Technical Research Paper 08

Building Structure and Construction Process

city of Melbourne

Study Outline

This study outline summaries key points raised in one of the 10 technical papers in the pre-occupancy study series that investigates the City of Melbourne's world leading Council House 2 (CH_2) office building. Each technical paper has been developed by independent authors from Australian universities as part of the CH_2 Commercial Green Building Technology Demonstration Project. To obtain copies of the full technical papers visit www.ch2.com.au

This project forms a major part of the CH_2 Study and Outreach Program – a coordinated effort to consolidate the various opportunities for study, research, documentation and promotion generated by the CH_2 office building. The primary aim of this program is to raise awareness of sustainable design and technology throughout the commercial property sector and related industries.

The target audience for these papers is professionals involved in the design, engineering, construction and delivery of office buildings, which explains the technical detail, length and complexity of the studies. Although these papers may be of interest to a wider audience, readers who possess a limited knowledge of the subjects covered should obtain further information to ensure they understand the context, relevance and limitations of what they are reading.

Significant funding for the technical papers was provided through an AusIndustry Innovation Access Program grant and supported by cash and in-kind contributions from the City of Melbourne, Sustainable Energy Authority Victoria, the Building Commission of Victoria, the Green Building Council of Australia and the CH_2 Project, Design and Consulting Team. The Innovation Access Program is an initiative of the Commonwealth Government's Backing Australia's Ability action plan.

An Australian Government Initiative

AusIndustry

6 star rating

green star Office Design v1

This rating represents World Leadership

CH_2

Technical Research Paper 08

Study Outline – Building Structure and Construction Process

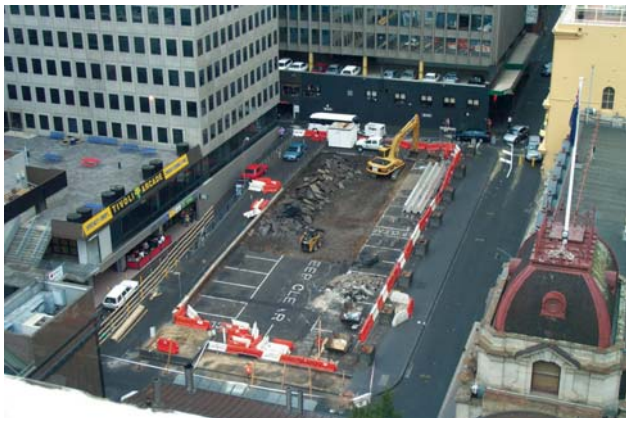
This paper examines some of the structural aspects of the City of Melbourne's new green building, Council House 2 (CH_2) as well as the selection of materials and the role of the builder during the construction process.

In order to gain a six star rating under the Green Building Council of Australia's (GBCA) new Green Star rating system, many innovative design initiatives were incorporated into the building.

The paper begins by outlining some of the key design features of CH_2 followed by a description of the integrated design process and how this facilitated innovative structural and design decisions. The team approach during design development continued through into the construction phase. Despite its many unusual design elements, the procurement and construction process for CH_2 was relatively conventional. This process contrasts with another recent green office building project in Melbourne, and it is argued that the new Green Star rating system and specification provides builders a more systematic basis for decision making around ecologically sustainable development (ESD) issues.

Issues relating to the construction process, such as structural rationale, materials selection, procurement methods and on-site construction practices are also discussed in this paper.

A. Central city location of CH_2.



B. Site at start of construction, February 2004.

C. Site excavation, August 2004.

Figures 1: Location of building and tightly constrained work site.

Construction Overview

Hansen Yuncken started construction of the 10-storey $51 million CH_2 building in early 2004. The 1,316 m^2 construction site was only accessible from city laneways. The concrete structure was a relatively conventional in situ construction except for the use of precast undulating concrete ceiling panels. Two rows of concrete columns are located at 8200 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 ceiling resolved difficulties arising from the 22 m building depth by providing enough space for air distribution ducts, while still allowing a maximum ceiling height so light could penetrate deep into office spaces. Other difficulties relate to the challenge of effectively ventilating deep open office space, especially when considering natural ventilation for thermal mass cooling. This was, however, resolved with the installation of a mechanical daytime ventilation system using underfloor swirl diffusers inlets and ceiling mounted air extraction points to provide effective distribution of air, while minimising mixing across the floor-plate. Car parking is provided on the basement level. The car park has a level floor, rather than ramped, allowing for future conversion to other uses.

A. Car park access link to adjacent building, October 2004.

B. First floor under construction, September 2004.

C. First floor formwork, November 2004.

Figures 2: Below ground and first level construction activities.

Integrated Design Process

The design process of most commercial buildings is complex, requiring collaboration with a range of consultants. The conceptual design for CH_2 was developed by an integrated design team during a two-week intensive workshop or 'charrette' in January 2002. Intense cooperation early in the design process is unusual and, in the case of CH_2, this enabled innovative decisions to be made with a degree of certainty in terms of constructability and cost. Most publications outlining recent international exemplars of sustainable architecture do not mention the importance of the architect working collaboratively with the client and consultants from early in design stage. One notable exception is Kibert (2005) who mentions the charrette as an emerging design process and gives guidelines for the successful integration of a high performing team.

A. Foam supports for delivery.

B. North end panel, note square penetration for ventilation exhaust (refer Figure 3B).

C. North end panel .

D. Ceiling panel with supports.

E. Placing central panel.

F. Positioning reinforcing steel and services. Green pipes are for cooling water supply for radiant chilled ceiling panels.

Figures 3: On-site insertion of a precast concrete undulating beam ceiling panel.

A. Apex of curve with structural support.

B. Plastic wrapped chilled ceiling panels and electrical services.

C. Positioning tile pattern on raised floor.

Figures 4: Internal view of undulating ceilings during construction.

Type of Contract

The type of construction contract has a significant impact on the success of developing and implementing a green building design. The issue of risk influenced the procurement choice for CH_2, with project director for the City of Melbourne, Rob Adams, saying:

"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…"

As a risk management strategy, the builder, Hansen Yuncken, confirmed as many contracts as possible early in the construction process. In contrast to other construction firms, Hansen Yuncken only employed a small core team. During construction, the company continued to research and advise the client on the availability and cost of some of the more unusual or innovative provisional elements of the design. For example, it was a challenge to find provisional items such as timber windows and rotating timber shutters that satisfied ESD, performance and cost criteria, and could also be delivered in a timely manner.

Sourcing Materials

During the time the project was tendered and construction began, some issues were experienced relating to sourcing materials and changing costs. Some materials had become difficult to source, others had become more expensive. The cost of steel from China, for example, doubled. Recycled timber was easy to source but it was more expensive than new timber and its density meant extra cutting costs due to the need to replace blades. Issues to do with the use of PVC, recycled steel and cement replacement with fly-ash are also described in the paper. In addition, Hansen Yuncken faced a dilemma when comparing overseas materials against local materials. Often the overseas product was less expensive but no accepted method exists to factor in the cost of extra embodied energy resulting from long distance transport.

Construction Site

Given its innovative design, the construction of CH_2 was relatively straightforward. Hansen Yuncken carefully selected subcontractors and many had worked with the company before. There was also a lot of goodwill for the project from the contractors, with the larger firms keen to be involved to boost their green building skills and credentials. A key sustainability issue during the construction phase was waste recycling.

A simple strategy was developed as part of Hansen Yuncken's Environmental Management Plan. A waste contractor provided one bin onsite for waste and then sorted the residual material offsite with a recycling success rate of around 80 per cent. The remaining 20 per cent was committed to landfill. The cost of transport and sorting of waste were carried by the recycler and recouped through the sale of recyclable materials. For this reason, site induction on waste procedures was relatively straightforward. All building waste went into one bin while domestic waste was sorted in the same way as for homeowners.

A. South-west view, July 2005.

B. North façade view, July 2005.

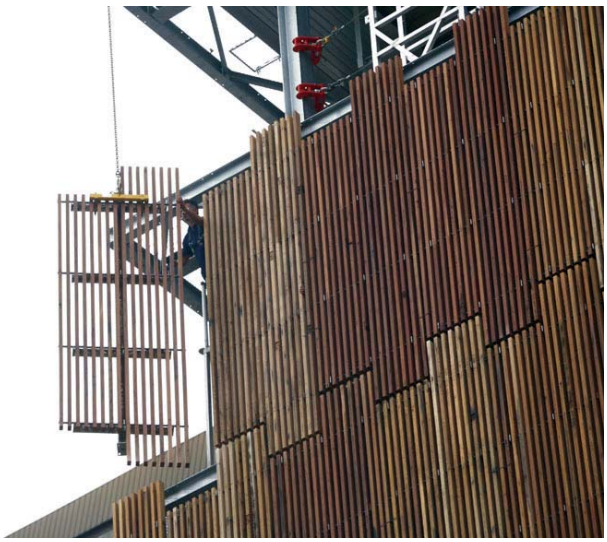
C. South façade view, August 2005.

Figures 5: Building structure and integrated façade design.

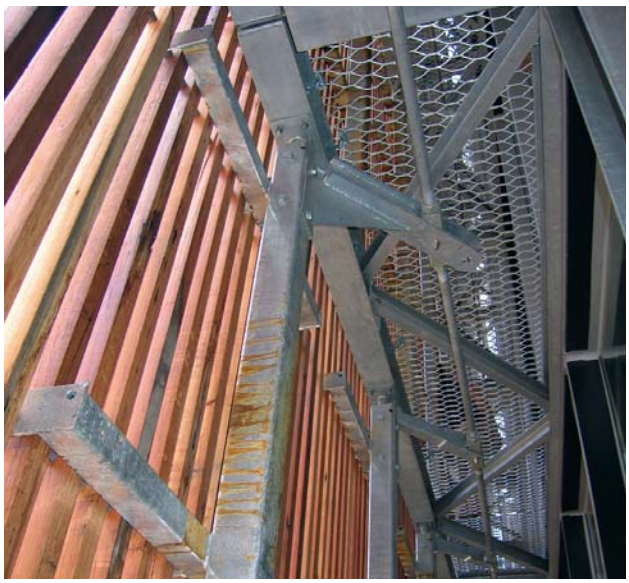
The compact nature of the CH_2 building site provided little room for storage of materials and cranage. As such there was only one central crane onsite, and Hansen Yuncken also maximised the use of precast concrete to minimise the number of people and trades onsite. The unique floor system, integral to the curved ceiling, required a change from the traditional construction processes of multi-storey buildings. The usual process is that services are fitted out to the lower levels while construction continues on the upper floors. In CH_2, the curved precast ceiling panels were positioned first followed by the in situ construction of the integrated floor beams. The services were then being fitted into the concave void above the precast ceiling before the in situ floor was placed between the beams to enclose the services. The resulting floor construction sequence was slower and more complex than traditional methods and required significant coordination between trades to achieve the integrated design in a timely manner.

As a government body, the City of Melbourne has a responsibility to manage risk appropriately. For this reason a conventional tendering process was seen as the best way of bringing certainty to the funding of the CH_2 project. Traditional contract management often places the builder and client as adversaries, with the architect or project manager acting as arbiter. However, anecdotal evidence suggests the integrated team approach used for CH_2 not only benefited the design phase but continued into the construction phase. It seems clear that goodwill between the team members was extended to site workers and unions.

A. West internal access stair and pattern of active natural timber façade.



B. Positioning façade opening element.



C. Actuating arm for opening active façade elements, note glass curtain behind façade space.

Figures 6: West façade under construction.

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