ENVIRONMENT DESIGN GUIDE

THE INTEGRATED DESIGN PROCESS OF CH_2

Stephen Webb

Council House 2 (CH_2) is a revolutionary, sustainable office building designed for the City of Melbourne. It meets the Council's long-term need to house staff and breathes new life into an under-used part of the central city. The process of designing CH_2 was highly collaborative and innovative - challenging traditional approaches to sustainability and building design.

The design process included an initial two-week workshop followed by regular design sessions that ran for eight months. The project team included architects, engineers, artists, environmental experts, future occupants, the CSIRO and the Sustainable Energy Authority of Victoria.

This intensive, collaborative approach facilitated many beneficial and unexpected design outcomes. It revealed how individual ideas are sustained working in collaboration and challenged what it means for a built environment to be 'biologically sustainable.'

1.0 INTRODUCTION

This case study will focus on the unique design process the design team undertook for CH_2 and some of the innovative solutions the process produced. The site is located in the centre of Melbourne on Little Collins Street. It has a long north and south boundary and receives some east and north shading from adjoining buildings. An exposed west face looks over an existing one-storey café onto Swanston Street.

The project's collaborative, eight-month design process resulted in many beneficial and unexpected design outcomes, such as:

- a vaulted precast concrete floor structure that integrates structure, cooling, lighting and ventilation
- façade designs inspired by natural systems that work with the external conditions rather than excluding them
- a healthy work environment that provides physical access to nature and a quality indoor environment.

During the design process the design team began to make use of a tree as an analogy for the building. A tree also served as an apt representation for the entire design process itself (Figure 1). The design workshop phase (shown on Figure 1 below the line) consisted of seeding the idea. Rather than grouping areas of expertise under the traditional consultant disciplines, types of knowledge such as health, art and behaviour were fed into a framework or root system.

The framework consisted of three aspects of the environment – the natural, social and economic. A design concept emerged after the two-week workshop that the project team then tested and reviewed. Following on from this the building would then be constructed and finally monitored. This case study will trace each of these design phases for the CH_2 project outlining the benefits and lessons learned from this approach. What was revealed as most important was the branching/heuristic nature of the process – ideas and options were explored, paths were retraced, better solutions were found – this was the 'nature' of the CH_2 design.

The key phases were:

- The Design Workshop:
  - Challenging tradition
  - Groups and unrelated ideas
  - Workshop techniques
  - Common values and goals
  - Expressing natural processes
  - The emergent design concept
- The Extended Design Process:
  - Individual discipline testing
  - Design signoff
  - Peer review and design ratings
  - Prototype solutions
  - Contractor review
  - Monitoring built form

2.0 THE WORKSHOP – SEEDING THE IDEA

2.1 Challenging tradition

The City of Melbourne brought together a group of consultants hand picked for both their specialised knowledge and their ability to think strategically. DesignInc Melbourne Architects joined with the City of Melbourne in-house design team and Advanced Environmental Concepts (AEC) Engineers to complete a core design triangle.

The workshop itself was made up of a series of presentations, discussions and working parties. These documents and their outcomes were then summarised in a series of internal publications.

2.2 Groups and unrelated ideas

The CH_2 project showed how working in groups could increase the chances of connecting seemingly unrelated ideas together. This concept was very different to notions of 'group design' or 'design by committee', rather, individuals benefited from the stimulation and dynamic interaction that occurs when people of different backgrounds come together.

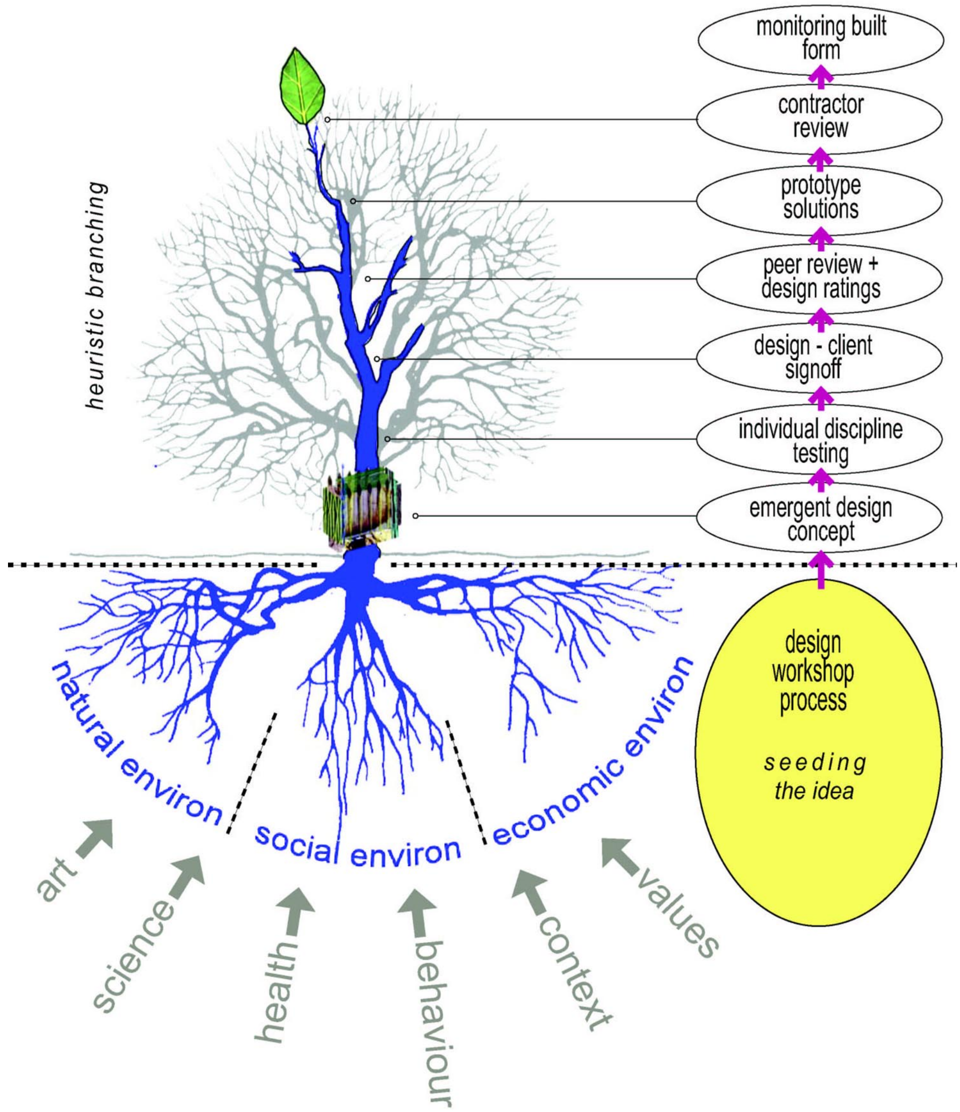

Figure 1. A biological design process

The team was made up of different people – complementary types that were willing to accept the contribution of others, work in teams and appreciate a good idea from wherever it came. Individuals were selected for both their specialised knowledge and their ability to think strategically in collaboration with others. The emergent ideas from this process remained the product of a single mind.

2.3 Workshop techniques

Intensive design workshops represented an effective method of benefiting from group interaction and knowledge. They 'fast tracked' the traditional consultant and client design meetings phase of a project. Working within a limited time frame the CH_2 team benefited greatly from this approach. All ideas and inputs were considered equally up front, including operational, functional and aesthetic imperatives. A direction was then distilled which all team members and stakeholders used to steer the design process throughout the project's life.

The team spent no more time on concept design than they would have working in a traditional way. However, the effectiveness of the design time was increased. This led to significant savings later in the project. For example:

- Team members shared a common understanding of the concept design, which led to better coordination between disciplines
- Critical dimensions and systems were resolved at an earlier stage
- Team members could spend more time refining, optimising and value managing the design.

Concept design workshops should vary in length according to project size, complexity and the potential for project innovation. CH_2 followed a multiple day session format as follows:

- Approximately 30 people with a nominated facilitator.
- The initial sessions included background project briefing by team leaders, discussion of site

constraints and opportunities. A summary of the key objectives of both the workshop and the project itself. For example, environmental objectives and targets.

- Specialists and consultants presented analysis and preliminary studies on: site, climate, energy, people, behaviour, program, values, technology, art and health. Analysis of exemplars and precedent was undertaken and discussed.
- In further sessions individual feedback from participants was presented to the entire group. Smaller groups (composed of a mix of people) worked together in afternoon sessions on specific issues/ideas via butcher's paper or white board design sketching. The best idea(s) and concepts were established through continuous feedback to the group as a whole.
- The ultimate focus was not only establishing design and construction ideas but representing, and to a certain extent testing, these ideas via concept drawings, calculation, and physical / computer modelling. This work became the basis of the design documentation and the brief for the project.

2.4 Common values and goals

The whole workshop process was supported by a relatively simple and clear brief to ensure CH_2 was:

- a lighthouse environmental project
- a building that was greenhouse neutral
- a space that would improve employee well-being.

Four key value areas emerged from the workshop process that formed the basis of the brief: Eco-Exchange, Eco-nomics, People and Green Print. Rather than develop these as text volumes these topics were represented by diagrams that attempted to prioritise qualitative and quantitative measures.

2.4.1 Eco-Exchange

Eco-Exchange (Figure 2) dealt with the building's proposed relationship with its total environment. This included everything from energy transfer and waste, to comfort and education. Every part of the building needed to be thought of as interacting with the environment. The interaction could be:

- in the past – its embodied energy or impact on habitat
- in operation – its energy consumption or toxicity
- in the future – its lifespan or reusability.

2.4.2 Eco-nomics

The second value area was the notion of Eco-nomics. One of the most important aspects of developing a truly sustainable model was considering the built environment as a closed loop. Key design aspects for CH_2 included designing for deconstruction, recycling, reuse, marketability and balancing costs. In their book *'Cradle to Cradle'*, McDononough and Braungart made a strong case for looking beyond simple 'eco-efficiency'. They outlined how man-made products should be conceived as either 'biological or technical nutrients', so that after their useful lives they provide nourishment for something new (McDononough and Braungart, 2002).

A recurring theme during the workshop process was how to achieve more for less – how a design element could solve more than one problem. For example, the external supply and return air ducts on the outside of the north and south façades were designed to:

- deliver fresh air to each floor at low level
- extract stale air at each floor at high level
- serve as solid external wall elements – optimising the extent of glass
- help reduce glare by their splayed plan profile
- taper in elevation to allow greater light to the lower levels of the building
- change in concrete colour from north to south to optimise thermal load
- help carry vertical landscape down the façade.

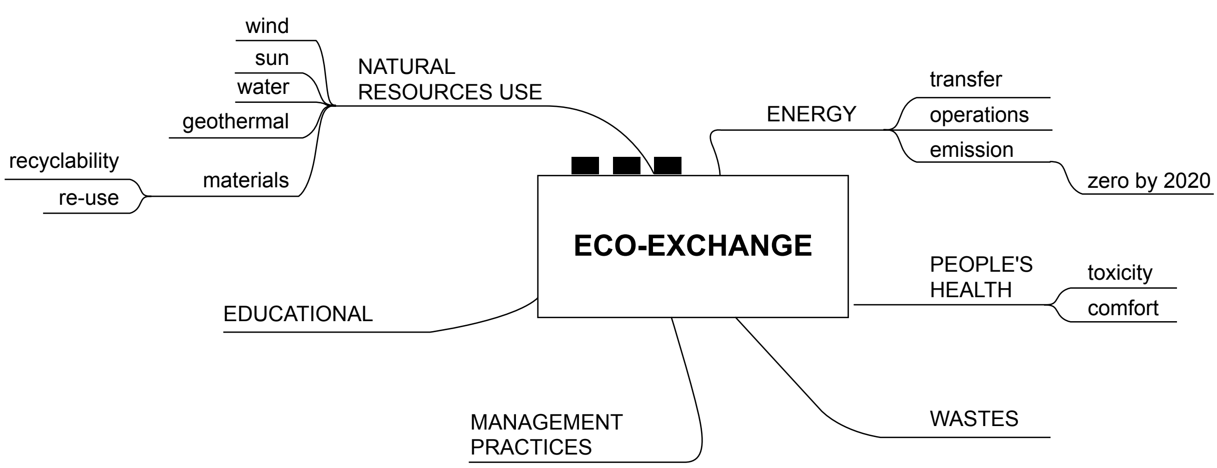

Figure 2. Condensed Eco-Exchange diagram

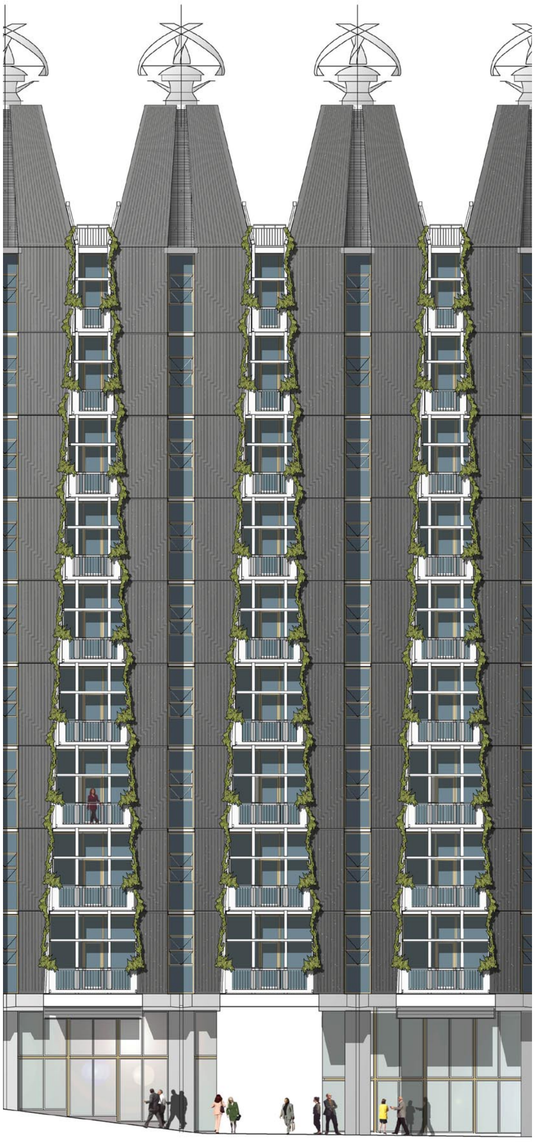

Figure 3. External ducts

2.4.3 People

Over recent years there has been an increasing shift by the design professions away from looking at sustainability purely from an energy point of view. The emerging trend is towards a more socially inclusive approach to sustainability that places sensory and psychological experience of the environment as a priority.

> 'Designers need to address not only the issue of providing clean air for the occupants of buildings, but also the problem of making sure buildings don't pollute their surrounding environments. This challenge is the key to the development of a sustainable environment.' (Battle, 2002).

The CH_2 project developed towards the theme that healthy environments equal healthy people. Aspects of comfort, social space, access to landscape, adaptability, productivity, air quality, ownership and pride became the key design outcomes to aim for.

2.4.4 Green Print

It was agreed the building should provide at least the same area of green cover (measured either vertically or horizontally) as its footprint. That is, there should be as many leaves on the building as if the land was still under native vegetation. The notion of green print also extended to include broader aspects of the urban environment such as:

- public space and the adjoining fabric
- integrated artwork
- implied continuity and growth
- the relationship between the city and nature.

2.5 Expressing natural processes

A dominant theme in the history of architecture in the 20th century was the story of buildings copying machines and technology. A belated global environmental awareness has now revealed how short-sighted the 'building as machine' analogy is. Combining technology with a large amount of energy is not the answer to a sustainable future.

> 'As sustainability gains greater moral urgency so, too, building development is increasingly responding to many pressing environmental issues rather than just a single one.' (Edwards, 2003).

Learning from nature and natural processes was the strongest influence on the early design process of CH_2. This design approach considered buildings and urban environments likened to living organisms, evolving in response to climate and topography. In the past this integrated approach to building and nature produced vernacular built forms that differed from place to place in an analogous way to how plants and animals differ from habitat to habitat. The natural environment has always inspired architects, however an unprecedented array of built and imagined 'bio-architecture' has emerged over the past 20 years.

> 'Designers such as MVRDV, SITE, and T.R. Hamzah and Yeang express the new scale of sustainable technologies by imaging new types of living and working environments that feature multilevel gardens, amorphous shapes and high tech imagery.' (Gissen, 2002).

Foster and Partners have continued to evolve a responsive 'eco-tech' for large scale structures while architect Eugene Tsui searches for a way of building that mimics nature in process and form.

For the designers of CH_2, nature represented a link between art and science. This approach centred on how the built environment could become an extension of the natural world rather than an adjunct to it. An understanding of natural processes, particularly local environmental conditions and air movement was critical.

Such environmental constraints became key design opportunities. In this sense the building was designed

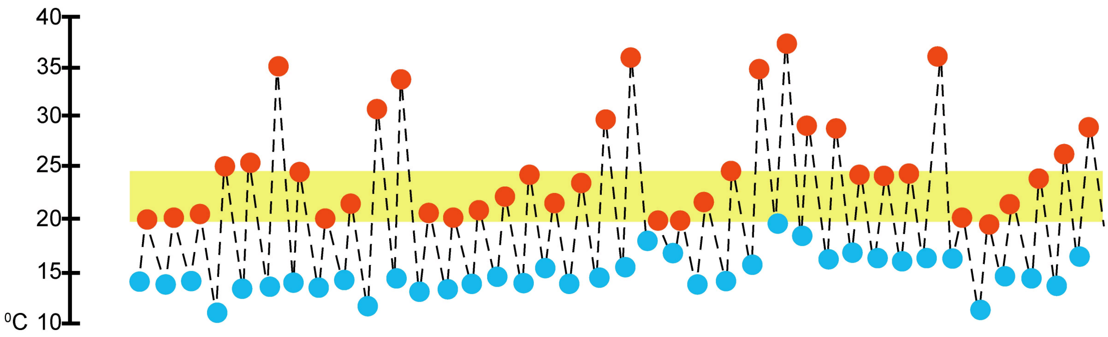

Figure 4. Melbourne daily maximum and minimum temperatures 1 Jan – 8 Feb 2002

simultaneously from the inside out and from the outside in. For example, in Melbourne conditions, what was found important was not so much the climate but the weather (see Figure 4). It was the isolated peak days in summer that had to be catered for – the majority of day time maximums were within comfort conditions. This led to the very early adoption of a cooling strategy that integrated overhead exposed thermal mass with radiative elements such as chilled ceilings and beams.

During the workshop stage detailed computer modelling was conducted to quantify and develop broad outcomes. This was an extremely important part of the process as it allowed the building form to be developed to maximise natural light, thermal comfort and energy efficiency.

2.6 Emergent design concept

2.6.1 A natural analogy

Following the two-week intensive workshop and subsequent design sessions a design concept emerged that used the guiding analogy of the tree and living systems. It had been found that using analogy in the design process could provide clarity and allow designers to understand complex systems quickly.

> 'Analogical design results from the designer using analogies with other fields or contexts to create a new way of structuring the problem.' (Lawson, 1997).

These comparisons to parts of the world that evoke similar emotional responses can quickly sum up the intent of the architectural expression. What is particularly revealing with architecture is how a guiding analogy or key idea can set goals that can guide the design process for all involved – designers, consultants, builders, clients and users.

For the CH_2 team the most compelling model for the buildings of the future was nature. A guiding diagram developed that visually captured many of the natural analogies of the design concept (Figure 5). It was based on the concept of synergy – a building comprised of many overlapping systems, each being more than the sum of its parts (Groak, 1992). Building fabric, people, engineering systems, energy flows, natural and man made landscapes all combined to form an inter-related whole.

The specific use of the nature analogy in the design process proved beneficial for many reasons. Nature became a:

- prompt to always look for integrated solutions
- functional model for complex processes
- way of valuing the natural world
- measure or ecological standard
- source for visual expression – e.g. the repetition of similar shapes at different scales.

For example, on the west façade – an epidermis (the outer living layer of an animal or plant) inspired the way the western façade moderated external climate and on the north and south, bronchi (wind pipes) came to symbolise expressed air ducts on the outside of the building.

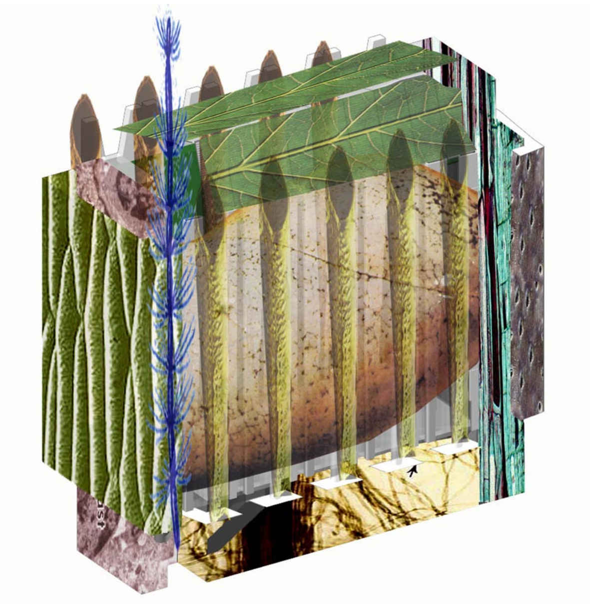

Figure 5. The emergent design concept

These concepts related to the emerging fields of 'biomimicry' – design innovation inspired by nature, and the concept of 'biophilia' – which deals with incorporating the natural environment into buildings.

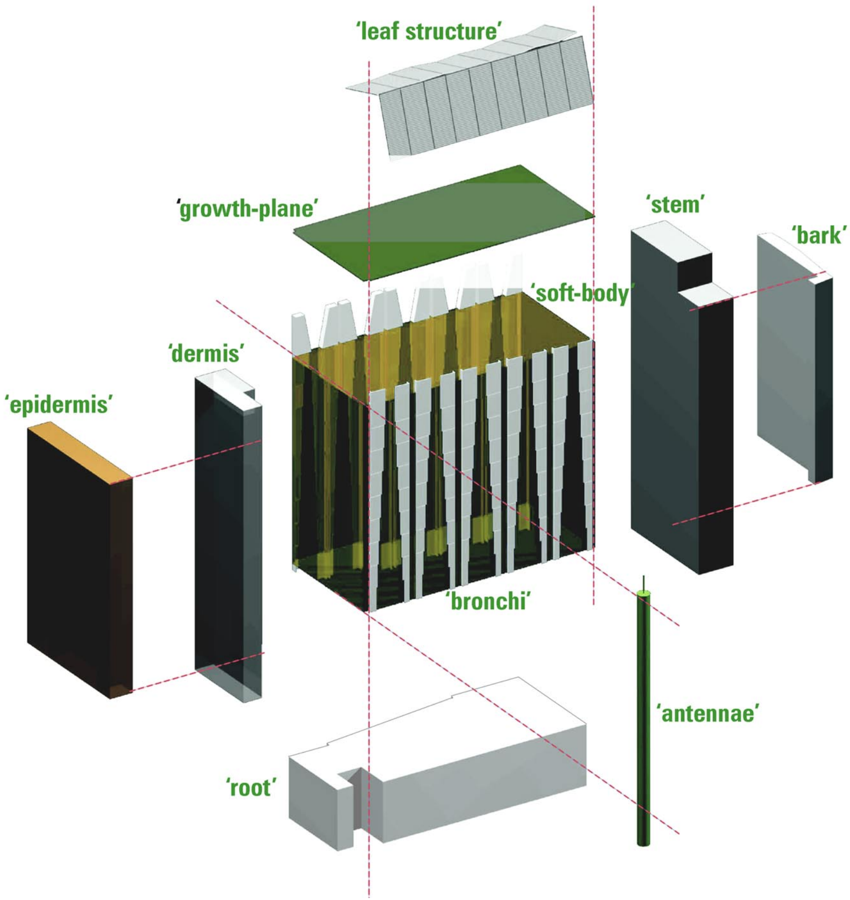

Figure 6. The natural analogy

Janine Benyus (1997) has described biomimicry in three parts:

'1. *Nature as model*. Biomimicry is a new science that studies nature's models and then imitates or takes inspiration from these designs to solve human problems, e.g. a solar cell inspired by a leaf.

2. *Nature as measure*. Biomimicry uses an ecological standard to judge the 'rightness' of our innovations. After 3.8 billion years of evolution, nature has learned: What works. What is appropriate. What lasts.

3. *Nature as mentor*. Biomimicry is new way of viewing and valuing nature. It introduces an era based not on what we can *extract* from the natural world, but on what we can *learn* from it.' (Benyus, 1997).

2.6.2 Naturally a hybrid

The goal of the design team was to produce a revolutionary office building that would propel the industry forward. However the team also acknowledged that many of the technologies and methods of integration that are required for a 'nature inspired building' haven't been developed yet. As a result, nature is used primarily as a source of inspiration rather than as a true functional model.

Therefore CH_2 is a hybrid – a fully functioning building, but one belonging to its particular time and space. Many of the advances taken with CH_2 will go further next time or be approached differently. The City of Melbourne was highly supportive of this ambitious approach and where possible encouraged the design team to include a 'less-tried' solution in parallel with a more conventional one in order to push the boundaries of sustainable design.

2.7 Workshop design benefits

The workshop process produced the following design benefits and outcomes:

- The rapid establishment of clear environmental values and goals set the basis for effective ongoing design review. For example, the early decision to incorporate north balconies for occupant access to nature became the primary generator of north shading and façade review.
- The opportunity for unexpected ideas (via cross discipline stimulation) led to the evaluation of many options. For example, the inclusion of artists stimulated the design team to consider a variety of textural and material solutions for surfaces;
- The emergence of a key guiding concept optimised time for further detail design and cost effective solutions. For example, the decision to express the service ducts on the outside of the

building enabled team members to focus on optimising duct/window size, cladding options and buildability.

- The testing of concepts using computer models as part of the workshop process provided immediate environmental and spatial feedback to the team.

2.8 Workshop lessons

Resource planning and industry preparation for an intensive design workshop was revealed to be critical. For example, preliminary subcontractor advice was possible on the design of the proposed precast floor units within a few days. This was largely due to the structural engineers' established relationship with the contractor. Armed with cost and buildability advice the team could continue to develop the unit with confidence during the workshop. Many other aspects of the early design could have benefited from having similar direct industry feedback at this stage.

3.0 THE EXTENDED DESIGN PROCESS

The phases that followed the workshop can be summarised as the *Extended Design Process*. The integrated approach to the design process ensured that each of these subsequent phases constantly reviewed and built upon the principles established in the workshop. It was the streamlined nature of the workshop process that permitted the ongoing design development.

3.1 Individual discipline testing

Following the collaborative stage of the design process it remained the task of individuals and individual disciplines to develop and further test many of the conceptual ideas. This became a far more streamlined process than in more conventional design methods that do not have an intensive design collaboration stage upfront. Time could be spent on research and testing because most of the principles of both form and system had been established. A great deal of effort was spent on materials research, eco-auditing, day lighting, thermal modelling and airflow.

For example, the eastern core and façade (which contains the service core and toilets to the building) used the analogy of bark (Figure 7). It was conceived as a protective layer that filtered light and air into the naturally ventilated wet area spaces behind. The final solution consists of two overlapping layers of perforated metal with polycarbonate walling and fixed metal louvres.

3.2 Design signoff

At the design signoff stage the team came back together for a review and summary of the process. Despite a very tight program, sufficient time was given to design representation, critical review, feedback sessions and client understanding. The final design solutions integrate as many of the individual components as possible - thus promoting the dual, or even three-fold, use of a particular element, system or material. In practice, this was a process requiring many value judgments and debates on the true environmental benefit of a component or method.

This process reflected the principal of *Occam's razor* – a principle of logic attributed to the mediaeval philosopher William of Occam. It stated that one should not make more assumptions than the minimum needed. It encouraged choosing, in a set of otherwise equivalent models, the simplest one (Davies, 1992). This is often nature's way and can be of great assistance in the design process when competing ideas or untested principles are at stake.

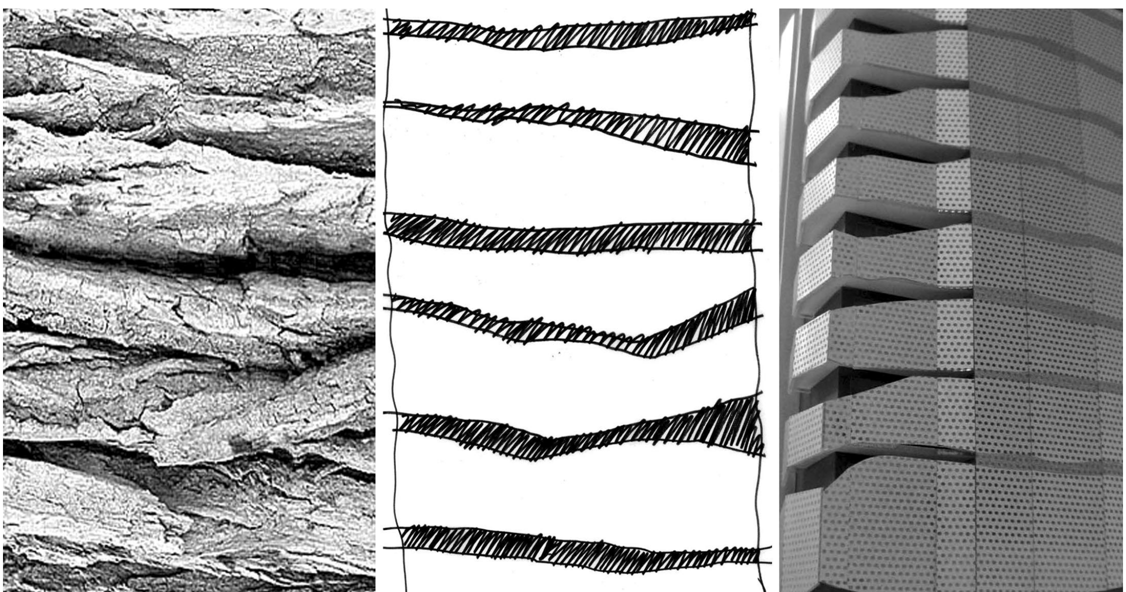

Figure 7. The bark

Figure 8. The precast floor / ceiling system

For example, in the design of the precast flooring system, many alternatives were investigated for the location of a return air penetration in the soffit. Environmental influences on its size and location included:

- optimum height for the air flow path
- thermal relationship to exposed chilled ceiling panels and curve
- structural and buildability constraints including proximity to ceiling services.

The final solution integrates the return air path with an oversized structural gap between the panels eliminating any penetration in the unit. The design of the precast flooring and ceiling system represented the most integral aspect of the design (Figure 8). The 180mm thick precast units provide:

- exposed thermal mass – assisting in passive cooling
- a vaulted ceiling profile assisting in airflow
- a hollow chamber that serves as a return air duct
- a more natural 'cave' aesthetic - assisting in maximising ceiling height
- attached chilled ceiling panels and beams provide an additional active cooling component as cool water is run through the panels creating gentle radiant cooling that descends into the workspace.

Key environmental design outcomes (refer Figure 9) presented at the design signoff stage included:

- All the air to the office spaces is 100 per cent filtered fresh air drawn from roof level, supplied via the south ducts and exhausted via the north ducts
- Fresh air is fed into the offices at low speed through individually controlled vents in the floor
- Operable windows north and south provide night-time purging of the space
- 'Shower towers' on the south side of the building act like passive cooling towers – air and water gently falls to provide extra cool water for building reticulation and cool air to supplement ground floor and retail cooling
- A 'green north façade' and roof top through the use of plants assists in shading, glare control and indoor plants improve air quality
- Water is piped through a battery like 'phase change' basement plant for pre-cooling
- Rain water collection and waste water basement treatment plant includes water mining from the Little Collins Street sewer
- Rooftop photovoltaic and solar hot water collectors and a co-generation plant.

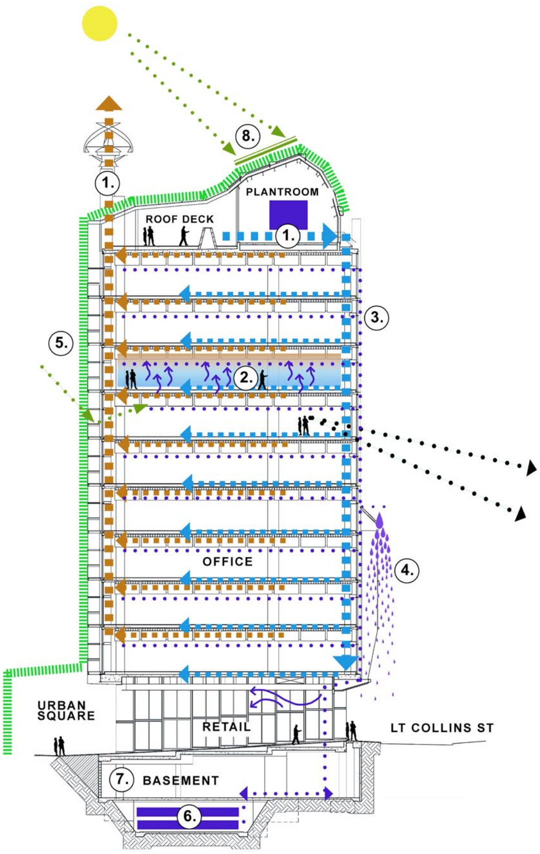

Figure 9. Bioclimatic north-south cross-section

3.3 Peer review and design ratings

Time was taken during the developed design period to consider independent forms of critique and assessment. For CH_2 this took the form of:

- reviews from other professionals
- input from the Sustainability Energy Authority of Victoria
- benchmarking and ratings

- salt bath modelling (salt bath modelling uses a scale model of a space using salt solutions to simulate thermal conditions and air flow).

The Green Building Council of Australia used CH_2 as one of its pilot evaluations for its Green Star office rating tool and CH_2 received a preliminary design stage rating of six stars, which recognised international leadership. This tool only became available to CH_2 during the design development phase, however as the design team moved into the construction stage this benchmarking proved to be a valuable tool for monitoring alternatives and options (see http://www.gbcaus.org).

3.3.1 Lessons

For many in the CH_2 team this part of the process was a new experience and one that involved additional time and research. Lessons included:

- Early peer review – greater benefit could have been had if peer reviews had been planned immediately following the workshop phase rather than towards the end of design development by which time many strategies were locked in.
- The early adoption of the Green Star tool – future projects should look to integrate the Green Star criteria into the structure of the workshop stage. This would ensure greater context for agreed environmental values and targets.
- DesignInc Melbourne have now adopted and integrated the Green Star approach into all conceptual design project phases and into the entire office set up – from office library to client briefing. This approach ensures all design decisions and alternatives are based on impacts on the total environment.

3.4 Prototype solutions

During the design development phase the use of prototypes was encouraged for certain key elements. A prototype suite developed over time and subsequently became the project office. Outcomes of this process included:

- The quality of the space could be tested not just systems – designers were able to visualise what the internal space would actually be like.
- Many customised elements could be interfaced. For example, lighting with chilled ceiling panel configurations (Figure 10) and timber windows with purge control arms.
- Actual work styles and flows could be tested assisting in the organisation adopting a significant change in work style culture.

3.5 Contractor review

The construction of CH_2 followed a traditional method of procurement with a builder selected via an expression of interest and tender stage. An important design initiative was the early introduction of the project to tenderers. Tenderers' representatives attended a number of workshops in the weeks leading up to tender. This led to a comprehensive understanding of the proposed systems and an opportunity for the builders to provide comment on the project before tender documents were completed.

Throughout the construction stage a *partnering* approach was established between the builder and other team members. This led to constant review and feedback by the builder. Alternative materials and construction approaches were encouraged and the builder became jointly responsible for monitoring the environmental appropriateness of all materials, systems and construction techniques. This approach ensured the builder (and therefore the broader construction industry) became an active part of the design team and a strong advocate for the ideas behind CH_2 rather than an adversary during the construction process.

Figure 10. Chilled ceiling prototype

3.6 Monitoring built form

The final phase of the process will close the design loop by monitoring the environmental performance of the completed building. At the time of writing, this phase of the project was yet to be commenced. Time will be dedicated to learning how the building performs. It is anticipated that the *tuning* of the building will extend over at least a 12-month period to accommodate all seasonal variation.

Sensors and monitoring systems have been built into many components of the building. Of equal importance to the physical monitoring of data will be occupant feedback. Outcomes such as:

- The extent of user control – how much freedom do individuals experience with regard to internal environmental conditions?
- The success of the indoor environment quality – are there greater senses of well-being, reductions in absenteeism and increases in productivity?
- Future proof – how successful and adaptable to change is the fit-out and service systems?

4.0 CONCLUSION

4.1 A natural conclusion?

While the integrated design process developed on CH_2 led to many beneficial and unexpected design outcomes, the majority of these outcomes represented hybrid solutions between traditional industry solutions and customised adaptation. Those who have worked on the CH_2 project were lucky enough to be part of a new shift in the way buildings are designed, procured and experienced – already there is growing precedence for this approach worldwide.

The buildings of the future may not look like CH_2, but nor will they resemble the predominant buildings of today. Through projects like CH_2, a new 'living architecture' is slowly emerging that expresses climate and culture and aims at creating environments that integrate people and buildings with the natural world.

4.2 Integrated lessons

The key lessons and design directions for future projects distilled from the integrated design process included:

- That for the foreseeable future biologically sustainable architecture will remain a hybrid – but one that can take all its key architectural ideas from natural principles.
- That biologically sustainable architecture should focus on the principles of a healthy building. For example, the ability to have a break from an immediate work environment and step outside to access nature. The low velocity and fresh air nature of the cooling system was expected to be critical in increasing well being and productivity and reducing absenteeism.
- That low velocity and night purge ventilation systems often require unobstructed floor areas. This naturally leads to an 'open plan' fit-out office space. It was found that for such layouts acoustic privacy could be placed under significant pressure. Strategies should be put in place early in the design phase to allow enough flexibility for a variety of work styles. For CH_2 the semi enclosed spaces were zoned on the south perimeter. These were encouraged to be quiet work spaces rather than 'owned' offices.
- That biologically sustainable architecture should remain sufficiently 'ordered' to suit a larger city context – individual buildings should remain a part of a greater fabric. Trusted urban principles of scale, functional articulation and active edges should be incorporated and thought to be as much a part of designing sustainably as energy reductions. Further research on sustainable city building dimensions and heights was found to be needed.
- Further to this, no overt attempt was made to create a green looking building. The approach taken was that sustainable design should equal good design. For example, façades respond to their respective orientation and use.
- That sustainable design rating tools should not only set initial project values but be embraced throughout the design process as a method of incorporating broader environmental imperatives. It was found that care needed to be taken to not strive for additional 'points' at the cost of buildability or prohibitive time penalties.

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BIOGRAPHY

Stephen Webb is an architect and design director of DesignInc Melbourne. Having first developed a zeal for climatically responsive design growing up and practising in Queensland, he has since worked on both the east and west coasts of Australia and extensively in the United Kingdom.

As design director at DesignInc Melbourne, Stephen has been instrumental in the development of the sustainable design philosophy of the practice – a philosophy that promotes building fabric as an evolving expression of natural systems and the active design of spaces to meet the social functions they carry. He was one of the principal designers of CH_2 and of the Bio21 project at The University of Melbourne. Recent design projects include research into the aesthetics of sustainability and how the science of complexity may manifest itself in the built environment.