



DREAMERS

Design REsearch, implementation And Monitoring of Emerging technologies for a new generation of Resilient Steel buildings

Definitive Structural and Architectural Project, Definitive Design of Electrical and Mechanical Systems of the Demonstration Building

Deliverable D1.1.1-WP1 – D1.7

WP 1: Definitive Design for the Demonstration Building
Task 1.1 – Architectural Challenges and Technological Requirements

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1. Introduction

This deliverable is aimed to provide a summary of the design choices concerning the definitive project of the demonstration building, the C3 Building of the University Campus within the framework of RFCS DREAMERS project.

This deliverable is related to Task 1.1. Within this task, starting from the goals to be achieved by the construction of the building, the destination of use and the performance requirements established by the University administration, the definitive design has been finalized. The architectural drawings have been provided by UNISA that, through its technical office and the support of the whole DREAMERS consortium, has produced the definitive architectural project of the building. The project complies with the quality standards set by the Italian law for executive projects (Decree Law 50/2016). The building is regular both in plan and elevation, TS has provided the definitive drawings for the realization of an appealing façade of the building. TS has also interacted with KNAUF to ensure the full feasibility of the solution since KNAUF will supply the external claddings during the construction. The concept of the façade has been integrated into the process of sustainability, complying with the instructions specified in Task 1.3.

The elements of the facade have been selected appropriately to accommodate all the possible movements that the structure exhibits under a severe seismic event, without conflicting with the structural elements and assuring no damage. Such a scope is ensured by the cooperation between TS and KNAUF that has provided the solutions able to accommodate the lateral sway displacements of the building considering properly the role of the connections between the façade and the structural elements.

The definitive design includes also the choices concerning the structural design of the building and the design of the main elements and issue concerning the mechanical and electrical systems.

According to the Grant Agreement all the design documentation is due in Italian language, because it has to fulfil the Italian Code provisions and has to be delivered to the National local authorities to obtain the relevant authorizations. Therefore, in this report only a brief discussion is provided. However, the detailed design documentation is also listed at the end of this report and fully delivered (in Italian) on the project website (www.dreamersproject.eu).

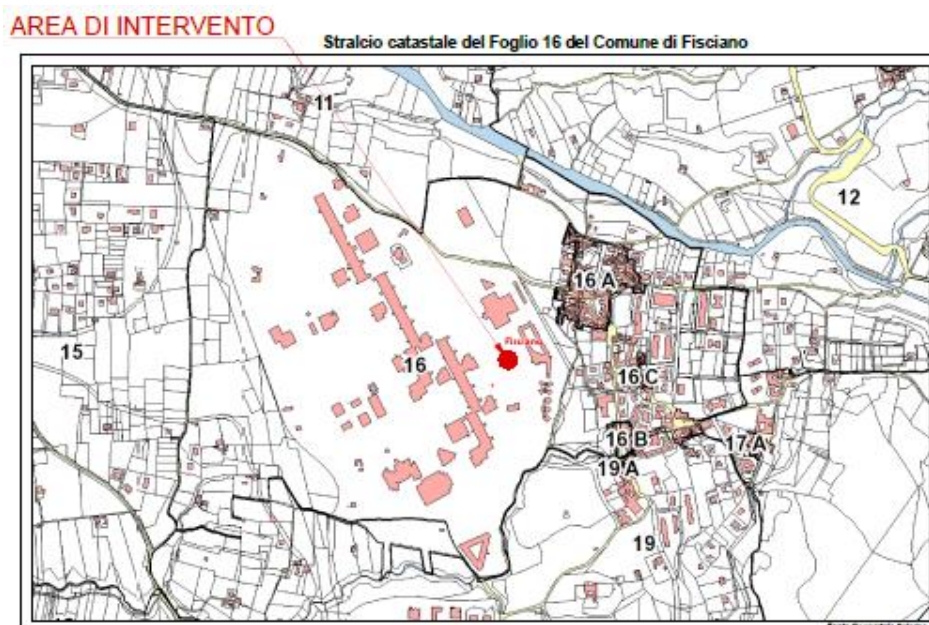


Figure 1: The area where the demonstration building will be located

2. The area of intervention

The demonstration building will be realized within the Salerno University Campus in an area close to the refectory and the students' residences. The red bullet in Figure 1 shows the of the University Campus where the demonstration building will be located.

Figure 2 shows an aerial view of the University Campus located in Fisciano in province of Salerno. It is the main campus hosting all the faculties with the only exception of the Faculty of Medicine which is located in a second Campus in Baronissi, a town close to Fisciano.



Figure 2: Aerial view of the Campus.

3. Description of the building

The building has as primary destination the “Life Science Hub Laboratory” with the ground floor partially open to host a parking area, the first floor devoted to the laboratory and the second floor devoted to offices. In addition, the roof floor will host a photovoltaic plant. All the floors are connected by a three-flight staircase made of hybrid steel-concrete structure.

The covered area is of about 350 sqm while the volume is about 3000 mc. The main dimensions of the building are 25x14 m for a rectangular shape. The ground floor inter-storey height is 3.5 m, while the first and second floor inter-storey heights are equal to 4.20 m.

At the first and second floor there are also toilets for ladies, gentlemen and handicapped.

The Ground floor is devoted to the main mechanical and electrical equipment and to storage. Half part of the storey is arcaded to allow the parking of the cars (Figure 3). The staircase is located on one side of the building.

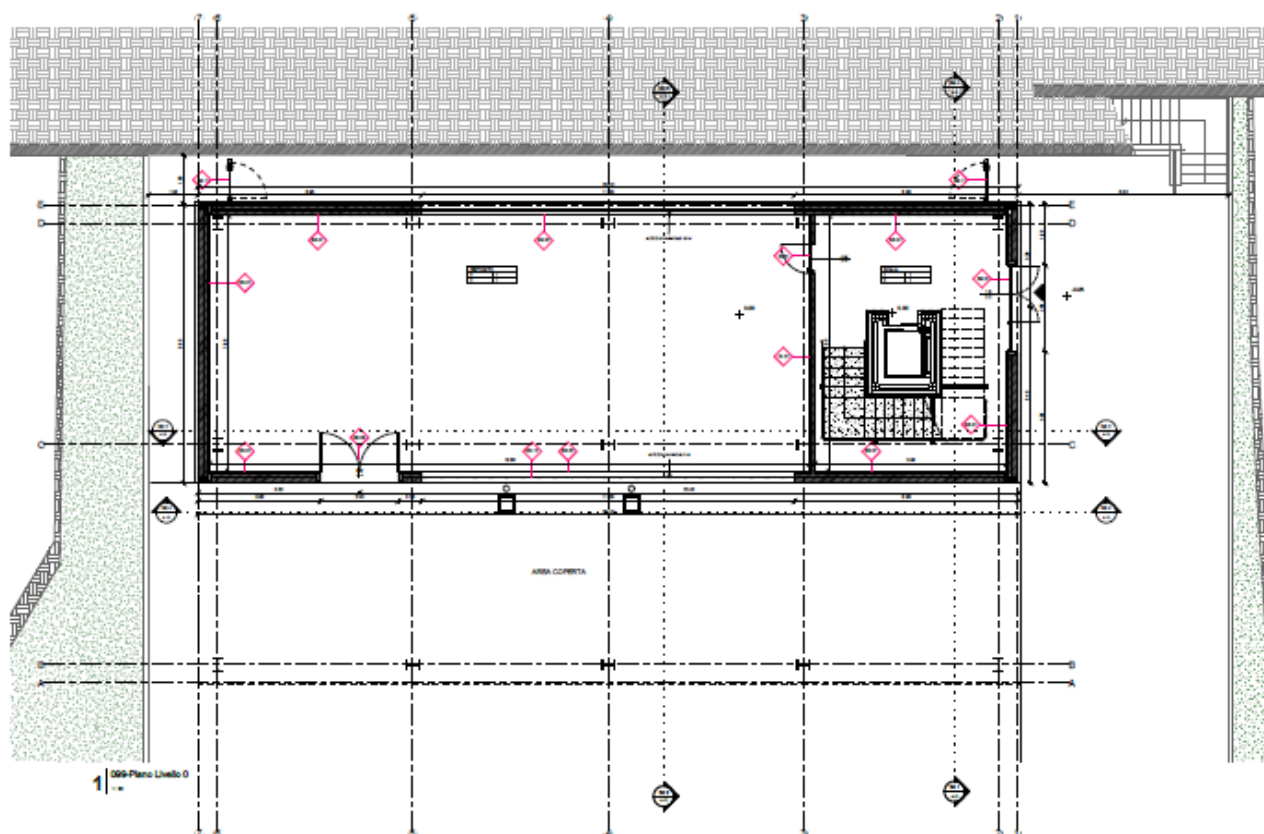


Figure 3: Storey plan of the ground floor

The first floor is completely devoted to laboratory activities. All the rooms have been dimensioned to accommodate the instrumentations for the laboratories. In particular, the rooms are listed as follows:

- Analysis laboratory
- Sample preparation room
- Weighing room
- Molecular modelling
- Discovery and development of lead compounds room
- Meeting room
- Samples reception
- Dressing room
- Samples preparation room
- Data processing room
- Toilet for ladies, gentlemen, and handicapped

A hallway allows the access to all the rooms. The plan configuration of the first floor is reported in Figure 4.

The first storey will constitute the “Life Science Hub Laboratory” and will be assigned to the Department of Farmacy of the University of Salerno.

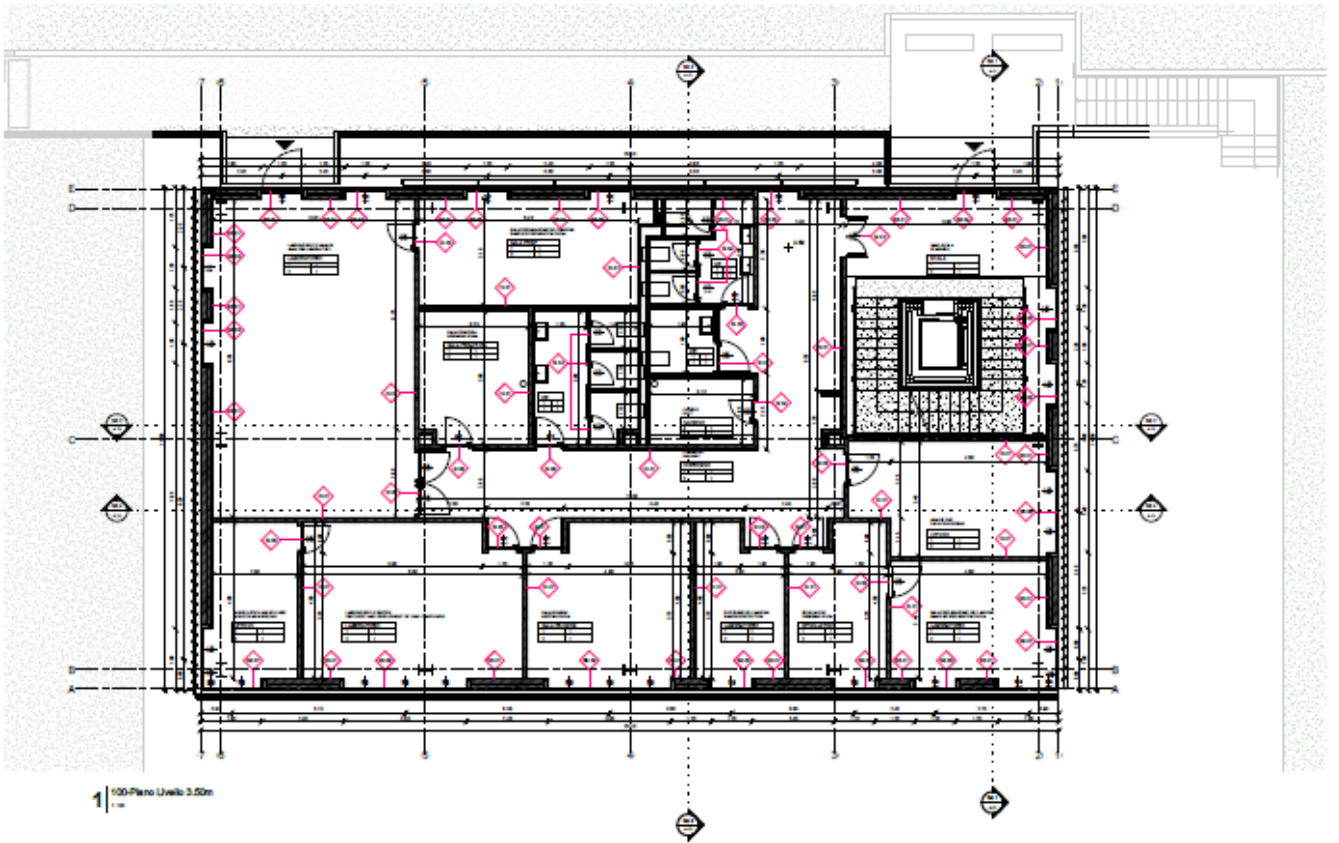


Figure 4: Storey plan of the first floor

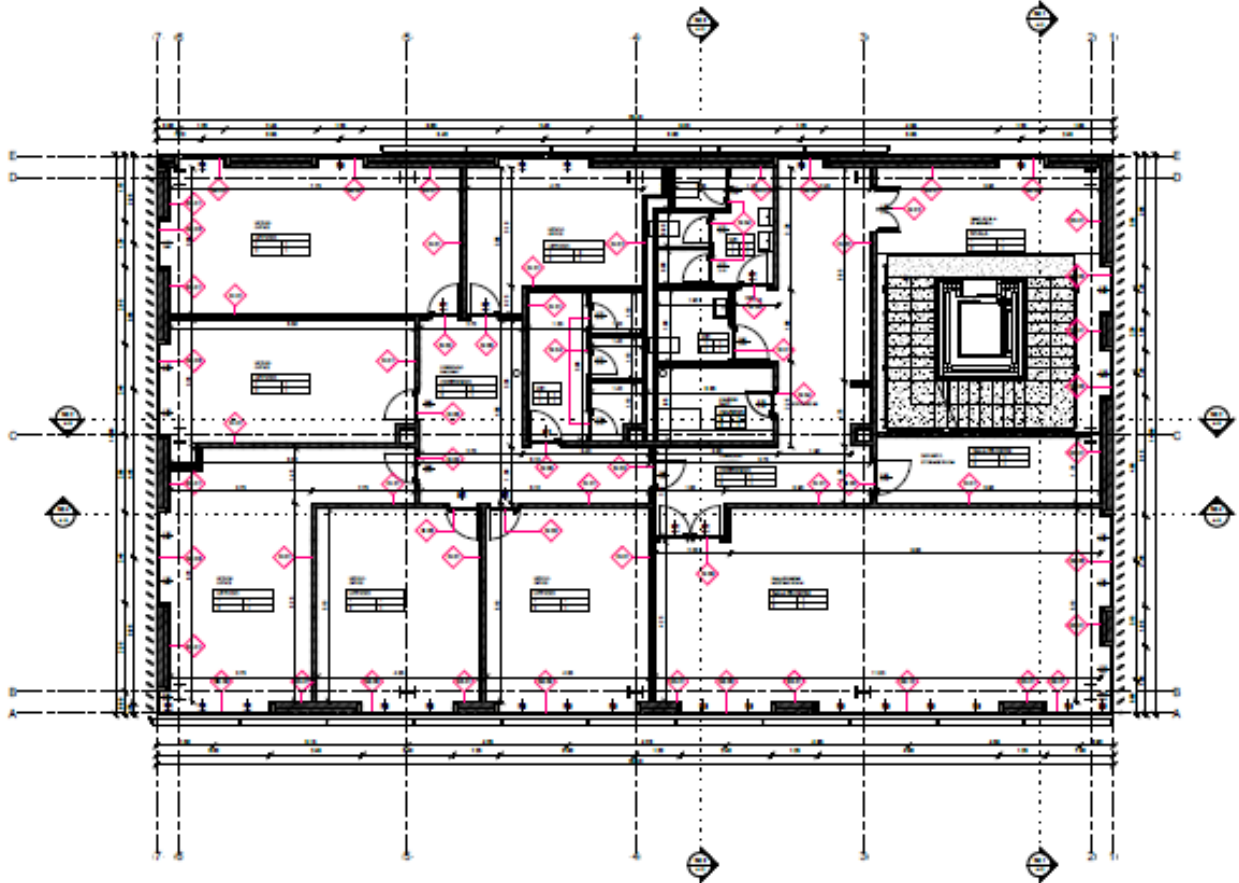


Figure 5: Storey plan of the second floor

The second floor (Figure 5) is destined to offices. Seven office rooms, one meeting room and a storage room are located at the second floor. The hallway allows the access to all the rooms. In the same floor toilet for ladies, gentlemen, and handicapped are also located.

Energy efficiency is no longer just an option. The Kyoto protocol has encouraged governments around the world to approve legislation that guarantees a more intelligent and conscious use of energy in buildings. In March 2007, the European Union undertook to achieve a 20% reduction in CO₂ emissions by 2020. This plan of measures, known as the "3x20 by 2020", also provides for a 20% increase in the level of Energy Efficiency and the achievement of 20% of the energy produced from renewable energy sources. Real changes will be needed to achieve these goals; governments are stepping up efforts to enact laws, regulate and set standards for better energy efficiency. This new move towards stricter energy efficiency regulations began with the Kyoto Protocol. Laws such as the US Energy Policy Act set the standard for the energy future.

In Italy it was published, with the D.L. no. 192 of 08/19/2005, the European directive 2002/91/EC (EPBD) relating to energy efficiency in buildings and, more recently, the D.M. 26/06/2009 (national guidelines for the energy certification of buildings). On 18/06/2010 the new European directive 2010/31/EC on energy performance in buildings was published, within which the importance of active control systems such as automation, control and monitoring systems aimed at saving energy was recognized. This directive is applied in the community standard UNI EN 15232:2012, which clearly indicates the benefits obtainable by opting for a specific efficiency class.

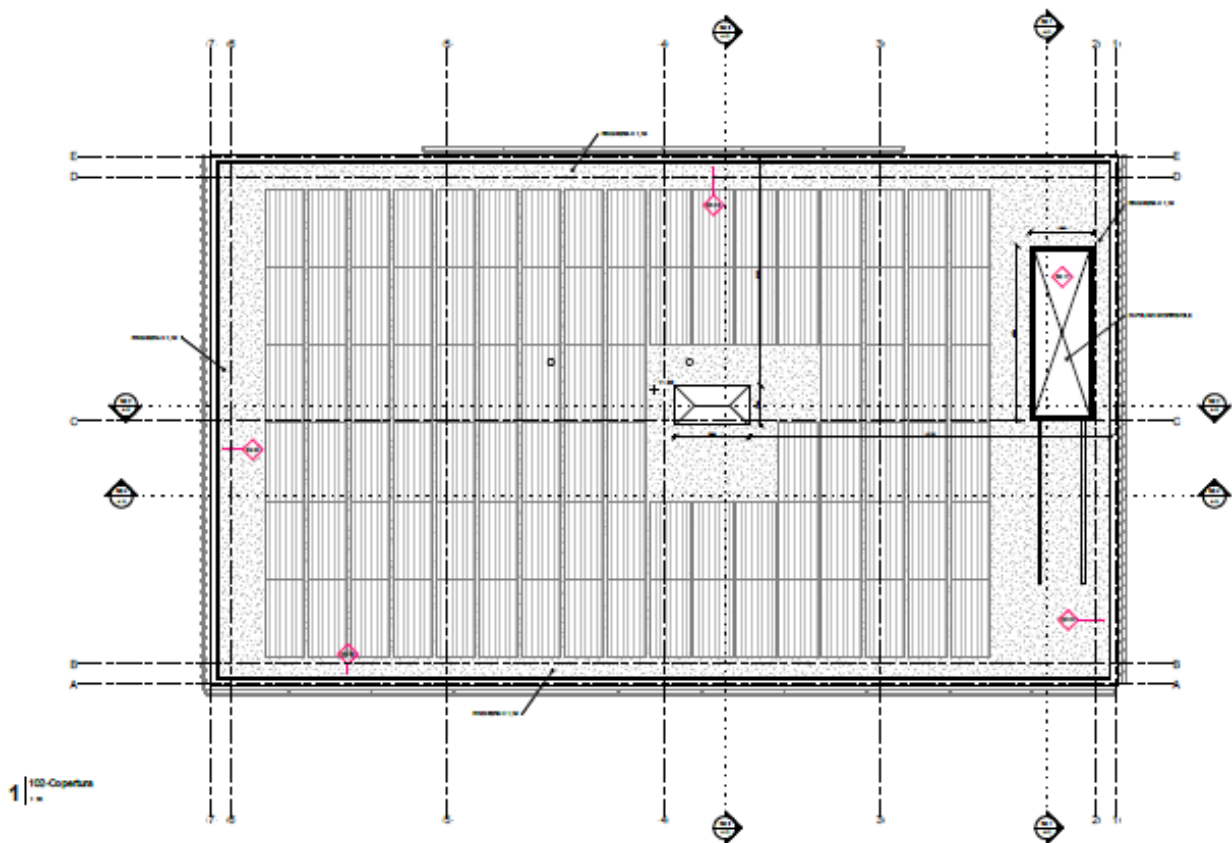


Figure 6: Photovoltaic park located on the roof of the building

In order to comply with energy efficiency requirements, the building will be electrically connected to the general switchboard of the "Invariante 7E" electrical substation, through a section of new underground canalization and a section in the existing technological tunnel. On the ground level, in the dedicated room, there will be the general electrical panel, the centralized absolute electrical

continuity group and the photovoltaic inverter. Most of all, at the roof level, the installation of photovoltaic generators (Figure 6) connected to the inverter located on the ground level is envisaged. The building, in any case connected to the university electricity system, will benefit from the energy benefits of the photovoltaic park in operation.

The stairs have been analysed in detail (Figure 7). They constitute a structure which is separated to the rest of the building by a seismic joint. Stairs are made by three-flight in reinforced concrete, supported by cantilever steel beams located at different heights. The main structure of the stairs is made of steel.

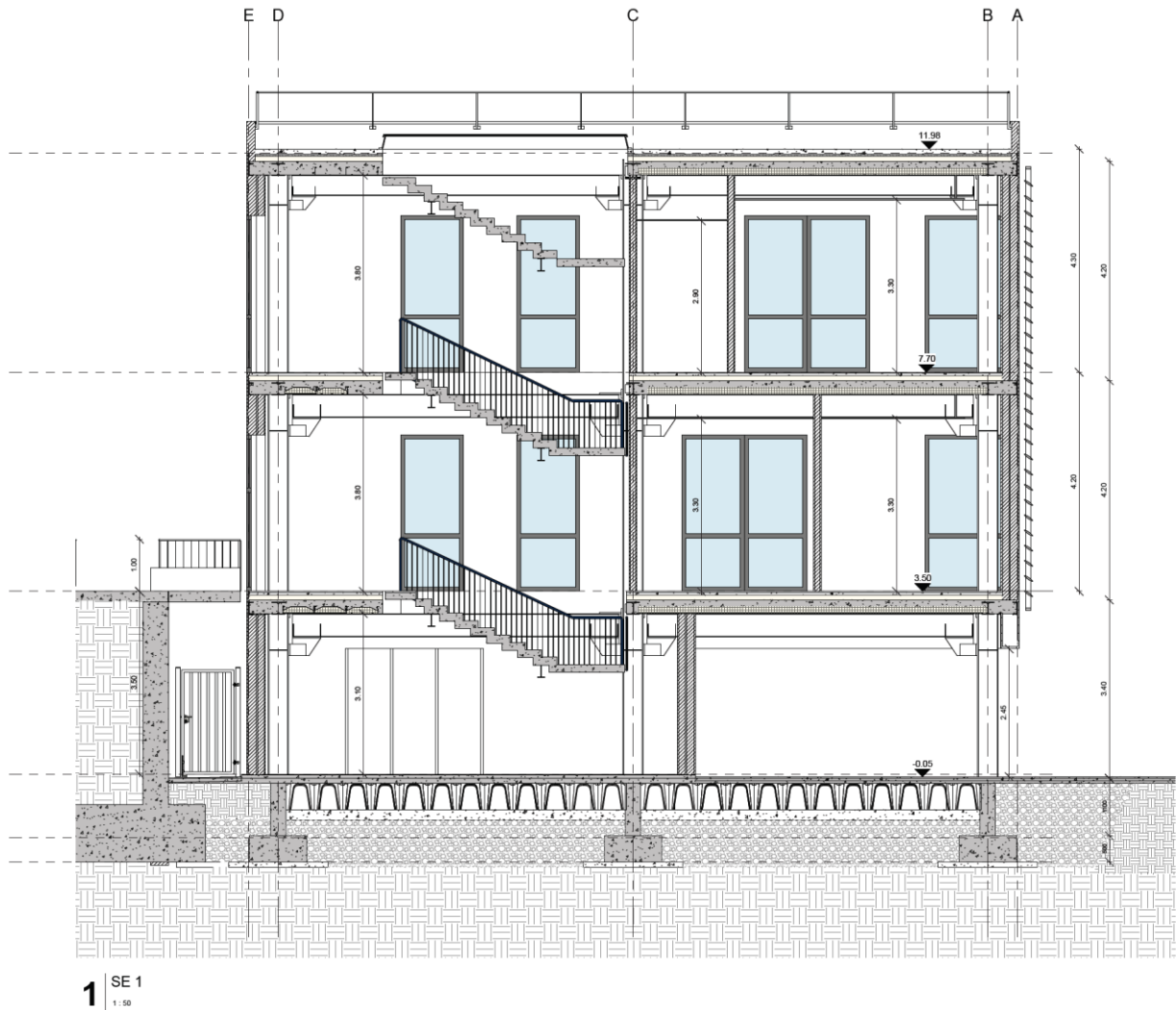


Figure 7: Section of the building evidencing the stairs' structure.

The stairs allows to have access to the roof of the building for all the maintenance needs. To this scope, the last ramp is covered with a movable light cover.

In Figure 8 a longitudinal section of the building is shown.

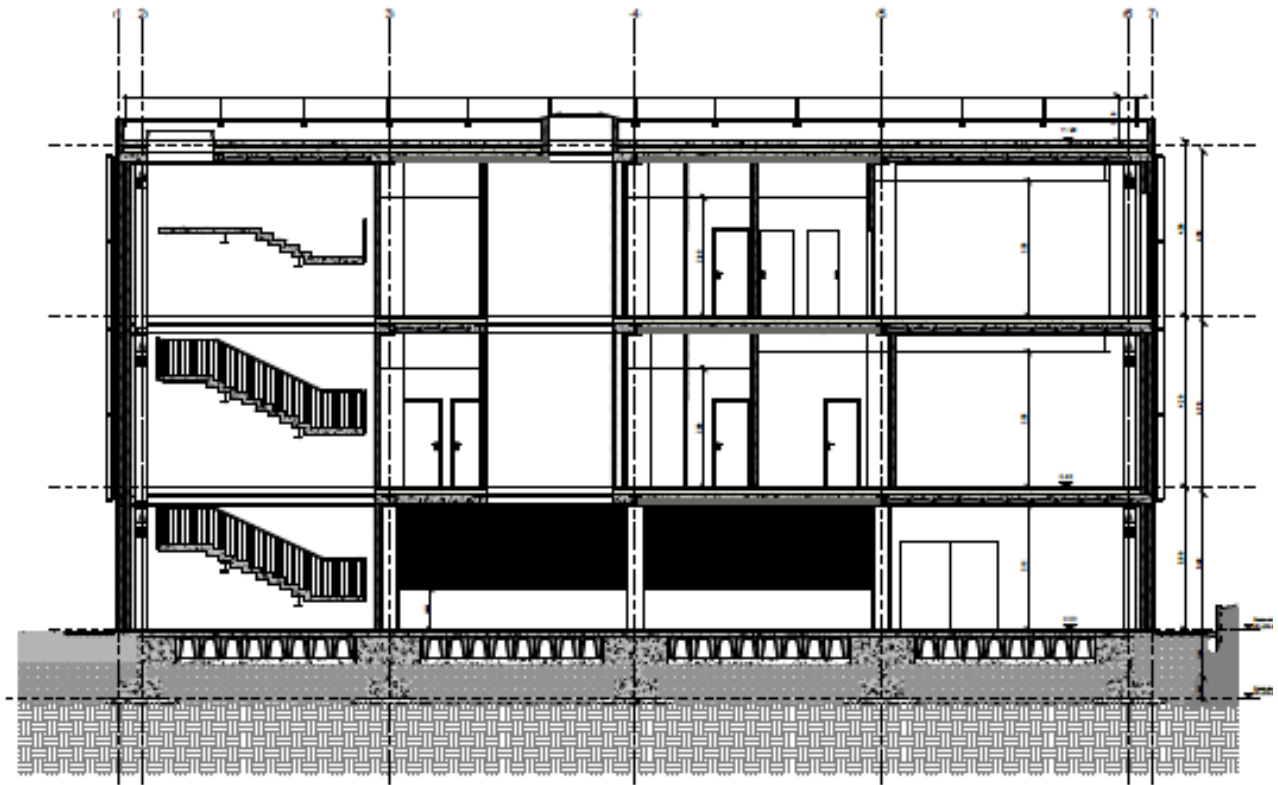


Figure 8: Longitudinal section of the building

4. The building facade

From the architectural point of view, the building is very simple because of its parallelepiped shape. Therefore, particular attention was devoted to the design of the façade, being the only component capable of providing the building with an architecturally attractive appearance.

For this reason, two options were investigated for the façade.



Figure 9: First option for the façade system (the adopted option)

The main feature of the first option (Figure 9), the chosen one, is the horizontal and vertical louvers system which envelops the sides of the building, acting as shading device. Each side will be covered in a different way, depending on the amount of solar irradiation. This feature, in addition to the possibility to change the angle of the louvers, adjusting the amount of solar radiation entering the building, allows to achieve a good equilibrium between daylight, electric lighting consumption and thermal comfort. The main structure is detached from the external walls and partially visible from the outside. A coating will protect the steel against environmental actions and will highlight the structural elements. The same philosophy is applied to the FREEDAM joint. Due to maintenance and monitor, the joint will be fully accessible to inspection, thanks to the recess of the suspended ceiling at the perimeter.

The second option (Figure 10) was driven by the same principles concerning the inside of the external walls: the structure would be isolated and highlighted. However, in this option, it would be more visible from the outside thanks to the presence of horizontal and vertical fixed shading devices that frame the façade but leave the glazed portion uncovered. These elements provide visual variation on each side of the building, through a standardized system. Windows have been sized to balance the required light levels for office and lab activities, whilst ensuring that solar heating loads are reduced. By placing the glazing on the inside of the boxing element, it would be possible to use the full depth of the façade for shading purposes, in conjunction with internal rolling blinds.



Figure 10: Second option for the façade system

Therefore, the first option was selected because adjusting the amount of solar radiation entering the building, it allows to achieve a better equilibrium between daylight, electric lighting consumption and thermal comfort.

Because of the selected option, the architectural aspect and aesthetic rendering of the building are shown in the **Figure 11** through a rendering that frames the building in the intervention area. In the background, you can see the university residences.



Figure 11: Selected option for the façade with rendering of the building

The external walls of the building consist of a highly insulated, double-framed dry panel system provided by KNAUF. As an alternative option, almost full-height glazing is utilized. A prominent feature of this chosen design is the integration of horizontal and vertical louver systems along the sides of the building, serving as shading devices (Figure 12).



Figure 12: North-west, south-west views

Each side of the building will be covered in a distinct manner, taking into account the level of solar radiation it receives. This feature, coupled with the ability to adjust the angle of the louvers, enables the regulation of solar heat gain and ensures a balance between natural daylight, electricity consumption for lighting, and thermal comfort.

5. Non-structural components

The non structural components and their connections with the structural part have been the subject of deep analysis. The details of the facades are provided by TS which has interacted with KNAUF to ensure the full feasibility of the solution since KNAUF supplies the external claddings. Several details of the interconnections between the structural and non-structural parts have been reported in the executive design. Some examples of typological details are reported in Figure 13 and in Figure 14.

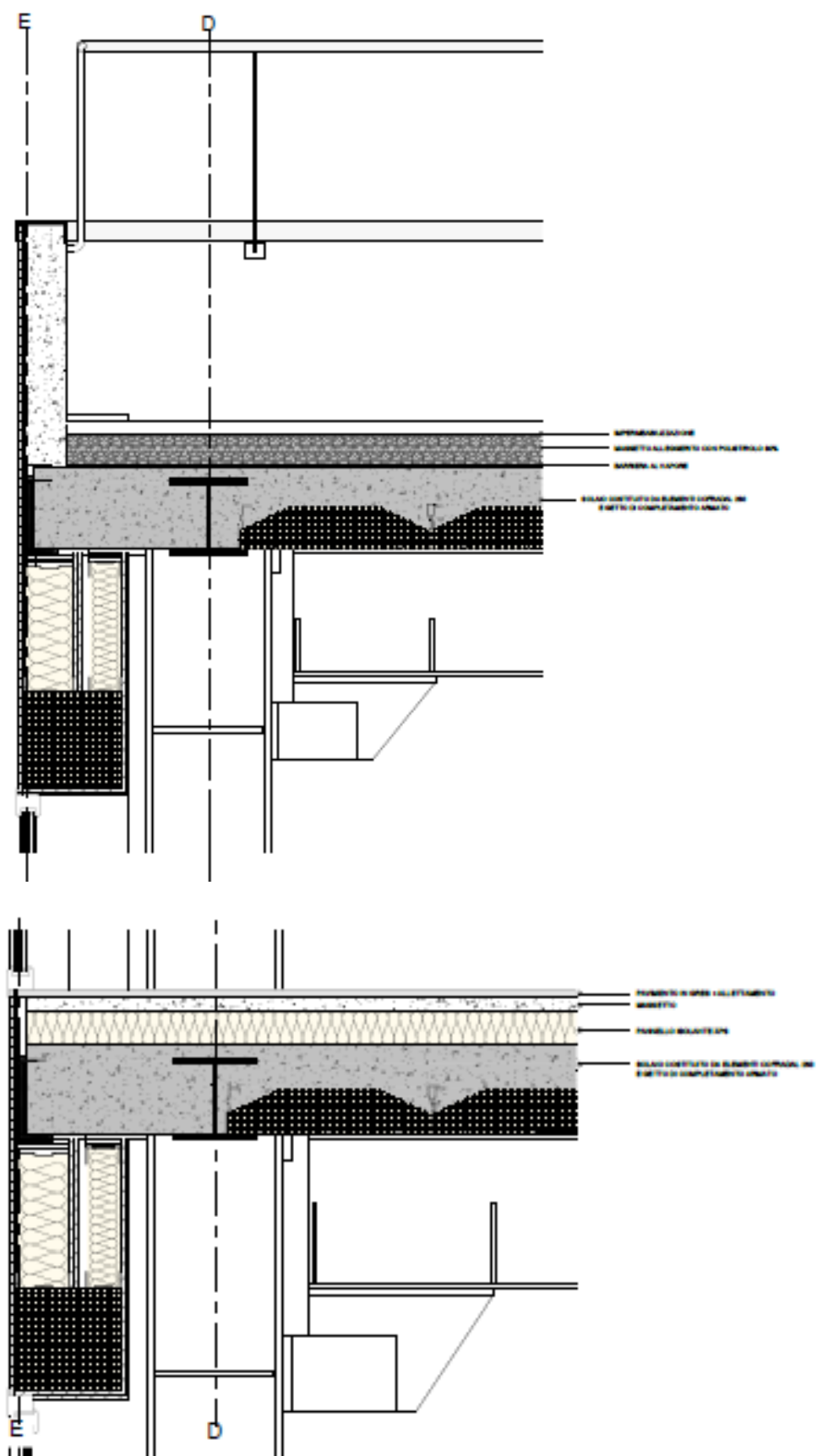


Figure 13: Typological details (1/2)

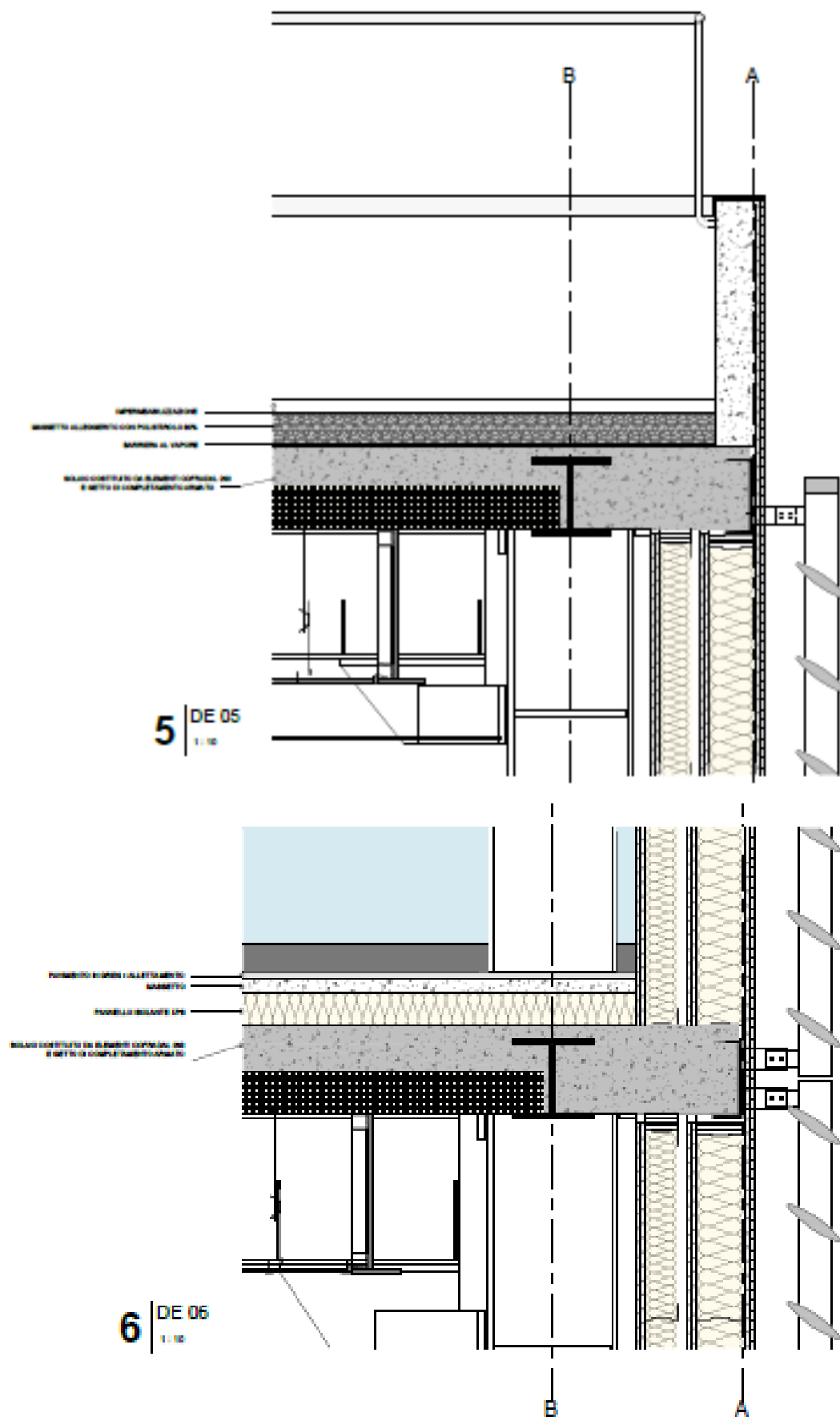


Figure 14: Typological details (2/2)

Additional details can be found in the complete design documentation given as Annexes to this deliverable and available on the project website (www.dreamersproject.eu).

The selection of LWS drywall products for optimal seismic response, with respect to damage limit states, is based on previous research funded by Knauf and summarized in the relevant deliverable of the project. Anti-seismic enhanced solutions have been chosen for non-load bearing partitions (Figure 15), façades (Figure 16), and suspended ceilings (Figure 17).

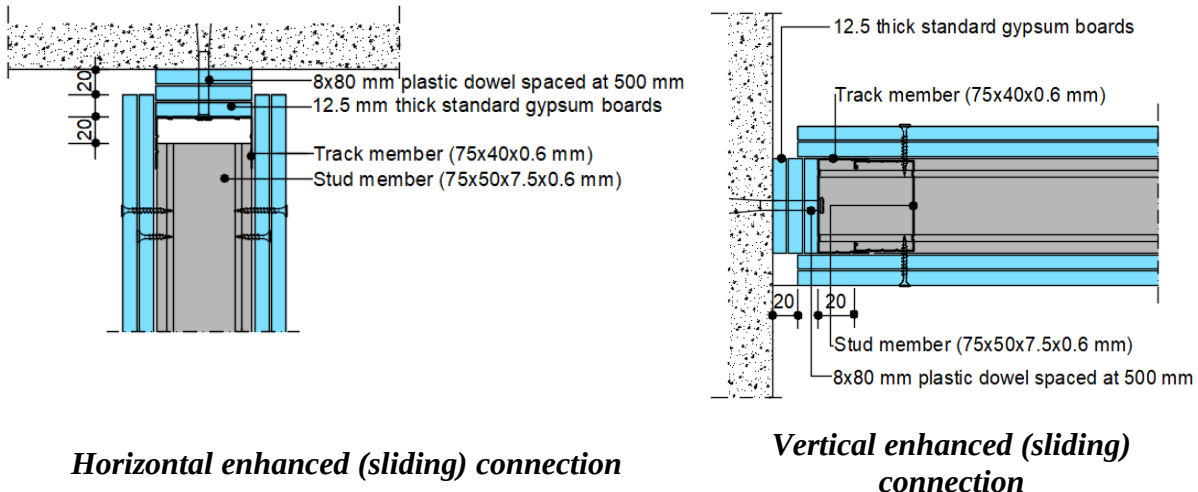


Figure 15: Anti-seismic enhanced connection details for partitions.

Figure 15 illustrates the details of anti-seismic enhanced connections for partitions, including horizontal enhanced (sliding) connections and vertical enhanced (sliding) connections. Figure 16 showcases the anti-seismic enhanced connection for façades, featuring horizontal basic (fixed) connections and vertical enhanced (sliding) connections. Figure 17 displays the anti-seismic enhanced connection details adopted in ceilings, specifically the connection between furring channels and the wall, and the connection between carrying channels and the wall.

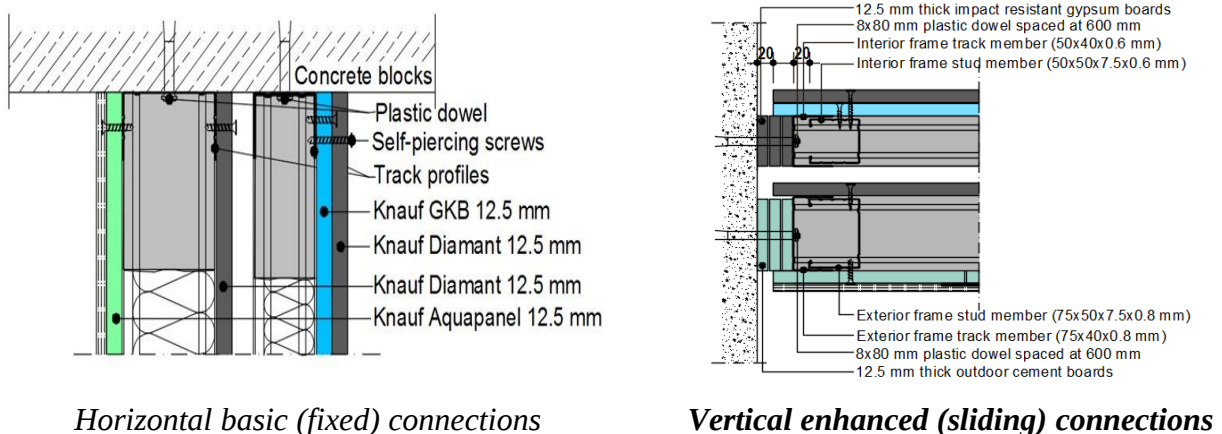
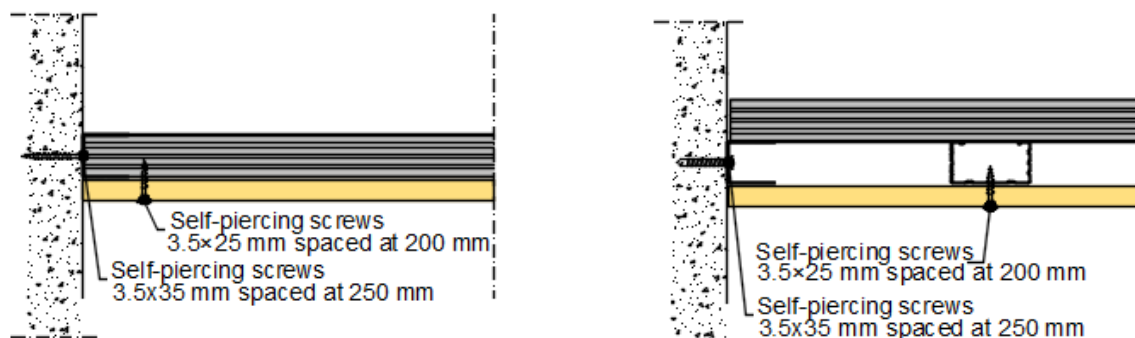


Figure 16: Anti-seismic enhanced connection for façades.

Based on test results from past research activities funded by Knauf, seismic fragility curves are available for selected partitions and façades.



Connection between furring channels and wall

Connection between carrying channels and wall

Figure 17: Anti-seismic enhanced connection details adopted in ceilings

The technical specifications for non-structural components (Knauf drywall system for partition, external wall and modular ceiling) are specified hereinafter.

Partition Wall – Single metal stud frame – Fire rating 120

Knauf metal stud partition W112: single metal stud frame with a double-layer cladding on each side with a double layer of Knauf Diamant board and sound insulation panels in the gap (Figure 18).

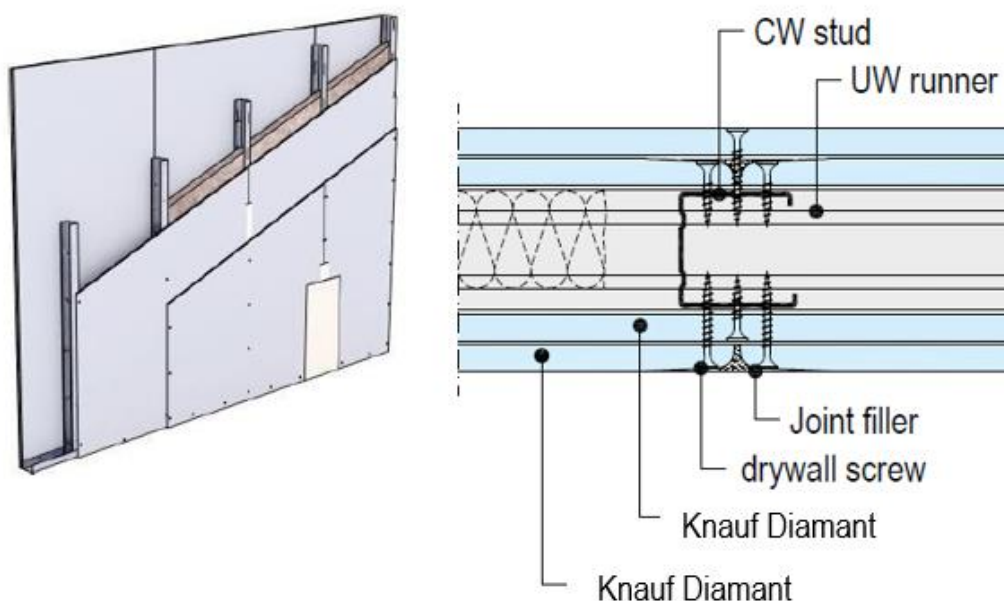


Figure 18: The Knauf metal stud partition W112: Axonometry and horizontal section

The delivery and installation of a non-load-bearing single-stud interior wall with metal framework, cladded with a double layer of Knauf Diamant on each side will occur during the construction according to the following features:

- Wall thickness: 125 mm Wall height: 4,00 m
- Sound Insulation rating = 63 dB

The solution consists of:

- A single metal frame with Knauf profiles made up of steel DX51D+Z-N-A-C with a thickness of 0,6 mm, CE marked according to EN 14195 – 2005, composed of:

- U runners: U profile 40/100/40 mm;
- C studs: single C profile 50/100/50 (*) mm, maximum spacing 600 mm.
- One layer of glass mineral wool, conforming EN 13162 - R2F A1
- Knauf Diamant (DFH2IR) board as inside and outside layer of the cladding, CE marked according to EN 520, fixed to the C studs with drywall screws.

Exterior Wall – Knauf Aquapanel Exterior partition

The delivery and installation of Knauf Exterior Wall as double stud system, installed between floors with intermediate board (Figure 19), will occur during the construction.

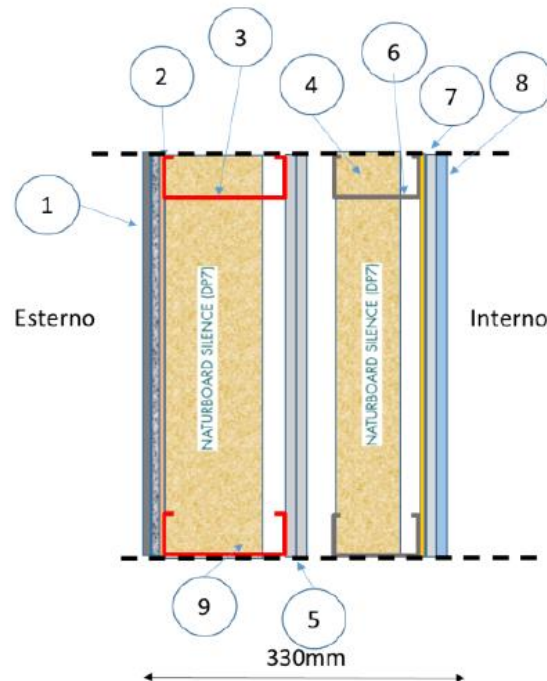


Figure 19: Knauf exterior wall horizontal section

The solution consists of:

- Exterior metal frame with Knauf profiles MgZ made up of steel DX51D+Z-N-A-C with additional Zinc-Magnesium coating, profile thickness of 0,6 mm, CE marked according to EN 14195 – 2005, composed of:
 - U runners: MgZ U profile 40/150/40 mm;
 - C studs: single MgZ C profile 50/150/50 (*) mm, maximum spacing 400 mm.
- Interior metal frame with Knauf profiles made up of steel DX51D+Z-N-A-C with profile thickness of 0,6 mm, CE marked according to EN 14195 – 2005, composed of:
 - U runners: U profile 40/100/40 mm;
 - C studs: single C profile 50/100/50 (*) mm, maximum spacing 400 mm.

Thermal and sound insulation materials between studs:

- Single layer of rockwool Knauf Insulation Naturboard Silence, conforming EN 13162 produced with Ecosse Technology, placed in the gap of the external metal framework. Technical data: dimensions 600x1000 mm, thickness 120 mm, density 70 kg/m³, λ_D : 0,034 W/mK, firereaction

class A1 (EN 13501-1), vapor resistance $\mu = 1$. Knauf products are endowed with the Euceb brand to ensure bio-solubility and compliance with note Q of European Directive 97/69 / EC.

- Single layer of rockwool Knauf Insulation Naturboard Silence, conforming EN 13162 produced with Ecosse Technology, placed in the gap of the internal metal framework. Technical data: dimensions 600x1000 mm, thickness 80 mm, density 70 kg/m³, λ_D : 0,034 W/mK, fire reaction class A1 (EN 13501-1), vapor resistance $\mu = 1$. Knauf products are endowed with the Euceb brand to ensure bio-solubility and compliance with note Q of European Directive 97/69 / EC.
- Cladding of the exterior side with Knauf Aquapanel Outdoor board, CE marked according to EN 12467 and ETA, fixed to the external MgZ C studs with Aquapanel Maxi Screws SB 25

Modular Ceiling with Knauf Topiq Efficient Pro board

The delivery and installation of demountable gypsum ceiling in exposed T-grid system (Figure 20) will occur during the construction.

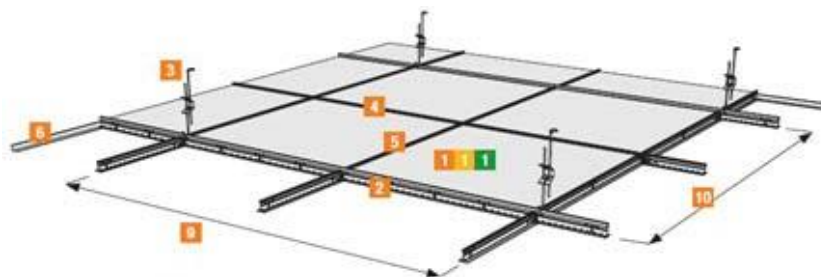


Figure 20: Modular Ceiling with Knauf Topiq Efficient Pro board

Products and materials:

Board: KCS Topiq Efficient Pro

Main runner

Type: T-profile

Material: 0.4mm galvanized steel Colour: White

Dimensions: Width < 15 or 24 mm > | Height 38 mm

Cross-tees

Type: T-profile

Material: 0.4mm galvanized steel Colour: White

Dimensions: Width < 15 or 24mm > | Height 38mm

Wall connection

Type: < L-profile or Shadow line trim > Material: 0.5mm galvanized steel Colour: White

Dimension: < 24x20mm or 15x15x8x25mm >

Suspension

Type: Adjustable hanger Dimension: < xxx - xxx mm >

Installation

- Screw spacing for attachment of wall connections max. 300mm c/c and in relation to the required ceiling height < xxx mm > (min. 120mm)

- Distance from wall to first hanger in direction of load-bearing (main runner) section ≤ 400 mm.
- Distance between hangers ≤ 1200 mm.
- Distance from wall to first load-bearing (main runner) section ≤ 600 mm.
- Distance between load-bearing (main runner) sections ≤ 1200 mm.
- Subdivision made with cross-tees length 1200 and 600 mm.
- Units of up to 3.0kg can be integrated directly into the ceiling tiles.

In the case of heavier units, the unit must be installed independently without any load on the ceiling tile. For loads above 3kg/m², additional hangers must be used.

6. Geotechnical report

6.1. Introduction

The present paragraph summarises the main geotechnical properties of the soil, useful for the calculation of foundations and support structures for the construction of Building C3, as part of the University Campus of Fisciano at the University of Salerno. Furthermore, the construction of Building C3 is part of the DREAMERS demonstrator project funded by the European Community under the RFCS 2020 call.

The geotechnical characterisation of the soils involved in the construction is based on the geotechnical survey and the corresponding Geological Report signed by Dr. Geologist Nicola Polzone.

The geotechnical survey consisted of two continuous coring geotechnical boreholes, both drilled to a depth of 30 meters from the ground level. The first borehole (S5 P2), referred to as the "pilot" borehole, was carried out to assess the stratigraphic arrangement and plan the subsequent in-hole tests conducted in the second borehole (S6 P2), including the retrieval of 3 soil samples and the execution of 3 Standard Penetration Tests (S.P.T.).

Additionally, for the geomechanical characterization of the subsurface, a Dynamic Penetration Test (D.P.S.H.) was performed, which was pushed to a refusal depth of 6.20 meters from the ground level. Finally, for seismic characterisation, a Multi-Channel Analysis of Surface Waves (MASW) seismic test (MASW No. 2) was conducted.

In particular, the conducted MASW test allowed for the classification of the foundation subsoil category based on shear wave propagation velocity. As reported in the Geological Report, the site's stratigraphy falls under category "B".

The reconstruction of the topographic profile revealed that the morphological layout is characterised by gentle slopes, with average values less than 7.5%, significantly lower than the 15° limit used in the NTC2018 for assessing seismic amplification effects related to morphology. Therefore, the examined area falls into topographic category T1, for which a topographic amplification coefficient (S_T) of 1.0 should be considered.

Based on reference data and field observations of geomorphological and hydrographic conditions, the Geological Report rules out the presence of a shallow water level within the first 30 meters from the ground level, which is an essential characteristic for excluding liquefaction verification of foundation soils.

6.2. Stratigraphic column

As also reported in the extended version of the geotechnical report, the conducted boreholes have revealed the following stratigraphy:

- Layer 1 (0.00-1.30 m)
Mixed organic soil with fill composed of loose sand – layer thickness: 1.30 m
- Layer 2 (1.30-5.20 m)
Moderately compacted sand with silt and scattered gravel – layer thickness: 3.90 m
- Layer 3 (5.20-30.00 m)
Loose coarse sand with polyhedral gravel alternating with lenses of pebbles and predominantly carbonate gravel – layer thickness: 24.8 m

Based on the results of in-situ and laboratory tests, the Geological Report suggests adopting the project stratigraphy, shown in **Table 1**, along with the corresponding values of the mechanical properties of the soils.

Table 1: Stratigraphy recommended in the geological report

Layer	Depth	Lithological Description	Unit Weight (kN/m ³)	Friction Angle (°)	Drained Cohesion (kPa)	Undrained Cohesion (kPa)	Edometric Modulus (MPa)
1	0,00 - 5.20 m	Silty sand	15.65	29	12.0	150	14.73
2	5.20 - 30.00 m	Sandy gravel with pebbles	14.50	35	0.0	-	-

The results suggested in **Table 1** are consistent with the interpretation of the in-situ S.P.T. (Standard Penetration Test) results, which indicate for the first layer an estimated internal friction angle cautiously ranging from 27.4 (5th percentile) to 31.5 (16th percentile). For the second layer, it indicates an internal friction angle value ranging from 31.3 (5th percentile) to 35.5 (16th percentile) at a depth of 11.5 meters and ranging from 31.5 (5th percentile) to 35.5 (16th percentile) at a depth of 17.5 meters.

6.3. Calculation of the ultimate foundation load

The foundation structure consists of a grid of foundation beams. The depth of the foundation's base level assumes a minimum value of approximately 4.30 meters. Therefore, the foundation's base level is located near the end of the first layer of the stratigraphic column. However, since the width of the strip foundation is 1.10 meters, the stress bulb certainly extends into the second layer. The evaluation of the ultimate foundation load was carried out conservatively, assuming the geotechnical properties of the first layer, namely a unit weight of the soil of 15.65 kN/m³ and an internal friction angle of 29°.

The calculation of the ultimate load is determined by the formula:

$$Q_{lim} = A_q \cdot N_q \cdot \gamma_1 \cdot D + A_c \cdot N_c \cdot c + A_\gamma \cdot N_\gamma \cdot \gamma_2 \cdot \frac{B}{2}$$

The formula used has a trinomial form in which each term is related to the angle of friction, cohesion, and the specific weight of the soil. A_q - A_c - A_γ are correction coefficients that represent the product of the depth factor, shape factor, inclination factor, and eccentricity of the loads (**Table 2**). Various authors propose different formulas for these factors as well as for the coefficients N_q , N_c , and N_γ . In particular, Meyerhof does not consider the inclination of the foundation and ground plane. For the sake of simplicity in statics, cohesion is neglected.

Table 2: Input data

$\gamma_1 =$	1595	Kg/m ³	Specific weight of the soil above the foundation
$\phi =$	29	°	Internal friction angle of the soil at the foundation level
$\gamma_2 =$	1595	Kg/m ³	Specific weight of the soil below the foundation
$c =$	0	Kg/cm ²	Cohesion of the soil
$D =$	4,3	m	Height or Depth of the foundation
$B =$	1,1	m	Width of the foundation (shorter side)
$L =$	17.2	m	Length of the foundation (longer side)
$\delta =$	0	°	Angle of inclination of the load relative to the vertical
$\varepsilon =$	0	°	Angle of inclination of the foundation base plane
$\eta =$	0	°	Angle of inclination of the ground plane
$E_B =$	0	m	Eccentricity of the load along the width B of the foundation
$E_L =$	0	m	Eccentricity of the load along the length L of the foundation

Foundation design dimensions: B = 1,10 m; L = 17,20 m.

The Hansen's theory has been applied.

Using the following formula:

$$Q_{lim} = A_q \cdot N_q \cdot \gamma_1 \cdot D + A_c \cdot N_c \cdot c + A_\gamma \cdot N_\gamma \cdot \gamma_2 \cdot \frac{B}{2}$$

with:

$$A_q = s_q \cdot d_q \cdot i_q \cdot g_q \cdot b_q$$

$$A_c = s_c \cdot d_c \cdot i_c \cdot g_c \cdot b_c$$

$$A_\gamma = s_\gamma \cdot d_\gamma \cdot i_\gamma \cdot g_\gamma \cdot b_\gamma$$

Considering $\phi=0$:

$$A_q = 1$$

$$A_c = 1 + s_c + d_c - i_c - g_c - b_c$$

where: s is the shape factor;
d is the depth factor;
i is the load inclination factor;
g is the ground plane inclination factor;
b is the foundation base plane inclination factor.

The values of the coefficients according to HANSEN's theory are (Table 3):

- coefficient of passive earth pressure $K_p = 2.882$;
- coefficients $N_q = 16.443$, $N_c = 27.860$, $N_\gamma = 12.84$.

Table 3: Corrective factors according to HANSEN's theory

	q	c	γ
Shape	1,035	1,038	0,974
Depth	1,020	1,027	1,000
Load inclination	1,000	1,000	1,000
Ground plane inclination	1,000	1,000	1,000
Foundation base plane inclination	1,000	1,000	1,000

The limit load is evaluated according to Hansen's theory.

CORRECTIVE COEFFICIENTS: $A_q=1,056$; $A_c=1,066$; $A_\gamma=0,974$

LIMIT LOAD: $Q_{lim} = 13,01 \text{ Kg/cm}^2 = 1276,28 \text{ kN/m}^2$

6.4. Estimation of the vertical reaction module of the soil

The estimation of the vertical reaction module of the soil (subgrade constant) is carried out using the method suggested by Bowles, which is the ratio between the ultimate bearing capacity of the foundation and the corresponding conventional settlement. Therefore, keeping in mind that this conventional settlement is equal to 1 inch, the result is:

$$k_s = \frac{q_{ult}}{\Delta H} = C(c \cdot N_c + \bar{q} \cdot N_q + 0.5 \cdot \gamma \cdot B \cdot N_\gamma)$$

where $C=40 \text{ m}^{-1}$ corresponds to a settlement ΔH equal to 0.025 m (1 inch), c is the cohesion, $\bar{q}$ is the effective stress at the depth of the foundation, γ is the unit weight of the soil at the depth in question, B is the width in contact with the ground, and N_c , N_q , and N_γ are the bearing capacity factors calculated according to Hansen.

Therefore, since the ultimate load is equal to 13.01 kg/cm^2 , the vertical reaction modulus of the soil can be estimated as:

$$k_s = \frac{q_{ult}}{\Delta H} = \frac{13.01}{2.5} = 5.20 \text{ kg/cm}^3$$

that corresponds to:

$$k_s = \frac{q_{ult}}{\Delta H} = \frac{1276.28}{0.025} = 51051 \text{ kN/m}^3$$

7. Structural report

7.1. Introduction

The need to create resilient societies requires the adoption of technologies capable of avoiding the impact of adverse events on people, such as those that occur in the event of intense earthquakes. The FREE from DAMage technology developed during the FREEDAM research project fits exactly this goal and, within the framework of the current DREAMERS project, will be implemented in a demonstration building providing a full-scale example in a relevant operational context.

The reasons that led to the design of this structure are based on UNISA's intention to further expand the services offered to the academic community through new offices, meeting and conference rooms, and by providing the Campus of Fisciano with a medical laboratory. The investment in this solution has provided the opportunity to make the construction the prototype for the application of the innovative FREEDAM steel beam-column connections (**Figure 21**), studied at the same University as part of the homonymous European research project.

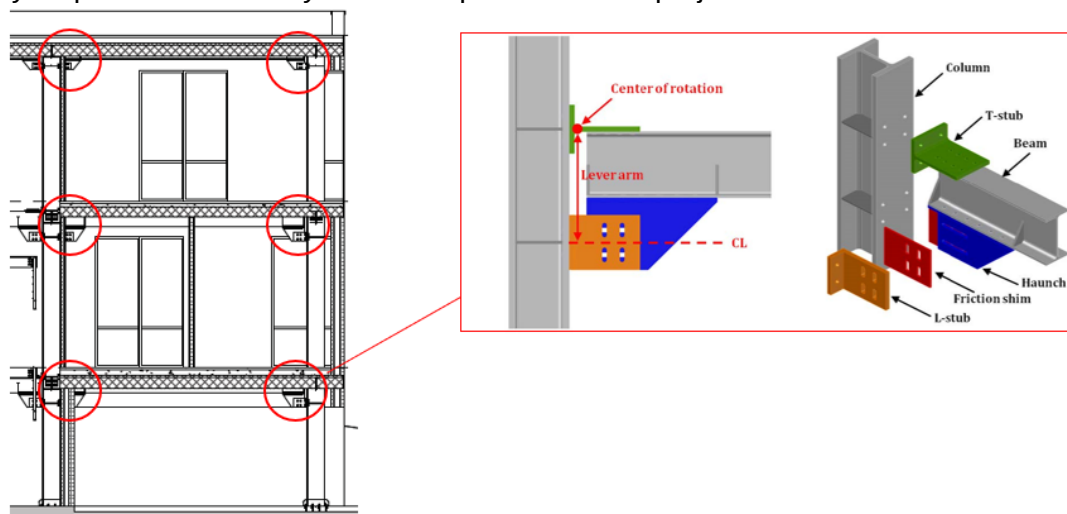


Figure 21: FREEDAM solution

The building to be erected is developed on a ground floor, used in part as a covered outdoor area for parking spaces and as research premises, a first floor intended for analysis and research laboratories, and a second floor used as offices and the coverage. In detail, the first floor houses a room for sample preparation, one for data analysis, an analysis laboratory, a weighing room and toilets. The second floor, on the other hand, is mainly used as offices, meeting rooms and toilets. The ground floor has a rectangular shape with dimensions of approximately 14.80m x 25.40m, equal to an area of 376 m². The building has a total height above ground of 12 m.

The structural design has been carried out complying with the Italian code NTC2018 (chapter 3, paragraphs 4.2, 4.3, 6.4, 7.1, 7.2, 7.3, 7.5, 7.6) and Eurocodes 1, 3 (parts 1.1 and 1.8), 4 (part 1.1) and 8 (part 1.1).

The vertical bearing structure of the building is characterised by:

- fifteen HE400B S355JR steel columns located at the intersections of the beams reported in the plan view of Figure 3;
- seismic-resistant frames (highlighted in red in **Figure 22**) equipped with FREEDAM joints belonging to IPE450 or IPE400 S355JR steel grade beams;
- pinned frames (highlighted in black in **Figure 22**) designed to support most of the gravitational loads and which do not contribute to bearing the horizontal actions, characterised by HE300B and HE240B beams with cut flanges, belonging to the Composite Slim Floor Beam (CoSFB) system conceived by Arcelor Mittal.

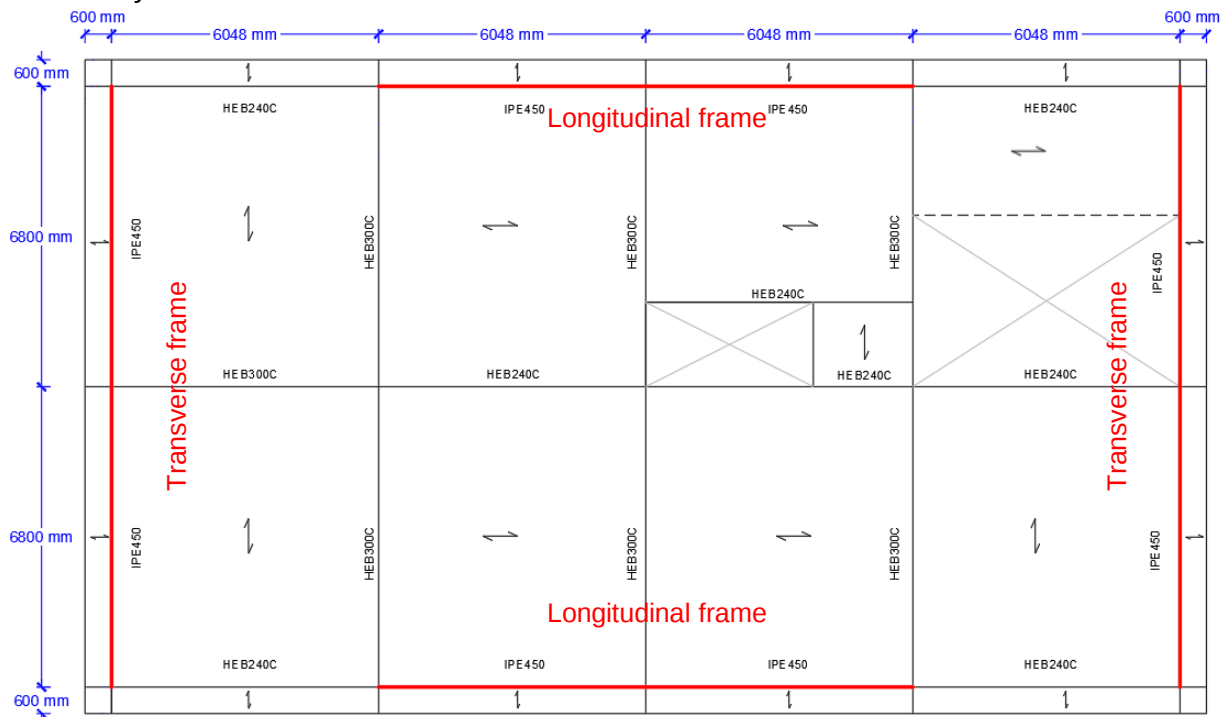


Figure 22: Plan view of floor 1 for the identification of Moment Resisting Frames (MRFs)

7.2. Composite floor

The horizontal structure of the building is made up of Cofradal260 prefabricated steel-concrete composite floors (**Figure 23**), a solution proposed by Arcelor Mittal. The choice of this composite system has been dictated by its easy and rapid realisation, the excellent performance of acoustic and thermal insulation, and excellent fire resistance.

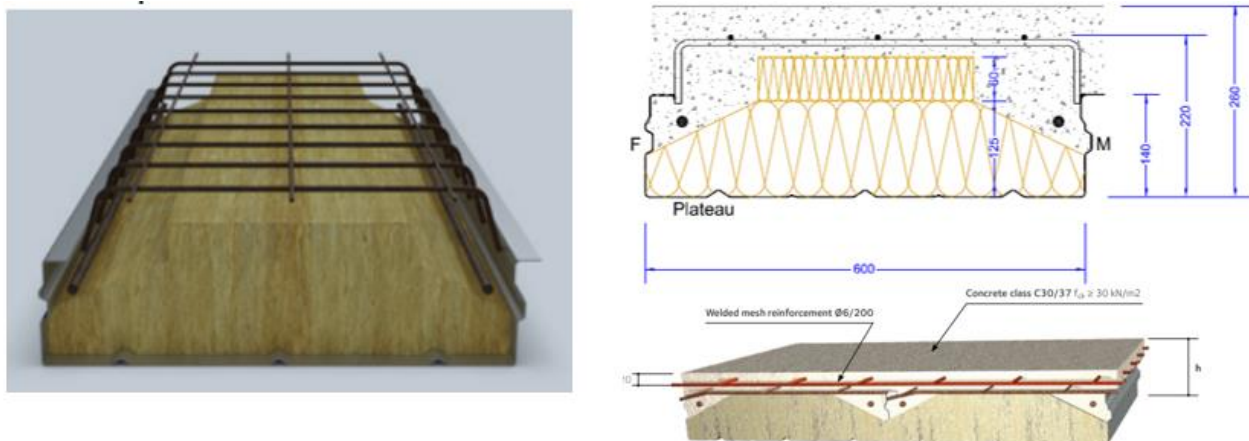


Figure 23: Cofradal260 composite floor solution

The role of the steel decking is twofold. Initially, in the construction phase, it allows casting concrete directly on site (with a limited number of supports) and works as a formwork. Subsequently, after that concrete is completely cured, concrete and steel realise a monolithic cross-section, in which the connection between profiled steel sheeting and concrete is assured mainly by adhesion or friction. In this second phase, the steel sheeting is a tension reinforcement for the sagging bending moment. The only additional steel needed in practice is typically provided to take care of shrinkage, limit cracking for temperature effects, and, considering the continuity of the slabs, it has to be provided to resist hogging bending moments.

In both previous stages, for the analysis of a slab characterised by one-meter width and a length equal to 6.80 m, corresponding to the maximum bay span, the following checks have been fulfilled: i) Ultimate Limit State (ULS) check for bending (hogging or sagging); ii) ULS check for longitudinal shear; iii) ULS check for transverse shear; iv) ULS punching check; v) Serviceability Limit State (SLS) deflection check; vi) SLS stress limitation check.

Additional analyses have been devoted to the assessment of the frequency vibration of the floor. In fact, the Italian Code requires that, considering the load combination $G_k + 0.15Q_k$, the frequency of the deck is greater than 3 Hz for non-cyclic loads and 5 Hz in the presence of cyclic loads. However, it does not provide formulations for evaluating this frequency. Therefore, reference has been made to documents of proven validity developed in the context of research projects. In particular, reference was made to the research project "Human induced Vibrations of Steel Structures" (RFS2-CT-2007-00033), whose design and evaluation methods for floor vibrations are related to human-induced vibrations, mainly caused by walking in normal conditions. The analysis has highlighted that the frequency of the composite floor is about 6.90 Hz, the modal mass of two structure bays is about 11.5 tons, and the damping is 4%. As a result, the analysed floor falls into class D, which, concerning the intended use for offices, appears to be a performance requirement recommended by the research referred to.

7.3. Secondary beams

The Cofradal 260 slabs transfer the loads to secondary beams, designed according to a steel-concrete composite solution. These elements represent a solution proposed and patented by Arcelor Mittal and are marketed as CoSFB beams (Composite Slim Floor Beams). The peculiarity of the CoSFB beams is that they consist of composite steel-concrete beams with the steel profile embedded in the thickness of the floor; moreover, the double T steel section has the particularity of having the upper flange with a smaller width than the lower flange (for this reason the term cut-off is used; this detail is shown in **Figure 24**).

These beams are characterised by cut HE240B and HE300B profiles designed to belong to non-seismic-resistant frames and, for this reason, are schematised as beams simply supported at their ends. This behaviour is recreated through shear connections.

Again, the checks have been carried out controlling that the maximum bending moments and shear actions were lower than the capacity of the CoSFB beams and that the maximum deflections and the deflections induced by variable loads at SLS were lower than $L/250$ and $L/300$, respectively (where L represents the lengths of the beams).

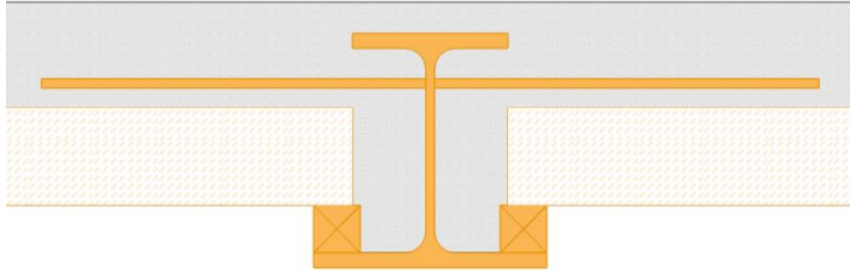


Figure 24: CoSFB beam

It is important to point out that, in the seismic-resistant longitudinal (**Figure 25**) and transverse (**Figure 26**) bays, the deck slab is located on the top flange of the beam while in the gravity load resisting bays the steel profile is embedded in the thickness of the deck slab. This solution is aimed to realize a structural detail for the beam-to-column joints equipped with friction dampers as close as possible to the detail already subjected to experimental tests during the previous FREEDAM project. The goal is to prevent any collaboration of the concrete slab to the joint behaviour, assuring that the connection behaves like a bare steel connection.

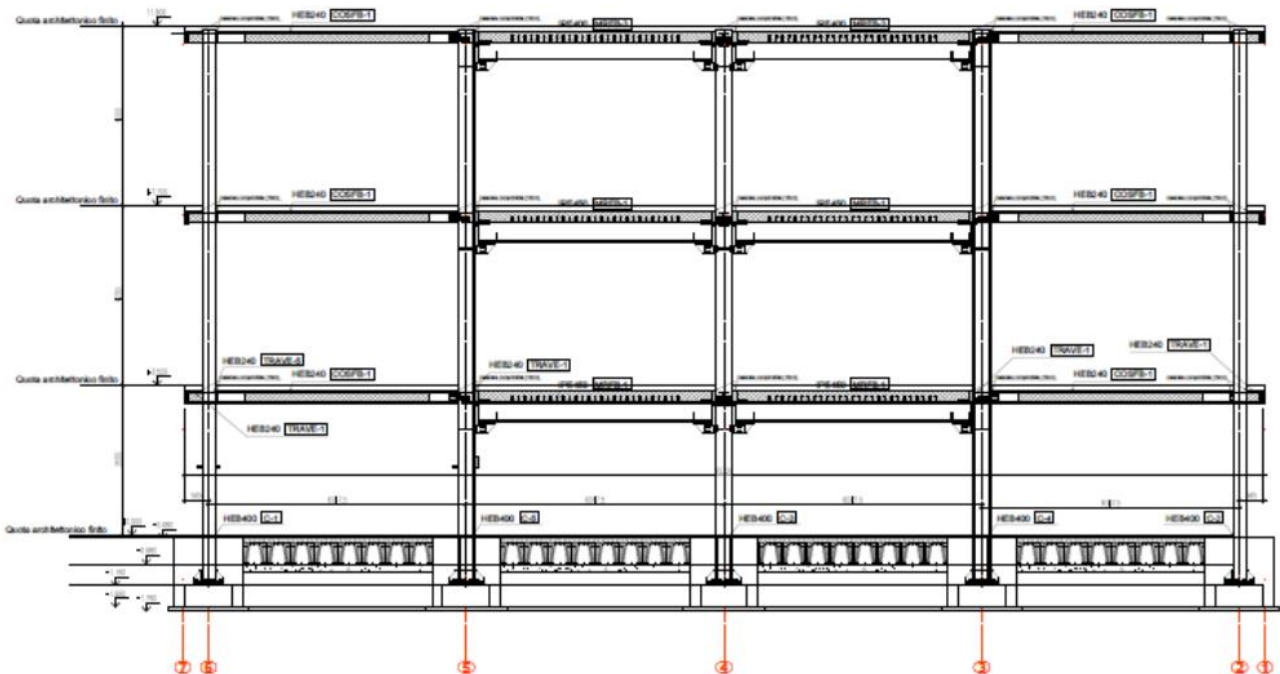


Figure 25: Seismic load resisting system – Longitudinal direction

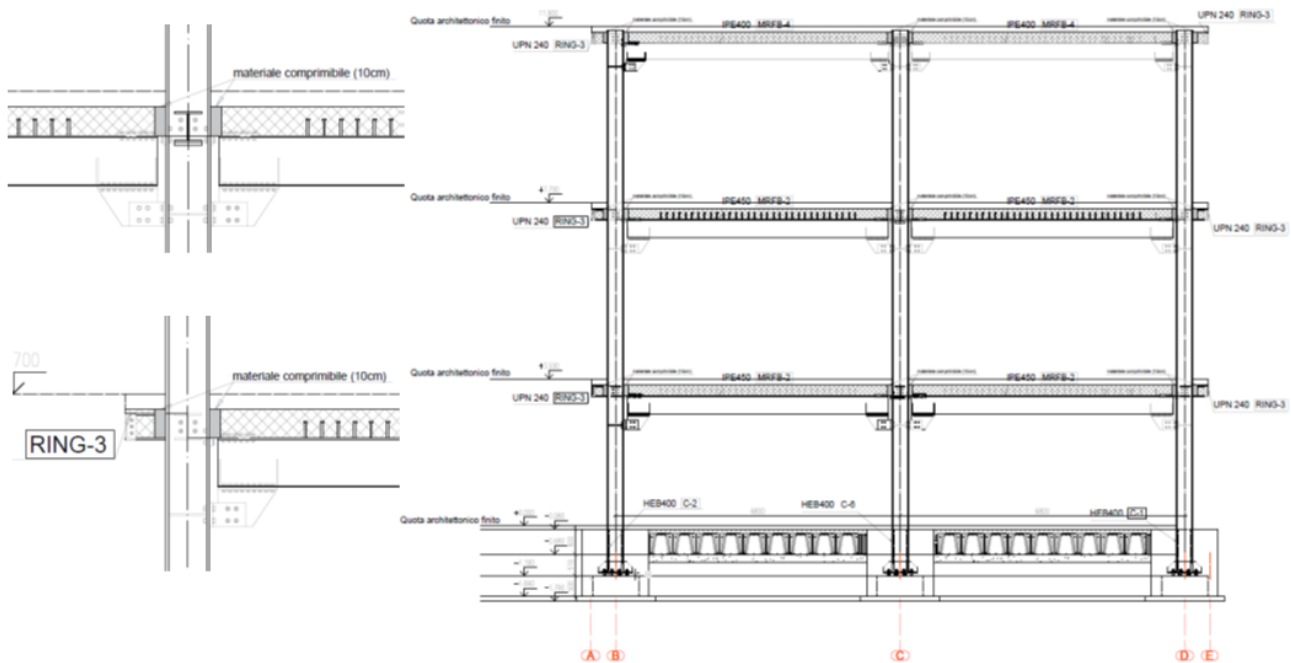


Figure 26: Seismic load resisting system – Transversal direction

7.4. Seismic-resistant frames

The design of the MRFs has been carried out according to Italian Code NTC2018, Eurocode 8 provision and the Theory of Plastic Mechanism Control (TPMC) considering a seismic action defined referring to the construction site located in Fisciano, characterised by type-B soil and topography class T1.

In particular, TPMC is based on the kinematic theorem of plastic collapse and the concept of the equilibrium curve of the mechanism. The equilibrium curve of any possible collapse mechanism is obtained through a second-order rigid-plastic analysis in which the external work is calculated including the work of the second-order effects induced by the gravitational loads applied to the structure. The kinematic theorem of plastic collapse extended to the concept of the equilibrium curve of the mechanism ensures that, in a range of displacements compatible with the rotational capacity of the structural elements, the collapse mechanism developed is the one whose equilibrium curve is placed under those of all other possible mechanisms. Thus, it is possible to design the column sections at each level by making a design requirement that the mechanism equilibrium curve corresponding to the desired global mechanism is below the equilibrium curves of all unwanted mechanisms. The second-order effects are explicitly and rigorously considered through the equilibrium curve of the collapse mechanism.

In the case of seismic-resistant frames equipped with FREEDAM connections, the TPMC can be easily applied, provided that the internal work of the dissipative zones is suitably evaluated. For this purpose, the plastic moment of the beams has been replaced by the sliding resistance moment of the FREEDAM connections. The behaviour of beam-column connections equipped with friction dampers has been evaluated in the design process via a perfectly plastic rigid bonding of the dissipative zones. Furthermore, according to the second principle of capacity design, the overstrength associated with the variability of the coefficient of friction has also been considered.

In the first phase of the work, the columns have been preliminarily sized to support only the vertical loads according to the fundamental gravitational combination (ULS). With this in mind, IPE360 beams and HEB300 columns have been used only in the pre-sizing phase for vertical loads. Even though specific limits for the cross-section classes are not strictly required, to ensure a minimum

level of local ductility to the structural members, the profiles of beams and columns have been selected to be at least in class 2. However, according to the seismic design procedures currently implemented, it was necessary to modify the profiles. The final solution consisted of adopting HEB400 profiles for the columns, IPE450 beams for the first two levels, and IPE400 beams for the top floor. Resistance and stability checks of the columns and beams have been satisfied.

According to the first principle of capacity design, the sliding moments of FREEDAM connections have been defined considering the design actions of the relevant seismic combination (ULS). The available rotational capacity is demonstrated through experimental testing according to EC8 provisions and AISC 358-16 prequalification protocols.

Since FREEDAM connections are partial-strength beam-to-column joints, the beam-column hierarchy criterion has been properly modified as follows:

$$\sum M_{Rc} \geq 1.2 \sum M_{Rd,connections}$$

$\sum M_{Rc}$ and $\sum M_{Rd,connections}$ are the sum of the design values of the columns' resistances and the sum of the sliding moments of the connections framing the joint. In particular, $M_{Rd,connections}$ is assessed considering the maximum value of the static friction coefficient.

Table 4 summarises the main geometric and mechanical properties of the FREEDAM connections adopted in the pilot building.

The general performance requirements for the DREAMERS building are summarised in **Table 5**.

Table 4: Properties of FREEDAM connections

	First and second level (transverse frames)	First and second level (longitudinal frames)	Third level
MARK	FREEDAM – IPE 450/0.4	FREEDAM – IPE 450/0.3	FREEDAM – IPE 400/0.3
Name	D1	D1	D1
$F_{slip,Rd}$ [kN]	345.3	292.4	244.2
$M_{j,Rd}$ [kNm]	242	181	139
Bolts	M16 HV 10.9	M16 HV 10.9	M16 HV 10.9
Number of bolts, n_b	4	4	4
Number of surfaces, n_s	2	2	2
Preload force, $F_{p,d}$ [kN]	93.64	79.30	66.23

Table 5: Seismic requirements for the DREAMERS building

Category	Limit states			
	IO (Immediate Occupancy)	DL (Damage Limitation) =SLS	LS (Life Safety) =ULS	CP (Collapse Prevention)
Structural members and non-dissipative joints	Fully Elastic at IO. For elastic design: $q_{IO} = 1$ Resistance and stability checks for columns and beams. Resistance checks for non-dissipative joints. $drift \leq \frac{2}{3} 0,01$	Fully elastic at DL. For elastic design: $1 < q_{DL} \leq 1,5$ Resistance and stability checks for columns and beams. Resistance checks for non-dissipative joints. $drift \leq 0,01$	Fully elastic at LS. For elastic design: $1,5 < q_{LS}$ $\leq \min \left(5 \frac{\alpha_u}{\alpha_1}; \frac{S_{e,LS}}{S_{e,DL}} q_{DL} \right)$ Resistance and stability checks for columns and beams also considering capacity design principles. Resistance checks for non-dissipative joints considering capacity design rules.	Slightly damaged at CP
Dissipative beam-to-column and column base joints	$M_{Ed}(q_{IO}) \leq M_{FREEDAM}$ Fully elastic friction pads for IO. $\vartheta_{device} = 0 \text{ mrad}$ $M_{Ed}(q_{IO}) \leq M_{ch}$	$M_{Ed}(q_{DL}) \leq M_{FREEDAM}$ Slight damage in the friction pads for DL $\vartheta_{device} \leq 10 \text{ mrad}$ $M_{Ed}(q_{DL}) \leq M_{ch}$	$M_{Ed}(q_{LS}) \leq M_{FREEDAM}$ Moderate damage in the friction pads for LS. $\vartheta_{device} \leq 25 \text{ mrad}$ $M_{Ed}(q_{LS}) \leq M_{ch}$	Significant damage in the friction pads for CP. $\vartheta_{device} \leq 40 \text{ mrad}$ $\vartheta_{ch} \leq 40 \text{ mrad}$

	Fully elastic friction pads for IO. $\vartheta_{cb} = 0 \text{ mrad}$	Slight damage in the friction pads for DL $\vartheta_{cb} \leq 10 \text{ mrad}$	Moderate damage in the friction pads for LS. $\vartheta_{cb} \leq 25 \text{ mrad}$	
Residual drifts	-	-	Residual interstorey drift $< 0,35\%$ [15]	Residual interstorey drift $< 0,5\%$ [15]
Partition walls, claddings	Elastic for $\text{drift} = \frac{2}{3} 0,01$	Out-of-plane resistance and stability checks according to NTC18 with a behaviour factor equal to $q_a = 1$ Elastic for $\text{drift} = 0,01$	Out-of-plane resistance and stability checks according to NTC18 with a behaviour factor equal to $q_a = 2$ Slightly damaged for drift at least equal to $\text{drift} = 0,025$	Damaged without any significant loss of resistance (less than 10%) for drift at least equal to $\text{drift} = 0,04$
False ceiling	Elastic for $\text{drift} = \frac{2}{3} 0,01$	Resistance and stability checks according to the NTC18 with a behaviour factor equal to $q_a = 1$ Elastic for $\text{drift} = 0,01$	Resistance and stability checks according to the NTC18 with a behaviour factor equal to $q_a = 2$ Slightly damaged for drift at least equal to $\text{drift} = 0,025$	Damaged without any significant loss of resistance (less than 10%) for drift at least equal to $\text{drift} = 0,04$
Plants	Specific detailing rules are needed to uncouple the deformation of the structure and the electric system, the water system, etc. for a $\text{drift} = \frac{2}{3} 0,01$	Specific detailing rules are needed to uncouple the deformation of the structure and the electric system, the water system, etc. for a $\text{drift} = 0,01$	Specific detailing rules are needed to uncouple the deformation of the structure and the electric system, the water system, etc. for drift at least equal to $\text{drift} = 0,025$	Damaged without any significant loss of resistance (less than 10%) for drift at least equal to $\text{drift} = 0,04$

It is worth highlighting that the detail of the FREEDAM joint has been widely studied so that it is able to exhibit bare steel behaviour. For this reason, it has been chosen to consider the misalignment of primary and secondary beams and design proper gaps around the connections in order to disconnect the slab from the connections (Figure 27).

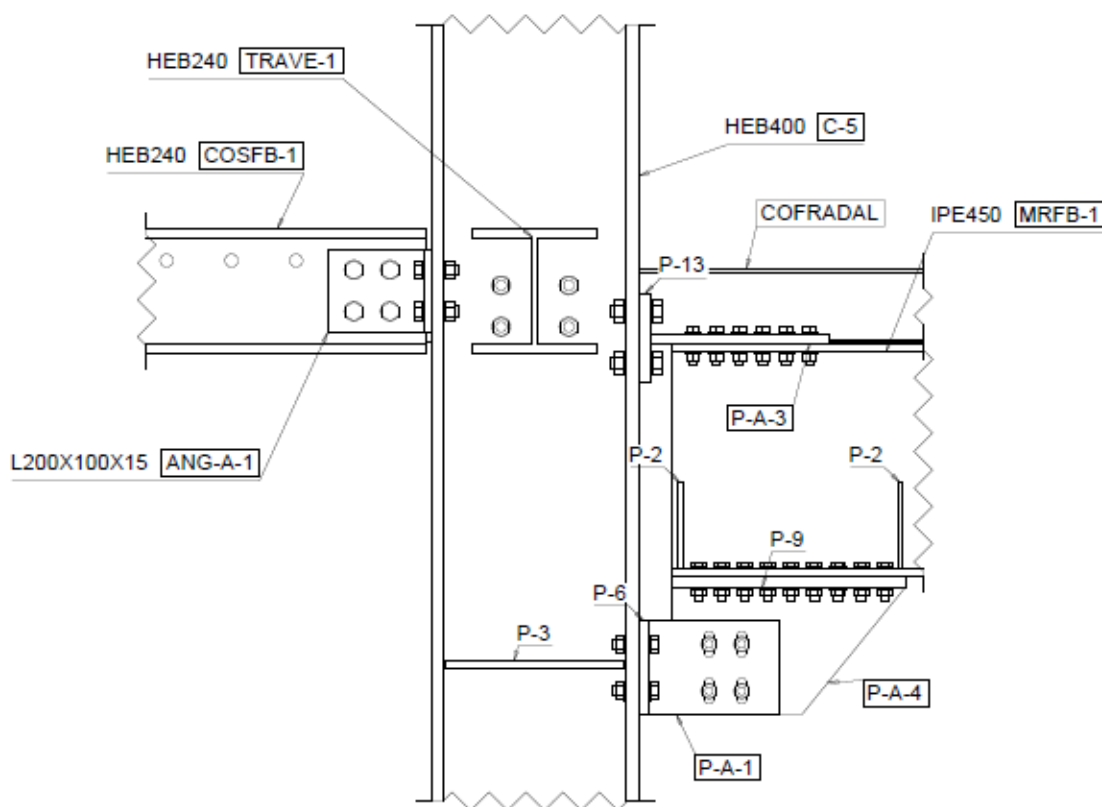


Figure 27: Detail of a connection

Linear analysis methods have been used in the design phase, while the fulfilment of the performance objectives has been checked by performing linear and non-linear (pushover and time-history) analyses. In particular, the structure has been numerically modelled through SAP2000 (**Figure 28**), Advance Design and OpenSess software.

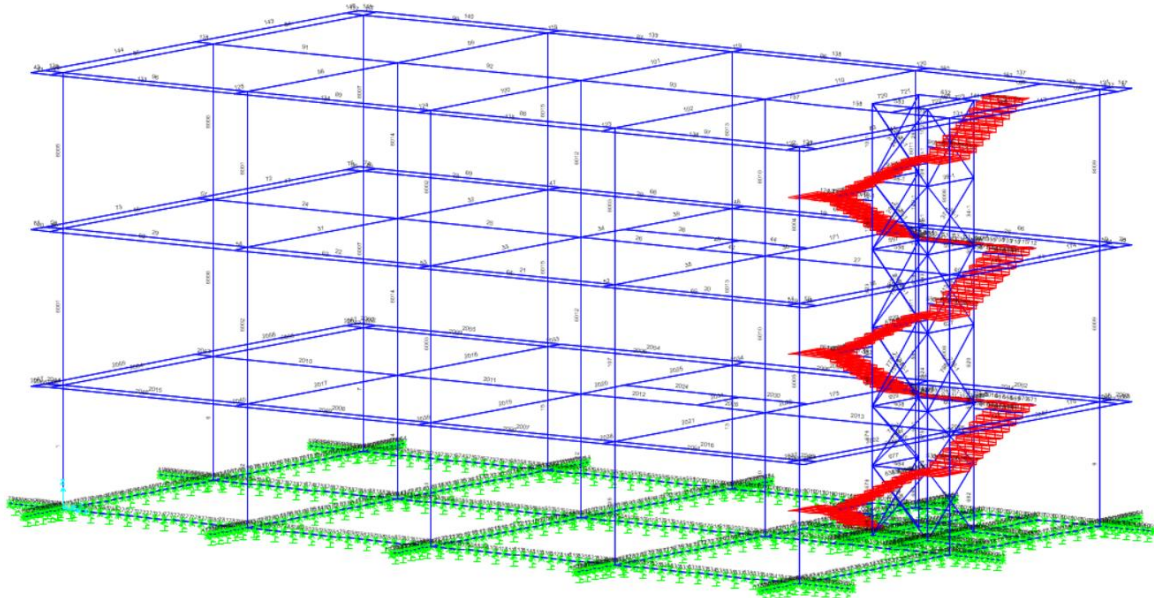


Figure 28: SAP2000 model of the pilot building

7.4.1. Summary of calculation results and verifications

All the checks are satisfied. For the sake of clarity, in **Figure 29** an image of the working rate of the structural elements is shown, while in **Table 6** the maximum working rates are reported.

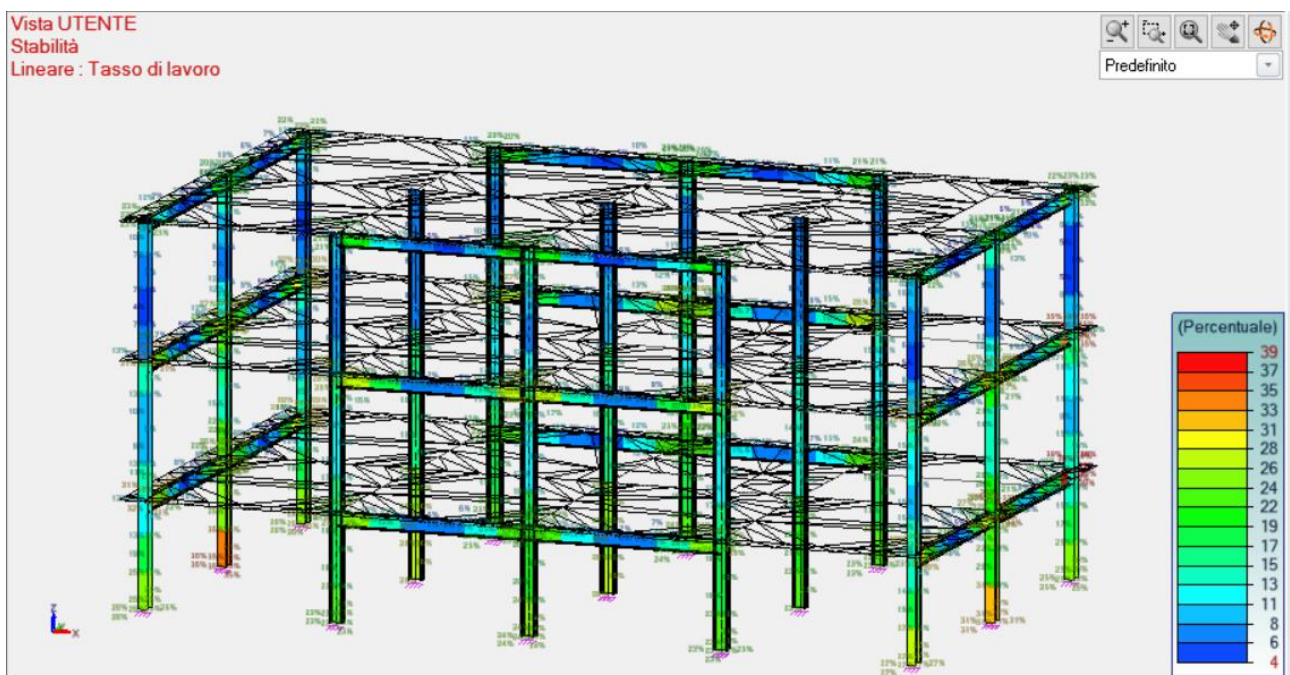


Figure 29: Working rate of structural elements

Table 6: Maximum working rate - stability: per element

Name	Section	Working rate (%)
Beam	IPE450	39 21
Column	HEB400	35 28

7.5. Staircase-elevator body structures calculation report

7.5.1. Description of the structure

This calculation report concerns the steel structure of the stair-elevator body of the C3 building on the Fisciano University Campus.

The structure of the stair-elevator body is designed in such a way as to be structurally independent of the structure of the C3 building. In particular, it consists of a braced steel castle structure. The castle has four columns made up of a pair of IPE240 profiles arranged in a cross in a welded composition. The castle has six levels, three of which coincide with the levels of the decks of building C3. The beams are made of IPE240 profiles. The braces are made of CHS 76.1x3.2 round tubular profiles. All members are in S355 steel.

The flights of stairs and the landings are made using a reinforced concrete slab, folded according to the development of the steps, which rests on cantilever beams made of IPE240 profiles, connected to the castle (Figure 30).

The beam-to-column connections are bolted according to the flanged type. The connections of the bracing diagonals are made using a bolted system of the gusset and fork type. The foundation-column connections are made using a base plate with anchor bolts, embedded in the concrete casting for a length equal to the size of the webs of the foundation beams. Therefore, the column-foundation connection can be considered rigid.

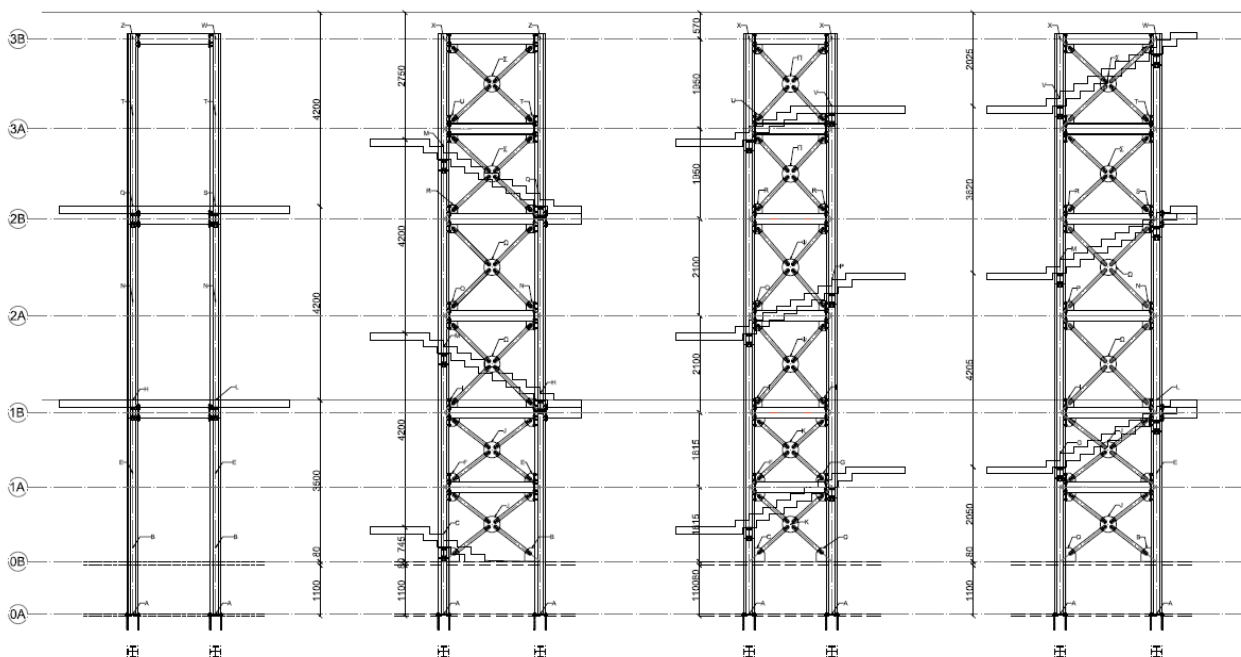


Figure 30: Staircase-elevator body structures

Figure 31 shows the structural finite element model. The steel members are modelled using finite elements of the "beam-column" type. The slab is discretized using two-dimensional finite elements of the "plate" type.

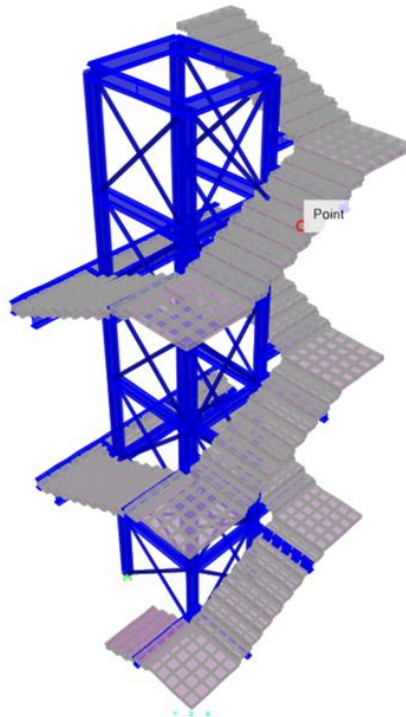


Figure 31: Structural model of the stairs

7.5.2. Project actions

The actions considered for the structure design are:

- permanent structural loads G_{k1} , which in the case in question are constituted only by the weight of the steel members and by the weight of the concrete slab constituting the ramps and landings;
- non-structural permanent loads G_{k2} , which in the specific case are made up of the stairs' slab and the elevator car's weight.
- variable loads due to the intended use of the structure.
- seismic actions.

The structure of the stair-elevator body is not subject to wind actions, as it is entirely inside the body of the C3 building. Furthermore, the effects of thermal variations are negligible.

7.5.3. Structural permanent loads

The structural permanent loads consist of:

Table 7: Materials' list

Section	Total length (m)	Total Weight (kg)
2X IPE240	46,4	2694,51
IPE240	81	2485,87
TUBO-D76.1X3.2	100,3192	577,09

The slab of the landings and ramps weighs 25 kN/m^3 .

7.5.4. Permanent non-structural loads

The non-structural permanent loads consist of the finishes of the stairs and the lift shaft for a total of 1.81 kN/m².

7.5.5. Variable loads

The variable loads, by the provisions of the legislation, are assumed to be equal to 4.0 kN/m².

7.5.6. Seismic actions

Concerning the town of Fisciano, the parameters for the determination of the design elastic spectra that define the seismic action for the various limit states envisaged by the legislation are shown in Table 8:

Table 8: Characteristics of the design elastic spectra

Stato Limite/ Limit State	T_R (years)	a_g (g)	F_0	T_c^* (s)
SLO/IO	45	0,053	2,361	0,313
SLD/DL	75	0,065	2,405	0,338
SLV/LS	712	0,148	2,527	0,431
SLC/CP	1462	0,182	2,591	0,448

The aforementioned parameters refer to Category of Use III for which $C_u=1.50$.

With these values of the parameters that define the seismic hazard of the site, the design elastic spectra for the reference site (rigid ground and horizontal countryside plane) are shown in Figure 32.

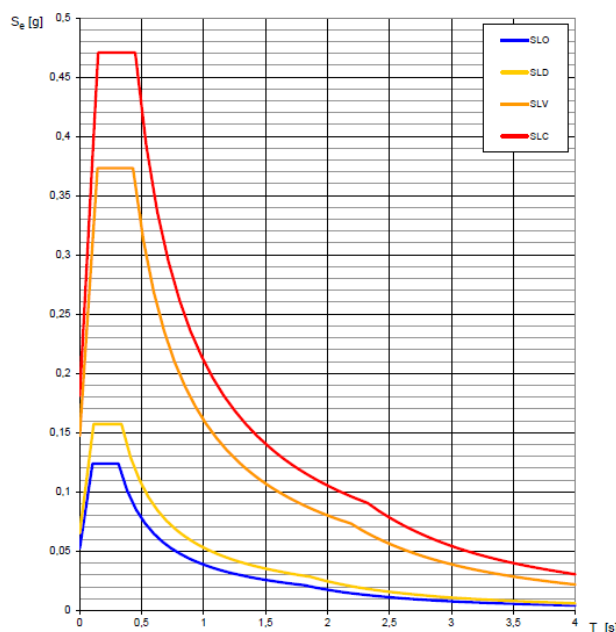


Figure 32: Site seismicity

From the tests carried out on-site, as shown by the geological report, the stratigraphic column falls within the case of soil type B.

The seismic-resistant design of the structure was carried out to ensure that the structure remains in the elastic range for a value of the seismic action equal to the heaviest one defined as the maximum deriving from the SLO spectrum and the SLV spectrum. For the benefit of statics, the design spectrum at the limit state SLV was determined by considering the structure factor $q=4$. In particular, this choice of the structure factor is lower than the value set by the law for framed structures and equal to that set for structures with concentric X-bracings.

The design spectra for the SLO and SLV limit states, determined as specified, are given in Figure 33.

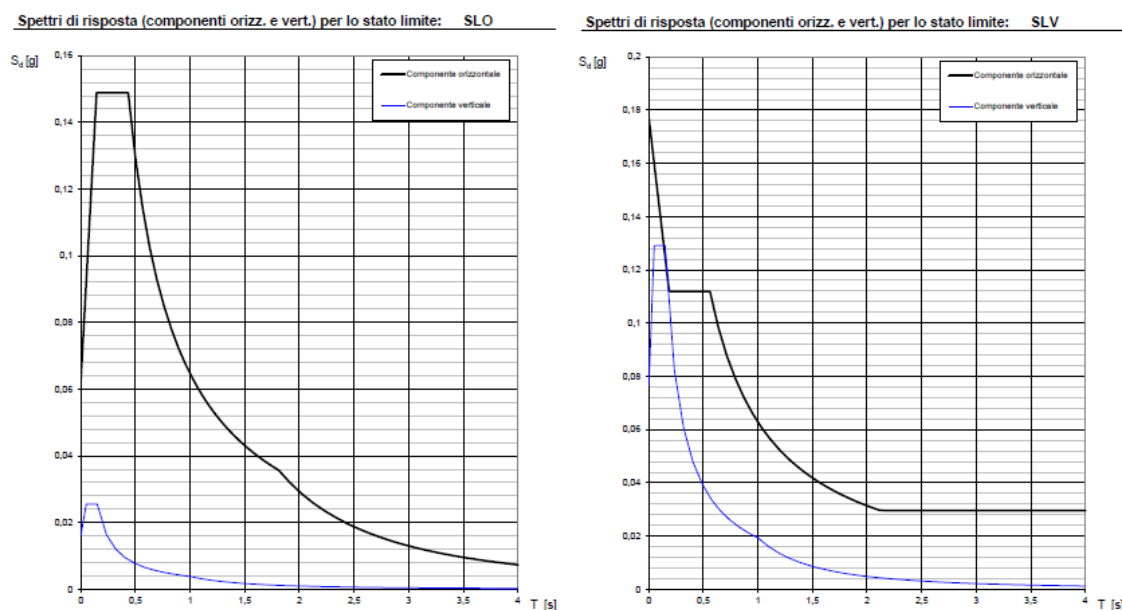


Figure 33: Design spectra at SLO (left) and design spectra at SLV (right)

The seismic analysis of the structure was performed using the modal response spectrum analysis. The modal combination technique employed is the CQC.

The analysis was carried out considering the first 12 vibration modes which guarantee modal participation of the masses greater than 98% for both an earthquake in the x direction and for an earthquake in the y direction.

The periods of vibration of the 18 modes of vibration considered are shown in Table 13:

Table 9: Modal Participating Mass Ratios

Mode	Period (sec)	UX	UY	SumUX	SumUY
1	0,4981	0,4243	0,0065	0,4243	0,0065
2	0,3569	0,2585	0,0548	0,6828	0,0613
3	0,3088	0,0060	0,6177	0,6888	0,6790
4	0,1690	0,0965	0,0035	0,7853	0,6825
5	0,1470	0,0451	0,0001	0,8304	0,6827
6	0,1283	0,0046	0,0362	0,8350	0,7188
7	0,1248	0,0140	0,0538	0,8489	0,7726
8	0,1215	0,0091	0,0016	0,8581	0,7742
9	0,1184	0,0001	0,0015	0,8582	0,7757
10	0,1081	0,0019	0,0015	0,8601	0,7772
11	0,1077	0,0024	0,0000	0,8625	0,7772
12	0,1051	0,0003	0,0000	0,8629	0,7772
13	0,1013	0,0019	0,0346	0,8647	0,8118
14	0,0989	0,0061	0,0002	0,8708	0,8120
15	0,0984	0,0022	0,0060	0,8729	0,8180
16	0,0972	0,0005	0,0111	0,8734	0,8292
17	0,0952	0,0002	0,0050	0,8736	0,8342
18	0,0885	0,0197	0,0152	0,8933	0,8493

7.5.7. Partial safety factors and load combinations

As prescribed by the NTC 2018, the design load combinations have been determined taking into account the partial safety factors shown in Table 10.

Table 10: *Partial safety factors*

	Symbol	if favourable	if unfavourable
Permanent structural loads	G1	1.00	1.30
Permanent non structural loads	G2	0.80	1.50
Variable loads	Q	0	1.50
Seismic actions for SLO limit state	SISMA-SLO	0	1.00
Seismic actions for SLV limit state	SISMA-SLU	0	1.00

In particular, the variable load was placed on all ramps (load condition Q), only on the left ramp (load condition QS), only on the right ramp (load condition QD) or only on the ramp parallel to the arrival landing (load condition QB). In other words, the gravitational load conditions that maximize the flexure of the frame in the longitudinal direction or the transversal direction were also investigated. Therefore the following load combinations have been considered:

- 1) $1.30 G1 + 1.50 G2$
- 2) $1.30 G1 + 1.50 G2 + 1.50 Q$
- 3) $1.30 G1 + 1.50 G2 + 1.50 QS$
- 4) $1.30 G1 + 1.50 G2 + 1.50 QD$
- 5) $1.30 G1 + 1.50 G2 + 1.50 QB$
- 6) $G1 + G2 + 0.60 Q + \text{SISMA-SLO-U1} + 0.30 \text{ SISMA-SLO-U2}$
- 7) $G1 + G2 + 0.60 Q + 0.30 \text{ SISMA-SLO-U1} + \text{SISMA-SLO-U2}$
- 8) $G1 + G2 + 0.60 Q + \text{SISMA-SLU-U1} + 0.30 \text{ SISMA-SLU-U2}$
- 9) $G1 + G2 + 0.60 Q + 0.30 \text{ SISMA-SLU-U1} + \text{SISMA-SLU-U2}$

where U1 denotes the earthquake in the x direction and U2 is the earthquake in the y direction.

7.5.8. Summary of calculation results and verifications

From the calculation tables and the resistance and stability checks of the members, it appears that all the checks are satisfied.

The following Figure 34 shows the work rates of the members (i.e. the ratio between the design stress and the design strength). A value less than 1.0 indicates that the representative stress state point is within the strength domain of the member.

In particular, the maximum working rates of the structural members are as follows:

Columns: 42.7%

Diagonals: 40.8%

Castle beams: 23.9%

Cantilever beams: 34.2%

The checks concerning the connections are given in extended calculation documentation.

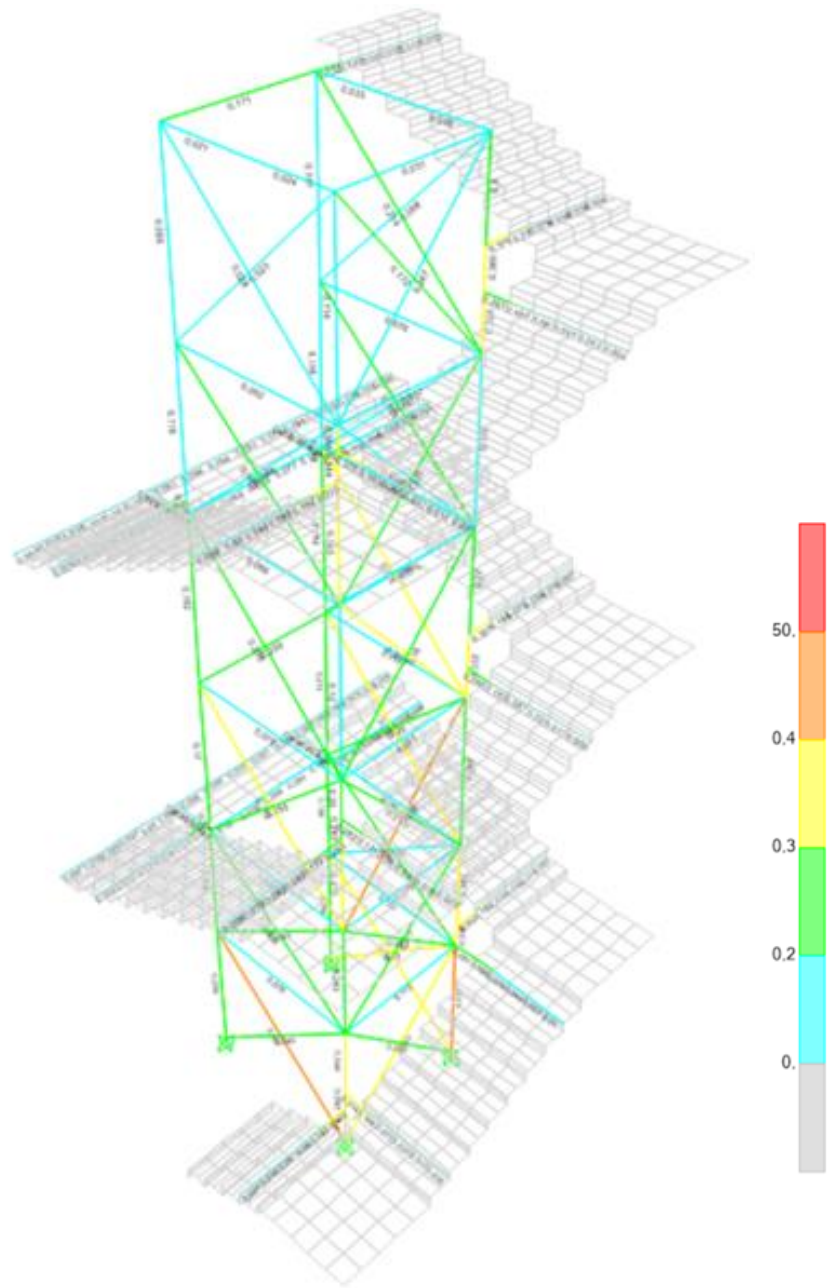


Figure 34: Maximum member work rates

7.6. Foundations

The peculiarity of the foundation system consists in the design of embedded column base connections. In fact, such a solution represents a very effective strategy for designing rigid and full-strength column bases, representing details closer to the fixed supports commonly adopted to model the columns' restraints. From a mechanical point of view, the main characteristic of embedded column bases is that the bending moment and shear force are transmitted by the embedded steel column to the concrete of the plinth through a contact pattern of stress (Figure 35), while the base plate plays a role primarily in terms of axial strength. In this case, by considering literature research by Wald et al. (2000), Grilli and Kanvinde (2017), the AISC provision and the Japanese code about such a kind of connections, the embedment length has been fixed equal to 1.10 m.

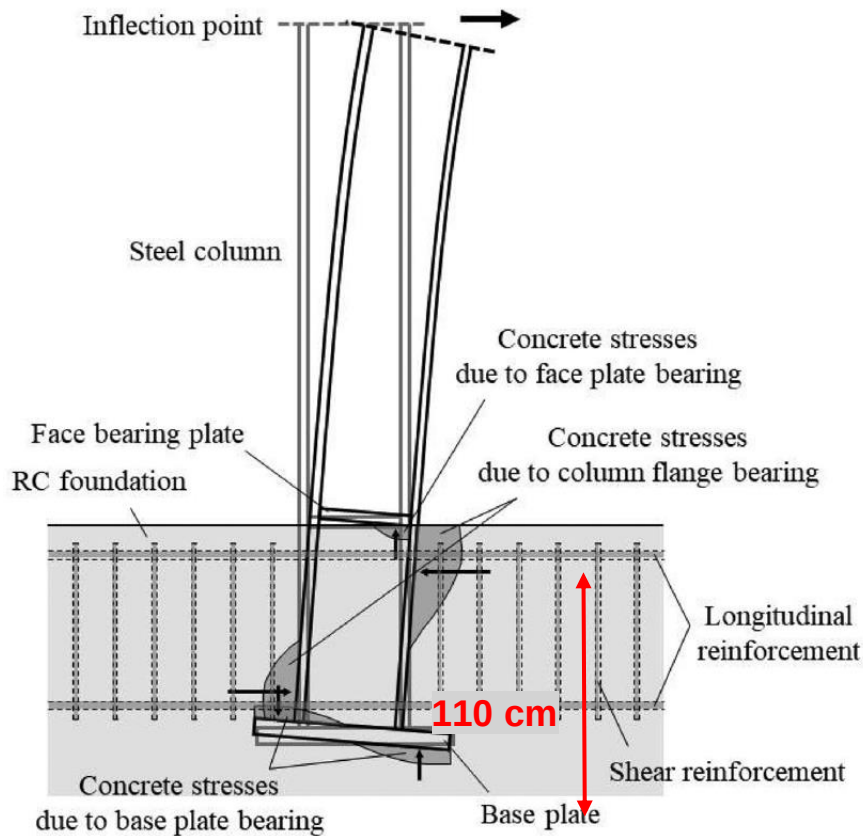


Figure 35: Embedment length

The embedded column base connections transfer the actions deriving from the structure to the plinths, which are connected through the adoption of T-shaped beams (Figure 36) in order to create the structural foundation scheme reported in Figure 37.

Even though the drawings can deduce additional information, it is worth focusing on the detail of the reinforcement bars in the plinths: since the columns are embedded in the web of the T-shaped cross sections of the foundation beams, the reinforcement bars located at the upper side of the beams need to be shaped so that they pass next to the columns, as shown in Figure 38.

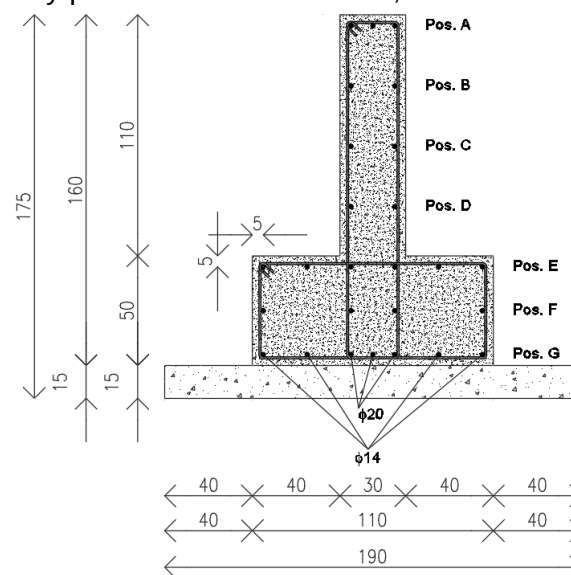


Figure 36: Cross-section of the foundation beams

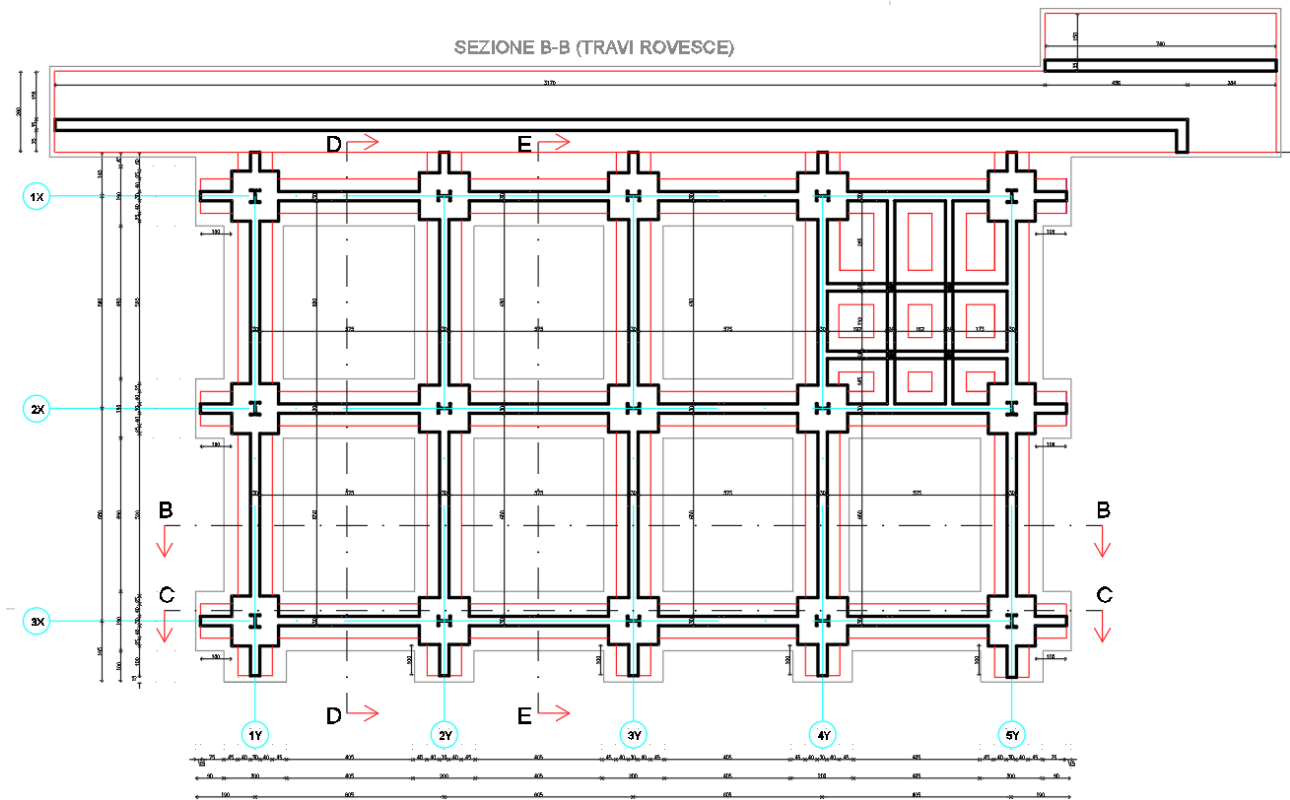


Figure 37: Foundations

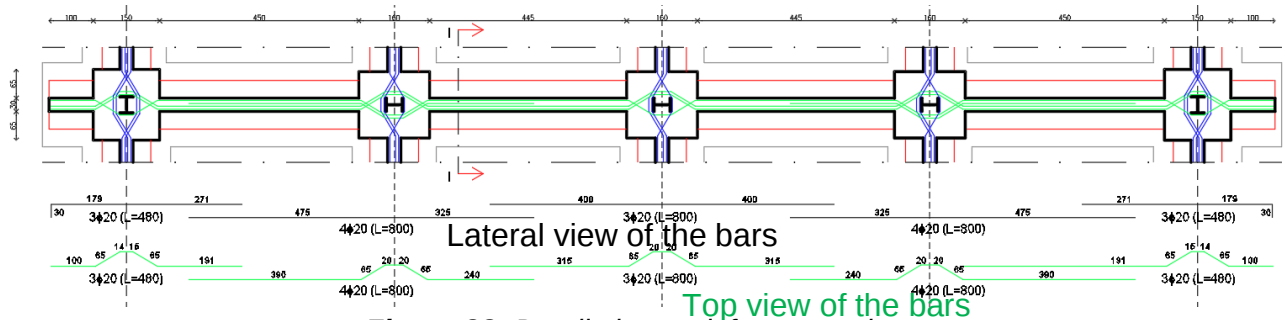


Figure 38: Detail about reinforcement bars

8. WINTER/SUMMER AIR CONDITIONING SYSTEM

The winter/summer air conditioning system envisaged for the building varies according to the intended use of the rooms, a hydronic system with fan coils will be implemented for the offices, while an all-air conditioning system is foreseen for the laboratories. The generation of the carrier-fluid used will take place through a system of high efficiency heat pump generators which work sequentially according to the actual requirements of the building, modulating power and flow rate. The heat pumps are equipped with a desuperheater unit which, through active heat recovery, allows the production of a hot vector fluid in a percentage of approximately 20% of the nominal cooling capacity, even when the generators work cold for summer air conditioning.

The use of the reversible heat pump and the hydronic terminals makes it possible to air-condition the rooms in all seasons, guaranteeing at the same time a high environmental comfort and the reduction of energy consumption due to the use of a low temperature heat vector (40-45°C).

The system described consists of the following components:

- Automated vector-fluid softening system;
- Reversible cascade heat pumps with high efficiency, low noise and complete with desuperheater module;
- Insulated 1500-litre buffer tank in hydraulic separator configuration;
- Inverter circulation units on primary heat pump circuit;
- Primary distribution manifolds;
- Separate inverter circulators for the Air Conditioning and Ventilation circuits;
- Air Handling Unit with Hydronic coils;
- Cross-flow Heat Recovery for Primary Ventilation;
- Supply lines on the various floors of the building;
- Floor distribution circuit;
- Hydronic Terminals - 4-Way Cassette Fan Coils;
- Hydronic Terminals - Channel coils.

The climatic data for the design of the winter/summer air conditioning system are given in Table 11.

Table 11: Climatic data

Location	Fisciano (SA)	
Degree Days	1637	
Climatic Zone	C	
Design external temperature (winter)	0 °C	
Outside temperature dry bulb (summer)	30.6 °C	
WINTER REFERENCE PARAMETERS		
External reference temperature	0,0	°C
Average relative reference humidity	70,0	%
Final internal temperature	21,0	°C
Average final relative humidity	50,0	%
SUMMER REFERENCE PARAMETERS		
External reference temperature	30,6	°C
Average relative reference humidity	45,0	%
Final internal temperature	24,0	°C
Average final relative humidity	50,0	%

The calculations were carried out using the transmittance values of the building components. The calculations of the thermal and cooling requirements were processed using software approved by the Italian Thermotechnical Committee. The results of the necessary heating and cooling capacities are summarized in Table 12.

Table 12: Heating and cooling capacities

SECOND FLOOR OFFICES					
Winter Power Air Conditioning	13,50	[kW]	Winter Power	29,50	[kW]
Winter Power Ventilation	16,00	[kW]			
Summer Power Air Conditioning	20,00	[kW]	Summer Power	27,00	[kW]
Summer Power Ventilation	7,00	[kW]			
FIRST FLOOR LABORATORIES					
Winter Power Air Conditioning	13,50	[kW]	Winter Power	64,50	[kW]
Winter Power Ventilation	36,00	[kW]			
Power for temperature control (+3°C) C)temperatura	15,00	[kW]			
Summer Power Air Conditioning	20,00	[kW]	Summer power	85,00	[kW]
Summer Power Ventilation	50,00	[kW]			
Power for temperature control (-3°C) C)temperatura	15,00	[kW]			
			Winter Calculation Power	94,00	[kW]
			Summer Calculation	112,00	[kW]

The vector-fluid distribution network will be made with different pipes depending on the area of use:

- Transport pipes in external environments and thermal power plant: Seamless pipes in black steel compliant with UNI 10255 standard;
- Distribution manifolds: Seamless pipes in black steel compliant with UNI 10255 standard joined by electric arc welding;
- Distribution inside the locals: Multilayer polyethylene pipes with vapor barrier (internal PE-X, intermediate AL, external PE-HD) connected by means of fittings with a "press" system.

The distribution circuit will consist of supply backbones with branches near the points of use, the pressurization system will ensure that the pressure and flow rate required by the application are maintained.

The delivery and return circuits will lead to the manifolds located in the technical compartment, will develop along the main backbones and will end in special terminal distribution manifolds, from which the connection pipes with the Fan Coil units will depart.

All the pipes making up the Carrier Fluid distribution circuit must be installed complete with insulation made with closed-cell elastomeric insulation, also as regards the pipes and shut-off devices installed in external environments, the insulation will be protected with casings made of aluminium plate and fixed with mechanical connections in order to guarantee the water proofing of the coating.

The sizing of the pipes was carried out according to the maximum speed criterion.

Concerning the equipment, a reversible heat pump is adopted: an air cooled water chiller/heat pump with axial fans, running on gas R410A, scroll type compressors, bearing structure in steel sheet panels, plate heat exchangers, complete with electrical panel pre-assembled on board the machine, power supply 400 V-3-50 Hz.

The reversible heat pump, the carrier fluid storage and distribution system will be located in the technical compartment (Figure 39) specially created in the basement, a solution that guarantees

complete management of the system even in adverse weather conditions.

The circulation group has the task of distributing the carrier fluid to all points of the secondary circuit, the design choice fell on a modular model capable of responding linearly to the demands of the system.

Regarding the Fan Coil Terminal Units of the Office Floor, based on the results obtained from the calculation of the thermal powers required for each individual room and maintained the initial hypotheses on the subdivision of the two systems serving them (Aeraulic, Hydronic), the sizing of the Fan Coil terminal units was carried out. The criterion used was to size the units on the basis of the demand in the summer period (which represents the most onerous condition).

The internal units provided are cassette fan coils with 4-way diffusion installed on the ceiling and equipped with a Brushless Inverter motor which allows precise adaptation to the real demands of the internal environment without temperature oscillations. The air flow rate can be varied continuously via a 1-10 V signal generated by regulation and control commands, which significantly improves acoustic comfort.

The hydronic terminal units will be equipped with a regulation system which, by acquiring the temperature and humidity values of the room from special sensors in the field, will be able to modulate the fluid flow rate and the speed of the internal motor according to the request.

The management of the flow takes place via the inverter circulators and the balancing of the circuit is guaranteed by the automatic regulation and balancing valves installed on board the individual terminals.

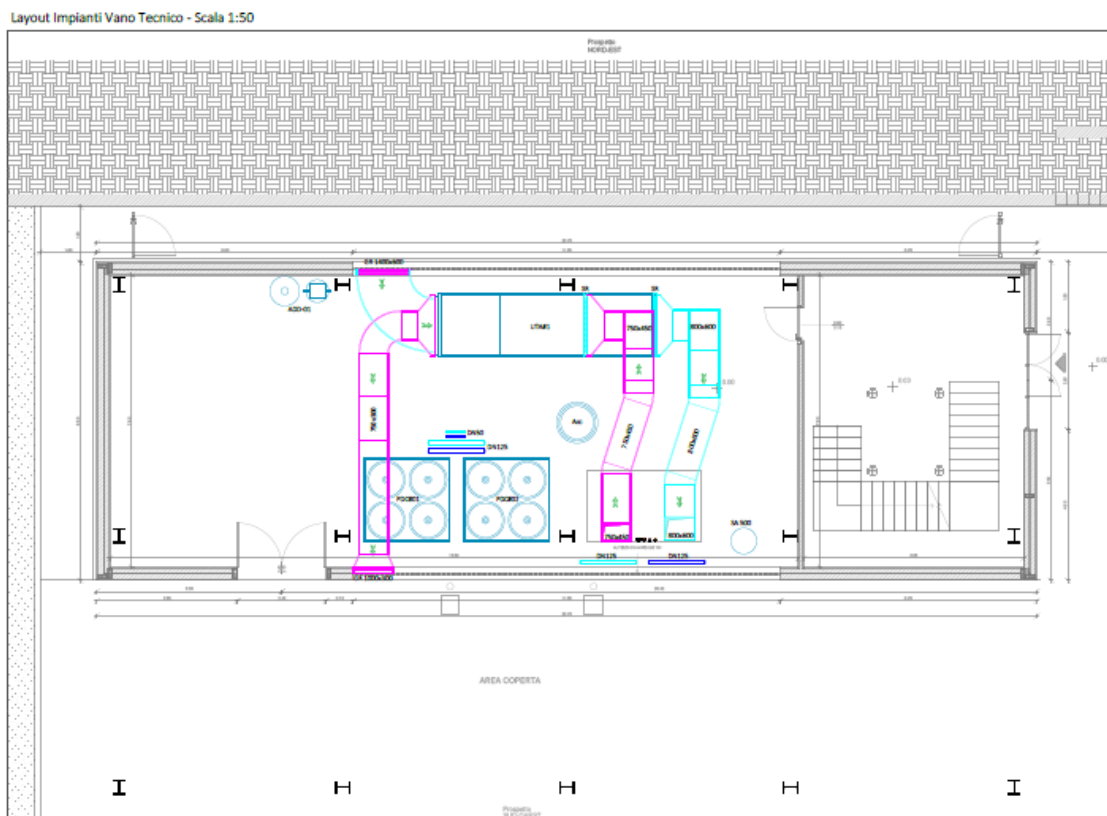


Figure 39: Heating and cooling system – ground floor with technical compartment

Concerning the Channel Hydronic Battery Terminal Units of the Laboratory Floor, hydronic coils powered by the vector fluid produced by the heat pump generators will be provided into each individual environment to allow the "fine" adjustment of the temperature of the air introduced. The heat flow will be adjustable via room thermostats and automatic two-way valves with three functions: regulation, pre-definition of maximum volumetric flow and automatic flow regulation.

Moreover, in order to prolong the life of the plant, it was decided to use treated water for the production of the carrier fluid, for this purpose the project involves the implementation of a duplex ion exchange softening system.

The air renewal systems inside the building will be implemented with an operating logic which involves introducing mechanically (through filtration) and thermally (by means of a hydronic battery) primary air into the environment in order to respond to the characteristics desired final temperatures. The primary air system is sized in compliance with the UNI 10339 standard which, in relation to the size and intended use of the rooms, imposes numerical coefficients for calculating the necessary air volume.

As far as the toilets are concerned, always responding to the dictates of the aforementioned legislation, an extraction of air equal to 8 volumes/hour will be envisaged.

The ventilation system proposed for the second floor where the offices are located involves the use of a cross-flow heat recovery unit, a single unit installed in the toilet rooms and sized in such a way as to make up for the required amount of air; the vector fluid (hot in winter and cold in summer) produced by the heat pump serving the system allows the thermal treatment of the air introduced through heat exchange coils installed in ducts.

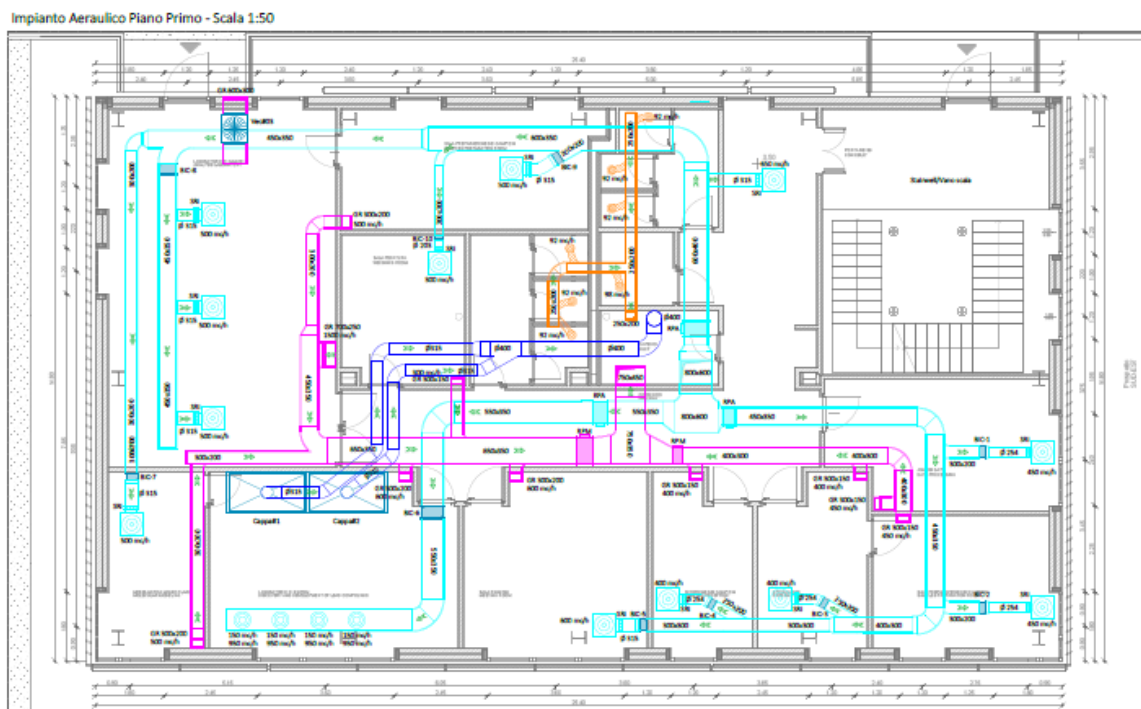


Figure 40: Heating and cooling system – first floor

The delivery and expulsion ducts of the air for distribution to the floor abut from the recuperator. The air speed in the primary supply and return ducts will always be below 6.0 m/s to limit noise.

In order to allow the correct diffusion of the air, the ducts will be equipped with aeraulic delivery and recovery elements equipped with adjustable calibration dampers to allow the correct balancing of the system, furthermore, near the connections on the heat recovery units, some manually operated regulation shutters. The distribution will take place in the locals in various ways; air inlet on the ceiling

by means of aeraulic diffusers installed in the false ceiling module and equipped with a plenum for a uniform distribution of the air and an adjustment damper for the correct balancing of the flow rate. The return air, on the other hand, will be conveyed by means of grilles positioned in the lower part of the rooms, which are also equipped with an adjustment damper. On the first floor where the laboratories are located (Figure 40), it was decided to implement an all-air ventilation system sized in compliance with UNI 10339 standard which, in relation to the size and intended use of the premises, imposes numerical coefficients for calculating the required volume of air. As far as the toilets are concerned, always responding to the dictates of the aforementioned legislation, an extraction of air equal to 8 volumes/hour will be envisaged. Also, in this case the introduced air will be treated mechanically and thermally by a treatment unit.

To obtain a uniform distribution of the temperature and comply with the number of air changes required by law, the air handling unit will be sized for an overall flow rate of 6350 m³/h in normal working conditions, while it will process a maximum flow rate of 9,550 m³/h to compensate for the air extracted by the hoods of the “Sintesi laboratory” when the latter go into operation.

Figure 41 shows the heating and cooling system at the second floor.

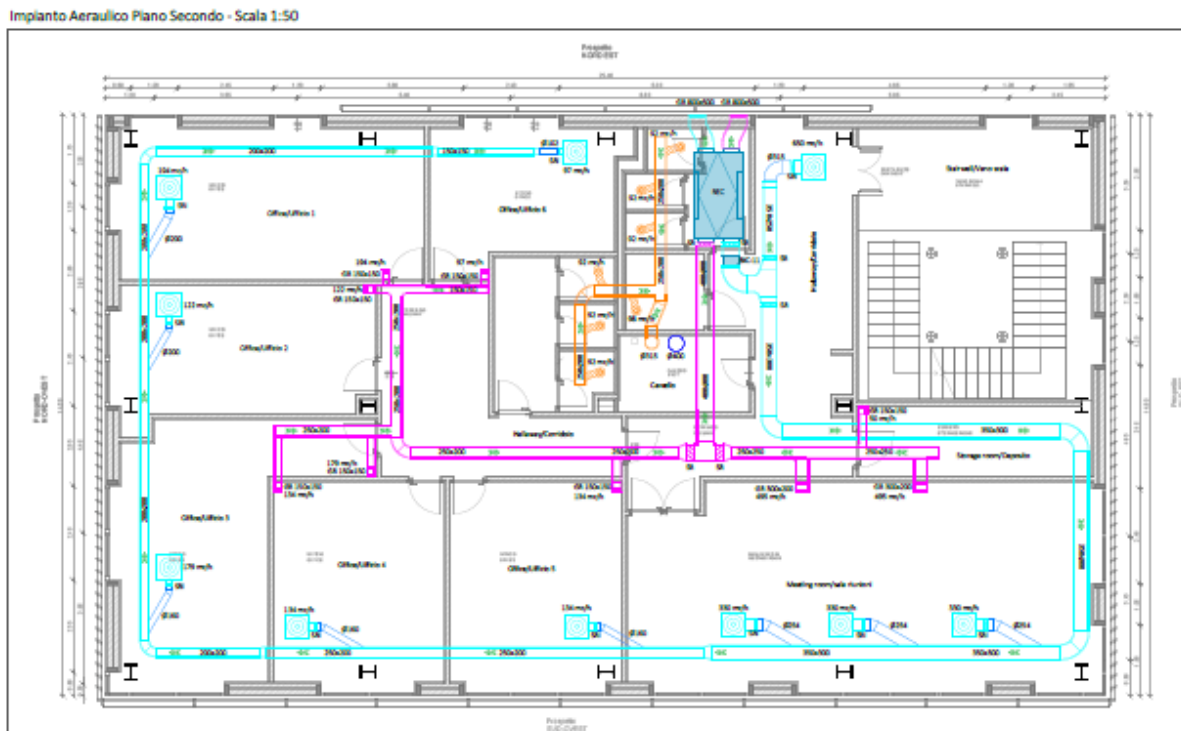


Figure 41: Heating and cooling system – second floor

The system is therefore configured with a variable flow delivery (managed by automatically operated duct flow regulators) and a fixed flow return. In addition to the heat treatment operated by the AHU coils, hydronic coils will be implemented in each room on the laboratory floor, controlled by the vector fluid and by a thermoregulation system that allow for the differentiation of the temperature for each room.

The ducts, necessary to connect all the equipment of the ventilation systems to each other, for making the external air intakes, the expulsions, the extractions, the plenums, the fittings, the special

pieces, will be in hot-dip galvanized steel sheet (Sendzimir lock - forming quality) of variable thickness according to the dimensions adopted.

Furthermore, all the channels will be extensively reinforced so as not to undergo appreciable deformation due to the effect of the air pressure and supported by special brackets conveniently secured to the building structure.

The ducts will be equipped with curves such as to reduce pressure drops to a minimum and, where necessary, these curves will be provided with internal deflectors. The 90° bends will be of the smooth type and formed by at least 5 sectors.

The radius of curvature of the axis of the channel will be equal to 1.5 times its diameter. Any junctions of channels built with different metals will be made with flexible joints in order to avoid the generation of galvanic currents.

Diffusion inside the rooms takes place through delivery vents including regulation dampers sized in such a way as to have a sound emission below 20.0 dB and placed at ceiling height to make the most of the “Coanda” effect.

The recovery diffusers, including regulation dampers, are distributed in the main corridors of the building and the passage of air between one room and another is ensured by transit grilles of suitable dimensions installed on the access doors.

Impianto Aeraulico Cavedio - Scala 1:50

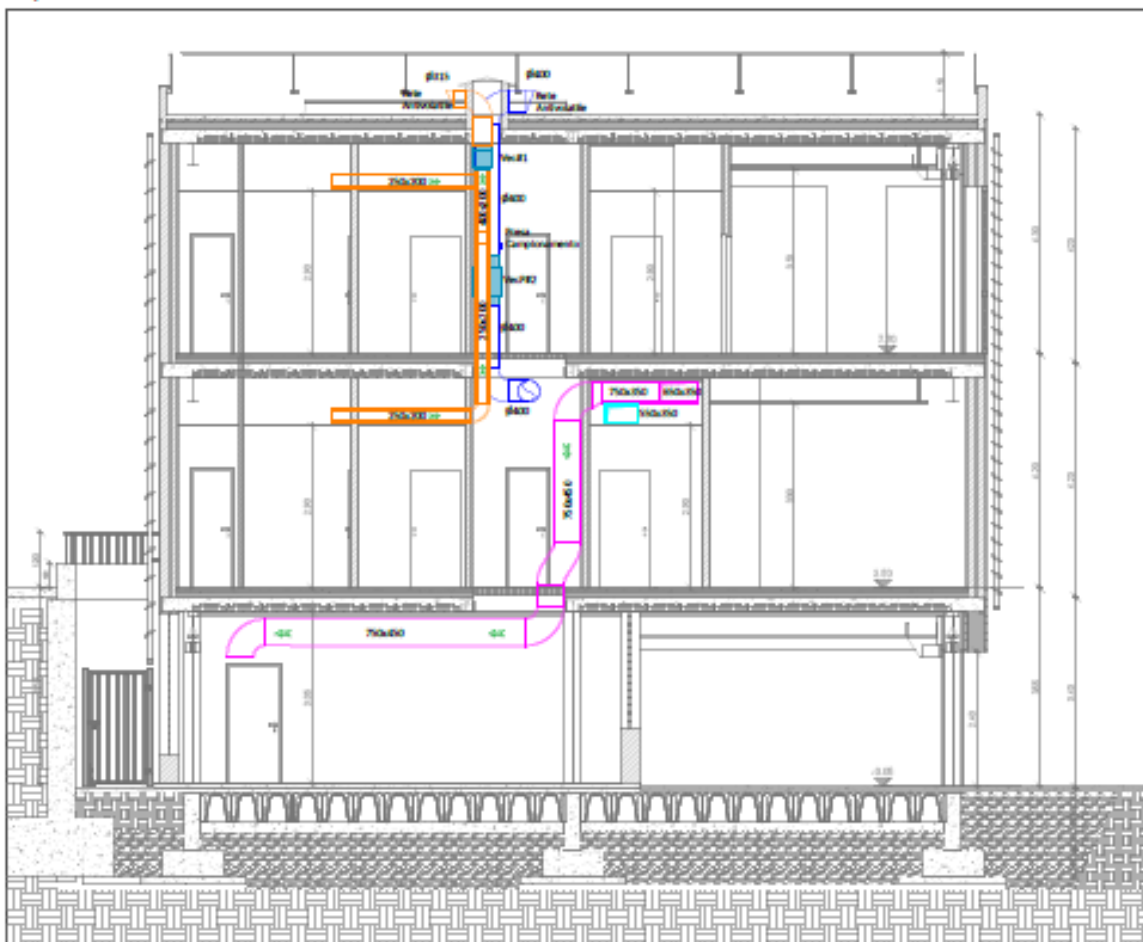


Figure 42: Heating and cooling system – distribution between the floors

The regulation and monitoring system at the service of the heating system involves the use of a compact PLC capable of managing and monitoring the entire heating system, providing real-time information about anomalies, and reading of the fluids produced thanks to the use of a network operator terminal, with Touch-screen technology, to be installed in a manned place. This solution, in addition to improving room comfort, supplying the fluids at a temperature in proportion to the outside temperature, allows for energy purposes a management economy of 10% and information to maintenance workers in real time.

Figure 42 shows the distribution between the floors constituting the heating and cooling system of the whole building.

9. ELECTRICAL BUILDING SERVICES

In this section of the technical report, the design criteria underlying the construction of the low voltage electrical distribution system, serving the new building are briefly illustrated.

The building will be structured on three levels above ground, with an ordinary internal staircase and an elevator system. It will be electrically connected to the general switchboard of the "Invariante 7E" electrical substation, through a section of new underground canalization and a section in the existing technological tunnel. On the ground level, in a dedicated room, there will be the general electrical panel, the centralized absolute electrical continuity group and the photovoltaic inverter. On the first level there will be a series of laboratories belonging to the Pharmacy department and a toilet block. On the second level there will be a series of offices and a toilet block. At the roof level, the installation of photovoltaic generators (Figure 43) connected to the inverter located on the ground level is envisaged. The building, in any case connected to the university electricity system, will benefit from the energy benefits of the photovoltaic park in operation.

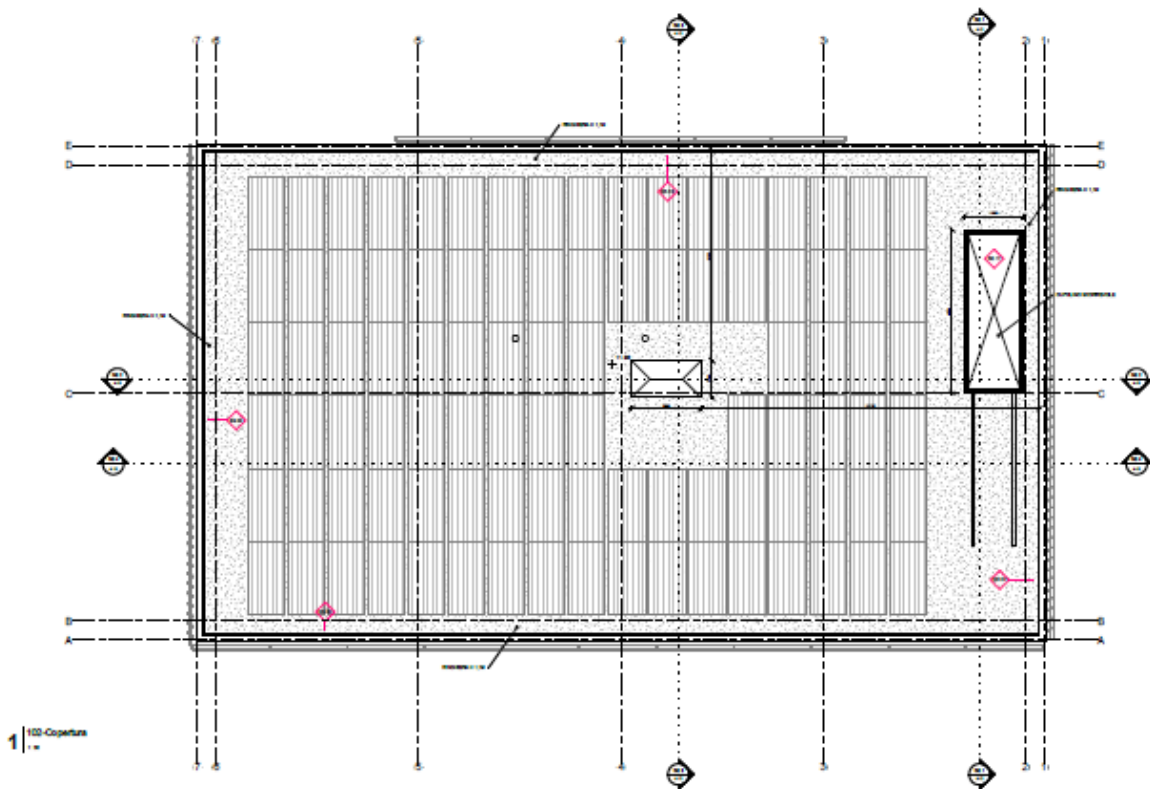


Figure 43: Photovoltaic park located on the roof of the building

Energy efficiency is no longer just an option. The Kyoto protocol has encouraged governments around the world to approve legislation that guarantees a more intelligent and conscious use of energy in buildings. In March 2007, the European Union undertook to achieve a 20% reduction in CO2 emissions by 2020. This plan of measures, known as the "3x20 by 2020", also provides for a 20% increase in the level of Energy Efficiency and the achievement of 20% of the energy produced from renewable energy sources. Real changes will be needed to achieve these goals; governments are stepping up efforts to enact laws, regulate and set standards for better energy efficiency. This new move towards stricter energy efficiency regulations began with the Kyoto Protocol. Laws such as the US Energy Policy Act set the standard for the energy future.

In Italy it was published, with the D.L. no. 192 of 08/19/2005, the European directive 2002/91/EC (EPBD) relating to energy efficiency in buildings and, more recently, the D.M. 26/06/2009 (national guidelines for the energy certification of buildings). On 18/06/2010 the new European directive 2010/31/EC on energy performance in buildings was published, within which the importance of active control systems such as automation, control and monitoring systems aimed at saving energy was recognized. This directive is applied in the community standard UNI EN 15232:2012, which clearly indicates the benefits obtainable by opting for a specific efficiency class.

The most recent UNI EN 15232-1:2017 standard, dated October 2017, indicates a method for defining the minimum requirements or any other specification concerning the control, automation and technical management functions of buildings that contribute to energy efficiency. In particular, it identifies, among other things, a structured list of the control, automation and technical management functions of buildings that contribute to their energy performance. The functions, called BAC - Building automation and control, are classified and structured with reference to building regulations, and a method for defining the minimum requirements or any other specification concerning the control, automation and technical management functions of the buildings that contribute to the energy efficiency of a building, which can be implemented in buildings of different complexity. In this sense, the building will be built to be classified as NZEB (Nearly Zero Energy Building). It will therefore be operated with energy consumption tending to zero, in relation to winter heating, summer cooling, domestic hot water production, lighting and ventilation for air exchange, in compliance with the European directive EPBD (31/2010 /THERE IS).

In this sense, the electrical system serving the building is equipped, among other things, with an advanced type of automation to pursue, as a primary objective, that of classifying the building itself as belonging to the energy efficiency class "A" according to the UNI-EN 15232 community standard.

As a discriminating element, therefore, it was envisaged to equip the various electrical panels with a real-time supervision, automation and control system, based on the by now consolidated KNX communication protocol, capable of managing the information for automatic regulation with appropriate logics of utilities.

The construction of the electrical system is completed with the use of lighting fixtures with a LED photodiode unit light source designed for the functionality of the regulation of the luminous flux which will be entrusted to the consolidated DALI communication protocol, suitably prepared by the automation panels zone and flanked by presence sensors and lighting level.

10. FIRE FIGHTING WATER SYSTEMS

This Section summarizes the hypotheses and calculation of the fire prevention system in particular active protection systems using water-based firefighting systems (networks hydrants) serving the "C3 BUILDING" to be built on the Fisciano Campus of the University of Salerno.

This project involves the construction of a building intended for laboratory and offices for university research with related services, therefore, in the design of the system of the building, reference was made to the provisions of the Ministerial Decree of 26 August 1992 "Fire prevention regulations for school buildings" and amendments and clarifications, with the extension to universities established by the decree of 5 August 1998, n. 363 In particular, the requirements valid for type 1 schools (with number of people present at the same time up to 100), in an "isolated" building equipped of fire-fighting water systems interconnected to the Campus network.

The hydrant network object of the project will have to serve a building intended for teaching and research in the university environment which is spread over four levels above ground of the same surface and same general purpose. Based on the provisions of the Decree and the UNI standards mentioned above, they were expected:

- A connection pipe between the planned building and the fire prevention water network of the Campus, consisting of an interconnected system of storage tanks and systems fire pressure capable of providing the required flow rate and pressure. In particular the new system will connect with the existing network located in the technological tunnel downstream of the canteen. The pipe in question is made of steel and installed via flanged junction with the existing pipe in the tunnel.
- An internal distribution network consisting of a circuit of steel pipes leading from supply manifold are distributed to the various floors inside a plant shaft. Inside each floor the supply pipes to the hydrants are always made of steel and will be placed in the false ceiling.
- N.3 UNI 45 hydrants with 20 m hoses, distributed in the number of 01 on each floor;
- N. 01 above ground hydrant type 2 x UNI 70 with motor pump connection and N. 01 group

Fire Brigade motor pump connection UNI 70 with two ports for pressurizing the network from part of the Fire Brigade's tankers installed outside on the road axis correspondence of the building. The supply of this hydrant will take place with a pipe buried in Pead terminal of the main circuit serving the building.

The entire system can be sectioned due to the presence of:

- A valve at the connection of the collector to the existing pipes (technological tunnel a Mensa valley);
- Valves at the foot of the riser in the building, and valves on the branches of supplying above-ground hydrants.

The hydrants are connected to the risers with 1" 1/2 pipes and will be located, for each floor, along the central balcony in a position not far from the stairs, always and in any case, in an easily accessible and visible position, marked by special signs that allow this identification and at a mutual distance such as to reach all areas with the jet to protect. Each hydrant will be equipped with a tap and 20 MISA certified flexible hose meters, lance and containment box in stove-painted steel sheet with crash-safe door.

The distribution network will be independent from that of health services. The pipes, where necessary according to the UNI EN 12241:2009 standard, will be insulated against frost using cups of glass wool insulating material protected with final aluminum coating. This material offers the advantage over other insulators of improve the fire behavior of the net to which it gives a resistance RE in case of fire.

Appropriate fire collars will be used, complying with EN 1366-3, for sealing penetrations on walls or slabs of any type and pipes combustible, non-combustible, with or without insulation, consisting of a metal structure with internally inserted thermo-expanding material, complete with fixing plugs and declaration of conformity for Class REI 120 (Classification report EN 13501-2).

For technical details, please refer to the graphic tables.

11. THE TECHNICAL GAS SYSTEMS

This Section refers to the "technical gas systems" to be built on the first floor of the building. In particular, the supply of the following technical gases is envisaged: N₂ (nitrogen 5.0); N₂ UHP (ultrapure nitrogen 5.5/6.0); Ar (Argon 5.0); He (Helium 5.0) serving the Analysis Laboratory, the Preparation Room and the Synthesis Laboratory.

Given that the exact location of the gas leak will be defined by the researchers, the project has exclusively involved the arrangement of the pipes in the false ceiling, subsequently, when supplying the furnishings, we will proceed with a separate procedure for supply and assembly.

The pure gas distribution system must be built according to the following specifications:

- Supply of 2 outdoor concrete boxes for neutral and flammable gases;
- Supply of 4 pure gas plants with automatic exchange and manual reset with pressure transducers;
- Construction of distribution lines in AISI 316L ASTM A269 steel;
- Supply of 1 general shut-off valve panel;
- Supply of 12 ball valves for sectioning lines in the false ceiling;
- Supply of ramp unloaded signaling control units on site;
- Supply of an O₂ gas detection system consisting of 8 sensors;
- Supply of 3 O₂ sensor alarm repeaters;
- Supply of 6 3-way solenoid valves on site;
- Supply of 1 unloaded ramp alarm reporting control unit;
- Supply of 1 oxygen alarm and display control unit on site.

More information is given in the design drawings.

12. THE WATER SYSTEM AND SEWAGE SYSTEM

This Section concerns the design of water and sewerage systems relating to the executive project of the "C3 BUILDING" to be built on the Campus Fisciano of the University of Salerno, and analyzes the sizing and the verification of the water-sanitary network and the internal sewerage system.

The intervention area currently consists of a green area located between the buildings: Canteen to the North, Lot I Residences to the East and Canteen Parking to the West of the Campus overlooking the nearest connection points with all existing water networks (potable and non-drinkable), in the tunnel that goes towards the Bus Terminal where all the arrangements for derive the project lines.

During the project phase it was decided to power the toilet sinks and bidets (when present) with drinkable water and to supply the toilets with non-drinkable water derived from the "pozzi" circuit of the Campus. Furthermore, it was decided to provide hot water only toilets intended for disabled people.

The correct sizing of the pipes and other system components must ensure that in the most unfavorable operating circumstances (periods of maximum consumption) there are normal supply conditions also at the supply points located in disadvantaged positions.

As stated, the drinking water supply pipeline will be derived from tunnel that goes towards the Bus Terminal where the necessary connections had already been prepared.

The derivation from the main pipeline, running in parallel along the "Via della Tecnica" will reach the first level (ground floor) of the new building, in particular it will branch out in a line that will serve the irrigation system in case of emergency and in a line that it will reach under the bathroom shaft where the relevant riser column will detach vertical which will serve the two bathroom groups located on the respective floors (P1, P2). Along the route, a service connection will be left for the room of the aforementioned thermal power plant and a coupling, equipped with a specific hydraulic disconnecter, for the possible power supply of the rising non-drinking water in the event of the latter being out of service.

The underground pipeline will be entirely in PE 100 (High Density Polyethylene) at depth between 1÷1.5 m which will cross the building and reach the side border wall A.DI.S.U. to then act as a connection to the planned C4 building.

The vertical drinking water upright will be made of steel and will serve the lines at the various levels supply to the sinks [pieces: $8 = (2+2) \times 2$], and in each of the two bathrooms for disabled people: the toilet shower and sink.

Obviously also the hot water boiler in the bathroom room for disabled people will be supplied by drinking water lines.

The intervention under consideration involves using well water as well as for irrigation of gardens and flowerbeds also to supply toilet flushing. It was also expected to equip the heating plant and the irrigation system with service socket points.

The power supply to the aforementioned points will be derived from the new pipeline coming from tunnel that goes up towards the Bus Terminal and will be completely in PE100.

The section will be underground and the power supply will be derived along its route irrigation system control unit. Subsequently the power supply for the uprights of the bathroom groups and for the boiler

room, and finally it will continue up to the wall of A.DI.S.U. side border to then act as a connection to the planned C4 building.

The vertical riser for non-drinking water will be in PE 100 and will serve at the various levels the supply lines to the toilets [pieces: $12 = (3+3) \times 2$], and in each of the two bathrooms for disabled people: toilet and will continue to the roof where a point will be set up with service tap.

The sewage systems designed take into account the fact that the Fisciano Campus has a separate drainage network for sewage and rainwater whose main collectors pass, in an underground position, a short distance from the intervention area.

In particular, near the building being planned there is: 1) A sewage collector along the embankment flanking Via della Tecnica a service of the university residences first lot of circular shape with diameter from 400mm; 2) A white water collector along Via della Tecnica with a circular shape and diameter from 500 mm.

Therefore the designed exhaust system was designed to convey the waste separately black flows (fecals and laboratory furniture waste) and flows of meteoric origin. In this design the following networks have been distinguished: a) Sewage drainage network inside the building; b) FECALS: This is the disposal network of the sanitary equipment present in the building ends at the wells connection to the external sewer system. The connecting sections between the devices and the fecal, the fecal itself for its entire vertical development and the stretch that goes from the foot of the fecal to the first well outside the building, will be made with polypropylene pipes (PP) with socket coupling equipped with double seal SBR gaskets.

The project involved the construction of a fecal: which conveys everyone's waste the appliances present in the bathrooms on the various floors. In line to fecal (configuration of system with primary ventilation in accordance with the UNI 12056-2 standard) has been foreseen ventilation pipes that cross the building and then flow into the roof. The anchoring of all pipes to the vertical and horizontal structures will occur with use of appropriately positioned clamps, collars and tie rods.

The following general requirements must be guaranteed:

- All direction changes must be performed with open turns ($<45^\circ$)
- The horizontal sections must have a slope $>2\%$
- All joints must be leak-proof
- All section changes must occur immediately before the next entry
- The pitch of the fixing/support brackets for non-steel pipes must be:
 - $<15 \text{ } \varnothing$ in the sections where the route of the rainwater/fecal pipes is vertical (slope $>200\%$);
 - $<7 \text{ } \varnothing$ in the sections where the route of the rainwater/fecal pipes is horizontal (slope $<200\%$) (where $\varnothing$ is the external diameter of the pipe to be supported).

In turn the supports will go anchored to the concrete walls using expansion bolts of appropriate dimensions and bars threaded.

In correspondence with the vertical/horizontal transition curves, provisions must be provided pipe support saddles.

Waste water drainage network inside the building – DOWNPIPES: This is the network disposal of rainwater falling on the building. The hypothesized system foresees that the water from the stairwell roof is conveyed through two downspouts in PP (Ø160) which will have a vertical trend except for a change of direction horizontal at the intrados of the first floor. Called downpipes they will pass inside the building partly inside the technical rooms. The pipes of the white water system between the intake points on the roof terrace and the first well outside the building will be made with HDPE pipes (High density polyethylene), whose joints will be made by welding electrofusion with electric sleeve. The system thus created must guarantee tightness at a minimum pressure of +5 Bar. Anchoring the pipes to the structures vertical and horizontal will take place with the use of appropriate clamps, collars and tie rods position yourself.

The following general requirements must be guaranteed:

- All direction changes must be performed with open turns (<45°)
- The horizontal sections must have a slope >2%
- All joints must be leak-proof

All section changes must occur immediately before the next entry.

The pitch of the fixing/support brackets for non-steel pipes must be:

- <15 Ø in the sections where the route of the rainwater/fecal pipes is vertical (slope >200%);
- <7 Ø in the sections where the route of the rainwater/fecal pipes is horizontal (slope <200%) (where Ø is the external diameter of the pipe to be supported). In turn the supports will go anchored to the concrete walls using expansion bolts of appropriate dimensions and bars threaded.

In correspondence with the vertical/horizontal transition curves, provisions must be provided pipe support saddles. White and black water drainage network outside the building is the network that collects the rainwater from the waterproof areas outside the building and into which the downspouts are inserted of the building itself, reaching the respective exhaust manifold. All piping drains have been made of PVC.

The external disposal network has been designed ensuring an equal or greater slope at 2% for all sections.

13. THE DATA NETWORK

The physical infrastructure of the University data network is hierarchical and, as described in the CEI EN 50173 standard, made up of the following elements:

- Telecommunication Outlet (TO), which represent the sockets to which the user's equipment is connected (computers, telephones, printers, etc.).
- Floor Distributor (FD), which represents the aggregation point of the TOs created on the single floor of a building.
- Building Distributor (BD), is the aggregation point of a building's FDs.

- Campus Distributor (CD), is the aggregation point of the BDs of all the buildings involved in the network infrastructure.

These functional elements are connected to each other through:

- Campus Backbone, which includes all cabling components (cables, patch panels, patch cords, etc.) to connect the CD to the BDs connected to it.
- Building Backbone, which includes all cabling components (cables, patch panels, patch cords, etc.) to connect the BD to the FDs connected to it.
- Horizontal Backbone, which includes all cabling components (cables, patch panels, patch cords, etc.) to connect the FD to the floor TOs. The regulations establish that horizontal cabling meets the following requirements:
 - 90 meters maximum distance permitted between the distribution cabinet and the workplace;
 - 10 meters of maximum length for the patch cords, calculating the total between the cord on the cabinet side and the one on the user side;
 - the connection cable must be single-track and without intermediate interruptions;
 - it is good practice to maintain a length of no less than 15 metres;
 - must support the IEEE 802.3bt standard, concerning Next Generation Power over Ethernet (NG PoE) technology for powering equipment through the network interface (power delivered up to 100W).

The functional elements of the subsystems are interconnected to form a basic hierarchical topology.

This structure is valid regardless of the category or class in which the wiring is made.

Currently the University data network is made up of:

- approximately n. 30,000 (thirty thousand) single network points, organized in TOs with 2, 3 or 4 sockets;
- n. 200 (two hundred) FD;
- n. 12 (twelve) BD;
- n. 1 (one) CD.

The entire C3 building will be equipped with a single FD, which will have to be built in the technical room located on Level 0. The FD will be made up of n. 1 (one) rack cabinet.

The FD created must be connected by single-mode optical fiber with the BD of building C (formerly Stecca 3) of the Fisciano Campus, as indicated in the diagram in Figure 1 and in detail in the RD04 plan.

The optical fiber will be single-mode OS 2 9/125μ, capable of supporting transmissions with the Ethernet standard of 100 GBit/s. A reinforced cable with LSZH sheath and CPR B2ca category according to the European regulation UE305:2011, anti-rodent, composed of 12 fibres, will be laid and will run along the cable duct that will be built to access the already existing technological tunnel. Patch panels will be installed in the FD and BD where the optical fibers will be connected to LC type connectors.

In general, the copper construction of the Horizontal Backbone (HB) will start from the FD, to connect the TOs to the network. The copper wiring will be made with Class EA performance channels, i.e. Category 6a with unshielded cable, according to the specifications dictated by the CEI EN 50173 standard. Therefore, all service pipes must have a minimum diameter of 40 mm, be placed in it operates with curvature radii such as to allow the creation of systems compliant with current standards, and be prepared for higher category systems in the event of future implementations. Each Telecommunication Outlet (TO) will be served by two cables.

The copper cables will comply with the European regulation EU305:2011 category CPR Cca.

The data network will consist of n. 1 (one) switch cabinet, called Rack A, which will act as a Floor Distributor (FD) for the entire building. He will be allocated to Level 0 in the room dedicated to technological services.

Both data sockets will be installed to serve users and equipment, as well as data sockets dedicated to services, such as the wi-fi network, video surveillance, access control, etc.

The equipment and users will be able to connect to the wired network with a throughput of 1 Gb/s and, in a "looped VLAN" architecture, will use the native network configurations of the relevant Department.

The passive infrastructure will be set up for the wi-fi network compliant with the latest generation Wi-Fi 6 standard, which allows connection to the network with a throughput of 5 Gb/s and management of transmission channels that improve the user experience through techniques of support to the high density. As in all buildings on the University campuses, authorized users will be able to access the Eduroam network (education roaming), a service that allows users on the move at other institutions to access the wi-fi network easily and securely using the same credentials provided by your organization.

Born in Europe, Eduroam is a service widespread in eighty-nine countries and there are approximately eighty million accesses by Italian users per year. It is based on the most secure encryption and authentication standards currently available. It uses the IEEE 802.1x protocol which makes the transmission of your credentials over the wi-fi network safe.

Regarding the floor distributor:

- Level 0.00m Rack A

The 42-unit switch cabinet will be placed in the dedicated technical room and from here the structured cabling of the 0.00m, 3.50m and 7.70m levels of Building C3 will be developed.

In total, n. 67 (sixty-seven) TO, according to the following scheme:

- Level 0:
 - n. 7 (seven) to be installed in the technical room through pipes laid in masonry tracks;
 - n. 1 (one) to be installed in the false ceiling, to be used for any video surveillance cameras, wi-fi access points or other services;
- Level 3.30m
 - n. 24 (twenty-four) to be installed in the rooms through pipes laid in brickwork or on the floor;

- n. 8 (eight) to be installed in the false ceiling, to be used for any video surveillance cameras, wi-fi access points or other services;
- Level 7.70m
 - n. 19 (nineteen) to be installed in the rooms through pipes laid in brickwork or on the floor;
 - n. 8 (eight) to be installed in the false ceiling, to be used for any video surveillance cameras, wi-fi access points or other services.

The details of the installations are indicated in the plans RD01, RD02 and RD03.

14. List of complete design documentation

As already stated, according to the Grant Agreement all the design documentation is due in Italian language, because it has to fulfil the Italian Code provisions and has to be delivered to the National local authorities to obtain the relevant authorizations. The detailed design documentation is listed in the following Tables and fully delivered (in Italian) on the project website (www.dreamersproject.eu).

Table 13: Definitive Design Reports

R 01	Relazione Generale	General Report
R 02	Quadro Economico	Economic Report
R 03	Disciplinare tecnico opere edili	Technical Specification for Construction Works
R 04	Disciplinare tecnico Impianti Elettrici e Speciali	Technical Specifications for Electrical and Special Systems
R 05	Disciplinare tecnico Rete Dati	Data Network Technical Specifications
R 06	Disciplinare Descrittivo (Impianti Meccanici)	Descriptive Specifications (Mechanical Systems)
R 07	Disciplinare tecnico impianti idrici di carico, scarico ed antincendio	Technical Specifications for Water Loading, Unloading and Fire Prevention Systems
R 08	Relazione Tecnica Impianti Elettrici e Speciali	Technical Report for Electrical and Special System
R 09	Relazione Tecnica Rete Dati	Data Network Technical Report
R 10	Relazione Tecnica Impianti Meccanici	Technical Report for Mechanical System
R 11	Relazione Tecnica ex L. 10/91	Technical Report Ex L.10/91
R 12	Relazione Geologica	Geological Report
R 13	Relazione Geotecnica	Geotechnical Report
R 14	Relazione di Calcolo delle Fondazioni e delle opere di sostegno	Computation Report of Foundations and Support Geotechnical Structures

R 15	Relazione generale di calcolo strutturale	General Report on The Structural Design
R 16	Relazione sui materiali	Materials Report
R 17	Relazione di calcolo Impianti Elettrici e Speciali	Computation Report of Electrical and Special Systems
R 18	Relazione di calcolo Impianti Meccanici	Computation Report of Mechanical Systems
R 19	Relazione tecnica impianti idrici di carico, scarico, antincendio ed irrigazione	Computation Report of Water Loading, Unloading and Fire Prevention Systems
R 20	Studio di Fattibilità Ambientale	Environmental Feasibility Study
R 21	Prime indicazioni e disposizioni per la stesura dei Piani di Sicurezza	Preliminary Indications and Provisions for Drafting of Security Plans
R 22	Relazione sulla Gestione delle Materie	Material Management Report
R 23	Relazione sulle interferenze	Interference Report
R 24	Relazione e Disciplinare Impianti Gas Tecnici	Report And Provisions for Technical Gas Systems

Table 14: Evaluation of costs

AP 01	Analisi Prezzi Strutture	Pricing Analysis of Structures
AP 02	Analisi Prezzi Opere Edili	Pricing Analysis of Construction Works
AP 03	Analisi Prezzi Impianti Elettrici e Impianti Speciali	Pricing Analysis of Electrical and Special Systems
AP 04	Analisi Prezzi Rete Dati	Pricing Analysis of Data Networks
AP 05	Analisi Prezzi Impianti Meccanici	Pricing Analysis of Mechanical Systems
AP 06	Analisi Prezzi Impianti Gas Tecnici	Pricing Analysis of Gas System
AP 07	Analisi prezzi Oneri della sicurezza	Pricing Analysis of Security Costs
EP 01	Elenco Prezzi Opere Edili	Pricing List of Construction Works
EP 02	Elenco Prezzi strutture	Pricing List of Structures
EP 03	Elenco Prezzi Impianti Elettrici e Impianti Speciali	Pricing List of Electrical and Special Systems
EP 04	Elenco Prezzi Rete Dati	Pricing List of Data Networks
EP 05	Elenco Prezzi Impianti Meccanici	Pricing List of Mechanical Systems
EP 06	Elenco Prezzi Impianti Gas Tecnici	Pricing List of Gas Systems
EP 07	Elenco Prezzi Oneri della sicurezza	Pricing List of Security Costs
CM 01	Computo Metrico Estimativo Opere Edili	Estimative Metric Computation of Construction Works

CM 02	Computo Metrico Estimativo strutture	Estimative Metric Computation of Structures
CM 03	Computo Metrico Estimativo Impianti Elettrici e Impianti Speciali	Estimative Metric Computation of Electrical and Special Systems
CM 04	Computo Metrico Estimativo Rete Dati	Estimative Metric Computation of Data Networks
CM 05	Computo Metrico Estimativo Impianti Meccanici	Estimative Metric Computation of Mechanical Systems
CM 06	Computo Metrico Estimativo Impianti Gas Tecnici	Estimative Metric Computation of Gas Systems
CM 07	Computo Metrico Estimativo Oneri della sicurezza	Estimative Metric Computation of Security Costs

Table 15: Architectural Drawings

A 01	Stralcio P.R.G. del Comune di Fisciano	Section of P.R.G. Plan of Fisciano City
A 02	Planimetria di Inserimento urbanistico - P.U.A.	Urban Inclusion Planning – P.U.A.
A 03	Planimetria Generale dello Stato di Fatto con Sezioni	General Plan of State before the Design
A 04	Planimetria Generale di Progetto	General Plan of the Design
A 05	Pianta Piano Terra	Ground Floor Plan
A 06 – A07	Pianta Primo Livello e Secondo Livello	First and Second Level Plans
A 08	Pianta Copertura	Roofing Plan
A 09	Sezioni e Prospetti	Sections and Elevations

Table 16: Structural Drawings

ST 01	Pianta Fondazioni e Opere di Sostegno	Foundation Plan and Support Geotechnical Structures
ST 02	Corpo Scale	Stairs Structure
ST 02.1	Armature Travi di Fondazione 1/3	Reinforcements Foundation Beams 1/3
ST 02.2	Armature Travi di Fondazione 2/3	Reinforcements Foundation Beams 2/3
ST 02.3	Armature Travi di Fondazione 3/3	Reinforcements Foundation Beams 3/3
ST 03	Posizionamento dime	Positioning of Jigs
ST 04.1	Carpenteria Elementi Metallici - Livello I	Metallic Carpentry – Level I
ST 04.2	Carpenterie I e II Livello - Armature Integrative	Carpentry I and II – Additional Reinforcements

ST 05.1	Carpenteria Elementi Metallici - Livello II	Metallic Carpentry – Level II
ST 06.1	Carpenteria Elementi Metallici - Livello III	Metallic Carpentry – Level III
ST 06.2	Carpenterie III Livello - Armature Integrative	Carpentry III – Additional Reinforcements
ST 07	Prospetto Telaio B-B	Frame B-B
ST 08	Prospetto Telaio C-C	Frame C-C
ST 09	Prospetto Telaio D-D	Frame D-D
ST 10	Prospetto Telai 2-2 e 3-3	Frames 2-2 and 3-3
ST 11	Prospetto Telaio 4-4 e 5-5	Frames 4-4 and 5-5
ST 12	Prospetto Telaio 6-6	Frame 6-6
ST 13	Vista 3D - livello I	3D View - Level I
ST 14	Vista 3D - livello II	3D View - Level II
ST 15	Vista 3D - livello III	3D View - Level III

Table 17: Fire-fighting water systems

IA 01	Rete antincendio Esterna	External Fire-fighting Network
IA 02	Rete antincendio interna ai vari piani	Internal Fire-fighting Network for each floor
IA 03	Impianti idrici antincendio - Schema distributivo	Fire-fighting Water Network – Distribution Scheme

Table 18: Water and wastage systems

IS 01	Rete fognaria - Planimetria generale	Drainage System – General Plan
IS 02	Reti adduzione acque - Planimetria generale	Water Adduction Systems – General Plan
IS 03	Rete irrigazione - Planimetria generale	Irrigation System – General Plan
IS 04	Impianti idrici di carico e scarico - Livello 0	Water and Wastage Systems – Level 0
IS 05	Impianti idrici di carico e scarico - Livello 1	Water and Wastage Systems – Level 1
IS 06	Impianti idrici di carico e scarico - Livello 2	Water and Wastage Systems – Level2
IS 07	Impianti idrici di carico e scarico - Copertura	Water and Wastage Systems – Roofing Level

Table 19: Electrical and special systems

IE 01	Schema altimetrico dell'impianto elettrico	Altimetrical Scheme of the Electrical System
IE 02	Impianto elettrico - Schema unifilare quadri elettrici primari e secondari	Electrical System - Single-line Scheme of primary and secondary electrical panels
IE 03	Impianto elettrico - Planimetria distrib. primaria e secondaria e di automazione PT	Electrical System – Primary, Secondary and Automation distribution Plan PT
IE 04	Impianto elettrico - Planimetria distrib. primaria e secondaria e di automazione P1	Electrical System - Primary, Secondary and Automation distribution Plan P1
IE 05	Impianto elettrico - Planimetria distrib. primaria e secondaria e di automazione P2	Electrical System - Primary, Secondary and Automation distribution Plan P2
IE 06	Impianto elettrico - Planimetria impianto fotovoltaico - piano copertura	Electrical System – Plan of Photovoltaic System – Roofing Level
IE 07	Imp. di illum. e di emergenza e sicurezza - Plan. componenti e canalizzazioni - PT	Lighting, Emergency and Security Systems – Component Plan and Distribution - PT
IE 08	Imp. di illum. e di emergenza e sicurezza – Plan. componenti e canalizzazioni - P1	Lighting, Emergency and Security Systems – Component Plan and Distribution – P1
IE 09	Imp. di illum. e di emergenza e sicurezza – Plan. componenti e canalizzazioni - P2	Lighting, Emergency and Security Systems – Component Plan and Distribution – P2
IE 10	Allaccio esterno - cabina 7E - Planimetria componenti e canalizzazioni	External Connection – Station 7E - Component Plan and Distribution
RI 01	Impianto di Rilevazione Incendi - Planimetria componenti e canalizzazioni PT	Fire Detection System - Component Plan and Distribution PT
RI 02	Impianto di Rilevazione Incendi - Planimetria componenti e canalizzazioni P1	Fire Detection System - Component Plan and Distribution P1
RI 03	Impianto di Rilevazione Incendi - Planimetria componenti e canalizzazioni P2	Fire Detection System - Component Plan and Distribution P2

Table 20: Data network systems

RD 01	Planimetria Rete Dati Piano Terra	Data Network Plan Ground Floor
RD 02	Planimetria Rete Dati Piano Primo	Data Network Plan First Floor
RD 03	Planimetria Rete Dati Piano Secondo	Data Network Plan Second Floor
RD 04	Planimetria Percorso Fibra Ottica	Optic Fiber Distribution Plan

Table 21: Mechanical systems

IM 01	P&ID Impianto Climatizzazione	P&ID Air Conditioning System
IM 02	Schema funzionale impianto Aeraulico	Functional Scheme of Aeraulic System
IM 03	Layout Impianto Aeraulico Piano Primo	Layout of Aeraulic System First Floor
IM 04	Layout Impianto Aeraulico Piano Primo	Layout of Aeraulic System First Floor
IM 05	Impianto Idronico Piano Primo e Secondo	Hydronic System First and Second Floors
IM 06	Impianti Speciali Piano Primo	Special System First Floor
IM 07	Layout impianti Piano Terra	Layout of Systems Ground Floor

Table 22: Technical gas systems

IGT 01	Impianti Gas Tecnici	Technical Gas Systems
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