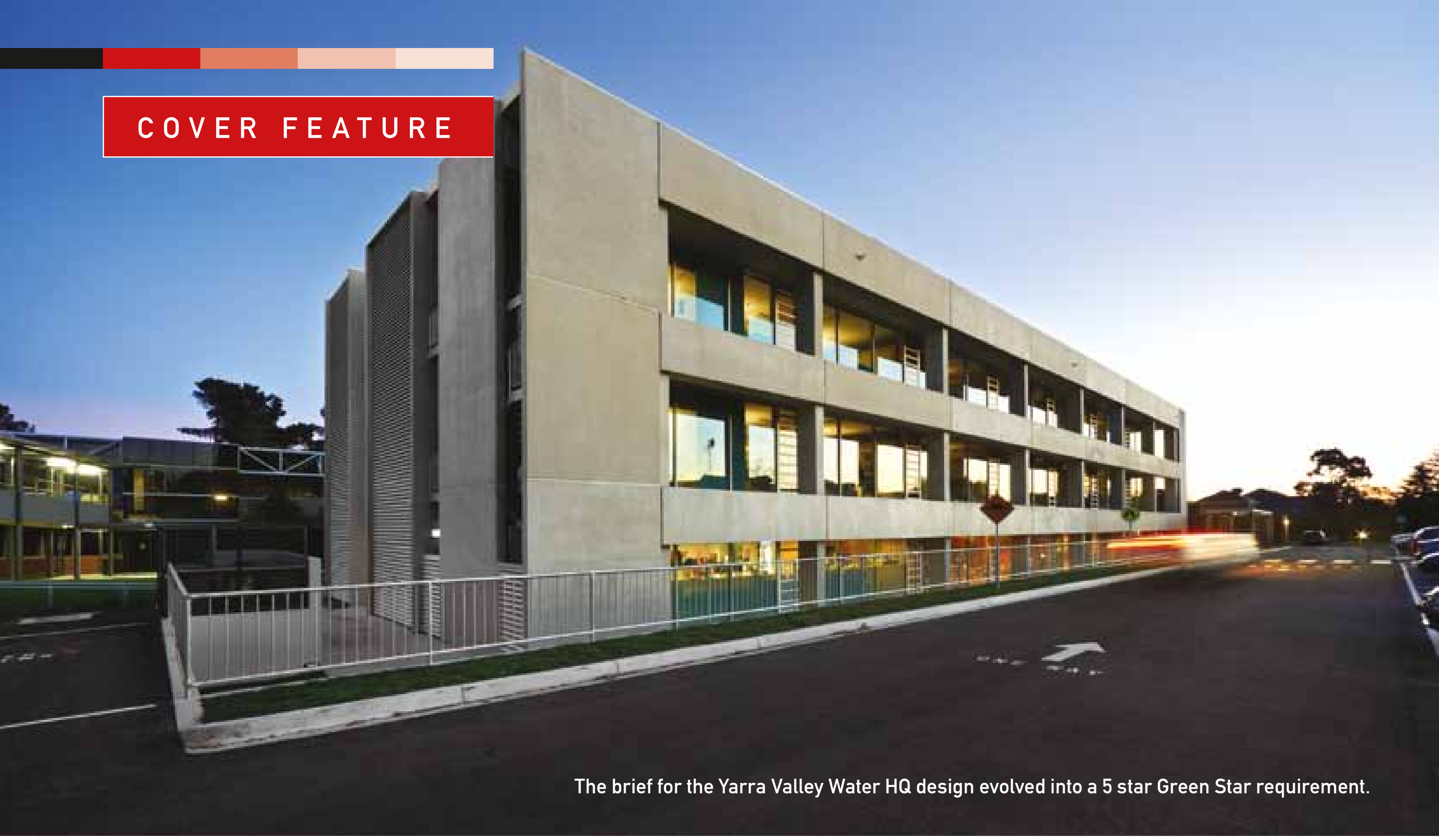


The brief for the Yarra Valley Water HQ design evolved into a 5 star Green Star requirement.

Water works

Designers of an extension to Yarra Valley Water's headquarters in the outer-eastern suburbs of Melbourne have used the combination of a sealed, high-performance building envelope and innovative in-slab technology to deliver an energy-efficient, 5 star Green Star outcome. Sean McGowan reports.

Like most contemporary commercial office projects, the brief for the extension to Yarra Valley Water's headquarters in suburban Melbourne focused most particularly on minimising the company's environmental impact, and, in keeping with its core business, managing water resources.

Having outgrown its existing 1960s-built building, Melbourne's largest water retailer sought to add a good quality, new office environment on the site of its headquarters in Mitcham. Initially, Yarra Valley Water targeted the equivalent of a 4 star NABERS Energy performance.

However, following the appointment of multi-disciplinary design firm GHD to the project in 2010, a number of the organisation's core objectives regarding sustainability performance were soon revealed.

Through this process, the brief evolved into a certified 5 star Green Star Office V3 requirement.

The first hurdle, however, was to solve the physical interface between the new and the old.

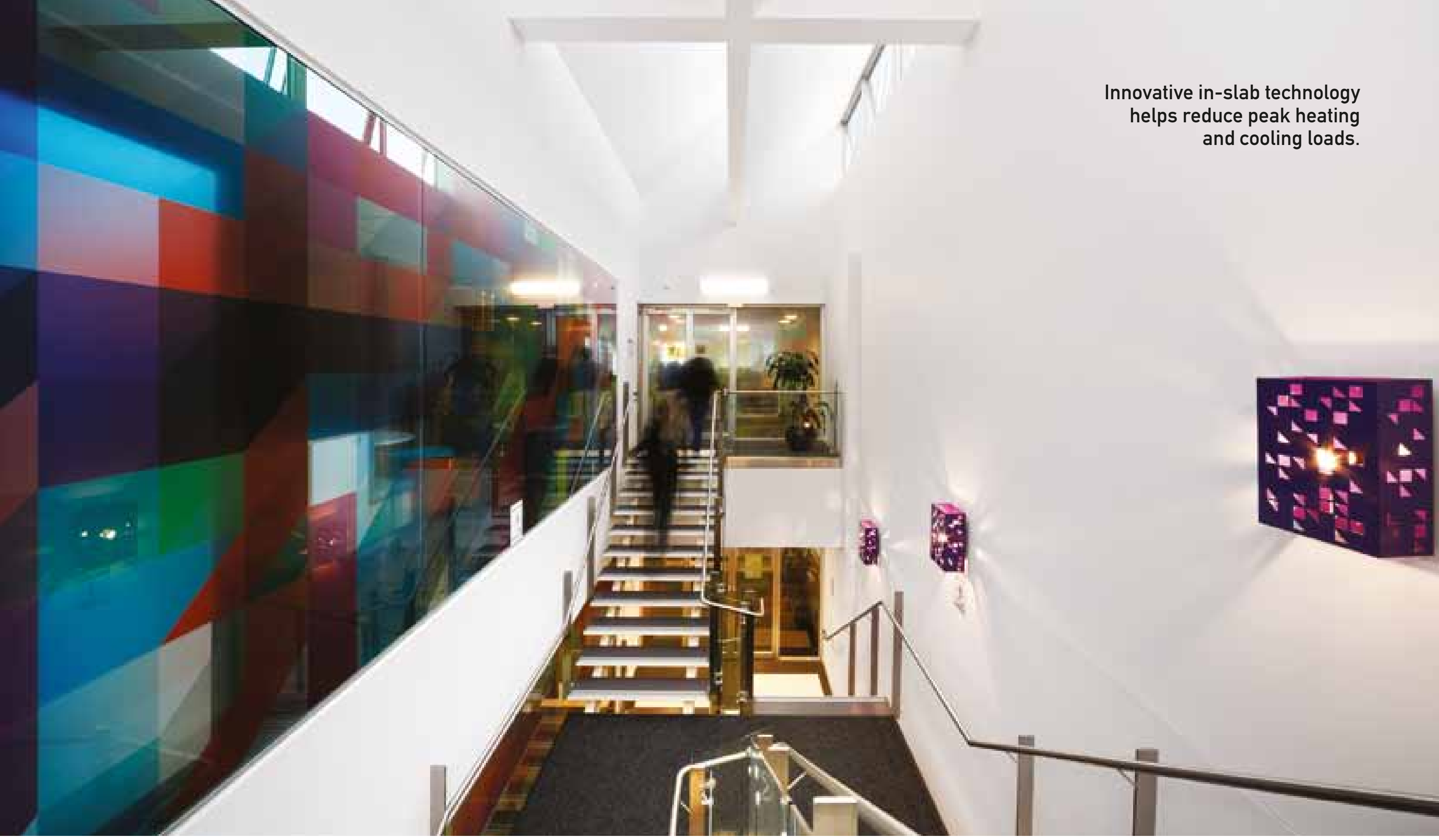
According to Tai Hollingsbee, App. AIRAH, principal engineer with GHD on the project, the existing finished floor levels needed to align with the new building. This locked in requirements around the height of raised floor voids and ceiling zones, and dictated key elements of the design.

Yet rather than disrupt the services of existing buildings that did not match the manner in which GHD intended for the new building to perform, another way was sought. A decision was made to progress with a stand-alone design featuring dedicated plant operating independently from the rest of the site.

"We found that the softer aspects of the project were actually the greater challenges – the brief around occupancy profile, occupant numbers and the function of the spaces that changed a number of times, affecting plant sizing and energy-consumption estimates," Hollingsbee says.

It is here that the benefits of operating as a multi-disciplinary practice became readily apparent. The team was able to rapidly iterate through design solutions – testing and quantifying performance to inform the architecture's development.

Hollingsbee says this arrangement allowed the team to achieve an optimum solution that met challenging metrics around allowable peak loads, thermal comfort parameters and façade performance.



Innovative in-slab technology helps reduce peak heating and cooling loads.

"It translates to shorter design cycles between engineer and architect when compared to a traditional arrangement," he says, "giving the team more time to test ideas and more room for innovation to flourish."

Rather than confuse, he says the blurring of roles between architect and engineer can deliver a solution that is both aesthetically pleasing and rational – an evidence-based approach to architecture.

"From a client perspective, we are able to present a unified front from all design disciplines and respond quickly to changes in the brief, budget or program," Hollingsbee says. "This neat arrangement is delivered through one contractual entity, which many of our clients find attractive."

A MODEL APPROACH

GHD set about developing an integrated solution based on the fundamental principles of climatic design for the Victorian climate using sophisticated simulation tools and modelling.

The three-storey form of the building was founded on maximising daylight penetration, and the opportunity for natural ventilation with a façade design that would respond to sunlight falling on the site.

Initially, the design team focused on the modelling of the HVAC systems to see how different building elements would interact.

"The design response came from a fundamental understanding that human physiological interaction with the spaces they inhabit is principally through a radiative energy exchange with surrounding surface temperatures," Hollingsbee says.

"From a client perspective, we are able to present a unified front from all design disciplines and respond quickly to changes in the brief, budget or program. This neat arrangement is delivered through one contractual entity"

He says about half of our total energy exchange with our environment occurs through this medium. Actively managing the surface temperatures inside an office space therefore naturally leads to comfortable conditions.

A desire for a column and beam-free space, as well as a rectilinear floor plate of some 2000 sq m featuring long spans, meant a concrete hollowcore structure became the favoured option. It also provided the opportunity to integrate mechanical systems into the fabric of the building to achieve the thermal comfort criteria.

As well as reducing ductwork by half, this design allowed for the use of the hollow concrete slab to act as an air-distribution path while concurrently controlling the exposed ceiling surface temperatures.

Hollingsbee says the concrete slab panels' natural thermal admittance properties means the temperature and energy retained in the building structure is actively controlled by the mechanical air systems. The result is a reduced peak heating and cooling load, and lower overall energy consumption while maintaining comfort conditions.

Complementing the innovative use of the slab, a high-performance building envelope was developed through careful attention to the detailing and specification of the building envelope elements.

"We worked through studies balancing beneficial thermal losses for winter versus conductive gains in summer to define thermal performances for each façade element," says Hollingsbee.

Studies around glazing performance were also completed, particularly as it related to useful daylight penetration and summer heat-gain protection.

The detailing of the interface between glazing systems and the wall, roof and floors focused on international best practice principles to reduce air leakage. Specified testing requirements for the entire building sought to achieve an air-

leakage rate better than 2.5 cubic m/h/sqm of façade at a pressure of 50Pa.

The raised floor, used in conjunction with the slab, was tested to not exceed a leakage rate of 0.9l/s/sq m at the same pressure.

In addition, the glazing systems were also rated for air tightness. This resulted in the installation of well-sealed, double-glazed thermally broken louvre systems for the elements that could be opened to the outside.

External walls were specified to a total thermal performance of R2.8, while roofing was specified to a value of R7.

Hollingsbee says thermally broken double-glazing systems were necessary to achieve the total U-value performance required for the building to operate well.

"Some of the poorer framing systems on the market can de-rate the overall weighted average U value performance by up to 30 per cent," he says.

"When you are trying to achieve very-low-energy consumption profiles and good thermal comfort performance adjacent to the façade, the total thermal performance of the façade system is critical. Therefore, limiting all paths of energy loss is important."

BELOW THE DECK

The HVAC design of Yarra Valley Water's Yellingbo extension saw the first and second-level floor areas serviced by displacement ventilation. The ground floor is serviced by a constant-volume, high-level, fully mixed air-distribution system.

On each floor, dedicated plant is positioned at the east and west wings. These independent plant rooms serve the internal spaces of each floor, providing independent control of the zone it serves.

Hollingsbee says this offers a sensible level of reliability for the building, and operational efficiencies relating to partial shut-down of sections of the floors that may not be occupied.

Along with acting as an air-distribution path for the mechanical systems, the exposed hollowcore concrete slab also forms part of the radiant temperature control mechanism for all spaces. It also actively manages the space's cooling and heating loads.

The first and second-floor systems have a "top-down" strategy for delivering air into a raised-floor plenum. Supply air from the AHU is ducted to the space at high level, forming a supply air header plenum. Spigots from this header plenum feed each slab panel such that the air passes through the panel before exiting into the space.

At the exit point, a spigot connected from the slab outlets is fed into the collector header plenum, mounted adjacent to the header supply plenum. At regular intervals, and adjacent to structural columns, an insulated drop duct connected to the collector header plenum

Each floor of the building has dedicated plant at the east and west wings.

Yarra Valley Water's HQ takes advantage of daylight penetration and natural ventilation.

enters the floor plenum, providing conditioned air into the floor plenum.

> We found that the softer aspects of the project were actually the greater challenges – the brief around occupancy profile, occupant numbers and the function of the spaces that changed a number of times

"The raised floor is a pressurised, low-loss floor void from which adjustable floor grilles installed in the raised floor panels provide air into the space directly from the floor void," explains Hollingsbee.

Air is delivered at a low velocity (<0.2m/s) at a minimum temperature of 18°C, helping to avoid the risk of cold draughts.

Return air through high-level return air ducts and grilles feeds air back to the AHU, where appropriate mixing occurs according to ambient-free cooling opportunity and CO_2 levels in the space.

A displacement ventilation system supplies air at low level at low velocities, and extracts hot vitiated air at high level. This system design is based on creating ideal flow conditions and using the air's buoyancy.

Individual control over ventilation rates at all workstations on the first and second floors is provided through adjustment to the floor-mounted supply air grille. The designed outside air provision of 18.75l/s/person is 150 per cent more than current best practice.

The first and second floors also have a direct-bypass arrangement for the supply air and slab panel pathways. This means that in the event that a boost in air conditioning is required, or maintenance is needed, motorised dampers in both supply and collector plenums actuate to directly supply air straight into the raised floor.

At night, the HVAC system operates at a predetermined level to maintain and control slab temperatures. It is also able to set air-supply temperatures according to the external ambient conditions, slab temperature and internal load conditions.

On the ground floor, a similar arrangement to the floors above exists.

A supply header plenum at high level is fed from the AHU, with spigots directly connecting into each panel. Air is passed through before being directly injected into the space at regular intervals via circular diffusers installed directly into the slab. Return air through high-level return air ducts and grilles feeds air back to the AHU, where appropriate mixing occurs.

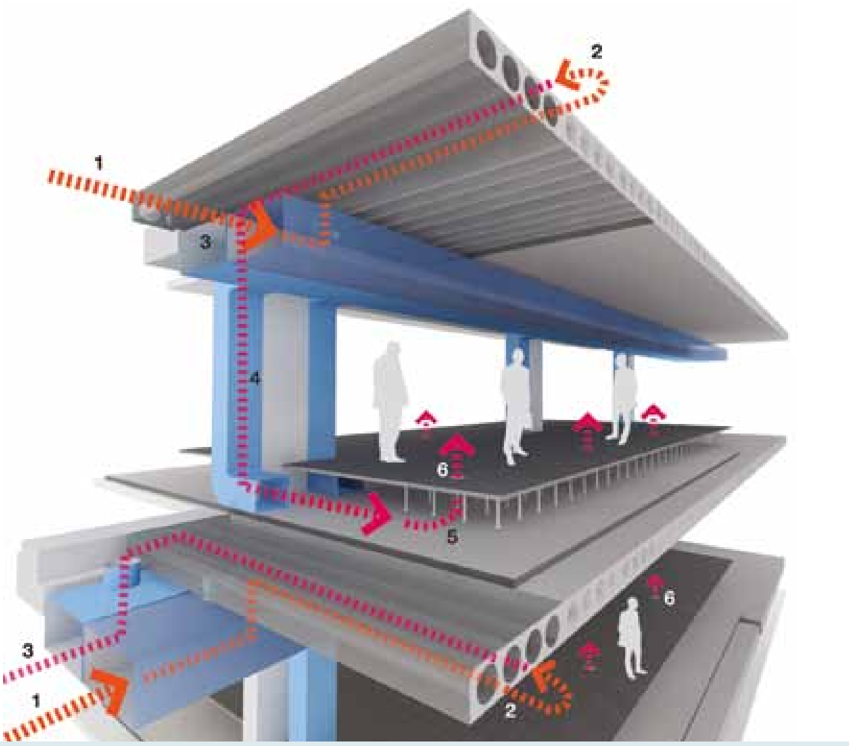
AHUs and coils, distributed vertically and external to the building, are served by an air-cooled chiller and condensing boiler for chilled water and heating hot water, respectively.

A peak chiller demand in February of 208kW (104W/sq m) and peak boiler demand in July of 93kW (46W/sq m) means the chiller is unlikely to be required from May through to August.

"The building operates as a mechanically air conditioned building," says Hollingsbee.

"Free cooling is utilised at all suitable periods of the year. We have been in the building on a 27°C day in the afternoon, with the office at full occupancy, and comfort conditions met – but with the chiller turned off."

In this instance, consecutive cool nights had charged the slab such that the chiller was not required to deliver chilled water to achieve 17°C supply air after the slab panel.



1. Conditioned air from modular AHU
2 Air passes through core where an energy exchange occurs to maintain beneficial surface temperature for the space below
3. Air leaving each Termodeck is collected in a low loss header duct
4. Air is equally distributed out across the floor via drop ducts integrated into the walls that feed the raised floor plenum.
5. A self-balancing, low-loss raised-floor plenum distributes air across the entire floor.
6. Low velocity air is delivered into the space via adjustable floor grilles and provides displacement ventilation for the office environment.

Perhaps against intuition, the system remains operable every night. Even in the depths of winter it operates at 50 per cent turn-down to ensure the slab temperature does not drop too low.

"We studied the energy-consumption profile, comparing running the system at night and turning it off, then running a boost cycle in the morning," says Hollingsbee.

The team found that using a boost cycle increased the total energy consumption substantially, due to the amount of heating required to bring the building's mass to temperature.

"It is better to get the building to temperature and maintain it than allow it to swing over the course of a few days," Hollingsbee says. "More fans hours are consumed, hence a low-loss, low-pressure ductwork system with high-efficiency fans was fundamental to ensuring we achieved our energy targets."

5 LESSONS LEARNED

Tai Hollingsbee, App.AIRAH, Principal GHD

1. Always iterate the design collaboratively and keep doing it until you have evidence that it is the optimal outcome.
2. Tightly specifying testing requirements at tender around infiltration rates, air leakage and thermal performance will lock in the costs and contractual obligation to deliver high performance.
3. More detail than usual is required in the tender documentation on a building of this nature under a "design and construct" arrangement. Adequate time and design effort needs to be put into the concept and schematic design to identify the metrics of performance that need to be written into the contract.
4. User consultation and philosophical buy-in is necessary throughout design and post construction, not just at concept design.
5. Human behaviour and organisational culture has a bigger impact on satisfaction than the application of technology and systems in a building.

CONTROL

Hollingsbee says a carefully considered control protocol that relates to the actual occupancy profile is critical to making a system like this work in terms of delivering true energy and comfort benefits.

"A slab system like this is a naturally slow-response system that has a long thermal lag," he says.

He says air-temperature sensors before and after the panel, and the addition of surface temperature probes, are necessary in order to modulate the incoming air temperature (actively or passively) to achieve the lowest energy outcome. It does this while maintaining the appropriate surface temperature for comfort.

Extensive analysis was carried out to refine the control logic, air-volume flows and set-point conditions. This was done in conjunction with the Swedish manufacturer of the concrete panels – a condition of using the product in Australia.

Similar energy and comfort conditions as those achieved by the use of concrete panels could have been achieved by radiant systems. Hollingsbee says the fact the slab panels were critical in achieving the architectural vision means their use in the HVAC solution was considered a "free kick".

Additionally, the modular approach to the HVAC design offers a high level of flexibility and redundancy.

Future changes to occupancy, lay-out and operation profile have been designed for.

The distributed plant arrangement has resulted in the installation of smaller, more efficient units, which can respond quickly to changes in volume requirements. Floor planning is made easier without risers for mechanical services.

The slab system has also enabled electrical and data cabling to be concealed, leading to a very clean ceiling surface. It also allowed for the installation of acoustic attenuation to manage reverberation rates in the open-plan office lay-out.

PERFORMANCE

Since taking occupancy in February 2012, Yarra Valley Water has enjoyed a smooth transition into the new space.

All inspections and observations have indicated the building is performing as intended. After some set-point adjustment on the ground floor, comfort conditions appear to be as designed.

Blinds on the building's northern façade, originally designed to be automated, have since been placed on manual operation in response to most occupants preferring to be able to control the blinds themselves.

"There has also been some fine tuning, which is still ongoing," says Hollingsbee.

This includes adjustment of volume flow rates and set-point temperatures in winter months, because occupant density and operating times had changed since the original design.

"When we have a full year's data, we will look at opportunities to drive down the energy performance further."

Once this fine tuning is completed, the building's designed energy consumption of 80.8kWh/sq m per year is expected to be realised, as will the designed carbon emissions of 58kg/sq m per year – a figure almost 61 per cent less than Australian best practice.

PROJECT AT A GLANCE

The professionals

Client: Yarra Valley Water

Controls: Electcon

Designer: GHD

Main contractor: ADCO

Mechanical contractor: Sharp and Pendry

The equipment

AHUs: GJ Walker

BMS: Reliable Controls

Chillers: Carrier

Computer modelling software: IES VE-Pro

Concrete panel system: Termodeck with Hollowcore

Condensing boiler: Baxi

Distribution fans: Ziehl-Abegg Australia

Distributions pumps: Grundfos

Exhaust fans: Ziehl-Abegg Australia

Floor grilles: Krantz

Spigots: Flakt Woods