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The heart of the matter

The Sydney home of ARBS has undergone a $1.5 billion transformation to position it as the Asia-Pacific region's premier integrated convention, exhibition and entertainment precinct. **Sean McGowan** reports on the new International Convention Centre (ICC) Sydney. Images courtesy of A.G. Coombs.

In the footprint of the former Sydney Convention and Exhibition Centre in Darling Harbour, the new International Convention Centre (ICC) Sydney represents one of the largest urban renewal projects to have ever taken place in Australia.

Developed through a public-private partnership (PPP) with the New South Wales government and the Darling Harbour Live consortium, ICC Sydney is significantly larger than its predecessor.

Expected to attract more than 26 million visitors to Darling Harbour every year, the facility spans three city blocks.

ICC Sydney features an exhibition capacity of 35,000 sq m, as well as convention facilities to accommodate up to 12,000 delegates and an 8,000-seat plenary hall – all connected by internal walkways.

It also houses an 8,000-seat "red carpet" theatre, a 5,000 sq m event deck, a grand ballroom with banqueting space for more than 2,000 people, and over 8,000 sq m of meeting room space across 70 rooms.

The project commenced in 2013 with the closure and demolition of the existing Sydney Convention and Exhibition Centre. Technical completion was reached in September 2016.

The venue officially opened to the public in December 2016. Over 400 events have reportedly been booked for its first year of business.

> The commissioning and delivery of three buildings simultaneously, with a variety of different systems, also presented a major challenge

He says AECOM typically took the lead role in validating concepts from a technical performance perspective, while A.G. Coombs took the lead role in validating buildability and cost.

Once the project reached the delivery phase, these roles were somewhat reversed. A.G. Coombs produced the documentation through to detailed design, shop drawings and eventually "as-installed" documentation. AECOM provided input to ensure the design intent was being met.

Among the performance outcomes prescribed in the brief from Infrastructure NSW (iNSW) were environmental comfort and sustainability targets. This led to Lendlease offering to build the first convention and exhibition facility in Australia to meet the Gold

A COLLABORATIVE ENVIRONMENT

As members of the winning bid team led by construction manager Lendlease, consulting engineer AECOM and mechanical services contractor A.G. Coombs worked collaboratively from the bid phase of the project in early 2012 through to project handover in 2016.

As the project consisted of many large spaces with large, highly transient populations, the mechanical services solutions needed to manage a high fluctuation of occupant and equipment loads, while providing low-energy operation.

"The two organisations met regularly at project-wide meetings as well as service-specific meetings to address various challenges," says Michael Dagher, M.AIRAH, AECOM technical director – buildings.

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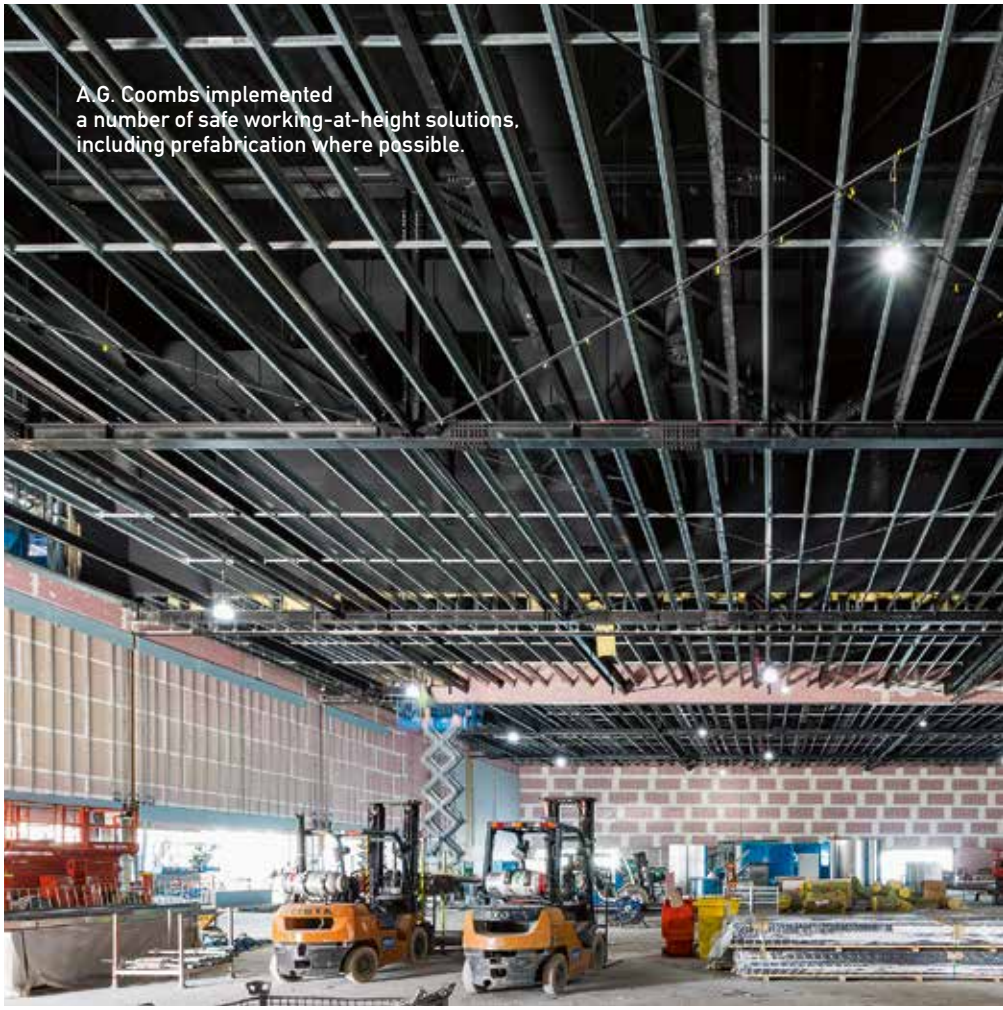

A.G. Coombs implemented a number of safe working-at-height solutions, including prefabrication where possible.

rating requirements of the US Green Building Council's LEED certification. This is roughly the equivalent of 5 star Green Star.

This decision influenced the design of the buildings and services, and saw the introduction of several sustainability initiatives, including a 400kW solar PV array, a centralised energy plant (CEP), rainwater harvesting and extensive CO_2 monitoring.

The architectural design also makes use of extensive natural daylighting to illuminate the building's perimeter spaces, including pre-function areas.

LESSONS FROM THE CONTRACTOR

Shane Durkin, M.AIRAH, A.G. Coombs' design manager, shares three key lessons from the ICC Sydney redevelopment.

- Validate and review solutions before implementing them. Use prototypes where possible and seek advice. This provides confidence in delivery.
- Collaboration gets the best results. A.G. Coombs partnered with AECOM from bid phase to completion to ensure the design intent was communicated at all stages.
- Unique buildings will be more challenging. A lot of problem-solving was required by the project team to overcome these challenges. You need to plan for this.

Re-use of the existing carpark and link building structure minimised the use of raw materials.

A CENTRAL PLANT

An important first step for the design team was to establish just how much, if any, of the existing mechanical systems could be re-used.

Dagher says the initial focus was on key central plant equipment, leading to surveys and inspections of equipment being carried out. Maintenance records were also reviewed to establish the suitability of existing equipment for ongoing service.

Decisions were made and design concepts pursued based on life-cycle analysis, which considered initial and operating costs, maintainability, environmental impact and reliability.

The retention and expansion of the existing seawater heat rejection system was also analysed and compared to its decommissioning and provision of new cooling towers to heat rejection.

"While these issues were being addressed, there was also the immediate need to establish plant spatials to guide the architect in the general design and layout of the buildings," Dagher says.

It was at this time that an assessment of a central thermal energy plant versus localised plant was made.

According to A.G. Coombs' design manager Shane Durkin, M.AIRAH, the central plant solution offered a number of benefits. These included piping efficiency, more flexibility for plant selection and optimisation, and better accessibility and maintainability from having equipment being housed in one location.

The facility's projected use and population scenarios were also analysed extensively to guide the sizing of the plant.

"A precinct peak day was determined to size the plant, and a yearly profile was determined to assess the most efficient arrangement of plant," says Durkin.

The central plant systems have been designed to provide inherent flexibility and redundancy through the installation of multiple chillers, pumps and cooling towers.

"These systems have all been designed to provide a level of availability that will not affect facility operations during planned maintenance or single-point failure of individual plant items," Durkin says.

The chilled water (CHW) plant consists of six high-efficiency centrifugal water-cooled chillers, with a total installed capacity of 22MWr. They are configured in a series counter-flow arrangement, with a variable-speed primary pumping system to support the wide range of load conditions.

Heat rejection from all cooling systems was determined to be best achieved by 12 cooling towers, which have an installed capacity of 25MW, configured in parallel. They deliver condenser water to the chillers, as well as the heat exchangers serving refrigeration plant for kitchen and hospitality services.

As the overall annual heating demand at ICC Sydney was considered to be minimal, and the load significantly lower than the cooling demand, a decision was made to localise heating plant.

Systems have been designed to provide a level of availability that will not affect facility operations during maintenance.

"The added cost of a centralised hot water distribution network outweighed the benefits associated with centralised hot water generators," says Dagher.

A total of six large, hot water generators with a total capacity of 10,650kW have been installed.

ACROSS THE SITE

A total of 210 separate air-handling units (AHUs) and fan-coil units (FCUs) have been installed across the ICC Sydney buildings.

"In most cases, the air-handling systems provide inherent reliability, with multiple fans operating to maintain system capacity," says Durkin.

He says EC (electronically commutated) fans were introduced in the high-capacity air- handling systems, because they are energy-efficient, quiet, compact, and are typically in a multiple-fan arrangement to support fan redundancy.

"Extensive coordination was required to get the optimum operation from the EC fans," Durkin says, "starting with the AHU supplier [through] to the electrical and controls installation, and the commissioning team."

The adoption of underfloor displacement systems for ICC Sydney's three theatres was assessed against overhead supply systems, with the former determined to provide superior comfort conditions that better met the iNSW criteria.

Design conditions required the space to be maintained at around 22°C while achieving the required thermal comfort of 10 per cent PPD (predicted percentage of dissatisfied).

AECOM conducted CFD (computational fluid dynamics) analysis to prove the displacement solution proposed would meet the required thermal comfort criteria.

BUILDING INFORMATION MODELLING (BIM)

A.G. Coombs used its building information modelling (BIM) capabilities to complete the design and support the construction of the mechanical and HVAC systems across ICC Sydney's three buildings.

According to Andy Robinson, A.G. Coombs' project leader, BIM was essential for developing, coordinating and communicating the design.

"All members of the project embraced the technology to deliver the project," Robinson says.

"The existing structure was accommodated in the model and evolved as the project progressed to integrate with the new."

ICC SYDNEY AT A GLANCE

The personnel

- **Architect:** Hassell + Populous
- **Builder:** Lendlease
- **Client:** NSW Government (iNSW) and Darling Harbour Live (PPP)
- **Mechanical services consultant:** AECOM
- **Mechanical services contractor:** A.G. Coombs

HVAC equipment

- **AHUs:** GJ Walker; Johnson Controls: (York Paragon)
- **BMS:** Johnson Controls
- **Boilers:** Simons
- **Chillers:** Johnson Controls – York
- **Cooling towers:** Evapco
- **Diffusers:** Krantz
- **Duct:** Kavanagh Industries
- **Fabric duct:** Klimagiel
- **Duct-mounted heating coils:** Coils Australia
- **EC fans:** EBM Papst
- **Fans:** Fantech
- **FCUs:** Temperzone/Sabiana
- **Grilles:** Air Grilles + Airfoil
- **Heat exchangers:** Alfa Laval
- **Pumps:** KSB Ajax
- **VAV terminals:** Celmec
- **Pressurisation units:** Automatic Heating

This also optimised the selection, placement and duty of displacement outlets.

"The airflow requirements varied between the low-tier and high-tier seating due to the stack effect and buoyancy associated with high ceilings," says Dagher.

The main theatre also presented the added complication of a retractable seating zone near the stage, where the population density varied depending on the function being held. For that zone, an overhead-supply-air system was determined to be more appropriate, because it provided the operator with the flexibility to reconfigure the space without being restricted by the air-distribution system.

AECOM and A.G. Coombs worked closely with suppliers to select the appropriate air diffusers for the theatres, with A.G. Coombs conducting offsite prototyping.

LESSONS FROM THE CONSULTANT

Michael Dagher, M.AIRAH, AECOM technical director – buildings, shares three key lessons from the ICC Sydney redevelopment.

- The importance of collaboration between team members, drawing on their strengths and making informed decisions quickly is key.
- Understand the requirements of not just the end client (iNSW), but also the events manager and operator (AEG Ogden) and facilities manager (Spotless). Regular meetings were conducted with all the key stakeholders, even from bid phase.
- Do the research and set realistic targets, ensuring the design is not over-complicated. Think about the operator – keeping the design simple and reliable – while still meeting environmental and financial targets.

"We tested the underfloor diffusion with the proposed seating arrangement based on locations coordinated with the structure," says Durkin. "This validated that the diffusers and their location would meet thermal comfort criteria before installation commenced."

Heat pipe technology was also used in the air-handling systems serving the theatre displacement systems to minimise the reheat required for the dehumidification process.

Durkin says the passive heat pipe system pre-cools air before it enters the cooling

The chilled-water plant consists of six high-efficiency centrifugal water-cooled chillers.

coil. Once cooled and dehumidified, energy absorbed by the heat pipe is used to reheat the air to a suitable supply temperature.

"The heat pipes were pre-engineered and fitted into the AHUs in the factory," he says, "with minimal site intervention required."

Although the ballroom had the same thermal comfort criteria as the theatres, the flexible layout of the ballroom (which can be partitioned into three smaller rooms) presented its own challenges.

To overcome this, an overhead distribution system was selected. The ductwork distribution and air-handling arrangement was coordinated to achieve the required flexible layout requirements.

A diffusing concept hidden from view avoided any impact on a series of folded panels, while meeting the stringent thermal comfort criteria.

AT HEIGHT

The ICC Sydney exhibition hall is designed to operate as one large open space or as multiple, smaller halls. The use of exposed, large-diameter fabric ducting coupled with self-adjusting radial diffusers was therefore preferred.

According to A.G. Coombs project leader Andy Robinson, fabric duct was selected for its light weight, lower embodied energy, and a more aesthetically pleasing finish.

"The radial diffusers are 1300mm in diameter, and the self-adjusting mechanism maintains thermal comfort in the halls for both cooling and heating by changing the airflow pattern," Robinson says.

"CFD analysis was also used to validate the diffuser performance for thermal comfort in the halls. It was also used to optimise the perforations in the fabric duct to minimise fan energy while achieving the correct thermal performance."

With so much of the mechanical services installation and commissioning work required to be carried out at significant height, A.G. Coombs devised a number of safe-working-at-height solutions, including prefabrication wherever possible.

These solutions met the requirements of the construction manager's stringent safety requirements. They also complied with A.G. Coombs' AS/NZS4801 and SafetyMAP Advanced certified safety management system.

The central plant solution offered better piping efficiency, more flexibility for plant selection and optimisation, and better accessibility and maintainability.

> The key to the satisfactory completion of the project was the early identification of the resources required to complete all the commissioning on time

"Where air diffusion was at high level, air-balancing time was minimised at height with pre-engineered solutions," says Robinson.

ENERGY EFFICIENCY MEASURES

Energy efficiency measures include the series counterflow configuration on the chillers, variable primary chilled water flow (with booster pumps), elevated chilled water temperature split (15.5°C/5.5°C) and low-velocity, low-pressure water distribution networks.

"As the site cooling loads are determined by the number of scheduled concurrent events, population and ambient conditions," says AECOM's Michael Dagher, M.AIRAH, "modelling indicated that the high efficiency part-load chillers would operate most extensively."

The commissioning and delivery of three buildings simultaneously, with a variety of different systems, also presented a major challenge.

Robinson says the key to the satisfactory completion of the project was the early identification of the resources required to complete all the commissioning on time.

"The commissioning process was thorough," he says, "and covered a large number of systems in a short period of time."

Technical completion was achieved on September 19 last year. This was followed by a three-month operational readiness period, which provided the opportunity to review and tweak systems before the official public opening in December 2016.

A tuning program remains in place at ICC Sydney to further improve the operation of all the systems.