

White Steel

The sports building works of Philip Cox, from 1977
and their global influence

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While COX Architects & Planners (COX) has grown into a multi-city and international practice of many collaborators, this essay will look at the COX 'manner' and language developed by founder Philip Cox through the sports and events projects of the firm in the latter part of the twentieth century. This is a story that starts in Canberra with the National Athletics Stadium and becomes a successful and influential approach for major sports buildings, perhaps best demonstrated by the Sydney Football Stadium of 1988. This path also reveals a strong interest in an Australian 'functional tradition' of construction, structural innovation such as the emerging 'high tech' work in England, the tensile experimental buildings of Frei Otto, and a tradition of structural expression in Australian architecture. Of particular interest is the practice's 'white stadia expressionism', which, after 1988, is adopted by other architects and becomes influential in the design of international sports facilities. This approach was epitomised by the use of expressed-steel masts, bracing and tensile cables for both structural efficiency and as part of an emerging design language, a language that embraces 'complete' stadia - as opposed to separated stands. It was part of a global move toward all-seat facilities, the need for uninterrupted views and the desire to shelter spectators.

The first use of expressed structural masts and cables by Cox was in Bruce, Canberra, at the National Athletics Stadium (now Canberra Stadium) in 1977 where the practice took onboard the efficiency and practicality of tensile structures, and rendered them in steel – both for structure and cladding. The use of steel cables enabled the suspension of the canopy roof without any internal supports to interrupt seating or views. Bruce stadium embraced a radical sense of tension, the masts angled and caught in a suspended moment between cables connected to the ground and those of the canopy. Tensile structures have a history in Australia, particularly through the exceptional 1959 Sidney Myer Music Bowl, Melbourne, designed by Yuncken Freeman with Bill Irwin as engineer – regarded as one of the seminal early structures in the world of its kind. Expression of structure and tensile cables can also be seen on the former Melbourne Olympic Swimming Pool, 1956, a great work of innovation designed by Peter McIntyre and Kevin Borland, again with structural engineering by Bill Irwin. It is this lineage that the National Athletics Stadium entered and developed upon.

The Bruce stadium was perhaps a transition from the more rustic 'Sydney School' palette of Cox's early work, exemplified by the 1965 C.B. Alexander Agricultural College in Tocal, New South Wales. The main hall and tower at Tocal demonstrate an early engagement with structural expression – in this case through timber. The chapel at Tocal features a large timber joint which joins over 400 shear-connector rings and was the first of its kind in the world¹. Even though Tocal has a particular rural vernacular, the use of structural expression

internally is overt –Philip Cox attributes this to large rural buildings such as the Cooling Towers in Kuri Kuri, New South Wales.¹¹ The expression of structure for Bruce stadium 'comes outside' in contrast to the internal expression at Tocal. The Kambah Health Centre, 1973, also features an internal expression of structure, with a large central timber truss creating an open-span working environment.

The Bruce stadium was considerably extended in the 1990s when it was converted from an athletics venue to a more general-purpose stadium, home now to Canberra's rugby teams and a rectangular pitch. The original black and white photographs of this exceptional project show the stadium's careful integration into the bushy landscape of the Canberra suburb of Bruce. Indeed, it was Cox's sensitivity to landscape, through such projects as Tocal, that led to the Bruce Stadium commission by the National Capital Development Commission. Having never produced a sports building before, but with a strong interest in structure, this project was in many ways a major break for Cox and his practice and led to the sporting and large span projects that now dominate the COX portfolio. Another key project is the Australian Institute of Sport (AIS) Arena, immediately next door to the former athletics stadium on the AIS campus in Bruce. Completed in 1981, this fully-enclosed sports and general-purpose arena uses one of the most original and innovative roof systems ever seen in Australia. Slung precast concrete slabs form the roof, which are supported by high strength grouped steel cables. The externalisation of structure finds full force in this exceptional building.

The key engineering principle here is to maximise the weight of the roof to ensure the cables are always in tension rather than flipping into compression in an uplift situation, for which more substantial solid steel members would be needed. A finer network of cables, using less material, is then possible. Cox himself suggests this in part came from an observation of certain thatched Irish cottages, in which ropes are cast across the thatch with stone weights at their ends. The roof of the Bruce stadium, although thin and with a floating appearance, is also concrete for the same reason. The result in both cases is finely poised and taut system, a moment of balance.

In the early work of the practice, structural engineering design was carried out by the office, with checking and certification completed by a third party. This not only shows a strong interest in structural engineering, but an ability to calculate and optimise structural design; Cox recalls using a large beam compass when working out structural sizings for the Bruce stadium in a pre-computing environment. The early work at Tocal was the first major exploration of structural expression, in local timber, acting in tension and compression. This was an architecture of 'rude timber', one directly connected

to an Australian vernacular tradition rather than an interest in more refined and imported Georgian models. The sports architecture that Cox developed was thus perhaps one of ‘rude steel’ – where innovation in structural expression was built from Australian-made steel, simply and effectively connected.

Historically, Richard Rogers used expressed ‘flying’ cables and masts for the first time with Fleetguard Factory in France (1979-81) – after Bruce stadium – following limited expression of bracing while working with Norman Foster in the early 1970s. Frei Otto had a long-standing interest in efficient tensile structures, and first used expressed tensile cables on a large scale in the remarkable 1972 Olympic Stadium in Munich. Cox does not emulate Otto – whose language is more organic – but converts the structural possibilities into a readily understood and conventional construction environment.

As a successful architect of large buildings, he drew initial inspiration from the big vernacular buildings in rural Australia generally associated with primary industry. The wheat silos, large sheds and cooling towers that dot the Australian landscape provided a typological tradition to enter into. The study of Australian vernacular, made through Philip Cox’s early writings on the subject in the 1960s and 70sⁱⁱⁱ, crystallised how an honest expression of structure can lead to a building language that brings the structural and architectural disciplines together. This approach enjoys a material efficiency and enduring quality, as opposed to a more façade or image-based technique, which generally re-emerges in the 1970s and 80s. It is through the ‘event’ projects of the office that the theme of both evident structure drawn from the vernacular and of constraint-based experimentation develops.

Perhaps the most important project in the mid-career work of COX Architects & Planners is the Sydney Football Stadium. A Bicentennial project, this stadium uses repetition of a common element in a fluid and sinuous manner to create a work that, 20 years on, is still contemporary. It was a project which adopted the early use of digital techniques to describe and document a form that does not conform to traditional elevation-based composition. This general move toward computing was well suited to the large repetition-based projects coming into the office in 1980s. The repetition at the Sydney Football Stadium is three-dimensional, with masts being both arrayed in plan and with varying heights. The complex roof edge and lighting fascia around the inside of the stadium describe the outcome of this process and form a remarkably fluid loop. In this way the project represents a giant leap forward in stadium design. The iconic nature of the project is also created by the restraint of the white palette, perhaps more dominant here than anywhere else. The three-dimensional web of steel members acting in a combination of compression and tension is forged into a complex but clear expression to the exterior of the building, one which is vivid

in its whiteness. Indeed, all of the projects completed at this time move toward extensive use of white painted steel. Philip Cox said this in relation to this use of white for the steel:

With the steelwork seen against the sky the main impression is it should be seen as more of a web rather than a heavy form. White is slightly reflective and gives almost a mystic quality, rather than if you painted in black or dark. You will read [these colours] in much more of an explicit way than you will if it's white, which tends to smudge the structure in a visual sense against the light blue Australian sky.^{iv}

There are many other possible readings into the use of white – the vernacular ‘purified’ and made ‘modern’ like the white avant-garde of interwar European Modernism; the colour of sailing; the legacy of Utzon and the Opera House; the dark ironwork of the nineteenth century bridges and train stations made new; an inversion of Mies Van Der Rohe’s obsession with black steel in big buildings; or, a homage to the white-painted steel of his seminal Farnsworth House.

Another ‘white’ Bicentennial project, the Sydney Exhibition Centre at Darling Harbour, pushes its expressed structural masts into the public space at the front of the building, recalling the AIS Arena in Canberra. Being next to water, analogies to white ships’ masts are hard to avoid, and Philip Cox himself welcomed these at the time. The fine white steel masts are indeed akin to modern white sailing boats, and in this way the language ‘comes home’ with the Exhibition Building at Darling Harbour. The other buildings by COX at Darling Harbour – the Maritime Museum and Aquarium – also abound with water-based comparisons – sails and waves typically.

The Exhibition Centre is a series of repeated halls offset from each other to establish a bay structure and avoid a completely continuous form. The perimeter space between the concrete cable anchor and the building itself forms a kind of minimal colonnade, in which users are partly within the structure. The historical precedent for work of exhibition and expressed frame is normally regarding as Joseph Paxton’s famous Crystal Palace of 1851, where new materials and the desire to internally display numerous, and often large, objects forced a new kind of building, one which was part super-cathedral and part grand-train-station. Indeed, the Sydney Exhibition Centre carries the same belief in structure and need to satisfy a contemporary problem. The use of minimal structure in steel has both its economic and sustainable benefits, and became part of the enduring image of the celebratory function of the Bicentennial and of exhibition.

Sydney and Canberra are not the only sites of influence for sports and exhibition work. One of the major works completed for the 1988 Bicentennial was the National Tennis Centre, Melbourne (now Rod Laver Arena). The building embraces the wrapping nature of a stadium and creates a significant arcade around its perimeter, formed through a series of structural concrete arches, and capped with a continuous expressed upper level and endless ribbon window. The building's presence on the skyline of Melbourne is formed through the white steel truss of the sliding roof, also its primary technical innovation. This has been an enduring figure in the psyche of Melbourne for 20 years; the roof opening to sun and closing to rain is a Melbourne tradition. The Princess Theatre (1886) had a retractable roof, and more recently, the Docklands Stadium does the same on a larger scale, drawing from Rod Laver Arena in its expression of the roof truss system. Rod Laver Arena is a project that through its semi-radial nature has gained a civic role in its setting of Melbourne Park and the southern edge of the city.

The trend in covered stadia with operable roofs has developed considerably since the Rod Laver Arena. One of the largest in the world is the Millennium Stadium in Cardiff, Wales. Completed in 1999-2000 and designed by HOK + Lobb Partnership, this work shows the influence of Rod Laver Arena in the use of large white steel corner-masts and a wrapping ribbon window around the perimeter (enlarged to suit the bigger arena). Interestingly, the building that was replaced by Millennium Stadium – the National Stadium designed in 1962 by Osborne V Webb and Partners – used an expressed concrete and steel structure in which the cantilevered roof was supported by an expressed-steel truss fixed back to massive concrete fin columns. Another seminal sports building in the UK was the Crystal Palace National Athletics Stadium, London, completed in 1964 and designed by Sir Leslie Martin. This used angled steel masts and rigid steel struts to support a cantilevered roof. This project bears similarities to the Bruce stadium in both program and structural approach.

The success in large 'all-round' buildings rendered in expressive white steel informed the work of other small COX projects such as the 1994 Arena Joondalup, in northern suburban Perth. This is a multi-function sports and community building, locating a football and cricket oval on its eastern side. The latter's partial stadium, or pavilion, recalls the stadium at Bruce which engages the surrounding landscape through earthworks. This 'stand' is the end of a white linear building with halls and pool inside, and shows two types cleverly merged together. Several other Perth projects are interesting in the development of an architectural language - the Rio Tinto Research and Development Facility, and Joondalup and Stirling Train stations, all completed in 1993. The Stirling Station successfully translates the designs developed for COX's sports building into a train and bus interchange in the centre of Perth's Mitchell Freeway.

Designed by Steve Woodland and Keat Tan of the now defunct Forbes & Fitzhardinge (later absorbed by COX Architects & Planners) it developed a clear structural system that avoids the 'heaviness' of many traditional rail and bus stations. The Joondalup train station introduced a curved-roof profile supported by cables, allowing light to enter a submerged train platform. A remarkably similar approach was taken for the main entry and circulation space for the Rio Tinto facility. Projects such as these represented the emergence of 'style', one removed from the need for large spans or uninterrupted views. In crossing typologies, the ideas grounded in stadia design had become a language.

This language has been 'exported' both through its influence on other firms and directly through several international commissions, particularly in Asia. The 1999 Singapore Expo building and 1998 Asian Games Stadium and Aquatic Centre, Bangkok, are two 'white' projects in the region that in many ways seem like Australian COX buildings expressed in different contemporary contexts.

The concentration of attention on Australia and Australian national identity in the late 1980s was driven by the Bicentennial and was a major opportunity for COX's work to be seen on a large scale, both through television coverage and the publication of the projects internationally. Key among this was the use of three COX projects in the revised 1991 edition of Dennis Sharp's book *Twentieth Century Architecture: a Visual History*. This European-published text assisted in making COX's 'white steel' work influential around the world. Sir Bannister Fletcher's *A History of Architecture* featured both the Bruce stadium and the Sydney Football Stadium in its twentieth edition (1996), bringing the works into one of the most well-known architectural texts of all time. The Bicentennial also brought cultural attention to Australia; the October 1988 edition of the London-based *Architectural Review* was an 'Australia' special, with articles on COX, Canberra, New Parliament House, Expo 88, Rex Addison, Edmond and Corrigan, Contemporary Aboriginal Architecture, Burgess' Brambuk Living Cultural Centre, Glenn Murcutt's 'Touch this earth lightly' and more. Jennifer Taylor's article 'Philip Cox's Bicentennial Buildings for Sydney' features the Sydney Football Stadium, the Sydney Exhibition Centre and National Tennis Centre extensively, but also both the key buildings at Bruce, completed up to 10 years earlier. Taylor also featured the Bruce stadium in her book *Australian Architecture Since 1960*, published by the RAI in 1990.

Perhaps the most interesting manifestation of a national architecture is that of the 1988 Australian Pavilion in Venice used for the various arts (and architecture) biennales since. An often-criticised project, this small white steel building is unique in a garden setting of various classical, and some exceptional modernist, national pavilions. Part-Australian 'tin shed' and part-miniature

event building, it is an appropriate record of Australia's architectural development in the late twentieth century.

The influence of COX's white work of the late 1980s can be seen in sports stadia around the world in the 1990s. The 1994 Hong Kong Stadium by HOK is such a project, with a symmetrical white roof and flying structure. Similarly, the 1992 Johannesburg Stadium, designed by engineering firm Arup can be seen as a white version of the Bruce stadium. Like many successful 'big building' architects, COX formed a strong relationship with the office of Arup in the 1980s, which led to them moving into the same building in 1986. While not all COX projects are engineered by Arup, all the key Sydney 1988 projects feature Arup as the structural engineer.

Australia's most well known building, the Sydney Opera House, is a pinnacle of the architect-engineer collaboration – the design is a result of Jorn Utzon and Ove Arup working together as an architect-engineer figure. Like the nearby National Maritime Museum, the Opera House has had trouble escaping the comparison to boat sails and waves. There is an important distinction, however, between this work and that of COX; while the Opera House is more of a cave, COX's style clearly leans towards that of the tent – lightweight, optimised, clear in its structure and perhaps an acknowledgement of the temporary nature of occupation. The strongest work in the substantial COX portfolio follows this line. The 2002 WA Maritime Museum, Fremantle, edges more toward representation – an abstracted fish is used here and the approach is less successful, as it moves away from a reworked vernacular and functional tradition, towards the referential.

Following the Bicentennial, the next major international focus on Australia was the 2000 Sydney Olympics, for which many facilities were commissioned, particularly at the Olympic site of Homebush in western Sydney, a former abattoir. Sydney Olympic Park now features four COX event buildings, and after Darling Harbour, is central to the practice's work in this area. The COX projects include the site masterplan, the International Athletics Stadium, the Aquatic Centre, the Sydney Superdome (for indoor sports) and the relocated Showgrounds. With the exception of the master plan, all were completed in collaboration with other local architects. The principal stadium, Stadium Australia, designed by Bligh Lobb Sports Architecture, carries the influence of the COX manner in its design, particularly through the use of white exposed steel trusses. COX's own scheme for Stadium Australia literally heightened the expression of structure, with two symmetrical giant framework arches with steel webbing underneath supporting the canopy roof. In many ways it bears similarities to Norman Foster's Wembley Stadium, designed some years later and possibly the most well known sports project to employ a white-steel flying-

arch structure large enough to be 'iconic'. The Khalifa Stadium by COX with PTW and GHD, used for the 2006 Asian Games, also shows the ongoing interest in the system developed for the main Sydney Olympic stadium.

The Sydney International Athletics Stadium, 1993, was the first project at the Sydney Homebush Olympic site. Here, the light towers are also giant structural masts from which cables supporting the canopy are suspended. The interest in efficiency creates a logical desire to merge the light tower and structural mast, and this can be seen in various COX projects since. The Sydney Showgrounds, relocated to the Homebush site as part of the redevelopment, also feature principal masts acting as light towers. Interestingly, the towers here are red rather than white, perhaps suggesting difference to the other buildings at Homebush. Cables are employed from both mast to roof, and roof to ground to resolve uplift forces – a different solution to the 'heavy roof' system explored in early projects. This further reduces the net quantity of material required, but does result in some visible cables within the seating area.

The Olympic Stadium for the 2004 Athens Olympic Games uses another large white-steel web structure – designed by Spanish architect Santiago Calatrava, known for his white and gothic-like structures, often transport buildings and bridges. His work contains a large degree of geometrical emphasis, and perhaps less of the functional tradition seen in COX's work. The 2008 Olympic Stadium in Beijing by Herzog and De Meuron shows another direction in global sports architecture, one which turns away from the COX tradition of expressed structure towards the expression of surface – often both structure and skin. Along with Herzog and de Meuron's exceptional *Allianz Arena* in Munich, such stadia represent an explicit move away from the growing universality of the expressed structure. While this interest continues for many, the work of COX Architects & Planners may now be aligning to such considerations. This is probably best seen in the new Melbourne Football Stadium, sitting alongside the seminal Melbourne Olympic Pool and National Tennis Centre. Essentially a series of optimised interlocking 'bubbles', this mid-capacity stadium uses EFTE cladding – all in white.

Whilst it is traditionally accepted that Glenn Murcutt has been a figure who has represented Australia overseas architecturally, it is clear that the work of Philip Cox and his practice has in fact been more influential at the level of large buildings, particularly those for sport and exhibition. Murcutt has made a highly successful and respected career from adopting the Miesian pavilion to regional concerns and identity but it is a model of adoption and one limited in size to domestic-scale projects.

COX proposes a different idea of a successful Australian architecture to that of the refined house in the landscape; instead these are big buildings and structures that resolve difficult issues and are mostly built in white painted steel. They are buildings that have tended to be built quickly and with modest budgets, and in this way have drawn on a pragmatic Australian tradition. COX has by and large avoided a historically referential language for sports buildings, partly due to the demands of cost and issues of span and visibility, and partly in recognition that many projects have been experiments in new typologies whereby constraints generate innovation. It is also possible to argue that the repetitive or serial nature of Cox's large event projects create a civic presence for the buildings in the same way classical buildings rely on repetition to establish a public sensibility. The opportunity to work at the scale of event facilities and stadia has allowed Cox to develop an influential Australian architecture that is not limited to the individual house, and embraces repetition, large spans and structure.

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ⁱ Established in an interview conducted by Stuart Harrison and Anna Johnson with Philip Cox, 20th March 2008

ⁱⁱ Cox Architects, *Cox Architects*, The Images Publishing Group, Victoria, 2000

ⁱⁱⁱ In Philip Cox's books such as *Rude Timber Buildings In Australia*, 1969 (with Max Freeland and Wes Stacey), *The Australian Homestead* in 1972 and *Australian Colonial Architecture* in 1978.

^{iv} From an interview conducted by Stuart Harrison and Anna Johnson with Philip Cox, 20th March 2008