Fabricating the future

The use of prefabrication and modular building techniques in the HVAC industry is growing, and for good reason. As well as leading to more accurate assembly, the process typically reduces costs and risk. **Sean McGowan** spoke to some leading proponents about the planning behind this evolving process.

Though slower to adopt prefabricated building techniques than our international counterparts in North America, Europe and Asia, the Australian construction industry is now making rapid ground.

On the back of the wider application of building information modelling (BIM) and 3D modelling, and a push for construction cost efficiencies, prefabrication of multiple services is finding its way into many types of projects – from commercial office buildings and residential accommodation to data centres and healthcare facilities.

For instance, projects such as the Queensland Children’s Hospital energy plant (as featured in Ecolibrium, October 2013) demonstrate advantages such as leaner construction timeframes, reduced waste, quality improvements and significantly lower safety risks.

But if you thought the alternative to traditional “stick build” methods is easy to implement, think again. As our three proponents of prefabricated and modular building techniques explain, the devil is in the detail.

We spoke to AE Smith national BIM operations manager Mark Jacobson, M.AIRAH, Warwick Stannus, M.AIRAH, group engineering manager for A.G. Coombs; and Nick Stavroulakis, M.AIRAH, mechanical project engineer, associate for Wood & Grieve Engineers.

Ecolibrium: Is the use of prefabrication in Australia becoming more common, and why?

WS: The use of prefabrication in Australia is continuing to grow; however, we still have some way to go to catch up to the levels of adoption seen in North America and the UK. Notwithstanding the relatively slow take-up to date, offsite fabrication is starting to play a major role in the delivery of healthcare projects around the country.

While there is no doubt that the percentage of work completed offsite will continue to increase as the industry seeks to lower costs and de-risk projects, it is likely that the Australian construction
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The sector will combine best practices from both the US and UK to develop its own unique approach to offsite fabrication.

MJ: It is very dependant on the design consideration given to the application of modularisation. This approach is becoming more the mainstay as designs evolve and services contractors work towards a more collaborative construction environment, and reap the benefit due to improvements in productivity.

The greatest advantages can be obtained where spaces contain multiple services within common areas and plant rooms, but in truth, it is only limited to the designers imagination.

NS: Another area is modular construction, which is prefabrication on a larger scale where we are constructing modules or building blocks that can be transported on a semi-trailer, train or ship to site. Typically two to three modules are combined to create an apartment or similar, which have almost all the internal fittings and finishings completed and are virtually ready to move into once the connections between modules and to the site are made.

Ecolibrium: How long has your firm used prefabrication?

NS: Wood & Grieve have been involved with partial prefabrication of some components for as long as I can remember.

We’ve been involved in the modular construction industry since 2010 and have delivered several large projects, the vast majority of which have been with our modular partner Hickory Building Systems. These include a six-storey residential building of 77 apartments in South Hedland, WA, and The Schaller Studio at the Bendigo Hospital, which features 66 hotel rooms over four storeys. The hotel component was installed onsite in just six days.

WS: The development of our modern prefabrication capability is closely aligned with our investment in BIM as our design and construction platform.

While there has been some element of offsite prefabrication in A.G. Coombs projects for many years, all our major projects in the last four or five years have incorporated significant offsite fabrication components including plant room modules, risers, services racks and sub-assemblies. Our large, dedicated offsite fabrication facility has now been operating for some five years and combines specialist pre-fabrication design expertise with flexible and adaptable manufacturing processes.

MJ: AE Smith utilise prefabrication to streamline the quality and delivery of multiple services within buildings such as hospitals, high-rise buildings, education buildings, research facilities and data centres.

This approach allows for parallel manufacturing techniques, and has the added benefit of precommissioning and in some cases, commissioning of skid-mounted equipment sets. The earliest modularisation system employed by AE Smith was on the Woodford
Correctional Centre in 1996, where the entire roof structure including services was prefabricated separately to the core building.

Ecolibrium: What are the key benefits and advantages of prefabrication?
WS: Offsite prefabrication helps reduce construction programs that can deliver significant project savings. Overseas data indicates offsite fabrication can lead to direct cost savings in the order of 10 to 15 per cent when executed effectively. In some instances, the labour savings can be dramatic – cutting the installation time by as much as 50 to 60 per cent – however, this must be offset against additional costs involved in framing, etc.

In today’s market, it is just as important for us to be able to de-risk projects by completing more of the work in a controlled environment offsite.

MJ: The commissioning activity can also occur as a concurrent process, allowing the early identification of potential performance and quality assurance issues. As these issues are identified in a controlled workshop environment, corrective actions can occur with little impact on the critical path of the construction program in a safe work environment.

NS: In my mind, the biggest advantage is safety. Even with recent improvements in site safety, conventional construction is still a risky business, and anything we can do to make it safer is worthwhile.

Ecolibrium: Does prefabrication lead to improved quality and accuracy of work?
NS: For the contractors it’s easier and more comfortable to build this way, so work quality is better.
WS: Accuracy is a key benefit as well as being an issue that needs to be carefully managed. Prefabrication tends to be built to manufacturing tolerances. With work completed on site, there is always a degree of site measure and problem solving that necessitates an as-built validation process. With the use of prefabrication and site lay-out tools such as Trimble, this time-consuming process is significantly reduced.

MJ: Due to the controlled environment, the prefabricated product is typically far superior to the site-built equivalent. Sub-components can be manufactured within the workshop by utilising construction jigs that ensure each and every component is millimetre-perfect, thus significantly reducing the need for site-measured components.

Ecolibrium: What are the downsides and issues for consideration?
WS: Due to size and weight constraints, compromises in offsite fabricated plantroom modules can occur with regard to plant access and maintenance provisions.

Without coordination, you will end up reworking entire modules, which is a very expensive site activity.

While prefabrication and modular construction will not eliminate all safety risks, by prefabricating in a controlled environment, risks such as manual handling are reduced by providing good lifting equipment, and falls from heights can be substantially reduced by having safe work platforms.
Off-site prefabrication is on the rise. Image: AE Smith.

It’s important that detailed safety in design reviews be completed – this can be completed more effectively in the 3D modelling environment. In some instances we have also used 3D printing to assist clients understand the design from a maintenance access perspective.

Construction tolerances and site layout are also critical if prefabrication is to be successfully utilised.

MJ: If the design does not contain the approach for prefabrication, it becomes quite difficult to retrofit this idea once the structural design has been finalised and the construction methodology has been defined.

The lifting capacity of the crane is also important, and consideration must be given to the size of the site module set-down areas.

WS: Prefabrication can also lead to more complex critical paths, and it is not unusual for prefabricated components such as riser modules to appear on the critical path, either on the core construction program and/or floor fit-out program.

NS: Due to the speed of construction, there is less time to respond to issues, so things can get quite hectic for the designers and constructors.

Fire ratings can also be more complicated, as the BCA wasn’t written with modular construction in mind. We have overcome this through close collaboration with our fire engineering team, the contractors and the manufacturers of passive fire-control systems.

Off-site prefabrication is on the rise. Image: AE Smith.

The greatest advantages can be obtained where spaces contain multiple services within common areas and plant rooms, but in truth, it is only limited to the designers imagination.

Ecolibrium: Concerning HVAC plant, what are the areas where offsite fabrication is unable to replace work done onsite?
NS: Onsite fabrication will always be required. In the modular situation, there are always site connections – connections between modules and large items of plant that need to be installed on site. These can be quite challenging, but we are always coming up with better ways to do them.
It really is a matter of identifying what is better to prefabricate and what is better to be done onsite.

NS: The extent to which we use offsite fabrication continues to increase. However, site-installation practices are also improving through use of recently introduced technologies such as point layout systems and copper press fittings that both support as well as off-set the potential benefits that can be gained through the use of prefabrication.

Prefabricated risers can have a significant impact on the structural design of the shafts, and hence if prefabrication is to be utilised it is always preferable to have the shafts designed to accommodate a prefabricated system from the outset.

MJ: The amount of site work required will depend on how well the design integrates with the finishes of all services. In the US I have seen a foyer module that included the bulkhead wall with the jet diffusers already fitted – and the only work left to be completed was the setting, sanding and painting of the wall.
Typically in Australia, the prefabrication process focuses on the bones of a system, with the fit-off being the final site-construction phase.

**Ecolibrium:** Does this technique place greater importance on the accuracy of all trades on site?

**MJ:** Very much so. Without coordination, you will end up reworking entire modules, which is a very expensive site activity. The earlier the involvement by all trades, the easier the process becomes.

**WS:** Accuracy is critical. Central to prefabrication is the virtual build process, and this must then be accurately replicated onsite. It is very difficult to modify prefabricated assemblies once manufactured and delivered to site; therefore, strict adherence to construction tolerances must be achieved in all areas of construction.

**NS:** There is no point prefabricating offsite only to bring equipment onto site and have to pull it apart and modify it because it doesn’t fit onsite. This applies to all trades.

**Ecolibrium:** How is the use of BIM related to prefabrication?

**WS:** Building information modelling (BIM) is the key to offsite fabrication, as without coordination certainty the additional investments needed in offsite fabrication design, framing and logistics can be easily wasted.

For our PPP (public-private partnership) projects, and where we are appointed to the project team early, we often provide prefabrication models to the design team to allow them to utilise the frames within their design documentation. We also work closely with the architects.
and structural engineers to assure that prefabrication modules are efficiently accommodated within the design.

MJ: BIM or at least 3D modelling is critical. It allows us to design to a higher level of accuracy, and to coordinate better between trades and structure than we can with 2D CAD.

When designing, not only do we need to think about the final installation, but how the components can be broken down into modules or assemblies, how to transport them to site and get them into place, how the connections work and then finally what the final solution will look like and how it will work.

NS: By using an information-rich model, the design process will progressively evolve to align with the special and performance requirements of the project. As already mentioned, the earlier prefabrication is incorporated with the building’s design, the greater the benefits to the delivery and operation of the building.

Ecolibrium: Is offsite fabrication possible where BIM is not applied? What are the minimum requirements around modelling and virtual build?

MJ: You can produce fully coordinated prefabricated modules by using the “B” and “M” of BIM. This has been the approach by the majority of the industry’s contractors for many years. When the information component is included within the model, design alternatives can be quickly appraised for suitability. This approach leads to a superior design than just a 3D-coordinated drawing.

NS: Smaller assemblies can definitely be documented in 2D; however, we have found that these require more physical prototyping. When we have 3D modelling available a lot of this prototyping can be done in the model.

Modelling time is much cheaper than materials and site labour, so the better we can prototype in the model, the more we save in real life.

WS: Prefabrication works best when the design process fully incorporates prefabrication strategies from the start, rather than as a value-engineering proposal during tendering and/or construction.

Ecolibrium: What are the planning implications and workflows of prefabrication?

NS: When we design modular, we are often designing multiple streams in tandem. For example, we may be designing site infrastructure and negotiating with authorities and at the same time working with the contractors to finalise our module design, inspecting prototypes and finishing modules before any works on site have commenced. As the timeframes can be shortened so dramatically, this can be challenging for all. However, when you can see construction times, such as The Schaller Studio, where 66 hotel rooms were installed over four levels in just six days, the challenge is worth it.

WS: Prefabrication works best when the design process fully incorporates prefabrication strategies from the start, revealing the benefits of the technology and allowing the contractor to deliver. Although clearly it is better if everyone is fully engaged in the virtual build process.

Need to know

Warwick Stannus will be part of a panel session to discuss BIM at ARBS.
We have developed detailed BIM and prefabrication design management plans that allow us to work with design teams to facilitate the integration of multiple services onto prefabricated horizontal frames and risers. This extends to prefabrication design development, structural analysis and approvals.

While one of the key benefits of offsite prefabrication is that manufacture can occur in parallel with the structure on site, to enable this to happen it is critical that the design be completed ahead of the site structure. Prefab fixings tend to carry significantly more weight than traditional hangers and it is therefore highly preferable to locate the fixings before the slab pours as well as ensure pipework anchors are cast into shaft walls where required.

MJ: We work closely with the structural and services design team from the design inception to ensure the project can support prefabrication. This design team, which now includes the mechanical contractor, allows the prefabrication design to be appraised at a much earlier stage of the project’s life.

One of the major benefits of this is a reduction in the design timeframe, thus allowing for a faster transition into the construction phase.

Ecolibrium: What impact does prefabrication have on employment numbers? Do the higher efficiencies lead to a smaller workforce?

MJ: There will be a shift from site to factory, but the fit-off works will still require a substantial workforce. With the improvement in productivity, the ability to carry out more work with the same staff numbers will only reinforce the benefits of prefabrication.

WS: Clearly, increased use of prefabrication is reducing the amount of labour required on site; however, our approach to prefabrication aims to utilise our skilled tradespeople either on site or in the prefabrication facility, depending on the project work profile.

NS: There is a shift in skills and types of work but we don’t see a great reduction in the number of workers. But we do see them being much more efficient with their time. On a conventional building, the amount of time wasted in simply getting up, down and around a high rise construction site is a huge portion of the overall time.
Ecolibrium: What is the future of prefabrication for our industry? Where might it lead to?

NS: It has a bright future in Australia – it will make construction safer, less wasteful, more efficient in materials, cost and time. As we continue to innovate, we can remain competitive on a global scale and export this technology overseas as well as into new markets.

WS: There can be little doubt that an increasing amount of project work will be completed offsite in prefabrication facilities, following the UK and US trend. Use of offsite modular construction will also increase.

Based on experience, we believe that prefabrication will continue to play a major role in all our projects moving forward, and will work hand-in-hand with our use of BIM and innovative site-installation practices.

MJ: We only have to look at what is being achieved overseas. In Asia, most of the modules are on a grand scale and include all items in a finished state. This approach further accelerates the fit-out of the building services to a point where the construction of the building becomes the main bottleneck.

I see that as the Australian construction industry becomes more collaborative, the more we will embrace this form of construction. The design process needs to start with this construction method to realise the major benefits that can be leveraged from this approach.

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<th>FLAGSHIP PROJECTS UTILISING PREFABRICATION</th>
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Pre-fab may cause a shift in skills, types of work, and where that work is carried out. Image: AE Smith.

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National BIM operations manager  
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Mechanical project engineer; associate  
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Australia’s ONLY international Air Conditioning, Refrigeration and Building Services trade exhibition is returning to Melbourne in 2014. Registrations are now open for the ARBS 2014 seminar program. From breakfast panel discussions to “just the facts” information sessions, there are more than 20 opportunities for your continued professional development, information and networking. See the full program or register NOW at www.arbs.com.au
The installation of Australia’s largest prefabricated multi-services risers was completed in record time by A.G. Coombs at a large project in Melbourne last year.

Measuring 18m wide, 3m deep and 10 storeys high, the complex prefabricated services riser was installed over a four-day period. Full onsite installation of this riser would have normally extended to several months.

Manufactured in eighteen three-storey-high interlinking sections each weighing up to 3.5 tonnes, the riser was transported by road from A.G. Coombs’ large dedicated off-site prefabrication facility in Moorabbin, and crane-lifted into place on site.

The multi-services riser was manufactured and installed as part of A.G. Coombs’ role as specialist design and construct mechanical and HVAC contractor on the project.

"Incorporating air conditioning and complex exhaust ductwork, including specialist PC4 exhaust systems natural gas and other building services, the risers were designed by A.G. Coombs using 3D CAD and BIM software to benefit from advanced prefabrication methodologies," says A.G. Coombs strategic development director Bryon Price, M.AIRAH.

“A.G. Coombs prefabricates integrated multi-services risers and runs, plant assemblies and other building services system components to exacting standards to ensure quality and accuracy, leading to ease of manufacture, installation and commissioning."