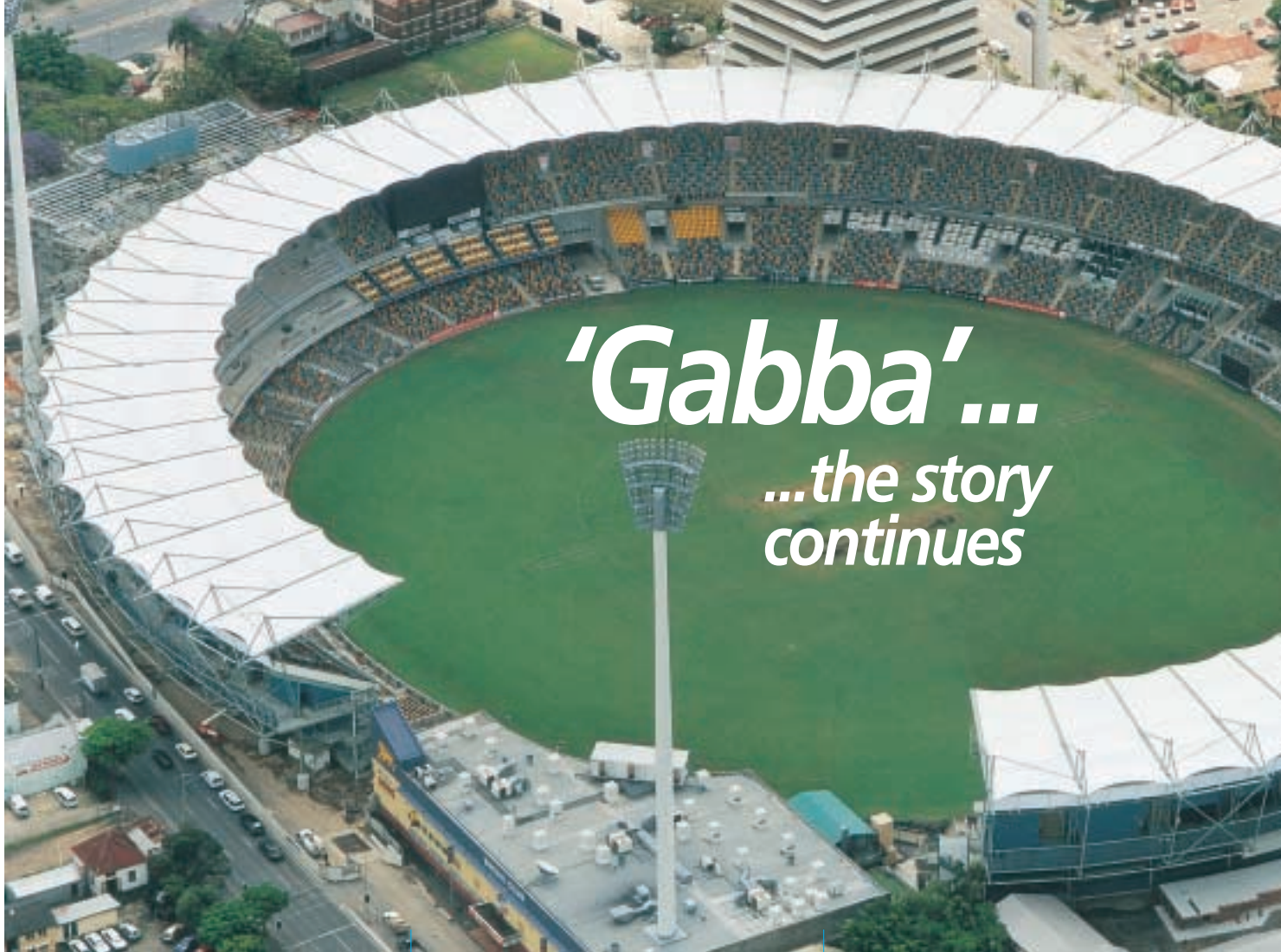


The Gabba's Steel Frame

May 2000

This case study was written at the time when InfraBuild (formerly Liberty OneSteel) was part of BHP. In that context, in some instances within this case study reference may be made to BHP.



'Gabba'the story continues

The transition is almost complete. Following on from the multi-award winning Northern Stand in 1995, the Brisbane Cricket Ground, affectionately known as 'the Gabba', has undergone two further stages of construction, with the completion of the Eastern and Western Stands (Stage 4) and the Southern Stand (Stage 5) in late 1999. Presently undergoing field reconstruction and Olympic overlay works, the 37,000 seat world class stadium is being readied to host the Olympic Football (soccer) tournament. Extensive Fire Engineering research support has provided a cost effective solution for the redevelopment of the stadium, utilising an unprotected steel frame.

Architecture

The master-plan undertaken in 1993 by Daryl Jackson Pty Ltd, in association with the International Facility Corporation, recommended that the design should:

- Have a structure that was incrementally expandable
- Be related to the Queensland ambience
- Have a ground capacity of 35,000.

The progressive development of the ground, and the continued involvement of the architect from master-plan stage through to its present highly acclaimed state, demonstrates how successfully the architects have met the original brief.

The Stage 4, 18 bay Eastern Stand comprises four levels, similar to the Northern Stand, whilst the Stage 4, five bay Western Stand is similar to the Eastern Stand, but includes ground maintenance facilities within Level 1, and the relocated Hill scoreboard.

The nomination of the Brisbane Cricket Ground by the Queensland Government as the venue for the Olympic 2000 soccer matches was the catalyst for development of the next stage of construction. Stage 5 incorporates a 15 bay Southern Stand, of five levels, extending from the end of the five bay Western Stand to the western end of the existing Lions Social Club. This stage required the removal of the famous

(infamous?) Hill, an area much loved by the populist poet Rupert McCall in his heyday. The Clem Jones Stand was demolished and the Hill scoreboard relocated to the Western Stand. According to architect Gary Carter of Daryl Jackson Pty Ltd, the ability to relocate the large scoreboard into the Western Stand construction without compromising the construction timetable is testimony to the flexibility of steel framing.

The ground operated very successfully at full capacity for the recent Australia versus Pakistan one-day cricket match. Gary believes that the use of structural steel as the main framing material has contributed to the success of the project. He is particularly pleased that the architectural vision for a light visual frame has been so gracefully achieved in the difficult cantilever structures over Stanley Sreet.

Structure and Construction

Watpac Australia Pty Ltd (Watpac), having built the existing Northern Stand in 1995, successfully tendered for the subsequent Stage 4 contract and were appointed as Managing Contractors for the works. The Eastern Stand was completed in March 1999, one month earlier than scheduled, and the Western



Stand was delivered on time for match use in May 1999. Watpac were again successful tenderers for Stage 5 and were appointed by the Trust to manage the design, documentation and construction for agreed fees, preliminaries and margin. The design consultants were novated to Watpac. A Guaranteed Maximum Contract Sum was developed and agreed, and a share of savings arrangement implemented.

Structural steel was used extensively throughout all stages of construction to support the seating, concourse and back of house amenities areas. The innovative design of the initial elliptical grid for the master plan, by Daryl Jackson Architects, required economical design solutions.

Watpac, in conjunction with structural engineers Robert Bird & Partners and with input from BHP Steel, decided upon structural steel to provide these solutions.

According to Watpac Design Manager, Gary Gisik, structural steel not only provided an innovative design solution for the primary structure, but also delivered the following additional benefits:

- Enhanced the architectural intent developed by the architect's master plan.
- Provided cost effective design solutions to support seating plats and large spans for suspended concourse areas.
- Maintained the majority of structural works being prefabricated off site, thereby eliminating congested storage of material on what was an extremely tight site.
- Enabled pre-finished structural and architectural elements to be combined and erected in single phases, which proved to be efficient in time. This also enabled immediate flow of subtrades to pre-finished areas.

"This last point was of particular benefit when constructing the majority of works over Stanley and Vulture Streets, where access and traffic restrictions meant that speed of construction was paramount," Gary said.

"The use of structural steel as the major building element was further supported by the introduction of the project specific Fire Engineering Design Brief (FEDB)," he said.

"The introduction of this brief enabled the level of fire risks to be established based on the nature of occupancy and building classification class. The FEDB provided economical design solutions which were carried throughout the design process and further encouraged the extensive use of structural steel as the primary framework without further fire protective site treatment."

Consulting civil and structural engineers for Stages 4 and 5, Robert Bird & Partners Pty Ltd, recreated the structural framing solution they had previously adopted on the Northern Stand. The system was modified to accommodate new design features such as an

The 'Gabba' played host to the recent Australia v Pakistan one-day match.



additional tier to the Western and Southern Stands and part of the Eastern Stand, and the relocation of the Hill Scoreboard to the Western Stand, and the dramatic cantilevering of the Southern Stand over Stanley Street. A particular challenge was the dramatic 13m cantilever over the four-lane Stanley Street.

The steel raking girders and steel beams are supported on steel columns comprising circular hollow sections and universal columns. Precast pre-tensioned concrete seating plats span distances of 8m to 11m between the steel raking girders. The horizontal floors (Level 3 and 4) beneath the seating tiers comprise 250mm and 300mm thick precast concrete hollow-core panels, also spanning 8 to 11m, and topped with 75mm insitu concrete.

Description	No. of Bays	General Seating	Corporate Suites (12p)	Corporate Boxes (8-10p)	Total Seating	No. of Seating Tiers	Total Cost (\$M)	Av. Cost per Seat(\$)	Steel Tonnage
Stage 3 - Northern Stand (built 1995)	15	9,132	19	27	9592	2	36.8	3836 ¹	450
Stage 4 - Eastern Stand	18	13,144	39	0	13612	2 & 3	35.7	2170	559
Stage 4 - Western Stand	5	2,445	11	30	2835	3	combined	combined	201
Stage 5 - Southern Stand	15	10,455	20	31	10961	3	41.5	3786 ¹	660
TOTAL	53	37,000	Total Seating Stages 3-5				\$114M		1870T
							Stages 3-5		

Note 1: The cost per seat for Stages 3 & 5 is significantly higher than Stage 4 due to extensive basement construction works.

Fire Engineering

Existing Northern Stand – fire engineering revisited

The existing three storey Northern Stand is not sprinklered and, under the deemed-to-satisfy requirements of the Building Code of Australia (BCA) is classified as Class 9b and 5, requiring Type A construction and an FRL of 120 minutes for the structure.

An application was successfully made to the Queensland Building Tribunal (based on a BHP Research report) to vary the building regulations to permit the use of fire engineering analysis and unprotected steel framing. The analysis considered the effect of a non-sprinklered “flashover” fire in various parts of the building and showed that unprotected steelwork would perform adequately in fire and could be used in most locations within the structure. The application was approved, enabling savings of approximately \$0.5M in the cost of passive fire protection to steelwork.



The distinctive steel signature of the Southern Stand.

In summary, the Northern Stand is not sprinklered, incorporates a smoke exhaust system in the Level 2 concourse, and the structure comprises generally unprotected steel. A more detailed account of the fire design is to be found in “BHP Structural Steel Casebook No.13, November 1996”. Following on from the experience of the Gabba Northern Stand, and other major stadia, BHP published “The Design of Sports Stand Buildings for Fire Safety” [Ref 1].

New Eastern, Western and Southern Stands - fire safety and the things that really matter

The proposed encirclement of the Gabba with grandstand construction meant that the resultant building was much larger than the existing Northern Stand. This raised questions about the need for compartmentation, and indeed whether the owners and operators could afford to have a major fire in such a public building. It also raised questions as

to whether a sprinkler system should be incorporated in the buildings, even though the BCA deemed-to-satisfy regulations do not specifically require it.

Grandstand construction differs from that of a typical public or office building situation in that it is usually of open layout, has generally low fire loads and is infrequently occupied. The risk to life safety and the risk of property damage and interruption of operations is minimised if fires are kept small. Sprinklers which keep the fire small have a very significant positive effect on life safety, greater in fact than other measures such as structural fire protection or smoke detection. It is also known from fire statistics that the majority of fire starts in a building will not develop further due to self-extinguishment, or early fire fighting action by the occupants, staff and perhaps the fire brigade. It has been found that 97 per cent of fires will not become threatening fires - even if the building is not sprinklered.

The safety level associated with a building is a function of the *likelihood* of a threatening fire and its *consequences*. How likely is it then, that a threatening fire—defined as one which is capable of extending beyond the area of fire origin—will occur during a major event? This has been estimated from [1], which for the Gabba construction gives an average probability of one such fire in every 1,700 years. If the building is sprinklered, the probability of having a threatening fire is reduced to one fire

in every 85,000 years. In that case, the design fire, according to [1], can be taken as the sprinklered fire.

New Eastern, Western and Southern Stands – the fire-engineered solution

A performance-based design was carried out by BHP in conjunction with Norman Disney & Young, the project building and fire services consultant. The BHP publication “Design of Sports Stand Buildings for Fire Safety” was included in the BHP submission. After consideration by the consulting team, Watpac, Qld Fire & Rescue Authority, and Project Services, the publication was accepted by the approving authority (Project Services) as the Fire Engineering Design Brief (FEDB) for the project.

The fire-engineered solution resulted in sprinklered construction utilising an unprotected steel frame, with a consequent saving in the cost of passive fire protection to the steel frame of approximately \$1.3M. By avoiding compartmentation of the new construction, the overall complex is better integrated, and allows the free movement of people.

Specifically, the following fire safety features are significant in the new construction:

- The buildings are generally open and all enclosures with a plan dimension of greater than 20m have alternative exits, thereby providing adequate care against entrapment. Exit spacings, widths, and travel distances throughout the buildings comply with the deemed-to-satisfy requirements of the BCA.
- A public address system to give instructions to the occupants. Documented action plans, in conjunction with Queensland Fire & Rescue Authority, to cover evacuation, and brigade access to the building.
- All areas are sprinklered in accordance with AS2118, with the exception of concourses, change rooms, toilets, and open seating areas.
- No need for other smoke exhaust systems (eg. mechanical systems) within the buildings.
- Activation of sprinklers will result in a signal to the FIP panel (and therefore to building management) and to the brigade. No further detection is required.
- Portable fire extinguishers, hose reels, and hydrants are provided in accordance with [1], and to AS2444, AS2441, and AS2419.1 These devices are to be routinely maintained, with this activity being systematically documented and audited. Procedures and programs are to be subject to audit.

- The seating tiers for the proposed building incorporate concrete slabs such that the spaces below the seating are isolated and there is no possibility of accumulated rubbish being built up.
- Floor slabs and other concrete members will be adequate if an FRL of 60 minutes is achieved. However, in the case of steel beams and columns, maximum exposed surface area to mass ratios (k_{sm}) of 30 and 26m²/tonne for beams and columns, respectively, should not be exceeded. The roof and roof support structure, being non-combustible, do *not* require an FRL in accordance with the concessions provided for open spectator stands in the BCA.
- The sprinkler system must be properly commissioned, maintained, and managed. A documented procedure is to be developed to ensure that sprinklers are not isolated during a major event and that, should the system need to be isolated, the isolation time will be kept to the absolute minimum.

Fabrication & Erection

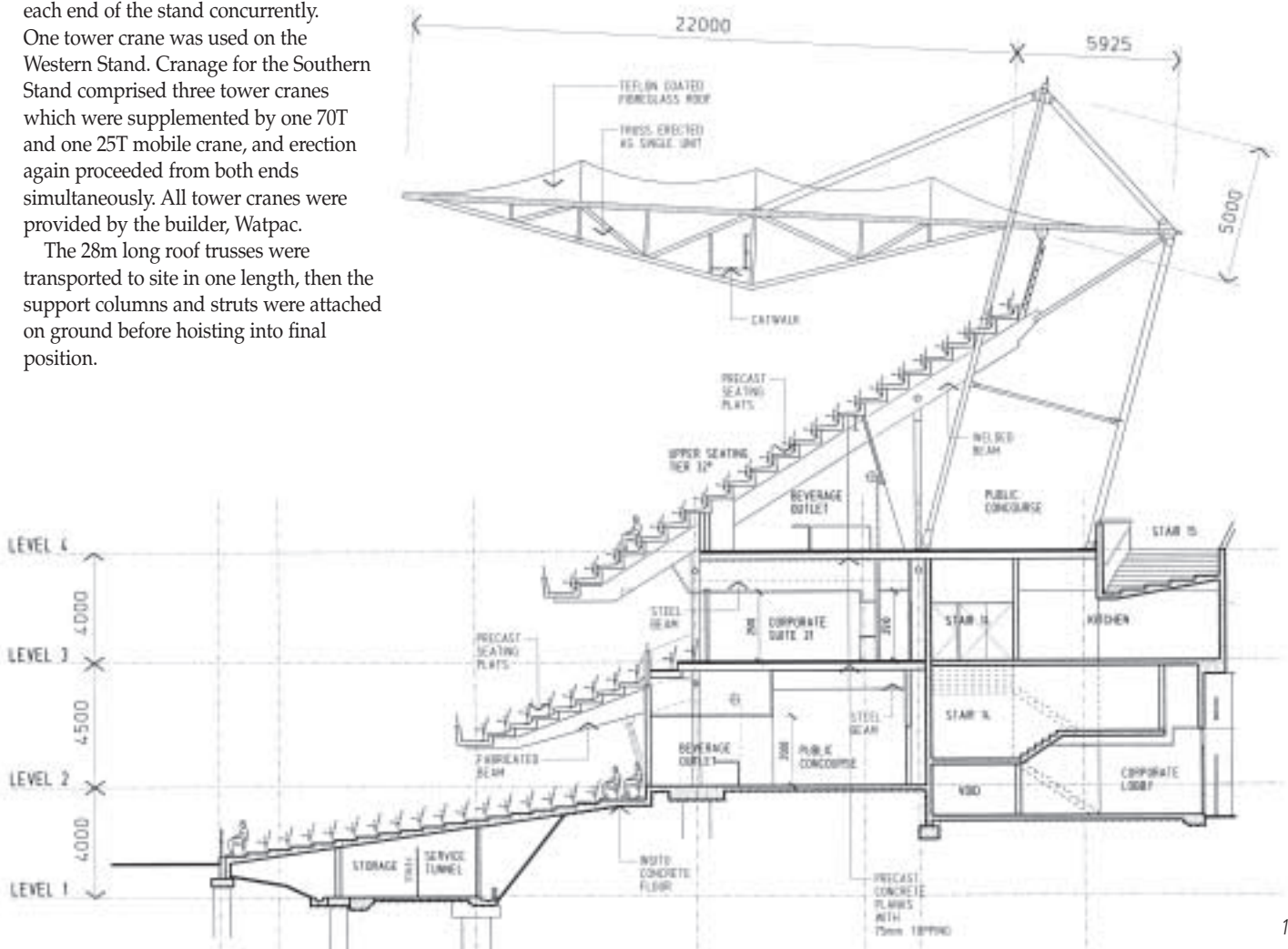
Beenleigh Steel Fabrications Pty Ltd fabricated and erected all 1,420 tonnes of steel for the project, as well as precast concrete items. Cranage for the Eastern Stand comprised three tower cranes, and steel erection proceeded from each end of the stand concurrently. One tower crane was used on the Western Stand. Cranage for the Southern Stand comprised three tower cranes which were supplemented by one 70T and one 25T mobile crane, and erection again proceeded from both ends simultaneously. All tower cranes were provided by the builder, Watpac.

The 28m long roof trusses were transported to site in one length, then the support columns and struts were attached on ground before hoisting into final position.

Grandstand	Steelwork (Tonnes)	
	Structurals & Plate	CHS & RHS
18 Bays East	418	141
5 Bays West	161	40
15 Bays South	508	152
Total	1087T	333T



Above: Eastern Stand, L4 transfer beams.
Below: Eastern Stand section, Bay 26.



Protective Coating

Three different protective coating systems were adopted, depending on the exposure conditions and the accessibility of the steel for future maintenance. The three systems all had a Class 2^{1/2} abrasive blast clean and were painted as follows:

Type 1: General steelwork, not exposed

- Zincode 402 to 75 microns DFT

Type 2: Exposed and accessible steelwork

- Amercoat 385 to 125 microns DFT
- Luxathane RT to 50 microns DFT

Type 3: Exposed and less accessible steelwork (eg roof structure)

- Zincode 402 to 75 microns DFT
- Amercoat 385 to 125 microns DFT
- Luxathane RT to 50 microns DFT

A more detailed report on the fire engineering and structural aspects of the Brisbane Cricket Ground Redevelopment is available from Steel Direct (phone 1800 800 789). The BCG Northern Stand is previously described in "Structural Steel Casebook No.13, Nov '96", and is also available from Steel Direct.

References

1. Bennetts, I.D. et alia (1998), *Design of Sports Stand Buildings for Fire Safety*
2. Bennetts, I.D. et alia (1998), *Fire Safety in Shopping Centres*, Final Research Report Project 6, Fire Code Reform Centre

Project Participants:

Client: Brisbane Cricket Ground Trust
Project Manager: Project and Development Services Pty Ltd
Document & Construct Contractors: Watpac Australia Pty Ltd
Consulting Architects: Daryl Jackson Pty Ltd
Consulting Engineer - structural & civil: Robert Bird & Partners Pty Ltd
Building Services Engineer: Norman Disney & Young Pty Ltd
Specialist Fire Engineering: BHP Research (Dr Ian Bennetts)
Hydraulics Engineer: Tom Cooper & Associates
Building Authority: Project Services, Dept of Public Works
Steel Fabricator & Erector: Beenleigh Steel Fabrications Pty Ltd
Shop Detailers: Tregar Engineering Services (St 4)
Online Drafting Services (St 5)