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BOSCO VERTICALE IN MILAN

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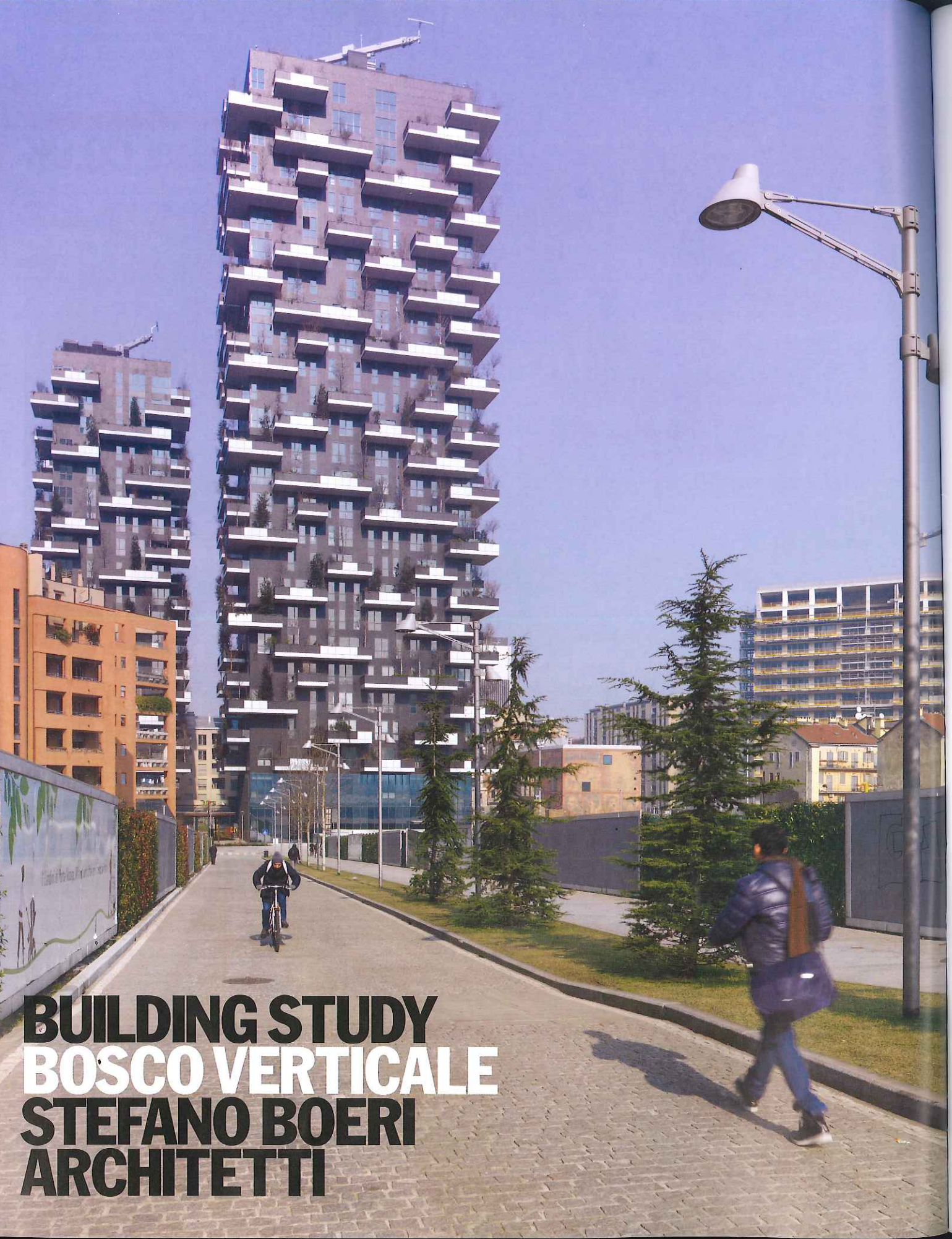

BUILDING STUDY
BOSCO VERTICALE
STEFANO BOERI ARCHITETTI

The brief

Milan's Bosco Verticale (Vertical Forest) is a new approach to high-rise buildings in which trees and humans coexist. Bosco Verticale is an architectural concept which replaces traditional materials on urban surfaces using the changing polychromy of leaves for its walls. The project consists of two towers of 80m and 112m, planted with almost 17,000 trees, shrubs and plants. This provides the equivalent greenery – over an urban surface of 1,500m² – of 20,000m² of forest and undergrowth.

Bosco Verticale increases biodiversity by promoting the formation of an urban ecosystem where various plant types create a distinct vertical environment. The diversity of plants creates a microclimate, which produces humidity, absorbs CO_2 and particles, produces oxygen and protects against solar radiation and noise pollution. The choice of species and their distribution according to the orientation and height of the facades is the result of three years of studies carried out by the practice alongside a group of botanists and ethologists. The green facades will help boost the city's flora and fauna, with an initial estimate that 1,600 birds and butterflies will find homes there.

The biological architect rejects a narrow technological and mechanical approach to environmental sustainability. Bosco Verticale is a model of vertical densification of nature within the city. This is an approach to metropolitan reforestation that contributes to the regeneration of the environment and urban biodiversity without expanding the territory of the city.
Stefano Boeri, founder, Stefano Boeri Architetti

Data

Start on site March 2010
Completion October 2014
Gross external floor area 40,000m²
Gross internal floor area 19,000m²
Construction cost Undisclosed
Client Hines Italia
Architect Boeri Studio (now Stefano Boeri Architetti) and Barreca & La Varra
Executive architect Tekne
Structural, geotechnical, wind consultant Arup
MEP and acoustic consultant Deerns Italia
Landscape and botanical consultants Laura Gatti and Emanuela Borio
Project manager and cost control J&A Consultants
Main contractor ZH General Construction Company (phase1); Colombo Costruzioni (phase 2)
CAD software used AutoCAD, Autodesk 3ds Max
Reduction of heat loss due to the micro-climate created by the plants Approx 2°C
Reduction of air pollution (transformation of CO_2 into O_2) Approx 20,000kg/year


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F.LLI FRANCESCHINI
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TEL 02/93255892 – FAX 02/93257958
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APPRAISAL

By Ellis Woodman
Photography by Charles Hosea

Italy may train more architects per capita than any country in the world, support an architectural publishing industry of unmatched scale and play host to the world's premiere architecture festival, but it has been decades since its enthusiasm for discussing progressive architecture has been matched by a commitment to build it.

Given the richness of the country's built heritage, that reluctance may be understandable, but it has had the effect of reducing many Italian cities to the condition of living museums. The extensive damage that Milan suffered as a result of Allied bombing might therefore be considered something of a blessing in disguise. While other Italian cities remained in aspic, post-war Milan was presented with an extraordinary opportunity for reinvention and, thanks to the rapid recovery of its industrial base and the efforts of a remarkable generation of Milanese architects, it met that challenge with vigour and sophistication. The construction of towers played a particularly significant role in that transformation, with projects such as Giò Ponti's Pirelli Tower and BPPR's Torre Velasca (both completed in 1958) providing a metropolitan image befitting Milan's status as the powerhouse of Italy's economic revival. In his book *Big Scale Grossform*, Josep Lluís Mateo argues that these projects represented a distinctly European departure from the American tradition of skyscraper design, their common characteristic being a determination to retain a relationship to the materials, forms and spatial structure of the existing city.

In describing the pair of luxury residential blocks that his practice recently completed in Milan's Porta Nuova district, the architect, Stefano Boeri, locates the project within that lineage. However, Porta Nuova represents a very different urban condition from the historic city. Formerly occupied by industry, the 71-acre site on the edge of central Milan is currently being transformed into a new business district by developer Hines Italia. On its completion in a couple of years' time, it is set to incorporate 20 high-rise buildings clustered around César Pelli's supremely bland Unicredit Tower (2012), the tallest building in Italy. As an urban proposition, the district has rather more in common with downtown Atlanta than the somber atmosphere of central Milan's long, stone-faced boulevards. Its most convincing

Bosco Verticale deserves to influence the future development of tower design

contribution to the city's public life promises to beThe Library of Trees, a large park conceived by Rotterdam-based practice Inside Outside as a reimagining of a botanic garden. But, despite the fact that the firm won the commission in competition in 2003, work has yet to commence, with the effect that Porta Nuova's new buildings currently look onto an expanse of fenced-off mud.

The development has not been universally well received, with residents of Isola, a working class district to the north, presenting particularly strong resistance. Boeri's project is their nearest neighbour and proved particularly controversial because it required demolition of a redundant industrial building that had been taken over by local artists and artisans. The masterplan had envisaged filling the plot with medium-rise buildings, effectively forming a wall of development between Isola and The Library of Trees. In reconceiving the project as two towers – one of 19 storeys, the other of 27 – Boeri was able to introduce a more perforate relationship, returning the larger part of the site to green space. Meanwhile, on nearby land overlooking the park, he has also built a new facility for the former occupants of the demolished building. The sense of a collision between two very different urban conditions (and demographics) remains but Boeri has made the encounter markedly less brutal than might have been feared.

The park's absence is particularly frustrating as its proximity provided the fundamental *raison d'être* for the towers' design. Dubbed Il Bosco Verticale (the Vertical Forest) the buildings support 780 trees, 11,000 perennial and covering plants and 5,000 shrubs on what amounts to more than 2 kms of dramatically cantilevered balconies. In effect, they form an extrusion of the ground condition from which they rise.

Unlike Edouard François' superficially similar Flower Tower in Paris (2004), Il Bosco Verticale incorporates a considerable variety of plant species, offering a major contribution to Porta Nuova's biodiversity. Sixty varieties of tree and 94 varieties of plant provide a home for an estimated 1,600 birds and butterflies. The planting has been distributed in response to considerations of aspect, with olives and fruit trees located on the south elevations and leaf-shedding trees chosen for the north so as to limit infringement of daylighting in winter. Changes in humidity and wind exposure as the buildings climb also had to be taken into account, requiring the planting to be specified floor-by-floor. The selection of species was informed by a three-year research project, undertaken with botanists and ethologists, during which the plants were pre-cultivated in a nursery to accustom them to the conditions they would be subjected to. Ensuring their stability was a particular challenge. The soil had to be dense enough to provide the roots with a firm grounding but not so heavy as to place excessive structural demands on the pre-stressed concrete balconies. Tests on mature tress in a wind tunnel in Florida helped develop a solution that involved connecting the roots to the inner face of the planters with stainless steel ties. Transferring the plants from the nursery took a further year and their maintenance via a bespoke hydration and irrigation system and quarterly pruning remains an ongoing commitment reflected in residents' service charges.

All of this highly experimental research represented a major commitment on the part of the developer so it is regrettable that its trust in Boeri did not extend to all aspects of the design. The apartment interiors are the work of another office and, while serviceable, are of negligible interest in detail or plan. Boeri's ambition that the exterior should be in concrete was also overruled. The walls have instead been faced in a black ceramic panel that contrast with the 140 white balconies. Particularly in winter, when foliage is reduced, it is this glibly graphic opposition that comes to define the buildings' appearance.

As the tokenistic and non-functioning wind turbines of London's Strata Tower remind us, green credentials claimed for tall buildings are not always to be taken at face value. Indeed, critics who view towers as fundamentally incompatible with values of sustainability may have cause to argue that Boeri has literally failed to see the wood for the trees. But as a response to the economic and urbanistic constraints imposed by the encompassing development, the project deserves to be judged more generously. We might regret the fact that Porta Nuova is representative of an urbanism that has been adopted the world over but Il Bosco Verticale demonstrates that possibilities remain for architects operating in such environments to deliver something richer than self-referential forms in off-the-shelf technology. A pioneering project, it deserves to exert significant influence on the development of tower design in the decades to come.

LUC BOEGLY/ARTEDIA/VIEW

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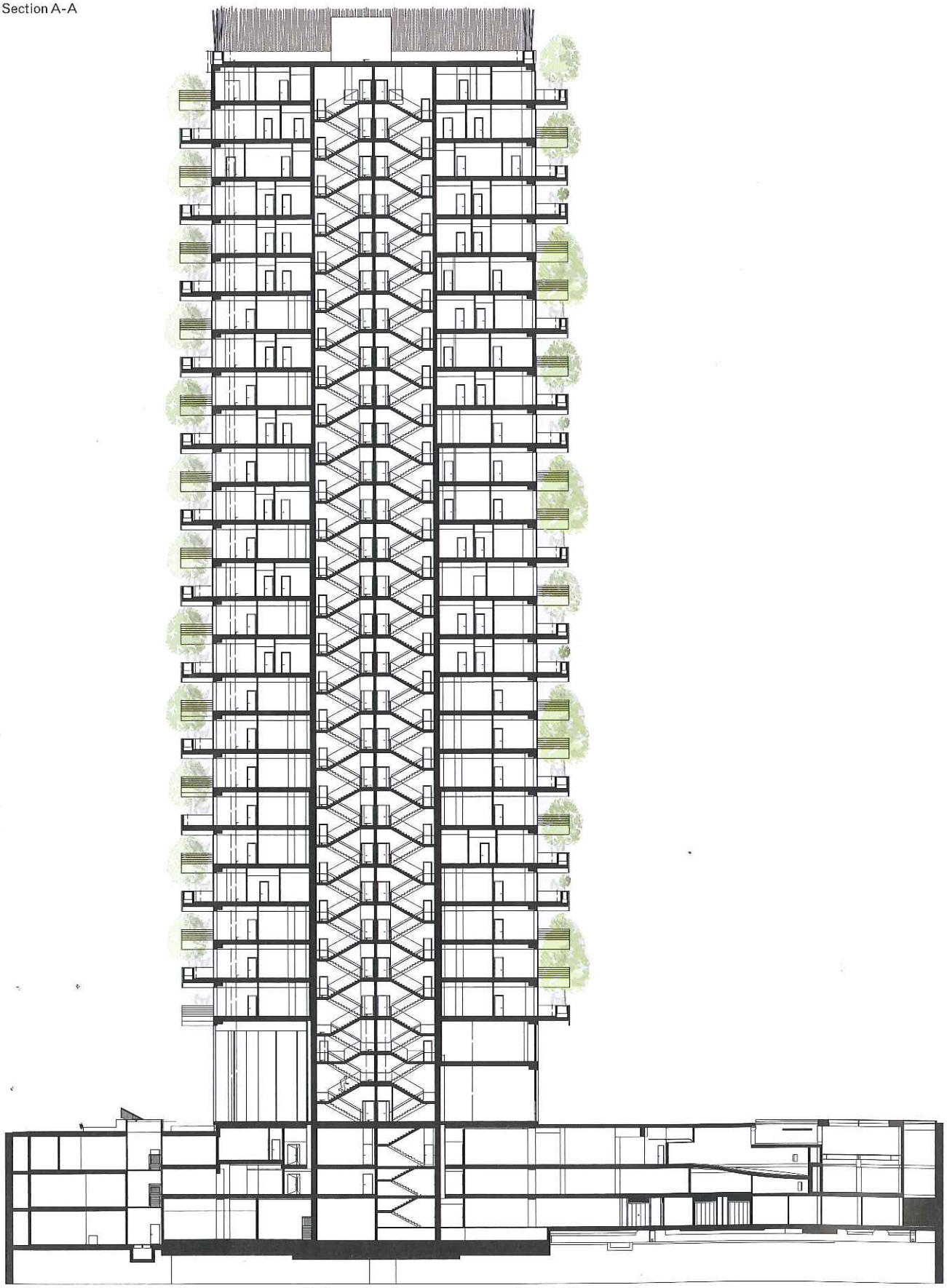
1. (*Previous page*) The Bosco Verticale towers are situated in Milan's Port Nuova district, north of the city centre
2. Gió Ponti's 32-storey Pirelli Tower (1958), a symbol of Milan's economic rebirth after the Second World War
3. (*Opposite*) Every flat benefits from a cantilevered planted balcony

Section A-A



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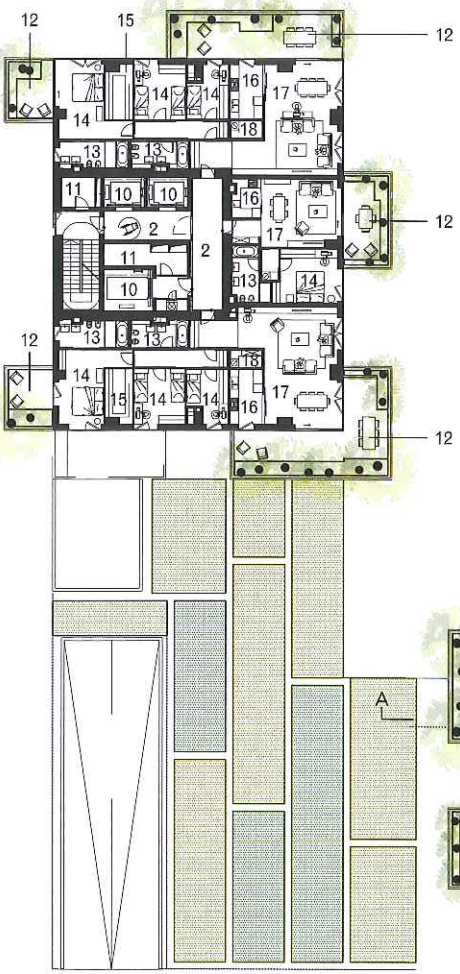
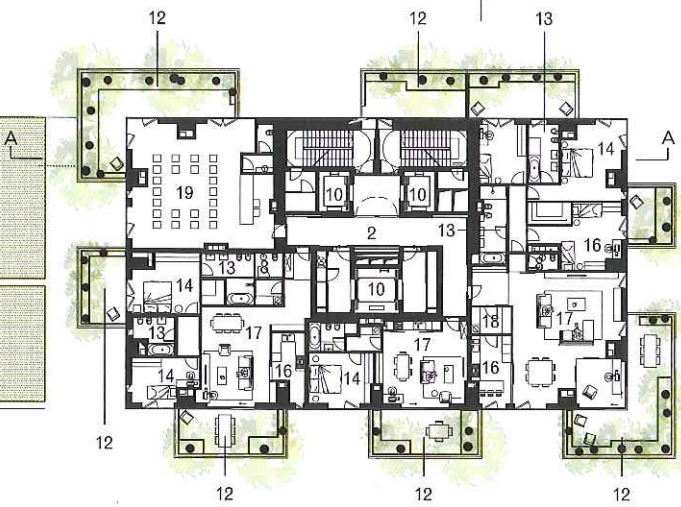
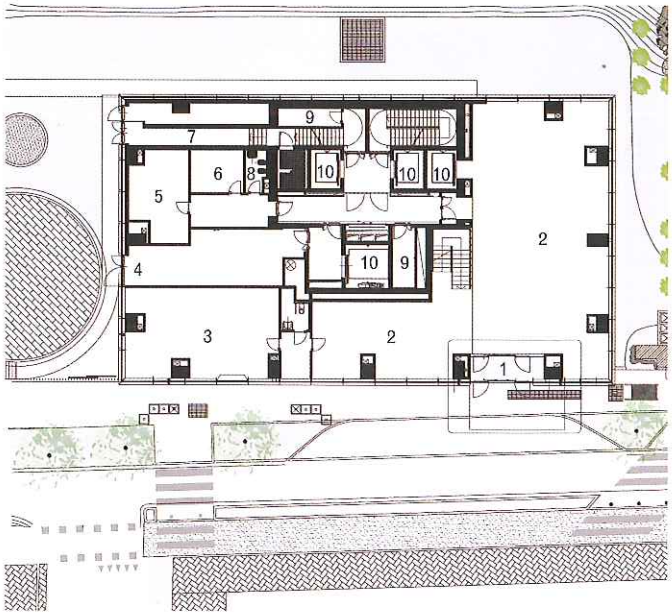


Typical floorplan

1. Entrance
2. Lobby
3. Temporary storage
4. Service entrance
5. Service area
6. Reception
7. Security exit
8. WC
9. Closet
10. Lift
11. Technical room
12. Balcony
13. Bathroom
14. Bedroom
15. Dressing room
16. Kitchen
17. Living/dining room
18. Laundry
19. Community space





Ground floor plan

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LANDSCAPE CONSULTANT'S VIEW

Laura Gatti, founder, Studio Laura Gatti

Bosco Verticale's planted facade contains approximately 21,000 plants, including about 800 trees. This pioneering approach to facade design meant that a large number of performance criteria had to meet the approval not only of the landscape consultants and the structural engineers, but also the project's insurers and legal team. Extensive research was undertaken to understand the requirements of the vertical planting, select the most appropriate nursery stock and address safety issues.

Species were selected according to ornamental and arboricultural criteria, as well as their maintenance regimes and ability to thrive on Bosco Verticale's exposed balconies. Ornamental factors which were considered included height, density and texture of canopy, duration of foliage, significance and duration of blooming and autumn colour.

The type of root system was also critical – it had to be suitable for cultivation in containers.

The proposed species were further screened for their resistance to cold and wind, solar exposure, their watering needs, resistance to pollution, disease and pests, tolerance of drought and soil compaction, and ease of transplanting.

Safety was of paramount importance. All trees and plants were pre-grown in containers to produce perfectly adapted roots and particularly hardy plants. The plant containers are fitted with special systems to prevent movement or lifting of the root balls, and restraining cables were designed for the larger trees to provide extra anchoring.

Due to the high wind speeds expected on the building facades (gusts can be up to 90mph), wind tunnel studies were undertaken early. These helped identify the most exposed locations on the building exteriors. Trees in those positions (about 6-7 per cent of the total) were carefully selected and fitted with a third anchoring system, an underground steel frame. The system was further tested using a real tree

in a wind tunnel with wind speeds up to 120mph at the International Hurricane Research Center of Florida International University.

All the planting at Bosco Verticale will be maintained through centralised management. The part of the balcony that contains plants is not sold to residents and individual owners cannot change the maintenance regime. All external planting is the responsibility of a single maintenance contractor, who will follow a five-year action plan written by the landscape consultant. A fixed crane located on the roof allows intervention from the outside to control the size of the tree crown.

The plants are watered by a dripline. The calculation of the irrigation requirements for the planting was based on the climatic conditions of the site and adjusted according to the exposure of the facades and the distribution of vegetation. Sensors detect humidity and activate and halt irrigation as necessary.

The annual water requirement for the two towers is estimated at 6,820m³ a year. Recycled waste water from other uses in the building supplies 100 per cent of the irrigation requirements. Starting later this year, the system's water and electrical usage will be monitored.

4. The towers are clad in a grey composite material
5. Interior view of lobby
6. Each balcony has a variety of sizes and types of planting, selected according to the balcony's exposure

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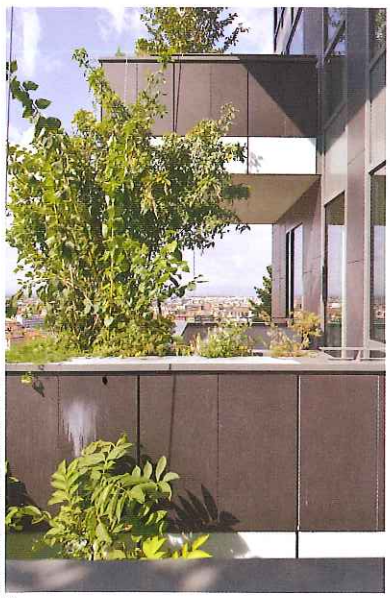
WORKING DETAIL

Valeria Migliori, senior structural engineer, Arup

Arup adopted high-strength concrete and bonded post-tensioning for the balcony floor slabs. This solution allowed limited dimensions for the structural elements with significant loads and cantilevers: up to 3.5m for the terraces and a maximum span of the cantilever in the corners of approximately 7.5m.

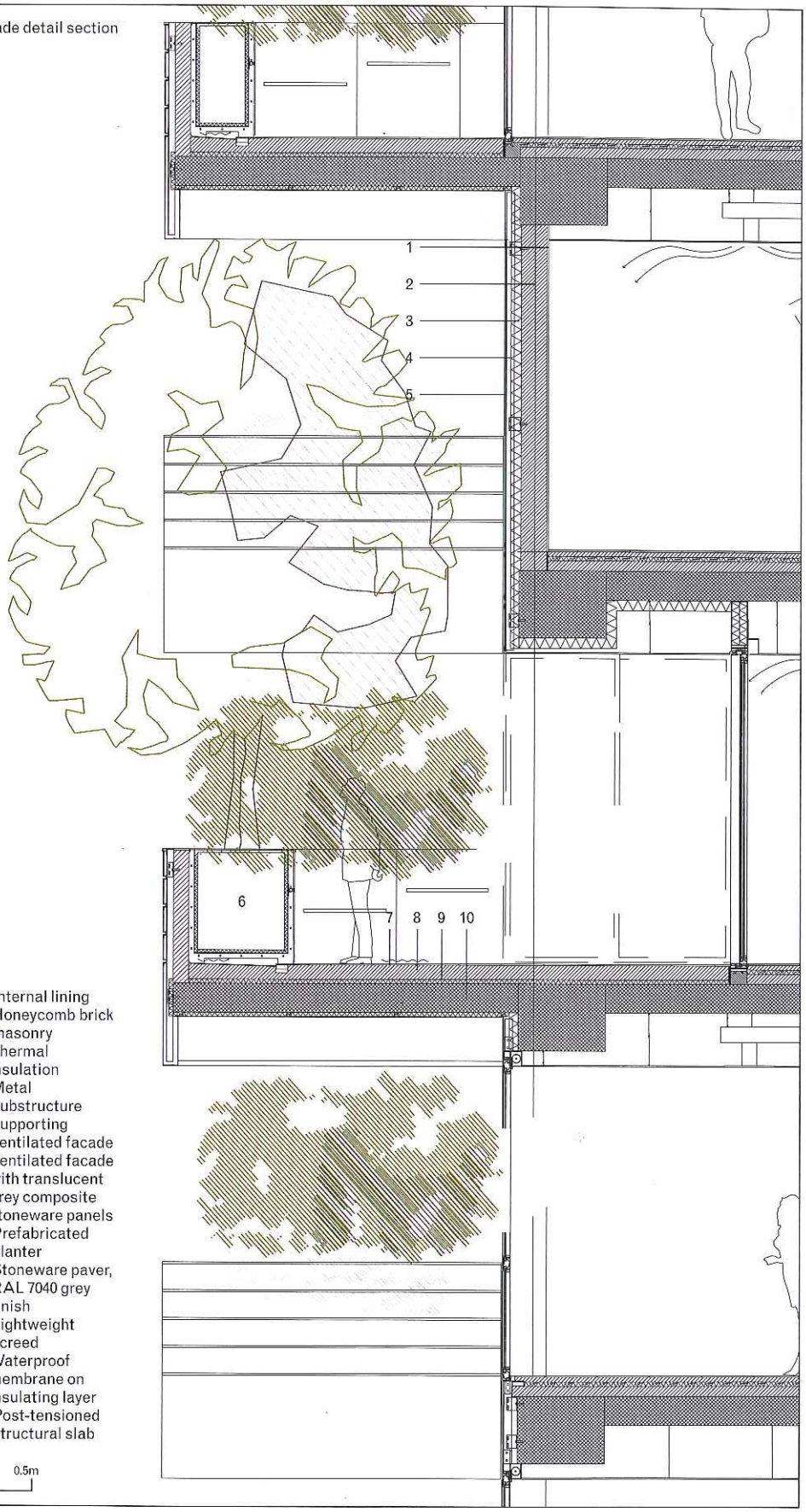
The structural stability of the trees was determined through a botanical analysis of the species and their geometry, a detailed wind climate assessment and two different wind tunnel tests. The first set of tests in the wind tunnel facility of the Politecnico di Milano assessed the forces on the trees in a 1:100 scale model. The second set of tests, carried out in the open-flow facility of the Florida International University, was designed to verify the forces on real trees.

Following the results of the analyses and tests, three restraining devices have been designed: all the trees have temporary elastic bands that connect the root bulb to a steel mesh embedded in the soil; all the medium and large trees have a safety cable to prevent the tree from falling in case the trunk breaks; the largest trees in those locations most exposed to wind have a safety steel cage that restraints the root-bulb and prevents it from overturning under major storm loads.



STEFANO BOERI ARCHITETTI

Facade detail section



1. Internal lining
2. Honeycomb brick masonry
3. Thermal insulation
4. Metal substructure supporting ventilated facade
5. Ventilated facade with translucent grey composite stoneware panels
6. Prefabricated planter
7. Stoneware paver, RAL 7040 grey finish
8. Lightweight screed
9. Waterproof membrane on insulating layer
10. Post-tensioned structural slab

SERVICE ENGINEER'S VIEW

Giuseppe Dibari, sustainability director, Deerns Italia

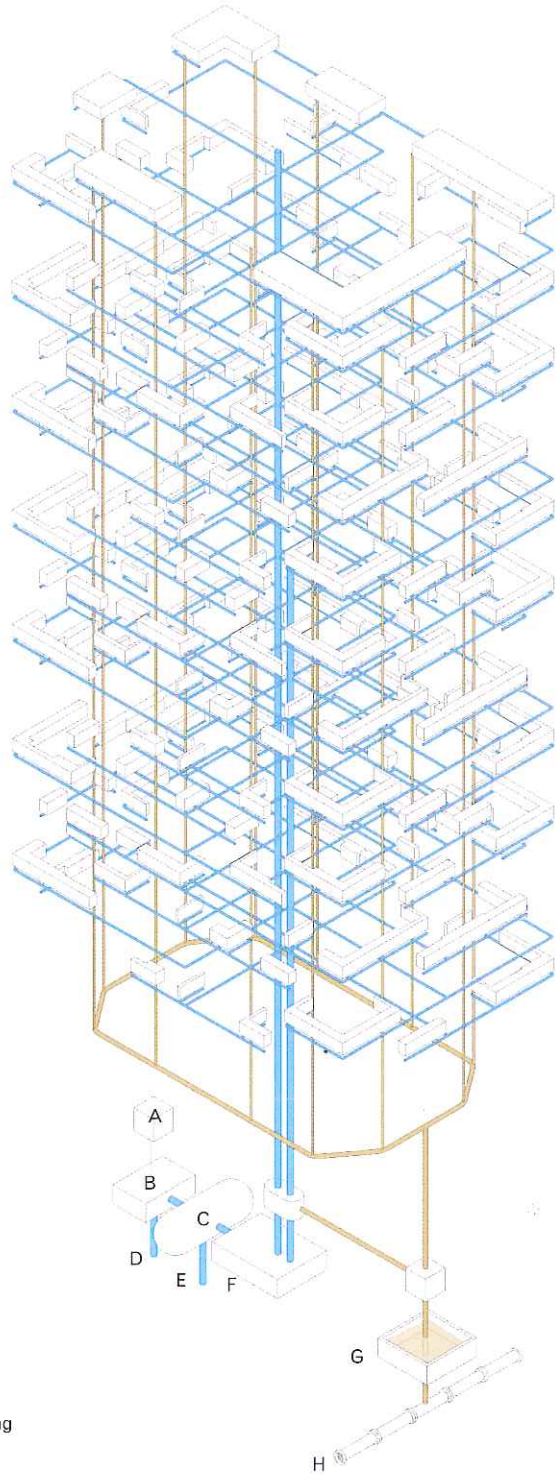
The two high-rise towers of Bosco Verticale form part of the Porta Nuova project in Milan's Isola district and are aiming for LEED Gold certification. The building form and the location and extent of its glazing have been optimised to reduce heat loss and solar gain. Balconies, terraces and glazing performance all contribute to controlling solar gain. Wall insulation surpasses the local code (0.17W/m²K, compared with 0.34W/m²K). Both U-values and g-values exceed local building regulation by 25 per cent. Windows have thermally broken aluminium frames with argon-filled, low-e double glazing. The Bosco Verticale towers are expected to reduce energy consumption by 20 per cent compared with a typical ASHRAE baseline building.

Four geothermal heat pumps provide heating and cooling generation to the entire Porta Nuova site. Heating and cooling in Bosco Verticale apartments is provided via radiant floors, which are integrated with fan coil units during the summer.

During mid-season, the radiant floor can also be fed by groundwater directly (via a heat-exchanger), avoiding the use of chillers. This both improves residents' comfort and reduces energy consumption. Bosco Verticale is equipped with about 200m² of PV panels, contributing about 2 per cent of predicted electrical consumption.

The project uses non-potable groundwater for heating and cooling through groundwater heat pumps. This waste water, which would normally be returned to the ground aquifer, is intercepted in a storage tank and used for 100 per cent of the daily irrigation of the planted facade. A drip irrigation system with weather-based controls and moisture sensors irrigates the facade planting.

Water supply system



A. Computer monitoring
B. Energy centre
C. Storage tank
D. Water intake
E. Return to aquifer
F. Irrigation tank
G. Excess rainwater collection
H. Municipal sewer

7. (*Opposite*) The extent of planting is intended to create a vertical microclimate when fully established
8. (*Opposite*) Balcony off community room
9. (*Opposite*) The balcony planting includes about 800 trees

RIGHT: STEFANO BOERI ARCHITETTI

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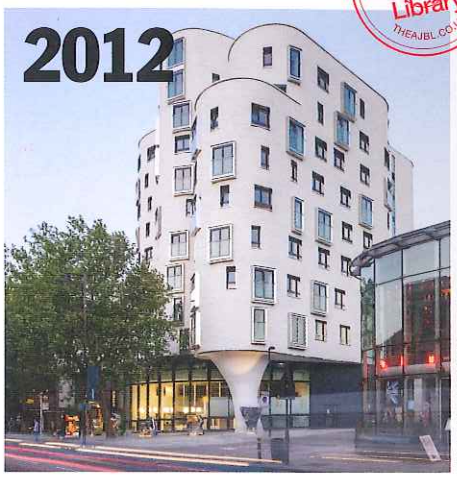

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