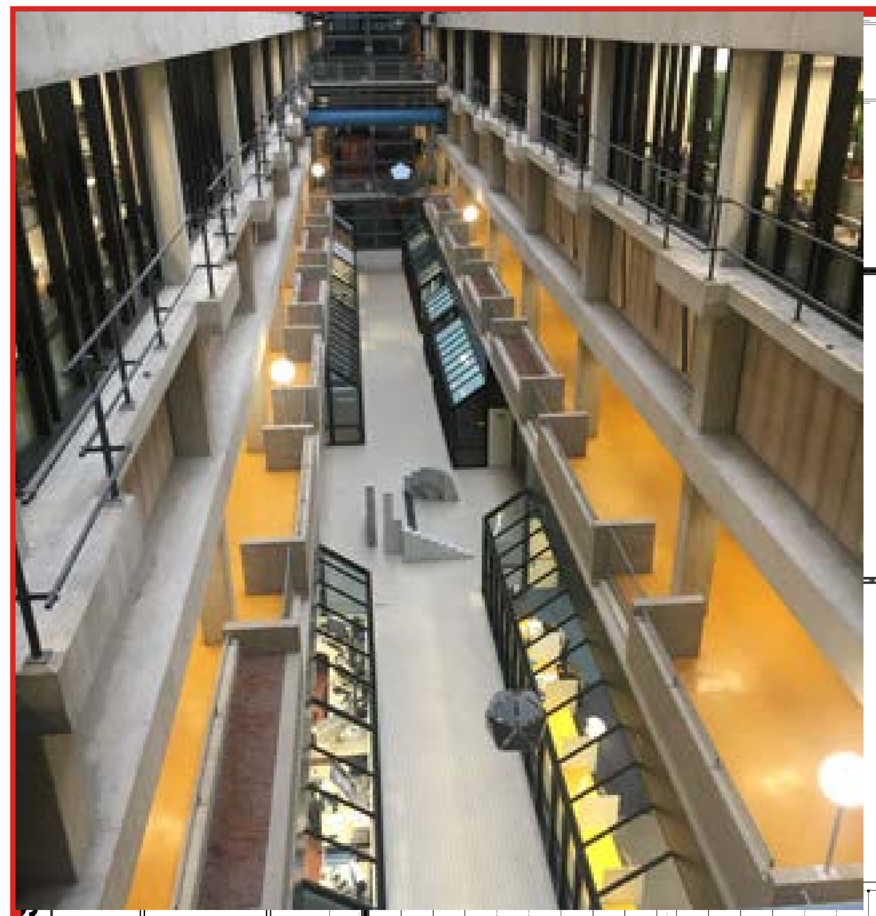
meant to be inviting and facilitate contact

- **serpents along the facades of the street**
- **Connects with each floor at the coffee corner**
- **connect with each subfloor**



Embodying the connection
The Stairs

Bottom of the Canyon



Concrete and steel

intentional feel of “in between space”

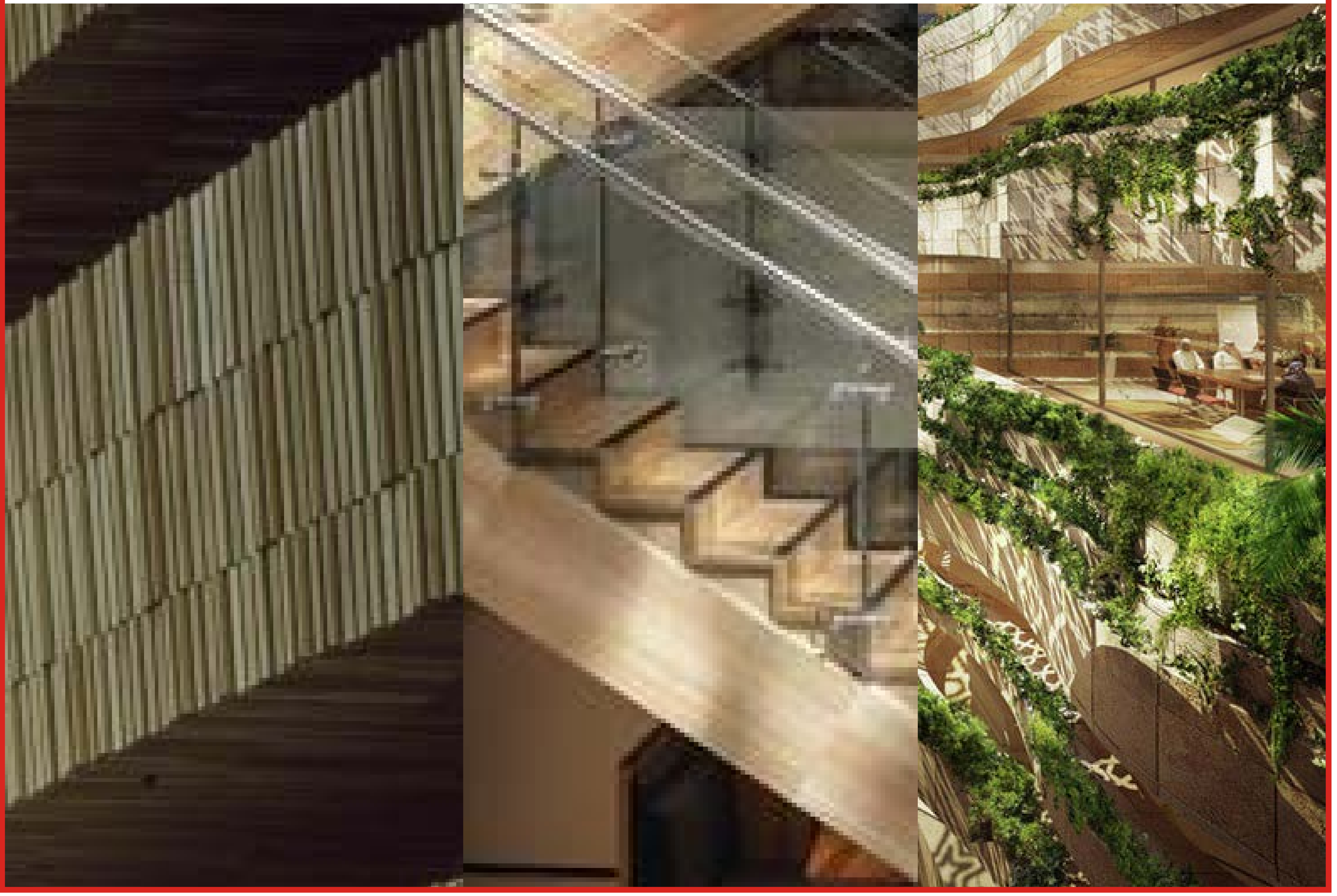
- **Concrete omnipresent : structure and interstitials’ walls.**
- **metal for circulations and in front of glass.**

Wood and glass

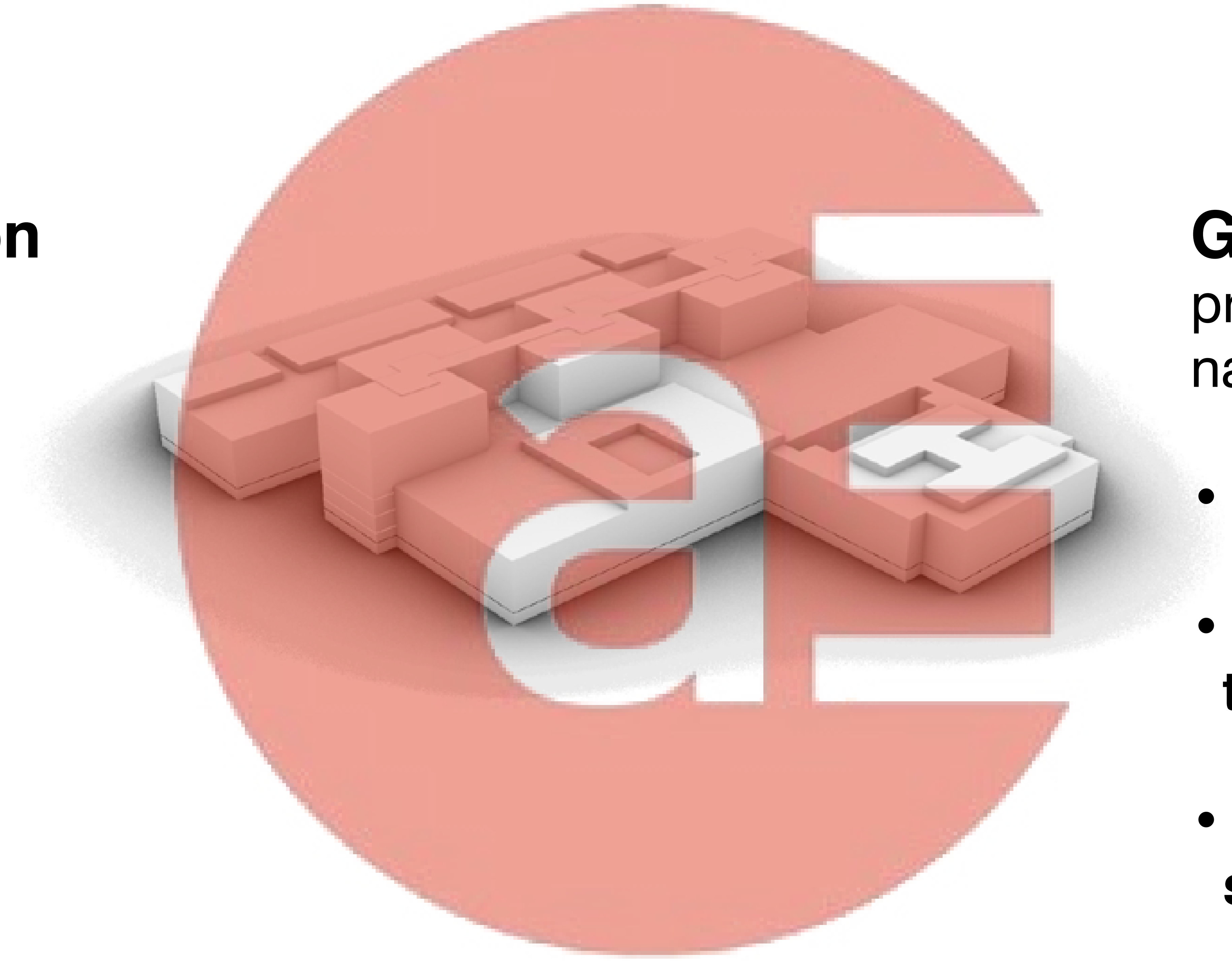
softening the hard character of the existing

Cladding of wooden pieces of varying width and thickness

- **esthetic qualities**
- **acoustic treatment of the atrium**



Thematic Research Question



How to choose a natural ventilation concept for a large building ?
that provides

- **Satisfactory air exchange rate**
- **Passive temperature treatment**

Goals
provide comprehensive understanding of natural ventilation

- **guidelines for project climate concept**
- **usable overview for designers that want to apply natural ventilation**
- **detailled research on systems separately available**

Methods

Literature research on natural ventilation

=> ***thematic research paper***

DRIVING FORCE	+	VENTILATION PRINCIPLE	+	CHARACTERISTIC ELEMENTS
- generate airflow - mechanical or natural		- used to exploit the driving force(s) = defines the flow of air throughout a space or building		- used to realise ventilation - added or integrated

VENTILATION CONCEPT

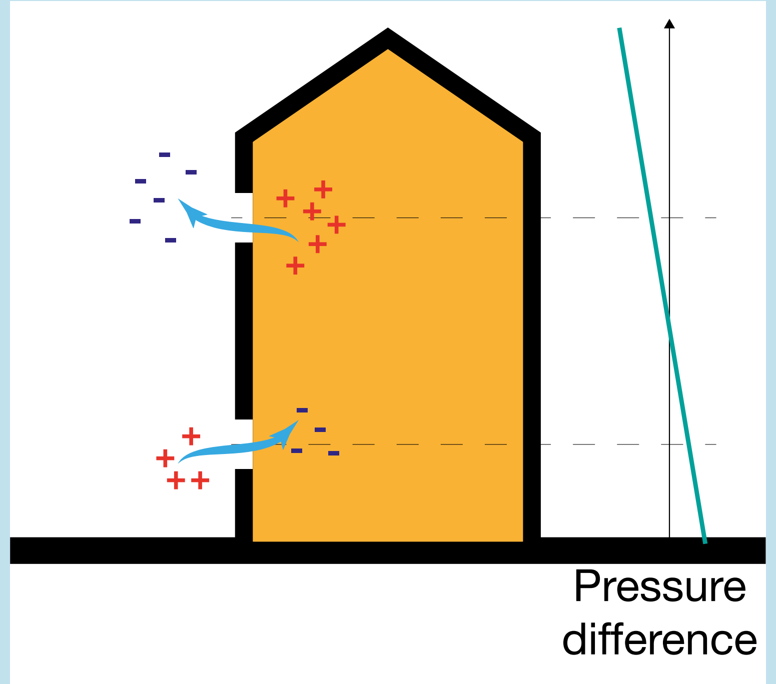
DRIVING FORCE

+

VENTILATION PRINCIPLE

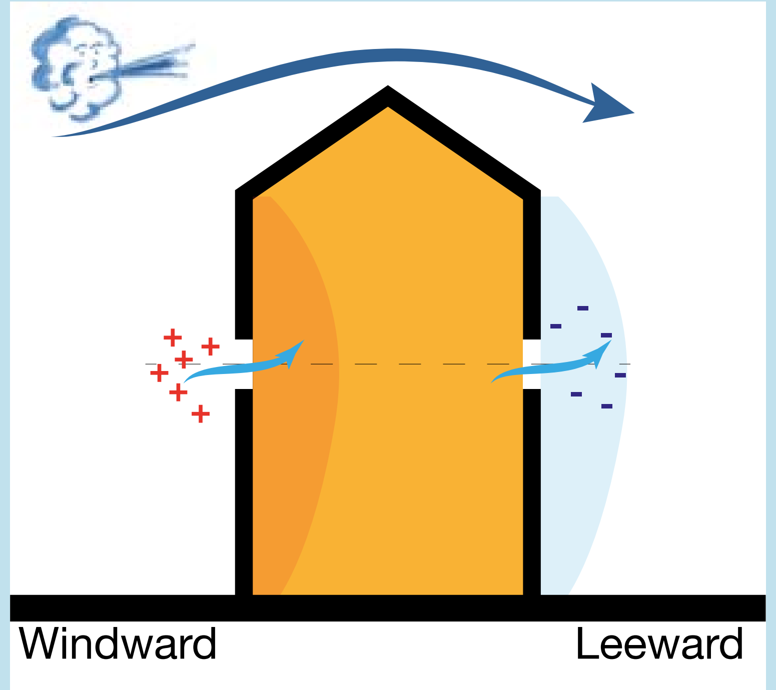
+

CHARACTERISTIC ELEMENTS



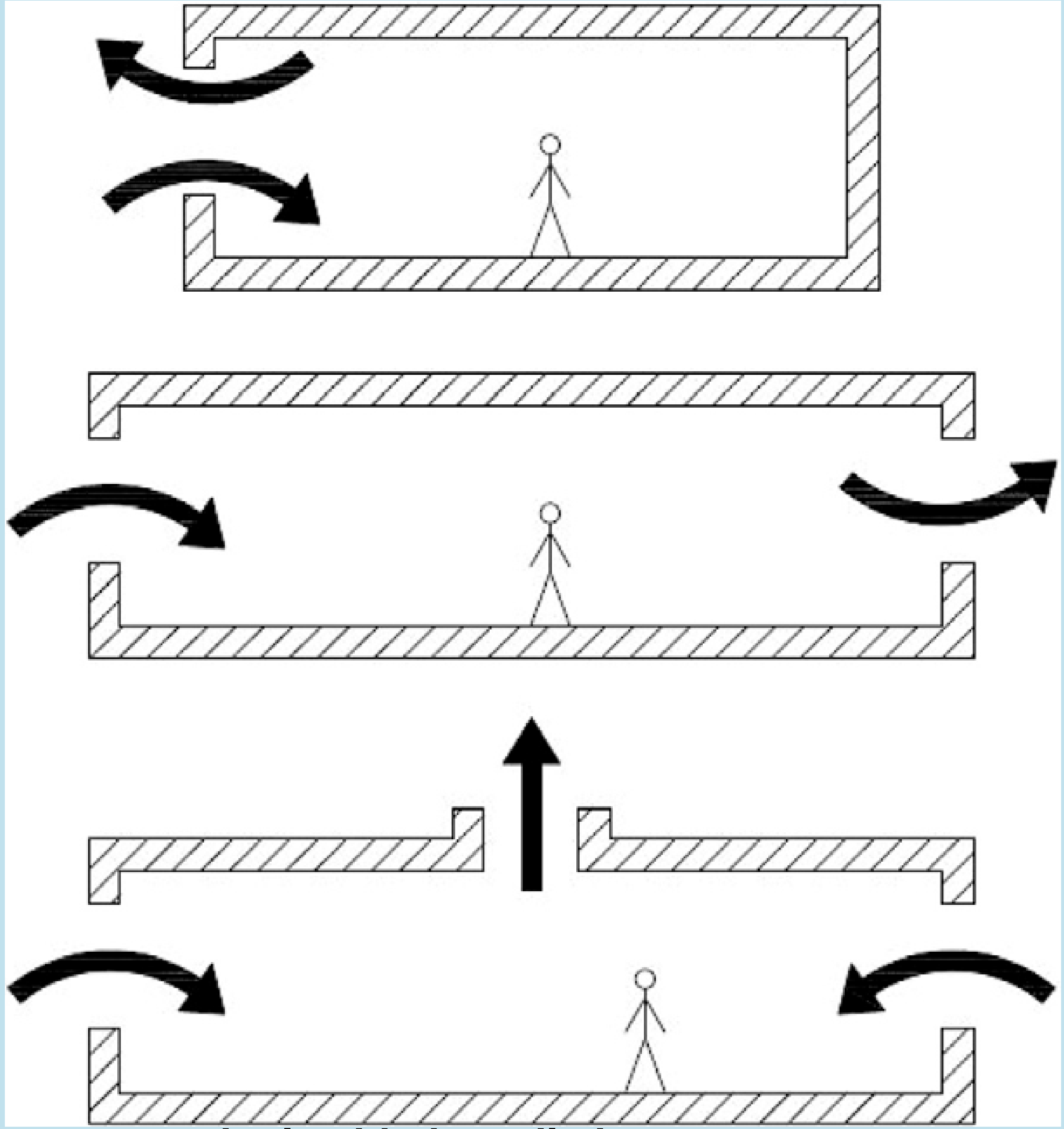
- Buoyancy or *stack effect*

Create airflow by temperature induced pressure differences.



- Wind

Create airflow by over- and under pressure on envelope of building



- single-sided ventilation

- cross-ventilation

- stack ventilation

Integrated

- **use combination of buoyancy and wind**
- **generally at least one driving force at work**
- **better yield when both active**

Elements:

- **(Solar) chimney**
- **Double-skinn facade**
- **Atrium**

Can be used either as air inlet or as exhaust

Source: Chenari et al. (2016) in *Renewable and Sustainable Energy Reviews, 59*, 1429

(Solar) chimney
buoyancy for exhaust

- **primary driving force : buoyancy**
- **can be enhanced by solar heat = solar**
- **can be enhanced by Venturi effect**

Double skin facade
many possible configurations

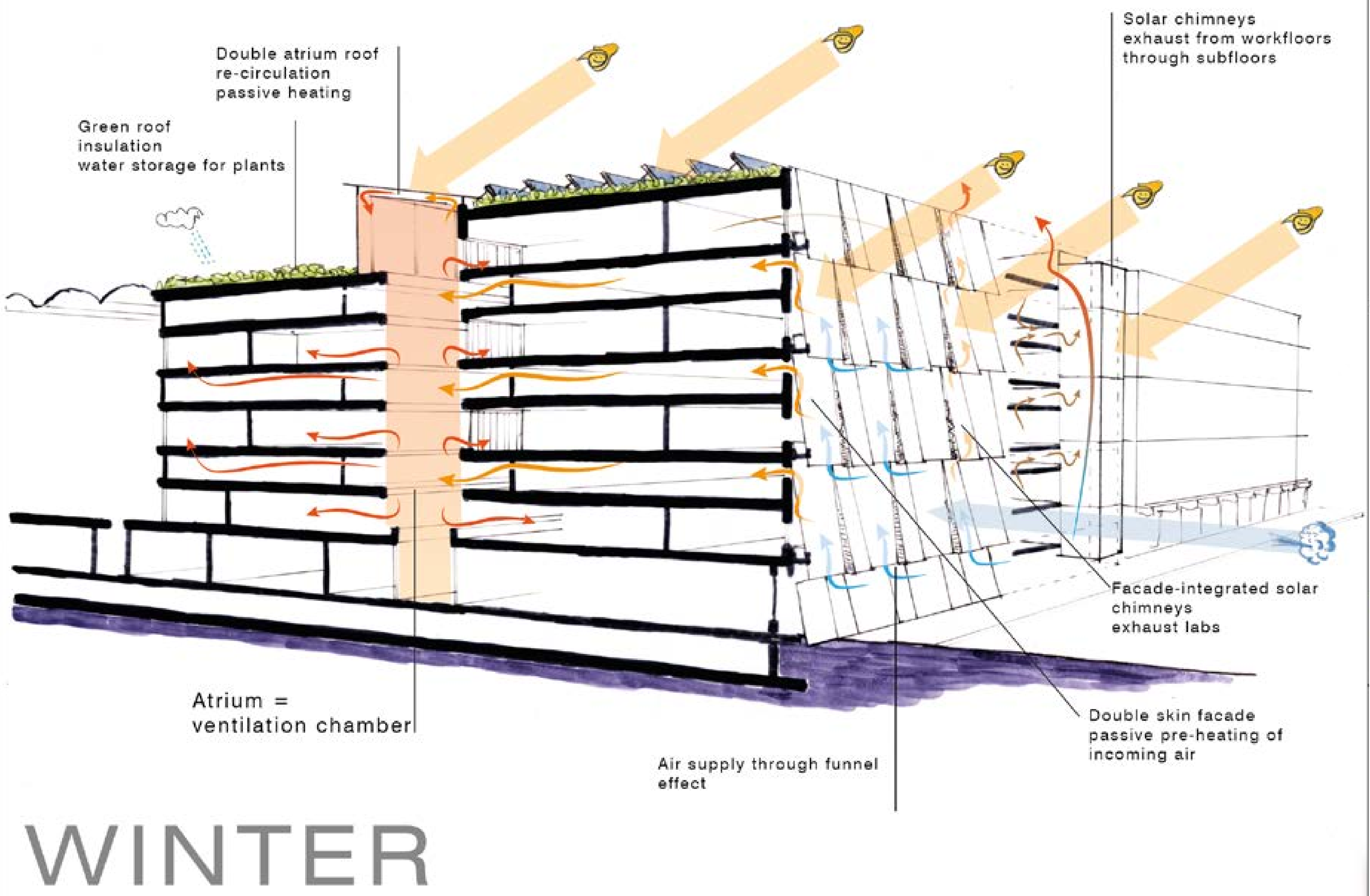
- **primary driving force : buoyancy**
- **makes use of solar generated heat**
- **can be used for inlet or exhaust**
- **ventilation coupled with passive pre-heating**
- **in exhaust configuration comparable with solar chimney**

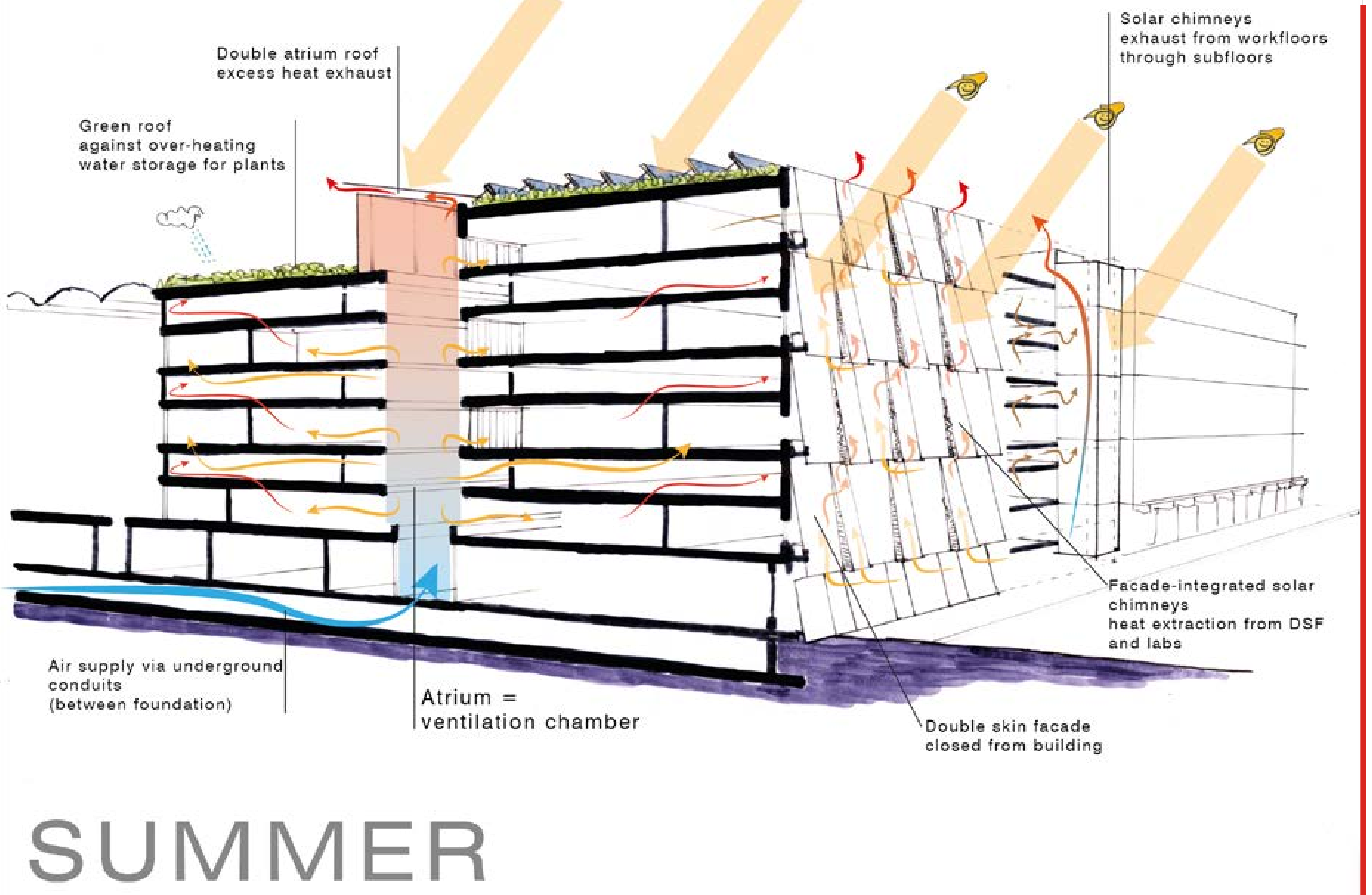
Atrium
different uses in natural ventilation

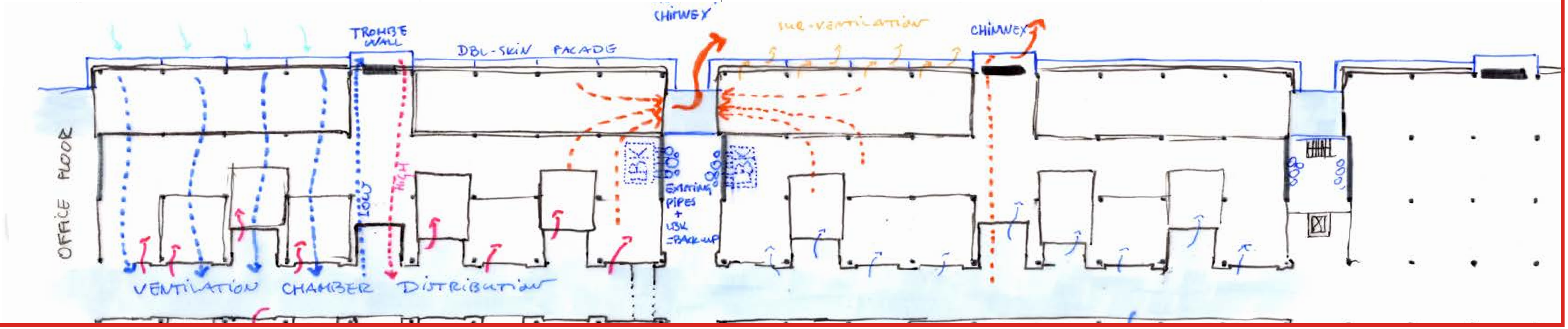
- **centrally leid down**
- **connected to all spaces**
- **can be used for inlet to adjacent spaces (wind)**
- **can be used for exhaust (buoyancy)**

= Ventilation chamber
spreading or gather air in combination with other elements

Climate concept



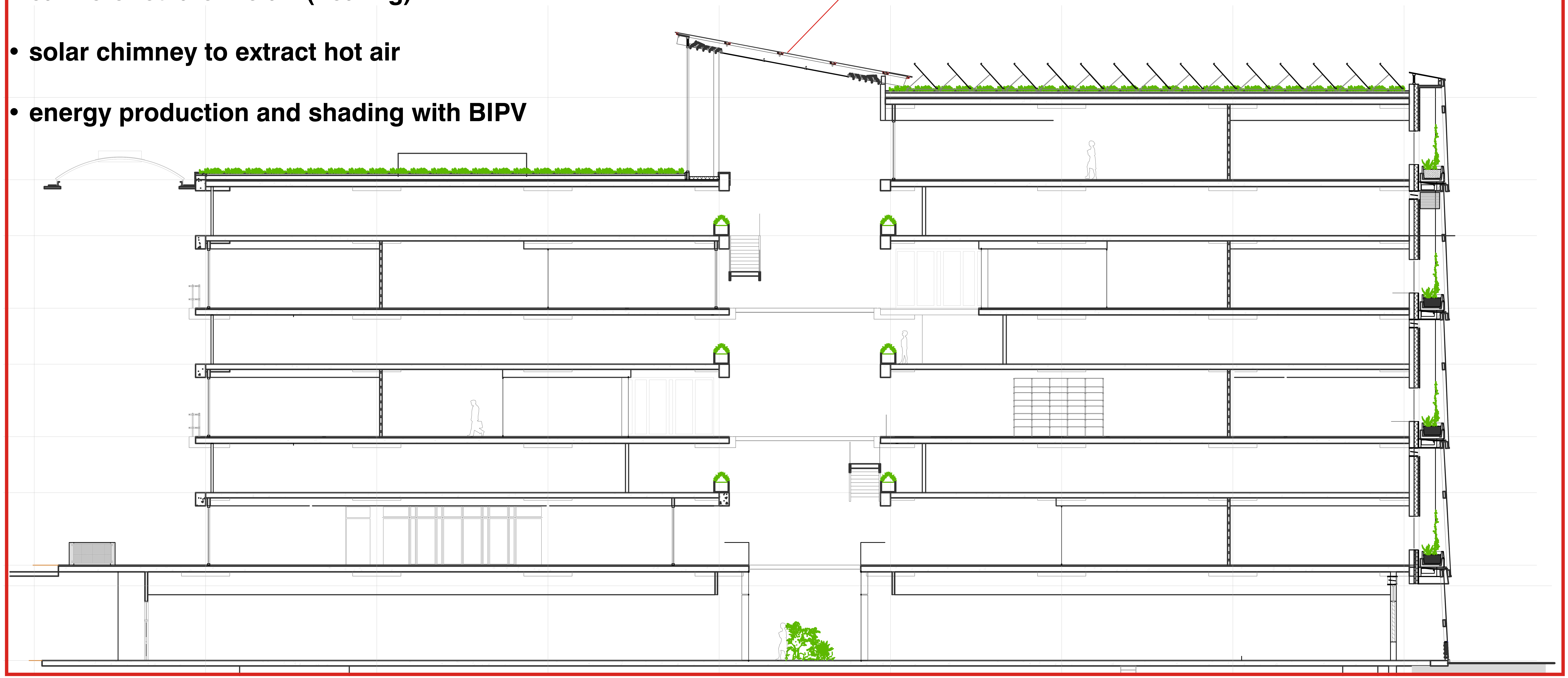




Atrium roof

Double skin roof

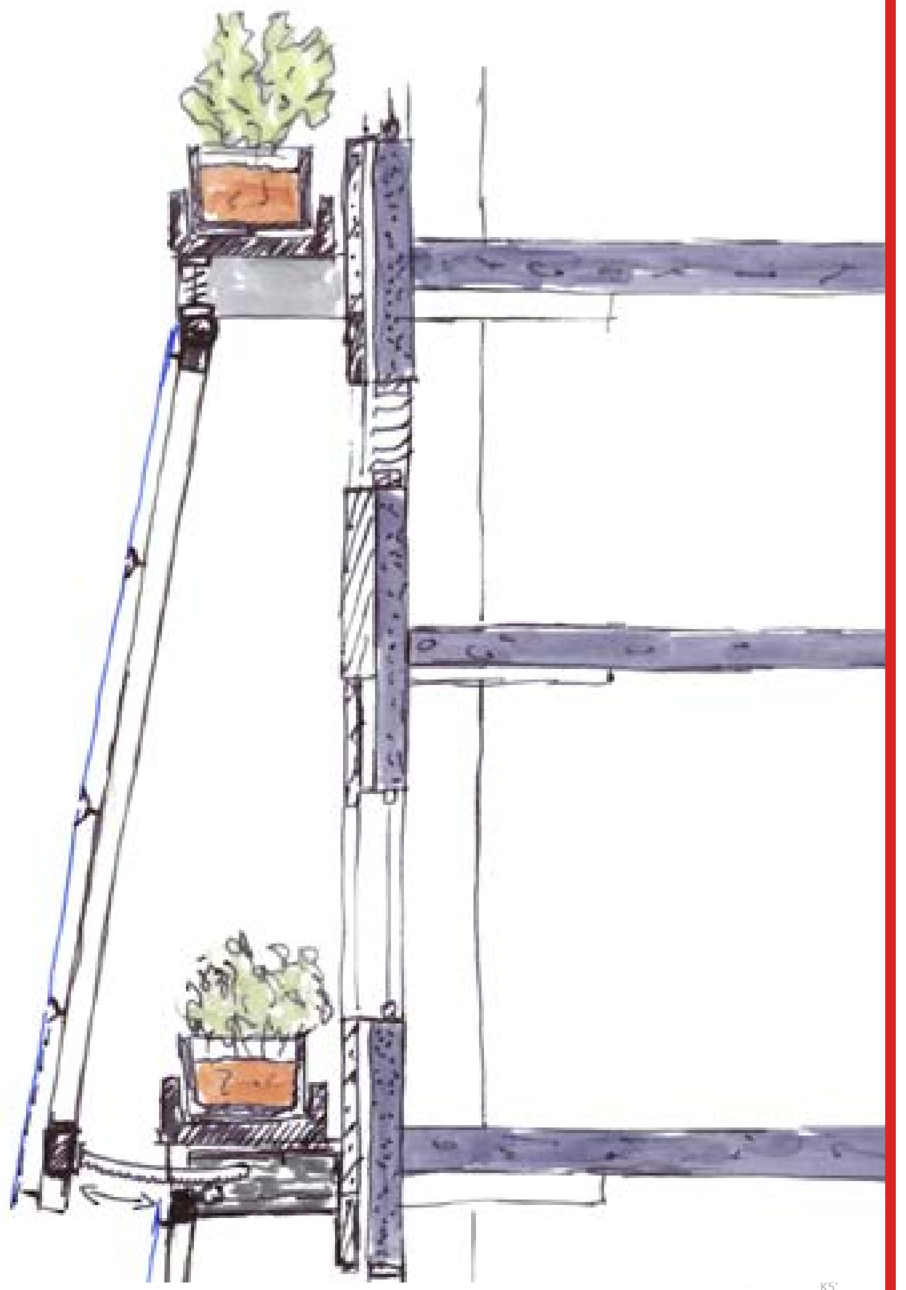
- **Helps insulating**
- **can re-circulate the air (heating)**
- **solar chimney to extract hot air**
- **energy production and shading with BIPV**

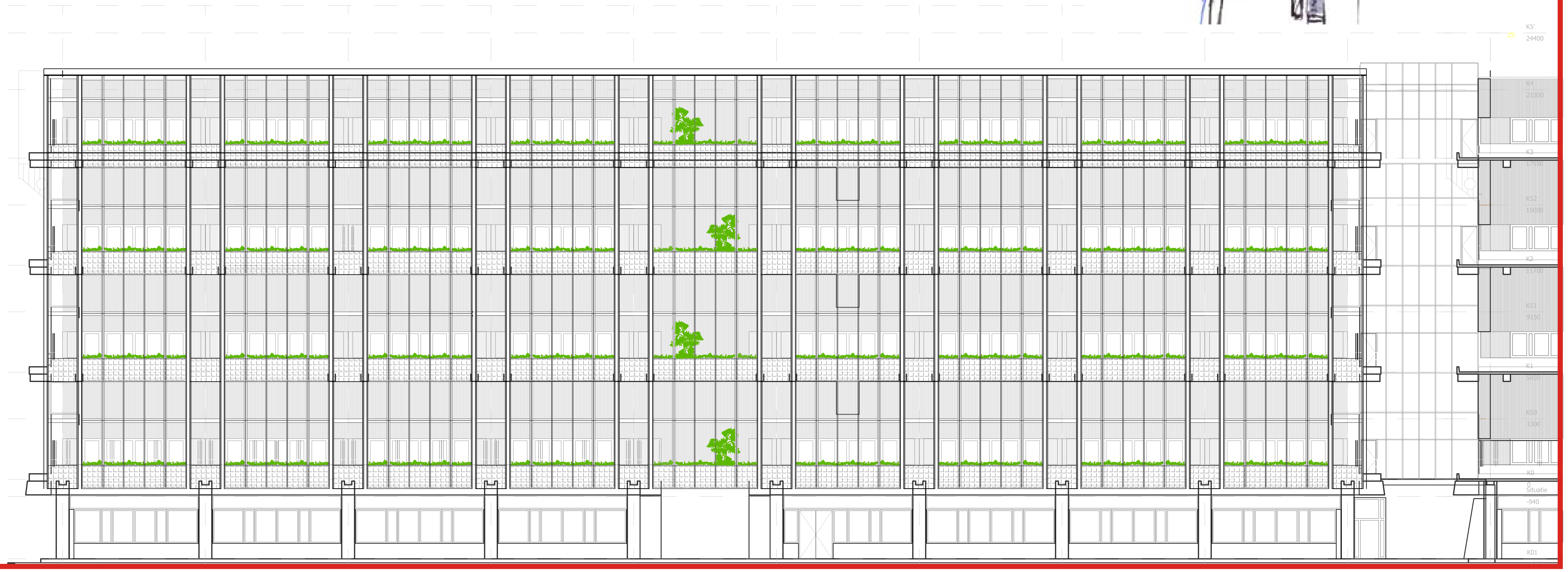


South facade

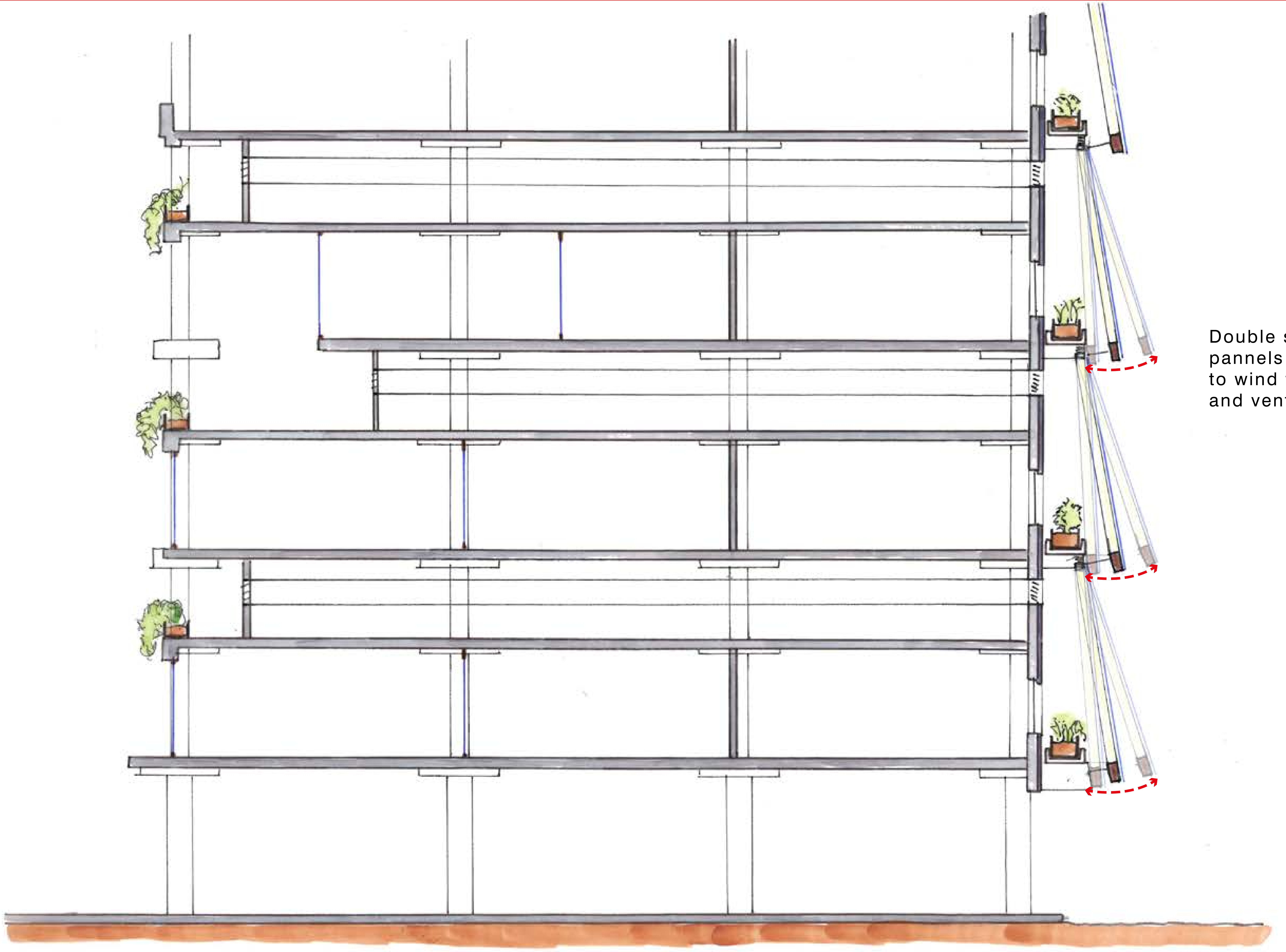
Re-use of the maintenance balconies

- Horizontal expression of the facade
- Balconies support planters
  - reintroduction of green elements
- Beams support DSF

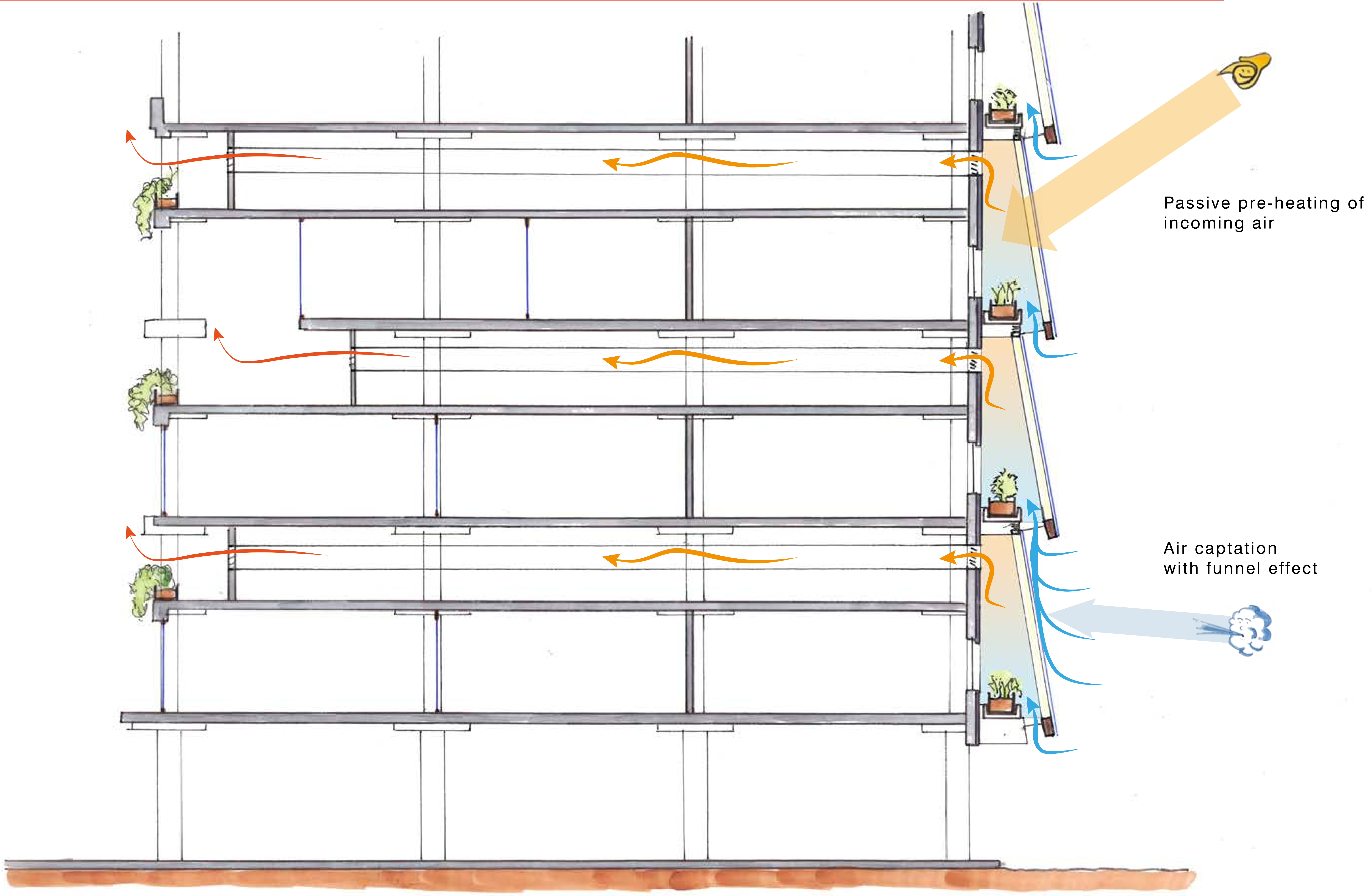




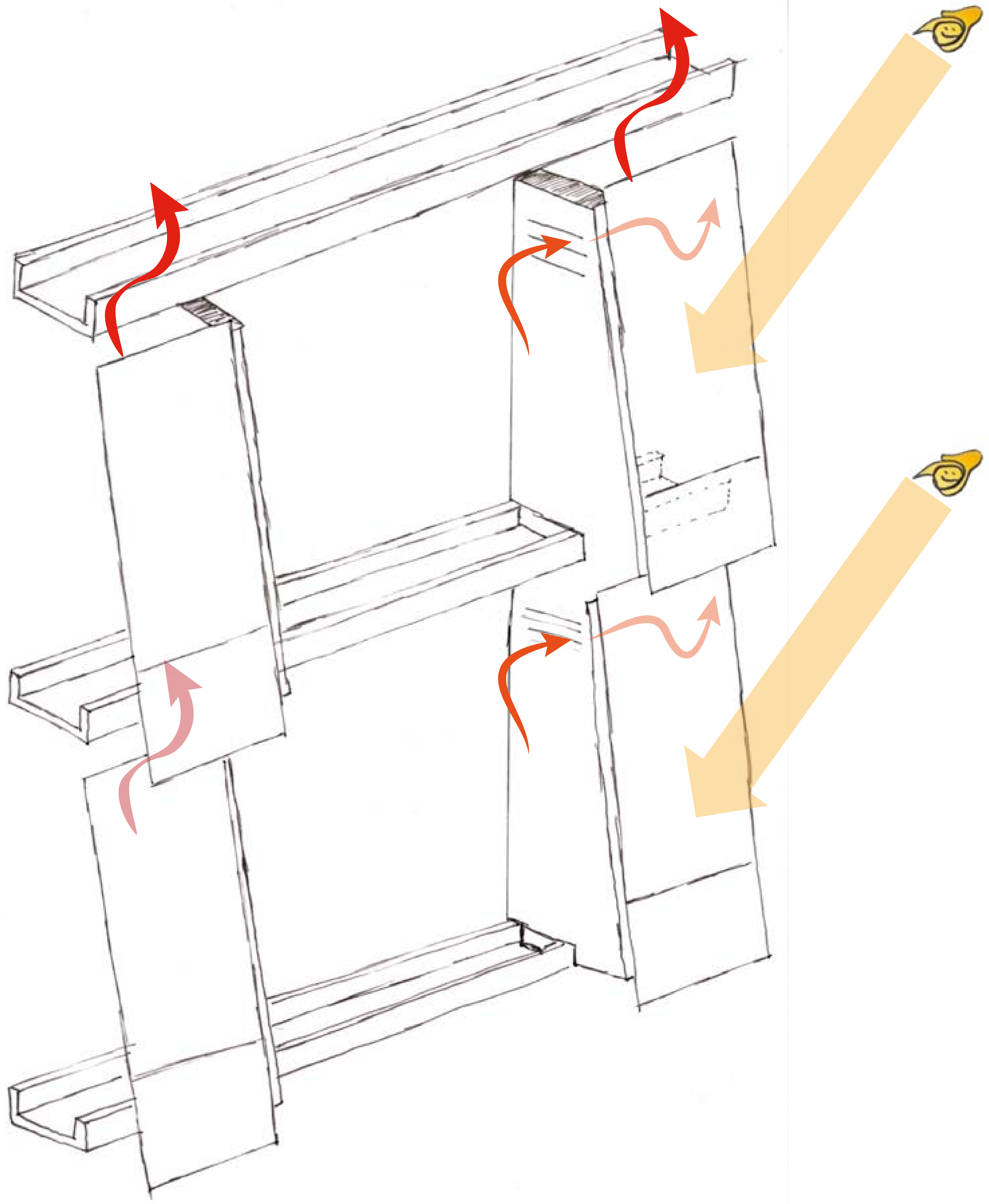
Double skin facade
Reclining panels



- make natural ventilation visible
- primary function of facade = air inlet
  - catch wind
  - funnel effect
  - shape of cavity also directs air
- Low tech


Passive pre-heating of
incoming air
Air captation
with funnel effect

WINTER



Summer configuration
Exhaust DSF

- **Helps insulating**
- **exhaust of hot air from cavity**
- **solar chimney to extract hot air**

Summer configuration
Exhaust lab

- **additional extraction**

Technical space
Maintenance

- **place to stand for maintenance**
- **space for watering systen**

Appendix

P5 - STORYLINE

1. INTRODUCTION

From the very beginning of my path in architecture, my focus has been sustainability, especially bioclimatic and passive design. Today, I am here to close the last chapter of my education, so it should come has no surprise that sustainability has an important role in this project I am about to present.

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In the Netherlands, there is a large amount of buildings that are outdated according to today's standards. Those existing buildings represent about 70% of the building stock in 2050. Updating these buildings in terms of functionality but mostly in terms of sustainability is therefore a highly relevant task at hand. To quote Prof. Mauro Overend in one of his lectures: "The most sustainable building is the one that has already been built".

Among those buildings, what we could call brutalist buildings from the 1970's and 1980's represent a large part of our cityscapes. Those buildings are mainly built of concrete, are in general structurally sound, but although they are not to everyone's taste, would cost a lot of energy to tear down. What's more, due to poor insulation and dated climate systems, their energy efficiency is generally atrocious.

One good example of those brutalist buildings is the Academic Medical Centre (Academisch Medisch Centrum) in Amsterdam. Built at the beginning of the 1980's, it is a concrete megastructure, Europe's largest at the time of completion.

The project I am about to present is approaching the AMC building as a case study of how the brutalist buildings of the 1970's and 1980's could be renovated in a sustainable fashion. If some passive systems can be retrofitted to one of the largest megastructures available, it stands to reason those smaller buildings could be addressed as well.

2. AMC

A. Presentation

Completed in 1983, it was designed in the late 1970's and was to be the embodiment of the work of a group of architects on a new philosophy of what a hospital is supposed to be to put the patient at the center. As such, it also marked the design of the other teaching hospitals built in the Netherlands in the following years.

Aiding multi-disciplinary work and optimal integration of the educational component in a synergy of patient care, research and teaching were crucial to the design.

In the design, this was translated into approaching the building as an urban assignment. The building, counting about half a million of square meters of floors, manifests itself as an inner city, with streets, squares, a large offer of facilities… This urban character is only strengthened by the large variety of public walking around (students bring the average age down). The hospital and research functions are hosted in blocks arranged around those streets. Above the central squares are the bedtowers, hosting the nursing wards, treated as the only high rise elements of that "city". On the North side of those towers, the heart of the hospital, with the "hotfloors" and polyclinics, on the South side the faculty and it's lab facility.

Another specificity of the AMC resides in its being a typical example of structuralism, where we see a permanent "carrying" structure combined with elements that could be easily and quicky replaced to adapt to the needs in the longer run. Between the conventional floors are technical subfloors, interstitials, that serve the floors directly under and above.

B. Climatic challenges

As one would expect from a building of such size, the energy demand of the AMC is extremely high 75 GWh/yr (comparable with that of cities such as Schiedam or Lelystad, around 80.000 inhabitants).

About 45% of that energy goes to heating, ventilation and other components of the climate control -which is twice as much as all medical and research equipment.

As we can see on the diagram, the two main posts of energy demand for climate control are heating and ventilation.

i. Heating

As previously mentioned, like many buildings from the same period, the AMC is poorly insulated. The 40 years old facades have but a very thin layer of insulation and the framed openings are still fitted with the original, highly inefficient doors and windows.

Even more notable, the covered streets and squares do not have any heating. They are heated from the warm air leaking from all the blocks while also barely being insulated (single glass roof)

ii. Ventilation

The AMC has an all-air system with central AHU (air handling units).

Aside from its consumption, this system has a couple of drawbacks : the temperature and flow of the units is fixed, which requires a painstaking adjustment of vents to adjust the flow in a specific space.

The current pandemic has also shed light on the dangers of such central AHU's in regards of infection spreading risks.

iii. Potential for passive design

Is this the right place ? Or should it come in the next part?

C. Conclusion : framework

Based on those primary discoveries, I decided to focus at first on the possibility to apply/retrofit natural ventilation to the AMC building.

Addressing the whole building would not have been a realistic task. I chose to focus on the university part of the complex, for a handful of reasons:

- Although it officially consists of 4 blocks, one of the covered streets splits those blocks into 2 wings each
- Combined with the presence of subfloors, it is actually a condensed "overview" of the specificities of the complex
- The university has an outer façade, which allows me to address that aspect too
- The façade is roughly orientated South, which allows to explore the use of the sun.
- The "hotfloors", hosting OR's, ICU's have much stronger requirements for air quality and therefore might not be suitable for natural ventilation.

In theory, a successful design of a natural ventilation at the scale of the university could be extended to the whole AMC.

3. RESEARCH FACILITY : FUNCTIONAL PROBLEM STATEMENT

Once the fragment of the complex selected, I dived into the spatial design , and therefore at first into the problem statement

A. Problem Statememt

To frame the problems at hand with the current facility, I talked with a professor at and the head of real estate of the AMC.

The first issue that came to light derives from the changed standards in labs in the past decades. Where the AMC was built with labs with a conventional layout (many tiles workbenches with water and gas supply), this layout is nowadays mostly limiting, since lab work relies more and more on machines, most of them being too large to easily fit within the grid of the labs.

A second aspect has to do with the ratio in time spent in the lab generating data and the time spent processing the data. A researcher's time used to be spent for the greater part in the lab, while they today spend more time at a desk. Yet the layout of the work floors still reflect the outdated ratio in dedicate surfaces.

The main issue however was mentioned by the professor I met with. Since the AMC was built, research has been done on the education and research in the medical field and novel insights have emerged. One of those is that the traditional structure on which the whole research facility of the AMC is built, where each researcher has their own desk (with some luck on the same floor as the lab they use) in a small office shared with 2 or 3 fellow researchers, is actually not favorable for creative insights. When researchers exchange more with colleagues from other departments, it leads to more innovative results.

The current research facility is however not at all fit for such socializing. Where the official meeting rooms are already scarce, the informal meeting spots are practically inexistant.

There is only one path along the street, at the entrance level, un=inviting as can be. Other sitting spots are scarce.

B. Main quality

The main quality I wanted to introduce in my design was to give shape to that desired connection.

It quickly appeared that the inner street would play a central role.

Now a cold hard space, uninviting and acting more as a barrier than a connecting space, it becomes the heart of my design.

Giving shape to the connection went in three steps:

1. *Creating informal meeting areas in the street*

For that step I made use of the subfloors

2. *Re-design the layout of a department's floor to connect it to the street*
3. *Creating an inviting route from the work floors until the meeting areas.*

4. DESIGN

A. Subfloor lounges

Playing on the unique characteristics of the AMC, I claimed part of the technical subfloors back to attach it to the public interior and create zones connected to the atrium and literally in-between departments.

Because the subfloors are man-high but do not have a comfortable high for a staying area, the strip along the street is primarily defined as a corridor, along which some lounge areas are fitted. Those lounge areas don't belong to any department or floor, so they offer an always rather close area to sit that is yet somewhat remote.

Another form of life that I decided to bring into the atrium was plant life. Aside from offering a softening aspect against the hardness of the concrete, plants have many effects on air quality. Through evaporation they can also contribute to reduce heat stress. It has also been proven that the presence of plants around patients reduces the healing period.

To create those lounge areas, the floor slab of the work floor above is cut open between the capitals of two columns till the depth of half a span.

Those cuts in the slabs introduced a crucial element to the design of a department's work floor.

B. Work floor

My first step in addressing the work floor was to flip the functional layout to support the idea of a living street. The labs' windows inherently not being intended to open, created a façade that contributed to the barrier character of the street., while the offices, where we want to introduce the idea of connection, were pushed to the outside.

The professor mentioned a wish, apparently shared by many colleagues and researchers, for an open work space next to the labs.

I did however found out that a sociological research by Harvard professors broke the myth of open workspaces:

- Face-to-face interactions have decreased by 70%.
- Mailings increased by 56%.
- Copying when sending emails increased by 41%.
- The use of internal instant messaging has finally increased by 67%.
- Employees try to re-create the lost privacy

Thus, the open workspace does not increase human interaction as its designers had imagined. On the contrary, it reduces it, which tends to drastically reduce the productivity of a company's employees.

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Each work floor consists of three strips

- The labs on the outer end,
- The offices adjacent to the atrium
- A flexible in-between zone, designed to favor connection at a department's level and to offer a threshold to the connection with other departments.

The office strip is in its turn built from three modules:

i. The base: offices

Those offices re-use the glass façade of the former labs in place, with its specific rhythm in frames.

The separation with the middle zone is a glass wall doubled by a wall-shelving system. Besides offering space for either storage or decoration, users can influence the degree of closeness and therefore privacy those shelves provide.

ii. Meeting rooms

The cuts realized to create the subfloor lounges require the inner façade to be offset at places. Behind those cuts are meeting rooms, that are pulled like drawers into the in-between space, creating a first layer of relief in the width of the semi-public zone.

A second layer of relief, aiming at giving more quality to the otherwise too open space makes use of the same modular shelving system, creating zones for sitting, standing tables, the print corner or cells where one can withdraw for focused work of a videoconference…

iii. Coffee corner

The last of those shelving elements hosts the coffee machine and is placed in the coffee lounge.

The coffee lounge is the threshold between the in-between zone of each floor and the last element: the serpentine staircase in the atrium.

The idea is that after grabbing your coffee, it feels as easy to take the "touristic route" towards one of the lounges as to go back to your own department.

C. The stairs

The stairs are the element that embody and express the guiding idea of connection. It comes in addition to the functional staircases and elevator shafts, that have been moved towards the side streets to open the view on the canyon. The stairs are an invitation to wander from the one place to the other, not on the most efficient route but the "touristic" route along the walls of the canyon.

The staircase is deployed as a ribbon from the ground floor, going up and down as it goes from the entrance until the "dead end" of the street and back, sometimes crossing over.

D. The bottom of the canyon

The bottom of the canyon is laid at -1. It is actually at ground level, but since the entrances are elevated, once in the building they appear to be the basement.

Interesting fact is that it is the only part of the building where level -1 is entirely open.

However, it is not treated as a space to use:

- The spaces around it stick out to catch some daylight but do not open on the street
- It has a tiled floor and a couple of artworks displayed.

My first intervention at that level is to bring a layer of green that connects the two side facades. The side facades are pushed back to reclaim the space to the quality of the atrium.

The second intervention is to improve the transition from level 0 to level -1.

Where it now is only accessible via the staircase, it shall terrace down from the entrance area to the inner garden via a set of stairs/bleachers. Next to a more gradual transition, they offer a multitude of sitting spots and a less formal lecture area, much like our orange stairs.

5. MATERIAL CONCEPT

Now the major elements of the spatial design have been presented it seems like a good moment to talk about the material concept.

A. Existing parts: concrete, metal and wooden frames.

Raw concrete omnipresent: structure, facades of subfloors

Metal as add-ons circulation elements (staircases, elevators, and bridges)

Also railings in front of all glazed facades

According to the architects, it was intentional to let visitors feel that they were in an intermediary space.

B. Additions: wood, glass and green

To break and contrast with the raw, hard character of the existing design, the elements I add are of wood, glass of plants.

To give a lighter character.

For the wooden façade elements, I worked with a cladding made of pieces of wood of varying width and depth. Aside from esthetic qualities, it works as acoustic treatment for the inner street.

6. CLIMATE CONCEPT

A. Research

i. Research topic/question

How to choose a natural ventilation concept for a large building that offers

- Satisfactory air exchange
- Passive thermal comfort pre-treatment possibilities

ii. Research results

Ventilation concept (framework Kleiven)

Driving force

Ventilation principle

Characteristic elements

Driving forces: only two natural

Buoyancy: stack effect: when the air changes temperature it changes density: hot air is less dense and rises. In a building it will create an overpressure at the top and and an under-pressure at the bottom

Wind: also over- and under pressure, only this time wind induced

Ventilation principle: exploit the driving force

Single-sided and cross ventilation not suitable for deeper buildings

Stack ventilation can have exhaust(s) in the middle = suitable

Characteristic elements

Out of research: integrated more suitable

(Solar) chimney uses stack for exhaust, can be supported by wind (venturi)Dbl skin facade stack, but many configurations possible inlet or exhaust

Same for atrium.

Another element discovered during research is the ventilation chamber. Though is doesn't actually create an airflow, it plays a role especially in large buildings where it spreads the air towards all other spaces, or gathers the "used" air from several spaces before exhausting it through another element.

My climate concept is a combination of double skin facades and atria in a bi-directional system.

iii. Relevance project/general

Besides guiding my choice for a ventilation concept for this specific project, the aim of my research was to provide guidelines that could help other designs of renovation of larger buildings.

B. Climate concept

i. Air inlet

Winter

Summer

ii. Air outlet

Winter

Summer

C. The atrium's roof

D. Building roofs: water and energy

7. SOUTH FAÇADE

Having determined the role of the façade in the climate concept, the challenge was to express the functionality in the design, particularly the natural ventilation.

A. Balconies: re-use as planters

Starting point: the existing maintenance balconies and the cantilevered beams that support them. I decided to use the beams to support the DSF and to leave the balconies in place as the contribute to the expression of the façade with its horizontal lines.

I re-introduced the element green on that side of the wing as well. Since it is the air inlet for part of the year, the filtering properties can be beneficial. Also, evaporative cooling could help in the summer.

B. Reclining panels

The main element of the façade are the panels.

Since their primary function is to let the air in, and then pre-heat it, I looked for a solution that catches the existing winds as well as possible while allowing to control the air flow.

The panels in their entirety incline or recline, creating a funnel and an opening at the same time. The more inclines, the stronger the funnel-effect and the larger the opening.

The angle also directs the air towards the top of the compartment and creates an overpressure there.

C. The inner facade

The panel work together with the inner façade to preheat the air before the overpressure pushes it towards the ventilation chamber.

The cladding I mentioned earlier is applied as well on the inner façade, in a darker shade. The greater contact surface with air exposed to the sun and the extra absorption due to the color enhance the working of the sun in heating the air.

The cladding also integrated the vent that leads the air towards the atrium.

D. Solar chimneys

Between two panels come narrower boxes that are fixed.

They offer a spot to stand on for maintenance, but their main function is to exhaust hot air. They are solar chimneys.

In a Winter situation, they contribute to exhausting air, but their main function is in summer. Through another vent, on the side of the boxes, the hot air at the top of the compartment, that is kept out of the building, is exhausted.