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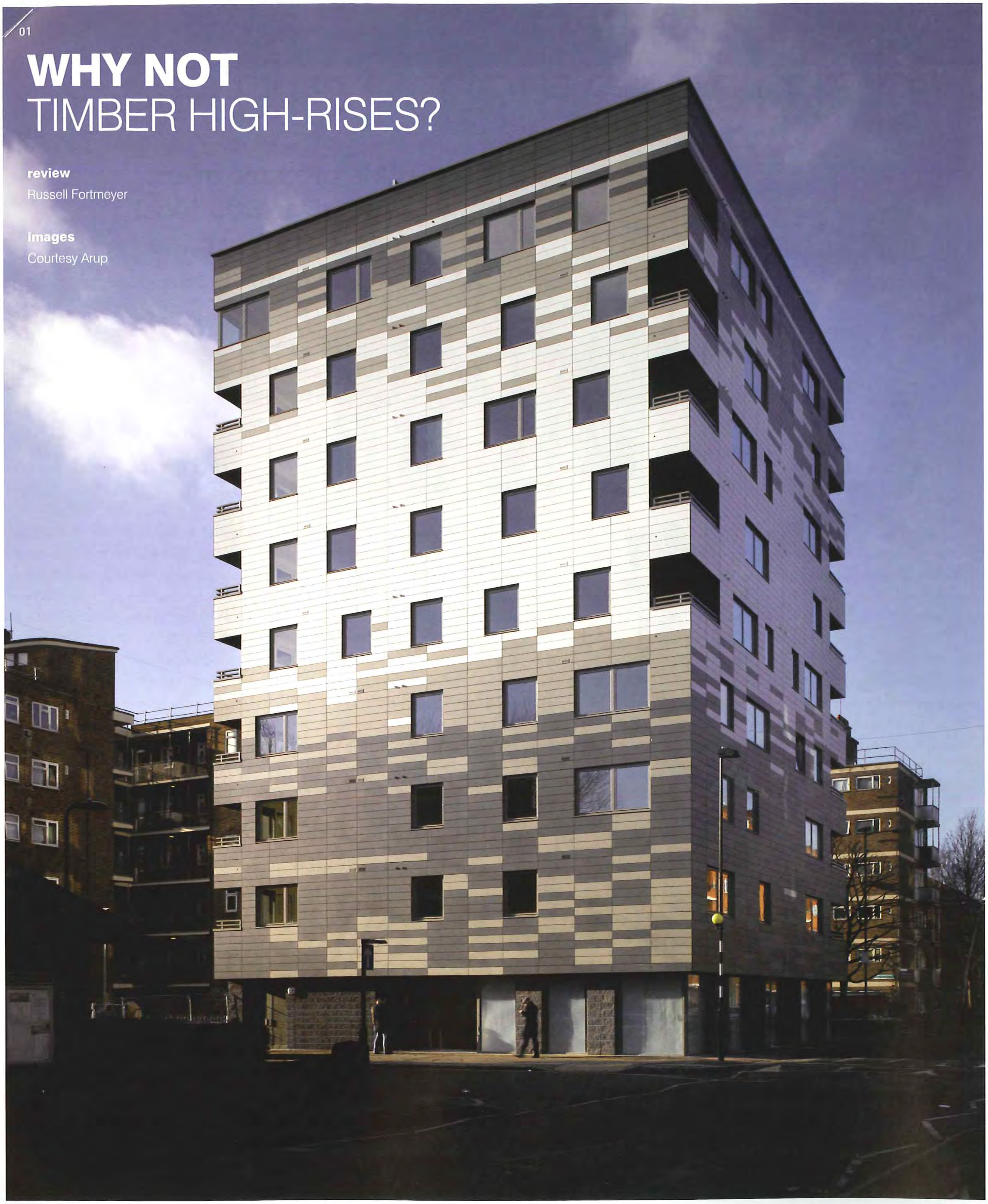
WHY NOT TIMBER HIGH-RISES?

review
Russell Fortmeyer

images
Courtesy Arup



In its simplest form, engineering is a myth-busting exercise. As **Russell Fortmeyer** describes, the elusive timber high-rise may be one of its greatest challenges and one particularly suited to the Australian temperament.

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The recycled-timber panels on the exterior of the London's Murray Grove residential building respond to sunlight and shading patterns in the surrounding neighbourhood.
Photo: Will Pryce

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Before being encased in plasterboard, the glued cross-laminated timber panels used for Murray Grove exude their own material purity and elegance.
Photo: Will Pryce

IN MILTON KEYNES, about 90 kilometres north-west of London, the architect firm Rogers Stirk Harbour and Partners (RSHP) has designed a prefabricated timber housing estate (called Oxley Woods) it believes could transform construction. Each of the estate's 145 homes were built in five days off-site in factory-controlled conditions using precision-cut sustainable timber, shipped to site and then constructed on poured slabs in what amounted to about 24 hours.

If you don't believe this, you can see a condensed film of the site process on the RSHP website (*www.richardrogers.co.uk/press/news/oxley_woods_video*). Ivan Harbour, a senior director at RSHP in London and no stranger to Sydney's design scene (as the RSHP director primarily responsible for the Barangaroo master plan), says the project was motivated primarily by health and safety issues, as limited construction time on-site reduces risk. "The purpose is speed and flexibility to manufacture anywhere, since it requires a low skill base," says Harbour.

RSHP developed the Oxley Woods model (a single-family home of closed timber panels, filled with insulation, waterproofed and used as load-bearing walls clad in a rain screen of sleek Trespa panels, priced at £60,000 or about $110,000) with UK developer George Wimpey and manufacturer Wood Newton. It just so happens the project's knock-on effects include high energy efficiency and sustainable performance (thanks mostly to the low embodied energy of the oriented strand board for the panels and the elimination of waste), so much so that RSHP has used Oxley Woods as a platform to investigate using the system on other building types. Harbour thinks there's no reason the approach could not be used in high-rise commercial construction in Australia and he's determined to prove it.

So, why not timber high-rises? We can call up any number of disproving responses to that question, like durability, strength, uniformity, supply, cost, risk, history, modernism, infestation, rot, aesthetics and, the granddaddy of them all, fire. Yet, each one of these concerns can be effectively addressed through design, except perhaps for history, which must be dealt with through cultural means. Although no one living today witnessed the great fires that levelled London in 1666 and Chicago in 1871, or watched Sherman burn Atlanta, the fallout from those historical facts are embedded in our modern building codes and industry best practices. Steel and concrete are so ubiquitous and seem to solve so many problems that we have stopped questioning their use. We cling to the myth that timber construction presents risks, while concrete and steel do not. Nonsense. Every material presents risks, but we manage them in different ways.

RSHP is proposing timber structures for the Bridport Place Hackney residential development in London, which consists of six- and eight-storey buildings. Hackney could be viewed as an extrapolation of Oxley – the same components, arrayed at a larger scale and set within a discrete frame. To cross-brace the delicate-looking timber structure, the architects have added steel diagonal elements that are expressed at times and concealed behind timber façade elements at others. If we are serious about building taller in timber, we can skirt many of the issues that make engineers squirm by considering such a hybrid structure. In tall buildings, timber enables us to reduce our dependency on the high-energy, high-carbon materials of concrete and steel, rather than completely eliminate it.

If you've pondered the feasibility of timber high-rises at all in the last few years, you would certainly know the Murray Grove project in London by Waugh Thistleton Architects and Techniker engineers, which lays claim to the title of 'world's tallest modern timber residential building'. Dubious qualifiers aside, the project is an elegant nine-storey reproach to the murky concrete-and-brick slabs of London. Instead, Murray Grove consists of glued cross-laminated timber panels for floors and load-bearing internal and external walls. The panels, manufactured in Austria by KLH, structurally suit the cellular quality of residential floor plans and can be easily clad, as they are at Murray Grove, with plasterboard and topping slabs. Residents wouldn't even necessarily know they lived in a timber building.

Perhaps more strikingly, Murray Grove represents an innovative approach to London's 10 percent carbon emissions reduction plan. Waugh Thistleton estimates the project saves 306,150 kilograms of carbon in construction (compared to steel and concrete equivalents), with an additional 181,360 kilograms of carbon already captured by the trees used for the timber panels. With 29 apartments, that's roughly 16,810 kilograms of carbon per unit sequestered in the building. As a rough estimate, to offset an equivalent


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Rhomberg has developed the LCA Tower to use pre-fabricated timber façade units that could be easily hung on the structure to significantly reduce construction time.
Courtesy: Rhomberg Bau

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Incorporating a high level of systems integration, the LCA Tower achieves the commercial requirements of the open floor plan that can respond to specific tenant needs.
Courtesy: Rhomberg Bau

amount over the 30-year span needed to regrow the trees, you'd need to drop two 300-watt solar photovoltaic panels on your roof.

Instead of forcing the installation of something like PVs to reduce emissions by 10 percent, however, the local council conceded the emissions reduction of the building process satisfied the intent of the regulation. This may be a first for sustainable design and suggests the potential for life cycle assessments (LCA) of embodied energy (still a nascent field in our business) to radically alter the way we report sustainability performance.

Which is not to say timber is a sure bet. To make the case for timber high-rises on sustainable grounds, we need consensus-based industry standards for calculating embodied energy, carbon, carbon dioxide or emissions of materials in a standard LCA process. Currently, no national body can provide reliable and reasonably accurate information for the embodied energy of materials, which is always a moving target anyway and needs consistent revision owing to a complicated construction supply chain. The UK's Building Research Establishment (BRE) has relatively good information that can be used for comparison, but exact numbers would be difficult to justify. Anyone making claims to the contrary should be viewed with scepticism, but there is a growing body of research that suggests we should focus more attention on timber.

A University of Sydney and Deakin University study from 2002, based on previous Swedish research methodologies, found for a sample building that using timber instead of concrete could result in a 20 percent reduction in embodied energy. That same research found that many LCA approaches were underestimating emissions by a factor of two, owing mostly to the limits of analysis when the supply chain under consideration (in LCA speak, your 'system boundary') is so large and complicated as to be unwieldy. Thus, accuracy in numbers is relative and establishing orders of magnitude for comparison is probably the best we can do for now. Another study, also from 2002, concluded manufacturing glued laminated beams produces approximately 20 percent of the carbon emissions of manufacturing steel beams. I could cite many more such studies.

Embodied energy is only part of the story, anyway, since we will need to ensure our timber sources are part of an ecologically responsible industry process. In that respect, some countries are better than others. RSHP's Oxley Woods project consists entirely of Forest Stewardship Council (FSC) certified timber from Finland, ground up and bonded by resin and wax. Many designers interested in sustainability express concern that by using engineered wood, such as glulam beams, that rely on resins and other bonding agents that can sometimes be toxic, we can be substituting one environmental issue for another. These products can off-gas and affect indoor air quality, as well as contribute to environmental degradation in their manufacture and disposal, but there are many formaldehyde-free wood products available now and there's no reason these concerns cannot be managed and mitigated.

Largely viewed as the most respected international sustainable timber organisation, FSC oversees a voluntary, independently-operated sustainable forestry certification process that is one of the more comprehensive supply chain ratings in the world. The standards that constitute the FSC process touch on everything from the social and political states of the local community to how finished timber products arrive and are installed on-site. FSC doesn't recognise plantation timber grown on land that was previously old-growth forest, therefore most of Tasmania would be ineligible for the certification. There are different schools of thought on this issue within the sustainable design community, since such a narrow reading of sustainability in regards to Tasmania suggests a fairly bleak outlook toward future developments in ecological practices. Also, growing evidence suggests that old-growth forests significantly slow their uptake of carbon, particularly after 30 years. According to an Australian Greenhouse Office study in 2001, Australian forest plantations are likely to sequester between one and 10 tonnes of carbon per hectare each year over a 30-year period.

Partly in response to just this issue, the Australian timber industry has developed its own approach, the Australian Forest Certification Scheme, which was recently recognised for a single point in Green Star's timber credit. At this point, however, it's unclear whether the AFCS program will mean much to a global market that will more than likely demand FSC timber in the future. A source within the Green Building Council of Australia tells me the organisation is still researching the issue of how it recognises FSC and AFCS, so it will likely change again.

Oxley Woods and Murray Grove illustrate the primary benefits of timber structures (reduced construction time and sustainable performance) giving us the impetus to investigate the primary technological challenges that remain: structural capacity and fire resistance. "We should use materials where they are most advantageous," says Andrew Johnson, a structural engineer and a colleague of mine in Arup's Sydney office. "We could use timber for compression, flexural and diaphragm elements like columns, beams, flooring and shear panels, and then use steel for tension elements, such as bracing. That's where I think we should be aiming." Arup has a working group of structural and fire engineers in the office investigating timber structures for various projects.

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The consensus of this group currently rests on two systems – steel columns with 'limbs' supporting timber joist floor panels and timber façade elements or a primarily concrete structure and core with timber structures filling in three- to four-storey 'fire compartments'. Like any engineered solution, there are variations, but either system could potentially result in substituting timber for nearly 70 percent or more of a building's structure. The steel-timber hybrid can ensure an 8.4-metre grid, which is commercially viable. Concerns like footfall noise between floors can be mitigated effectively with drop ceilings and carpet or topping slabs. More promising, the concrete-timber hybrid could bring increased flexibility to our buildings. The concrete super-structure could last 100 years or more, while the timber infill could be rearranged every 30 years as needed. If the timber components were prefabricated modular units, such replacement could be done over a weekend.

The steel-timber hybrid does present a fire issue, however, since you would end up with a void in the timber joist floor. Voids typically gather detritus over the years, offering a perfect fuel source for fires. Felix Gamon, a fire engineer in Arup's Sydney office and part of the timber working group, says any void over 200 millimetres could potentially require sprinklers. That may present a costly headache. The two big fire issues for timber are the surface spread of the flame and the fire resistance of the timber. The former can be addressed with retardants. The latter mainly concerns char, which is the amount of timber that burns off a wood member in a fire before insulating the core. High char rates do not bode well for timber buildings (since this can erode the strength of the overall structural system), but we have accepted analytical models for determining charring rates and can design timber members to suit. "Structural design for timber in fire is very simple," Gamon says. "But there's a difference between doing regulatory approval and fire engineering." Safely evacuating occupants before letting the floor of a building burn would satisfy regulations, but it would leave little opportunity post-fire for reclaiming the structure. The concrete-timber hybrid solution starts to answer this by compartmentalising the timber structural components.

Arup's Berlin office used concrete to address the fire problem on the Life Cycle Tower project, a speculative model for constructing 20-storey timber high-rises from prefabricated elements. Arup is collaborating with the building contractor Rhomberg Bau and timber contractor Wiehag, both in Austria. The structure combines a core of 36-centimetre-thick glued laminated timber panels with perimeter timber columns for a floor-to-floor span with a clear height of three metres. A composite slab of precast concrete and timber beams spans approximately 11.3 metres from the core to the perimeter.

Harald Professner, a project manager for Rhomberg Bau in Austria, says the project was motivated by a desire to shorten construction time and reduce ecological impact. He estimates they could build one level per day, including the façade elements. Rhomberg has proposed constructing the basement and ground level from reinforced concrete, which imparts robustness to the ground level, adds some fire protection from adjacent structures, and addresses termite concerns. The timber structure itself is sealed within the building envelope, which further protects it from weather concerns. "The lifetime of a timber house is much longer than a wood plantation, which takes 20 to 30 years to grow," Professner says, noting that 300- to 400-year-old timber structures in Austria are not uncommon.

For now, the only things holding back the Tower are codes and recessionary market forces. "In Austria, anything over 22 metres high must be constructed with non-combustible products and timber isn't it," says Professner. "Our challenge is to demonstrate our system is comparable and that we have good ideas to solve it." The recent developments in the UK have largely relied on testing undertaken by BRE, which built a six-storey, timber residential building in its testing facility in Cardington. In 1999, BRE investigated the effects of various fires on the building, finding that timber structures contribute 17 percent to the total fire load before concluding that medium-rise, timber-frame structures can meet code requirements for limiting the internal spread of fire and maintaining structural integrity. Although this has inspired the residential developments in the UK (after the usual time-consuming regulatory deliberations) it has not led to commercial timber high-rise construction.

We are stuck, it seems, weighed down with tradition. Timber could not satisfy the modernist desire for purity and hygiene, which necessitated the 'clean' white surfaces of concrete and plaster and the simplicity of steel. You can't design a tree, for the most part, and you certainly can't specify the ring patterns of wood down to the millimetre. But if we can remove the distractions (the structural issues, the questions of fire resistance, the availability of product, the code restrictions and the lack of experienced labour) we should have no reason to deny timber's place in our high-rise buildings. It has so much potential to simplify construction by eliminating pouring delays and enabling prefabrication; it's a pity it's used mostly as decoration. And if we're serious about reducing carbon emissions in the building industry, we will have to build a timber high-rise. **ar**

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