COVER FEATURE

# Killer queen

**Described as Brisbane's most significant new building of the past 40 years, the Queen Elizabeth II Courts of Law occupies an entire city block in a configuration unique to Australia. And as Sean McGowan reports, the AIRAH Awards finalist has set a new benchmark for innovation in public building design.**

The Queen Elizabeth II Courts of Law building uses a double-skin façade with automatic motorised blinds to prevent direct solar ingress into courtrooms.

Accommodating Brisbane's Supreme and District courts, the new $570 million Queen Elizabeth II Courts of Law building creates a unique legal precinct in Queensland's capital by linking a new major public square and the existing Brisbane Magistrate's Court.

The 64,000 sq m building features 42 courtrooms, 67 judicial chambers and a public library – as well as numerous custodial cells, offices, archive and administrative areas – over 19 levels.

It is configured into two wings, the first of which houses the criminal courts and faces onto George St. The second is home to the civil courts, and overlooks the new public square.

Public circulation spaces connect the two wings and provide a vista over Roma St.

Described by Lend Lease's project director Allan Robertson as "a sculpture, not a concrete structure", the building's architecture is a radical departure from traditional court design.

The vision of architects Architectus and Guymer Bailey, it features an open and accessible design that is in stark contrast to the 1970s precast concrete courthouse it replaces.

It features an active double-skin façade comprising an inner, insulated double-glazed unit (IGU) and outer glass skin, with motorised blinds located in the 1000mm cavity.

As well as making full use of natural light in all the court rooms, public spaces and offices, this façade system provides both privacy and an outlook for those inside. Externally it gives the building the appearance of light and transparency.

> "It features an active double-skin façade comprising an inner, insulated double-glazed unit (IGU) and outer glass skin, with motorised blinds located in the 1000mm cavity"

The motorised blinds operate automatically depending on the location of the sun, and prevent direct solar ingress into the court rooms. This is particularly salient given each has been designed to have one external glazed wall on which a judge's podium is located.

The active façade system was just one design element conceived by the team that won the contract for the project's design and construction in June 2007.

Marco Hopman, M.AIRAH, is an associate for buildings with Aurecon, which formed part of the successful Architectus lead team. Hopman says the original brief largely centred on the building's functional requirements.

"We were to provide a design that would be energy-efficient equivalent to a NABERS 4.5 star rating, provide flexibility

in building operation, and design a façade to limit solar gains," he says.

Specific requirements within the brief included enhanced levels of energy efficiency, indoor air quality and thermal comfort, strict acoustics requirements, and ESD initiatives.

"The architectural design intent was to provide a building filled with daylight, and a 'simple' architectural form that did not distract from the important proceedings within the courts," Hopman says.

Hopman describes the Courts of Law as being like five different buildings of various function sitting atop each other. A number of different HVAC solutions were therefore investigated, taking into account the building's varying spaces and uses.

These included chilled beams – both active and passive – for the court rooms, as well as overhead air distribution and underfloor displacement ventilation.

However, following detailed discussion with all stakeholders, Aurecon proposed an underfloor displacement system as the most appropriate in addressing the numerous – and at times conflicting – project aspirations.

Elsewhere in the building, alternative solutions were prescribed, including underfloor air distribution (UFAD) for the lower administration floors, and a 100 per cent fresh air system for the custodial areas.

Low-temperature variable air volume (VAV) was selected to service the library and chamber floors.

Brisbane's sub-tropical climate makes the supply of dehumidified conditioned air an energy-efficiency challenge in the big spaces.

"If air is simply cooled down to the supply air temperature of 19°C, humidity in the space will not be controlled and will be unacceptably high," he says.

"The traditional method of providing dehumidified air at higher temperatures is to sub-cool the air to achieve the required dewpoint, and then reheat the air back to the required supply air temperature."

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This solution, however, imposes significant energy penalties not in alignment with the project's sustainability aspirations.

Rather, the design team was able to provide conditioned air to the courtroom spaces in an energy-efficient manner by decoupling the dehumidification and cooling processes.

This was achieved by providing central, dedicated outside-air systems (DOAS) and dedicated on-floor air-handling units (AHUs) to all courtrooms.

Incorporating run-around heat-recovery coils, cooling coils, supply-air fan and filters, the DOAS units precondition

## SUB-TROPIC DISPLACEMENT

For a number of reasons, displacement systems are not traditionally used in sub-tropical environments. As such, its implementation in the Queen Elizabeth II Courts of Law represents a significant break from the conventional.

According to Hopman, such systems originate from low-humidity European climates, where 100 per cent outside air can be used with minimal cooling and no dehumidification requirements.

However, in a sub-tropical climate such as Brisbane's, the challenge is to provide dehumidified conditioned air to the space in an energy-efficient method.

## LESSONS FROM THE CONSULTANT

**Marco Hopman, M.AIRAH, shares the wisdom gleaned from the project.**

1. Keep an open mind and be willing to listen to new ideas.
2. Constant and open communications with all parties is critical.
3. Always refer back to the design goals that you are trying to achieve.
   Building design is always full of compromises, and you need to be aware of what can change with negligible effect and the items that cannot change without significant impact.
4. Use of advanced analysis to influence the design early in the design process is invaluable.

Computational fluid dynamics and environmental modeling optimised air distribution methods and locations.

and dehumidify the outside air before it is supplied to the courtroom AHUs. In doing so, they address the large loads associated with the introduction of outside air, whether due to low ambient conditions, high ambient conditions or high humidity of the outside air.

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The DOAS units utilise 100 per cent outside air with run-around coils and cooling coils to supply air at 19°Cdb/12.7°Cwb at 48 per cent relative humidity. The chilled-water cooling coil is controlled to a coil-off temperature, nominally 8°C and reset based on ambient and space-relative humidity.

The run-around coil variable-speed drive (VSD) pumps are controlled to achieve a 19°C supply-air temperature. This air is then mixed with the return air in the courtroom AHUs.

"The on-floor AHUs are only required to provide sensible cooling to supply air into the floor plenum," says Hopman.

"The BMS trend logging reviewed during the building tuning period indicated that typically the supply air temperature is approximately 20–21°C to achieve a room temperature of 23°C within the occupied zone."

Mechanical services contractor Siganto and Stacey was engaged early in the design process to allow greater collaboration with the design consultant.

Siganto and Stacey undertook thorough psychometric analysis of the AHU cooling coil and run-around coil selections.

Floor diffusers were also judiciously selected to not only minimise draught, but also restrict the maximum vertical throw.

"Our engineering and commissioning teams worked closely to ensure the control strategies were clearly understood and implemented to satisfy the design intent," says Joe Briguglio, national construction manager for Siganto and Stacey.

To improve indoor air quality, outside air intakes were located on level 11 so as to be as far as possible from ground-level traffic fumes and other contaminants.

## LESSONS FROM THE CONTRACTOR

### Siganto and Stacey's Joe Briguglio says modularised project delivery is the way to go.

The key success factor for any project is to deliver an on-time, defect-free quality installation. Based on this premise, our learning was to adopt a modularised project delivery method.

Modularisation and offsite manufacture offer three key benefits:

1. Improved workplace health, safety and environmental impacts by reducing hot works on site. Fewer deliveries (deliveries will be larger in volume but fewer in number) coupled with fewer site-operative vehicles and journeys to site will reduce the project's carbon footprint.
2. Increased quality, because the manufacturing process will be undertaken in a controlled factory environment and the works will not be subjected to any inclement weather conditions.
3. Construction programs can be expedited, as the fully designed and coordinated modules will significantly reduce installation times.

The economy cycle was also designed to make use of outside air when ambient conditions allow. These outside-air intakes are located on each floor.

In addition to enthalpy-based control strategies, an ambient $CO_2$ sensor was also incorporated in the control strategy to override the economy cycle should ambient $CO_2$ levels be excessive during peak traffic periods.

## ALL RISE

The courtroom comfort levels have been designed to achieve the most stringent comfort criteria of PMV (predicted mean vote) between +0.5 and -0.5 for the judges' podium location.

Elsewhere in the building, a PMV of between +1 and -1 was required and easily achieved.

The design lay-out dictated the location of the judges' podiums to be directly adjacent the external façade to optimise daylight. Yet this proved to be a highly challenging location for environmental temperature control and comfort.

### PROJECT AT A GLANCE

#### The professionals

**Acoustics Engineering:** Aurecon

**Architect:** Architectus

**Client:** Queensland Government

**Fire engineering:** Aurecon

**Managing contractor:** Lend Lease

**Mechanical services engineering:** Aurecon

**Mechanical services contractor:** Siganto and Stacey

#### The key equipment

**AHUs:** AirDesign

**AHU fans:** Ziehl-Abegg Australia

**BMS:** Schneider Electric

**Cooling towers:** Baltimore Aircoil (BAC)

**CRAC:** Stulz

**Low-temperature VAV:** Holyoake

**Pumps:** KSB-Ajax

**Water-cooled chillers:** Carrier

To optimise comfort, each influence – temperature, humidity, radiant heat and air movement – was analysed, and response measures adopted.

To accommodate the personal preference of each judge, the local temperature at the podium can be adjusted.

Aurecon also used computational fluid dynamics (CFD) and environmentally modelling software to optimise floor grille locations, air distribution, air velocity and temperatures.

Maintaining the seal integrity of the courtroom plenums was also critical to the mechanical services' performance and indoor air quality.

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Siganto and Stacey carried out on-site inspections throughout the construction process to visually check the plenum build-quality before installing the grilles. Plenum mock-up and testing was also carried out to verify that air leakage rates, access to floor tiles and spatial allowances were adequate for HVAC, electrical, communications, plumbing and finishes.

A series of compression tests were also conducted on different types of grilles at varying crushing loads to measure deformation. This process informed the selection of fit-for-purpose grilles for the project.

The positioning of linear bar-floor grilles adjacent to the facades and in the public circulation spaces also required a significant amount of coordination, with CFD analysis used to reduce the grille dimensions as much as possible.

## QUIET IN THE COURT

Aurecon also provided a high level of acoustic analysis to meet the project's exacting requirements. This led to the design of flat-plate speakers for the PA and emergency warning and intercommunication systems (EWIS), which were integrated into the linear bar floor grilles.

Prototype AHUs were also acoustically tested. This testing highlighted tonal noise issues from the direct-drive plug fans, issues that were not apparent from the fan manufacturer's data. As a result, sound attenuator requirements were re-analysed to ensure compliance with the acoustic requirements.

Fans were selected that did not exceed the scheduled maximum sound power levels, attenuators were installed and all courtroom ductwork was internally insulated to obtain noise level ratings in the occupied areas as per the acoustic brief.

"We constructed all the courtroom underfloor ductwork with sheet metal gauge to standards exceeding AS/NZS 4245 requirements, to reduce sound transmission from the ductwork to the occupied space," Siganto and Stacey's Briguglio says.

This served a two-fold purpose of absorbing sound transmission while providing additional strength to the ductwork should it sustain any damage.

## COORDINATION RISK

Floor congestion was recognised as a significant coordination risk early in the design process, such that a decision was made to separate the locations of mechanical plant rooms, electrical riser and distribution boards, as well as the main hydraulic risers.

Hopman says this ensured that all services avoided the need to return to a common, central location, as is often the case in most buildings.

"Congestion and coordination requirements were reduced by designing out highly congested areas," he says.

Siganto and Stacey was given the responsibility of lead services coordinator, and developed accurate, construction documentation to accommodate a clash-free installation.

Briguglio says the mounting of duct on the floor created issues not usually encountered, and made the coordination of systems supplying the floor below all the more critical.

"While duct installation was simplified by not requiring the duct to be lifted to the slab above, installing the duct under the floor posed its own unique set of challenges," he says.

Routes for the major in-floor services, such as ductwork, electrical cable trays and IT cable trays, were established early,

and clear zones and pathways provided. Other services providers were reminded of the importance of not walking on or crushing installed duct.

The installation of spigots and general fit-off required extra care and attention, while the logistics of material handling and manoeuvring around the duct had to be carefully planned and managed.

Sprinkler pipework also proved challenging, because the sleeves for sprinklers had to be cast in concrete. The sprinkler pipework reticulated in the floor void of the floor above.

"The structural solution for the building was also changed to a flat-plate solution with no beams," says Hopman.

"While slightly reducing the floor void by approximately 130mm, the flat-plate structural solution did not have any upstand beams in the floor voids that would have obstructed the reticulation of services."

## REDUCING PEAK DEMAND

In addition to the 5,565kW capacity chilled water plant, a thermal energy storage (TES) system was incorporated as a major sustainable design element of the Queen Elizabeth II Courts of Law building.

Hopman says that in adopting thermal energy storage, the Queensland government has been able to promote and showcase the benefits of peak demand reduction to the community.

The system comprises an underground 1,500 cu m stratified chilled water tank to provide 6,000kWh of thermal storage.

Along with reducing peak electrical demand on the grid by up to 300kW, the TES allows the building to take advantage of night-time reduced off-peak electrical tariffs.

During winter, it also allows the building to operate during business hours without the need for chillers, which only operate at night.

A range of other sustainability measures have also been incorporated, including water harvesting and recycling, passive solar design, recycled building materials, solar hot water and photovoltaic cells.

## JUBILEE YEAR

The Queen Elizabeth II Courts of Law building was completed on schedule within four years – a significant achievement given the high level of detail and finish required.

Coinciding with Her Majesty Queen Elizabeth II's Diamond Jubilee year, the building was officially opened on August 3, 2012 by the Premier of Queensland Campbell Newman.

Court operations began on August 27, 2012.

### Did you know?

Aurecon was finalist in the AIRAH Awards 2013 Excellence in Innovation category for its work on the Queen Elizabeth II Courts of Law.