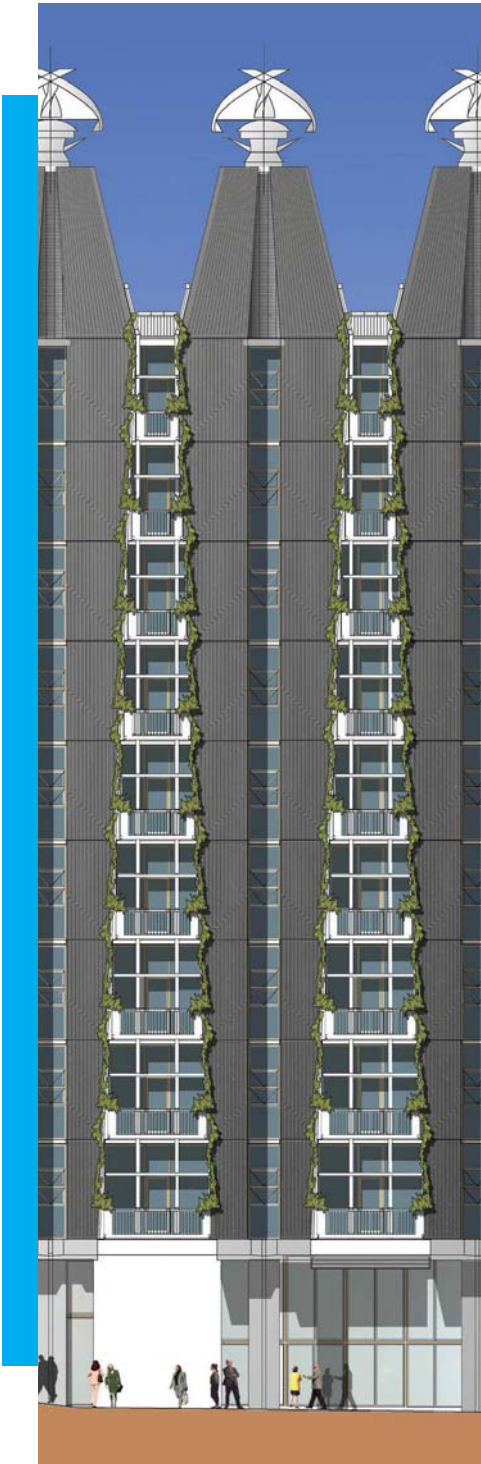


Technical Research Paper 08

The Building Structure and the Process of Building



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Disclaimer

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6 star rating



This rating represents World Leadership

CH₂

Preface

Council House 2 (CH₂) is a visionary new building that is changing forever the way Australia – indeed the world – approaches ecologically sustainable design.

With its Six Star Design Rating granted by the Green Building Council of Australia, CH₂ is one of the cleanest and greenest buildings on earth.

This paper, one in a series of 10 technical papers, investigates the design and systems of CH₂ prior to occupancy and availability of operational performance data. The papers have been written by independent authors from Australian universities, as part of the CH₂ Study and Outreach Program – a coordinated effort to consolidate the various opportunities for study, research, documentation and promotion generated by CH₂.

The aim of the CH₂ Study and Outreach Program is to raise awareness of sustainable design and technology throughout the commercial property sector and related industries.

While the pre-occupancy research papers are a valuable resource, they do have some limitations. For instance, these studies have been written before operational experience. This means the authors' views are based on existing knowledge, which can be difficult to apply when significant innovation exists.

Many of the innovations in CH₂ have been subject to limited, if any, rigorous or directly relevant research in the academic field, which is reflected in the lack of literature cited for systems such as the shower towers and phase change materials used in the cooling system.

Another major limitation is the exclusion, by academics generally, of industry experience of new technologies. The extensive knowledge gained by industry is often not well documented and can be difficult to access through traditional academic channels.

One example, where industry expertise exists, is the use of phase change materials for reducing peak cooling loads and energy use in commercial and institutional settings, such as offices, hospitals, prisons and factories.

In addition, to enable the authors to complete their task, they have based their study on CH₂ project reports prior to the design being finalised. This means some of the descriptions of systems and findings in the papers are to some extent out dated. In particular, findings related to the wind turbines and the heating, cooling and ventilation systems have changed somewhat as a result of final design decisions.

To reduce the impact of these limitations for readers, the Council has provided additional comment as footnotes in some papers.

It is important to inform readers the target audience for these papers is professionals and academics involved in the research, design, engineering, construction and delivery of high performance buildings. This helps to explain the technical detail, length and complexity of the studies.

Although these papers may be of interest to a range of audiences it's important that readers, who possess a limited knowledge of the subjects covered, obtain further information to ensure they understand the context, relevance and limitations of what they are reading.

For more information or to make comment and provide feedback, readers are invited to contact the Council. The details are available at the end of this document.

We hope you enjoy reading these technical studies and find they are a useful resource for progressing your own organisation's adoption of sustainable building principles and encouraging the development of a more sustainable built environment.

Foreword

In 2000 the City of Melbourne made the decision to embark on a revolutionary new project called Council House 2 (CH₂). The decision was due to a pressing need for office space for its administration and the desire to breathe life into an under-used section of the city.

The project gave the Council the opportunity to exercise its environmental credentials by creating a building that was at once innovative, technologically advanced, environmentally sustainable and financially responsible.

This approach allowed the Council to insulate itself against exposure to rising energy and water prices, the diminishing availability of resources and the uncertain long-term availability, while providing a healthy workplace attracting the best workforce in a labour-constrained market.

CH₂ has been designed to reflect the planet's ecology, which is an immensely complex system of interrelated components.

From the revolutionary cooling storage system in the basement to vertical gardens and wind turbines on the roof, the building has sustainable technologies integrated throughout its 10 storeys.

Although the majority of the technologies and principles adopted in the building are not new, never before in Australia have they been used in an office building in such a comprehensive and interrelated fashion.

This includes innovations such as: using thermal mass for improving comfort; phase change material to reduce peak energy demands and energy use; generating electricity onsite from natural gas; and using waste heat for cooling and heating.

Through CH₂, the Council plans to trigger a lifestyle and workstyle revolution. The building will be used as a living, breathing example, demonstrating the potential for sustainable design principles and technologies to transform the way industries approach the design, construction and philosophy of our built environment.

As with many revolutions, there are sceptics. The Council's response has been to patiently press ahead with the construction of CH₂ while actively and energetically encouraging lively debate.

Some of the papers in this pre-occupancy study and outreach series make compelling points in favour of the case for sustainable development. Others reflect a more subtle or sometimes overt scepticism that may be encountered throughout the community.

The City of Melbourne welcomes all of this debate but in the long term intends to demonstrate the effective performance of CH₂ and prove the doubters wrong. Collectively, the studies demonstrate the enormous value to be gained by researching the case for sustainable development and the scope for much more study and documentation in this field in the future.

The City of Melbourne wants CH₂ to be copied, improved on and enthusiastically taken up throughout Melbourne and far beyond.

Technical Research Paper 08

The Building Structure and the Process of Building



Introduction

This paper documents the building process of the City of Melbourne's Council House 2 (CH₂), as well as elements such as the project's major structural design, material selection, construction processes and transport issues. It examines CH₂ in relation to other Australian and overseas best practice within an ecologically sustainable design (ESD) framework. An assessment of the current state of related industries within Australia is included, and areas for improvement in meeting the needs of the expanding ESD industry are identified.

CH₂ was one of the first buildings in Australia to use the new Green Star rating system in its design process. Introduced in 2003 by the Green Building Council of Australia (GBCA), the Green Star rating system provides a systematic framework to quantify the degree to which ESD principles have been incorporated into a building design. The system helped the building contractors of CH₂ to identify and address key ESD issues in its construction, which resulted in a more pragmatic and faster decision making process.

This paper begins by discussing the key design features of the CH₂ building, followed by a description of the integrated design process and how this facilitated innovative structural and design decisions¹. There are many unusual design aspects within the CH₂ building, and so a surprising finding was that the procurement and construction process of CH₂ was relatively conventional. This contrasts with another recent green office building constructed in Melbourne, and it is argued that the Green Star rating system and specification provides builders with a more systematic basis for decision making on ESD issues.

Issues relating to construction such as the structural rationale, the materials, the procurement method and the onsite construction practices are also described in this paper. By detailing these issues, readers can compare and contrast CH₂ with their own experiences of construction. While innovative in design, the key observation is that the construction process of CH₂ follows conventional wisdom.

The Design and the Structure

Hansen Yuncken began construction of the 10-storey, \$51 million CH₂ building for the City of Melbourne in early 2004. The construction site of 1,316m² was only accessible from city laneways and Little Collins Street. The concrete structure is relatively conventional insitu construction, except for the use of precast curved concrete ceiling panels. Two rows of concrete columns are located at 8200mm centres just inside the north and south facades, with a further row of columns offset from the centre of the floor plate. The proportions of the site dictated a 'deep space' floor plate which presented design challenges in terms of lighting and ventilation. The undulating design of the ceiling has resolved difficulties arising from the 22m building depth by allowing for air distribution ducts, yet enabling a maximum ceiling height so light can penetrate deep into office spaces. Other difficulties relate to the challenge of effectively ventilating deep open office spaces, especially when considering natural ventilation for night purging. This was, however, resolved with the installation of a mechanical ventilation system using underfloor swirl diffuser inlets and ceiling mounted air extraction points to distribute air, while minimising cross-floor mixing. Car parking is provided at basement level. The car park floor is level rather than ramped to allow it to be converted to other uses in the future.

The new CH₂ building has been designed to replace the existing Council House 1 (CH1), as the costs of relocating staff from CH1 for the duration of construction led the design team to consider the adjacent, smaller site owned by the City of Melbourne, and used as a temporary car park. The decision to change the site resulted in several positive outcomes. The cost of the project was reduced by over \$13 million while still providing most of the benefits of the original plan. This created the option to renovate rather than demolish the existing CH1 building, which would mean retaining the embodied energy of the existing building. Further, the footprint of the new site allowed the long axis of the proposed building to be oriented east-west rather than north-south, which allowed greater access to northern aspects.

¹ City of Melbourne clarifying note: The building structure is about structural design and associated technical problems. The building process on the one hand is about sequence of operations, space for building, such as access and cranes etc., while the other aspect of process is the procurement process from documentation to tendering to form of contract to supervision and all the associated problems. This paper discusses aspects of these.

The Green Building Council of Australia gave the design stage of CH₂ a six-star rating. Under this new method of comparing the environmental performance of commercial properties, a six-star rating is considered as an international best practice model.

The key design features of CH₂ are listed below due to their construction implications.

100 per cent fresh air:

- Air supply to the office spaces will be 100 per cent filtered fresh air drawn from the roof level through ducts on the south side of the building and extracted via the north ducts with the help of wind turbines. In contrast, typical air conditioning systems used in office buildings recirculate 85 per cent of air already passed through the building.
- CH₂ has five towers on the south facade that shower water down to cool air and water using evaporative cooling.
- Air cooled using evaporative cooling is supplied to the retail spaces on the lower levels, while the cool water is used to assist with the process of removing heat stored in the centralised 'phase change material' (PCM) thermal storage system located in the basement.

Heating and cooling:

- Heat entering through the fabric of the building and generated by occupants, office equipment and lights is absorbed into 'chilled panels' situated in the ceiling and in front of windows. This replaces the conventional method of delivering large volumes of cooled air through big ducts. The PCM is central to this system. Chilled water is fed to the PCM holding tank heat exchanger from the shower tower, chiller and cooling tower configuration, and cools the PCM to 15°C. A separate stream of water, which travels through the chilled panels and beams to cool office spaces in the building, passes through the PCM tank so direct heat exchange with the stainless steel encased PCM spheres occurs. The circulating water is thus re-chilled by releasing heat to melt the PCM.
- Natural night purging adds to the overall cooling system for CH₂. Windows on the north and south facades automatically open at night to allow cool air in, and flush warm air out. Sensors close the windows when they detect high winds, rain or high ambient temperatures. Cold air entering at night removes heat from the thick concrete ceilings absorbed during the day.
- Warm air from convective fin heaters in the perimeter floor slab near windows help reduce heat loss through windows in winter, and primary air from the ventilation air supply system is heated to provide morning warm-up cycle. During day time operation, heat from people's bodies, lights and equipment helps maintain thermal comfort, with assistance provided as required by the primary and perimeter heating systems.

Lighting:

- The lighting strategy takes account of the building's orientation and height to maximise natural lighting and reduce glare. For example, the windows of CH₂ are larger on lower levels, as they receive less daylight than upper floors. Light shelves reflect sunlight onto ceilings, thus reducing artificial lighting requirements. Sensors will increase or decrease the amount of reflected light.
- Different shading techniques were applied to control glare within CH₂. On the north façade, a series of vertical gardens nine stories high are supported by steel trellises and balconies. The east façade incorporates perforated metal louvres, and the west façade of the building features recycled timber louvres that move with the sun.

Energy consumption:

- The cooling, heating, ventilation and lighting systems of CH₂ discussed above are largely powered using electricity generated onsite using a mix of solar, wind and gas fired co-generation power production systems. Consequently, the City of Melbourne expects to reduce its electricity consumption by 85 per cent and its gas consumption by 87 per cent compared to existing premises.

Integrated Design Teams

The conceptual design for CH₂ was developed by an integrated design team over a two-week period in January 2002. During this two-week charrette², the consultants were paid for their time in addition to their tendered and accepted fees to complete the work. The brief to charrette participants from Professor Rob Adams, Director Design and Culture, City of Melbourne, was to raise all the issues they could think of for discussion so they didn't come back months later saying that it could have 'been done better' (Hes, 2004, p24).

When the undulating ceilings featured in CH₂ were first proposed during the charrette, the Quantity Surveyor was uncertain about the cost implications. To resolve this, the structural engineer, Nat Bonacci, contacted precast concrete manufacturers and worked with them to obtain a costing. Stephen Webb, a director of the architectural firm DesignInc, described the importance of having Bonacci attend:

... I mean to have Bonacci, for instance, up front in the first few weeks actually going to the precast concreters and getting prices and advice on things that were, you know, just ideas at that stage, just totally started the whole process. I... think they had a section of the precast ceiling panels virtually drawn in the first month that we started the project, so there were some really basic decisions set up and agreements that we used to structure the building from day one that we really did sort of follow through (Hes, 2004, p22).

² The French term 'charrette' originated in the Ecole des Beaux Arts in the 19th century. Architecture and art students worked frantically in the studios to complete their work as before the cart or 'charrette' was circulated to collect the final drawings

After the charrette phase, the design of CH₂ continued to be developed by individual companies who were members of the integrated design team. The companies charged fixed fees over a 12 month period and held weekly meetings to coordinate and resolve issues.

Integrated design teams like the one established for CH₂ allow interaction and cross fertilisation of ideas before a design is finalised. Traditionally, conceptual designs are conceived by architects and developers and then passed to the structural and services engineer and builders for design detailing and construction. With green buildings, where building orientation, energy consumption, ventilation and lighting considerations drive the design, the expertise of the services engineer is needed at the conceptual stage. By contrast, in a traditional office building, the services engineer is given a final design and instructed to provide lighting, heating and cooling systems to the sealed building.

It is useful to compare the CH₂ process with two recently completed green buildings in Melbourne. Green Building Partnership (GBP), the developers of the green commercial building '60L', conducted a series of design workshops or charrettes over four months to develop the design of the building and services. They established an integrated design team with all critical players represented, including the primary tenant. Following the design workshops, 10 months were spent researching, developing and writing the specifications. GBP provided a detailed and prescriptive green specification to ensure ESD principles were explicitly incorporated in contract documents.

By contrast, the current trend is to use performance-based specifications to increase flexibility and encourage innovation in the construction phase. Design planning for the National@Docklands also involved collaboration, but over a longer timeframe. The Design Review Group (DRG) conducted weekly meetings to coordinate and resolve issues over 18 months involving 10 to 25 people. The primary groups represented at all meetings included the tenant (National Bank), the architect Bligh Voller Nield (BVN) and the Lend Lease Group. The Lend Lease Group comprised the development unit, General Property Trust as owner, Bovis Lend Lease as builder, and Lend Lease Corporate Solutions for workplace issues.

The design process of commercial buildings is complex and collaboration between a range of consultants is essential. However, intense collaboration so early in a design process as occurred in CH₂ is more unusual. The collaborative process enabled innovative decisions with a degree of certainty in terms of constructability and cost. It is surprising that most publications outlining recent international exemplars of sustainable architecture do not mention the importance of the architect working collaboratively with the client and consultants at an early design stage. One notable exception is Kibert (2005), who includes the charrette as an emerging tool and provides guidelines for the successful integration of a high performing team.

Contract Types and Organisational Structures for Project Delivery

The type of construction contract selected for the delivery of a project has a significant impact on the success of developing and implementing a green design. More time is needed at the design stage to fully integrate ESD design features, and this must be reflected in the type of project contract selected. Innovative green technologies using less common materials and methods are more difficult to document in advance of tendering for a traditional contract. Best practice depends on where products are sourced from, transport costs and manufacturing methods.

A traditional construction tender based on detailed design documentation, a 'novation' contract or an 'alliance' contract could all be successfully used for the delivery of green commercial buildings, if sufficient time is invested at the conceptual design stage.

In a true alliance partnership, all the parties involved have collective responsibility for delivering a project. Under an alliance arrangement, non-owner participants are paid on an 'open-book compensation model', in which direct costs and project-specific overheads are reimbursed based on audited actual costs. The alliance partners also share in the profit and loss, depending on how actual project outcomes compare with the pre-agreed targets (Ross 2003).

Alliance contracts in other sectors have been found to dramatically improve innovation, troubleshooting and significantly reduce litigation. They have also been shown to reduce costs and timelines, as all parties have a responsibility and incentive to make a project succeed and, conversely, share the pain if things go wrong. Many experts suggest green buildings are natural candidates for alliances due to the importance of innovation and new work practices needed for them to succeed.

Alliances are a relatively new form of construction contract within Australia, and this may have been one of the reasons why the City of Melbourne preferred to negotiate a more traditional procurement process. The contracts for the CH₂ project were conventional, with a tender for construction based on a detailed design, documentation, green specification and guaranteed Bill of Quantities offered to a short-list of building contractors.

Hansen Yuncken was the successful tenderer and entered into a contract with the City of Melbourne based on a modified version of AS2124 with a Council representative appointed as the superintendent for the project. Hansen Yuncken came to the project with expertise from '60L', a smaller green office building constructed for the Green Building Partnership (GBP). In contrast with 60L, the construction process of CH₂ was relatively conventional. During the construction of 60L, significant emphasis on ESD issues was placed on every construction task, sometimes at the expense of budget and program. As a result, the construction process and relationship between the client and the building contractor was more complex.

One possible reason why the construction of CH₂ was more conventional is due to the newly developed Green Star rating system, which provides builders with a systematic basis for decision making on ESD issues. Thanks to the Green Star framework it was not necessary for every decision to be argued within an environmental framework providing the Green Star ratings were not compromised.

Hansen Yuncken entered into a 'partnering arrangement' with the City of Melbourne, the design team, subcontractors and unions. The aim of this arrangement was to foster a more consultative and collaborative relationship between all players where issues could be identified and solved in an expedient, collaborative manner. The partnering agreement does not have the profit and loss sharing components found within an alliance agreement. Its primary purpose is to remind all participants of the joint ambitions and good will of the project.

As a government body, the City of Melbourne needed to be confident that risks were controlled. Rob Lewis, the CH₂ Project Superintendent, ensured the initial budget was realistic and the Quantity Surveyor guaranteed the final building costs would come within five per cent of the original budget. The builder signed off the documentation before contracts were let to say the building would be fit for construction (Hes 2004 p 13).

The issue of risk and certainty influenced the procurement choices for CH₂. Professor Rob Adams, Director Design and Culture, City of Melbourne explains why this occurred in the following quote:

"I think if you look at the process of procuring the building... it is very traditional... it is full documentation, guaranteed bill of quantities, the stuff that people used to do 10-15 years ago. I have a great belief that it is at the front of the project where you need to do the work. Our industry has moved away from this approach and although they have cut down on consultants fees and save two to three per cent, they then wonder why it blows out at the other end by 10 or 20 per cent. I think it's poor economics. Right from the start we've said we're a Government organisation and we're going to be audited throughout this project, everyone's going to be looking over our shoulders, so let's just do it properly..."

(Hes, 2004, p14).

As a risk management strategy, the builder let out as many contracts as possible early in the process. The builder for CH₂ only employs a small core team of staff on an ongoing basis, so they always aim to confirm sub-contracts as early as possible. In contrast, many other firms work with more permanent teams. This enabled the builder for the CH₂ project to seek the most suitable subcontractors for the work. The building contractor had eight staff in the site office, including three foremen. Two carpenters and eight labourers employed directly by the contractor worked with various subcontractors. In the final six months of construction around 110 workers were employed onsite during the week.

In relation to CH₂ there was a slightly unusual relationship between Hansen Yuncken and the client/developer. In most construction projects, a project manager or architect would normally take on the role of independent arbiter between the client and the builder. For CH₂, the superintendent was a client employee, which had the potential to be a cause for concern by the site manager as decisions by the superintendent may not have remained entirely independent. However, possibly due to the goodwill developed as part of project, the mistrust that can potentially develop between client and builder was replaced with a collaborative partnership, where requests for information (RFIs) from the builder were quickly resolved. The site manager commented that RFIs were more effectively dealt with for CH₂ than any other project he had previously worked on.

Hansen Yuncken also researched and advised the client on some of the more unusual or innovative provisional items that required further design development after contract signing. For example, provisional items such as timber windows and rotating timber shutters on the western façade of CH₂ provided challenges in terms of satisfying both ESD and performance criteria in a cost effective and timely manner.

In addition, there were ongoing issues to do with sourcing materials and changing costs. Since the project was originally tendered, some materials had become difficult to source, and the consumption demands created by China's growth contributed to a significant increase in structural steel costs. The recycled timber was easy to source, although it is more expensive than new timber and its hardness means extra costs in cutting due to the need to replace blades.

Design Documentation

It is difficult to fully document a green building if new technologies are being incorporated and/or if unusual materials are being sourced. The structure of CH₂ was fully documented when the project went to tender, but some aspects were still being finalised during construction. The decision to use provisional sums extensively within the tendered project budget allowed ongoing research and development during construction.

For example, the building's western shutters were designed within a provisional budget of \$1.8 million. Signage, roof landscaping, lighting, installation of the phase change materials, fit-out of the lift car and the wind turbines were also included as provisional sums within the original tender documents.

A performance specification was provided for the windows and Hansen Yuncken offered a fixed price for these in the tender. Hansen Yuncken then took over the role of sourcing the supplier and providing prototypes for wind tunnel testing. They could find just one window manufacturer in Australia who would attempt to manufacture the windows. City buildings normally use aluminium window suites, but re-growth hardwood was specified for CH₂. Hansen Yuncken employed Meinhardt as the façade consultant to advise them on the design and testing of the façade. This resulted in the finessing of the façade to achieve the briefed requirement using re-growth forest timber as the structural element.

The development of the design for CH₂ involved a documentation system that used a File Transfer Protocol (FTP) site where all consultants involved could upload and download the latest drawings and specifications. Each consultant was responsible for uploading their latest drawings on Friday afternoons, at whatever stage of completion they were at, so all members of the integrated design team could access and download drawings on Monday morning. Consultants were also responsible for ensuring their designs were consistent with other discipline areas so an integrated design was achieved in a timely and informed manner with maximum coordination.

This online process was supported by weekly design meetings. As Jean-Claude Bertoni, a project architect from DesignInc, noted:

Essentially what we tried to do was have an establishment of a central file location. It was an FTP site where everybody was contributing their base files. So for arguments sake, an engineer would put up the latest column layout, or a grid layout that was then up to us to take that basic information off the FTP site and load it onto our base drawing, so that the engineers' drawing forms part of our drawings and so we wouldn't redraw that information, so we knew it was potentially right to begin with. The same thing occurred with the mechanical and hydraulic designs. Their information formed part of ours, so essentially it was an overlay concept of more services and disciplines, so you knew that every different stage, the drawings were coordinated, so it sort of alleviated a lot of coordination issues later on (Hes, 2004, p25).

A prototype space was developed from which part of the project team started working. Elements of the design continued to be tested and developed within the early stages of the construction process. For example, chilled beams and ceiling panels, while not unknown in Australia, are relatively untested. The ceiling panels were redesigned through several prototypes to ensure they were effective and aesthetically compatible with the curved ceiling. The original mock-up was a flat panel, but this gradually evolved into a curved panel with expressed pipes to help with acoustic properties.

Material Selection

The choice of construction materials is one of the key determinants of the environmental performance of a building in terms of embodied energy, greenhouse gas emissions and toxicity. Desirable material features include:

- reused and recycled materials;
- materials with zero or low harmful emissions and toxicity;
- materials with high recycle potential, durability and longevity;
- materials that require less maintenance and have lower replacement costs over the life of the building; and
- materials that have greater flexibility under changing design requirements over the life of the building.

Life cycle analysis (LCA) of materials is required to provide a 'cradle to grave' inventory and impact assessment of the materials and systems. Embodied energy studies are needed to assess the energy used by a material in its production, including mining, manufacture, transport, installation, maintenance, and finally demolition and recycling. This is a complex and developing field.

Research into the ecology of building materials, such as those by Berge (2000) and Lawson (1996), attempt to itemise the energy and environmental impact of building materials, manufacture and construction. The major structural materials of concrete and recycled steel are listed by Berge as being durable, with readily available reserves and relatively low primary energy and water consumption in their manufacture (2000, Table 1.3). New analysis tools on the market such as 'Ecospecifier' are providing guidance on the environmental impact of commonly available building products. EcoSpecifier is a commercial database of building products that have been independently vetted against sustainability criteria. A similar tool is the US Greenbuild database that also rates the environmental performance of building products.

Green buildings materials are gradually becoming available but are not yet sufficient to allow quick and informed decisions. For CH₂, design phase interviews were held with clients, consultants and builders, asking them to nominate areas where they found a lack of information. All those interviewed mentioned materials selection as an area where limited information was available. One major problem was how to compare various options such as wool carpet versus nylon carpet (Hes, 2004, p40).

The CSIRO developed a method to help with the selection of materials in CH₂. It was a hybrid between a system of Environmental Performance Data Sheets (EPDS) developed by RMIT University and an expert panel (Hes, 2004, p42). An EPDS was a detailed questionnaire sent to all product and material suppliers with the aim of completing a life cycle assessment. Many manufacturers or suppliers were unable to answer all questions, but expert opinion was used to make informed decisions on the basis of information supplied.

Pre-planning techniques were employed on the CH₂ project to avoid unnecessary delays in approving ESD materials. For example, early in the contract, a number of low volatile organic compound (VOC) caulking and surface finishing products were identified and approved for use throughout the project.

A lot of material selection was completed during the design stage but, in the end, the key materials were relatively straightforward. The key materials of CH₂ are steel, glass, reinforced concrete and timber in the windows. There are very few additional materials used in the structure and façade construction.

A review of material selection issues associated with the construction of other green buildings indicated some compromise was required during construction, either due to unacceptably high costs or availability and timely supply issues.

PVC

CH₂ Initiatives

In CH₂, PVC is only used for the stormwater in the basement. High Density Poly-Ethylene (HDPE) was typically used as a substitute product for PVC conduits and cabling with significant cost implications as there was only one supplier. In addition, the need to heat weld the joins was more labour intensive than using PVC adhesive. New greener products like HDPE are likely to become more affordable as their use and industry competition increases, and PVC is slowly phased out of the market.

Australian Perspective

Melbourne's green commercial office building '60L' building specification originally banned the use of PVC but subsequent reviews and calculations revealed that a 100 per cent substitution of PVC would at least double the cost and have significant implications for some products which contained PVC components. As a compromise, PVC was eliminated from all water and wastewater pipes, electrical conduits and light fittings. This resulted in a 50 per cent reduction in the use of PVC in the 60L building compared with a typical commercial building of the same size and use.

Steel

CH₂ Initiatives

Green Star compliance requirements stipulated a minimum of 60 per cent recycled steel for structural steel requirements, by weight of the total structural steel and connections.

All reinforcing steel for use in concrete was required to be 95 per cent recycled steel to receive Green Star credit points. A number of Australian reinforcing steel manufactures source their feed stock totally from recycled scrap, hence the 95 per cent was relatively easy to obtain.

Australian manufacturer BHP Billiton Ltd recycles steel, but as a primary producer of steel from iron ore it is unable to achieve the high recycled content requirements of the Green Star rating. Achieving Green Star credits for steel materials forces the purchasing of steel from overseas. Steel sourced from overseas for CH₂ was only available in limited sections and it may have high silocon content, which can affect hot dipped galvanising finish. However, it does meet the Australian Standards for equivalent grade of steel. In the construction of CH₂, recycled structural steel was sourced from Thailand to satisfy cost and availability.

Australian Perspective

Australia has a relatively immature market for recycled building products which can result in delays in the sourcing and supply of products and encourage contractors to purchase new products when price and availability are guaranteed. This barrier will be overcome as the recycled market supply chain develops, matures and becomes more dependable.

Concrete

CH₂ Initiatives

Design

The strength of concrete, as stipulated by the Australian design code is specified by the strength it achieves after 28 days. Concrete mixes containing fly ash and furnace slag as a substitute for Ordinary Portland Cement exhibit a slower strength gain than normal mixes. In order to maximize the use of these concrete blends, the design of CH₂ considered where slow strength gain was tolerable (eg. footings and columns) and the design strength of those elements was specified at 56 days.

Specification

The specification for concrete for the CH₂ project tender was instituted prior to the finalisation of the Green Star rating system and hence did not prescribe the requirements for CH₂. The design team, including specialist concrete technologists, were of the opinion that meeting the Green Star specification for concrete required such a large and generally untried step for the local industry in production, handling, placement, finishing and curing it could potentially overburden the builder's construction program. Additionally, as CH₂ was a multistorey building subject to high loads and incorporating high strength and high class finish elements, the structural engineers required the 'structural' attributes of the concrete to prevail over those that were 'ESD'. This made attaining the Green Star credits practically unachievable.

Rather than being prescriptive, the specifications required the builder to address the following ESD objectives of concrete mix design to:

- minimise embodied energy (i.e. energy consumed in the production of all constituents);
- minimise the content of ingredients which create greenhouse gasses in their manufacture;
- maximise the use of reclaimed, recycled, waste or by-product materials; and
- minimise water use.

Council also expected the average Type GP Cement, previously known as Type A Portland Cement, content per cubic meter of concrete supplied to the project to be reduced by at least 25 per cent when compared to equivalent grade concrete incorporating no supplementary cementitious ingredients.

Re-claimed and Recycled Aggregates

Reclaimed aggregates are sourced from unused fresh concrete that is returned to the batch plant. This aggregate can be easily reused. Recycled aggregates are generally sourced from crushed concrete and are not structurally acceptable due to possible inclusions of weak material.

Concrete Ceiling Panels

The unique curved concrete ceiling panels were manufactured offsite with steel forms and a standard concrete mix with superplasticers applied to ensure a satisfactory surface finish. It took four months of trials before a satisfactory concrete mix for the precast ceilings was developed. The formwork for the curved ceilings is a totally sealed unit and so the concrete needed a high percentage of plasticers in order to achieve the correct flow without compromising strength.

Although it was not possible to use recycled aggregates in these forms as they behave too unpredictably, Boral Green Mix was used for the in situ columns. Originally the team tried the mix with 40 per cent cement replacement with fly ash but there were too many shrinkage cracks. This was adjusted to 20 per cent cement replacement. The recycled aggregate tends to absorb the available moisture, making it stickier and hence harder to work with and position.

Australian Perspective

The experience of the recycled aggregate and fly ash are reflected in other Australian and overseas examples.

Research and development has shown that desired surface finishes are more difficult to achieve when using recycled aggregates or cement replacement products.

Timber

CH₂ Initiatives

Timber use on CH₂ is to be recycled or from regrowth hardwood.

Within the CH₂ documents, some materials were originally specified as products while others were required to meet a performance specification. While recycled timber used for the windows in CH₂ was sourced in a timely manner, considerable extra costs were associated with milling the well seasoned hardwood timber. The ESD varnish finish originally specified for the timber windows could only be guaranteed for 18 months, and was consequently replaced with a standard acrylic paint product with a 10 year manufacturers guarantee.

Australian Perspective

Recycled and regrowth hardwood are readily available in Australia. Much public attention has been focussed on the use of renewable timber, and Australia does have extensive sustainable timber available.

Builders face a dilemma when considering overseas materials against local materials. Often the overseas product is less expensive than the local product but there is no easy way to include the cost of extra embodied energy resulting from long distance transport. A further issue faced by builders is that some local products do not meet required ESD specifications.

A balance must be met between the environmental credentials of the material with its physical performance. Some materials with low environmental impact (such as low embodied energy or toxicity levels) do not necessarily have strength, performance or durability characteristics, which could result in a shorter life and higher maintenance implications.

The CH₂ site manager highlighted another difficulty when using recycled materials. At present, Australian standards and building regulations assume new materials are used in construction. Therefore recycled products sometimes need testing to show they meet required standards, and this can dramatically slow the approval process.

Site Practices and the Environmental Management Plan

The construction site of a project provides great challenges to the successful implementation of sustainable building practices. Construction practices reviewed in a 2004 study demonstrated varying degrees of environmental performance. In this study (UniMelb, BOE, 2004), all construction firms interviewed commented that the Australian construction industry is still driven by financial performance, with success measured by cost, time and quality. In many cases, environmental performance is still regarded as a peripheral or secondary issue.

Tender documents for CH₂ required the contractor to provide and implement a comprehensive Environmental Management Plan (EMP) in accordance with NSW Environmental Management System Guidelines (1998). The EMP covered issues such as the construction impact on air quality, water supply and land quality. Under the EMP, the contractor was required to develop policies for reducing site waste, energy use, the selection and supply of materials and products and the re-use or recycling of salvaged products. Induction of all onsite staff was a mandatory part of the EMP. Good environmental and waste management, as required in the tender documents, achieves five points towards the Australian Green Star rating. In England, the comparable LEED rating system used for commercial buildings does not include points for the development of an EMP but does include points for construction waste management (Kibert, 2005, p 75).

While Hansen Yuncken had an environment policy in place and are fully accredited to AS/NZS ISO 14001:1996, their project specific Environmental Management Plan was developed uniquely for CH₂. Collex Waste Management Pty Ltd was nominated within the EMP document to manage the site waste disposal. The EMP is not limited to site activities but extends to issues of trade waste and energy use in the off-site trades. Hansen Yuncken's monthly project reports contained a section on environmental issues, and environmental audits of site practices were held at the start and the completion of the project, and at six-monthly intervals during construction (Hansen Yuncken, 2004).

A significant challenge for the building contractors of CH₂ was the continued management of large numbers of suppliers, subcontractors and tradespeople, which changed regularly during the construction phase. Onsite induction involving staff and subcontractors helps communicate the green intent of a project and the expected sustainable practices, but as some people commented, "It's like telling a group of children about caring for the environment; most will learn but a few just won't listen." For this reason, the union movement, which is a key player in the building industry, needs to be engaged as a supporter of green buildings. Experience onsite has demonstrated that some unions are actively involved in applying the principles of sustainability, while other unions and tradespeople are indifferent.

Surprisingly, the CH₂ construction site was relatively straightforward. Hansen Yuncken carefully selected subcontractors, many of whom had previously worked with the company. There was also a considerable amount of good will for the project from the various contractors, with larger firms keen to be involved as they consider green buildings and techniques increasingly important.

A key sustainability issue in the construction phase of CH₂ was waste recycling, or the management of residual material. Some project contracts specified that demolition and construction waste were to be separated into waste streams such as timber, concrete, steel, plaster and PVC. On previous sites, it was observed that the initial enthusiasm for separating waste dissipated as the project progressed, and many recycling skips were found to contain a mix of materials. This type of behaviour may reflect ignorance, laziness or time pressures to complete a project and clean-up expediently. To ensure sustainable practices are implemented onsite, the developers and building contractors often employ different strategies such as 'environmental policing'. This involves either appointing an officer dedicated to check practices, or random onsite visits by project managers. 'Soft' strategies are also applied such as involving union representatives in site meetings to reinforce the benefits to workers of sustainable practices.

A simple, alternative strategy used at CH₂ due to the tight space constraints of the site was to outsource the sorting and recycling of the residual material. Consequently, only one bin was provided at the site for waste and the waste contractor then sorted the residual material off site with a recycling success rate of around 80 per cent. The remaining 20 per cent of waste was committed to landfill. The cost of transporting and sorting waste was carried by the recycler and recouped through the sale of recyclable materials. The recycler provided a monthly report.

Site induction into waste procedures at CH₂ was therefore relatively straightforward. Building waste was dropped into one bin, while domestic waste was sorted in the same way as most homeowners. Washout of concrete pumps was restricted to one area.

While waste recycling was tracked during construction of CH₂, power usage was not considered a key element in the overall energy savings possible. The site offices were within an existing City of Melbourne car park in which all lights are either on or off. Although not ideal, the cost to rewire was not considered efficient. Site water was not allowed to run into stormwater drains but this is now normal for all construction sites and water usage is not monitored.

The CH₂ building site was extremely compact, with minimal space for storing materials and cranes. Consequently, there was only one central crane used on the site, and the contractor emphasised the use of precast concrete to minimise the number of people and trades onsite. The unique floor system, integral to the curved ceiling of CH₂, required a change from the traditional construction processes of multi-storey buildings. The usual process is that services are fitted out to lower levels whilst construction continues on the upper floors. In CH₂, the curved precast ceiling panels were placed first followed by the in situ construction of the integrated floor beams. Services were then fitted in the concave void above the precast ceiling before the in situ floor was positioned to span between the beams and enclose the services. The resulting construction sequence required significant coordination between the different trades to achieve the integrated design in a timely manner.

The floor construction process of CH₂ was therefore slower than for a normal city building of the same size. The limited site conditions and access, with just one crane onsite, resulted in other logistical issues. In addition, the building had many unusual construction methods and was aesthetically complex, requiring many trades to work concurrently. For example, the decision to include services within the floor voids meant that trades like electrical, services and sprinklers worked alongside each other rather than consecutively.

For CH₂, the work practices of the Hansen Yuncken and the various subcontractors was very similar to conventional building construction, although one extra person was employed to manage the project's environmental issues and document processes to ensure compliance with the Green Star rating system. Similarly, power and water use and waste water treatment during the construction of CH₂ construction were considered similar to more conventional construction contracts. Major differences were associated with the façade systems and services such as heating, cooling, ventilation and lighting.

There were minimal union issues on the CH₂ site. It is worth noting that the head of the plumbers' union endorsed the project and wished it well. There were also no unusual site penalties and or shop steward issues.

The Green Building Council of Australia may require an independent auditor to ensure the installation of services meets the Green Star requirements. Currently the construction process is largely self-audited by the builder and client. There was some uncertainty about the auditing process, although there was goodwill to ensure the building was constructed in accordance with the requirements.

A key aspect of the Green Star rating system is the incorporation of green principles into the tender and contract documents. This is one of the key points made within 'A Green Vitruvius' which was written as a green architecture handbook (ACE et al, 1999).

Commissioning, Fit-Out and Operations

A Green Star design rating only considers the base capability of a building in relation to ESD principles. The successful environmental performance depends on the building owners, operators and tenants and codification of these responsibilities in the form of 'green leases'. The Green Building Council of Australia is introducing a tool to rate the 'green credentials' of existing office buildings. General disclosure of building performance is already a requirement in some Scandinavian countries and helps focus tenants on the life-cycle costs and environmental impacts of the buildings they occupy, rather than just the rent. In Canberra, energy performance must be disclosed in vendor statements during property sales. The Australian Building Greenhouse Rating (ABGR) tool provides a method for determining operational energy performance and greenhouse emissions associated with the sources of energy consumed.

As CH₂ was still being constructed at the time of writing this paper, some aspects discussed will need further study on completion and occupation. The City of Melbourne has allowed a 12 month commissioning period after occupation for the contractors to fine tune all building services and passive systems.

Conclusion

CH₂ building contractor, Hansen Yuncken, took a key role in resolving some of the more unusual aspects of the building such as the use of recycled timber cladding. Difficult decisions in the selection and procurement of sustainable materials illustrate the extent of uncertainty that still exists in obtaining life-cycle data to help inform decisions. For example, the ESD requirement for certified recycled steel resulted in a decision to import an appropriate product from Thailand, which in turn resulted in extra energy consumption for transport.

Given the innovative nature of the design and material selection of CH₂, its contracting and construction process was surprisingly conventional. The client, as a government body, needed to manage risk and therefore a conventional tendering process was seen as important to bring certainty to the funding of the project. Traditional contract management often places the builder and client as adversaries, with the architect or project manager acting as arbiter. Anecdotal evidence suggests the integrated team approach at CH₂ not only helped facilitate the design stage but continued into the construction phase. In CH₂ it seems good will created through Hansen Yuncken's partnering approach was extended to site workers and unions.

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