CRC promotes innovation *as it happens*

According to recent research, everyone in the Australian building and construction industry, no matter where they fall in the supply chain, can benefit from innovation.

The Cooperative Research Centre for Construction Innovation's BRITE project recently launched a series of six innovation case studies, to demonstrate the benefits of innovation and successful implementation strategies across the industy. They are presented as short booklets highlighting the lessons learnt by innovators, and two are published infull in this issue of Building Australia. All six case studies can be downloaded for free from www.brite.crcci.info.

Key findings from the first three studies suggested that:

- the benefits of innovation are significant;
- innovation involving adoption of advanced technologies and practices developed elsewhere is just as beneficial as original innovation;
- the type of contract employed on a project can have a profound impact on the opportunities for innovation and the benefits derived ;
- successful implementation of innovation relies on good relationships between related parties;
- building relationships with clients is a key means of gaining competitive advantage through innovation;
- successful innovation is often dependent on good linkages with global experts; and
- small, local businesses can be technology leaders.

BRITE Case Study No 1 demonstrates how whole-of-life costs for commercial buildings can be dramatically reduced without increasing up-front building costs. This achievement arose largely from a clever combination of proven air-conditioning technologies and innovative building design. Energy costs were reduced by 37%.

BRITE Case Study No 2 shows the benefits that can be achieved through appropriately designed prefabricated building components. In this case, a concrete planking innovation saved more than $300,000 on a major sports stadium.

BRITE Case Study No 3 illustrates the importance of the form of contract employed on projects. In this case, the alliance contract facilitated very substantial project benefits on a complex motorway development, including a 10% reduction in project costs and a 30% reduction in time required for project completion.

BRITE Leader Dr Karen Manley has announced that the project is seeking case study nominations from businesses wanting their innovations documented and profiled for free. Nominees must be able to demonstrate that they have quantified the benefits of their innovation, and the project is particularly interested in the activities of small and medium-sized business, especially in regional areas. To pre-register your interest, send an email to k.manley@qut.edu.au.

The BRITE Project is also conducting an Innovation Survey in April/May 2004, covering contractors, consultants, clients and suppliers. It enhances work by the Australian Bureau of Statistics.

The CRC intends to use the survey results to design its programs, which aim to improve industry performance. The CRC would like to encourage industry participants to complete the four-page survey, should they receive it. BA

William McCormack Place in Cairns benefited from energy, capital and maintenance costs as a result of airconditioning innovations.

A suite of air-conditioning innovations on a new government office building in Cairns – William McCormack Place – is delivering substantial estimated benefits compared to a more conventional approach, including:

- 37% savings in energy costs; and
- 61% savings in air-conditioning capital and maintenance costs.

These and other innovations incorporated in the building demonstrate that environmental sustainability can be addressed without compromising quality, cost, time or scope.

The Project

William McCormack Place is a 4568m^2 (net lettable area) four-storey commercial office building in Cairns. It was built by a private sector construction manager under a two-stage, design and construct, guaranteed maximum price contract with an overall budget of $17.5m including fitout and public art. The building was opened in September 2002, delivered on time and within budget, after an 18-month design and construction program.

The Achievement

Queensland Department of Public Works (DPW) wanted to demonstrate that an office building could be constructed to meet strict environmental sustainability targets while

Outstanding whole-of-life gains without higher costs

remaining commercially viable. The Department stipulated that the building must meet a minimum 4-star energy rating under the Australian Building Greenhouse Rating Scheme, administered by the Sustainable Energy Development Authority (SEDA). In fact, the building has exceeded this standard without compromising commercial objectives.

An extensive energy audit conducted in August 2003 found that William McCormack Place has achieved a 5-star energy rating, which is the maximum possible under the SEDA scheme. William McCormack Place was the first commercial office building in Australia to be awarded this rating.

The client and project team have succeeded in designing and constructing a commercial building which minimises life-cycle costs without increasing project costs. The building cost no more to build than a comparable conventional building and will be nominated for the Facility Management Association of Australia, Awards for Excellence, 2004.

The Innovations

The 'innovation' on the William McCormack Place project is the adoption of a unique package of proven technologies and advanced practices, many of which had not previously been employed on DPW projects. The Department notes that often, improved building performance is "not a case of the development of complex or costly new technologies but one of effectively using a combination of existing technologies".

The improvement in life-cycle costs at William McCormack Place is largely due to a collection of well-combined advanced and proven air-conditioning technologies, comprising:

- chilled water thermal storage tank: eliminating the need for a low-load chiller and associated prolonged periods of inefficient low-load operation of chiller sets;
- moisture absorbing thermal (heat exchanger) wheel: used to recover cool and dehumidified outside spill air energy to precondition incoming hot, moist ventilation air;
- variable speed motor drives applied to air-conditioning pumps and fans: so that only the amount of air or water required at any time is mobilised;
- 'duty-standby' operation of the two 100% chiller sets: reaping efficiency gains over the suggested alternative 'lead-lag' configuration of two sets at 70% each, plus a low-load set; and
- rotary screw chillers and low fan power cooling towers: facilitating high efficiency chilled water generation.

The thermal tank and wheel are the most novel and influential elements of the air-conditioning system, and the focus of this case study. Internal and external quantity surveyors' reports on William McCormack Place indicate that the cost of a commercial building with environmental enhancements, such as those listed above, need be no greater than the cost of a comparable building without such enhancements. The cost of some additional plant at William McCormack Place directly resulted in cost savings in other plant. For example, the cost of the thermal wheel was partly offset by an associated reduction in the required capacity for the refrigeration plant. Additional modest cost savings were achieved through a Value Management study.

The Benefits

The thermal tank and wheel are major contributors to significant energy savings. Energy costs for William McCormack Place are currently 37% less (on a per square metre net lettable area basis) than the energy costs for similar North Queensland government properties. The savings arise largely from the air-conditioning technologies, assisted by the building structure's thermal qualities.

These substantial whole-of-life gains are augmented by savings in capital and maintenance costs due to adoption of the thermal tank in preference to a low-load chiller. Comparison of the projected hardware and service costs over 45 years shows savings of 61%. Over that period, the low-load chiller would require on-going maintenance, including a complete rebuild or replacement, while the thermal tank is largely maintenance free.

The above project benefits have been achieved by the adoption of proven advanced technologies and practices, rather than through the development of original innovations. The extent of benefits indicates the significant value of adopting innovations that are simply new in a particular context, rather than necessarily 'new to the world'.

The Implementation Process

A key driver for adoption of the thermal tank and wheel was DPW's desire to improve the energy efficiency of its buildings, while the mechanical and electrical engineer, MGF Consultants (MGF), was motivated by the potential improvement to their reputation and the belief that this would enhance their competitive position in the marketplace.

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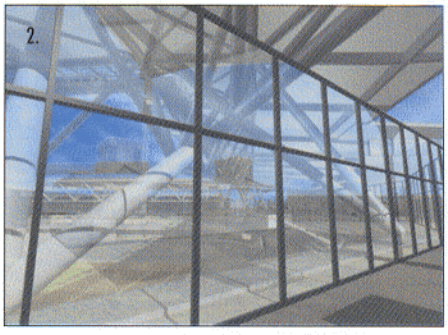
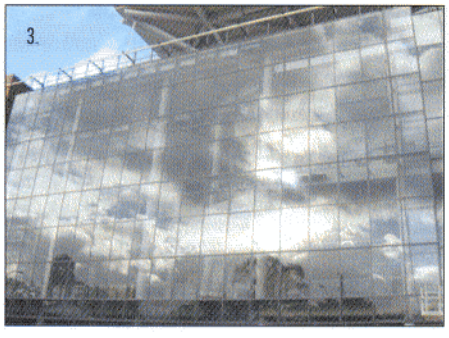
Concrete plank solution offers major savings





1. Clever planks, showing rebates and steel studs that facilitated composite connection to steel beams

2. An early impression of Suncorp Stadium

3. The glass façade at Suncorp Stadium

A new method of manufacturing concrete planks and connecting them to supporting steel beams has resulted in substantial benefits to the Suncorp Stadium project in Brisbane.,. The new 'composite' connection method generated estimated savings of:

- $260,000 in steelwork costs; and
- $70,000 in labour costs.

The Project

Suncorp Stadium is a 52,500-seat, world-class football facility, constructed by a private sector managing contractor under a two stage, document and construct, guaranteed maximum price contract, with a project budget of $280m. The stadium was opened in June 2003, delivered on time and within budget, after a 2-year documentation and construction program.

The Achievement

The 'clever plank' innovation involves the design of *formed* rebates in the ends of precast prestressed *polystyrene-voided* concrete planks, together with the design of concrete topping and reinforcement details, to provide a crack-free, reliable composite connection between the planks and steel beams supporting the grandstands at Suncorp Stadium. The two main elements of this innovation, the polystyrene-voided planks, and the formed rebate detail, have only been combined on a few occasions globally in the building industry. The *particular* planks supplied by Quickcell Technologies, and the *particular* rebate and associated details designed by Arup, are unique to the Stadium project and have resulted in substantial benefits.

The Innovation

Quickcell Technologies is a small Queensland company that supplied clever planks to the Lang Park Redevelopment Joint Venture. Their unique approach to constructing precast prestressed polystyrene-voided concrete planks contributed to their selection by the managing contractors. Instead of saving plank weight through a more conventional extrusion process which creates a hollow core, Quickcell casts polystyrene blocks into the planks to create voids. This technology is relatively common in the civil sector for bridge beams; however, it is only just beginning to be transferred and modified for use in the building industry.

Comparing clever planks to traditional extruded building planks reveals their greater flexibility in the occurrence of voids within each plank. The voids in the cast planks provided by Quickcell Technologies can be positioned to keep the ends of the planks solid, providing enhanced shear resistance, compared to extruded planks, which have the same pattern of voids throughout their length. Arup recognised the opportunities offered by the casting process to shape the ends of the panels to achieve reliable *composite* connection to steel beams.

The Arup-designed rebates could be readily formed during the plank casting process, and facilitated efficient and effective composite connection of clever planks to supporting steel beams. The strength of the composite connection in turn created the opportunity to use lighter steel beams, which provided the key savings. Composite connections have been successfully made in the past between steel beams and extruded planks, but this has involved a labour-intensive process of on-site cutting and forming that has negated the cost benefits of the reductions in steel weight.

Quickcell Technologies was the first company in Australia to manufacture precast prestressed *polystyrene-voided* concrete *building* planks (as opposed to bridge beams), and one of the first in the world to do so. Their first use of voided planks was in 1995, and since then the planks have been used on a number of major projects, including the Brisbane Cricket Ground. The planks are protected by a range of intellectual property laws and treaties, domestically and internationally.

The efficiency of the clever plank, with its rebates and capacity for composite connection, was not covered by the Australian Building Code or available research data. Therefore, Arup sponsored an engineering student to conduct full-scale prototype testing to verify the performance of the novel connection design. The testing confirmed its structural efficiency, and the Stadium concourses have been successfully constructed with crack-free concrete topping. Arup and Quickcell Technologies are happy to share in the benefits of the innovation and both organisations intend to apply similar ideas on new projects.

The Benefits

The use of clever planks reduced the weight of the Stadium grandstand steel floor beams by approximately 25%, due to the efficiency of the composite connection between the planks and the steel beams. This translated to an estimated saving of $260,000, which represented approximately 8% of the cost of the grandstand steelwork. Further, the concrete topping detail resulted in toppings free of the cracking that normally occurs with use of standard planks. Not having to repair cracks resulted in an estimated saving of $70,000. These combined benefits, totalling $330,000, have been estimated compared to precast prestressed polystyrene-voided concrete planks with a conventional *non-composite* connection to steel beams.

The Implementation Process

The clever plank innovation arose in part from the opportunities for designer and contractor interaction inherent in a document and construct contract. The preliminary stadium design on which the managing contract was tendered incorporated a structural system assessed as the lowest cost option by quantity surveyors, that is, conventionally formed concrete beams and slabs. When the Joint Venture was appointed, they agreed that the conventional approach was the cheapest in direct costs; however, they pursued the idea of a steel beam and plank design, based on advantages related to time, risk and management of sub-contractors. The Joint Venture asked Arup to explore the technical feasibility of such an approach. It was found that while the components were more expensive for beam and plank construction, the timber and sub-contractor savings related to the absence of formwork were significant.

The above advantages result for either extruded or voided planks employed in a conventional non-composite way, although voided planks can be more efficiently attached to supporting beams by adjusting the pattern of voids to create solid ends for more robust fixing. Arup looked beyond these advantages in response to the contractor's request to find further savings.

The contractor's interest in savings was driven by the form of contract, which allowed for the development of alternative designs and for shared benefits between the contractor and client if the project was delivered below the guaranteed maximum price. It seems this contractual driver helped to create an environment where innovative ideas were explored and embraced.

Arup's study of a series of steel and precast plank options identified the potential cost savings of lighter steel beams if a reliable and practical method of achieving composite connections between planks and beams could be developed. After consulting with leading researchers in the field of composite steel connections, Arup devised the innovative rebate design. They then calculated the theoretical capacity by extrapolating from available theory and codes, and arranged for full-scale prototype testing to verify the accuracy of the design calculations and the efficiency of the connections. The construction programme dictated that the manufacture of the clever planks commenced before the prototype testing was completed, but the designers were confident that the results would be positive. Arup's confidence in the design has subsequently been borne out by the prototype test results and the faultless performance of the planks and concrete topping on site.

The implementation of the clever plank innovation will not end with this project: both Arup and Quickcell intend to use the innovation on future projects. Arup will maximise these opportunities by publicising clever planks on its internal skills network, plans to submit a paper for publication with the Institute of Engineers, and is currently providing advice to colleagues considering similar plank and beam approaches. Further, the clever plank innovation has been submitted to Arup's innovation competition, which feeds into the organisation's marketing efforts. Such initiatives encourage employees to take the time to write up the benefits of their innovations, an activity that can otherwise be marginalised in the project-to-project rush of work.

Overcoming Difficulties

A large part of Arup's role as engineering consultants on projects is to provide ideas to clients and contractors, which benefit those two parties, but not necessarily Arup in a direct sense. Certainly, reputation is important for consultants, especially reputation for money-saving innovations, and Arup profits in this sense. Nevertheless, the benefits from construction innovation are not evenly spread along the supply chain, nor does the proponent/inventor necessarily profit directly. This problematic incentive structure is likely to constrain innovation efforts.

In the clever planks case, Arup was aware of recent changes under the Queensland Department of Public Works prequalification system for building industry consultants, which have seen 'innovation history' added as a criterion. Such moves help to make the benefits of innovation to a company's reputation more tangible, by recording and valuing the extent of the organisation's innovation activity.

Overall, there were few obstacles to the implementation of clever planks on the Stadium project, due to the positive drivers established by the form of contract, which encouraged the contractor to seek and support money-saving innovations.

Lessons Learned

- Contract type plays a critical role in establishing incentive structures for innovation on projects.
- Robust linkages between suppliers and more central project participants can yield significant dividends.
- Innovation is dependent on good linkages with global experts.
- Prefabricated building components can offer significant project savings.
- Local firms can be global technology leaders.
- Robust relationships between firms and universities provide mutual benefit, enhancing learning and innovation opportunities.
- Government clients play a key role in shaping the industry's innovation opportunities, through both prequalification activities and contract types.
- Internal company award competitions can provide incentives for learnings to be documented and encourage employees to suggest new approaches.
- Labour conditions associated with various trades can effect the direction of innovation by impacting on the likely cost of alternatives.
- Borrowing ideas from related industries is a useful innovation strategy.

For more information about this or other BRITE project case studies, contact: Dr Karen Manley, CRC for Construction Innovation by phone on 07 3864 1762 or email k.manley@qut.edu.au. BA

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Thermal Tank

DPW's original brief suggested that three chiller sets be installed to manage air-conditioning requirements; however, MGF's experience indicated a more efficient system would replace the third low-load chiller with a thermal tank to obtain maximum efficiency from the chillers. MGF designed the first large-scale tank in Australia in the late 1990s, roughly a decade after the first use of tanks overseas, motivated to do so after having monitored their performance via industry newsletters and networks.

MGF understood the technology and had 'runs on the board' proving its effectiveness and the accuracy of payback periods. DPW audit engineers reviewed the design and agreed that energy performance was likely to be significantly improved by the thermal tank. The adoption decision was made against the climatic backdrop of the building. The heat and humidity in Cairns is quite extreme, demanding the use of innovative technologies in order to minimise environmental impacts.

Thermal Wheel

MGF introduced the first total enthalpy thermal wheel into Queensland in 1986 and has since designed several hundred. The firm was an early adopter of this technology, as such wheels only emerged globally in the mid-1980s.

The company's ability to encourage client use of the wheels was assisted by their review of developments overseas. Their knowledge and experience enabled them to strongly champion the use of a thermal wheel on the William McCormack Place project, and DPW was able to confirm the value of the technology with internal mechanical engineers who knew they were widely used in Europe.

The Queensland Government had an interest in local employment for this regional project through its Local Industry Participation Policy, which provided MGF with the opportunity to be involved. MGF was a local firm with considerable expertise, and experience with the often extreme local weather conditions, whilst also having linkages with the technical experts in Australia, America and Europe. The success of this project shows that regional firms can be technology leaders and that knowledge can be gained from them, rather than merely imparted to them.

Overcoming Obstacles

Obstacles to the adoption of environmentally friendly technologies, such as the thermal tank and wheel, have traditionally been high up-front costs and risk aversion. However, this case study has shown that:

- the cost element is circumventable when addressed in the context of the overall design and construction of a building; and
- clear objectives and design can reduce the risks, for both managing contractors and clients, to acceptable levels.

Another historical problem has been the lack of awareness of building users about the negative environmental impacts of conservative approaches to building. However, as concerns about energy and other conservation issues have become more prominent, building users have become more savvy: demanding energy-minimising buildings and creating the need for appropriate project delivery mechanisms.

For William McCormack Place, DPW decided that the team responsible for the ongoing management of the building would deliver the project. This gave the opportunity for project decisions to be made not only on the basis of time, budget and quality, but also in terms of the functionality and manageability of the property based on the building life cycle from a facility management perspective.

This was the first time a major contract was managed by DPW in this way, with the facility manager playing such a significant role. The approach enhanced DPW's role as an informed client, with the required awareness to encourage the adoption of advanced technologies.

The adoption of advanced technologies was also facilitated by the construction management style of contract, which involved the builder very early in the design process. Their early involvement meant no 'rude shocks' when it came to advanced technologies being incorporated into the design. The guaranteed maximum price element of the contract ensured that the design was as thorough as possible, to reduce the builders' risk, and to ensure that the final design was 'buildable'.

Finally, there are often obstacles to adoption of advanced technologies and practices when tender selection is based solely on cost, as innovation is rarely associated with the lowest cost tender. In this case, the mechanical and electrical consultant, MGF, was selected on experience and ability, not just on competitive cost. This approach and MGF's selection was critical to adoption of the thermal tank and wheel.

Lessons Learned

Environment

- Up-front costs associated with environmental improvements can be modest and manageable, within the context of overall design and construction of a building.
- Environmentally sustainable technologies offer significant improvements in the performance of commercial buildings.
- Clear environmental objectives and thorough design processes reduce risk for both the builder and the client.

Local Firms

- Local firms can offer significant value on large projects, particularly in terms of understanding local conditions.
- Local firms are not always 'behind the game' and can in fact be technology leaders.

Clients

- Informed clients facilitate the adoption of advanced technologies and practices through their ability to expertly cross-check innovative proposals.
- Clients willing to entertain acceptable risks can lead the industry in demonstrating the benefits of innovation.

Innovation Processes

- Early involvement of users (eg. facility managers) can lead to optimal outcomes (eg. building performance)
- Attention to international developments is an effective way for industry participants to gain competitive advantage.
- Standards can drive innovation, particularly when set just beyond current capabilities.
- Innovation, via adoption of existing advanced technologies and practices, sits alongside original innovation, as a powerful driver of performance improvement. BA