THE **BRITE** PROJECT

Innovation Case Study No 2

Concrete Planking Innovation Saves over $300,000 on Major Sports Stadium

This series of innovation case studies has been developed by the BRITE Project of the Cooperative Research Centre for Construction Innovation. The case studies demonstrate the benefits of innovation and successful implementation strategies in the Australian Building and Construction Industry.

Who should read this? Participants in the building and construction industry, particularly concrete product manufacturers, structural engineering consultants, and commercial building clients.

CRC AUSTRALIA

CRC Construction Innovation

BUILDING OUR FUTURE

Concrete Planking Innovation Saves over $300,000 on Major Sports 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, Australia. The new 'composite' connection method generated estimated savings of:

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

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

Selected Project Participants

Client:	Sport and Recreation Queensland (SRQ)
Project Director:	Queensland Department of Public Works (DPW)
Project Manager:	DPW
Managing Contractor:	Multiplex Constructions and Watpac Australia, as the Lang Park Redevelopment Joint Venture
Architects:	HOK Sport and PDT Architects
Engineers:	Arup *Structural/Civil/ Transportation/Geotechnical/ Environmental/Traffic*
Plank Supplier:	Quickcell Technologies

Organisations consulted in preparing this report: Arup and Quickcell Technologies

Cover photo: Constructing Suncorp Stadium, Brisbane

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.

Hossein Shamsai, Managing Director, Quickcell Technologies:

'manufacturers have a lot to offer the industry'

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. Bridge and building applications are very different; for example, building planks are often required in far greater numbers than bridge beams; further, building planks have a much lower depth and much higher width and a lesser requirement for load bearing, all of which results in different manufacturing processes.

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. Arup have noted that:

> … the contractual arrangement was not like a lump sum fully documented contract, where the contractor is basically given the design and told to go away and build it. Here, the Joint Venture was encouraged to look at alternative forms of construction.

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.

Formwork is very material and labour intensive. The advantages of not requiring formwork for the stadium included a less congested site without large numbers of form workers; reduced car parking and concrete truck access problems in the inner city location; and no concreter delays/disputes to hold up following trade work. Previous experience with highly unionised workforces and industrial action fed into the decision-making process. Further, the absence of formwork meant that areas underneath the grandstand were not obstructed with temporary propping, which restricts trade work. Finally, formwork is a relatively risky activity because when concrete is poured, subcontractors have to erect scaffolding,

planks and ply, designed properly to support the weight. Quality control is an easier proposition, and standards can be guaranteed, when concrete planks are manufactured off-site.

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. The contract 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.

Stephen Davies, Structural Engineer, Arup Cairns:

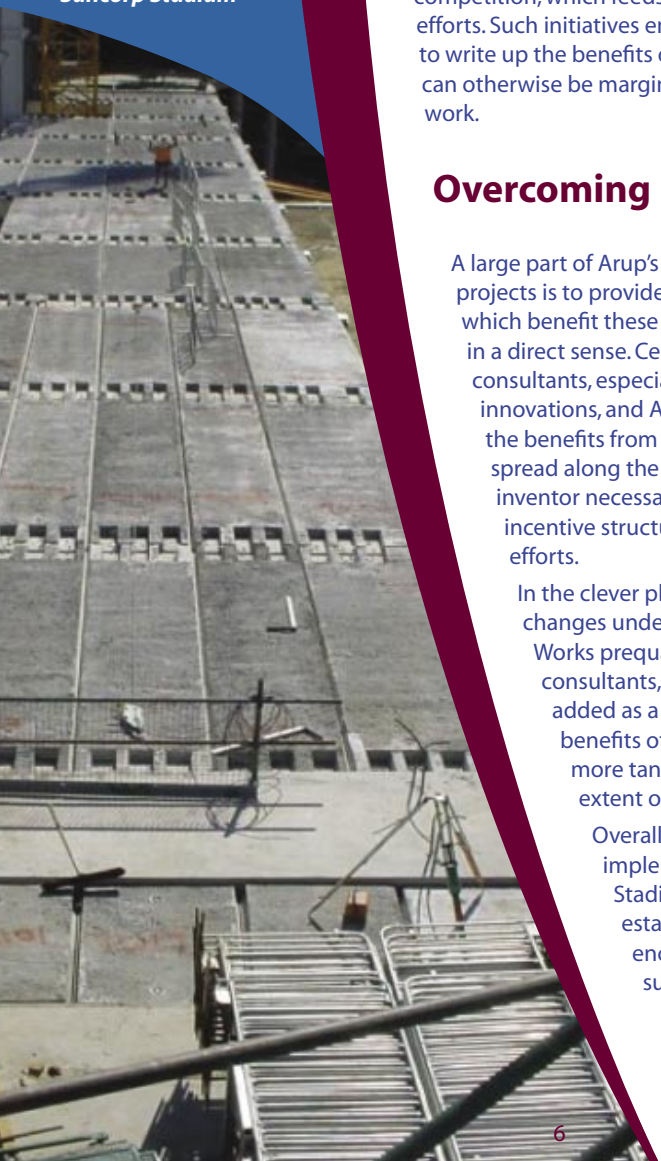
'it's been a collaborative effort'

Close-up of clever plank connection prior to the application of topping concrete

Ian Ainsworth, Manager Building Structures, Arup Brisbane:

'this is more than just talk, the benefits of the innovation have been tangible'

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 their internal skills network, which is a formalised knowledge-sharing system operating across the organisation's global operations. They observe that this system 'is imperative because otherwise many of the benefits of a large organisation would be lost'. The company also 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.



Clever Planks at Suncorp Stadium

Overcoming Difficulties

A large part of Arup's role as engineering consultants on projects is to provide ideas to clients and contractors, which benefit these 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.

Aerial view of Suncorp Stadium, Brisbane

An early impression of Suncorp Stadium

Brite Project Partners:

CSIRO

QUT

University of Western Sydney
Bringing knowledge to life

ARUP

Queensland Government
State Development

Queensland Government
Department of Main Roads

Queensland Government
Department of Public Works

Brite Project Supporters:

acif
Australian Construction Industry Forum

Construction Best Practice

ACEA

CCF

Movement for Innovation

Further information:

Dr Karen Manley
Research Fellow
School of Construction Management and Property
Queensland University of Technology
GPO Box 2434
Brisbane Qld 4001
Australia

ph: 61 7 38641762
email: k.manley@qut.edu.au

www.brite.crcci.info

2004