UCLouvain

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École polytechnique de Louvain

Sustainable architecture and modular construction

The new frontier of engineering

Author : **Luca Manuel Minerva**
Supervisors : **Pierre Latteur**, **Paolo Piantanida**
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Academic year 2021–2022
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to my BROTHER, to my MOTHER, to my FATHER,

foundations and pillars of my life,

always with me on this long journey

ABSTRACT

In abandoned places we will build with new bricks. There are hands and machines and clay for new bricks and lime for new mortar. Where the bricks have fallen, we will build with new stone, where the beams are rotten, we will build with new timber, where words are not spoken, we will build with new language. There is a common work, a Church for all, and a task for each: each to his work.

-Thomas Stearns Eliot-

Building is a great thing and it is first of all having a purpose and sharing it with others. Building is participating in creation, in which everyone makes a piece. Building is therefore working. Every piece, every job, every moment that construction is made of, is because you need that thing and it's because you stay. You build something, but through that thing you also build yourself. You become great. Man builds and in doing so builds himself.

Europe is a patchwork of landscapes that reflect the evolutionary pattern of man's past changes. The changes continue today to change our landscape and the environment, leaving large and often irreversible traces in the use of the territory. Europe has the highest percentage of land used for housing, production systems and infrastructure. Often conflicting demands arise in relation to land use, which requires decisions that will entail difficult compromises. Land is a finite resource: the way it is used is one of the main reasons for environmental change, with significant consequences on the quality of life and ecosystems. Most of the buildings in the world consume large amounts of energy and are built with polluting materials that degrade the environment with significant repercussions on human health.

Sustainable Building comes from the need to respect the close relationship between man, building and environment, reducing as much as possible the impact of buildings on the health of people and the environment, using non-harmful materials and minimising the use of resources that cannot be renewed. It can therefore also be considered a cultural approach, the concept of which can be summarized in "building and living healthy" in order to protect the well-being and protection of our ecosystem.

This work therefore aims to be an opportunity to immerse oneself in the great eternal challenge, that of the builder man, making everyone participate in his evolution. An adventure that has always been characterized by the goals achieved with new materials and the progress of scientific knowledge, today more than ever transformed by digital technologies such as those of the BIM methodology. Inside each work live the great challenges, the limits, the unexpected, the successes and the failures.

In balance between art and technique, between intuition and scientific rigor.

RÉSUMÉ

Dans les endroits abandonnés, nous construirons avec de nouvelles briques. Il y a des mains et des machines et de l'argile pour de nouvelles briques et de la chaux pour du nouveau mortier. Là où les briques sont tombées, nous construirons avec de nouvelles pierres, là où les poutres sont pourries, nous construirons avec du nouveau bois, là où les mots ne sont pas prononcés, nous construirons avec un nouveau langage. Il y a un travail commun, une Eglise pour tous, et une tâche pour chacun: chacun à son travail.

-Thomas Stearns Eliot-

La construction est une grande chose et c'est d'abord d'avoir un but et de le partager avec d'autres. Le bâtiment participe à la création, dans laquelle chacun fait sa part. Le bâtiment fonctionne donc. Chaque pièce, chaque travail, chaque moment de construction est fait, c'est parce que tu as besoin de cette chose et c'est parce que tu restes. Vous construisez quelque chose, mais à travers cette chose, vous vous construisez vous-même. Vous devenez grand. L'homme construit et en faisant cela se construit lui-même.

L'Europe est un patchwork de paysages qui reflètent le modèle évolutif des changements passés de l'homme. Les changements continuent aujourd'hui à changer notre paysage et l'environnement, laissant des traces importantes et souvent irréversibles dans l'utilisation du territoire. L'Europe a le pourcentage le plus élevé de terres utilisées pour le logement, les systèmes de production et les infrastructures. Des demandes souvent contradictoires se posent en ce qui concerne l'utilisation des terres, ce qui exige des décisions qui entraîneront des compromis difficiles. La terre est une ressource limitée: son utilisation est l'une des principales raisons du changement environnemental, avec des conséquences importantes sur la qualité de vie et les écosystèmes. La plupart des bâtiments dans le monde

consomment de grandes quantités d'énergie et sont construits avec des matériaux polluants qui dégradent l'environnement avec des répercussions importantes sur la santé humaine.

La Construction Durable découle de la nécessité de respecter la relation étroite entre l'homme, le bâtiment et l'environnement, en réduisant autant que possible l'impact des bâtiments sur la santé des personnes et de l'environnement, l'utilisation de matériaux non nocifs et la réduction de l'utilisation des ressources qui ne peuvent être renouvelées. Elle peut donc aussi être considérée comme une approche culturelle dont le concept peut être résumé dans "construire et vivre en bonne santé" afin de protéger le bien-être et la protection de notre écosystème.

Cette œuvre se veut donc une occasion de s'immerger dans le grand défi éternel, celui de l'homme constructeur, en faisant participer chacun à son évolution. Une aventure qui a toujours été caractérisée par les objectifs atteints avec de nouveaux matériaux et le progrès des connaissances scientifiques, aujourd'hui plus que jamais transformé par les technologies numériques telles que celles de la méthodologie BIM. À l'intérieur de chaque œuvre vivent les grands défis, les limites, l'inattendu, les succès et les échecs.

En équilibre entre art et technique, entre intuition et rigueur scientifique.

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PREMISE

Despite the tender love I have for my country, I never knew how to be a great patriot or a nationalist. And soon I was born a distrust of borders and a deep love, often passionate, for those human goods that by their nature are beyond the borders. As the years passed I felt ineluctably driven to appreciate more what unites men and nations rather than what divides them.

-Hermann Hesse-

It is always interesting to understand the reasons why a person decides to go abroad. And it is a theme, that of displacement, that has fascinated the thinkers of every age. The Latins, in this regard, spoke of *commutatio loci*, representing the existential failure of those who, expatriating, hoped to meet better fate elsewhere. In contrast to the wisdom of the Latins however, the benefits that this choice can offer are the most disparate. One of all: the chance to change your life and better understand who you really are. These experiences certainly help you to feel stronger and safer, allowing you to deal with all the more or less problematic situations that will arise in the future. In these eighteen months the unforeseen have not been few but in the end you learn to stand up stronger than before and always with your head held high.

Moving alone to a foreign country involves sacrifices and a spirit of adaptation. But the discovery of new habits and new cultures is just what it takes to deal with any kind of situation in life with a more open and flexible mind. Improving one's own problem solving processes means acquiring a greater sense of autonomy: being able to react to the various challenges of life and not feeling overwhelmed by them; exercising power over decisions that affect oneself and not feeling helpless with respect to important choices are fundamental factors for a person's sense of independence.

Abandoning your usual context allows you to take a critical distance even towards yourself, and only by looking at your life from the outside you can see all those elements that are intoxicating you. We are used to seeing stability as a value, a clear sign of clear ideas, and change as a weakness, as if physiological insecurities and confusion were a shame to hide. This way of thinking makes it more difficult to achieve personal satisfaction. What we need is a good dose of courage to get rid of unnecessary opinions and prejudices and to be able to live authentically. Authenticity is not an innate condition, but is the result of a path made of breaks, contradictions and changes in which you are called to continuously redesign your social role.

It is as if every day we were wearing a mask that represents our being, that we remove when we leave, but that at every return is exactly where we left it, and we can only wear it again, even if it would no longer be our job to do it. Of course, it's not easy to embrace change. Because the human mind is afraid of the unknown, and by definition abandoning one's country means plunging into the unknown. It is not enough to change our coordinates so that all our problems automatically find a solution, but moving abroad can be the moment of radical rupture that you need to understand what is not working, where you can improve, what's best to give up.

Nowadays, in which many young people graduate and the labour market is increasingly saturated, the difference, rather than the degree, is made by the experiences that each of us lives over the years. Erasmus, therefore, is something that everyone should look forward to. Even more so if the course includes the "Double Degree": in my case Master Degree in Building Engineering at the Polytechnic University of Turin (Italy) and Master Degree in Civil Engineering at the *École Polytechnique de Louvain* (Belgium). Getting a double title still sounds "out of the chorus" because for the most part it seems to be just another "piece of paper" to frame.

In fact, I believe that such an experience can broaden horizons, both personal and professional. Of course it is not all easy, there is a lot of work to be done and the effort is great but the satisfactions certainly will not be late to arrive. There have been and continue

to be many discussions about what is the best between civil engineering and construction engineering. Regardless of all the debates, the point is that, in many ways, both careers have been very crucial to the rapid progress of our society. The field of civil engineering is one of the oldest branches of engineering; it is a discipline that deals with the design, construction and maintenance of the physical and natural environment including large public works. Construction engineering has to do with applying technical and scientific knowledge to the construction of infrastructure. The academics and curriculum of these two branches of engineering are somewhat similar and sometimes used in the same context. You have to have real talent to succeed in a career as a civil engineer or construction engineer. Pursuing a career in construction or civil engineering is usually very rewarding. So why not combine the two different but complementary professions in a single course of study?

What does the future hold for the engineering profession? The time pressure associated with increased workload and increasingly simple and immediate international communication, are changing the skills required for designers who will increasingly assume the role of project manager to face more coordination tasks. Have an increasingly interdisciplinary mentality in order to shorten the gap between the different countries of the world.

The impact of Coronavirus has shown how vital soft skills are as flexibility and adaptability for engineers, but these capabilities will be needed even after the pandemic is over. The ability to adapt quickly to the new circumstances will remain important even when it is over, because the pace of change is growing in the world of work and will increase further in the years to come.

It is the match between innovation and traditionalism that will define the future of construction. It will have to answer the tumultuous questions of society and the economy of the post-Covid era, in a world that does not want to stand still. New housing, work and infrastructure are rapidly being defined. The technologies to accelerate are already there, others are born every day: we must eliminate the cultural, political and regulatory barriers that hinder them. Building can be the engine of economic recovery, converging on some key concepts such as environmental and social sustainability and technological innovation.

In addition, no one thinks of the building as a mere shell anymore, because evolution leads us to see it as a "system", in which the different systems evolve and integrate, to provide users with optimal and sustainable living conditions. In this context, the synergy between the various technologies will be the driving force.

The only certainty is that in a limited world unlimited development is impossible. At this rate, with the progressive consumption of available resources, by 2030 we will need a second Earth, which does not exist. It is therefore necessary to draw the road on two parallel tracks. On the one hand we must operate with intelligent and significant redevelopment measures on the existing assets, trying to improve as much as possible the energy consumption compared to the energy monster that represents today the majority of the building of the last decades. On the other hand, it is necessary to establish clear, precise and, above all, shared laws on new buildings, with related protocols that indicate the way to be followed in order to realize really efficient dwellings and structures with almost zero consumption.

There is no doubt that the cultural leap that this choice imposes in some parts of the country and in the sector is radical, and therefore we need to convince people, technicians, local administrations not only of this new perspective, but also the consequences that this would entail, namely more training and more expertise to produce results in terms of energy savings.

We need to invest a lot in training. And this is the path that is perhaps still being underestimated, and we need this kind of experience to spread across the country.

CHAPTER 1

URBAN OBSTINATION

CONSTRUCTIVE POLITICS

If you tell the adults: «I saw a beautiful pink brick house, with geraniums on the windows and doves on the roof...», they cannot imagine the house. You must say: «I have seen a house of a hundred thousand francs». Then they immediately exclaim: «Oh, what a beauty!»

-Antoine de Saint-Exupéry-

In recent times economic historians have begun to pay more attention to construction thus obviating a paradoxical situation, namely the presence of a sector of obvious economic importance that had been studied very little, if not hastily liquidated[1] at the time of the deep economic crisis of our country.

Studying the building sector in depth offers not only the opportunity to create opportunities for contact with other disciplines, but is primarily a way to enrich economic history in different directions. Think first of all of the history of productive activities, dominated, as far as the pre-industrial age is concerned, by studies on the textile sector and on metal working, with the inevitable distortive effects that are derived from it.

Beyond the mere quantitative data, the study of this sector of activity is able to clarify very well the operational logic of the "merchant entrepreneur"[2]. At the same time, it should be stressed that control of the supply, if not of production, of building materials has been a

[1] JEAN-FRANÇOIS CHAUVARD – LUCA MOCARELLI, *City and History*, year IV, no. 1, pp. 65-88, Roma Tre University-CROMA, 2009

[2] MANUEL VAQUERO PIÑEIRO, *The University of Fornaciai and the production of bricks in Rome between the end of the 1500s and half of the 1700s,* in *Modern and contemporary Rome*, vol. 4, no. 2, pp. 471-494, REGESTA IMPERII, 1996

fundamental component in the construction of the fortunes of large contractors of construction works. If we then move on to consider the contemporary age, we cannot fail to highlight how the changes in scale produced by industrialization also with regard to building materials and the presence of epochal innovations in the sector, like reinforced concrete and prefabrication, have led to the emergence of successful multinational realities.

The study of the relationship between the construction sector and the economic cycles has acquired full legitimacy in the field of the history of cities and economy. This evolution is recent, and authorizes the reflections of works that have helped to recall how this area of research has long been neglected by both architectural historians[3], more concerned about the concrete achievements than about the conditions under which they are implemented, both by the economy, which is inclined to give primacy to the study of trade, agriculture or proto-industry, and which, in fact, have tended to interpret in negative terms the link between investment in construction and economic development.

Historians agree on one point: at the origin of the immobilization of capital in the brick there is an impressive accumulation of wealth generated by the long period of prosperity of the country's economy. Nevertheless, the periodic absence of coincidence between the period of economic dynamism and building development has led some to express reservations about this correlation.

Of course, purchases of land and real estate were already in the Middle Ages, but in the flourishing times of commerce they were the tangible sign of a wealth acquired on the seas and in fairs and a secure investment to guard against the risks of distant enterprises. In modern times the nature of land ownership has changed, becoming the essential component of assets, at different levels according to the families. Within two or three generations, the merchant became a landowner[4]. If the marginalization of commercial and industrial activities by the major merchant dynasties in favour of safer investments, in particular land, is indisputable, however, the chronology and modalities of the process need to be clarified.

[3] ALBERTO GROHMANN, *Construction and the city. Historiography and sources,* in *Construction before the industrial revolution secc. XIII-XVIII, Acts*, pp. 109-136, Datini International Institute of Economic History, 2005
[4] FREDERIC CHAPIN LANE, *The merchants of Venice*, pp. 3-121, Giulio Einaudi publisher, 1996

It is necessary to reiterate a seemingly obvious aspect: construction was not conditioned by the development of commercial activities, but by the economy of annuity as a whole. During urban expansion, the capital employed in the construction of buildings could generate large profits mainly due to demographic pressure.

When the urban territory could no longer expand, the investment in brick was directed to the purchase of existing properties but remained profitable. If construction can legitimately appear, as the case may be, as a sign of prosperity or as a result of a change of orientation in investment, it is precisely because the sector was subject to a series of circumstances that each obeyed different timing. None of them, taken in isolation, constituted a sufficient explanatory key.

The dynamism of the construction sector also depended on the diversity of the players involved. The more potential clients – ecclesiastical institutions, hospitals, public offices, confraternities, princes, nobles, merchants – were involved in the lotting operations, the more wealth was distributed among numerous people who shared in emulation, and the more conditions of a sustained constructive rhythm were present. Finally, it is necessary to recall the decisive role played by the public authorities in defining legal frameworks favourable to expropriation and construction, in pursuing a more or less pro-owner-friendly fiscal policy and in exercising forms of protection over the organisation of work.

The list of factors influencing the sector could be further extended, but the challenge is above all to understand their hierarchy and their evolution over time. In this direction, historian Aleksander Panjek proposes a global analysis of the construction trend showing the interaction and possible correlation between commercial development, the legislative machinery, public planning of infrastructure works, the strong demographic growth and the impulse represented, in a purely mercantile economy, by real estate investments aimed at obtaining credit and having access to the capital of insurance companies[5].

[5] ALEKSANDER PANJEK, *Construction and development. The city and free port of Trieste in the eighteenth century*, in *Construction before the industrial revolution secc. XIII-XVIII, Acts*, pp. 723-735, Datini International Institute of Economic History, 2005

All these factors made up a system which was now in favour of, now at the expense of, the dynamism of the sector. The ambition to hold all the threads together and to propose a global interpretation in the long term allows to escape the blindness to which the study of a single yard can lead, authorizing comparisons with other realities.

1.1 THE EVOLUTION OF THE BUILT WORLD

If there's one thing evolution history has taught us, it's that life doesn't allow you to stand in its way. Life breaks free, expands into new territories and breaks down all barriers painfully, maybe, dangerously, but... That's all.

-Jeff Goldblum-

According to Vitruvius «*stone, earth, bricks, lime, sand, some pigments and lead*» are the basic building materials[6]. Over the centuries, architects and designers have added new materials to the building, creating increasingly complex buildings both from an architectural and aesthetic and decorative point of view. From the Egyptian pyramids built with simple blocks of granite, the history of building materials has undergone a constantly expanding evolution that often translates into a stylistic choice and a constant research that listens to the needs of man, the culture and consumption of society.

The house, intended as a residential property, over the centuries has undergone infinite variations both sociologically and architecturally and structurally. From the dawn of time, the search first and then the construction of a house was an essential activity for man; however, the house was interpreted in a very different way from the way in which it is conceived today[7].

Architecture is an art that finds its origins in the Middle Ages and is made by men with the aim of placing individuals in space not only real, but also mental and has the aim of

[6] «*In all these things that one has to do, one must have for his purpose solidity, utility, and beauty*». Thus Marcus Vitruvius Pollio wrote in his *De Architectura*, text and theoretical foundation of Western architecture, about any construction whose intent was to survive history

[7] RENATO GUIDI – ROBERTO SANTORI, *The history of building materials from the pyramids to Dubai Al Mamzar*, Bioedil Projects, october 2017

developing and growing in the interiority of the human being a full self-awareness. At the center of this great art we find a very important concept and worthy of meaning: the word "living" represents an expression that manages to combine physical, visual and tactile experience, where its meaning has changed over the years.

The history of the built was born with the aggregation of man into a tribe. In the Upper Paleolithic man began to design the first villages consisting of wooden huts and animal skin. In the Neolithic, due to unfavorable environmental conditions such as cold and frequent rains, there were the first wooden houses with roof. Up to more complex constructions in the Bronze Age when the first carpentry work gave life to the stilt houses. The building materials began to evolve and vary; the first stone architectures for the construction of buildings and walls were diffused.

In the classical age, thanks to the new construction techniques, the first complex constructions took place: temples, villas and places of the city public life. They laid the foundations of the styles of templar architecture of the Mediterranean civilizations: Doric, Ionic and Corinthian.

Hundreds of years later, the Romans discovered themselves real competent and conscientious builders: they were the first, in fact, to wonder if a land was suitable or not to bear the weight of a building and so they began to analyze it, to solidify it and then to build by developing materials processing techniques that gave life to Roman concrete, a building material considered one of the most resistant thanks to its unique composition. In addition, new building materials were introduced and the techniques of working with existing materials were implemented: brick became the standard for construction, while stone was a covering to beautify the most important structures.

In the Middle Ages the art of Gothic builders dusted off the use of stone that was used for the most prestigious works such as churches and castles. At this time, glass began to spread as a material for the embellishment of buildings.

In the Renaissance period the use of stone was set aside to give space to the use of brick that dominated the scene of building materials until the nineteenth century. He depopulated the

use of plaster both as a reinforcement and as an aesthetic element to give continuity to the lines of the surface. We discover the sense of welcome and hospitality that led to a transformation of housing that followed this artistic influence going in search of beauty. It was the Industrial Revolution of the second half of the nineteenth century that brought great innovation in building materials. Reinforced concrete, iron and steel laid the foundations of modern buildings. This period saw a huge increase in the demand for housing which unfortunately turned into the first construction speculation in history.

In October 1965 the Italian SAIE, the International Exhibition of Building Industrialization, was born. The experience and the parable of this event were decisive for the culture of the sector, in many respects[8]. Thousands of engineers and architects, surveyors and experts, entrepreneurs and craftsmen, as well as students, have learned and updated on new regulations and technologies and have grown in awareness of their role and in the development of a complex and multidisciplinary culture of primary importance, at a time of maximum expansion of plans and investments in our country.

The advent of Personal Computers has allowed designers and technicians to speed up the calculation, the graphic definition of projects in CAD environment, up to the development of more sophisticated software for 3D and Virtual Reality representation and when the Internet and digital technologies became available to support this sector they enabled a great deal of design progress, the planning and programming of works. Today the challenge of the BIM represents the landing place of this path.

The specialization of each building has increasingly moved it away from its original archetype, of which it is no longer related. The building is a sum of systems, each of which becomes increasingly sophisticated, but closed in on itself. Intelligence is all in the technological subsystems, and does not pervade the system as a whole[9].

[8] GIUSEPPE STAGNITTO, *Scientific evolution and construction. History of scientific methods applied to architecture and engineering*, C.L.U., 2005

[9] MARIO BUTERA, *The building that evolves*, in *QualEnergia*, year XII, no. 4, Legambiente Bimonthly, november 2014

The variety of building materials today is so wide that it allows designers to push the architectural rod higher and higher.

From High-Tech architecture with its smog-eating cement and self-supporting structures, through the examples of green building characterized by self-sufficient homes thanks to technologies that exploit renewable resources, the most innovative anti-seismic systems, up to the new trends in building materials such as translucent cement, osmotic cement and even recycled cardboard, building materials give a new impetus to the design universes.

1.2 THE ANTHROPIZATION OF THE NATURAL LANDSCAPE

Many are the extraordinary things, yet nothing more extraordinary than man exists; this even beyond the grey sea with stormy wind advances, under waves of rumbling proceeding, and among the goddesses the highest, the indestructible Earth, tireless he weary treading ploughs from year to year, treating it with equine species.

-Sophocles-

The Italian landscape is now at the center of a heated debate, aimed at considering the problem of its protection in relation to its precise enhancement, in the awareness that protection and development of a territory are indispensable conditions for planning a future[10].

In a few decades, especially since the Second World War, we have witnessed an impressive and progressive transformation of the territory, characterized by an intense reconstruction and urbanization that accompanied in a disorderly way a late industrial revolution, reaching cementification rates in the territory far removed from the limit values established at national level.

[10] ANDREA DALL'ASTA – MASSIMO VENTURI FERRIOLO, *The betrayed landscape. Glimpses of a compromised territory*, in *Landscape Biennial-Reggio Emilia*, Galleria San Fedele in Milan, 2006

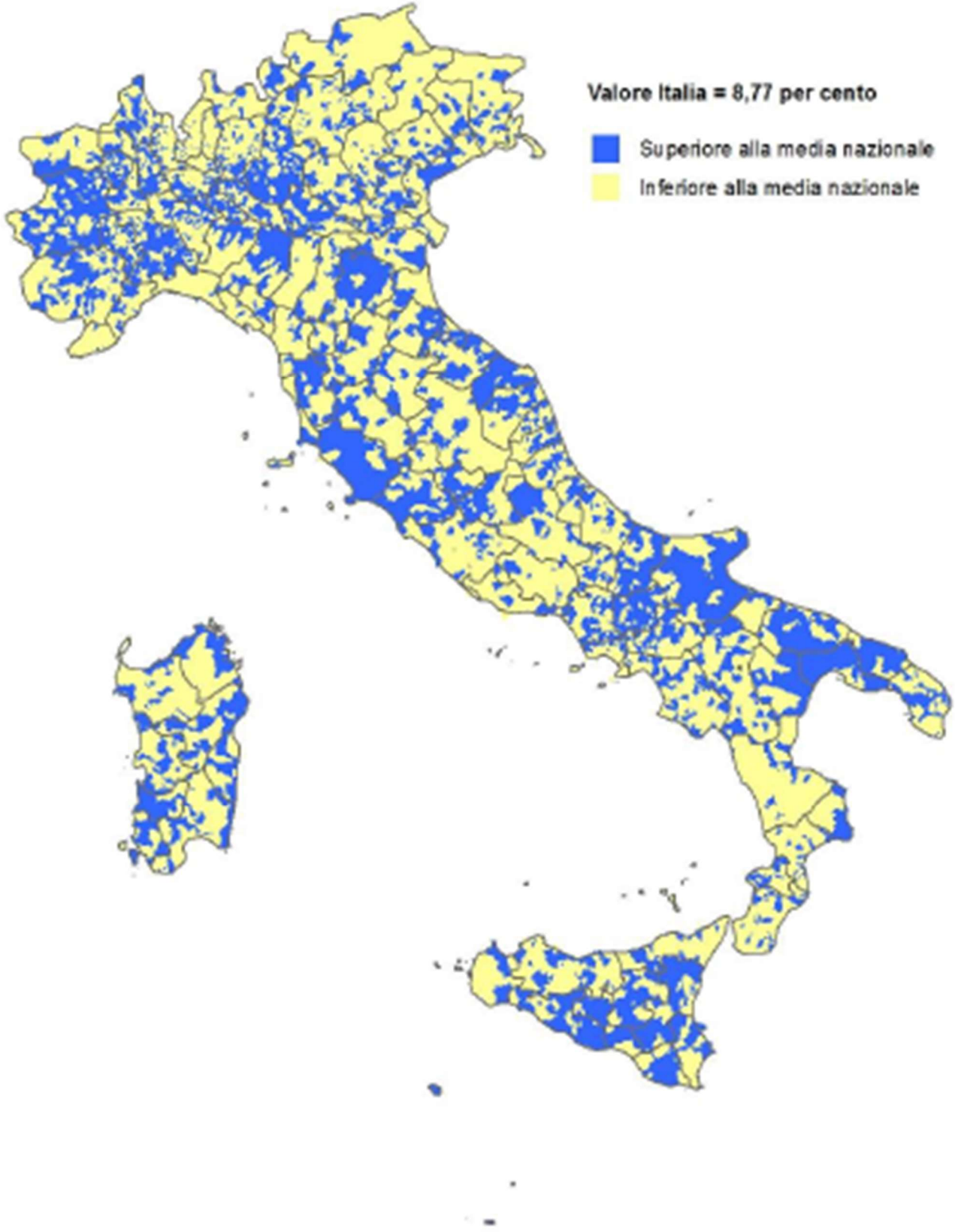


Figure 1: Cementation of the national territory in the last ten years (2001 – 2011) {ISTAT 2012}

More than 55% of Italian territory has zero soil permeability

Although in other European countries – Denmark, Luxembourg, Finland, Sweden, Norway – social economic development has tried other ways to defend the quality of the environment, in Italy too late the awareness of the need for integration between protection and safeguard policies and development policies has arrived. On the contrary, often, in these countries, the more development has increased, the more the environment has been protected and the cities safeguarded. In Italy, the uncertainty of spatial planning and an almost total insensitivity to the landscape in its ecological, aesthetic, historical and social aspects, have given rise to a settlement chaos that has not spared environmental havoc, buildings without architectural qualities, endless suburbs developed like oil and without infrastructure, the cementing of the coasts. It has allowed the development of a building without rules.

Man builds, lives and builds. He knows no stopping. He creates and characterizes his home, perfecting it more and more: an occupation in continuous movement. No place can be fixed; it marks the space it fills. It creates places characterized by the contemporary presence of present and past. A millennial relationship founds the widespread aesthetics of a landscape, shaped by art that projects the temporary human existence beyond the passage of time. Without memory there is no prospect of life[11].

The landscape changes over time. Before man appeared on Earth, its appearance depended solely on natural forces such as mountain formation, erosion, earthquakes. The first signs of human presence on the planet were paths and bridges, used to move from one place to another to hunt for food, to escape animal threats or in any case to look for better living conditions. All this allowed man to get in touch with other people. When man became sedentary and began to cultivate the fields he also began to leave more and more evident traces of his presence in the landscape: he learned to control the waters of rivers by building dams, canals, locks. This made the land more fertile and led to the development of agriculture. Over the years, to have more and more land for agricultural use, has felled forests, irrigated soils poorly fertile, reclaimed marshland.

[11] MARC AUGÉ, *Ruins and rubble. The sense of time*, Bollati Boringhieri, 2004

The invention of the steam engine and the great availability of mineral and energy resources such as iron and coal led to the Industrial Revolution in the 1700s with the birth of factories that attracted thousands of workers who left the countryside, more and more depopulated to move to the city. Mineral deposits were excavated and facilities built for metal working. Railways were built to make the transport of people and goods faster and cheaper. Consequently, man changes the landscape to suit his own needs. He cuts through the woods to get timber and to cultivate the soil; he creates roads and tunnels that pierce the mountains; he builds cities and ports on the sea; he creates artificial lakes to produce electricity: he transforms the environment to live better.

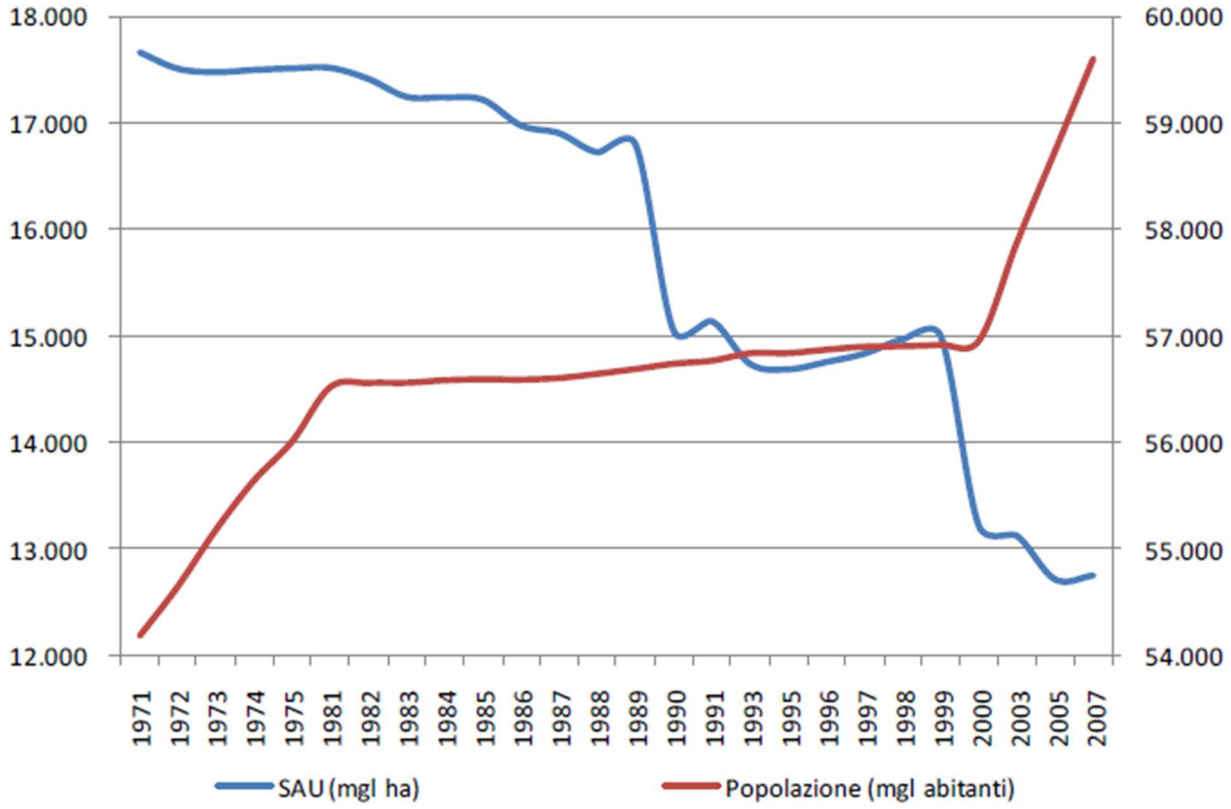


Figure 2: Evolution of the Utilized Agricultural Area (SAU) and demographic trend {INEA-ISTAT}

The gap between demand and availability of natural resources has now become unbridgeable

Landscapes are therefore a complex construction of human life. They express its qualitative essence: we observe what we have done for good and for evil with the associated socio-cultural modifications. Man is indeed a "builder", but it is through a project that most of the time fails: that of the human world. To denounce a state of affairs and a reality which unfortunately operates, also means proposing solutions, opening a debate on the possibility

of recovering a lost relationship with the landscape, in order to save the material and spiritual patrimony of our society. The European Landscape Convention[12] recognizes to the inhabitants of a given place an active role for any decision related to the transformation of landscapes, to offer them the opportunity to identify with the territories where they live and work, to give them the opportunity to identify with the overall context of their lives in the ethical totality of their characters, with their history, with their traditions, especially with their culture. Perhaps, today, fewer concrete monsters are built, in contrast, the building interventions appear more widespread and pervasive. Last but not least, we are witnessing the parallel and progressive abandonment of that building of the past that had characterized the Italian landscape for centuries. The awareness of the transformation of the Italian landscape cannot therefore be limited to a mere denunciation, but it should make us reflect on the ways in which a company can launch management models that are able to promote actions of environmental protection and social responsibility with a serious development policy. Addressing the theme of the landscape, means educating every citizen to respect and value the territory as a collective good. The landscape cannot be exploited. The citizen is called to perceive the identity value of the landscape as a place where he plans his own history. It is about promoting a real culture of the environment. Man creates space and in some way reflects its image. It is necessary to learn to inhabit the earth, to know how to guard it, to take care of it.

1.3 GLOBAL STATUS REPORT

Our contemporaries mobilize more easily for the future of their retirement than for that of the planet, when the planet has already entered the phase of retirement and is preparing – shaken by global warming and pandemics – to lose all its laboriously accumulated assets over the millennia.

-Fabrizio Caramagna-

The construction sector is the source of 38% of total CO_2 emissions related to energy.

[12] The Convention is the first international treaty dedicated exclusively to the European landscape as a whole. Equally recognizes landscapes considered exceptional, everyday landscapes and degraded landscapes

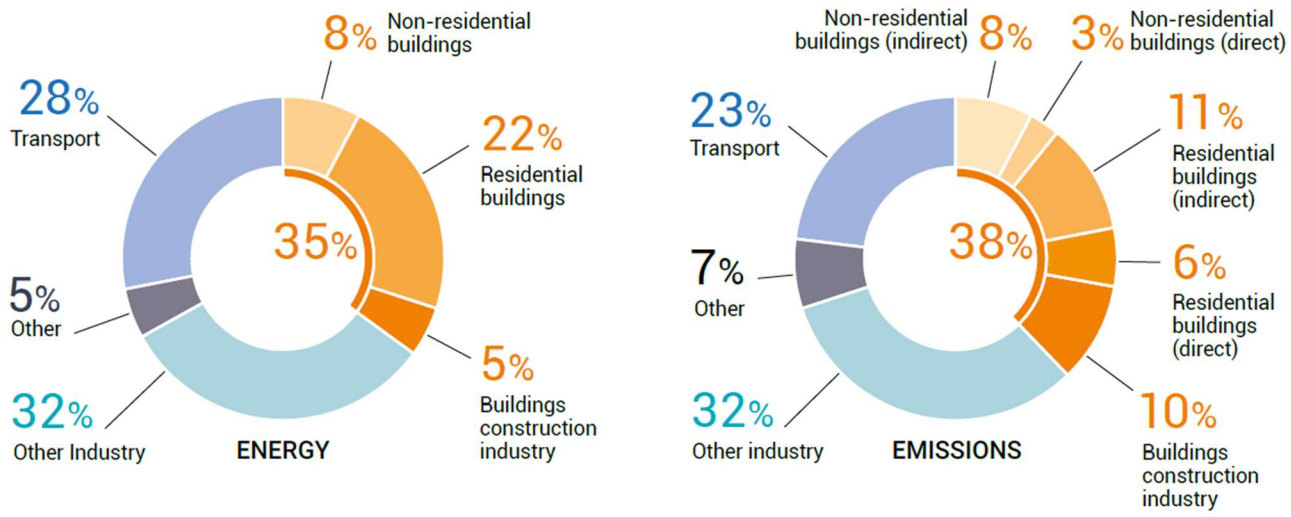


Figure 3: Global share of energy and final emissions of the building sector {IEA-2020d}

That of the constructions represents the section more consuming and polluting of the world-wide economy

According to the new UN report[13], emissions from the operation of buildings have reached the highest level ever touched. While the global energy consumption of buildings has remained constant year after year, energy-related CO_2 emissions have increased to 9.95 gigatonnes in 2019. The increase is due to the shift from the direct use of coal, oil and traditional biomass to electricity, which had a higher CO_2 content due to the high percentage of fossil fuels used in energy generation.

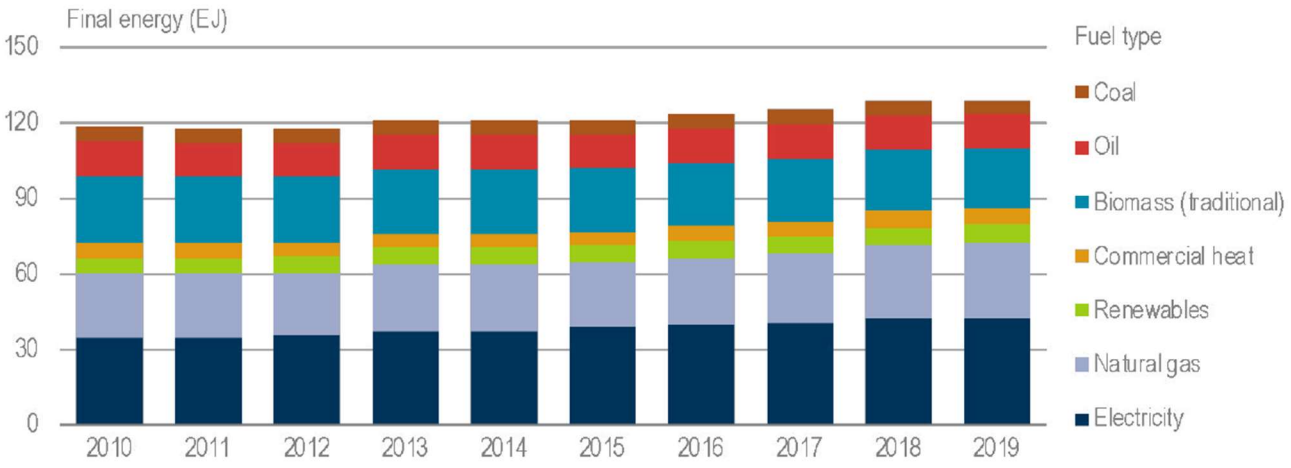


Figure 4: Final energy consumption of the global building sector by type of fuel {IEA-2020d}

Over the past decade, the consumption of non-renewable fuels has increased rather than decreased

[13] UNITED NATIONS ENVIRONMENTAL PROGRAMME, *Global State of Buildings and Construction Report: Towards a Zero-Emission, Efficient and Resilient Buildings and Construction Sector*, Global Alliance for Buildings and Construction, 2020

This underlines the importance of a targeted strategy to aggressively reduce energy demand in the built environment, decarbonising – and thereby reducing the carbon-hydrogen ratio in energy sources – the energy sector and implementing materials strategies that reduce carbon emissions throughout the life cycle of the building. In order to achieve a zero-carbon building stock by 2050, the International Energy Agency estimates that direct CO_2 emissions from buildings will have to decrease by 50% by 2030 and indirect emissions from the construction sector by 60%.

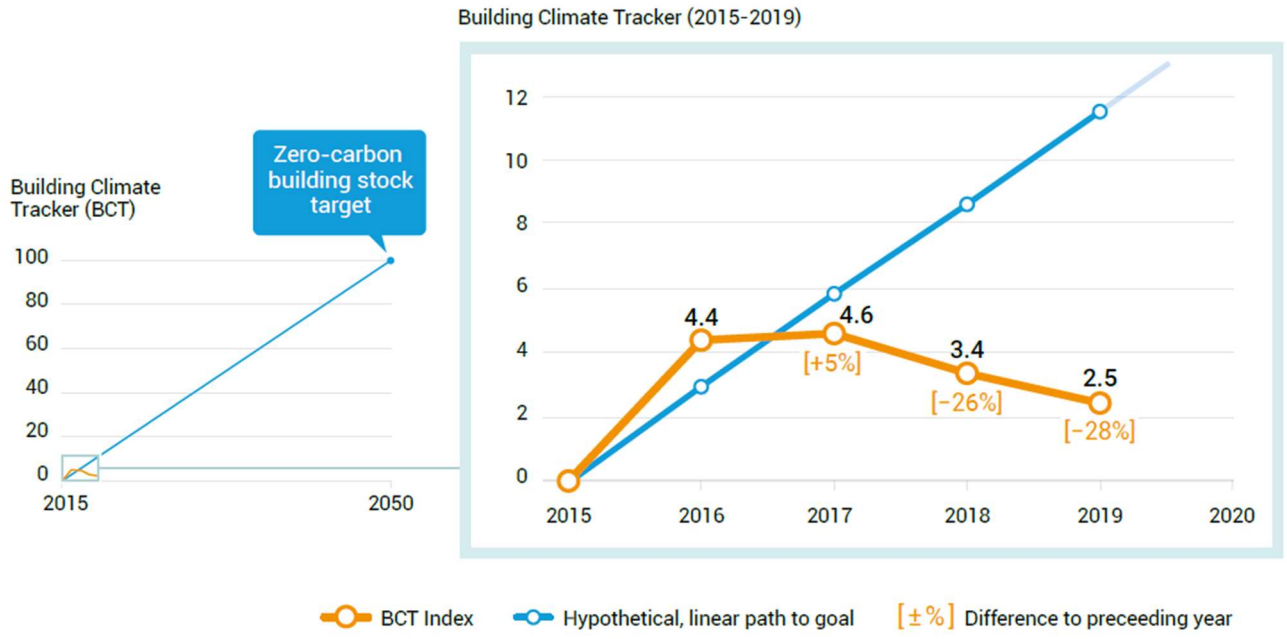


Figure 5: Trend of the decarbonisation index for buildings and constructions {IEA-2020d}

The trend of decarbonisation is moving further and further away from the Global Agenda 2030

Governments could help achieve these results by systematically including measures for the decarbonisation of buildings in recovery programmes, increasing restructuring rates, channelling investment into low-carbon buildings, thus providing jobs and increasing the value of real estate. Many countries have not yet submitted their Determined National Contributions plan to help maintain global temperature growth within 2 Celsius degrees. Unfortunately, the construction sector lacks specific mitigation policies despite its global importance. Today, more buildings than ever are built using sustainable building codes and certification standards. However, these need to be strengthened and expanded in order to achieve the zero emissions target across the sector.

In 2019, expenditure on energy-efficient buildings increased for the first time in three years, with an increase in the energy efficiency of buildings in global markets of up to 152 billion dollars in 2019, 3% more than the previous year[14]. Investors, therefore, should reassess all real estate investments through an energy efficiency and CO_2 reduction lens.

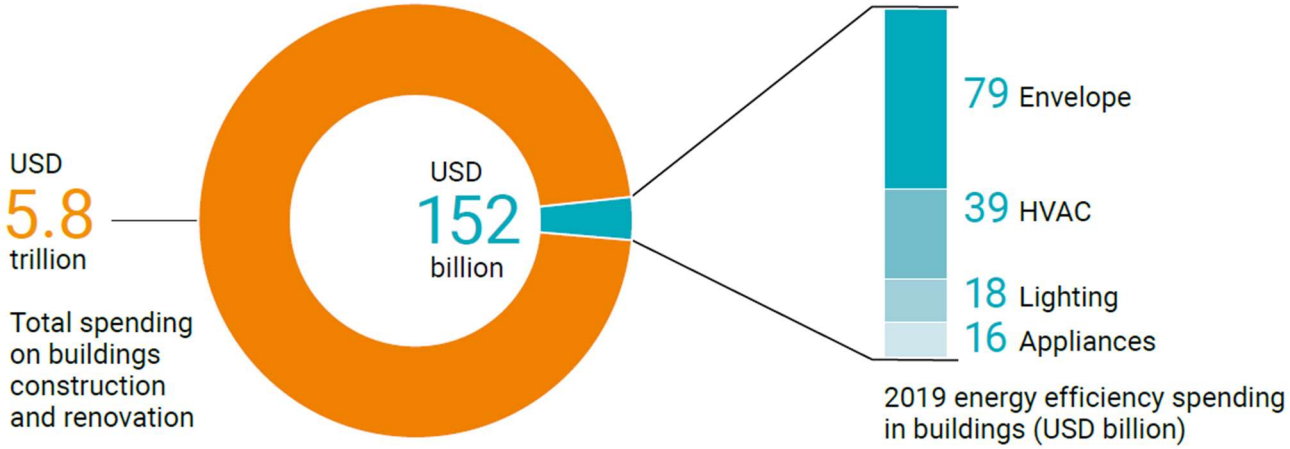


Figure 6: Investments in construction and energy efficiency {IEA-2019b}

Energy efficiency expense only amounts to 0.003% of total expense in the construction sector

In the last two years, the global health crisis has added to the housing crisis, further destabilizing the whole world. Indeed, as many people around the world are forced to spend an increasing amount of time indoors, well-ventilated and energy-efficient buildings are crucial for public health, air quality and economic recovery. The slowdown in global construction will have a knock-on effect on sustainable building development, but it will also provide a time for governments and private organisations to restore and realign commitments to higher levels of sustainability in the future. Stimulus programmes for the construction and construction sector are a proven tool to respond to economic crises, as they create jobs, stimulate economic activity and activate local value chains. Out of this emergency situation, it will be time for the breakthrough: firstly because economic recovery reforms will be adopted to rebuild our economies, thus offering a unique opportunity to include in-depth renovation of buildings and performance standards for new buildings; secondly, because in view of the new plans of Determined National Contributions, there

[14] CLAUDIO GERINO, *UN: buildings' CO_2 emissions are record-breaking*, in *La Repubblica*, year 27, no. 49, GEDI Publishing Group, december 2020

will be an opportunity to strengthen and include more explicit measures in the entire construction sector. It is therefore high time that governments, together with public and private organisations, undertake assessments of their carbon contributions and develop detailed strategies from which to support the transition to a sustainable global housing stock, zero net carbon emissions.For all other actors along the value chain, it means adopting concepts on the circular economy to reduce the demand for building materials and reduce embedded carbon and adopt solutions that improve the resilience of buildings. A circular built environment is based on an emerging economic model that covers both techniques and business models to keep the materials and resources in use as long as possible, and ideally forever, in an extended use cycle, reuse and recycling where the potential of materials is enormous. The development and implementation of new technologies are needed to reduce the demand for construction materials and enable their circularity and contribution to resilience.

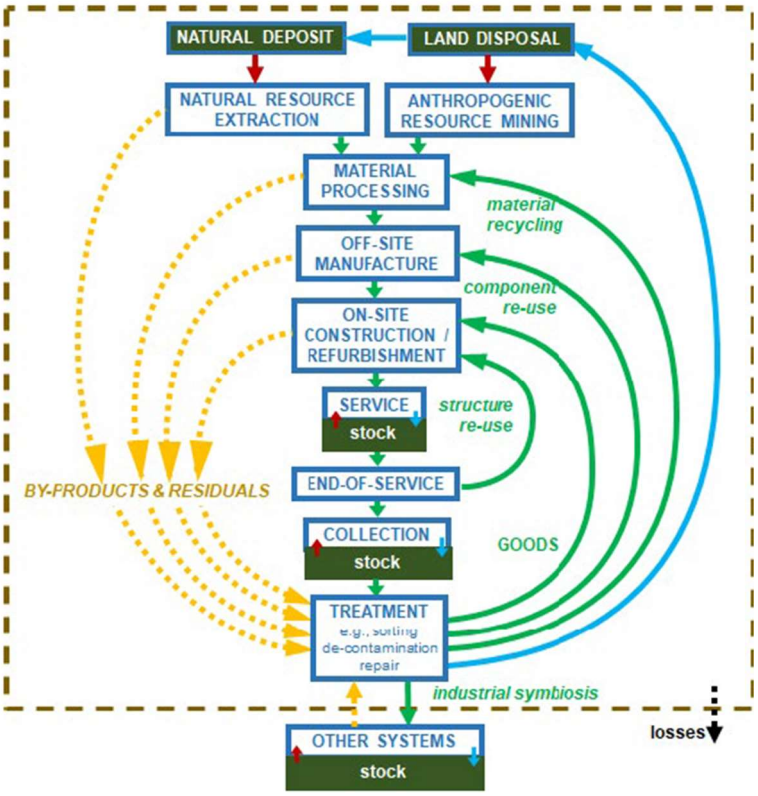


Figure 7: Circular economy of building materials {IEA-2020d}

Make the most of available resources from materials sharing and recycling processes

Just to name a few we find new-generation solar panels but also innovative solutions to increase the potential of offshore structures for wind or alternative materials to replace the traditional concrete in buildings. And more heat pumps and geothermal systems, high efficiency engines for Industry 4.0 and advanced technologies to increase the circularity of plastics. Very rich is also the section that collects projects intended to increase the energy performance of buildings, where stands out the widespread use of intelligent sensors and digital tools in design and engineering processes[15].

All this presupposes the consideration of health principles in the development of new buildings and in the renovation of existing ones to safeguard the community. Only then will we fully align with the Sustainable Development Goals; only then will we achieve a zero-emission, efficient and resilient construction sector, ensuring that our livelihoods are protected now and in the future.

[15] GIANNI RUSCONI, *Here are the technologies that will reduce CO_2 emissions in Europe*, in *Il Sole 24 ORE*, year 156, no. 294, Group 24 ORE, october 2020

CHAPTER 2

CONSUMPTION OF LAND

TERRITORIAL DYNAMICS

Man is the only creature that consumes without producing. He doesn't give milk, he doesn't lay eggs, he's too weak to pull the plow, he can't run fast enough to catch rabbits. And yet he is the king of all animals.

-George Orwell-

The consumption policies and continuous growth of the last century have caused the impoverishment of the landscape, reducing its value and privatizing it. Today it is therefore vital to think about sustainable land use through the reuse of disused areas[1]. A strategy that is taking hold in European territories is that of the architectural grafting in interstitial places of the consolidated fabric of cities.

The aim is to limit the outward expansion of population centers by saturating disused places through contemporary compositional methods. It is therefore necessary to enhance the abandoned places and urban voids of the city by solving its problems.

To reclaim itself, the territory needs an interdisciplinary and integrated path of regeneration, functional to the future development of the area. Many of the attempts made failed due to the complexity of the issues to be addressed. The alternative to failure is a change of perspective[2]. There are many ways in which you could face the transition from

[1] LUCA GAMBINI, *Urban ruins: a recovery project for the abandoned church of San Nicolò di San Felice in Bologna*, Master's Degree Thesis, University of Bologna, 2017

[2] ILARIA GUIDALOTTI, *Urban obstinacy. Experiences, addresses and tools for integrated urban regeneration processes*, Master's Degree Thesis, University of Bologna, 2017

the recent economic crisis. One of these is the ability to seek with conviction a sartorial logic and not tire of exploring together with the market, operators and institutions of possible ways for urban renewal.

The protection of the environmental heritage, the landscape and the recognition of the value of natural capital are tasks and themes to which Europe recalls, even more fundamental for us in the light of the particular conditions of fragility and climatic criticality of our country. Particularly marked is the consumption of land in peri-urban and urban areas, where there is a continuous and significant increase in artificial surfaces, with an increase in the density of the building at the expense of agricultural and natural areas, together with the criticality of the areas around the infrastructure system, more fragmented and subject to interventions of artificialization because of their greater accessibility.

Land consumption, land degradation and the loss of the functions of our ecosystems continue at an unsustainable pace, while the gradual slowdown of new artificial coverings of past years, mainly due to the economic crisis, stopped. In some areas of the country, it consolidates, on the contrary, a reversal of the trend, with a resumption of the transformation still to the detriment of the natural soil, due to the absence of effective regulatory action or pending its implementation and the establishment of a homogeneous policy framework at national level.

The initiative of the Regions and Local Administrations seems to have succeeded marginally, for now, and only in some parts of the territory, to stem the increase in artificial areas, making clear the inertia of the phenomenon and the fact that the current instruments have not yet shown the desired effectiveness in the governance of land consumption. This represents a serious *vulnus* in view of the hoped-for economic recovery, which must not be accompanied by a resumption of the artificialisation of natural soil, which fragile national territories can no longer afford[3]. A substantial reduction in land consumption, in order to achieve the European objective of its zeroing soon, is the prerequisite for ensuring a

[3] MICHELE MUNAFÒ, *Land consumption, territorial dynamics and ecosystem services*, in *Report SNPA 08/19*, Isprambiente, 2019

sustainable recovery of our territories through the promotion of natural capital and the landscape, urban regeneration and quality construction, as well as the reuse of contaminated or disused areas.

The possibilities to finally reach a successful conclusion of this path are hinged to at least two contents: the first, in terms of principle, concerns the recognition of environmental and landscape values of the soil, as a common good and non-renewable resource, which performs functions and produces ecosystem services; the second is the decision to reassess the urban costs as an indispensable contribution to development, allocating the proceeds to the provision of equipment and services of general interest necessary for the quality and urban livability, but also providing for their use in support of the interventions of reuse and regeneration of the built, protection and rehabilitation of the environment and the landscape, as well as measures to encourage the establishment of agricultural activities in the urban environment[4].

Strategies in other countries demonstrate that effective action to contain urbanisation processes requires an integrated approach, combining control and regulation of land use with disincentive policies, mitigation, compensation and monitoring of the impacts of transformations.

The possibility of making practical and sustainable interventions of recovery and redevelopment, town planning and socio-economic of those parts of cities that require a widespread reorganization of urban planning, constitutes, in fact, the necessary condition to ensure the practicability of a concrete and effective strategy to limit the consumption of free soils. Procedures should be simplified where they are too complicated, act on the flexibility of implementation and especially on the reduction of time for interventions within the existing city. A course of action which does not mean, of course, deregulating planning instruments and regulatory arrangements, but which means ensuring certain and clear operating conditions in environmental remediation procedures, give certainty to the timing

[4] CHAMBER OF DEPUTIES, *Bill no. 2039. Norms in matter of valorization of the agricultural areas and containment of the consumption of soil*, Italian Parliament, XVII Legislature, february 2014

of approval and implementation of interventions, encourage, where compatible with urban contexts, greater flexibility in the transformations of use and recovery of the existing city.

2.1 LAND CONSUMPTION IN ITALY

Our tendency is to be interested in something that grows in the garden, not in the bare ground itself. But if you want to have a good harvest, the most important thing is to make the soil fertile and cultivate it well.

-Shunryu Suzuki-

Given its extremely long formation times, soil may be considered to be a limited resource that is not substantially renewable. For these reasons and its intrinsic value, natural soil must be protected and preserved for future generations[5]. The ecological functions that a soil of good quality is able to ensure, in addition to their intrinsic value, also guarantee an economic and social value through the provision of various ecosystem services necessary for the biological and social sustenance of man, such as the production of biomass and raw materials, the regulation of hydrological and bio-geochemical cycles, the conservation of the historical-archaeological archive of the landscape.

It would be useful to be able to measure the quality of these values by implementing monetary evaluations that can certainly help to increase the attention on natural resources, through an articulated consideration of the values at stake, but which must not lead to reducing the value of Nature to a single criterion that does not take into account the political substance of the choices. In fact, if monetization has in itself good reasons such as, for example, the ability to show the value of a resource with a code known to all, risks fueling a perverse and indelible retro-thought according to which, after all, every resource is a commodity with a price and, therefore, with a possible trading market that cannot take into account the true value and the concept of immeasurability of Nature[6].

[5] COUNCIL OF THE EUROPEAN PARLIAMENT, *Decision No. 1386/2013/EU on a general Union environment action programme until 2020. Living well within the limits of our planet*, European Parliament, VIII Legislature, november 2013

[6] PAOLO PILERI, *100 words to save the soil. Small Italian-urban dictionary*, Altreconomia, 2018

Using the words of George Monbiot[7], the expectation that we can defend the living world by applying the same mentality that is destroying it is quite illusory. Ideas such as that nature exists to serve man, that its value is in the instrumental benefits that can be derived from it, that this value can be measured in cash, and that what cannot be measured does not matter, have proven lethal for the rest of their lives on Earth[8].

The consumption of soil, therefore, is a process associated with the loss of a fundamental environmental resource, limited and non-renewable, due to the occupation of an area originally agricultural, natural or semi-natural with artificial coverage.

It is a phenomenon linked to the dynamics of settlement and infrastructure and is mainly due to the construction of new buildings, buildings and settlements, the expansion of cities, the densification or conversion of land within an urban area, the infrastructure of the territory.

The activities of monitoring the territory in terms of land use, coverage and consumption in our country, ensured by the National System for the Protection of the Environment, allow to have an updated picture annually of the evolution of the phenomena of land consumption, the dynamics of land transformation and urban growth.

This system establishes the Essential Levels of Environmental Technical Performance, which constitute the minimum level homogeneous throughout the national territory of the activities that the National System is required to guarantee.

[7] British journalist, academic, essayist, environmentalist and political activist

[8] ALDO FEMIA – GEORGE MONBIOT, *Price Less, Nature is not Capital*, in *XX Report Sbilanciamoci! How to Use Public Spending for Rights, Peace, Environment*, Sbilanciamoci!, 2019

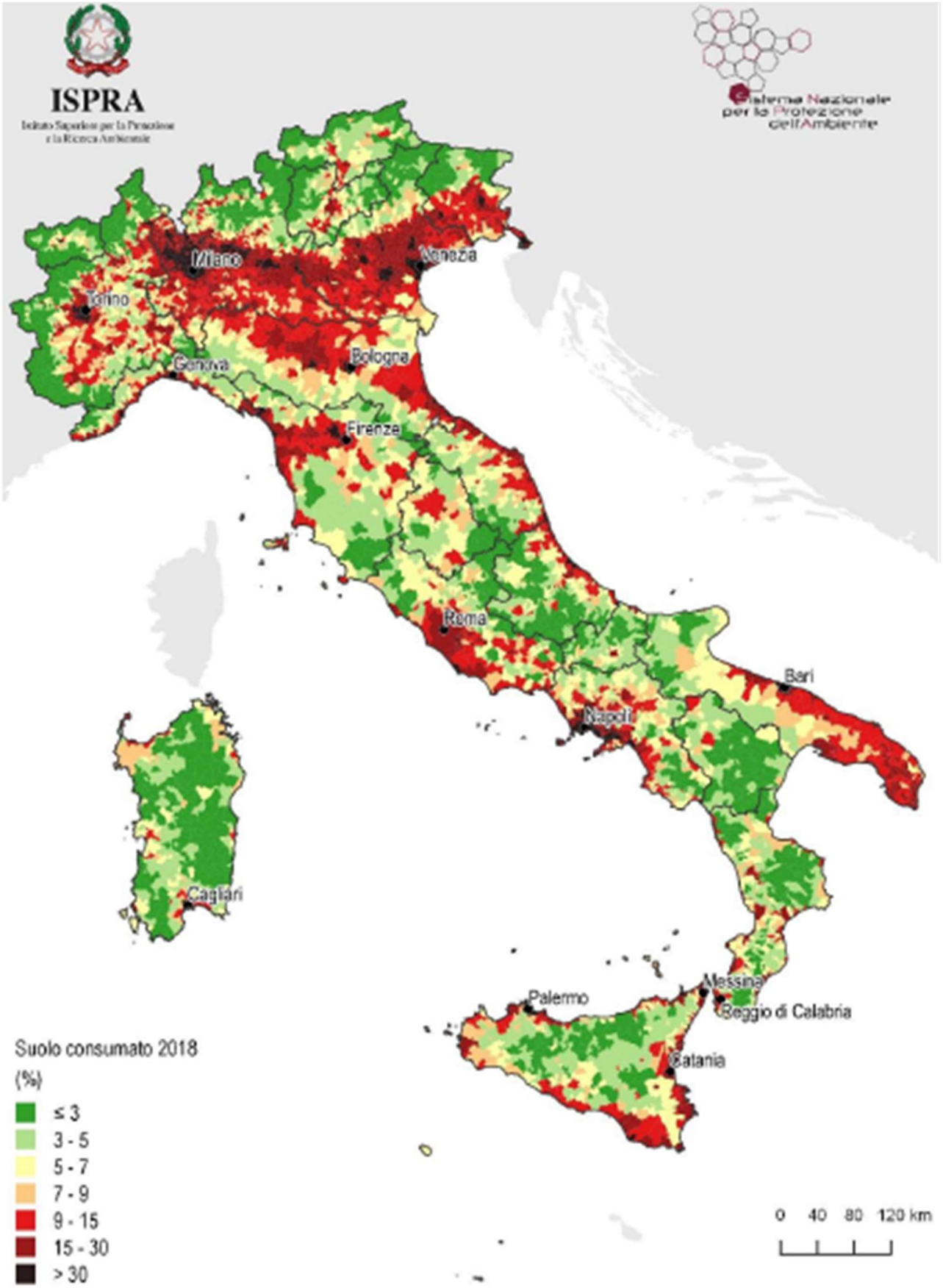


Figure 1: Soil consumption in Italy in 2018 {ISPRA-SNPA}

More than 60% of land consumption impacts on cultivated agricultural areas

At the National level, the Space Economy Strategic Plan[9] is being developed to allow Italy to transform the space sector into one of the engines of the new growth of the country, through the integration of territorial development policies with space policy. Many applications that can be enabled from this platform, as the National Operational Infrastructure for environmental monitoring to support the National System with some operational services related to the monitoring of the territory and the main environmental resources, such as management of the resilience of the built environment, maritime surveillance, nowcasting[10], precision agriculture and its impacts on land and soil.

In 2015, the United Nations Global Agenda for Sustainable Development defined the Sustainable Development Goals and indicated, among others, some targets of particular interest to the territory and the soil, to be integrated into national programmes in the short and medium term and to be achieved by 2030.

At the National level, the tool for the implementation of the 2030 Agenda is represented by the National Strategy for Sustainable Development. In the light, inter alia, of the changes that have taken place as a result of the economic and financial crisis of recent years, it is the main instrument for the creation of a new circular economic model, with low CO_2 emissions, resilient to climate change, changes in land use and other global changes causing local crises.

In order to achieve this objective, it is clear that effective legislation is needed which can steer government policies and land transformation actions towards a rapid reduction in the consumption of agricultural or natural soil. The first bill to limit land consumption dates back to 2012 when the then Minister of Agricultural Food and Forestry Policies presented the Report "Building the Future: Defending Agriculture from Cement"[11].

With the bills proposed subsequently, however, many expectations remained disregarded linked to the need to relaunch the building industry towards a strategy of redevelopment

[9] Initiative promoted from the Presidency of the Council of Ministers for the definition of national politics in the space field in collaboration with the Cabin of Space Control

[10] Short-term marine weather forecast

[11] MINISTRY OF AGRICULTURAL FOOD AND FORESTRY POLICIES, *Report – Building the future: defending agriculture from cement*, Italian Parliament, XVI Legislature, july 2012

of the existing, as well as those of regeneration of urban tissues aimed at improving the quality of life of citizens, the improvement of the environment and urban and suburban landscape, the recovery of ecosystem functions and adaptation to climate change.

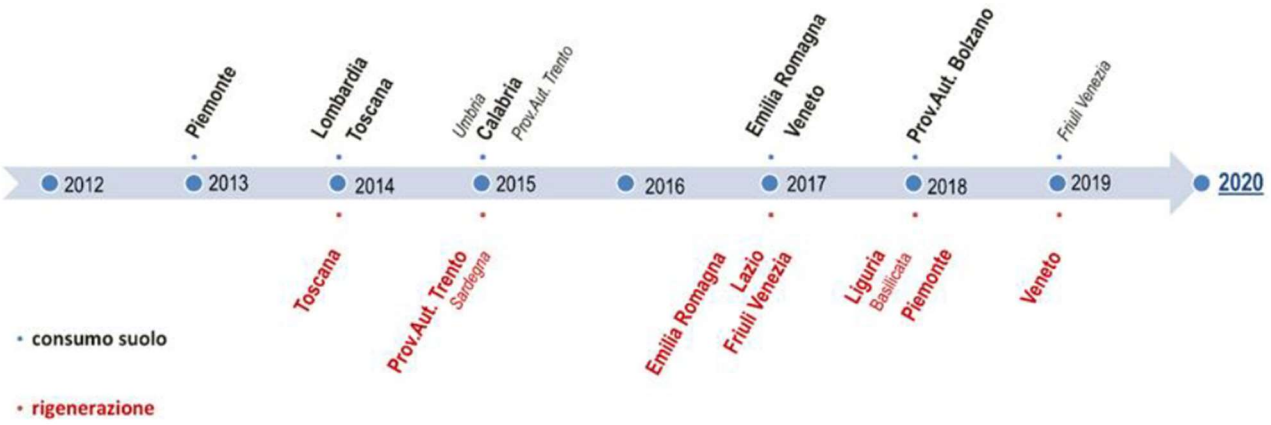


Figure 2: Development of Italian legislation on land use and urban regeneration {ISPRA-ANCE}
Since 2013 the Italian regions are moving independently to regulate environmental activities

Unfortunately, still missing in our country, a fundamental law for the protection of the environment, the territory and the Italian landscape, indispensable also to ensure a suitable future for the citizens of today and tomorrow, with a view to the sustainable development of land use and increasing the resilience of urban areas in the face of old and new challenges, due both to the known fragility of our territory and to the need to adapt to the climate change in progress.

2.2 LAND CONSUMPTION IN EUROPE

The earth as a community is the basic principle of ecology, but that it is something to love and respect is an extension of an ethical nature. That the earth produces culture is a fact long known, but lately too often forgotten.

-Aldo Leopold-

The landscape of Europe is changing. Cities and their infrastructure are expanding into productive agricultural land, further fragmenting the landscape and affecting wildlife and ecosystems. The question then arises: why not recycle the territory already occupied by cities and urban infrastructure, instead of using new agricultural land?

A careful analysis of the results of the monitoring of the *Copernicus*[12] programme on recent land cover changes at European level reveals two trends that are noteworthy. Firstly, cities and cement infrastructure continue to expand with an artificial surface growth rate of around 711 square kilometers per year between 2012 and 2018[13].

Secondly, the greatest losses have been recorded in agricultural land, mainly due to urban expansion and declining agriculture. The area of arable land, pastures and lost natural grasslands was almost equivalent to the increase in artificial areas.

Furthermore, as European cities have been built mostly on and surrounded by fertile land, the areas occupied and covered by artificial surfaces are often productive agricultural land.

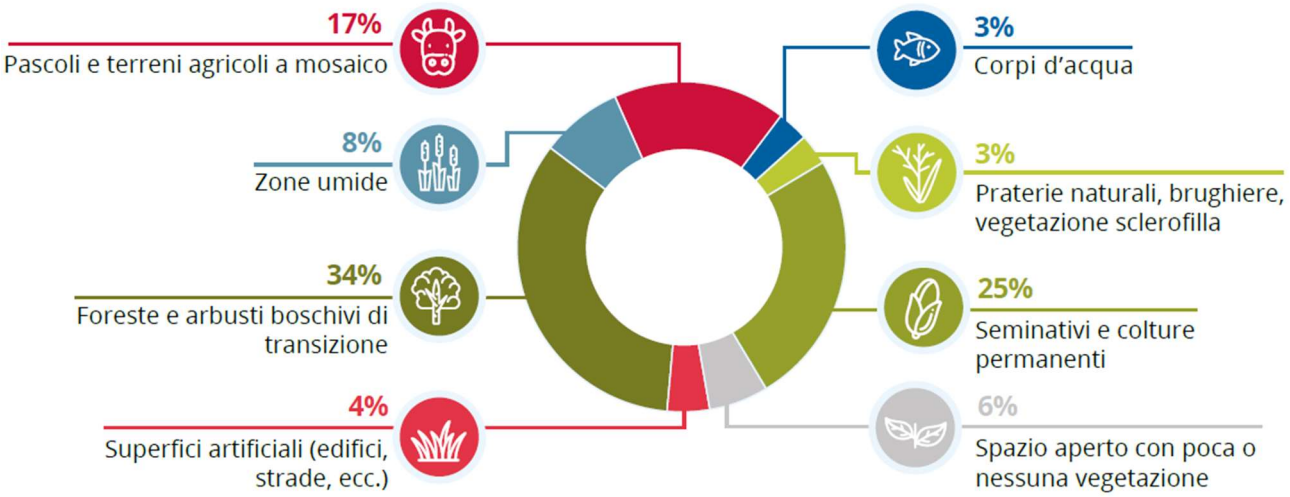


Figure 3: Land cover in Europe {EEA Signals 2019}

The artificialization of the soil inevitably implies the disappearance of the natural cover of the landscape

In many respects, the expansion of urban areas and the extension of their infrastructure go hand in hand with the growing number of socio-economic benefits that the European population has enjoyed in recent decades.

Europe's urban population is expected to continue to grow, increasing by an additional 30 million people by 2050.

[12] CORINE monitoring programme promoted by the European Commission within the Land Cover initiative
[13] HANS BRUYNINCKX, *Soil and territory in Europe. Can we stop the expansion of cities and concrete?*, in *EEA SIGNALS 2019*, European Environment Agency, 2019

More housing and infrastructure will be needed to accommodate the growing European population, both urban and overall. Roads and railways connect people and urban and rural areas, but they often constitute real barriers to the dispersal of wildlife and plants.

Expanding into the landscape, urban areas and their supporting infrastructure fragment habitats into smaller spaces.

Like many other environmental policy issues, landscape fragmentation also poses a dilemma. On the one hand, the expansion of transport networks is fragmenting the landscape and putting further pressure on ecosystems, including in terms of pollution. On the other hand, transport networks also offer economic opportunities to rural communities, often heavily dependent on agriculture and affected by land abandonment.

It is expected that over the next 20 to 30 years a significant proportion of agricultural land in various parts of Europe will be abandoned. In Europe, urbanisation, population growth and a growing economy, on the one hand, and the abandonment of agricultural land, on the other, have meant that more people now have a more limited space in which to live and rely.

While some areas suffer from depopulation and decline in agricultural and economic activities, other areas – both urban and rural – are subject to increasingly intensive use.

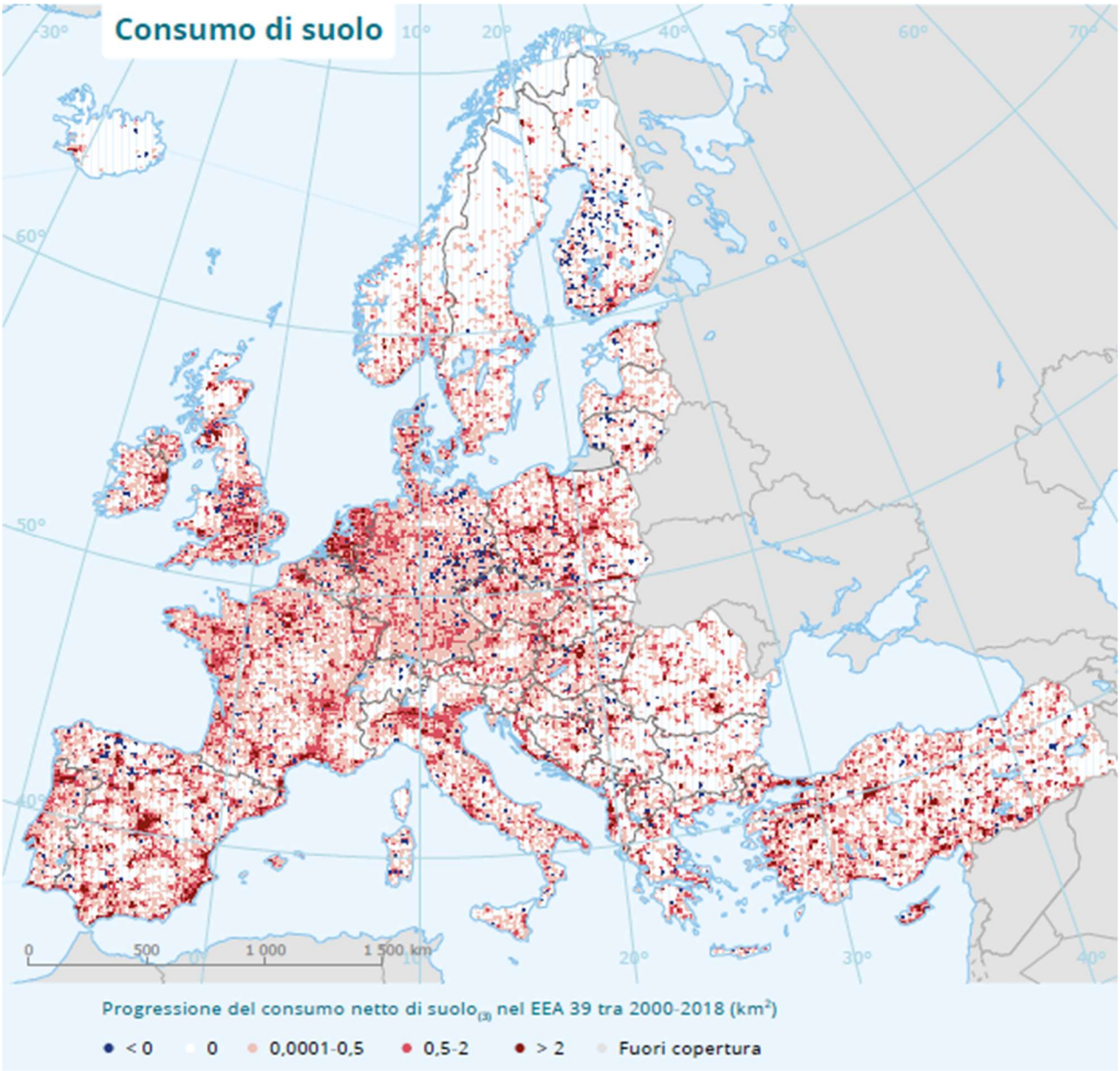


Figure 4: Land use in Europe in 2018 {EEA Signals 2019}

The average speed of land consumption at European level is around 7 square metres per second

Intensive land use can strongly and in various ways influence the soil and its functions, for example in the form of waterproofing, erosion, compaction and contamination.

When waterproofed[14], the soil loses, among other things, the ability to absorb and retain water and produce food. The use of heavy machinery can change its structure and make it more compact, reducing the quantities of air and water present in the soil portions where the roots of the plants absorb water and nutrients and where the soil animals and micro-

[14] That is covered by buildings, asphalt or concrete

organisms decompose organic matter. Waterproofed or heavily compacted soils absorb less rainwater, resulting in increased surface runoff, soil erosion and the risk of flooding[15].

Given that land and soil are valuable but also limited resources, the only viable option is to prevent their degradation and to use them sustainably. The European Union aims to achieve the objective of a net land consumption of zero by 2050 in accordance with the objectives of sustainable development.

A simple way to limit the expansion of urban areas is to make better use of existing urban spaces. Today, the reuse of land represents only a small part[16] of new developments, while land consumption continues to be a problem.

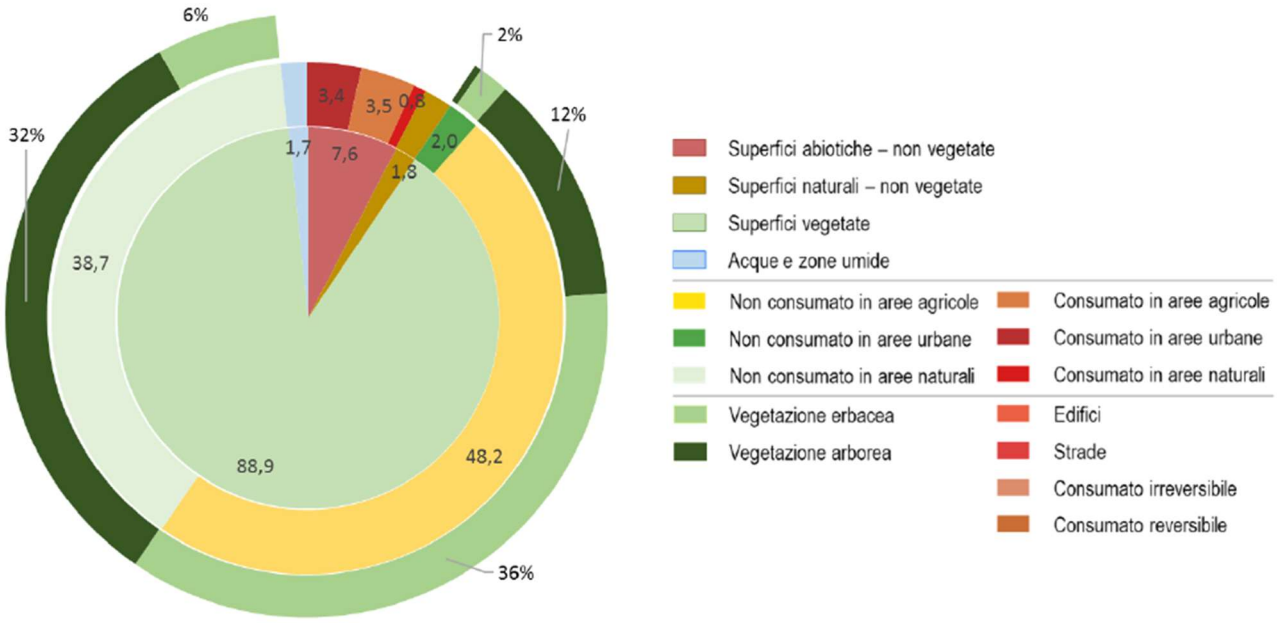


Figure 5: Coverage and land use destination in Italy {ISPRA}

About 45% of the consumed soil is irreversible

Spatial planning experts – and in particular urban planners – in the European context have a decisive role to play in limiting urban expansion; to this end they will have to design compact but green cities, equipped with important recreational areas within walking distance or mobility systems designed to reduce distances and travel times, and an extensive

[15] DAVID RUSSEL, *Interview – Soil: a living treasure under our feet*, European Environment Agency, december 2019

[16] The European Environment Agency reports the reuse rate of pre-settled land for new buildings to 13%

network of green infrastructure that connects all natural areas of the entire continent. In the light of the above, it can be said that the ground is not just a spatial or territorial entity. It is the community as a whole that uses the land and takes care of it.

In this context, the earth and its resources placed above and below the ground are common goods. When we all use the land and depend on its resources, for sustainable management it is necessary that owners, legislators and users at every level – from local to global – cooperate with each other.

In our daily life the soil/territory dichotomy can have many meanings at the same time. It may refer to a space on the surface of the Earth's mass of our planet. It can also indicate the soil, rocks, sand or waterways on the earth's surface and its upper layers. In some cases it may include all minerals and other resources such as groundwater, oil and precious stones present in the depths of an area. It can even express a cultural link with the rural lifestyle or with nature.

Despite global and European efforts, the complexity of soil and land governance means that binding targets, incentives and measures for the protection of soil and land resources are still almost entirely lacking. Nevertheless, a number of initiatives are being developed in various areas of society to improve soil and land management. In conclusion, we all have a duty to take care of the soil and the territory, of which we are all responsible as users, owners, legislators, managers and consumers.

2.3 THE FRAGMENTATION OF THE LANDSCAPE

We think only in fragments, so our ideas are right from the human point of view, but often wrong from the universe point of view.

-Franz Fischer-

The phenomena of urban expansion, implemented in more or less sustainable forms, are the main culprits of territorial fragmentation that generates a progressive reduction of the surface of natural and semi-natural environments and an increase of their isolation, transforming large areas of land into smaller and more isolated areas. The resulting reduced

ecological connectivity impacts negatively on the resilience and capacity of habitats to provide ecosystem services, sometimes causing adverse effects on the quality and value of the landscape.

A functioning ecological connectivity allows the ecosystem to continue to provide the services that we benefit every day. The presence of human infrastructures that literally fragment natural habitats, different laws of neighbouring states and low environmental awareness can cause insurmountable barriers to ecological connectivity and high-moving wildlife species, also creating unpleasant conditions of potential conflict with humans.

These issues are highly topical in Europe, a continent where human progress has literally fragmented the natural environment into small portions that are disconnected from each other. The spatial discontinuity of ecosystems is, therefore, one of the main causes for the local loss of animal species, especially if at the top of the food and ecological chain, such as large predatory mammals. This leads to a progressive and substantial decrease in the quality of habitats, with ecological and healthy repercussions also on the human species itself.

Limiting fragmentation of land and landscape is one of the key elements to protect preserve and improve the natural capital of our country and therefore must be among the aspects to be considered in territorial planning and landscape at different territorial levels. Analyzing the fragmentation index of the landscape, that is the ratio between the total sum of the perimeters of the polygons of the built areas and their surface, almost 39% of the national territory is classified in high and very high fragmentation areas in 2018 with an increase of 2.5% compared to 2012. A third of the national territory is classified as medium fragmentation[17].

[17] MINISTRY OF ENVIRONMENT AND PROTECTION OF LAND AND SEA, *First Report on the State of Natural Capital in Italy*, Italian Parliament, XVII Legislature, may 2017

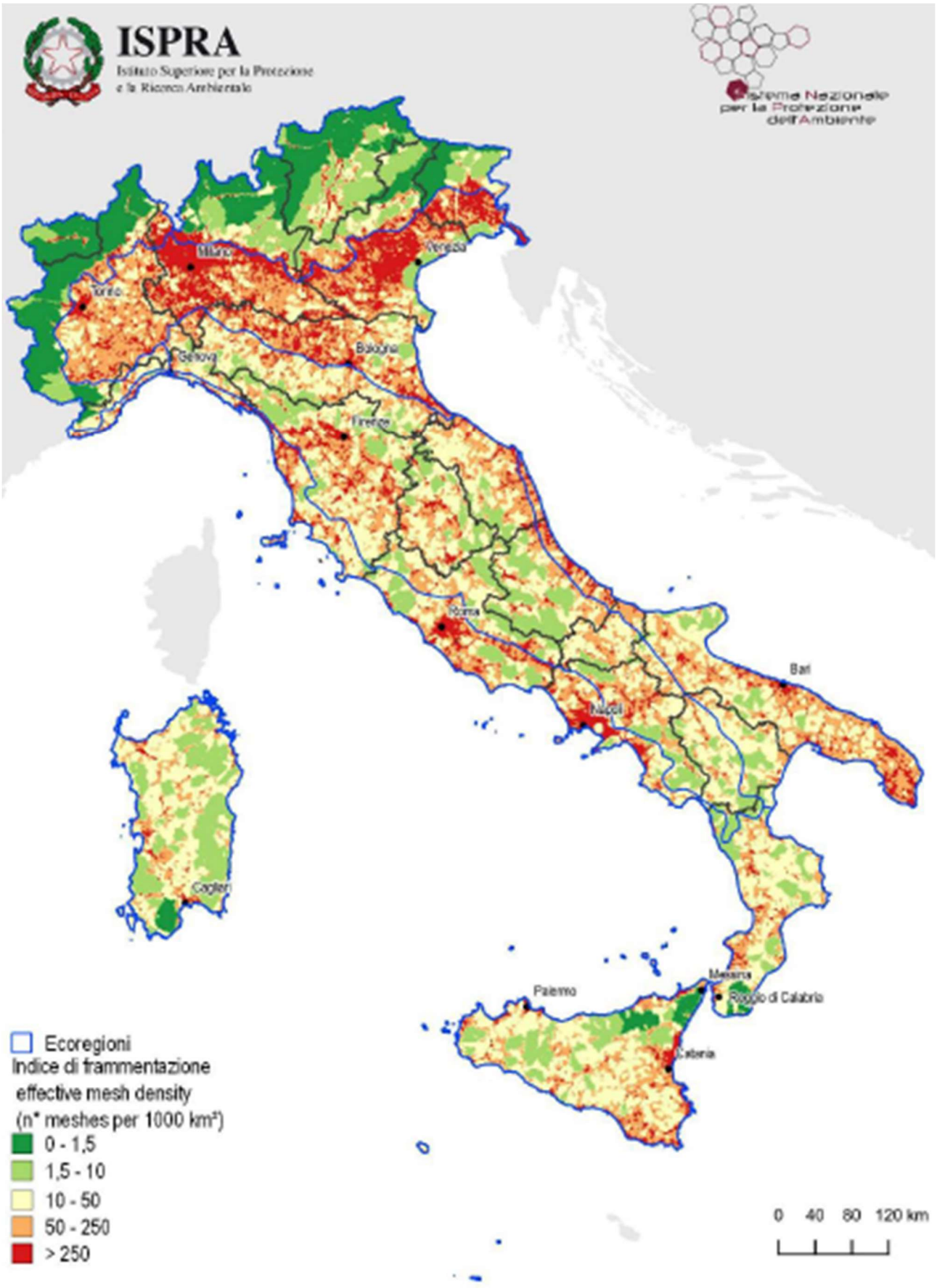


Figure 6: Fragmentation index of the Italian landscape in 2018 {ISPRA-SNPA}

Only the territories of the Alpine chain have a very low fragmentation of the territory

The close correspondence between fragmentation and urbanisation emerges clearly from the analysis of fragmentation with respect to different degrees of artificial coverage density. In Italy, 77% of artificial areas are classified with very high fragmentation. However, it is noted that, despite the low degree of artificial coverage density, the natural agricultural area is covered only for a third by territory little fragmented.

As part of the United Nations Global Agenda for Sustainable Development and its Sustainable Development Goals, some built-up density thresholds have been defined to be considered for the classification of urban, suburban and rural areas.

In order to analyse the contexts in which land consumption occurred, the bioclimate changes between 2012 and 2018 and the density classes defined by the Global Agenda were linked. At the national level, about 58% of changes occurred in areas with medium or low density of soil consumed, to which is added a further 10% in very dense areas. 32% of the changes, however, occurred in a predominantly agricultural or natural context[18].

The analysis shows, therefore, that urban areas with low density are clearly more exposed to the consumption of soil, probably due to the predisposition in these territories to the saturation of free spaces enclosed in areas already artificialized.

An evaluation carried out by the ISPRA[19] Institute of the transformation scenarios of the Italian territory, in the event that the rate of transformation is confirmed to be equal to the current rate in the coming years, leads to estimate the new ground consumption in 1˙461 square kilometers between 2019 and 2050.

A value far removed from the sustainability objectives of Agenda 2030 which, on the basis of current demographic forecasts, would require, in order to achieve the desired results, a negative balance of land consumption resulting in the creation of new natural soil.

[18] SIMONE PESARESI, *Bioclimate of Italy: Application of the global bioclimatic classification system*, in *Journal of Maps*, pp. 538-553, Taylor & Francis, 2014

[19] Higher Institute for Environmental Protection and Research

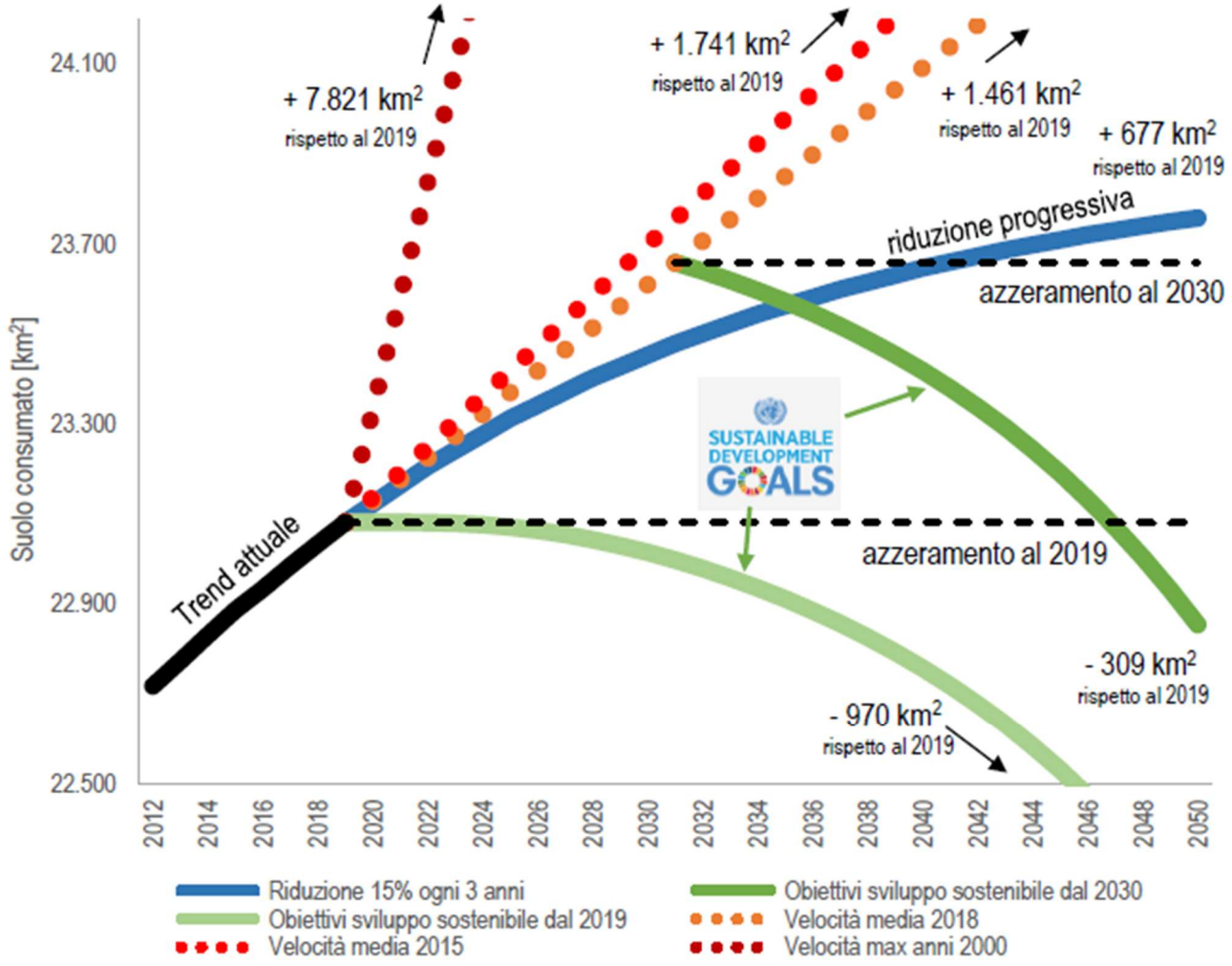


Figure 7: Land use scenarios in Italy {ISPRA}

Given the current trend, the targets set by the Global Agenda 2030 remain increasingly distant

In view of the uneven picture of regional standards and the urgent need for soil protection, it is considered essential that a text should be adopted soon to ensure that Community and international objectives are achieved and that a significant reduction target should be set immediately for both the permanent and reversible components.

These objectives are fundamental for Italy, in the light of the particular conditions of fragility and criticality of our territory, making urgent the definition and implementation of policies, rules and actions for radical containment of land consumption and the revision of the forecasts of existing town planning instruments, often oversized compared to the real demand and the capacity of load of the territories[20]. The national objective is necessary in

[20] COUNCIL OF THE EUROPEAN PARLIAMENT, *Communication No. 2002/0179/DEF towards a thematic strategy for soil protection*, European Parliament, V Legislature, 2002

order to frame and guide the possibilities of transformation and development of the territory and to ensure the adaptation, in not too long time, of the town-planning instruments and the adoption of techniques of restoration and recovery of the soil.

At European level, the adoption of "thematic strategies" made binding by specific Directives and aimed at establishing cooperation measures and guidelines for Member States and local authorities has often been used in the environmental field.

The objective of zero net land consumption, that is to say the balance at par between land consumption and the increase in agricultural areas, natural and semi-natural due to recovery, demolition, renaturalisation, must also be seen as an engine of regeneration and redesign of the urban fabric and as an opportunity for redevelopment of buildings, urban and territorial; that must be achieved through the simultaneous implementation of all possible actions to bring it into line with the objectives of Europe and the United Nations.

The definitions should be adapted from a technical and scientific point of view in order to make monitoring possible in line with the instruments and overall Community and National objectives, ensuring unambiguousness and homogeneity throughout the national territory and consistency with the monitoring activities of the territory envisaged at Community and national level to which reference has been made.

CHAPTER 3

RESILIENCE

SUSTAINABLE BUILDING

If it is true that we are not able to control the tides of change, we can, however, learn to build better boats; to design or redesign organizations, institutions and systems capable of better absorbing the upheavals, to operate under a wider variety of conditions and to move more smoothly from one situation to another.

-Andrew Zolli-

The choice of the theme "Designing resilient" is presented as an obligatory choice as a result of the growing debate at national and international level on the effects, already evident, determined by climate change on the built environment and social and economic, not secondary, which significantly characterize the beginning of the new millennium. An indispensable theme on which to surround the position of technological design[1].

In this sense, resilience is assumed as a transversal condition to the different areas and scales of the project, comparable to the capacity of a system – settlement, construction, functional/dimensional, environmental, technological – to preserve over time its qualitative and performance characteristics to absorb changes and to react to them with adaptation and reactive capacity.

Certainly the existential approach of governing the procedural dimension of the project, as well as a systemic and multiscale vision, are the elements of greater disciplinary significance on resilience for the intrinsic ability to develop and apply knowledge, methods and

[1] MARIA TERESA LUCARELLI – ELENA MUSSINELLI – LAURA DAGLIO, *Designing Resilient*, Maggioli Publisher, 2018

techniques necessary to configure resilient, effective and measurable forms and levels. On the other hand, the fragility and vulnerability of urbanised areas require the adoption of strategies aimed at, in addition to the construction of appropriate intervention policies, especially the development of methodologies, protocols and actions to deal with technical and functional obsolescence of the building, strongly linked to the reference context, with the provision of low-impact, flexible interventions, as required by the very concept of resilience, capable of developing stress-adaptive behaviour.

The first predictive phase, *ex ante*, is crucial to identify the characteristics and requirements of resilience, passing through the preventive analysis of risks and their mitigation, managing to identify the appropriate intervention methodologies to act on strengthening the dynamic and evolutionary character of environmental, building and urban systems, consolidating their capacity to deal with alterations and changes, in compliance with specific regulations and standards of law.

Ex post reading, on the other hand, is defined as the moment of identification of the interventions necessary to restore the state of functionality and usability of the built environment, aiming at the adaptability generated not by the emergency, but by the necessary renewal, predictive and resilient, able to maintain the functionality of the system and its recognizability[2].

Despite the continuous and difficult to control technological evolution in this field, the strategies adopted to absorb a stress without affecting the characteristic functionalities of a material, are essentially two. The first requires a reserve of resources, to be mobilised to respond to critical solicitation. Thus, the height and strength of the embankment, or the thickness of the castle walls, are sized well beyond what is required to meet ordinary conditions.

On the contrary, the second strategy, the resilient one, does not aim to counter the adverse action, but to mitigate its destructive effects, accepting even significant changes in static

[2] CRAWFORD STANLEY HOLLING – LANCE GUNDERSON, *Resilience and adaptive cycles,* in *Panarchy: Understanding transformations in human and natural systems*, pp. 25-62, Island Press, 2002

balances. It therefore offers the river the possibility of flooding by flooding areas where the flood produces not catastrophic damage, or, instead of erecting cyclopean massive bastions, it builds only two thin parallel walls, filling the intermediate space with material capable of absorbing the energy of the projectile, accepting damage on the outer layer of the defensive belt, while avoiding the collapse of the structure.

"Bending but not breaking" is the typical response offered to the solicitation by biological organisms, whose adaptive capacity has always exerted on man an irresistible attraction and provided inspiration for the development of the technique.

This operational framework makes it necessary to reconfigure the urban built environment and its architectures at the various scales of intervention, in a way that responds more to the new and multiple needs of contemporary society. It is in the social role historically held by architecture that a link can be identified, revisiting the traditional role of the designer, mediator between the instances of the community and the interests of the user groups. This figure has to hold together two indissoluble necessities: to receive the indications coming from the final users and to render the adopted solutions practicable, concrete and convenient in planning, technological, economic and environmental field.

This must be accompanied by the adequate training of technicians in the multiple modes of governance of the iterative cycles underlying the collaboration. The technological disciplines of the project can help to train designers ready to manage the quality of housing in co-design processes, incorporating the concept of smartness[3] and the enabling role that the project must have.

The customer, as a simple user who has the role to express his needs, through an open source project can also take on tasks in the implementation processes, conditioning the links between urban components, individuals and communities that can act on the adaptive capacity of spaces and people. In this new process, the "enabler designer" can operate using

[3] The quality of being smart, or able to think quickly and intelligently in difficult situations

systems of collection and analysis of the variables in play and manage the multiplicity of data.

In this way participatory design meets the logic of collaboration and the designer can not only configure the categories of works preferable but can do it in relation to multiple scenarios, integrating participatory actions, faster, more flexible and more adaptable than conventional programming tools to ensure active community involvement in real time.

The "enabler designer", who becomes a member of the participatory design group alongside the "facilitator", puts the project at the center of the collaborative process, thanks to the proactive vision that by its disciplinary status the Technological Area possesses and promotes.

3.1 NEEDS OF A CHANGING SOCIETY

You feel the absolute need to move. And above all to move in a particular direction. A double need: to move and know in which direction.

-David Herbert Lawrence-

The sudden change in society, development policies and new housing experiences. These are the main themes addressed in the meeting "A new way of living. Cities, associations and social housing. Test experiences" organized by the National Association of Builders and held in August 2019 in Rimini.

The starting point was to observe, evaluate and understand the epochal change that our society is experiencing, so that concrete answers can be given to the new housing needs. In recent times factors of strong social impact, such as the increase in immigration, the economic crisis and environmental sustainability, have inevitably affected our way of living and the places of housing.

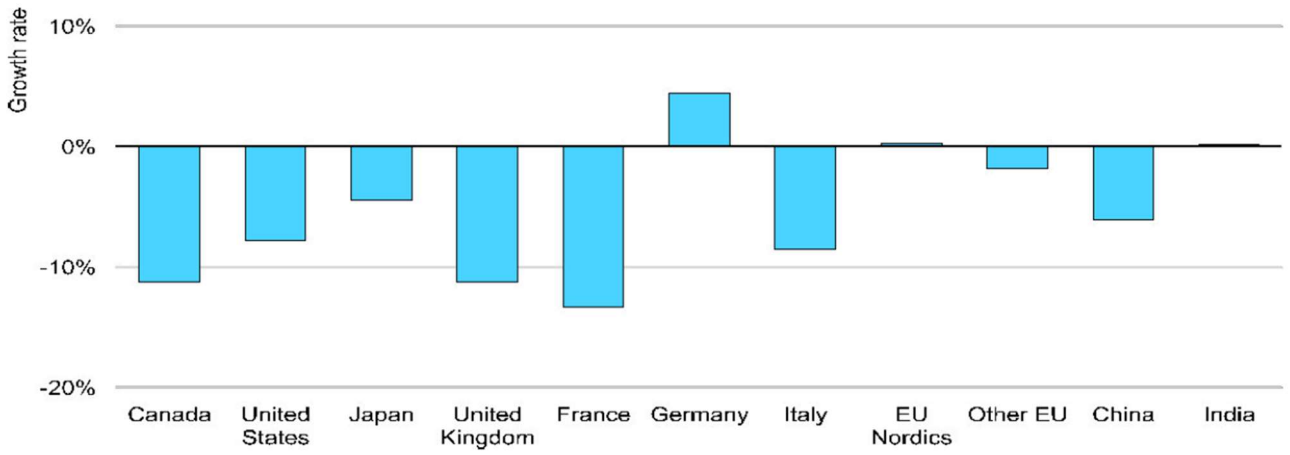


Figure 1: Annual growth project of residential construction activity in 2020 {IEA-2020b}

In the last year only Germany has dedicated itself incisively to interventions of new residential construction

In this sense, a rather recent experience in Italy is that of Social Housing[4], understood not as a low quality living experience, but as a valid and concrete opportunity to city life.

In the times of Coronavirus, having lived for entire weeks locked in the house without the possibility of escape of any kind, has created new needs and new domestic inspirations in the population that inevitably are reflected in a new way of thinking about space. Therefore, new lifestyles and models of living are being born that one would like to adopt in everyday life, but also and above all to rethink and reorganize the domestic walls to make them hospitable to a new routine. The "house" comes back to life, less and less used to living there. Its value re-emerges, its importance flourishes again. The relationship between the concept of living and that of psychophysical well-being emerges. It is relevant the need for how important it is to design an environment in which you feel satisfied, at ease and in connection with your own interiority.

From the results of a survey published by the online platform Houzz[5], it emerged that 62% of users said they want to make improvements to their home, after discovering limitations, but also potential. Living so much in the house, 24 hours a day, 7 days a week, has brought

[4] Being located halfway between social housing and private properties sold or rented at market price, its main objective is to provide accommodation with good or excellent quality standards, with calmierato rent, which does not exceed 25/30% of the salary. In addition, social housing is characterized by social projects that have the aim of creating communities and developing integration, such as the use of common spaces and services among the inhabitants

[5] Online community of architecture, design, landscape design and home improvement

awareness in 35% of respondents to have underestimated some spaces that, if cared for and rethought under a new point of view, can become corners of relaxation. 27% of the participants, however, realized that they had not made the most of the space available. There is also a 14% of the population that has decided to leave room for new furniture. Finally, a 12% admits to having always lived the house as a dormitory and now, instead, has discovered the pleasure of living domestic spaces that would like to adapt according to their own tastes and personality[6].

From an overall vision of the results, in addition to the desire to enjoy outdoor spaces, considered a real extra room, there was no space for the home office, a personal space welcoming and practical, where you can work with concentration and tranquility. The majority of the population today would not do any less than the privilege of an outdoor space, whether it be a garden, a terrace or even just a small balcony.

The idea of living in a modern home, where every member of the family can enjoy a private room, thus guaranteeing privacy, a very felt need during these last months, thinking of the house through flexible and modular spaces, is spreading more and more adaptable to every need.

The key word is therefore multifunctionality: reconfigurable environments not only according to needs, but also according to the time of day. The spaces will expand and transform, always assuming different purposes.

The goal will increasingly be to create continuity with the adjacent areas, thus giving life to indoor-outdoor living areas, bedrooms with private patio. It will be used to the maximum every single space before little considered, whether it is closets, roofs, understairs or hallways.

Widely used in older houses, the corridor, often guilty of the dysfunctional distribution of space inside the houses, will be eliminated to reallocate the size of the antiques in a more intelligent way. All gained meters that allow you to transform the environments, making

[6] MARIA COMOTTI, *The house engine of recovery*, in *ambientecucina*, year 44, no. 257, New Business Media, july-august 2020

them more pleasant to live. Whether it's just a dedicated desk, a room of its own, or a corner created following the rethinking of a space, the home office will now enter all homes by right. Spaces therefore not only better equipped for remote work, but designed and furnished specifically as a workstation to all effects.

This process of enormous change and innovation must therefore lead modern constructors to think of their activity not only as a sales and profit tool, but a real response to the needs and needs of citizens.

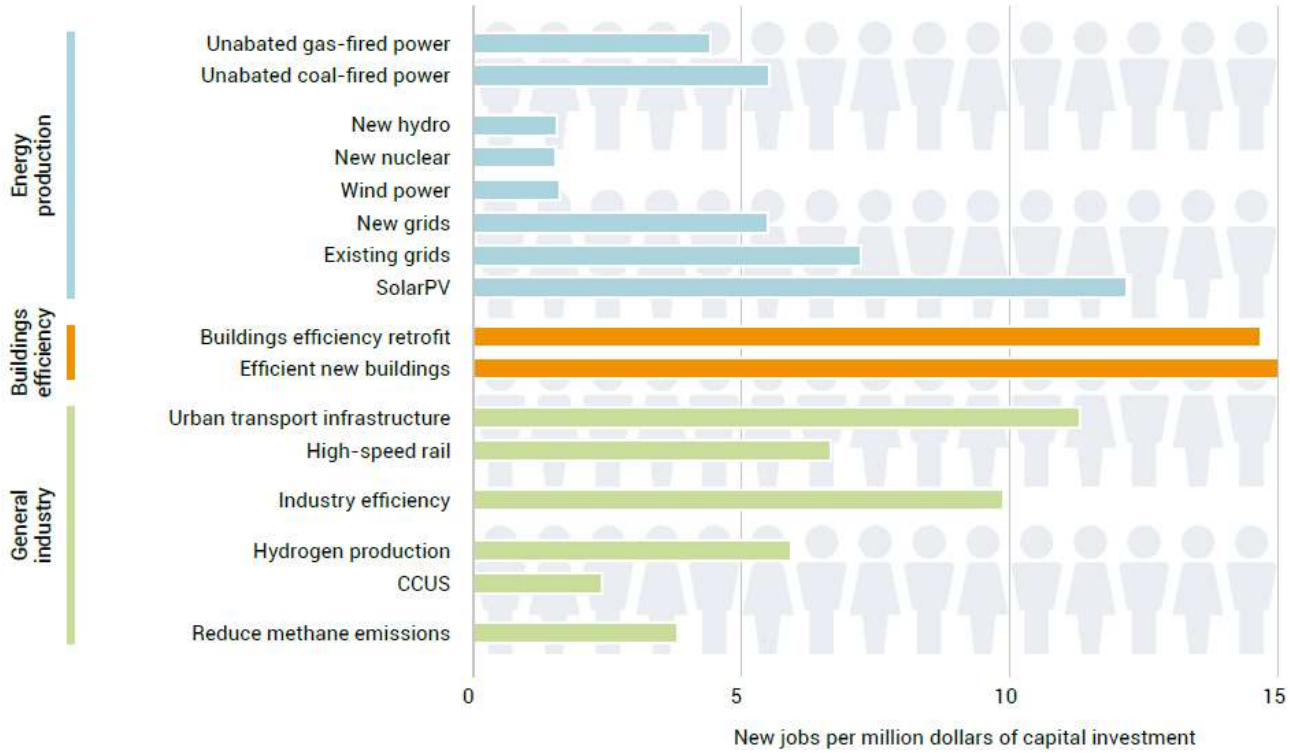


Figure 2: Jobs created per million dollars of investment {IEA-2020g}

That of the energetic requalification of existing buildings has been the most profitable field of the last year

In agreeing on the need for urban regeneration that also takes into account the change that we are experiencing, it is clear that we need to think of a new regulatory system that allows and makes it easier to implement new housing experiences. It is therefore essential to engage with the institutions so that we can better understand what is really happening in our society[7].

[7] EUGENIO ANDREATTA, *Press Release – Observing and understanding change to meet new housing needs*, Rimini meeting, august 2019

The comparison is therefore the starting point for understanding which direction to take. To conceive the spaces of daily life, having the awareness that the same can condition and influence thoughts, emotions and, therefore, the behavior of the individuals, with their way of approaching the events in continuous change.

Therefore, the moral duty of each of us is to rely on trained people who have the wisdom to think plans, programs, projects and internal solutions that influence in a functional way the individual perspective of each, towards a perspective oriented to well-being. Designing consciously means, not only using in a formal and appropriate way the right architectural canons and the right design associations. It means building a stimulating, fulfilling, creative, flexible place to change that cannot give rise to feelings of constraint. Because, in the words of Le Corbusier, «*a house is the epidermis of the human body*».

3.2 THE MODULAR BUILDING

Inventing is repeating something that in turn repeats something that has been repeated in some unknown part of reality.

-Miguel Ángel Arcas-

Social changes also affect the world of construction. In a single life the need for space varies quickly. Families expanding, children growing up. A diverse and diversified social fabric.

In the 1950s, families required apartments with two to four bedrooms, while today many people live alone. The housing market has not yet adapted to the needs of citizens. There are few housing solutions close to the needs of that segment of the population, constantly increasing, composed of singles, couples, students, young or even elderly left alone.

The traditional building model of the 21st century is inexorably changing. A typical evolution for an average real estate owner, although each path in this sense is different, usually begins with a "basic house", followed by a qualitative leap, with a larger home for the whole family, until a new scaling or diversification of ownership, once the children find their accommodation.

The obvious answer seems to be a house that grows and changes over time, a modular building able to adapt to different situations. A modular building model, therefore, which includes a prefabricated or pre-assembled house instead of built in situ with construction practices profoundly different from those of the Western world: it is usually considered a basic module that can be integrated with other modules or even simplified, at the design stage or later, as needed.

Modular houses are the emblem of the sustainable "revolution" that involved the construction industry. A "house-object" is radically opposed to the traditional house: it can be produced in series, it is manufactured in a different place than that of stock and can move. On the contrary, the "house-building" takes up the model of the traditional house: although conceived with a new production system, it does not renounce to the spatial and expressive richness of a classical house. The peculiarity of modular houses lies in the ability to incorporate these two aspects.

Modular houses are not mobile homes, because they have solid foundations; more simply, the modular construction takes place before moving on site. Once the design has been completed and the prefabricated building is in fact transported and installed in situ. These structures need to be built by skilled workers, architects and professional engineers in terms of skills and experience in the field.

Engineering, architecture, design, graphics and communication are intertwined in a multidisciplinary project. An alternative choice that seeks to respond to the heterogeneity of needs, in a flexible and easily adaptable way: a house that grows with us. In this model, the project is seen as a dynamic container, able to be completed over time according to the real sold, with limited initial investment structured in simple modules.

A new type of housing that provides a new way of building sustainable with wet and dry yard, expanding or reducing space as needed. It is also, however, a new model for the real estate market, as well as a new purchase model, because the initial investment corresponds to the needs and economic resources of the moment.

One of the most cited advantages of prefabricated construction companies is that a modular house is much more customizable and follows safer construction procedures in highly controlled environments. The modular construction is faster, less expensive, allows high levels of quality control and significantly reduces waste and the transport of rubber components: the overall construction time is reduced by 35% compared to a traditional house[8].

Thanks to their modularity, the environments can be combined in different ways, depending on their style and needs. The modularity also allows you to expand the house over time. The different finishes and innovative construction techniques make these buildings suitable to be inserted in any context, so countryside, mountain, sea but also city.

The fact that the realization is rather fast, along with the possibility of growth due to the modular component and energy savings that allow, are the strengths of these models. A project, in short, that will be able to carry on a new way of living the house, more intimate and welcoming.

Prefabricated modular construction is a building approach that has proven to help reduce the environmental impact of buildings and at the same time increase the energy efficiency and overall sustainability of the structure.

During a normal construction site it is estimated that up to 8000 kilograms of waste can be generated while recycling is becoming an increasingly common practice in the construction of modular houses where the reuse of residual material from other projects is frequent.

Modularity seems therefore the most sensible choice not to weigh too much on the environment and to build houses and housing complexes sustainable and well integrated with the surrounding environment. We are definitely in a new era for prefabricated buildings, where digitalisation and the possibilities offered by technological innovation allow us to produce state-of-the-art construction solutions oriented to low environmental impact.

[8] RENATO RIZZI, *Bildung-Building*, in *DOMUS*, no. 1002, EditorialDomus, may 2016

Currently 45% of this type of construction is concentrated in the Scandinavian countries, followed by 15% of Japan and 10% of Germany[9]. To ensure that this potential is reflected in a reference market, more investment is needed in terms of technological research and industrial know-how.

There is still a long way to go in terms of materials and especially in terms of digital design and logistics. Finally, much will depend on the support, in terms of economic strategies and technical regulation, which will come from the individual States.

However, it remains to break down the cultural barrier that represents the most fearsome obstacle, the one that sees in the meaning of the term "prefabricated" a low quality and something provisional, unfinished, passing. Having overcome technical and technological obstacles, this is perhaps the real problem still to be solved.

3.3 OPOD TUBE HOUSING

We have to live small in the city, because we cannot afford the space, however, this does not mean that we have to live in a squalid or inhuman environment such as fractional apartments or cages. A well, a small designed space can still be a quite hospitable, very warm, very cozy house.

-James Law-

In recent years Hong Kong is experiencing one of the worst housing crises in the world due to a sudden increase in population, which results in a strong demand for housing. Real estate prices are skyrocketing, the land on which to build are increasingly scarce and the available spaces are really limited due to the wild urban speculation that has invested most of the countries of East Asia from the 2000s to today[10].

For this reason, the majority of the less well-off population lives in apartments of a few square metres and in precarious sanitary conditions. As evidence of this, in 2021 the

[9] ERIKA SEGHETTI, *Prefabrication and modularity, is the future of construction?*, Teknoring Wolters Kluwer, september 2019

[10] WENDELL COX – HUGH PAVLETICH, *16th Annual Survey on International Housing Convenience, Demographia Institute*, Performance Urban Planning, 2020

Demographia International Housing Affordability Survey ranked Hong Kong as the least affordable housing market in the world.

Architect James Law, founder and CEO of James Law Cybertecture, has designed a prototype of low-cost micro-homes to fit into the empty spaces of city buildings to overcome the problem of the lack of apartments and spaces in which to build them.

The project, Opod Tube Housing, takes its name from real concrete pipes used for the pipes of large water infrastructure, each 2.5 meters in diameter, transformed into houses of 9.29 square meters.

«I got the idea at the base of the OPod when I was in a construction site, I got into a pipe and was surprised by how big they were. I thought: wouldn't it be a really good idea to use these concrete pipes to create "microarchitectures" at very low costs, and also interesting enough for young people in Hong Kong?»[11]

The idea that Law considers winning is that, by exploiting tubes already produced in series for other purposes, the OPods are potentially cheap, well designed and, since made of concrete, very resistant and with good insulating and fire-tightness properties.

Since each unit weighs about 20 tons and can be lifted easily with medium-sized cranes, the architect imagines that these tubular structures can be stacked on top of each other up to four times without the need for additional supports, thus creating modular buildings and creating a new idea of interdependent community.

The prototype, built under a bridge in Kwun Tong, gives a good idea of what the architect Law could be the futuristic and functional concept of his project. Inside the large concrete tube there are all the facilities for living, cooking and bathing.

A glass front panel at the entrance of the "capsule" acts as a door and window, unlockable via smartphone, now indispensable in times where technology governs us every day. The

[11] JAMES LAW, *Cybertecture*, Oro Editions, 2011

interior walls are whitewashed, diminishing the industrial aesthetic, while there is a flat wooden floor to level the base and thus facilitate the movement of the occupant.

Inside there is space for a bench, transformed if necessary into a bed, a mini fridge and a microwave, a rail to hang clothes, a support to place a suitcase and an air conditioner; there is also a separate room for the bathroom, equipped with shower and toilet.

Law also employed some lighting tricks to make the interior less cramped with light points pointed upwards and in the concavity to streamline the walls.

At first glance it might look like a cage but the project aims to optimize the spaces to make it more comfortable and less claustrophobic the stay within the structure.

The production costs of one OPod are around 15˙500 dollars, a much lower cost than a property in central Hong Kong, where a single parking space can cost 760˙000 dollars.

To all intents and purposes this project is part of what many consider the future of housing: the Tiny Houses, houses of very small size but equipped with every comfort. From the social movement born in the USA in the 1970s[12], the phenomenon of miniature houses soon turns into a real need, especially in those countries characterized by a constant increase in population and real estate and, as a result of the lack of space.

[12] The Small House Movement is an architectural and social movement that supports the downsizing of living spaces, their simplification and essentially the "living with less"

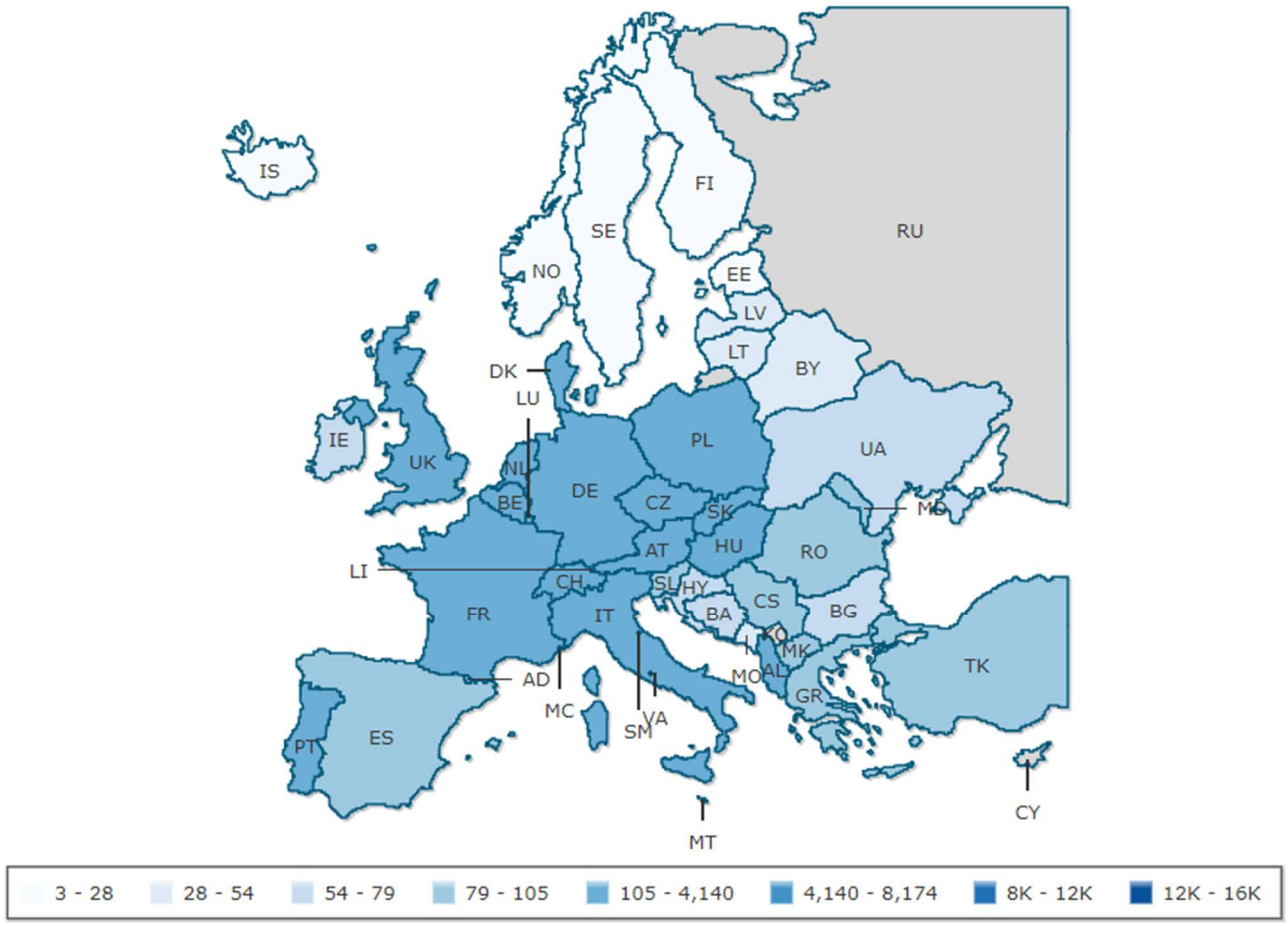


Figure 3: Population density in Europe in 2020 {CIA World Factbook}

Between 1960 and 2015 there is an overall growth of the European population of 101.7 million inhabitants

Thanks to their small size and very limited energy requirements, tiny houses are undoubtedly an inexpensive and environmentally friendly housing solution. When these micro dwellings are mobile, they have the advantage of being able to be moved easily and have a limited impact on the environment and the community.

Designing a tiny house, over time, becomes an exciting challenge and their type of design increases a trend so much to take the form of an architectural phenomenon of considerable importance. While it is true that small spaces impose many limitations on design, at the same time it is also true that they offer interesting opportunities. Every centimeter is fundamental and therefore you will have to think about how to exploit it, finding architectural solutions that maximize the space, playing with light, furniture, materials and colors.

Returning to the intuition of James Law, the ultimate goal of this new design frontier is not only an architectural and real estate redevelopment of the territory but also and above all a social housing project «*to help these young people, to nourish them, to protect them, to allow them a dignified step forward in life. We need to be innovative in terms of how we design and build our cities. Only then people can have a better environment, a more accessible environment. And I think this leads to a new generation of architecture*».

CHAPTER 4

MODULARITY

PREFABRICATED ENGINEERING

Architecture is not a product of materials and functions - nor, by incidence, of social conditions - but of the changing spirit of changing epochs. It is the spirit of an era that pervades his social life, his religion, his science, his art.

-Nikolaus Pevsner-

Until a few years ago, the combination of building and sustainability, sounded almost out of tune, while today, the situation has definitely changed, thanks to the greater attention paid to issues of energy efficiency and environmental impact. The giant steps of sustainable building are therefore helping to create increasingly innovative solutions. We are talking about the emblem that is driving the sustainable revolution, and that has involved the entire construction industry and its related industries. These particular houses, prefabricated, contribute to reduce the environmental impact by increasing at the same time the energy efficiency as well as the sustainability of the house itself[1].

The idea of modularity and prefabrication has very ancient origins. In the buildings of the past the complex designs were reserved for a few buildings, mainly of cult and power. The "common" building was instead made up of different combinations of materials and techniques, purely empirical, which were handed down between generations and prepared the rules, of size and proportion, to be respected for the construction.

[1] ALESSIA NOCIARO, *Modularity and Prefabrication. Historical outline and evolution of systems*, MoDoM, february 2017

The thought of modularity was, implicitly, immediately at the basis of construction techniques, based on lifestyles, availability of materials and empirical knowledge. The concept of prefabrication has instead followed a slower path because the idea of creating buildings with assembly techniques and prefabricated materials needed design, knowledge and production of elements that, except for exceptions, were not available until the first half of the nineteenth century. The experimentation of the concept of prefabricated building in the field took place only thanks to the mechanization of the site, the availability of machinery suitable for lifting and transport and for the first companies for the production of materials combined with technological developments in the civil and industrial construction sector.

While the Industrial Revolution was advancing in Europe, the East knew the era of colonization. The need to urbanize large cities in a short time in the Indies and in all colonies has in fact pushed the British construction companies to produce mass-produced components that were quickly assembled on site[2]. Nothing to do with today's highly customized prefabricated wooden houses, but the concept of production was almost identical: components of houses produced in specialized industries that were then assembled on the place where the building would arise.

At the turn of the 19th and 20th centuries, the development of the United States of America and its westward run led to the need to have houses ready to be built and, as had happened in the previous century in the Indies, companies specialized in the production of real kits for prefabricated houses proliferated. Known all over the world for its visionary structures, in the '10s even the famous architect Frank Lloyd Wright had designed a modular house built on the basis of standardized modules. The valuable materials and high production costs meant that his Assembled House was never built, but Wright's theories opened the way to a new concept of prefabricated house: no longer a building to be built in haste and fury for necessity, but prestigious houses built according to standard procedures to optimize processes and increase quality.

[2] THOMAS KÄLIN, *Prefabricated houses: a 400-year history*, BAUTRUST, february 2021

Planning economically the construction of your own prefabricated house is one of the first steps to be taken to verify the feasibility: if it is true that they allow an almost total control of expenditure, up to the last cent, it is also true that the construction company, the various technical requirements, the municipal charges, the connections and some unforeseen that there can always be, must be taken into account in order not to exceed the costs and exceed the budgeted.

Focusing now on the bureaucratic process[3] necessary for the construction of a prefabricated structure, it would seem less dense than that of a traditional dwelling. In reality, this is not the case, on the contrary: building a prefabricated house is not very different from building a traditional masonry house. Building a house through prefabrication is not an expedient to circumvent the legal constraints envisaged in the field of construction. The practices to be managed are the same, as are the permits, the building permits and the buildability of the land.

It is a fully-fledged housing structure, subject to regulations for the construction of housing structures, intended in the classical sense, also considering the fact that being mounted on reinforced concrete foundations, it becomes a real permanent structure with a duration equal to the traditional masonry dwellings.

As in the case of conventional constructions, the project for the construction of a prefabricated house must be initiated and followed by a qualified technician – such as an engineer, an architect or a surveyor – as director of works and site manager. Subsequently, he will be joined by additional professional figures who will take care of all the phases concerning the project.

Prefabricated houses today represent a modern and reliable construction solution, a valid alternative to traditional masonry systems. Not surprisingly, the relative market is knowing a slow but continuous increase. The advantages in terms of costs and expenses are considerable. They are highly performing constructions, which comply with the latest

[3] MAURA CORRADO, *Prefabricated houses: what permissions do they serve?*, laleggepertutti, september 2016

regulations on energy saving, safety, insulation, and can be customized in every detail, but still retain the key concept of their invention: the ease and speed of building a comfortable and cozy home.

I thank Prof. Pierre Latteur and Prof. Paolo Piantanida for the careful supervision and the important contribution given to the design.

I thank Prof. Ilaria Butera, Prof. Emilia Maria Garda and Prof. Yvette Pelsser for their availability and the time dedicated.

4.1 PROJECT STATUS

In every field of design it is necessary to be able to predict the works of the future and to strive to understand which innovations will be subjected to; it is appropriate to explore every possibility opening the design vision to its quantum future.

-Patrizia Boi-

The project is born from the widespread need to combine comfort, well-being and eco-sustainability in an intelligent housing worthy of being lived. The hope is to respond to the different problems and questions of classical building that with almost proverbial delays in the work and the dizzying increase in costs caused by each variant in the course of work, seems almost to be "admitting its defeat".

The chosen construction system is dry, based on the easy, stable and safe assembly of prefabricated steel elements, following a simple and effective method to design all the components of the building and program its use on site as "bricks" manufactured to high standards of manufacturing and control. In this way it is possible to reduce the amount of waste material, increase the speed of execution and ensure a measurable economic advantage in the construction.

The materials calculated and used with modular criteria allow a precise and optimized planning of expenses, with a decided reduction of waste, while the lightness of the

structures ensures the lowering of costs related to foundations, excavation volumes and casting. Clearly, the short and predictable construction times also contribute to containing and forecasting the financial commitment.

The steel structure is ductile, able to face any seismic shock with multiple effectiveness compared to the more rigid materials such as cement and masonry, moreover allowing easier restoration of the parts if damaged. The dry construction also guarantees a great passive resistance in case of fire and the industrial manufacture of all elements requires more controls and ensures superior reliability for each individual component of the building.

For the project, a concrete foundation was chosen with the subsequent drowning of the anchor bolts. Continuous foundations thus developed ensure the correct absorption of the loads transmitted by the overlying structure and the effective distribution to the ground. The perimeter structure of modular elements is supported by a structural steel frame while the floor is made of laminated wooden beams combined with a high quality plank. The roof is flat to increase the space available.

Thanks to the construction system of the outer coat with its metallic currents, the coatings are characterized by customization and flexibility. As well as the windows integrated in the overall appearance of the building: sturdy, safe and able to ensure the correct thermal insulation. Thanks to the steel structure, doors and windows open onto walls not limited by structural constraints.

The planimetric distribution, implemented in an initial design solution, has the task of condensing all the environments, making the housing unit a replicable concept and easy to realize. The spaces have been redesigned in order to ensure fewer workstations, making the environments diffused and no longer centralized.

The project then describes a "mini-house" of a few tens of square meters but exploited to the maximum. The light inside is maximized thanks to the large windows. The rooms are characterized by a minimal design, but without sacrificing the comforts of everyday life.

The unit is able to easily accommodate two people, thus meeting the needs of a constantly evolving society.

On the ground floor we find a large central open space that serves as an open-plan kitchen, dining and living room, and the bathroom area in an independent environment. On the first floor a bedroom with a study area. Wall cabinets, shelves and shutters integrated into the walls are just some of the space-saving solutions designed for this project. The roof is used as a private green space.

All systems are conveyed to the rear of the house and on the roof are installed photovoltaic panels to meet the energy needs of the unit. High thermal acoustic insulation, optimized heating and air conditioning systems that are perfectly integrated into the structure, guarantee healthy and moisture-free environments. The interior lighting provides LED lights with greater durability and less expense. The internal temperature is regulated by a solid biomass system and the diffusion in the rooms is ensured by floor systems. A controlled ventilation system reduces the energy requirement for heating and ensures constant air exchange, in view of increased and optimal living comfort. An electric automation system completes the project giving practicality and efficiency.

The project, in its entirety, is modular in the materials but not in the conception, thus allowing the realization of authentic houses, tailored to the wishes expressed by the client. The modular concept and the prefabricated technique do not limit the possibilities of customization and development of the project according to the actual and specific needs, or tastes, of the client. Each building is different and responds to the needs, history, style chosen, and the final appearance is, in all respects, a traditional house.

For what is not expressly stated above, please refer to the attached "PROJECT TABLES" forming an integral part of this work.

4.2 PROJECT TABLES

The most beautiful phrase I remember in my life was said by a child when he spoke of a drawing: "What is a drawing? It's an idea with a line around it". It's beautiful, this is my whole life.

-Bruno Bozzetto-

The design and drafting of the technical tables were conducted using the suite of the company Autodesk, in particular the software Autodesk Revit that allows the design with parametric modeling and drawing elements. BIM modeling allows an approach closer to perceived reality, getting closer to concreteness. From a general overview, in deepening the study, we move to the view of detail focusing on the design solutions adopted.

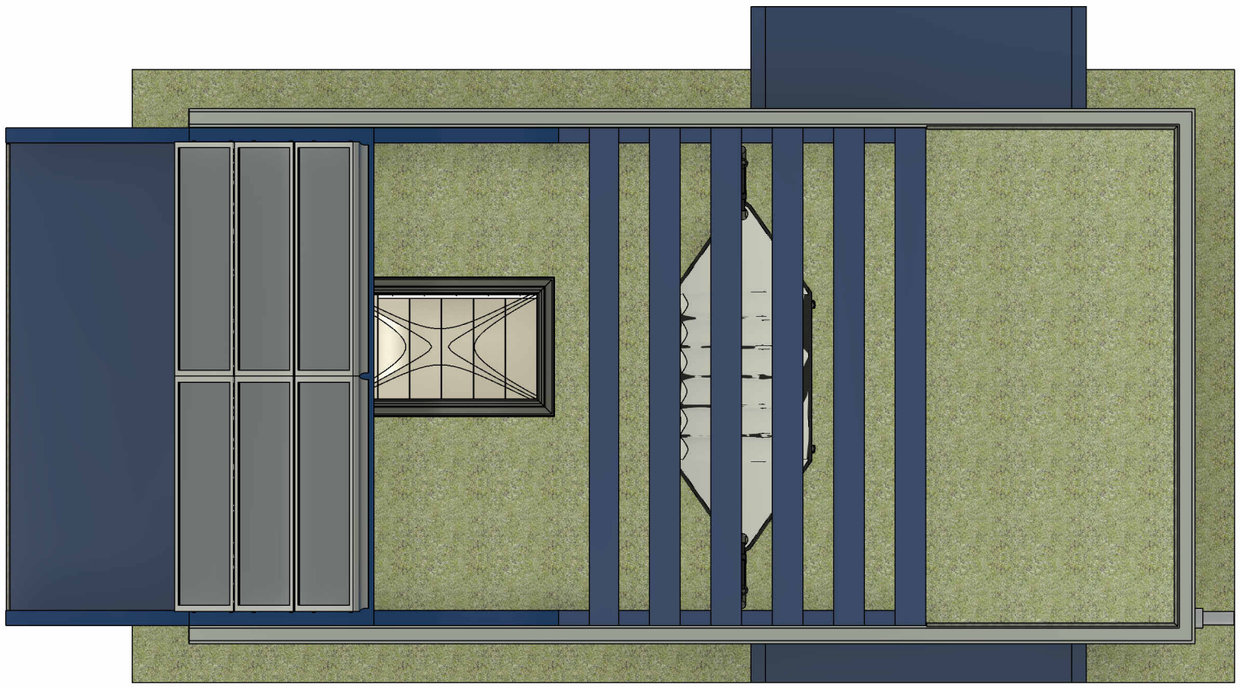
4.3 ANALYSIS MODELS

The real genius lies in the ability to assess uncertain, dangerous and conflicting information.

-Winston Churchill-

The interoperability offered by the digital modeling software used allows the implementation of analysis models for the study and verification of the entire project. In this regard, the essential aspects to complete this work have been explored:

- Structural analysis of the steel frame – SCIA software, Nemetschek Group
- Maintenance plan of the load-bearing structures – ManTus software, ACCA Software
- Overall cost analysis – PriMus software, ACCA Software
- Ecological footprint level of the housing unit – ITACA classification criteria
- Energy performance certificate – DOCET software, ENEA National Agency



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MASTER THESIS

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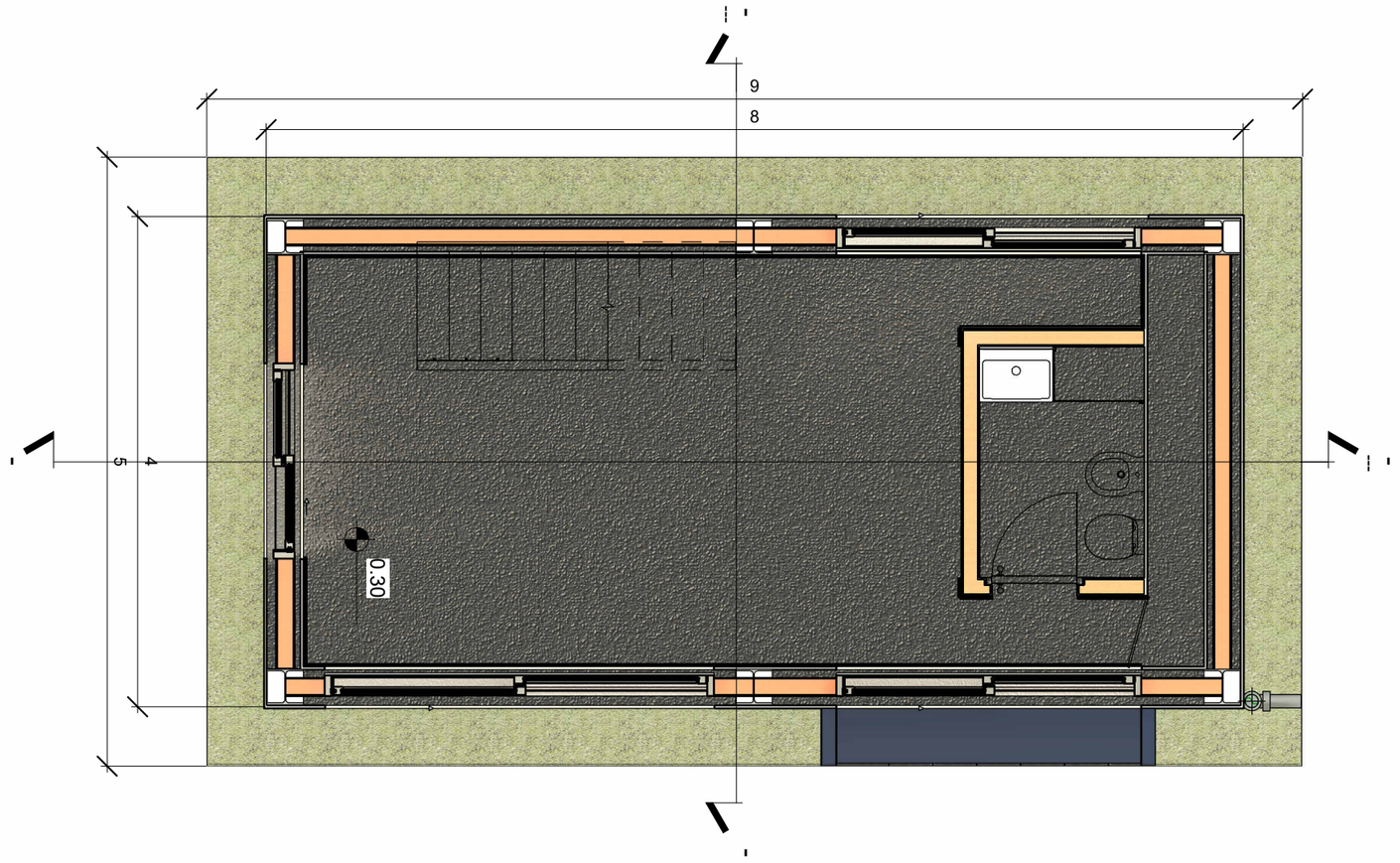
Prof. Eng. Pierre LATTEUR
Prof. Eng. Paolo PIANTANIDA

AUTHOR
Luca Manuel MINERVA

TABLE N. 01

PROJECT STATUS
GENERAL PLANIMETRY
SCALE 1:50 [m]



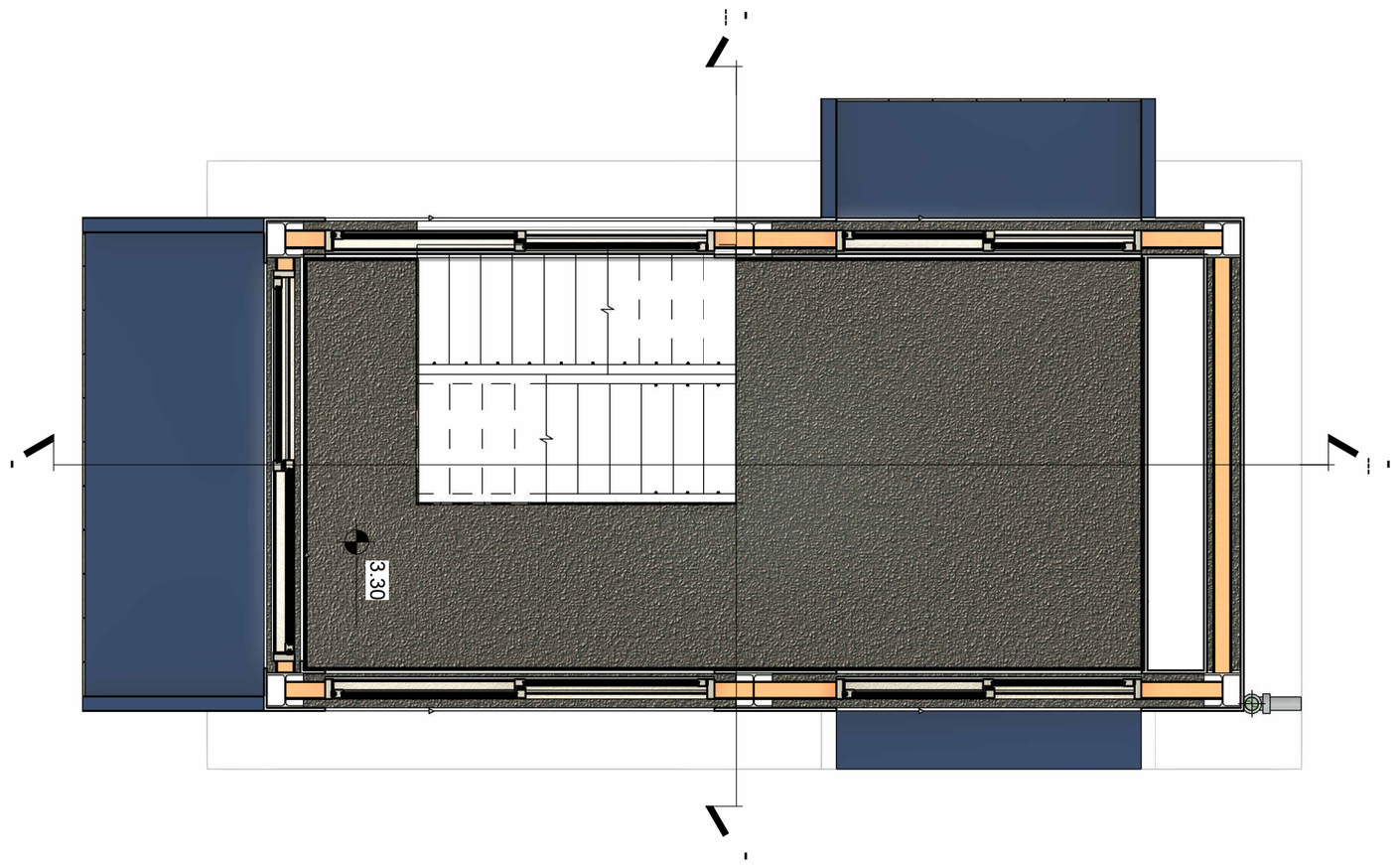


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TABLE N. 02

PROJECT STATUS
GROUND FLOOR PLAN - FIRST FLOOR PLAN
SCALE 1:50 [m]

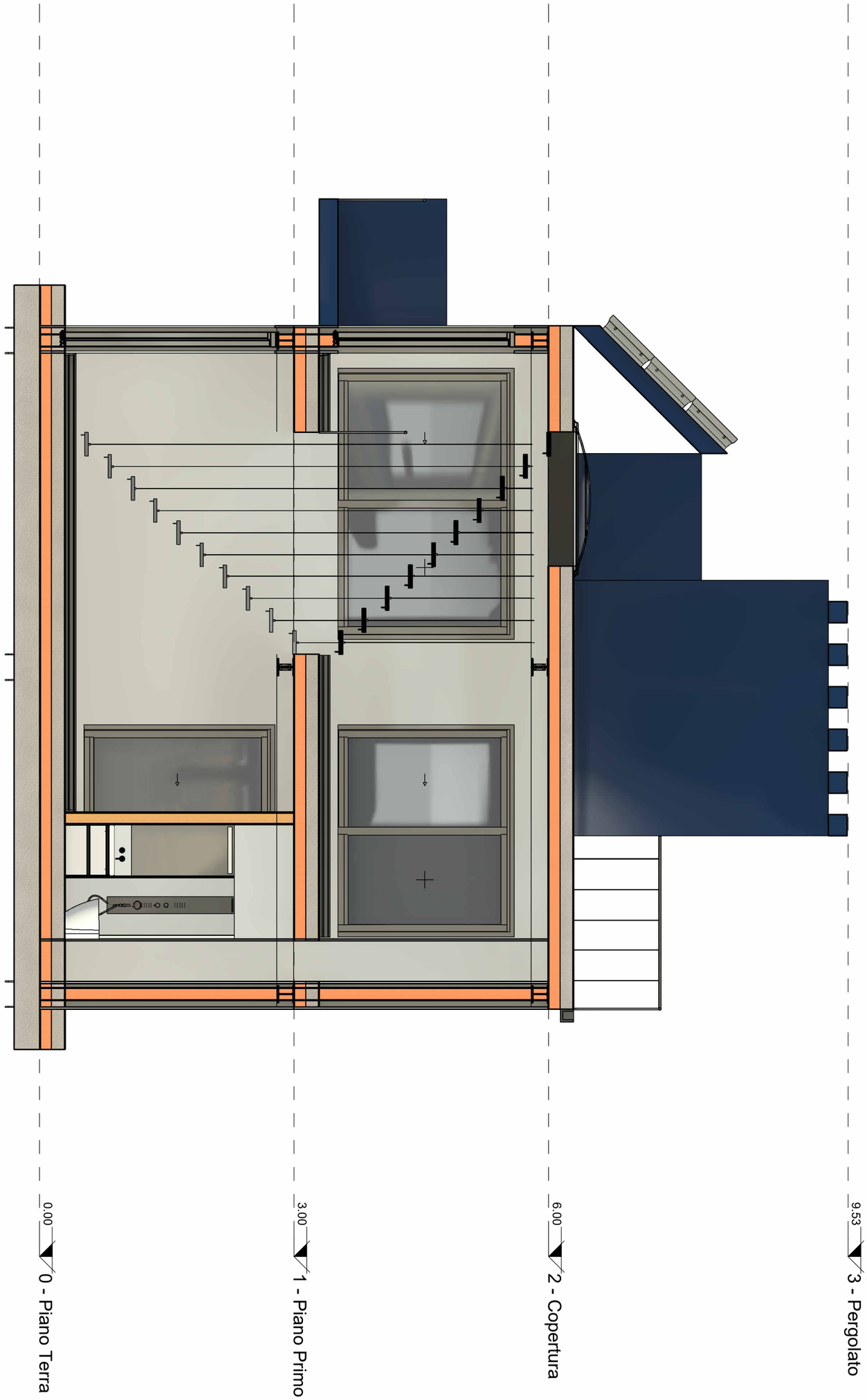

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TABLE N. 03

PROJECT STATUS
LONGITUDINAL SECTION
SCALE 1:50 [m]

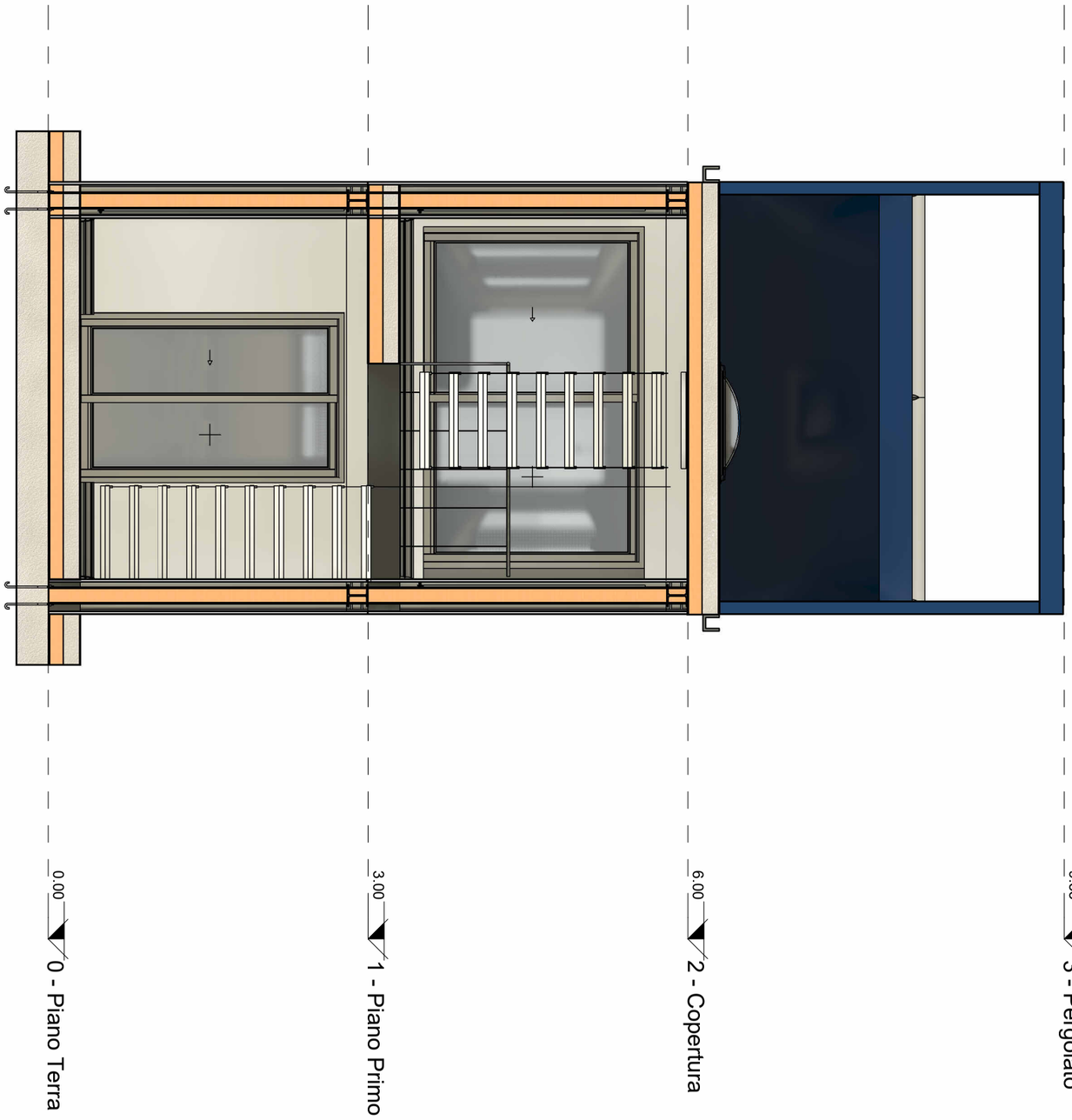

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TABLE N. 04

PROJECT STATUS
TRANSVERSAL SECTION
SCALE 1:50 [m]

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AUTHOR
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TABLE N. 05

PROJECT STATUS
SOUTH ELEVATION - EAST ELEVATION
SCALE 1:50 [m]

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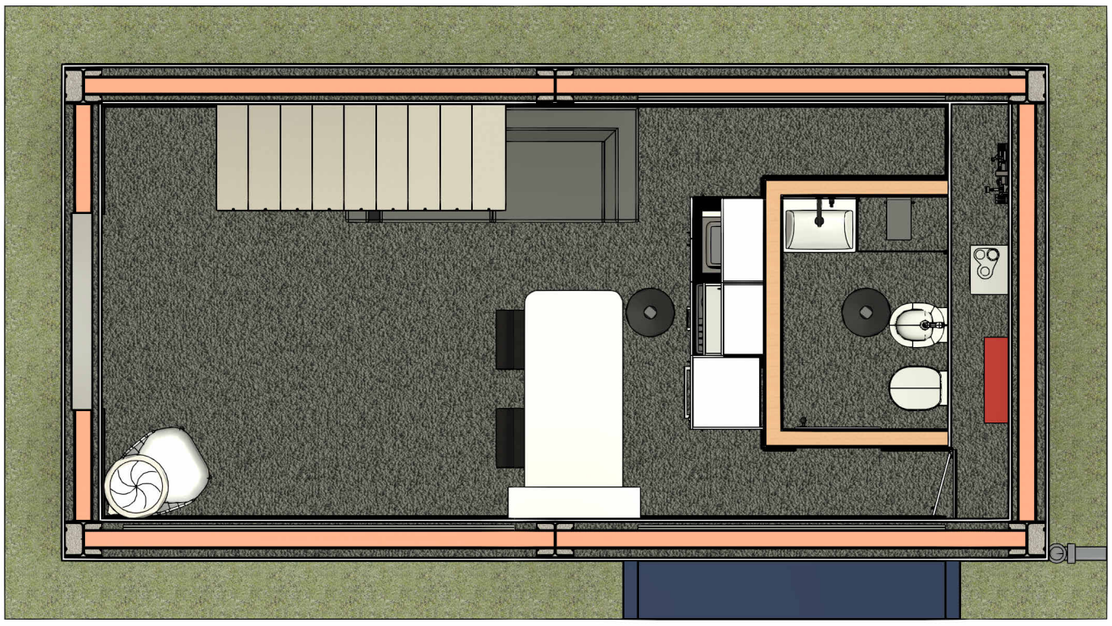
TABLE N. 06

PROJECT STATUS
NORTH ELEVATION - WEST ELEVATION
SCALE 1:50 [m]



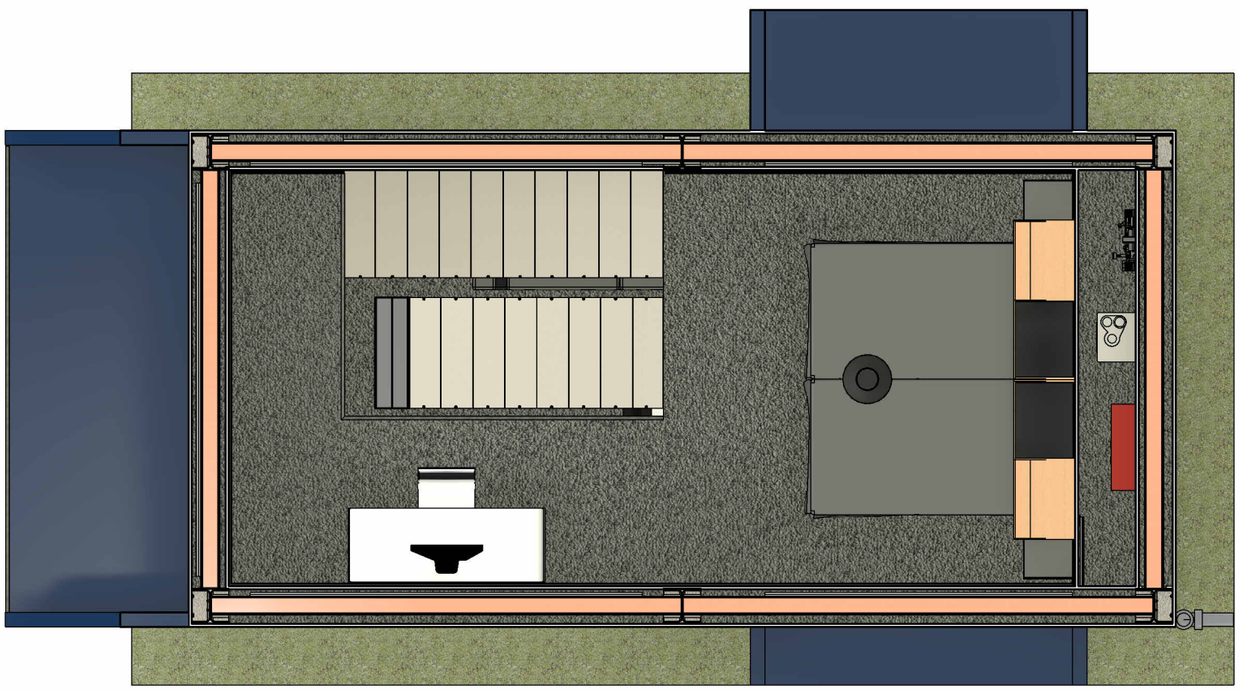


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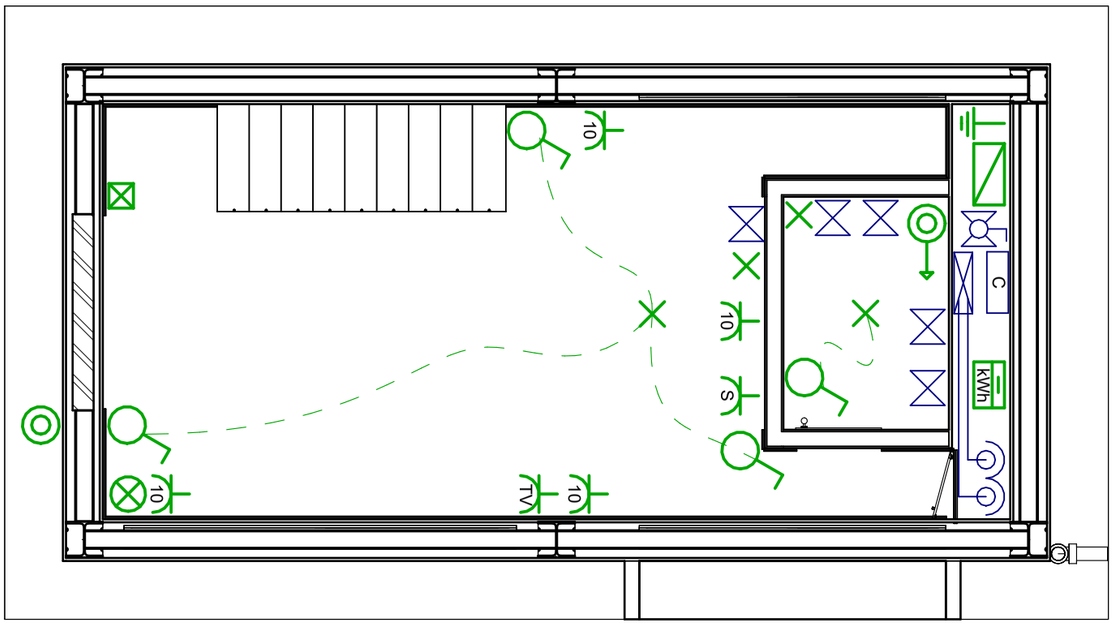
TABLE N. 07

PROJECT STATUS
GROUND FLOOR DECOR - FIRST FLOOR DECOR
SCALE 1:50 [m]



ELECTRICAL PLANT

HYDRAULIC PLANT

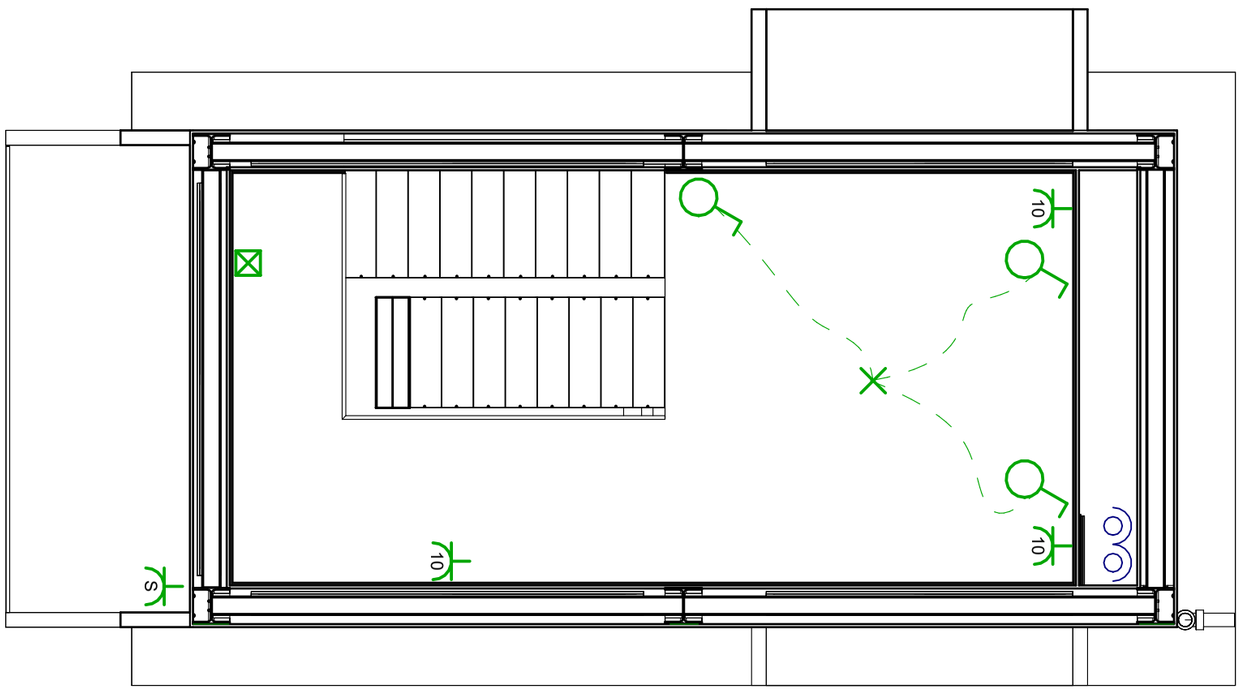


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TABLE N. 08

PROJECT STATUS
GROUND FLOOR PLANT - FIRST FLOOR PLANT
SCALE 1:50 [m]

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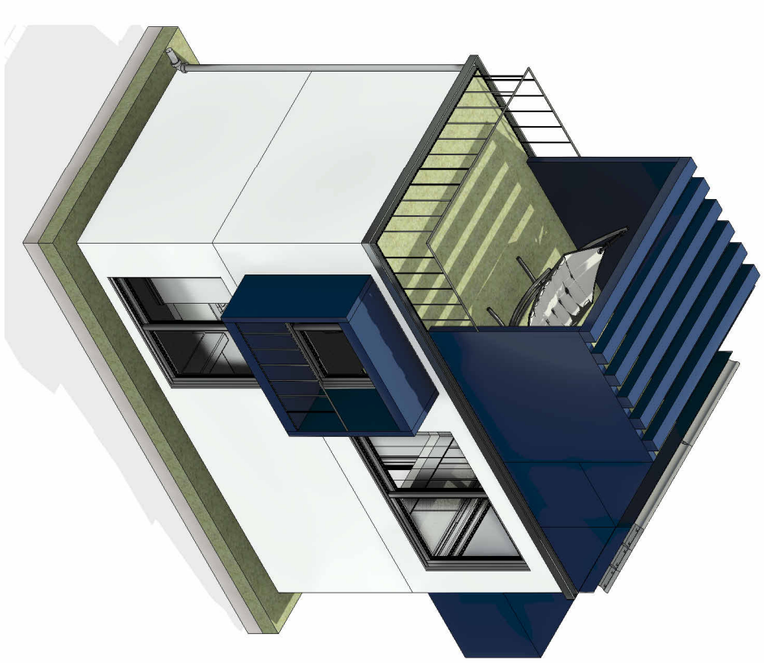
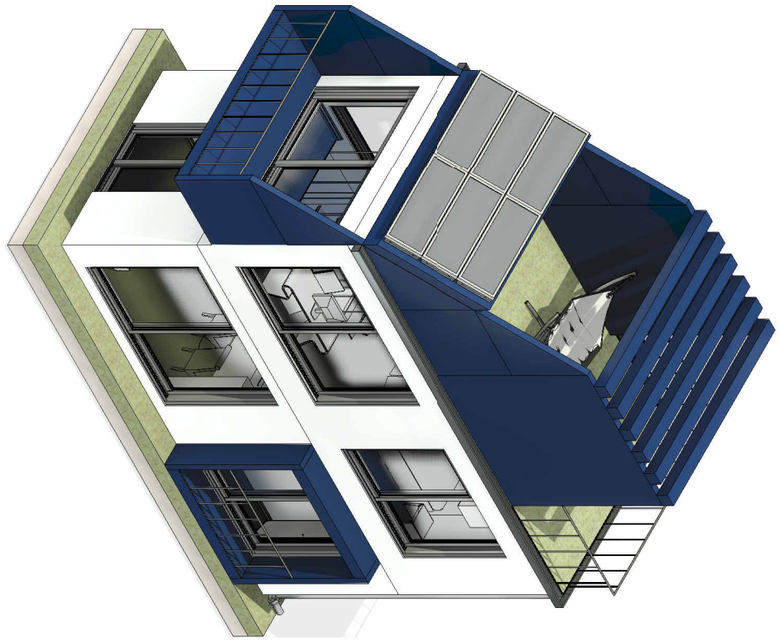
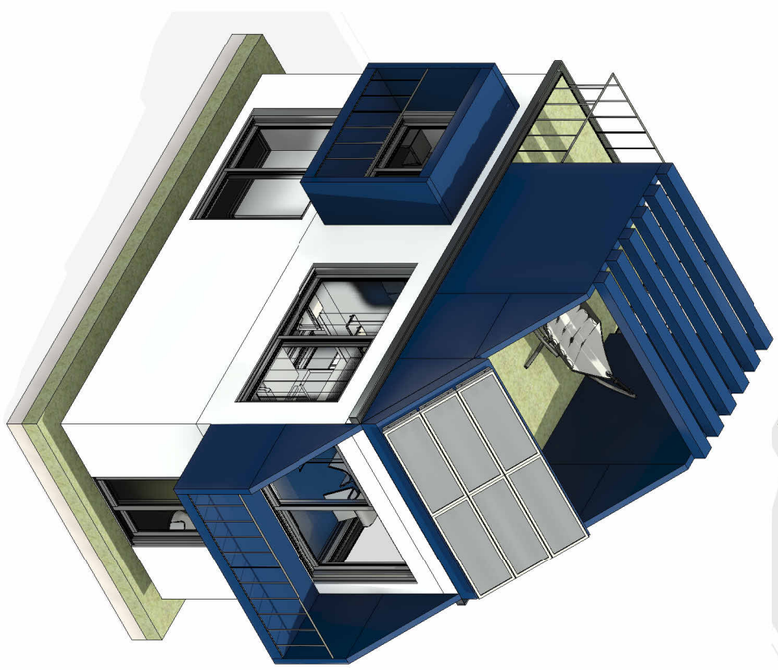
TABLE N. 09

PROJECT STATUS
INTERIOR RENDERING
SCALE 1:50 [m]







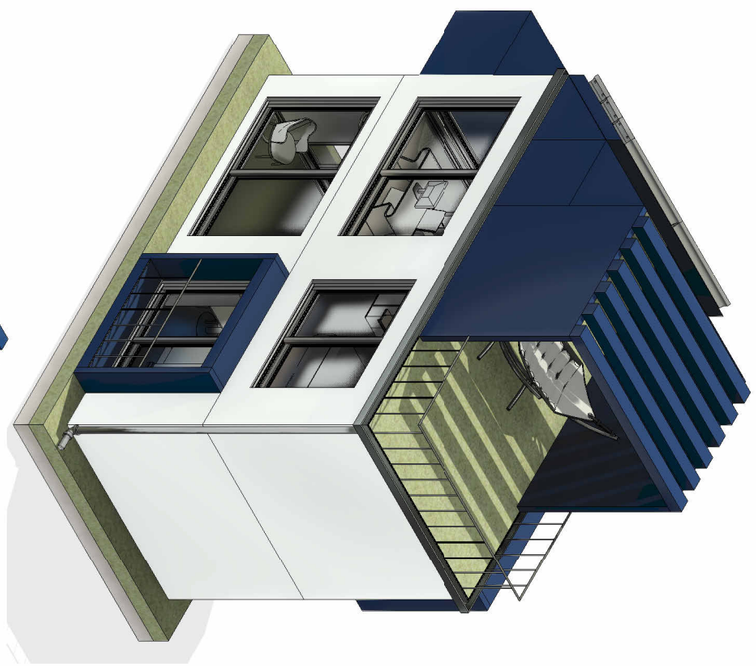


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TABLE N. 10

PROJECT STATUS
EXTERIOR RENDERING
SCALE 1:100 [m]

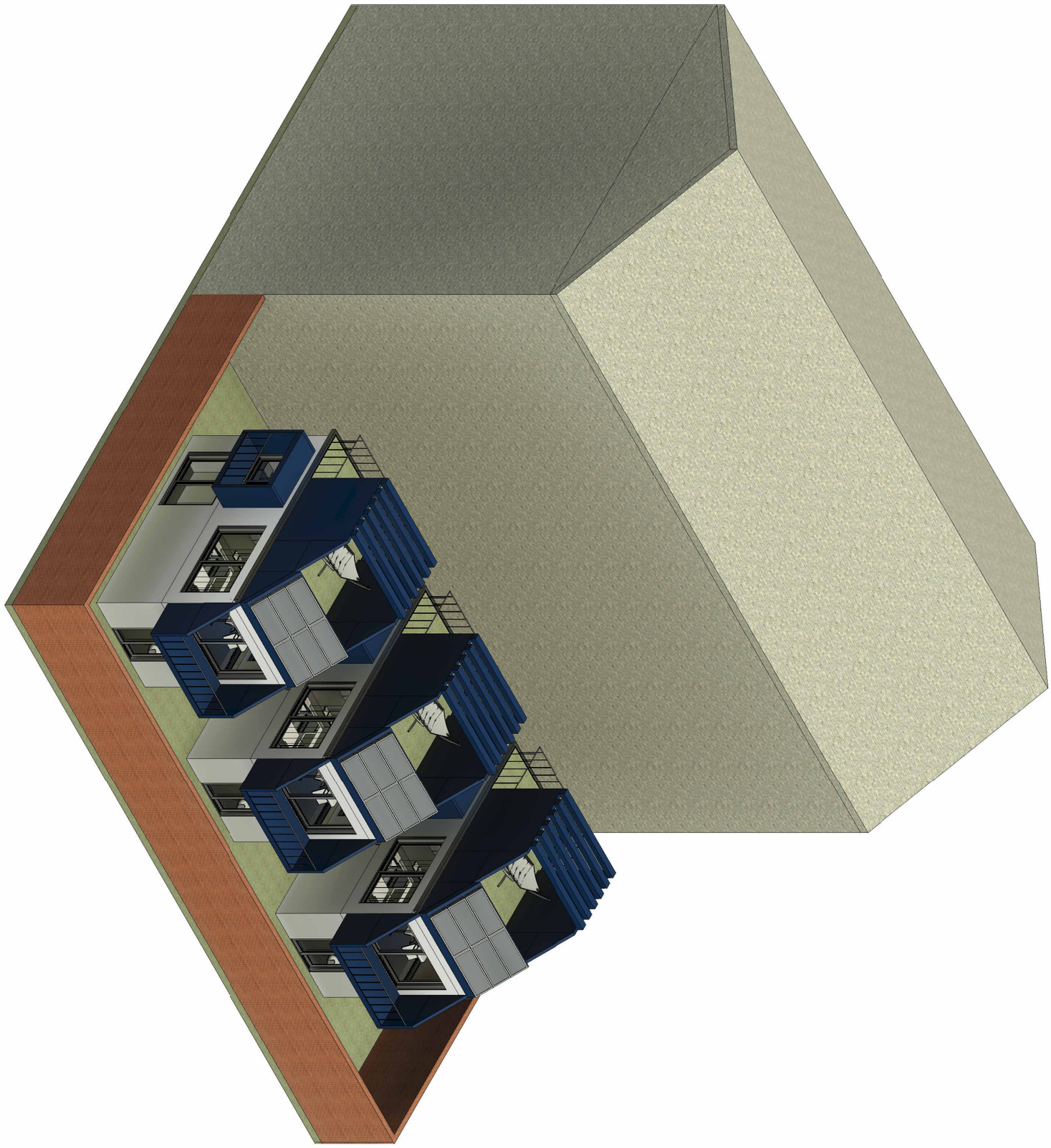

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TABLE N. 11

PROJECT STATUS
COURTYARD ARRANGEMENT RENDERING
SCALE 1:150 [m]

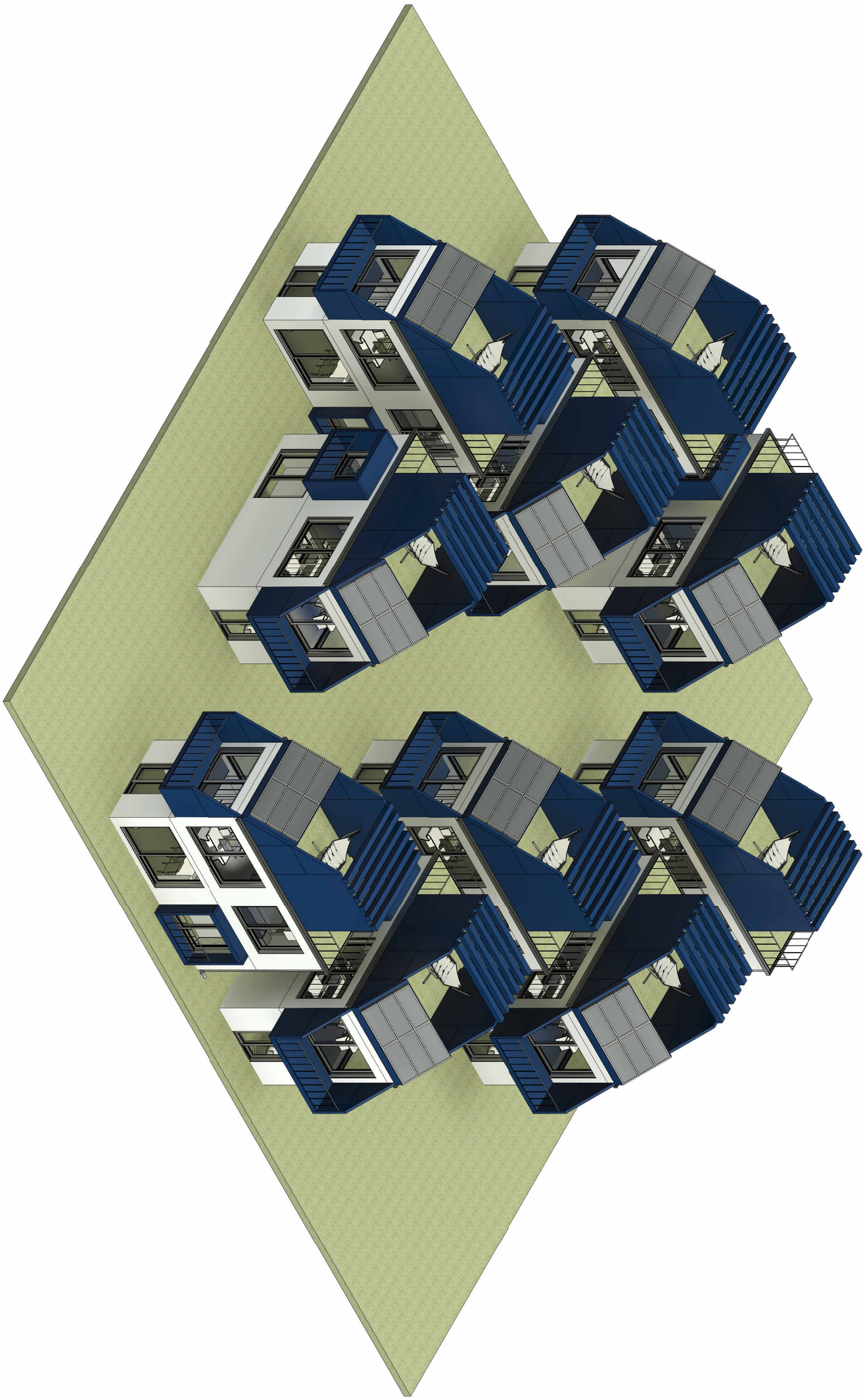

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TABLE N. 12

PROJECT STATUS
HORIZONTAL ARRANGEMENT RENDERING
SCALE 1:150 [m]

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Prof. Eng. Paolo PIANTANIDA

AUTHOR
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TABLE N. 13

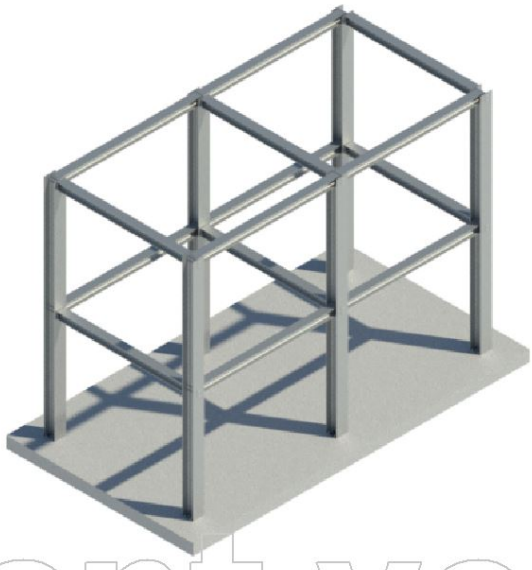
PROJECT STATUS
VERTICAL ARRANGEMENT RENDERING
SCALE 1:150 [m]

1. Table of contents

2. Project

Licence name	Ecople Polytecnique Louvain
Project	Structural steel frame
Description	Analysis of loads and deformations
Author	Luca Manuel Minerva
Date	03. 10. 2021
Structure	General XYZ
No. of nodes :	18
No. of beams :	20
No. of slabs :	0
No. of solids :	0
No. of used profiles :	2
No. of load cases :	2
No. of used materials :	1
Acceleration of gravity [m/s^2]	9,810
National code	EC - EN

3. BIM structure



4. Setup manager

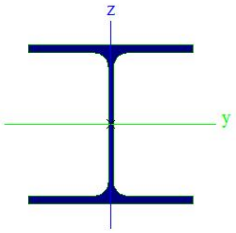
Psi factors

Load	Psi0	Psi1	Psi2
CategoryA	0.7	0.5	0.3
CategoryB	0.7	0.5	0.3
CategoryC	0.7	0.7	0.6
CategoryD	0.7	0.7	0.6
CategoryE	1	0.9	0.8
CategoryF	0.7	0.7	0.6
CategoryG	0.7	0.5	0.3
CategoryH	0	0	0
Snow	0.5	0.2	0
Wind	0.6	0.2	0
Temperature	0.6	0.5	0
Construction loads	1	0	0.2

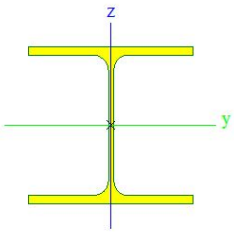
Load combination factors

Permanent action - unfavorable	1,35
Permanent action - favorable	1,00
Leading variable action	1,50
Accompanying variable action	1,50
Reduction factor ksi	0,85
Permanent action - unfavorable	1,00
Permanent action - favorable	1,00
Leading variable action	1,30
Accompanying variable action	1,30

5. Cross-sections

CS2		
Type	HEA300	
Formcode	1 - I section	
Shape type	Thin-walled	
Item material	S 355	
Fabrication	rolled	
Colour		
Flexural buckling y-y, Flexural buckling z-z	b	c
A [m^2]	1,1300e-02	
A_y [m^2], A_z [m^2]	8,1300e-03	2,6502e-03
A_L [m^2/m], A_D [m^2/m]	1,7200e+00	1,7164e+00
$c_{Y.UCS}$ [mm], $c_{Z.UCS}$ [mm]	150	145
α [deg]	0,00	
I_y [m^4], I_z [m^4]	1,8300e-04	6,3100e-05
i_y [mm], i_z [mm]	127	75
$W_{el.y}$ [m^3], $W_{el.z}$ [m^3]	1,2600e-03	4,2100e-04
$W_{pl.y}$ [m^3], $W_{pl.z}$ [m^3]	1,3833e-03	6,4167e-04
$M_{pl.y.+}$ [Nm], $M_{pl.y.-}$ [Nm]	4,92e+05	4,92e+05
$M_{pl.z.+}$ [Nm], $M_{pl.z.-}$ [Nm]	2,28e+05	2,28e+05
d_y [mm], d_z [mm]	0	0
I_t [m^4], I_w [m^6]	8,5200e-07	1,1998e-06
β_y [mm], β_z [mm]	0	0
Picture		

CS3		
Type	HEA200	
Formcode	1 - I section	
Shape type	Thin-walled	

Item material	S 355	
Fabrication	rolled	
Colour		
Flexural buckling y-y, Flexural buckling z-z	b	c
A [m^2]	5,3800e-03	
A_y [m^2], A_z [m^2]	3,8781e-03	1,3287e-03
A_L [m^2/m], A_D [m^2/m]	1,1400e+00	1,1360e+00
$c_{Y.UCS}$ [mm], $c_{Z.UCS}$ [mm]	100	95
α [deg]	0,00	
I_y [m^4], I_z [m^4]	3,6900e-05	1,3400e-05
i_y [mm], i_z [mm]	83	50
$W_{el.y}$ [m^3], $W_{el.z}$ [m^3]	3,8900e-04	1,3400e-04
$W_{pl.y}$ [m^3], $W_{pl.z}$ [m^3]	4,2917e-04	2,0375e-04
$M_{pl.y.+}$ [Nm], $M_{pl.y.-}$ [Nm]	1,53e+05	1,53e+05
$M_{pl.z.+}$ [Nm], $M_{pl.z.-}$ [Nm]	7,24e+04	7,24e+04
d_y [mm], d_z [mm]	0	0
I_t [m^4], I_w [m^6]	2,1000e-07	1,0800e-07
β_y [mm], β_z [mm]	0	0
Picture		

Explanations of symbols	
Formcode	h - Height b - Flange width t - Flange thickness s - Web thickness r - Radius at flange root r1 - Radius at flange toe a - Flange slope W - Internal bolt distance wm - Unit warping at flange toe
A	Area
A_y	Shear Area in principal y-direction
A_z	Shear Area in principal z-direction
A_L	Circumference per unit length
A_D	Drying surface per unit length
$c_{Y.UCS}$	Centroid coordinate in Y-direction of Input axis system
$c_{Z.UCS}$	Centroid coordinate in Z-direction of Input axis system
$I_{Y.LCS}$	Second moment of area about the YLCS axis
$I_{Z.LCS}$	Second moment of area about the ZLCS axis
$I_{YZ.LCS}$	Product moment of area in the LCS system
α	Rotation angle of the principal axis system
I_y	Second moment of area about the principal y-axis
I_z	Second moment of area about the principal z-axis
i_y	Radius of gyration about the principal y-axis

Explanations of symbols	
i_z	Radius of gyration about the principal z-axis
$W_{el.y}$	Elastic section modulus about the principal y-axis
$W_{el.z}$	Elastic section modulus about the principal z-axis
$W_{pl.y}$	Plastic section modulus about the principal y-axis
$W_{pl.z}$	Plastic section modulus about the principal z-axis
$M_{pl.y.+}$	Plastic moment about the principal y-axis for a positive My moment
$M_{pl.y.-}$	Plastic moment about the principal y-axis for a negative My moment
$M_{pl.z.+}$	Plastic moment about the principal z-axis for a positive Mz moment
$M_{pl.z.-}$	Plastic moment about the principal z-axis for a negative Mz moment
d_y	Shear center coordinate in principal y-direction measured from the centroid
d_z	Shear center coordinate in principal z-direction measured from the centroid
I_t	Torsional constant
I_w	Warping constant
β_y	Mono-symmetry constant about the principal y-axis
β_z	Mono-symmetry constant about the principal z-axis

6. Materials

Steel EC3

Name	ρ [kg/m³]	E_{mod} [MPa]	μ	Lower limit [mm]	Upper limit [mm]	F_y [MPa]	F_u [MPa]	Colour
		G_{mod} [MPa]	α [m/mK]					
S 355	7850,0	2,1000e+05	0.3	0	40	355,0	490,0	
		8,0769e+04	0,00	40	80	335,0	470,0	

7. ShearConnectors

Name	Type	Diameter/width [mm]	Nominal height [mm]	In-situ height [mm]	Material
SC1	Stud	25	100	95	S 355

8. Load cases

Name	Description	Action type	Load group	Direction
	Spec	Load type		
LC1	Self weight	Permanent	LG1	-Z
		Self weight		
LC2	Analysis	Permanent	LG1	
		Standard		

9. Combinations

Name	Description	Type	Load cases	Coeff. [-]
SLS-Char (auto)1		EN-SLS Characteristic	LC1 - Self weight	1,00
ULS-Set B (auto)		EN-ULS (STR/GEO) Set B	LC1 - Self weight	1,00
			LC2 - Analysis	1,00
SLS-Char (auto)		EN-SLS Characteristic	LC1 - Self weight	1,00
			LC2 - Analysis	1,00

10. Point force in node

Name	Node	Load case	System	Dir	Type	Value - F [kN]
F1	N14	LC2 - Analysis	GCS	Z	Force	-10,50
F2	N17	LC2 - Analysis	GCS	Z	Force	-10,50
F3	N18	LC2 - Analysis	GCS	Z	Force	-10,50
F4	N15	LC2 - Analysis	GCS	Z	Force	-10,50
F5	N16	LC2 - Analysis	GCS	Z	Force	-19,50
F6	N13	LC2 - Analysis	GCS	Z	Force	-19,50

11. Line force

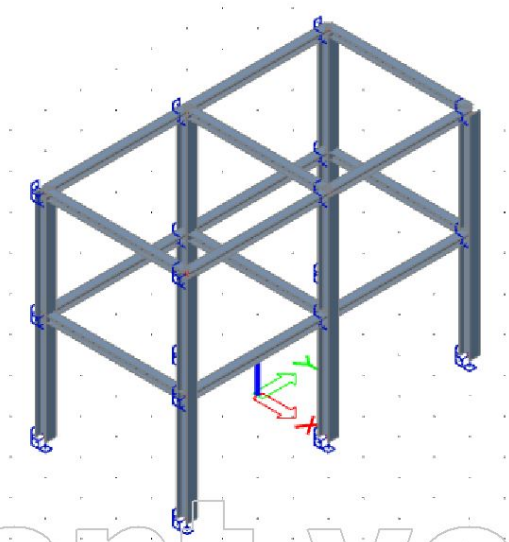
Name	Member	Type	Dir	Value - P_1 [kN/m]	Pos x_1	Coor	Orig	Ecc ey [m]
	Load case	System	Distribution	Value - P_2 [kN/m]	Pos x_2	Loc		Ecc ez [m]
LF1	B13	Force	Z	-3,00	0.000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1.000	Length		0,000
LF2	B12	Force	Z	-3,00	0.000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1.000	Length		0,000
LF3	B11	Force	Z	-3,00	0.000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1.000	Length		0,000
LF4	B10	Force	Z	-3,00	0.000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1.000	Length		0,000
LF5	B20	Force	Z	-3,00	0.000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1.000	Length		0,000
LF6	B19	Force	Z	-3,00	0.000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1.000	Length		0,000
LF7	B18	Force	Z	-3,00	0.000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1.000	Length		0,000

Name	Member	Type	Dir	Value - P_1 [kN/m]	Pos x_1	Coor	Orig	Ecc ey [m]
	Load case	System	Distribution	Value - P_2 [kN/m]	Pos x_2	Loc		Ecc ez [m]
LF8	B17	Force	Z	-3,00	0.000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1.000	Length		0,000
LF9	B9	Force	Z	-3,50	0.000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1.000	Length		0,000
LF10	B16	Force	Z	-3,50	0.000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1.000	Length		0,000
LF11	B14	Force	Z	-3,50	0.000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1.000	Length		0,000
LF12	B7	Force	Z	-3,50	0.000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1.000	Length		0,000
LF13	B8	Force	Z	-6,00	0.000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1.000	Length		0,000
LF14	B15	Force	Z	-6,00	0.000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1.000	Length		0,000

12. Members

Name	Cross-section	Material	Length [m]	Beg. node	End node	Type
B1	CS2 - HEA300	S 355	6,000	N1	N13	column (100)
B2	CS2 - HEA300	S 355	6,000	N3	N16	column (100)
B3	CS2 - HEA300	S 355	6,000	N5	N18	column (100)
B4	CS2 - HEA300	S 355	6,000	N7	N17	column (100)
B5	CS2 - HEA300	S 355	6,000	N9	N14	column (100)
B6	CS2 - HEA300	S 355	6,000	N11	N15	column (100)
B7	CS3 - HEA200	S 355	4,000	N17	N18	beam (80)
B8	CS3 - HEA200	S 355	4,000	N16	N13	beam (80)
B9	CS3 - HEA200	S 355	4,000	N14	N15	beam (80)
B10	CS3 - HEA200	S 355	4,000	N18	N13	beam (80)
B11	CS3 - HEA200	S 355	4,000	N17	N16	beam (80)
B12	CS3 - HEA200	S 355	4,000	N13	N15	beam (80)
B13	CS3 - HEA200	S 355	4,000	N16	N14	beam (80)
B14	CS3 - HEA200	S 355	4,000	N8	N6	beam (80)
B15	CS3 - HEA200	S 355	4,000	N4	N2	beam (80)
B16	CS3 - HEA200	S 355	4,000	N10	N12	beam (80)
B17	CS3 - HEA200	S 355	4,000	N6	N2	beam (80)
B18	CS3 - HEA200	S 355	4,000	N2	N12	beam (80)
B19	CS3 - HEA200	S 355	4,000	N8	N4	beam (80)
B20	CS3 - HEA200	S 355	4,000	N4	N10	beam (80)

13. SCIA model



14. EC-EN 1993 Steel check ULS

Linear calculation
Load case: LC2
Coordinate system: Principal
Extreme 1D: Global
Selection: All

Overall Unity Check

Name	dx [m]	Case	Cross-section	Material	$UC_{Overall}$ [-]	UC_{Sec} [-]	UC_{Stab} [-]
B8	0,000	LC2	CS3 - HEA200	S 355	**0,05**	0,05	0,00

15. EC-EN 1993 Steel Check SLS

Linear calculation
Load case: LC1
Coordinate system: Principal
Extreme 1D: Global
Selection: All

Limit setting

Name	dx [m]	$L_{def,y}$ [m] $L_{def,z}$ [m]	Total load y [1/xx] Total load z [1/xx]	Variable load y [1/xx] Variable load z [1/xx]	Lim. $u_{y,max}$ [mm] Lim. $u_{z,max}$ [mm]	Lim. $u_{y,var}$ [mm] Lim. $u_{z,var}$ [mm]
B7	0,000	**4,000** 4,000	1/200 1/200	1/360 1/360	20,0 20,0	11,1 11,1

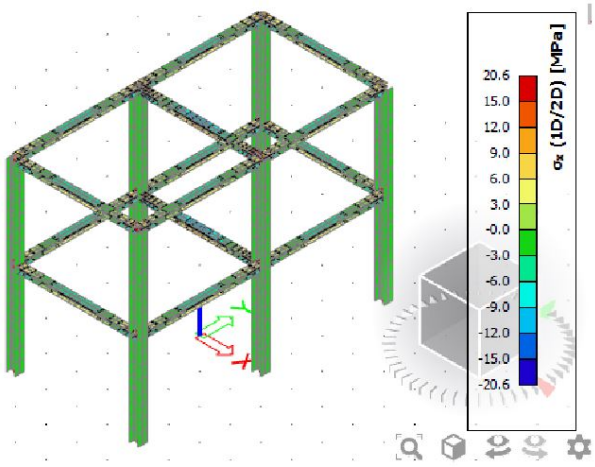
16. 3D stress

Linear calculation
Load case: LC2
Selection: All
Location: In nodes avg. on macro. System: LCS mesh element
Basic magnitudes

Results on 1D member

Extreme 1D: Global

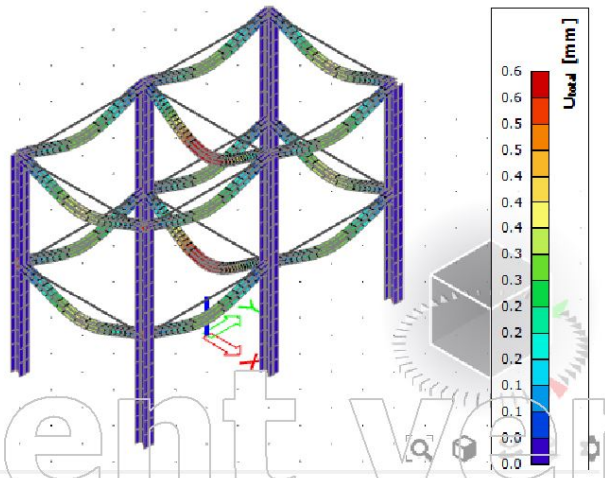
Name	dx [m]	Fibre	Case	σ_x [MPa]	τ_{xy} [MPa]	τ_{xz} [MPa]	τ_{tor} [MPa]
B8	0,000	1	LC2	**-20,6**	0,0	0,0	0,0
B8	0,000	13	LC2	**20,6**	0,0	0,0	0,0



17. 3D displacement

Linear calculation
Load case: LC2
Selection: All
Location: In nodes avg. on macro. System: LCS mesh element
Results on 1D member:
Extreme 1D: Global

Name	dx [m]	Fibre	Case	u_x [mm]	u_y [mm]	u_z [mm]	φ_x [mrad]	φ_y [mrad]	φ_z [mrad]	U_{total} [mm]
B1	0,000	1	LC2	0,0	0,0	0,0	0,0	0,0	0,0	**0,0**
B8	2,000-	1	LC2	0,0	0,0	-0,6	0,0	0,0	0,0	**0,6**



18. Results analysis

Up to this point we have used the software for the calculation of the deformations of the structural elements inserted in the calculation model. Let us now analyze the results obtained to verify that the structure and therefore the calculated deformations respect the constraints imposed by the construction legislation.

As for the preservation of the appearance and functionality of the work, the long-term arrows of the beams, calculated under the quasi permanent condition of the loads, should not exceed the limit of 1/250 of the span.
We therefore consider the beam where we have the maximum value of the calculated deformation:
Beam length = 3.4 m
Imposed limit = 3.4/250 m = 0.0136 m = 13.6 mm
Calculated deformation = 0.6 mm
Since the calculated deformation is much smaller than that imposed by the standard, this verification is satisfied.

With regard to the integrity of the partition walls and bearing walls, the arrows of the beams, calculated under the quasi permanent condition of the loads, should not exceed the limit of 1/500 of the span.
We therefore consider the beam where we have the maximum value of the calculated deformation:
Beam length = 3.4 m
Imposed limit = 3.4/500 m = 0.0068 m = 6.8 mm
Calculated deformation = 0.6 mm
Since the calculated deformation is much smaller than that imposed by the standard, this verification is satisfied.

From the results we can also deduce that the design was carried out maintaining results largely in favor of safety, corroborating the thesis of the effectiveness of prefabricated structures.

1. Table of contents

2. Project

Licence name	Ecole Polytechnique Louvain
Project	Tower structural steel frame
Description	Analysis of loads and deformations
Author	Luca Manuel Minerva
Date	04. 12. 2021
Structure	General XYZ
No. of nodes :	126
No. of beams :	200
No. of slabs :	0
No. of solids :	0
No. of used profiles :	5
No. of load cases :	2
No. of used materials :	1
Acceleration of gravity [m/s^2]	9,810
National code	EC - EN

3. BIM structure

4. Setup manager

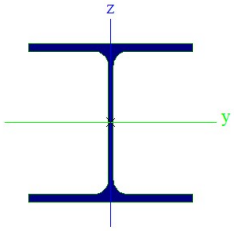
Psi factors

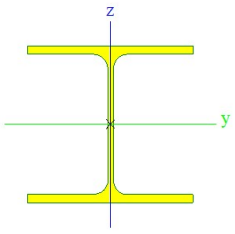
Load	Psi0	Psi1	Psi2
CategoryA	0,7	0,5	0,3
CategoryB	0,7	0,5	0,3
CategoryC	0,7	0,7	0,6
CategoryD	0,7	0,7	0,6
CategoryE	1	0,9	0,8
CategoryF	0,7	0,7	0,6
CategoryG	0,7	0,5	0,3
CategoryH	0	0	0
Snow	0,5	0,2	0
Wind	0,6	0,2	0
Temperature	0,6	0,5	0
Construction loads	1	0	0,2

Load combination factors

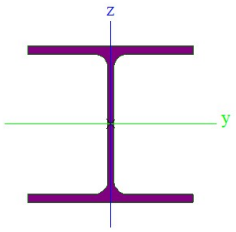
Permanent action - unfavorable	1,35
Permanent action - favorable	1,00
Leading variable action	1,50
Accompanying variable action	1,50
Reduction factor ksi	0,85
Permanent action - unfavorable	1,00
Permanent action - favorable	1,00
Leading variable action	1,30
Accompanying variable action	1,30

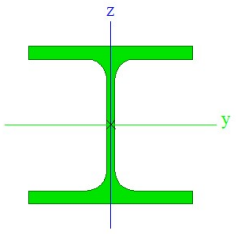
5. Cross-sections

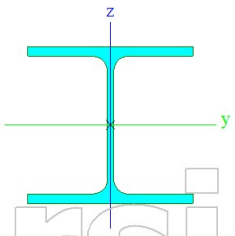
CS2		
Type	HEA300	
Formcode	1 - I section	
Shape type	Thin-walled	
Item material	S 355	
Fabrication	rolled	
Colour		
Flexural buckling y-y, Flexural buckling z-z	b	c
A [m²]	1,1300e-02	
A_y [m²], A_z [m²]	8,1300e-03	2,6502e-03
A_L [m²/m], A_D [m²/m]	1,7200e+00	1,7164e+00
$c_{Y.UCS}$ [mm], $c_{Z.UCS}$ [mm]	150	145
α [deg]	0,00	
I_y [m⁴], I_z [m⁴]	1,8300e-04	6,3100e-05
i_y [mm], i_z [mm]	127	75
$W_{el.y}$ [m³], $W_{el.z}$ [m³]	1,2600e-03	4,2100e-04
$W_{pl.y}$ [m³], $W_{pl.z}$ [m³]	1,3833e-03	6,4167e-04
$M_{pl.y.+}$ [Nm], $M_{pl.y.-}$ [Nm]	4,92e+05	4,92e+05
$M_{pl.z.+}$ [Nm], $M_{pl.z.-}$ [Nm]	2,28e+05	2,28e+05
d_y [mm], d_z [mm]	0	0
I_t [m⁴], I_w [m⁶]	8,5200e-07	1,1998e-06
β_y [mm], β_z [mm]	0	0
Picture		

CS3		
Type	HEA200	
Formcode	1 - I section	
Shape type	Thin-walled	
Item material	S 355	
Fabrication	rolled	
Colour		
Flexural buckling y-y, Flexural buckling z-z	b	c
A [m²]	5,3800e-03	
A_y [m²], A_z [m²]	3,8781e-03	1,3287e-03
A_L [m²/m], A_D [m²/m]	1,1400e+00	1,1360e+00
$c_{Y.UCS}$ [mm], $c_{Z.UCS}$ [mm]	100	95
α [deg]	0,00	
I_y [m⁴], I_z [m⁴]	3,6900e-05	1,3400e-05
i_y [mm], i_z [mm]	83	50
$W_{el.y}$ [m³], $W_{el.z}$ [m³]	3,8900e-04	1,3400e-04
$W_{pl.y}$ [m³], $W_{pl.z}$ [m³]	4,2917e-04	2,0375e-04
$M_{pl.y.+}$ [Nm], $M_{pl.y.-}$ [Nm]	1,53e+05	1,53e+05
$M_{pl.z.+}$ [Nm], $M_{pl.z.-}$ [Nm]	7,24e+04	7,24e+04
d_y [mm], d_z [mm]	0	0
I_t [m⁴], I_w [m⁶]	2,1000e-07	1,0800e-07
β_y [mm], β_z [mm]	0	0
Picture		

CS4		
Type	HEA180	
Formcode	1 - I section	
Shape type	Thin-walled	
Item material	S 355	
Fabrication	rolled	
Colour		
Flexural buckling y-y,	b	c

Flexural buckling z-z		
A [m²]	4,5300e-03	
A_y [m²], A_z [m²]	3,2772e-03	1,0992e-03
A_L [m²/m], A_D [m²/m]	1,0200e+00	1,0241e+00
$c_{y.ucs}$ [mm], $c_{z.ucs}$ [mm]	90	86
α [deg]	0,00	
I_y [m⁴], I_z [m⁴]	2,5100e-05	9,2500e-06
i_y [mm], i_z [mm]	74	45
$W_{el.y}$ [m³], $W_{el.z}$ [m³]	2,9400e-04	1,0300e-04
$W_{pl.y}$ [m³], $W_{pl.z}$ [m³]	3,2500e-04	1,5667e-04
$M_{pl.y.+}$ [Nm], $M_{pl.y.-}$ [Nm]	1,15e+05	1,15e+05
$M_{pl.z.+}$ [Nm], $M_{pl.z.-}$ [Nm]	5,56e+04	5,56e+04
d_y [mm], d_z [mm]	0	0
I_t [m⁴], I_w [m⁶]	1,4800e-07	6,0211e-08
β_y [mm], β_z [mm]	0	0
Picture		

CS5		
Type	HEA100	
Formcode	1 - I section	
Shape type	Thin-walled	
Item material	S 355	
Fabrication	rolled	
Colour		
Flexural buckling y-y, Flexural buckling z-z	b	c
A [m²]	2,1200e-03	
A_y [m²], A_z [m²]	1,6076e-03	5,3156e-04
A_L [m²/m], A_D [m²/m]	5,6100e-01	5,6130e-01
$c_{y.ucs}$ [mm], $c_{z.ucs}$ [mm]	50	48
α [deg]	0,00	
I_y [m⁴], I_z [m⁴]	3,4900e-06	1,3400e-06
i_y [mm], i_z [mm]	41	25
$W_{el.y}$ [m³], $W_{el.z}$ [m³]	7,2800e-05	2,6800e-05
$W_{pl.y}$ [m³], $W_{pl.z}$ [m³]	8,2917e-05	4,1125e-05
$M_{pl.y.+}$ [Nm], $M_{pl.y.-}$ [Nm]	2,95e+04	2,95e+04
$M_{pl.z.+}$ [Nm], $M_{pl.z.-}$ [Nm]	1,46e+04	1,46e+04
d_y [mm], d_z [mm]	0	0
I_t [m⁴], I_w [m⁶]	5,2400e-08	2,5813e-09
β_y [mm], β_z [mm]	0	0
Picture		

CS6		
Type	HEA160	
Formcode	1 - I section	
Shape type	Thin-walled	
Item material	S 355	
Fabrication	rolled	
Colour		
Flexural buckling y-y, Flexural buckling z-z	b	c
A [m²]	3,8800e-03	
A_y [m²], A_z [m²]	2,8071e-03	9,8390e-04
A_L [m²/m], A_D [m²/m]	9,0600e-01	9,0613e-01
$c_{y.ucs}$ [mm], $c_{z.ucs}$ [mm]	80	76
α [deg]	0,00	
I_y [m⁴], I_z [m⁴]	1,6700e-05	6,1600e-06
i_y [mm], i_z [mm]	66	40
$W_{el.y}$ [m³], $W_{el.z}$ [m³]	2,2000e-04	7,7000e-05
$W_{pl.y}$ [m³], $W_{pl.z}$ [m³]	2,4500e-04	1,1750e-04
$M_{pl.y.+}$ [Nm], $M_{pl.y.-}$ [Nm]	8,71e+04	8,71e+04
$M_{pl.z.+}$ [Nm], $M_{pl.z.-}$ [Nm]	4,18e+04	4,18e+04
d_y [mm], d_z [mm]	0	0
I_t [m⁴], I_w [m⁶]	1,2200e-07	3,1410e-08
β_y [mm], β_z [mm]	0	0
Picture		

Explanations of symbols	
Formcode	h - Height
	b - Flange width
	t - Flange thickness
	s - Web thickness
	r - Radius at flange root
	r1 - Radius at flange toe
	a - Flange slope
	W - Internal bolt distance
	wm - Unit warping at flange toe

Explanations of symbols	
A	Area
A_y	Shear Area in principal y-direction
A_z	Shear Area in principal z-direction
A_L	Circumference per unit length
A_D	Drying surface per unit length
$c_{y.ucs}$	Centroid coordinate in Y-direction of Input axis system
$c_{z.ucs}$	Centroid coordinate in Z-direction of Input axis system

Explanations of symbols	
$I_{Y.LCS}$	Second moment of area about the YLCS axis
$I_{Z.LCS}$	Second moment of area about the ZLCS axis
$I_{YZ.LCS}$	Product moment of area in the LCS system
α	Rotation angle of the principal axis system
I_y	Second moment of area about the principal y-axis
I_z	Second moment of area about the principal z-axis
i_y	Radius of gyration about the principal y-axis
i_z	Radius of gyration about the principal z-axis
$W_{el.y}$	Elastic section modulus about the principal y-axis
$W_{el.z}$	Elastic section modulus about the principal z-axis
$W_{pl.y}$	Plastic section modulus about the principal y-axis
$W_{pl.z}$	Plastic section modulus about the principal z-axis
$M_{pl.y.+}$	Plastic moment about the principal y-axis for a positive My moment
$M_{pl.y.-}$	Plastic moment about the principal y-axis for a negative My moment

Explanations of symbols	
$M_{pl.z.+}$	Plastic moment about the principal z-axis for a positive Mz moment
$M_{pl.z.-}$	Plastic moment about the principal z-axis for a negative Mz moment
d_y	Shear center coordinate in principal y-direction measured from the centroid
d_z	Shear center coordinate in principal z-direction measured from the centroid
I_t	Torsional constant
I_w	Warping constant
β_y	Mono-symmetry constant about the principal y-axis
β_z	Mono-symmetry constant about the principal z-axis

6. Materials

Steel EC3

Name	ρ [kg/m³]	E_{mod} [MPa]	μ	Lower limit [mm]	Upper limit [mm]	F_y [MPa]	F_u [MPa]	Colour
		G_{mod} [MPa]	α [m/mK]					
S 355	7850,0	2,1000e+05	0,3	0	40	355,0	490,0	
		8,0769e+04	0,00	40	80	335,0	470,0	

7. ShearConnectors

Name	Type	Diameter/width [mm]	Nominal height [mm]	In-situ height [mm]	Material
SC1	Stud	25	100	95	S 355

8. Load cases

Name	Description	Action type	Load group	Direction
	Spec	Load type		
LC1	Self weight	Permanent	LG1	-Z
		Self weight		
LC2	Analysis	Permanent	LG1	
		Standard		

9. Combinations

Name	Description	Type	Load cases	Coeff. [-]
SLS-Char (auto)1		EN-SLS Characteristic	LC1 - Self weight	1,00
ULS-Set B (auto)		EN-ULS (STR/GEO) Set B	LC1 - Self weight	1,00
			LC2 - Analysis	1,00
SLS-Char (auto)		EN-SLS Characteristic	LC1 - Self weight	1,00
			LC2 - Analysis	1,00

10. Point force in node

Name	Node	Load case	System	Dir	Type	Value - F [kN]
F7	N31	LC2 - Analysis	GCS	Z	Force	-195,00
F8	N32	LC2 - Analysis	GCS	Z	Force	-105,00
F9	N33	LC2 - Analysis	GCS	Z	Force	-105,00
F10	N34	LC2 - Analysis	GCS	Z	Force	-195,00
F11	N35	LC2 - Analysis	GCS	Z	Force	-105,00
F12	N36	LC2 - Analysis	GCS	Z	Force	-105,00

11. Line force

Name	Member	Type	Dir	Value - P_1 [kN/m]	Pos x_1	Coor	Orig	Ecc ey [m]
	Load case	System	Distribution	Value - P_2 [kN/m]	Pos x_2	Loc		Ecc ez [m]
LF1	B13	Force	Z	-30,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF2	B12	Force	Z	-30,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF3	B11	Force	Z	-30,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF4	B10	Force	Z	-30,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF5	B20	Force	Z	-30,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF6	B19	Force	Z	-30,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF7	B18	Force	Z	-30,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF8	B17	Force	Z	-30,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF9	B9	Force	Z	-35,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF10	B16	Force	Z	-35,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF11	B14	Force	Z	-35,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF12	B7	Force	Z	-35,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF13	B8	Force	Z	-60,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF14	B15	Force	Z	-60,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF15	B27	Force	Z	-3,50	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF16	B28	Force	Z	-6,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF17	B29	Force	Z	-3,50	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF18	B30	Force	Z	-3,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF19	B31	Force	Z	-3,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF20	B32	Force	Z	-3,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF21	B33	Force	Z	-3,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF22	B34	Force	Z	-3,50	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF23	B35	Force	Z	-6,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF24	B36	Force	Z	-3,50	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF25	B37	Force	Z	-3,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF26	B38	Force	Z	-3,00	0,000	Rela	From start	0,000

Name	Member	Type	Dir	Value - P_1 [kN/m]	Pos x_1	Coor	Orig	Ecc ey [m]
	Load case	System	Distribution	Value - P_2 [kN/m]	Pos x_2	Loc		Ecc ez [m]
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF27	B39	Force	Z	-3,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF28	B40	Force	Z	-3,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF29	B47	Force	Z	-31,50	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF30	B48	Force	Z	-54,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF31	B49	Force	Z	-31,50	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF32	B50	Force	Z	-27,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF33	B51	Force	Z	-27,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF34	B52	Force	Z	-27,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF35	B53	Force	Z	-27,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF36	B54	Force	Z	-31,50	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF37	B55	Force	Z	-54,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF38	B56	Force	Z	-31,50	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF39	B57	Force	Z	-27,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF40	B58	Force	Z	-27,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF41	B59	Force	Z	-27,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF42	B60	Force	Z	-27,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF43	B67	Force	Z	-28,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF44	B68	Force	Z	-48,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF45	B69	Force	Z	-28,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF46	B70	Force	Z	-24,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF47	B71	Force	Z	-24,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF48	B72	Force	Z	-24,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF49	B73	Force	Z	-24,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF50	B74	Force	Z	-28,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF51	B75	Force	Z	-48,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF52	B76	Force	Z	-28,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF53	B77	Force	Z	-24,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF54	B78	Force	Z	-24,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF55	B79	Force	Z	-24,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF56	B80	Force	Z	-24,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF57	B87	Force	Z	-24,50	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF58	B88	Force	Z	-42,00	0,000	Rela	From start	0,000

Name	Member	Type	Dir	Value - P_1 [kN/m]	Pos x_1	Coor	Orig	Ecc ey [m]
	Load case	System	Distribution	Value - P_2 [kN/m]	Pos x_2	Loc		Ecc ez [m]
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF59	B89	Force	Z	-24,50	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF60	B90	Force	Z	-21,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF61	B91	Force	Z	-21,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF62	B92	Force	Z	-21,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF63	B93	Force	Z	-21,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF64	B94	Force	Z	-24,50	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF65	B95	Force	Z	-42,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF66	B96	Force	Z	-24,50	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF67	B97	Force	Z	-21,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF68	B98	Force	Z	-21,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF69	B99	Force	Z	-21,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF70	B100	Force	Z	-21,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF71	B107	Force	Z	-21,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF72	B108	Force	Z	-36,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF73	B109	Force	Z	-21,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF74	B110	Force	Z	-18,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF75	B111	Force	Z	-18,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF76	B112	Force	Z	-18,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF77	B113	Force	Z	-18,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF78	B114	Force	Z	-21,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF79	B115	Force	Z	-36,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF80	B116	Force	Z	-21,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF81	B117	Force	Z	-18,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF82	B118	Force	Z	-18,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF83	B119	Force	Z	-18,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF84	B120	Force	Z	-18,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF85	B127	Force	Z	-17,50	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF86	B128	Force	Z	-30,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF87	B129	Force	Z	-17,50	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF88	B130	Force	Z	-15,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF89	B131	Force	Z	-15,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF90	B132	Force	Z	-15,00	0,000	Rela	From start	0,000

Name	Member	Type	Dir	Value - P_1 [kN/m]	Pos x_1	Coor	Orig	Ecc ey [m]
	Load case	System	Distribution	Value - P_2 [kN/m]	Pos x_2	Loc		Ecc ez [m]
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF91	B133	Force	Z	-15,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF92	B134	Force	Z	-17,50	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF93	B135	Force	Z	-30,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF94	B136	Force	Z	-17,50	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF95	B137	Force	Z	-15,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF96	B138	Force	Z	-15,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF97	B139	Force	Z	-15,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF98	B140	Force	Z	-15,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF99	B147	Force	Z	-14,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF100	B148	Force	Z	-24,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF101	B149	Force	Z	-14,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF102	B150	Force	Z	-12,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF103	B151	Force	Z	-12,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF104	B152	Force	Z	-12,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF105	B153	Force	Z	-12,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF106	B154	Force	Z	-14,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF107	B155	Force	Z	-24,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF108	B156	Force	Z	-14,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF109	B157	Force	Z	-12,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF110	B158	Force	Z	-12,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF111	B159	Force	Z	-12,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF112	B160	Force	Z	-12,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF113	B167	Force	Z	-10,50	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF114	B168	Force	Z	-18,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF115	B169	Force	Z	-10,50	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF116	B170	Force	Z	-9,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF117	B171	Force	Z	-9,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF118	B172	Force	Z	-9,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF119	B173	Force	Z	-9,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF120	B174	Force	Z	-10,50	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF121	B175	Force	Z	-18,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF122	B176	Force	Z	-10,50	0,000	Rela	From start	0,000

Name	Member	Type	Dir	Value - P_1 [kN/m]	Pos x_1	Coor	Orig	Ecc ey [m]
	Load case	System	Distribution	Value - P_2 [kN/m]	Pos x_2	Loc		Ecc ez [m]
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF123	B177	Force	Z	-9,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF124	B178	Force	Z	-9,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF125	B179	Force	Z	-9,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF126	B180	Force	Z	-9,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF127	B187	Force	Z	-7,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF128	B188	Force	Z	-12,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF129	B189	Force	Z	-7,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF130	B190	Force	Z	-6,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF131	B191	Force	Z	-6,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF132	B192	Force	Z	-6,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF133	B193	Force	Z	-6,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF134	B194	Force	Z	-7,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF135	B195	Force	Z	-12,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF136	B196	Force	Z	-7,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF137	B197	Force	Z	-6,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF138	B198	Force	Z	-6,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF139	B199	Force	Z	-6,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000
LF140	B200	Force	Z	-6,00	0,000	Rela	From start	0,000
	LC2 - Analysis	LCS	Uniform		1,000	Length		0,000

12. Members

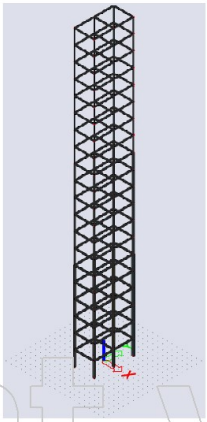
Name	Cross-section	Material	Length [m]	Beg. node	End node	Type
B1	CS2 - HEA300	S 355	6,000	N1	N13	column (100)
B2	CS2 - HEA300	S 355	6,000	N3	N16	column (100)
B3	CS2 - HEA300	S 355	6,000	N5	N18	column (100)
B4	CS2 - HEA300	S 355	6,000	N7	N17	column (100)
B5	CS2 - HEA300	S 355	6,000	N9	N14	column (100)
B6	CS2 - HEA300	S 355	6,000	N11	N15	column (100)
B7	CS3 - HEA200	S 355	4,000	N17	N18	beam (80)
B8	CS3 - HEA200	S 355	4,000	N16	N13	beam (80)
B9	CS3 - HEA200	S 355	4,000	N14	N15	beam (80)
B10	CS3 - HEA200	S 355	4,000	N18	N13	beam (80)
B11	CS3 - HEA200	S 355	4,000	N17	N16	beam (80)
B12	CS3 - HEA200	S 355	4,000	N13	N15	beam (80)
B13	CS3 - HEA200	S 355	4,000	N16	N14	beam (80)
B14	CS3 - HEA200	S 355	4,000	N8	N6	beam (80)
B15	CS3 - HEA200	S 355	4,000	N4	N2	beam (80)
B16	CS3 - HEA200	S 355	4,000	N10	N12	beam (80)
B17	CS3 - HEA200	S 355	4,000	N6	N2	beam (80)
B18	CS3 - HEA200	S 355	4,000	N2	N12	beam (80)
B19	CS3 - HEA200	S 355	4,000	N8	N4	beam (80)
B20	CS3 - HEA200	S 355	4,000	N4	N10	beam (80)
B21	CS5 - HEA100	S 355	6,000	N127	N31	column (100)

Name	Cross-section	Material	Length [m]	Beg. node	End node	Type
B22	CS5 - HEA100	S 355	6,000	N130	N34	column (100)
B23	CS5 - HEA100	S 355	6,000	N132	N36	column (100)
B24	CS5 - HEA100	S 355	6,000	N131	N35	column (100)
B25	CS5 - HEA100	S 355	6,000	N128	N32	column (100)
B26	CS5 - HEA100	S 355	6,000	N129	N33	column (100)
B27	CS6 - HEA160	S 355	4,000	N35	N36	beam (80)
B28	CS6 - HEA160	S 355	4,000	N34	N31	beam (80)
B29	CS6 - HEA160	S 355	4,000	N32	N33	beam (80)
B30	CS6 - HEA160	S 355	4,000	N36	N31	beam (80)
B31	CS6 - HEA160	S 355	4,000	N35	N34	beam (80)
B32	CS6 - HEA160	S 355	4,000	N31	N33	beam (80)
B33	CS6 - HEA160	S 355	4,000	N34	N32	beam (80)
B34	CS6 - HEA160	S 355	4,000	N26	N24	beam (80)
B35	CS6 - HEA160	S 355	4,000	N22	N20	beam (80)
B36	CS6 - HEA160	S 355	4,000	N28	N30	beam (80)
B37	CS6 - HEA160	S 355	4,000	N24	N20	beam (80)
B38	CS6 - HEA160	S 355	4,000	N20	N30	beam (80)
B39	CS6 - HEA160	S 355	4,000	N26	N22	beam (80)
B40	CS6 - HEA160	S 355	4,000	N22	N28	beam (80)
B41	CS2 - HEA300	S 355	6,000	N13	N43	column (100)
B42	CS2 - HEA300	S 355	6,000	N16	N46	column (100)
B43	CS2 - HEA300	S 355	6,000	N18	N48	column (100)
B44	CS2 - HEA300	S 355	6,000	N17	N47	column (100)
B45	CS2 - HEA300	S 355	6,000	N14	N44	column (100)
B46	CS2 - HEA300	S 355	6,000	N15	N45	column (100)
B47	CS3 - HEA200	S 355	4,000	N47	N48	beam (80)
B48	CS3 - HEA200	S 355	4,000	N46	N43	beam (80)
B49	CS3 - HEA200	S 355	4,000	N44	N45	beam (80)
B50	CS3 - HEA200	S 355	4,000	N48	N43	beam (80)
B51	CS3 - HEA200	S 355	4,000	N47	N46	beam (80)
B52	CS3 - HEA200	S 355	4,000	N43	N45	beam (80)
B53	CS3 - HEA200	S 355	4,000	N46	N44	beam (80)
B54	CS3 - HEA200	S 355	4,000	N40	N39	beam (80)
B55	CS3 - HEA200	S 355	4,000	N38	N37	beam (80)
B56	CS3 - HEA200	S 355	4,000	N41	N42	beam (80)
B57	CS3 - HEA200	S 355	4,000	N39	N37	beam (80)
B58	CS3 - HEA200	S 355	4,000	N37	N42	beam (80)
B59	CS3 - HEA200	S 355	4,000	N40	N38	beam (80)
B60	CS3 - HEA200	S 355	4,000	N38	N41	beam (80)
B61	CS2 - HEA300	S 355	6,000	N43	N55	column (100)
B62	CS2 - HEA300	S 355	6,000	N46	N58	column (100)
B63	CS2 - HEA300	S 355	6,000	N48	N60	column (100)
B64	CS2 - HEA300	S 355	6,000	N47	N59	column (100)
B65	CS2 - HEA300	S 355	6,000	N44	N56	column (100)
B66	CS2 - HEA300	S 355	6,000	N45	N57	column (100)
B67	CS3 - HEA200	S 355	4,000	N59	N60	beam (80)
B68	CS3 - HEA200	S 355	4,000	N58	N55	beam (80)
B69	CS3 - HEA200	S 355	4,000	N56	N57	beam (80)
B70	CS3 - HEA200	S 355	4,000	N60	N55	beam (80)
B71	CS3 - HEA200	S 355	4,000	N59	N58	beam (80)
B72	CS3 - HEA200	S 355	4,000	N55	N57	beam (80)
B73	CS3 - HEA200	S 355	4,000	N58	N56	beam (80)
B74	CS3 - HEA200	S 355	4,000	N52	N51	beam (80)
B75	CS3 - HEA200	S 355	4,000	N50	N49	beam (80)
B76	CS3 - HEA200	S 355	4,000	N53	N54	beam (80)
B77	CS3 - HEA200	S 355	4,000	N51	N49	beam (80)
B78	CS3 - HEA200	S 355	4,000	N49	N54	beam (80)
B79	CS3 - HEA200	S 355	4,000	N52	N50	beam (80)
B80	CS3 - HEA200	S 355	4,000	N50	N53	beam (80)
B81	CS3 - HEA200	S 355	6,000	N55	N67	column (100)
B82	CS3 - HEA200	S 355	6,000	N58	N70	column (100)
B83	CS3 - HEA200	S 355	6,000	N60	N72	column (100)
B84	CS3 - HEA200	S 355	6,000	N59	N71	column (100)
B85	CS3 - HEA200	S 355	6,000	N56	N68	column (100)
B86	CS3 - HEA200	S 355	6,000	N57	N69	column (100)
B87	CS4 - HEA180	S 355	4,000	N71	N72	beam (80)

Name	Cross-section	Material	Length [m]	Beg. node	End node	Type
B88	CS4 - HEA180	S 355	4,000	N70	N67	beam (80)
B89	CS4 - HEA180	S 355	4,000	N68	N69	beam (80)
B90	CS4 - HEA180	S 355	4,000	N72	N67	beam (80)
B91	CS4 - HEA180	S 355	4,000	N71	N70	beam (80)
B92	CS4 - HEA180	S 355	4,000	N67	N69	beam (80)
B93	CS4 - HEA180	S 355	4,000	N70	N68	beam (80)
B94	CS4 - HEA180	S 355	4,000	N64	N63	beam (80)
B95	CS4 - HEA180	S 355	4,000	N62	N61	beam (80)
B96	CS4 - HEA180	S 355	4,000	N65	N66	beam (80)
B97	CS4 - HEA180	S 355	4,000	N63	N61	beam (80)
B98	CS4 - HEA180	S 355	4,000	N61	N66	beam (80)
B99	CS4 - HEA180	S 355	4,000	N64	N62	beam (80)
B100	CS4 - HEA180	S 355	4,000	N62	N65	beam (80)
B101	CS3 - HEA200	S 355	6,000	N67	N79	column (100)
B102	CS3 - HEA200	S 355	6,000	N70	N82	column (100)
B103	CS3 - HEA200	S 355	6,000	N72	N84	column (100)
B104	CS3 - HEA200	S 355	6,000	N71	N83	column (100)
B105	CS3 - HEA200	S 355	6,000	N68	N80	column (100)
B106	CS3 - HEA200	S 355	6,000	N69	N81	column (100)
B107	CS4 - HEA180	S 355	4,000	N83	N84	beam (80)
B108	CS4 - HEA180	S 355	4,000	N82	N79	beam (80)
B109	CS4 - HEA180	S 355	4,000	N80	N81	beam (80)
B110	CS4 - HEA180	S 355	4,000	N84	N79	beam (80)
B111	CS4 - HEA180	S 355	4,000	N83	N82	beam (80)
B112	CS4 - HEA180	S 355	4,000	N79	N81	beam (80)
B113	CS4 - HEA180	S 355	4,000	N82	N80	beam (80)
B114	CS4 - HEA180	S 355	4,000	N76	N75	beam (80)
B115	CS4 - HEA180	S 355	4,000	N74	N73	beam (80)
B116	CS4 - HEA180	S 355	4,000	N77	N78	beam (80)
B117	CS4 - HEA180	S 355	4,000	N75	N73	beam (80)
B118	CS4 - HEA180	S 355	4,000	N73	N78	beam (80)
B119	CS4 - HEA180	S 355	4,000	N76	N74	beam (80)
B120	CS4 - HEA180	S 355	4,000	N74	N77	beam (80)
B121	CS3 - HEA200	S 355	6,000	N79	N91	column (100)
B122	CS3 - HEA200	S 355	6,000	N82	N94	column (100)
B123	CS3 - HEA200	S 355	6,000	N84	N96	column (100)
B124	CS3 - HEA200	S 355	6,000	N83	N95	column (100)
B125	CS3 - HEA200	S 355	6,000	N80	N92	column (100)
B126	CS3 - HEA200	S 355	6,000	N81	N93	column (100)
B127	CS4 - HEA180	S 355	4,000	N95	N96	beam (80)
B128	CS4 - HEA180	S 355	4,000	N94	N91	beam (80)
B129	CS4 - HEA180	S 355	4,000	N92	N93	beam (80)
B130	CS4 - HEA180	S 355	4,000	N96	N91	beam (80)
B131	CS4 - HEA180	S 355	4,000	N95	N94	beam (80)
B132	CS4 - HEA180	S 355	4,000	N91	N93	beam (80)
B133	CS4 - HEA180	S 355	4,000	N94	N92	beam (80)
B134	CS4 - HEA180	S 355	4,000	N88	N87	beam (80)
B135	CS4 - HEA180	S 355	4,000	N86	N85	beam (80)
B136	CS4 - HEA180	S 355	4,000	N89	N90	beam (80)
B137	CS4 - HEA180	S 355	4,000	N87	N85	beam (80)
B138	CS4 - HEA180	S 355	4,000	N85	N90	beam (80)
B139	CS4 - HEA180	S 355	4,000	N88	N86	beam (80)
B140	CS4 - HEA180	S 355	4,000	N86	N89	beam (80)
B141	CS5 - HEA100	S 355	6,000	N91	N103	column (100)
B142	CS5 - HEA100	S 355	6,000	N94	N106	column (100)
B143	CS5 - HEA100	S 355	6,000	N96	N108	column (100)
B144	CS5 - HEA100	S 355	6,000	N95	N107	column (100)
B145	CS5 - HEA100	S 355	6,000	N92	N104	column (100)
B146	CS5 - HEA100	S 355	6,000	N93	N105	column (100)
B147	CS6 - HEA160	S 355	4,000	N107	N108	beam (80)
B148	CS6 - HEA160	S 355	4,000	N106	N103	beam (80)
B149	CS6 - HEA160	S 355	4,000	N104	N105	beam (80)
B150	CS6 - HEA160	S 355	4,000	N108	N103	beam (80)
B151	CS6 - HEA160	S 355	4,000	N107	N106	beam (80)
B152	CS6 - HEA160	S 355	4,000	N103	N105	beam (80)
B153	CS6 - HEA160	S 355	4,000	N106	N104	beam (80)

Name	Cross-section	Material	Length [m]	Beg. node	End node	Type
B154	CS6 - HEA160	S 355	4,000	N100	N99	beam (80)
B155	CS6 - HEA160	S 355	4,000	N98	N97	beam (80)
B156	CS6 - HEA160	S 355	4,000	N101	N102	beam (80)
B157	CS6 - HEA160	S 355	4,000	N99	N97	beam (80)
B158	CS6 - HEA160	S 355	4,000	N97	N102	beam (80)
B159	CS6 - HEA160	S 355	4,000	N100	N98	beam (80)
B160	CS6 - HEA160	S 355	4,000	N98	N101	beam (80)
B161	CS5 - HEA100	S 355	6,000	N103	N115	column (100)
B162	CS5 - HEA100	S 355	6,000	N106	N118	column (100)
B163	CS5 - HEA100	S 355	6,000	N108	N120	column (100)
B164	CS5 - HEA100	S 355	6,000	N107	N119	column (100)
B165	CS5 - HEA100	S 355	6,000	N104	N116	column (100)
B166	CS5 - HEA100	S 355	6,000	N105	N117	column (100)
B167	CS6 - HEA160	S 355	4,000	N119	N120	beam (80)
B168	CS6 - HEA160	S 355	4,000	N118	N115	beam (80)
B169	CS6 - HEA160	S 355	4,000	N116	N117	beam (80)
B170	CS6 - HEA160	S 355	4,000	N120	N115	beam (80)
B171	CS6 - HEA160	S 355	4,000	N119	N118	beam (80)
B172	CS6 - HEA160	S 355	4,000	N115	N117	beam (80)
B173	CS6 - HEA160	S 355	4,000	N118	N116	beam (80)
B174	CS6 - HEA160	S 355	4,000	N112	N111	beam (80)
B175	CS6 - HEA160	S 355	4,000	N110	N109	beam (80)
B176	CS6 - HEA160	S 355	4,000	N113	N114	beam (80)
B177	CS6 - HEA160	S 355	4,000	N111	N109	beam (80)
B178	CS6 - HEA160	S 355	4,000	N109	N114	beam (80)
B179	CS6 - HEA160	S 355	4,000	N112	N110	beam (80)
B180	CS6 - HEA160	S 355	4,000	N110	N113	beam (80)
B181	CS5 - HEA100	S 355	6,000	N115	N127	column (100)
B182	CS5 - HEA100	S 355	6,000	N118	N130	column (100)
B183	CS5 - HEA100	S 355	6,000	N120	N132	column (100)
B184	CS5 - HEA100	S 355	6,000	N119	N131	column (100)
B185	CS5 - HEA100	S 355	6,000	N116	N128	column (100)
B186	CS5 - HEA100	S 355	6,000	N117	N129	column (100)
B187	CS6 - HEA160	S 355	4,000	N131	N132	beam (80)
B188	CS6 - HEA160	S 355	4,000	N130	N127	beam (80)
B189	CS6 - HEA160	S 355	4,000	N128	N129	beam (80)
B190	CS6 - HEA160	S 355	4,000	N132	N127	beam (80)
B191	CS6 - HEA160	S 355	4,000	N131	N130	beam (80)
B192	CS6 - HEA160	S 355	4,000	N127	N129	beam (80)
B193	CS6 - HEA160	S 355	4,000	N130	N128	beam (80)
B194	CS6 - HEA160	S 355	4,000	N124	N123	beam (80)
B195	CS6 - HEA160	S 355	4,000	N122	N121	beam (80)
B196	CS6 - HEA160	S 355	4,000	N125	N126	beam (80)
B197	CS6 - HEA160	S 355	4,000	N123	N121	beam (80)
B198	CS6 - HEA160	S 355	4,000	N121	N126	beam (80)
B199	CS6 - HEA160	S 355	4,000	N124	N122	beam (80)
B200	CS6 - HEA160	S 355	4,000	N122	N125	beam (80)

13. SCIA model



14. EC-EN 1993 Steel check ULS

Linear calculation
Load case: LC2
Coordinate system: Principal
Extreme 1D: Global
Selection: All
Overall Unity Check

Name	dx [m]	Case	Cross-section	Material	$UC_{Overall}$ [-]	UC_{Sec} [-]	UC_{Stab} [-]
B8	0,000	LC2	CS3 - HEA200	S 355	**0,53**	0,53	0,00

15. EC-EN 1993 Steel Check SLS

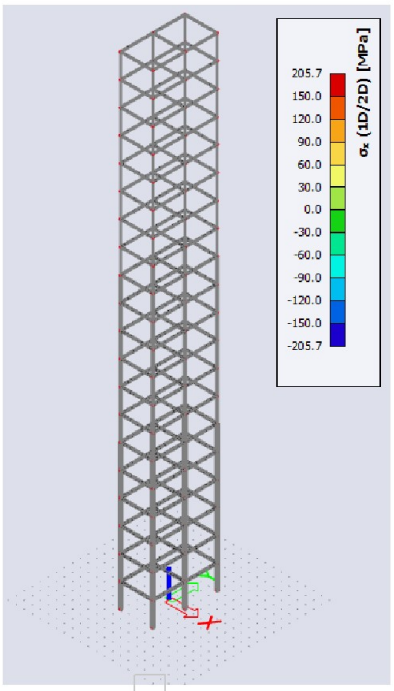
Linear calculation
Load case: LC1
Coordinate system: Principal
Extreme 1D: Global
Selection: All
Error E-C01: This load case was not calculated.
Nothing in selection to display.

E/W/N	Present on members
E-C01	all

16. 3D stress

Linear calculation
Load case: LC2
Selection: All
Location: In nodes avg. on macro. System: LCS mesh element
Basic magnitudes
Results on 1D member
Extreme 1D: Global

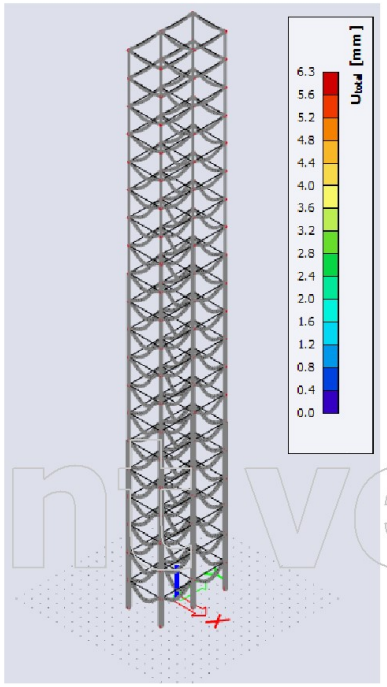
Name	dx [m]	Fibre	Case	σ_x [MPa]	T_{xy} [MPa]	T_{xz} [MPa]	T_{tor} [MPa]
B8	0,000	1	LC2	**-205,7**	0,0	0,0	0,0
B8	0,000	13	LC2	**205,7**	0,0	0,0	0,0



17. 3D displacement

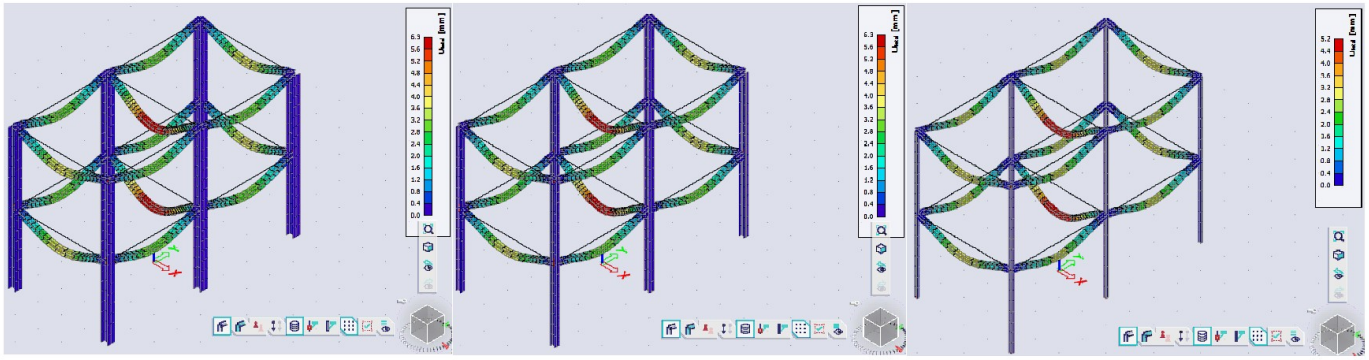
Linear calculation
Load case: LC2
Selection: All
Location: In nodes avg. on macro. System: LCS mesh element
Results on 1D member:
Extreme 1D: Global

Name	dx [m]	Fibre	Case	u_x [mm]	u_y [mm]	u_z [mm]	φ_x [mrad]	φ_y [mrad]	φ_z [mrad]	U_{total} [mm]
B1	0,000	1	LC2	0,0	0,0	0,0	0,0	0,0	0,0	**0,0**
B8	2,000-	13	LC2	0,0	0,0	-6,3	0,0	0,0	0,0	**6,3**



18. Results analysis

In this second analysis, we studied the structural behavior of a tower building obtained by employing ten housing modules, appropriately choosing the steel profiles according to the loads and stresses considered. Logically, the more you level up in the structural skeleton, the lighter the structure becomes. The following image shows the three levels where the structural elements change, namely in the lower part of the structure (first three levels), in the central part (following three levels) and finally in the terminal part of the tower (last four levels).



Therefore, with the help of the normative considerations made for the previous structural analysis on the complete two-story module, we can draw some important considerations on the structural behavior of the tower. The following table summarizes the main information on the profiles used and the results obtained depending on the loads considered:

CENTRAL BEAM LENGHT [mm]	IMPOSED LIMIT 1/250 [mm]	IMPOSED LIMIT 1/500 [mm]
3400	13,6	6,8

BUILDING SECTOR	LEVEL	COLUMN	BEAM	MAX DISPLACEMENT [mm]	CHECK
BOTTOM	FROM 1 TO 3	HEA 300	HEA 200	6,3	OK
CENTER	FROM 4 TO 6	HEA 200	HEA 180	6,3	OK
TOP	FROM 7 TO 10	HEA 100	HEA 160	5,2	OK

As we can see, with the chosen configuration, deformations close to the limit ones are reached but in any case within the limits set by the regulations. So we can assert that even for this tower building, the structural characteristics are optimal.

Municipality of the Metropolitan City of Turin

Province of Turin

MAINTENANCE PLAN

PROGRAM OF MAINTENANCE

(Article 38 of Presidential Decree No. 207 of 5 October 2010)

OBJECT: Master's thesis project Minerva Luca Manuel

CLIENT: École polytechnique de Louvain, Polytechnic of Turin

22/10/2021, Louvain La Neuve

THE TECHNICIAN

_____

(Luca Manuel Minerva)

Compliance with minimum environmental criteria

The maintenance plan complies with the "Minimum Environmental Criteria "(CAM), contained in the Annex of Environment Ministerial Decree of 11 October 2017.

For each maintainable element, the requirements and controls necessary to preserve the environmental performance of the work over time are identified, an innovative objective that is added to those already provided for by law (conservation of functionality, efficiency, economic value and quality characteristics).

The performance levels of the CAM provide characteristics superior to those prescribed by the national and regional laws in force, are aimed at reducing the consumption of energy and natural resources, and aim at containing polluting emissions.

The maintenance interventions identified envisage the use of non-toxic, recycled and regenerable materials, for the protection of human health and the environment and for the mitigation of climate-altering impacts.

The environmental performances contained in the following document refer both to the basic technical specifications and to the rewarding ones contained in the CAM, also taking into account the monitoring and control of the indoor air quality of the work.

Indoor air quality monitoring and control program

A detailed monitoring program will be defined by qualified personnel after the start-up of the plant.

The maintenance plan includes all the interventions necessary to eliminate or contain indoor air pollution, adaptable and modifiable in itinere, according to specific needs occurring after the start-up phase of the plant.

The various sources of indoor air pollution must be monitored taking into account the relative contaminants (Volatile Organic Compounds - VOCs, Radon, bacteria, viruses, mites, allergens, etc.) to ensure that the limits indicated by current regulations are respected. or, otherwise, promptly take the necessary measures to restore safety conditions.

PERFORMANCE SUB-PROGRAM

Class Requirements:

01 - Bearing structures

01.01 - Surface foundation works

Code	Maintainable Elements / Requirements and Performance / Controls	Typology	Frequency
01.01	Surface foundation works		
01.01.R02	Requirement: Use of materials, elements and components characterized by high durability Rational use of resources through the use of materials with high durability. • Minimum level of performance: In the planning phase it is necessary guarantee an adequate percentage of construction elements characterized by high durability. • Normative requirements: Environment Ministerial Decree 8.5.2003, n. 203; Legislative Decree 3.4.2006, n. 152; CM Environment 15.7.2005, n. 5205; Dir. 2008/98 / EC; CM Ambiente 19.7.2005; UNI EN ISO 14020; UNI EN ISO 14021; UNI EN ISO 14024; UNI EN ISO 14025; UNI 11277; Environment Ministerial Decree 11.10.2017.		
01.01.01.C02	Control: Control of use of durable materials Check that components characterized by high durability are used in the maintenance phases of the elements.	Verify	when needed

01.02 - Steel structures in elevation

Code	Maintainable Elements / Requirements and Performance / Controls	Typology	Frequency
01.02	Elevated steel structures		
01.02.R03	Requirement: Use of materials, elements and components with a high recyclability potential Use of materials, elements and components with a high degree of recyclability • Minimum level of performance: Calculate the percentage of materials to be sent for recycling processes. Determine the percentage in terms of quantity (kg) or surface (m2) of material used in the technical element in relation to the functional unit assumed. • Normative requirements: Environment Ministerial Decree 8.5.2003, n. 203; Legislative Decree 3.4.2006, n. 152; CM Environment 15.7.2005, n. 5205; Dir. 2008/98 / EC; CM Ambiente 19.7.2005; UNI EN ISO 14020; UNI EN ISO 14021; UNI EN ISO 14024; UNI EN ISO 14025; UNI 11277; Environment Ministerial Decree 11.10.2017.		
01.02.02.C02	Control: Control of the degree of recyclability Check that materials, elements and components with a high degree of recyclability are used in the maintenance phases.	Check	when needed
01.02.01.C02	Control: Control of the degree of recyclability Check that materials, elements and components with a high degree of recyclability are used in the maintenance phases.	Check	when needed

01.02.R04	Requirement: Use of materials, elements and components characterized by high durability Rational use of resources through the use of materials with high durability. • Minimum level of performance: In the planning phase it is necessary guarantee an adequate percentage of construction elements characterized by high durability. • Normative requirements: Environment Ministerial Decree 8.5.2003, n. 203; Legislative Decree 3.4.2006, n. 152; CM Environment 15.7.2005, n. 5205; Dir. 2008/98 / EC; CM Ambiente 19.7.2005; UNI EN ISO 14020; UNI EN ISO 14021; UNI EN ISO 14024; UNI EN ISO 14025; UNI 11277; Environment Ministerial Decree 11.10.2017.		
01.02.02.C03	Control: Control of use of durable materials Check that components characterized by high durability are used in the maintenance phases of the elements.	Verify	when needed
01.02.01.C03	Control: Control of use of durable materials Check that components characterized by high durability are used in the maintenance phases of the elements.	Verify	when needed

01.03 - Unions

Code	Maintainable Elements / Requirements and Performance / Controls	Typology	Frequency
01.03	Unions		
01.03.R03	Requirement: Use of materials, elements and components characterized by high durability Rational use of resources through the use of materials with high durability. • Minimum level of performance: In the planning phase it is necessary guarantee an adequate percentage of construction elements characterized by high durability. • Normative requirements: Environment Ministerial Decree 8.5.2003, n. 203; Legislative Decree 3.4.2006, n. 152; CM Environment 15.7.2005, n. 5205; Dir. 2008/98 / EC; CM Ambiente 19.7.2005; UNI EN ISO 14020; UNI EN ISO 14021; UNI EN ISO 14024; UNI EN ISO 14025; UNI 11277; Environment Ministerial Decree 11.10.2017.		
01.03.02.C02	Control: Control of use of durable materials Check that components characterized by high durability are used in the maintenance phases of the elements.	Verify	when needed
01.03.01.C02	Control: Control of use of durable materials Check that components characterized by high durability are used in the maintenance phases of the elements.	Verify	when needed

Of stability

01 - Bearing structures

01.01 - Surface foundation works

Code	Maintainable Elements / Requirements and Performance / Controls	Typology	Frequency
01.01	Surface foundation works		
01.01.R01	Requirement: Mechanical resistance The works of surface foundations must be able to counteract any manifestations of significant deformations and subsidence due to the action of certain stresses (loads, seismic forces, etc.). • Minimum level of performance: Please refer to the minimum levels the requirements of the law and regulations in force on the subject. • Normative requirements: Law 5.11.1971, n. 1086; Law 2.2.1974, n. 64; Ministerial Decree of Infrastructure and Transport 17.1.2018; UNI 8290-2; UNI EN 196-1; UNI EN 1356; UNI EN 12390-1; UNI EN 1992 1/2; UNI EN 1090-3; UNI 9503; UNI EN 1993; UNI EN 1999; UNI EN 1994; UNI EN 1994 1/2; UNI EN 1995; UNI EN 384; UNI EN 1504-8.		
01.01.01.C01	Control: Structure control Check the integrity of the walls and pillars, verifying the absence of any injuries and / or cracks. Check for any landslides in the ground surrounding the structure that may be indicators of structural failure. Carry out in-depth checks and controls particularly in correspondence with manifestations of natural disasters (earthquake, storms, etc.).	Visual inspection	every 12 months

01.02 - Steel structures in elevation

Code	Maintainable Elements / Requirements and Performance / Controls	Typology	Frequency
01.02	Elevated steel structures		
01.02.R02	Requirement: Mechanical resistance The elevation structures must be able to counteract any manifestations of significant deformations and subsidence due to the action of certain stresses (loads, seismic forces, etc.). • Minimum level of performance: Please refer to the minimum levels the requirements of the law and regulations in force on the subject. In particular to the Ministerial Decree of Infrastructures and Transport 17.1.2018. • Normative requirements: Law 5.11.1971, n. 1086; Law 2.2.1974, n. 64; Ministerial Decree of Infrastructure and Transport 17.1.2018; UNI 8290-2; UNI EN 384; UNI EN 1356; UNI EN 12390-1; UNI EN 1090-3; UNI 9503; UNI EN 1993; UNI EN 1999.		
01.02.02.C01	Control: Control of deformations and / or displacements Check for any deformations and / or displacements of the structural element due to external causes that alter its normal configuration.	Visual inspection	every 12 months
01.02.01.C01	Control: Control of deformations and / or displacements Check for any deformations and / or displacements of the structural element due to external causes that alter its normal configuration.	Visual inspection	every 12 months

01.03 - Unions

Code	Maintainable Elements / Requirements and Performance / Controls	Typology	Frequency
01.03	Unions		
01.03.R02	Requirement: Mechanical resistance The elements used to make different joints must guarantee mechanical resistance to the stresses transmitted to them • Minimum level of performance: The materials used for the unions must meet the requirements indicated by the regulations in force. • Normative requirements: Law 5.11.1971, n. 1086; Law 2.2.1974, n. 64; Ministerial Decree of Infrastructure and Transport 17.1.2018; UNI EN 1382; UNI EN 1383; UNI EN 15048-1; UNI EN 20898.		
01.03.02.C01	Control: General control Check of the junction elements between parts and check of the correct tightness of tightening. Check the continuity of the welded parts and the absence of obvious anomalies.	Revision	every year
01.03.01.C01	Control: General control Check of the junction elements between parts and check of the correct tightness of tightening. Check the continuity of the welded parts and the absence of obvious anomalies.	Revision	every year

Class Requirements:

Technological durability

01 - Bearing structures

Code	Maintainable Elements / Requirements and Performance / Controls	Typology	Frequency
01.03	Unions		
01.03.R01	Requirement: Corrosion resistance The joining elements used must not decay in corrosion processes. • Minimum level of performance: The materials used for the unions must meet the requirements indicated by the regulations in force. • Normative requirements: DM Infrastructure and Transport 17.1.2018; UNI EN 15048-1; UNI EN 20898.		
01.03.02.C01	Control: General control Check of the junction elements between parts and check of the correct tightness of tightening. Check the continuity of the welded parts and the absence of obvious anomalies.	Revision	every year
01.03.01.C01	Control: General control Check of the junction elements between parts and check of the correct tightness of tightening. Check the continuity of the welded parts and the absence of obvious anomalies.	Revision	every year

Protection from chemical and organic agents

01 - Bearing structures

01.02 - Steel structures in elevation

Code	Maintainable Elements / Requirements and Performance / Controls	Typology	Frequency
01.02	Elevated steel structures		
01.02.R01	Requirement: Resistance to aggressive agents The elevation structures must not undergo dissolution or disintegration and changes in appearance due to the action of aggressive chemical agents. • Minimum level of performance: Please refer to the minimum levels the requirements of the law and regulations in force on the subject. In particular to the Ministerial Decree of Infrastructures and Transport 17.1.2018. • Normative requirements: Legislative Decree 9.4.2008, n. 81; Ministerial Decree of Infrastructure and Transport 17.1.2018; UNI 7699; UNI 8290-2; UNI 9944; UNI 10322.		
01.02.02.C01	Control: Control of deformations and / or displacements Check for any deformations and / or displacements of the structural element due to external causes that alter its normal configuration.	Visual inspection	every 12 months
01.02.01.C01	Control: Control of deformations and / or displacements Check for any deformations and / or displacements of the structural element due to external causes that alter its normal configuration.	Visual inspection	every 12 months

CHECKS SUB-PROGRAM

01 - Bearing structures

01.01 - Surface foundation works

Code	Maintainable Items / Controls	Typology	Frequency
01.01.01	Plates in ca.		
01.01.01.C02	Control: Control of use of durable materials Check that components characterized by high durability are used in the maintenance phases of the elements. • Requirements to be checked: 1) Use of materials, elements and components characterized by high durability. • Detectable anomalies: 1) Use of non-durable materials. • Specialized firms: Higher level technicians.	Verify	when needed
01.01.01.C01	Control: Structure control Check the integrity of the walls and pillars, verifying the absence of any injuries and / or cracks. Check for any landslides in the ground surrounding the structure that may be indicators of structural failure. Carry out in-depth checks and controls particularly in correspondence with events involving natural disasters (earthquake, storms, etc.). • Requirements to be checked: 1) Mechanical resistance. • Detectable anomalies: 1) Settlements; 2) Detachment of walls; 3) Cracks; 4) Injuries; 5) Non-perpendicularity of the building; 6) Penetration of humidity; 7) Deformations and displacements. • Specialized firms: Higher level technicians.	Visual inspection	every 12 months

01.02 - Steel structures in elevation

Code	Maintainable Items / Controls	Typology	Frequency
01.02.01	Pillars		
01.02.01.C02	Control: Control of the degree of recyclability Check that materials, elements and components with a high degree of recyclability are used in the maintenance phases. • Requirements to be checked: 1) Use of materials, elements and components with a high recyclability potential. • Detectable anomalies: 1) Low degree of recyclability. • Specialized firms: Higher level technicians.	Check	when needed
01.02.01.C03	Control: Control of use of durable materials Check that components characterized by high durability are used in the maintenance phases of the elements. • Requirements to be checked: 1) Use of materials, elements and components characterized by high durability. • Detectable anomalies: 1) Use of non-durable materials. • Specialized firms: Higher level technicians.	Verify	when needed
01.02.01.C01	Control: Control of deformations and / or displacements Check for any deformations and / or displacements of the structural element due to external causes that alter its normal configuration. • Requirements to be checked: 1) Resistance to aggressive agents; 2) Mechanical resistance. • Detectable anomalies: 1) Corrosion; 2) Deformations and displacements. • Specialized firms: Higher level technicians.	Visual inspection	every 12 months
01.02.02	Beams		
01.02.02.C02	Control: Control of the degree of recyclability	Check	when needed

	Check that materials, elements and components with a high degree of recyclability are used in the maintenance phases. • Requirements to be checked: 1) Use of materials, elements and components with a high recyclability potential. • Detectable anomalies: 1) Low degree of recyclability. • Specialized firms: Higher level technicians.		
01.02.02.C03	Control: Control of use of durable materials Check that components characterized by high durability are used in the maintenance phases of the elements. • Requirements to be checked: 1) Use of materials, elements and components characterized by high durability. • Detectable anomalies: 1) Use of non-durable materials. • Specialized firms: Higher level technicians.	Verify	when needed
01.02.02.C01	Control: Control of deformations and / or displacements Check for any deformations and / or displacements of the structural element due to external causes that alter its normal configuration. • Requirements to be checked: 1) Resistance to aggressive agents; 2) Mechanical resistance. • Detectable anomalies: 1) Corrosion; 2) Deformations and displacements. • Specialized firms: Higher level technicians.	Visual inspection	every 12 months

01.03 - Unions

Code	Maintainable Items / Controls	Typology	Frequency
01.03.01	Connections with foundation plates		
01.03.01.C02	Control: Control of use of durable materials Check that components characterized by high durability are used in the maintenance phases of the elements. • Requirements to be checked: 1) Use of materials, elements and components characterized by high durability. • Detectable anomalies: 1) Use of non-durable materials. • Specialized firms: Higher level technicians.	Verify	when needed
01.03.01.C01	Control: General control Check of the junction elements between parts and check of the correct tightness of tightening. Check the continuity of the welded parts and the absence of obvious anomalies. • Requirements to be checked: 1) Corrosion resistance; 2) Mechanical resistance. • Detectable anomalies: 1) Loosening; 2) Corrosion; 3) Clique; 4) Interruption; 5) Refollation; 6) Tearing; 7) Blanking. • Specialized firms: Higher level technicians.	Revision	every year
01.03.02	Flange connections (beam / through column - column / through beam)		
01.03.02.C02	Control: Control of use of durable materials Check that components characterized by high durability are used in the maintenance phases of the elements. • Requirements to be checked: 1) Use of materials, elements and components characterized by high durability. • Detectable anomalies: 1) Use of non-durable materials. • Specialized firms: Higher level technicians.	Verify	when needed

Code	Maintainable Items / Controls	Typology	Frequency
01.03.02.C01	Control: General control Check of the junction elements between parts and check of the correct tightness of tightening. Check the continuity of the welded parts and the absence of obvious anomalies. • Requirements to be checked: 1) Corrosion resistance; 2) Mechanical resistance. • Detectable anomalies: 1) Loosening; 2) Corrosion; 3) Clique; 4) Interruption; 5) Refollation; 6) Breakage; 7) Tearing; 8) Cutting. • Specialized firms: Higher level technicians.	Revision	every year

SUB-PROGRAM OF THE INTERVENTIONS

01 - Bearing structures

01.01 - Surface foundation works

Code	Maintainable Elements / Interventions	Frequency
01.01.01	Plates in ca.	
01.01.01.I01	Intervention: Interventions on the structures Following the appearance of signs of structural failure (lesions, cracks, breaks), carry out accurate checks for the diagnosis and verification of the structures, by qualified technicians, who can identify the cause / effect of the failure and highlight any structural changes such to compromise the stability of the structures, in particular check the perpendicularity of the building. Then proceed to consolidate them according to the type of damage found. • Specialized firms: Various specialists.	when needed

01.02 - Steel structures in elevation

Code	Maintainable Elements / Interventions	Frequency
01.02.01	Pillars	
01.02.01.I01	Intervention: Interventions on the structures The reparative interventions must be carried out according to the type of anomaly found and after diagnosis of the causes of the ascertained defect. • Specialized firms: Various specialists.	to failure
01.02.02	Beams	
01.02.02.I01	Intervention: Interventions on the structures The reparative interventions must be carried out according to the type of anomaly found and after diagnosis of the causes of the ascertained defect. • Specialized firms: Various specialists.	to failure

01.03 - Unions

Code	Maintainable Elements / Interventions	Frequency
01.03.01	Connections with foundation plates	
01.03.01.I01	Intervention: Restoration Restoration of the tightening seals between elements. Replacement of any corroded or degraded elements with others of similar characteristics. Removing defective welds and making new ones. • Specialized firms: Various specialists.	when needed
01.03.02	Flange connections (beam / through column - column / through beam)	
01.03.02.I01	Intervention: Restoration Restoration of the tightening seals between elements. Replacement of any corroded or degraded elements with others of similar characteristics. Removing defective welds and making new ones. • Specialized firms: Various specialists.	when needed

Louvain la Neuve, Turin

Belgium, Italy

METRIC COMPUTE

OBJECT: Estimated bill of quantities: entire construction, excluding furnishings. Master's Thesis Project
Minerva Luca Manuel

CLIENT: École Polytechnique de Louvain, Polytechnic of Turin

Louvain La Neuve, 21/10/2021

THE TECHNICIAN

Order number RATE	DESIGNATION OF THE WORKS	DIMENSIONS par.ug.	length	width	H / weight	Amount	AMOUNTS unitary	TOTAL
	REPORTING							
	WORK TO MEASURE							
1 01.A01.A05. 020	Execution of stripping of the surface layer of the soil, with adequate mechanical means, for depths up to 30 cm, including the removal of existing bushes and scrubs and arrangement within the site area Even in the presence of thinned trees and with stems of maximum diameter of 10 cm		9.00	5,000	0.300	13.50		
	ADD m³					13.50	6.16	83.16
2 01.A01.A10. 010	General excavation, excavation or open section splitting, in loose or compact soils, up to 4 m deep, carried out by mechanical means, excluding mine rock but ... means, transport and accommodation within the site area Also in the presence of water up to a maximum head of 20 cm		9.00	5,000	0.300	13.50		
	ADD m³					13.50	3.89	52.52
3 01.A01.B87. 020	Backfilling of excavations in general, with excavated materials previously extracted and deposited within the site, including loading, transport, unloading, compaction and regularization Performed by mechanical means					3.72		
	ADD m³					3.72	8.03	29.87
4 01.P26.A60. 010	Transport and unloading of excavation, demolition and / or waste material to an authorized treatment plant, excluding the related charges and taxes if due. In an authorized treatment plant, up to a distance of 5 km					9.78		
	ADD m³					9.78	1.69	16.53
5 01.A04.B15. 010	Concrete for non-structural use mixed with 32.5 R type cement in a batching plant, maximum nominal diameter of the aggregate 30 mm, supplied on site. ... the casting, the vibration, the scaffolding, the formwork and the reinforcing bar; calculated separately. Performed with 150 kg / m³		9.00	5,000	0.020	0.90		
	ADD m³					0.90	67.89	61.10
6 01.A04.H00. 005	Formwork for reinforced concrete structures, simple or prestressed, with reduced section such as slabs, crosspieces, etc., including shoring and stripping by measuring exclusively the development of the parts in contact with the castings in timber of any shape		28.00		0.300	8.40		
	ADD m²					8.40	46.45	390.18
7 01.A50.B20. 025	Concrete with guaranteed performance in accordance with UNI EN 206 for plinths with a height <1.5 m, foundation slabs and walls <80 cm thick, curbs, poles, inverted beams, parat ... x aggregates 32 mm, Cl 0.4. Supply at the foot of the work, excluding any other charge. Compression resistance class C35 / 45		9.00	5,000	0.300	13.50		
	ADD m³					13.50	108.31	1 462.19
8 01.A04.C30. 005	Pouring on site of ready-mixed cementitious concrete carried out with a pump including its rental In foundation structures							
	Cleaning		9.00	5,000	0.020	0.90		
	Stalls		9.00	5,000	0.300	13.50		
	REPORT					14.40		2 0 95.55

Order number RATE	DESIGNATION OF THE WORKS	DIMENSIONS par.ug.	length	width	H / weight	Amount	AMOUNTS unitary	TOTAL
	REPORTING					14.40		2 0 95.55
	ADD m³					14.40	20.95	301.68
9 01.A04.F70. 010	Electro-welded wire mesh in B450A and B450C steel for concrete reinforcement, machined and cut to size, installed In rod from 4 to 12 mm in diameter		9.00	5,000	6.170	277.65		
	THEY AMOUNT kg					277.65	1.37	380.38
10 01.A04.E00. 005	Vibration by immersion vibrator, including compensation for the greater quantity of material used, vibrator rental and consumption of electricity or fuel Of reinforced concrete		9.00	5,000	0.300	13.50		
	ADD m³					13.50	8.98	121.23
11 01.A18.A10. 010	Carpentry for large or industrialized frameworks, trusses, trusses, pillars and the like, including coloring with a rust inhibitor finish, only masonry works In iron in normal profiles and nailed or bolted processing Pillars	6.00	6.00		88,300	3 178,80		
	Beams	6.00	3.70		42.300	939.06		
	Beams	8.00	3.85		42.300	1 302.84		
	THEY AMOUNT kg					5 420.70	2.59	14 039.61
12 01.A18.A20. 005	Installation of iron carpentry, for large frames, trusses, trusses, pillars and the like In normal profiles with welded, nailed or bolted processing							
	Pillars	6.00	6.00		88,300	3 178,80		
	Beams	6.00	3.70		42.300	939.06		
	Beams	8.00	3.85		42.300	1 302.84		
	THEY AMOUNT kg					5 420.70	2.84	15 394.79
13 03.A05.B01. 005	Creation of a ventilated crawl space consisting of a casting of lean concrete with a minimum thickness of 10 cm to support square-shaped disposable formworks (with the function of an ... 10x10 cm mesh: Formwork height 5 cm		9.00	5,000		45.00		
	ADD m²					45.00	117.55	5 289.75
14 01.A17.A71. 010	Supply and installation of structural panels in XLAM multilayer wood in boards of fir (Picea abies, Abies alba) or larch (Larix decidua) with 3, 5 and 7 layers encr ... certificate of qualification. 5-ply, made of fir wood (Picea abies, Abies alba)							
	Ground floor	31.46			0.130	4.09		
	First floor	23.77			0.130	3.09		
	Coverage	31.26			0.130	4.06		
	ADD m³					11.24	1 2 21.42	13 728.76
15 01.A17.A74. 005	Supply and installation of a ventilated wall consisting of a 4.5x14.5 cm fir structure, external covering in OSB, windproof sheet, battens with a 40 cm pitch in fir and ... ti, no works excluded; excluding the supply and installation of insulating material of the internal finish OSB thickness 1 cm							
	Ground floor					49.80		
	First floor					48.59		
	ADD m²					98.39	136.00	13 3'81.04
16 03.A02.I03.0	Light partitions. Partition wall in gypsum board reinforced with fiberglass and with tongue-and-groove edges to be screwed on both sides							
	REPORT							64 732.79

Order number RATE	DESIGNATION OF THE WORKS	DIMENSIONS				Amount	AMOUNTS	
		par.ug.	length	width	H / weight		unitary	TOTAL
	REPORTING							64 732.79
05	to the supporting structure ... the corners and screw heads, in order to obtain a surface ready for finishing. 2.5 cm thick plate							
	Ground floor					10.23		
	First floor					10.23		
	ADD m²					20.46	72.19	1 477.01
17 03.A02.F04. 005	Partition in formwork blocks of wood conglomerate - concrete, density 500 kg / m³, with horizontal and vertical interlocking joints, for complete elimination of thermal bridges, thermo-acoustic and hygrothermal insulators, fire resistant (class rei 180) With blocks of 20 cm thick							
						11.76		
	ADD m²					11.76	82.77	973.38
18 01.A17.A80. 010	Provided and installation of a false frame (counterframe) for fastening the windows to the masonry, in fir wood (Picea abies, Abies Alba), including the necessary hardware. Over 10 cm wide and 2 cm thick. MEASURED BY THE LINEAR METER (on the actual development of the subframe).							
	Ground floor					38.12		
	First floor					50.00		
	Coverage					4.86		
	ADD m					92.98	10.76	1 000.46
19 03.A05.A03. 005	Execution of a dry sand substrate for wooden floors and radiant floor heating system, consisting of: sand and cement screed for the passage of ... and all charges for the execution in a workmanlike manner, excluding the supply and installation of the radiant panels and the floor. . . .							
	Ground floor					31.46		
	First floor					23.77		
	ADD m²					55.23	63.49	3 506.55
20 03.P13.C03.0 15	Dry floor radiant system, consisting of aluminum thermo-conducting lamellas and flexible high density cross-linked polyethylene pipes with oxygen barrier, edge insulation mount and polyethylene sheet to protect the panel from humidity. Center distance for laying the pipes 30 cm							
	Ground floor					31.46		
	First floor					23.77		
	ADD m²					55.23	31.19	1 722.62
21 03.A12.C03. 005	Installation of a dry radiant floor system: drafting of the perimeter frame, installation, coupling and cutting of the shaped insulating panels, installation of the heat-conducting lamellas and fixing of the piping in the lamellas Price increase of art. 03.P13.C.03 (percentage of 25%)							
		1722.62			0.250	430.66		
	ADD €					430.66	1.00	430.66
22 03.P07.D02. 005	Soft clay facing tiles - hand-made type - made up of precious mixtures of selected clays without the use of pigments, dyes or additives, for coating of pa ... 4; in compliance with the European directive 89/106 / EC (radon) and the Euratom Recommendation n. 143/90 Dimensions: 250x120 mm							
	Ground floor					31.46		
	First floor					23.77		
	ADD m²					55.23	68.82	3 8'00.93
23 03.A06.B02.	Terracotta. Laying of soft-paste tiles (not extruded) laid on sight, according to the indications of the designer and construction manager with lime mortar							
	REPORT							77 6'44.40

Order number RATE	DESIGNATION OF THE WORKS	DIMENSIONS par.ug.	length	width	H / weight	Amount	AMOUNTS unitary	TOTAL
	REPORTING							77 6'44.40
005	low-cost natural plumbing ... temporary works Glued with compound based on casein, quartz sand, marble flour, lime and cellulose							
	Ground floor					31.46		
	First floor					23.77		
	ADD m²					55.23	67.43	3 724,16
24 01.A17.C40. 015	Partitions, bushes, parapets and the like of any shape and size, with a thickness of about 40 mm and a mirroring of about 30 mm, including hardware, locks and oil priming In fir (Picea abies, Abies alba) worked on two faces							
	Decorative projections					77.83		
	ADD m²					77.83	348.74	27 1´42.43
25 01.A17.C50. 005	Installation of partitions, bushes, parapets and the like, including ancillary works in wood of any kind							
	Decorative projections					77.83		
	ADD m²					77.83	51.83	4 033.93
26 01.A20.E47. 040	Execution of a transparent or colored protective and / or decorative finish, obtained by spray, roller or brush application of titanium dioxide-based paints, with separate products. Colored paint for interiors or exteriors, applied twice on: plastered or brick surfaces.							
	Ground floor					64.21		
	First floor					27.72		
	Decorative projections					77.83		
	ADD m²					169.76	8.73	1 4 82.00
27 01.A17.B40. 106	Interior doors, of any shape, size and number of leaves, mounted on hinges or tarpaulins with full or glass mirrors, with molding including carry-over, including keys and oil primer (excluding glass). In fir (Picea abies, Abies alba) with a thickness of less than 60 mm							
						2.73		
	ADD m²					2.73	247.19	674.83
28 01.A17.B70. 005	Installation of simple or hollow-core internal doors, with panels or glass, of any shape, size and number of leaves, for any thickness, mounted on hinges or tarpaulins In any type of timber							
						2.73		
	ADD m²					2.73	44.56	121.65
29 01.A18.B00. 075	Supply and installation of external metal frames, complete with frame in thermal break profiles and low-emissivity chamber mounted glass, for windows and French windows ... the use of a glazing as per code 01.P20.B04 .025]							
	In aluminum, with doors, with a surface area greater than 3.5 m².							
	Ground floor		1.60	3,000		4.80		
	Ground floor		3.20	2.260		7.23		
	Ground floor	2.00	2.50	2.260		11.30		
	First floor	3.00	3.20	1,960		18.82		
	First floor	2.00	2.50	1,960		9.80		
	ADD m²					51.95	433.13	22 501.10
30 01.A18.B00. 065	Supply and installation of external metal frames, complete with frame in thermal break profiles and low-emissivity chamber mounted glass, for windows and French windows ... the use of a glazing as per code 01.P20.B04 .025]							
	In aluminum, with doors, with a surface area of less than 2,0 m² Cover		1.58	0.850		1.34		
	REPORT					1.34		137 3'24.50

Order number RATE	DESIGNATION OF THE WORKS	DIMENSIONS par.ug.	length	width	H / weight	Amount	AMOUNTS unitary	TOTAL
	REPORTING					1.34		137 3'24.50
	ADD m²					1.34	466.54	625.16
31 03.A03.B01. 005	Countertops. Adherent ceiling consisting of a simple metal frame and covered with gypsum fiber plates fixed to the structure with adjustable metal hooks Panel 1 cm thick							
	Ground floor					23.66		
	First floor					30.10		
	ADD m²					53.76	46.68	2 509.52
32 01.A18.B45. 005	Execution of gates, railings, railings, handrails and the like in AISI 304 stainless steel with 300/500 grain satin finish In round, square, flat or profiled elements with curved or intertwining lines designs							
	Ground floor		2.50	1,000	8,500	21.25		
	First floor		10.91	1,000	8,500	92.74		
	Coverage		8.13	1,000	8,500	69.11		
	THEY AMOUNT kg					183.10	17.94	3 284.81
33 01.A40.A20. 020	Stairs Wall step - Supply and installation of pre-machined stainless steel wall step. Including anchors of any type (4 or 6 depending on the substrate), sealing, shooting and anything else to give the finished work.							
	Ground floor					10.00		
	First floor					10.00		
	ADD each					20.00	218.54	4 370.80
34 01.P07.B48.0 05	Equipped with skirting board in fine porcelain stoneware, obtained from a mixture of noble clays, of a homogeneous full-thickness type, without surface treatment, physical and chemical, with rounded or square edges, including special pieces (corners and edges) In the format 10x20 cm							
	Ground floor					21.72		
	First floor					22.48		
	ADD m					44.20	9.49	419.46
35 01.A12.B60. 005	Installation of smoothed and polished skirting board 1 cm thick, height from 6 to 10 cm, including sealing the plaster on the upper edge For a length of at least 2 m							
	Ground floor					21.72		
	First floor					22.48		
	ADD m					44.20	6.89	304.54
36 03.A09.A02. 010	Supply and installation of green roofing according to UNI 11235 standard on insulated floor, consisting of a multilayer technological system consisting of: - anti-root sheet in c ... b layer not exceeding 390 kg / m²; water storage capacity of the system at 20 cm of substrate not less than 85 l / m².							
						30.36		
	ADD m²					30.36	102.14	3 1'00.97
37 20.A27.A10. 005	Lawn formation, including the regularization of the sowing plan with leveling, crushing and raking of the earth, provided with seeds and sowing, loading and transport to an authorized treatment plant of any residual materials With manual preparation of the soil							
						12.40		
	ADD m²					12.40	2.16	26.78
38 09.P04.A15.	Supply and implementation of products for biofertilization and mycorrhization: widespread biofertilization of lawn surfaces with							
	REPORT							151 966.54

Order number RATE	DESIGNATION OF THE WORKS	DIMENSIONS par.ug.	length	width	H / weight	Amount	AMOUNTS unitary	TOTAL
	REPORTING							151 966.54
005	direct distribution of inocula based on ecto-endomycorrhizal fungi and pgp (plant growth promoting) bacteria of the rhizosphere (0.3 kg of product per m²)					42.76		
	ADD m²					42.76	0.18	7.70
39 03.P14.A08. 005	High efficiency photovoltaic modules, monocrystalline silicon cells or with HIT technology, maximum system voltage 1000 V, connection box IP 65 complete with anodized aluminum diodes, IEC 61215 certification, module efficiency> 16% Power peak from 180 Wp to 315 Wp	6.00			315,000	1 8 € 90.00		
	ADD Wp					1 8 € 90.00	2.09	3 950.10
40 03.A13.A01. 005	Installation of photovoltaic modules with a rigid structure in crystalline or amorphous silicon, on a modular support structure consisting of aluminum or steel profiles, including c ... or other equipment for transport on the roof On flat roofs or on the ground, installed surface up to 100 m²	6.00	1.91	0.633		7.25		
	ADD m²					7.25	82.93	601.24
41 NP1	Supply and installation of gutter channels in pre-painted galvanized sheet metal. Thickness 10/10 mm, development 50 cm. For each meter.					19.85		
	ADD m					19.85	35.03	695.35
42 01.A19.A20. 015	Provision and installation of rain pipes, in galvanized iron sheet no. 28, stapled, including all accessories for fixing With a diameter of 10 cm					6.08		
	ADD m					6.08	21.45	130.42
43 01.A19.B20. 005	Refurbishment of gutter gargoyles and rain pipes, including all supplies needed for new storks, brackets or nails, complete welds (labor and supplies), ... the price refers to the m of gutter or downpipe, excluding the new sections: For sections of at least 15 meters in length Eaves Downpipes					19.85 6.08		
	ADD m					25.93	25.91	671.85
44 01.A28.C70. 005	Provided and installed with a statutory house number In white marble measuring 14x11x2 cm with two pins for anchoring to the wall or on a fence, and engraving and painting in black of letters and numbers with a height of 10 cm					1.00		
	ADD each					1.00	53.61	53.61
45 06.A20.N01. 010	FO Supply and installation of a new portable or trolley-mounted fire extinguisher, approved according to current legislation, excluding any supply on site of the support. For each type, the minimum required extinguishing capacity is indicated. FO of Co2 extinguisher kg 5 113BC					1.00		
	ADD each					1.00	121.93	121.93
46 NP2	Realization of general lighting network (SG & U included). Connection quota and vertical distribution of the network					1.00		
	ADD each					1.00	750.00	750.00
	REPORT							158 9'48.74

Order number RATE	DESIGNATION OF THE WORKS	DIMENSIONS				Amount	AMOUNTS	
		par.ug.	length	width	H / weight		unitary	TOTAL
	REPORTING							158 9'48.74
47 NP3	Creation of a distribution network. Horizontal distribution quota of the network up to the junction boxes					46.09		
	ADD m2					46.09	50.00	2 304.50
48 06.A09.B01. 005	FO Supply of switchboard in insulating material, self-extinguishing, minimum protection degree IP 40, with door of any type (blind, transparent or smoky), plaster guide and all accessories for installation. FO of PVC IP40 flush-mounted switchboard with 4-module door					1.00		
	ADD each					1.00	40.42	40.42
49 NP4	Creation of a video door entry system complete with external push-button panel and internal terminals. Two-wire shielded with high performance, with the possibility of communicating with intercoms between condominiums. Up to a maximum of 25 users.					1.00		
	ADD each					1.00	440.00	440.00
50 NP5	Supply and installation of light points (SG & U included). Normal concealed light point in plastic tubes, including junction box, switch etc.					13.00		
	ADD each					13.00	57.00	741.00
51 NP6	Supply and installation of light points (SG & U included). Concealed bipolar power socket in plastic tube, including all materials and masonry, holes, junction boxes, etc.					12.00		
	ADD each					12.00	31.93	383.16
52 NP7	Burglar alarm system with volumetric protection of two environments and peripheral access protection of three points. All with an audible alarm with optical display. The architecture of the system is based on modular logic with guaranteed spare parts.					1.00		
	ADD each					1.00	2 796.37	2 796.37
53 NP8	Electric bell for entrance door consisting of ringtone, junction box, plastic button, concealed in plastic tube, etc.					1.00		
	ADD each					1.00	48.80	48.80
54 06.A19.A02. 005	FO Supply and installation of microprocessor control units for conventional smoke detection with absorption lines analysis, lcd display for alarm zone signaling with FO antinc ... ntors, conv. > = 12 expandable zones, with power supply > = 1.8 A 24V, display, keyboard, events memory.					1.00		
	ADD each					1.00	567.47	567.47
55 06.A19.B01. 030	FO Supply and installation of explosive gas detectors (methane, ethane, propane, butane, etc.) complete with control unit with analysis device and resettable siren temperature range ... bar heating current 0.14 FO of catalytic explosive gas sensor. explosion proof cesi certified for atex areas					1.00		
	REPORT					1.00		166 270.46

Order number RATE	DESIGNATION OF THE WORKS	DIMENSIONS par.ug.	length	width	H / weight	Amount	AMOUNTS unitary	TOTAL
	REPORTING					1.00		166 270.46
	ADD each					1.00	514.35	514.35
56 NP9	Masonry assistance for the installation of systems					8 5'86.07		
	ADD €					8 5'86.07	0.10	858.61
57 11.A01.A10. 030	Installation, by means of electric butt welding, of steel pipes, as per art. 11.P01.A24 of this price list, laid according to the pre-established levels and the prescriptions of what is necessary for the tests and any other burden necessary to give the work done in a workmanlike manner. DN 300					2.60		
	ADD m					2.60	20.14	52.36
58 05.A01.A01. 010	Boilers. Supply and installation of wall-mounted condensing boiler of any type, shape and size complete with all accessories to ensure correct operation, with acc ... of wall-mounted condensing boiler for heating and instant domestic hot water, power to the firebox up to 25 kW					1.00		
	ADD each					1.00	1 8'78,22	1 8'78,22
59 NP10	Realization of general water network (SG & U included). Vertical distribution share of the drainage network					14.63		
	ADD m2					14.63	25.00	365.75
60 NP11	Creation of a water point (SG & U included). Horizontal distribution quota of the drainage and / or adduction network, up to the point of installation of the appliance					6.00		
	ADD each					6.00	210.00	1 260.00
61 NP12	Supply and installation of equipment (SG & U included). Cistern for backpack toilet, including plate and tube					1.00		
	ADD each					1.00	115.00	115.00
62 NP13	Supply and installation of equipment (SG & U included). White suspended toilet with wall drain, including fixing structure and plastic seat					1.00		
	ADD each					1.00	536.00	536.00
63 NP14	Supply and installation of equipment (SG & U included). Ceramic shower tray, complete with built-in unit consisting of two operating taps, chromed shower arm and fixed jointed jet shower head with 50x80 cm anti-limescale system					1.00		
	ADD each					1.00	382.00	382.00
64 NP15	Supply and installation of equipment (SG & U included). Vitrified porcelain washbasin on enamelled cast iron shelves, 70x55, including taps					1.00		
	ADD each					1.00	420.00	420.00
	REPORT							172 6'52.75

Order number RATE	DESIGNATION OF THE WORKS	DIMENSIONS par.ug.	length	width	H / weight	Amount	AMOUNTS unitary	TOTAL
	REPORTING							172 6'52.75
65 NP16	Supply and installation of equipment (SG & U included). White ceramic bidet, including taps					1.00		
	ADD each					1.00	339.00	339.00
66 NP17	Masonry assistance for the installation of systems					5 233.45		
	ADD €					5 233.45	0.10	523.35
	Partial CUSTOM-MADE WORK euro							173 515.10
	TOTAL euro							173 515.10

Louvain La Neuve, 21/10/2021

The technician

.....

	REPORT							

DESCRIPTION	AMOUNT
ECONOMIC FRAMEWORK OF WORKS	
a1) Amount for the execution of the Work (including the amount for the implementation of the Safety Plans) To measure	173 515.10
A body	
In economics	
They add up	173 515.10
a2) Amount for the implementation of the Security Plans (NOT subject to auction discount)	
A body	
In economics	3 470.30
They add up	3 470.30
b) Sums available to the contracting authority for:	
b1) Economic work, foreseen in the project, and excluded from the contract, including refunds upon invoice b2) Reliefs, assessments and investigations	
b3) Connections to public services b4) Unforeseen events	8 8'49.27
b5) Acquisition of land or buildings and relevant indemnities. b6) Provision for the increase in the prices of materials	
b7) Expenses of an instrumental nature and for the insurance of PA employees in charge of the design, technical expenses relating to: design, the necessary preliminary and support activities, as well as the coordination of safety in the design phase, service conferences, construction management and safety coordination during the execution phase, daily assistance and accounting	
b8) Expenses for technical administrative activities related to the design, support to the person in charge of the procedure, and verification and validation b9) Any expenses for judging commissions and for tenders with the most economically advantageous offer (Article 77 paragraph 10 of Legislative Decree 50 / 2016) b10) Expenses for advertising and, where applicable, for artistic works	14 158.83
b11) Expenses for laboratory checks and technical checks provided for in the special tender specifications, technical-administrative testing, static testing and any other specialist tests	
b12) Expenses for planning activities, preventive evaluation of projects, preparation and control of tender procedures, execution of public contracts, RUP, construction management and technical, administrative and static testing (Article 113 paragraph 2 of Legislative Decree no. lgs. 50/2016)	1 2˙38,90
b13) Charges for the preparation of the feasibility project (Article 183 paragraph 2 of Legislative Decree 50/2016) b14) Costs for the preparation of the scientific balance provided for cultural heritage assets (Article 102 paragraph 9 of Legislative Decree 50/2016) b15) VAT and any other taxes and contributions due by law	38 936.79
They add up	63 183.79
TOTAL	236 6'98.89

Score Summary

NATIONAL ITACA PROTOCOL 2014 RESIDENTIAL

PROITACA

Calculation made with the Proitaca Nazionale 2014 Residential software - www.proitaca.org

15181.0001 - Minerva LucaManuel Master's Degree Thesis Project

project name

GLOBAL SCORE: 3.12

Score	P. Weighed	AREA / CATEGORY / CRITERION	Indicator
2.96	0.30	SITE SELECTION	
2.96	**2.96**	**A. Quality of localization**	
2.96	**2.96**	**A.1 Site selection**	
3.00	1.02	A.1.5 Reuse of the territory	3.00
0.56	0.13	A.1.6 Accessibility to public transport	4.45
5.00	1.15	A.1.8 Functional mix of the area	220.00
3.33	0.67	A.1.10 Adjacency to infrastructures	50.00
3.14	2.83	QUALITY OF THE BUILDING	
2.12	**1.00**	**B. Consumption of resources**	
-1.00	**-0.30**	**B.1 Non-renewable primary energy required during the life cycle**	
-1.00	-0.50	B.1.2 Primary energy for heating	120.97
-1.00	-0.50	B.1.5 Primary energy for domestic hot water	13.10
2.80	**0.28**	**B.3 Energy from renewable sources**	
5.00	2.50	B.3.2 Renewable energy for thermal uses	60.00
0.61	0.30	B.3.3 Energy produced on the site for electrical use	112.12
3.57	**0.89**	**B.4 Eco-friendly materials**	
2.62	0.47	B.4.6 Recycled / recovered materials	26.19
1.99	0.36	B.4.7 Materials from renewable sources	19.89
5.00	0.90	B.4.8 Local materials	100.00
5.00	0.90	B.4.9 Local materials for finishes	100.00
4.00	0.40	B.4.10 Recyclable and removable materials	5.00
3.00	0.54	B.4.11 Certified materials	15.00
4.02	**0.60**	**B.5 Drinking water**	
5.00	3.20	B.5.1 Drinking water for irrigation	219.37
2.28	0.82	B.5.2 Drinking water for indoor use	22.83
3.21	**0.64**	**B.6 Performance of the envelope**	
5.00	2.90	B.6.2 Net energy for cooling	10.67
0.75	0.31	B.6.3 Thermal transmittance of the building envelope	95.02
3.70	**0.78**	**C. Environmental loads**	
5.00	**1.50**	**C.1 CO2 equivalent emissions**	
5.00	5.00	C.1.2 Expected emissions in the operational phase	1.11
5.00	**0.75**	**C.3 Solid waste**	
5.00	5.00	C.3.2 Solid waste produced in the operational phase	1.00
2.39	**0.83**	**C.4 Waste water**	
1.52	1.08	C.4.1 Gray water sent to the sewer	30.44
4.50	1.31	C.4.3 Soil permeability	90.00
3.07	**0.61**	**C.6 Impact on the surrounding environment**	
3.07	3.07	C.6.8 Heat island effect	61.45
3.90	**0.82**	**D. Indoor environmental quality**	
2.00	**0.40**	**D.2 Ventilation**	
2.00	2.00	D.2.5 Ventilation and air quality	2.00
3.00	**0.75**	**D.3 Thermohygrometric well-being**	
3.00	3.00	D.3.2 Air temperature in the summer period	3.00
5.00	**1.00**	**D.4 Visual well-being**	
5.00	5.00	D.4.1 Natural lighting	78.59
5.00	**1.25**	**D.5 Acoustic well-being**	
5.00	5.00	D.5.6 Acoustic quality of the building	5.00
5.00	**0.50**	**D.6 Electromagnetic pollution**	
5.00	5.00	D.6.1 Power frequency magnetic fields (50Hertz)	5.00
5.00	**0.55**	**E. Quality of service**	
5.00	**1.25**	**E.2 Functionality and efficiency**	
5.00	5.00	E.2.4 Quality of the data transmission system	5.00
5.00	**1.25**	**E.3 Controllability of plants**	
5.00	5.00	E.3.6 Home automation systems	15.00
5.00	**2.50**	**E.6 Maintenance of phased performance operational**	
5.00	3.35	E.6.1 Maintenance of performance of the building envelope	100.00
5.00	1.65	E.6.5 Availability of documentation building technique	5.00

Score Summary

NATIONAL ITACA PROTOCOL 2014 RESIDENTIAL

PROITACA

Calculation carried out with the Proitaca Nazionale 2014 Residential software - www.proitaca.org

15181.0001 - TOWER Master's thesis Minerva LucaManuel

project name

GLOBAL SCORE: 3.76

Score	P. Weighed	AREA / CATEGORY / CRITERION	Indicator
2.96	0.30	SITE SELECTION	
2.96	**2.96**	**A. Quality of localization**	
2.96	**2.96**	**A.1 Site selection**	
3.00	1.02	A.1.5 Reuse of the territory	3.00
0.56	0.13	A.1.6 Accessibility to public transport	4.45
5.00	1.15	A.1.8 Functional mix of the area	220.00
3.33	0.67	A.1.10 Adjacency to infrastructures	50.00
3.84	3.46	QUALITY OF THE BUILDING	
5.00	**0.25**	**A. Site quality**	
5.00	**5.00**	**A.3 Design of the area**	
5.00	1.35	A.3.3 Equipped outdoor areas of common use	5.00
5.00	3.65	A.3.4 Support for the use of bicycles	45.45
3.51	**1.58**	**B. Consumption of resources**	
3.98	**1.19**	**B.1 Non-renewable primary energy required during the life cycle**	
3.62	1.81	B.1.2 Primary energy for heating	45.64
4.33	2.17	B.1.5 Primary energy for domestic hot water	5.10
3.25	**0.32**	**B.3 Energy from renewable sources**	
5.00	2.50	B.3.2 Renewable energy for thermal uses	60.00
1.50	0.75	B.3.3 Energy produced on the site for electrical use	129.94
3.05	**0.76**	**B.4 Eco-friendly materials**	
1.50	0.27	B.4.6 Recycled / recovered materials	15.02
0.20	0.04	B.4.7 Materials from renewable sources	1.99
5.00	0.90	B.4.8 Local materials	100.00
5.00	0.90	B.4.9 Local materials for finishes	100.00
4.00	0.40	B.4.10 Recyclable and removable materials	5.00
3.00	0.54	B.4.11 Certified materials	15.00
3.95	**0.59**	**B.5 Drinking water**	
5.00	3.20	B.5.1 Drinking water for irrigation	219.37
2.08	0.75	B.5.2 Drinking water for indoor use	20.76
3.21	**0.64**	**B.6 Performance of the envelope**	
5.00	2.90	B.6.2 Net energy for cooling	27.67
0.75	0.31	B.6.3 Thermal transmittance of the building envelope	95.02
3.67	**0.73**	**C. Environmental loads**	
5.00	**1.50**	**C.1 CO2 equivalent emissions**	
5.00	5.00	C.1.2 Expected emissions in the operational phase	0.04
5.00	**0.75**	**C.3 Solid waste**	
5.00	5.00	C.3.2 Solid waste produced in the operational phase	1.00
2.29	**0.80**	**C.4 Waste water**	
1.38	0.98	C.4.1 Gray water sent to the sewer	27.67
4.50	1.31	C.4.3 Soil permeability	90.00
3.07	**0.61**	**C.6 Impact on the surrounding environment**	
3.07	3.07	C.6.8 Heat island effect	61.45
3.90	**0.78**	**D. Indoor environmental quality**	
2.00	**0.40**	**D.2 Ventilation**	
2.00	2.00	D.2.5 Ventilation and air quality	2.00
3.00	**0.75**	**D.3 Thermohygrometric well-being**	
3.00	3.00	D.3.2 Air temperature in the summer period	3.00
5.00	**1.00**	**D.4 Visual well-being**	
5.00	5.00	D.4.1 Natural lighting	78.59
5.00	**1.25**	**D.5 Acoustic well-being**	
5.00	5.00	D.5.6 Acoustic quality of the building	5.00
5.00	**0.50**	**D.6 Electromagnetic pollution**	
5.00	5.00	D.6.1 Power frequency magnetic fields (50Hertz)	5.00
5.00	**0.50**	**E. Quality of service**	
5.00	**1.25**	**E.2 Functionality and efficiency**	
5.00	5.00	E.2.4 Quality of the data transmission system	5.00
5.00	**1.25**	**E.3 Controllability of plants**	
5.00	5.00	E.3.6 Home automation systems	15.00
5.00	**2.50**	**E.6 Maintenance of phased performance operational**	
5.00	3.35	E.6.1 Maintenance of performance of the building envelope	100.00
5.00	1.65	E.6.5 Availability of documentation building technique	5.00

ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE IDENTIFICATIVO: 57062000-269618 VALIDO FINO AL: 2031

APE 2015

GENERAL DATA

Intended use

- [x] Residential
- [ ] Non residential

Classification DPR 412/93: E.1

Subject of the certificate

- [x] Whole building
- [ ] Real estate unit
- [ ] Group of real estate units

Number of real estate units of which the building is composed: 1

- [x] New construction
- [ ] Change of ownership
- [ ] Lease
- [ ] Major renovation Energy
- [ ] requalification Other:
- [ ]

Identification data

CITTA' DI TORINO

Region:	Piedmont	Climate zone:	E
Common:	Turin	Year of construction:	2021
Street address:	Corso Duca degli	Civ. 24	Useful heated surface (m_2): 55
Floor:	1		Useful surface cooled (m_2): 55
Indoor:			Gross volume heated (m_3): 144
GIS coordinates: Lat.	45.062611	Long. 7.662359	Gross volume cooled (m_3): 144

Cadastral municipality	Turin								Section				Sheet				Particle			
Subordinates	from		to			from		to			from		to			from		to		
Other subordinates																				

Energy services present

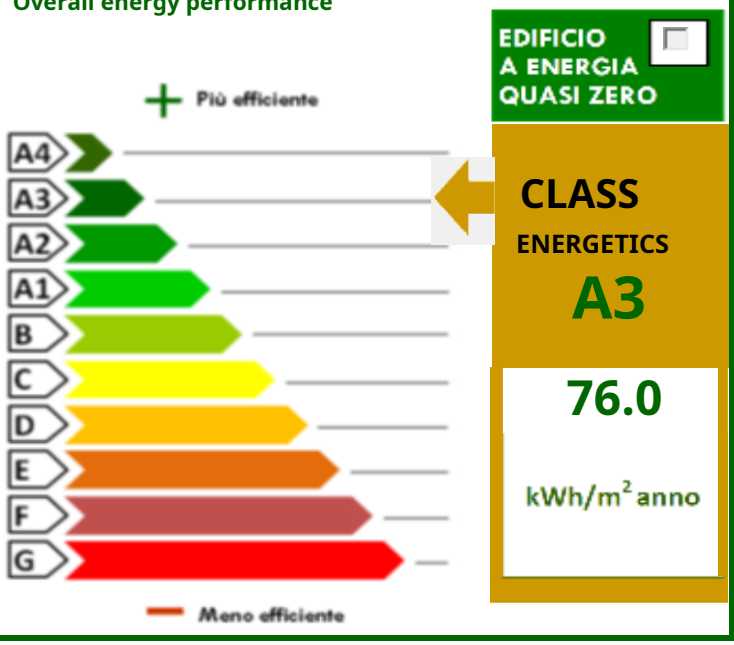
- [x] Winter air conditioning
- [x] Summer air conditioning
- [ ] Mechanical ventilation
- [x] Prod. Domestic hot water
- [ ] Lighting
- [ ] Transport of people or things

GLOBAL AND BUILDING ENERGY PERFORMANCE

The section reports the global non-renewable energy performance index according to the building and the energy services present, as well as the energy performance of the building, net of the performance of the existing plants.

Energy performance of the building

Overall energy performance



References

Similar properties they would have on average the following **classification:**

If new: A4 43.3

If existing: A3 76.0

ENERGY PERFORMANCE OF THE PLANTS AND ESTIMATED CONSUMPTIONS

The section reports the renewable and non-renewable energy performance index, as well as an estimate of the energy consumed annually by the property according to its standard.

Energy performance of plants and estimation of energy consumption

	ENERGY SOURCES USED	Annual quantity consumed in standard use (um)		Global energy performance indices ed emissions
☑	Electricity from the grid	385	kWh	Non-renewable energy performance index EPgl, nren kWh / m2 year 76.0
☐	Natural gas		Sm3	
☐	LPG		Sm3	
☐	Coal		kg	
☐	Diesel and fuel oil		kg	
☑	Solid biomass	3530	kg	Renewable energy performance index EPgl, ren kWh / m2 year 262.6
☐	Liquid biomass		kg	
☐	Gaseous biomass		kg	
☑	Solar photovoltaic	610	kWh	
☐	Solar thermal		kWh	
☐	Wind power			CO emissions2 kg / m2 year 18.8
☐	District heating		kWh	
☐	District cooling			
☐	Other (specify)			

RECOMMENDATIONS

The section reports the recommended interventions and the estimate of the achievable results, with the single intervention or with the realization of all of them, expressing a rough evaluation of the potential for improvement of the building or property covered by the energy performance certificate.

ENERGY REQUALIFICATION AND IMPORTANT RENOVATION

RECOMMENDED INTERVENTIONS AND ACHIEVABLE RESULTS

Code	TYPE OF SURGERY RECOMMENDED	It involves one Renovation important	Return time of the investment years	Energy class reachable with the intervention ($EP_{gl,\ nren}$ kWh / m2 year)	ENERGY RATING reachable if they are realized all interventions recommended
R.EN1		NO			**0**
R.EN2		NO			
R.EN3		NO			0.0
R.EN4					
R.EN5					kWh / m2 year
R.EN6					

OTHER GENERAL ENERGY DATA

Energy exported	72.8	kWh / year	Energy carrier:	Solar radiation

OTHER DETAILS OF THE BUILDING

V - Heated volume	144	m_3
S - Dispersing surface	208	m_2
S / V ratio	1.45	
$EP_{H, nd}$	175.4	kWh / m_2 year
$TO_{sol, east}/TO_{sup useful}$	0.106	-
Y_{IE}	0.13	W / m_2K

DETAIL DATA OF THE PLANTS

Energy service	Type of implant	Year of installation	Land registry code regional facilities thermal	Vector energetic used	Power nominal kW	Average efficiency seasonal		EP_{ren}	EP_{nren}
Air conditioning winter				Biomass		0.62	$h_{H.}$	221.8	59.7
	-	-	-	-	-				
Summer air conditioning				En. Electric		0.00	$h_{C.}$	4.1	3.2
	-	-	-	-	-				
Prod. Hot water sanitary				Biomass		0.40	h_W	36.6	13.1
Combined systems							h_{HW}		
Production from sources renewable	Photovoltaic			Rad. Solar		0.10	h_{PV}	9.7	0.0
							h_{ST}		
Ventilation mechanics	-	-	-	-	-	-	-	-	-
Lighting	-	-	-	-	-	-	-	-	-
Transport of people or things	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-

INFORMATION ON IMPROVING ENERGY PERFORMANCE

The section provides information on the opportunities, also in terms of national or local support tools, related to the execution of energy audits and energy requalification interventions, including major renovations.

CERTIFIER SUBJECT

☐ Public body / organization	☑ Qualified technician	☐ Body / Company

Name and Surname / Denomination	**Luca Manuel**	**Minerva**	
Street address	**Via Dante di Nanni, 104**		
E-mail	s269618@studenti.polito.it		
Phone	**3288330073**		
Title	**Luca Manuel**		
Order / registration	**Graduate student**		
Indipendence declaration	**The undersigned certifier, aware of the responsibilities assumed pursuant to art. The absence of conflict of interest, among other things expressed through the direct or indirect non-involvement with the producers of the materials and components incorporated therein, as well as with respect to the advantages that may derive from it to the applicant, and to be neither spouse, nor relative until at the fourth degree of the owner, pursuant to paragraph b), art. 3 of Presidential Decree April 16, 2013, n.75.**		
Additional information			

SURVEYS AND ENTRY DATA

Has at least one inspection / survey been carried out on the mandatory building for the preparation of this EPA?	☑ **Yes** ☐ **No**

SOFTWARE USED

Does the software used meet the requirements of compliance and guarantee of maximum deviation of the results achieved with respect to the values obtained by means of the national reference tool?	☑ **Yes** ☐ **No**
For the purposes of drawing up this certificate, has software been used that uses a simplified calculation method?	☑ **Yes** ☐ **No**

This certificate is provided, by the undersigned, in the form of a substitutive declaration of notary deed pursuant to article 47 of Presidential Decree 445/2000 and article 15, paragraph 1 of Legislative Decree 192/2005 as amended by article 12 of Legislative Decree 63/2013.

Date of issue 22/10/2021 **Signature and stamp of the technician or digital signature** _____

LEGEND AND NOTES FOR COMPILATION

This document attests the **performance** and the **energy rating** of the building or real estate unit, or the amount of energy necessary to ensure comfort through the various services provided by the technical systems present, under conventional conditions of use. In order to identify the potential for improving energy performance, the certificate contains specific information on the energy performance of the building and systems. The highest energy class achievable in case of implementation of the recommended improvement measures, as described in the section, is also indicated **"Recommendations"** (page 2).

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Energy performance of the building: qualitative index of the energy requirement necessary to satisfy internal comfort, independent of the type and performance of the systems present. This index gives an indication of how the building, in summer and winter, thermally insulates the internal environments from the external environment. The qualitative evaluation scale used observes the following criterion:

 HIGH QUALITY	 MEDIUM QUALITY	 LOW QUALITY

The threshold values for the definition of the quality level, divided by type of indicator, are reported in the Guidelines for the energy certification of buildings referred to in the decree provided for in Article 6, paragraph 12 of Legislative Decree 192/2005 .

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References: comparison with the global non-renewable performance index of a similar building but with the minimum requirements of new buildings, as well as with the average of the performance indexes of similar existing buildings, or characterized by the same type of use, type of construction, area climatic conditions, dimensions and exposure of the one covered by the certificate.

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Recommendations: Below is the table that classifies the types of intervention recommended for energy requalification and major renovation.

ENERGY REQUALIFICATION AND RENOVATION OF IMPORTANT BUILDING / REAL ESTATE UNIT - Table of Codes

Code	TYPE OF SURGERY
REN 1	BUILDING - OPAQUE ENCLOSURE
REN 2	BUILDING - TRANSPARENT ENCLOSURE
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REN 6	RENEWABLES

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The third page shows the quantity of energy produced in situ and exported annually, as well as its type.
Finally, it reports, divided into two sections relating to the building and the systems respectively, the more detailed data underlying the calculation.

ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE IDENTIFICATIVO: 57062000-269618 VALIDO FINO AL: 2031

APE

GENERAL DATA

Intended use

- [x] Residential
- [ ] Non residential

Classification DPR 412/93: E.1

Subject of the certificate

- [ ] Whole building
- [x] Real estate unit
- [ ] Group of real estate units

Number of real estate units of which the building is composed: 1

- [x] New construction
- [ ] Change of ownership
- [ ] Lease
- [ ] Major renovation Energy
- [ ] requalification Other:
- [ ]

Identification data

CITTA' DI TORINO

Region:	Piedmont	Climate zone:	E
Common:	Turin	Year of construction:	2021
Street address:	Corso Duca degli	Civ. 24	Useful heated surface (m_2): 200
Floor:	1		Useful surface cooled (m_2): 200
Indoor:			Gross volume heated (m_3): 144
GIS coordinates: Lat.	45.062611	Long. 7.662359	Gross volume cooled (m_3): 144

Cadastral municipality			Turin						Section			Sheet				Particle			
Subordinates	from		to			from		to			from		to			from		to		
Other subordinates																				

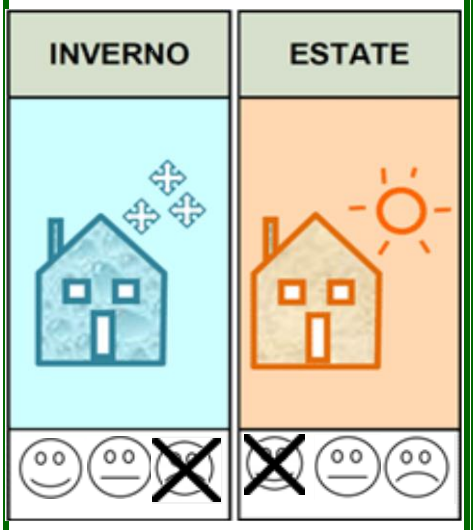
Energy services present

- [x] Winter air conditioning
- [x] Summer air conditioning
- [ ] Mechanical ventilation
- [x] Prod. Domestic hot water
- [ ] Lighting
- [ ] Transport of people or things

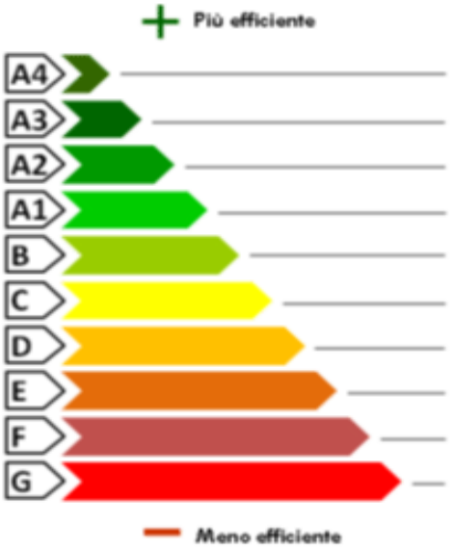
GLOBAL AND BUILDING ENERGY PERFORMANCE

The section reports the global non-renewable energy performance index according to the building and the energy services present, as well as the energy performance of the building, net of the performance of the existing plants.

Energy performance of the building



Overall energy performance



EDIFICIO A ENERGIA QUASI ZERO [ ]

CLASS ENERGETICS **A4**

25.3 kWh/m² anno

References

Similar properties they would have on average the following **classification:**

If new: A4 20.7

If existing: A4 25.3

ENERGY PERFORMANCE OF THE PLANTS AND ESTIMATED CONSUMPTIONS

The section reports the renewable and non-renewable energy performance index, as well as an estimate of the energy consumed annually by the property according to its standard.

Energy performance of plants and estimation of energy consumption

	ENERGY SOURCES USED	Annual quantity consumed in standard use (um)		Global energy performance indices ed emissions
☐	Electricity from the grid		kWh	Non-renewable energy performance index EPgl, nren kWh / m2 year 25.3
☐	Natural gas		Sm3	
☐	LPG		Sm3	
☐	Coal		kg	
☐	Diesel and fuel oil		kg	
☑	Solid biomass	5187	kg	Renewable energy performance index EPgl, ren kWh / m2 year 114.6
☐	Liquid biomass		kg	
☐	Gaseous biomass		kg	
☑	Solar photovoltaic	7545	kWh	
☐	Solar thermal		kWh	
☐	Wind power			CO emissions2 kg / m2 year 6.3
☐	District heating		kWh	
☐	District cooling			
☐	Other (specify)			

RECOMMENDATIONS

The section reports the recommended interventions and the estimate of the achievable results, with the single intervention or with the realization of all of them, expressing a rough evaluation of the potential for improvement of the building or property covered by the energy performance certificate.

ENERGY REQUALIFICATION AND IMPORTANT RENOVATION

RECOMMENDED INTERVENTIONS AND ACHIEVABLE RESULTS

Code	TYPE OF SURGERY RECOMMENDED	It involves one Renovation important	Return time of the investment years	Energy class reachable with the intervention (EPgl, nren kWh / m2 year)	ENERGY RATING reachable if they are realized all interventions recommended
R.EN1		NO			0
R.EN2		NO			
R.EN3		NO			0.0
R.EN4					
R.EN5					kWh / m2 year
R.EN6					

OTHER GENERAL ENERGY DATA

Energy exported	4877.3	kWh / year	Energy carrier:	Solar radiation

OTHER DETAILS OF THE BUILDING

V - Heated volume	144	m_3
S - Dispersing surface	208	m_2
S / V ratio	1.45	
$EP_{H, nd}$	66.2	kWh / m_2 year
$TO_{sol, east}/TO_{sup useful}$	0.016	-
Y_{IE}	0.13	W / m_2K

DETAIL DATA OF THE PLANTS

Energy service	Type of implant	Year of installation	Land registry code regional facilities thermal	Vector energetic used	Power nominal kW	Average efficiency seasonal		EP_{ren}	EP_{nren}
Air conditioning winter				Biomass		0.64	$h_{H.}$	82.6	20.2
	-	-	-	-	-				
Summer air conditioning				En. Electric		1.08	$h_{C.}$	8.3	0.0
	-	-	-	-	-				
Prod. Hot water sanitary				Biomass		0.50	h_W	23.7	5.1
Combined systems							h_{HW}		
Production from sources renewable	Photovoltaic			Rad. Solar		0.10	h_{PV}	13.3	0.0
							h_{ST}		
Ventilation mechanics	-	-	-	-	-	-	-	-	-
Lighting	-	-	-	-	-	-	-	-	-
Transport of people or things	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-

INFORMATION ON IMPROVING ENERGY PERFORMANCE

The section provides information on the opportunities, also in terms of national or local support tools, related to the execution of energy audits and energy requalification interventions, including major renovations.

CERTIFIER SUBJECT

☐ Public body / organization	☑ Qualified technician	☐ Body / Company

Name and Surname / Denomination	**Luca Manuel**	**Minerva**	
Street address	**Via Dante di Nanni, 104**		
E-mail	s269618@studenti.polito.it		
Phone	**3288330073**		
Title	**Luca Manuel**		
Order / registration	**Graduate student**		
Indipendence declaration	**The undersigned certifier, aware of the responsibilities assumed pursuant to art. The absence of conflict of interest, among other things expressed through the direct or indirect non-involvement with the producers of the materials and components incorporated therein, as well as with respect to the advantages that may derive from it to the applicant, and to be neither spouse, nor relative until at the fourth degree of the owner, pursuant to paragraph b), art. 3 of Presidential Decree April 16, 2013, n.75.**		
Additional information			

SURVEYS AND ENTRY DATA

Has at least one inspection / survey been carried out on the mandatory building for the preparation of this EPA?	☑ **Yes** ☐ **No**

SOFTWARE USED

Does the software used meet the requirements of compliance and guarantee of maximum deviation of the results achieved with respect to the values obtained by means of the national reference tool?	☑ **Yes** ☐ **No**
For the purposes of drawing up this certificate, has software been used that uses a simplified calculation method?	☑ **Yes** ☐ **No**

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CONCLUSIONS

Engineering is not simply knowing and knowing its own facts, like a walking encyclopedia; engineering is not pure analysis; engineering is not the mere possession of the ability to obtain elegant solutions to non-existent engineering problems; engineering is practicing the art of the organized application of technological changes. Engineering operates in the interface between science and society.

-Gordon Stanley Brown-

A. TACTICAL URBANISM

The public policies and in particular the territorial planning have seen years in which the only decision-maker was the architect-urbanist who with his idea of plan or project dropped from above an intervention to modify a portion of the city, a public space or a road without consulting the citizens and the inhabitants of the place. Tactical Urbanism, on the other hand, has the task of healing this gap, creating opportunities for exchange between city users and city makers: intervening in public space thanks to the involvement of the citizens, using temporary and low-cost interventions.

For ordinary citizens, this open and iterative process is an immediate way to reclaim and redesign part of public space, targeting people, removing it from degradation, abandonment: a true demonstration of the need for change. For local associations it is a way to show the effectiveness and results of some interventions, thus obtaining a consensus by the decision-making bodies and civil society. For public administrators and local government it is a way to develop good practices in a short time and with significant economic savings.

Tactical Urbanism can therefore be a solution to create new spaces, helping the design of new interventions in the preliminary phase or regenerating some spaces that over time have lost shape and function. The underlying principle is to develop a series of interventions that can trigger a process of multiplication of effects.

Technological innovation, climate change combined with the global crisis affecting the economies of the last decade of the 21st century, and also taking into account the health crisis of the world pandemic, have definitively put in crisis the old model of living and crossing one's own city, the complex and collective living, with all the articulations, opportunities and connected activities. The rethinking of public space has therefore become crucial and strategic for the virtuous redesign of our metropolises.

Acting on everything that today in our cities consists of empty lots, brown fields, unused commercial fronts, oversized roads, underpasses, surface parking: test new ideas in real time. Of course, the criticalities exist. The theme of the parking space for example or the problem of noise where assemblies were created. Quoting the words of the architect and urban planner Matteo Dondè «*in Italy projects are made but they tell little. Instead, telling a vision of a different city is fundamental*». It is necessary to reflect on how it is possible to insert temporary experimentation within the traditional planning tools, to develop an urban discipline that can be more flexible, dynamic and able to adapt to different contexts.

The drama we are experiencing, due to the global crisis and, not least, the pandemic, makes it all the more necessary to consider our cities as laboratories of experience and creativity, bearers of a new humanistic culture, of new values to build a better society that takes care of the environment as the most fragile neighbour: to be able to rebuild from the rubble and survive as urban *homo sapiens* in the years to come.

B. HOUSING DENSIFICATION

Cities and towns are growing. People are increasingly in need of housing. But the building areas are not infinite. The solution therefore lies in the construction densification, that is in the centripetal development of the settlements: block the further expansion of the

building with a stop to build in land not yet urbanized; occupy the still-free inner city areas and build new neighborhoods by designing compact settlements; increase land occupation with a higher density of the built.

Densifying is today for urban planning the indispensable therapy to stop this disastrous expansion of the town in the territory, with villages close to the large centers upset by an expansion beyond measure. It means, compared to the current regulations of the Town Development Plan, increasing the heights of the buildings and allowing a greater compactness of the building. It means building in land that is still free or freed with the demolition of existing buildings. It means building neighborhoods in areas already urbanized and equipped with services, public transport. An exercise not always easy unfortunately.

The ideas can be many, but the principle remains the same: use spaces already occupied to create new and more functional: a first suggestion may be to build a new house on a flat roof by revaluing the existing building and increasing its value. Or add new buildings to a building complex, preserving its structural stability. Or again, transforming disused structures, such as barns or roadhouses, into dwellings.

The modern passivity of those who manage the building processes of our cities has led to the formal anarchy and spatial poverty that characterizes the urban areas built in recent decades. It is time to use the new concepts of land planning laws to redesign the city. Which means having to decide – assessing the existing, quality, beauty, ugliness, shortcomings – which neighborhoods to protect, which areas to leave green or where to create new, which urban area must be qualified in densifying, where to create squares and pedestrian paths, and in which places it is possible and appropriate to create neighborhoods *ex novo*.

Rethinking the existing, opening up to new ideas for a conscious redesign of the city: it is only through collaboration between architects, overseers of fine arts and construction sector that population density can become sustainable and a relationship can arise between constructive activity and culture.

C. GREEN BUILDING

The Green Building stands as a new frontier of building, which is born from the reinterpretation of an ancient practice: a strategy of recycling urban space and the introduction of new architectural bodies into existing buildings and structures. The "parasitic" organism distinguishes itself from the host in terms of both shape and space, but remains linked to it by a state of necessity, such as the sharing of plants.

The materials used in the construction are one of the key elements in the sustainability assessment of a building. Today, normality in the field of construction is expressed through the concept of sustainable buildings, projects where energy saving, quality of materials and indoor environments are pillars. Whether they are new buildings or renovation works, the goal is environmental sustainability and the well-being of those who live there. Construction materials must be innovative, sustainable and healthy. And in more circular, consisting of materials as recycled as possible as ingredients of production and fully recyclable at the end of the cycle.

The trend in this area sees the perfect union between tradition, with the return to the use of natural materials and technological innovation, with the development of new materials with zero impact. The design and construction of green buildings therefore involves the use of certified materials and an economic investment that will be repaid over time as the properties designed according to sustainability criteria will see their economic value increase. The world of construction and built, in Italy as in the rest of the world, must regenerate to make a concrete contribution to achieving the goals of sustainability set and the environmental energy rating systems of the building are concretely a part of the response to this need.

The building system has a huge impact from the environmental point of view and also on the health of individuals. That is why it is necessary to activate concrete actions and measurable strategies as soon as possible if the important decarbonisation objectives imposed by Europe are to be achieved, placing the building and the districts at the centre as an ecosystem. Precisely for this reason, there is no shortage of finance, a sector that is

increasingly approaching the aspects of sustainable construction and the correct investment that guarantees a lower credit risk as a driver. By analysing percentage data on energy consumption and greenhouse gas emissions, a European Renovation Wave initiative was launched to strengthen energy performance rules, standards and information, with the aim at least of doubling the rates of renewal over the next ten years. An ambitious goal that requires substantial financial resources.

The urban development of cities, in a historical phase in which it is essential to converge every effort to respond to major climatic issues, is intrinsically linked to the quality of the building in terms of energy performance. To consolidate this trend we must intervene on two different levels, with measures concerning the new and old buildings: on the one hand, the obligation for new buildings to be carbon neutral, on the other hand, state incentives for the environmental development of the existing building sector.

This commitment will have consequences on training, work and therefore social and financial well-being of all citizens and especially of young people. It is time to be concrete to embrace with awareness the epochal challenge that the planet and public health impose on us.

D. MODULAR CONSTRUCTION

Modular building shows that the construction sector and environmental protection can find a meeting point. The enormous progress made in the field of construction has led to a rethinking of the traditional construction method with a new and less expensive: prefabricated modular building which, in recent years, has shown how it is possible to reduce the environmental impact of buildings, while increasing their energy efficiency and sustainability of the structure. The new design and construction methods involve the use of sustainable, easy-to-maintain materials that do not harm the environment.

It is therefore clear the direction that sustainable building is taking, which day after day is increasingly approaching the standard of the prefabricated house.

Given that modular houses are far from being "makeshift shelters", the concrete advantages offered by this innovative type of construction are many. Controlling waste, through factory production of buildings, is vital to optimize production and its costs. Just think that in such factories can be realized practically everything, walls, floors, wooden structures, leading to a total saving that can reach over 50%. The modular buildings, are designed from the early stages, with a view to saving energy, analyzing every single aspect that could lead to any waste, and studying solutions to ensure the construction of a kind of energy independence. The advantage of the use of innovative materials is not only reflected in the construction: the insulation provided for the buildings, also made in the factory, are made of recycled materials, contributing to a lower environmental impact and a further reduction in costs. In the old conception of the house, this was built, and only later people entered it, beginning to live it. In modular houses, however, these are built around the needs of its future inhabitants.

To date, the number of modular buildings is still quite contained. Sustainability continues to be something reserved for a few willing, but the signals that the market is returning are really positive. There are, therefore, more and more companies offering this possibility, thanks to the growing public interest in the issues of sustainability and energy saving.

If we wanted to make a market forecast, we could say that it is now ready to accommodate these innovative buildings, which in some situations are also not ordinary in terms of design, compared to the homes to which you are accustomed. The potential, the freedom that they can guarantee in the choice of each component, and the ability to adapt to the needs of each user, are all aspects that are making the house modular, in all probability, the future of sustainable construction.

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MAURA CORRADO, *Prefabricated houses: what permissions do they serve?*, laleggepertutti, september 2016

I've learned so much from you men...

I learned that everyone wants to live on top of the mountain, without knowing that true happiness lies in how this mountain was climbed. I learned that when a newborn child holds his little fist, for the first time, his father's finger, it encloses it forever. I learned that one man has the right to look at another man from above just to help him get up. There are so many things that I could learn from you, but in truth they would not serve much, because when you put me in that bag, unhappily I will be dying. Always say what you feel and do what you think. If I knew that today would be the last day I see you sleeping, I would hug you tightly and pray to the Lord that I might be the guardian of your soul. If I knew this was the last time I saw you walk out the door, I'd hug you, kiss you, and call you back for more. If I knew this was the last time I would listen to your voice, I would record every word of you so I could listen to it over and over again. If I knew these were the last minutes I saw you, I'd tell you "I love you" without hiring, foolishly, that you already know. There's always a tomorrow and life gives us another opportunity to do things right, but if I'm wrong and today is all I have left, I'd like to tell you that I love you, and I'll never forget you. Tomorrow is not assured to anyone, young or old. Today may be the last day you see those you love. So don't wait any longer, do it today, because if tomorrow never comes, you will surely complain the day you didn't take time for a smile, a hug, a kiss, and that you will have been too busy to grant one last wish. Keep those you love close to you, tell them how much you need them, love them and treat them well, take time to say "I'm sorry", "forgive me", "please", "thank you", and all the words of love you know. No one will remember you for your secret thoughts. Ask the Lord for strength and wisdom to know how to express them; and show your friends how much they matter to you.

-Gabriel García Márquez-

To my family, to my friends, to my university professors and to everyone who crossed their life with mine, leaving me with something good. Thank you for always being there, at all times. Thank you for always encouraging me to never give up and look forward with my head held high to get to this moment.

Thank you for making this milestone really special! AD MAIORA SEMPER

UNIVERSITÉ CATHOLIQUE DE LOUVAIN
École polytechnique de Louvain
Rue Archimède, 1 bte L6.11.01, 1348 Louvain-la-Neuve, Belgique | **www.uclouvain.be/epl**